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THE

AMERICAN JOURNAL OF SCIENCE AND ARTS.

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Art. I.—*Charles Grafton Page.*

Prof. Charles Grafton Page, whose death at his residence in Washington, D. C., was announced in the last July number of this Journal, was born in Salem, Mass., on the 25th day of January, 1812. He was prepared for College in the Grammar School at Salem, and entered Harvard University in 1828, graduating in 1832. He studied medicine at the medical school in Boston, and in the year 1838, he removed with his parents into Virginia, pursuing there the practice of his profession. About the year 1841, he was appointed one of the Principal Examiners in the United States Patent office. At that time there was but one other Principal Examiner, and the office was one of great responsibility, since upon the Principal Examiner alone generally depended the decision of all applications for patents in the classes of inventions under his charge.

In 1844, he was elected Professor of Chemistry, in the Medical Department of Columbian College, D. C., but in 1849, he resigned his professorship on account of the pressure of his duties in the Patent Office. In the year 1852, he retired from the Patent Office for the purpose of devoting himself to the effort in which he was then engaged to introduce electro-magnetism as a motive power. This enterprise having been relinquished with the failure of means to extend his experiments, he associated himself with Messrs. J. J. Greenough and Charles L. Fleischman in the publication of the *American Polytechnic Journal*, which commenced with the beginning of the year

1853. After the discontinuance of that Journal with the close of the year 1854, Prof. Page does not appear in any public capacity until the year 1861, when he again entered the Patent Office as Examiner of Patents, a position which he held for the remainder of his life.

Prof. Page is best known to the scientific world as an electrician. We have learned, moreover, "from his mother and other near friends that he evinced a most remarkable fondness for natural science in all its branches at a very early age. Once when about nine years old he was missing during a severe thunder storm, and on being sought by his anxious friends he was found on the top of the house, holding up at arm's length a fire shovel to see if he could not catch a shock of electricity from the surcharged cloud!" It has been related also by his early friends that at ten years of age, having begged a lamp glass of his mother, he in due time surprised her with a successful electric machine made by himself. Entomology received a portion of his attention while a school boy, and he had a passion for botany and floriculture and indulged in it to the extent of his ability. Respecting his school and college life we extract the following from a communication of Dr. Henry Wheatland, President of the Essex Institute, of Salem, Mass. "My acquaintance with C. G. Page commenced when we were classmates in the Salem Latin School. At that time he had the reputation of being interested in electricity, having made or was making an electric machine. * * * * * The same taste followed him in his college course. In our junior year several of us, including Page, organized a chemical club. Each of the members was expected to lecture in alphabetical order. Page lectured on electricity, the air pump, &c. At this time he had a large collection of apparatus for a student, an electrical machine, air pump, &c. Several of us were also interested in natural history, as botany, mineralogy, insects, &c. Page was also enrolled in our number. After leaving college, whilst a medical student, he carried his investigations still further, taking up voltaism and constructing batteries of different kinds, culminating in his extensive researches in 1836, or thereabouts, which resulted in producing motion by the magnetic power.* During his medical studies he delivered a course of lectures in chemistry to a class in the Lyceum Hall. Page during his school and college days, was always full of fun and frolic and took a lively interest in all boyish occupations. He was a leader among the gymnasts, a famous skater, a good singer, a loved companion, and a very great favorite

* Prof. Page, in the American Polytechnic Journal, vol. i, p. 6, attributes the invention of the first electro-magnetic engine to Prof. Henry.—L.

with all." To this, Gen. H. K. Oliver, of Salem, his early instructor and friend, adds, "I myself remember seeing during Prof. Page's residence here—at his office—a miniature railway, an elliptic curve of about twelve feet long and six wide, around which travelled a miniature magnetic engine drawing at high speed a miniature car."

The zeal and activity in the pursuit of electrical science and experiment, which marked especially these few years that he resided in Salem, after completing the study of his profession, are evidenced by his numerous contributions to this Journal about that time. He had much fertility of invention, and delighted in mechanical contrivances for the practical application and for the interesting illustration, of the laws of electric and electro-magnetic action. He was not only a skillful experimenter, well versed in the theory of electricity, but was also a ready and spirited writer, and his published papers must have contributed greatly to extend the knowledge of, and excite an interest in, electrical science. The writer of this notice can certainly testify to his own obligations to him in this respect.

In the year 1836, he made a valuable series of experiments, published in the 31st volume, 1st series of this Journal, upon the induction of electric currents, following up the previous discoveries of Prof. Faraday and Prof. Henry on that subject. Prof. Henry (this Journal, 1st series, vol. xxviii, p. 328) had obtained sparks and shocks from the "Calorimotor" by means of the induction of the current upon itself in a long copper riband wound into a close flat spiral, after having been wrapped with an insulating covering. Prof. Page repeated and varied these experiments with a spiral riband an inch wide and 220 feet long, and made the important step of augmenting the intensity of the shock by means of a reduced length of battery circuit in conjunction with a greater length of induction circuit, the induction circuit being, of course, in part or in whole exterior to the battery circuit. Among other forms of experiment detailed in the paper alluded to, he obtained the shock from a part of the spiral entirely external to the part in the battery circuit, which is in conformity with Faraday's elementary observation of the induction of a current upon a neighboring conductor, but he ascertained that the greatest shock was obtained, with that helix and the battery of a single pair used, when the whole length of the spiral was included in the induction circuit, and a fraction only of its length in the battery circuit. He did not offer any theory in explanation of this result, but at this day, when the laws of the voltaic circuit have become not only known but familiar, and since the laws of induction have become better under-

stood than they were at the time of which we speak, especially from the extensive series of investigations made by Prof. Henry about two years afterward, it is easy to see that after a given volume of conducting metal has been filled (so to speak) with a current by an amount of battery surface proportional to the volume of metal, the effectiveness of the resistance of a break in the circuit in the rapidity with which it destroys the current, is measurably proportional to the smallness of the number of plates into which the battery surface is divided in series, with the volume of metal disposed in a length suitable thereto, and that the intensity of the shock from the induction circuit, the length of the latter remaining unchanged, will in this way be increased by reducing the length and intensity of the battery circuit. Or, to state the same otherwise, if the spark formed by a break in the induction circuit is to be of greater length (resistance) than the short spark formed by the break in the battery circuit, the length of the induction circuit must be in like ratio greater than that of the battery circuit; and it is in this point of view that Prof. Page himself has stated the primary characteristic principle upon which the voltaic induction coils depend for their effects. The step made by him in 1836, as above mentioned, was, so far as we are aware, the first step made in this direction. An account of it was carried to Europe by the late Francis Peabody of Salem, and communicated, rather imperfectly, to the English philosopher Sturgeon, in advance of its publication here. This communication would appear, by Sturgeon's account, to have given the first impulse to a quite extensive series of experiments made by the latter, and, within a year from the time of his interview with Peabody, he constructed an induction coil, described in the Annals of Electricity for Oct., 1837, vol. i, p. 477, in which the battery circuit consisted of an inner helix of rather thick bell wire 260 feet long, and the induction circuit of an outer helix of 1300 feet of very thin wire. This he used sometimes with, and sometimes without, an iron core in the common axis of the two helices, and obtained strong shocks in either case. In the meantime, however, Prof. Callan of Maynooth College, Ireland, had been making experiments on an extensive scale, and had carried the multiplication of the length of the induction circuit, as compared with that of the battery circuit, to a much greater extent than was done in the coil of Sturgeon, just noticed, and his results had been published in Sturgeon's Annals. But in his experiments he used the induction of very large solid masses of iron, and by overlooking the interference of the electric currents that must be induced in the solid metallic mass of the electro-magnet, he was prevented from dis-

covering one remaining step of primary importance in the improvement of these machines. The electro-magnet and induction coil in which he first, and several months earlier, used the shortened battery circuit, was in this particular, very nearly a repetition of Page's coil, giving an induction circuit of double the length of the battery circuit, but Page preceded him three months, as shown by the date of Page's paper in this Journal for Jan., 1837, and that of Callan's paper in the London and Edinburgh Philosophical Magazine for Dec., 1836. Mr. Peabody's communication to Mr. Sturgeon and Mr. Clarke, is stated by Sturgeon to have been made one or two weeks before the Bristol meeting of the British Association. This meeting took place Aug. 22d, 1836, and Callan's last mentioned paper was dated Maynooth, Aug. 23d, 1836. While, therefore, there appears no doubt that Prof. Callan was quite independent of Prof. Page in making this important step, it is clear that priority belongs to the latter.

We have thus dwelt at some length upon this subject because we have not found it possible otherwise to do justice to Prof. Page, and to all most directly concerned.

Related to this principle, another discovery of interest which Prof. Page made in the same series of experiments was that the intensity of the shock was increased by making the break of the battery circuit (over mercury) take place under a non-conducting liquid. The question suggests itself whether this observation might not deserve renewed attention.

In the course of his experiments with the flat spiral he obtained the spark and the shock from a thermo-electric current (this Journal, I, vol. xxxiii, p. 118), and thus added one more to the links which Faraday had already supplied to demonstrate the identity of thermo-electricity, voltaic electricity, and statical electricity. He also succeeded in charging a leyden jar by means of the induced current, a result belonging to that class of facts which warrants the use of the term *current* as correctly expressive of the actual relation existing between statical electricity and voltaic, or dynamic electricity, and after having increased his flat spiral to the length of 320 feet, he even succeeded in doing this with a voltaic battery of a single pair. It should also be mentioned that he projected the induced current (this Journal for Oct., 1837, p. 355) between charcoal points "before contact."

To Prof. Page also belongs the adaptation to the induction coil, of the self-acting circuit breaker, that is, a circuit breaker operated by the current itself. The circuit breaker he first used (1836), was Barlow's spur wheel, which turns between the poles of a permanent horse-shoe magnet. Soon afterward,

(this Journal, 1st series, vol. xxxii,) he contrived several other forms of self-acting circuit breakers, one of which consisted of a miniature vibrating lever moved by the action of the current and so limited and regulated in the extent of its motion by a set screw as to give it the extremest rapidity of oscillation desired. The breaking of the circuit of a voltaic current by the action of the current itself was done some years previously in the electro-magnetic motor of Prof. Henry, already mentioned, but Prof. Page appears to have been the first to contemplate the availability of this mode of action to produce the extreme rapidity of alternation called for in these induction machines,* and to make and bring before the public a construction embodying this idea. This early instrument is, in this respect, the type of the self-acting circuit breakers now very generally used with the voltaic induction coil.

The discovery of the remarkable effect produced by substituting iron wires for a solid iron bar in induction coils, was made by Sturgeon, by Bachoffner, and by Page, all independently of each other, but the discovery by the English philosophers was prior in time. In April, 1838, Daniel Davis, Jr., of Boston, made, under the direction of Prof. Page, a coil machine embracing all the discoveries and improvements made up to that time by himself and others, including a provision for making the break of the battery circuit under a liquid; and with some variety in the accessory details these machines were soon manufactured in large numbers in this country. The only considerable improvements made since that time, apart from the construction by Ruhmkorff upon a greatly enlarged scale, are the invention by Fizeau of the condenser, as it is rather inaptly called, and Richie's improved mode of winding the secondary, or induction, coil of fine wire, so as to divide, in an extreme degree, the strain upon its insulation.

The United States Government has testified its appreciation of Prof. Page's share in the invention and development of this class of machines, by the enactment of a special law authorizing the grant of a patent, at the discretion of the Commissioner of Patents, which accordingly was issued to him in the last days of his life, after going through the usual course of examination in the Patent Office.

* To guard against all possible injustice, we extract the following from Prof. Henry's paper in vol. xx, 1831, of this Journal, as republished by Prof. Page in the American Polytechnic Journal, vol. i, p. 6, premising that the oscillating electro-magnet of Henry's motor was "about *seven inches* long, and movable on an axis at the center." "If the tumblers be filled with strong diluted acid, the motion is at first *very rapid and powerful*, but it soon almost entirely ceases. By partially filling the tumblers with weak acid, and occasionally adding a small quantity of fresh acid, a uniform motion at the rate of *seventy-five vibrations in a minute*, has been kept up for more than an hour." The italics are ours.—L.

Another machine constructed by Prof. Page, and described in this Journal for Oct., 1838, consisted of a U-formed electro-magnet of iron wires, around this an extra coil of wire for induced currents in addition to the coil for the battery current, and an iron armature made to rotate before the poles of the electro-magnet, together with a rotating circuit breaker for the battery current made adjustable on the shaft of the rotating armature. Induction could be produced in the extra coil of wire, without breaking the battery circuit, by the magnetic disturbance consequent on the passage of the rotating armature across the poles of the electro-magnet. But on bringing into play, and properly setting, the breaker of the battery circuit, the motion of the armature was maintained by the battery, and by leaving opened or leaving closed the circuit of the extra, or induction coil, and varying the set of the rotating circuit breaker on the armature shaft, some curious and instructive results were produced in illustration of the influence of induced currents upon the motion of electro-magnetic engines, for the detail of which we must refer to the paper alluded to.

In the same volume of this Journal he also describes a magneto-electric machine, similar to the machine of Saxton, which he constructed on a large scale, and in which he provided the rotating pair of armatures with commutators by which the alternating induced currents of the armature coils were made to pass all in one direction through a conductor joining the extremities of the wire of these coils. The armatures were straight iron bars ten inches long, parallel to the axis on which they rotated, and covered, each, with 800 feet of No. 20 copper wire, and were placed between a *pair* of powerful compound permanent magnets, one at each end of the armatures. The two coils could be used as 800 feet of double wire, or 1,600 feet of single wire. With this machine water was decomposed very rapidly, and by breaking the circuit of the coils a half inch spark was produced, and a variety of interesting results is detailed which we have not room to repeat here.

Another magneto-electric machine constructed by him, and still more remarkable for the results obtained with it, is the subject of a notice in the Patent Office Report, for 1844, reproduced in the 48th vol., 1st series, of this Journal. By the current from this machine an electro-magnet was charged to such a degree as to sustain one thousand pounds. Unfortunately, no complete description of the machine is in existence so far as we know. The machine itself was presented to the Smithsonian Institution, but was destroyed by the fire that swept away a part of the contents of the building a few years

ago. It was, however, similar in its general construction to the last mentioned machine, except that the helices around the rotating armatures were "made up of a series of copper discs, instead of wires, each disc being split, and one of its split edges joined to the edges of the adjoining disc." Prof. Page has also informed us (History of Induction, p. 124), that "the steel magnets weighed about sixty pounds each, and when first charged would each sustain its own weight," and that "the combined lifting power was not at any time more than one hundred and thirty pounds." It is obvious that the length of conductor in the helix of this construction was comparatively small. Of the length and size of the wire that surrounded the electro-magnet of one thousand pounds we find no direct information. But that the length was far greater than the virtual length of the rotating armature helices of the machine is fairly deducible, we think, from the result. The current induced in the rotating armature helix must be generated in a half revolution, and the limit which is set to its quantity by its induction upon itself, and by its reaction upon the magnetization of the armature, is the same for all velocities of rotation however great. But if a resistance interposed between the terminals of the helix prevent the current from reaching that limit of quantity, the electro-motive force with which it will break through that resistance may be increased indefinitely by increasing the velocity of revolution. Hence, an outside wire joining the terminals of the helix, provided only the currents of the helix are discharged, by means of a pole-changer, in one constant direction through this outside wire, so that there is no induction in it of the current upon itself, may have its length greatly multiplied beyond that of the helix conductor, without any proportionate reduction in the quantity to which the current is at any rate limited. Hence the powerful electro-magnet that can be produced by forming this lengthened outside wire into a coil around an iron bar. Admitting that this must be, in fact, the principle of action to which Prof. Page resorted in producing an electro-magnet of a sustaining power of 1,000 pounds, from magnets whose united sustaining power was not over 125 or 130 pounds, we have in this result one main element of the recent famous Wilde machine, which uses the powerful electro-magnet so formed, for the magnet of a second magneto-electric machine.

The "History of Induction," to which we have referred above, a work of 124 octavo pages, was written by Prof. Page in the last year of his life, while laboring under his fatal malady, and contains a detailed history of discovery and invention relative to this branch of electrical science.

The greatest enterprise of Prof. Page's life was his effort to introduce electro-magnetism as a substitute, to a greater or less extent, for steam power. He was an original, though not the first projector of electro-magnetism as a motive power, and his first investigations on that subject were made in the latter part of 1836. In 1839 he published in this Journal, vol. xxxv, p. 106, a very instructive paper on the conditions of action in electro-magnetic engines composed of electro-magnets. The peculiar difficulties of this class of engines led him to rely more on the force with which the pole of an electro-magnet is drawn into its magnetizing helix. The availability of this force for electro-magnetic motors, as we learn from his own account, suggested itself to him on seeing an electro-magnet of Mr. Vail, in which the minute force exhibited by an iron needle drawn into a small helix, was augmented to half or three quarters of a pound, though the electro-magnet and helix were still of quite small size. Our friend was quick to perceive that on further increase of the size, a prodigious development of the force was to be expected, being in somewhat duplicate ratio, and that this form of force offered far greater facilities for combining the force with a wide range of motion, than does the mutual action between pieces of magnetized iron. He accordingly projected an engine in which a large range of motion is obtained by making the pole of the electro-magnet traverse the axis of a number of wire coils in series, the voltaic current being sent first through one coil, next through a second, next through a third, and so on, following the pole of the electro-magnet. A small engine of this description was constructed, with the aid of means furnished by a friend, about the year 1846. It contained a pair of reciprocating U-shaped electro-magnets formed of one-inch round bar iron, and these were formed with brass connecting pieces, into one moving piece, in such a way as to come into action alternately with each other. The writer was present at a trial of this engine in July, 1848. The Grove's battery used contained fifty platinum plates, each four inches square. The same reciprocating engine with, we believe, the same battery, was also exhibited in a short course of public lectures on electricity and electro-magnetism which he delivered in Washington in the month of February, 1849. On that occasion, in presence of a committee of the U. S. Senate headed by Mr. Benton, the engine was used to drive a small planing machine, and pieces of board a few feet long and three or four inches wide were planed. On the same occasion a bar of iron weighing fifty pounds was lifted by its magnetizing helix. It is worth stating, as illustrative of his

experimental judgment and tact, that though this last is but the second advance step he is known or believed to have made beyond the scale of the one-inch round bar of the engine, the writer had the opportunity to admire the success of both steps at the first trial of each. On the 1st of March the same engine was employed to run at the rate of 1,200 impressions per hour, a single Napier printing press, bed 24 by 41 inches, with $1\frac{1}{2}$ square feet of printed page at each impression. The Senate committee were so favorably impressed with the experiments they had witnessed that on their report an appropriation was made by Congress to defray the expense of experiments upon a large scale. Operations were immediately commenced. Numerous preparatory experiments were made with iron bars of various sizes and qualities of iron, solid and hollow, in one series with the bars motionless in their magnetizing helices, in another series with the bars moving in a small experimental engine specially constructed for the purpose. It is much to be regretted that the record of these preliminary experiments has been lost. And, indeed, of the great engines afterward built, and the experiments made with them, with the exception of a few, the records remaining, mostly already published, are very incomplete. In the course of his experiments large round iron bars, hundreds of pounds in weight, were lifted from the floor by their magnetizing helices, with more than the weight of a full sized man in addition. Of one experiment the result is thus stated by Prof. Page, in a letter to the editors noticed in this Journal for Jan., 1851. "*The bar weighing* 532 *pounds placed within the helix, is made to start up in the coil and vibrate in the air without visible support.* It requires a force of 508 pounds additional to its own weight to pull it out of the helix, so that it is equivalent to lifting a bar in the helix, of 1040 pounds in weight." Collating this with his Report to the Secretary of the Navy, copied in vol. x, 2d series of this Journal, from the National Intelligencer of Sept. 4th, 1850, where mention is made of bars from two to eight inches in diameter, and generally three feet in length, we conclude that this bar of 532 pounds was eight inches in diameter, and consequently about three feet in length.

The first large engine built, or at least the first of which we are able to give anything like a particular account, had a pair of round iron bars, each six inches in diameter and three feet long, balanced against each other in a two foot vertical stroke by means of opposed cranks on a common fly wheel shaft. The lower end of each bar played in the vertical axis of what was in effect a single continuous coil of large square copper wire, and the outside diameter of the coil, to the best

of the writer's recollection, must have been not far from fifteen inches. But the coil was composed of a large number of very short sections, of an axial length or thickness of something like perhaps three inches each, made separately and joined end to end, with a flat metallic contact piece connected to each joining, for contact with one pole or the other of the battery. The several contact pieces formed together a continuous plane surface from end to end of the entire coil, with the exception of spaces between them sufficient to secure them from contact with each other. Over these contact pieces travelled the poles of the battery, taking their motion direct from the iron bar, the one pole near the lower, or advancing end of the bar, and the other pole above or in the rear (this was the arrangement in effect, though in this one machine there was a separate line of contact pieces for each pole), so as to include between them and take simultaneously into the battery circuit a number of short sections of the coil around the advancing end of the bar. In this way, during the downward stroke, a single short section at a time would be taken into the circuit in advance, and a single short section at a time dropped off in rear. So far the induction sparks, which gave the Professor great trouble, were rendered comparatively light. The difficulty, however, in dropping the current entirely off at the end of the stroke still remained, particularly in this one engine in which the magnetism of the bar was not kept up, and in which, if the recollection of the writer is correct, the upward stroke was not used. Even in the engines which succeeded this, and in which the magnetism of the bar was kept up by using both strokes, the transfer of the current from one end of the bar to the other was not effected without a still remaining very heavy spark, very destructive to the contact pieces employed for this purpose. We shall see that he afterward devised what he thought a partial, but what we think would have been found a pretty complete remedy for this difficulty, though too late to carry it into effect.

After a variety of experiments with this engine, it was taken down "and its available parts employed" in constructing a horizontal reciprocating engine of two foot stroke. Whether in this last were used the identical coils and one of the bars (six inch) of the upright engine we are not able to affirm, but it appears that a single bar was used, with coils at each end, so as to keep up the magnetism of the bar by their alternate action upon it in the direct and return stroke. The coil at each end of the bar in this machine had precisely the same serial arrangement that either coil had in the upright engine just described, and substantially the same way of trans-

ferring the battery circuit along the serial coil. This horizontal double acting engine was exhibited in a public lecture at the Smithsonian Institution, where it was employed to do some mechanical work, sawing we believe. Systematic experiments were, however, made to measure its power. The experiments of which we have the most complete account were conducted by the late Prof. Walter R. Johnson, and his report of them appears in the Appendix to the 10th vol., 2d series, of this Journal. According to his determinations, which seem sufficiently reliable, though not very exact, the engine made, in his experiments, about seven horse-power at the maximum. In a letter to the Editors of this Journal, Prof. Page announces that the engine had subsequently reached ten horse-power. The inquiry will of course arise what fractional part this engine realized of the whole power due to the galvanic current of the battery used, which, if the determination of Petrie in 1850, may be relied on, is one horse-power for one and a half (1·56) pounds of zinc per hour consumed in a Daniell's battery, or about six tenths of that weight consumed in a Grove's battery. This point does not appear to have been tested at all in the experiments made by Prof. Johnson. Some observations were made by Prof. Page himself and his chief engineer, of the consumption of zinc to the horse power in one of the engines tried, but it was our impression at the time that they were not carried far enough to give reliable results. In fact Prof. Page thought these tests of less importance than attention to the working of some of the details of the engine, and in an important sense he was right in this, since the theoretical mechanical equivalent of zinc consumed is best found without an engine, and the elementary conditions of high economic efficiency in the action of the galvanic current in these "axial engines" are easily recognized. One of these is to avoid the waste of power in heavy induction sparks, and to the subject of these induction sparks he gave a great deal of attention, though, till after the close of his experiments, he did not hit upon a method of getting rid of the particularly heavy induction spark at the end of the stroke. Subsequently, however, he devised and described in the American Polytechnic Journal, vol. i, p. 369, a device by which this may be effected. By this device no *coil circuit* need be broken with a current in it, and we do not think, as he seems to, that its use need be restricted to a slow motion of the engine. We also believe that he modestly overrates the objection to the momentary closing of the battery, incident to this device, in a short circuit or by a resistance wire, and the spark from the immediate breaking of the battery circuit so formed. If a resistance wire

be used, its induction, as is well known, can be almost destroyed by doubling it upon itself.

Although Prof. Page failed to realize his first cherished hope of seeing electricity take the place of steam for a motive power on a large scale, for which he underwent so much labor, and for the pursuit of which he relinquished his hold upon a lucrative office, yet his labors had this result; the concentration within a moderate space, and by simple means, of a large amount of electro-motive mechanical power, and so soon as a galvanic battery shall be discovered which is easy to manage at the same time that it gives its current by the consumption of cheap materials, or as incidental to some extensive chemical manufacture,* his engine is ready we think to perform a large part of the work done by the steam engine.

In the electro-magnetic locomotive, which our readers will remember, two engines were used to act upon the driving wheels at quarter crank. These engines did not differ essentially in their construction from the stationary engines last described. The locomotive did not allow of any exact measure of the power, and was intended chiefly as a demonstration to the public, so that the single trip which was made with it added little to the results already obtained with the stationary engine. Unluckily, the credit of the experiment with the public was greatly marred by a series of accidents in the rupture of porous cells in the Grove's battery, and in the encounter of repeated obstructions and delays on the track, so that although, according to the timing of the driving wheels by a gentleman on board, on what was said to be a level track, the highest speed noted was 19 miles per hour, the whole time occupied by the entire trip from Washington to Bladensburg and back, a distance of five miles, or a little over, from place to place, was about two hours and a half. To those who, with the writer, were on board, it was evident the machine could give a better account of itself than this. But the battery was now seriously reduced by the loss of porous cells which could not be replaced, and Prof. Page found that his expenditures over and above the appropriation from government, had left him at this unsatisfactory point without means to perfect the experiment. The Grove's battery used in this locomotive trip, before it was reduced by the breakage of cells, contained one hundred platinum plates of between 100 square inches and 1 square foot each. These particulars are derived partly from the writer's own recollection, and partly from the account of the locomo-

* The utilization of battery products was a subject frequently discussed by Prof. Page.

tive and trip given by J. J. Greenough, Esq., in the American Polytechnic Journal, vol. iv, p. 257.

Of the experiments subsequently made in a course of lectures delivered in New York city, some account was given in the Scientific American, and they need only be mentioned here, as they were chiefly a repetition of such as we have already described.

The grand scale on which these experiments were conducted afforded a rare opportunity for observing some very interesting and instructive incidental phenomena, which were published by Prof. Page partly in this Journal at the time, and partly in the American Polytechnic Journal, and are worthy to be recalled here. When the battery circuit through the great coil around the great electro-magnet was broken, the prolongation of the falling current by the induction upon it of itself and of the falling magnetism, became so extraordinary as to be distinctly cognizable to the senses, and when the battery was cut out by making metallic contact of the extremities of the coil, then a renewed break in the metallic circuit showed a spark at any time within half a second. With the coil alone he estimated the time of the rise and fall of the current, by aid of a metronome, at $\frac{1}{6}$th or $\frac{1}{5}$th of a second, and with the soft iron bar included at from $\frac{1}{2}$ to $\frac{3}{4}$ths of a second. He concluded that the time of fall of the current on *breaking* the battery circuit was about the same as the time of rise of the current. But the time of rise, with abundant battery surface, is probably about the same as the time of fall in the *closed metallic circuit*, and hence it seems probable the result mentioned was incidental to the intensity of the particular battery used, which may have been somewhat equal to the resistance of the "arc of flame." In the case of the electro-magnet of 532 pounds, before mentioned, he found the "full time required to charge this magnet and raise the voltaic current to its maximum" to be two seconds. "Nine-tenths of the charge is attained in one second."

When the break of the circuit took place at a distance from the electro-magnet, the induction spark, though heavy from the quantity and unusually long continuance of the current, was quiet ; but when the break was made near the pole of the electro-magnet, the connecting wires being drawn somewhat quickly and widely asunder, the conflict of the current in the opening with the powerful deflecting force of the electro-magnet was very remarkable, and produced a loud report, and vivid flash of light. Prof. Page varied and studied the conditions of this interesting phenomenon with considerable care, and described them in this Journal for March, 1851.

Of similar interest are other phenomena of which we extract the following account from a paper by him in the American Polytechnic Journal, vol. i, p. 305, on the subject of the difficulties encountered in the great electro-magnet engines, from the destruction of metallic contact pieces by the induction sparks. "In the attempt to remedy this defect, our first efforts were directed to the entire suppression of the combustion. The current was first broken under oil, naphtha, and other hydrocarbons, with the expectation that the absence of oxygen would give a favorable result. To our surprise, however, we found that when the current was broken between two metallic surfaces entirely covered with oil, the consumption of the metal was much greater than when the break occurred in the air between clean metallic surfaces. The hydrocarbons were rapidly decomposed by the intense heat, and a black powder formed which appeared to be a carburet of the metal, though it was not chemically examined. This curious result we explain as follows:—The hydrocarbons are non-conductors of electricity and heat, and when the metallic surfaces are separated, the secondary spark is concentrated, and its action upon the metal becomes topical and intense. The action is analogous to that in the familiar experiment of perforating a glass bottle with the electric spark; a very feeble spark passing through oil, being sufficient to make a hole through a thick glass bottle. When the secondary current is one of great power, the oil is thrown about with considerable force. To illustrate this, we broke the circuit under oil contained in a small cavity in a block of wood, having first driven by a hammer a small bullet into the cavity over the oil. The spark from a large magnet drove the bullet out with some force.

"We next tried breaking the circuit in the following manner:—We procured two thick plates of glass, ground carefully together so as to exclude the air from between their surfaces. Through each of these plates we drilled a hole one quarter inch in diameter, and when the plates were so arranged that the holes corresponded with each other, they were filled with mercury in the following manner:—The under side of the hole in plate *b*, fig. 1, was stopped by a plate of copper, and mercury then poured in so as to form one column. Another plate of copper was laid over the hole in plate *a*, and thus between these two plates of copper there was a complete metallic circuit. The proper connection being formed, it will be seen that by sliding the plates *a* and *b* upon each other, the mercury in *a* must separate from that in *b*, and the break produced under the entire absence of air. Here occurred a brilliant and unexpected phenomenon. Whenever the break was made, the spark

was intense, and it was soon noticed that the glass around the edges of the holes was undergoing decomposition, and upon separating the plates, loose gritty particles were found between them, and their surfaces furrowed so as to present the appearance represented in fig. 2. The mercury was also oxydized at the expense either of the alkali or silicic acid of the glass. The most interesting result, however, of this experiment, was a fitful repetition of sparks after the circuit was broken. That is, the secondary sparks were kept up in quick succession without any repetition of contact. It would be foreign to our present purpose to discuss now the cause of this singular phenomenon. We next tried breaking the circuit in vacuo, in the ordinary mode of producing the *arc of flame* in the receiver of an air pump. But we were also baffled here. The metals were rapidly wasted by mere volatilization from the intense heat."

Of the large number of machines invented by Prof. Page in the early part of his career, illustrative of electrical science, we cannot in this notice even give a list. Among the instruments of his invention we will mention, as not having been described in this Journal, a voltameter of very convenient use, which measures the volume of the gas by that of the displaced liquid. This is described in the American Polytechnic Journal, vol. ii, p. 15.

Among his earlier discoveries, in 1837, was the production, in a horse-shoe magnet, of musical vibrations, like those of a tuning fork we believe, by the establishment, and especially the interruption, of a voltaic current in a flat spiral placed between the prongs of the magnet, with the plane of the spiral at right angles to the line of the poles of the magnet. A year or two afterward he made a series of experimental investigations on the action of the voltaic battery, which were published in this Journal.

While engaged in his college lectures as professor of chemistry, he discovered the curious action of the rocking of a rounded metallic bar, laid across a pair of parallel horizontal metallic rails, made to form the poles of a voltaic battery. The action is apparently similar to that of the heated brass bar of Trevelyan, rocking upon a cold plate of lead. But the new voltaic experiment does not depend upon dissimilarity of composition in the bar and rails, which may be all of the same metal, though it may depend, as its discoverer supposes, upon heating at the points of contact. The rocking of the bar is maintained by the passage of the voltaic current through its points of contact with the rails, at which it shows frequent slight sparks. This experiment was reproduced about ten years since by the English philosophers, with some variations,

but they must have overlooked the much earlier discovery of Page, as they made no mention of it.

After the close of his experiments with electro-magnetic engines, he discontinued, for the most part, his labors in electrical science, and devoted himself largely to horticulture, in the rural homestead where he then dwelt, near the suburbs of the city of Washington. It was here that he had conducted the greater part of his experiments on electro-magnetic power. It was here, too, that during the war of the rebellion, a party of soldiers broke into an outhouse containing the most of his philosophical apparatus, and destroyed nearly the whole, the accumulation of thirty years labor, little thinking, and, it may be feared, too little caring, that their owner was as good a friend as our government had.

Professor Page was married to Miss Priscilla S. Webster in 1843, who survives him with three sons and two daughters. He always took a lively interest in the great questions of the day, and in his home circle, and in all the relations of life, he was ever distinguished by the same lively geniality and amiability of temper that was so characteristic of him in his school and college days. L.

ART. II.—*On Hortonolite, a new member of the Chrysolite group;* by GEO. J. BRUSH, with measurements and observations on the crystalline form of the mineral, by JOHN M. BLAKE.

SEVERAL years since Mr. Silas R. Horton called my attention to peculiar dull black crystals from an iron mine at Monroe, in Orange county, New York. On a simple inspection I determined that the crystals represented two species, the one, magnetite, in dodecahedrons; the other a prismatic mineral with somewhat rounded planes, which I took to be pyroxene. At the time I was deterred from making a chemical examination of the latter mineral by the fact that the crystals appeared to be very impure from admixture with magnetite and graphite. I have, however, never been quite satisfied that it was correctly determined, and on recently selecting with care a portion of the substance free from impurities, it proved to gelatinize with acids and to have the pyrognostic characters of an iron chrysolite; and on a more careful examination of the crystals they seemed to be orthorhombic rather than monoclinic, a conclusion confirmed by Mr. Blake's measurements, further on.

The mineral has a yellow to dark yellowish green color on the fresh fracture and a vitreous to resinous luster, although the

crystals have a black coating and are quite dull. In large masses the mineral is sometimes nearly black, but on the thin edges by transmitted light the color is almost honey-yellow. Minute specks of magnetite are disseminated through the mass with occasional flakes of graphite. The crystals are sometimes imbedded in calcite, as also associated in cavities with dodecahedral magnetite. They are frequently half an inch long by one quarter broad and one eighth of an inch thick, in some instances much larger. H. = 6·5. Sp. gr. = 3·91. Before the blowpipe in the closed tube no change takes place; in the open tube and on charcoal the mineral becomes dull and magnetic, and fuses in the platinum forceps at 4; with borax and salt of phosphorus, it reacts for iron and silicic acid, and with soda for manganese. The pulverized mineral forms with chlorhydric acid a gelatinous mass and is almost completely decomposed. Qualitative analysis showed the presence of silica, protoxyd of iron, manganese and magnesia, with a minute quantity of potash and a trace of lime. It was found by pulverizing the mineral and suspending the fine powder in water in a beaker and stirring with an electro-magnet of soft iron, that the magnetite could be completely separated from the silicate. Two quantitative analyses made on material thus prepared gave Mr. Wm. G. Mixter—

	1.	2.	Mean.	Oxygen.	
Silica,	33·52	33·66	33·59	17·91	
Ferrous oxyd,	44·28	44·46	44·37	9·85	
Manganous oxyd,	4·72	3·98	4·35	·98	
Magnesia,	16·79	16·56	16·68	6·67	17·56
Lime,	trace	trace			
Potash,	·30	·47	·39	·06	
Ignition,	·26	·26	·26		
	99·87	99·39	99·64		

These analyses represent two different samplings by means of the electro-magnet, and demonstrate that the method of purification was as perfect as could be desired. In the decomposition by chlorhydric acid it was found that the silica separated contained a very small portion of undecomposed mineral, and this was consequently fused with carbonate of soda to effect a complete decomposition. The iron was separated as basic acetate, redissolved and reprecipitated; the manganese in the solution was oxydized and separated by bromine, then redissolved and precipitated as phosphate. The magnesia was weighed as pyrophosphate, and the alkali determined by Smith's method. A spectroscopic examination of the concentrated chlorhydric solution showed sodium, potassium and calcium lines only. A direct determination of the protoxyd of iron on mineral selected

as free as possible, by aid of the magnifier, from magnetite, gave 42·69 per cent ; this, considering the difficulty of selecting absolutely pure material and the fact that the mineral, although almost entirely, is not completely, decomposed by acid, shows that the iron is most probably present only as protoxyd.

The calculation of the oxygen for the mean of the two analyses gives the ratio of $\breve{S}i : \dot{R}$ as 17·91 : 17·56 or 1 : 1, in which the relation of the iron to the magnesia is very nearly as 3 : 2, and the composition of the mineral is that of an iron-magnesia-manganese chrysolite. In chemical composition this member of the chrysolite family is between hyalosiderite and fayalite, although it differs very materially from both, as will be seen by comparing the analysis with these and allied varieties.

	$\breve{S}i$	$\ddot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{M}g$	$\dot{C}a$	$\dot{K}$	$\dot{C}u$	
1. Hyalosiderite,	31·63	2·21	29·71	0·48	32·40	—	2·79	—	$\dot{C}r$ tr.=99·22, W.
2. Dalarne chrysolite,	35·20	1·93	35·55	0.58	26·24	---	—	tr.	Ni,Sn tr.=99·51, S.
3. New chrysolite,	33·59	—	44·37	4·35	16·68	tr.	0 39	—	=99·64, Mixter.
4. Eulysyte "	29 16	1·56	55·87	8·47	3·23	2·29	—	—	=100·58, Erdm.
5. Fayalite, Fayal,	28·27	3·45	63·80		tr.	0·45	—	1·29	FeS3·35=100·61,R.

1. Hyalosiderite, Walchner, Schweigger, Journ. xxxix, 65. 2. Analysis made by Struve, given by Svanberg in Ak. H. Stockholm, 1848, p. 2. 3. This article. 4. A. Erdmann, Min., 278. 5. Rammelsberg, Min. Chem., 435.

The new mineral contains more iron than hyalosiderite, with a correspondingly smaller amount of magnesia, while the opposite is true with fayalite. It more nearly approaches the variety of iron-manganese chrysolite described by Erdmann as occurring near Tunaberg in Sweden, associated with garnet and augite forming a rock which has been named *eulysyte;* from this, however, it differs in containing 13 per cent more magnesia, and about 16 per cent less iron and manganese, and no lime. The mineral therefore, forms a marked variety of iron-magnesia-manganese chrysolite.

In view of these facts, it is proper to designate this new variety with a special name, and I propose for it the name *Hortonolite*, after Mr. Horton, who first discovered the mineral. If found in quantity, this may prove to be a valuable iron ore, if smelted with more basic or calcareous ores. It is free from undesirable impurities, while it contains a considerable amount of manganese. There is reason to believe that it may occur in sufficient abundance to be of economic importance.

It gives me pleasure to acknowledge my indebtedness to Mr. Horton for kindly supplying me with specimens of this mineral for examination; to Mr. W. G. Mixter, assistant in the Sheffield laboratory, for aid in the chemical investigation ; and to Mr. John M. Blake for his discussion of the crystallographic characters of the mineral which here follows.

2. *Observations on the crystalline form, optical characters, and cleavage of Hortonolite;* by JOHN M. BLAKE.

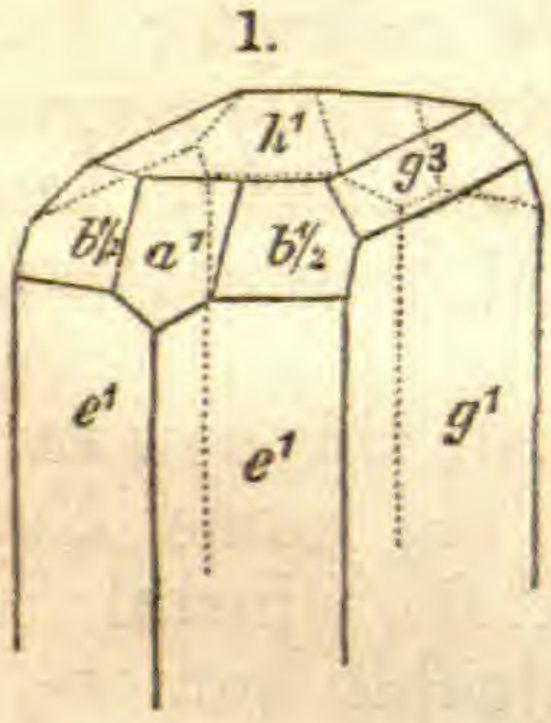
The examination and measurement of crystals of Hortonolite, which were placed in my hands for this object by Prof. Brush, show unmistakably that the mineral belongs to the chrysolite group. A comparison was made with other members of the group, to determine its relation to them. For this purpose, several species were measured, crystals having been placed at my disposal by Prof. Brush. The points compared were the occurrence and proportional development of planes, and to some extent the optical properties and cleavages. This examination is not yet completed, but it being desired that a description of this mineral should be furnished as soon as possible, the results must be given in a form that will require the least explanation. For the present purpose, the symbols of Des Cloizeaux are adopted, so that comparison can be more readily made with the figures in his mineralogy. It will be noticed that the "vertical prism" is differently selected.

The observed planes on this variety, are: h^1, g^1, e^1, a^1, g^3, $b\frac{1}{2}$ and γ; or in Dana's symbols: O, i-$\breve{i}$, i-$\bar{2}$, 1-$\bar{i}$, 1-$\breve{i}$, 1-$\bar{2}$ and 1-$\bar{4}$.

A deposition of some foreign substance had destroyed the brilliancy of the planes, and this could not be entirely removed so that they would give perfect reflections; and, besides this, some parts of crystals appear to have been originally rounded.

Fig. 1 is proportioned from some of the larger crystals. They were partially imbedded, so that but a portion of the planes could be distinguished on any one of them. The intersections with the other planes satisfactorily determined the planes $b\frac{1}{2}$, on these particular crystals.

1.



2.

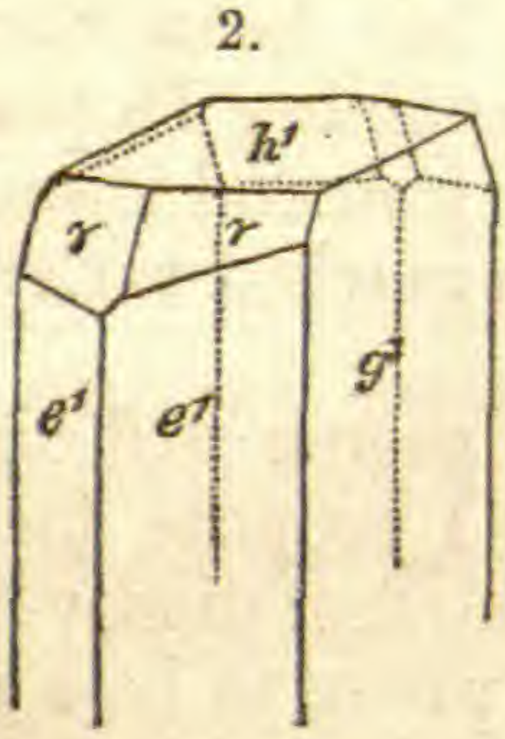


Fig. 2 is a common form of the medium-sized crystals. The upper planes on the front side, can be explained as the planes γ. The directions of their intersections with e^1 and an approximate measurement of their inclination on g^1 leaving little doubt of their identity with this plane. The goniometer readings were as follows on this crystal.

For the prismatic zone: g^1, 0°; e^1, 65° 35′; e^1, 116° 15′; g^1, 181° 20′; e^1, 245° 50′; e^1, 295° 15′ ?, g^1, 0° 45′.

For zone 2, including the front upper planes: g^1, 0°; γ, 78° to 80°; γ, 100° to 101°; g^1, 178°.

Zone 3, including the back, upper planes: g^1, 0°; $b\frac{1}{2}$, 69°; a^1, 90° ? $b\frac{1}{2}$, 110°.

From the first zone the average inclination of g^1 on e^1 is 65° (normals); Brooke and Miller give 65° 2′. From the second zone we have γ on g^1, 77° to 80°; B. and M. give 79° 40′.

From zone 3: g^1 on $b\frac{1}{2}$, 69° to 70°. The same authority give 69° 57′. The following readings were taken from another crystal having the planes g^3 better defined: g^1, 0°; g^3, 320°; h^1, 268° 20′; g^3, 220° 30′; g^1 179°. From this the average for g^1 on g^3 is 40° 45′; B. and M. give 40° 27′.

An examination of the measurements above recorded will show that although the mean values deduced from them accord well with the angles of chrysolite, yet there is some variation when the angles are taken singly. This variation is not greater than the imperfections of the planes gave reason to expect.

It is probable that the planes γ, a^1, and $b\frac{1}{2}$, occur together on some of the crystals. These planes lie very near together, and a slight rounding of the crystal might be expected to obliterate them. Fig. 3 represents an occasional form. It is introduced to show the variation in crystals upon the same specimen. Another small crystal had the prismatic planes nearly equal in breadth, and g^3 largely developed, while the other terminal planes were rounded.

3.

Notwithstanding this great variation in development, the crystals do not at all resemble those of hyalosiderite in habit; neither do they resemble certain crystals occurring as furnace products, which I have directly compared with them.

The crystals appear black externally, but some small portions are found which are transparent in thin sections, and have a yellowish color. A portion was selected from a section parallel to g^1, which admitted of an approximate measurement of the separation of the optical axes. The acute bisectrix was found perpendicular to g^1, and the axes to lie in a plane parallel to h^1. Their separation was, from 83° to 86°, measured in olive oil.

The smallness of the transparent part of the section and the presence of one or more oblique cracks in its interior, rendered it difficult to determine satisfactorily the direction of the dispersion of the axes, but it was judged that the separation of the red rays was greater than for the violet about the bisectrix normal to g^1. This agrees with Des Cloizeaux's observations on the dispersion and plane of the axes in a specimen from Torre del Greco, and in tephroite. In the former he found the separation to be 86° to 87° about a bisectrix normal to p, and in tephroite the separation of the axes for the

red rays was 83° 41′, and 80° 29′ for the blue, measured in oil. The bisectrix in this case being negative, and normal to g^1.

For comparison, a measurement was made of olivine occurring in lava from the Sandwich Islands, and the separation of the axes about the normal to g^1 was found 107°; in a furnace product 68°. Both were measured in olive oil. Reducing the measurement on the chrysolite, from Torre del Greco, to the same bisectrix, but without making a correction for the refraction of the oil, and of the mineral which would be necessary to make the results compare accurately with the others measured in oil, we have 94°.

It so far appears that the optical axes in this group lie in a plane parallel to h^1, but vary in separation with the chemical composition, according to some law. It seems generally preferable to make sections parallel to g^1, for the purpose of comparing species; since this is usually a cleavage plane, and there is then a better chance of success in cutting some varieties which are brittle, and the plane p seldom occurs, while g^1 is often well defined, and serves as a guide. It is to be understood that reference is made to such sections as can be most readily cut for the purpose of comparing varieties of this mineral, as is done with the micas.

The cleavage which occurs parallel to h^1, is perhaps most clearly defined. There are two cleavages about the plane g^1, and possibly one not well defined parallel to this plane. They lie in the *prismatic zone*, g^1, e^1, etc. This was first discovered in the following way: a fragment showing several cleavage surfaces, and at least one plane of the crystal, was measured on a zone with the following result: first cleavage (goniometer reading) 0°; second cleavage, 49° 30′; a plane of crystal (g^1), 203° 30′. On plotting the normals, it was found that the normal of the plane of the crystal, when extended, bisected the angle of the normals of the two cleavages. Hence the cleavages are symmetrically situated about the plane g^1, and in the zone, g^1, e^1, $e^{\frac{1}{2}}$, etc.; since another cleavage was found on this fragment perpendicular to the intersections of the two others, giving as an approximate measurement an inclination of 92° 20′ on one of them, and this cleavage had also a different appearance to the eye, and was therefore considered to be the cleavage parallel to the basal plane h^1. No reflection from a cleavage was detected on this specimen parallel to g^1. The three cleavages actually found gave bright reflections in a good light, but admitted of no very exact measurement; though sufficiently exact to show that those on the prism are not parallel to any observed plane, except it be the rarely occurring planes $e^{\frac{1}{4}}$ or $e^{\frac{1}{5}}$. The inclination of $e^{\frac{1}{4}}$ to g^1, is given as 28°

13′, and of $e\frac{1}{5}$, 23° 13′, (normals). The cleavage as above determined measures 24° 40′ on g^1. This result appeared so extraordinary, that a piece was clipped out of the plane g^1, on a crystal upon which there could be no mistake as to the exact location of these cleavages ; for the crystal had the prism well defined, with terminal planes, and a basal cleavage. The result just given was verified, although the measurement could not be so exactly made as upon the first fragment. The zone readings were : g^1, 0° ; cleavage, 24° ; e^1, 67° ; e^1, 114° ; g^1, 176° ; cleavage, 337° to 340°. It now becomes a matter of interest to discover these cleavages upon other members of the group. A rounded grain of olivine washed from the lava of the Sandwich Islands, was cleaved, and presented a bright surface judged to be the cleavage plane g^1. This gave three reflections, the readings for the instrument being : 0° ; 6° ; 13°, approximatively. In olivine in lava, also from the Sandwich Islands, there were indications of cleavages about the plane g^1, but they are not well defined, while, parallel to g^1, this variety cleaves readily ; although the surfaces developed are not brilliant.

Besides the interest these cleavages have crystallographically, they may be found to have an important bearing, in comparing some members of this group, which do not occur in well defined crystals.

ART. III.—*Notes on some points in the Structure and Habits of the Paleozoic Crinoidea ;** by F. B. MEEK and A. H. WORTHEN, of the State Geological Survey of Illinois.

THROUGH the kindness of Mr. Charles Wachsmuth, of Burlington, Iowa, we have recently had an opportunity to examine some unique and exceedingly interesting specimens of Carboniferous Crinoids, presenting parts of the structure of these animals, in some instances, never before observed, so far as we are at this time informed. In a few instances, these specimens show internal organs entirely free from the matrix, and although like all the other solid parts of these curious creatures, composed of numerous calcareous pieces, really surpassing in delicacy of structure the finest lace-work, and so frail that a touch, or even a breath, might almost destroy them.† Some of these specimens we propose to notice here, but, before proceeding to do

* From the Proceedings of the Acad. Nat. Sci. Philadelphia, 1869, p. 323.

† By Mr. Wachsmuth's permission, we have prepared for future publication, drawings of all of these instructive specimens.

so, we avail ourselves of this opportunity to express our thanks to Mr. Wachsmuth for the zeal, industry, skill and intelligence he has brought to bear, in collecting and preparing for study, such an unrivaled series of the beautiful fossil Crinoidea of this wonderfully rich locality. Some idea of the extent of his collection of these precious relics may be formed,. when we state that of the single family *Actinocrinidæ* alone, after making due allowance for probable synonyms, he must have specimens of near 150 species, or perhaps more, and many of them showing the body, arms and column.

It is also due to Mr. Wachsmuth, that we should state here that he is not a mere collector only, but that he understands what he collects, and knows just what to collect, as well as how to collect.

Below we give substantially some notes of observations made in his collection, followed by some remarks on other specimens at Springfield :

1. *Synbathocrinus* Phillips.—Some of Mr. Wachsmuth's specimens of a species of this genus show that it is provided with a long, slender, pipestem-like ventral tube, or proboscis, apparently equaling the arms in length. Also, that a double row of minute alternating marginal pieces extends up within the ambulacral furrows of the arms, apparently all their length. We are not aware that these characters have been hitherto noticed in any of the publications on this genus. It will be seen, however, farther on, that minute marginal pieces probably occupied the furrows along the inner side of the arms of other types of Crinoidea, as well as this.

2. *Goniasteroidocrinus* Lyon and Casseday.—Some unusually fine specimens of the typical species of this genus (*G. tuberosus*) in Mr. Wachsmuth's collection, from Crawfordsville, Ind., show the slender pendent arms much more distinctly than any we had before seen, and from these it seems evident that these arms are stouter than we had supposed, and that there are not more than five or six of them to each of the ten openings. In the specimen figured by us on page 220 of the second volume of the Illinois Reports, these arms were only imperfectly seen by working away, with great difficulty, the hard matrix between two of the produced rays of the vault, which we have termed pseudobrachial appendages, or false arms. In clearing away the matrix of this specimen, we had cut just far enough to expose the edges of the arms on each side of the deep ambulacral furrow, so that each of these edges presents the appearance of being a separate and distinct, very slender arm, composed of a single series of pieces, and without any ambulacral furrow on the outer or ventral side ; whereas there is a well-defined

ambulacral furrow, bearing the tentacula along its margins, on the outer side of the arms, and when the matrix is removed from these ambulacral furrows, the arms can be seen to be composed each of a double series of small alternately-arranged pieces. It is barely possible that in specimens of this species with the arms *perfectly preserved*, the ambulacral furrows may be covered on the outer or ventral side by a double series of alternating pieces, and that the tentacula* may connect with little openings along each side, though there certainly *appear* to be only open furrows in the specimens examined.

It is worthy of note, in this connection, that there certainly are species, agreeing exactly in all other known characters with this genus, that have no open furrow along the outer or ventral side of the arms, which are distinctly seen to be round on the outer side, and show there a double series of interlocking pieces along their entire length, while the tentacula connect along the inner, or under side, as the arms are seen hanging down. This is clearly seen to be the case in a beautiful specimen of *G. typus* (=*Trematocrinus typus* Hall) in Mr. Wachsmuth's collection, and we can scarcely doubt that in this species there is an open furrow on the inner (under) or dorsal side of the arms. If not, the arms must be tubular, in consequence of having the ambulacral canal enclosed all around, excepting at the points where the tentacula connect along each side.

3. *Cyathocrinus* Miller. Specimens of this genus showing the vault (more properly the ventral disc) have very rarely been seen. In England a few examples have been found, and these have been supposed to show two openings, one central and another lateral; the latter, according to Prof. Phillips' and Mr. Austin's figures, being provided with a slender marginal tube, or so-called proboscis. Some of Mr. Wachsmuth's specimens, however, of *C. malvaceus* and *C. Iowensis* Hall, showing the vault, have led us to doubt the existence of a central opening in the vault of this genus, when the specimens have this part entire. The specimen of *C. malvaceus* shows the remains of the usual narrow lateral proboscis, and also has an opening in the middle of the vault, but from the appearance of this opening, as well as from the structure of the vault of a specimen of *C. Iowensis*, in which this opening is closed, we can scarcely doubt that it was also closed in the specimen of *C. malvaceus*, when entire. The remaining parts of the vault of the *C. malvaceus* mentioned consist of only five comparatively large pieces, alternating with the upper inner edges of the first radial pieces,

* We use the term tentacula here in the sense it is generally used by paleontologists, with reference to the delicate pinnulæ along the arms of Crinoids, and of course not as applying to the minute fleshy organs along the ambulacral furrows, usually termed tentacles by those who have investigated the recent Crinoids.

—the one on the anal side being larger than the others, and forming the base of the inner side of the proboscis. These five pieces connect with each other laterally, and extend inward some distance, but not so far as to meet at the center, where there is a subsemicircular opening, nearly as large as that in the remaining base of the proboscis. Along each of the sutures between the five vault pieces mentioned, a comparatively large furrow extends inward from each arm-base to the central opening. These we regard as continuations of the ambulacral furrows from the arms, though there is also a minute opening at each arm-base, passing directly downward into the cavity of the body, which was probably for the passage of the arm-muscles.

Looking at this specimen alone, one would naturally suppose that there must have been, during the life of the animal, two distinct openings in the vault, as appears to be the case in the specimen of *C. planus* Miller, figured by Prof. Phillips and Mr. Austin. But on examining the specimen of *C. Iowensis* mentioned above, we find that it shows the base of the small lateral proboscis, with the five principal vault pieces alternating with the first radials (the one on the anal side being larger than the others), and the same ambulacral furrows extending inward from the arm-bases, all exactly as in the *C. malvaceus*. But here we find the central opening undoubtedly closed by several vault pieces, while the ambulacral furrows, extending inward from the arm-bases, pass in under these central pieces, and are themselves occupied, or covered, by a double series of alternating, very minute pieces, which probably also extend on, all the way up the ambulacral furrows of the arms as marginal pieces.

From our examinations of these two specimens, which are the only examples of the genus we have seen, showing the vault pieces, and seem to be typical forms of the genus in all other respects, we are strongly inclined to think the specimen of *C. planus*, figured by Prof. Phillips and Mr. Austin, has had these central vault pieces removed by some accident. The fact that these pieces in the specimen examined by us, in Mr. Wachsmuth's collection, seem not to be deeply implanted between the five larger surrounding pieces mentioned, but rather rest as it were, partly upon the narrow beveled points of the inner ends of the latter, between the ambulacral furrows, so as to allow room for these furrows to pass under, would render them less firm, and more liable to be removed by any accident, and may possibly account for their absence in the English specimen mentioned.

In regard to the pieces covering the central part of the vault, and which, from the way they are arranged for the ambulacral furrows to pass under them, were apparently more liable to be

removed than the others, we would remark that they do not present the prominent appearance, and uniformity of size and form, of the movable pieces composing what is often called the ovarian pyramid in the Cystids, but certainly have all the appearances of true fixed vault pieces, and scarcely project above the others surrounding them. Consequently we cannot believe it at all probable that this genus had a central mouth, opening directly through the vault; though its ambulacral canals evidently converged from the arm-bases to the middle of the vault, partly above the outer vault pieces, and under those composing the middle of the vault. That these furrows terminated at the entrance of the alimentary canal, under the middle of the vault, as those of *Comatula* converge to the mouth, in the same central position, is highly probable; and, as will be seen further on, we are much inclined to believe that the minute organisms upon which we are led, from analogy, to think these animals subsisted, were conveyed to the entrance of the alimentary canal along the ambulacral furrows, without the agency of any proper mouth, opening directly through the vault. Hence we think it probable that the small tube, usually called the proboscis, situated near the posterior side of the ventral disc, rather corresponds to the tubular anal opening similarly situated in *Comatula Mediterranea.*

From our description of the vault of these species, it will be seen to present considerable similarity to that of *Crotalocrinus rugosus*, excepting that in that genus, owing to its great number of arms, the ambulacral furrows, or canals, bifurcate several times between the middle of the vault and the arm-bases, while in *Crotalocrinus* there is no lateral proboscis, nor, apparently, even any visible opening, judging by the figures we have seen, though we suspect it may have a small opening at the periphery of the ventral disc, on the posterior or anal side. In the group of depressed *Platycrini* for which Troost proposed the name *Cupellœcrinus* we observe a somewhat similar vault, at least in some of the species; also in *Coccocrinus.* In such forms there would seem to be, as it were, an intermediate gradation between the modern Crinoids and the prevailing Paleozoic types, as has been pointed out by Mr. Billings.

4. *Convoluted support of the digestive sack, in the Actinocrinidæ.*—The presence of a large convoluted body, resembling in form the shell of a *Bulla* or *Scaphander*, within the body of several types of the *Actinocrinidæ*, was noticed by Prof. Hall [this Journal, volume xli, p. 261], in 1866, though he made no suggestions there in regard to the functions it probably performed in the internal economy of these animals. In the second volume of the Illinois Geological Reports, published

soon after, we figured, on page 191, a specimen of *Strotocrinus*, with this body seen in place, and stated that we regarded it as having been connected with the digestive apparatus of the animal.

Both in Prof. Hall's, and our own remarks, this organ was spoken of as a convoluted *plate*. This, however, we now know is not strictly correct, for although composed of hard calcareous matter, and in some species somewhat dense in structure, it seems to be always constructed of a great number of minute pieces, and generally has a more or less open or porous texture; while in some cases it presents the appearance of an exceedingly delicate net-work. It seems never to be attached to the bottom of the visceral cavity, though it extends down nearly to the bottom. It is open at both ends (the opening at the lower end being generally smaller than the other), and is placed with its longer axis nearly so as to coincide with that of the body of the Crinoid. In some species it is more or less dilated at the upper end, while in others it is contracted at both ends, so as to present, as above stated, the form of the shell of a *Bulla*. It has apparently no columella, but is more or less loosely convoluted, with a spiral ridge descending the interior, and sometimes another ascending the exterior. Its walls are generally of moderate thickness, but they often appear to be thicker than natural, in consequence of the presence of inorganic incrustations, of calcareous or siliceous matter, which also disguise its real structure.

In *Actinocrinus Verneuilianus* Shumard, this body is narrow below, and subcylindrical above to the top, which is slightly dilated. The small opening at the lower end has a thickened rim, which passes around spirally, so as to ascend the outside, as a rather stout ridge, all the way to the top, making nearly two turns, and apparently also forming a rim partly around the top. The surface of the whole organ, as well as of its external spiral ridge, has the usual rough appearance, and when fragments of it are held up, so as to be examined by transmitted light, through a good pocket-glass, it is seen to be composed of a great number of very minute polygonal pieces, varying somewhat in form and size. When these pieces are examined under a magnifier, by reflected light, they show shining facets, like crystals, though they are evidently not surface incrustations, but actually compose the walls, or substance of the organ itself. No pores or meshes were observed passing through the walls of this organ in this species, in which it appears to be more than usually dense.

In another specimen in Mr. Wachsmuth's collection, apparently of *Actinocrinus proboscidialis*, this organ, as seen with

one or more of the outer turns removed, has an oval or subelliptic form, being contracted and twisted at both ends, so as to present very nearly the appearance of the shell of some species of *Ovulum*. Its walls are quite thin, and seem to form more convolutions than in any other species in which we have had an opportunity to examine it. As seen by the aid of a magnifier by transmitted light, it presents a very beautiful appearance, being composed of a great number of minute pieces, with numerous openings passing through between them. The little pieces and the openings between them are of nearly uniform size, and arranged so that there are usually one or two of the former intervening between any two of the openings.

Another of Mr. Wachsmuth's specimens of *Actinocrinus securus* Hall, has one side of the body removed so as to show about two thirds of the convoluted organ, the upper part of which is broken away. The part remaining has a short wide subcylindrical form, with a rather broad, obliquely truncated lower end, which is not tapering, as in the other species. Under a magnifier it is seen to be composed of an extremely fine net-work, far surpassing, indeed, in delicacy of structure, the finest laces that it is perhaps within the power of human skill to fabricate; and as it is entirely free from any surrounding matrix, excepting at one side below, the specimen has to be handled with great care, as a mere touch of this delicate part would probably cause it to fall into hundreds of minute fragments. On examining it under a magnifier, the little bars of which it is composed are seen not to intersect each other at any uniform angle, but anastomose, so as to impart a kind of irregular regularity, if we may so speak, to the form and size of the meshes. Of these little bars there are two sizes, the larger forming the larger meshes, while within the latter a smaller set of processes extend partly or entirely across, so as to form more minute meshes; the whole presenting a beautiful appearance, of which it would be difficult to convey a correct idea by a mere description alone, without the aid of figures.

From analogy, judging from what is known of the internal structure of the recent genus *Comatula*, in which several authors have noticed a reticulated calcareous structure secreted within the tissue of the softer parts of its alimentary canal, we may infer that this convoluted organ was, as it were, a kind of frame work, secreted for the support of the digestive sack, which was probably more or less convoluted in the same way in many, if not all of the Paleozoic Crinoids, though not apparently, in all cases, endowed with the power of secreting a sufficient dense structure of this kind to leave traces of its existence in a fossil state.

So far as we are at this time informed, this organ has yet been very rarely observed in any other family than the *Actinocrinidæ*, though it was probably more or less developed in various other groups. In one instance Mr. Wachsmuth found it in a *Platycrinus*, but here it seems to be, in the specimen found, merely a spongy mass, not showing very clearly the convoluted structure. Some traces of what was supposed to be something of this kind were also observed by him in one of the Blastoids.

5. *Ambulacral canals passing under the vault in the Actinocrinidæ.*—In the third and fourth Decades of descriptions and illustrations of the Canadian Organic Remains, Mr. Billings, the able paleontologist of the Geological Survey of the Canadian provinces, gives some highly interesting and instructive remarks on the ambulacral and other openings of the Paleozoic Crinoids. In these remarks he noticed, at length, some striking differences between the vault, or ventral disc, of these older types, and that of the few living examples of this extensive order of animals. That is, he noticed the facts, that while in the living *Comatula* and *Pentacrinus*, the ambulacral canals are seen extending from the arm-bases across the surface of the soft skin-like ventral disc, to the central mouth, and these genera are provided with a separate anal opening, situated excentrically between the mouth and the posterior side, that in the paleozoic Crinoids the ventral disc is very generally, if not always, covered by close-fitting, solid plates, showing no external traces whatever of ambulacral furrows extending inward from the arm-bases; and that in nearly all cases they are merely provided with a single excentric, or subcentral opening, often produced into a long tube which, like the vault, is made up of solid plates. He showed that there is no evidence whatever that the ambulacral canals, in these older types, were continued along the surface of the vault from the arm-bases to the only opening, whether subcentrally or laterally situated, and that in cases where this opening is produced in the form of a greatly elongated proboscis, or tube, such an arrangement of the ambulacra would be almost a physical impossibility. Hence he concluded that the ambulacral canals must have passed directly through the walls of the body at the arm-bases; and he gave several figures of various types, showing openings at the base of the arms, through which he maintained that the ambulacra must have passed to the interior of the body from the arms.

Although these arm-openings had long been well known to all familar with our numerous types of western Carboniferous Crinoids, in which they are very conspicuous, and we had never

entertained any other opinion in regard to them, than that they are the only passages of communication that could have existed between the softer parts occupying the ambulacral furrows of the arms, and the interior of the body, Mr. Billings was the first author, so far as we are at this time aware, who called especial attention to them in this regard. We regret that we have not space to quote a portion, at least, of his remarks on this subject, and would advise the student to read attentively the whole of both of his articles alluded to.

The specimens at Mr. Billings's command enabled him to trace the courses of the ambulacral canals from the arms, through the walls of the body at the arm-bases, and to ascertain the additional fact that, after passing through the walls, they seemed to have turned upward; but beyond this he had not the means of tracing them farther.

A single specimen of *Actinocrinus proboscidialis*, however, in Mr. Wachsmuth's collection, is in a condition (thanks to the great skill of that gentlemen and the exceedingly fortunate state of preservation, by which its delicate internal parts remain almost entire, and without any surrounding matrix) to throw much additional light on this subject. By very dextrous manipulation, Mr. Wachsmuth succeeded in removing about half of its vault, so as to expose the internal parts, in place, and in an excellent state of preservation. The convoluted organ already described in other species is in this comparatively large, subcylindrical in the middle, apparently tapering at the lower end, and a little dilated at the upper extremity. It seems to be rather dense, and shows the usual rough appearance, but as we had no opportunity to examine any detached fragments of it by transmitted light, we did not determine whether or not it has pores passing through it, though it probably has, at least when entirely free from any inorganic incrustation. Its slightly dilated upper end seems to stand with its middle almost, but apparently not exactly, under the middle of the nearly central proboscis of the vault; while at the anterior side of its upper margin, and a little out from under the proboscis, it shows remains of a kind of thickened collar, which we found to be composed of minute calcareous pieces. From this there radiate five ambulacra, composed of the same kind of minute pieces as the collar itself, each ambulacrum consisting of two rows of these minute pieces alternately arranged. They are each also provided with a distinct furrow along their entire length above. As they radiate and descend from their connection with the top of the convoluted frame work of the digestive sack, they all bifurcate, so as to send a branch to each arm-opening, those passing to the posterior rays curving

a little at first above, so as not to pass directly under the proboscis. These ambulacra, although passing along obscure furrows in the under side of the vault, which are deepest near the arm-openings, are not *in contact* with the vault, or visibly connected with any other parts than the top of the convoluted digestive sack, and the outer walls at the arm-openings. Each of their subdivisions can be traced into an arm-opening, and it is very probable that they continued on out the ambulacral furrows of the arms and tentacula. At one point in one of these ambulacral canals, beneath the vault, some evidences of the remains of two rows of minute pieces were observed alternating with the upper edges of those composing the under side of these canals, and thus apparently covering them over. The condition of the parts is such however, as scarcely to warrant the assertion that this was really the case, though we are much inclined to think it was. If so, these canals must have been, at least under the vault, hollow tubes, formed of two rows of pieces below, and two above, all alternately arranged.

We are not aware that any evidences of the existence of these delicate ambulacral canals, composed of minute calcareous pieces, and passing beneath the vault from the arm-openings to the summit of the convoluted digestive sack, have ever before been observed in any Crinoid, recent or extinct; and we can but think it probable, that the extremely rare combination of circumstances that brought them to light in this instance may not again occur for centuries to come, with regard to another specimen. That they correspond to the ambulacral canals seen extending from the arm-base to the mouth, on the *outside* the ventral disc in *Comatula*, is clearly evident.

The presence of furrows radiating from the central region of the under side of the vault to the arm-openings, in various types of paleozoic Crinoids, must have been frequently observed by all who have had an opportunity to examine the inner surface of this part. Messrs. de Koninck and Lehon figure a portion of the vault of *Actinocrinus stellaris*, in their valuable *Recherches sur les Crinoides du Terr. Carb. de la Belgique*, pl. iii, fig. 4 f., showing these furrows, which they seem to have regarded as the impressions left by the muscles of the viscera. The inner surface of the vault of most of our western Carboniferous Crinoids is known to have these furrows more or less defined, either from specimens showing this inner surface, or from natural casts of the same. In some instances they are very strongly defined from the central region outward to the arm-bases, to each of which they send a branch. In *Actinocrinus ornatus* Hall, for instance, they are generally so strongly defined as to raise the thin vault into strong radiating ridges,

separated by deep furrows on the outer side. In *Strotocrinus*, the vault of which is greatly expanded laterally, and often flat on top, these internal furrows, in radiating outward, soon become separated by partitions, and as they go on bifurcating, to send a branch to each arm, they actually assume the character of rounded tubular canals, some distance before they reach the arm-bases.

That these furrows or passages of the inner side of the vault were actually occupied during the life of the animal by the ambulacral canals as they radiate from the top of the convoluted digestive sack to the arm-openings, we think no one will for a moment question, after examining Mr. Wachsmuth's specimen of *Actinocrinus proboscidialis*, which we have described, showing all these parts in place. It is also worthy of note, that in all the specimens of various types in which these furrows of the under side of the vault are well known, whether from detached vaults, or from casts of the interior of the same, they *never converge directly to the opening of the vault, but to a point on the anterior side of it*, whether there is a simple opening or a produced proboscis. The point to which they converge, even in types with a decidedly lateral opening of the vault, is always central or very nearly so, and even when the opening is nearly or quite central, the furrows seem to go, as it were, out of their way to avoid it, those from the posterior rays passing around on each side of it to the point of convergence of the others, a little in advance of the opening. That the ambulacral canals here, under this point of convergence of the furrows in the under side of the vault, always came together and connected with the upper end of the convoluted frame-work of the digestive sack, we can scarcely entertain a doubt.

Now in looking at one of these specimens, especially an internal cast of the vault, showing the furrows (or casts of them) starting from a central, or nearly central point, and radiating and bifurcating so as to send a branch to each arm-base, while the opening or proboscis of the vault (or the protuberance representing it in the cast) is seen to occupy a position somewhere on a line between this central point from which the furrows radiate, and the posterior side, one can scarcely avoid being struck with the fact, that this point of convergence of the ambulacra, under the vault, bears the same relations in position to the opening of the vault, that the *mouth* of a *Comatula* does to its *anal* opening. And when we remember that eminent authorities, who have dissected specimens of the existing genus *Comatula*, maintain that these animals subsisted on microscopic organisms floating in the sea-water, such as the

Diatomaceæ, minute *Entomostraca*, etc.,* which were conveyed to the mouth along the ambulacral canals, perhaps by means of cilia, we are led from analogy to think that paleozoic Crinoids subsisted upon similar food, conveyed in the same way to the entrance of the digestive sack. If so, where would there have been any absolute *necessity* for a mouth or rather opening directly *through* the vault, when, as we know, the ambulacral canals were so highly developed *under* it from the arm openings to the entrance into the top of the alimentary canal? Indeed it seems at least probable, that if the soft ventral disc of *Comatula* had possessed the power of secreting solid vault pieces, as in most types of paleozoic Crinoids, that these vault pieces would not only have covered over the ambulacral furrows, as in the paleozoic types, but that they would also have hermetically covered over the mouth, and converted the little flexible anal tube into a solid calcareous pipe, such as that we often call the proboscis in the extinct Crinoids.

From all the facts therefore now known on this point, we are led to make the inquiry whether or not, in all the paleozoic Crinoids in which there is but a single opening in the vault—whether it is a simple aperture or prolonged into a proboscis, and placed posterally, subcentrally, or at some point on a line between the middle and the posterior side—this opening was not, instead of being the mouth, or both mouth and anus as supposed by some, really the anal aperture alone; and whether in these types the mouth was not generally, if not always, hermetically closed by immoveable vault pieces, so far as regards any direct opening through the vault?

We are aware of the fact, that at least one apparently strong objection may be urged against this suggestion, and in favor of the conclusion that the single opening seen in these older Crinoids was the mouth, or at least performed the double office of both anal and oral aperture. That is, the frequent occurrence of specimens of these paleozoic species, with the shell of a

* Bronn mentions the fact (Klassen des Thierreichs. Actinozoa, II, p. 211), that the remains of *Diatomaceæ*, of the genera *Navicula*, *Actinocyclus*, *Coscinodiscus*, and of Entomostraca, were found in the stomach of *Comatula*, and suggests that, when such objects, in floating in the sea-water, came in contact with the ambulacral furrows of the pinnulæ, they were conveyed along these furrows to those of the arms, and thence in the same way into the mouth. He ridicules the idea, sometimes suggested, that the food may have been handed by the pinnulæ or arms directly to the mouth.

Dujardin and Hupé also state (Hist. Nat. de Zoophytes Echind., p. 18), that the living *Comatula* was "nourished by microscopic *Algæ* and floating corpuscles, which the vibratile cilia of the ambulacra brought to the mouth." That they may have sometimes swallowed a larger object, that accidentally floated into the mouth, however, is not improbable, and would not, if such was the case, by any means disprove the generally accepted opinion that these animals received their food almost entirely through the agency of their ambulacral canals.

Platyceras in close contact by its aperture, either with the side or the vault of the Crinoid, and not unfrequently actually covering the only opening in the vault of the latter, so as to have led to the opinion that the Crinoid was in the very act of devouring the Mollusk at the moment when it perished.

Amongst the numerous beautiful specimens of Crinoids found in the Keokuk division of the Lower Carboniferous series at Crawfordsville, Indiana, there is one species of *Platycrinus* (*P. hemisphæricus*), that is so abundant that probably not less than two hundred, and possibly more, individual specimens of it have been found there by the different collectors who have visited that noted locality; and, judging from those we have seen, apparently about one-half of these were found with a moderate sized, nearly straight, or very slightly arched and conical *Platyceras* (*P. infundibulum*), attached to one side by its aperture, between the arms of the crinoid, and often so as to cover the single lateral opening in the vault of the same.* From the direction of the slight curve of the apex of the *Platyceras*, it is also evident that it it is always placed in such a manner, with relation to the Crinoid, that the anterior side of the mollusk was directed upward, when the vault of the Crinoid was turned in that direction.† A species of *Goniasteroidocrinus* (*G. tuberosus* Lyon & Casseday), found at the same locality, also has frequently a *Platyceras* attached to the top of its nearly flat vault, so as to cover the only opening in the same. It is worthy of note, however, that it is always another, subspiral, *Platyceras* (very similar to *P. æquilaterum*), that we find attached to this Crinoid, so that here at least, it would

* We at one time thought these shells attached to the side of this *Platycrinus*, to be out of reach of the opening, or supposed mouth, because we had not seen, specimens showing the position of the opening in this species, and had supposed from its similarity to *Platycrinus granulatus* Miller, and other species without a lateral opening, that such was also the case with this. We have since seen specimens, however, showing that it has a lateral opening, and therefore belongs to the group *Pleurocrinus*, so that it is probable these shells often cover this opening.

† Prof. Richard Owen has noticed, in his Report on the Geological Survey of Indiana, p. 364 (1862), the frequent occurrence of a *Platyceras* attached to this same *Platycrinus*, at this locality, and proposed to name the *Platyceras P. pabulocrinus*, from the supposition that it formed the chief food of these Crinoids. It is probable that the *Platyceras* for which he proposed this name, is the same we named *P. infundibulum*, but as he gave no description of the species, and but an imperfect figure, we cannot speak *positively* as to its identity. Prof. Hall has also proposed the name *P. subrectum* for this Crawfordsville *Platyceras*, but he had previously used the same name for a very different, New York, Devonian species of this genus.

Prof. Yandell and Dr. Shumard have also figured in their paper entitled "Contributions to the Geology of Kentucky," a specimen of *Acrocrinus*, with a very similar *Platyceras* apparently attached to its vault.

Amongst all the Crinoids found at Burlington, Iowa, we are aware of but a single instance of one being found with a *Platyceras* attached, and that is a specimen of *Actinocrinus ventricosus* in Mr. Wachsmuth's collection, which has a crushed shell of a *Platyceras* connected with its vault.

seem that each of these two Crinoids has its own particular species of *Platyceras.*

In all of these, and numerous other examples that might be mentioned, it is worthy of note that it is to species of Crinoids with a simple opening in the vault, and not to any of those with a produced proboscis, that we find these shells attached in this way;* and it is so rarely that we find shells of any other genus than *Platyceras*, apparently attached to, or in contact with, the body of a Crinoid, that it seems probable where other shells are occasionally so found, that their connection with the Crinoid may be merely accidental. If it could be established as a fact, that these Crinoids were actually devouring these mollusks, by sucking out, or otherwise extracting and swallowing their softer parts, in any instance where they have been found with a shell attached over the opening of the vault, this would, of course, establish the fact that this opening is the mouth, or, at least, that it must have performed the office of both oral and anal aperture. But to say nothing in regard to all that is known of the habits and food of the recent Crinoids being so directly opposed to such a conclusion, the fact that so large a proportion as nearly one-half of all the individuals of some species should have died at the precise moment of time when they were devouring a *Platyceras*, and should have been imbedded in the sediment and subsequently fossilized without separating from the shell, seems, to say the least of it, very improbable.

And it is even more difficult to understand upon what principle an animal with its viscera incased in a hard unyielding shell, composed of thick, close-fitting calcareous pieces, and with even its digestive sack, as we have reason to believe, at least to some extent, similarly constructed, could have exerted such powers of suction as to be able to draw out and swallow, through an aperture in its own shell, often less than one-tenth of an inch in diameter, the softer parts of a mollusk nearly or quite equal in volume to the whole of its own visceral cavity. That they ever did so, however, becomes still more improbable, when we bear in mind the fact, that the animal supposed to have performed this feat, lived, at least during the whole of its adult life, attached to one spot by a flexible stem, that only allowed it a radius of a foot or so of area to seek its prey in; while the mollusk it is supposed to have so frequently devoured, from its close affinities to the genus *Capulus*, may be supposed to have almost certainly lived most of its life attached to one spot.† In such a case, why should the Crinoid have so frequently left

* Possibly due to the fact, that in species with a proboscis there is much less room for attachment to the vault.

† Most of the best European authorities on paleontology refer these shells even to the existing genus *Capulus*.

the *Platyceras* to grow within its reach to nearly its adult size before devouring it? But if from some unknown cause it should have done so, by what means could the Crinoid have pulled loose the mollusk (which from analogy we may reasonably suppose held with some degree of tenacity to its place of attachment), and placed it with the aperture of its shell over the opening supposed to be its own mouth? That it could have used its arms and tentacula as prehensile organs, in this sense, is extremely improbable from their very structure, so much so indeed that few if any of the best authorities who have investigated the recent Crinoids, believe that they ever used these appendages to hand directly to the mouth, even minute organisms.*

But we believe the strongest argument against the conclusion that the Crinoids, so frequently found with the shell of a *Platyceras* attached to them, died while in the act of sucking out, or otherwise extracting the softer parts of these mollusks, remains to be stated. In the first place, if such really was the nature of the relations between the Crinoid and the mollusk, it is of course self-evident that the continuation of the life of the latter must have necessarily been of very short duration after it came in contact with the Crinoid. Yet we have the most conclusive evidence that such was not the case; but that on the contrary, in most if not all of these instances, the *Platyceras must have lived long enough in contact with the Crinoid to have adapted the sinuosities of the margins of its shell exactly to the irregularities of the surface of the Crinoid.*

We have taken some trouble to examine carefully a number of specimens of *Platycrinus hemisphæricus*, and *Goniasteroidocrinus tuberosus*, from Crawfordsville, Indiana, each with a *Platyceras* attached, and in all cases where the specimens are not too much crushed or distorted, or the hard argillaceous

* In many instances it is clearly evident that it would have been an *absolute impossibility* for certain types of our Carboniferous Crinoids to have handed any object great or small, directly to the only opening through the vault: that is, where this opening is at the extremity of a straight rigid tube, often nearly twice the length of the arms, even to the extreme ends of their ultimate divisions. We are aware that some have supposed this tube, or proboscis, to have been flexible, and the Messrs. Austin even thought it was especially designed and used for the purpose of sucking out the softer parts of Polyps. If flexible, we might suppose that in those cases where it was so much longer than the arms, it could have been curved so as to bring its extremity within reach of the ends of the arms; but although we have in a few instances seen this tube more or less bent, a careful examination always showed that, where this was not due to an accidental fracture after the death of the animal, it was caused by the plates composing it being on one side larger, or differently formed from those on the other, and evidently not to flexibility. We find the arms, which were evidently flexible, folded and bent in every conceivable manner, but the tube of the vault is, in nine cases out of ten, if not more frequently, when not accidentally distorted, found to be perfectly straight, or a little inclined to one side or the other.

shaly matter too firmly adherent to prevent the line of contact between the shell and Crinoid to be clearly seen, the sinuosities of the lip of the former closely conform to the irregular nodose surface of the latter. Owing to the fact that in some cases the shell has evidently been forced by accidental pressure against the surface of the Crinoid, so as to become somewhat crushed, this adaptation is not always so clearly evident; but in most cases it is more or less visible, while in some it is strikingly manifest. In one instance of a *Platycrinus* now before us, with a *Platyceras* attached, as usual, to its side, between the arm-bases of two of its adjacent rays, and of rather larger size than those usually found attached to this species, the adaptation of the irregularities of its lip, so as to receive the little nodes and other prominence of the Crinoid, is so clearly manifest that a moment's examination must satisfy any one that the shell must have grown there. Being, as we stated, a larger individual than we usually see so situated, it not only occupies the whole of the interradial or anal space to which it is attached, but its lateral margins on each side coming in contact with the arm-bases of the Crinoid, as the shell increased in size, had formed on either side *a profound sinus in its lip for the reception of these arms.* These sinuses are not only in precisely the *proper places*, but of exactly the *proper size and form* to receive the adjacent arm on each side; the entire adjustment being so exact, that it seems scarcely possible that the shell could have been removed during the life of both animals, and after the mollusk had attained its present size, without either breaking its lip or breaking off the arms of the Crinoid. Unfortunately, in clearing away the rather hard argillaceous matrix, before the arrangement of the parts was clearly comprehended, these arms were broken away, but their stumps are still seen protruding from the sinuses, which are so deep as almost to present the appearance of isolated perforations, though it is evident, on a careful examination, that they are only deep emarginations extending up from the edge of the lip.

In looking at the sides of this *Platyceras* which has the form of a very slightly arched cone,* and stands out nearly at right angles to the side of the Crinoid, it is easy to see, from abrupt curves in the lines of growth, along up its sides, on a line above the sinuses mentioned, that these sinuses commenced forming abruptly at points about half way up; and on measuring across between these points with a pair of dividers,

* It being the common species of *Platyceras* that is usually found attached to this *Platycrinus*.

the space between is found to coincide very closely with that between the inner sides of the arm-bases protruding from the sinuses. Hence it is evident that the shell had commenced forming these sinuses in its lip exactly at the period of its growth, when it had attained a breadth that brought the edges of its lip in contact with the arm-bases. After this, it had increased very little *in breadth* between the arms of the Crinoid, though it had grown somewhat wider above and below, and *nearly doubled its length.* Whether or not it covers the opening in the side of the vault of the Crinoid we are unable to say, since the folded arms (which are, as usual in these cases, well preserved), and adhering matrix, cover the vault. We have scarcely any doubt now, however, that the *Platyceras* does, in this, as in most of the other cases, actually cover the opening in the side of the vault of the Crinoid.

From the facts stated it is, we think, evident that these mollusks actually lived long enough after their connection with the Crinoids, to which we find them attached, not only to have adapted the edges of their lip to fit the surface of the Crinoid, but to have generally increased more or less in size, and in some instances, at least, to have actually nearly or quite doubled their size. Admitting this to be the case—and we think there can be no reasonable doubt on this point—we can no longer believe that these Crinoids were preying upon the mollusks ; and we therefore think no well grounded arguments can be based upon the fact of their being so frequently found attached in the manner described, in favor of the conclusion that the opening in the vault of these Crinoids is the mouth.

But, if they were not in the habit of eating these mollusks, it may be asked what could have been the nature of the relations between the two, that so frequently brought them together as we now find them ? The first explanation that suggests itself is, that possibly the mollusk may have been preying upon the Crinoid. But the fact, already stated, that these mollusks evidently lived long enough attached to these Crinoids, as we have every reason to believe, during the life of the latter, to have at least increased the size of their shells considerably, if not indeed during their entire growth, is alone an almost insurmountable objection to such a conclusion. Doubtless, like other marine sedentary animals, these mollusks, when very young, floated freely about in the sea, until they found a suitable station to attach themselves, where they remained during life. May they not, therefore, have been attracted to the bodies of Crinoids by the numerous little organisms brought in by the action of cilia, along the ambulacral furrows

of the arms of the Crinoids, or in currents produced by the motions of the arms of the latter? The excrementitious matter of the Crinoid could doubtless have passed out under the foot of the *Platyceras*, supposing the opening in the Crinoid sometimes covered by these shells to have been the anus, but it is difficult to conceive how food could have passed in, if we suppose this opening to be the mouth.

ART. IV.—*On the effect of Atmospheric Air when mixed with Gas in reducing its illuminating power;* by B. SILLIMAN, and HENRY WURTZ.

THE data given in this article were obtained during an investigation of the Hydrocarbon Gas Process by the "*Gwynne-Harris*" or "*American System*," some notice of the results of which we propose to publish in a future number of this Journal. In the course of this investigation it became important to measure exactly the effect of atmospheric air in reducing the illuminating power of gas. Owing to a mechanical defect in the apparatus connected with the exhauster, it was found that a variable quantity of air had for some time found its way into the gas holder, the influence of which in diminishing the brilliancy of combustion was sufficiently conspicuous before the cause was ascertained. The only experiments on this subject known to us when its study was undertaken by us were those of Messrs. Audouin and Bérard* (also quoted in the American Meter Cos. Pocket Almanac.) By these results the ratio of loss in illuminating power by the addition of each one per cent of air appeared to us so enormous, that we were desirous of confirming them. Subsequently we became acquainted with an important paper on this subject by Mr. Carl Schultz,† the main points of which are reproduced in this article; as they appear to have escaped attention; the author having modestly given us only his initials, and the journal in which they appeared being almost inaccessible to scientific readers.

In conducting this research we soon found that the attempt to introduce by measure a given volume of air into the gas holders connected with the photometric apparatus, was attended with many sources of error, and that the requisite accuracy could be obtained only by the eudiometrical analysis of each successive

* Ann. de Ch. et Phys., 3d series, vol. lxv, p. 423, 1862.
† American Gaslight Journal, August 1, 1860, p. 41.

mixture.* The apparatus employed consisted of two gas holders of ten cubic feet capacity each, connected in such a manner that each could be used independently, or the contents of one transferred to the other and back again to secure a complete admixture of the contents. The air was introduced by opening a stop cock connected with the interior and adding

* Our labors in this research have been greatly aided by the facilities courteously extended to us by the officers of the Manhattan Gas Light Company, in New York, who with great liberality placed at our disposal their well appointed experimental laboratory and apparatus at their Eighteenth-Street Station.

TABLE I.

Dates.	Densities.		Composition.			Illuminating Power.						
Gas of Manhattan Co., N. Y., 18th St. Station, from Street Mains.	Density of Street Gas.	Density after Air was added.	Air found by Analysis in Street Gas, in 100 Volumes.	Air found by Analysis after the addition.	Volumes of Air added.	Candle power of Street Gas, before addition of Air.	Candle power after addition of Air.	Candle Power of Gas alone, Air being deducted.	Loss of Candle power, by Air added.	Percentage loss of Candle power.	Ratio of loss in Candle power in percentage volumes.	Loss of Candle power for each one per cent.
1869.												
March 17	401	409	1·96	3·01	1·05	15·12	14·20	14·96	·92	6·08	5·79	·723
" 18	392	405	3·15	4·97	1 82	14·67	13·27	14·40	1·40	9·54	5·24	·511
" 23	401	421	1·50	3·75	2 25	14·71	12·96	14·37	1·75	11·82	5·25	·582
" 19	387	419	1·61	4·61	3·00	14·81	12·49	14·46	2·32	15·69	5·23	·656
" 19	387	433	1·61	6·54	4·95	14·81	11·28	13·76	3·53	23·83	4·83	·501
" 19	387	467	1·61	13·32	11·71	14·81	8·67	13·07	6·14	41·46	3·54	·419
" 20	387	490	1 61	17·79	16·18	14·81	6·29	12·41	8·52	57·53	3·55	·378
" 23	403	525	1·12	21·88	20·76	15·09	4·09	11·96	11·00	72·90	3·50	·377
" 20	401	551·5	1·61	26·29	24·68	14·11	2·18	10·52	11·93	84·55	3·42	·380
(Gas burned in a 5-foot 15-hole Standard Argand.)	1	2	2	4	5	6	7	8	9	10	11	12

weights to the counterpoise, measuring the influx by a centissimal scale of equal parts attached to the drum of each holder. This rude admeasurement was controlled by an analysis of each mixture. This required also the prior analysis of the street gas on each occasion, columns 3, 4, and 5 of the accompanying Table I, show the results of these mixtures as made known by the eudiometer. The illuminating power of each sample was determined by the Bunsen photometer on the average of fifteen successive observations of one minute each with the usual corrections. Columns 6 and 7 give these results, and in columns 1 and 2 will be found the corresponding densities determined by diffusion.

Since the air added in each case is rendered *as gas* by the meter during the photometric measurement, it is important to determine the illuminating power of the gas alone after deducting the known volume of air present. The results of these calculations are given in column 8. In columns 9 and 10 the loss of illuminating power is given: in 8 in terms of the candle power lost for each admixture, and in 9 this loss is stated as a percentage. The ratio of loss of illuminating power in percentage volumes of gas and air is given in column 11, and in column 12 is the loss of power corresponding to each one per cent of air added.

The results of the analyses and photometric measurements are more conspicuously seen in the curve projected from columns 5 and 10 of the table upon the annexed diagram, on which the vertical and horizontal scales are as 1 : 3.

The following inferences depend upon the data herein given, viz :—

1*st*. For any quantity of air, less than five per cent, mixed with gas, the loss in candle power due to the addition of each one per cent is a little over $\frac{6}{10}$ of a candle (·611 exactly) ; above that quantity the ratio of loss falls to $\frac{1}{2}$ a candle power for each additional one per cent up to about 12 per cent of air ; above which, up to twenty-five per cent, the loss in illuminating power is as shown by column 12 of the table, nearly $\frac{4}{10}$ths of a candle for each one per cent of air added to the gas. In column 11 of Table I, the ratio of loss in candle power is given in percentages for the several volumes, while in column 10 the destructive effect of air upon the illuminating power of gas is most conspicuously exhibited, twelve per cent of air destroying over 40 per cent of the illuminating power. In the diagram this loss of power is represented by the numerals in the right hand column, which are inverse to those in column 10, and stand with the maximum intensity =100.

2*d*. With less than one-fourth of atmospheric air, not quite

15 per cent of the total illuminating power remains; and with between 30 per cent and 40 per cent air, it totally disappears.

Now, during December and January the hydro-carbon gas made at Fair Haven had often as much as 12 per cent of air in it; during the month of February the air by analysis averaged nearly 9 per cent; while in March after the separation of the pump from the exhaustion apparatus, the air was reduced at times to nearly nothing. By column 3 of the Table it will be observed that the air found by analysis in the street gas at the Eighteenth-Street Station of the Manhattan Gas Light Campany, New York, averaged nearly 2 per cent, and the New Haven City Gas contained about the same quantity. We allow, therefore, this quantity (2 per cent) as a normal amount of air in street gas; and consequently in the Journal of the daily operations with the hydro-carbon process at Fair Haven,* these corrections have been applied; giving in two columns the "corrected candle power," by the addition of the ratio determined in our Manhattan experiments, and the "corrected volume," or yield per pound of coals carbonized, air being deducted. It is obvious that the records of the station meter give the contaminating air as gas, and without the correction thus obtained the apparent yield is too great.

In large gas-works the liability to contamination by air accidentally introduced from various causes, diminishes in proportion to the total make of gas, and an amount of air which, when diffused in a very large volume of gas, becomes insignificant, if confined to ten or fifteen thousand feet daily product, will become a most serious injury to its illuminating power. This cause of deterioration in gas has been overlooked almost entirely by gas engineers; but in all small gas-works it deserves special attention, and we have no doubt that the low illuminating power too often obtained in such works is largely due to this cause.

Results of Messrs. Audouin and Bérard.—We have already alluded to these results obtained by Messrs. A. and B. which form part of an important memoir published in 1860, under authority of the French Government 'upon the various burners employed in gas lighting and researches on the best conditions for the combustion of gas.' Their table, which we append for the sake of comparison, shows "a considerably higher ratio of loss than we have obtained, being rather more than six per cent loss for each one per cent of air added to the

* *The Hydro-carbon Gas Process.* Report of working results on a large scale under the Gwynn-Harris Patents, Nov., 1868, to May, 1869, by Benjamin Silliman, M.A, M.D., and Henry Wurtz, M.A., N. Y. 8vo, pp. 126, printed for private distribution.

gas, reaching a total loss of 80 per cent with 15 per cent of air added; while we obtain 57·53 per cent loss with 16 per cent; and 93 per cent loss with 20 per cent air, while with the latter volume of air added we get 72·90 per cent loss. These differences may be accounted for by the French trials being made upon a gas of not more than 12 candles power, our trials being made on a gas averaging nearly 15 candles. Also, by the fact that in the French experiments the gas was burned from a batswing burner, ours from a standard Argand.

In the experiments of Messrs. Audouin and Bérard, two gas holders of equal capacity were filled, one with standard gas and the other with the same gas mixed with 1, 2, 3, etc. per cent of air. Each fed a burner of the second class, regulated to a consumption of 140 litres of gas per hour. The illuminating power of the two were compared by making that of the pure gas equal unity. The results are given in the following Table, where each figure gives the mean of 6 or 8 concordant observations.

TABLE II.

Table showing the results of mixture of air with gas, by Messrs. Audouin and Bérard.

Common Gas.			Gas mingled with Air.				
Intensity.	Size of Flame.		Quantity of air per 100.	Intensity.	Intensity. Loss of	Size of Flame.	
	Height.	Breadth.				Height.	Breadth.
	mm.	mm.				mm.	mm.
100	49	92	1	0·94	6	43	102
"	48	92	2	0·89	11	42	100
"	49	93	3	0·82	18	42	97
"	48	94	4	0·74	26	42	94
"	46	94	5	0 67	33	42	96
"	45	93	6	0·56	44	41	95
"	48	93	7	0·47	53	40	94
"	48	93	8	0·42	58	39	94
"	46	94	9	0 36	64	39	93
"	47	93	10	0·33	67	38	89
"	46	93	15	0·20	80	35	86
"	45	92	20	0·07	93	33	86
"	45	92	30	0·02	98	26	79
"	"	"	40	0·01	99	21	60
"	"	"	45	0·00	100	18	47
"	"	"	50	0·00	100	12	24

By this table it appears that the introduction of 6 to 7 per 100 of air, suffices to diminish the intensity by one half, and a mixture of 20 of air with 80 of gas leaves almost no illumination. Unfortunately Messrs. A. and B. do not record the actual illuminating power of their standard gas, which however we are led to believe cannot be more than 12 candles of the English and American standard.

We have already alluded to the experiments of Mr. Carl Schultz, and annex below a summary of his results.

Mr. Schultz concludes from his experiments, that the loss of illuminating power due to the addition of air to gas, is about one-half of one candle for each one per cent of air added. He makes the very remarkable observation, that, within limits, the addition of air to *very rich* cannel gas, up to 12 per cent of air, was followed by no loss of illuminating power, but, on the contrary, by a small gain. Thus boghead cannel gas, giving for 88 per cent gas an illuminating power of 27·47 candles, or for 100 per cent gas 31·32 candles, with 12 per cent of air, gave 28·29 candles, showing that 12 per cent of atmospheric air had increased the illuminating power of the flame by 0·82 candles. These results are obtained only by the use of an Argand burner. By substituting an intensity burner for the Argand, the results obtained with gas from boghead conform to the rule of half a candle loss for each one per cent of air. (Rev. Mr. Bowditch also states generally, that "impurities are far less destructive of light in Argand burners.")

Mr. Schultz sums up his results in the following propositions:

1. When coal gas is mixed with atmospheric air, its illuminating power for all five feet burners is reduced in the proportion of half a standard candle to every 1 per cent of air present, except in case of very rich gas burned with a 15 hole Argand.

2. One cubic foot of atmospheric air will destroy an amount of light equal to 10 English standard candles, during one hour.

3. This loss being constant, the percentage of aggregate loss will vary with the illuminating power of the gas used.

While our results confirm in general those of Mr. Schultz in 1860, and of Messrs. Audouin and Bérard, in 1862; it is obvious that the ratio of loss, with equal increments of air added to a 15 candle gas, is by no means constant. The difficulty of obtaining exact results, by the method of mixture of measured volumes is so considerable, especially with quantities below 10 per cent, that the only safe control of the results is that which is obtained by eudiometrical analysis of the several mixtures tested, as was done by us in all cases both before and after the addition of air. It is obvious that the surprising loss of intensity by the addition to illuminating gas of small percentages of air must be owing not merely to the interior combustion due to the presence of oxygen, but still more, probably, to the associated nitrogen which acts not only as a diluent, or deductive quantity, but its specific heat is an actual *divisory* function in diminishing the flame temperature. The interest-

ing observation, first made by Mr. Schultz, that in very rich cannel gas, there is actualy an increase of intensity within certain limits due to the presence of oxygen, suggests another series of experiments with successive additions of oxygen to a gas of high illuminating power, which we propose to undertake at our early convenience, as also another series upon mixtures of progressive quantities of carbonic acid.

May 17, 1869.

NOTE.—*Erdmann's Photometer* ("*Gasprüfer*") depends on the use of air to destroy the illuminating power of gas. Elster has employed this instrument in a series of researches undertaken to determine the theoretical illuminating power of different materials (*Journal für Gasbeleuchtung*, Munich, 1862, p. 384, *et seq.*) After removing the illuminants by sulphuric acid, he found that ordinary illuminating coal-gas required 150 volumes of air to destroy completely the yellow flame of 100 volumes of gas. If the amount of light obtained by the addition of 1 per cent of olefiant gas to the decarburetted gas employed in a definite burner, is called *one candle*, it was found necessary to add 6·5 per cent of air to destroy the illuminating power of this gas containing one per cent of olefiant gas or to destroy one candle power. As a like quantity of carbon, carried to a white heat, produces always, in a gas burning from the same burner, the same quantity of light, and it requires the same quantity of air to transform it into carbonic acid, we may regard an ordinary 12-candle gas as a mixture of an unknown non-luminous gas, holding in suspension during combustion a quantity of white-hot carbon, equivalent to 12 per cent of olefiant gas, and requiring, consequently, a quantity of air equal to 210 volumes for 100 volumes of gas ($88\times1{\cdot}5+12\times6{\cdot}5=210$). Each additional candle power requires an addition of 5 volumes of air, as the constant indicated by these results of Elster. [*Translated from Schilling, French Edition of* 1868.]

In the use of the Erdmann apparatus, it is found that the volume of air required completely to destroy the illuminating power of coal-gas ranges from 188 to 245 volumes per 100 volumes of gas, varying with its richness.

These results, it will be observed harmonize in a satisfactory manner with those obtained by us, as embodied in Table I.

Every chemist will at once recur, also, to the action of air upon gas in the Bunsen burner, in constant use in all laboratories provided with gas—an instrument identical in principle with the *Gasprüfer* of Erdmann.

ART. V.—*Description of a new Species of Protichnites from the Potsdam Sandstone of New York;* by O. C. Marsh, Professor of Paleontology in Yale College.* (With a plate.)

THE first discovery of footprints in the Lower Silurian of this country appears to have been made in 1847, in the Potsdam sandstone at Beauharnois, Canada East. In 1851 an account of the locality was published by Sir Wm. E. Logan, and with it appeared a short description of the impressions themselves by Prof. Owen, of London, who then considered them tracks of a Tortoise.† Subsequent explorations by the Geological Survey of Canada brought to light new localities and additional specimens in the same region, and in the following year

* Read before the Am. Association of Science, Chicago Meeting, August, 1868.

† Journal of the Geological Soc. of London, vii, pp. 247 and 250.

the geological age of the strata containing them was fully discussed by Sir Wm. E. Logan, and a more detailed description of the footprints was given by Prof. Owen, who now regarded them as made by a large crustacean, probably allied to the modern *Limulus*.* He applied to these impressions the generic name *Protichnites*, and distinguished six species, or varieties, apparently quite distinct from each other.† A trail of a different character was afterwards discovered in the same formation, near Perth, Canada West, and described by Sir Wm. E. Logan, under the name *Climactichnites Wilsoni*.‡ This was supposed to be the track of a Gasteropod, but Prof. Dana has since suggested that it may have been made by a large Trilobite.§ Up to the present time, eight localities of footprints have been found in the Potsdam sandstone of Canada, along the strike of the formation for about 400 miles, and all at about the same horizon, or within 50 to 70 feet of the top.‖

From the Lower Silurian of the United States, no footprints appear to have been described hitherto, although their existence in these strata is now clearly established. An interesting series of impressions was discovered by the writer on the western shore of Lake Champlain, during a visit to that region in August, 1867. They were found on a ripplemarked surface of Potsdam sandstone, just above the then water-line of the lake, a short distance north of the village of Port Kent. The rock is a hard, white quartzite, resembling that containing the footprints in Canada, although probably belonging to a somewhat lower horizon. The impressions obtained, which indicate a new form of Crustacean track, were in two portions, on the same surface, and evidently made by the same animal. They form together a series of footprints, about six feet in length, consisting of two parallel rows of impressions, separated from each other by a space of about one and three fourth inches, and having an extreme width between their outer edges of two and a half inches. Their form and general appearance is represented, one fifth the natural size, in the accompaning plate, which does not, however, give all of the minor impressions.

One of the most striking features of this series, which readily distinguishes it from the *Protichnites* already described, is the absence of a medial trail, or tail-mark. No indication of such an impression can be detected, even when the track passes over the ridges of the ripplemarks, where it certainly would be

* This opinion has since been confirmed by Dr. J. W. Dawson, after an examination of the tracks of a living specimen of *L. polyphemus*. Canadian Naturalist, vii, p. 271.

† Journal of the Geological Soc. of London, viii, pp. 199 and 214.

‡ Canadian Naturalist, v, p. 279, 1860.

§ Manual of Geology, p. 189. ‖ Geology of Canada, 1863, p. 108.

seen if at all. The footprints indicate, moreover, a muchsmaller animal than those which made the other forms of *Protichnites*, the width of this series being in general less than one half that of the other species, excepting *P. multinotatus*, from which, however, it differs in the absence of the medial groove, and in the less numerous, and more irregular footmarks.

The margins of the individual impressions are not in most instances accurately defined, partly perhaps owing to the fact that the surface of the sandstone has been somewhat worn by the water and ice of the lake. In this way some of the smaller impressions may have been obscured or obliterated, as it is now difficult to trace with certainty through the whole series the groups of footprints which correspond to the repeated applications of the same limbs of the animal; although such a repetition is easily recognized where the tracks are best preserved. In such places the impressions are seen to be arranged in groups of six, which in each row evidently represent successive applications of the same series of limbs, the corresponding set on the other side making a group nearly or quite opposite when the animal moved directly forward, but partially alternating when it turned to the right or left. Each group appears to consist of four impressions in the direct linear series, and two additional ones inside, and a little behind the last two. The divergence of the impressions thus produced probably indicates, as Prof. Owen has shown in regard to the other species, the direction in which the animal was moving.

The bottoms of some of the tracks are sharply defined, and were evidently impressed by hard pointed limbs. This would show conclusively that they were not made by a Trilobite, to which their origin might otherwise naturally be attributed; while the absence of a medial groove would probably exclude a Crustacean of the type that made the other *Protichnites*. The points of difference between this species and those hitherto described are sufficiently marked to justify its separation, and it may very appropriately be named, *Protichnites Logananus*, in honor of Sir Wm. E. Logan, Director of the Canadian Geological Survey, to whom this branch of paleontology is so much indebted.

The peculiar interest attached to these various footprints on the oldest Silurian strata depends in part upon the fact, that we thus have evidence of forms of life before unsuspected; since no other indications of the animal that made them have as yet been discovered. An exception should perhaps be made of the small Limuloid Crustacean (*Aglaspis Barrandi*,) described by Prof. Hall, from the Potsdam sandstone of Wisconsin and Minnesota, which may have made footprints some-

what similar to the *Protichnites.** Indistinct impressions, resembling those of Canada, have indeed been observed by Mr. Daniels in this formation in Wisconsin, although not at the same horizon in which the remains were found. The *Aglaspis* of the Potsdam, and the *Eurypterus* of the Upper Silurian at least indicate the general affinities of the Crustaceans that have recorded their existence in the *Protichnites*, and the remains of the animals themselves will doubtless be brought to light at no distant day, and thus reveal their true nature.

Art. VI.—*Notices of papers in Physiological Chemistry*—No. II; by George F. Barker, M.D.

5. *On the formation of sugar in the liver.*

[Concluded from vol. xlvii, p. 398.]

(64.) On the 24th of January, 1861, Dr. Pavy presented a paper to the Royal Society,† upon the influence of alkalies on the production of sugar. His previous experiments showed that the introduction of sodic carbonate into the circulation of an animal whose sympathetic nerve was divided, prevented the diabetes which would normally result; that on excising, for example, the superior cervical ganglia, or on dividing the ascending branches of the superior thoracic ganglia of a dog, diabetes would appear almost uniformly; and that in ten experiments now reported, about 200 grains of crystallized sodic carbonate, introduced into the jugular vein before the operation, entirely prevented this diabetic state. Under this treatment, the urine is copious, light-colored, and alkaline to test-papers, effervescing strongly on the addition of an acid. But on the other hand, if life be destroyed after the introduction of the carbonate of sodium, and the circulation be artificially maintained, the appearance of sugar in the urine is not prevented. This must be so, since the post-mortem changes produce it in the liver, whence it enters the blood and is eliminated by the kidneys. In two experiments 200 grains sodic carbonate were introduced into the jugular vein previous to the destruction of life by pithing; the circulation being maintained by artificial respiration, an enormous flow of alkaline urine took place, which was saccharine. If, however, the sodic carbonate reaches the liver in sufficient quantity, it prevents the production of sugar there, and of course, its appear-

* Sixteenth Regents' Report on N. Y. Cabinet, p. 181, 1863.

† Proc. Roy. Soc, xi, 90.

ance in the urine also. If the injection be made into the general venous system, the amount which reaches the liver is too small to produce the effect ; but if introduced into the portal vein, all must go to the liver and exert its action. 200 grains sodic carbonate dissolved in an ounce of water, were injected into a branch of the portal vein of a dog, and the animal was then killed. Artificial respiration was kept up for $1\frac{3}{4}$ hours, the heart beating vigorously all the time. The urine which collected in the bladder was pale and alkaline, and effervesced with acids, but gave no trace of sugar. The liver was also devoid of sugar, but became saccharine in 24 hours. Dr. Pavy then investigated the action of an alkali on the hepatine during life. He had long before noticed that the ingestion of potassic carbonate caused the hepatine to disappear very rapidly from the liver ; and this without the production of sugar. 200 grains in two ounces of water, injected through the esophagus into the stomach of a dog recently fed, caused the death of the animal within 12 hours ; no trace of hepatine or sugar existed in the liver. If the carbonate be injected into a branch of the portal vein, the disappearance of the hepatine takes place in a proportionally shorter time. In one experiment, 80 grains sodic carbonate in $6\frac{1}{2}$ ounces of water were injected into one of the mesenteric veins, and the dog was killed in one hour. The liver was somewhat congested but contained neither hepatine nor sugar. Hence it appears that by the influence of this salt, the whole of the hepatine may be rapidly destroyed during life, without the formation of sugar. To ensure success, however, in such experiments, Pavy found it necessary to use the solution quite concentrated, and to throw it in rapidly ; it then seems to suspend the liver circulation, and to exude into the tissue. Holding the muzzle of the animal so as to check his breathing, has the same effect. Using the cautions suggested by his experience, Pavy was able to cause the disappearance of the hepatine in even a few minutes ; 100 grains sodic carbonate in half an ounce of water were injected into one of the mesenteric veins of a large dog, and the liver tested at once ; it contained a trace of sugar but no hepatine. Caustic alkalies cannot replace the carbonated, since they coagulate the blood, and perforate the vessels. Dr. Pavy next asks how this disappearance is effected, and what the substance is into which the hepatine is transformed. First, he proves that the hepatine is really absent or transformed in these cases, and is not merely masked in its reactions by the injection. Moreover, the presence of alkalies or of their carbonates does not prevent the precipitation of hepatine by alcohol; the solution is still lactescent, is colored red by iodine, and when boiled with acids or acted upon by saliva, is conver-

ted into sugar. In the cases mentioned, however, all these tests failed. Again, the hepatine is not changed into sugar by the alkaline carbonate ; inasmuch as, were this the fact, an ordinary liver weighing 7½ lbs. and containing 7 per cent of hepatine, ought to yield—allowing 1½ parts of hepatine to produce 1 of sugar—over one hundred and fifty grains of sugar, an amount readily detected. Nor, further, is it decomposed as fast as formed ; at least not by the carbonate, which appears to have no action on sugar. 200 grains each of sodic carbonate and grape sugar were dissolved together in an ounce of water, and the solution was injected into a mesenteric vein of a good-sized dog. Blood afterward drawn from the carotid was saccharine; and in half an hour when the animal was killed, both the liver and the blood contained sugar. The urine was bloody —as is always the case when so much sodic carbonate is injected—and contained sugar. Finally, the hepatine does not seem to disappear from any direct chemical action of the carbonate upon it ; since even caustic alkalies at a boiling heat are without effect. Pavy therefore concludes "that the rapid disappearance of hepatine is due to one of those catalytic actions of which we have such numerous examples occurring amongst the phenomena of life." Another remarkable fact which Pavy states is that while the post-mortem injection of sodic carbonate into the liver prevents the production of sugar, it does not cause the disappearance of the hepatine. Moreover, in the liver of a cod-fish which he examined, the ordinary post-mortem production of sugar seemed to be spontaneously resisted ; no sugar appearing after 24 hours repose nor after exposure to warmth for three hours. In this liver either the hepatine was protected, as in the experiments with sodic carbonate, or the catalytic agent was wanting to effect the change. Pavy also notices that after the introduction of sodic carbonate into the liver, this organ yields on analysis a very high percentage of fat. The usual quantity being from 4 to 6 per cent, Pavy's analyses of livers after the above treatment showed them to contain from 10 to over 13 per cent of fat ; obviously establishing a close connection between hepatine and fat. From the results obtained, Pavy concludes : 1st, That sodic carbonate introduced into the blood, prevents the production of saccharine urine after lesions of the sympathetic nerve, which otherwise occasion it. 2d, That this salt injected into the general venous system, does not prevent the diabetic condition after death when the circulation is artificially maintained ; but injected into the portal system so that it all may pass into the liver, it keeps the urine free from sugar. 3d, That sodic carbonate when injected into the portal system dur-

ing life causes a rapid disappearance of hepatine from the liver without any evidence of the production of sugar. 4th, That in this disappearance, the hepatine is not concealed, nor transformed into sugar, nor destroyed by any direct chemical power possessed by the carbonated alkali ; but the facts suggest its transformation by a process like catalysis, the products yet escaping discovery. 5th, That sodic carbonate injected into the liver after death, does not cause a disappearance of hepatine, but, even in moderate quantity, holds its change into sugar completely in check. 6th, That there is probably a close connection between the disappearance of the hepatine, the production of fat, and the state of the bile.

(65.) On the ninth of December, G. Colin communicated to the French Academy* a paper on the various conditions of the cellules of the liver, in their relation to the activity of glycogeny. According to the facts which have now been established, says the author in conclusion, it will be seen that the condition of the fat in the liver presents the following well characterized differences: 1st, in the herbivora, as the horse, the ox, and the sheep, the fatty matters collect in the cellules in large amount, and in the form of large droplets ; 2d, in the case of flesh-eaters, as the dog and the hedgehog, the fat of the cellules is always much more finely divided, and is not therefore easily distinguished from the fine granular corpuscles with which it is mixed ; and 3d, in birds, —where the hepatic cellules are very small,—and especially in fishes, the fat is extra-cellular in large part, and is entirely free in the tissue of the organ. These differences Colin does not attempt to explain fully, but suggests that the route which the products of intestinal absorption take in these classes of animals, may well be one of the principal causes. With animals whose chyliferous system is highly developed, and whose enormous villosities are well arranged for absorbing fats, these take in great measure the channel of the lacteals and do not therefore traverse the liver in order to reach the general circulation. With birds, on the contrary, and especially with fishes, in which the chyliferous system is atrophied, the portal vein takes almost the whole of the fatty matters brought into the intestine. They may therefore be arrested in the liver, and a large quantity be retained.

(66.) A memoir on the amyloid substance of the liver and its ultimate destination in the animal economy, was presented to the Royal Society by Dr. McDonnell, on the 13th of February, 1863.† After a recapitulation of the views

* C. R., liii, 1063.

† Proc. Roy. Soc., xii, 476.

thus far held on this subject, the author states that his experiments sustain Pavy's view, that the amyloid matter is not changed into sugar during life. Hence, it becomes necessary to account for the disappearance of this substance and to show what its function really is in the animal economy. In the opinion of the author, the amyloid substance is "on its way upward toward the more exalted or complex animal principles;" and he accordingly suggests three points to be investigated: 1st, The chemical and physiological relation of amyloid substance, not only in the liver but also in other tissues. 2d, The comparison of portal and hepatic blood with each other, and with arterial and venous blood from other parts of the body. 3d, The relation which the different functions of the liver bear to each other. The last of these is the most important, since, if it be true that the fibrin and albumin of portal blood disappear in the liver, forming the amyloid substance, and at the same time only a trace of nitrogen is excreted in the bile, then we may infer that this nitrogen issues in the hepatic blood united to amyloid substance as a new nitrogenous principle, which is the protoplasm, from which according to Bernard, organic evolution is to be accomplished. McDonnell then calls attention to the occurrence of the amyloid substance in the fœtal placental cells, and also in their tissues, as shown by Bernard and Rouget; and remarks that these tissues are "so impregnated with amyloid substance, that it appears to be the formative material from which these tissues are evolved," being related to their growth and development, as starch is to that of vegetable tissues. He observes that the horny tissues contain it plentifully; enough for a chemical examination may be obtained from a single hoof of a fœtal calf, and from the muscles of these embryos from three to seven months old, from 20 to 50 per cent may be extracted. Being convinced of the truth of Pavy's view that amyloid substance is not normally changed into glucose, and having himself proved the accuracy of the facts stated by Bernard and Rouget concerning the relations of this substance to the fœtal tissues, McDonnell asks "may not the liver do for the adult what the fœtal tissues do in the embryo? may not this great organ form with the help of the amyloid substance secreted in its cells, a nitrogenous compound, just as the muscles of the fœtus convert the amyloid substance contained in them into the highly nitrogenous material of muscular tissue? May not the amyloid substance of the liver be the basis of an azotized protoplasma forming a constituent of the blood of the adult animal, as the amyloid substance of muscle is the basis of the material from which the evolution of muscular tissue is accomplished?" The author is disposed

to answer these questions in the affirmative, since the disappearance of portal fibrin and albumin leaves so much nitrogen unaccounted for. He supposes this nitrogen to be united with the amyloid substance and to leave the liver as a newly-formed proteic compound, partly perhaps as globulin, and partly as a body intermediate in properties between casein and albuminose. As to the function of the liver, three points need investigation; 1st, what is the action of this organ on the fibrin and albumin of the blood; 2d, what are the nitrogenous constituents of healthy bile; 3d, what is the relative composition and character of the blood which enters and that which leaves, the liver. McDonnell's experiments confirm Lehmann's opinion of the fibrin-destroying function of the liver; and they appear to show that the quantity of nitrogen eliminated in the bile is very small in comparison with that which disappears; and also that the blood in passing through the liver becomes greatly enriched in colorless corpuscles, and contains a peculiar azotized body termed blood-casein. The blood which leaves the liver therefore, is richer in this compound than arterial blood; and this again is richer in it than venous blood. Moreover, it contains five or ten times as many colorless corpuscles as portal blood. It is hence fair to infer that these colorless corpuscles are formed within the liver by the union of amyloid substance with nitrogen derived in some form from the retrograde metamorphosis of tissue.

(67.) The same year WINOGRADOFF published* a method for quantitatively estimating the glycogen and the sugar of the liver. A piece of this organ is sliced off, at once weighed and plunged into boiling water, then finely divided and rubbed to a pulp with boneblack in a mortar, thrown on a filter and washed with distilled water till the filtrate passes through clear. This filtrate is then poured into five times its bulk of strong alcohol and allowed to stand. After 24 hours, when the glycogen is completely deposited, it is brought on a filter and washed with alcohol; it is then dissolved in distilled water, again precipitated by alcohol, the alcohol carefully decanted, the precipitate collected on a weighed filter, dried at 100° C., and weighed. In the first alcoholic filtrate after evaporation to dryness and re-solution, the sugar is estimated by means of a freshly prepared Fehling's solution. Fresenius, after quoting this method,† remarks that it can make no claim to accuracy, since it is well known that glycogen so prepared is tough and contains albuminates; these may be easily and completely removed by boiling with potassic hydrate, which leaves the glycogen unaltered. The purification may also be effected by precipitation with glacial acetic acid.

* Virchow's Archiv., xxvii, 543.

† Zeitschr. f. Analyt. Ch., ii, 453.

(68.) In his notices of the progress of physiology in 1862,* MEISSNER gives Pavy's views at length,† and remarks that they are sustained by his own experiments. He had proved that blood removed from the right side of the heart of a healthy dog during life—the animal not being narcotized—contained only minute traces of sugar; no more indeed, than was found in the blood of the femoral artery drawn at the same time. He confirms the statement that plunging the liver into boiling water immediately after death, prevents the production of sugar; a piece of liver, cut from a living rabbit and thus treated, yielding not a trace of sugar, while another piece of the same organ, taken a short time after death, was saccharine. He maintains too, the correctness of Pavy's conclusions (1) that the blood of the general circulation always contains traces of sugar; and (2) that the liver is either entirely free from sugar during life or contains but a trace; though after death, as well as during certain abnormal conditions in life, the amyloid substance is converted into sugar with astonishing rapidity.

(69.) In a second communication, made to the Royal Society, May 30, 1864,‡ MCDONNELL continues his observations on the amyloid substance of the animal economy. Pure amyloid matter, whether obtained from the liver, or from fœtal tissues, has the composition $C_6H_{10}O_5$, according to his analyses. His previous assertion that this substance is dextro-rotatory like dextrin, he has been unable to verify, as even half a grain in an ounce of distilled water produces an opalescence,—due to partial solution,—which prevents its use in the saccharimeter. As to the amount of amyloid substance in the different tissues and in the same tissues at different periods of fœtal life, the author thinks that the extreme delicacy of the acidulated tincture of iodine test is such (one-tenth of a grain of amyloid matter in an ounce of water being readily detected) as to lead to error in its estimation. McDonnell maintains too, that the amyloid substance grows less and less in proportion as the tissues are developed, and that, contrary to the opinion of Bernard, it disappears long before birth. In cartilage it very early appears in the cellules, but very soon afterward disappears. The epithelial cells of the skin, particularly where these cells aggregate together for the commencing development of a feather or a hair, show a great abundance of the amyloid matter. So also the horny appendages of the skin, as the bill of the chick, the claws, hoofs, etc., all contain it in large amount up to a certain stage of development. From seven grains of the horny tissue of the feet of a fœtal calf of four

* Bericht über die Fortschritte der Physiologie im Jahre 1862, 310. Leipzig, 1864.
† Researches on the nature and treatment of Diabetes, London, 1862.
‡ Proc. Roy. Soc., xiii, 317.

months, dried at 212° F., 1·3 grains of amyloid substance were obtained. An examination of the same weight of tissue from a nearly full-grown fœtus, gave an amount too small to be estimated. If the tails from a series of fœtal lambs of different ages be placed in a weak acidulated tincture of iodine, the gradual increase of the coloring up to a certain period of intra-uterine life, and then its diminution from that point, is well exhibited. In the sheep the maximum amount is found in the fœtus of nine inches. The lung-tissues of mammalian embryos contain at certain periods an immense quantity of amyloid matter; this substance constituting more than 50 per cent of the dry residue. Before the animal has drawn its first breath, however, it has all disappeared. In voluntary muscle, the amount is not as uniform; and, though it diminishes before birth it does not entirely disappear, since voluntary muscle can hardly be said to reach maturity at birth. The muscle of the heart, however, which attains maturity earlier than any other muscular tissue, loses its amyloid matter earlier. The amyloid substance in the liver increases up to and after birth, though it does not make its appearance in that organ until a late period. The quantity is small even at birth, being only two per cent in a fœtal lamb 20 inches long. The rapidly-growing horn of a young stag, on the other hand, contained no amyloid matter, nor did the horn of a calf; the hair bulbs of adults do not contain it, nor is it to be detected in the new muscular fibres of the uterus after delivery. It does not change into sugar during fœtal life, nor does it give rise to fat; it seems rather to be a formative material which, uniting gradually with nitrogen, gives origin to the azotized structures.

(70.) The results above given were communicated by McDonnell to the French Academy nearly a year later, May 8, 1865.* With them, however, some new facts were given. His experiments show that with animals living on their usual food, and apparently healthy, not only the weight of the liver varies considerably as compared with that of the entire body, but the proportion of starchy matter in this organ also varies greatly, as is shown in the following table, which gives the mean of six experiments upon each kind of animal:

Animals.		Weight of liver compared with that of entire body.	Proportion of amyloid matter.
Dogs,	as	1 : 30	4·5
Cats,	"	1 : 19	1·5
Rabbits,	"	1 : 35	3·7
Pigeons,	"	1 : 44	2·5
Guinea pigs	"	1 : 21	1·4
Rats,	"	1 : 26	2·5
Hedgehogs,	"	1 : 27	1·5

* C. R., lx, 963.

From this it will be seen that the volume of the liver of the cat in a state of health and when fed on meat is almost double that of the rabbit at the period of most active digestion; nevertheless, the liver of a large well-fed cat gives not more than $\frac{2}{3}$ the quantity of amyloid matter yielded by the liver of a rabbit fed on carrots, bread, and parsley. Saccharine food causes the production of amyloid matter in the liver much more readily than nitrogenous food; although it is a well established fact that this organ can make the amyloid substance from blood-fibrin, from wheat-glutin, or from fresh meat. McDonnell claims also to have proved, contrary to the opinion of an eminent physiologist, that there is no more amyloid matter in the liver of an animal fed on gelatin than there is in the liver of a fasting animal. Gelatin therefore, is not transformed into amyloid matter by the liver. The same is true of fat.

(71.) The same year F. RITTER published* some experiments upon the normal conversion of glycogen. His paper begins by stating the views at that time held upon this subject. As to its origin he inclines to the belief that it comes from the splitting up of albuminates, rather than from a metamorphosis of carbohydrates. Pavy's assertion of its non-conversion into sugar is easily verified; but, though confirmed by McDonnell, who showed the absence of sugar in the blood of the right ventricle, and by Meissner, who found no sugar in perfectly fresh liver, the need of further proof was still apparent; his experiments were undertaken to furnish this proof, being made under Professor Meissner's direction. The method which he pursued is as follows: the abdomen of a living rabbit, firmly held by an assistant, is opened by a single stroke of a sharp knife, a piece of the liver cut or torn off, and cut into fine pieces, which are plunged into water kept actively boiling. The use of too large a liver-fragment is to be avoided; and the author prefers to use scissors in cutting it fine, holding it over the boiling water so that the pieces as cut shall fall therein. The solution is freed from coloring matter and albumin, by adding a few drops of acetic acid; on filtering, an opalescent, weak wine-yellow colored liquid is obtained. In all the experiments made, in which the above process was performed expeditiously, not a trace of sugar was detected in this liver-extract, which was tested as follows: a small quantity of cupric sulphate solution was added to the still warm extract, and then potassic hydrate. If on heating to boiling no separation of cuprous oxyd took place, a few drops of a freshly prepared solution of potassic ferricyanid were added; a pure yellow precipitate proved the absence

* Zeitschr. f. rat. Med., III, xxiv, 65, 1865.

of all reducing substances. Ritter believes that the use of pure solutions of cupric sulphate and of potassic hydrate, mixed only when used, prevents many errors which arise from the use of tests prepared beforehand with some organic substance. That the failure of the reaction in the above experiments was not due to the presence of a substance which either prevented the oxydation of the sugar or masked in some way the reaction, is shown: 1st, by the fact that no other test detected sugar; and 2nd, that on digesting the liver-extract with saliva or boiling it with a dilute acid, it afforded the reaction distinctly. Moreover, a solution of the same liver, less rapidly prepared, reduced readily the copper-tests. A series of experiments were then made by taking a number of capsules containing boiling water, and in the first, converting a piece of liver into extract at once, as above; a second piece of liver was then taken, the animal having died meanwhile, and treated in the second capsule; in the third, a third piece was treated, taken still later; and so on. All the solutions thus prepared, excepting only the first, reduced the copper-tests; the reaction always being stronger, the longer after death the piece was taken; thus proving that the absence of sugar in the first specimen is due to the fact that the time was too short for the post-mortem changes to take place. Bernard admits only an *increase* of the sugar after death; these experiments show that it is rather a *production* of this substance. If the pieces put into boiling water are moderately large, then the heat penetrates them slowly and sugar is found in the extract. Ritter finds therefore that it is better to divide them finely, since there is less change during this process than during the time required for the heat to penetrate a large mass. These experiments, repeated a great number of times on rabbits, gave in every case save one—where too much time was used in the preparation—a uniform result. "The liver of a healthy living rabbit, though rich in glycogen, contains not a trace of sugar; though after death the formation of sugar begins at once." Ritter also experimented on two dogs, two cats, and three pigeons, with the same results. The process is easiest with birds. With larger animals, their struggles interfere with the liver-circulation and sugar is produced in that organ, even before death. The dogs were killed by a blow on the head, and liver was instantly examined; no sugar was found in it, though glycogen was abundant. Ritter finds moreover, that Bernard's method of removing hepatic venous blood is faulty, since the time occupied in reaching and ligating these veins, suffices to cause the production of sugar in the liver. The easiest mode of procuring pure hepatic blood is to catheterize the right ventricle, since hepatic blood constitutes a large

proportion of its contents. The experiment is easily performed with dogs by passing an elastic catheter through the right jugular vein for a distance equal to that of the heart ; the animal must not be too tightly bound, nor the quantity of blood removed too great. The blood as drawn, is allowed to flow directly into an equal volume of boiling water, a trace of acetic acid is added, the albumin—thus coagulated—with the adhering coloring matter, removed by filtration, and the scarcely colored filtrate tested, either directly or after extraction with alcohol, for sugar. Blood taken from the artery or vein of an extremity at the same time, was examined in the same way. The results show that the blood of the right ventricle, as well as arterial blood, contains a minute quantity of sugar, like all healthy blood ; but that no more is contained in the blood of the right ventricle than in other blood. That it was really sugar that reduced the copper-tests was proved by fermentation. In one experiment, a dog was catheterized as above, and a portion of blood taken from the right ventricle. The catheter remained, while blood for comparison was drawn from the thigh. After this operation, which occupied some minutes, a second portion of blood was drawn from the catheter. On examination, the first portion of ventricular blood contained only the trace of sugar ordinarily found; while the arterial blood from the thigh, and also the blood subsequently taken from the ventricle, were rich in sugar. Hence, the blood had become saccharine in the course of the experiment, and this sugar reappeared in the arterial blood, not having been destroyed in the lungs. With regard to the influence exerted by narcosis, Ritter found that when morphine was injected under the skin of a dog, the blood of the femoral artery and vein, as well as that of the right ventricle, taken fifteen minutes afterward, was rich in sugar, about an equal quantity being in each specimen; the urine was also diabetic. Pavy's assumption that both the liver and the blood contain a ferment, founded on the injection of amyloid substance into the blood and the consequent increase of sugar, Ritter had not been able to confirm. He injected 15 or 20 c. c. of a warm concentrated solution of glycogen into the femoral veins of rabbits. Nothing abnormal was noticed in their behavior, and scarcely a perceptible increase of sugar was observed. He suggests that possibly the glycogen may have been changed to lactic acid. Nor do his experiments show that amyloid substance can be changed into sugar by the action of freshly-drawn blood. Ritter maintains therefore, that the ferment itself is a post mortem production ; and inclines to the belief that the amyloid substance is a stage in the physiological production of fats.

(72.) A paper by MICHAEL FOSTER, on the existence of glycogen in the tissues of certain entozoa, was presented to the Royal Society, November 4, 1865.* Although this substance has been found in many of the invertebrata by various observers, no one has thus far noticed the very large amount obtainable from certain entozoa. This fact was first observed by Dr. Foster in a tape-worm, though the exact quantity was not determined. His principal observations were made on the round worm (*ascaris lumbricoides ?*) found in the intestines of the common pig. When minced and boiled with water, a milky decoction is obtained, which is turned port-wine red by iodine and does not reduce the copper tests. When treated with saliva at 35° C., however, the liquid becomes clear and then reacts for sugar. On pouring the milky solution into alcohol, an abundant white precipitate falls. Glacial acetic acid causes the same precipitation. As only a minute trace of sugar, if any, accompanies the glycogen, Foster estimated the amount of the latter substance existing in these animals by converting it into sugar and determining this by a copper-test. From two worms weighing when fresh 10·2 grams, with three others weighing ten grams, he obtained 2·2 per cent of sugar; a very large amount when compared with vertebrate tissues, or, indeed, the invertebrate in other cases; a caterpillar weighing 6 grams yielding only traces, and a handful of maggots, no glycogen. In the ascaris this substance seems to be located in the muscular parietes. The author calls attention to the singular fact that an animal living in the midst of fluids, one of whose chief functions is to change starch into sugar, should thus accumulate glycogen in its body. He accounts for it by the fact that no ferment exists with the glycogen in the entozoa to change it into sugar. The use which this glycogen has is a difficult question. The intestinal worms being animals, must consume oxygen; but the amount which they find in the intestinal juices is very small. Nor can they be supposed to need "respiratory or calorifacient material," since they are kept warm by the animal in which they live. Whatever the use of glycogen in the mammalia, no heat-producing function can be offered as the reason of its presence in the ascaris. "Its abundance in the muscular parietes might suggest that it was material on its way to become muscle. If so, since the animals I studied were adults and ova-producing, the analogy of this glycogen would be, not with the glycogen of the muscles of the early mammalian embryo, but with the glycogen occurring in small quantities in the full-grown muscles (unless one were to push an idea, and say that the tissues of the lower

* Proc. Roy. Soc., xiv, 543.

animals were *chemically* homologous with the embryonic tissues of the higher ones)." Its quantity as compared with that in the caterpillar and maggot excludes the hypothesis of immature chitin. Nor in the tenia, certainly, can it have a muscular future, though it might be there provided for the use of the ova. The small amount in the generative apparatus at first opposes this view, but the analogy between the ascaris, with its glycogen, and the plant, with its blanched starch-storing tissues, is striking. May not "migration" occur as well in the animal as in the vegetable economy?

(73.) JAFFÉ has published the results of some examinations of the organs of persons variously diseased, for glycogen.* Only in rare cases was he able to find this substance in the organs of diabetic patients, and then only traces were detected. Once he found it in the brain, once in the spleen, and once in the pia mater; in the latter case the patient had died from suppurative meningitis.

(74.) A paper was sent to the French Academy on the 19th of March, 1866,† by BIZIO, in which, after alluding to the discovery of amyloid matter by BERNARD in the liver and the fœtal tissues, he notices particularly McDonnell's research, and states that the large amount of this substance found by him—50 per cent of the dried fœtal pulmonary tissue—led him to undertake the examination of this question. In reflecting upon the conditions of animal life at the period when this glycogen is so abundant in the tissues, aided also by other considerations, he concluded that this substance was the more abundant the less the energy with which the force of innervation acted, a view which the facts have subsequently confirmed. Proceeding from this hypothesis, he argued that the glycogen should be as abundant in the classes of adult inferior animals as in the embryonal tissues of superior ones. Certain acephalous mollusks were first examined for glycogen; as, for example, the oyster (*Ostrea edulis* L.), the *Cardium edule* L., the *Mytilus edulis* L., the *Solen siliqua* L., and the *Pecten jacobæus* L. They all contained it, some of them in large proportion. To extract it, the finely-divided mollusk is boiled for a long time in water, the water poured off, and the operation repeated twice or thrice. The liquids thus obtained are concentrated, precipitated by alcohol, and the precipitate treated with strong acetic acid. Only a portion dissolves; the supernatant liquid is decanted, and the residue is washed with acetic acid. The acid solution is precipitated again with alcohol, and the precipitate is again dissolved in acetic acid;

* Virchow's Archiv., xxxii., 20; Jahresb., 1866, 753. † C. R., lxii. 675.

the process being repeated until the glycogen is freed from inorganic matter, and particularly from magnesia, of which it at first contains a large quantity. Finally, the last precipitate is digested in glacial acetic acid to remove the proteic substances which it still contains, is well washed, first with alcohol, and then with ether, and then dried at 100° C. To compare the weight of the glycogen thus obtained with that of the mollusk, it is necessary to know how much each of the species mentioned loses in weight by desiccation at 100° C., a datum easily obtained. Proceeding as above, Bizio found 14 per cent of glycogen in *Cardium edule*, and 9½ per cent in *Ostrea edulis*, while *Solen siliqua* gave a precipitate too small to be determined. These numbers acquire significance when it is remembered that they refer, not to one single organ, but to the whole body. He calls attention to the rapidity with which these mollusks pass into the lactic fermentation, and states that where the glycogen is present in considerable quantity, the lactic acid produced suffices to keep the animal from putrefaction. Hence, from the more or less ready putrefaction of the animal, the quantity of glycogen may be inferred. Experiments show that while the *Mytilus edulis* and the *Cardium edule* are thus perfectly preserved, the *Solen siliqua* and *Pecten jacobæus*, which contain less glycogen, readily putrefy. Arguing from this analogy up to the tissues of the higher animals, Bizio took a piece of human liver, and a piece of ox liver, and kept them seven days. The acidity of the former was less, and it evolved no odor, while the second gave an unpleasant odor of volatile acids, and gas slowly escaped. In these cases the result is complicated by secondary actions; there is analogy with the mollusks, but not identity.

(75.) A note, by Bizio, was presented to the Academy, July 22, 1867,* on some new researches on glycogen. He had established the identity of the amylaceous substance which he had discovered in the invertebrates, with glycogen. He states that this substance, however prepared, always aggregates into a gummy transparent mass, when, after being precipitated by alcohol, it is allowed to dry slowly in the air at ordinary temperatures; the reason of which is, that, after the evaporation of the alcohol, it absorbs atmospheric moisture. The pulverulent state in which it has generally been obtained, depends on its being rapidly dried. Bizio also remarks that the lactic fermentation which glycogen suffers when in contact with fibrin or casein is exceeding slow. The principal point which he examined, however, was the composition of the glycogen. He finds that this substance, whether dried at 100° C., or at the ordinary

* C. R., lxv., 175.

temperature in a vacuum over sulphuric acid, has uniformly the composition $\mathrm{C_6\,H_{10}\,O_5}$. A portion was then exposed to humid air till it was perfectly hydrated, and then dried over chlorid of calcium at the ordinary temperature, until it ceased to lose weight. This specimen yielded on analysis the formula $\mathrm{C_{12}\,H_{22}\,O_{11}}$. A molecule of water remains united in this case to the group $\mathrm{C_{12}\,H_{20}\,O_{10}}$, which is the glycogen formula given above, doubled. This, the author thinks, is the true composition of glycogen, since it agrees perfectly with the experiments and views of Musculus on dextrin, and also with the current views on this class of bodies. Moreover, the lead compound obtained by precipitating a solution of glycogen with basic plumbic acetate is $\mathrm{C_{12}H_{18}Pb''O_{10}}$.

(76.) On the 15th of March, 1868, EULENBURG published* the results of some experiments which he had conducted in the laboratory of Professor Städeler, on the sugar-forming power of the liver. He had repeated the experiments of Ritter, following most explicitly his directions; and to his great surprise obtained a distinct sugar-reaction several times. Indeed, if sufficient potassic hydrate was added, and the boiling continued for a long time, the reaction never failed. The liver-extract, therefore, prepared by Ritter's method, contains uniformly a trace of sugar. To settle the question whether this sugar originated in an imperfection of this method, Eulenburg modified the process as follows: the abdomen of a rabbit was opened by a transverse incision just below the sternum, a fragment was torn from the liver, and immediately triturated in a mortar with pounded glass and strong alcohol. Every trace of ferment-action is excluded by the instantaneous action of the alcohol; in a few seconds, the piece taken is bruised to the finest pulp. The alcoholic extract is digested at a gentle heat, filtered, the alcohol evaporated, the residue dissolved in a little water, precipitated by a few drops of plumbic acetate, filtered, the lead removed by sulphydric acid, again filtered, warmed to expel excess of the gas, exactly neutralized with sodic hydrate, and then used for testing. A somewhat more rapid method is to treat the filtrate, after precipitation with plumbic acetate, with sodic hydrate till the turbidity at first produced disappears; the excess of lead left in the solution being without effect on the sugar-reaction. In testing, for sugar, Eulenburg prefers Städeler's mixture.† It is raised to boiling, the liquid

* J. pr. Ch., ciii, 108.

† The copper solution—which contains 0·1 gram of metal or 0·1252 of oxyd in every 10 c. c.—is prepared by dissolving 10 grams pure copper wire in about 50 c. c. concentrated hydrochloric acid, with some nitric acid, carefully neutralizing the excess of acid, and diluting the cold solution to 1000 c. c. The tartaric acid solution contains 15 grams acid in every 40 c. c. The potassic hydrate solu-

to be tested is added, and the ebullition continued for three minutes. If at the end of this time, no reaction takes place, the absence of sugar may be assumed. With six healthy rabbits, experiments conducted in this way gave a negative result throughout; hence not a trace of sugar exists in the livers of these animals during life. With five other rabbits, two parallel series of experiments were made; two pieces of the liver were taken from each animal and examined, the one by the method now given, the other by Ritter's mode. In some instances the latter process was at once applied to the piece first taken. In every case, the piece of liver treated with boiling water gave the reaction for sugar, while the piece prepared by trituration with alcohol, never afforded the slightest trace of sugar. Eulenburg differs also from Ritter on the effect of narcosis on the production of sugar. He shows that the ether-narcosis, at least, when not carried too far, does not cause the appearance of sugar in the liver, by the following experiments: two powerful albino rabbits inhaled pure sulphuric ether for 1 or 1½ minutes to complete insensibility to mechanical irritation, when the abdomen was opened, a piece of the liver removed and examined as usual. In both animals, the liver was entirely free from sugar, as also was the urine. After the death of the animals, however, the liver reduced readily the copper-test. A third rabbit was narcotized with carbonic tetrachlorid, until serious disturbances of the respiration, facial breathing and dispnoetic convulsions appeared. At this stage, the animal seemed dead; the abdomen was opened—the heart pulsating regularly—and a piece of the liver removed, and found to contain sugar. The urine was also saccharine. "It appears therefore, that only a narcotization by inhalation rising to a fatal, or at any rate to an extraordinarily intense intoxication, can cause the ante-mortem production of sugar in the liver." In conclusion, Eulenburg maintains with Ritter, that "even instantly after death, a fragment of the liver, ever so carefully triturated with alcohol, shows itself distinctly saccharine."

tion contains 150 grams commercial hydrate—which should not contain more than 10 per cent of hygroscopic water—in 1000 c. c. Before each experiment, the three fluids are mixed together—10 c. c. copper solution, 10 c. c. potassic hydrate solution, and 2 c. c. tartaric acid solution, the last being added before the potash solution—diluted with an equal bulk of water and heated to boiling. If no turbidity appears, the solution may be used for testing; if it is troubled, the tartaric acid solution must be prepared anew.—*Jahresbericht*, 1854, p. 747.

ART. VI.—*Aurora at Toronto, Canada ;* by G. T. KINGSTON.

A VERY grand exhibition of aurora, occupying more or less the whole sky, took place on the night of April 15, and continued with but slight interruption from dusk till daylight on the following morning.

One part of the display deserving notice from its comparative rarity was a dark segment similar to those commonly seen in the north, though not so well defined, which appeared about 9 P. M. in the south, with an altitude of about 25°. But the feature of still more unusual occurrence consisted in a belt of luminous haze from 5° to 10° in width, extending through the zenith from the eastern to the western point of the horizon, the material of which (*in appearance*) moved like a torrent from east to west with prodigious velocity.

The *apparent* movement of translation continued from about $13^h\ 10^m$ to $13^h\ 50^m$, when the matter composing the belt became affected by pulsations, which succeeded each other in the order from east to west, and with a rapidity still greater than that of the previous apparent motion of translation.

About 14^h the belt broke up and the pulsations became visible over the whole sky, the order of their succession being from the horizon to the zenith. At 15^h the pulsations became intermittent and ceased to maintain any apparent order in their occurrence: they gradually became more feeble and ceased with daybreak.

Throughout the night a generally diffused luminosity prevailed, such as is commonly seen with a full moon and hazy sky. This was evidently not occasioned by the moon, which was scarcely four days old, and was low in the horizon, but was part of the aurora itself, the brilliancy of whose more active features it greatly impaired.

Throughout the day and night a considerable magnetic disturbance was going on.

From a table giving the digressions of the declination, total force, and inclination from their respective standard values the remarks which follow have been derived. The standards employed for the sake of brevity for the declinometer and the horizontal and vertical force magnetometers were the approximate mean normals of those instruments relative to the *whole* day. The digressions therefore are affected by the diurnal variations proper to the times of observation ; but as these are small compared with the actual digressions, the inaccuracy occasioned by using the same standard throughout will not materially dis-

guise the *changes* between consecutive observations. The digressions of the total force and of the inclination have been computed from those of the horizontal and vertical components of the force.

Magnetic Disturbance which preceded and accompanied the Aurora of April 15, 1869.

Table giving the digressions of the declination, total force, and inclination.—The digressions of the declination are expressed to the nearest minute of arc, those of total force and inclination are expressed in terms of the disturbance limits. The disturbance limit of the total force is four times the ten thousandth part of the force, and the limit for the inclination is one minute of arc.

Toronto Astronomical Time.			Deviations from the mean normal.			Toronto Astronomical Time.			Deviations from mean normal.		
			Declination.	Total Force unit= ·0004 of the total force.	Dip.				Declination.	Total Force unit= ·0004 of the total force.	Dip.
April	H.	M.				April	H.	M.			
14.	18	0	4′ E.	— 1	— 1′	15	9	15	9 W.	— 1	+ 10
	20	0	15 E.	— 11	+ 8		9	30	24 W.	+ 3	+ 2
	22	0	25 W.	— 3	+ 4		9	45	17 W.	0	— 3
15	2	0	14 E.	+ 7	— 3		10	0	6 E.	— 1	+ 1
	3	0	93 E.	— 5	— 64		10	15	19 W.	0	+ 24
	3	15	42 E.	+ 10	— 37		10	30	36 W.	+ 1	+ 35
	3	30	5 W.	+ 11	— 30		10	45	26 E.	— 16	+ 14
	3	45	9 E.	+ 9	— 21		11	0	74 W.	+ 5	+ 21
	4	0	9 W.	+ 9	— 31		11	15	21 W.	— 13	+ 21
	4	15	7 E.	+ 3	— 14		11	30	30 E.	— 8	+ 25
	4	30	9 W.	+ 5	— 8		11	45	25 E.	— 5	+ 15
	4	45	12 W.	+ 6	— 8		12	0	9 E.	— 8	+ 22
	5	0	3 E.	+ 10	— 18		12	15	1 E.	— 2	+ 21
	5	15	8 E.	+ 11	— 45		12	30	6 E.	+ 1	+ 9
	5	30	31 W.	+ 11	— 36		12	45	18 E.	+ 1	+ 3
	5	45	19 W.	+ 7	— 33		13	0	11 E.	+ 3	— 3
	6	0	6 E.	+ 6	— 25		13	15	4 E.	+ 3	— 1
	6	15	19 E.	+ 1	— 24		13	30	15 E.	+ 4	+ 2
	6	30	14 E.	— 6	— 23		14	0	1 E.	+ 1	+ 6
	6	45	4 E.	— 10	— 18		14	30	4 E.	0	+ 5
	7	00	14 W.	— 11	— 11		15	0	1 W.	+ 3	+ 6
	7	15	85 W.	— 7	+ 15		15	30	4 W.	+ 1	+ 7
	7	30	68 W.	— 14	+ 16		16	0	1 W.	— 3	+ 6
	7	45	9 W.	— 11	+ 1		16	30	6 E.	— 3	+ 5
	8	0	3 W.	— 23	+ 6		17	0	10 E.	+ 2	+ 4
	8	15	19 E.	— 15	+ 10		18	0	7 E.	— 2	+ 3
	8	30	28 E.	— 20	+ 14		18	30	11 E.	— 2	+ 3
	8	45	37 E.	— 12	+ 21		19	0	13 E.	— 2	+ 3
	9	0	8 E.	— 6	+ 20						

Declination.—As regards the declination the average deviation was 15′ of arc, or three times the limit required to entitle a disturbance to be considered as large. The easterly deviations were the more numerous, but the westerly were on the average 50 per cent greater in extent.

The greatest easterly deviation was 93′ at 3 P. M. and the greatest westerly deviation 85′ at 7^h 15^m P. M.

The deviations after midnight were nearly all easterly.

Total Force.—The disturbances of the total force were on the average nearly seven times what may be designated as the inferior limit of a disturbance, or ·0004 of the total force.

The number of the disturbances which increased and of those which diminished the force were nearly equal; but the average magnitude of the latter was to that of the former in the ratio of 8 to 5.

The greatest disturbance which increased the force was 11 (the unit being ·0004) and occurred at 5^h 15^m P. M., while the greatest disturbance diminishing the force was 23 and occurred at 8 P. M.

The disturbances which diminished the force nearly all took place between 6 30 P. M. and midnight.

Inclination or Dip.—The disturbances of the dip had an average value of about 15′, or 15 times the disturbance limit.

The disturbances which increased the dip were the more numerous, but those which diminished the dip were of nearly twice their magnitude. The greatest increase of dip was 35 and occurred at 10^h 30^m P. M., and the greatest diminution of dip was 64′ and occurred at 3 P. M.

The disturbances increasing the dip nearly all took place after 7 P. M., those that diminished the dip having occurred during the day.

On the whole, the aurora, together with the magnetic disturbance which preceded and accompanied it, was more remarkable than any that have been witnessed at Toronto since September, 1859.

Magnetic Observatory, Toronto, May 1, 1869.

Art. VII.—*A Qualitative Separation of Cobalt and Nickel;* by Frank Wigglesworth Clarke, S.B.

Although the methods employed for the quantitative separation of cobalt and nickel are exceedingly exact, none of them are sufficiently convenient for ordinary qualitative work. Stromeyer's process is tedious, and Gibbs's modification of Liebig's method cannot be used with certainty by beginners, although excellent for experienced chemists. Of the purely qualitative methods hitherto recommended, none are wholly reliable, nor particularly delicate,—probably the blowpipe tests are the best.

I find, however, that the different properties of their ferricyanids afford an easy means of distinguishing between these metals. As is well known, potassium ferricyanid precipitates cobalt and nickel from their solutions. The cobalt precipitate is of a deep reddish brown color, while the nickel compound is of a dirty yellowish brown. The nickel ferricyanid, however, dissolves with the greatest ease in ammonia water, or in solution of potassium cyanid, while the corresponding cobalt compound is absolutely insoluble in either. It is a noteworthy fact, however, that the previous presence of either ammonia water or potassium cyanid, entirely prevents the precipitation of cobalt by the ferricyanid; the solution, when ammonia is present, merely assuming an intense blood red color. This coloration has, I believe, been recommended as a test for cobalt, but by whom I do not know.

It is always best to employ the ammonia to dissolve the nickel precipitate, since the presence of a cyanid renders the subsequent detection of that metal rather difficult.

In an analysis I proceed as follows. To the slightly acid solution containing the two metals, I first add an excess of ammonium chlorid. This causes the cobalt precipitate, which otherwise would run through the filter, to fall in a denser state, and also of a much darker color, often nearly black. I then add the potassium ferricyanid until the precipitation is complete, and afterward agitate strongly with a considerable excess of ammonia. Upon filtering, all the cobalt remains upon the filter, being recognized by the characteristic color of the precipitate, and the nickel is readily detected in the filtrate, by means of ammonium sulphid. If, upon filtering, the portion at first running through is turbid, it may be disregarded, or returned to the filter, that which filters through subsequently, being almost invariably clear.

I offer this process merely as a convenient means of detecting cobalt and nickel in presence of each other in *ordinary* analyses. It is not particularly delicate, for, although the minutest trace of cobalt is detected, *very* small quantities of nickel will escape recognition. For exceedingly delicate work it is perhaps better to employ some good quantitative process, but for all ordinary purposes I find this method very convenient, and quite reliable. It has been employed with success in the laboratory of Cornell University, and beginners have found no difficulty in using it.

Cornell University, May 13th, 1869.

ART. VIII.—*Notes on the structure of the Crinoidea, Cystidea and Blastoidea*; by E. BILLINGS, F.G.S., Paleontologist of the Geological Survey of Canada.*

1. *Position of the mouth in relation to the ambulacral system.*

THE earlier Paleontologists, Gyllenhal, Wahlenberg, Pander, Hisinger and others, described the large lateral aperture in the Cystidea as the mouth, apparently on account of its resemblance to the five-jawed oral apparatus of the sea-urchins. In his famous Monograph "Uber Cystideen," 1845, Leopold von Buch advocated the view, that it was not the mouth but an ovarian aperture; and that the smaller orifice usually situated in the apex, from which the ambulacral grooves radiate, was the true oral orifice. These opinions were adopted by Prof. E. Forbes in his Memoir on the British Cystidea, by Prof. J. Hall in the Paleontology of New York, and by most others who have described these fossils, including myself, in my first paper on the Cystidea of Canada, published in the Canadian Journal in 1854. In 1858 I re-investigated the subject while preparing my Decade No. 3, and came to the conclusions that the lateral aperture was the mouth, in those species which were provided with a separate anus; and that in all others it was both mouth and anus. The small apical orifice I described as an ambulacral aperture. According to these views, the mouth of a Cystidean does not stand in the center of the radial system, as it does in all the existing Echinodermata. On this point Prof. Wyville Thompson has the following observations;

"I can see no probability whatever in the opinion lately advocated by Mr. Billings, and which has received some vague support from the writings of De Koninck and others, that the "pyramid" in the Cystideans is the mouth, and that the aperture whence the ambulacra radiate is simply an "ambulacral orifice." Such an idea appears to me to be contrary to every analogy in the class. There can be no doubt of the existence of distinct openings for the passage of the ambulacral nerves

* This paper was prepared for the press last December, but, as my collection of the Blastoidea was small, I thought it best to delay publication until I could examine a greater number of specimens. In January I applied to S. S. Lyon, Esq., of Jeffersonville, Indiana, and he replied that, if I would let him know what points I wished to investigate, he would supply me with the materials. On my giving him the desired information, he, in the most liberal manner, sent me a large collection—much larger than I expected to receive—consisting of numerous specimens of several genera, many of them in the state of preservation best adapted for investigation—some of them empty and others silicified in a matrix of limestone. Prof. E. J. Chapman (Prof. of Geology and Mineralogy, Univ Coll., Toronto) also kindly supplied me with several Russian Cystideans. To both of these gentlemen I here tender my thanks.

and vessels from the calyx of many of the paleozoic crinoids; but I think we must certainly assume that in this, as in all other known instances, these vessels had their origin in an annular vessel surrounding the mouth. In the whole class the æsophageal circular canal seems to be the origin and center of the ambulacral system. It is the first part which makes its appearance in the embryo, and is so permanent and universal that one could scarcely imagine a radiating ambulacral vessel rising from any other source. The early origin of this important vascular center, in this annular form and in this position, evidently depends upon, and is closely connected with, the origin of the nervous system in the æsophageal nerve ring, constant in the whole invertebrate series."*

With all due deference I cannot admit that we must assume that, in the Cystidea, the ambulacral tubes had their origin in "an annular vessel surrounding the mouth." It is true that such a vessel does surround the mouth of existing Echinodermata, but there is no essential or direct physiological connection between the two organs. Their functions are exercised independently of each other. There is no organ issuing out of the alimentary canal that communicates with the annular vessel. This latter might be situated in any other part of the body and still perform its functions, provided there were a connection between it and the ambulacra. In this class, the position of the various organs, in relation to each other, and also to the general mass of the body, is subject to very great fluctuations. Thus, the mouth and vent are separated in some of the groups, but united in others, while either, or both, may open out to the surface directly upward, or downward, or at any lateral point. The ovaries may be either dorsal or ventral, internal or external, and associated with either the mouth, the anus or with neither. The ambulacral skeleton may be imbedded into and form a portion of the general covering of the body or lie upon the surface, or borne upon free moving arms. In genera belonging to the same family these relations are constant, or nearly so, but are found to be extremely variable when different orders or when remotely allied families are compared.

While preparing my Decade No. 3, I investigated this subject and satisfied myself that in, at least, a large proportion of the paleozoic Crinoids, the mouth was disconnected altogether from the radial system. A great many species might be referred to in which we can see both the center, from which the ambulacra proceed, and the mouth; and at the same time see that they are not in the same place. A long train of reasoning is not necessary—only simple inspection. It will be

* Edinburgh N. Phil. Jour., vol. xiii, p. 112, 1861.

quite sufficient to notice a few of these species to prove that the rule laid down by Prof. Wyville Thompson, is not a general rule.

1. 2. 3.

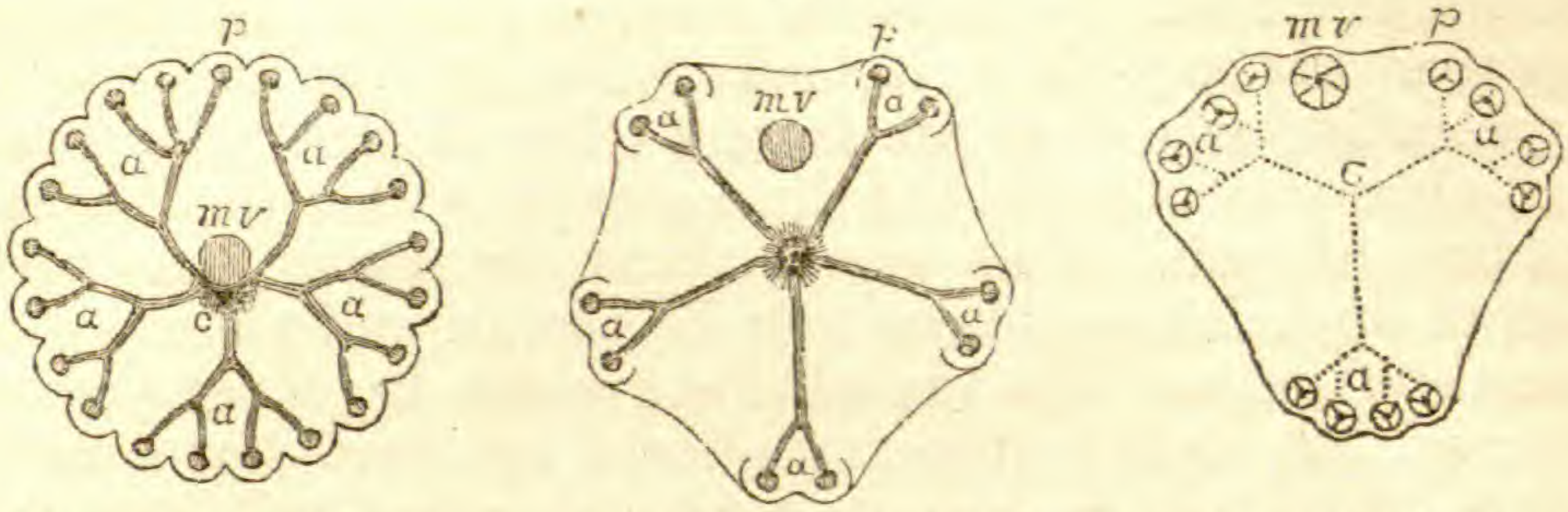


Fig. 1.—This figure is a diagram of the interior of the vault of a Crinoid which appears to be *Batocrinus icasodactylus* (Cassiday), a fossil that occurs in the Carboniferous rocks of Kentucky. It was sent to me by Mr. S. S. Lyon of Jeffersonville, Indiana, several years ago. The test is in a beautiful state of preservation and perfectly empty, so that all of the markings on the inner surface can be distinctly seen. There are twenty-one arms, arranged in five groups (*a*), and the same number of ambulacral openings (*p*), each just large enough to admit of the entrance of a slender pin. The mouth (*mv*) is nearly central, and close to it, on the posterior side, there is a small rudely pentagonal space (*c*) with no markings except several small tubercles. The grooves are scarcely at all impressed and, indeed, I think they never are so in any Crinoid, except in those which have a thick test. In this specimen their course is clearly indicated by the remains of the thin partitions which either separated them or to which the vessels were attached. They do not run directly toward the mouth, as they would do if that organ were the center of the ambulacral system, but to the small space (*c*) behind it where there appears to have been situated a vesicle or some other apparatus, to which all of them were united. Whatever may have been the structure of this central organ, from which the five main grooves radiate, it no doubt represented the annular vessel of the recent Echinodermata to which Prof. Thompson alludes.

Fig. 2—represents the structure of an *Amphoracrinus* from the Carboniferous rocks of Ireland,—precise locality and species not determined. There are ten arms; the test is very thick; the ambulacral channels converge to the central point (*c*) but do not quite reach it; the mouth (*mv*) is about half way between the center and the margin. In this Crinoid it is perfectly impossible that the mouth can be the center of the radial system because the two anterior passages, between which it is situated, are for their whole length tunneled, as it were,

through the substance of the plates, and only penetrate downward into the interior at the central space (*c*).

Fig. 3—is a plan of the summit of the widely known and remarkable fossil *Caryocrinus ornatus* (Say). In this species there are only three, instead of five, groups of arms. In large individuals there are from twelve to twenty free arms (but always arranged in the three groups) with a small pore at the base of each. This pore is about the size of the ovarian pore of an *Echinus* and can only be seen in well preserved and clean specimens. The ambulacral grooves have not yet been observed but their course is indicatd by three low rounded ridges, which may be seen, in some specimens, radiating from a large heptagonal plate situated at (*c*). The mouth (*mv*) is valvular, composed of from five to eight or ten plates, and is always situated near the margin between the two anterior groups of arms. With the exception of the ambulacral pores there is positively no other aperture in the summit of *Caryocrinus*. If it be true that the mouth of an Echinoderm must be always situated in the radial center, then *Caryocrinus* and also nearly all the paleozoic genera were destitute of that aperture.

Caryocrinus is a genus which seems to form a connecting link between the Crinoidea and the Cystidea. By examining numerous well polished sections I find that the structure of the respiratory areas is the same (in general plan) as that of the genera *Glyptocystites*, *Pleurocystites* and *Echinoencrinites*, as will be shown further on. The arms are also arranged in three groups as in *Sphæronites* and *Hemicosmites*, while the mouth is valvular. On the other hand, the long cylindrical column and the arrangement of the arms around the margin, with the ambulacral pores at their bases, are crinoidal characters.

In addition to the above, the following species may be referred to, as examples of Crinoids with the mouth separate from the center of the radial system.

Amphoracrinus tesselatus (Phillips).—Figured by J. Rofe, Esq., Geol. Mag., vol. ii, p. 8, f. 3. The figure represents a cast of the interior of the vault showing the five ambulacral grooves in relief. The mouth is situated in the angle between the two anterior grooves.

Strotocrinus perumbrosus (Hall, sp.).—Figured by Meek and Worthen in the Geology of Illinois, vol. ii, p. 188, f. 5. The specimen is 13 lines in diameter, the ambulacral center 13 lines from the anterior margin, and the mouth 11 lines.*

* In April last I received from Messrs. Meek and Worthen a paper entitled, "Notes on some points in the structure and habits of the Paleozoic Crinoidea." Of all the papers relating to this subject yet published on this continent, this one,

Glyptocrinus armosus (McChesney sp.).—This extraordinary Crinoid is figured by McChesney in his "New Pal. Foss.", pl. 7, f. 6, and also by Prof. Hall, in the 20th Reg. Rep., N. Y., pl. 10, f. 11. The specimens are between 2 and 3 inches in length. There are ten arms, the anterior side is much inflated, the proboscis appears to be large at its base and excentric in its position, but instead of standing erect, it bends down to the surface of the vault, and lies upon it, crossing over to the posterior margin. Judging from the figures, the center of the base of this organ must be distant from the radial center at least one-fourth of the whole width of the vault. *G. siphonatus* (Hall), figured on the same plate, shows, that the anterior grooves curve round to the posterior side of the proboscis, as they do in *B. icosadactylus* above cited.

I should also state here that two or three years ago, Mr. Meek, to whom I had written for information on this subject, wrote me that in all cases, where he had observed the grooves on the interior of the vault, they radiated, not from the mouth, but from a point "in front of it." (This would be not in front of, but behind the mouth, according to the terminology used in these notes. I think that the side in which the mouth is situated should be called "anterior" or "oral" even although both the mouth and anus should be included in it.)

In all the species above cited, the figures (with the exception of *C. ornatus*) exhibit the relative position of the mouth and radial center, as it has been actually seen in casts of the interior of the vault. But besides these, numerous examples may be found in the works of Miller, Austin, De Koninck, Phillips, Meek, Worthen, Shumard, Hall, Lyon, Cassaday and others,

at least so it appears to me, is the most interesting and important. It is written with a clearness and particularity rarely to be seen in paleontological memoirs. In some respects it confirms the opinions advocated in these notes, but bears directly against my views on the question here under discussion, i. e.—"the position of the mouth with relation to the radial center." As I wish to give the remarkable observations of the authors full consideration, I shall not discuss them now but delay until the September No. of this Journal. [Meek and Worthen's paper is given in this No., p. 23.—Eds.] I shall only state here, that I believe that the grooves on the ventral disc of *Cyathocrinus* and. also, the internal "*convoluted plate*" of the Paleozoic Crinoids, with the tubes radiating therefrom, belong to the respiratory and, perhaps, in part, to the circulatory systems—not to the digestive system as is supposed by the authors. The convoluted plate with its thickened border, seems to foreshadow the "æsophageal circular canal" with a pendant madreporic apparatus is in the Holothuridea. To me the final determination of this question is of much importance, for, if Meek and Worthen are right, then I must be wrong so far as regards nearly all that I have published with reference to the functions of the apertures of the Paleozoic Echnodermata. It is fortunate that the solution of this curious problem is now undertaken by men who have access to the magnificent cabinets of the geologists of the western States, and also by men who habitually discuss scientific subjects with the sole object in view of arriving at the truth.

of Crinoids whose external characters show that, in them, the mouth cannot be in the central point from which the grooves radiate.

With respect to Prof. Thompson's theory, I freely admit that if it is true that in all the echinodermata, fossil and recent, the mouth is the radial center, then, that aperture, must be the one which I call the ambulacral orifice in the Cystidea. The views, however, advocated by me in my Decade No. 3, appear to be gradually gaining ground. As these fossils are rare, few have occasion to study them, and consequently the subject has not been much discussed since 1858, the date of the publication of that work. The following are the only authors, so far as I have ascertained, who have given their opinions on this vexed question during the last eleven years :—

Prof. Wyville Thompson, op. cit., p. 111 (1861), agrees with me that the lateral aperture is not an ovarian orifice, but, as we have seen, is strongly opposed to the view that it is the mouth. He calls it the anus.

Prof. Dana (Man. Geol., p. 162, 1863) recognizes it as the homologue of the simple aperture (oral and anal) in the summit of those Crinoids which have but one. This is exactly my view. [J. W. Salter agrees with Prof. Thompson that it is the anus, not the ovarian aperture. (Mem. Geol. Sur. G. B., vol. iii, p. 286, 1866.) Prof. S. Lovén of Stockholm has described, in the "Proceedings of the Royal Swedish Academy", 1867, the remarkable sea Urchin, *Leskia mirabilis* (Gray), which has the mouth constructed on the same plan as that of the Cystidea, that is to say, with five triangular valve-like plates, which are immediately attached to the interambulacral plates, without the intervention of a baccal membrane. After comparing this structure with the valvular orifice of *Sphæronites pomum* (Gyll.) he says, " that the 'pyramid,' which in *Leskia* is the armature and covering of the mouth, is the same thing in the *Cystidea* is now quite certain ; in the last-named group it was, doubtless, also the vent. The mouth does not lie where J. Müller and Volborth sought for it, viz : in the center of the ambulacral furrows ; and the organ, interpreted as the vent by Volborth and von Buch, is more correctly regarded as an external sexual organ." Geol. Mag., vol. v, p. 181, Dr. Lütken's trans.]

2. *On the pectinated rhombs and calycine pores of the Cystidea.*

None of the organs of the Echinodermata have been the subject of so much speculation as the calycine pores and the so-called "pectinated rhombs" of the Cystidea. Their relations and function long remained in doubt but there seems to be, now, sufficient data to show that they are respiratory

organs, and also, that they are the homologues of the tubular apparatus which underlies the ambulacra of the Blastoidea. J. Müller suggested a comparison between these peculiar organs and the respiratory pores of the *Asteridæ*. (Über den bau der Echinodermen, p. 63, 1854.) Prof. Huxley has placed them in the same relation. (Medical Times, Dec. 1856.) Eichwald calls them respiratory pores. (Lethaea Rossica, vol. 1, p. 614, 1860.) Prof. Dana says "they are probably connected with an aquiferous system and respiration." (Man. Geol., p. 162, 1863.) Mr. Rofe, after showing that their structure is the same as that of the striated surfaces between the rays of *Codaster*, says, "From the construction of these striations on the face of *Codaster*, and on the 'pectinated rhombs' of the cystidea, may we without assumption suggest the possibility of their being respiratory sacs, lined with cilia, and constructed of a porous test, through which air from the water could pass by diffusion." (Geol. Mag., vol. ii, 251, 1865.) As for myself, when I prepared my decade on the cystidea, I gave this subject a great deal of consideration, and studied a large number of specimens, but could arrive at no conclusion satisfactory to myself. I am now convinced that the view of the above named distinguished authors is the correct one. These are respiratory organs. In all the species in which they occur, they seem to be constructed on the same general plan, i. e., the interposition of an exceedingly thin partition, between the circumambient water, and the fluid within the general cavity of the body. They are usually of a rhomboidal shape—each rhomb being divided into two triangles by the suture (*c*, *c*, figs. 4, 5,) between two of the plates. In several of the genera the two halves of the hydrospires are reniform, ovate or lunate, and either internal or external.

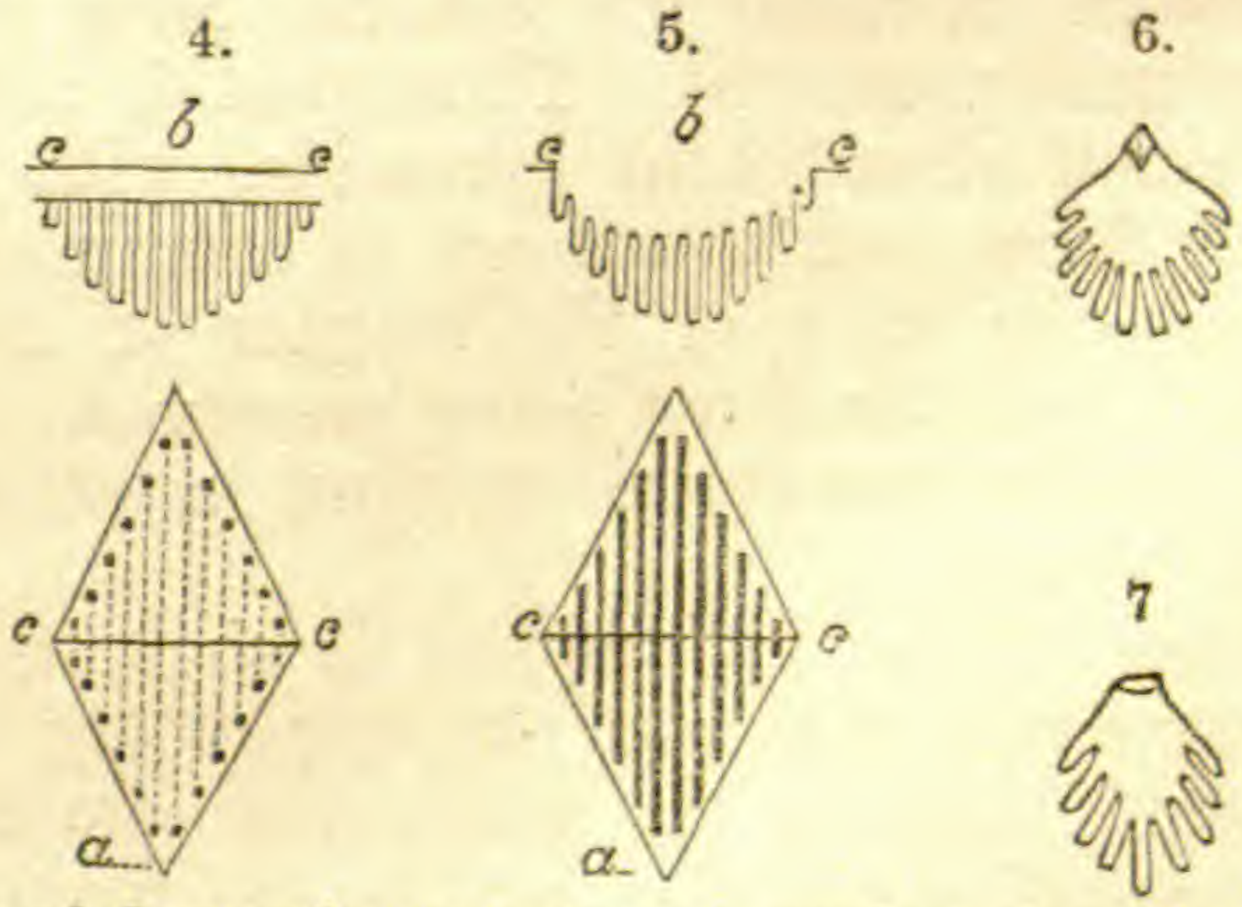


Fig. 4. Hydrospire of *Caryocrinus ornatus*. *a*, surface view, the dots around the margin are the spiracles, the small dotted lines represent the course of the flat internal canals; *c*, *c*, suture between the two plates; *b*, transverse section. 5. Hydrospire of *pleurocystites*. *a*, surface view: *c*, *c*, suture; *b*, transverse section. 6. The same with the points *c*, *c*, drawn together. 7. Internal gill of a spider.

In order to avoid the use of double terms, I propose to call them "*hydrospires*," and their apertures, "*pores*," "*fissures*," or "*spiracles*" according to their form.

In Caryocrinus ornatus the hydrospires (fig. 4,) are of a rhomboidal form, and have each of the four sides bordered by a single row of small tubercles. Some of these tubercles have a single pore in the summit, while others are perforated with a variable number,—from two to twenty, or perhaps more,—thus becoming vesicular or spongy. It is only the apex of the tubercle, however, that has this structure, for, when this is worn off, there is only a single pore to be seen. The pores penetrate through the plates but do not communicate directly with the general cavity of the body. Internally each hydrospire consists of a number of flat tubes arranged parallel to each other and lying side by side, in the direction of the dotted lines in fig. 4, *a*. Each tube receives two of the pores seen on the exterior—one pore at each end. These tubes are composed of a very thin shelly membrane, which although possessed of sufficient rigidity to maintain its form, was no doubt of such a minutely porous texture as to admit of the transfusion of fluids in both directions, outward and inward. In a large hydrospire there are about twenty of those tubes. Their greatest breadth is at their midlength where they are crossed by the suture *c*, *c*; and as they become narrower accordingly as their length decreases, the one in the middle projects the deepest into the perivisceral cavity. In consequence of this arrangement when a section is made across the hydrospire at the suture *c*, *c*, fig. 4 *a*, the form *b*, is obtained where *c*, *c*, is the surface of the shell, while the comb-like structure below represents the tubes.

Specimens of *C. ornatus* almost entirely empty are often found and in some of these the internal form of the hydrospires is sometimes preserved. Those that I have seen have the form of small rhomboidal pyramids, with four slightly convex sloping faces, and composed of a number of vertical parallel plates—the casts of the interior of the tubes—the substance of the tube itself not being preserved. I have, however, several polished transverse sections, in which I think the thin walls can be seen.

The structure of the hydrospires is such, that there can scarcely be any doubt that they are respiratory organs. The sea-water entered through the pores, and ærated the chylaqueous fluid, contained in the perivisceral cavity, by transfusion through the exceedingly thin membranous shell, that composed the walls of the tubes. The number of pores varies with the size of the individual. In large specimens these are from 800 to 1000.

It has been stated by some authors that the pores were passages for the protrusion of internal organs connected with the vitality of the animal. The fact, however, that the pores do not penetrate into the general cavity of the body, disproves this theory; and, moreover, through many of the tubercles—those with a vesicular and spongy summit, such protrusion would be utterly impossible.

In *Caryocrinus ornatus* there are thirty hydrospires arranged as follows :

1. Ten at the base—half of each on a basal plate and the other half on one of the subradials, their longer diagonal vertical.

2. A zone of six around the fossil at the mid-height—their longer diagonals horizontal. These seem to be imperfectly developed, for, on the inside, the tubes occupy only a small space in the center.

3. A third band of fourteen—two of them with their longer diagonals vertical and the others arranged in six pairs, the diagonals of each pair inclining toward each other, upward, at an angle of about 30°. There are only three interradii in *Caryocrinus :* the mouth is placed in one of them and the two hydrospires with vertical diagonals in the other two.

In *Pleurocystites* the hydrospires are also of a rhomboidal form, but instead of having the tubular structure of *Caryocrinus*, they consist of a number of parallel inward folds of an exceedingly thin part of the shell. These folds no doubt represent the tubes of *Caryocrinus*. If we grind down a hydrospire of this latter, so as to remove all the shell, and expose the edges of the tubes, it then exhibits precisely the same form as fig. 5 *a*, i. e., the form of a rhomb, longitudinally striated at right angles to the suture, and with no pores. The transverse section in *Pleurocystites* only differs from that in *Caryocrinus* in having no shell between the points *c*, *c*. In the hydrospire of *Pleurocystites robustus*, of the Trenton limestone, we have the commencement of the formation of an internal gill with a single spiracle. The surface is not flat, as it is in many species, but concave as shown in the section ; and it is evident that if the concavity should be carried further, and at the same time the points *c*, *c*, made to approach each other, the effect would be to produce an elongated sack, deeply folded on one side, and with a fissure extending the whole length on the other side. The transverse section of such a sack would be fig. 6, the same as in *Pentremites*. Again, if we contract the four sides, gradually curving them outward at the same time, but not diminishing the superficial extent of the walls of the folds although altering the form to corres-

pond with the decreasing aperture, the result would be a deeply folded, flask-shaped sack, with a small round orifice like fig. 7, which is the internal gill of a spider.

In *Palæocystites tenuiradiatus*, a species very characteristic of the Chazy limestone, the whole surface (in the condition in which the fossil is usually found) is covered with deeply striated rhombs, the fissures being deepest where they cross the suture and growing gradually shallower as they approach the center of the plates, where they die out altogether. Detached plates occur in vast abundance but no perfect specimens have ever been found. I discovered, however, several fragments of the body sufficient to give the general form and to show that, when the surface is perfect, all these fissures are completely covered over by a very thin shell, and that, when they cross the suture there is a small pore in the bottom of each which penetrates to the interior. The rhombs of this species are thus external hydrospires. The fissures seen in the ordinary weathered specimens are the remains of flat tubes like those of *Caryocrinus*, situated on the outer instead of the inner surface of the test. The chylaqueous fluid passed outward through the pores and filled the tubes, to be ærated through the thin external covering by the surrounding water. In *Caryocrinus* the water passed inward, through the pores, into the tubes and ærated the fluid within the general cavity of the body.

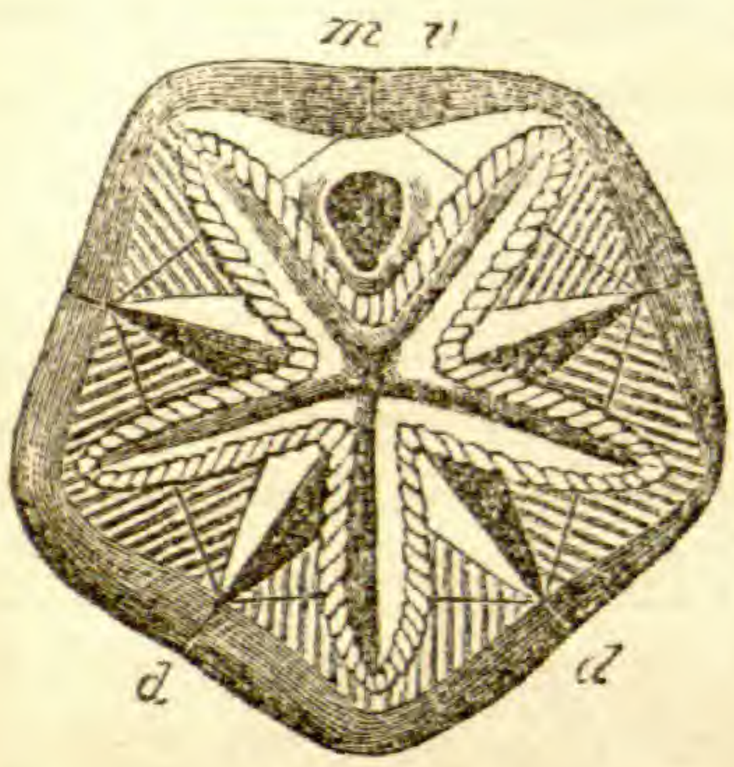
The discovery that the fissures and pores of the Cystidea, do not communicate directly with the general cavity of the body is entirely due to Mr. Rofe. After reading his highly important paper, I re-examined a great number of specimens and found sufficient to confirm his observations.

3. *On the genus Codaster.*

Every author who has described a species of this genus has remarked the peculiar striated areas in the interradial spaces. Prof. McCoy, the founder of the genus, pointed out their resemblance to the hydrospires of the Cystidea, but it was Mr. Rofe who first showed that they were also identical in structure therewith. On comparing one of those with that of the cystidean *Pleurocystites*, fig. 5, we at once perceive that they are the same in the external form while Mr. Rofe's figures show that the section at *d*, *d*, has the structure of fig. 9, which only differs from fig. 5 *b*, in being straight above instead of concave, and in being divided into two parts. This division is the result of the position of the arm which cuts the hydrospire in two, in a direction parallel to the fissures. By drawing the points *d*, *a*, and *a*, *d*, together we get figure 10, which

is, in general plan, a section across one of the ambulacra of a Pentremite. On examining nearly all the published figures of species of this genus I find that there is a series of forms which exhibit a gradual passage, from those with the hydrospires almost entirely exposed, as in fig. 8, through others in which they are crowded more and more under the arms, until at length they become altogether internal.

8.



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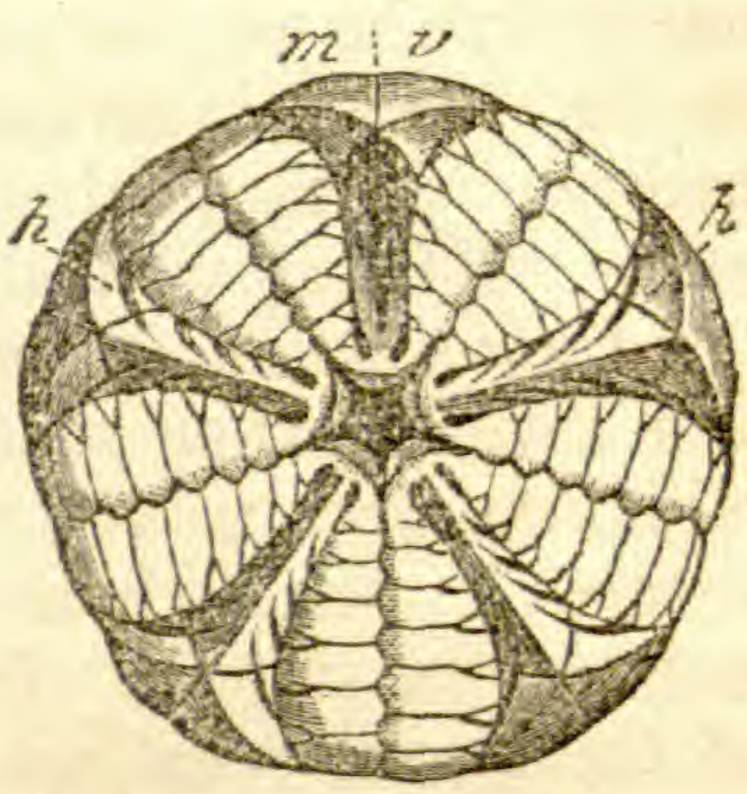


Fig. 8. Summit of *C. acutus* McCoy, *m*, *v*, mouth and vent; *d*, *d*, suture across the posterior hydrospire. 9. Section across the hydrospire from *d*, to *d*, at *a*, is the place of the arm. 10. The section contracted as in fig. 6. 11. Summit of *Pentremites caryophyllatus* De Koninck.

In *C. acutus*, fig. 8, only a small portion of the hydrospire is concealed under the arm. In *C. Canadensis*, a new species lately discovered in the shales of the Hamilton group in Canada West, each of the four interradial spaces, in which the hydrospires are placed, is excavated, in such a manner as to form *a small triangular pyramid*, with two of its faces sloping down toward the sides of the two adjacent arms. On these two slopes are placed the hydrospires, which appear to have one fissure entirely under, and another partly under the arm, five others being fully exposed. S. S. Lyon has described a species under the name of *C. alternatus* in the "Geology of Kentucky," vol. iii, p. 494, from the Devonian rocks of that State, which closely resembles *C. Canadensis*, but is still distinct therefrom. Speaking of the structure of the summit he says: "the depressed triangular intervening spaces are filled with seven or more thin pieces, lying parallel to the pseudambulacral fields, articulating with the summit of the second radial, and the prominent ridge lying between the pseudambulacræ. These pieces were evidently capable of being compressed or depressed: the "*point*" at the lateral junction of the second radials is in some specimens folded over toward the mouth so as to entirely obscure these triangular spaces by covering them." This important observation proves that even in the same species the hydrospires may be

either partly or wholly concealed under the arm. The "*point*" to which Mr. Lyon alludes is seen above, in fig. 11, just below the letter *b*. It is the same as the "*small triangular pyramid*" in *C. Canadensis*. It is evident that (supposing the shell to be flexible) if these points were to be drawn inward, the movement would gradually cause what remains exposed of the hydrospire to be covered until at length it would be entirely concealed under the arm. The five points would then be situated in the angles between the five ambulacra as they are in the genus *Pentremites*, fig. 15. The concealment of the hydrospires may also be the result of the widening of the arm. This is well shown in *P. caryophyllitus* DeKoninck, (*P. Orbignyanus* according to Roemer,) *P. Schultzii* De Ver., and several other species. In these the apices of the pyramids remain near the margin, but the hydrospires are nearly covered by the wide arms. This is shown in fig. 11, where the ends of the fissures of the hydrospires are seen along the sides of the angular ridges which extend from the apices of the pyramids to the angles between the arms. I do not think that such species can be referred to *Pentremites*, and if I had specimens before me instead of figures only, I would most probably institute a new genus for their reception.

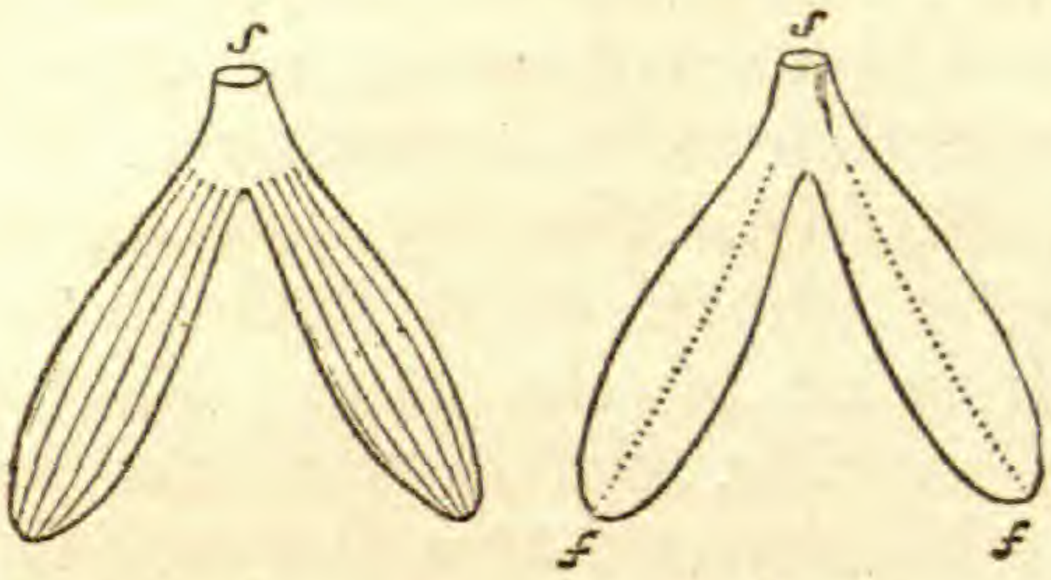
Our specimens of *C. Canadensis* are well preserved and show the characters of the arms perfectly. After many careful examinations under the microscope, I can state positively that in this species the so-called "pseudambulacral fields" have no pores. The markings that have hitherto been mistaken for ambulacral pores in *Codaster* are not pores, but the small pits or sockets which received the bases of the pinnulæ. The rays therefore in this genus are not "pseudambulacral fields," in the sense in which that term is used in descriptions of species of *Pentremites*, but simply recumbent arms, identical in structure with those of the cystidean genera *Glyptocystites*, *Callocystites*, *Apiocystites*, and others. They lie upon the surface of the plates which constitute the shell of the animals—not imbedded into them as in *Pentremites*. The large lateral aperture is both mouth and vent, and the central opening heretofore called the mouth is the ambulacral or more properly, the ovarian orifice. As, therefore, *Codaster* has the arms of *Apiocistites*, the hydrospires of *Pleurocystites* and the confluent mouth and vent common to all *Cystideans*, I propose to remove it from the *Blastoidea* and place it in the order *Cystidea*.

4. *On the genus Pentremites.*

In *Pentremites* the hydrospire is an elongated, internal sack, one side of which is attached to the inside of the shell while

the side opposite, or toward the central axis of the visceral cavity, is more or less deeply folded longitudinally. There are two of these to each ambulacrum, attached along the two lines of pores. There appears to be a fissure extending nearly the whole length in the direction of the dotted line *f*. One edge

12.



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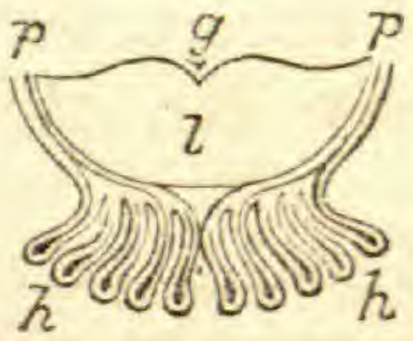

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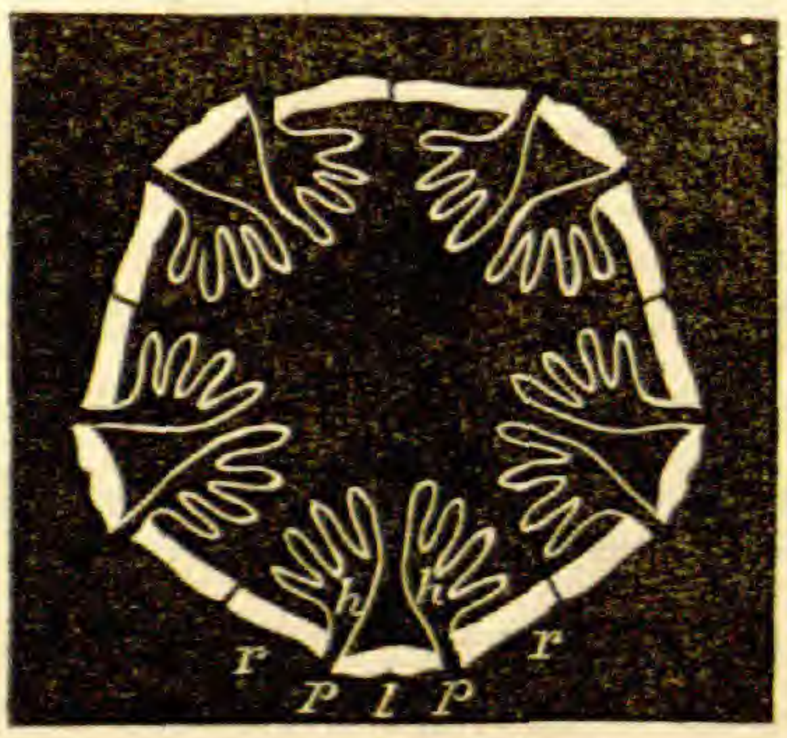

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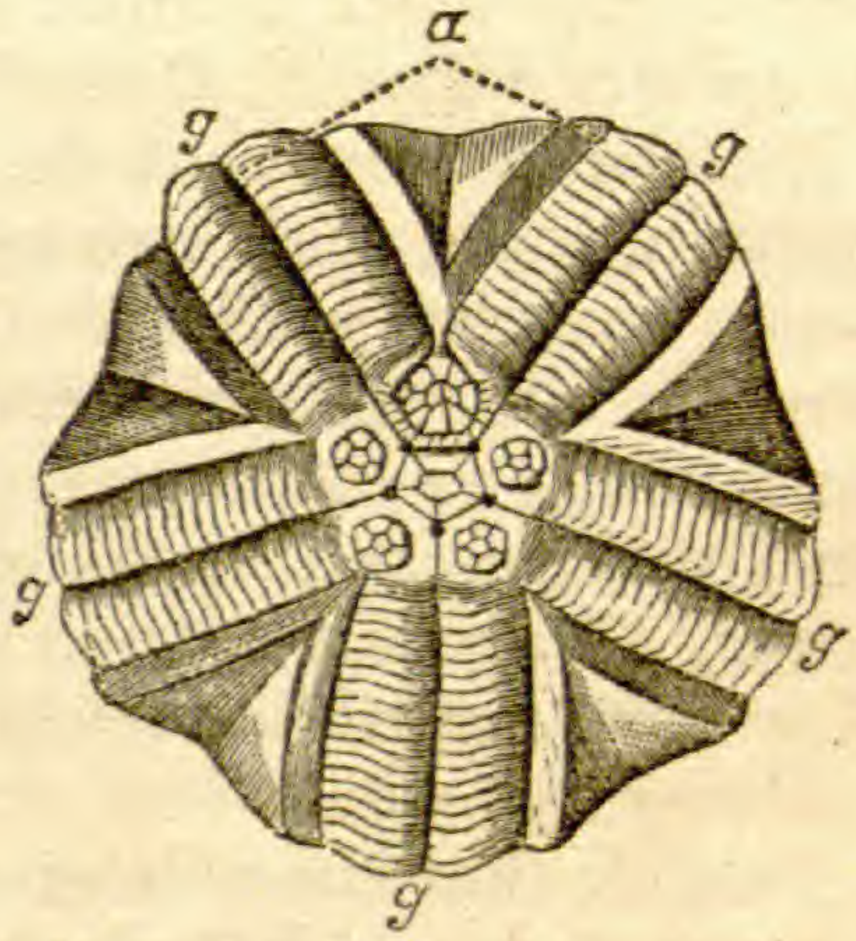


Fig. 12.—Diagrams of one pair of the hydrospires of a *Pentremite*,—*a*, the inner side; *b*, the outer, or side attached to the shell; *f*, the fissure. 13. Section across an ambulacrum of a specimen of *P. Godoni*, enlarged 3 diameters,—*l*, lancet plate; *g*, ambulacral groove; *p*, *p*, pores leading into the hydrospires; *h*, *h*, the two hydrospires, in transverse section. 14. Ideal figures of a transverse section through an entire specimen showing the ten hydrospires,—*l* one of the five lancet plates; *p*, *p*, pores; *r*, *r*, the two branches of one of the radial plates. 15. Summit of *P. conoideus*,—*a*, anterior side; *g*, ambulacral grooves (copied from Dr. Shumard, but with the ovarian pores added).

of this fissure, is attached to the lancet plate, along one side of the line of pores; the other to the shell, on the other side of the row. The pores all enter the hydrospire through this fissure. There are ten hydrospires, connected together in pairs, each pair communicating with the exterior through a single spiracle. The arrangement of the folds varies according to the species. In *P. Godoni* there are five folds, the outer sides of which are close up to the inner side of the lancet plate, fig. 13. In a specimen of *P. obesus* Lyon, nearly two inches in diameter at the mid-height, the hydrospires extend

inward about three lines, the main body being about one line from the lancet plate. There are five folds, each two lines deep; and thus, if the thin shelly membrane, which constitutes the wall of the hydrospire, were spread out, it would have a width of 22 lines,—and the ten together would form a riband, about 18 inches in length, and nearly two inches wide. The object of the folding is, of course, to confine this large amount of surface to a small space, an arrangement which at once proves the function to be respiratory. Of those figured by Mr. Rofe, *P. ellipticus* Sowerby appears to have only one fold, *P. inflatus*, id., shows eight folds in one, and eleven in the other hydrospire of the same ambulacrum. Another specimen figured by Mr. Rofe under the name of *P. florealis* Say, has five folds situated at a distance from the inner surface of the lancet plate as in *P. obesus*. From the form of the organ I think that Mr. Rofe's specimen cannot be the species called *P. florealis* by Say.

If it be granted that these organs are respiratory in their function, then, their five apertures should be called *spiracles*, —not "ovarian orifices." The large anterior aperture would thus be the *oro-anal spiracle*. Applying this system of terminology to other groups,—the so-called ovarian orifice of the Cystidea, the homologous aperture of *Nucleocrinus*, *Codaster*, *Granatocrinus* and of the Paleozoic Crinoidea generally (but not of the recent forms), should be styled the *oro-anal orifice*.

I think that the side of an Echinoderm in which the mouth is situated should be called "anterior" even although the anus and the mouth be confluent in one orifice. Most starfishes have but one aperture for mouth and vent and yet it is called the mouth by naturalists generally. Why not call the underside of a star-fish "the anal or posterior side," and the central aperture the "anus?"

Dr. B. F. Shumard has shown (Trans. Acad. Nat. Sci. St. Louis, vol. 1, p. 243, pl. 9, fig. 4,) that in perfect specimens of *P. conoideus* Hall, the six summit apertures are closed by several small plates. In a specimen of the same species sent me by Mr. Lyon, in which those plates are partly preserved, I find that there is a small pore in each of the five angles of the central aperture. The five ambulacral grooves enter the interior through these pores. I have copied his figure but modified it by adding the pores, fig. 15. He also found that the summit of *P. sulcatus*, Roemer, was covered with an integument of small plates arranged in the form of a pyramid. From these facts he infers that in all the pentremites the summit apertures will be found in perfect specimens, to be closed in a similar manner.

Dr. C. A. White, at present State Geologist of Iowa, in a paper on the same subject, (Bost. Jour. N. H., vol. 8, pp. 481–488,) describes *P. Norwoodii* Owen and Shumard and *P. stelliformis*, id., as having a similar structure—but he goes further,—he considers the central orifice "*not to be the mouth,*" and I believe that he is the first naturalist who ever published such an opinion. His idea of its function is thus expressed: "It seems more probable that as the ova were germinated within the body, they found their exit through the central aperture, and were conveyed along the small central grooves of the pseudambulacral fields before mentioned, beneath the plated integument, to the bases of the tentacula, where they were developed and discharged as in the true crinoids." I perfectly agree with Dr. White in this view. The central aperture is not the mouth, in fact it is not a natural orifice, but a breach in the summit caused by the destruction of a portion of the vault. The true natural orifices of this part are those that I have discovered in *P. conoideus* as above mentioned. They are the homologues of the *ovarian pores* at the bases of the arms of *caryocrinus* and in part, as I shall show in another part of these notes, of the ambulacral orifices of the true crinoids.

With regard to the structure of the calyx of *Pentremites*, it is generally supposed that there are only three series of plates—the basal, radial and interradial. Mr. Lyon has advanced the opinion that there are three small plates below those now called the basals (Geol. Ky., vol. iii, p. 468, pl. II, fig. 1*c*). I have examined a number of specimens with reference to this point and I think he is right. There are three small pentagonal basals, the two upper sides of each of which are excavated to receive the sub-radials, i. e., those at present designated "the basals." They are, in general, anchylosed to the subradials, but in one of Mr. Lyon's specimens that I have seen they are distinctly separate.

[To be continued.]

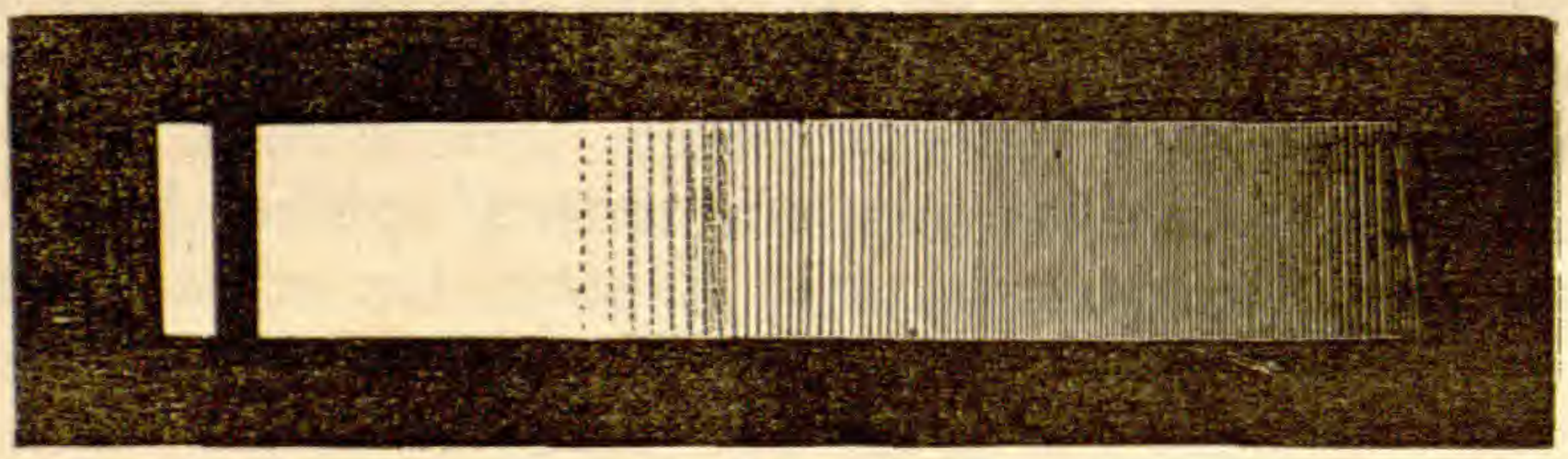
Art. IX.—*Spectroscopic examination of the Diatomaceæ;* by H. L. Smith.

The vegetable nature of the Diatomaceæ is now generally admitted, but if any further proof is needed we have it in marked results from the application of the spectroscope. I have been enabled to prove the absolute identity of *chlorophyl* or the green endochrome of plants with *diatomin* or the olive yellow endochrome of the Diatomaceæ. The spectrum-micro-

scope is now too well known to need any description here. The one I have used was made by Browning of London. It is not at all difficult to obtain a characteristic spectrum from a living diatom, and to compare it directly with that of a desmid, or other plant.

I need not here give the results in detail. Suffice it that from about fifty comparisons of spectra, I can unhesitatingly assert that the spectrum of chlorophyl is identical with that of diatomin.

The spectrum in question is a characteristic one, and is figured below.



A very black, narrow band in the extreme red, reading at the lower edge, which appears to be constant, about $\frac{7}{8}$ of Mr. Sorby's scale, is too characteristic to be mistaken. There are two other very faint bands, not easily seen, and somewhat more variable in position. The black band in the red is always present, and is remarkably constant in the position of its lower edge. In making comparisons of spectra it is of the utmost importance that the slit of the spectroscope should be absolutely in the focus of the achromatic eye lens. If this be not attended to, there will be a slight parallax; and bands really identical in position, e. g., those of blood (scarlet cruorine), will not absolutely correspond when two spectra are formed, one from blood on the stage of the microscope, and the other from the same on the stage of the eye-piece.

The dark band of the chlorophyl spectrum is slightly variable in width—and the action of acids and alkalies sometimes causes a slight displacement, the former raising (moving toward the blue end) and the latter depressing. The endochrome of a diatom after treatment with acid, is green, and the acid, in this case, produces scarcely any displacement of the band, which may be observed even in the dark reddish mass of the dead diatomaceæ, almost identical in color, with the ferrous carbonate, so often found in bogs where the larger diatoms are abundant; and what is more remarkable, is, that the carbonate gives no absorption bands at all. As a general rule, alcoholic solutions of chlorophyl and diatomin have the band slightly depressed, reading 1 to $1\frac{1}{2}$ on the interference scale.

ART. X.—*Note on Wollongongite, a remarkable hydro-carbon found in the Wollongong District of the Illawarra Coal Field, N. S. Wales ;* by B. SILLIMAN.

IN the course of a research conducted by Prof. Wurtz and myself, lately, on the Hydro-carbon Gas Process, my attention was recalled to a peculiar kind of cannel coal from Australia which was brought to this country in 1866, by Mr. Hall of Australia, from whom I obtained my first knowledge of its existence. As it turns out on examination to be by far the most remarkable substance of its class hitherto discovered I propose to describe it.

It is found in the Wollongong district of the Illawarra Coal Field, New South Wales, and in the range known as the Kembla Mountains, or Blue Mountain range. The locality appears to be of recent discovery, as the section taken down from Mr. Hall's dictation is quite different from any section given by Prof. Dana in his account of the Illawarra coal field.* Mr. Hall's enumeration of the strata was as follows.

150 feet superincumbent sandstones.
12 " bituminous coal resembling Newcastle.
30 " bituminous shales.
1½ " cannel.
20 " sandstone.
3 " splint *coal*—cannel.
10 " sandstones.
1½ " kerosene shale.
21 " coarse conglomerates and shale.
4 " cannel.
14 in. diagonal shale.
Underlying conglomerates.

Associated with the bituminous shales is a seam of 18 inches of a semi-elastic material resembling mineral caoutchouc which cuts easily with a knife, is easily kindled by a match and yields the odor of a candle when extinguished. It affords about 60 gallons of crude oil. I failed to note its position in the section.

* The only account we have seen of the geology of this region is that given by Prof. James D. Dana, in his Report on the Geology of the Countries visited by Wilkes's U. S. Exploring Expedition, pp. 449, et seq.; accompanied by a map of the Illawarra coal field, in which the Wollongong mineral exists. This remarkable mineral was discovered long subsequent to the date of Prof. Dana's explorations in 1840. The writer examined and analyzed the coals brought home by Prof. Dana from Australia, which analyses are published on page 476 of the Report quoted. But among them there was nothing at all resembling the remarkable body now for the first time, as he believes, introduced to the knowledge of gas chemists.

The remarkable substance which is the subject of this note has been observed only in one place, about 250 feet above tide, and five miles inland at a point about 40 miles south of Sidney. Its mineralogical characters are as follows:

In cubical blocks without lamination. Breaks in broad conchoidal surfaces, extremely tough and resounding like hard wood under the blows of the hammer.

H.=2 to 2·5. G.=1·04—1·49. Luster resinous, somewhat silky. Color greenish black and brownish black. Streak light brown to yellowish. No odor when rasped. Tasteless. Sectile, the thin shavings curling up under the knife. Not electric by friction of the mass, but the chips cut off by the knife are highly electric. Translucent in thin shavings and under the microscope transmits amber yellow light. Alone in a test tube does not melt, decrepitates and distills a copious flow of oil of a yellow color and heavy odor, giving off much gas.

Insoluble in alcohol, ether, or benzole, but is slightly dissolved in carbonic disulphid to which it imparts a slighty yellowish tinge.

It is readily kindled in thin splints by a match, burning with a brilliant flame and much smoke. The analysis in a platinum crucible yields the following results.

Volatile matter, - - - - - -	82·5
Fixed carbon, - - - - - -	6·5
Ash, - - - - - - - -	11·0
	100·0

From these characters this substance obviously resembles succinite and is probably as well entitled to a place in the system as bathillite or torbanite. An ultimate organic analysis of the mineral is required before its true composition can be ascertained. It may provisionally be called *Wollongongite.*

The following technical results were obtained by us at the experimental gas laboratory of the Manhattan Gas Light Co., in New York, made with a view to determine the technical value of this mineral as an enriching material in gas making.*

* Mr. Young, of Glasgow, well known for his researches upon coal oils, of which industry he is a well known promoter, obtained the following results on the Wollongong cannel, by distillation for oil.

The cannel yields per ton of crude oil, *Sp. Gr.* 0·860=152 gallons, divided as follows:

"Mineral turpentine" (light naphtha,) -	Sp. Gr.=0·739=8 galls.	
Burning oil, - - - - - -	" 0·815=72	"
Lubricating oil, - - - - - -	" 0·890=33	"
Paraffin, 49 pounds, - - - - -	5	"
Loss, ash, etc., - - - - - -	32	"
Total - - - - - -	152	"

Gas found by Mr. Young, - - - - 16,000 cubic feet per ton.

Private communication by Mr. Hall.

Average yield of (5 charges) gas per ton, -	13,716 cubic feet.
Coke (very light and lustrous), - - -	420 lbs. per ton.
Illuminating power of 5 feet of gas burned in Scotch fish-tail burner, - - -	132·94 candles.
One bushel of lime purifies, - - -	5686 cubic feet.
Gas from one ton equals sperm, - - -	6251·26 lbs.*

The gas obtained was so rich that its illuminating power could be measured only by diluting it very largely with common street gas of known power. Even when 10 per cent of the Wollongong cannel gas was added to 90 per cent of street gas, whose illuminating power was 14·98 candles, it was found still too rich to burn in the 15-hole standard Argand. But it could be burned, however, at the rate of five cubic feet in a Scotch tip fish-tail burner, giving from the mixture an illuminating power of 26·54 candles. From these data, the candle power of one cubic foot of the gas of this material is equal to 26·59 candles —a degree of illuminating power unexampled, so far as we are informed, in the records of gas-making from any material heretofore examined. This appears more clearly on comparing this result with some of the best-known of the cannels of England and the United States, thus :—

				1 cubic foot =candles.
Wollongong cannel	=lbs. of sperm per ton,		6251·26	26·54
Boghead cannel	= "	"	†1967·10	
" "	= "	"	‡2755·6	10·38
" "	= "	"	§1235·	5·29
Albert coal, N. B.	= "	"	‖3016·37	11·73
Peytona cannel,	= "	"	‖1440	8·4
Lesmahago cannel,	= "	"	1529	8·77
Capeldræ,	= "	"	1670	10·01
Donibristie,	= "	"	1277·5	7·51
Wigan,	= "	"	627·4	3·04
Pelton Main (caking),	= "	"	532	3·12
Ramsay's (Newcastle),	= "	"	553	3·33
Westmoreland, Pa.	= "	"	‖541·25	3·32

The theoretical density of the gas obtained in this process is surprising, inasmuch as 1816 pounds avoirdupois of gas gives for each cubic foot of gas 926·72 grains. Now as 536·96 grains

* The standard candle in use among gas engineers consumes 120 grains of sperm per hour. The total economical value of any gas coal is best obtained by multiplying the candle power of the gas produced from one ton of the coal into the volume of the gas: thus as the Wollongongite yields 13,716 cubic feet of gas, *one* foot of which has an illuminating power of 26·54 candles, therefore we have 26·54×120×13716÷7000=6251·26 pounds of sperm as the value of the gas from one ton of this mineral.

† Advertisement of the proprietors.
‡ Dr. Fyfe.
§ Manhattan Co., *loc. cit.*
‖ Our own results.

of air make one cubic foot, it follows that the density of the gas is 1·716, or nearly double the density of olefiant gas. Refrigerated at −6° F. this gas loses 41·8 per cent of its illuminating power, a loss not greater than we have found in common street gas at the same temperature.

The quantity of this material was represented by my informant, as extremely abundant, adequate to any demand which might arise for it in commerce. I have taken steps, since discovering its remarkable technical value, to obtain more exact data respecting it. The masses which came under my observation resembled in appearance the finest varieties of English cannel, but differs in color and especially in streak as already described. Two of these masses weighed about one hundred pounds each, were prismatic in form and exhibited no structure, opposing an equal resistance to the hammer in all directions and breaking only with extreme difficulty.

Accompanying the *Wollongongite* brought to New York by Mr. Hall were specimens of a bituminous shale quite earthy in its character, of an elastic bitumen, and also of a cannel coal somewhatresembling the *wollongongite* but unlike that substance in its essential features. It has a well developed laminated structure, a nearly black color and is streaked with micaceous and earthy particles visible in its mass. A block of this material, sent to the Columbia College School of Mines, was examined by Prof. C. F. Chandler, who has kindly communicated to me the following results of his analyses.

"*Australian shale.*" *Density* = 1·106

Gases,	21·11	
Water,	3·33	
Oil,	35·08	
Fixed carbon,	26·48	Coke=40·48
Ash,	14·00	
	100·00	

Gravity of the crude oil 0·876=31° B.
Quantity =96·8 gallons (of 231 cub. inches) per ton of 2,000 lbs.

Comparing this analysis with the results stated on p. 86, we see 20 per cent more of fixed carbon in the 'shale' giving 40·48 per cent of coke against 17·50 per cent from the wollongongite.

The probabilities are that the material occurs in various degrees of purity, and that these may shade off by imperceptible degrees into each other, as is observed to be true of many cannel coals. It is therefore quite possible that the wollongongite may sometimes be found on more extensive ex-

ploration free to a greater degree of the contaminating 'ash,' and in that case we may expect to see it assuming a more or less transparent honey or wax yellow aspect, such as it now shows in thin shavings under the microscope.

I should remark that the illuminating power of the gas from the wollongongite was determined upon its *maximum* yield of nearly 14000 cubic feet to the ton of 2240 lbs. Had the yield been restricted to 10,000 cubic feet it is quite probable its illuminating power would have been at least 150 candles for 5 cubic feet. This opinion is based on comparative results obtained with the albertite of New Brunswick. The maximum yield of gas from this remarkable material is per 2,240 pounds, 15,000 cubic feet with an illuminating power of 58·14 candles. But when the yield of gas is restricted to 10,000 cubic feet per ton of 2,240 pounds the illuminating power rises to 70·38 candles. The amount of coke left by one ton of albertite is 946 pounds corresponding very closely to the results of analysis in a platinum crucible which show for 100 parts :—

Volatile matter, - - - - - -	57·0
Fixed carbon, - - - - - -	42·5
Ash, - - - - - - - -	0·5
	100·00

This ration would require 963 pounds of coke, as near an approach as operations in the large way can be expected to give, being within 1·76 per cent. The quantity of sulphur in the albertite is less than in the wollongongite, the number of cubic feet of the gas from the former completely purified by one bushel of lime being 9025 against 5686 feet of the latter.

At −7° F. the gas from the albertite lost 34 per centof its illuminating power.

I am indebted to J. A. Sabbaton, engineer of the Manhattan Gas Light Company, New York, for the facts here given as to the technical value of the albertite, being the results of a recent determination, called out by the remarkable facts furnished by the wollongongite.

New Haven, May 19, 1869.

June 3, 1869.—Since the foregoing was in press I have had an opportunity to test the value of the *wollongongite*, by the Hydro-carbon Gas Process, with the following results.

A mixture was made of 5 per cent of wollongongite with 95 per cent of bituminous (caking) coal of Westmoreland, Penn., the value of which coal when treated alone by the same process had been previously determined. Of this mixture charges of 200 pounds each were employed, and the total yield of gas after

purification produced measured by the station meter. Also a mixture of 10 per cent wollongongite with 90 per cent of Westmoreland coal was prepared and treated in the same charges of 200 pounds and the gas produced measured in the same manner.

The time of carbonization was in each case, two hours, and during all the time the products from the anthracite retort (hydrogen and carbonic oxyd) were acting in full force on the distillation-products of the coal mixture.

The following is a transcript from the record of the experiment.

Date, June 2d, 1869. Fair Haven Hydro-carbon Gas Works.* All the retorts hot and ready for action, but the making of gas suspended preparatory to this experiment. Four charges of 200 pounds each of the above mixture of wollongongite and Westmoreland coal were carbonized successively, the total weight carbonized being 800 pounds.

Time of beginning.	Readings of Station Meter.	Yield.	Time of duration of each charge.	
12h 43m	935020		1h. 2m.	
1 45	935700	680 cubic feet,	10 "	
1 55	935770			1st charge = 750 c. f.
	935700	70 " "	10 "	=1h. 12m.
2 35	936470			
	935770	700 " "	40 "	
3 05	937020			
	936470	550 " "	30 "	2d charge =1250 "
3 15	937150			=1h. 10m.
	937020	130 " "	10 "	
3 35	937590			
	937150	440 " "	20 "	
3 45	937770			
	937590	180 " "	10 "	3d charge =1310 "
4 15	938330			
	937770	560 " "	30 "	
4 40	938910			=1h. 10m.
	938330	580 " "	25 "	
5 15	939600			
	938910	690 " "	30 "	4th charge =1270 "
6 15	940900			=55m.
	939600	1300 " "	60 "	5th hour = 1300 "
				=60 m.
Totals,		5880 " "	5h. 27m.	5880 "

* There were in action two benches, or beds, of three clay retorts each. The upper one charged with anthracite furnished, from superheated steam, the water-gas, H_2+CO, with a little CO_2+HS.

At the end of the second hour from the commencement of the last charge the operation was closed, giving an average product for each charge of 1470 cubic feet of gas, or a yield of 7·35 cubic feet for each pound of the mixture employed. As by former trials I had determined the value of the Westmoreland coal *alone*, by the Hydro-carbon Process, to be 6·27 cubic feet of gas, it follows that the increase of 1·08 cubic feet of gas is due to the average addition of 7½ per cent of the wollongongite.

The yield of gas per one ton (2240 lbs.) of such a mixture would therefore be 16,464 cubic feet.

The illuminating Power of the Gas.—The illuminating power of the gas in these experiments was determined by the Bunsen Photometer in the usual manner.

From the two first charges of 5 per cent of wollongongite and 95 per cent of Westmoreland coal the corrected result of 15 observations gave an illuminating power of 18·79 candles.

From the charges containing 10 per cent of wollongongite the illuminating power was 26·98 "

Average power for whole quantity containing an average of 7½ p. c. of wollongongite, 22·88 "

These results are given for the usual standard of 5 cubic feet of gas burned in one hour in an Argand standard burner.

The total economical effect of a mixture containing ten per cent of wollongongite is best stated in the quantity of spermaceti, equivalent to one ton (2240 lbs.) of such a material which in this case is found to be 1774·9 lbs.

The Westmoreland coal alone when treated by the same process yields a total economical effect, 797·6 "

Gain of total economical effect due to the use of 10 per cent of Wollongongite, 977·3 "

Equivalent to $221\frac{9}{15}$ per cent gain.

As the yield of gas per ton of this mixture is 16464 c. f.

And Westmoreland coal alone by same treatment, 14057 "

It is evident that 7½ per cent of wollongongite (or 168·2 lbs.) have yielded gas, 2407 "

This quantity (2407÷168·8) corresponds to 14·31 cubic feet of gas to the pound of material. When treated alone by the common process the wollongongite yields as already stated in the former part of this paper, 6·11 cubic feet per pound. There is an increase therefore of $232\frac{5}{10}$ per cent in the volume of the gas obtained from the wollongongite under the influence of the hydro-carbon process. It is evident therefore that

under the influence of this process the extremely dense and rich gas which the ordinary process returns from this coal is broken up into a much larger volume of gas of a less density and lower illuminating power. Wollongongite has therefore the power to raise the illuminating intensity of gas from common caking coals when treated by the hydro-carbon process, even when so small a quantity as five per cent is employed, much above the average of illuminating gas in common use; while at the same time the volume of the gas produced exceeds 16,400 cubic feet per ton against about 10,000 cubic feet by the common process, of a much lower illuminating power.

ART. XI.—*The Rules of Zoological Nomenclature. From the Report of a Committee "appointed to report on the changes which they may consider desirable to make, if any, in the Rules of Zoloogical Nomenclature*, drawn up by Mr. H. E. STRICKLAND, at the instance of the British Association, at their meeting in Manchester in 1842." With notes by A. E. VERRILL.

THAT the value and utility of the binomial system of nomenclature, established by Linné and at once adopted by nearly all scientific zoölogists and botanists, depends directly upon the uniformity and universality of the rules regulating its application is so evident as to require no demonstration; yet very many writers, both in this country and abroad, constantly ignore, either ignorantly or carelessly, if not wilfully, many of the most essential laws proposed by the author of the system, and confirmed and made sacred by the usage of the best naturalists of the past century. The advance of zoölogical and botanical sciences has, it is true, made necessary certain restrictions to and extensions of the rules established by Linnæus, but later codes of laws regulating this matter are based upon and, in all the principal points, are essentially identical with those originally proposed.*

To secure greater uniformity and bring about certain reforms in this matter, the British Association in 1842 appointed a committee, consisting of Mr. C. Darwin, Professor Henslow, Rev. L. Jenyns, Mr. W. Ogilby, Mr. J. Phillips, Dr. Richardson,

* An excellent exposition of the Linnæan canons, as elaborated in the Philosophia Botanica, has been given by Prof. Agassiz in the preface to his Nomenclator Zoologicus, 1846, together with a review of those of the British Association. See also A. Gray's review of the work, this Journal, 2d Series, vol. iii, p. 302, 1847.—V.

Mr. H. C. Strickland, Mr. J. O. Westwood, to draw up and report a code of rules "by which the nomenclature of zoölogy may be established on a uniform and permanent basis." To this committee were afterward added W. J. Broderip, Professor Owen, W. E. Shuckard, G. R. Waterhouse and W. Yarrel. This committee in 1842 submitted to the Association a "series of propositions," which were adopted and printed in the Report for that year.* They were also published separately for private distribution.

A committee was afterward appointed by the Association of American Geologists and Naturalists to consider this subject. The committee reported at the sixth meeting, 1845, in favor of adopting the British Association's Rules, with slight modifications, the principal objection being to the writing of proper names of species without an initial capital, a change since introduced also by the British Association. The report was accepted and the amended rules adopted.† Although the reformatory influence of these rules, thus brought so prominently to the notice of zoölogists, has doubtless been very great, yet their success was but partial, even in England, for a considerable number of English authors have either ignored them or adopted them only in part, often violating the most obvious and important rules. In the department of conchology, especially, the violations of such laws have been lamentably numerous and disastrous. This result may, perhaps, have been due in part to a few propositions, which, though of but secondary importance, were regarded as objectionable, in practice, by some of the best writers, and have now been modified. In 1863, a new committee of sixteen was appointed by the British Association to consider the "changes, *if any*, which they may consider it desirable to make in the Rules." At the Birmingham meeting in 1865, a Report was submitted and adopted by the Association,‡ recommending the following:—

I. That Botany should not be introduced into the Strickland rules and recommendations.

II. That the permanency of names and convenience of practical application being the two chief requisites in any code of rules for scientific nomenclature, it is not advisable to disturb

* Report of the twelfth meeting, 1842, p. 106,—also reprinted in Annals of Natural History; Philosophical Magazine; translated into French, in the Journal of 'L'Institut'; and translated into Italian and approved by the Scientific Congress at Padua, in 1843. See also reviews in this Journal, vol. xlv, p. 1, 1842; and 2d series, vol. iii, p. 302, 1847.

† These amended rules were printed in this Journal, 2d series, vol. ii, p. 423, 1846.

‡ Report of the British Association for the Advancement of Science, Birmingham, 1865, p. 28.

by any material alterations the rules of zoological nomenclature which were authorized by Section D at the Meeting of the British Association at Manchester in 1842.

III. The Committee are of opinion, after much deliberation, that the XIIth edition of the 'Systema Naturæ' is that to which the limit of time should apply, viz., 1766. But as the works of Artedi and Scopoli have already been extensively used by ichthyologists and entomologists, it is recommended that the names contained in or used from these authors should not be affected by this provision. This is particularly requisite as regards the generic names of Artedi, afterward used by Linnæus himself.*

In Mr. H. E. Strickland's original draft of these Rules and Recommendations the edition of Linnæus was left blank, and the XIIth was inserted by the Manchester Committee. This was done not as being the first in which the Binomial nomenclature had been used, as it commenced with the Xth, but as being the last and most complete edition of Linné's works, and containing many species the Xth did not. For these reasons it is now confirmed by this Committee, and also because these rules having been used and acted upon for twenty-three years, if the date were altered now, many changes of names would be required, and in consequence much confusion introduced.

IV. In Rule 13th, "*Specific names, when adopted as generic, must be changed.*" The committee agree that it is exceedingly injudicious to adopt a specific name as a generic name, but they are of opinion that where this has been done, it is the *generic name* which must be thrown aside, not the old specific name, and that this rule should be so altered as to meet this.

V. The recommendations under "*Classes of objectionable names,*" as already pointed out, cannot be too carefully attended to. *Specific names* from persons have already been sufficiently prostituted, and personal *generic* names have increased to a large and undeserving extent. The handing down the name of a naturalist by a genus has always been considered as the highest honor that could be given, and should never be bestowed lightly.

* If the XIIth edition is to be adopted as the limit of priority, it will be necessary to make additional exceptions. Thus the excellent and important work of Pallas, *Elenchus Zoophytorum*, was published nearly two years before the last volume of the Systema Naturæ, ed. XII, and contains a much greater number of species than were included in the latter work, while the descriptions of genera and species are far superior and the system purely binomial. To reject the earlier names of Pallas would be doing gross injustice to an able naturalist, who was among the first to adopt the binomial system after its appearance in the Xth edition. The more logical and just course would be to limit the law of priority to the Xth edition, thus applying the law to its author. This course is also sanctioned by the usage of many of the best zoölogical writers. But in several other departments of zoölogy it will make no difference whether the Xth or XIIth edition be regarded as the limit.—v.

VI. The recommendation, "*Specific names to be written with a small initial.*" The Committee propose that this recommendation should be omitted. It is not of great importance, and may be safely left to naturalists to deal with as they think fit.

These are the chief alterations and modifications the Committee have to suggest. It is scarcely possible to make any code of rules for a subject so extensive as zoölogy either perfect in itself or such as will meet the opinions of every one. It must be a matter of compromise, and as working by *no rules* is creating great confusion and an immense increase in synonymy, the Committee would ask this Section to approve their present report or finding, and to give their sanction to these Rules and Recommendations as now proposed to be modified.

Signed on the part of the members of Committee present at Birmingham* by WM. JARDINE, *Reporter*.

On the preceding Report being read to Section D, upon Tuesday, 19th September, the following motion was made and carried unanimously :—

Moved by Mr. Gwyn Jeffreys, seconded by Dr. Sclater,—*That the Report now read be approved of and adopted by the Section, and that the Rules or propositions, as thereby altered and amended, be printed in the Reports of the British Association and recommended for the general use of zoologists.*

PART I.

RULES FOR RECTIFYING THE PRESENT ZOOLOGICAL NOMENCLATURE.

[*Limitation of the Plan to Systematic Nomenclature.*]—In proposing a measure for the establishment of a permanent and universal zoölogical nomenclature, it must be premised that we refer solely to the Latin or systematic language of zoölogy. We have nothing to do with vernacular appellations. One great cause of the neglect and corruption which prevails in the scientific nomenclature of zoölogy, has been the frequent and often exclusive use of vernacular names in lieu of the Latin binomial designations, which form the only legitimate language of systematic zoölogy. Let us then endeavor to render perfect the Latin or Linnæan method of nomenclature, which, being far removed from the scope of national vanities and modern antipathies, holds out the only hope of introducing into zoölogy that grand desideratum, an universal language.

[*Law of Priority the only effectual and just one.*]—It being admitted on all hands that words are only the conventional signs of ideas, it is evident that language can only attain its end effectually by being permanently established and generally recognized. This consideration ought, it would seem, to have checked those who are continually attempting to subvert the established lan-

* The members of the Committee present at Birmingham were A. R. Wallace, Professor Babington, Dr. Francis, Dr. Sclater, C. Spence Bate, P. P. Carpenter, Professor Balfour, H. T. Stainton, J. Gwyn Jeffreys, A. Newton, G. Bentham, and Sir W. Jardine, Bart. (Reporter).

guage of zoölogy by substituting terms of their own coinage. But forgetting the true nature of language, they persist in confounding the *name* of a species or group with its *definition*; and because the former often falls short of the fulness of expression found in the latter, they cancel it without hesitation, and introduce some new term which appears to them more characteristic, but which is utterly unknown to the science and is therefore devoid of all authority.* If these persons were to object to such names of men as *Long*, *Little*, *Armstrong*, *Golightly*, &c., in cases where they fail to apply to the individuals who bear them, or should complain of the names *Gough*, *Lawrence* or *Harvey*, that they were devoid of meaning, and should hence propose to change them for more characteristic appellations, they would not act more unphilosophically or inconsiderately than they do in the case before us; for, in truth, it matters not in the least by what conventional sound we agree to designate an individual object, provided the sign to be employed be stamped with such an authority as will suffice to make it pass current. Now in zoölogy no one person can subsequently claim an authority equal to that possessed by the person who is the first to define a new genus or describe a new species; and hence it is that the name originally given, even though it may be inferior in point of elegance or expressiveness to those subsequently proposed, ought as a general principle to be permanently retained. To this consideration we ought to add the injustice of erasing the name originally selected by the person to whose labors we owe our first knowledge of the object; and we should reflect how much the permission of such a practice opens a door to obscure pretenders for dragging themselves into notice at the expense of original observers. Neither can an author be permitted to alter a name which he himself has once published, except in accordance with fixed and equitable laws. It is well observed by Decandolle, "L'auteur même qui a le premier établi un nom n'a pas plus qu'un autre le droit de le changer pour simple cause d'impropriété. La priorité en effet est un terme fixe, positif, qui n'admet rien, ni d'arbitraire ni de partial."

For these reasons, we have no hesitation in adopting as our fundamental maxim, the "law of priority," viz:

§ 1. The name originally given by the founder of a group or the describer of a species should be permanently retained, to the exclusion of all subsequent synonyms (with the exceptions about to be noticed).

Having laid down this principle, we must next inquire into the limitations which are found necessary in carrying it into practice:

[*Not to extend to authors older than Linnæus.*]—As our subject matter is strictly confined to the *binomial system of nomenclature*, or that which indicates species by means of two Latin words, the one generic, the other specific, and as this invaluable method originated solely with Linnæus, it is clear that, as far as species are concerned, we ought not to attempt to carry back the principle of priority beyond the date of the 12th edition of the 'Systema Naturæ,' 1766. Previous to that period, naturalists were wont to indicate species not by a *name* comprised in one word, but by a *definition* which occupied a sentence, the extreme verbosity of which method was productive of great inconvenience. It is true that one word sometimes sufficed for the definition of a species, but these rare cases were only binomial by accident and not by principle, and ought not therefore in any instance to supersede the binomial designations imposed by Linnæus.

* Linnæus says on this subject, "Abstinendum ab hac innovatione quæ nunquam cessaret, quin indies aptiora detegerentur ad infinitum."

The same reasons apply also to generic names. Linnæus was the first to attach a definite value to genera, and to give them a systematic character by means of exact definitions; and therefore, although the *names* used by previous authors may often be applied with propriety to modern genera, yet in such cases they acquire a new meaning and should be quoted on the authority of the first person who used them in this secondary sense. It is true that several of the old authors made occasional approaches to the Linnæan exactness of generic definition, but still these were but partial attempts; and it is certain that if in our rectification of the binomial nomenclature we once trace back our authorities into the obscurity which preceded the epoch of its foundation, we shall find no resting-place or fixed boundary for our researches. The nomenclature of Ray is chiefly derived from that of Gesner and Aldrovandus, and from these authors we might proceed backward to Ælian, Pliny, and Aristotle, till our zoölogical studies would be frittered away amid the refinements of classical learning.*

We therefore recommend the adoption of the following proposition:—

§ 2. The binomial nomenclature having originated with Linnæus, the law of priority in respect of that nomenclature, is not to extend to the writings of antecedent authors, and therefore specific names published before 1766 cannot be used to the prejudice of names published since that date.†

[It should be here explained, that as the works of Artedi and Scopoli have already been extensively used by ichthyologists and entomologists, the names contained in or used from these authors should not be affected by this provision. This is particularly requisite as regards the generic names of Artedi, afterward used by Linnæus himself. Brisson also, who was a contemporary of Linnæus and acquainted with the 'Systema Naturæ,' defined and published certain genera of birds which are *additional* to those in the twelfth edition of Linnæus's works, and which are therefore of perfectly good authority. But Brisson still adhered to the old mode of designating species by a sentence instead of a word, and therefore while we retain his defined genera, we do not extend the same indulgence to the titles of his species, even when the latter are accidentally binomial in form. For instance, the *Perdix rubra* of Brisson is the *Tetrao rufus* of Linnæus; therefore as we in this case retain the generic name of Brisson and the specific name of Linnæus, the correct title of the species would be *Perdix rufa* (Linn.).

[*Generic names not to be cancelled in subsequent subdivisions.*]—As the number of known species which form the groundwork of zoölogical science is always increasing, and our knowledge of their structure becomes more complete, fresh generalizations continually occur to the naturalist, and the number of genera and other groups requiring appellations is ever becoming more

* "Quis longo ævo recepta vocabula commutaret hodie?"—*Linnæus.*

† If the Xth edition be taken as the limit, which seems to be the tendency among recent writers, especially in this country and in northern Europe, the date would be 1758. The second volume of the XIIth edition bears the date of 1767. Disregard of this important and essential law has brought into conchology and some other branches of zoölogy an almost incredible amount of confusion within a few years, the indefinite names of Link, Klein, Brown, Columa. and other ante-binomial and polynomial writers, having been revived and substited for the well known names of Linnæus and later authors. Thus *Dactylus* Klein, 1753, has been substituted for *Oliva* Brug., 1789, by the Messrs. Adams, while for the same genus Gray has substituted *Strephona* Brown. (See also Gunther's Record of Zoölogical Literature, 1864, p. 246).

extensive. It thus becomes necessary to subdivide the contents of old groups and to make their definitions continually more restricted. In carrying out this process, it is an act of justice to the original author that his generic name should never be lost sight of; and it is no less essential to the welfare of the science, that all which is sound in its nomenclature should remain unaltered amid the additions which are continually being made to it. On this ground we recommend the adoption of the following rule:—

§ 3. A generic name, when once established, should never be canceled in any subsequent subdivision of the group, but retained in a restricted sense for one of the constituent portions.

[*Generic names to be retained for the typical portion of the old genus.*]—When a genus is subdivided into other genera, the original name should be retained for that portion of it which exhibits in the greatest degree its essential characters as at first defined. Authors frequently indicate this by selecting some one species as a fixed point of reference, which they term the "type of the genus." When they omit doing so, it may still in many cases be correctly inferred that the *first* species mentioned on their list, if found accurately to agree with their definition, was regarded by them as the type.* A specific name, or its synonyms, will also often serve to point out the particular species which by implication must be regarded as the original type of a genus. In such cases we are justified in restoring the name of the old genus to its typical signification, even when later authors have done otherwise. We submit therefore that:—

§ 4. The generic name should always be retained for that portion of the original genus which was considered typical by the author.

Example.—The genus, *Picumnus* was established by Temminck, and included two groups, one with four toes, the other with three, the *former* of which was regarded by the author as typical. Swainson, however, in raising these groups at a later period to the rank of genera, gave a new name, *Asthenurus*, to the *former* group, and retained *Picumnus* for the *latter*. In this case we have no choice but to restore the name, *Picumnus* Temm., to its correct sense, canceling the name, *Asthenurus* Sw., and imposing a new name on the three-toed group which Swainson had called *Picumnus*.

* This course has been systematically followed by some writers, and when carelessly done has often led to unfortunate and absurd results, especially when applied to the earlier writers, since it often happens that the actual position of the *first* species, in the restricted modern genera, cannot be determined with certainty. Thus in the XIIth edition, Syt. Nat., *Mactra* includes eight species, most of which are now referred to distinct genera, but the original name is variously restricted. Conrad pretends to take the *first* species, *M. Sprengleri*, as the type, and thus forms a group with but *five* species, which had long before received another name, while to the largest group, including the well known European species and proper type, *M. stultorum* (type of Lam. 1801) he applies the name *Trigonella* Da Costa, but (as it would seem) being somewhat doubtful as to the *real* affinity of *M. Sprengleri*, he puts this species also in *Trigonella!* Thus we have in the same catalogue *one species of Mactra*, and that the *first*, appearing in two different genera,—an instance that might be regarded as an accidental error were it not that other cases of like character appear in the same and other lists, viz., *Hemimactra Sayi*, p. 33. appears again as *Spisula* (*Mactromeris*) *Sayi*, on p. 45, being in this case placed in a different "subfamily," and *Anatina trapezoides* Lam., p. 51, appears again on the same page as a synonym of *Periploma inequivalvis*, with no explanation. (See American Journal of Conchology, vols. iii and iv, Appendix, "Catalogue of Recent Mollusca").—v.

[*When no type is indicated, then the original name is to be kept for that subsequent subdivision which first received it.*]—Our next proposition seems to require no explanation:—

§ 5. When the evidence as to the original type of a genus is not perfectly clear and indisputable, then the person who first subdivides the genus may affix the original name to any portion of it at his discretion, and no later author has a right to transfer that name to any other part of the original genus.*

[*A later name of the same extent as an earlier to be wholly canceled.*]—When an author infringes the law of priority by giving a new name to a genus which has been properly defined and named already, the only penalty which can be attached to this act of negligence or injustice, is to expel the name so introduced from the pale of the science. It is not right, then, in such cases to restrict the meaning of the latter name so that it may stand side by side with the earlier one, as has sometimes been done. For instance, the genus, *Monaulus* Vieill., 1816, is a precise equivalent to *Lophophorus* Temm., 1813, both authors having adopted the same species as their type, and therefore, when the latter genus came in the course of time to be divided into two, it was incorrect to give the condemned name, *Monaulus*, to one of the portions. To state this succinctly:—

§ 6. When two authors define and name the same genus, *both making it exactly of the same extent*, the later name should be canceled *in toto*, and not retained in a modified sense.†

This rule admits of the following exception:—

§ 7. Provided, however, that if these authors select their respective types from different sections of the genus, and these sections be afterward raised into genera, then both these names may be retained in a restricted sense for the new genera respectively.

Example.—The names, *Œdemia* and *Melanetta*, were originally coextensive synonyms, but their respective types were taken from different sections, which are now raised into genera, distinguished by the above titles.

[No special rule is required for the cases in which the later of two generic names is so defined as to be *less extensive* in signification than the earlier, for if the later includes the type of the earlier genus, it would be canceled by the operation of § 4; and if it does not include that type, it is in fact a distinct genus.]

* This law, though very important and necessary, is too often neglected. and at times seems difficult of application. Thus *Astræa* Lam., 1801, had two species only, as types of two sections. Oken, in 1815, named the first group, *Favia*, and Blainville afterward named the second group, *Siderastræa*. Edwards and Haime adopt *Astræa* for the latter, in accordance with this rule, but later observations show that it does not belong to the family, *Astræidæ*, nor even to the same suborder, but to the *Fungidæ*, so that if we adopt this view it would require numerous changes in the names of the families, subfamilies, and suborder. On the other hand *Favia* has become pretty well established as the name of a large and well-known genus, and yet it appears necessary to reject it for *Astræa*.—V.

† These discarded names may, however, be *tolerated*, if they have been afterward proposed in a totally new sense, though we trust that in future no one will *knowingly* apply an old name, whether now adopted or not, to a new genus. (See proposition *c*. *infra*).

But when the later name is *more extensive* than the earlier, the following rule comes into operation :—

[*A later name equivalent to several earlier ones is to be canceled.*]—The same principle which is involved in § 6 will apply to § 8.

§ 8. If the later name be so defined as to be equal in extent to two or more previously published genera, it must be canceled *in toto*.

Example.—*Psarocolius* Wagl., 1827, is equivalent to five or six genera previously published under other names, therefore *Psarocolius* should be canceled.

If these previously published genera be *separately adopted* (as is the case with the equivalents of *Psarocolius*), their original names will of course prevail; but if we follow the later author in combining them into one, the following rule is necessary :—

[*A genus compounded of two or more previously proposed genera whose characters are now deemed insufficient, should retain the name of one of them.*]—It sometimes happens that the progress of science requires two or more genera, founded on insufficient or erroneous characters, to be combined together into one. In such cases the law of priority forbids us to cancel *all* the original names and impose a *new* one on this compound genus. We must therefore select some one species as a type or example, and give the generic name which it formerly bore to the whole group now formed. If these original generic names differ in date, the oldest one should be the one adopted.

§ 9. In compounding a genus out of several smaller ones, the earliest of them, if otherwise unobjectionable, should be selected, and its former generic name be extended over the new genus so compounded.

Example.—The genera, *Accentor* and *Prunella* of Vieillot, not being considered sufficiently distinct in character, are now united under the general name of *Accentor*, that being the earliest.

We now proceed to point out those few cases which form exceptions to the law of priority, and in which it becomes both justifiable and necessary to alter the names originally imposed by authors.

[*A name should be changed when previously applied to another group which still retains it.*]—It being essential to the binomial method to indicate objects in natural history by means of *two words* only, without the aid of any further designation, it follows that a generic name should only have one meaning—in other words, that two genera should never bear the same name. For a similar reason, no two species in the same genus should bear the same name.* When these cases occur, the later of the two duplicate names should be canceled, and a new term, or the earliest synonym, if there be any, substituted.

* The principle of this rule is sufficiently obvious and simple, but its application is not always easy, as when a well established specific name is found to be identical with an older one which may be an old and long neglected synonym of some other species of the same genus. Also when the identity of the specific names of two species, originally in one genus, is not discovered until the species have been referred to different genera. Thus *Tellina tenera* Leach, antedates *Tellina tenera* Say, but the former was referred to *Macoma* before the name of the latter was changed. Should it now be changed? If not, when on this account a specific name has been changed *before* the generic separation, should the rejected name be restored *after* the separation? We think not.—V.

When it is necessary to form new words for this purpose, it is desirable to make them bear some analogy to those which they are destined to supersede, as where the genus of birds, *Plectorhynchus*, being preoccupied in Ichthyology, is changed to *Plectorhamphus*. It is, we conceive, the bounden duty of an author, when naming a new genus, to ascertain by careful search that the name which he propo-es to employ has not been previously adopted in other departments of natural history.* By neglecting this precaution he is liable to have the name altered and his authority superseded by the first subsequent author who may detect the oversight, and for this result, however unfortunate, we fear there is no remedy, though such cases would be less frequent if the detectors of these errors would, as an act of courtesy, point them out to the author himself, if living, and leave it to him to correct his own inadvertencies.† This occasional hardship appears to us to be a less evil than to permit the practice of giving the same generic name *ad libitum* to a multiplicity of genera. We submit, therefore, that :—

§ 10. A name should be changed which has before been proposed for some other genus in zoölogy or botany,‡ or for some other species in the same genus, when still retained for such genus or species.

[*A name whose meaning is glaringly false may be changed.*]—Our next proposition has no other claim for adoption than that of being a concession to human infirmity. If such proper names of places as Covent Garden, Lincoln's Inn Fields, Newcastle, Bridgewater, &c., no longer suggest the ideas of gardens, fields, castles, or bridges, but refer the mind with the quickness of thought to the particular localities which they respectively designate, there seems no reasons why the proper names used in natural history should not equally perform the office of correct indication, even when their etymological meaning may be wholly inapplicable to the object which they typify. But we must remember that the language of science has but a limited currency, and hence the words which compose it do not circulate with the same freedom and rapidity as those which belong to every-day life. The attention is consequently liable in scientific studies to be diverted from the contemplation of the thing signified to the etymological meaning of the sign, and hence it is necessary to provide that the latter shall not be such as to propagate actual error. Instances of this kind are indeed very rare, and in some cases, such as that of *Monodon*, *Caprimulgus*, *Paradisea apoda*, and *Monoculus*, they have acquired sufficient currency no longer to cause error, and are therefore retained without change. But when we find a Batrachian reptile named in violation of its true affinities *Mastodonsaurus*, a Mexican species

* This laborious and difficult research is now greatly facilitated by the very useful work of M. Agassiz, entitled "Nomenclator Zoologicus," and "Index Universalis" to that work.

† This slight penalty for negligence is, perhaps, one of the strongest incentives to greater caution. To point out an author's errors, unless a personal friend, too often results in unpleasantness, and frequently fails in its object, since many men prefer to be corrected by another writer, rather than retract personally. Each author should regard it as a duty to correct every error in nomenclature at the earliest suitable opportunity, that its diffusion may be arrested as soon as possible. Monographic memoirs and general works are, however, the most proper places for such changes.—v.

‡ The number of names now in use and well established in both botany and zoölogy, is so great as to render their change on this account very objectionable and nearly impossible, as no concert of opinion is likely to be obtained on this point. But all appear to admit the necessity of allowing the same name to be used but once in either kingdom.—v.

termed (through erroneous information of its habitat) *Picus cafer*, or an olive-colored one *Muscicapa atra*, or when a name is derived from an accidental monstrosity, as in *Picus semirostris* of Linnæus, and *Helix disjuncta* of Turton, we feel justified in canceling these names, and adopting that synonym which stands next in point of date.* At the same time we think it right to remark that this privilege is very liable to abuse, and ought therefore to be applied only to extreme cases and with great caution. With these limitations we may concede that:—

§ 11. A name may be changed when it implies a false proposition which is likely to propagate important errors.

[*Names not clearly defined may be changed.*]—Unless a species or group is intelligibly defined when the name is given, it cannot be recognized by others, and the signification of the name is consequently lost. Two things are necessary before a zoölogical term can acquire any authority, viz., *definition* and *publication*. Definition properly implies a distinct exposition of essential characters, and in all cases we conceive this to be indispensable, although some authors maintain that a mere enumeration of the component species, or even of a single type, is sufficient to authenticate a genus.† To constitute *publication*, nothing short of the insertion of the above particulars *in a printed book* can be held sufficient. Many birds, for instance, in the Paris and other continental museums, shells in the British Museum (in Dr. Leach's time) and fossils in the Scarborough and other public collections, have received MS. names, which will be of no authority until they are published with characters.‡ Nor can any unpublished descriptions, however exact (such as those of Forster, which are still shut up in a MS. at Berlin), claim any right of priority till published, and then only from the date of their publication. The same rule applies to cases where groups or species are pub-

* Under this rule it would be well to exclude all names that refer to abnormal, diseased and mutilated structures, and to deformities caused by parasites. Thus *Echinus gibbosus* Val. proves to be identical with our *Euryechinus imbecillis*, but the gibbosity is caused only by a parasitic crab lodged in the anal region, and is not present in normal specimens. *Tænia mediocannellata* was so named from an abnormal specimen. Such names are not uncommon and are always liable to mislead students and perpetuate error.—V.

† The custom of establishing genera by merely naming one or more species, without indicating any generic character or even giving figures, is exceedingly objectionable and liable to lead to confusion, especially when, as often happens, the same author afterward *describes* the genus and adopts a different type. Thus *Toxopneustes* Ag. was originally *named* with "Echinus pileolus" as its type; afterward it was *described* and *E. tuberculatus* Lam. (a species generically distinct from the former) was named as the type; five years later (in Catal. Rais.) the genus was extended so as to include not only *E. tuberculatus* and its allies, but also several other forms which have since been separated as genera, but *E. pileolus* was not included; in later works the name has been restricted to *E. Dröbachiensis* and allied species (our genus, *Euryechinus*) which were referred to the *restricted* genus, Echinus, when Toxopneustes was originally separated. Finally a new generic name, *Toxocidaris* A. Ag., has recently been proposed for the species allied to *T. tuberculatus*. In this case it becomes difficult to determine whether *Toxopneustes* should be restricted to the genus represented by *E. pileolus* (*Boletia*) or to that having *E. tuberculatus* as its type (*Toxocidaris*). Other serious difficulties arise when, as often happens, an author's type is incorrectly identified and does not agree with the original species, bearing the same specific name, even in generic characters.—V.

‡ These MS. names are in all cases liable to create confusion, and it is therefore much to be desired that the practice of using them should be avoided in future.

lished but not defined, as in some museum catalogues, and in Lesson's 'Traité d'Ornithologie,' where many species are enumerated by name, without any description or reference by which they can be identified. *Therefore*:—

§ 12. A name which has never been clearly defined in some published work should be changed for the earliest name by which the object shall have been so defined.

[*Specific names, when adopted as generic, must be changed.*]—The necessity for the following rule will be best illustrated by an example. The *Corvus pyrrhocorax* Linn., was afterward advanced to a genus under the name of *Pyrrhocorax*. Temminck adopts this generic name, and also retains the old specific one, so that he terms the species *Pyrrhocorax pyrrhocorax*. The inelegance of this method is so great as to demand a change of the generic name.* We propose, therefore, that:—

§ 13. A specific name must not be altered in order to use that name for the genus; where this has been already done the old specific name must be restored, and a new generic name given to prevent an unharmonious repetition.

N.B.—It will be seen, however, below that we strongly object to the further continuance of this practice of elevating specific names into generic.

[*Latin Orthography to be adhered to.*]—On the subject of orthography it is necessary to lay down one proposition:—

§ 14. In writing zoölogical names, the rules of Latin orthography must be adhered to.

In Latinizing Greek words there are certain rules of orthography known to classical scholars which must never be departed from. For instance, the names which modern authors have written *Aipucnemia*, *Zenophasia*, *poiocephala*, must, according to the laws of etymology, be spelt *Ægypcnemia*, *Xenophasia*, and *pœocephala*. In Latinizing modern words the rules of classic usage do not apply, and all that we can do is to give to such terms as classical an appearance as we can, consistently with the preservation of their etymology. In the case of European words whose orthography is fixed, it is best to retain the original form, even though it may include letters and combinations unknown in Latin. Such words, for instance, as *Woodwardi*, *Knighti*, *Bullocki*. *Eschscholtzi*, would be quite unintelligible if they were Latinized into *Vudvardi*, *Cnichti*, *Bullocci*, *Essolzi*, &c. But words of barbarous origin, having no fixed orthography, are more pliable, and hence, when adopted into the Latin, they should be rendered as classical in appearance as is consistent with the preservation of their original sound. Thus

* This seems most necessary in those numerous instances where adjective specific names, or even substantives in the genitive, have been raised to the rank of generic names. Thus *Venus mercenaria* was changed to *Mercenaria violacea*, and finally many recent writers have restored the old specific name, so that its name stands at present *Mercenaria mercenaria!* The well known case of the soup-shell of Rumphius, *Tellina gari*, is another marked instance of the absurd results of such practises. Schumacher raised the species to generic rank, under the genitive term, *Gari*, and the original specific name having been restored, the species appears in recent works under the ridiculous "name," *Gari gari!* And yet it is said that *Gari gari* is not the original *soup-shell* of Rumph after all! When the specific name is a substantive the result is, perhaps, less absurd, though still very objectionable. Thus we have among our common shells *Ensis ensis*, *Gemma gemma*, etc.—V.

the words *Tockus*, *awsuree*, *argoondah*, *kundoo*, &c., should when Latinized, have been written *Toccus*, *ausure*, *argunda*, *cundu*, &c. Such words ought, in all practicable cases, to have a Latin termination given them, especially if they are used generically.

In Latinizing proper names, the simplest rule appears to be to use the termination *-us*, genitive *-i*, when the name ends with a consonant,* as in the above examples; and *-ius*, gen. *-ii*, when it ends with a vowel, as, *Latreille*, *Latreillii*, &c.

In converting Greek words into Latin the following rules must be attended to :—

Greek.		Latin.
αι	becomes	æ.
ει	"	i.
ος	terminal,	us.
ον	"	um.
ου	becomes	u.
οι	"	œ.
υ	"	y.

Greek.		Latin.
θ	becomes	th.
φ	"	ph.
χ	"	ch.
κ	"	c.
γχ	"	nch.
γγ	"	ng.
'	"	h.

When a name has been erroneously written and its orthography has been afterward amended, we conceive that the authority of the original author should still be retained for the name, and not that of the person who makes the correction.

PART II.

RECOMMENDATIONS FOR IMPROVING THE ZOOLOGICAL NOMENCLATURE IN FUTURE.

The above propositions are all which, in the present state of the science, it appears practicable to invest with the character of laws. We have endeavored to make them as few and simple as possible, in the hope that they may be the more easily comprehended and adopted by naturalists in general. We are aware that a large number of other regulations, some of which are hereafter enumerated, have been proposed and acted upon by various authors who have undertaken the difficult task of legislating on the subject; but as the enforcement of such rules would in many cases undermine the invaluable principle of priority, we do not feel justified in adopting them. At the same time we fully admit that the rules in question are, for the most part, founded on just criticism, and therefore, though we do not allow them to operate retrospectively, we are willing to retain them for future guidance. Although it is of the first importance that the principle of priority should be held paramount to all others, yet we are not blind to the desirableness of rendering our scientific language palatable to the scholar and the man of taste. Many zoölogical terms, which are now marked with the stamp of perpetual currency, are yet so far defective in construction, that our inability to remove them without infringing the law of priority may be a subject of regret. With these terms we cannot interfere, if we adhere to the principles above laid down; nor is there even any remedy, if authors insist on infringing the rules of good taste by introducing into the science words of the same inelegant or unclassical character in future. But that which cannot be enforced by law may, in some measure, be effected by persuasion; and with this view we submit the following propositions to naturalists, under the title of *Recommendations for the Improvement of Zoological Nomenclature in future.*

[*The best names are Latin or Greek characteristic words.*]—The classical languages being selected for zoölogy, and words being more easily remembered in proportion as they are expressive, it is self-evident that :—

§ A. The *best* zoölogical names are those which are derived from the Latin or Greek, and express some distinguishing characteristic of the object to which they are applied.

* There are many names, which, though ending with a consonant, are more euphonious if terminated with *-ius*.—V.

[*Classes of objectionable names.*]—It follows from hence that the following classes of words are more or less objectionable in point of taste, though, in the case of *genera*, it is often necessary to use them, from the impossibility of finding characteristic words which have not before been employed for other genera. We will commence with those which appear the least open to objection, such as,

a. Geographical names.—These words being for the most part adjectives can rarely be used for *genera*. As designations of *species* they have been so strongly objected to, that some authors (Wagler, for instance) have gone the length of substituting fresh names wherever they occur; others (*e. g.* Swainson) will only tolerate them where they apply *exclusively*. We are by no means disposed to go to this length. It is not the less true that the *Hirundo javanica* is a Javanese bird, even though it may occur in other countries also, and though other species of *Hirundo* may occur in Java. The utmost that can be urged against such words is, that they do not tell the *whole truth*. However, as so many authors object to this class of names, it is better to avoid giving them, except where there is reason to believe that the species is confined to the country whose name it bears.

b. Barbarous names.—Some authors protest strongly against the introduction of exotic words into our Latin nomenclature, others defend the practice with equal warmth. We may remark, first, that the practice is not contrary to classical usage, for the Greeks and Romans did occasionally, though with reluctance, introduce barbarous words in a modified form into their respective languages. Secondly, the preservation of trivial names which animals bear in their native countries is often of great use to the traveler in aiding him to discover and identify species. We do not therefore consider, if such words have a Latin termination given to them, that the occasional and judicious use of them as scientific terms can be justly objected to.

c. Technical names.—All words expressive of trades and professions have been by some writers excluded from zoölogy, but without sufficient reason. Words of this class, *when carefully chosen*, often express the peculiar characters and habits of animals in a metaphorical manner, which is highly elegant. We may cite the generic terms *Arvicola*, *Lanius*, *Pastor*, *Tyrannus*, *Regulus*, *Ploccus*, &c., as favorable examples of this class of names.

d. Mythological or historical names.—When these have no perceptible reference or allusion to the characters of the object on which they are conferred, they may properly be regarded as unmeaning and in bad taste. Thus the generic names *Lesbia*, *Leilus*, *Remus*, *Corydon*, *Pasiphae*, have been applied to a Humming-bird, a Butterfly, a Beetle, a Parrot, and a Crab, respectively, without any perceptible association of ideas. But mythological names may sometimes be used as generic with the same propriety as technical ones, in cases where a direct allusion can be traced between the narrated actions of a personage and the observed habits or structure of an animal. Thus when the name *Progne* is given to a Swallow, *Clotho* to a Spider, *Hydra* to a Polyp, *Athene* to an Owl, *Nestor* to a grey-headed Parrot, &c., a pleasing and beneficial connection is established between classical literature and physical science.

e. Comparative names.—The objections which have been raised to words of this class are not without foundation. The names, no less than the definitions of objects, should where practicable, be drawn from positive and self-evident characters, and not from a comparison with other objects, which may be less known to the reader than the one before him. Specific names expressive of comparative size are also to be avoided, as they may be rendered inaccurate by the after discovery of additional species. The names *Picoides*, *Emberizoides*, *Pseudoluscinia*, *rubeculoides*, *maximus*, *minor*, *minimus*, &c., are examples of this objectionable practice.

f. Generic names compounded from other genera.—These are in some degree open to the same imputation as comparative words; but as they often serve to express the position of a genus as intermediate to, or allied with, two other genera, they may occasionally be used with advantage. Care must be taken not to adopt such compound words as are of too great length, and not to corrupt them in trying to render them shorter. The names *Gallopavo*, *Tetraogallus*, *Gypaetos*, are examples of the appropriate use of compound words.

g. Specific names derived from persons.—So long as these complimentary designations are used with moderation, and are restricted to persons of eminence as scientific zoölogists, they may be employed with propriety in cases where expressive or characteristic words are not to be found. But we fully concur with those who censure the practice of naming species after persons of no scientific reputation, as curiosity dealers (e. g. *Caniveti*, *Boissoneauti*), Peruvian priestesses (*Cora*, *Amazilia*), or Hottentots (*Klassi*).

h. Generic names derived from persons.—Words of this class have been extensively used in botany, and therefore it would have been well to have excluded them wholly from zoölogy, for the sake of obtaining a *memoria technica* by which the name of a genus would at once tell us to which of the kingdoms of nature it belonged. Some personal generic names have, however, crept into zoölogy, as *Cuvieria*, *Mulleria*, *Rossia*, *Lessonia*, &c., but they are rare in comparison with those of botany, and it is perhaps desirable not to add to their number.

i. Names of harsh and inelegant pronunciation.—These words are grating to the ear, either from inelegance of form, as *Huhua*, *Yuhina*, *Craxirex*, *Eschscholtzi*, or from too great length, as *chirostrongylostinus*, *Opetiorhynchus*, *brachypodioides*, *Thecodontosaurus*. It is needless to enlarge on the advantage of consulting euphony in the construction of our language. As a general rule it may be recommended to avoid introducing words of more than five syllables.

k. Ancient names of animals applied in a wrong sense.—It has been customary in numerous cases to apply the names of animals found in classic authors at random to exotic genera or species which were wholly unknown to the ancients. The names *Cebus*, *Callithrix*, *Spiza*, *Kitta*, *Struthus*, are examples. This practice ought by no means to be encouraged. The usual defence for it is, that it is impossible now to identify the species to which the name was anciently applied. But it is certain that if any traveller will take the trouble to collect the vernacular names used by the modern Greeks and Italians for the Vertebrata and Mollusca of southern Europe, the meaning of the ancient names may in most cases be determined with the greatest precision. It has been well remarked that a Cretan fisher-boy is a far better commentator on Aristotle's 'History of Animals' than a British or German scholar. The use, however, of ancient names, *when correctly applied*, is most desirable, for "in framing scientific terms, the appropriation of old words is preferable to the formation of new ones."*

l. Adjective generic names.—The names of genera are in all cases essentially substantive, and hence adjective terms cannot be employed for them without doing violence to grammar. The generic names *Hians*, *Criniger*, *Cursorius*, *Nitidula*, &c., are examples of this incorrect usage.†

m. Hybrid names.—Compound words, whose component parts are taken from two different languages are great deformities in nomenclature, and naturalists should be especially guarded not to introduce any more such terms into zoölogy, which furnishes too many examples of them already. We have them compounded of Greek and Latin, as *Dendrofalco*, *Gymnocorvus*, *Monoculus*, *Arborophila*, *flavigaster*; Greek and French, as *Jacamaralcyon*, *Jacamerops*; and Greek and English, as *Bullockoides*, *Gilbertsocrinites*.

* Whewell, Phil. Ind. Sc., vol. i, p. lxvii; Nov. Org. Ren. iv, iii.

† Generic names in the genitive should also be included. See note p. 103.—V.

n. Names closely resembling other names already used.—By Rule 10 it was laid down that when a name is introduced which is *identical* with one previously used, the later one should be changed. Some authors have extended the same principle to cases where the later name, when correctly written, only approaches in form, without wholly coinciding with the earlier. We do not, however, think it advisable to make this law imperative, first, because of the vast extent of our nomenclature, which renders it highly difficult to find a name which shall not bear more or less resemblance in sound to some other; and, secondly, because of the impossibility of fixing a limit to the degree of approximation beyond which such a law should cease to operate. We content ourselves, therefore, with putting forth this proposition merely as a recommendation to naturalists, in selecting generic names, to avoid such as too closely approximate to words already adopted. So with respect to species, the judicious naturalist will aim at variety of designation, and will not, for example, call a species *virens* or *virescens* in a genus which already possesses a *viridis*.

o. Corrupted words.—In the construction of compound Latin words, there are certain grammatical rules which have been known and acted on for two thousand years, and which a naturalist is bound to acquaint himself with before he tries his skill in coining zoölogical terms. One of the chief of these rules is, that in compounding words all the radical or essential parts of the constituent members must he retained, and no change made except in the variable terminations. But several generic names have been lately introduced which run counter to this rule, and form most unsightly objects to all who are conversant with the spirit of the Latin language. A name made up of the first half of one word and the last half of another, is as deformed a monster in nomenclature as a Mermaid or a Centaur would be in zoölogy; yet we find examples in the names. *Corcorax* (from *Corvus* and *Pyrrhocorax*) *Cypsnagra* (from *Cypselus* and *Tanagra*), *Merularis* (*Merula* and *Synallaxis*), *Loxigilla* (*Loxia* and *Fringilla*), &c. In other cases, where the *commencement* of both the simple words is retained in the compound, a fault is still committed by cutting off too much of the radical and vital portions, as is the case in *Bucorvus* (from *Buceros* and *Corvus*), *Ninox* (*Nisus* and *Noctua*), &c.

p. Nonsense names.—Some authors having found difficulty in selecting generic names which have not been used before, have adopted the plan of coining words at random, without any derivation or meaning whatever. The following are examples: *Viralva*, *Xema*, *Azeca*, *Assiminia*, *Quedius*, *Spisula*. To the same class we may refer *anagrams* of other generic names, as *Dacelo* and *Cedola* of *Alcedo*, *Zapornia* of *Porzana*, &c. Such verbal trifling as this is in very bad taste, and is especially calculated to bring the science into contempt. It finds no precedent in the Augustan age of Latin, but can be compared only to the puerile quibblings of the middle ages. It is contrary to the genius of all languages, which appear never to produce new words by spontaneous generation, but always to derive them from some other source, however distant or obscure. And it is peculiarly annoying to the etymologist, who, after seeking in vain through the vast storehouses of human language for the parentage of such words, discovers at last that he has been pursuing an *ignis fatuus*.

q. Names previously canceled by the operation of § 6.—Some authors consider that when a name has been reduced to a synonym by the operations of the laws of priority, they are then at liberty to apply it at pleasure to any new group which may be in want of a name. We consider, however, that when a word has once been proposed in a given sense, and has afterward sunk into a synonym, it is far better to lay it aside for ever than to run the risk of making confusion by re-issuing it with a new meaning attached.*

* It cannot always be certainly known whether a name has really become a permanent synonym, for the limits of genera are continually being changed. Therefore names once used can seldom be again employed with safety.—V.

r. Specific names raised into generic.—It has sometimes been the practice in subdividing an old genus to give the lesser genera so formed, the names of their respective typical species. Our Rule 13 authorizes the forming a new generic name in such cases; but we further wish to state our objections to the practice altogether. Considering as we do that the original specific names should as far as possible be held sacred, both on the grounds of justice to their authors and of practical convenience to naturalists, we would strongly dissuade from the *further continuance* of a practice which is gratuitous in itself, and which involves the necessity of altering old names or making new ones.

We have now pointed out the principal rocks and shoals which lie in the path of the nomenclator; and it will be seen that the navigation through them is by no means easy. The task of constructing a language which shall supply the demands of scientific accuracy on the one hand, and of literary elegance on the other, is not to be inconsiderately undertaken by unqualified persons. Our nomenclature presents but too many flaws and inelegancies already, and as the stern law of priority forbids their removal, it follows that they must remain as monuments of the bad taste or bad scholarship of their authors to the latest ages in which zoölogy shall be studied.

[*Families to end in* idæ, *and Subfamilies in* inæ.]—The practice suggested in the following proposition has been adopted by many recent authors, and its simplicity and convenience is so great that we strongly recommend its universal use.*

§ B. It is recommended that the assemblages of genera, termed *families*, should be uniformly named by adding the termination, *idæ*, to the name of the earliest known, or most typically characterized genus in them; and that their subdivisions, termed *subfamilies*, should be similarly constructed with the termination, *inæ*.

These words are formed by changing the last syllable of the genitive case into *idæ* or *inæ*, as *Strix*, *Strigis*, *Strigidæ*, *Buceros*, *Bucerotis*, *Bucerotidæ*, not *Strixidæ*, *Buceridæ*.

[*The authority for a species, exclusive of the genus, to be followed by a distinctive expression.*]—The systematic names of zoölogy being still far from that state of fixity which is the ultimate aim of the science, it is frequently necessary for correct indication to append to them the name of the person on whose authority they have been proposed. When the same person is authority both for the specific and generic name, the case is very simple; but when the specific name of one author is annexed to the generic name of another, some difficulty occurs. For example, the *Musicapa crinita* of Linnæus belongs to the modern genus, *Tyrannus* of Vieillot; but Swainson was the first to apply the specific name of Linnæus to the generic one of Vieillot. The question now arises, Whose authority is to be quoted for the name, *Tyrannus crinitus*? The expression, *Tyrannus crinitus* Linn., would imply what is untrue, for Linnæus did not use the term *Tyrannus*; and *Tyrannus crinitus* Vieill., is equally incorrect, for Vieillot did not adopt the name, *crinitus*. If we call it *Tyrannus crinitus* Sw., it would imply that Swainson was the first to describe the species, and Linnæus would be robbed of his due credit. If we term it, *Tyrannus*, Vieill., *crinitus*, Linn., we use a form which, though expressing the facts correctly, and therefore not without ad-

* There are some generic names that will not readily receive these terminations, and as numerous other forms of family and subfamily names are already in good use, a little more latitude might well be allowed in this matter.—V.

vantage in particular cases where great exactness is required, is yet too lengthy and inconvenient to be used with ease and rapidity. Of the three persons concerned with the construction of a binomial title in the case before us, we conceive that the author who *first* describes and names a species which forms the ground work of later generalizations, possesses a higher claim to have his name recorded than he who afterward defines a genus which is found to embrace that species, or who may be the mere accidental means of bringing the generic and specific names into contact. By giving the authority for the *specific* name in preference to all others, the inquirer is referred *directly* to the original description, habitat, &c., of the species, and is at the same time reminded of the date of its discovery; while genera, being less numerous than species, may be carried in the memory, or referred to in systematic works without the necessity of perpetually quoting their authorities. The most simple mode then, for ordinary use, seems to be, to append to the original authority for the species, when not applying to the genus also, some distinctive mark implying an exclusive reference to the *specific* name, as *Tyrannus crinitus* (Linn.), and to omit this expression when the same authority attaches to both genus and species, as *Ostrea edulis* Linn.* Therefore :—

§ C. It is recommended that the authority for a specific name, *when not applying to the generic name also*, should be expressed thus, (Linn.), as *Tyrannus crinitus* (Linn.).

[*New genera and species to be defined* amply *and* publicly.]—A large proportion of the complicated mass of synonyms, which has now become the opprobrium of zoölogy, has originated either from the slovenly and imperfect manner in which species and groups have been originally defined, or from their definitions having been inserted in obscure local publications, which have never obtained an extensive circulation. Therefore, although under § 12 we have conceded that mere insertion in a printed book is sufficient for *publication*, yet we would strongly advise the authors of new groups always to give, in the first instance, a full and accurate definition of their characters, and to insert the same in such periodical or other works as are likely to obtain an immediate and extensive circulation.† To state this briefly :—

* If but *one* person's name can be allowed as authority it should, without doubt, be that of the author who has given the *full name*, as adopted, but in catalogues and other works where no synonym is given, it would be well to write also the name of the original describer, when not the same, enclosing it in a parenthesis for distinction. But in works giving synonymy this is unnecessary. (See the articles in this Journal referred to above; also the amended rules of the American Association.) The name of the authority should be regarded rather as a matter of convenience than as a means of conferring a supposed *honor* on the author, discoverer or describer,—a distinction which often becomes a disgrace if coupled with bad and careless descriptions or objectionable names.

There is a great disagreement among authors as to the punctuation that should intervene between a name and the authority, the same author often using two or more systems in the same volume, as is the case, for example, in the works of Cuvier, Agassiz, and Linné, who often use indifferently a comma or else no punctuation. The best usage appears to be without any punctuation, the authority in this case being understood to be a noun in the genitive, though written in the nominative form, or more frequently abbreviated.—v.

† Since *publication* implies both printing and *distribution*, it is obvious that the date when a memoir was read (often only by title) is not to be regarded as the date of actual *publication* of genera and species. And yet many Societies give in their publications *only* the dates when the papers were read,—often several months or a year before their real publication. In this country this is especially the case with the Proceedings of the Philadelphia Academy. Many Societies have adopted the more just and reasonable custom of giving the actual date of publication of each number, part, or signature.—v.

§ D. It is recommended that new genera or species be *amply* defined, published, and *extensively* circulated in the first instance.

[*The names to be given to subdivisions of genera to agree in gender with the original genus.*]—In order to preserve specific names as far as possible in an unaltered form, whatever may be the changes which the genera to which they are referred may undergo, it is desirable, when it can be done with propriety, to make the new subdivisions of genera agree *in gender* with the old groups from which they are formed. This recommendation does not, however, authorize the changing the gender or termination of a genus already established. In brief:—

§ E. It is recommended that in subdividing an old genus in future, the names given to the subdivisions should agree in gender with that of the original group.

[*Etymologies and types of new genera to be stated.*]—It is obvious that the names of genera would in general be far more carefully constructed, and their definitions would be rendered more exact, if authors would adopt the following suggestion:—

§ F. It is recommended that in defining new genera the etymology of the name should be always stated, and that one species should be invariably selected as a type or standard of reference.

In concluding this outline of a scheme for the rectification of zoölogical nomenclature, we have only to remark, that almost the whole of the propositions contained in it may be applied with equal correctness to the sister science of botany. We have preferred, however, in this essay to limit our views to zoölogy, both for the sake of rendering the question less complex, and because we conceive that the botanical nomenclature of the present day stands in much less need of distinct enactment than the zoölogical. The admirable rules laid down by Linnæus, Smith, Decandolle, and other botanists (to which no less than to the works of Fabricius, Illiger, Vigors, Swainson, and other zoölogists, we have been much indebted in preparing the present document) have always exercised a beneficial influence over their disciples. Hence the language of botany has attained a more perfect and stable condition than that of zoölogy.; and if this attempt at reformation may have the effect of advancing zoölogical nomenclature beyond its present backward and abnormal state, the wishes of its promoters will be fully attained.

Art. XII.—*Contributions from the Sheffield Laboratory of Yale College.* No. XIX.

1. *On the estimation of Carbonic Acid ;** by S. W. Johnson.

In the processes usually employed, carbonic acid is determined by the loss of weight of an apparatus which contains no carbonic acid gas at the beginning and which must be completely emptied of this gas at the conclusion of the analysis. It is a matter of experience, however, that accurate results are not attainable with certainty, in this way. Nothing short of actual boiling for some time will expel all carbonic acid gas from the dilute acid liquid. This cannot be done conveniently without loss of aqueous vapor. The fact that good results are often obtained is due to the compensation of opposite errors, as the analyst may convince himself by repeatedly heating and sucking through air. If the suction go on to just the right extent, the loss of the apparatus will exactly correspond to the carbonic acid that was contained in the substance, but further exhaustion of the air will diminish the weight of the apparatus, not by complete removal of the carbonic acid, but by loss of aqueous vapor which easily escapes the desiccating material. By continued working on a carbonate of known composition one may soon learn how long to exhaust in order to bring out the proper loss, but where the analyst is out of practice, an error of 1 to 2 per cent is not unlikely to happen, and the process itself furnishes no means of judging when it will give a correct result.

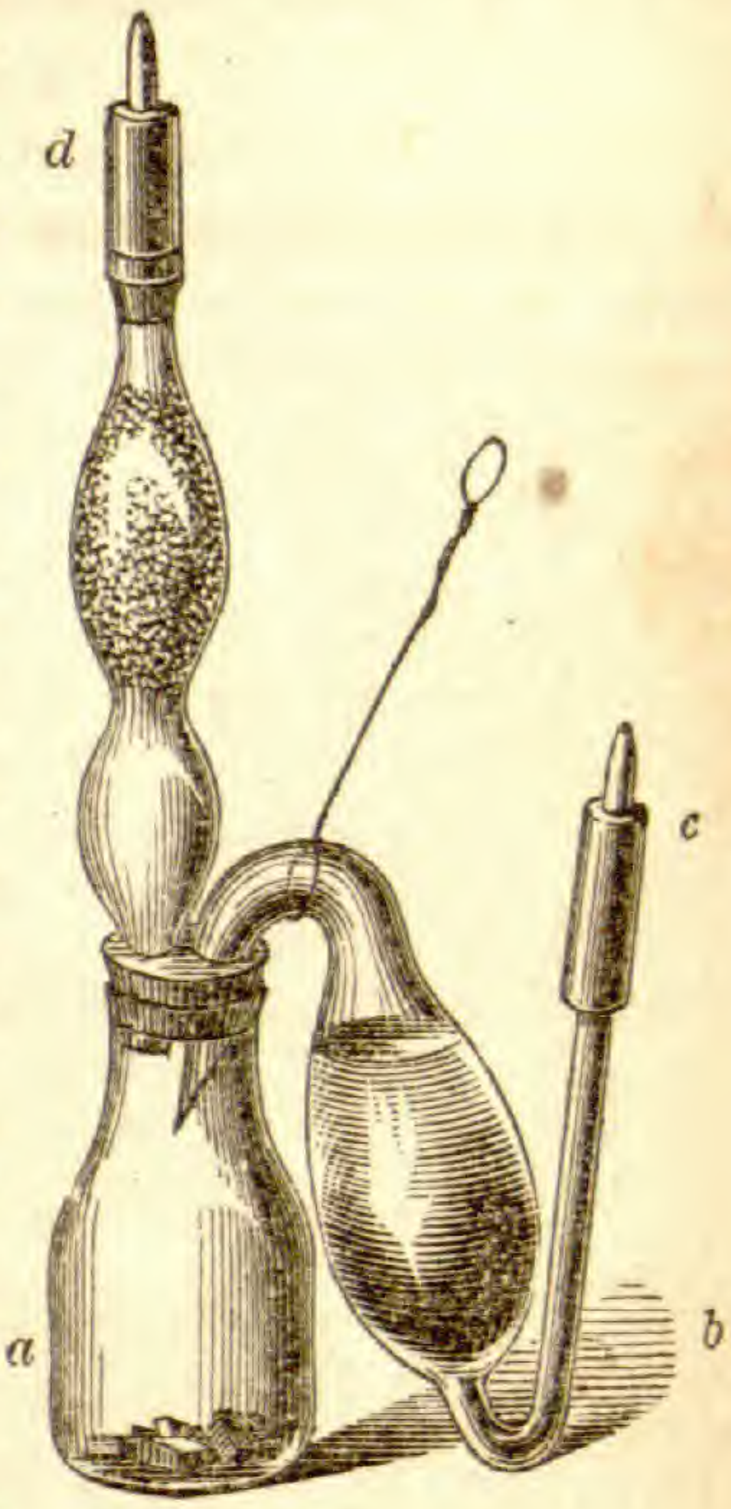
The writer employs a simple modification of this method which, under proper conditions, gives very accurate results and furnishes to a great extent its own control. The process is novel in this particular, viz : the charged apparatus is in the first place filled with carbonic acid gas, the substance is then decomposed, and as soon as disengagement of gas ceases, the apparatus, still filled with carbonic acid gas, is weighed again. In this manner all aspiration is done away with, and the desiccating material has simply to dry as much gas as is yielded by the substance under analysis.

It is, however, essential that the substance under examination dissolve freely and completely in cold acid ; it is likewise necessary that the analysis and weighings be conducted in an apartment not liable to change of temperature.

The apparatus may consist of a light flask or bottle with

* The substance of this paper was verbally communicated to the National Academy of Sciences in August, 1868.

wide mouth which is closed by a soft rubber stopper, through which there passes, on the one hand, a chlorid of calcium tube, the lower bulb of which contains cotton, and, on the other, the neck of a vessel which contains the dilute acid. This acid reservoir is so constructed that on suitably inclining it, its contents will flow freely into the flask. For this purpose the tube connecting with the latter has an internal diameter of seven millimeters, and its extremity is cut off obliquely; at its other end, the acid reservoir terminates in an upturned narrow tube, *b*. This and the upper termination of the CaCl tube are chosen of such diameter that they fit quite snugly into short, narrow and thick-walled rubber connecters which are again provided with glass-rod stoppers; all these joints must be gas-tight. In the figure the apparatus is represented in one-third its proper dimensions.



The weighed substance, in case of carbonate of lime, e. g., is placed at the bottom of the flask, most conveniently in the form of small fragments. The acid vessel is nearly filled with hydrochloric acid of sp. gr. 1·1. It and the CaCl tube are tightly adjusted to the neck of the flask, and the glass-rod stoppers being removed, the apparatus is connected at *c* with a self-regulating generator of washed carbonic acid, and a rather rapid stream of the gas is transmitted through the apparatus for 15 minutes, or until the liquid in *b* is saturated and the air is thoroughly displaced. Then the opening at *d* is stopped and afterward the apparatus is disconnected with the carbonic acid generator and stopped at *c*. During these as well as the subsequent operations, the apparatus must be so handled that its temperature shall not change. It is immediately weighed. When removed from the balance, loosen the stopper at *d*, and, holding the flask by a wooden clamp, incline it so that the acid may flow over upon the carbonate. The decomposition should proceed slowly, so that the escaping gas may be thoroughly dried. As soon as solution of the carbonate is complete, replace the stopper at *d* and weigh again. Should there be any leak in the apparatus the fact is made evident by a slow but steady loss of weight, when it is brought upon the balance. If all the joints are sufficiently tight, the weight remains the same for at least fifteen minutes.

When properly executed the process gives extremely accurate results; a slight change of temperature or of atmospheric pressure between the two weighings of course greatly impairs the results or renders them worthless. Since the apparatus usually rises a little in temperature during the solution of the carbonate, it is better, as soon as the substance is decomposed, to stopper the CaCl tube and let the whole stand fifteen minutes, then to connect as before with the CO generator and pass *dried* CO_2 for a minute, and finally to stopper again and bring upon the balance. In seven analyses of pure calcite in quantities ranging from 0·5 to 0·9 grm., the writer obtained the following percentages of carbonic acid, viz: 44·07, 44·07, 43·98, 44·01, 44·04, 44·11, 44·16; calculation requires 44·00.

In case of alkali-carbonates which absorb carbonic acid gas, it is necessary to modify the apparatus. Instead of the light flask *a* we may employ a small bottle of thick glass and wider mouth, and a thrice-perforated rubber stopper. Through the third orifice pass a narrow tube 3 to 4 inches long enlarged below to a small bulb to contain the carbonate. This bulb must be so thin that on pushing down the tube within the bottle, it shall be easily crushed to pieces against the bottom of the latter. The carbonate is weighed into the bulb-tube, the latter is wiped clean, down to the bulb, corked and fixed in the stopper. The apparatus is filled as before with CO_2 and weighed. Then the bulb is broken and the process finished as before described. In three estimations on carbonate of soda the writer found 41·54, 41·64 and 41·58 per cent of CO_2. Calculation requires 41·51 per cent.

2. *On the construction of Bunsen's Air-Pump.*

In supplying the Sheffield Laboratory with the means of quick filtration, the following plan has been adopted. The laboratory being on the ground floor, with no well accessible, and having hydrant water under an adequate head, a lead *supply-pipe* of $\frac{1}{4}$ inch bore was connected with the service pipe and carried up an empty flue to the garret. There it returned in a short curve, and at a height of about 35 feet, was soldered into the end of a vertical piece of lead pipe 8 inches long and of 1 inch bore, within which it penetrated two inches. Another leaden *air-pipe* of $\frac{1}{4}$ inch bore was also soldered into the top of the inch tube and ran down parallel with the one just mentioned, terminating at the laboratory desk below. To the bottom of the inch pipe in the garret flue was attached a third leaden *fall-pipe* of $\frac{1}{4}$ inch bore which passed down to the cellar bottom with a vertical height of more than 40 feet, and there entered into a drain pipe. The supply-pipe and air-pipe were

brought out at a convenient point above the assistant's desk. The former was provided with two cocks, one to regulate the flow of water and another for emptying it in cold weather.

At 3 feet above a shelf of the desk, a branch was fitted to the air-pipe which was connected by rubber to a vertical glass tube whose lower end stands in a small vessel of mercury and serves as a manometer. This arrangement was put up by a plumber in two days' time and gives the full Torricellian vacuum less the tension of water-vapor.

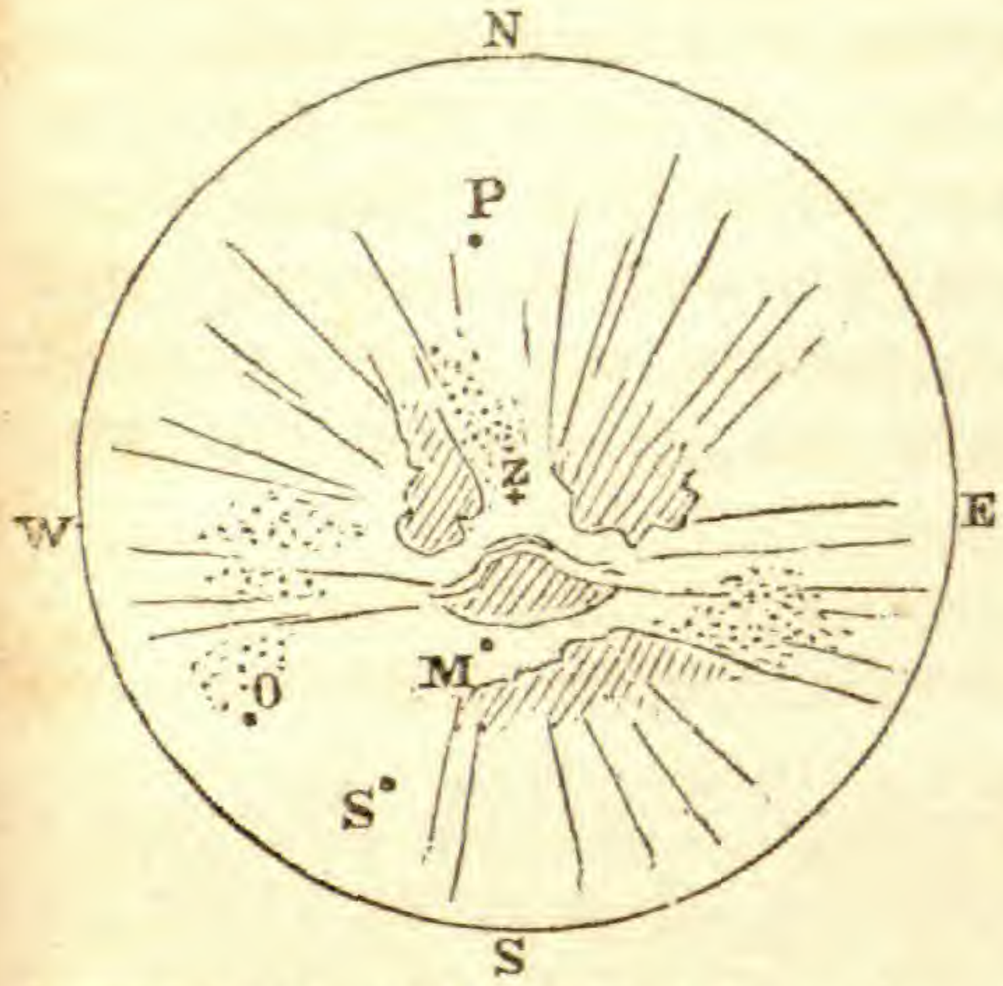
For the working students, four similarly constructed pumps were made, each being in the center of a double table that accommodates four operators. In case of these pumps it was not practicable to place the pipes within flues; so they are carried up to the ceiling of the laboratory, a height of 13 feet, and the fall-pipes pass below into a drain in the cellar bottom. The pipes are supported on the faces of a narrow vertical plank secured above to the ceiling, and below to the reagent shelf. The glass manometer-tube is brought into a slot in this plank so as to stand in full view of all four operators. The water supply is regulated from either side of the desk by a cock with a double lever-handle eight inches long, which works against a stop when open to the point of maximum exhaustion. The air-pipes terminate in a horizontal brass tube screwed on a shelf and open at either end for connecting with the filtering apparatus. These pumps when in action support a column of mercury of about 19 to 20 inches, which is sufficient for most ordinary purposes, and their use is in great favor with the students. It is needful to intervene between the filter flask and the metal pipes a small bottle to collect the liquids which condense in the latter, as they contain lead in solution or suspension.

ART. XIII.—*On the Aurora seen in New York, April* 15, 1869; by W. S. GILMAN, Jr. (In a letter to Prof. ELIAS LOOMIS, Yale College.)

I SEND herewith a brief account of the grand aurora of last evening, as seen by a party of three from the roof of the Observatory of Mr. Jacob Campbell, in Brooklyn.

On coming out of doors to go to the Observatory at $\frac{1}{2}$ past 7 in the evening the writer called the attention of one of the party to thin streaky clouds pointing upward from the horizon, and remarked that it was the beginning of an auroral display. Hardly had we paused when by their changing, wavy light we perceived we were not in error, and in a few minutes afterward saw the formation of the corona as in the sketch below.

The nucleus or apex of the phenomenon was a cloud, shaped like the internal area described by a bow with the string drawn aside. The southwest was clear, as it was generally during the evening. From this point the wind had been blowing all day.



Aurora of April 15, 1869, 7·40 P. M., as seen from space. M, Mars; O, Orion; P, Polaris; S, Sirius; Z, Zenith.

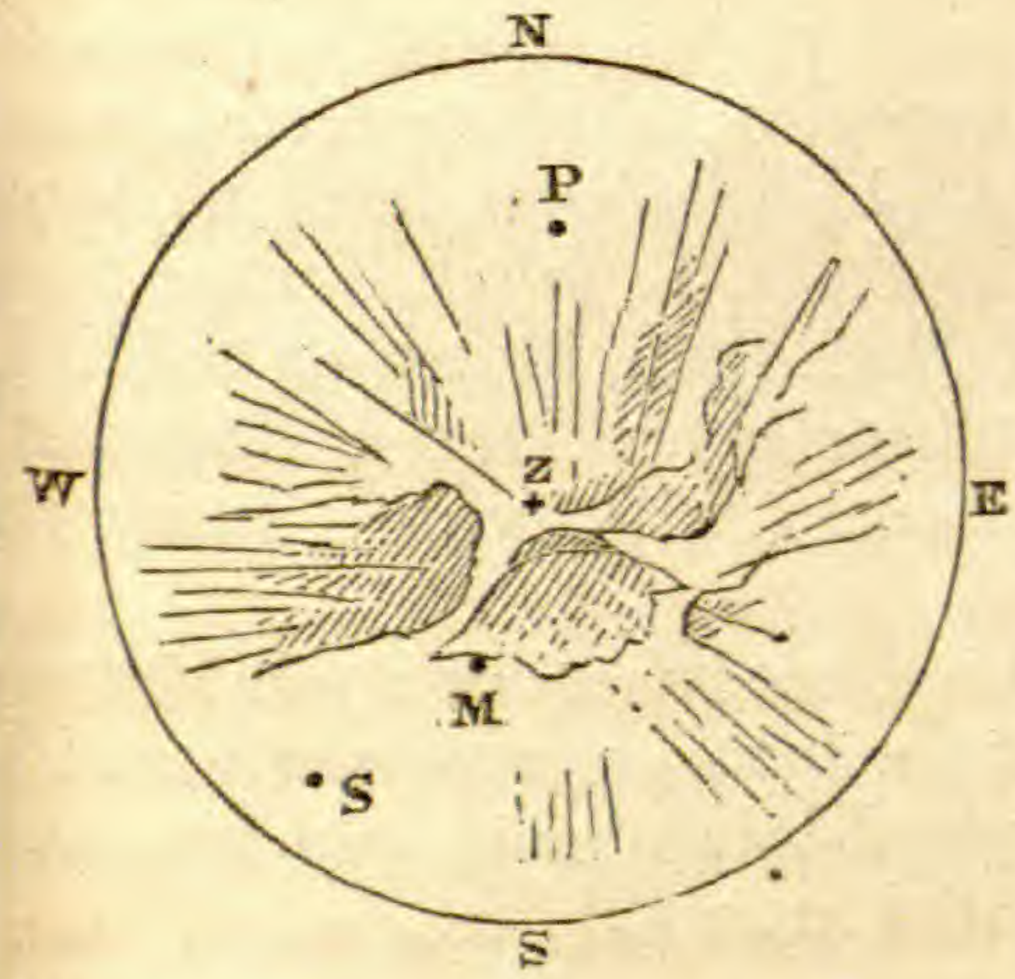
To the south the auroral beams did not extend nearer the horizon than Sirius, and indeed it was noticeable that at no time did the display exhibit great strength on the horizon.

At 7·40 rosy tints appeared at different points of the compass. Remarkably deep tints were noticed both to the east and west of the zenith, and generally at an altitude of 45° or more.

At 8 P. M. the phenomenon brightened after a dull period of some minutes. *The rose tints were now very beautiful.* In the west a very deep carmine was observed. Sulphurous-yellow and greenish hues were also noted.

At 10 P. M. the aurora was faint, but still quite striking in its arrangement.

At 10·30 it brightened again, the corona reappearing with redoubled brilliancy. The nucleus of light overhead was much larger than earlier in the evening, and in shape resembled the denser part of the Great Nebula of Orion. Indeed the entire phenomenon wore the appearance of that nebula, as if it had been suddenly brought near to our system, so as to cover a quarter of the sky.



Aurora of April 15, 1869, at 10 30 P. M., as seen from space. M, Mars; P, Polaris; S, Sirius; Z, Zenith.

At 2 A. M. we ceased observations. At this hour there were still faint beams in the north proceeding from the dark segment along the horizon, from the

N.N.E. to N.N.W.

I rank this aurora as inferior in brilliancy to the grand aurora I witnessed at Mount Desert, Maine, on the 15th of September last, but possessing more interest than the latter in the greater grotesqueness of the clouds forming the corona, and

the rosy, greenish and yellowish tints assumed by the broad sheets of light which streamed on all sides from the nucleus overhead. The September aurora was *grander near the horizon*, and particularly in the N.E., from which point the great strength of the aurora in appearance originated. The flashings or flickerings along the beams from the horizon upward were *far more grand* in the Maine phenomenon, on which occasion they were so impressive as to suggest the simile of "*a world on fire.*"

ART. XIV.—*Contributions to Zoölogy from the Museum of Yale College.* No. I.—*Descriptions of a remarkable new Jelly-fish and two Actinians from the coast of Maine;* by A. E. VERRILL.

DURING an excursion to the coast of Maine and Bay of Fundy last season, many interesting and rare marine animals were observed and collected by myself and companions.* Among the most remarkable new species is a very large and beautiful Discophorous jelly-fish, which is the type of a new genus and represents a family previously unknown upon our Atlantic coast.

In size and general appearance it has some resemblance to *Cyanea arctica*, for which it may, possibly, have been hitherto mistaken by casual observers, for it seems scarcely probable that such a large and conspicuous species, which occurred twice among the wharves at Eastport, could otherwise have so long escaped observation. Its color, however, is much lighter than that of *Cyanea*, and yellowish rather than brown or reddish, while the much less numerous tentacles are larger, flattened, with one edge crenulated and bordered with white, while its entire structure is quite different.

It is far more nearly allied to *Heccædecomma ambiguum* Brandt, of the North Pacific, but the latter is represented with round tentacles, different marginal-lobes and ovaries, and broader and much more complicated mouth-folds.

CALLINEMA Verrill, gen. nov.†

Disk broad, moderately thick, with numerous broad channels running to the marginal one, arranged in sixteen systems, two or three parallel and undivided tubes alternating with a group of five or six branching ones, which unite together into one, toward the central portion of the disk, each of which cor-

* Messrs. S. I. Smith, G. A. Jackson, H. E. Webster, and E. F. Verrill.

† *κάλλος*, beauty, *νῆμα*, thread.

responds in position with one of the sixteen, eye-bearing marginal lobes. Toward the marginal channel the branching tubes anastomose freely, the undivided ones but slightly or not at all, though two often unite into one near the margin. Margin deeply and regularly divided into scolloped lobes, sixteen of which bear eyes and are bilobed for more than half their length, bearing the eye at the division, just below which the channel in the lobe divides into two divergent branches, one of which goes to each division. Alternating with the eye-lobes are somewhat longer lobes, which are divided at the edge into two, three, or four rounded scollops, each of which receives a simple channel. Tentacles in a nearly regular circle, but arranged in groups of five or six at the bases of the inter-ocular lobes, very long, highly contractile, flat; one edge double, finely scolloped, the scollops again finely crenulate. Ovaries large, much convoluted, pendant pouches. Lobes of the actinostome, four, large, elongated, pointed, complexly lobed and frilled.

Callinema ornata Verrill, sp. nov.

Disk large, up to 18 inches in diameter, with conspicuous radiating tubes, ·1 to ·3 inch broad. Actinal appendages, when extended, about as long as the diameter of the disk, broad, much convoluted and deeply frilled at base, the edges with fine papilliform divisions. Ovaries large, hanging loosely from the under side of the disk, and nearly equal in length to the radius of the disk. Tentacles ·2 inch broad, extending to the length of at least 15 feet in large specimens, capable of contracting to a length of less than six inches, about 80 or 90 in number, arranged in a nearly regular circle, one to each of the marginal scollops, except those of the eye-bearing lobes; double edge neatly scolloped, frilled and minutely crenulated.

Disk transparent, the radiating tubes light brownish yellow, the central area marked interiorly with lines of light orange, enclosing large, irregularly polygonal areas, below which the lobes of the actinostome show through, giving a yellow center about three inches in diameter; outside of this the ovarian lobes, which are light brownish yellow, show through the disk and extend at times nearly to its margin. They are grouped somewhat into four divisions, and float about variously as the animal moves. Eyes pearl-white. Tentacles transparent, the complex edge flake-white. Actinal folds lemon-yellow or light buff. Lobes of the reproductive organs either yellowish white or brownish yellow, with darker borders of yellowish brown or orange-brown. Phosphorescent with white light. Diameter of largest specimen 18 inches; length of tentacles 15 feet or more, in extension. Another specimen was 10 inches in diam-

eter; disk at center 1·5 inches thick; largest marginal lobes 1·25 long; smallest ·75; actinal appendages 8 to 10 inches long; ovaries hang down 4 inches from disk; tentacles 12 feet long.

Eastport Harbor, swimming near the surface at noon; three specimens observed, one preserved in the museum of Yale College.

Edwardsia elegans Verrill, sp. nov.

Body elongated, slender; epidermis thick, light yellowish brown, with entangled mud, the upper edge slightly free and prominent. Tentacles 16, slender, variously curved and entwined, pale flesh-color, with a central longitudinal line of light orange-red; naked part below the disk pale pink with longitudinal white lines corresponding with the internal lamellæ; mouth light yellowish; disk pale flesh-color.

Eastport, Me., at low water under stones, rare; also on Indian Island, N. B.

Edwardsia farinacea Verrill, sp. nov.

Body small, changeable in form, not very slender, often swollen in the middle or near the base, tapering upward; epidermis firm, dark yellowish, covered with small, firmly adherent grains of sand, the internal lamellæ showing through faintly, but becoming more distinct on the naked, transparent, protruded basal portion, which is marked by 12 corresponding whitish sulcations, meeting at the end and alternating with some finer lines. Upper part of column transparent and naked for about ·12 inch. Tentacles 12, short, conical, in a single circle at the margin of the disk, not crowded, pale yellowish white, sprinkled with fine flake-white specks which become more crowded on the inner median line and at the tips. Disk small, protruded; mouth largely dilatable, at times elevated on a cone; lips with 6 to 12 irregular lobes. Disk and naked space below the tentacles pale yellowish white, finely speckled with flake-white, the disk with faint whitish radiating lines. Length, ·5 inch; greatest diameter, ·15; diameter of disk, ·12.

South Bay, Lubec, on a muddy bottom in 8 fathoms, rare.

No. II.—*Descriptions of a new genus and two new species of Scyllaridæ and a new species of Æthra from North America;* by SIDNEY I. SMITH.

Evibacus, gen. nov.

Carapax very broad; lateral border expanded, incision at the cervical suture closed, and the margin behind it not incised. Rostrum broader than long, very slightly bilobed. Eyes situ-

ated midway between the rostrum and the outer angle; the orbits entire, slightly removed from the anterior margin and connected with it only by a suture. Antennæ with the inner margins approximate.

This genus is most nearly allied to *Ibacus* and *Parribacus* but is very distinct from both of them in the entire lateral margin of the carapax, the closing of the orbits in front, and the form of the rostrum.

Evibacus princeps, sp. nov.

Whole upper surface verrucose and nearly naked; five low, tuberculose elevations on the median line of the carapax, of which one is at the base of the rostrum, two on the gastric region, one on the anterior part of the cardiac, and one on the posterior margin; similar elevations on the middle of the second and third segments of the abdomen, and a very slight one on the fourth. Carapax strongly convex transversely; the anterior margin nearly straight, except at the lateral angle where it is slightly curved forward; lateral margin strongly curved, with a broad notch at the cervical suture behind which the margin is very slightly, obtusely and irregularly toothed. Antennæ together as broad as the anterior part of the carapax; the outer margins coarsely and irregularly serrate and their outline forming the segment of a circle. Everywhere beneath naked and nearly smooth. External maxillipeds with the outer margin of the merus divided into a number of slender processes. Legs so short that when bent forward in their natural position they are concealed beneath the expansions of the carapax; those of the first and second pairs with the superior angle of the merus raised into an obtuse crest; dactyli of all the legs short and stout, in the female those of the posterior pair closing against a process from the propodus. Abdomen with the lateral projections of the second, third and fourth segments long and rather acutely pointed, those of the fourth shorter and triangular at tip; lamella of the terminal segment half as long as broad. Whole length of body, 14 in.; length of carapax, including rostrum, 5·8; breadth of carapax, 7·9.

A single female specimen of this remarkable species, the first of the Scyllaridæ discovered upon the west coast of America, was sent from La Paz, Lower California, by Capt. Jas. Pedersen.

Arctus Americanus, sp. nov.

Carapax as broad as long, median crest high, covered with low squamiform tubercles, tridentate, the anterior tooth small and situated half way between the front and the second tooth; lateral crests very high, anterior portion with two teeth above the eye and separated by a deep notch from the posterior por-

tion which is covered to the lateral margin with low squamiform tubercles; depression between the median and lateral crests broad and deep, smooth or slightly punctate, with a median line of four depressed tubercles; lateral margin broken by a deep fissure at the cervical suture, and by a slight one a little more posteriorly. Antipenultimate segment of the antennæ as broad as long; anterior angle not prominent; outer margin arcuate, bidentate; anterior margin armed with several denticles; median carina prominent but smooth and even; terminal segment short, the extremity almost truncate and rather deeply five-lobed, the lobes rounded; the inner margin bidentate. Exposed portions of the abdominal segments sculptured as if covered with rows of scales; fourth segment with a prominent median elevation above. Feet nearly naked; the merus segments slightly carinated above. Length, 1·45 in.; length of carapax, along the median line, ·45, lateral margin, ·50; breadth, anteriorly, ·49. Male and female do not differ.

Several specimens from Egmont Key, west coast of Florida, collected by Col. E. Jewett and William T. Coons. It is specially interesting as the representative of a genus hitherto known only from the old world.

Æthra scutata, sp. nov.

Carapax transversely and regularly elliptical; margins thin, slightly dentate, the denticles separated by broad and very shallow sinuses; posterior margin nearly straight in the middle; anterior margin straight and parallel to the posterior margin for a short space outside the eyes; front projecting horizontally, its margin forming a semicircle; gastric region elevated, with a broad median depression extending to the front; anterior lobe of branchial region large and prominent; the broad space between the branchial region and the antero-lateral margin concave; summits of the elevations and a space along the posterior border tuberculose, rest of the upper surface smooth; inferior lateral regions slightly convex and smooth. Chelipeds fitting closely to the carapax; the angles projecting into dentate crests; outer and inferior surface of the hand coarsely granulous. Ambulatory legs short; the angles projecting into thin, dentate crests. Sternum and abdomen deeply vermiculated. Length of carapax, 1·39 in.; breadth, 2·23.

A single male of this species, the first of the genus discovered in America, was sent with the *Evibacus* from La Paz by Capt. Pedersen. It is at once distinguished from *Æ. scruposa* Edw., by the much broader and more regularly elliptical carapax.

The genus *Æthra* should evidently be placed near *Crypto-*

podia as has been done by Stimpson. The gastric region is narrow and projects far forward as in the Maioids. The expansions on the sides of the carapax, which give it a Cancroid form, are thin, and contain none of the internal organs, and their removal would give the carapax very much the form of *Cryptopodia*.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS AND CHEMISTRY.

1. *Spectroscopic observations of the Sun.*—LOCKYER has communicated a number of interesting facts resulting from his further observations on the spectroscopic phenomena of the sun. Of these the following are especially worthy of notice.

(1.) The lines of magnesium, sodium and barium when observed in a spot, are thicker than their usual Fraunhofer lines.

(2.) The same lines when observed in the chromosphere are thinner than their usual Fraunhofer lines.

The author considers these facts additional proof of the truth of his assertion made in 1865, on telescopic evidence alone that a spot is the seat of a downrush, as we now know, to a region where the selective absorption of the upper strata varies from what it would be at a higher level. We have then two causes for the darkening of a spot:—first, the general absorption of the chromosphere, thicker here than elsewhere as the spot is a cavity, and secondly, the greater selective absorption of the lower sodium, barium, magnesium stratum, the surface of its last layer being below the ordinary level. Mr. Lockyer endeavored to observe the solar prominences by using a very rapidly oscillating slit, but up to the present time without satisfactory results. By using, however, a wide slit, without the absorbing media employed by Mr. Huggins, Mr. Lockyer obtained very striking results. The solar and atmospheric spectra being hidden and the image of the wide slit alone visible, the telescope or slit is moved slowly, when fleecy delicate cloud-films are seen, of various beautiful forms. By this method, the smallest details of the prominences and of the chromosphere are rendered visible and easy of observation. Mr. Lockyer found it best for sketching purposes to have the open slit in a radial direction, but in studying the chromosphere it is best to place the slit tangent to the sun's limb. The outline of the chromosphere varies greatly, being sometimes undulating and billowy, sometimes ragged and sometimes nearly even for some distance, but very uneven near a prominence. The prominences sometimes undergo very marked changes in a few minutes; in one case, in about ten minutes, a portion of one about 27,000 miles in height entirely disappeared, another portion of the same protuberance increasing at the same time. In a former paper Mr. Lockyer pointed out the

fact that the F line widens as it approaches the sun, the bright line appearing sometimes to extend upon the sun itself, sometimes on one side of the dark F line and sometimes upon the other. Dr. Frankland and Mr. Lockyer believe that they have found that the widening of the F line is due to pressure, and not to temperature *per se.* It is remarkable, however, that the widening does not always show itself upon both sides of the line F. In one case Mr. Lockyer found that the bright F line underwent strange contortions, as if there were some disturbing cause which varied the refrangibility of the line. At the same time and in the same protuberance characteristic lines of barium, magnesium, nickel (?) and some unknown substance were observed. In this case, therefore, there was an uprush from the photosphere into the chromosphere, accompanying which there were changes of enormous magnitude in the prominence, and when the uprush ceased the prominence died away. In a subsequent paper Mr. Lockyer communicated the results of observations made in the neighborhood of a fine spot not very far from the sun's limb. The author's results, in his own words, are as follows:

I. Under certain conditions, the C and F lines may be observed *bright on the sun*, and in the spot-spectrum also, as in prominences or in the chromosphere.

II. Under certain conditions, although they are not observed as bright lines, the corresponding Fraunhofer lines are blotted out.

III. The accompanying changes of refrangibility of the lines in question show that the absorbing material moves upward and downward as regards the radiating material, and that these motions may be observed with considerable accuracy.

IV. The bright lines observable in the ordinary spectrum are sometimes interrupted by the spot-spectrum, *i. e.*, they are only visible in those parts of the solar spectrum near, and away from, spots.

V. The lines C and F vary excessively in thickness over and near a spot, and on the 11th in the deeper portion of the spot they were much thicker than usual.

VI. Stars in the spectrum of which the absorption lines of hydrogen are absent, may either have their chromospheric light radiated from beyond the limb just balanced by the light absorbed by the chromosphere on the disk, or they may come under the condition referred to in (II), either absolutely or on the average.

Mr. Lockyer remarks that a mere uprush or downrush at the sun's limb will not affect the wave length, but that the wave length will be altered by cyclones or backward and forward movements, while near the centre of the disk the wave length will be altered by upward or downward movements. The author remarks that the fact that the hydrogen-lines do not invariably broaden out on both sides shows that the phenomena are not always due to greater pressure. The F line always widens on both sides, when the pressure of the hydrogen is increased. In observing a spot very near the sun's limb, Mr. Lockyer found that the spectrum of the

chromosphere showed that the whole adjacent limb was covered with prominences of various heights blended together. These prominences seemed to be fed, as it were, from the preceding edge of the spot as C. F and the line near D were very bright on the sun itself. In the prominences C and F were strangely irregular, and the magnesium lines were seen far above the spectrum of the limb. Mr. Lockyer infers that a portion of the upper layer of the photosphere had been lifted up beyond the usual limits of the chromosphere. The vapor of sodium was also present in the chromosphere, in which Mr. Lockyer also for the first time saw the iron lines.—*Proc. Royal Society*, xvii, 350, 415. W. G.

2. *On the existence of a stratum giving a continuous spectrum between the chromosphere and the sun's limb.*—In a letter to the perpetual secretary of the Academy of Sciences in Paris, SECCHI states that he has seen between the chromosphere and the limb of the sun all the finer rays disappear, and the dark rays D and *b* become almost invisible. The stratum or layer which gives the almost uninterrupted spectrum in this case is extremely thin. Secchi estimates its angular thickness as hardly two or three seconds. The observation stands in great need of confirmation by other observers.—*Comptes Rendus*, lxviii, 580. W. G.

We are indebted to Prof. Winlock for the following interesting notices:—

The light of the beautiful Aurora of the evening of April 15th, examined with the spectroscope, gave five bright lines corresponding in position to the following lines of Mr. Huggins' scale:—

1280 (brightest.)
1400
1550
1680 near F.
2640 near G.

On the evening of June 6th, the same lines were again observed, the brightest corresponding to 1280 of Mr. Huggins' scale. These lines could readily be seen and measured with an ordinary chemical spectroscope, with the collimator pointed directly to the heavens. On the 14th of January, a bright solar line was seen near G, and on May 21st, another line was seen between G and H and between 4420 and 4430 of Mr. Huggins' scale. This is probably the fourth hydrogen line first identified by Angström.

The spectrum of Winnecke's comet, as lately observed, resembles that of carbon. The comet is seen as a bright object, with a telescope of 4 inches aperture. W. G.

3. *On a new alkaloid isomeric with toluidine.*—Previous to 1863 it was supposed that the production of rosaniline required the use only of aniline; but about that time Hofmann showed that toluidine was also necessary. Attempts were then made to obtain these alkaloids pure, in the hope that by their judicious mixture, the yield of coloring matter would be increased. Coupier by carefully fractionating, obtained benzol and toluol pure;

but though the former yielded a pure aniline, the latter gave a toluidine which remained liquid and did not entirely crystallize. notwithstanding its boiling point was exactly 198°, and its elementary composition was that of toluidine. This result was accounted for by the hypothesis that this substance existed in two modifications, one liquid, the other solid. The same anomalies have been noticed in nitro-toluol; that which crystallizes yielding a crystallizable toluidine. Kekulé supposes the crystallization is prevented by some foreign substance; though the Scotch coals yield a toluol completely transformable into the crystallized nitro-toluol. These facts suggested to ROSENSTIEHL the possibility that ordinary toluol is not a single body, but a mixture of two or more isomers. This view was strengthened by Coupier's announcement of the production of a red coloring matter from toluidine alone. He therefore submitted Coupier's toluidine to proximate analysis, founding his method 1st, on the crystallization of the toluidine; and 2d, on the absolute insolubility of its oxalate in ether free from alcohol. On cooling the liquid toluidine to 0° and dropping in a crystal, the mass becomes almost solid; on pouring off the still liquid portion and repeating the operation, more crystals separate; and finally, after 32 per cent has crystallized, the non-crystallizable liquid is converted into oxalate and treated with ether, which leaves behind oxalate of toluidine, while it dissolves the isomeric oxalate. This after recrystallization, yielded, on being decomposed by sodic hydrate, a liquid base boiling at 198°, not giving a red with arsenic acid, and having the formula $\mathrm{C_7H_9N}$. The amount obtained was 36 per cent of the toluidine used. On drying the oxalate at a temperature just above 100°, a body was produced which crystallized from solution in water in long beautiful silky needles, markedly in contrast with the oxalate. On analysis these crystals yielded the formula $\mathrm{C_{16}H_{18}N_2O_3}$, which is that of the oxalate, minus one molecule of water. The body is therefore intermediate between the oxalate and the corresponding oxamid. It possesses the characters of an amid; salts of calcium do not precipitate it; boiling solution of sodic hydrate reacts with it to produce sodic oxalate, setting the base free; at 120° it melts and losing another molecule of water, becomes the true amid which is insoluble in water, is not attacked by sodic hydrate, boils at 240° and volatilizes without decomposition. The compound corresponding to this which true toluidine yields, does not fuse below 220°, is not volatile, but chars when over heated. The base yielded by the new compound is identical with that obtained from the oxalate, and has the precise ultimate composition of toluidine. Rosenstiehl proposes for it provisionally the name *pseudo-toluidine*. It is a colorless liquid when recently distilled, but becomes slowly colored in the air—though less easily than aniline—it has a feeble though peculiar odor, is highly refractive, does not affect polarized light, has a density at 16·3° of 1·0002, boils at 198° when dry, but at 195° if a trace of moisture be present. It appears to be identical neither with methyl-aniline—which boils at 192° and is

colored blue by chlorid of lime—nor with the benzylamine of Limpricht—which boils at 183°—nor with the alkaloid described by Mendius—which distils between 182° and 187·5°. To compare the three alkaloids together, it was necessary to prepare them perfectly pure. The aniline was prepared from Coupier's product, which contained only five per cent of the two other bodies, by transforming it into oxalate and treating this with ether—in which it is extremely insoluble—in a Payen's apparatus for 300 hours. This oxalate, which no longer gave the reaction for pseudo-toluidine, was freed from toluidine by converting it into chlorhydrate and recrystallization. Pure aniline chlorhydrate was thus obtained, 129·4 parts of which required 100 parts of water at 17·7° for solution. Aniline oxalate crystallizes easily in right rectangular prisms, and is the most soluble in water of the three oxalates. Pseudo-toluidine chlorhydrate also crystallizes in the ortho-rhombic system, the crystals having a peculiar tendency to collect any coloring matter accidentally in the solution at their two extremities, the middle being colorless; some of the crystals were violet-red at one end, and a yellowish green at the other. 37·4 parts of this salt dissolved in 100 of water at 15·5°. For the preparation of pure toluidine, the oxalate insoluble in ether left in the preparation of the pseudo-toluidine was submitted to a current of ether as above for 1,000 hours; though even then it contained traces of aniline. Transformed into chlorhydrate and obtained pure by recrystallization, 22·9 parts required 100 parts of water at 11° for solution. It crystallizes in the monoclinic system. In the production of color from these alkaloids Rosenstiehl finds that the solvent as well as the reagent employed, is of importance; the former may be either a mixture of water and ether, or dihydrated sulphuric acid (H_4SO_5); the reagents may be divided into two classes, whose action is diametrically opposite: the one including chlorine and active oxygen, the other nitric acid and the mixtures which produce it. With the first named he proceeds thus: dry aniline is dissolved in sulphuric acid of density 1·84, and a little chromic acid in the same acid is added; on dropping in water drop by drop, an intense blue color is developed which is deepest after the acid is diluted with one half its volume of water. Chromates, permanganates, chlorates, hypochlorites, chlorine, manganic and plumbic peroxyds, electrolytic oxygen and a mixture of nitric and chlorhydric acids may be used as oxydizing agents. The same colorations are given by pseudo-toluidine, but toluidine is not thus colored. If, however, nitric acid be used in the same solution, these reactions are inverted; aniline and pseudo-toluidine give no result, while toluidine is colored strongly blue. This reaction is so delicate that Rosenstiehl proposes it as a test for nitrates; and as chlorates do not give it, it may serve to distinguish these bodies in presence of each other as also from chlorids. In one experiment, 10 grams sodic chlorid and ·01 of niter were mixed together and ·01 grm.—corresponding to $\frac{1}{100}$ of a milligram of nitrate—was

added to the sulphuric solution of toluidine, with the production of a distinct blue zone. If on the other hand, a mixture of water and ether be used as the solvent, then chlorid of lime becomes the most delicate test for the free alkaloids. Aniline becomes distinctly blue even in presence of toluidine, and greenish in presence of pseudo-toluidine. The alkaloid is dissolved in ether, an equal volume of water is added and then chlorid of lime drop by drop, agitating strongly till the color appears. On decanting the ethereal layer into a tube containing water, adding a drop of any dilute acid and shaking, there is developed a magnificent red color comparable to that of permanganate. This is a most delicate test for pseudo-toluidine; neither aniline nor toluidine give it. With regard to the influence of pseudo-toluidine on the production of fuchsine, Rosenstiehl finds that 2 parts pseudo-toluidine and 1 of aniline yield 50 per cent of a red substance undoubtedly isomeric with rosaniline; 1 part pseudo-toluidine and 2 parts toluidine yield 25 per cent; 1 part aniline and 2 parts toluidine yield 39 per cent. To determine the value of an aniline for the production of the red coloring matter, it is sufficient to take its mean boiling point. The same is true for aniline-black.—*Bull. Soc. Ch.*, II, x, 192, Oct., 1868. G. F. B.

II. MINERALOGY AND GEOLOGY.

1. *Extracts from "Report on the Precious Metals;"* by W. P. Blake. (Continued from vol. xlvii, p. 433.)—

Production of gold from placers and from veins compared.—It must be remembered that the production of gold from placers is necessarily transitory and comparatively abnormal, inasmuch as the placer miner takes advantage of the work which has been performed by the grand operations of nature extending over enormous periods of time. He, in fact, "cleans up" gold which has been already mined. The force required to detach the metal from its rocky matrix has been applied. The vein-stone has been broken out and ground up by the power of streams rolling for unnumbered ages over the rocks, and by the resistless power of glaciers, covering the mountains, filling the valleys, and everywhere cutting away the rocks and veins of the mountains, and throwing the fragments into the rivers, there to be ground and distributed by the currents in terraces and bars while the grains of gold settle to the bottom.

To obtain an ounce of gold from a ton of quartz rock requires a certain amount of force. The rock must be broken and ground to dust. The operation is slow and tedious. It may be said, in truth, that every ounce of gold in placers has required the expenditure of force equal to that now required to extract the same quantity from veins. The advantage in cheapness of production which the placer miner has over the quartz miner is thus made manifest. The work of mining and crushing has been performed for him by nature.

As soon, therefore, as placer deposits are comparatively exhausted the miners will be driven to the veins, a normal production of gold will begin, and it may be said, in general, that every ounce of gold wherever produced, will require a nearly equal expenditure of power. Of all metals gold is the most uniform in its mode of occurrence. The conditions in which it occurs in veins are nearly the same in all parts of the world. Its common matrix is quartz, and the percentage of the metal in the vein-stone in all workable veins may be considered as remarkably uniform. Other metals are found in a variety of conditions; sometimes with one matrix and sometimes with another of a very different nature and hardness. They are also in combination with a variety of elements from which it is more or less difficult to separate them, and the quantity of such metals in different veins varies greatly. They may thus be produced in some places or countries very much cheaper than in others. The cost of transportation varies greatly. The conditions of production are so varied and different in different parts of the world, that these metals require in some places much more or less labor than at others, and thus a given weight of the products can never represent a constant or uniform expenditure of labor. Not only mechanical but chemical processes are involved for their isolation. With the metal gold in veins, on the contrary, the conditions are so simple and similar that to produce a given weight of it requires nearly the same amount of labor in any part of the world.* It does not occur like the ordinary metals in great beds and masses, but is disseminated in comparatively small grains in a vast amount of hard rock. The operation of separating it from this rock is simply a mechanical one. The quartz must be crushed and ground, and as the hardness of this mineral is nearly the same all over the world, and as the percentage of gold in all workable veins of it is remarkably even, compared with workable veins of silver or other metals, it will be seen that gold is the best measure or evidence of applied power or labor that we can have. It is this, combined with the other valuable qualities of the metal, its utility, beauty, and indestructibility, and its almost universal distribution† that renders it above all other substances the most appropriate and desirable for money.

Probable rise in the value of gold.—In proportion as the miners exhaust the store of mined gold, which nature has so bounteously deposited in the placers, the gold production will become more equable and constant, and, at the same time, more costly. We may confidently rely upon a large production from veins in the future, especially if such mining is encouraged by suitable legislation. Yet under the most favorable conditions the production of gold from veins cannot be expected to be as great and rapid as it has been from the placers. With this continued decrease in the

* This, of course, is stated in a very general way, and there may be exceptions.

† The distribution of gold may be said to be coincident with the mountain chains of the globe. There is no extended region, no great political division of the globe without its gold fields. It is a notable fact, also, that it occurs chiefly in mountain regions where water-power can be readily obtained for its extraction.

annual production it seems probable that gold will soon begin to sensibly appreciate in value unless some new and unlooked for discovery of placers shall be made, of which, however, there does not appear to be much probability.*

It was argued by Chevalier and others soon after the great discoveries of gold in California and Australia, that gold would necessarily depreciate in value—that its purchasing power was destined to be much lessened by the great influx of the metal from these new sources. But the relative value of gold has not changed as much as was expected, and it would now seem that the supply did not more than keep pace with the ever-increasing demands of commerce and industry, stimulated as they have been by an increased supply of gold. The wonderful increase of the industrial activity of the world, resulting chiefly from the varied developments and applications of the physical sciences, has been sufficient to appropriate all the excessive production of the past 20 years. * * *

Corps of Mining Engineers.—In connection with, and as partly growing out of such a mining college, the government should organize and make provision for a corps of mining engineers, to be filled subsequently by the graduates of the college; the members of the corps to have rank and promotion corresponding with the grades of the corps of military engineers.

Such a body of thoroughly educated men should be charged with the duty of exploration of our mineral regions; with the collection of information upon them; with the preparation of reports upon mineral deposits, and memoirs upon mining and metallurgy, all of which would form the basis for publications at regular intervals, giving to the people such information as would best promote their interests and the national prosperity.

Engineers, so educated and sustained by the government, would be animated by laudable ambition and enthusiasm, and would be strengthened by an *esprit de corps* tending to their moral and æsthetic elevation. They would be in a position to give independent and reliable opinions and advice upon the value of our mineral deposits and the best method of developing them.

Such an organization would open a new and inviting field to our young and enterprising men, the graduates of schools of science, and others, who seek a career in the fields of science.

In view of the recognized necessity of thorough technical education to the highest industrial and commercial development of a nation, the organization of a national corps of mining engineers has an increased importance; for, as already argued in regard to the influence of a mining college, it would have an immense influence in promoting general scientific education, thereby causing an exact knowledge of the fundamental laws of nature to pervade

* The great and at present but imperfectly known gold region of Siberia and China, has already been mentioned. There is in addition to this a possibility of extensive virgin placers being found in Africa; some indications of the existence of a valuable gold region there have already been discovered. Some recent discoveries are reported in Mexico, but these are probably quite local in extent.

the people, and giving them a greater power over our vast material resources.

Another great means of increasing the production of the precious metals is the construction of railways across the country, by which prospectors and supplies can be carried into the heart of what are now comparatively unexplored and unknown mineral regions; and by which machinery can be delivered at moderate cost to extensive regions already known, but remaining comparatively dormant for the want of rapid and cheap communication with the centers of supply both east and west.—page 241.

Government Protection of Mining Enterprises.—It is a primary duty of the government having a public domain of such great extent and wonderful richness to foster and protect mining enterprises, not only in order to promote the production of gold, silver, and ordinary metals, but as one of the best means of stimulating immigration, settlement, and the march of industry in all directions. Mining, considered in its importance to the wealth of the country, is an interest which cannot be neglected in legislation without serious loss.

The veins of gold, silver, and other metals should be regarded as the heritage of the people, and while these veins should be left free to all who choose to work them, they should not be completely abandoned to hap-hazard destructive development. The government should exert over them an intelligent protecting and directing care, and adopt such laws and regulations as will best promote permanent successful mining, preventing waste, the loss of the precious metals by careless and ignorant working, the complication and conflict of titles, and the holding of claims for merely speculative purposes, without any efforts being made to open and work them.

Nearly all the great exhibitions of mineral products in the Exposition illustrated the value of government direction and regulation of mining industry. The most satisfactory and perfect exhibitions were those made under the direction of government mining engineers. The collections were methodical and complete exhibits of the mineral resources of each country, and they were accompanied by maps and sections of mines in detail and by statistical publications prepared with the greatest care every year. The relations of position of the veins of ores and of beds of coal to the geological formations were shown by geological maps and sections and by models on a large scale, showing not only the inequalities of the surface of great districts of country, but the position of the coal beds below the surface, and the location of every mine.

By fostering mining enterprises and by thoroughly educating and training men to conduct them, many countries, whose resources in the precious and other metals are comparatively meager, are successful producers of gold and silver from ores and veins such as in the United States would not be regarded as worth the labor of working. Every portion of an ore is utilized, and valuable products are obtained where without science and skill they would

be wasted in residues. It has been shown in these pages that gold ores produced upon the slopes of the Rocky mountains and found to be "rebellious"—difficult to work—have been transported with profit, in a partly worked state, over the immense plains and across the whole breadth of the States east of the Mississippi, and then shipped across the Atlantic, to be successfully worked at Swansea, in Wales, simply for the want of a proper development of metallurgical science and industry in the United States. We must not lose sight of the fact that we not only send some of our ores abroad to be worked, but that many of our young men are sent abroad to obtain that thorough education and training in government institutions which they are unable to obtain at home.

Importance of a National Mining College.—The establishment of a national mining college would be one of the best or most effcetive means of securing the proper working of the mines and of promoting permanent and profitable mining enterprises, and thus tend to maintain a large production of the precious metals, especially from veins and deep placers, or wherever capital and skill is required. The dissemination of accurate information regarding mineral veins and their contents, and upon the various methods for extracting and reducing the ores economically, would prevent much of the present ill-directed energy and expenditure of time and money, often upon localities where there is little room to hope for success. Such institutions are absolutely necessary to gather the teachings of experience and to place them in a form available to the many persons now interested and yet to be engaged in mining, and to the prospectors who are penetrating our unequaled mineral regions in all directions and are constantly discovering new sources of wealth. The country cannot do too much to sustain and encourage the men who are thus prospecting the unexplored and almost inaccessible portions of the public domain, and to whom we are chiefly indebted for the discoveries which have been made. We should not leave them to labor unaided, but should follow them by organized explorations, by careful examinations of the veins and mineral deposits which they discover, and by the speedy publication of reliable and full information upon them. One of the prominent features of a school of mines should be practical laboratories and metallurgical works upon a moderate scale, in which the students could take practical lessons in the working of ores by all the known and approved methods, including the mechanical preparation of ores, their concentration by water and by fire in furnaces, or their reduction in pans or otherwise. These laboratories would be miniature metallurgical establishments, where ores of all kinds, "docile" or "rebellious," would be received, experimented upon, and treated by the best methods, while the theory of the processes would be fully given and the chemical reactions explained, so that the students would obtain a thorough knowledge and comprehension of the principles involved in the chemical treatment of ores and be prepared to adapt themselves to other circumstances in which they might be placed, when called upon to treat ores in regions remote

from supplies. Such a government mining school would not only directly promote mining industry, but it would greatly increase the amount of exact scientific knowledge among the people, and thus promote, in the most effectual manner, general scientific education, the results of which would be felt in all our industrial pursuits.

2. *Notes on the origin of Bitumens, together with experiments upon the formation of Asphaltum;* by S. F. PECKHAM.—This paper, presented to the National Academy of Sciences at its August meeting by Professor J. D. Whitney, was also communicated by him to the American Philosophical Society on the 2d of October, and has been published in their Proceedings. After alluding to the vague character of the nomenclature used to designate natural hydrocarbons, Mr. Peckham proposes a classification of these substances on the basis proposed in this Journal (II, xxxv, 157) by T. S. Hunt; i. e., their solubility or insolubility in bisulphid of carbon. He would limit the term "Bitumen" to those liquid and solid hydrocarbons thus soluble, as well as to those minerals from which these are derived which are not true coals; the coals themselves being called bituminous. Taking petroleum as normal bitumen, he classifies the derivatives as follows:

Petroleum	Lower derivatives, naphthas, and gaseous hydrocarbons, (by distillation).		
	Higher derivatives (by inspissation or decomposition).	Malthas.	Asphalts.
			Pyro-asphalts.
		--------	Asphaltic-schists.
			Pyro-schists.

Assuming that petroleum is "the primary product of the decomposition of marine animal or vegetable organisms, chiefly the former, and that nearly all other varieties of bitumen are products of a subsequent decomposition of petroleum," Mr. Peckham proceeds to consider the various theories of its origin which have been proposed, and to express his own conviction that it is more largely animal in its origin than has been supposed, the different varieties being due to the varied forms of animal life from which they originated. This view he considers to be sustained by the fact that while the amount of nitrogen which is found in the paleozoic petroleums is small, (a fact which Dr. Hunt attributes to the low character of the animal life at that time, the tissues of these animals being "destitute of nitrogen and very similar to the woody fiber of plants,") the tertiary petroleums which are associated with abundant fossil remains of higher animals, are rich in nitrogenous matters. Such are the Miocene products of Southern California and of the Baku region of the Caspian Sea. The different hypotheses are then enumerated at length; Bischof's as modified by Hunt, is possible as a matter of theory; but Mr. Peckham maintains "that petroleum has never been observed under such circumstances as to leave no possibility of a doubt that it was derived from wood." Wood has been changed to lignite in historic times, it is true; but never to petroleum, which seems to argue the neces-

sity of a peculiar decomposition to the production of this substance; a decomposition requiring conditions which not only are not now present, but such as never were universal. Destructive distillation may form petroleum from either vegetable or animal matters; but we have no right to assume that anything analogous to this has ever been active in nature. As to Lesquereux's view that early petroleums are derived from marine algæ, Mr. Peckham thinks that while it is possible, it cannot be established; since the differences in composition between this and the animal life of the deep sea "are too slight to admit of any nice theoretical distinctions being drawn respecting the products of their decomposition." Berthelot's synthetical theory, he dismisses as insufficient to account for the different varieties of petroleum in different countries, or for the uniformity of the product in the same general locality.

Too much weight has been given to identities observed between petroleums from various parts of the earth's surface. Because Warren and Storer have shown the same proximate principles in Rangoon and Pennsylvania petroleum, "it must not be taken for granted that all petroleums contain those principles." Moreover, the denser portion of neither has yet been studied; and this, which in Pennsylvania petroleum amounts to 30 per cent, rises in other samples to 70 per cent. The theory of the animal origin of these products, on the ground of their gradually increasing content of nitrogen as we pass upward in the geologic scale, is the only one competent to account for the facts. Chemically, it of course is possible; and the geologic association of petroleum with animal remains, as in the Lias of England, the Silurian of Canada, and the Miocene of California, strengthens the argument derived from the highly nitrogenous character of the petroleum itself. That the phosphorus and sulphur of animal tissues is not found in the hydrocarbons, is to be attributed to their easy oxydation and removal by water; though in California, sulphur and sulphuretted hydrogen are of frequent occurrence.

In view of the foregoing facts, viz: (1) that petroleum is the primary product of the decomposition of organic matter, and (2) that this matter is chiefly animal, Mr. Peckham divides all the different varieties into two groups. The first group forms asphaltum by inspissation, if at all; it contains paraffin, and all the products of its distillation contain this substance. This group—which he designates as "Class *A*"—is represented by the petroleums of Oil Creek and vicinity, Pennsylvania. The second group yields asphaltum by decomposition; it does not contain paraffin, nor do its distillates. This group—"Class *B*"—includes the petroleums of Southern California. "Naphtha" is a term which he applies to "those extremely volatile and slightly colored mineral oils which are occasionally met with in different localities, and which are evidently the product of a distillation carried on by natural processes." "Maltha" is allied to tar, and is particularly distinguished from petroleum by its viscidity and by the difficulty of freeing it from mechanical admixture with liquid or gaseous impurities. The same causes which produce maltha from petroleum,

will, if continued, produce solid asphaltum; and this whether the petroleum be of class *A* or *B*. Asphaltum and pyro-asphaltum are pure amorphous bitumens, having a conchoidal or angular fracture; the former is soluble in bisulphid of carbon, the latter not. Asphaltic schists and pyro-schists are produced either by the saturation of pervious strata with petroleum, or by admixture of earthy with the organic matter, and subsequent conversion into asphaltum. Under one of these heads is included all bituminous minerals containing an excess of earthy matter.

As to the formation of asphaltum by simple inspissation of the petroleum of class *A*, Mr. Peckham suggests that the small deposits found in rock-cavities may have been thus formed; but he is inclined to attribute the production of so-called inspissated petroleum, like the albertite for example, to "the distillation of asphaltic or pyro-asphaltic schists, at a very low temperature." Asphaltum from decomposition of the petroleum of class *B*, forms enormous deposits in Southern California, where every form of bitumen of this class is found, except naphtha, pyro-asphalts and pyro-schists. Light petroleums of a beautiful green color pass through every degree of blackness and density to solid asphaltum; but none of these either contain paraffin or yield it on distillation. Study of these deposits had convinced him that even in that warm climate, such changes could not be produced by inspissation.

Two points were experimentally investigated: 1st, the amount of nitrogen in the California, as compared with the Pennsylvania oil; and 2d, the action of oxydizing agents on both these varieties. The former oil taken nine months previously, yielded 1·105, 1·0165, 1·0855 per cent of nitrogen in the three samples; one of maltha gave ·5645 per cent. Three samples of Pennsylvania oil, taken five months before, gave only ·1912 per cent as a mean. One year later, the first sample above given yielded only ·48775 per cent. A sample of Mecca oil gave ·230 per cent, and one from West Virginia ·054 per cent. The oxydation of the petroleums was attempted by means of ozone, obtained from dry potassic permanganate and sulphuric acid. The Pennsylvania oil underwent no change, while that from California deposited a large amount of solid bitumen, which had all the properties of an asphalt.—*Proc. Am. Phil. Soc.*, x, 445.

3. *Paleontology of the Geological Survey of California*, J. D. Whitney, State Geologist. Vol. II, Cretaceous and Tertiary fossils by W. M. Gabb. pp. 300, large 8vo, with 36 lithographic plates of fossils. 1869. Published by authority of the Legislature of California.—The descriptions of the Cretaceous fossils in this volume by Mr. Gabb are in continution of those of vol. I. A large number of new species are here described and figured, including some new genera, and in addition other species from Sonora, Mexico. Prof. Gabb has been led by his investigations to a new subdivision of the formation in California, a brief statement of which is here taken from the Preface of the volume by Prof. Whitney.

"The Cretaceous formation is found covering large areas on the west coast, from Vancouver and the adjacent islands of the San Juan Archipelago, on the north, through Washington Territory and Oregon to Southern California, as well as isolated patches in Eastern Oregon and in Mexico. Except that in Mexico, which seems to be an extension of one of the best known members of the Texan Group, it is divided into four groups, as follows:

"1st. The Tijon group, the most modern member, the division B. of Paleontology, vol. I, is peculiar to California. It is found most extensively developed in the vicinity of Fort Tijon and about Martinez. From the latter locality it forms an almost continuous belt in the Coast Ranges to Marsh's, fifteen miles east of Mt. Diablo, where it sinks under the San Joaquin plain. It was also discovered, by the different members of the Survey, at various points on the eastern face of the same range, as far south as New Idria, and, in the summer of 1866, by Mr. Gabb, in Mendocino county near Round Valley, the latter locality being the most northern point at which it is yet known. It is the only coal-producing formation in California.

"This group contains a large and highly characteristic series of fossils, the larger part peculiar to itself, while a considerable percentage is found extending below into the next group, and several species still farther down into the Chico Group. Mr. Gabb considers it as the probable equivalent of the Maestricht beds of Europe.

2d. The Martinez Group is proposed provisionally, to include a series of beds of small geographical extent found at Martinez on the northern flank of Monte Diablo. It may eventually prove to be worthy of ranking only as a subdivision of the Chico Group.

3d. The Chico Group is one of the most extensive and important members of the Pacific coast Cretaceous. Its exact relations with the formation in Europe have not yet been fully determined, though it is on the horizon of either the Upper or Lower Chalk, and may probably prove to be the equivalent of both. It is extensively represented in Shasta and Butte counties and in the foot hills of the Sierra Nevada as far as Folsom, occurring also on the eastern face of the Coast Ranges bordering the Sacramento valley, at Martinez, and again in Orestimba Cañon in Stanislaus county. It includes all of the Cretaceous of Oregon and of the extreme northern portion of California, and is the coal-bearing formation of Vancouvers Island.

4th. The Shasta Group is a provisional name, proposed to include a series of beds of different ages, but which, from our imperfect knowledge of the subject, cannot yet be separated; it includes all below the Chico Group. It contains fossils, seemingly representing ages from the Gault to the Neocomien, inclusive, and is found principally in the mountains west and northwest of the Sacramento Valley. Two or three of its characteristic fossils have been found in the vicinity of Monte Diablo, and one of the same species has been sent from Washington Territory, east of Puget's

Sound. Few or none of its fossils are known to extend upward into the Chico Group."

The section on the Tertiary also contains many new species, and Part III a synopsis of all the species which have been hitherto described from Oregon as well as California.

The Survey has also issued a large map of the vicinity of the Bay of San Francisco, on a scale of two miles to an inch, and it has other volumes in preparation. A catalogue of the series is given on page 151.

The geological survey of California has been suspended by the State: we trust, however, only temporarily. The admirable style of the publications thus far issued, their excellent science, and the great value of the results, in all these respects unsurpassed by any other of the geological surveys of the country, may well gratify the pride of the State, and lead it to continue the work until all its departments are completed.

4. *Reliquiæ Aquitanicæ;* being contributions to the Archæology and Palæontology of Périgord and the adjoining provinces of Southern France, by EDOUARD LARTET and HENRY CHRISTY. Edited by Thomas Rupert Jones, Prof. of Geology, &c., Royal Military College, Sandhurst. Pages 95–102; 97–112, Plates A. XXI–XXIV. XV–XVI. London: (H. Baillière.)—We cite here a few paragraphs from Chapter ix by Prof. Paul Broca, General Secretary of the Anthropological Society of Paris, on the human skulls and bones found in the cave of Cro-Magnon, near Les Eyzies, referring to the work itself for more details.

"No discovery could be of greater interest to Anthropologists than that of these bones. It is the complement, I may say the crowning, of the important discoveries made by M. Edouard Lartet and his lamented collaborator Henry Christy in the Caves of Périgord, especially in that of Les Eyzies. The objects found in these Caves not only furnished us with the most satisfactory proofs of the contemporaneity of Man and the Mammoth, but they revealed the most curious details of the life and manners of the old Cave-dwellers of Périgord; still we were without any knowledge of the anatomical characters of this intelligent and artistic race, whose clever carvings are objects of our astonishment.

"The excavations lately made near Les Eyzies, by M. Louis Lartet, enable us to supply this want; and there cannot be any doubt of the authenticity and high antiquity of the human bones there exhumed. The stratigraphical details of the contents of the Cro-Magnon Cave, furnished by M. Louis Lartet (see the work, pages 62–72), prove that the human bones are not only as old as, but even perhaps older than, the carved objects from the great Les-Eyzies Cave. The latter corresponds with the period when the Reindeer predominated in the Fauna; whilst the former belong rather to the period of the Mammoth; and though a considerable time must have elapsed between the two periods, yet there is nothing to hinder the belief of the gradual passage from one to the other, without any ethnic revolution, the same race maintaining itself in the

same district uninterruptedly; so that, if the bones from Cro-Magnon are not those of the artists of the Reindeer Period, they are at least those of the ancestors of that people.

"The remains of the men of the Quaternary Period that we have hitherto been able to study belonged, for the most part, to individuals of short stature, with a rather small cranium, and a more or less prognathous face. Hence it has been concluded that the primitive population of Europe belonged to a Negroid race, according to some, and according to others to a Mongoloid race, whose stature did not much exceed that of the modern Laps. The facts on which this opinion rests I take as exact; but it rests also on a preconceived idea, which, for my part, I have long combated—namely, that in Quaternary Europe there was only one race of Men. Starting with the ethnogenic theory, that the diversity of the human race is produced by the influence of time and circumstances, the holders of the above-mentioned opinion admit that the typical differences ought to be less and less as we look back to past ages; and when the Polygenists object that the separation of the principal groups of races was already complete in the earliest historical times, they are told that it was not in those times, so close to our own, but in the immense and incalculable preceding periods that the divergences from the original type were manifested. Reduced to these terms, the question of the unity of the human race is adjourned to the time when Paleontology shall have discovered the remains of primitive man, or at least relics of the races of the Quaternary Epoch. The Monogenists suppose that these races, separated from us by thousands of ages perhaps, and for certain infinitely nearer to original man than the most ancient of the historic races, ought to present, if not an absolute uniformity, at least a manifest convergence toward the type of the common mould whence, they believe, all the races came.

"It comes to this, however, (and it is usually the case,) that facts begin to contradict a preconceived hypothesis. The Quaternary race of Dordogne (Cro-Magnon) differs from the Quaternary race of the Belgian Caves, as much at least as dissimilar modern races differ one from another. The contrast is complete, not only when we look at the conformation and volume of the head, but also if we look at the form and dimensions of the bones of the limbs."

5. *Report on the Mineral Resources of the States and Territories west of the Rocky Mountains;* by Rossiter W. Raymond, Special Commissioner of Mining Statistics, Treasury Department. 256 pp. 8vo. Washington, 1869. (Government Printing Office.)—This report is a continuation of, or a supplement to, the Report of Commissioner Brown noticed in this Journal, vol. xlvi, p. 430. Mr. Raymond was appointed to the position of Commissioner, April 1st, 1869; and as he was obliged to submit his report in October, he had but a few months in the field. He seems, however, to have made excellent use of the time at his disposal: and in his notes on California, Nevada, Idaho, Montana, Utah, and Arizona, he has given, in a very systematic manner, the leading

facts with regard to the present condition of these states and territories. His report is illustrated with sections of a large number of the principal quartz mines, which aid materially in comprehending the character and extent of the veins and workings.

Mr. Raymond also devotes 40 pages to the discussion of the relations of government to mining, stating the mining laws of different countries. In addition, he has several chapters on mining education, with a sketch of some of the principal mining schools of Europe. The following estimate of the annual product of bullion for 1868 is given by the commissioner:

California,	$22,000,000
Nevada,	14,000,000
Montana,	15,000,000
Idaho,	7,000,000
Washington and Oregon,	4,000,000
Arizona,	500,000
Colorado and Wyoming,	3,250,000
All other sources,	1,000,000
	$67,000,000

being a decrease of $8,000,000 from the product of 1867; a portion of this is, however, accounted for by the fact that the previous commissioner estimated the bullion from unknown sources at $5,000,000, whereas here it is reduced to $1,000,000. For further particulars we must refer to the report, which will well repay perusal. We understand that the author's edition of the report can be obtained from D. Van Nostrand, publisher, in New York.

6. *On a transparent Wolfram;* in a letter from Mr. DesCloizeaux to J. Lawrence Smith. (Communicated for this Journal.)—"I found last summer a Wolfram of Bayonka in the Ural, of which the composition is—

Tungstic acid,	74·32
Oxyd of manganese,	20·90
Protoxyd of iron,	2·11
Lime,	1·30
Silica,	0·28
	98·99

Density 7·357. This is about the composition of hübnerite; besides, this wolfram is transparent in very thin layers, and I was enabled to establish that the bisectrix of the optical axes is notably oblique to the vertical axis about 20°, which confirms my previous observation made on very small crystals from the neighborhood of Limoges, that the form of wolfram is clinorhombic, and that the primitive form is a rhombic prism very slightly oblique. I suppose that the hübnerite is also trans parent." [Hübnerite is transparent, and is hyacinth-red in thin scales.—G. J. B.]

7. *On the Descloizite of the Wheatly mine, Pennsylvania;* by J. Lawrence Smith. (Communicated for this Journal.)—I submitted a short time since some small crystals of the vanadate

of lead which I found at the Wheatly mine near Phœnixville, Penn. (see this Jour., II, xx, 247, 1855.) They were the best crystals that had been discovered, except two or three a little larger, that were placed in the hands of a crystallographer, who misplaced them before they were examined. The results of Mr. DesCloizeaux's observations are contained in the following communication to me.

"I have examined your crystals of Descloizite. They are truly very small, and somewhat confused; I have, however, recognized as the form a rhombic table. This has the angle approximatively of $m:n=$ 4° to 65°, which corresponds to the angle of the prism adopted by me for Descloizite. This character, in connection with your analysis seems to make it *more than probable* that the mineral you found at the Wheatly mine is really Descloizite."

8. *Geological Survey of Indiana.*—The Legislature of Indiana has made an appropriation for a Geological and Natural History Bureau, in connection with the State Board of Agriculture. The bill creating this bureau provides, also, for a geological survey of the state, and for building up a scientific museum at Indianapolis. Prof. E. T. Cox has been appointed, by the Govornor, state Geologist, to take charge of this department and has already commenced work. We anticipate very important results from the survey under the superintendence of this able geologist.

9. *On a new locality of Franklinite;* by Wm. A. Fonda.—A vein of Franklinite has been opened at Centerville, 5 miles above Paterson, on the side of "Second Mountain." The ore has the same general characteristics with that obtained from the Stirling Hill and Franklin furnace mines. The gangue is rhodonite, and calc spar in some specimens.

10. *Révue de Géologie pour les années*, 1866 *et* 1867, par M. Delesse, Ingénieur en chef des Mines, Professeur de Géologie a l'Ecole Normale, etc., et M. DeLapparent, Ingenieur des Mines, Secrétaire de la Société Géologique de France. 304 pp. 8vo. Paris, 1869.—This volume is the sixth in the series of Reviews of the progress of Geology prepared by Delesse and Lapparent. Like its predecessors, it gives pretty full abstracts of various papers on Lithological, Dynamical and Stratigraphical Geology, especially those by European authors, with brief references to many on paleontology.

11. *Etudes sur le Métamorphisme des Roches*, par Delesse, Ingénieur des Mines, Professeur de Géologie a l'école normale, etc. Ouvrage Couronné par l'Académie des Sciences. 92 pp. 8vo. Paris, 1869.—This work is a reprint of one of the memoirs of Delesse upon metamorphism. It reviews and discusses the bearings of a large number of facts bearing on the subject, and may be perused with profit by those interested in that department of geology.

12. I. *Réapparition du genre Arethusina* Barr.; II. *Faune Silurienne des environs de Hof, en Bavière;* par Joachim Barrande.—Each of these valuable memoirs by Barrande is illustrated

by a plate. The first presents new facts bearing on his view as to the reappearance of types; and the second describes several new Trilobites, Pteropods, Brachiopods and Cystidea from the Silurian beds of Hof, besides a comparison of the Silurian beds of Hof with those of Bohemia.

III. ZOOLOGY.

1. *On some of the more recent works upon Annulata.*—Since the appearance of the Familien der Anneliden of Grube in 1856 no general work upon the same subject has been published, but a large number of monographs bearing upon the development, anatomy and the classification of different families of Annulata have appeared at various times, and are scattered through scientific journals. It was a most propitious time for any one having access to large collections to review the material accumulated and write a general work upon the subject. This has been done in part by Ehlers* who went nearly over the same ground as Grube, while Quatrefages† has taken up all the orders, which, according to the title of Ehler's monograph, did not come within the scope of his work. Both profess to give the present condition of our knowledge of these animals. Ehlers' work is based upon the study of the species to which he had access from collections made principally in European seas, though as assistant to Professor Keferstein he has had access to the collections of the Göttingen Museum and those of the Museum of Comparative Zoology of Cambridge. His work consists of monographs of the different species to which he has had access, connected by general remarks, and illustrated by excellent plates; the whole of the descriptions and illustrations are thorough and most accurate and his minute knowledge of what has been done in his department will leave the student but little to hunt for himself.

The volumes of Quatrefages can more strictly be called a revision of the Annulata, based upon the many memoirs which the author has published at various times concerning the anatomy, development and systematic zoology of the class. The plates are entirely original, having all been drawn from nature by the author himself, and form a striking contrast to the customary rehash we usually find in general text books in most departments of natural history. We can fairly take it as an excellent guide for the determination of Annulata, and it will take its place by the side of the capital works of Milne Edwards on Crustacea and Polyps, published in the same series. It is however somewhat unfortunate that many species hitherto unknown should have been described by Quatrefages from alcoholic specimens, when the careful study even of the living specimens of this class is subject to so many difficulties and likely to encumber us with additional synonyms for

* Dr. E. Ehlers, Die Borstenwürmer, Pt. I, 1864, Pt. II, 1868.
† A. de Quatrefages, Histoire Naturelle des Annelés, 1865.

want of authentic specimens for comparison. Nor has the author always paid sufficient attention to the labors of some of his predecessors, having allowed a number of prominent memoirs by Skandinavian naturalists to escape him altogether.* The nomenclature introduced by Quatrefages is on the whole very acceptable; the statement he makes of several histological and anatomical points is somewhat meager, the results of various German writers bearing on the subject having escaped his attention, and thus due credit is unintentionally not always given to the original investigator. The chapter on the respiratory apparatus and its functions is particularly defective and we must go back to the exposition given by Grube and Delle Chiaje for the proper interpretation of the process of respiration. We owe to Quatrefages the first attempt at a geographical distribution of Annelids, though the Faunal works which have appeared since the publication of his treatise, show that he has given too narrow limits to his Faunæ, and that we must have a larger amount of material than can be collected from the observations of Schmarda,† of Grube‡ or of Kinberg,§ as the results of various scientific explorations in different parts of the globe, before any satisfactory conclusions can be reached. We must look forward to many such Faunæ as we now have in the beautiful memoirs we owe to Malmgren‖ on the Northern Annelids and to Claparède¶ for the Annelids of the coast of France and Italy before we can begin to theorize on the subject. Our knowledge of Annulata is by far too incomplete, and no field offers a richer reward. There is no coast which when explored carefully will not amply repay its explorer, and no district, however poor in appearance, where a rocky point cannot be found which will reward the search; when such observations are accompanied by bathymetrical figures of distribution like those of Malmgren they are doubly valuable, and we may soon hope with the expected Reports on the Deep Sea Fauna of the English, Swedish and American expeditions, to have a good basis for a bathymetrical distribution of the Annelids of the Northern Atlantic, added to what data we have from our own coasts and the European coasts of the Atlantic in memoirs already published and the collections of the various Museums of the new and old world.

The difference to be noticed in the number of species enumerated by Malmgren in his two memoirs and the old fauna of Œrsted covering nearly the same ground, gives us a fair criterion of what we may expect from a thorough exploration of our own coast. Even on the well explored coast of Europe we find that valuable

* Particularly the monograph of Kinberg in Eugenies Resa and the smaller notices of Sars on Northern Annelids, which contain much of importance.

† L. K. Schmarda, Neue Wirbellose Thiere.

‡ E. Grube, Die Anneliden d. Novara Expedition.

§ Kinberg in Eugenies Resa.

‖ Dr. Malmgren, Annulata polychaeta Spitzbergiae, 1867; Nordiska Hafs Annulater, 1865.

¶ E. Claparède, Annélides Turbellariés, Opalines, 1861; Anatomie des Oligochètes, 1862; Glanures Zootomiques, 1864; Beobachtungen ueber Wirbellose Thiere, 1863; Annélides du Golfe de Naples, 1868.

additions are made by any careful investigator. This is most strikingly illustrated in the late publications of Claparède, who has within the last few years enriched our literature with the best monographs on annelids, full of new matter on their anatomy, classification and development, and written with constant reference to all that has been done on the subject previously to him. His memoirs are always well illustrated, his last paper on the annelids of Naples containing no less than 32 exquisitely drawn plates. His criticisms invariably show an exhaustive acquaintance with the subject, though he is at times somewhat too severe when analyzing opposing views.

We are now fast accumulating materials toward a natural classification of Annulata. The affinities of the various orders as understood by Schneider‡ are a great step in advance of our present systems, as also the emancipation from the consideration of such characters as were used by Grube in his classification, and which have until recently received such universal recognition. The late embryological investigations of Claparède, Krohn, Schneider, A. Agassiz, Kovalewsky, Keferstein, Knappert, Fritz Müller, Mecznikow† have done much toward clearing up the affinities of many families of Annelids, while the memoirs of Bastian‡ and Ebert§ on Nematods, of Van Beneden‖ and of Van Beneden and Hesse¶ and Krabbe** on intestinal worms and on Nematods; of Keferstein†† on Sipunculids and the various Reports of Williams on British Annelids, have immensely enlarged our previous acquaintance of this subject. Bastian's attempt to prove the affinities of the Nematoids to Echinoderms on anatomical grounds, and thus bring up again the view taken originally by Huxley of the affinities of Annulata and Echinoderms, has found no supporter except Haeckel; he has, however, never paid special attention either to Annulata or Echinoderms, and merely adopts this view in his Generelle Morphologie, as a convenient one for his tables of genealogical descent. As handbooks of Entozoa we must specially mention Cobbold's Entozoa, which, though not having much claim to original matter, yet will be found an excellent compendium, faithful, accurate and well illustrated, and written with full references to what has been done in this field up to the present time. Leuckart's "Menschliche Parasiten" has reached the second part of the second volume, and like every thing coming from the pen of that most accurate investi-

* A. Schneider, Die Nematoden, Berlin, 1866.

† I do not cite the titles of these shorter papers; they will be found in Wiegmann's Archiv; Zeitschrift f. Wiss. Zool.; Müller's Archiv; Mem. Acad St. Petersburg; Annals Lyceum Nat. Hist., N. Y.; Journal Bost. Soc. Nat. Hist; Acad. of Utrecht.

‡ C. H. Bastian, Anguillulidæ, Trans. Lin. Soc., xxiii; Anatomy and Physiology of Nematoids, Trans. R. S., 1866.

§ Ebert. Die Nematoden.

‖ Van Beneden. Vers Intestinaux, Paris, 1858.

¶ Van Beneden and Hesse. Recherche sur les Bdellodes, 1862.

** Krabbe, in Trans. Dansk. Acad., v, vi.

†† W. Keferstein, Sipunculiden in Zeit. f. W. Zool., 1865.

gator, it promises to be an exhaustive handbook full of original observations. The text is abundantly illustrated by woodcuts.

It may not be out of place to close this notice, by referring to two short but capital papers on the development of Bryozoa,* which throw considerable doubt on their systematic position. With the exception of Leuckart, almost all naturalists have homologised Bryozoa and Brachiopoda to their complete satisfaction, and they are universally placed among Mollusks. Smitt's paper on the development of Bryozoa gave Leuckart an opportunity to reaffirm his views with considerable force, and now he receives the support of Schneider,† who in a memoir on the development of Cyphonantes into Membranipora has attacked the subject from a new point of view, and has homologised, apparently, the larva of Membranipora with undoubted Annulate larvæ (Actinotrocha). For the final solution of this exceedingly interesting question, we must look to the development history of a greater number of Bryozoa than we know at present. A. A.

2. *Mémoires pour servir à la Connaissance des Crinoïdes Vivants ;* par Michael Sars. Programme de l' Université royale de Norvège. 66 pp. 4to, with 6 plates.—Christiania, 1868. (Imprimerie de Brogger et Christie). In the first part of the memoir the author gives an elaborate and careful description of the external appearance and anatomy of a very interesting new genus of attached crinoids (*Rhizocrinus Lofotensis*), which is one of the numerous new forms brought to light by the deep-sea dredgings of Mr. G. O. Sars, at the Islands of Lofoten and on the coast of Norway. This species occurred at depths ranging from 100 to 300 fathoms, and appears to be gregarious, and rather abundant in its localities since 75 specimens were obtained. It is a small species, with a long crooked stem, attached only by numerous lateral root-like cirri, which are scattered along the lower portion. The joints of the stem are elongated and articulated as in *Bourguetocrinus*, but appear incapable of motion; the upper joint is enlarged, obconic, and forms the lower part of the head. The arms are undivided, usually five, but vary from 4 to 7; their length in the largest specimens was 10 to 11^{mm}, or about one seventh the length of the stem. The pinnulæ are few, alternating on the two sides, the lower ones shorter and in one specimen swollen, containing the reproductive organs. The mouth is circular, in the center of the disk, surrounded by a circle of tentacles, two corresponding with each tentacular groove, alternating with two interradial ones. The mouth and tentacles are enclosed by movable, valve-like, prominent laminæ, corresponding in number and position with the interradial areas of the disk, and strengthened by a fine calcareous network. Reticulated calcareous plates are also scattered through the membrane of the disk. The anus is a simple circular aperture through the membrane of the disk, in one of the interradial regions, midway between the mouth and the edge of the disk, not

* F. A. Smitt. Hafsbryozoernas utveckling och Fettkroppar. Stockholm, 1865.

† A. Schneider. Zur Entwickelungsgeschichte und Systematischen Stellung der Bryozoen und Gephyreen, 1869.

prolonged into a tube. It is, in fact, according to Mr. Sars, a degraded type of the family of Apiocrinidæ, having most affinity with *Bourguetocrinus*, and forming so to speak the transition from the Apiocrinidæ to the living genus, *Antedon* (*Comatula* Lam.), and especially to its larval state (Pentacrinoid).

This new form* presents many features of interest and will doubtless throw light upon some obscure and doubtful points in the structure of fossil crinoids. So far as its anatomy bears upon the points discussed in the articles of Mr. Meek and Mr. Billings, it appears to confirm the views of the former in regard to the positions of the mouth and anus of the fossil forms. For if we imagine the convergent valves around the mouth to be enlarged and united together over it by their edges and summits, we should have nearly the structure made out by Mr. Meek.

The second part of the memoir is devoted to a description of the Pentacrinoid state of *Antedon Sarsii*, illustrated by two elaborate plates. v.

3. *Contributions to the Natural History of the Bermudas, Coralliaria;* by J. Matthew Jones. (Proc. and Trans. of Nova Scotian Inst. of Nat. Science, vol. ii,) Halifax, June, 1869.—The author enumerates 13 species of corals, found at the Bermudas, and gives accounts of their mode of occurence, etc. The species are as follows: *Isophyllia dipsacea* Verrill, *Mæandrina cerebriformis* Lam. (=*Diploria cerebriformis* Ewd. and H.), *Siderastræa radians* V., *Oculina diffusa* Lam., *O. varicosa* Les., *O. Valenciennesii* E. and H. (=*O. Bermudiana* Duch. and M.), *Mycedium fragile* Dana, *Porites clavaria* Lam., *Millepora alcicornis* Linn., *Gorgonia flabellum* Linn., *Plexaura crassa* Lamx., *P. flexuosa* Lamx., *Pterogorgia Americana* Ehr. The synonymy is in some cases faulty: thus *Porites conglomerata* is not a synonym of *P. clavaria*, but a more massive species from the East Indies; the massive form referred to as a variety of *P. clavaria* is perhaps *P. astræoides* Les.; *Leptoseris fragilis* is very distinct from *Mycedium fragile*; *Madrepora palmata* Lam., *M. muricata*, var. Esp. and *M. alces* Dana are not synonyms of *Millepora alcicornis*, but true Madreporæ,—the first being a large and common species from the Florida reefs and West Indies. Further exploration will doubtless add quite a number of additional species. I have already seen Bermuda specimens of *Isophyllia rigida* V., *Plexaura homomalla* Lamx., and *Pterogorgia acerosa* Ehr., in addition to those enumerated. v.

4. *Occasional Papers of the Boston Society of Natural History, Vol. I. Entomological Correspondence of Thaddeus William Harris, M. D.* Edited by Samuel H. Scudder, Boston, 1869. 8 vo. with cuts and five plates, pp. 375.—This valuable volume is interesting, both on account of the numerous accurate observations upon the structure, habits, transformations, and classification of insects, with which it is replete, but also for the pleas-

* This species is regarded by Prof. Agassiz as identical with the crinoid dredged by Pourtales in 237 to 306 fathoms off the coast of Florida, and described under the name of Bourgueticrinus Hotessieri *D'Orb.* in the Bulletin of the Museum of Comp. Zoology, p. 120, Dec, 1868.

ing picture it gives us of the private life and character of one who must always rank high among American Naturalists. It contains a biographical sketch of Dr. Harris, by Col. T. W. Higginson, accompanied by a steel engraving; his entomological correspondence with Hentz, Melsheimer, Doubleday, Herrick, J. L. Le Conte, Miss M. H. Harris, Thomas Say, and others; descriptions of larvæ and their habits; unpublished descriptions of various mature insects; and republications of several of his rarer and most inaccessible papers. The plates are well executed, from drawings made by Harris, or formerly in his possession. The volume is accompanied by a copious index, which adds greatly to the utility of the work. V.

5. *The Butterflies of North America, with colored Drawings and Descriptions;* by Wm. H. Edwards. Part 3, quarto, with five colored plates. Philadelphia (American Entomological Society).—The third part of this admirable work excels, if possible, in the accuracy and beauty of the figures the two previous parts. The plates include 24 figures, illustrating *Argynnis monticola*, *A. Halcyone*, *Limenitis Proserpina*, *Lycæna violacea*, *L. Lygdamus*, *Thecla læta*, and *T. Acadica*. A synopsis of North American Butterflies, with synonymy, is commenced in this part, which will prove of great utility to all students of this interesting group. The author bids fair to do for North American Butterflies, what Audubon did for the birds. V.

6. *American Cervus.* Read before the Ottawa Academy of Natural Sciences, May, 1868; by John D. Caton, LL. D.—In this paper we have a detailed description of the external covering of the deer and elk; and a very interesting account of the phenomena connected with the growth and shedding of their horns, both under natural and abnormal circumstances; together with many observations upon their habits. The author has had excellent opportunities for studying large numbers of these animals in his extensive parks, and has made important additions to our knowledge of these subjects. V.

7. *Observations on the Genus Unio, together with descriptions of new species in the family Unionidæ, and descriptions of new species of Melanidæ and Paludinæ;* by Isaac Lea, LL.D. Vol. XII, 106 pp. 4to, with 26 plates. Read before the Academy of Natural Sciences of Philadelphia, June 2d, 1868, and published in their Journal.—Dr. Lea, in this twelfth volume of his *Observations on the Genus Unio, etc.*, describes 76 species of Unionidæ, 28 of Melanidæ, and one of Paludinæ. Of the Unionidæ, 36 are new North American species, making the whole number of species of this continent recognized by him to be 772. Dr. Lea states that the South American species here included, (which he received in alcohol, from Don Patricio M. Paz of Madrid,) have the same South American characteristics before noticed by him; that is, "round palpi or mouth-lips," and "divergent folds" at the tips of the beaks, neither of which peculiarities has he found, he observes, in any North American species.

We add here that Dr. Lea, on June 9th, read a paper before the Philadelphia Academy, on Unionidæ from the Lower Cretaceous formation of New Jersey, in which he described 10 species, 8 of Unio and 2 of Anodonta. The specimens were furnished him by Prof. Cope. They were from a bed of bluish clay, six miles northeast of Camden, N. J. The bed is subordinate to the Green sand, in which occur the Hadrosaurus and other reptilian remains, besides, in some parts, marine mollusca. Fresh water species had not before been recognized in it.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Remarkable Meteor of May* 20th (from a notice by Prof. E. Loomis in the College Courant of May 29).—A meteor of unusual brilliancy was seen at New Haven and many other places on Thursday evening, May 20th, a few minutes after eleven o'clock. Its light exceeded that of the full moon which was shining at the time, and was generally compared to a vivid flash of lightning; its duration was estimated at five seconds. It left behind a brilliant train of light, and finally exploded, separating into numerous fragments. Its splendor was such as to attract general attention at Philadelphia, Newark, New York, Newburg, Poughkeepsie, New Haven, Hartford, Springfield, Norwich, Worcester, Providence and Boston, and doubtless at numerous other places from which no reports have yet been received.

At New York the meteor was first observed at a point 10° N.N.W. of the star Altair (in Aquila) and it moved in an arc of 30°, to the N. E. According to this statement, the point of origin was about east, at an elevation of 30°, and its termination about N. 60° E. at an altitude of 15°.

At Poughkeepsie, its course was from the south toward the east, making an angle of about 30° with the horizon, and it burst at an altitude of about 15°.

At New Haven it moved from a point somewhat west of south, to a point somewhat north of east, and its altitude when it exploded was estimated at 30°.

At Hartford its course was from S.S.W. to E.N.E.

From these observations it is not possible to assign the actual path with much precision, but it is inferred that the meteor moved nearly horizontally at an elevation of 50 miles above the earth's surface and the length of its visible path was about 200 miles. The point where it exploded was over the Atlantic ocean, somewhat north and east of Boston. The time of flight was estimated at five seconds, which would indicate a velocity of 40 miles per second.

Several observers have stated that the explosion of this meteor was followed by a sound which resembled distant thunder. The distance of the meteor from New Haven at this time was about 170 miles, and sound would require more than ten minutes to

traverse this distance. Any sound which followed soon after the explosion must therefore be ascribed to some other cause than this meteor.

2. *Meteor of May 20th* (from a letter of E. A. Smith, dated Moriches, Long Island, Suffolk Co., N. Y., July 1, 1869).—I have obtained the following facts respecting the meteor of May 20th, from two persons, Mr. and Mrs. Fling, residing at the time at Catchogue, 13 or 14 miles east of Riverhead. Mrs. Fling compared the light to the Drummond light which she had seen in Broadway. The meteor passed from S.W. to N.E., parallel with the front of the house, (which she says points to the S.E.,) and at an altitude half way between the horizon and the zenith. She thought the body of the meteor, which sent off constant scintillations, was about the apparent size of the moon. Mr. F. thought it might be a shade less. The color varied from reddish to purple, though different in different parts and times. In about three minutes after the passage of the meteor, a terrific sound was heard. Not realizing the character of the meteor, Mrs. F. said she first thought it was an earthquake; but on second thought, concluded it must have come from the meteor. It jarred the whole house, doors, windows, &c., to the very foundations. Rev. Thomas Owen, half a mile east of us, says he was just about retiring for the night, when he heard a tremendous jarring sound, and thought it must be a cannon fired from a ship in distress; others corroborate the statement of great noise. I have since conversed with Mr. and Mrs. Clark, very worthy people in Centre Moriches, and their account agrees in all important particulars, with the former by Mr. and Mrs. F. Taking the diameter at 30′, and the distance (from the time 3m.) 39 or 40 miles, the altitude above the earth must have been 28 miles; and the diameter of the body 1843 feet. The velocity must have been very great, probably equal to that of the noted meteor which traversed Europe from N.W. to S.E., about 9½ P. M., Aug. 18, 1783, which it seemed to resemble. The time of occurrence of the late meteor was about 11h. 20m. P. M. (some say 11½).

3. *Aurora Borealis of the evening of April 15th.*—Besides the two articles on the auroral display of April 15th, to be found on pages 65 and 114 of this volume, other accounts have reached us from various correspondents over the country; and also we have, through the European journals, notices of its being widely seen over that continent. We defer to another time a summary of the facts.

4. *American Association for the Advancement of Science.*—The Eighteenth Meeting of the Association will be held in Salem, Mass., commencing on Wednesday, August 18, at 10 A. M. Arrangements are in progress by the Local Committee to make the meeting a scientific success, and a large attendance from all parts of the country is expected.

An interesting feature of the meeting is anticipated in the proposed microscopical gathering, and a large room will be specially

devoted to the display of Microscopes, and all that pertains thereto. The Local Committee respectfully requests all persons having first-class instruments, to bring them to the meeting, and also such apparatus as they have found useful in their manipulation. Agents and makers of Microscopes are requested to bring specimens of their different manufactures.

On the afternoon of the first day of the meeting, the Association will be invited to assist in the dedication of the Museum of the Peabody Academy of Science. The Rooms of the Essex Institute and of the Academy, also those of other institutions of the city, will be open during the meeting.

The meetings of the Association will take place in the several halls of the County Court House, which furnish most ample accommodation for the different sections and committees. The office of the Local Committee will be at the new Court House, where members will be conducted immediately on their arrival in the city.

A circular giving all necessary information relating to the meeting, will be sent to any one requesting it, on application to the Local Secretary. The volume of Proceedings for the Chicago meeting is now nearly printed, and will be ready for delivery at this meeting.

Any person wishing to join the Association can report his name to any of the Secretaries. The entrance fee is $5, and the annual assessment is $3, including the price of the yearly volume of Proceedings.

Farther information relating to the Association can be had by addressing the Local Secretary, F. W. PUTNAM, Salem, Mass.

5. *List of papers read before the National Academy of Sciences at its April Session*, 1869.

1. On the age of beaver dams, by A. Agassiz.
2. On the cooling of the sun and planets, by B. Peirce.
3. On the most plausible reconstruction of the original Apalachian surface, by J. P. Lesley.
4. On the pure phosphate beds of South Carolina, their formation, age and fossils, including the human remains lately discovered, by H. S. Holmes.
5. On a new meridian equal altitude instrument used in the Coast Survey, by J. C. Hilgard.
6. On the deep sea explorations of the Gulf Stream, by A. Agassiz.
7. On tidal researches, by W. Ferrell.
8. On tidal rainfall, by P. E. Chase.
9. On the products of the action of the alkaline nitrites upon uric acid and its derivatives, by Wolcott Gibbs.
10. Upon inversion in Algebra, by B. Peirce.
11. On a mode of examination of potable waters, by Dr. Craig.
12. On the meteorite which fell in Franklin Co., Alabama, Dec. 5th, 1868, by G J. Brush.
13. On a new member of the chrysolite group, by G. J. Brush.

14. On the effects of expansion and contraction in large ice fields, illustrating the formation of anticlinal and synclinal axes in geological formations, by M. C. Meigs.

15. On the great tornado in Iowa and Illinois, June 3d, 1860, by W. L. Nicholson.

16. On earthquake waves and the depth of the ocean, by J. E. Hilgard.

17. On the history and present condition of an investigation of the winds, by Jas. H. Coffin.

18. On the connection between solar spots, the magnetic declination and the exhibition of the Aurora Borealis, by Elias Loomis.

19.* On certain new methods of eudiometrical analysis, with examples of the analytical work done therewith, by B. Silliman and H. Wurtz.

20.* On the effect of atmospheric air in reducing the illuminating power of coal gas, by B. Silliman and H. Wurtz.

21.* On an important modification of the hydrocarbon process for the production of illuminating gas, by B. Silliman.

22. On the physical construction of the sun, by J. H. Lane.

23. On the periodic star η Argus, by Elias Loomis.

V. MISCELLANEOUS BIBLIOGRAPHY.

1. *The Yosemite Guide Book;* A description of the Yosemite valley and the adjacent region of the Sierra Nevada, and of the Big Trees of California. 156 pp. large 8vo, illustrated by maps and woodcuts. Geological Survey of California, J. D. Whitney, State Geologist. Published by authority of the Legislature.—Prof. Whitney has here prepared a model Guide Book, worthy of the State of California and of the remarkable region it illustrates. After general observations on the physical features of California, he treats with much detail of the valley which is the special subject of the work. The routes to the valley and the Big Trees, are given with much detail and other information indispensable to the traveler. He then describes in a graphic style the grand scenery along the routes, the lofty precipices, peaks and waterfalls, mentioning the modes of access to each, and whatever is of popular or scientific interest along the way, closing this chapter with observations on the origin of the wonderful valley. The High Sierra, the Alps of California as sometimes called, where there are traces of ancient glacers of vast extent and probably the highest mountain peaks of the Continent north of Mexico, is the subject of the next chapter; and here also there is that combination of special practical information with regard to routes, grand descriptions of scenery, and able discussions of the physical geography and geological structure of the region which could be given only by Prof. Whitney, the Geologist of the California Survey. The highest summit was first ascended by Clarence King and named by him Mount Whitney: he found the height of the point he reached

* These papers were read by title only.

14,740 feet, with 300 or 400 feet of inaccessible rocks still above him. (See this Jour., xxxix, 10.)

The work contains two admirable maps, one, of the part of the Sierra Nevada adjacent to the Yosemite valley, from surveys made by Charles L. Hoffman and James T. Gardner, the other, of the Yosemite valley itself, from surveys by Clarence King and J. T. Gardner. The maps are minute in their details of this mountain region, but not more so than is warranted by the thoroughness of the surveys. The volume is published in elegant style, and illustrated by numerous woodcuts representing with great beauty the remarkable scenery of the region. The cuts are from among those used in the first volume of Prof. Whitney's Report on the Geology of California.

The Guide Book has also been issued in quarto form with *photographic* illustrations.

2. *Investigations in the Military and Anthropological Statistics of American Soldiers;* by BENJAMIN APTHORP GOULD, Ph.D., &c., Actuary to the U. S. Sanitary Commission. 655 pp. 8vo. New York, 1869.—This volume is one of the Memoirs of the recent war, prepared under the authority of, and published by, the United States Sanitary Commission. Rarely have circumstances favored the collection of so valuable a mass of anthropological statistics as is here submitted to the study of those who are devoted to this line of research. The investigation is based upon a very broad foundation of facts, the discussion of which has taken a wide range, embracing the consideration of the military population and enlistments in the loyal states; nativity and age of volunteers; age of recruits, statures, complexions, color of hair and eyes; previous occupations; mean dimensions of body; dimensions and proportions of head; weight and strength; pulmonary capacity, respiration and pulse; vision; miscellaneous characteristics, and military service. All of these topics are considered in separate chapters, supported with a vast amount of detail tabulated with immense labor with subdivisions for white soldiers, sailors, students, colored soldiers, Indians, and abnormal cases.

The most interesting data obtained in these extended investigations are laid down upon charts in curves constructed to develop the coördination of the facts classified under the important subdivisions of the work. These charts are admirable examples of the value of this mode of taking general truths from a great mass of details, which appear chaotic even in the best tabular digests compared with the clearness brought out by the geometrical projection of the same data. It is quite impossible without an extended discussion to give any adequate notion of the importance of this addition to anthropological statistics, based as it is on an aggregate of over two millions of men. The conclusions are all brought to the test of mathematical analysis, and a clear idea of the general scope of the investigation is offered by a well digested synopsis of the contents of each chapter at the close of the volume, covering over forty closely printed pages. In the preface Dr. Gould does justice

to his fellow laborers by whose coöperation alone could this laborious work have been brought to a compact and scientific unity.

3. *Modern Practice of the Electric Telegraph. A Handbook for Electricians and Operators.* By Frank L. Pope. 128 pp. 8vo. New York, 1869. (Russell Brothers.)—This is by far the best exposition and discussion of the *American System* of Telegraphic Practice which has fallen under our notice; and does credit to the erudition and practical skill of the author. It is well known that in every art involving the use of scientific principles there are many points of construction and practice familiar to those skilled in the art which are slow in finding their way into scientific literature. Mr. Pope, in his excellent handbook, has given us a clear and exact statement of those features in the American system of telegraphic practice which for the most part are very imperfectly discussed or altogether ignored in the more elaborate treatises of electricians. Mr. Pope modestly disclaims the character of a scientist, but his work shows a degree of familiarity with the principles of science involved in his art, creditable alike to his own knowledge and to the present development in the United States of the important subject on which he writes. The book is clear and unpretending in style, exact and concise in statement, and remarkably well illustrated by original drawings of the apparatus and instruments in use in America. These qualities must secure it a high place and general favor.

4. *The Mississippi Valley; its Physical Geography, including sketches of the Topography, Botany, Climate, Geology, and Mineral resources; and of the progress of development in population and material wealth;* by J. W. Foster, LL.D., President of the American Association for the Advancement of Science, [for the year 1869.] 444 p. 8vo. Illustrated by maps and sections. Chicago, 1869. (S. C. Griggs & Co.)—In this volume the author discourses in a popular style on the physical geography, geology, and resources of the Mississippi Valley. The work does not claim to be the result of original research to any great extent, or to be complete in the treatment of its topics. It is a readable book containing much valuable information. The author does not confine himself to the valley, but has many pages on the general subject of climate, the origin of prairies, etc., and embraces at times the whole country and nation in his widely ranging observations. He closes his work with brief chapters on the influence of climate on man; origin of civilization; colonization and progress of population in the valley; the Indians. The paper, printing and external appearance of the volume are excellent.

5. *The Origin of the Seasons considered from a Geological point of view;* by Samuel Mossman, with a map and diagrams. 472 pp., 8vo. Edinburgh and London. 1869. (Wm. Blackwood and Sons.)—This volume on the seasons contains an indefinite variety of facts or statements from astronomy, geology, physical geography, etc., bearing more or less, often the latter, on the subject of climate in the past and present; and in connection, the au-

thor offers his views and speculations. The author does not appear to be thoroughly acquainted with either of the above mentioned sciences, and quotes many of his geological facts loosely, or without fully understanding them. His speculations accordingly are for the most part not well founded, although presented along with some right views, and in an attractive manner.

6. *Lecture Notes on Physics.* By ALFRED M. MAYER, Ph.D. 112 pp. 8vo.—In the discharge of his duties as Professor of Physics in the Lehigh University at Bethlehem, in Pennsylvania, Prof. Mayer has prepared a clear and concise synopsis of the fundamental principles and notions of physics in accordance with modern views and the recent progress of science, which will be consulted with interest by those whose duties lead them in the same direction. These notes have been republished from the Journal of the Franklin Institute where they have appeared during the past year as a series of articles.

7. *Strength of Iron parts of Steam Machinery.* By J. D. VAN BUREN, Jr., C.E. 70 pp. 8vo. New York, 1869. (Van Nostrand.)—This is an analytical discussion of the formulæ employed by mechanical engineers in determining the rupturing or crippling pressure in the different parts of a machine. The formulæ are founded upon the principle that the different parts of a machine should be equally strong, and are developed in reference to the *ultimate* strength of the material in order to leave the choice of a factor of safety to the judgment of the designer. Engineers will find this a valuable contribution to the literature of their profession.

Publications of the Geological Survey of California.—The publications of the Geological Survey of California issued up to this date, or nearly ready, are as follows:—

GEOLOGY, vol. i, with 525 pages of text, in royal 8vo form, 81 wood engravings and 1 steel plate; containing a Report of Progress and Synopsis of the Field Work, from 1860 to 1864. Price in cloth, $7.50.

PALÆONTOLOGY, vol. 1, with 263 pages of text, and 32 steel and lithographic plates, comprising descriptions and figures of the Cretaceous and Triassic fossils, by W. M. Gabb, and of the Jurassic and Carboniferous, by F. B. Meek. Price in cloth, $7.50.

PALÆONTOLOGY, vol. 2, with 299 pages of text, and 36 lithographic plates, containing the remainder of the Cretaceous and the whole of the Tertiary Palæontology, by W. M. Gabb. Price in cloth, $7.50.

ORNITHOLOGY. The birds of California and the adjacent States and Territories will be described and illustrated in a work now in preparation, which will embrace two volumes. The illustrations of the first of these, including the land birds, are now completed, and the volume is in press and will be ready for delivery before the end of the year. The illustrations are on wood and consist of a full-length figure of one species of each genus, with a diagram illustrative of the details of its external anatomy, and a full-sized figure of the head of each species carefully colored in the text. This mode of illustration is believed to be that best adapted to make the work one of high scientific and practical value, at the lowest possible cost. The work is based on the manuscript and collections of Dr. J. G. Cooper, Zoologist of the Survey, and edited by Prof. S. F. Baird.

MINING STATISTICS, No. 1, comprising a Tabular Statement of the Quartz Mines and Mills between the Merced and Stanislaus Rivers, in 1865, by A. Remond. Price 50 cents.

GEOGRAPHICAL CATALOGUE OF THE MOLLUSCA found west of the Rocky Mountains, between latitudes 33° and 49° North, by J. G. Cooper, M. D., 40 pages (for check list and labels). Price 50 cents.

THE YOSEMITE GUIDE-BOOK. A work in one volume, 8vo, elegantly printed, and illustrated with wood-cuts (taken from Geology, volume 1), and two elaborate topographical maps of the region described, namely the Yosemite Valley and its surroundings. Price in cloth, with maps in pockets, $5.00.

THE YOSEMITE BOOK. Nearly the same text as that of the Guide-Book, and with the same maps; but superbly printed in 4to form with 28 photographs by Watkins, taken expressly for this volume, of which the edition is strictly limited to 250 copies. Only a few copies still on hand. Price, in half morocco binding, gilt edges, $30.00.

MAP OF THE VICINITY OF THE BAY OF SAN FRANCISCO:—scale two miles to one inch, size four feet by three, in two sheets. Price, mounted on cloth, and varnished, and municipal township boundaries colored, $6.50: mounted on cloth, cut to fold, for traveller's use, in cloth case, $6.00. Printed on thin paper, not mounted, but folded in cloth case, $5.00.

MAP OF THE SIERRA NEVADA adjacent to the Yosemite valley:—scale two miles to one inch, size thirty inches by twenty. Price, on thin paper, in cloth case, $1.50.

The agents for the sale of the publications of the Geological Survey of California are: for the Eastern States and Europe, Messrs. B. Westermann and Co., 471 Broadway, N. Y.; for the Pacific States, Messrs. H. Payot & Co., 640 Washington St., San Francisco.

Cambridge, Mass., June 1st, 1869.

Astronomical and Meteorological observations made at the United States Naval Observatory during the year 1866. Rear-Admiral Charles H. Davis, Superintendent. Published by authority of the Hon. Secretary of the Navy. 474 pp. 4to. Washington, 1868.

Paris Universal Exposition, 1867. Report upon Wool and Manufacturers of Wool, by E. R. Mudge, United States Commissioner, assisted by John L. Hayes, Secretary of the "National Association of Wool Manufacturers." Pp. 143, 8vo. Washington, 1868.

Sugli Spettri Prismatici dei Corpi Celesti. Memoire del R. P. A. SECCHI, Direttore dell' Osservatorio del Collegio Romano. pp. 70. Roma, 1868. A work containing many original observations.

PROCEEDINGS BOSTON SOC. NAT. HIST. Vol. xii.—p. 267, Tin Ore at Winslow, Me.; *C. T. Jackson.*—p. 268, Description of a Shark (*Carcharias tigras* Atwood); *N. E. Atwood.*—p. 269, Descriptions of North American Bees, No. 2, Andrenidæ; *E. T. Cresson.*—p. 274, Notes on new or little known species of American Cancroid Crustacea; *S. I. Smith.*—p. 289, Notes on the Concentric Structure of Granitic Rocks; *N. S. Shaler.*—p. 294, Synopsis of the Birds hitherto described from the Hawaiian Is.; *S. B. Dole.*—p. 310, Descriptions of some Extinct Fishes previously unknown; *E. D. Cope.*—p. 321, Notice of the Hemiptera obtained by the Expedition of Prof. James Orton in Ecuador and Brazil; *P. R. Uhler.*—p. 327, List of the Coleoptera collected by Prof. Orton; *G. D. Smith.*—p. 330. Notes on the Orthoptera collected by Prof. Orton on either side of the Andes of Equatorial South America; *S. H. Scudder.*—p. 345, A study of the Gigantic Lobe-crested Grasshoppers of South and Central America; *S. H. Scudder.*—p. 357, Use of the Microscopes; *H. Hagen.*—p. 361, Double Plate of Aulacodiscus oreganus, and Diatoms from Ashley River, S. C.; *R. C. Greenleaf.*—p. 364, Traces of ancient operations in the Oil-region of Penn.; *W. H. Niles.*—p. 366, Notes on Mexican Pompilidæ; *E. T. Cresson.*—p. 380, Limits of Genera; *C. S. Minot.*—p. 381, On new and imperfectly known Echinoderms and Corals; *A. E. Verrill.*—398, Antiquity of Man as shown by excavations at High Rock-Spring, Saratoga, N. Y.; *H. McGuier.*—p. 400, The Rough-winged Swallow and the Yellow-bellied Flycatcher; *P. R. Hoy.*—p. 401, Method of accommodation in the eyes of Birds: *B. J. Jeffries.*—p. 402, Halibut and Blue-fish; *N. E. Atwood.*—p. 404, Report upon a Collection of Diurnal Lepidoptera made in Alaska; *S. H. Scudder.*—p. 408, Notice of a new cave insect (Hadenœcus); *S. H. Scudder.*—p. 409, Boreus brumalis Fitch; *F. G. Sanborn.*—Index to the vol.

PROTICHNITES LÔGANIANUS *Marsh*

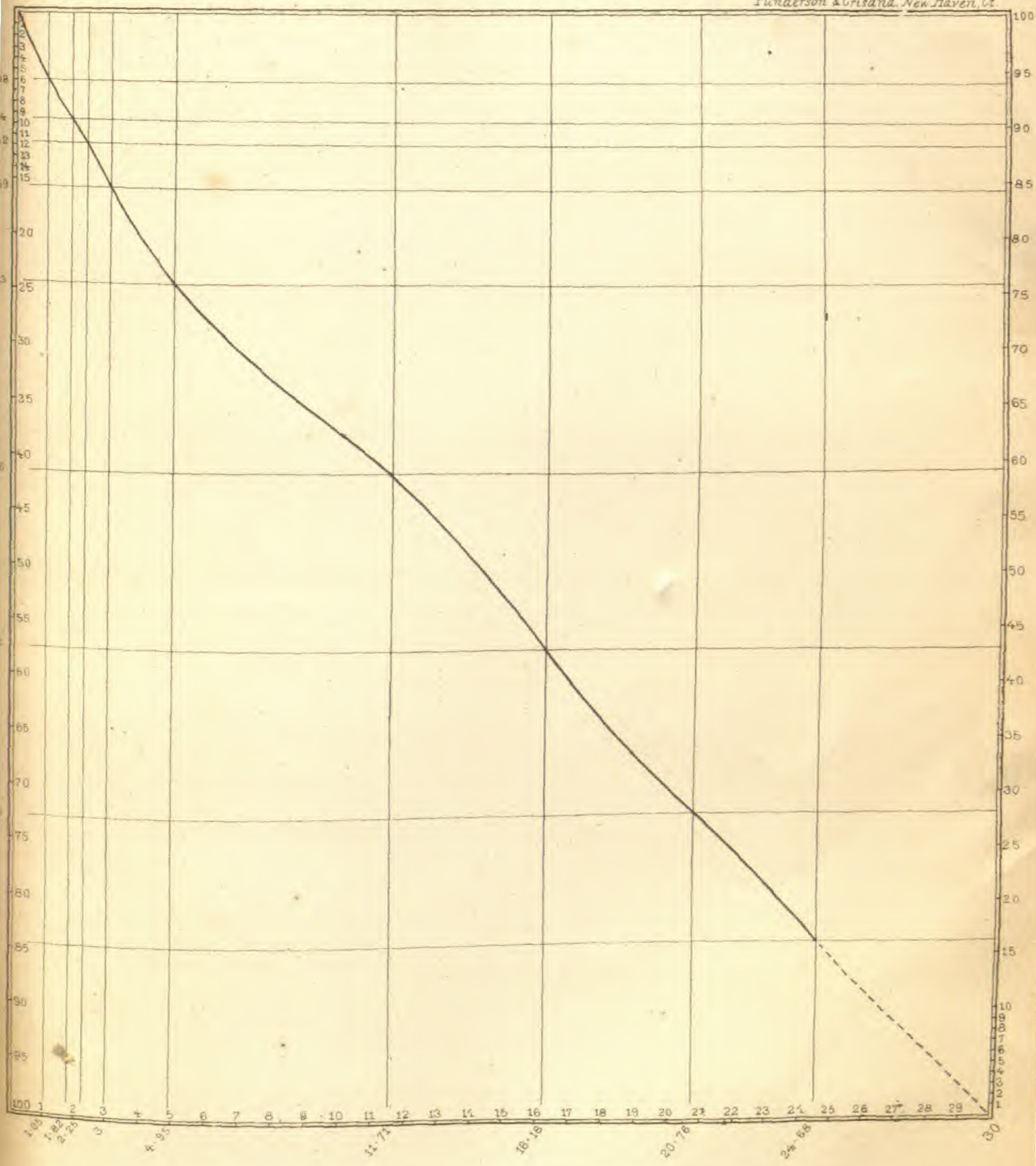
CURVE

SHOWING THE LOSS OF INTENSITY IN ILLUMINATING GAS

DUE TO ADMIXTURE OF AIR.

American Journal of Science & Arts, 2nd Series, Vol. XLVII. No. 142.

Punderson & Crisand. New Haven, Ct.



Note. 100 = maximum intensity. The vertical and horizontal scales are as 1-3.
The numerals on the left indicate the loss of light observed given in per centage.
The numerals on the lower line are the per centage volumes of air added as found by analysis of the mixture.
Below 84,55 pc. the curve is estimated.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XV.—*On the nature and duration of the discharge of a Leyden jar connected with an induction coil;* by OGDEN N. ROOD, Professor of Physics in Columbia College.

[Read before the National Academy of Sciences, August, 1867.]

PART 1ST.

WHEN the terminal wires of an induction coil of sufficient size are connected with the exterior and inner coating of a Leyden jar, it is well known that the act of breaking the primary current charges the jar with electricity, and that a discharge will take place if the distance between the electrodes is not too great, otherwise the union of the two electricities is effected backward in the coil itself. The brightness of the light, and the ease with which it is generated, render it the most convenient means in our possession for the production of a nearly instantaneous illumination, while its richness in the violet and ultra-violet rays, make it suitable for experiments on fluorescence and phosphorescence. Before, however, it can become useful for these and other delicate investigations, involving the appreciation of minute intervals of time, it is of course necessary that the nature and duration of the discharge itself should be studied, a matter which, so far as I know, has thus far not received attention.

The case of a jar charged by an ordinary frictional machine is quite different from the above: here, during the the act of charging and discharging, the two metallic coatings of the jar are entirely insulated, while when the induction coil is used in

the manner above indicated, these coatings are during both acts in metallic connection, a circumstance which alone might be supposed to modify the duration of the discharge and its nature; besides this, it is known that the electricity from the coil continues to flow for a considerable fraction of a second along the terminal wires into the jar, which fact renders it questionable whether the duration of the discharge of the jar itself may not be proportionately lengthened. Hence it is evident that it would not be safe to conclude without experiment, that the results obtained by Feddersen with jars charged by ordinary frictional electricity, were applicable to those connected with an induction coil.

Historical.—In the year 1835, Wheatstone published in the Philosophical Transactions, part II, page 583, an account of his celebrated experiment on the duration of the discharge of a Leyden jar charged by a common frictional machine. The light from the spark was received directly on a plane mirror revolving at rates between 30 and 800 times in a second; the mirror was driven by a set of multiplying wheels connected *by strings*. This apparatus was constructed by Mr. Saxton of Washington, who at that time was residing in London. The eye of the observer was placed near the mirror, and as the image of the spark was not sensibly drawn out by the rotation of the mirror, Wheatstone concluded that its duration was less than the one millionth of a second, a result which was accepted by the scientific world for about a quarter of a century, passing unquestioned till the publication in 1858 of the first of an admirable series of investigations of this subject by Feddersen; (Pogg. Annalen, Bd. 103, seite 69.) This physicist employed a concave mirror with a radius of half a meter, driven by a train of *toothed wheels*, and obtained as high a rate of rotation as one hundred per second; the spark was generated in one of the conjugate foci of the mirror, and its image, formed at the other conjugate focus on a plate of ground glass, was in a condition to be conveniently seen and measured by the naked eye or to be photographed. It was found that the image of the spark was drawn out by the revolving mirror into a whitish streak, from 20 to 30 millimeters long, which when a large amount of electricity was employed, was still farther lengthened by the addition of a red tail of about the same dimensions, this latter being due to the gradual cooling of the heated particles. With a jar of 2·2 feet inner coating, the distance of the copper balls which served as electrodes being 1·5 millimeters, and all the connections as short as possible, the duration of the discharge exclusive of the red tail was ·00004 of a second. It was also

found by him, that an increase in the size of the coating of the jar or of the "striking distance," prolonged the duration of the discharge; so, for example with a spark 3·75 millimeters long, the duration of the whitish portion was ·00007 of a second.

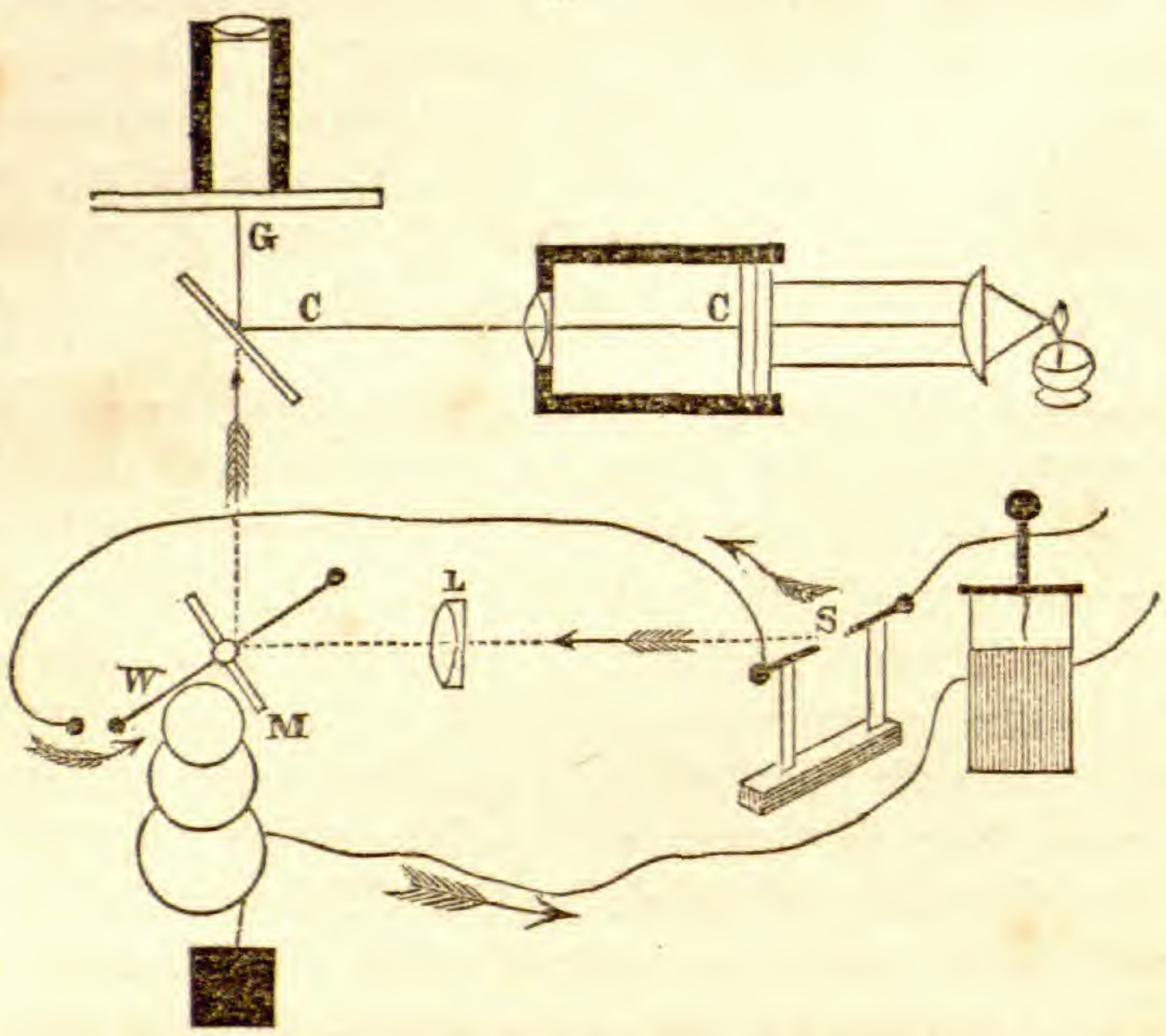
A series of observations detailed at the end of this article, will point out a probable explanation of the great discrepancy existing between the results of Feddersen, which are undoubtedly correct, and those of Wheatstone. Finally, Feddersen in the course of his investigation found abundant proof of the oscillatory nature of the electric discharge, which had been predicted from the results of a set of experiments by Prof. Joseph Henry as far back as 1842.

Apparatus.—I arranged in the first place an apparatus like that of Feddersen, but it was soon found that to attain a rotation of one hundred per second, it was necessary in my case to employ a weight of 200 pounds, and in addition when using this form, I labored under the disadvantage of not being able to vary the size or curvature of the mirror readily; in short it was found to lack *flexibility*, a quality more necessary in the present case than in the investigation which engaged the attention of the German physicist. On this account I decided to employ a plane revolving mirror with a stationary achromatic lens. The addition of an extra wheel, with a few other mechanical changes, converted the train of wheels furnished by Duboscq for Becquerel's phosphoroscope, into an admirable means for driving the revolving mirror, and with a weight of 30 pounds, 300 rotations per second were readily obtained, the motion being smooth and sufficiently uniform. In order to measure the rate of rotation, the cylinder on the lowest wheel was made to wind up a fillet of paper, upon which dots were made by an electro-magnetic apparatus regulated by a seconds pendulum, when a simple calculation furnished the rate of the wheel to which the mirror was attached. By this method it became possible to put to a sharp test the regularity of the rate of the train, which was found in all cases to be considerably greater than was at all necessary. These determinations were afterwards made with a watch having large second spaces, the dots being made by hand, as the refinement of a seconds pendulum and battery was found for my purpose to be superfluous.

The mirrors employed were always plane, being sometimes silvered at the back, while for the most delicate observations the rear surface was painted with black varnish, so as to destroy the second reflection. They varied in size from 1·5 inches square, down to ·2 by ·5 in., and were used sometimes double on the axis back to back, and at other times four mirrors were em-

ployed together. The arrangement is seen in figure 1. The light diverging from S, was received by an achromatic lens L, of nine inches focal length ; it then fell on the plane mirror at M, and was finally brought to a focus on the plain or ground glass at G, which was distant from the mirror about 16 inches.

1.



For the purpose of measuring the extent to which the image of the spark had been drawn out by the motion of the mirror, a scale consisting of bright lines on a dark ground, was projected on the ground glass, as seen in the figure at CC, the flame of a small lamp furnishing the illumination. The spark was generated between the balls or wires of a spark-micrometer, graduated in millimeters ; this was placed of course in one of the conjugate foci of the achromatic lens. An automatic arrangement for breaking the circuit from three to six times in a second, was employed, mercury and alcohol being used in it. The coil was a large one by Ritchie of Boston ; it was excited during these experiments by two cups of the Bunsen form ; the simple sparks furnished by it did not at the time exceed seven inches in length. The Leyden jar had a coating of 114·4 square inches, and all the connections were made as short as possible, so as to offer the least amount of resistance to the flow of the electricity. The experiments were usually made in a room not *entirely* darkened, as in a perfectly dark room it was found difficult to preserve the proper "accommodation" of the eyes.

If no means are employed to regulate the moment at which the discharge takes place, it is evident that images of the spark

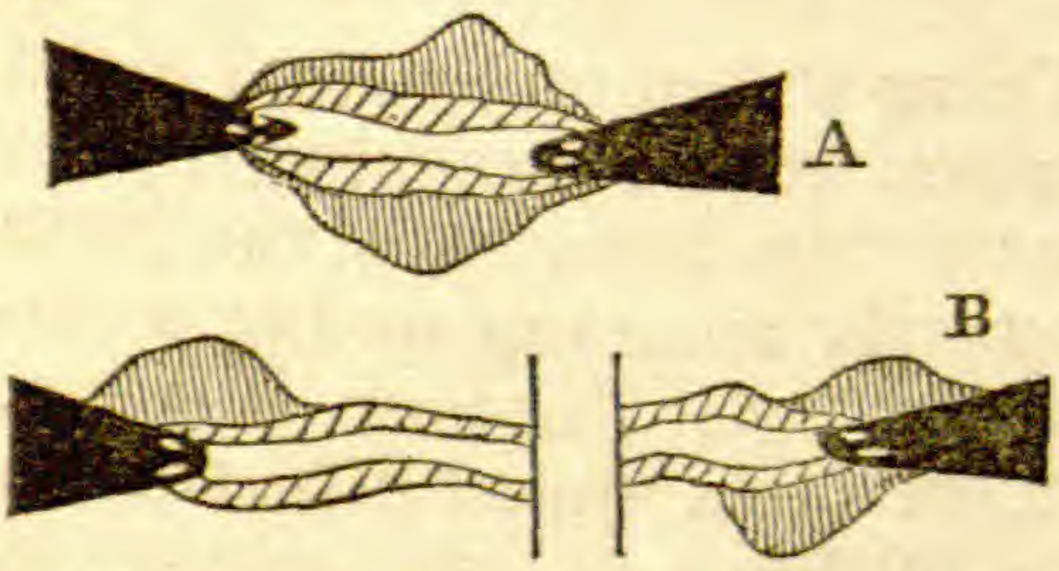
will be thrown on the ground glass only when the mirror happens to be in a favorable position, still as several of them occurred in a second, and as the mirror was always double it did not very often happen the weight ran entirely down before a single observation had been made. I selected a certain portion of the ground glass along the line of images, and exclusively fixed the attention on it, and disregarding the images formed in its neighborhood waited for their appearance in this locality. If the precaution be neglected, much time will be wasted in accumulating observations of comparatively little value. With velocities up to 223 per second, I succeeded in causing the discharge to take place when the mirror was in the proper position, by attaching to its axis a brass wire W, which was made to complete the connection between the exterior and inner coatings of the jar. The arrangement is seen in figure 1, and it was found quite valuable in facilitating *the use of the eye-pieces*, which were employed to magnify the lengthened images of the spark, or to examine the micrometer described at the end of this article. I had been apprehensive that this plan would not answer, as it evidently assumes that the jar remains charged a fraction of a second before it discharges itself backward through the coil.

Appearance presented by the spark, viewed with the stationary mirror.

(*a*) *With brass balls as electrodes.* Here the spark presented its ordinary well known appearance, being merely magnified by the eye-piece.

(*b*) *With pointed wires as electrodes.* When the "striking distance" was one millimeter, the form was that represented in figure 2 at A, viz: a central white portion surrounded by a yellowish envelop, which in the figure is shown by the coarse shading; the second envelop more densely shaded, being green and much inferior in brightness. With a "striking distance" of ten millimeters, the green envelop was produced only in the neighborhood of the electrodes. (see B, fig. 2.) In both cases a number of brilliant minute jets of white light were seen to issue from the electrodes; these are only partially shown in the figures. The green color was due to the heated particles of metal, and the bright points of light to successive discharges, as will be shown farther on.

2.



(*c*) *With fine platinum wires.* The appearance was the same as the last, except that the green tint was replaced by a grey or violet-grey hue. These observations were made with a mirror of plane glass, the rear side being blackened, which reduced the intensity of the light adequately for the purposes of distinct vision. The ground glass was replaced by a polished plate, which supported an eye-piece magnifying five diameters.

Appearance presented by the revolving mirror.

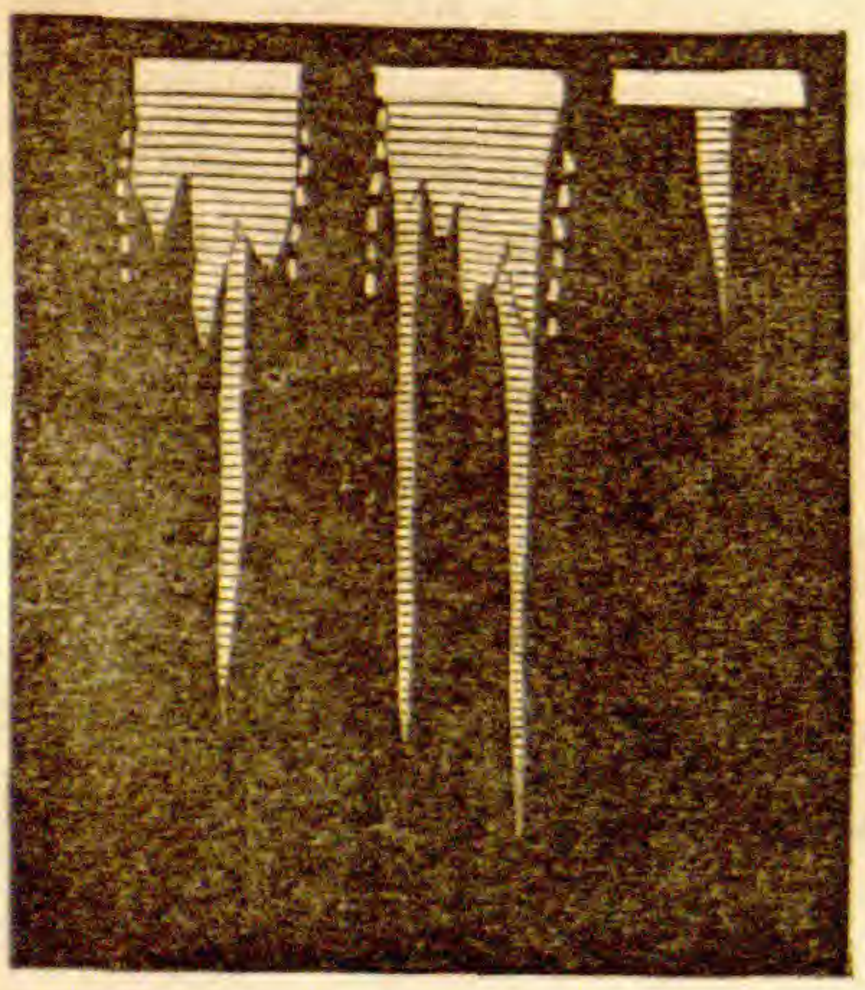
(*a*) *With brass balls as electrodes.* With a "striking distance" of one or two millimeters, the image being thrown on the ground glass and viewed by the naked eye, it was found that the spark was drawn out into a streak one and a half or two inches long, according to the rate of the mirror; the portion at W, (fig. 3) was white; this shaded into a brownish yellow tint, (B Y) the latter passing into a pretty distinct green, (G.) It will be found by comparison that this result is exactly that obtained by Feddersen with frictional electricity, except that in my case the green color of the tail seems to have been much stronger, which is explained by the lower intensity of the illumination.

3.

With the unaided eye and ground glass, nothing additional of a remarkable character could be discerned, but on using the polished plate of glass and an eye-piece magnifying five diameters, a series of bright dots on each side of the streak became visible in the positions indicated by the dots in figure 3. These resemble the photographs obtained by Feddersen with frictional electricity. Here it is seen that the bright points before spoken of, correspond to a series of discharges following the first.

(*b*) *With platinum points.* Using the ground glass, I found that the form of the streak was some times identical with that produced from brass balls, the green color merely being replaced by a violet-grayish tint. The form, however, was more often quite different, as shown in figure 4, the change in shape being due to the partial suppression of the tail, and to its irregular production; with low velocities the shape was often as in the smallest of the three sketches.

4.



With eye-piece, polished glass and high velocities, the series of bright points was seen beautifully developed.

(c) *With brass points*, this same figure was produced, yet not quite so distinctly. The tail was of course green.

Total duration of the discharge.

(a) *Using brass balls.*

Rate of rotation per second.	Number of observations.	Distance of electrodes in millimeters.	Duration in seconds.
109·	6	3	·000050
291·	5	2	·000028
294·	9	1	·000017
120·	6	1	·000030
30·	8	1	·000023
110·	15	1	·000022

No red tail was ever observed in my experiments, the amount of electricity employed not being sufficient for its production. The difference in these observations arises partly from the faintness of the terminal portion of the tail, and also from the fact that its length is a little variable even in discharges following each other in quick succession. Still on the whole, these results correspond pretty well with those obtained by Feddersen, when it is remembered that the coating of the jar employed by me, was less than one half the size of that used by him, which, as well as shortening the "striking distance," tends to lessen the duration of the discharge as proved by his observations.

(b) *Using brass points.*

Rate of rotation per second.	No. of observations.	Distance of electrodes in millimeters.	Duration in seconds.
100	10	1	·000025
48	10	1	·000028

(c) *When platinum points* were used as electrodes, with a striking distance of three millimeters, the duration, as obtained, varied between ·00004 and ·00014 of a second: the variation seems to be owing to the faintness and narrowness of the tail, which rendered observation difficult and rather uncertain.

Duration of the white and yellow portion.

As it had all along been evident that the main illuminating power of the spark was concentrated in the first explosive act, I made still further efforts to determine the duration of the white and yellow portion of the discharge. The image of the spark, using platinum wires as electrodes with a striking distance of five millimeters, was thrown on the ground glass, a set of observations being made with the naked eye, and also with the aid of the magnifying lens. The color was found to be rather brownish-yellow, shading off and becoming fainter in illumination toward its farther boundary. This yellow flame-

like portion was not nearly so bright as the white band, the latter being to all appearance unaffected by the motion of the mirror. The appearance was that indicated in figure 4, the farther boundary *resembling the irregular outline and color of a burning splinter of wood.*

The duration was found to vary from

·000003
·000007

of a second. The rate of rotation was 206 per second. Determinations of this same point had previously been made at an early stage of the work; their result was

·000008
·000006

of a second. There can be no doubt but that the duration of the yellow portion in individual sparks varies within limits like the above as can be seen by a comparison of successive discharges.

Duration of the white band.—Up to this time I had been able to obtain no evidence that the duration of the white band was other than instantaneous, indeed with this mode of experimenting the contrary cannot be proved. The preceding analysis had shown that a large portion of the light of the spark resided in this white band, i. e., in the first discharge, and when points were used as electrodes its superior brightness to some extent isolated it from the rest of the streak. To ascertain whether it was to be regarded as a separate act by itself, or as only the beginning of a continuous action lasting ·000005 of a second or longer, I made the following simple experiment: instead of receiving the light of the spark directly on the achromatic lens L, it was used to illuminate a strip of white paper ·14 of an inch in breadth; this was placed horizontally, the direct light from the spark being prevented from reaching the lens by a screen. The "striking distance" was 1·3 millimeters. With low rates of rotation, the appearance of the image of the band *viewed by an eye-piece* magnifying five diameters, was quite unaltered; as the rates of rotation were increased the illumination of the image of the band grew fainter, but with the highest velocity, 223 per second, it was *distinctly visible and of the same breadth*, as far as could be ascertained by the use of the micrometer. This proves of course that the first discharge is a simple act, and isolated from those that follow. Next, as an appropriate termination to this experiment, I blackened all the surface of the strip of white paper except so much as served to form a square. On examining the image of this with the same rate of rotation, the square was tolerably

visible: it was followed by a faint flame-shaped tail, corresponding to the yellowish portion of the discharge.

Having thus proved the existence of an isolated discharge, at once the first and most brilliant act in the explosion, a method was contrived for measuring its duration, or at all events for setting a limit to it on at least one side. Ordinary micrometric methods, conducted on the naked spark or on a strip of paper illuminated by it, were out of the question, and would have served no purpose except to lead the observer into error, so I contrived the following plan, which is moderately easy of application and safe.

A small piece of cardboard was ruled with two black lines; their distance apart was ·0067 inches, and they were separated by a space exactly equal to the width of a single line. A small dividing engine was used for their production; they were tested with a microscope. These lines were illuminated by the spark, and their image examined by an eye-piece magnifying five diameters. The breadth of the image of a single line on the ground glass was ·011 inches, that is, each line subtended an angle of 2′ 24″, reckoning from the mirror. With a velocity of 223 per second the mirror is able to move the reflected image through 2′ 24″ in the ·00000024 of a second. If now this first discharge had actually lasted this minute portion of time, it is evident that the motion of the mirror would just have carried the image of one of the black lines forward, so that at the end of this infinitesimal period, it would have occupied the space where just before the white line had been traced: hence owing to the retention of impressions by the retina the white central line would have been obliterated, and in place of three lines, a gray band would have been seen. On the other hand if the duration had been only $\frac{1}{10}$ or $\frac{1}{5}$ of the above mentioned interval, the white line not having been much encroached on, would still have remained visible. The correctness of the above reasoning can be experimentally proved, by means of a revolving disc of card board with a single slit cut in it, lines being drawn on its white side, and viewed by reflection with a mirror through the slit, the blackened side of the disc being turned toward the eye.

To facilitate matters, *three sets* of these lines were drawn on the small cardboard at considerable distances apart to prevent confusion, and while illuminated by the electric spark were examined with increasing velocities. With low rates they were quite unchanged in appearance, with a velocity as high as 102 per second, a duration of the first discharge of ·00000052 seconds would just have obliterated them; they were however perfectly distinct, though more faintly traced: the rate of ro-

tation was then by degrees carried up to 223 per second, when the lines were still distinctly visible, though of course with less contrast between the white and black, than was the case with low velocities or a stationary mirror.

This experiment proves then, that the duration of the light accompanying the first discharge is considerably less than ·00000024 of a second, probably less than half this period, or less than one ten millionth of a second of time. To make the observations required some patience, as it was necessary to use an eye-piece, the ground glass being replaced by a plain polished plate, and it was seldom that the image of the lines fell exactly in that portion of the field to which the attention was directed. To obviate this difficulty, I afterward *covered* a piece of cardboard half an inch broad with alternate white and black lines of this character, their real diameter was ·0075 in., that on the plate of glass being ·0125 in. With these I repeated the above mentioned set of experiments with rapidity, obtaining with ease the same result, as some of the lines were almost certain to be in the right part of the field of view. It is thus shown, that the first act of the electric explosion lasted through an interval of time so short as to be immeasurable with the means then at my disposal; it is not impossible that it may still be reached by the use of finer lines, and a lens of greater focal length.

From the foregoing then it appears that if a jar having a metallic coating of about 100 square inches, be connected as above described with an induction coil, its discharge will be effected by a considerable number of acts, of which the first is by far the most intense. Farther, the metallic particles heated up by the first discharge to a white heat, almost instantly assume a lower temperature, marked by a corresponding change from white to brownish yellow, and as their temperature continues to fall the tint changes in the case of brass electrodes to green, in that of platinum to a gray or violet-gray. A spectroscopic examination of these isolated tints would be interesting but not without difficulty. These observations farther demonstrated the fact, that two ten millionths of a second is an interval of time quite sufficient for the production of distinct vision.

When the light from the spark is received directly on a plane revolving mirror, and viewed by the eye as in Wheatstone's original experiment, only the white unanalyzed portion of the spark is ordinarily visible; at least in repeating the experiment a few times, it is all that I saw. Its form is of course

that of the spark itself. In all probability this is also the case in a jar charged by frictional electricity, and may serve to explain the great discordance between the results obtained by Wheatstone and Feddersen, the method used by the former furnishing only a view of the first act, the eye being too much dazzled to perceive those that are subsequent and of far less intensity.

Art. XVI.—*The Star-Mapper;* by Henry M. Parkhurst.

Early in the year 1856, I commenced the construction of a star-mapper, designed to extend the principle of the Chronograph, which maps right ascension only, to an instrument mapping both right ascension and declination. On the 7th of October, 1856, having completed with my own hands the necessary apparatus, I took my first map.

In my first apparatus a concave lens was moved in declination, perpendicular to the axis of the eye-piece, the telescope being fixed in the meridian and the stars as they crossed the field of view were thus optically brought in succession to the crossing of two fixed illuminated wires. A few levers converted this motion into a horizontal motion of the marking point or star-key, at right angles with the motion of a roll of telegraph paper one inch wide carried by a clock movement. Striking the star-key, at the instant of the transit at the center of the field, mapped the star in its proper position. In order to take a map several degrees in width, I omitted the concave lens and moved the telescope itself in declination, with a slightly varied system of levers.

So far there was no difficulty. But a star-mapper which would only map in the meridian would have been to me valueless; and I reconstructed and rearranged very many times the system of levers by which I could convert the visible motion at any desired parallactic angle into a horizontal motion of the star-key. My experience in the fall of 1856 convinced me that my apparatus had two radical defects.

1. The motion of the telescope to obtain the declination was troublesome, even for a 3-foot telescope, owing to the necessity of overcoming at every star the inertia and momentum of the whole telescope, and the consequent inaccuracy; and it would have been impossible with my means to mount my 8-foot telescope, which I procured the following year, with such accuracy as to make this method of mapping possible. And further, when the telescope is clamped we have twice the ini-

tial motion with the same field, and the error from any mechanical inaccuracy is therefore proportionally less.

2. Several of my early plans involved the motion of the star to a fixed point in the field. I abandoned this, substituting the motion of the point to the star, for two reasons.

(1.) It required a continual motion of the eye-piece, (or telescope,) to bring within the field the stars to be mapped; for while mapping a northern star, a southern star which ought to be mapped would be outside of the field.

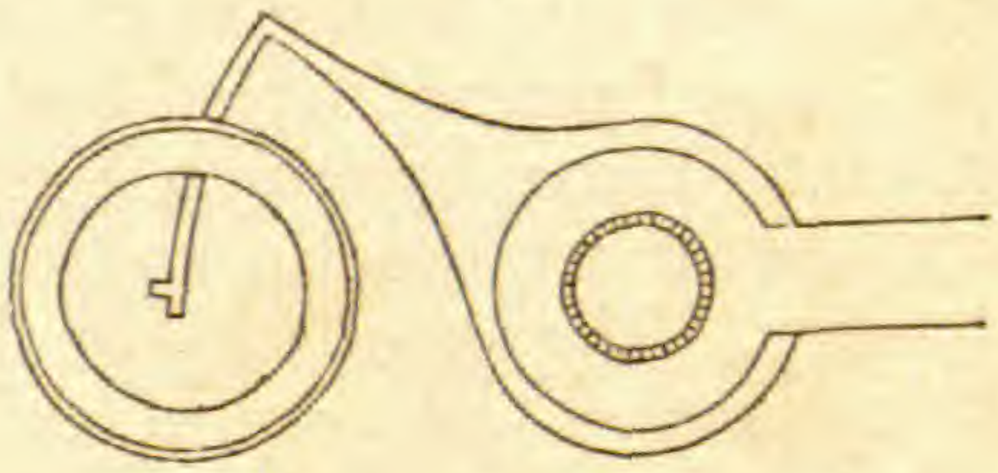
(2.) It brought within the field twice as many stars as I desired to map, with no line of demarcation between them.

In 1860, thinking that I had worked with my pine mappers and narrow paper long enough, the instrument being readily adjustible and convenient for mapping in any desired position, I procured my first permanent star-mapper, chiefly of brass, adapted to map 90′ in declination upon the scale of the Chacornac charts. In 1863, desiring to make charts upon twice that scale, I had another and larger mapper constructed, varying only in unimportant details. This latter instrument I will proceed to describe.

A large diagonal prism placed in the meridian inverts the image in declination, bringing the north point to the top of the field, the stars moving toward the left. Then if I wish to map in the eastern sky, I turn the prism to the left upon the axis of the telescope, and turn the field-piece with its attachments the same angle upon its own axis, also to the left, the angle being such as will be most convenient to the eye, the plane of the field making an angle of about 60° with the horizontal plane.

Figure 1 represents the plane of the field of view. In the center of the field of view is represented the star-point, by which the stars are to be successively occultated, there being a projection upon the left, easily seen in the absence of illumination, to mark the exact point of occultation. This star-point describes an arc, the center of motion being represented to the right, outside of the field of view, and being firmly supported by the field-piece. The line connecting the center of motion with the center of the field is parallel to the apparent motion of the stars. Into the field piece is fitted a positive eye-piece of suitable magnifying power.

1.



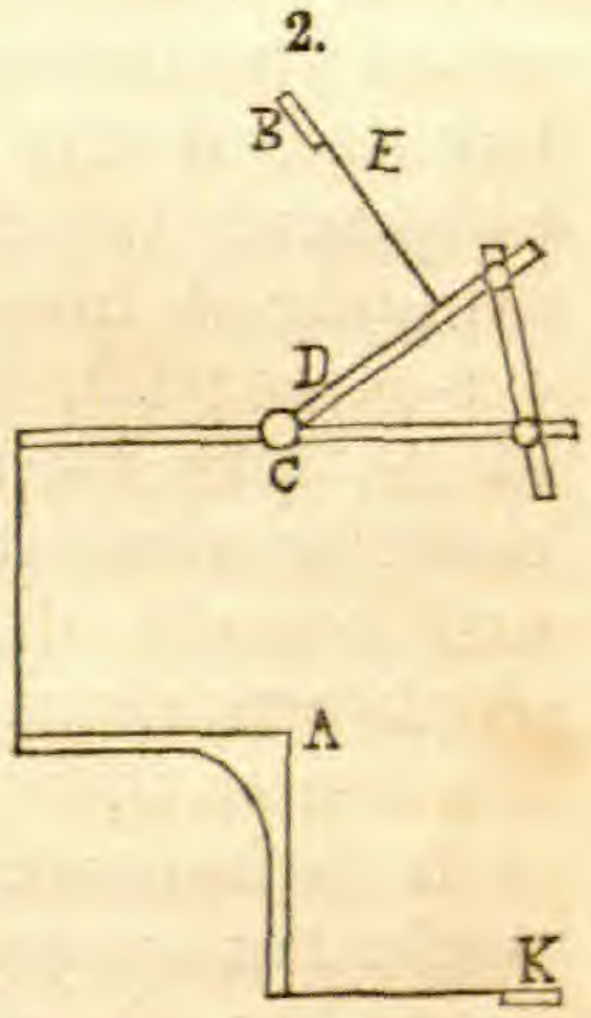
The arc described by the star-point is exactly equal to that described by the star-key; and the levers connecting the two are so adjusted that moving the star-key across the width of

the map shall exactly carry the star-point across the field of view. Unless it is desired to record the right ascension of the stars by the chronograph simultaneously with the mapping, it is better thus to map in corresponding curves than to provide means, as I did in my early apparatus, for moving both the star-key and star-point in straight lines.

The star-point receives its motion from a star-point-bar, which turns upon the same center of motion. A circular disk two inches in diameter, carrying the star-point, is clamped to a similar disk on the left end of the star-point-bar, as represented, at such an angle that the bar shall be horizontal when the star-point is in the center of the field.

The star-mapper must next be adjusted at a convenient height and distance, so that the arm of the star-key, when in the center of the map, shall be parallel to the star-point-bar. Fig. 2 represents the connecting levers, as seen from the left. K represents a cross section of the further end of the arm of the star-key, playing, as thus seen, horizontally to the right and left. It is connected by a rod with a universal joint at each end, to the right-angled lever pivoted at A. A perpendicular rod adjustible in length communicates the motion to a horizontal lever, whose center C may be adjusted in height. Turning on the same center C is a bar D, which communicates the motion through a rod E, of variable length, with universal points, to the star-point-bar B, previously adjusted, a cross section of the further end of which is represented in the figure. The angle of the bar D to the horizontal bar may be adjusted by a clamp upon the connecting bar. By the adjustment of this angle, and of the position of the mapper, the connecting rod E must be brought into the plane of the motion of the bars B and D, and at right angles with them.

2.



All these adjustments having been properly made, when the star-key is at the center of the map each connecting rod will be in the plane of the motion of each bar with which it is connected, and at right angles therewith; and these rods being of suitable length, moving the star-key will not vary these relative positions so far as to produce any important want of uniformity of motion of the star-point. The adjustment of the rate of motion of the star-point may be most conveniently made, either by varying the effective length of the bar B, or of the bar D, or both.

As an illustration of the ease with which the apparatus may be adjusted with sufficient accuracy for the identification of the stars, I will state that I have found it easy to take a succession of twelve 15-minute maps, in selected places varying many degrees in right-ascension and declination, in but little over three hours.

The minor details, such as the mode of supporting the various centers of motion, the mode of securing the requisite ease and accuracy of motion at the various centers without lateral motion, the mode of securing the proper motion of the paper, the mode of making the universal joints, &c., may be varied according to the desired accuracy and the allowable expensiveness of the apparatus.

Some of these details it may be well, however, to refer to more particularly.

The perpendicular arm of the right-angled lever A is of board about nine inches wide, connected at the left end with the star-key and at the right end with the levers C D, answering three purposes: 1st, it carries the star-key nine inches to the left, bringing it into a more convenient position in relation to the eye-piece; 2d, lateral motion is obviated by placing the pivots at A, nine inches apart; 3d, this arrangement protects the clock movement, which is immediately in front of this board and beneath the solid framework supporting the pivots. The clock-pendulum is supported by the stout bar which supports the center C.

It is important that lateral motion should also be guarded against at the center C, and at the center of motion of the star-point-bar, shown in figure 1. Each of these centers is therefore constructed with pivots sufficiently separated to accomplish that object. The ends of the rod E are connected with slides clamped upon the respective bars B and D, so as to be easily varied in adjusting the rate of motion of the star-point. The simplest mode of making a universal joint, and that which I have therefore adopted in my own mapper, is bending the ends of two wires snugly around each other.

The arm of the star-key K moves horizontally, and is pivoted opposite the center of the paper, to the left, describing an arc exactly equal to that described by the star-point, but of about three times the radius. It strikes an adjustible stop on each side by which the width of the map is limited. The star-key itself I have used in many different forms. The only form which has been satisfactory, although not constructed with such perfection as I should desire, is the following:

The star-key is compound, consisting of a series of eight vertical keys or manuals, either of which may be used at

pleasure to impress the paper. These manuals are enclosed in a cylindrical box, and the series may be revolved horizontally by turning the knob on the top of the box, a projecting pin indicating by its direction which of the keys is to the right hand. This pin having been turned as desired, pressing on the knob, locks the plate holding the series of manuals from further horizontal rotary motion, and depresses the manuals so that they nearly touch the paper. The outside casing is cut away above the manual to the right, so that at the proper instant that may be struck by the finger to impress the paper in the proper position.

Not only are the several manuals thus interchangeable, by the rotation of the series, but each of the eight manuals may be turned upon its own axis. Thus, that with which I indicate the 10th to the 13th magnitude, impresses upon the paper a short dash like a hyphen, pointing in any required direction; the horizontal dash indicating the 10th magnitude, and a revolution of 45° being allowed for each lower magnitude. The brighter stars are indicated by more conspicuous forms; and there are special marks for double stars, clusters, nebulæ, &c. The approximate form of the impression upon the paper is given to the top of the manual, so that any error in bringing the wrong manual to the right, would be instantly detected and rectified before impressing the paper.

The star-maps thus impressed, if the paper is of good quality, do not need inking; but I have marked with pencils and ink of different colors, such stars as I have recognized upon two or more than two maps, in order that any new stars might be conspicuous from their remaining unmarked.

I have used paper cut in strips of the proper width and wound upon a roller at the left of the star-key and beneath the arm of the star-key. The end is passed between guides and over the mapping cushion, between the rollers which are carried by the clock movement, and then the paper is wound upon another roller, also carried by the clock movement. The gradually increasing size of the roller on which the paper is wound, from the addition of the paper, is compensated for by a spring, which is at first gradually relaxed and afterwards again tightened; but which is sufficiently wound up by a key before commencing to map, to keep the paper always tight.

In the action of the levers of the mapper, arranged as above described, there is a slight theoretical inaccuracy, which, in my own instrument, is sufficiently compensated for by two expedients, but which may be entirely removed by a slight change in the construction. For instance, as described, the motion of the lower end of the arm A is exactly equal to that of K in

the middle of their motion; but moving the arm K, either forward or backward, moves that end of the connecting rod slightly to the left, and at the same time slightly raises the other end. Hence the effective length of the rod will be a little less at the edges of the map than in the center, and the southern portion of the map will be slightly condensed in declination. The same inaccuracy is repeated at the connecting rod E. In the latter case, instead of adjusting the real rod E as described, I adjust an imaginary connecting rod, each end of which is drawn toward the center of the motion of the bar to which it is attached by one-half the versed sine of the arc which that bar describes, thus reducing the inaccuracy to one-fourth. But in the other case I have slightly raised the star-key, and increased the angle of the lever A by an amount equal to the mean angle of depression of the connecting rod, accomplishing the same result. The remaining error from this cause is inappreciable, unless the connecting rod E is extremely and unnecessarily short.

In order entirely to remove this theoretical error, it is only necessary to substitute for those two connecting rods, chains moving at both ends over arcs, and kept constantly tight by springs. The effective portion of each chain will then remain in an invariable position and be of invariable length. With this modification, I believe this construction to be absolutely free from theoretic inaccuracy; and I believe it to be the only apparatus yet devised to record with theoretic accuracy, by mechanical means, the right ascension and declination at the same instant, or in other words, to make a chart of the stars observed, the errors of which shall be entirely errors of observation and inaccuracy in the mechanical construction of the apparatus.

The mode of operation will be readily understood. Removing the cap from the telescope, I take my seat in total darkness, and start the paper. Selecting the first star to be mapped, with my right hand I move the star-key back and forth until the star-point visible in the focus of the eye-piece comes into the same declination with the approaching star. At the same time with my left hand I turn the knob of the star-key until the projecting pin indicates that the desired manual is at the extreme right, where it is accessible. Then pressing down the knob, I properly turn the manual on its axis, with my right hand, and placing my fore-finger upon it, I wait for the occultation of the star opposite the outer edge of the projecting bar upon the star-point. At that instant I tap on the manual and the star is mapped. I then select another star and map it in the same way; and so on, at a rate varying from

two or three to thirty per minute, and averaging nearly 500 stars per hour. When several stars present themselves almost at the same instant, I have preferred, rather than to omit any of them, to divide the error of right ascension and to map them as rapidly as possible. Usually by predetermining the order of mapping, I can map six or eight stars in quick succession, without an error exceeding two seconds. When the paper reaches the end, a spring constantly pressing upon it, locks into the star-key, and thus indicates the conclusion of the map.

It may not be improper for me to add briefly my reasons for not having before described my invention in the columns of any scientific journal. I wrote at an early day a general account of my apparatus to various astronomers, among whom were Dr. Gould, Dr. Bache, and Prof. Mitchell, who was then at the Dudley Observatory; but I desired to give a practical illustration of its utility in the discovery of a new asteroid. On Sept. 30th, 1862, I announced by a printed circular, my discovery of a new asteroid, "by the aid of my star-mapper," and briefly stated in that circular the history of my invention. My discovery of Galatea was announced in the next number of this Journal, (page 430), Mr. Tempel's prior discovery being yet unknown in the United States. On the 18th of October, the director of the Dudley Observatory called upon me and saw my apparatus and maps, and they were afterwards shown by me to Dr. Gould, Mr. Rutherfurd, and others who were interested in astronomy. But at that time I had devised an apparatus by which not only the exact places but the measured magnitudes of the stars observed should be recorded; and I decided to defer the publication of the description of the star-mapper until I should be able to publish in connection with it a description of my Photo-mapper. With your permission, I will, in your next number, proceed to describe this latter instrument.

ART. XVII.—*Additional remarks on the Nineteen-band Test-plate of Nobert;* by J. J. WOODWARD, Asst. Surgeon and Brevet Lieut.-Colonel U. S. Army. Contributed by permission of the Surgeon General.

IN a former paper in this Journal (II, vol. xlvi, page 352) I gave an account of certain observations made on the new nineteen-band test plate of Nobert with various lenses. The general result of these observations was, that, with the $\frac{1}{25}$th

of Powell and Lealand, with which lens I secured the best definition, the lines of the fifteenth band were distinctly resolved. In the higher bands spurious lines, fewer in number than the real ones, were seen. The nature of these lines was conclusively shown by a count. With the paper, I sent to the editors a series of photographs, taken by Brevet Major E. Curtis at the Army Medical Museum, which showed in a satisfactory manner precisely what had been done. Upon the basis of these experiments and photographs, I expressed the opinion, that, those who had previously supposed they had seen the true lines in higher bands than the fifteenth, had been misled by the spurious lines described ; an opinion which has been still further strengthened by subsequent experiments with lenses by the maker whose objectives were supposed to have been successful.

During March of the present year I received from Nobert another nineteen-band test-plate made differently from any I have as yet seen in this country. The glass cover measures but the $\frac{1}{275}$th of an inch in thickness, and this is cemented to a glass circle the $\frac{1}{00}$th of an inch thick, supported on a strip of brass. The new plate, therefore, permits the use of lenses of the highest power, and may be illuminated by extremely oblique light or by an achromatic condenser of very short focus.

I found, nevertheless, that the $\frac{1}{25}$th of Powell and Lealand would go no further on this than on the former plate and their $\frac{1}{50}$th gave the same result ; it would not resolve the sixteenth band.

With a new immersion $\frac{1}{16}$th, just made for the Museum by these makers, however, I had the satisfaction of distinctly resolving the four refractory bands, and Dr. Curtis has prepared for me photographs of them, which accompany this paper. With the same lens, also, I satisfied myself more positively about the real number of lines in the fifteenth band. The counts I obtained were as follows: fifteenth band 45 lines, sixteenth band 48 lines, seventeenth band 51 lines, eighteenth band 54 lines, nineteenth band 57 lines. The photographs of Dr. Curtis were taken without an eye-piece, and with such a distance that the immersion $\frac{1}{16}$th gave 1,000 diameters. The illumination was by sunlight passed through the ammonio-sulphate of copper, a $\frac{1}{5}$th objective of 148° angle of aperture being used as the condenser, without diaphragm or stop, and obliquity of light obtained by means of the centering screws of the secondary stage.

I send two prints on glass, of which, the first shows the 16th, 17th, and 18th bands, satisfactorily resolved. The second shows satisfactorily the 19th band only. These pictures should

be studied under a power of from two to six diameters. In counting the lines on them some doubt might arise, especially in the case of the 18th and 19th band, as to the real number of lines; for certain spurious lines, which are interference-phenomena, may be seen on the margin of the bands, and it is not always easy to tell which is the last real and which is the first spurious line. A comparison of several glass positives from different negatives with each other, and with the bands as seen in the microscope, where a change of focus materially aids in the determination, has led me to adopt the count above given.

Besides the prints on glass, I send some paper prints enlarged to two thousand diameters. These show the lines very well to the naked eye, but the loss of definition, inevitable in enlarged paper-prints, leaves so little difference in appearance between the real lines, and the spurious ones, on the edges of the bands, that they cannot be used for a count.

On comparing other lenses with the new immersion $\frac{1}{16}$th of Powell and Lealand, thus found to excel so far their dry $\frac{1}{50}$th and $\frac{1}{25}$th, I obtained the following results.

An immersion $\frac{1}{15}$th by Wales resolved the sixteenth band; an immersion $\frac{1}{20}$th by Wales resolved the seventeenth band. The same was done by a Hartnack immersion, No. 11, belonging to Dr. Barnard. A Tolles' immersion $\frac{1}{5}$th, just constructed for Dr. J. C. Rives of this city, resolved the fourteenth band, but failed to go further. I learn also from my friend, Mr. W. S. Sullivant, who received one of the new Nobert's plates on thin glass at the same time as myself, that with an immersion $\frac{1}{6}$th just constructed for him by Mr. Tolles, he also failed to go beyond the fourteenth band. While this paper was being prepared, I received through Mr. Charles Stodder, a new immersion $\frac{1}{10}$th by Tolles, with an angle of aperture of 175°. With this lens, after repeated trials, neither Dr. Curtis nor myself succeeded in seeing the true lines beyond the sixteenth band, and this was not as well shown as the nineteenth band was by the Powell & Lealand lens.

Returning now to this immersion $\frac{1}{16}$th, it may be remarked that the work just done with it has an important bearing on the question of the real limits of microscopic vision. Nobert in sending me the plate above described, wrote me, that in his opinion, the fifteenth band was the limit of possible microscopic vision. He based this opinion upon Fraunhöfer's formula with regard to the spectra of gratings, and upon the known wave length of light undulations. Dr. Barnard of Columbia College, New York, after reading Nobert's letter, writes me that in his opinion, Fraunhöfer's formula does not apply to the

visibility of fine lines when observed with a modern microscope of high power, since the great angle of aperture of the objective permits oblique rays to reach the eye, and Fraunhöfer's formula applies only when the eye is perpendicular to the grating. Dr. Barnard is therefore of the opinion that the limit suggested by Nobert has no real existence. In his letter, which I should mention was written before he was aware that I had satisfactorily resolved any of the bands beyond the fifteenth, he proposed that a trial should be made, to resolve the test-plate with monochromatic light, of colors having longer wave-lengths than the violet which I had been using. Accordingly, obtaining monochromatic light by a prism on which a ray of sunlight was thrown, I succeeded after some trials, in satisfactorily resolving the nineteenth band with each of the colors of the spectrum, from the violet to the red. It may therefore be concluded, that, the present limit to microscopic vision is simply the goodness of the objective, and the rapidity of recent improvements may well lead us to hope for a still further advance.

Art. XVIII.—*On some remarkable relations and characters of the Western Boulder Drift;* by E. Andrews, M. D.

Throughout central Illinois and probably in the corresponding latitude of adjacent States, the ancient Pliocene soil still lies undisturbed beneath the boulder drift. This soil has been met with in excavations at so many independent points, that in its own region it may probably be considered as the usual floor on which the drift rests. Two of the best observations upon it were obtained at Bloomington, Ill. In sinking two coal shafts the workmen first passed through 118 feet of unmodified drift clay, whose boulders and pebbles were all of northern origin and often scratched by the action of ice. Directly beneath this was a bed of ancient soil, on which logs of wood lay scattered confusedly about, and in which the stump of a tree still stood where it grew. Beneath the soil bed lay various sands, gravels and clays, and a second dirt bed, but no more northern drift. The stump was of coniferous wood.

The extensive existence of this preglacial soil has only recently been realized by scientific men, and hence the efforts to restore its fauna have been few, and as yet unsuccessful. Patches of the same formation exist farther north. One has been exposed by the erosion of the waves of Lake Michigan, twelve miles north of Chicago. One has been struck near Beloit, Wisconsin;

another, supposed to be of the same age, lies on the south shore of Lake Huron; and others have been struck by sinking wells at several places both in the northern States and in Canada. Another fact is of considerable interest, as showing how closely the succession of Quaternary formations here follows the relations in Europe, as shown by Mons. Dupont in Belgium. Upon the top of the glacial drift, and separating it from the loess there is another dirt bed, which has been studied mainly at Davenport, Iowa, by the Davenport Academy of Sciences. It appears that at the close of the glacial drift in that region, the waters of the Mississippi subsided within the rock bluffs, and the drift slopes were covered with soil, which showed its atmospheric exposure by the fact that it was guttered to some depth by small streams which cut perpendicularly into it. Over this soil lies the loess often forty feet in depth. The same formation apparently is exposed at Quincy, Ill., and traces of it are seen in other parts of the west. It appears therefore that the fresh-water submergence which deposited the loess was not a continuation of the drift action, but was in this region separated from it by a tranquil period, during which the rivers were down within their banks, and at or near their present levels. The loess at Davenport a short distance above the dirt bed, yielded the skeleton of an *Elephas*, probably *americanus*. The shells found there were all land species so far as yet discovered. The following comparison shows how closely Quaternary events in the Mississippi valley have kept step with those in Europe.

American Section.	*European Section,* (from Dupont's Belgian Excavations.)
Present soil.	Present soil
Loess. Extensive submergence.	Loess. Extensive submergence. Terre a brique of Belgium and France.
Ancient soil, worn by aerial denudation. Streams within their banks. Great Pachyderms alive. Human relics reported but not established.	Ancient soil and land surface. Streams within their banks. Middle river drift of Belgium and France. Great Pachyderms apparently existing. Paleolithic human relics.
Glacial Drift. Rolled stones and boulders derived from the north. No fossils either human or otherwise. Great ice action.	Lower river drift of Belgium and France. Rolled stones and large boulders transported from a distance, in the direction of the river valleys. No human relics. Pachyderm bones abundant. Evidences of ice action.
Pre-glacial soil, probably Pliocene. Fauna not explored.	Pre-glacial soil seen at Norfolk Crag. (Lyell.)

Another characteristic of western drift is that as a whole it is beyond all question a stratified water deposit. There is probably in no part of the world so good an opportunity to settle this disputed point by field observation. The waves of the great lakes eroding their shores keep exposed hundreds of miles

of magnificent drift sections, both modified and unmodified. Besides there are over fifty railroads which have cut the hills in every direction, and innumerable wells, coal shafts, tunnels, and river erosions, making in all probably 2000 linear miles of drift section exposed to observations. It is impossible to mistake the meaning of the facts, and the result has been to oblige those western geologists most familiar with the sections to abandon the glacier theory and admit that the boulder drift of this region is altogether an aqueous deposit, though the waters floated vast quantities of ice.

It has often been stated that the only stratified drift is that which has been rearranged by water since its first deposit. This rule entirely fails in the west, the original drift being clearly stratified. I ought to remark that the distinction between the two is easily made out by the form of the surface. Original drift is marked by a peculiar style of undulation, and by the frequent occurrence of circular and oval valleys without any outlet. Modified drift arranges all its excavations with reference to lines of drainage, and its valleys all have outlets. The eye once educated to these distinctions will rarely commit an error in deciding between the two. Now the stratification, with its beds of clay, sand, gravel, etc., is often just as clear in the original drift as in that which is modified, and even the summits of lofty hills show both stratification and cross stratification in the plainest manner, such as water only can produce. It is true however that there are thick beds of clay and other materials where the lines of lamination are so obscure that they escape attention when penetrated with the pick and the shovel, but even then, they are generally intercalated with well stratified layers of sand and gravel so as to establish the aqueous origin of the whole. These thick and at first glance non-laminated beds almost invariably show their strata when exposed on the lake shores to the erosion of the waves, and of the atmosphere, so that it may be said that a proper study of the boulder drift is impossible to one who neglects to examine the shore bluffs. Perhaps the most remarkable series of facts connected with the western drift is that which indicates the energy of the water action during its deposit. The first of these facts was observed by Prof. Jewell of Chicago, and was published in this Journal. A brief re-statement may be necessary. The city of Chicago pushed a tunnel for two miles in the unmodified boulder clay beneath Lake Michigan for the purpose of drawing water from a point distant from shore contaminations. This clay was stratified in thick beds, and contained two kinds of erratic blocks, viz., boulders of rock and *boulders of loose gravel.* The latter were sometimes three feet

in diameter, and had exactly the shape of ordinary boulders, and terminated abruptly on all sides in the solid clay. In many intances projecting angles near the upper parts overhung their bases, and in general the whole contour was such as was impossible for loose gravel to assume under the mere action of water. Every scientific man that saw them was convinced of two things, viz., that the gravel was dropped from floating ice in frozen masses, and that it was covered up and supported in position by the clay before the frozen masses had time to melt, otherwise the loosened pebbles would have fallen down in conical heaps. An unavoidable, and, at that time, a very perplexing inference was, that in order to support the gravel masses before they melted the clay must have been deposited with enormous and unacountable rapidity; but later observations upon the drift north of us have dispelled the wonder so far as this section is concerned, by showing a still greater violence of water action in the regions from which the clay and the gravel came, as the following facts show.

The state of Wisconsin is channelled with a remarkable valley. Commencing north of Lake Michigan near Lake Superior, this depression runs southwest and contains in its northern part the waters of Green Bay, and in its southern portion those of Rock river. It pursues an almost straight course for 400 miles and terminates at the Mississippi river where Rock river empties into it.

From the northwest, the country descends by a gentle slope into the valley, but from the southeast it breaks down suddenly and often by a perpendicular precipice, as though the rocks on that side had been lifted along the line of a fault. A rocky ridge or rather an elevated region of Silurian rock some 300 feet in height, separates this valley from Lake Michigan, upon which reposes a thick and remarkable drift deposit. The peculiarity of the formation is that it consists of a vast body of very coarse stratified, and well water-worn gravel, which for some distance on the side next the valley is almost pure rolled stone, but as we recede to the southeast becomes mixed with clay, and at a distance of 20 miles gradually shades off into the boulder clay of Illinois, such as contained the gravel boulders above described from Chicago tunnel. This gravel deposit, which is partly described in Lapham's Antiquities of Wisconsin, rises along its central part into a ridge of lofty hills, some of which run up in sharp eminences to over 800 feet above the level of Lake Michigan. The gravel deposit commences on the peninsula between Green Bay and Lake Michigan and runs southwest about two hundred miles, and being over 20 miles in width it covers an area of over four thousand

square miles. The hills are often sharp and conical and interspersed with deep circular valleys without outlets, from which the region has obtained the popular name of "The Potash Kettles." In the northern part the gravel is very coarse, many of the pebbles being more than a foot in diameter, and yet well water worn, and thrown up into steep round hills so lofty as to imply great violence in the water action that threw them up; but as we trace it southward the material becomes finer and the hills lower, until they shade off imperceptibly into the drift clay of the Illinois Prairies. The stratified character of the gravel, though often obscured by the coarseness of the material is on the whole too evident to admit of any possible doubt, as in innumerable places it exhibits both stratification and cross-stratification in the plainest manner. On the opposite or northwest slope of the valley no such gravel formation exists. It would seem to be an unavoidable inference that our drift of this region not only came from the north, but it came in a vast sweep of water deep enough to cover gravel hills more than 800 feet high, and with velocity enough to throw such coarse material into lofty and steep summits. It would appear that the uninterrupted sweep of the waters down the gradual northern slope of the valley allowed no great deposits, but that the current striking the precipice constituting the southern edge, was partly obstructed, and thrown into extraordinary and irregular commotion, piling lofty gravel hills in some places, and leaving deep hollows in others, as it swept across the elevation. The finer materials would be carried onward and settle as clays farther south as we find actually the case. Under such circumstances it is no longer surprising that masses of frozen gravel dropped by icebergs south of the gravel range, were covered with clay before they had time to melt. If any one claims that this gravel range is a lateral moraine of some ancient glacier occupying the Green Bay valley, it is sufficient to answer, first, that the gravel in no manner resembles moraine material, and secondly that such a glacier would have its moraine on both sides, and at the end, whereas the gravel is only on the southeast flank of the valley.

It is interesting to notice that a similar gravel range flanks the southwestern border of the valley of the Georgian Bay, which juts out southeast from Lake Huron. This is described by Rev. Thos. Hurlburt, of Caistorville, Ontario, Canada, in a paper to the Chicago Academy of Sciences, not yet published.

Another fact which shows the aquatic character of our drift agencies, is that the gravel hills, as well as nearly all the other drift of this region are covered with a thin stratum of orange-colored loam, which varies from a few inches to several feet in

thickness, and follows all the undulations of the surface except the valleys of erosion. This loam is free from boulders, and is very plainly stratified. It seems to have been a deposit of quieter water, after the violence of the previous action had expended itself, or perhaps after the rising again of the crest of the Laurentian Hills above the waves had cut off the further progress of both water and floating ice. I am not sure whether this loam covers the very highest summits, but it certainly lies like a blanket over all the lower country up to several hundred feet above the lake, and seems to prove that this region remained for a time under water after the boulders ceased to arrive. That it was not the product of a later submergence cotemporary with the loess, I infer, because I have never been able to discover any trace of black soil between it and the boulder drift, such as would have been found, had there intervened a period of dry land between the two. This loam is found both in the basin of the lakes, and outside of the rim of the latter on all the seaward slopes, except the northern.

If we follow the western drift toward its sources in the far north, we are confronted with still further marks of the violence of the action which transferred it. Rev. T. Hurlburt, whose paper was quoted above and who has been for forty years an acute observer of drift phenomena over the whole region from the Hudson's Bay to the Ohio river, says there is little or no drift material on the north slope of the Laurentian Hills. The whole country is scratched and pounded by the drift action, but the loose material has nearly all been swept southward. Not even the boulders could keep their footing. The only exceptions are where abrupt declivities front north in such positions as to oppose the current. In these cases though the finer materials are gone the boulders are piled up in vast slopes with their surfaces rammed together like a pavement. The soil of the country consists only of vegetable mould resting on the smooth rock. Prof. Dawson of Montreal, whose observations I presume were made in the eastern part of the range, says the region of the Laurentian Hills, though well worn by drift action, is nearly destitute of drift material. He believes fully in the aquatic character of all our drift deposits. Maj. Robert Kennicott, whose arctic journal is now being printed by the Chicago Academy of Sciences, crossed the western part of the range and remarks that the northern slope for hundreds of miles is smooth rock, almost absolutely destitute of any other soil than a few inches of decomposed vegetation. We seem therefore to have testimony that the drift action for a thousand miles, east and west along the Laurentian crest, and an unknown distance north of it was too violent to admit of

drift deposits, even the boulders being swept off. South of the crest the waters were less violent, and deposits commenced. In northern Wisconsin, the impinging of the current against the line of precipice flanking Green Bay valley left the marks of violent disturbance in the great gravel range. In northern Illinois the gravel shades off into clay, and in Central Illinois the ancient Pliocene soil is not stripped from the surface, nor even the stumps, nor the rotten logs that lay upon it removed. This could not be had the country been scraped by the advance of a glacier, but might readily occur were it submerged by turbid waters coming to rest after their southward rush.

Another remarkable fact, is the sudden retirement of the drift waters after the deposit of the orange loam above mentioned. No sea or large lake remains long at or near the same level, without throwing up a beach or eroding a bluff which when produced is as indestructible as any other geological monument. Ancient beach lines have little tendency to disappear. The basins of the great lakes like so many cups were left full of water, and the ancient beaches are perfectly distinct to-day up to their very brims, but outside, on the seaward slope there are no such lines. From the uplands of Wisconsin to the Ohio river there is a descent of over 1300 feet on which the most diligent search has failed to find a single beach. The Illinois Central Railroad, which runs two north and south lines the whole length of Illinois, has spent much money in vain, to find such ridges to furnish gravel for their tracks. The chief engineer, Mr. Clark, informs me that there is positively no beach line crossing either of their routes. It follows that the waters at length retired with a degree of suddenness that left no time to accumulate beaches. It is possible that this sudden retirement, and the consequent rush of waters was the cause of the valleys of our streams being excavated to such an enormous breadth as compared with the feeble brooks that now meander through them.

I see it stated in a recent Smithsonian volume that the fossils of western drift are fresh water, and of the eastern deposits marine. So far as this region is concerned I think this must be a mistake, for after fifteen years search I have never been able to find nor hear of a well authenticated fossil of any kind in the true boulder drift, except such as seemed to belong to the previous formations—Pliocene, or older; and even these are surprisingly rare, when we reflect that the drift action passed over a region already teeming with animal and vegetable life. It cannot be, however, that they are totally absent on any theory we adopt. If the glacier theory be true, terminal moraines are haunted by all sorts of land animals, and where the materials are

fertile they are soon covered with vegetation which is often buried *in situ* by temporary advances in the glacier. Besides, insects die on the ice, and falling leaves are blown into its crevasses. If the theory of submergence be preferred, then aquatic fossils should be found, and one would hardly suppose that any violence of the currents would wholly destroy them. If we adhere to the theory of submergence we must of course refer the erosion and smoothing of the rocks to the violent action of floating ice. Without venturing any dogmatic opinion on these difficult points, it seems to me that the phenomena favor the following inferences.

1. The western boulder drift is a stratified water deposit.

2. A breadth of some 200 miles along its southern border rests on the Pliocene soil, small patches of which are also found a hundred miles north of Chicago.

3. The drift does not merge directly into the loess but is separated from it by a bed of soil.

4. The waters of the drift had at the north a great velocity, and a depth of over 800 feet above Lake Michigan, but as it passed southward the water lost its swiftness and deposited its sediment.

5. A considerable depth of stiller water remained after the cessation of the great current, long enough to deposit the thin stratum of orange loam.

6. The final retirement of the drift waters from this region was rather sudden, the water falling at least 1300 feet without leaving any beach lines.

81 Monroe st., Chicago, June 7, 1869.

Art. XIX.—*Contributions from the Sheffield Laboratory of Yale College.* No. XX.—*On Durangite, a fluo-arsenate from Durango in Mexico ;* by George J. Brush.

The stream-tin deposit of Durango in Mexico is well known among American mineralogists for the remarkable specimens of tin-stone, as well as for the beautiful crystals of topaz which it affords. Quite recently a bright orange-colored mineral has been found at that locality, and I am indebted to Mr. Henry G. Hanks, of San Francisco, for the opportunity of investigating it. Mr. Hanks generously placed at my disposal three small crystals, with the request that I would examine the mineral and describe the species should it prove to be new.

The crystals have a rhombic aspect; color, bright orange-red, almost exactly the shade of the Uralian chromate of lead ;

streak, cream yellow ; lustre, vitreous. Cleavage distinct in two directions, corresponding to two of the planes of the crystals at an angle of 110° 10′, according to measurements by Mr. J. M. Blake, who makes the crystallization monoclinic. (See note on the crystallization of the mineral, at the close of this article.) Hardness =5 ; specific gravity =3·95–4·03.

When treated in the closed tube the mineral blackens at a moderate temperature, but regains its color on cooling; at a higher heat it fuses easily to a yellow glass and gives a faint white sublimate ; this sublimate proved to be volatile, and the glass appeared dimmed from corrosive action. Not the least trace of moisture was perceptible in the closed tube. In the open tube the same reactions were observed, with the addition that blue litmus paper was reddened when inserted in the upper end of the tube. On charcoal fuses readily, and in R. F. gives a strong arsenical odor and coats the coal with a faint white volatile sublimate. With soda the arsenical odor is more marked, but in R. F. the assay affords no reducible metal. When fused with dry carbonate of soda and charcoal powder in a matrass yields a metallic ring of arsenic ; with borax and salt of phosphorus it gives only a reaction for iron, while with soda it yields a manganese-green. In the forceps, fuses with intumescence at 2 and gives a strong soda flame.

The mineral is only partially attacked by chlorhydric and nitric acids, but is completely decomposed by sulphuric acid, with evolution of fluohydric acid. A qualitative examination showed the presence of arsenic acid, alumina, iron, manganese, soda, lithia and fluorine. Search was made for other metallic acids, as well as for the rarer earths and metals, with a negative result; it also proved to be free from phosphoric acid and chlorine.

The very small quantity of mineral which I felt at liberty to use for the quantitative determinations has prevented my making the examination as complete as I could desire ; but I have been able to obtain direct duplicate estimations of every constituent except fluorine. This last element must exist in considerable quantity in the substance, as the fluohydric acid evolved on attacking the mineral by sulphuric acid in a platinum vessel etched glass with great readiness and distinctness. The following results were obtained :

	I.	Oxygen.	II.	III.
Arsenic acid,	55·10	19·16	53·22	----
Alumina,	20·68	9·63	20·09	----
Ferric oxyd,	4·78	1·44	5·06	----
Manganous oxyd,	1·30	0·30	1·28	----
Soda,	11·66	3·01	----	11·86
Lithia,	0·81	0·43	----	0·70
Fluorine,	undetermined.			

In No. 1, the decomposition was effected by sulphuric acid, the arsenic acid was reduced to arsenous acid by sulphurous acid, and the arsenic precipitated by sulphydric acid gas as ter-sulphid; this last was re-dissolved in fuming nitric acid, and after freeing the solution from most of the acid by evaporation it was made ammoniacal and the arsenic acid precipitated by the ordinary magnesia mixture, and estimated as ammonia-arsenate of magnesia. The iron and alumina were thrown down by ammonia and subsequently separated by caustic soda; the small amount of manganese remaining with the iron was separated from it by converting the iron into basic acetate and oxydizing the manganese by means of bromine. A portion of the manganese also was found with the alkalies; these were weighed first as sulphates; the manganese was then separated by soda and the lithia determined as phosphate. The precipitates were examined as carefully as possible, considering their small amount, and found to be pure.

In No. 2, the decomposition was made by fusion with carbonate of soda. This was dissolved in water, acidulated with chlorhydric acid and reduced as before. The low amount of arsenic acid may be due to the fact that the soda fusion was made over a gas blast-lamp, and possibly a portion of arsenic acid was reduced to arsenous acid and volatilized; or the loss may be attributed to other accidental causes.

No. 3 was a qualitative-quantitative analysis in which only the alkalies were estimated; the soda and lithia were first weighed as sulphates, then converted into chlorids, and the alkalies separated by dissolving the chlorid of lithium in a mixture of absolute alcohol and ether. The alkalies examined with the spectroscope showed only the lines of sodium and lithium.

The oxygen ratio in No. 1, between the protoxyds, sesquioxyds and arsenic acid is 3·74 : 11·07 : 19·16, or, very nearly, 1 : 3 : 5. This involves the assumption that the small amount of manganese exists as protoxyd, of which we have no proof, but it seems probable that this ratio is the true one, although it is impossible at present to determine the exact state of oxydation of the iron and manganese. This composition and ratio suggest an analogy between the new mineral and amblygonite, a fluo-phosphate of alumina, lithia and soda, and it may be viewed as an arsenic-acid amblygonite, containing a small percentage of iron and manganese and more soda than lithia.

The formula may be written $(\frac{1}{4}\dot{R}^3 + \frac{3}{4}\ddot{R})\,\ddot{A}s$, and, as in amblygonite, a portion of the oxygen is replaced by fluorine. A number of hypotheses showing the possible relation of the fluorine might be suggested, but until further investigation these

are unnecessary. I hope before long to be able to obtain a sufficient quantity of the mineral to continue the study of its composition. The results here given are sufficient to demonstrate it to be a new species, and I believe it to be the only observed native *fluo-arsenate.* I propose for it the name *Durangite.*

Preliminary Note on the Crystallization of Durangite; by JOHN M. BLAKE.

I defer, for the present, a detailed account of my observations on this mineral, with the hope that I may have an opportunity to examine other specimens better adapted for measurement, and the study of the habit of the species. The angular measurements, as well as the optical characters distinguish the species, and show that the crystals are monoclinic, and that they do not correspond either with amblygonite or the other anhydrous phosphates and arsenates, of which I have been able to find crystallographic descriptions, and belonging in the division to which the chemical characters appear to assign this mineral.

An approximation in all the angles, to those of keilhauite, and sphene, is interesting. The figure of keilhauite* is so good a representation of the crystals of Durangite, that for present purposes it may be used for illustration, by making *I* the cleavage plane, and omitting *O* and the plane there marked $-2i$, which were not found, and adding $4i$, which occurs in sphene, and on Durangite is a small plane of infrequent occurrence.

ART. XX.—*Remarks on the Galvanic Battery;* by G. W. HOUGH, Director Dudley Observatory.†

THE constant use of Daniell's battery for nearly ten years, made us desirous of more fully understanding the mode of its action, and the cause of the decline in the strength of the electric current. For this purpose, during the past year, a series of experiments were instituted, with batteries of various forms. As they were undertaken solely for the purpose of securing the best form of battery for every day use, delicate instruments were not provided, and consequently great precision of measurement could not be obtained.

The Galvanometer consisted of a steel needle one and a half inches in length, attached to a light strip of brass, having a radius of five inches. This needle was mounted horizontally over a coil of silk-covered copper wire. The graduation of

* See Dana's Mineralogy, 5th edition, p. 387.

† Abstract read at the Chicago meeting of the American Association.

the instrument was effected by two methods, viz: by means of the divided current, and by the revolving disk.

The Rheostat was constructed by winding No. 30 silk-covered wire, around a wooden cylinder ten inches in circumference and 8 inches in length. The coils were separated in different groups, and so connected with switches that any number could readily be introduced in the circuit.

For measuring the comparative resistance of different liquids, two small platinum plates, attached to protected wires, were fastened to a block of wood, and maintained at a uniform distance from each other.

Daniell's Battery.—The battery originally constructed by Daniell consisted of a copper cylinder 6 inches high and $3\frac{1}{2}$ inches in diameter, with a porous cell or ox-gullet passing through the center, in which was suspended a rod of zinc 6 inches in length, and $\frac{1}{2}$ inch in diameter. The porous cell passed through the bottom of the copper cylinder and the end was connected with a glass siphon, bent in such a manner that the top was on a level with the surface of the liquid. The battery was excited with a saturated solution of sulphate of copper and water acidulated with sulphuric acid. When fresh water and acid was poured in the top of the porous cell, an equal amount of liquid was forced out from the bottom through the siphon. It was intended by this arrangement to maintain at all times the same strength of acidulated water about the zinc. After this battery came in general use, porous clay cells were substituted for the membranous bag, and the siphon was discarded.

Hill's Battery.—As many of our experiments were made with Hill's modification of Daniell's battery, a description of its peculiarity is deemed necessary. This battery consists of a glass jar, with a sheet of copper placed in the bottom and a disk of zinc, perforated in the center, suspended horizontally near the top. Protected copper wires are attached to the zinc and copper forming the two poles of the battery. When thus arranged the jar is filled with a solution of *s. z.** after which a few crystals of *s. c.* are dropped in through the orifice in the zinc, and lie on the copper plate. If the liquid is not agitated the copper will lie in a solution of *s. c.* and the zinc in a solution of *s. z.*, so long as the specific gravity of the latter is less than 36° B. The intervening liquid *s. z.* acts as a protection in the same manner as the porous cell in Daniell's battery.

The formation of Sulphate of Zinc.—As soon as the poles of the battery are joined *s. z.* is formed in the cell containing

* The following abbreviations are used: *q.* Quantity of electricity flowing in the external circuit; *s. c.* sulphate of copper; *s. z.* sulphate of zinc.

the zinc, and metallic copper is deposited on the copper plate. A long series of experiments were instituted to determine the rate of formation of the *s. z.*, during the various conditions of the battery. A Hill's element was put on a closed circuit through the galvanometer, without any external resistance, and the specific gravity of the *s. z.* was measured daily, by means of a Baumé hydrometer. The indications of the galvanometer needle and the temperature, was also ascertained at the same time. The jar containing the liquid was 7 inches high and 6 inches in diameter. The zinc and copper plates each presented a surface of 28 square inches. The distance between the plates was $5\frac{1}{2}$ inches. The battery was started with *s. z.* at 21° B. specific gravity. This element was on a closed circuit for 30 days; at the end of that time the *s. z.* was nearly saturated 43° B., temperature 50°, and *q.* had decreased to only one seventh of its normal value. For the first 23 days, or while the specific gravity of the *s. z.* was less than 40° B., *q.* was sensibly the same from day to day.

It is a fundamental principle that the formation of *s. z.* is directly proportional to the quantity of electricity passing in the circuit. This would be strictly true, provided there was no local action; but actual experience demonstrates that this condition is never fulfilled. On laying down the daily results in the form of a curve, having the specific gravity of the *s. z.* for one ordinate, and the time for the other, it was found that the observations could be well represented by an equation of the second degree in which $\Delta_1 = +1{\cdot}66°$ and $\Delta_2 = -0{\cdot}08°$. For this element, the amount of liquid saturated with *s. z.* between the limits 12° to 40° B., was 3·6 cubic inches daily. A second element of the same size in which the distance between the plates was reduced to 4 inches, gave similar results. But the amount of liquid saturated daily was nearly twice as great, with but a small increase in the quantity of electricity generated; showing a much greater local action.

The experiments with a Daniell's element of the usual size, using a porous cell $2\frac{1}{2}$ inches in diameter and 7 inches high, gave 5·7 cubic inches for the amount of liquid saturated daily, during the normal condition of the element. As *q.* was nearly double that of Hill's element, and the amount of liquid saturated, less in proportion, it shows less local action. From these experiments it follows that once having determined *q.* the length of time the battery will maintain the currents at its normal force can readily be computed; since it depends entirely on the capacity of the cell holding the sulphate of zinc. With a porous cell of the usual size, when no external resistance is introduced, the battery will begin to decrease at the

end of three days and at the end of five days there will be scarcely any action. On the contrary with Hill's element, of the size before described, *q.* will continue uniform for more than thirty days, and will be but little less at the end of fifty days.

Most of the writers on galvanism seem to imagine that sulphuric acid is essential for exciting the battery, but our experiments show that this is not the case; in fact we consider it a detriment; for if too great a quantity is used, crystals of sulphate of zinc are deposited on the zinc, thereby greatly lessening *q.* It seems to me that the only office of the sulphuric acid, is to make the water a better conductor; since nitric acid, muriatic acid, salt, sulphate of copper, or sulphate of zinc, will answer equally well. By using a solution of *s. z.* of a certain specific gravity, the same quantity and electro-motive force is obtained, as with sulphuric acid. This is also true for Grove's and the bi-chromate of potash battery.

The use of a number of porous cells in the same jar.—Since the decrease of *q.* is due to the formation of *s. z.*, the question naturally arises, how can a battery be constructed that will give a uniform current for a long period of time? The answer is plain, we must increase the capacity of the cell in which the zinc is placed.

In a two-gallon stone jar, three porous cells were placed with a sheet of copper surrounding them. The current was then passed through the galvanometer and rheostat, and sufficient resistance inserted to make *q.* equal to that due to a single cell, when used alone. The amount of *s. z.* formed in a given time was then measured, when it was found each cell made as much *s. z.* as if only a single one had been employed. This combination showed very great local action. Nothing, therefore, would be gained by such an arrangement, but on the contrary a much greater amount of zinc would be consumed without advantage.

We next had constructed large porous cells 6 inches in diameter and 7 inches high having a capacity of 180 cubic inches. Our previous experiments enable us to calculate with considerable precision the length of time one of these elements will maintain a maximum current of electricity. Allowing 5·7 cubic inches for the amount of liquid saturated daily between the limits 12° to 40°, it is apparent that a battery of this size should remain constant for more than 30 days, without any external resistance being introduced in the circuit. When electro-magnets are operated, as the external resistance should at least be equal to that of the battery, the current would remain constant for more than two months on a continually closed circuit.

The relation between the quantity of electricity and the specific gravity of the sulphate of zinc.—Svanberg's experiments are quoted by recent writers to prove that the electro-motive force for Daniell's battery is not materially changed by the nature of the liquid about the zinc. Although this statement is strictly true, yet it does not give us correct views in regard to the battery. We prepared different solutions of *s. z.* ranging from zero to saturation. These were alternately used in the porous cell and *q.* measured by the galvanometer. The time for each experiment was about five minutes. Above the specific gravity of 15° B. *q.* was sensibly the same up to saturation. These results were so directly contrary to all our experience with the battery in actual use, that at first we were at a loss to understand them. The experiments were accordingly continued, by putting an element on a closed circuit through the galvanometer. The quantity of electricity and the specific gravity of the *s. z.* was then noted from time to time. So soon as the *s. z.* approached near saturation, from 43° to 46° B. depending on the temperature, it was found that the element gradually decreased in force until finally *q.* was less than one twentieth of its normal value. As the electro-motive force remained constant it indicated an internal resistance more than twenty times as great. But we know by direct experiment that a saturated solution of *s. z.* is a better conductor than a dilute solution, and hence we ought to expect the resistance to be less. A careful study of the phenomena led us to conclude that the increased resistance was due to the polarization in the battery itself. When the current is passed through a voltameter or electrolyte solution, it is found a much greater resistance is introduced, than that due to the liquid alone. This increased resistance is ascribed to polarization of the electrodes in the solution and has been ably discussed by a number of scientists. But the polarization in the battery itself does not appear to have been investigated. After an element has been on a closed circuit for a long time, if the circuit be opened for a few minutes, on closing it, the galvanometer will at first indicate the maximum quantity due to the element, but in a few seconds the needle will gradually recede and stand as before. It appears that when the specific gravity of the *s. z.* approaches saturation it becomes charged with electricity like a Leyden jar or prime conductor. From numerous experiments, we find *q.* reaches its maximum when the specific gravity of the *s. z.* is between 20° and 30° B. However, for practical purposes the battery gives essentially the same force between 15° and 38° B. Below 15° B. the conducting power of the *s. z.* is considerably less, and consequently the resistance greater, and above 38° B.

the resistance is again increased by polarization. The conducting power of *s. z.* was found to be essentially the same between 30° B. and saturation. At 1° B. it was one fourth, at 7° one half, and at 14° three fourths as great as for a saturated solution.

On the use of the negative metal in Daniell's Battery.—The negative metal in Daniell's battery is only useful as a conductor of the current.

For the purpose of testing the correctness of this conclusion, experiments were made with the following metals as the negative plate: 1, Copper; 2, sheet lead; 3, sheet iron; 4, sheet iron tinned (the ordinary sheet tin); 5, sheet zinc; 6, cast zinc.

The *s. c.* was a saturated solution, and the *s. z.* had a specific gravity of 25° B. The quantity of electricity and the electromotive force was found to be the same for copper, lead, iron and tin. When zinc was used for both the positive and negative metal, the action was somewhat different. For two or three seconds after immersion in the *s. c.* there was a small negative current, after which the galvanometer needle was gradually deflected until it indicated a quantity of electricity nearly equal to the normal condition of the element. It then remained at rest for a few seconds after which it receded and stood at a degree indicating about one half the quantity. The whole time required to bring it to rest, was three minutes from the time of immersion. During the progress of the experiment the hydrogen was evolved so rapidly from the zinc immersed in the *s. c.* that the bubbles could be exploded by holding a lighted match near the surface of the liquid. As soon, however, as the galvanometer came to rest, the evolution of hydrogen had nearly ceased. On removing the zinc it was found covered with a loose copper powder, not reguline metal but such as is deposited when a large battery is employed to act on a small surface. This powder did not adhere closely to the zinc, but was separated by a thin layer of *s. z.* or hydrogen. On washing the zinc and repeating the experiment, precisely similar results were obtained. Although the zinc was capable of conducting the maximum quantity of electricity, yet the electro-motive force was considerably less than for the other metals. A careful examination of these experiments, leads us to the conclusion that the negative metal in Daniell's battery, only acts as a conductor of the electricity.

On the internal resistance of the battery.—In a battery with two liquids the internal resistance is made up of two elements, viz: the specific resistance of the liquid, and the resistance of the porous cell. Although recent writers have remarked the variation of resistance due to different kinds of earthen cells, yet

we have not learned that any one has determined separately the resistance due to the cell and that due to the liquids. By our method it is necessary to use at least two cells of different size. In these experiments three were employed—

No. 1, White clay cell 0·31 inches in thickness, 6 inches in diameter and 7 inches high.
No. 2, White clay cell 0·15 inches in thickness, 3 inches in diameter and 7 inches high.
No. 3, Split-leather cell 0·06 inches in thickness, 5 inches in diameter and 7 inches high, fitted to a bottom of inch pine.

The resistance of the element was first determined for each cell separately. Then the cells were placed one inside of the other and the total resistance determined as before. After which it was found for two at a time. These several determinations gave us a series of equations, involving the resistance of each separate cell together with the specific resistance of the liquids.

The following are the results expressed in an arbitrary unit.

No. 1,	resistance,	22
No. 2,	"	17
No. 3,	"	7

Specific resistance of the liquids *s. c.* saturated solution, *s. z.* 25° B. 13. From which it appears that the specific resistance of the liquids is about the same as for a white clay cell of the ordinary size.

As *q.* is increased by lessening the internal resistance, other things being equal, it is apparent that the leather cells are superior to those made of white clay.

On the construction of Daniell's battery.—For a local battery, where the external resistance is small, two-gallon stone jars may be used for the vessel holding the *s. c.* solution. The negative plate is best made of sheet lead instead of copper as heretofore; as it it is less expensive and is easier bent in the proper form. It is desirable to perforate the sheet with an ordinary punch, in order to secure a more free circulation of the liquid surrounding it. Ordinary sheet tin makes the cheapest negative plate, but it is unfit for general use, where the battery is required to be kept in constant action for a long period. For if the *s. c.* solution is not kept saturated, chemical action takes place between the iron and tin which soon dissolves the plates. I have, however, used it successfully. If the solution is kept saturated, in a month or so the sheet will be covered with a fine plate of copper, which may be easily separated, provided the original plate has been properly prepared by being oiled and black-beaded before being used. The porous cell in

which the zinc is placed should have a capacity of at least 150 cubic inches. As the resistance of large clay cells is more than three times as great as for those made of leather, the latter are preferred ; since with the same surface of zinc, *q.* is nearly doubled. The constant use of leather cells during the past year fully demonstrates their superiority over those made of white clay. For it is found in practice that for working magnets such as are used in telegraph offices for local sounders, one element as described above gives more effective working force than two of those in ordinary use. The zinc casting may be of any form ; for cells of this size, it should have an external surface of 50 square inches.

The battery should be started with *s. z.* at 15·° B. specific gravity. Sulphuric acid should never be used in the cell containing the zinc. Crystals of *s. c.* are suspended in a bag or perforated cup near the top of the liquid surrounding the negative plate, in order to keep the solution at saturation. After a battery has been in constant use for a number of months, crystals of *s. c.* will be found precipitated on the bottom of the jar. When this is the case, the liquid must be poured in another vessel, and all the *s. c.* removed, as it seems to lessen *q.* During cold weather the battery may be improved by adding occasionally a little sulphuric acid to the *s. c.* solution. Between 40° and 100° Fahr., the specific resistance of the liquids is increased about one sixth for every 10° decrease of temperature. It is not desirable therefore, to work the battery at a temperature below 50° Fahr.

The zinc need not be amalgamated, but it should be cleaned once in two or three months, and all the sediment removed from the porous cell.

When the specific gravity of the *s. z.* approaches 40° B. one half of the liquid should be removed, and fresh water added. It is always best, however, to keep the specific gravity of the *s. z.* between the limits 15° to 38° B.

If Hill's form of battery is employed, a jar of the same size may be used. With plates of 50 square inches each, placed at a distance of 5 inches from each other, *q.* is the same as for a Daniell's element of the ordinary size. The negative plate may be made of sheet lead, having a protected copper wire firmly attached to it. The zinc should be cast with an opening in the center of one and one half inches in diameter. Iron bars for supporting it near the top of the jar, can be cast in the zinc. This battery should be started with a solution of *s. z.* having a specific gravity 15·° B. The *s. c.* is dropped in through the orifice in the zinc plate. The battery should be examined occasionally with the hydrometer, and the specific gravity of the liquid never allowed to become greater than 36·° B.

ART. XXI.—*Contributions of the Massachusetts Institute of Technology.* I.—*On Nitric Acid and Chlorate of Potassium as an Oxydizing Mixture applicable to Sulphur, Sulphids, Chromium, Arsenic, Organic Matters, etc.;* by FRANK H. STORER, Professor of General and Industrial Chemistry in the Massachusetts Institute of Technology.

SOME years since while studying the action of various oxydizing agents upon oxyd of chromium, I was struck by the superior oxydizing power of a mixture of ordinary nitric acid and chlorate of potassium over that of the mixtures of chlorate of potassium and chlorhydric or sulphuric acid, commonly used in analysis. Inasmuch as the fact of the great oxydizing power of a mixture of nitric acid and the chlorate had already been noticed and explained by several observers,* I at that time contented myself with a simple statement of my own observations of the action of the mixture upon chromic oxyd† without referring in any way to the general value of the mixture as an oxydizing agent. Since that time, however, I have had frequent occasion to employ the mixture for effecting the oxydation of many substances, besides oxyd of chromium, such as present themselves in the ordinary experience of an analytical laboratory, and have satisfied myself that the merit of the process has not hitherto been duly appreciated.

Experience has convinced me, not only that a mixture of nitric acid and chlorate of potassium oxydizes more rapidly than the common mixture of chlorhydric acid and chlorate of potassium, but that it is really to be preferred in the great majority of cases to any of the agents ordinarily employed to effect oxydation in the wet way. Instead of occupying as now a secondary or alternative place in the treatises on analysis it ought to take precedence of the other processes of oxydation. It may be used with advantage in many instances where dry methods of oxydation are now recommended. With the exception perhaps of the sulphids, or other compounds, of antimony and tin, there are probably but few cases where its use will be found inadmissible.

The following notes include the results of several researches made by students of the Massachusetts Institute of Technology with the view of testing the capabilities of the process :—

* Compare Gmelin's Handbook of Chemistry, iii, 61.

† Proceedings of American Academy, 1859, iv, 342; Journal für pracktische Chemie, lxxx, 44.

Estimation of Sulphur in Organic Compounds; by A. H. Pearson.

It is easy to determine sulphur in non-volatile organic compounds by oxydizing the substance with chlorate of potassium and nitric acid, precipitating the sulphuric acid as sulphate of barium and washing the latter with a solution of acetate of ammonium, to remove any nitrate of barium which may have adhered to it.

To oxydize the sulphur compound, place a weighed quantity of it in a porcelain dish, pour upon it three or four table spoonfulls of strong nitric acid (39° B.), free from sulphuric acid, and add to the acid half a teaspoonful of chlorate of potassium. Cover the mixture with an inverted glass funnel, the stem of which has been bent to a right angle. Place the dish on a wire gauze support and heat its contents. From time to time lift the funnel slightly and throw a small fragment of chlorate of potassium into the hot acid.

The funnel must be of such size that its rim may fall within the rim of the dish and rest securely upon the sides of the dish, above the liquid; it serves to retain the particles of liquid which are thrown up from the dish by the gas evolved during the decomposition of the chlorate.

The oxydation will be completed more or less rapidly according to the character of the substance operated upon. Only five or ten minutes are required to completely oxydize a third of a gram of sulphocyanid of potassium, while from half to three quarters of an hour are needed to destroy the same weight of ordinary free sulphur. It may be observed in passing, that sulphur which has just been distilled dissolves twice as rapidly in a mixture of nitric acid and chlorate of potassium as sulphur which has long been exposed to the air.

Several samples of sulphocyanid of potassium, oxydized in this way, gave the following results:—

A. 0·2015 grm. of the sulphocyanid gave 0·5114 grm. of sulphate of barium. (I).

A. 0·265 grm. of the sulphocyanid gave 0·6547 grm. of sulphate of barium. (II).

B. 0·149 grm. of the sulphocyanid gave 0·3796 grm. of sulphate of barium, (I).

B. 0·012 grm. of the sulphocyanid gave 0·03 grm. of sulphate of barium. (II).

C. 0·101 grm. of the sulphocyanid gave 0·2387 grm. of sulphate of barium.

D. 0·028 grm. of the sulphocyanid gave 0·067 grm. of sulphate of barium. (I).

D. 0·084 grm. of sulphocyanid gave 0·204 grm. of sulphate of barium. (II).

The sulphocyanid used for the experiments mentioned in the paragraphs marked "A" was prepared by fusing together ferrocyanid of potassium, carbonate of potassium, and sulphur in the usual way, treating the fused mass with hot alcohol and allowing the alcoholic solution to crystallize. That used for the experiments in paragraphs B was prepared in precisely the same way as the foregoing, but at another time. The salt prepared in this way is evidently contaminated with free sulphur, or some sulphur compound other than the sulphocyanid, which has been taken up by the alcohol.

The experiment recorded in paragraph C was made with crystals which separated from the alcoholic mother-liquid of B.

The experiments marked D, were made with purified crystals obtained as follows:—A quantity of the crude alcoholic crystals, similar to those used in experiments B, were dissolved in water, the solution was filtered to separate sulphur and placed under a bell glass, over strong sulphuric acid, to crystallize. The crystals thus obtained were redissolved in alcohol, the solution filtered to separate carbonate of potassium, then concentrated by evaporation and made to crystallize. The crystals were quickly pressed between folds of filter paper and portions of them were weighed out for the analyses.

The crystals obtained directly from the aqueous solution of the sulphocyanid were contaminated to a considerable extent, with carbonate of potassium, but after they had been recrystalized from alcohol only traces of the carbonate were found upon them.

Stated in terms of per cents, the results may be tabulated as follows:—

		I. Found.	II. Found.	Theory.
A.	Impure crystals.	34·85	33·91	
B.	Impure crystals.	34·98	34·33	
C.	---------	32·45	-- --	32·90
D.	---------	32·85	32·86	32·90

I have applied the foregoing method not only to sulphocyanid of potassium and to free sulphur as above described, but also for estimating sulphur in vulcanized caoutchouc and in several samples of anthracite and bituminous coal. It is easy to completely oxydize either of these substances by means of the mixed chlorate of potassium and nitric acid. Anthracite dissolves even more readily than bituminous coal, since, unlike the latter, it does not fuse to a single mass in the hot acid.

It is not improbable that by a slight variation of the foregoing process it may be found practicable to determine the carbon of an organic compound at the same time as the sul-

phur. Thus, the oxydation might perhaps be effected in a flask provided with a wide funnel tube for the addition of the chlorate and a delivery tube through which the carbonic acid formed could be led into baryta-water or some other substance fit to absorb that gas. Upon this point, however, I have as yet made no experiments.

May, 1869.

Assay of Sulphur in Iron Pyrites ; by A. H. PEARSON.

The proportion of sulphur in iron pyrites ("Sulphur-ore") may be readily and accurately estimated as follows :—Weigh out a gram or less of the powdered ore, place the powder in a porcelain dish, together with a small quantity of chlorate of potassium, pour upon it some 50 c. c. of pure nitric acid of 39° B., and cover the mixture with an inverted glass funnel, with bent stem. Set the dish upon a water bath and heat the water to boiling. From time to time throw crystals of chlorate of potassium into the hot acid. By adding rather large crystals of the chlorate at frequent intervals it is easy to oxydize the whole of the sulphid in half an hour. But since the solution obtained in that case is highly charged with saline matter it will usually be found more advantageous to use less of the chlorate of potassium and to allow a somewhat longer time for the process of oxydation.

When all the sulphur has been oxydized, rinse the funnel with water and remove it from the dish. Evaporate the liquid to a small bulk, then add to it a little concentrated chlorhydric acid and again evaporate to absolute dryness in order to render silicic acid insoluble. Moisten the residue with concentrated chlorhydric acid, mix it with water and filter, to separate silicic acid and gangue.

To the filtrate from the silicic acid add a quantity of solid tartaric acid about as large as that of the pyrites originally taken, heat the liquid almost to boiling and add to it an excess of chlorid of barium to precipitate the sulphuric acid. After the sulphate of barium has been allowed to subside, wash it thoroughly by decantation first with hot water and afterward with a dilute solution of acetate of ammonium. The latter may be prepared at the moment of use, by mixing ammonia-water and acetic acid. The purpose of the acetate of ammonium is to dissolve any nitrate of barium which may adhere to the sulphate ; that of the tartaric acid is to prevent the precipitation of iron compounds together with the sulphate of barium. In an experiment where 0·7 grm. of pyrites was oxydized with chlorate of potassium and nitric acid, and the

filtrate from silica was acidulated with chlorhydric acid without the addition of tartaric acid, there was thrown down on the addition of chlorid of barium a bright yellow precipitate which became darker colored when the solution was boiled. It was not only found to be impossible to wash out the iron with which this precipitate was contaminated but the consistency of the precipitate was such that it was a difficult matter even to wash away the saline liquor in which the precipitate was formed.

In another experiment, the attempt was made to remove the iron from the filtrate from silica before adding the barium salt to throw down the sulphuric acid. But in that case a considerable portion of the sulphuric acid was dragged down, as sulphate of potassium, by the iron precipitate and so lost. The precipitation of the iron was effected in this experiment by adding an excess of ammonia-water to the acidulated filtrate from silica and washing the precipitate for a long time, by decantation, with boiling water. To prove that the iron precipitate really retained sulphuric acid a quantity of the precipitate was dried, ignited and powdered and the powder boiled with water. The clear liquid thus obtained was acidulated with chlorhydric acid and tested with chlorid of barium. An abundant precipitate of sulphate of barium was at once thrown down.

After the sulphur of the pyrites has been determined by precipitating it from a tartaric acid solution, as above described, the iron might perhaps be estimated in the filtrate by one of the new methods of titration with hyposulphite of sodium. I have made no experiments with the hyposulphite, but have failed completely in several attempts to determine the iron as a sulphid, by precipitating with sulphid of sodium, as directed by Fresenius. I found it impossible to wash the sticky, slimy mass of sulphid of iron. It is not easy, on the other hand, to destroy the tartaric acid by igniting the dried filtrate, from sulphate of barium, in a muffle, for on evaporating this solution the saline matters with which it is charged continually creep over the edges of the dish.

November, 1868.

Assay of Copper pyrites; by F. P. Pearson.

The following method of treating copper pyrites has been found more advantageous than the ordinary process of oxydizing the mineral with aqua regia and subsequently evaporating the solution repeatedly with chlorhydric acid, or with sulphuric acid, to expel the last traces of nitric acid :—

Place a weighed quantity of the powdered mineral together with some chlorate of potassium in a porcelain dish.—Five grams of a variety of pyrites containing about 18 per cent of copper was found to be enough for one analysis, and a quantity of chlorate of potassium equal to a small teaspoonful, was added to the ore.—Invert a glass funnel with bent stem in the dish above the pyrites and pour upon the latter rather more ordinary strong nitric acid than would be sufficient to completely cover the powder. Place the dish upon a water-bath, and, from time to time, throw into it small quantities of chlorate of potassium. The doses of the chlorate must be repeated at frequent intervals until free sulphur can no longer be seen in the dish. If need be, add nitric acid also from time to time, to replace that lost by evaporation.

As a general rule it is safer and more convenient to heat the mixture on a water-bath than upon sand, though I find that the oxydation of sulphur can be effected more easily and quickly when the mixture of nitric acid and chlorate is heated to actual boiling than at the temperature obtainable by means of a water-bath. When the last particles of sulphur have been destroyed remove the inverted funnel from the dish, rinse it with water and collect the rinsings in a beaker by themselves. Allow the liquid in the evaporating dish to become cold, pour upon it a quantity of ordinary strong chlorhydric acid rather larger than the quantity of nitric acid taken at first, evaporate the mixed solution to dryness and heat the dry residue, to render silica insoluble in case any silica be present.

Pour water upon the cold residue, and, without filtering the liquor, wash the contents of the dish into the beaker which contains the rinsings of the funnel. Heat the liquid in the beaker nearly to boiling, add to it about 25 c. c. of a strong aqueous solution of ferrous sulphate slightly acidulated with sulphuric acid, and keep the mixture at a temperature near boiling during four or five minutes, in order to destroy the small quantity of nitric acid which has escaped decomposition in spite of the evaporation with chlorhydric acid.

The ferrous salt seldom or never acts instantaneously, but the reducing action proceeds rapidly and perfectly satisfactorily when once begun. If need be, add more of the ferrous solution, little by little, until the entire contents of the beaker became dark colored, or almost black, and no more gas is disengaged.

In order to be sure that all the nitric acid has been reduced, it is well enough, after the mixture of liquid and solution of ferrous sulphate has been duly heated, to place a drop of the mixture upon porcelain and test it with ferricyanid of potas-

sium. In general, however, the coloration of the liquor in the beaker due to the formation of nitrous or hyponitric acid will be a sufficient indication that the copperas has done its work. The nitrous fumes quickly disappear from the liquid at a subsequent stage of operations when metallic iron is immersed in the solution.

When enough of the ferrous sulphate has been added, filter the mixed solution into a wide beaker, precipitate the copper, in the metallic state, upon a sheet of iron in the usual way and ignite the copper in a porcelain crucible, in a current of hydrogen, before weighing it.

By means of the ferrous salt, the last traces of nitric acid may be got rid of far more quickly, conveniently and certainly than by the old system of evaporating the pyrites solution with several successive portions of chlorhydric acid. By treating the pyrites with chlorate of potassium and nitric acid it is easy to oxydize and dissolve every particle of the sulphur in the mineral so that no portion of the latter can escape decomposition by becoming enveloped in free sulphur. When aqua regia is used on the other hand, or a mixture of chlorate of potassium and chlorhydric acid, a certain proportion of sulphur almost invariably remains undissolved and might easily enclose portions of the mineral so as to protect them from the solvent action of the acids.

The method of oxydation above described can manifestly be employed with advantage for dissolving many other sulphuretted ores besides copper pyrites.

January, 1869.

Estimation of Sulphur in Sulphid of Mercury; by E. W. Bowditch.

In order to contrast the action of the mixed nitric acid and chlorate of potassium with that of the mixture of chlorhydric acid and chlorate of potassium ordinarily employed by chemists, as an oxydizing agent, a series of comparative experiments were made upon commercial vermilion.

Eight portions of the vermilion were operated upon in succession, as follows :—In each instance about 0·5 or 0·6 grm. of the vermilion was placed in a small glass flask set in an inclined position upon a wire gauze support above a lamp. A quantity of nitric acid, of 39° B., or of concentrated chlorhydric acid as the case might be, was poured into the flask, a small quantity of chlorate of potassium was added and the mixture heated. From time to time small bits of chlorate of potassium were thrown into the flask, the contents of which were maintained near the boiling point until all the sulphur, or as much of it as possible, had dissolved.

In every instance where nitric acid was employed, the vermilion was in a short time oxydized and dissolved so completely that no trace of free sulphur could be seen in the liquor. But when chlorhydric acid was used to decompose the chlorate, there remained, invariably, floating upon the liquid, one or more yellow globules of undissolved sulphur, varying in size from that of a pin's head to a flax seed. These floating globules could not be destroyed by any practicable amounts of the chlorate and acid. In fact, it may be said to be impossible to destroy such globules with these reagents.

Whenever chlorhydric acid was used, therefore, to decompose the vermilion, the solution obtained had to be filtered, to separate the free sulphur, before the sulphuric acid in the solution could be precipitated as sulphate of barium. The presence of free sulphur is objectionable not only because time is lost in collecting, washing, drying and weighing it, but also on account of its liability to enclose and conceal particles of the substance to be analyzed, which would be dissolved by the acid if the latter were able to act upon them. The determination of sulphur may thus be rendered incorrect by weighing the undissolved substances with the sulphur.

When nitric acid was used with the chlorate, it happened sometimes, when the proportion of nitric acid was small, that a considerable quantity of saline matter crystallized in the flask. It was found, however, that enough water to redissolve this precipitate might be added to the mixture without impairing to any material extent the oxydizing power of the chlorate subsequently added. The acid liquor resulting from the action of nitric acid and chlorate of potassium upon the vermilion was evaporated to dryness on a water bath and the residue treated with strong chlorhydric acid in order to destroy most of the nitric acid before proceeding to precipitate the sulphuric acid with chlorid of barium. Before adding the chlorhydric acid to the residue the latter must be allowed to become perfectly cold lest the mixture froth violently and portions of it be thrown out of the flask. After the acid has once been added, however, the mixture may be heated gently without risk of loss.

No matter whether chlorhydric or nitric acid is employed with the chlorate, the solution must at last be largely diluted with water before adding the chlorid of barium.

In my experiments, nothing but hot water was employed to wash the sulphate of barium. Naturally enough it was more difficult to wash in this way the precipitates obtained from solutions contaminated with nitric acid, than those from the solutions which contained only chlorhydric acid. But in spite

of this disadvantage and of the long time required to wash out the last traces of nitrate of barium I have always found that a sulphur determination made by the nitric acid process requires much less time for its completion than one made by the old way with chlorhydric acid.

In a final trial made expressly for the purpose of testing this point, the precise times consumed in making each experiment were carefully noted. Two portions of the vermilion were weighed out into flasks and treated, one with chlorhydric acid and chlorate of potassium and the other with nitric acid and the chlorate. The portion treated with chlorhydric acid weighed 0·5695 grm. and the other 0·519 grm. The flask containing the sample treated with chlorhydric acid was taken from the fire a few minutes before the last traces of sulphur in the nitric acid flask had been destroyed and the separation of the undissolved sulphur was proceeded with as rapidly as possible, but in the end it was found that eleven hours and three quarters were required to complete the determination of sulphur in the portion of vermilion treated with chlorhydric acid while the estimation of sulphur in the other portion, treated with nitric acid was finished in nine hours and a half. 14·32 per cent of sulphur was found in the portion treated with nitric acid and 14·25 per cent in the portion treated with chlorhydric acid, instead of the 13·79 per cent required by theory.

February, 1868.

Estimation of Chromium as Chromate of Barium; by A. H. Pearson.

As Prof. Storer has shown,* chromic oxyd is quickly changed to chromic acid, when boiled with a mixture of concentrated nitric acid and chlorate of potassium. All the chromium in half a gram of hydrate of chromium or of any of the ordinary chrome salts can in this way be converted into chromic acid in a few moments, and even compounds as refractory as chrome-iron-ore, or oxyd of chromium which has been strongly ignited, can be oxydized in less time than would be required to complete their oxydation by the process of fusion ordinarily employed.

As will appear from the experiments which follow, the chromic acid thus formed in the wet way, can be readily and accurately estimated in the form of chromate of barium, if care be taken to wash the precipitated chromate with acetate of ammonium or some other saline solution in which chromate of barium is insoluble.

I. A quantity of anhydrous chromic oxyd was prepared by heating bichromate of potassium with an excess of strong chlor-

* Proceedings of American Academy, 1859, iv, 342.

hydric acid, until chlorine ceased to be evolved, saturating the acid liquor with ammonia water, washing and drying the precipitated hydrate and finally igniting it intensely in a platinum crucible over a blast-lamp.

0·102 grm. of this anhydrous oxyd was placed in an evaporating dish, together with a quantity of nitric acid and some chlorate of potassium, and covered with an inverted funnel with a bent stem. The acid was heated and fragments of chlorate of potassium were added to it from time to time, until the chromic oxyd had completely disappeared. This result was attained in the course of half an hour.

The acid solution was diluted with water, then neutralized with ammonia and the ammoniacal solution in its turn treated with enough acetic acid to make it slightly acid. After the acidulated solution has become cold, a solution of chlorid of barium was added to it, in slight excess, and the mixture was left at rest for ten or twelve hours. The precipitated chromate of barium was washed, by decantation, with a cold solution of acetate of ammonium, then collected on a filter, rinsed with water, dried, heated in a crucible to expel the last traces of water and of the ammonium salt, and weighed.

The amount of chromate of barium obtained in this experiment was equal to 0·336 grm., which is equivalent to 68·31 per cent of chromium instead of 68·62 per cent as required by theory.

The precipitate of chromate of barium must be allowed to stand for some time before filtering lest it pass through the pores of the filter and render the filtrate cloudy.

The acetate of ammonium employed for washing serves to dissolve any nitrate of barium or chlorid of barium which may have been precipitated with the chromate. It has the further advantage of dissolving less of the chromate of barium than pure water would.

II. A quantity of hydrate of chromium precipitated from a solution of reduced bichromate of potassium, as in the previous experiment, was dried at 115° and the proportion of water retained by the dried hydrate was determined once for all by ignition.

0·11 grm. of this dried hydrate, equal to 0·0688 of the anhydrous oxyd, was then treated with nitric acid and chlorate of potassium as in experiment I. It was found that the oxydation was completed as soon as the acid became hot enough to decompose the chlorate. Less than five minutes were sufficient in this instance for the complete conversion of the chromium to chromic acid.

The chromate of barium obtained weighed 0·2286 grm., equiv-

alent to 68·65 per cent of chromium in the oxyd taken instead of the theoretical 68·62 per cent.

III. 0·113 grm. of the dried hydrate containing 0·0707 grm. of the anhydrous oxyd of chromium was mixed with a quantity of nitrate of magnesium,—prepared by dissolving carbonate of magnesium in nitric acid—before the treatment with nitric acid and chlorate of potassium. 0·2346 grm. of chromate of barium was obtained. In other words, 68·60 per cent of chromium instead of the 68·62 per cent required by theory.

IV. 0·114 grm. of the dried hydrate of chromium, containing 0·0713 grm. of the anhydrous oxyd, was mixed with nitrate of aluminum,—prepared by dissolving hydrate of aluminum in nitric acid—before the treatment with chlorate of potassium. 0·2356 grm. of chromate of barium, was obtained. That is to say, 68·31 per cent of chromium instead of 68·62 per cent.

V. A small quantity of chrome-iron-ore was ground to very fine powder and treated in a dish with nitric acid and chlorate of potassium as above described. At the end of half an hour, that portion of the ore which still remained undissolved was washed with water, dried, fused with a mixture of carbonate of sodium and nitrate of potassium, and the fused mass boiled with water; but the solution thus obtained gave no reaction for chromium when tested for that substance.

It appears from the foregoing experiments that chromium can be readily estimated, in this way, in presence of aluminum and magnesium. The process can doubtless be employed also for separating chromium from iron, cobalt, nickel and zinc. As a matter of course, special care must always be taken to employ reagents which are absolutely free from any contamination of sulphuric acid.

April, 1869.

On the use of Chromate of Barium in Quantitative Analysis; by R. H. Richards.

A sample of pure bichromate of potassium examined simultaneously by three of the students in the Institute's laboratory for the purpose of determining the percentage of chromium by precipitating that element in the form of chromate of barium, gave the following discordant results. The method of analysis was similiar to that described below.

Name of experimenter.	Grms. of K_2O, $2CrO_3$ taken.	Grms. of BaO, CrO_3 found.	Percentage of Chromium. Found.	Theory.
N. F. Merrill,	0·516	0·8640	34·67	35·56
F. P. Pearson,	0·500	0·8788	36·38	" "
C. E. Avery,	----	----	36·31	" "
" " "	----	----	36·24	" "

At the suggestion of Prof. Storer, I have examined other portions of the same sample of bichromate of potassium, with the view of discovering, if possible, the sources of error which vitiated the foregoing analyses.

A quantity of the bichromate was heated until it fused, the cold mass powdered and several portions of it, weighing from one to two grams each, were taken for analysis. Each of the weighed quantities of bichromate was dissolved in distilled water, the solution was heated nearly to boiling and a lump of acetate of sodium twice the volume of the bichromate of potassium taken was thrown into the hot liquor. Acetic acid was then added to strongly acid reaction, and afterward a solution of chlorid of barium, with occasional stirring, until no more precipitate was formed on the further addition of chlorid of barium and until the supernatant fluid became absolutely colorless. It is easy to hit this point in a hot solution but not so easy when the liquid is cold.

After the precipitate had been allowed to stand for some time, the clear liquid above it was decanted into a filter. The precipitate was then washed with cold water, first by decantation in the beaker and afterward upon the filter. The filtrate proper, that is to say, the clear liquor decanted from the precipitate, was in every instance colorless. It gave a white residue when evaporated on platinum foil and no precipitate when tested with acetate of lead. But all the subsequent liquors obtained by decantation and washing came through the filter distinctly yellow-colored. They gave yellow residues when evaporated upon foil and bright yellow precipitates when tested with acetate of lead. It was, consequently, no easy matter to determine when to stop washing. The precipitates were in fact put aside to dry as soon as there was any reason to suppose that the saline mother-liquor had all been washed out from them.

In the 2nd of the following experiments the chromate of barium was weighed upon a tared filter, as was the case also in the experiments cited above, but in Nos. 1, 3 and 4 the dry precipitate was ignited gently in a porcelain crucible before weighing.

No. of the Experiment.	Grms. of K_2O, $2CrO_3$ taken.	Grms. of BaO, CrO_3 found.	Percentage of Chromium found.	Theory.
1.	1·0095	1·7301	35·47	
2.	1·0175	1·8444	37·53	35·56
3.	1·5456	2·7541	37·74	
4.	1·5020	2·5696	35·49	

Experiments 3 and 4 were carried out side by side, and every effort made to treat them exactly alike.

From the appearance and behavior of the wash-water, as above described, it appears that chromate of barium is somewhat soluble in pure water, but is insoluble in tolerably strong saline solutions, even in the presence of acetic acid. This observation agrees in the main with a statement* in Prof. Storer's Dictionary of Solubilities to the effect that "chromate of baryta is very slightly soluble in water, and even insoluble when other salts are present in solution."

On the other hand, the excess of precipitate found in experiments 2 and 3, would go to show that chlorid of barium is liable to be dragged down by chromate of barium in the same way that it is apt to go down with sulphate of barium. It would appear therefore that some saline solution, competent to dissolve chlorid and nitrate of barium, should be used instead of water for washing chromate of barium. [P. S.—In accordance with this view Mr. A. H. Pearson has recently employed a solution of acetate of ammonium, with the best results, for washing both the chromate and the sulphate of barium.]

April, 1868.

Approximate Determinations of the Solubilities of Nitrate of Barium, Chlorid of Barium, Perchlorate of Potassium and Chlorate of Potassium in several saline solutions; by A. H. PEARSON.

The following experiments were undertaken in order to discover a saline solution proper to wash out from precipitated chromate of barium the difficultly soluble substances which might be thrown down with it in the operations described above, on page 199.

Quantities of dry nitrate of barium, chlorid of barium, perchlorate of potassium (tolerably, but not absolutely, pure), and chlorate of potassium were finely powdered and a number of small equal portions of each of the powders were measured out into test-tubes. The contents of each of the tubes were then treated with successive drops of the solvent until the last particles of the powders had dissolved. A special dropping tube was provided for each of the solvents and the drops were of such size that 50 of them were very nearly equal to 1 c. c. The test-tubes were thoroughly shaken immediately after the addition of each drop of the solvent, then allowed to stand for some time and again shaken before adding another drop of the liquid. Due allowance was made for the excess of liquid in case the last drop of the solvent was manifestly more than sufficent to dissolve the last traces of the salt.

The powdered salts were measured in a small glass tube, such as is provided in Plattner's blowpipe apparatus, for measuring

* Cited from Dumas's Traité de Chimie appliquée aux Arts.

powdered lead. As the mean of several weighings, it was found that the charge of nitrate of barium weighed 0·15 grm., that of chlorid of barium 0·12 grm., that of perchlorate of potassium 0·1 grm. and that of chlorate of potassium 0·08 grm.

For the experiments made "at the temperature of boiling water," long, narrow open tubes, to condense aqueous vapor, were fitted to the mouths of the test-tubes by means of perforated corks and the test-tubes were kept immersed in a bath of boiling water. By means of pasteboard screens the tops of the tubes were protected from the steam and heat of the bath.

The results of the experiments may be tabulated as follows :--

Nitrate of Barium.

I. Experiments made at the ordinary temperature of the air.

Name of solvent.	No. of drops of the solvent required to dissolve the charge (= 0·15 grm.) BaO, N_2O_5.	No. of c.c. of the solvent required to dissolve one grm. of BaO, N_2O_5.
Water,	100	13·33
Chlorid of ammonium,	104	13·67
Ammonia water (strong),	110	14·67
Acetate of sodium,	110	14·67
Ammonia water (weak),	124	16·50
Acetate of ammonium,	130	17·33
Acetate of copper,	130	17·33
Grape-sugar,	140	18·67
Nitrate of ammonium,	180	24·00
Chlorhydric acid (dil.),	210	28·00
Acetic acid,	220	29·00
Nitric acid (dil.),	Insoluble.	

II. Experiments made at the temperature of boiling water.

Acetate of ammonium,	33	4·33
Water,	35	4·67
Chlorid of ammonium,	35	4·67
Acetate of sodium,	40	5·33
Ammonia water (strong),	43	5·67
Acetate of copper;	45	6·00

Chlorid of Barium.

I. Experiments made at the ordinary temperature of the air.

Name of solvent.	No. of drops of the solvent required to dissolve the charge (= 0·12 grm.) of $BaCl_2$.	No. of c. c. of the solvent required to dissolve one grm. of $BaCl_2$.
Water,	24	4·00
Ammonia water (strong),	30	5·00
" " (weak),	32	5·33
Chlorhydric acid (dil.),	32	5·33
Grape sugar,	34	5·67
Acetate of ammonium,	36	6·00
Chlorid of ammonium,	36	6·00
Acetate of copper,	38	6·33
Acetate of sodium,	40	6·67
Acetic acid,	48	8·00

Perchlorate of Potassium.

I. Experiments made at the ordinary temperature of the air.

Name of solvent.	No. of drops of the solvent required to dissolve the charge (= 0·1 grm.) of K_2O, Cl_2O_7.	No. of c. c. of the solvent required to dissolve one grm. K_2O, Cl_2O_7.
Nitrate of ammonium,	80	16
Water,	110	22
Nitric acid (dil.),	112	22·4
Acetate of ammonium,	122	24·4
Chlorid of ammonium,	128	25·6
Acetate of sodium,	128	25·6
Cane sugar,	136	27·2
Acetate of copper,	146	29·2
Ammonia water (conc.),	148	29·6
" " (dil.),	152	30·4
Chlorhydric acid (dil.),	152	30·4
Grape sugar,	184	36·8
Acetic acid,	226	45·2.

II. Experiments made at the temperature of boiling water.

Water,	20	4·00
Nitrate of ammonium,	20	4·00
Nitric acid (dil.),	25	5.00
Acetate of ammonium,	30	6·00
Chlorid of ammonium,	30	6·00
Acetate of copper,	35	7·00
Acetate of sodium,	35	7·00

Chlorate of Potassium.

I. Experiments made at the ordinary temperature of the air.

Name of solvent.	No. of drops of the solvent required to dissolve the charge (= 0·08 grm.) $KClO_3$.	No. of c. c. of the solvent required to dissolve one grm. of $KClO_3$.
Nitrate of ammonium,	72	18·00
Water,	118	29·50
Nitric acid (dil.),	122	30·50
Chlorid of ammonium,	126	31·50
Acetate of copper,	126	31·50
Acetate of sodium,	130	32·50
Chlorhydric acid (dil.),	132	33·00
Cane sugar,	134	33·50
Acetate of ammonium,	136	34·00
Ammonia water (strong),	142	35·50
Grape sugar,	146	36·50
Ammonia water (weak),	156	39·00
Acetic acid,	192	48·00

The strengths of the various solutions employed as solvents were as follows :—

Ammonia-water, strong = ordinary liquor ammoniæ.
Ammonia-water, weak = a mixture of 1 volume of the strong ammonia-water with 3 vols. of water.
Nitric acid, dilute = a mixture of 1 volume of the strong acid (of 39° B.), with 5 vols. water.
Chlorhydric acid, dilute = 1 vol. of the ordinary concentrated acid with 4 vols. water.
Acetic acid = 1 vol. of the commercial acid mixed with 1 vol. of water.
Chlorid of ammonium = 1 part of the crystallized salt in 10 parts of water.
Nitrate of ammonium = 1 part of the crystallized salt in 10 parts of water.
Acetate of ammonium = ammonia-water dilute, neutralized with the acetic acid of the given strength.
Acetate of sodium was made by saturating a quantity of commercial acetic acid with carbonate of sodium and diluting the liquid with 4 volumes of water.
Acetate of copper was prepared according to the directions of Stolba.*
Cane sugar = 1 part of sugar in 10 parts of water.
Glucose (starch sugar)=1 part of sugar in 10 parts of water.

It will be observed that the solvent power of acetate of copper,—recommended by Stolba for washing sulphate of barium,—is inferior to that of several other salts.

It may here be said that contrary to what might be supposed, no perchlorate of potassium seems to be carried down with chromate or sulphate of barium when these salts are precipitated, in the estimation of chromium or of sulphur, as described on pp. 191 and 198. At all events none of the perchlorate could be detected on searching for it in several samples of sulphate of barium precipitated from liquors obtained by oxydizing sulphur and sulphur compounds with a mixture of nitric acid and chlorate of potassium.

The method employed in testing for the perchlorate was as follows :—A few drops of an aqueous solution of iodid of potassium were placed in a porcelain crucible together with a small quantity of thin starch paste ; the mixture was acidulated with chlorhydric acid, free from chlorine, and a quantity of the precipitate to be tested was stirred into the mixture. In no instance did the starch become blue on the addition of the precipitate, although nothing but water was used for washing the latter. But a blue coloration was immediately produced, whenever a

* Zeitschrift analyt. Chem., ii. 390.

small speck of perchlorate of potassium was added to the acidulated mixture of starch and iodid.

January, 1869.

Arsenic Compounds.—Of the experiments with arsenic compounds, it will be sufficient to say that both metallic arsenic and arsenious acid are easily changed to arsenic acid by the action of nitric acid and chlorate of potassium, and that the arsenic acid thus formed may be precipitated without inconvenience in the form of arseniate of magnesium and ammonium.

Boston, May 20, 1869.

Art. XXII.—*On the Action of Light on Uranium;* by H. Carrington Bolton, Ph.D.

Compounds of uranium were found to be sensitive to the sun's rays at a very early period in the history of the element. Klaproth, who discovered uranium in 1789, makes no allusion to the property in question, but Bucholz in 1805 remarked the effect of light on solutions of the sulphate and nitrate. Since Bucholz's discovery seems to have escaped the observation of most chemists, I may be allowed to quote from his communication published in the "Annales de Chimie et de Physique," for 1805.

"Sulphate of uranium dissolves in 25 parts of alcohol, and the solution undergoes remarkable changes on exposure to the sun, the yellow liquid becomes turbid, and deposits a grayish green substance. After several days' exposure, the solution acquires an odor resembling nitric ether, rather than sulphuric; the filtrate is colorless and contains no uranium; the precipitate is of a green color, and retains sulphuric acid."

Bucholz remarks in another paragraph: "Nitrate of uranium is very soluble in ether, and the yellow solution exposed to the sun's rays becomes green, an odor of nitric ether is developed, and a black substance is precipitated." Chemists added little to these facts for many years; Gehlen observed that the oxychlorid was sensitive to the light, when in a solution containing alcohol; Berzelius states, in his "Lehrbuch," that the precipitate formed in the solution of the sulphate is a basic protosalt, and adds that the precipitate produced by the reduction of the nitrate has not been examined.

In 1841, Ebelmen* made a complete investigation of the decomposition of the oxalate of the sesquioxyd. He writes in

* Ann. Ch. Pharm., xliii, 286.

the "Annalen der Chemie und Pharmacie": "On exposing a solution of the oxalate of the sesquioxyd of uranium to the action of the sun's rays, the liquid becomes turbid and deposits a brown violet mass. Carbonic oxyd and carbonic acid, in varying proportions, are evolved throughout the experiment. The liquid becomes colorless and the precipitate begins to turn yellow, and when dried on a filter changes into a yellow mass, the hydrate of the sesquioxyd. The ease with which the violet precipitate absorbs oxygen, makes its examination difficult. When washed and dried *in vacuo*, it forms a hard black mass, of conchoidal fracture, resembling some varieties of pitchblend." After describing certain experiments with this violet precipitate, Ebelmen pronounces it to be a hydrate of the green oxyd.

Ebelmen also examined the action of light on the sulphate of uranium. He dissolved the three-fourths oxyd in concentrated sulphuric acid, diluted with water and alcohol, and exposed the solution in a stoppered bottle. Little by little crystals attached themselves to the sides of the vessel, while the liquid acquired the odor and characteristic reactions of aldehyde. The green crystals proved to be sulphate of the protoxyd of uranium. Ebelmen confirmed Bucholz's observation with regard to the alcoholic solution of the sulphate of the sesquioxyd, and established the composition of the green precipitate formed in the sunlight. He calls it bibasic sulphate of the protoxyd, having the formula $2UO, SO_3 + 2HO$.

A year later, Lucien Bonaparte* found that the valeriana e of the sesquioxyd was decomposed on exposure to the sunlight in a similar manner to the oxalate. He calls the violet precipitate obtained, valerianate of the protoxyd; is it not rather Ebelmen's hydrated green oxyd?

Péligot, Rammelsberg, Wertheim, and other chemists, who subsequently made extensive researches on uranium, do not appear to have examined its actinic reactions. Neither Herschel nor Hunt, in their valuable researches on light, notice the discoveries made up to this date. I can find no mention of investigations on this subject, until the year 1857, when C. J. Burnett† published his discovery of the use of uranium salts in photographic printing.

It seems strange that attempts to employ uranium were not made at an earlier date, when it is remembered that Bucholz's discovery, in 1805, was contemporaneous with those of Sir H. Davy and Wedgewood, who procured the first sun-pictures of which we have authentic record. Burnett was quickly followed by Niepce de St. Victor,‡ who rediscovered processes similar to

* J. prakt. Chem., xxx, 308.
† Liverpool Journ. Phot., 1857.
‡ Compt. Rend., xlvi, 449.

Burnett's, and obtained a patent for them in February, 1858. We have no evidence that Niepce de St. Victor was ignorant of Burnett's invention. Credit, however, is due to him for an experimental illustration of the remarkable property possessed by nitrate of uranium of absorbing actinic rays of light, and retaining them in an active condition for a long time. He exposed behind a negative, paper strongly impregnated with nitrate of uranium, and then hermetically sealed it in metallic tubes. This paper retains the power of darkening chlorid of silver, for weeks and even months. On opening a tube, and placing the paper on a sensitive surface, an image is obtained identical with that of the negative employed.

In the following year, Niepce de St. Victor, together with Corvisart,* discovered that the presence of a small quantity of nitrate of uranium increased ten-fold the action of light on amylaceous matter, converting it into dextrine and glucose. They also remarked the decomposition of oxalic acid in presence of nitrate of uranium, with formation of carbonic acid. Corvisart's last-mentioned experiment was repeated by Seekamp† with greater accuracy; he employed solutions containing 5 per cent oxalic acid, and 1 per cent oxalate of uranium; 100 c. c. of this solution, exposed to light for three minutes, furnishcd 22 c. c. of gas, which consisted of carbonic oxyd and carbonic acid. Seekamp observed the formation of crystals of oxalate of the protoxyd, and determined the presence of formic acid in the solution. The same chemist subsequently examined the action of light on the succinate and pyrotartrate of uranium.‡ The succinate acid is converted into propionic acid, and the pyrotartaric into butyric. A detailed account of these interesting reactions would lead us into the field of organic chemistry.

The processes for printing with salts of uranium were modified by numerous photographers among whom Hagen in Germany, Draper and Cary Lea in this country made the chief improvements. In 1860 Wothly§ announced that he had discovered a process for printing entirely dispensing with salts of silver and requiring no fixing except washing. This statement attracted much attention and photographers awaited details: but two or three years afterward when the process became known by the publication of the specification, its value was found to be exaggerated. Both nitrate of silver and hyposulphite of soda were employed and the only novelty consisted in

* Compt. Rend., xlix, 368; also Bull. Soc. Chim., 1862, 62.
† Ann. Chem. Pharm., cxxii, 113. ‡ Ann. Chem. Pharm., cxxxiii, 253.
§ Bull. Belge de Phot., 1864. Original announcement in Horn's Photog. Journ. for 1860.

the use of collodion and of a method of combining a salt of uranium with one of silver.

Having thus sketched the history of the action of light on uranium, I will return to Burnett's and Wothly's photographic processes. According to Burnett, ordinary paper is sensitized by floating on a bath of nitrate of uranium and hung up to dry. By exposing this paper behind a negative from one to thirty minutes (according as direct rays or diffused light are employed) a weak image is obtained which is then developed by a bath of nitrate of silver or of chlorid of gold. Simple washing being insufficient to remove the excess of silver salt, a bath of hyposulphite of soda may be used with advantage.

By developing with ferricyanid of potassium, red pictures are obtained, and by floating these red ones on a bath of sesquichlorid of iron, green pictures result.* Burnett, who studied this whole subject with care, did not confine himself to the use of nitrate of uranium, but experimented with the oxalate, tartrate, formiate, citrate, acetate, succinate, benzoate, chlorate, bromate, oxychlorid, oxybromid, and oxyfluorid. He tried both acid and ammoniacal solutions. Not having been able to obtain Burnett's original communications to the "Liverpool Journal of Photography," I cannot give details of results obtained with the various salts, but the nitrate being a commercial article, is the only one which ever came into use. Burnett's efforts to obtain pictures on glass plates in a camera were unsuccessful.

Wothly prepares a double salt by crystallizing together nitrate of uranium and silver, and sensitizes a resinized collodion with this substance. Paper prepared in a special manner with arrowroot starch and albumen is then coated with the sensitized collodion. After exposing the print, which requires no development, it is toned with chlorid of gold, washed with dilute acid and fixed with sulphocyanid of potassium or hyposulphite of soda. The pictures obtained by this process are said to be very beautiful and of a characteristic tone.

In 1866 when studying the compounds of uranium in the laboratory of the University of Göttingen, I obtained a salt having the formula $2(U_2O_2Fl)+3KFl$. It is prepared by adding a slight excess of fluorid of potassium to a solution of nitrate of uranium, washing the slightly soluble precipitate and crystallizing it from a hot solution. It forms yellow fluorescent crystals belonging to the monoclinic system.† When a solution of this salt acidified with formic acid, is exposed to direct sunlight, decomposition ensues, a green precipitate falls,

* The writer invariably obtained *blue* pictures; compare photograph No. 15.

† Berl. Akad., Ber. 1866, 299.

and the liquid becomes colorless; the precipitate is insoluble in water and dilute acids, and has the composition 4(U Fl)+ K Fl. Oxalic acid effects a similar reduction, but with the formation of Ebelmen's violet hydrate as secondary product. I have made many attempts to obtain green prints with this salt. Last winter I exposed behind a negative, paper sensitized with oxyfluorid of uranium and potassium to which a little formic acid was added. After ten days constant exposure faint indications of a picture were perceptible.* This was not very promising, but I recently repeated the experiment, first floating the paper on a bath of formic acid and then on a bath of oxyfluorid of uranium and sodium, it being more soluble than the corresponding potassa salt. In one hour a weak print is obtained which scarcely becomes darker by longer exposure; owing to the simultaneous formation of the green fluorid and the violet hydrate, the picture when first printed presents a singular appearance. Simple washing with water removes the excess of uranium salt and fixes the green parts, but the violet parts turn yellow and weaken the image.† Could the formation of the violet hydrate be prevented, one might obtain uniform prints of a delicate green. By exposing paper sensitized as above for a shorter period, one to two minutes, and developing with nitrate of silver or ferricyanid of potassium the usual black and red pictures may be obtained. These, however, are no novelty, but experiments with certain metallic salts to ascertain their value as developers brought out some interesting results.‡

At this time, not fully cognizant of the completeness of Burnett's experiments, I attempted printing with other salts of uranium. The formiate I found too insoluble though it furnished pictures, the same objection applies to the oxalate. According to my experience, after the nitrate, the ammonio-citrate of uranium is the most sensitive salt. This double salt was prepared by neutralizing a given weight of citric acid with oxyd of uranium and an equal portion of the acid with ammonia, mixing the solutions and evaporating. The golden yellow solution showing no tendency to crystallize, it was evaporated to dryness and gave a semi-vitreous mass somewhat resembling citrate of iron. The uranium in a solution of this salt is not precipitated by many reagents; an excess of ammonia is without effect, ferricyanid of potassium and sulphid of ammonium only darken the liquid, the presence of citric acid preventing their action as in the case of iron, manganese and aluminium. On boiling with caustic potash the solution is decomposed with

* See Photograph No. 1.

† See Photographs No. 2 and No. 3.

‡ See Photographs Nos. 20 to 24.

precipitation of uranate of potash. The salt is insoluble in alcohol which throws it down from an aqueous solution. This ammonia-citrate is the only compound of uranium which I have observed to be sensitive to sunlight in the dry state. The yellow powder turns dark brown on exposure to the direct rays of the sun. The change is far more striking with the solution, which rapidly acquires a deep brown red color without depositing a precipitate. This red solution turns yellow on standing a few days in an open glass, but preserves its color much longer in stoppered bottles. Owing to the presence of citric acid (which prevents precipitation after exposure as before) it is very difficult to determine what compound of uranium exists in this solution. On evaporating to dryness on a water bath a brown powder is obtained resembling that formed by exposing the dry salt. Potash produces in the *red* solution a *green* precipitate which gradually turns *yellow*. This reaction leads me to believe that the red solution contains the suboxyd U_3O_2 discovered in 1863 by a French chemist named Guyard. By the prolonged action of zinc on the sesquioxyd dissolved in hydrochloric acid, Guyard obtained a deep red solution which furnished a green precipitate with alkalies.*

Nitrate of uranium is not only very soluble in water, alcohol and ether, but also in glycerine. Even when deprived of its water of crystallization the nitrate dissolves in pure glycerine.

The syrupy liquid exhibits the same behavior with reagents as an aqueous solution. On exposure to the sunlight the yellow solution turns green and finally becomes reddish brown without depositing a precipitate; no evolution of gas was perceptible. The brown liquid yields a dark brown precipitate with ammonia and this precipitate washed and dissolved in acids forms green solutions. It is probably a mixture of protoxyd and suboxyds. An aqueous solution of the nitrate with a few drops of glycerine, acquires on exposure a green hue and contains only the protoxyd. The transformation of the glycerine is reserved for further investigation.

Solutions of the sulphate, oxychlorid and oxyfluorid of uranium mixed with glycerine, are reduced in a similar manner; the double oxyfluorid of uranium and sodium (or potassium) is reduced more rapidly than with formic or oxalic acids, forming the green precipitate in an acid solution and the violet hydrate in a neutral one.

I have printed a number of photographs with solutions of various salts to which a small quantity of glycerine was added; by comparing these prints with those obtained without glycerine I have come to the conclusion that the addition of glycerine

* Bull. Soc. Chim. 1864, i, 94.

both shortens the necessary time of exposure and quickens development. One minute's exposure yields a clear print when the paper is sensitized with the oxyfluorid of uranium and sodium with glycerine, whereas five to ten minutes is the time necessary in other processes. I recommend the use of glycerine to such photographers as may experiment with uranium pictures.

The actinic reactions of uranium salts much resemble those of iron; like the latter the sensitive uranium compounds all contain oxygen and the physical and chemical changes are due to complete or partial deoxydation. We also notice the necessary coöperation of organic matter, the part which the latter plays being clearly that of a reducing agent. Under influence of the actinic rays, the uranium salts part with some of their oxygen, which goes over to the oxydizable organic material. An aqueous solution of nitrate of uranium exposed to light in a glass vessel remains unchanged; but as soon as organic matter whether in the form of alcohol, ether, glycerine, cellulose or an organic acid, is brought in contact with the uranic solution a reduction is effected and the organic matter is oxydized at the expense of the uranium. Accordingly, salts of uranium with organic acids are for the most part sensitive as such. In the printing processes, cellulose effects the reduction, which is, however, assisted by the addition of alcohol (recommended by Hagen) or glycerine.

Attempts to obtain reactions with other agents than the actinic rays of the sun, gave negative results. A series of 23 uranium salts exposed to the light of magnesium wire, exhibited no fluorescence, nor was a solution of the oxyfluorid with formic acid reduced by exposure to the magnesium light. An experiment made with the intention of effecting reduction at a high temperature under pressure, was also unsuccessful. A solution of the oxyfluorid acidified with formic acid was heated in a sealed tube at 100° C., and afterward at 120° C. for many hours, but without producing the least change.

Details of manipulation, strength of solutions, &c., such as may be found in any practical work on photography, have been purposely omitted, it being my object to consider the subject strictly from a chemical point of view.

Description of Photographs.

No. 1. (Jan. 25, 1868.)—Common filtering paper sensitized with a mixture of oxyfluorid of uranium and potassium and formic acid. Exposed ten days. Fixed by washing. Barely perceptible outline.

The remaining experiments were made with unsalted non-albumenized *papier de saxe.* The prints were well washed before development. An unvarnished negative was used.

No. 2. (March 11, 1869.)—Sensitized 1st with formic acid, 2nd oxyfluorid of uranium and sodium. Exposed one hour. Fixed (?) by washing. A weak print, green when first obtained, turned yellow on exposure.

No. 3. Sensitized with oxyfluorid of uranium and sodium mixed with glycerine. Exposed one hour—a violet print, which turned lemon-yellow on exposure.

No. 4. Sensitized with 1st, oxalic acid; 2nd, oxyfluorid of uranium and potassium. Exposed 15 minutes. Developed with ferricyanid of potassium—fixed by washing. A red picture.

No. 6. Sensitized with citrate of uranium and ammonia. Exposed 10 minutes. Developed with ferricyanid of potassium. A clear red picture.

No. 7. Sensitized with 1st, oxalic acid; 2nd, oxyfluorid of uranium and sodium. Exposed ——. Developed first with perchlorid and then with nutgalls solution. A blue black *negative.*

No. 8. Sensitized with oxyfluorid of uranium and sodium mixed with formic acid. Exposed 1 minute. Developed with ferricyanid of potassium. A weak red print not very clear.

No. 9. Sensitized with oxyfluorid of uranium and sodium mixed with glycerine. Exposed one minute. Developed with ferricyanid of potassium—a clear well defined red print.

No. 12. Sensitized with nitrate of uranium mixed with glycerine. Exposed 2 minutes. Developed with ferricyanid of potassium. An inferior red print.

No. 13. Sensitized with nitrate of uranium mixed with glycerine. Exposed 2 minutes. Developed with nitrate of silver and fixed with hyposulphite of soda. A fair print.

No. 14. Sensitized with oxyfluorid of uranium and sodium mixed with glycerine. Exposed one minute. Developed with nitrate of silver and fixed with hyposulphite of soda. An excellent well defined picture.

No. 15. Sensitizer S = oxyfluorid of uranium and sodium with glycerine. Exposed one minute. Developed with ferricyanid of potassium and then with perchlorid of iron. A brown picture which turned light *blue* while drying in the air.

No. 16. Sensitizer S. Exposed 1 minute. Developed with ferricyanid of potassium and then with protosulphate of iron. A well defined *green* picture.

No. 18. Sensitizer S. Exposed 70 seconds. Developed with 1st, ferricyanid of potassium; 2nd, mixture of same with perchlorid of iron. A clear snuff-colored print.

Employed following developing solutions.

A = 1 grm. $K_3Fe_2Cy_6$ in 60 grms. water.
B = 20 drops Fe_2Cl_3* in 60 grms. water.
C = mixture of 1 part A and 2 parts B.
D = mixture of 1 part A and 1 part B.
E = mixture of 2 parts A and 1 part B.
F = 1 grm. $FeO\,SO_3$ in 60 grms. water.

No. 20. Sensitizer S. Developer C. Exposed one minute—a clear dark lead colored print having a shade of blue.

No. 21. Sensitizer S. Developer D. Exposed one minute—a brown print with a shade of red.

No. 22. Sensitizer S. Developer E. Exposed one minute; a reddish brown picture.

No. 23. Sensitizer S. Developer, 1st, A; 2d, C. Exposed one minute—a black color nearly resembling nitrate of silver prints. In several trials a blue color predominated.

No. 24. Sensitizer S. Developers A and FB. Exposed one minute. A clear greenish black picture.

The photographs enumerated above are but a small portion of those taken; some of the processes were repeated and only the best pictures retained. In describing them it is difficult to convey in words a correct idea of color, tone, intensity, clearness, &c. Inexperience in manipulation was often a cause of ill success.

No. 7 is a novelty; the chlorid of iron penetrates the paper where not reached by the light and the nutgalls bring out an ink negative. By comparing No. 8 and No. 9 we observe the superiority of glycerine. No 14 is a far better print than No. 13, which is taken by known methods. By modifying the strength of solutions A, B, C, D, E and F, and varying time of exposure and intensity of development a great variety of colors may be obtained; passing from brick red, through brown red, brown, black brown, green black, blue black to light blue, besides intermediate neutral tints. The color of nitrate of silver may be fairly imitated, but I candidly confess I have been unable to reproduce the delicacy of line, beauty of tone and finish characteristic of ordinary gold and silver prints.

New York, June, 1869.

* Ordinary commercial solution.

ART. XXIII.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School.* No. 8.—*On the action of the alkaline nitrites upon uric acid and its derivatives;* by WOLCOTT GIBBS, M.D., Rumford Professor in Harvard University.

[Read before the National Academy of Sciences, April 15th, 1869.]

THE products of the action of nitrous acid upon the members of the uric acid group have been little examined. Baeyer has shown that hydurilic acid by the action of potassic nitrite yields alloxan and potassic violurate, the equation expressing the decomposition being as follows:

$$\mathrm{C_8H_6N_4O_6 + KNO_2 + 2HNO_2 = C_4H_2KN_2O_4 + C_4H_2N_2O_4 + 2NO + H_2O}$$

The nitrous acid in this case exerts an oxydizing action and is reduced to nitric oxyd. The action of nitrous acid upon urea has long been familiar to chemists, but, so far as I have been able to find, urea and hydurilic acid are the only members of the uric acid group the relations of which to the nitrites may be considered as known. I have undertaken in some measure at least to supply this deficiency in our knowledge and present the following as the result of my work.

Uric acid was diffused in cold water and a current of the red gas resulting from the action of nitric acid upon starch or sawdust passed into the liquid; effervescence almost at once commenced and after a time the acid was wholly dissolved. On evaporation the liquid yielded an abundance of yellowish crystals together with a small quantity of a brick red insoluble substance. The crystals were easily purified by solution, treatment with animal charcoal and recrystallization. They were then perfectly colorless, but became slightly pink on drying and possessed all the properties of parabanic acid. On analysis

1·0358 gr. gave 0·1790 gr. water and 1·2103 gr. carbonic acid, corresponding to 31·86 per cent of carbon and 1·91 per cent of hydrogen.

The formula $\mathrm{C_3H_2N_2O_3}$ requires carbon 31·58, hydrogen 1·75; the substance analyzed was therefore parabanic acid. With ammonia it yielded ammonic oxalurate, easily recognized from its characteristic properties. The red matter mixed with the parabanic acid dissolved in a very large quantity of water to an orange yellow liquid which, on cooling, deposited a reddish flocky matter in quantity too small for analysis. The mother-liquor of this substance fluoresced strongly with a blue color. In a second experiment alloxan and alloxantin were detected

in the liquid resulting from the action of nitrous acid gas upon uric acid; it is therefore shown that the gas simply exerts an oxydizing action analogous to that of dilute nitric acid. When uric acid is heated with an alkaline solution of potassic or sodic nitrite no sensible reaction occurs. The addition of any strong acid produces a violent effervescence and the uric acid soon disappears. The solution on evaporation is found to contain only salts of the alkaline metal and the usual products of the oxydation of uric by nitric acid. In this case also nitrous acid exerts no specific action.

When on the contrary acetic acid is present in small excess the alkaline nitrite acts in a wholly different manner. The uric acid dissolves with effervescence arising from the escape of carbonic acid, nitrogen and nitric oxyd, and a clear pale yellow liquid is obtained. The action is greatly facilitated by heating the mixture upon a waterbath and adding the alkaline nitrite and acetic acid alternately until the whole of the uric acid disappears, acetic acid being in small excess. On cooling, the liquid deposits crystals which vary in composition according to the conditions of temperature and concentration under which the experiment is made.

The uric acid employed in the present investigation was obtained from guano, and I am indebted for a liberal supply to the kindness of Prof. Horsford, by whom it was prepared. As the crude acid had a well marked yellow tint, various methods of purification were employed, of which the following modification of Fritzsche's process was found to be the best. The crude acid was dissolved in strong sulphuric acid with the aid of heat, and the dark brown liquid heated for some hours upon a waterbath. It was then gradually diluted with strong commercial chlorhydric acid as long as this produced a precipitate of uric acid. After the subsidence of the latter, the supernatant liquid was poured off and the uric acid washed with chlorhydric acid by decantation, and afterward with cold water. The dried mass had a faint grayish tint, and dissolved in caustic alkalies with a slight brownish color. Fritzsche states that uric acid may be obtained perfectly white by his process, but in repeated trials I have never succeeded in getting rid of the last traces of color.

Before the completion of my investigation I discovered, however, a better method of purifying the acid. Crude uric acid from guano is to be dissolved in a solution of caustic potash, any large excess of the alkali being avoided. To the solution potassic dichromate is added in quantity equal to about 5 per cent of the uric acid employed. The solution is to be boiled for a short time, diluted with an equal volume of water, agitated strongly with animal charcoal and filtered. Chlorhydric

acid then precipitates the uric acid from the solution with a pale yellowish color. After the complete subsidence of the acid the supernatant liquid is to be poured off and the uric acid boiled with strong chlorhydric acid, in repeated portions, until it becomes perfectly white and gives with caustic potash a colorless solution. In this manner a kilogram of deep yellow crude uric acid may be rendered perfectly white in little more than an hour's time.

Action of potassic nitrite.—When uric acid is heated for some time with potassic nitrite, the liquid being kept acid by the occasional addition of acetic acid, a clear yellow solution finally results, which, after filtration and cooling, usually deposits a voluminous potassic salt in fine, pale sulphur yellow needles felted together. By washing with cold water and repeated recrystallizations this salt may be obtained pure. It has then a very pale sulphur yellow color, from which it cannot be freed by treatment with animal charcoal, and a peculiar astringent bitter taste. To the acid contained in this salt I give the name of stryphnic acid, from *στρυφνος*, astringent-bitter. Potassic stryphnate dissolves readily in boiling water and separates almost completely on cooling—a character which it possesses in common with all the soluble salts of the same acid. Its formula when dried at 102°C., is $K(\text{C}_4H_2N_5\Theta_2)$ as the following analyses show :

1·3513 gr. salt gave 0·1527 gr. water and 1·2410 gr. carbonic acid = 1·25 per cent hydrogen and 25·04 per cent carbon.
1·1617 gr. salt gave 0·1307 gr. water and 1·0684 gr. carbonic acid = 1·24 per cent hydrogen and 25·08 per cent carbon.
0·9345 gr. salt gave 280 c. c. nitrogen at 4° C. and 757^{mm} = 36·76 per cent.
0·7322 gr. salt gave 224 c. c. nitrogen at 6° C. and $746·5^{mm}$ = 36·55 per cent.
0·8869 gr. salt gave 0·3978 gr. potassic sulphate = 20·12 per cent potassium.
0·6716 gr. salt gave 0·3008 gr. potassic sulphate = 20·07 per cent potassium.

The formula $\text{C}_4H_2KN_5\Theta_2$ requires

	Calculated.	Found	
Carbon,	25·13	25·04	25·08
Hydrogen,	1·04	1·25	1·24
Nitrogen,	36·64	36·76	36·55
Potassium,	20·41	20·12	20·07
Oxygen,	16·78	----	----
	100·00		

The combustions were all made with plumbic chromate, and the nitrogen determinations with the assistance of Sprengel's mercurial pump. Crystallized potassic stryphnate contains three atoms of water to two molecules of salt :

0·6338 gr. dried in pleno over sulphuric acid lost by heating to 102° C. 0·0800 gr. water = 12·62 per cent. 100 parts of the crystallized salt, $2(C_4H_2KN_5O_2)+3H_2O$, in becoming anhydrous should lose 12·38 per cent.

The accurate determination of the alkali in this salt is extremely difficult. The salt on being heated melts and takes an orange color. It then on carbonization intumesces and yields a mass from which the carbon cannot be burned off by the usual methods. The best results were obtained by means of Kämmerer's process,* but as seen above are only tolerably good.

In the mother-liquor from which the potassic stryphnate has separated, I have succeeded thus far in detecting only allantoin and oxalic acid, the quantity of the former being extremely variable. When the action of the alkaline nitrite has been continued for a long time, the allantoin disappears entirely. The mother-liquor in question is to be evaporated on a water bath to dryness, and the dry mass extracted with alcohol. After distilling off the alcohol basic acetate of lead yields with the aqueous solution a more or less copious white precipitate which, after washing and decomposition by sulphydric acid gas, yields a colorless solution, from which beautiful prismatic crystals of allantoin may be obtained. In one experiment, cupric acetate was added directly to the solution obtained by the action of potassic nitrite upon uric acid. A flocky blue precipitate was thrown down, and the filtrate from this deposited on standing fine colorless crystals which had all the properties of allantoin.

0·8782 gr. gave 0·3077 gr. water and 0·9779 gr. carbonic acid = 30·37 per cent carbon and 3·89 per cent hydrogen.
The formula $C_4H_6N_4O_3$ requires 30·38 per cent carbon and 3·80 per cent hydrogen.

The crystals obtained by the decomposition of the last compound obtained as above, were also analyzed ;

0·8650 gr. gave 0·3121 gr. water and 0·9623 gr. carbonic acid = 30·50 per cent carbon and 4·01 per cent hydrogen.

To prove the existence of oxalic acid in the mother-liquor from the potassic stryphnate, plumbic acetate was added, the buff colored precipitate washed, treated with very dilute nitric acid and filtered. The filtrate gave abundance of beau-

* Zeitschrift für analytische Chemie, B. vi.

tiful crystals of plumbic oxalo-nitrate. Of this salt 0·7315 gr. gave 0·4933 $Pb\Theta$ = 67·43 per cent; the formula $Pb(\mathrm{C_2\Theta_4}) + Pb(N\Theta_3)_2 + 2H_2\Theta$ requires 67·47 per cent. Furthermore it was found that 664 milligrams of the salt required for oxydation, 27·63 c. c. of a solution of potassic hypermanganate of which 27·73 c. c. corresponded to 16 milligrams of oxygen. This fully identifies the salt.

A portion of the lead salt precipitated by plumbic acetate from the mother-liquor of the potassic stryphnate was boiled with an excess of ammonic carbonate and the filtrate allowed to crystallize. It had all the properties of pure ammonic oxalate.

0·142 gr. required for oxydation 18·56 c. c. of potassic hypermanganate, of which 18·51 c. c. corresponded to 16 milligrams of oxygen.

These results show conclusively that oxalic was the only organic acid present. The quantity of potassic stryphnate formed by the action of potassic nitrite upon uric acid is very small, amounting to not more than five per cent of the latter; I cannot, therefore, with any reasonable degree of probability express the reaction in the form of an equation in which all the products of the decomposition shall appear. The derivation of stryphnic from uric acid may very probably be represented by the equation

$$\mathrm{C_5H_4N_4\Theta_3 + HN\Theta_2 = C_4H_3N_5\Theta_2 + C\Theta_2 + H_2\Theta;}$$

and the formation of allantoin by the equation

$$\mathrm{C_5H_4N_4\Theta_3 + 2HN\Theta_2 = C_4H_6N_4\Theta_3 + C\Theta_2 + 2N\Theta.}$$

As it seemed possible that stryphnic acid might be formed directly from allantoin by a reaction obtained by the equation

$$\mathrm{C_4H_6N_4\Theta_3 + 2(HN\Theta_2) = C_4H_3N_5\Theta_2 + HN\Theta_3 + 2H_2\Theta;}$$

I endeavored, but without success, to obtain it by treating pure allantoin with potassic nitrite.

Potassic stryphnate gives with acids, after a short time, a precipitate of stryphnic acid in pale yellow granular indistinct crystals. I have not succeeded in forming an acid stryphnate and consider it therefore as most probable that the acid is monobasic. The salt gives crystalline precipitates with the salts of various metals; with cupric sulphate a pale bluish rather flocky precipitate soluble in hot acetic acid; with ferrous sulphate a flocky precipitate, which soon becomes granular crystalline and pale yellowish white; with cadmic sulphate perfectly white granular crystals; with manganous chlorid a white crystalline precipitate, and with mercurous nitrate a snow-white, very copious precipitate. The salts of barium, strontium, calcium, magnesium, lead and zinc are easily prepared by double decomposition.

Sodic stryphnate $Na(C_4H_2N_5O_2)+H_2O$, closely resembles the potassic salt, and may be obtained directly by the action of sodic nitrite upon uric acid. It is, however, more difficult to purify than the corresponding potassic salt, in consequence of the insolubility of the sodic oxalate formed at the same time. The salt crystallizes in pale sulphur yellow needles, which when large, have a bright yellow color. It is rather easily soluble in hot water and separates slowly, but almost completely, from the solution on cooling.

0·5235 gr. burnt with plumbic chromate, gave 0·4680 gr. CO_2 = 24·79 per cent carbon.
0·4352 gr. gave 0·0910 gr. H_2O = 2·32 per cent hydrogen.
0·2910 gr. gave 125·86 c. c. nitrogen at 18° C. and 559^{mm} = 36·28 per cent nitrogen.

	Calculated.	Found.
Carbon	24·86	24·79
Hydrogen	2·07	2·32
Nitrogen	36·26	36·28

In the analyses the carbon and hydrogen were determined separately as, in consequence of the large quantity of oxyds of nitrogen formed, it was found necessary to add metallic mercury to the chromate employed for combustion.

Baric stryphnate is precipitated after a short time in pale yellow needles when a solution of potassic stryphnate is added to one of baric chlorid. The salt may be washed with cold water and purified by repeated recrystallization. It dissolves readily in hot water and separates from the solution almost completely as it cools.

0·9475 gr. of the salt dried at 102° C. gave 0·1386 gr. of water and 0·7093 gr. carbonic acid = 20·41 per cent carbon and 1·62 per cent hydrogen.
0·4858 gr. gave 0·2384 gr. baric sulphate = 28·74 per cent barium.

		Calculated.	Found.
Carbon	8	20·12	20·41
Hydrogen	8	1·67	1·62
Barium	1	28·72	28·74

The formula of the salt is therefore $Ba(C_4H_2N_5O_2)_2 + 2H_2O$.

Strontic stryphnate is formed in precisely the same manner, and cannot be distinguished in appearance from the baric salt. It also crystallizes almost completely from a hot solution on cooling.

0·7526 gr. gave 0·1544 gr. SrO = 20·51 per cent. The formula $Sr(C_4H_2N_5O_2)_2 + 6H_2O$ requires 20·72 per cent SrO.

Calcic stryphnate closely resembles the baric and strontic salts. The salt analyzed was prepared by precipitating calcic

chlorid with potassic stryphnate and repeated recrystallization. Of the pale yellow needles

0·5553 gr. gave 0·5179 gr. carbonic acid and 0·1171 gr. water = 25·43 per cent carbon and 2·34 per cent hydrogen.
0·3157 gr. gave 0·0454 gr. lime = 10·27 per cent calcium.

		Calculated.	Found.
Carbon	8	25·26	25·43
Hydrogen	8	2·10	2·34
Calcium	1	10·52	10·27

The salt was dried at 102° C. Its formula is therefore

$$\mathrm{Ca(C_4H_2N_5O_2)_2 + 2H_2O}$$

Magnesic stryphnate was prepared by precipitating magnesic sulphate with potassic stryphnate and recrystallizing. It forms very beautiful small yellow prismatic crystals. The salt was dried in pleno over sulphuric acid for analysis.

0·8429 gr. gave 0·2876 gr. water and 0·6833 gr. carbonic acid = 22·10 per cent carbon and 3·79 per cent hydrogen.
0·5080 gr. gave 0·0467 gr. magnesia = 5·51 per cent magnesium.

		Calculated.	Found.
Carbon	8	22·02	22·10
Hydrogen	16	3·69	3·79
Magnesium	1	5·50	5·51

The formula of the salt is therefore $\mathrm{Mg(C_4H_2N_5O_2)_2 + 6H_2O}$. It is, of all the stryphnates examined, that which crystallizes most perfectly.

Plumbic stryphnate $\mathrm{Pb(C_4H_2N_5O_2)_2 + 3H_2O}$, is precipitated from plumbic acetate as a very pale yellow granular crystalline powder which is almost perfectly insoluble in water. It becomes basic by treatment with boiling water or even by long washing with cold water.

1·3839 gr. gave 0·2332 gr. water and 0·8228 gr. carbonic acid = 16·21 per cent carbon and 1·87 per cent hydrogen.
0·6014 gr. gave 0·2298 gr. plumbic oxyd = 35·46 per cent of lead.

		Calculated.	Found.
Carbon	8	16·52	16·21
Hydrogen	10	1·72	1·87
Lead	1	35·50	35·46

A portion of the lead salt by long washing with boiling water became bright yellow, and on analysis

0·6895 gr. gave 0·0960 gr. water and 0·3219 gr. carbonic acid = 12·74 per cent carbon and 1·53 per cent hydrogen.
1·0874 gr. gave 0·6139 gr. plumbic oxyd = 52·39 per cent lead.

These results correspond tolerably well to the formula $\mathrm{Pb(C_4H_2N_5O_2)_2 + PbO + 3H_2O}$ which requires carbon 12·48 hydrogen 1·27, and lead 52·54 per cent.

Zincic stryphnate is a pale yellowish-white granular precipitate nearly insoluble even in boiling water. Argentic stryphnate is a white gelatinous precipitate, insoluble in water and in nitric acid. This salt could not be completely washed and obtained pure for analysis.

Stryphnic acid.—When potassic stryphnate is dissolved in boiling water and an excess of chlorhydric acid is added, no precipitate is at first produced, but after standing, very pale yellowish white granular crystals are formed, and the whole of the stryphnic acid present is thrown down. The acid is soluble in boiling water and crystallizes, when the solution cools, in small indistinct crystalline grains, which have a faint but distinct yellowish tint and an astringent bitter taste. The solution has no sensible acid reaction. The acid unites directly with alkalies and expels carbonic acid from the alkaline carbonates when boiled with them.

0.6257 gr. gave 0·1734 gr. $H_2\Theta$ and 0·6578 gr. $\mathrm{C}\Theta_2$ = 3·08 per cent hydrogen and 28·67 per cent carbon.
0·4213 gr. gave 0·1210 gr. $H_2\Theta$ and 0·4428 gr. $\mathrm{C}\Theta_2$ = 3·21 per cent hydrogen and 28·66 per cent carbon.
0·3636 gr. gave 0·1078 gr. $H_2\Theta$ and 0·3837 gr. $\mathrm{C}\Theta_2$ = 3·29 per cent hydrogen and 28·77 per cent carbon.
0·8042 gr. gave 282 c. c. nitrogen at 15·2° C. and 758^{mm} = 40·81 per cent nitrogen.

	Calculated.	Found.		
Carbon,	28·07	28·67	28·66	28·77
Hydrogen,	2·92	3·08	3·21	3·29
Nitrogen,	40·93	40·81	----	----
Oxygen,	28·08	----	----	----
	100·00			

The large excess of carbon in these analyses is due to the extraordinary difficulty of deoxydizing by metallic copper the nitrous acid formed during the combustion.

From these analyses it appears that the formula of stryphnic acid is

$$\mathrm{C}_4\mathrm{H}_3\mathrm{N}_5\Theta_2$$

I have not found it possible to determine with certainty whether the acid is monobasic or bibasic, and have therefore adopted the simpler view. The peculiar color of the acid, as well as of its salts, leads to the suspicion that it may be a nitro-derivative and that its true formula is

$$\mathrm{C}_4\mathrm{H}_3(\mathrm{N}\Theta)\mathrm{N}_4\Theta.$$

Stannous chlorid and chlorhydric acid do not exert a sensible action upon stryphnic acid. When, however, the acid is digested with metallic magnesium or zinc and chlorhydric acid, the solution soon becomes yellow and finally orange. The

liquid then, on cooling, yields grouped masses of dark dull red crystals which dissolve to a deep orange red liquid becoming orange, and finally yellow, by dilution. These crystals may prove to be amido-stryphnic acid, $C_4H_3(NH_2)N_4O$. Want of material has prevented me from making a more complete examination.

In my paper on the constitution of uric acid and its derivatives,* I gave to the acid which I now term stryphnic acid the name urocyanic acid, and attributed to it the formula $C_5H_4N_6O_3$. A more extended study has enabled me to correct this formula and to select a more appropriate name. Retaining the same views as to the constitution of the members of the uric acid series respectively, that is to say, considering them as derivatives of the polymeric forms of cyanic acid, I propose for the atomic structure of stryphnic acid the formula

$$\begin{array}{l} N = C - NO \\ | \quad\quad | \\ N - C - H \\ | \quad\quad | \\ N = C - HO \end{array}$$

It is therefore to be regarded as a derivative of the hypothetical tetracyanic acid, and belongs to the same group with mycomelic acid, allantoin, &c.

Action of potassic nitrite upon alloxantin.—Alloxantin treated in the cold with potassic nitrite and acetic acid dissolves completely with effervescence. The solution has a pale purplish tint and stains the skin to an onion red color. On evaporation small granular crystals of alloxan are deposited in abundance. From this it is evident that, under the circumstances, the action of the nitrous acid is one of oxydation simply. In this connection I may mention that potassic hypermanganate oxydizes alloxantin to alloxan, the end reaction being tolerably well defined. In two experiments 322 milligrams of alloxantin required 27·31 c. c. and 27·26 c. c. of a solution of the hypermanganate, of which 27·5 c. c. corresponded to 16 milligrams of oxygen. A molecule of alloxantin required therefore one atom of oxygen for oxydation.

Action of the nitrites upon alloxan.—When alloxan is boiled with a solution of sodic nitrite, acetic acid being added in small quantities, an abundant evolution of gas is observed and the filtrate on cooling deposits a white and rather insoluble salt which is sodic oxalurate. A portion of this salt was dissolved in hot water and argentic nitrate added, when a white precipitate was formed which was washed on a filter with cold water

* This Journal, vol. xlvi, p. 289, Nov. 1868.

and dissolved in boiling water. Beautiful colorless needles of argentic oxalurate were formed.

0·3925 gr. gave 0·1771 gr. silver = 45·12 per cent.
0·2821 gr. gave 0·1277 gr. silver = 45·22 per cent.

The formula $\mathrm{C_3H_3AgN_2O_4}$ requires 45·18 per cent silver.

The formation of oxaluric acid from alloxan might be represented by the equation

$$\mathrm{C_4H_2N_2O_4 + H_2O + N_2O_3 = C_3H_4N_2O_4 + CO_2 + 2NO}$$

It seems, however, more probable that the alloxan is first oxydized to parabanic acid which then passes into oxaluric acid by taking up an atom of water; thus

$$\mathrm{C_4H_2N_2O_4 + N_2O_3 = C_3H_2N_2O_3 + CO_2 + 2NO}$$

and $$\mathrm{C_3H_2N_2O_3 + H_2O = C_3H_4N_2O_4}$$

When alloxan is boiled for some time with an alkaline nitrite and acetic acid, the oxaluric acid is more or less completely decomposed into oxalic acid and urea, which last is, however, resolved, as fast as set free, into carbonic acid, nitrogen and water, according to a well known reaction.

Action of the nitrites upon alloxanic acid.—Baric alloxanate was boiled with potassic nitrite and acetic acid. The usual effervescence was observed and after some time a buff-colored crystalline barium salt was formed while the supernatant liquid had a strong yellow tint. The barium salt proved on examination to be merely not quite pure baric oxalate. It gave 59·8 per cent BaO in place of 58·4 per cent. It is, to say the least, probable, that in this case oxalic acid is a final product only, and that oxaluric acid is the intermediate product, since alloxanic acid differs from alloxan only by the elements of one atom of water.

Action upon parabanic acid.—Perfectly colorless crystals of parabanic acid were treated for a short time only with potassic nitrite and acetic acid. A strong effervescence ensued, and after cooling, large colorless crystals of a potassic salt separated, which were purified by repeated recrystallization.

0·9349 gr. gave 0·1639 gr. water and 0·7230 gr. carbonic acid = 21·09 per cent carbon and 1·94 per cent hydrogen.
0·8593 gr. gave 115 c.c. nitrogen at 6·25° C. and 762·7^{mm} = 16·50 per cent.

		Calculated.	Found.
Carbon	3	21·17	21·09
Hydrogen	3	1·76	1·94
Nitrogen	2	16·47	16·50

The formula is therefore $\mathrm{C_3H_3KN_2O_4}$, which is that of potassic oxalurate. The salt was dried at 102° C. The acid obtained

from it possessed the characteristic properties of oxaluric acid. The corresponding sodium salt was also analyzed. 0·5729 gr. salt dried at 100° C. gave 0·1171 gr. water and 0·4910 gr. carbonic acid = 23·37 per cent carbon and 2·26 per cent hydrogen. The formula $C_3H_3NaN_2O_4$ requires carbon 23·37, hydrogen 1·94 per cent.

From this result it appears that, in the presence of the alkaline salt, the parabanic acid simply unites with the elements of water to form oxaluric acid. It is not easy to say whether the decomposition which occasions the effervescence observed is due to the direct oxydation of one portion of the parabanic acid or to that of the oxaluric acid formed. In several experiments I have observed that when parabanic acid is boiled for some time with potassic nitrite but without acetic acid, a very distinct odor like that of formic acid is observed. Only oxalic acid is found among the liquid products of the reaction when the boiling is long continued, and the actual quantity of acid vapor is very small. It seems probable that a small portion of the parabanic acid is decomposed in accordance with the equation :

$$C_3H_2N_2O_3 + N_2O_3 = CH_2O_2 + 2CO_2 + 4N,$$

but further investigations must decide this point.

A hot solution of parabanic acid in presence of free sulphuric acid is readily oxydized by potassic hypermanganate. In three experiments, 114 milligrams of parabanic acid required 53·3, 53·3, 53·5 c. c. of a solution of the hypermanganate, of which 53·6 c. c. contained 16 milligrams of available oxygen. This is exactly one atom of oxygen for one molecule of paraban. The oxydizing action of the hypermanganate is probably represented by the equation

$$C_3H_2N_2O_3 + 2H_2O + O = 3CO_2 + 2NH_3.$$

I consider it certain that parabanic acid is directly oxydized by potassic hypermanganate and not after previous conversion into oxaluric acid, as I shall show that this last can only with extreme difficulty be oxydized in an acid solution.

Action upon oxaluric acid.—Potassic nitrite in presence of free acetic acid acts readily upon oxaluric acid with effervescence. After long boiling only oxalic acid is to be detected in the solution. The effervescence arises evidently from the decomposition of the urea, the oxaluric acid being converted by boiling into oxalic acid and urea, which last is decomposed as fast as formed.

Potassic hypermanganate oxydizes oxaluric acid in an acid solution with great difficulty, and no well defined end reaction can be observed. The same remark applies to alloxan, alloxantin, and generally to all bodies belonging to the uric acid

series of which urea is one of the products of decomposition in presence of water.

Dialuric acid.—Pure colorless crystals of dialuric acid, obtained by boiling alloxantin with zinc-dust and small quantities of chlorhydric acid, were treated with potassic nitrite and acetic acid. Strong effervescence ensued and on cooling beautiful colorless prismatic crystals separated in abundance. After repeated recrystallizations the crystals were burnt with oxyd of copper.

0·6984 gr. gave 0·2462 gr. water and 0·7694 gr. carbonic acid = 30·27 per cent carbon and 3·91 per cent hydrogen.

0·6730 gr. gave 189 c. c. nitrogen at −1° C. and 761·5^{mm} = 35·40 per cent nitrogen.

		Calculated.	Found.
Carbon	4	30·38	30·27
Hydrogen	6	3·80	3·91
Nitrogen	4	35·40	35·40
Oxygen	3	30·42	----
		100·00	

The results of these analyses agree perfectly with the formula, $C_4H_6N_4O_3$, of allantoin, with which the substance corresponds in all its properties. In the mother-liquor from the allantoin I detected no other organic body. It is therefore most probable that the reaction resulting in the formation of allantoin from dialuric acid is expressed by the equation

$$\underset{\text{Dialuric acid.}}{2C_4H_4N_2O_4} + 2N_2O_3 = \underset{\text{Allantoin.}}{C_4H_6N_4O_3} + 4CO_2 + H_2O + 2NO + 2N.$$

I am not aware that allantoin has hitherto been obtained from dialuric acid. Murexid is not sensibly acted upon by the alkaline nitrites in presence of acetic acid, even by long boiling.

My investigation of the products of the action of nitrous acid upon uric acid and its derivatives was nearly completed when I became acquainted with the memoir of Sokoloff* upon the same subject. By the action of nitrous acid upon uric acid, Sokoloff obtained a new acid to which he has given the name of urinilic acid, and to which he ascribes the formula $C_8H_7N_7O_6$. I have not observed the formation of this acid, but will simply remark that the Russian chemist appears to have studied the action of nitrous acid under wholly different conditions, so that the diversity of his results is easily accounted for. The difference between the properties of urinilic and stryphnic acids is too great to permit even a suspicion of their identity. My acknowledgments are due to Mr. W. N. Hill for most efficient aid in the prosecution of my work.

Cambridge, June 15th, 1869.

* Zeitschrift für Chemie, Bd. v, p. 78 (3d Heft June, 1869.)

Art. XXIV.—*Account of the Swedish North-Polar Expedition of* 1868, *under the command of* A. E. Nordenskiöld *and* Fr. W. von Otter.*

The study of the natural history of the polar regions has been of late years prosecuted in Sweden with so much interest that, exclusive of the present year's undertaking, no less than three† separate expeditions have been sent out from this country to the arctic seas. When Nordenskiöld last winter again brought forward a proposal for a new expedition, on a different plan, which was to set out in the autumn from the northern coast of Spitzbergen and penetrate farther northward, the means requisite to defray the expenses of the expedition were in a few days raised in the second city of Sweden, Göteborg [Gottenburg], at the instance of the resident governor, Count Ehrensvard. When, moreover, the Government, in order to assist the undertaking, fitted out and manned the steamship *Sofia*, well adapted for the purpose, strongly built of Swedish iron, and originally intended to carry the mails over the Baltic in winter, the new expedition was enabled to assume a more extensive character and embrace a wider compass than had originally been intended. Most expeditions of this kind have had for their object to attain as high a degree of north latitude as possible ; but a glance

* Extracts from the full report, here reprinted from the Minutes of the Royal Geographical Society of the meeting March 22, 1869.

† These were the following:—

The Expedition of 1858, fitted out at the expense of Otto Torell. The following gentlemen took part in the undertaking: O. Torell, A. E. Nordenskiöld, A. Qvenuerstedt. The Expedition visited the western coast of Spitzbergen, and brought home considerable zoological and geological collections.

The Expedition of 1861, fitted out at the public expense. The gentlemen who took part in the expedition, besides the proposer and chief, O. Torell, were A. Von Goës, A. T. Malmgren, F. A. Smitt, G. Von Yhlen, zoologists and botanists; B. Lilliehöök and W. Kuglenstjerna, commanders of the vessels; C. W. Blomstrand, C. Chydenius, N. Dunér and A. E. Nordenskiöld for geological and physical investigations. The expedition visited, in both vessels, the western and northern coasts of Spitzbergen, made extensive journeys in boats for the purpose of constructing a topographical and geological map of the group of islands, and of examining the northern part of the triangulation for degree-measuring, which the present President of the Royal Society, General E. Sabine, as early as 1826, proposed to get executed, in these high northern regions ; and lastly brought home with them a collection of materials for studying the *fauna*, *flora*, and geology of the islands, probably not surpassed in completeness by any similar collections from districts situated at so great a distance from the centers of civilization.

The Expedition of 1864, fitted out at the public expense, chiefly for the purpose of continuing the survey for the measurement of the degree. The gentlemen who took part in the undertaking were A. E. Nordenskiöld, chief, N. Dunér and A. J. Malmgren. The expedition visited the southern part of Spitzbergen and Storfjord, completed the survey for the degree-measuriug, and brought home rich geological, zoological and botanical collections.

at their history will convince us how difficult and uncertain the attainment of this object is, and how frequently an insignificant circumstance has obliged the, in other respects, best planned expeditions to return without any scientific result whatever,—a contingency which there would have been no reason to apprehend if proper care had been taken in the scientific furnishing and manning of the expedition. In order to remove all fear of the new Swedish expedition having a result of this kind, it was determined that in this, as in the preceding Swedish arctic expeditions, a continuation, as general as possible, should be made of the researches in natural history commenced by their predecessors. For this purpose the expedition was provided, by the Royal Academy of Science in Stockholm, with a carefully-selected and appropriate scientific apparatus,* and was accompanied by as numerous a body of professional scientific men as room and circumstances permitted.

The plan of the journey was, during the summer and early part of the autumn, to pay a visit in the *Sofia* to Beeren Island and Spitzbergen, and carefully examine both the marine and terrestrial fauna of these lands ; their flora, both phanerogamous and cryptogamous, as also their geography and geology. It was also intended to make deep soundings, and to take meteorological and magnetical observations, &c. A supply of coal was to have been deposited by a ship, hired for that especial purpose, at some fitting spot on the northwest corner of Spitzbergen, which is accessible till late in the season ; which tract the *Sofia* was accordingly to visit during the course of the autumn, and whence some of the scientific men were, in the beginning or middle of September, to return in one of the colliers to Norway. The rest were to endeavor, in the *Sofia*, to make their way farther north, and, if necessary, to pass the winter (circumstances permitting) in some appropriate harbor of the Seven Isles, which form the Old World's most northern archipelago.

The gentlemen who took part in the expedition were :—*Geologist*,—A. E. Nordenskiöld ;† *Captain*,—Fr. W. v. Otter, R. SW. N. ; *Lieutenant*,—A. L. Palander, R. SW. N. ; *Physician*,—C. Nyström ; *Natural Philosopher*,—S. Lemström ; *Zoologists*,—A. E. Holmgren, A. J. Malmgren, F. A. Smitt ; *Botanists*,—Sv. Berggren, Th. M. Fries; *Geologist*,—G. Nauckhoff.

* The London Royal Society and the University of Helsingfors contributed to the instrumental apparatus of the expedition.

† The geographical and hydrographical researches were to be performed by Nordenskiöld, von Otter and Palander. These last—of whom, in consequence of their office, one was almost always on board—also took upon themselves the meteorological observations. Nyström assisted the zoologists, and also directed his attention to the remarkably interesting hygienistic features of these regions.

The vessel was manned by fourteen seamen, together with the zoological conservator Svensson, and six dredgers, hired in Norway. The ship placed at the disposal of the expedition having been under the inspection of Captain von Otter, duly fitted out in Carlscrona, and furnished with provisions for something more than a year—or, when account is duly made of the game that in these parts one may always reckon upon, for about a year and a half—and touched at Göteborg to take on board the scientific apparatus and the men of science who took part in the undertaking, anchor was weighed on the 7th of July. The 16th–20th Tromsö was visited for the purpose of taking in coal, &c.

On the 22nd the *Sofia* cast anchor in the southern harbor of Beeren Island, where some members of the expedition landed to study the natural phenomena of a place difficult of access on account of the want of a good harbor; while the remainder continued on board the vessel, which cruised in the neighborhood, and occupied themselves with soundings and with an examination of the local marine fauna.

The expedition left Beeren Island on the 27th of July. Our course was directed to the eastern coast of Spitzbergen, which had not been visited by any of the previous Swedish expeditions; but already at South Cape we met with ice, which, as we approached the Thousand Isles, became more and more abundant, and we were obliged to turn back. After some hesitation as to whether we should wait at South Cape till the water became more free from ice, in order to proceed farther eastward, or immediately begin the scientific operations on the west coast of Spitzbergen that entered into the plan of the voyage, we embraced the latter alternative; and it was very fortunate that we did so, for on our return home we learned that the east coast, during the whole summer of 1868, had been rendered completely inaccessible by the ice.

Our course was now directed to Ice-fjord, where the *Sofia* cast anchor on the morning of the 31st of July. We continued a fortnight in the different harbors of that extensive fjord, and penetrated, in our boat-excursions, to the innermost parts of the fjord's northern arm, which had not previously been visited by the Swedish expeditions. During this time all the members of the expedition were busily occupied in scientific researches, and in collecting objects of natural history. The change was, indeed, advantageous, as well for our zoological and botanical as especially for our geological investigations.

The previous Swedish expeditions had pretty fully explored the principal features of the geology of Ice-fjord, and had found it, in consequence of the varying strata on its shores, full of different types both of animal and vegetable remains, and un-

usually rich in materials illustrative of the geological history of the extreme north. Innermost in the fjord are found immense beds of red clay-slate, and sandstone, probably Devonian, which, however, do not here contain fossils. On them lie strata of limestone, gypsum and flint, filled with large coarse-scaled mountain-limestone brachiopoda ; then come *Trias* beds, with large nautilus-forms and remains of saurians ; after these, *Jura* strata with *ammonites;* then *Tertiary* strata, in many places rich in plant-impressions, indicating a former temperate climate ; and, lastly, scanty remains of *Post-tertiary* strata, with plant-fragments and sub-fossil marine shells, *some of which now first occur in living condition in the northern parts of Norway.* The preceding Swedish expeditions had brought home specimens from all these strata ;* not, however, sufficiently numerous to give a geological representation of the place's former history so complete as the importance of the subjects requires. To supply this defect was one of the chief objects of the expedition of 1868 ; and we succeeded in bringing home unusually rich collections, especially of plant-impressions and Trias petrifactions, which, when duly studied, will, no doubt, throw much light on the condition of the climate and arrangement of the land of the arctic regions at that remote period.

Spitzbergen, as is generally known, is at present frequently visited by Norwegian ships engaged in walrus and seal fishing, or in fishing for the "haakjoering" (*Scymnus microcephalus*) on the banks beside the island's coast. The walrus is, however, now but very rarely met with on the western side of Spitzbergen ; and its fjords are therefore only occasionally visited for the purpose of taking in water or hunting the reindeer. On how large a scale the hunting of these animals may be carried, is evidenced by the circumstance that the vessels fitted out from Tromsö alone in 1868, according to official returns, killed 996 head. From Hammerfest the returns are still greater ; whence we may conclude that, in spite of the war of extermination which, under the name of hunting, has for some time been carried on against these animals, two or three thousand head are annually slaughtered. If we compare that number with the scanty extent of ice-free meadow-land in Spitzbergen, we are tempted to suppose that an immigration must take place from Novaja Zembla, which, nevertheless, is

* The first mountain-limestone petrifactions in Spitzbergen were found by Parry in 1827 at Cape Fanshawe, and the same year by Keilhau at South Cape. Jura fossils were first discovered by Lovén in 1838; the tertiary plant-remains by Nordenskiöld in the Swedish expedition of 1858; the Trias strata by Blomstrand in 1861 : the post-tertiary beds, containing Mytilus, by Torell, Malmgren and Blomstrand in 1861; the Saurian strata by Nordenskiöld in 1864.

scarcely possible, unless some large island or group of islands facilitates the communication between these two countries, situated at a distance of between 400 and 500 nautical miles from one another. Of late years the Norwegians have resumed the method, formerly employed by the Russians, of using large nets, formed of rope, to catch the Beluga (*Delphinopterus leucas*); and in 1868 several vessels were fitted out exclusively for that species of fishing. Some of the fishermen whom we met had, on one or two occasions, taken from twelve to twenty head at a single drag of the net: right handsome sport, when one considers that the *Delphinopterus* is often larger than the walrus itself.

Ice-fjord, like most of the other gulfs of Spitzbergen, is surrounded by vast glaciers with their mouths turned toward the sea, which offer to the geologist an opportunity of studying that phenomenon so important in the history of the earth's development. But extensive valleys or declivities free from ice and snow are also met with, especially in the inner parts of the fjord, and the fertile soil here produces a vegetation more luxuriant than in other parts of this island group. One may here see whole fields yellow with poppies (*Papaver medicante*), or covered with a thick green and red carpet of the beautiful *Saxifraga oppositifolia*. The fjord, which lies beneath them, and in the summer months is often as still and clear as a looking-glass, abounds with marine animals of various kinds. Everything contributes to make this a most important spot for the study of both animal and vegetable life in the Arctic regions. The zoologists and botanists of this expedition here gathered a rich harvest; among the results of which we may mention the taking of several fine salmon, and fully-developed examples of the esculent mushroom, &c.

We left Ice-fjord on the 13th of August. At the entrance a boat-party was sent out northward, to map and examine geologically Foreland Sound. Their work was now—as during the expedition of 1861, when Blomstrand and Dunér sailed through the sound—rendered difficult by almost perpetual fog. During this time the vessel made a somewhat longer excursion westward for the purpose of taking soundings; which, however, were on the occasion rendered almost impossible by the heavy swell. We had arranged to meet at King's Bay, whither both parties came on the 17th, in the afternoon. Several zoological, botanical, and geological excursions having been made from this point, and a large number of miocene fossil plants collected, the *Sofia*, on the 19th, proceeded on her course farther northward.

We had hoped here, in some degree at least, to reinforce our already considerably diminished stock of coal, but we soon found that that would necessarily cause too great a delay. In fact, whereas, more to the south, the tertiary formation occupies the greater part of the extensive peninsula between Icefjord and Bell Sound, and there in many places forms mountains above a thousand feet high, at King's Bay, on the contrary, its extent is very inconsiderable, so that at present it forms only a few small hills consisting of strongly-folded strata, and separated from each other by the furrows cut by the glacier-streams. By this the supplies of coal, notwithstanding the thickness of the beds by no means inconsiderable and their accessibility (they lie only a few hundred feet from the shore of one of the best harbors in Spitzbergen), become of but little value, especially as the frost, which begins at a very short distance under the surface, renders the breaking of them extremely difficult; in fact, in consequence of the extreme toughness of the ice-drenched coal, almost impossible without regular mining. It is even to be expected that the whole of what still remains of the miocene formation of this spot will, in a comparatively short period, be washed away.

Late at night, on the 20th August, the *Sofia* anchored at Amsterdam Island, and the following day we had the pleasure of hailing the first of the ships which had been hired in Norway for the expedition for the transport of coals. A coal depôt having been established on the low tongue of land that shoots out south-eastward from Amsterdam Island, and five of the scientific members of the expedition having been landed at Kobbe Bay, together with the necessary tents and boats, to prosecute their zoological, botanical, and physiological researches, the *Sofia* sailed off with the rest on a sounding-tour toward Greenland. Our intention was to penetrate thither along the 80th degree of N. latitude, but before we had reached the longitude of Greenwich we were met by impassable masses of drift-ice. It was evident that the coast of Greenland was accessible only at a latitude much lower than was compatible with the plan of our voyage. We therefore turned our course north and northeast, and gradually, after innumerable zigzags in the ice, arrived at 81° 16′ N. latitude. The temperature had now sunk to 6° (centigr.), with thick ice, fogs, and snow-storms. The ocean was sometimes covered with a thin coating of new ice, and the old ice northward was quite impassable, so that we were obliged to seek a passage out in a southeasterly direction. After another vain attempt to reach Depôt Point, in Brandewijne Bay, the *Sofia* anchored, on the 29th, in Liebde Bay.

During the passage of the *Sofia* from Norway to Spitzbergen, its officers, Captain Baron von Otter and Lieutenant Palander, took a number of soundings in the deeper parts with a "Bull-dog" apparatus of the same kind as that constructed at Tromsö, by Torell and Chydenius, for the voyage of 1861, and which was found to be particularly applicable. These soundings were zealously continued during our cruising amid the drift-ice between 80° and 82°, and gave very interesting results not only as regards the ocean's depth in the parts visited by us, but also concerning Arctic animal life at the greatest measurable depths. It showed us that Spitzbergen may in a manner be looked upon as a continuation of the Scandinavian peninsula, inasmuch as that island-group is not separated from Norway by any very deep channel (not above 300 fathoms), whereas a little to the north and west of Spitzbergen there is a depth of 2000 fathoms and more. From these great depths specimens of clay were brought up by the Bulldog-apparatus, which, on immediate and close examination, were found to contain not only several microscopic, but even larger and tolerably highly-organized animal forms (*e. g.*, several kinds of Crustacea and Annellata). The greatest depth from which any specimen was procured was 2,600 fathoms, and the mass there raised consisted for the greatest part of white and red Foraminifera, in general scarcely as large as a pin's head. It is, moreover, deserving of remark, that, during our cruisings amidst the ice, we met with and collected, not only a number of pieces of drift wood, but also (as, for example, at 80° 40′ E.) glass balls of the kind used by the Norsemen, at their Loffoden fisheries for floats; an additional proof of the already well-established fact,* that the Gulf Stream reaches, though in a greatly weakened state, even these tracts.

Liebde Bay had never before been visited by any scientific expedition, and its topography and geology were accordingly entirely unknown. A boat-party, consisting of Malmgren, Nordenskiöld, and Nyström, with three men, were therefore left here, while the ship went to fetch their comrades who had been left at Kobbe Bay. The boat's journey was favored with calm and mild weather and a clear sky; although a high wind, accompanied by snow-storms, prevailed out at sea—a circumstance very common at Spitzbergen, and which is said especially to characterize that beautiful, and, according to the unanimous testimony of the fishermen, appropriately named, fjord. We

* Among the proofs of this already given may be mentioned, that Torell, in 1861, at Shoal Point, met with a bean that had come from the Gulf of Mexico, the *Entada gigantilobium*.

were thus enabled, during the few days that our boat-voyage lasted, to map it, and ascertain the character of its somewhat uniform geology. Its shores are occupied exclusively by the same red, green, and dark grey kinds of slate, which in Ice-fjord are covered by mountain-limestone strata with *Producti*, and in Mount Hecla form the uppermost stratum of the vast series of schists to which the name of that mountain has been applied. But, as yet, no petrifications had been discovered in these strata. Their age was accordingly somewhat doubtful, and the probably Devonian fish-remains which we now found here are therefore a discovery of great value in the explanation of Spitzbergen geology. The lower slatebeds contained some vegetable remains, though probably of too indistinct a character to admit of identification.

On the 2nd of September, the boat's company and the ship, returning with our comrades from Kobbe Bay, met at a little distance off the promontory that separates Wijde Bay and Liebde Bay. After remaining in that bay a couple of days longer, the *Sofia* weighed anchor and touched at the now ice-free Cape Depôt, in Brandewijne Bay, in order to fetch away the supply of pemmican that (in 1861) had been left there, an iron boat, &c. We thence steered northward, with the intention of passing round Nordostland to Giles' Land. The greater part of the arm of the sea, that lies between the Seven Islands, Cape Platen and North Cape, which, in 1861, was already, in the middle of August, perfectly free from ice, we now, in the beginning of September, found covered with a firm crust of ice. It was therefore impossible to reach Giles' Land by this route, and we were therefore obliged, after having for the purpose of botanical and zoological researches, remained a short time a Castién's Islands and Parry's Island, which last, being still encompassed by a girdle of land-ice, was approachable only walking over the ice, to seek another passage, namely, that through Hinloopen Strait. Our course was directed to its southern part.

Already, before the end of September, some signs of the approach of autumn had been visible, and the hill-tops had frequently in the morning been for some time covered with a white mantle of new-fallen snow, which, however, had melted away again without causing any hindrance to our scientific pursuits. But now, during our passage to South Waijgats Islands, a copious fall of snow rendered all further researches in natural history on land impossible, and gave us pretty clearly to understand that the season for our purely scientific pursuits was to be considered as at an end. We accordingly turned back at Mount Lovén, in the southern part of Hin-

loopen Strait, having first on that spot collected, from under snow of a foot deep, an additional number of mountain-limestone petrifactions. On the 12th of September we again anchored at our coal depôt on Amsterdam Island, and there met our second coal-ship, by which some of the members of the expedition (Fries, Holmgren, Malmgren, Nauckhoff, and Smitt) returned to Norway, carrying with them the valuable collections of objects of natural history which the expedition had up to that time succeeded in acquiring. These collections have now safely arrived in Stockholm, and will, after having been duly studied, be divided between the National Museum in that city, where already the extraordinarily rich Arctic collections formed by the preceding Swedish expeditions are preserved, and the Museum of Göteborg, the city whose liberal initiative first gave occasion to the new expedition. To give an idea of the extent of these collections, I need only refer to the notices above given of our geological operations, and remark that the zoological sciences were represented by no less than three members of the expedition, who, besides, had with them a taxidermist. Messrs. Malmgren and Smitt had also at their disposal a boat manned with four men for dredging every day, holidays excepted, when the ship lay still. They were thus enabled not only to make a searching examination of the Arctic marine fauna, which, in individual copiousness at least, is comparable with that of many more southern countries, but also to pay due attention to the terrestrial fauna of the locality, more especially the entomological branch, which is poor both with respect to individuals and species, and accordingly presented especial difficulties to its investigator, Mr. Holmgren. The dredgings also yielded rich contributions to the ocean's algaflora. Every opportunity that offered itself for land-excursions was used by the two botanists of the expedition, both for investigating the flora and for forming a collection of specimens for normal herbaria of Spitzbergen's phanerogamia, mosses, lichens, and algæ.

On the 16th of September we took leave of our homeward-bound companions, and immediately proceeded northward. Our intention was to touch at the Seven Isles, but these were now found to be still more thickly surrounded by ice than when we had visited that tract about a fortnight before. We accordingly determined to avail ourselves of a channel tolerably free from ice, stretching northward from those islands.

After a number of zigzags amidst the drift-ice, our vessel, in longitude $17\frac{1}{2}^\circ$ east from Greenwich, succeeded in arriving at 81° 42′ north latitude, probably the highest northern latitude a ship has ever yet attained. Northward lay vast ice-

masses, it is true as yet broken, but still so closely packed that not even a boat could pass forward, and we were therefore obliged to turn to the southwest and seek for another opening in the ice; but we found, on the contrary, that the limit of the ice stretched itself more and more to the south the more we went to the west, so that, on the 23rd September, in the longitude of Greenwich, we were south of the parallel of 79° N. latitude. On the way we had in several places met with ice black with stones, gravel, and earth, which would seem to indicate the existence of land still farther north.

The ice itself had, moreover, a very different appearance from that which we had met in these tracts at the end of August. It consisted now, not only of larger ice-fields, but also of huge ice-blocks, so that it seems as if the former ice had drifted to the south, and given place to new ice-masses coming from the north. The temperature had now sunk to 8° or 9° (centigr.) below the freezing point, and the ice, which in these parts had before been of tolerably loose texture, had now become so compact that any more violent collision with it was combined with no little danger. Furthermore, the nights were now so dark, that it was necessary at that time to lay the ship to by the side of some large sheet of ice, at the hazard of finding ourselves blocked up there in the morning. Already, in the beginning of September, the surface of the ocean, after a somewhat heavy fall of snow, had shown itself, between the ice-masses, covered with a coating of ice, which, however, was then thin, and scarcely hindered the vessel's progress. Now it was so thick that it was not without difficulty that a way could be forced through it. All things clearly indicated that the season of the year, during which it is possible to sail in these tracts, was nearly at an end, and as we intended to make yet another attempt to find a northern passage from the Seven Isles, or seek a harbor for the winter, we determined to return to our coal-depôt.

On the 25th of September the *Sofia* once more cast anchor at the north-west corner of Spitzbergen, after having slightly struck upon a rock situated under the surface of the water in the middle of South-gat, and which has been forgotten in Buchan and Franklin's admirable chart of the harbor, although it appears, from Beechy's description, that they themselves happened to strike on the same shallow.

After a few days' rest, spent in inspecting the engine and taking in coal (the last remains of our store of coals had to be seached for under a thick covering of snow), and after having placed in the letter-box on the island in Kobbe Bay notices of our journey and our plans for the future, we steamed away

again, on the 1st of October, northward, notwithstanding a strong wind and a snow-fog that prevailed in the harbor we left. Our suspicion that this was only local seemed to be confirmed when we got out a little farther north, as the weather became clearer and calmer, but at the same time we met already, in lat. 80° 40′, sporadic blocks of drift-ice, which, as we proceeded farther north, increased in number and size. We continued our northward course during the following day, but it was soon evident that no open water would be arrived at that way, and in the afternoon we were again steering in a southerly direction. During the night we lay to under cover of a large sheet of ice. The temperature had now sunk to 14° 5′ (centigr.) so that in calm weather the surface of the water between the ice-masses was covered with ice of two or three inches' thickness, which considerably impeded the progress of the ship. But the following day we stood southward till we got into something like open water, and then followed the edge of the ice in a northerly and northwesterly direction. By this means we again arrived at 81° N. lat., but here the *Sofia* met with a misfortune which put an end to all further efforts to proceed northward. In the morning of the 4th October, during a storm from the southeast, and with a high sea, the ship was thrown violently upon a huge ice-block, or rather a small iceberg, whereby she sprang an extensive leak. We were therefore forced to turn back immediately and seek our harbor, where we arrived late in the evening, after eleven hours of incessant labor to keep the vessel free from water. Nevertheless, though all took part in this work, the water continually rose, so that, when the anchor was cast at Amsterdam Island, it stood about two feet over the cabin floor. Fortunately the provisions, being kept between water-tight bulkheads, were uninjured, and we succeeded, though with great difficulty, in keeping the engine-room so free from water that the fires were not extinguished. Had this not been the case, our ship must unquestionably, in a short time, have been the prey of the storm and the extremely heavy sea, which now, contrary to our former experience, raged among the thinly-scattered fields of drift-ice. Immediately on our arrival at Amsterdam Island the ship was careened and the leak provisionally stopped, so that already the next day we were in a condition to seek a more secure harbor in King's Bay. Here the ship was hauled so close to land at flood, that we, at ebb, were enabled to come at the leak and stop it effectually.

King's Bay, which in summer time is almost free from ice, was now filled with innumerable ice-blocks fallen from the mighty glaciers of the fjord, which, when carried by the flood-

tide in toward land, totally barricaded the barbor in which the *Sofia* had taken refuge ; and, notwithstanding that the temperature here was considerably higher than in the neighborhood of 81° N. lat., these blocks froze during the calm weather so fast together, that when we on the 12th of October, were again in a condition to sail, it was only with the utmost difficulty that our vessel could get out.

Our stay in King's Bay, like all the preceding occasions on which the ship remained any length of time still, was taken advantage of by our natural philosopher Dr. Lemstrom, for the purpose of making observation for the determination of the magnetic constants and variations. The ground was, however, too deeply covered with snow to allow of any geological or botanical operations. Even the brooks, so copiously supplied with water in the summer time, which intersect the lowlands adjoining the coal harbor, were now so entirely dried up by the effect of the cold that we endeavored in vain to reinforce our now considerably reduced supply of water.

Our ship, which had had two ribs broken by the blow that caused the leak, was now too weak to be exposed, with the slightest prospect of success, in any new attempt to force a way through fields of drift-ice, as would in all probability be necessary, should we endeavor to visit the Seven Islands, which place we had intended to make our winter harbor ; and the wintering in any other part of Spitzbergen not having entered into our plan, nor promising results commensurable with the costs, dangers, and hardships, we determined to return to Norway. But yet we wished to make an attempt to reach Giles' Land round the southern point of Spitzbergen, which was probably still free from ice. Already during our passage along the west coast of Spitzbergen, which in summer is entirely free from ice, we passed large, though scattered, fields of ice, which farther to the east, near the Thousand Isles, completely obstructed the way. We were, therefore, constrained to relinquish that plan also, and to direct our course toward Norway. After having been once more, on the shallow banks off Beeren Island, during a severe storm and in a high sea rendered to the last degree boisterous by the shallowness of the water, in great danger of being ice-beset, the *Sofia* anchored again on the 20th of October in Tronsö Harbor, where we had the pleasure of learning that our comrades had happily arrived and reached home in safety.

From the above it appears that the expedition, as regards its second object—namely, hydrographical investigations in the Polar Basin—did not succeed in reaching any remarkably high

degree of latitude; so that the portion of our globe that is known to us has not been to any material amount increased by it. I hope, however, that it has afforded a by no means unimportant contribution to the solution of the so-called Polar question.

A lively controversy has, as is generally known, been of late years carried on between the principal geographical authorities concerning the real character of the Polar Basin, some geographers maintaining that it is covered by an unbroken surface of ice, presenting an impassable barrier to the progress of a ship; while others look upon this as only an obsolete prejudice, arising in a great measure from exaggerated descriptions of the difficulties which the sailor encountered at the point where he turned back. That this latter view, at least as regards that portion of the Polar Basin that borders on Europe during the actual sailing-season in the Northern Seas, *i. e.* the summer, is not in conformity with the real fact, has been proved, not only by the adventurous journeys of the older Arctic travelers, but by a number of expeditions sent out during the last century for the exclusive purpose of such investigations, among which may be mentioned :—

Tschitschagaff's	1st	expedition,	1765,	which with their ship could reach only	80° 21′	N. lat.
"	2nd	"	1766,	which reached	80 28	"
Phipps		"	1773,	"	80 37	"
Buchan and Franklin's		"	1818,	"	80 34	"
Scoresby's		"	1806,	"	81 30	"
Sabine and Clavering's		"	1823,	"	80 20	"
Parry's		"	1827,	"	81 6*	"
Torell's		"	1861,	" about	80 30†	"

It might then have been considered as already absolutely decided that it was not possible at that season of the year to penetrate very far into the Polar Basin, and any repetition *at the above-named season of the year* of these attempts could therefore only be looked upon as continually treading in old footsteps, which demonstrably do not lead to the intended object. But one doubt remained. At the season of the year when, in consequence of the heat of the summer and the influence of the ocean-waves and ocean-streams, the ice-masses have been reduced to their minimum—that is to say, in the autumn, before the formation of the new ice, no ship had ever before visited the Polar Basin. We could with certainty foresee that it might then be possible to go farther than in summer. There was a possibility that we might at that season be able to penetrate very far, perhaps to some land lying north of Spitz-

* By ship, but on the ice the party penetrated to 82° 45′.
† By ship, but in boats and by land journeys as far as 80° 45′.

bergen, which might hereafter serve as base from whence to push still farther onward. These considerations constituted the ground for the plan of operations for the latter portion of the Swedish expedition, and it may now be considered as proved, that a ship may, during autumn, reach a latitude considerably higher than that which has been attained by most of the summer expeditions. Unless this year is to be considered as unusually unfavorable with regard to the condition of the ice, we might in all probability have proceeded a considerable distance farther, perhaps beyond 83° N. lat. But we have at the same time convinced ourselves that, even in autumn, farther progress is soon rendered impossible by impenetrable masses of broken ice. The voyage itself, moreover, at that season of the year, in consequence of the cold, the darkness, and the boisterous winds, accompanied by snow-storms that are then prevalent in the polar basin, and the heavy sea amidst the masses of drift-ice caused by these latter, is rendered so dangerous that the risk to which the traveler exposes himself is far from being compensated by the meager prospect of success. The idea itself of an open polar sea is evidently a mere hypothesis, destitute of all foundation in the experience which has already by very considerable sacrifices been gained; and the only way to approach the pole, which can be attempted with any probability of success, is that proposed by the most celebrated arctic authorities of England, viz., that of—after having passed the winter at the Seven Islands, or at Smith Sound—continuing the journey toward the North on sledges in the spring.

ART. XXV.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXI.—*On the Meteoric Stone which fell Dec. 5th*, 1868, *in Franklin Co., Alabama;* by GEO. J. BRUSH.

IN a letter addressed to the editors of this Journal, dated Tuscumbia, Ala., Dec. 22d, 1868, Mr. Benjamin Pybas stated that an aerolite weighing 1 lb. 9½ oz. had fallen four miles south of Frankfort, in Franklin Co., Ala., on the 5th of December. Subsequently, through Mr. Pybas's influence, the stone was sent to me for examination. Mr. Pybas has taken great pains in collecting all the facts connected with the fall, as will be seen by the following abstract from a letter received from him in March last.

"The meteorite fell Dec. 5th, 1868, four miles south of Frankfort, the county town of Franklin County, Alabama. The country around Frankfort is broken and hilly, being the termination of the western branch of the Cumberland Mountains. Frankfort is sixteen miles southeast of Tuscumbia.

"Mr. James W. Hooper witnessed the fall and describes it in a note to Dr. T. D. West, which I copy. 'About 3 o'clock, P. M., the afternoon being cloudy and cold, we heard a strange, harsh, roaring noise up in the air. Three distinct reports were heard; at first these were supposed to be cannon, but the noise immediately changed into a series of bursting sounds, like a great fire blazing and crackling through the air. It appeared to pass from the north toward the south. Immediately after the first sound or roaring had passed over, another was heard coming from the same direction, like the whizzing of a bomb-shell as it cuts through the air, making a loud humming noise. I gazed intently in the direction of the noise and found that something was coming downward at a rapid rate. I looked, with my hand up, standing in a dodging position, for fear of its striking me, until I saw it strike some willow sapplings about seventy or eighty yards from where I was and fall thence to the ground. Upon going to the spot I found a strange looking rock, nearly buried in the ground and still warm.'

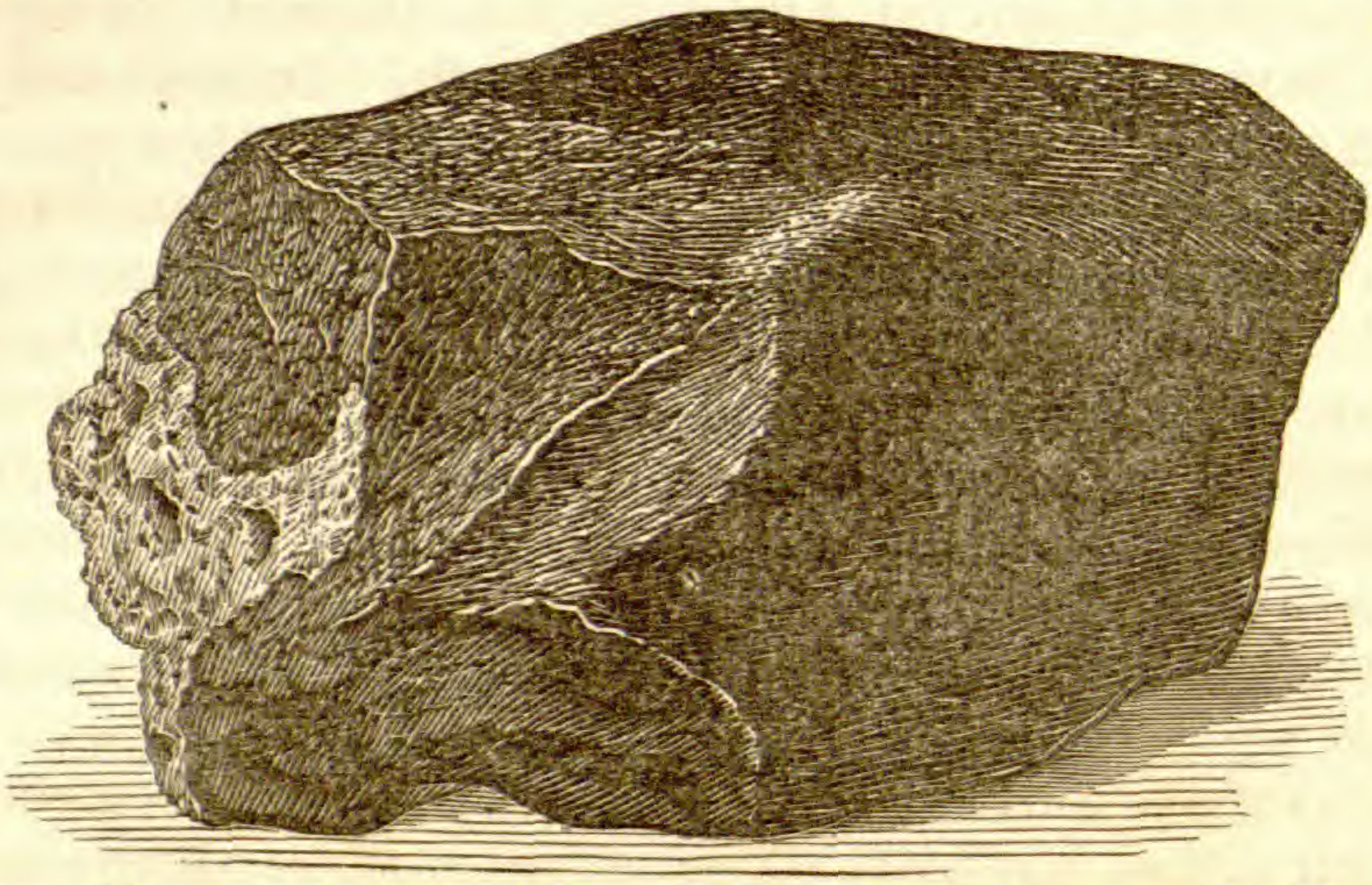
"Major Slass, editor of "the Alabamian and Times" in this place, has taken considerable trouble to collect all the information he could on the subject. He says, 'that the noise was heard for several miles around, before the final explosion. It burst, apparently, over the heads of twenty men, who were at work felling wood, one and a quarter miles from Mr. Hooper's house. One piece appeared to go southeast, another southwest, and the third northwest. There were afterward heard the reports resembling the bursting of shells. One piece was heard to fall some distance from Mr. Hooper's, making a loud, crashing noise and frightening a lot of hogs near by.'

"The reports resembling artillery were plainly heard for twenty or twenty-five miles east and west of Frankfort, and from fifteen to twenty north. I have no information as to the south. Mr. Hooper deserves much credit for noting the particulars of the fall, and for sending the meteorite for analysis and description. He refused with scorn, money offers that must have been tempting to a person of limited income, preferring the advancement of science to dollars and cents.

"In a personal interview, he told me that he was sitting by a fire with his family when he heard the first noise. He instantly arose and walked forty or fifty yards from the house before the meteorite fell. His sister, Miss Hooper, living near,

called to her brother to 'run quickly, the house is on fire—don't you hear it?' Mr. H. thinks it was three or four minutes from the first noise until its fall. The place where it struck the ground is a partially decomposed conglomerate, mixed with vegetable mould. The fracture was made by striking a fragment of limestone rock."

When received by me the meteoric stone weighed 615 grams. The crust was entire with the exception of a small corner, although the whole mass seemed to have a fresh fracture running through it. The weight of the entire meteorite could not have been over 650 grams. The accompanying cut will serve to



give some idea of its general outline; it is drawn half the actual size of the stone. The coating has a very brilliant luster, as bright as if newly varnished, strongly resembling that of the Stannern, Petersburg, Tenn., and Bishopville stones. It seems to have been in a condition of viscid fusion as shown by the ridges on the edges represented by the white lines. The crust was so thin in some parts that fragments of olivine could be distinguished through it.

On the fractured surface, as seen by the naked eye, it presented a pseudo-porphyritic structure, having a gray ground with black, green, white and dark gray spots upon it. A careful microscopic, mineralogical, and blowpipe examination of the different parts was made, with the following results: 1. The *black* mineral was coal-black, brightly lustrous and slightly magnetic; B.B. difficultly fusible and became more magnetic; on treating with the fluxes it reacted for chromium and iron; it proved to be *chromite*. 2. The *white* mineral fused with difficulty to a transparent glass, reacted for silica and soda or lime. I could not determine whether it was *chladnite* or anorthite; it seemed too difficultly fusible for labradorite. 3. A *yellowish green* mineral passing into *yellow* and also apparently

shading into *dark gray*; this was fusible with difficulty on the edges and became magnetic on heating; the green mineral appeared to be olivine, but the gray had also the same pyrognostic characters, while in physical characters it cannot be distinguished from Haidinger's *Piddingtonite*, found in the Shalka meteoric stone. 4. The lens revealed brilliant points with metallic luster, which on examination proved to be sulphid of iron (*troilite*). 5. One or two delicate black veins were observed with the glass which were at first supposed to be schreibersite, but I was unable to detach enough for a blowpipe test, and a careful qualitative examination showed no traces of phosphorus. 6. On pulverizing several grams of the stone I found a few flakes of niccoliferous iron, amounting in all to a few hundredths of one per cent of the mass.

The specific gravity of the stone in four determinations gave 3·35, 3·33, 3·31, 3·26, the mean being 3·31.

An attempt was made to separate the different silicates by the action of chlorhydric acid. It was found, however, that only about 26 per cent of the mass was soluble in acids, and the bases in the acid solution and in the insoluble portion were the same, save that the insoluble contained all the *chromite*. A complete analysis of the meteorite was made by fusion with carbonate of soda with a small amount of nitrate of soda to effect the oxydation of the chromium and the sulphids and metallic substances present. The alkalies were determined by Smith's method. The results of the analysis, commenced by myself but completed by Mr. Wm. G. Mixter, were as follows:

		Oxygen.	
Silica,	51·33	26·37	
Alumina,	8·05	3·75	
Ferrous oxyd,	13·70	3·04	
Chromic oxyd,	0·42		
Magnesia,	17·59	7·04	12·28
Lime,	7·03	2·06	
Soda,	0·45	·11	
Potash,	0·22	·03	
Sulphur,	0·23		
Niccoliferous iron,	tr.		
	99.02		

The chromic oxyd corresponds to 0·62 per cent chromite, and the sulphur to 0·63 troilite.

From this composition it would appear that the mass is probably made up of uni- and bi-silicates. In a preliminary qualitative-quantitative analysis I found that more lime was contained in the acid solution than in the portion undecomposed by acid, while with the magnesia the larger amount re-

mained in the insoluble residue. The silicate decomposed by acids containing lime is most probably either anorthite, labradorite or a lime-olivine. The large portion of magnesia and iron insoluble in acid indicates the presence of a pyroxenic mineral. Further investigation is needed to fully establish the specific character of the constituent minerals of this meteorite, although we are justified in concluding that it contains an olivine, a pyroxenic mineral and a feldspar, besides chromite, troilite and a very small amount of niccoliferous iron. I think by sacrificing a large portion of this stone that its constituent minerals could be mechanically separated from each other by careful selection with the aid of a magnifier, and their specific characters accurately determined by analysis. At present I do not feel at liberty to undertake this, but hope at some future time to return to the study of this problem.

In general physical characters this meteorite very much resembles the Petersburg, Tenn., meteoric stone anlayzed and described by Prof. J. Lawrence Smith.* It has the same lustrous coating, and the constituent minerals are very much the same in character. It seems to belong to the class of meteorites that Prof. G. Rose† calls *Howardite*, and which he describes as being granular mixtures of olivine, with a white silicate (*anorthite ?*) and a small amount of chromite and niccoliferous iron. This class, according to Rose, includes the stones from Loutalox, Bialystok, Mässing, Nobleborough and Mallygaum.

I take pleasure in expressing my thanks to Mr. Hooper for his generosity in placing the stone at my disposal for examination, and to Mr. Pybas for his great interest in furnishing the data connected with its fall.

Sheffield Laboratory of Yale College, May, 1869.

Art. XXVI.—*Contributions to Zoölogy from the Museum of Yale College.* No. III.—*Descriptions of some new American Phyllopod Crustacea ;*‡ by A. E. Verrill.

Artemia Leach.

This interesting genus is remarkable for its habit of living and flourishing best in very saline and alkaline waters, such as the natural salt lakes of Egypt, Utah, etc., and the artificial brines formed by the evaporation of sea-water by exposure to the heat of the sun, as in England, France, and the West Indies.

* This Journal, II, xxxi, 264.

† Beschreibung und Eintheilung der Meteoriten, p. 107.

‡ Abstract from a paper read before the American Association for the Advancement of Science, Salem, Mass., Aug., 1869.

The species first made known, *A. salina* Leach (*Cancer salinus* Linn.), was first described by Schlosser,* who found it in great profusion in the brines of Lymington, England. Linné indicates it also from the salt lakes of Siberia (perhaps a distinct species) and probably the same as that observed by Pallas† in great numbers in the Great Schimélée. More recently it has been described from the salterns of southern France, at Montpellier, etc.‡ The genus has been found also in the Lakes Goumphidich, Amaruh and Bédah in Egypt, which are reported to be both very saline and alkaline, their bottoms being "covered with a layer of crystals of carbonate of soda, sulphate of soda, and common salt," while the density of the water is stated at 1·255. The Egyptian species appears not to have been described as yet.§ In the Antilles *A. Guildingi* Thompson occurs.‖ *A. Mulhausenii* Edw. (Fischer sp.) is found in Lake Loak in the Crimea.¶ A few years ago Prof. Silliman presented to the museum of Yale College a number of specimens of a new species, *A. Monica* V., which he collected in Mono Lake, California, where it occurs in great abundance associated with the larvæ of *Ephydra*.** The water of this lake is very dense, and not only very saline, but also so alkaline that it is said to be used for removing grease from clothing. I have been unable, however, to find any reliable analysis of this water. It is said to contain, also, biborate of soda. Prof. Silliman informs me that the genus also occurs in Little Salt Lake. It occurs in great abundance in Great Salt Lake, Utah, as I am informed by Prof. D. C. Eaton, who ob-

* Observations périodiques sur la physique, l'histoire naturelle et les beaux-arts, par Gautier, 1756, (with figures). An extract from this is republished in Annals des Sciences nat., 2e ser., t. 13, p. 226, 1840, in an elaborate description of the anatomy, development, habits, etc., of *Artemia salina* by M. Joly, illustrated by two excellent plates of the female and young. M. Joly failed to observe the male among more than a thousand females, and therefore doubted whether the sexes were distinct, suggesting that the males very well described by Schlosser were only the young, although that author described them as clasping the females in the well known manner, but he did not observe the actual copulation.

See also an article by Thomas Rackett, in Trans. Linn. Soc. of London, vol. xi, p. 205, pl. 14, 1812, (figures very bad); Thompson, Zoölogical Researches, No. 5, p. 105 t 1 and 2; W. Baird, Nat. Hist. of the British Entomostraca, p. 61, tab. ii, figs. 2–4, (figures very good, but the specimens probably not full-grown).

† Voyage en différentes provinces de l'empire de Russie, t. ii, p. 505, (t. Joly).

‡ M. Payen, Note sur des animaux qui colorent en rouge les marais salans, Ann. des Sci. nat., 2e ser., t. 6, 1836, p. 219 (contains experiments on the effects caused by altering composition and density of the water); also op. cit., t. 10, 1838, p. 315; Joly, op. cit., t. 13, p. 225, 1840 (see above); Milne Edwards, Crustacés, t. iii, p. 369, 1840.

§ Audouin, Ann. des Sci. nat., 2e ser., t. 6, 1836, p. 230.

‖ Thompson, Zoöl. Researches, fas. 7, pl. I, figs. 11–12.

¶ Edwards, Crustacés, t. iii, p. 370, 1840.

** Verrill, Proceedings Boston Soc. Nat. Hist., vol. xi, p. 3, 1866, (the larvæ were wrongly referred to *Eristalis*); Packard, on Insects inhabiting salt-water, Proc. Essex Inst., vol. vi, p 41, 1869.

tained specimens there during the present summer, but these have not yet come to hand. The water of Great Salt Lake has usually been described by travelers as destitute of all life, but according to Prof. Eaton it contains not only an abundance of *Artemiæ*, but also various other small animals, insect larvæ, etc. The density of the water is stated at 1·170°, but doubtless varies much according to the season.* It yields, according to Dr. Gale, over 22 per cent of solid matter,† while the Syracuse Saline, one of the richest natural brines in the United States, contains but 19·16 per cent.‡ A few weeks ago Mr. Oscar Harger discovered another new species, *A. gracilis* V., near New Haven under very peculiar circumstances. On the long wooden bridge across West river and the extensive salt marsh on the West Haven side, are placed large wooden tubs filled with water from various pools on the marsh, to be used in case of fire. By long exposure to the sun and air the water in these becomes concentrated and thus furnishes suitable stations for the rapid increase of *Artemiæ*. On examining the tubs the first of August I found eight of them partly filled with water, in six of which the *Artemiæ* were found in abundance, though more numerous in one than in any of the others. In one tub, in which the water had a decidedly milky appearance, they were so abundant that hundreds could be obtained in a few minutes. The water in some of the other tubs containing them was of a reddish or brownish hue, or about the color of weak tea. In two no Artemiæ could be seen, and in these the water appeared to have been more recently renewed. Search was made in the pools from which the water had been taken, but no *Artemiæ* were found, though doubtless from these places the progenitors of those inhabiting the tubs must have been taken. It is probable that in the pools they exist in very small numbers, being kept in check partly by various small fishes and other enemies and partly by the unfavorable character of the water, while in the tubs the density of the water is more favorable for their rapid increase, and unfavorable or fatal to their enemies.§ The water

* The density of the water of the Atlantic ocean is stated at 1·020; that of the Dead Sea 1·130 to 1·227.

† This solid matter, according to Dr. Gale, (this Journal, II, vol. xvii, p. 129), has the following composition:

Chlorid of sodium,	20·196
Sulphate of soda,	1·834
Chlorid of magnesium,	·252
Chlorid of calcium,	trace
	22·282

‡ For analyses of several of these brines, see Dana's System of Mineralogy, p. 113.

§ The density of the water in two of the tubs containing most *Artemiæ*, was 1·065, equivalent to a brine containing 9·07 per cent of salt. One of those tested was brownish, the other milky.

from the tubs, when examined with a high power of the microscope, was found to be filled with immense numbers of infusoria of various kinds, such as monads, vibrios, and bacteria, most of which were so small as to be distinguishable only as moving points with a $\frac{1}{5}$ inch objective.

In the salterns of France the *Artemiæ* are associated with immense numbers of a monad, usually bright red in color, which has been named *Monas Dunalii* by Joly, who attributes to it the red color which the brine assumes just before crystallization,* as well as the red color observed in the *Artemiæ*, which doubtless feed upon it, as well as upon various other living infusoria, and dead animal and vegetable matter of various kinds.† The *Monas Dunalii* appears in abundance in the water having the density most favorable for *Artemia*, but increases in far greater proportion in the still denser, nearly or quite saturated brine in which *Artemia* does not live. The observations of Payen and Joly show that the *A. salina* of France can exist in waters varying in density from 4° to 20° Baumé, but that they flourish best in those that have a density of 10° to 15°.‡ According to Rackett those of Lymington do not live in the water which is undergoing the first stage of concentration, but only in the pans of concentrated brine, containing about "a quarter of a pound of salt to the pint."

Our *A. gracilis* can exist without apparent inconvenience when the water in which they occur is diluted with an equal bulk of fresh water as well as when it is much concentrated by evaporation. The water in which they were found varies in density from 1·060 to 1·065.

The genus is characterized by having eleven pair of four-jointed branchial "feet" or fins along the sides of the body, the middle ones being longest. Each joint of the "feet" bears flat branchial appendages, ciliated by sharp setæ, as in the other genera of the family. The abdomen is slender, six-jointed, the last joint long, terminated by two small projecting appendages, each bearing six to ten plumose setæ. The first abdominal segment bears the external sexual organs of the male, and a short, dilated, ovigerous pouch in the female. In the male the head bears in front a pair of large, three-jointed hooks or clasping organs, each of which has on the inner side of its basal joint a

* Reserches sur la Coloration en rouge des Marais Salans Méditerranéens, par M. Joly, Annals des Sciences naturelles, 2e ser., t. 13, 1840, p. 266.

† According to M. Joly, op. cit. p. 262, a beetle, *Hydroporus salinus* Joly, also inhabits the salterns, where the water has a density of 6° or 7° Baumé, and preys upon the *Artemiæ*.

‡ 4° to 20° Baumé is equivalent to a density of about 1·02 to 1·16; 10° to 15° =1·075 to 1·117. A brine having a density of 1·020, which is nearly that of sea-water, contains about 2·766 per cent of salt; one of 1·160 contains 21·219 per cent; one of 1·075 about 10·279 per cent; 1·117 about 15·794 per cent.

small, rounded, appendage; a pair of slender antennæ just back of these, terminated by two or three minute setæ; a pair of pedunculated compound eyes, and a dark spot on the middle of the head, which is the remains of the single eye of the young. The mouth below is provided with a broad labrum, a pair of mandibles, two pairs of jaws, and a pair of lateral papillæ. In the female the head lacks the stout claspers, which are replaced by a pair of comparatively small, simple, horn-shaped organs.

Artemia gracilis Verrill, sp. nov.

Body slender, in the male about ·3 of an inch long, in the female ·4. Claspers of the male relatively long and powerful, first joint thickened, with a distinct angle at the articulation on the outside and a short, rounded, nearly semicircular process on the inside near the base, about its own diameter from the base; second joint broad, flattened, continuous with the third joint, strongly curved, outline nearly regularly convex on the outside, until near the middle it suddenly bends inward forming an obtuse angle, beyond which the outline is concave to the last articulation, where it becomes again convex, forming on the last joint a slight, rounded angle, the inner edge is nearly straight, or but slightly concave, to the last articulation, where there is a slight but distinct angle; last joint triangular, longer than broad, tapering to the acute, slightly excurved point. Antennæ slender, elongated, reaching beyond the first articulation of the claspers, terminal setæ minute. Abdomen slender, smooth, the terminal lobes small, longer than broad, broadly rounded at the end, slightly constricted at the base inside, each bearing usually 7 or 9 plumose setæ, the central ones much the longest. Ovigerous pouch of the female, when seen from below, flask-shaped, the neck extending backward and downward, short, thick, subcylindrical toward the end, the body of the "flask" short, thick, swollen laterally, broader than long, the sides terminating outwardly in a small, triangular, sharp tooth, sometimes showing a minute spine. This pouch is generally filled with numerous large, brownish eggs.

Color generally reddish, flesh-color, or light greenish, translucent, the males usually lighter, greenish white, the intestines generally showing through as a dark reddish or greenish median line; eyes very dark brown, or black; ovaries often whitish, along each side of the abdomen.

An adult male gives the following measurements:

Distance between eyes 1·81^{mm}; breadth of head ·76; length of eye-stalks ·62; length of first joint of the claspers ·91; its breadth ·72; breadth of its appendage ·18; length of second

and third joints from outer edge of first articulation to the tip 2·48; greatest breadth ·86; breadth at last articulation ·72; length of last joint 1·05; length of last joint of abdomen, exclusive of appendages, 1·00; its breadth ·31; length of preceding joint ·42; its breadth ·37; length of terminal appendages ·21; breadth ·096; length of longest setæ ·70.

Near New Haven, in tubs of water from salt marsh.

Artemia Monica Verrill, sp. nov.

Form similar to that of the preceding species, but a little larger and stouter. The largest female is 13^{mm} (·52 of an inch) long, the abdomen being 6^{mm}; and 5^{mm} across the branchial feet in their natural, partly extended position. The largest male is 11·5^{mm} (·45 of an inch) long, the abdomen being 6^{mm}. The claspers of the male are relatively stouter, the hook or outer two joints being much broader, more triangular, and less elongated. The inner edge of the first joint, as seen from below, is regularly convex, bearing the appendage on its most convex part and not so near the base as in *A. gracilis*, the distance being about twice the breadth of the organ, which is about as broad as long and regularly rounded. At the articulation the outer edge of the joint projects as a distinct angle. The second and third joint together have a nearly triangular form, the breadth being about half the length; the outer edge is regularly rounded, shorter than in the preceding; it forms little more than a right angle with the front edge, which is nearly straight or a little concave, sometimes slightly convex at the last articulation, but not forming a distinct angle there; the inner edge of the hook is a little concave on the first joint, becoming convex at the last articulation where there is a distinct but very obtuse angle. The last joint is almost regularly triangular, about as broad as long, tapering to an obtuse point, the inner edge being a little convex. The antennæ are very slender and do not reach the first articulation of the claspers. The caudal appendages are smaller than in *A. gracilis*, and scarcely longer than broad, rounded at the end, terminated by nine or ten very slender plumose setæ. The egg-pouch of the female is broad flask-shaped, strongly convex in the middle below, the sides not forming such sharp angles as in *A. gracilis*.

The English specimens of *A. salina*, as figured by Baird, differ from both the preceding species in having longer, more curved, and sharper clasping hooks, and the basal appendage more elongated; the egg-pouch, though badly figured, is of a very different form. The French specimens, as figured by Joly, appear like a distinct species, the egg-pouch being of a very different form, and the caudal appendages very much longer and

larger than in either of our species, while Baird's figure represents them as very small; but his specimens appear to have been smaller, and may have been immature, for these species begin to breed before they are half grown. Whether the French species be distinct from the English can only be determined by additional examinations, especially of the male, for the male of the former appears not to have been figured hitherto.

Branchipus Shœffer.

Branchipus Shœffer, Elementa entomologica, 1766, (type, *B. pisciformis*=(?) *B. stagnalis* Linn. sp.).

Branchipus (*pars*) Lamarck; Latreille; Leach; Edwards.

Chirocephalus (*pars*) Dana, (non Bénédict-Prévost, 1803; Jurine; Thompson; Baird).

Under the name of *Branchipus* at least four generic groups have been confounded by various authors.

Branchipus should be restricted to the original species described by Shœffer and the allied species, of which *B. stagnalis* (Linn. sp.) is one, and if not identical with *B. pisciformis*, as is generally supposed, must be closely allied.

As thus restricted the genus is characterized by the stout, two-jointed claspers of the male, with or without a tooth near the base of the hook, the basal joint being swollen; by having a pair of simple appendages resembling antennæ between the bases of the claspers in front; by the large, thick, oval egg-pouches of the female, and, apparently, by the structure of the branchial organs. It includes *B. stagnalis*, *B. spinosus* Edw., *B. vernalis* Verrill, sp. nov., etc. Perhaps *B. paludosus* Müller also belongs here.

Branchinecta.—A group of species allied to these,—but destitute of all appendages between the bases of the claspers of the male, which are more slender and simple; with a much elongated egg-pouch, having lateral lobes at the base; a more slender body, with more elongated branchial organs, the middle ones longest; and having, in general appearance, a much stronger resemblance to *Artemia*,—probably constitutes another genus, but for the present we prefer to regard it as a subgenus of *Branchipus*.

For this group we propose the name *Branchinecta*. It includes two new arctic species, *B. Grœnlandica* and *B. arctica*, and *B. ferox* (Edw. sp.) from near Odessa.

Heterobranchipus.—Dr. Loven* has described a singular species, *B. Cafer*, which appears worthy to constitute a distinct genus. It is remarkable on account of the very curious claspers of the male, which are very long, three-jointed, flexuous, the

* Kongl. Vet. Akad. Handl, 1846, p. 433, tab. V.

basal joint bearing a long cirrus externally and a lacerate tooth on the inner side of the base, the outer joint bifid, the internal part cirriform, the external one deeply bilobed. External male organs very long, slender, curved, outer portion serrate on the outer edge, with short setæ on the inner edge; egg-pouches long, slender, slightly enlarged and beaked at the end; branchiæ of a peculiar structure; front of head, between the claspers, with a short bimucronate rostrum.

H. Cafer is from the marshes of Natal, South Africa.

Chirocephalus Prevost, 1803.—This genus, established for *C. diaphanus*, is evidently very distinct from all the preceding. The typical species is large, stout, and remarkable for the singular appendages between the claspers of the male, on the front of the head. These consist of two long, ligulate, fleshy processes, serrated on each side, which coil in a spiral beneath the head, but when extended, as in copulation, reaching beyond the claspers; attached to the outer side of each of these are four long processes, strongly serrate on the inner edge, and near the base another large, broad, thin, subtriangular appendage, its edges strongly serrate, especially in front, capable of folding up like a fan when not in use. The claspers have a much swollen basal joint, a strongly serrate tooth on the inside of the base of the second joint, which is beyond this slender and regularly curved. Egg-pouch long-oval, large and thick; caudal appendages large; male organs and branchiæ peculiar.

C. diaphanus Prev., inhabits fresh water pools in France, Switzerland, and England. It is well described and figured in Baird's British Entomostraca, p. 39, tab. III and IV.

Branchipus vernalis Verrill, sp. nov.

Form rather stout, large; the full grown females are 23^{mm} (·90 of an inch) long, the abdomen being 14^{mm}; and 6·5^{mm} wide across the branchial organs in their natural position; breadth of head across the eyes 4^{mm}. A large male is 22^{mm} (·86 of an inch) long, the body 12^{mm}; the breadth of head across eyes 5^{mm}; the entire length of claspers 8^{mm}. The claspers are very large and strong, the basal joint much swollen with a soft integument, capable of retracting the basal portion of the second joint into itself by involution of its outer edge; the second joint is elongated, broad and stout at base, with an angle on the outside, from which it rapidly narrows by strongly concave outlines on each edge, but most so on the outside; at the constricted portion, not far from the base, it bears a large, strong, very prominent, crooked, bluntly pointed tooth, which is directed inward and backward, not serrate on its outer side; beyond the tooth the rest of the joint is long and

rather slender, curved outward and forward at base, having just beyond the tooth on the inside a distinct but very obtuse rounded angle, from which the outline slightly curves inward to near the tip, which is a little dilated and recurved. The basal portion, including the tooth, is retracted into the first joint in some specimens. On the front of the head between the basal joints of the claspers are two flat, short, lanceolate, ligulate, fleshy processes, with finely serrate edges, usually coiled down, but when extended scarcely more than half as long as the basal joint of the claspers. Antennæ small and very slender, tapering, reaching a little beyond the eyes. Caudal appendages long, rather narrow, slightly swollen at base, gradually tapering to the acute tips, and bearing along the sides, except at base, very numerous, long plumose setæ. Egg-pouches short, broad-oval, nearly as wide as long, slightly three-lobed posteriorly, the central lobe largest, sides extended and largely adherent to the sides of the abdomen, length 4^{mm}, width 3·5. Body flesh color or pale red, the intestine darker red or greenish.

A large male gives the following measurements: length of first joint of claspers $4{\cdot}62^{mm}$; diameter 2·40; length of second joint 4·14; breadth at base 1·90; at tooth ·72; in middle ·52; length of tooth ·90; its diameter ·33; length of caudal appendages 4; breadth at base ·33; in middle ·20; length of setæ 2; length of antennæ 3.

New Haven, in stagnant pools,—J. D. Dana, D. C. Eaton, A. E. Verrill; Salem, Mass., April 19, 1859, R. H. Wheatland, C. Cooke (from Essex Institute); Cambridge, Mass., A. E. Verrill.

This species differs widely from all described species of Europe, in the character of the claspers of the male and their appendages. *B. stagnalis* has a pair of long setiform organs between the claspers, and a tooth on the outer side of their second joint; *B. spinosus* resembles our species somewhat in the frontal appendages between the claspers, but lacks the conspicuous tooth at the base of their second joint. The shape of the egg-pouch in our species is also characteristic.

This is doubtless the species referred to by Dr. Gould under the name of *Branchipus stagnalis*.* Dekay† copies the diagnosis of *B. stagnalis* (*?*) from a foreign work, and gives a figure of *Chirocephalus diaphanus*, copied apparently from Desmarets, pl. 56, which is itself a copy.

* Invertebrata of Massachusetts, p. 339.

† Natural History of New York, Zoölogy, Part I, Crustacea, p. 63, pl. IX, fig. 36.

This species appears very early in spring, often in great numbers, in quiet pools. I have never seen it later than the middle of May, yet since the individuals seen in early spring are full-grown, it might, doubtless, be found also in autumn.

Branchipus (*Branchinecta*) *arcticus* Verrill, sp. nov.

Branchipus paludosus Packard, Invertebrate Fauna of Labrador, in Mem. Boston Soc. Natural History, i, p. 295, (*non* Müller).

Form slender, body short, abdomen elongated. A full sized male is 20^{mm} (·80 of an inch) long, exclusive of the claspers, the abdomen being 13^{mm}; the breadth between the eyes 3^{mm}. A female 20^{mm} long, with the abdomen 12^{mm}, has an egg-pouch 6·2 long. Branchial "feet" slender, elongated, the middle ones longest, 4 to 5^{mm} long when extended. Claspers of the male rather long and slender; the basal joint is but little swollen, elongated, regularly curved, with a small tooth or prominent angle at the articulation on the inside, and on the inner side a row of numerous small, distinct, sharp teeth, extending from the articulation about half way to the base, and arranged somewhat obliquely; second joint slender, regularly curved, tapering to a blunt point, the inner edge minutely serrulate. Front simply curved, with no appendages. Antennæ slender, scarcely more than half the length of the basal joint of the claspers. Labrum long and narrow, mandibles stout, strongly curved, bluntly pointed. Caudal appendages slender lanceolate, rather small, with long slender setæ. Egg-pouch much elongated, slender, subcylindrical, beaked or slightly bilobed at the end, the upper or dorsal lobe longest, its basal portion with two small rounded lateral lobes.

A large male gives the following measurements: breadth between outer extremity of eyes 3·46^{mm}; diameter of eyes ·66; length of basal joint of claspers 1·66; breadth ·71; length of second joint 1·29; breadth at its base ·46; width of mandibles at middle ·66; length of caudal appendages ·96; breadth at base ·16; length of longest setæ ·84 to 1^{mm}.

Color of preserved specimens pale reddish, with dark green intestine. Labrador, at "Indian Tickle" on the north shore of Invuctoke Inlet, abundant in a pool of fresh water,—Dr. A. S. Packard.

Branchipus (*Branchinecta*) *Grœnlandicus* Verrill, sp. nov.

A little stouter than the last; the largest male is 17^{mm} long exclusive of claspers, the abdomen being 10^{mm}, including caudal appendages. Claspers similar to those of *B. arcticus* but more elongated, the basal joint less curved, and the second joint longer, less regularly curved, tapering more quickly at base and consequently more attenuated beyond the middle and with more slender tips, which are nearly straight. The tooth on the in-

side of the first joint is rather more prominent, but the row of teeth along the inside is similar. Caudal appendages stouter, tapering more rapidly. External male organs slender, curved outward, swollen at base. The largest female is not mature and the egg-pouch contains no eggs; it is small, slender, elongated, subcylindrical, beaked at the end.

The largest male gives the following measurements: breadth between eyes 3·20^{mm}; length of basal joint of claspers 2·81; breadth ·95; length of second joint 2·24; its breadth at base ·76; length of caudal appendages ·86; width at base ·24; length of setæ ·76.

Greenland,—Dr. Chr. Lutken, (from the University Zoölogical Museum, Copenhagen.)

Of this species I have seen but four specimens, which were sent to Dr. A. S. Packard by Dr. Lutken under the name of *B. paludosus* Müller. The latter appears to be quite distinct, to judge from the figures; it is represented as having appendages between the claspers, and very slender, linear, caudal appendages. In the form of the egg-pouch, and the serration of the first joint of the claspers it is similar.

This species is very closely allied to *B. arcticus*, and when a larger series of specimens can be examined it may prove to be only a local variety, but the specimens studied show differences that seems to warrant their separation.

ART. XXVII.—*On the Lesleyite of Chester Co., Penn., and its relations to the Ephesite of the Emery formation near Ephesus, Asia Minor;* by J. LAWRENCE SMITH.

SEVERAL years ago a small amount of mineral from Chester Co., Penn., was handed to me for examination by Dr. Isaac Lea of Philadelphia. The specimen was too impure to warrant any conclusion upon analysis. Its character and associates, however, led me to suppose that it was the same mineral described by me as associated with the emery of Asia Minor and to which I gave the name *Ephesite*. In the mean time Dr. Lea described his mineral as a new species, calling it *Lesleyite;* and in a recent number of the American Journal of Science, S. P. Sharples has given an analysis of it, that at once brought to my recollection my original opinion that it was close to *Ephesite*, and on recurring to my examination of this mineral, making due allowance of the impurities contained in it, the opinion was confirmed.

I then obtained from Dr. Lea another specimen of his mineral and proceeded to analyze both it and the Ephesite for mutual comparison. Much labor was bestowed in selecting the pure

mineral from each, the greater part of a day having been consumed in procuring the necessary quantity for analysis. They are similar in their associations and identical in color and luster, and general physical properties. They are both very difficult to decompose by carbonate of soda, even when aided with caustic potash; so that in both analyses the silica obtained was fused a second time and much alumina separated from it.

My original description of the mineral will be found under Emery, in this Journal, II, vol. x, 1850, as follows:

"It is of a pearly white color, and lamellar in structure; cleavage difficult. It scratches glass easily, and has a sp. gr. of from 3·15 to 3·20. Heated before the blowpipe it becomes milk-white but does not fuse. At first sight it might be taken for white disthene. It is decomposed with great difficulty by carbonate of soda even with the addition of a little caustic soda."

The Lesleyite has identically the same properties. On analysis the two minerals were found to be composed as follows:

	Ephesite.	Lesleyite.
Silica	30·70	31·18
Alumina	55·67	55·00
Lime	2·55	0·45
Soda	5·52	1·20
Potash	1·10	7·28
Water	4·91	4·80
	100·45	99·91

The alkalies in the two varieties are reversed, the Ephesite containing principally soda, and the Lesleyite potash.

This close relation of the two minerals is an interesting fact as regards the associate minerals of corundum found in different parts of the world.

In regard to the reddish variety of Lesleyite examined by Roepper, the analysis cannot be considered as giving very satisfactory results, for the mineral may have been impure, and the difficulty in decomposing by the soda fusion may give very erroneous results in a silica determination.

Louisville, Ky., August, 1869.

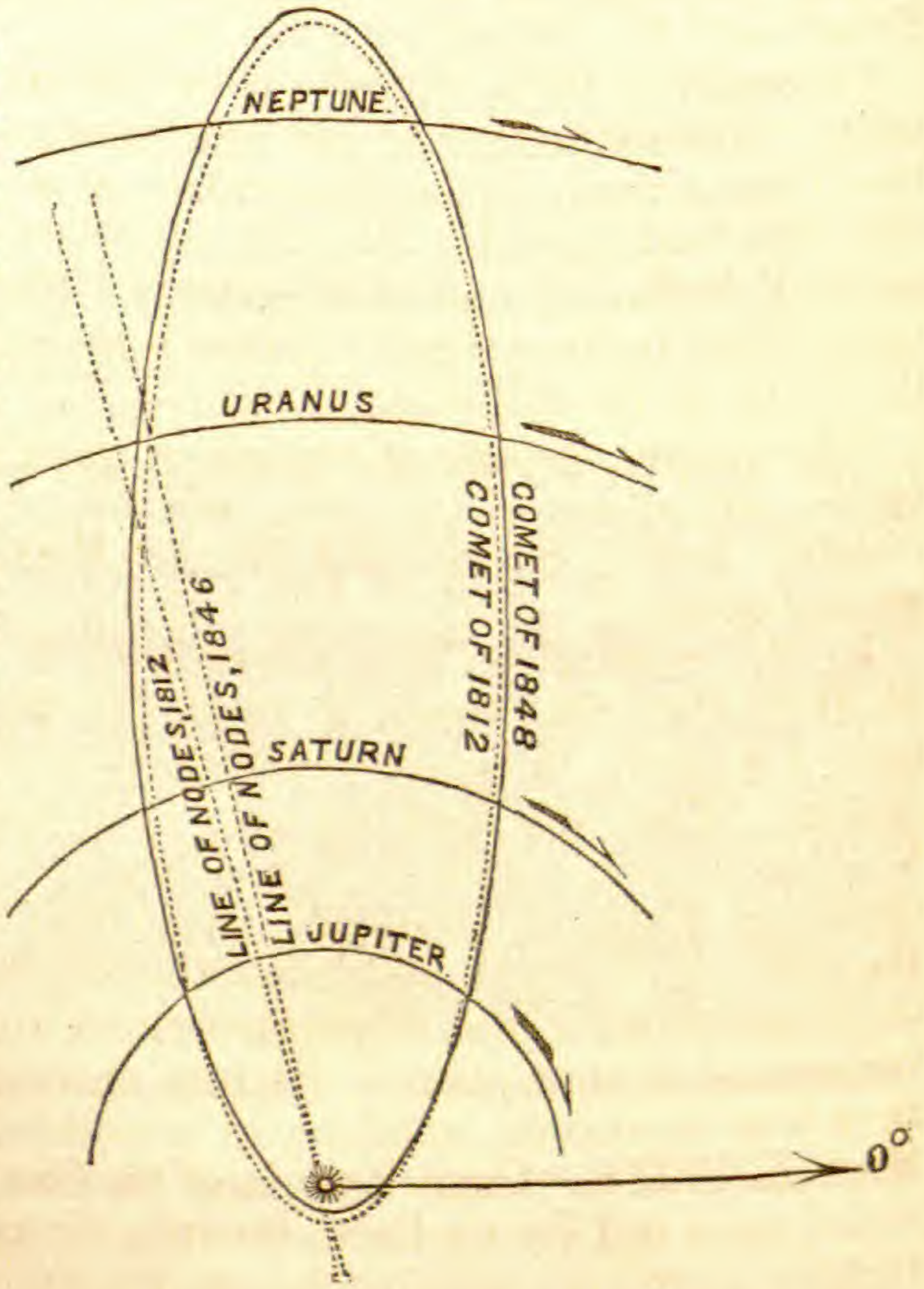
Art. XXVIII.—*On the Origin of the Comets of* 1812 *and* 1846 IV; by Prof. Daniel Kirkwood.

The comet of 1812 was discovered by Pons on the 20th of July, and continued to be observed till about the last of September. It became visible to the naked eye shortly after its discovery, its tail attaining a length of more than 2°.

The fourth comet of 1846 was discovered by DeVico, at the Collegio Romano, on the 20th of February, and continued visible about 10 weeks. The elements of these comets are as follows:

Perihelion Passage.	Long. of Per.	Long. of Asc. Node.	Incl.	Perih. Dist.	Eccentricity.	Period.	Direction.	Computor.
						y.		
1812, Sept. 15d, 7h.	92° 51′	253° 33′	73° 57′	0·7771	0·95454	70·68	D	Encke.
1846, Mar. 5, 12,	90° 31′	77° 37′	85° 6′	0·6637	0·96224	73·715	D	Peirce.

The wonderful similarity of these elements, except in the longitude of the ascending node, is at once apparent. It will also be noticed that the longitude of the *descending* node of the latter is very nearly coincident with that of the *ascending* node of the former. These remarkable coincidences are presented to the eye in the following diagram, where the dotted ellipse represents the orbit of the comet of 1812, and the continuous curve, that of the comet of 1846.



It is infinitely improbable that these coincidences should be accidental: they point, undoubtedly to a common origin of the two bodies.

The theory of comets now generally accepted is that they enter the solar system *ab extra*, move in parabolas or hyperbolas around the sun, and, if undisturbed by the planets, pass off beyond the limits of our system to be seen no more. If in their motion, however, they approach very near any of the larger planets, their direction is changed by planetary perturbations; their orbits being sometimes transformed into ellipses. The new orbits of such bodies would pass very nearly through the points at which their greatest perturbation occurred: and

accordingly we find that the aphelia of a large proportion of the periodic comets are near the orbits of the major planets. "I admit," says M. Hoek, "that the orbits of comets are by nature parabolas or hyperbolas, and that in the cases when elliptical orbits are met with, these are occasioned by planetary attractions, or derive their character from the uncertainty of our observations. To allow the contrary would be to admit some comets as permanent members of our planetary system, to which they ought to have belonged since its origin, and so to assert the simultaneous birth of that system and of these comets. As for me I attribute to these a primitive wandering character. Traveling through space they move from one star to another in order to leave it again, provided they do not meet any obstacle that may force them to remain in its vicinity. Such an obstacle was *Jupiter*, in the neighborhood of our sun, for the comets of Lexell and Brorsen, and probably for the greater part of periodical comets; the other part of which may be indebted for their elliptical orbits to the attractions of *Saturn* and the remaining planets.

"Generally then, comets come to us from some star or other. The attraction of our sun modifies their orbit, as had been done already by each star through whose sphere of attraction they had passed. We can put the question if they come as single bodies or united in systems. This is the point I have undertaken to investigate. Since some time already I had felt the truth of the following thesis:—

"*There are systems of comets in space that are broken up by the attraction of our sun, and whose members attain, as isolated bodies, the vicinity of the Earth during a course of several years.*"*

In the researches here referred to it has been shown by M. Hoek that the comets of 1860, III, 1863, I, and 1863, VI, formed a group in space previous to their entrance into our system. The same fact has also been demonstrated in regard to other comets which need not here be specified. Now, the comets of 1812 and 1846 IV. have their aphelions very near the orbit of Neptune, and hence the original parabolas in which they moved were probably transformed into ellipses by the perturbations of that planet. Before entering the solar domain they were doubtless members of a cometary system. Passing Neptune near the same time, and at some distance from each other, their different relative positions with regard to the disturbing body may account for the slight differences in the elements of their orbits.

At what epoch did they enter the solar system?—The mean between the longitudes of the aphelia of the two comets is

* Monthly Notices, vol. xxv, p. 243.

271° 41′. Neptune had this longitude in 1775; the comet of 1812, in 1777; and that of 1846, in 1809. Now, with the known period of Neptune and the periods of the comets as determined by Encke and Peirce, we find (neglecting perturbations) that—

Neptune was in longitude 271° 41′ in the year 694 B. C.;
the comet of 1812, " " " 696 "
" 1846, IV. " " " 696 "

It seems, therefore, that the three bodies were very nearly together about 695 years before the Christian era. It is consequently not improbable that the elliptical form of the two comentary orbits dates from this epoch.

Bloomington, Indiana, June 17th, 1869.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS.

1. *On the Blue Color of the Sky, the Polarization of Skylight, and on the Polarization of Light by Cloudy matter generally;* by JOHN TYNDALL, LL.D., F.R.S.—Since the communication of my brief abstract "On a new Series of Chemical Reactions produced by Light," the experiments upon this subject have been continued, and the number of the substances thus acted on considerably augmented. New relations have also been established between *mixed vapors* when subjected to the action of light.

I now beg to draw the attention of the Royal Society to two questions glanced at incidentally in the abstract referred to,—the blue color of the sky, and the polarization of skylight. Reserving the historic treatment of the subject for a more fitting occasion, I would merely mention now that these questions constitute, in the opinion of our most eminent authorities, the two great standing enigmas of meteorology. Indeed it was the interest manifested in them by Sir John Herschel, in a letter of singular speculative power, that caused me to enter upon the consideration of these questions so soon.

The apparatus with which I work consists, as already stated to the Society, of a glass tube about a yard in length, and from $2\frac{1}{2}$ to 3 inches internal diameter. The vapor to be examined is introduced into this tube in the manner described in my last abstract, and upon it the condensed beam of the electric lamp is permitted to act until the neutrality or the activity of the substance has been declared.

It has hitherto been my aim to render the chemical action of light upon vapors *visible*. For this purpose substances have been chosen, *one* at least of whose products of decomposition under light shall have a boiling-point so high that as soon as the substance is formed it shall be *precipitated*. By graduating the quantity of the vapor, this precipitation may be rendered of any de-

gree of fineness, forming particles distinguishable by the naked eye, or particles which are probably far beyond the reach of our highest microscopic powers.

I have no reason to doubt that particles may be thus obtained whose diameters constitute but a very small fraction of the length of a wave of violet light.

In all cases when the vapors of the liquids employed are sufficiently attenuated, no matter what the liquid may be, the visible action commences with the formation of a *blue cloud.* I would guard myself at the outset against all misconception as to the use of this term. The blue cloud to which I here refer is totally invisible in ordinary daylight. To be seen, it requires to be surrounded by darkness, *it only* being illuminated by a powerful beam of light. This blue cloud differs in many important particulars from the finest ordinary clouds, and might justly have assigned to it an intermediate position between these clouds and true cloudless vapor.

With this explanation, the term "cloud," or "incipient cloud," as I propose to employ it, cannot, I think, be misunderstood.

I had been endeavoring to decompose carbonic acid gas by light. A faint bluish cloud, due it may be, or it may not be, to the residue of some vapor previously employed, was formed in the experimental tube. On looking across this cloud through a Nicol's prism, the line of vision being horizontal, it was found that when the short diagonal of the prism was vertical, the quantity of light reaching the eye was greater than when the long diagonal was vertical.

When a plate of tourmaline was held between the eye and the bluish cloud, the quantity of light reaching the eye when the axis of the prism was perpendicular to the axis of the illuminating beam, was greater than when the axes of the crystal and of the beam were parallel to each other.

This was the result all round the experimental tube. Causing the crystal of tourmaline to revolve round the tube, with its axis perpendicular to the illuminating beam, the quantity of light that reached the eye was in all its positions a maximum. When the crystallographic axis was parallel to the axis of the beam, the quantity of light transmitted by the crystal was a minimum.

From the illuminated bluish cloud, therefore, polarized light was discharged, the direction of maximum polarization being at right angles to the illuminating beam; the *plane of vibration* of the polarized light, moreover, was that to which the beam was perpendicular.*

Thin plates of selenite or of quartz, placed between the Nicol and the bluish cloud, displayed the colors of polarized light, these colors being most vivid when the line of vision was at right angles to the experimental tube. The plate of selenite usually employed

* I assume here that the plane of vibration is perpendicular to the plane of polarization. This is still an undecided point; but the probabilities are so much in its favor, and it is in my opinion so much preferable to have a physical image on which the mind can rest, that I do not hesitate to employ the phraseology in the text. Even should the assumption prove to be incorrect, no harm will be done by the provisional use of it.

was a circle, thinnest at the center, and augmenting uniformly in thickness from the center outward. When placed in its proper position between the Nicol and the cloud, it exhibited a system of splendidly colored rings.

The cloud here referred to was the first operated upon in the manner described. It may, however, be greatly improved upon by the choice of proper substances, and by the application in proper quantities of the substances chosen. Benzol, bisulphid of carbon, nitrite of amyl, nitrite of butyl, iodid of allyl, iodid of isopropyl, and many other substances may be employed. I will take the nitrite of butyl as illustrative of the means adopted to secure the best result with reference to the present question.

And here it may be mentioned that a vapor, which when alone, or mixed with air in the experimental tube, resists the action of light, or shows but a feeble result of this action, may, by placing it in proximity with another gas or vapor, be caused to exhibit under light vigorous, if not violent action. The case is similar to that of carbonic acid gas, which diffused in the atmosphere resists the decomposing action of solar light, but when placed in contiguity with the chlorophyl in the leaves of plants, has its molecules shaken asunder.

Dry air was permitted to bubble through the liquid nitrite of butyl until the experimental tube, which had been previously exhausted, was filled with the mixed air and vapor. The visible action of light upon the mixture after fifteen minutes' exposure was slight. The tube was afterwards filled with half an atmosphere of the mixed air and vapor, and another half atmosphere of air which had been permitted to bubble through fresh commercial hydrochloric acid. On sending the beam through this mixture, the action paused barely sufficiently long to show that at the moment of commencement the tube was optically empty. But the pause amounted only to a small fraction of a second, a dense cloud being immediately precipitated upon the beam which traversed the mixture.

This cloud began *blue*, but the advance to whiteness was so rapid as almost to justify the application of the term instantaneous. The dense cloud, looked at perpendicularly to its axis, showed scarcely any signs of polarization. Looked at obliquely the polarization was strong.

The experimental tube being again cleansed and exhausted, the mixed air and nitrite-of-butyl vapor was permitted to enter it until the associated mercury column was depressed $\frac{1}{10}$ of an inch. In other words, the air and vapor, united, exercised a pressure not exceeding $\frac{1}{300}$ of an atmosphere. Air passed through a solution of hydrochloric acid was then added till the mercury column was depressed three inches. The condensed beam of the electric light passed for some time in darkness through this mixture. There was absolutely nothing within the tube competent to scatter the light. Soon, however, a superbly blue cloud was formed along the track of the beam, and it continued blue sufficiently long to permit of its thorough examination. The light discharged from the cloud at

right angles to its own length was *perfectly* polarized. By degrees the cloud became of whitish blue, and for a time the selenite colors obtained by looking at it normally were exceedingly brilliant. The direction of maximum polarization was distinctly at right angles to the illuminating beam. This continued to be the case as long as the cloud maintained a decided blue color, and even for some time after the pure blue had changed to whitish blue. But as the light continued to act the cloud became coarser and whiter, particularly at its center, where it at length ceased to discharge polarized light in the direction of the perpendicular, while it continued to do so at both its ends.

But the cloud which had thus ceased to polarize the light emitted normally, showed vivid selenite colors when looked at *obliquely*. The direction of maximum polarization changed with the texture of the cloud. This point shall receive further illustration subsequently.

A blue, equally rich and more durable, was obtained by employing the nitrite-of-butyl vapor in a still more attenuated condition. Now the instance here cited is *representative*. In all cases, and with all substances, the cloud formed at the commencement, when the precipitated particles are sufficiently fine, is *blue*, and it can be made to display a color rivaling that of the purest Italian sky. In all cases, moreover, this fine blue cloud polarizes *perfectly* the beam which illuminates it, the direction of polarization enclosing an angle of 90° with the axis of the illuminating beam.

It is exceedingly interesting to observe both the perfection and the decay of this polarization. For ten or fifteen minutes after its first appearance the light from a vividly illuminated incipient cloud, looked at horizontally, is absolutely quenched by a Nicol's prism with its longer diagonal vertical. But as the sky-blue is gradually rendered impure by the introduction of particles of too large a size, in other words, as real clouds begin to be formed, the polarization begins to deteriorate, a portion of the light passing through the prism in all its positions. It is worthy of note that for some time after the cessation of perfect polarization the *residual* light which passes, when the Nicol is in its position of minimum transmission, is of a gorgeous blue, the whiter light of the cloud being extinguished.* When the cloud texture has become sufficiently coarse to approximate to that of ordinary clouds, the rotation of the Nicol ceases to have any sensible effect on the quality of the light discharged normally.

The perfection of the polarization in a direction perpendicular to the illuminating beam is also illustrated by the following experiment. A Nicol's prism large enough to embrace the entire beam of the electric lamp was placed between the lamp and the experimental tube. A few bubbles of air carried through the liquid nitrite of butyl were introduced into the tube, and they were followed by about 3 inches (measured by the mercurial gauge) of air

* This seems to prove that particles too large to polarize the blue, polarize perfectly light of lower refrangibility.

which had been passed through aqueous hydrochloric acid. Sending the polarized beam through the tube, I placed myself in front of it, my eye being on a level with its axis, my assistant, Mr. Cottrell, occupying a similar position behind the tube. The short diagonal of the large Nicol was in the first instance vertical, the plane of vibration of the emergent beam being therefore also vertical. As the light continued to act, a superb blue cloud visible to both my assistant and myself was slowly formed. But this cloud, so deep and rich when looked at from the positions mentioned, *utterly disappeared when looked at vertically downward, or vertically upward.* Reflection from the cloud was not possible in these directions. When the large Nicol was slowly turned round its axis, the eye of the observer being on the level of the beam, and the line of vision perpendicular to it, entire extinction of the light emitted horizontally occurred where the longer diagonal of the large Nicol was vertical. But now a vivid blue cloud was seen when looked at downward or upward. This truly fine experiment was first definitely suggested by a remark addressed to me in a letter by Prof. Stokes.

Now, as regards the polarization of skylight, the greatest stumbling block has hitherto been that, in accordance with the law of Brewster, which makes the index of refraction the tangent of the polarizing angle, the reflection which produces perfect polarization would require to be made *in* air *upon* air; and indeed this led many of our most eminent men, Brewster himself among the number, to entertain the idea of *molecular reflection.* I have, however, operated upon substances of widely different refractive indices, and therefore of very different polarizing angles as ordinarily defined, but the polarization of the beam by the incipient cloud has thus far proved itself to be *absolutely independent of the polarizing angle.* The law of Brewster does not apply to matter in this condition, and it rests with the undulatory theory to explain why. Whenever the precipitated particles are sufficiently fine, no matter what the substance forming the particles may be, the direction of maximum polarization is at right angles to the illuminating beam, the polarizing angle for matter in this condition being invariably 45°. This I consider to be a point of capital importance with reference to the present question.*

That *water-particles*, if they could be obtained in this exceedingly fine state of division, would produce the same effects, does not admit of reasonable doubt. And that they must exist in this con-

* The difficulty referred to above is thus expressed by Sir John Herschel:—"The cause of the polarization is evidently a reflection of the sun's light upon *something*. The question is on what? Were the angle of maximum polarization 76°, we should look to water or ice as the reflecting body, however inconceivable the existence in a cloudless atmosphere, and a hot summer's day of unevaporated molecules (particles?) of water. But though we were once of this opinion, careful observation has satisfied us that 90°, or thereabouts, is a correct angle, and that therefore whatever be the body on which the light has been reflected *if polarized by a single reflection*, the polarizing angle must be 45°, and the index of refraction, which is the tangent of that angle, unity; in other words, the reflection would require to be made *in* air *upon* air!" ('Meteorology,' par. 233).

dition in the higher regions of the atmosphere is, I think, certain. At all events, no other assumption than this is necessary to completely account for the firmamental blue and the polarization of the sky.*

Suppose our atmosphere surrounded by an envelope impervious to light, but with an aperture on the sunward side through which a parallel beam of solar light could enter and traverse the atmosphere. Surrounded on all sides by air not directly illuminated, the track of such a beam through the air would resemble that of the parallel beam of the electric lamp through an incipient cloud. The sunbeam would be *blue*, and it would discharge laterally light in precisely the same condition as that discharged by the incipient cloud. In fact the azure revealed by such a beam would be to all intents and purposes that which I have called a "blue cloud."†

But, as regards the polarization of the sky, we know that not only is the direction of maximum polarization at right angles to the track of the solar beams, but that at certain angular distances, probably variable ones, from the sun, "neutral points," or points of no polarization, exist, on both sides of which the planes of atmospheric polarization are at right angles to each other.

I have made various observations upon this subject which I reserve for the present; but pending the more complete examination of the question, the following facts and observations bearing upon it are submitted to the Royal Society.

The parallel beam employed in these experiments tracked its way through the laboratory air exactly as sun-beams are seen to do in the dusty air of London. I have reason to believe that a great portion of the matter thus floating in the laboratory air consists of organic germs, which are capable of imparting a perceptibly bluish tint to the air. This air showed, though far less vividly, all the effects of polarization obtained with the incipient clouds. The light discharged laterally from the track of the illuminating beam was polarized, though not perfectly, the direction of maximum polarization being at right angles to the beam.

The horizontal column of air thus illuminated was 18 feet long, and could therefore be looked at very obliquely without any disturbance from a solid envelope. At all points of the beam through-

* Any particles, if small enough, will produce both the color and the polarization of the sky. But is the existence of small water-particles on a hot summer's day *in the higher regions of our atmosphere* inconceivable? It is to be remembered that the oxygen and nitrogen of the air behave as a vacuum to radiant heat, the exceedingly attenuated vapor of the higher atmosphere being therefore in practical contact with the cold of space.

† The opinion of Sir John Herschel, connecting the polarization and the blue color of the sky is verified by the foregoing results "The more the subject [the polarization of skylight] is considered," writes this eminent philosopher, "the more it will be found beset with difficulties, and its explanation when arrived at will probably be found to carry with it that of the blue color of the sky itself and of the great quantity of light it actually does send down to us." "We may observe, too," he adds, "that it is only where the purity of the sky is most absolute that the polarization is developed in its highest degree, and that where there is the slightest perceptible tendency to cirrus it is materially impaired." This applies word for word to the "incipient clouds."

out its entire length the light emitted normally was in the same state of polarization. Keeping the positions of the Nicol and the selenite constant, the same colors were observed throughout the entire beam when the line of vision was perpendicular to its length.

I then placed myself near the end of the beam as it issued from the electric lamp, and looking through the Nicol and selenite more and more obliquely at the beam, observed the colors fading until they disappeared. Augmenting the obliquity the colors appeared once more, *but they were now complementary to the former ones.*

Hence this beam, like the sky, exhibited its neutral point, at opposite sides of which the light was polarized in planes at right angles to each other.

Thinking that the action observed in the laboratory might be caused in some way by the vaporous fumes diffused in its air, I had a battery and an electric lamp carried to a room at the top of the Royal Institution. The track of the beam was seen very finely in the air of this room, a length of 14 or 15 feet being attainable. This beam exhibited all the effects observed with the beam in the laboratory. Even the uncondensed electric light falling on the floating matter showed, though faintly, the effects of polarization.*

When the air was so sifted as to entirely remove the visible floating matter, it no longer exerted any sensible action upon the light, but behaved like a vacuum.

I had varied and confirmed in many ways those experiments on neutral points, operating upon the fumes of chlorid of ammonium, the smoke of brown paper, and tobacco smoke, when my attention was drawn by Sir Charles Wheatstone to an important observation communicated to the Paris Academy in 1860, by Professor Govi, of Turin.† His observations on the light of comets had led M. Govi to examine a beam of light sent through a room in which was diffused the smoke of incense. He also operated on tobacco smoke. His first brief communication stated the fact of polarization by such smoke, but in his second communication he announced the discovery of a neutral point in the beam, at the opposite sides of which the light was polarized in planes at right angles to each other.

But unlike my observations on the laboratory air, and unlike the action of the sky, the direction of maximum polarization in M. Govi's experiment enclosed a very small angle with the axis of the illuminating beam. The question was left in this condition, and I am not aware that M. Govi or any other investigator has pursued it further.

I had noticed, as before stated, that as the clouds formed in the experimental tube became denser, the polarization of the light discharged at right angles to the beam became weaker, the direction of maximum polarization becoming oblique to the beam. Experiments on the fumes of chlorid of ammonium gave me also reason

* I hope to try Alpine air next summer.

† Comptes Rendus, tome li, pp. 360 and 669.

to suspect that the position of the neutral point *was not constant*, but that it varied with the density of the illuminated fumes.

The examination of these questions led to the following new and remarkable results:—the laboratory being well filled with the fumes of incense, and sufficient time being allowed for their uniform diffusion, the electric beam was sent through the smoke. From the track of the beam polarized light was discharged, but the direction of maximum polarization, instead of being along the normal, now enclosed an angle of 12° or 13° with the axis of the beam.

A neutral point, with complementary effects at opposite sides of it, was also exhibited by the beam. The angle enclosed by the axis of the beam, and a line drawn from the neutral point to the observer's eye, measured in the first instance 66°.

The windows of the laboratory were now opened for some minutes, a portion of the incense smoke being permitted to escape. On again darkening the room and turning on the beam, the line of vision to the neutral point was found to enclose with the axis of the beam an angle of 63°.

The windows were again opened for a few minutes, more of the smoke being permitted to escape. Measured as before, the angle referred to was found to be 54°.

This process was repeated three additional times; the neutral point was found to recede lower and lower down the beam, the angle between a line drawn from the eye to the neutral point and the axis of the beam falling successively from 54° to 49°, 43° and 33°.

The distances, roughly measured, of the neutral point from the lamp, corresponding to the foregoing series of observations, were these:—

1st observation	2	feet	2	inches.
2nd	"	2	"	6	"
3rd	"	2	"	10	"
4th	"	3	"	2	"
5th	"	3	"	7	"
6th	"	4	"	6	"

At the end of this series of experiments, the direction of maximum polarization had again become normal to the beam.

The laboratory was next filled with the fumes of gunpowder. In five successive experiments, corresponding to five different densities of the gunpowder smoke, the angles enclosed between the line of vision to the neutral point and the axis of the beam were 63°, 50°, 47°, 42°, and 38° respectively.

After the clouds of gunpowder had cleared away the laboratory was filled with the fumes of common resin, rendered so dense as to be very irritating to my lungs. The direction of maximum polarization enclosed in this case an angle of 12°, or thereabouts, with the axis of the beam. Looked at, as in the former instances, from a position near the electric lamp, *no neutral point* was observed throughout the entire extent of the beam.

When this beam was looked at normally through the selenite and Nicol, the ring system, though not brilliant, was distinct. Keeping the eye upon the plate of selenite and the line of vision normal, the windows were opened, the blinds remaining undrawn. The resinous fumes slowly diminished, and as they did so the ring system became paler. It finally disappeared. Continuing to look along the perpendicular, the rings revived, but now the colors were complementary to the former ones. *The neutral point had passed me in its motion down the beam consequent upon the attenuation of the fumes of resin.*

In the fumes of chlorid of ammonium substantially the same results were obtained as those just described. Sufficient I think has been here stated to illustrate the variability of the position of the neutral point. The explanation of the results will probably give new work to the undulatory theory.*

Before quitting the question of the reversal of the polarization by cloudy matter, I will make one or two additional observations. Some of the clouds formed in the experiments on the chemical action of light are astonishing as to form. The experimental tube is often divided into segments of dense cloud, separated from each other by nodes of finer matter. Looked at normally, as many as four reversals of the plane of polarization have been found in the tube in passing from node to segment, and from segment to node. With the fumes diffused in the laboratory, on the contrary, there was no change in the polarization along the normal, for here the necessary differences of cloud-texture did not exist.

Further. By a puff of tobacco smoke or of condensed steam blown into the illuminated beam, the brilliancy of the colors may be greatly augmented. But with different clouds two different effects are produced. For example, let the ring system observed in the common air be brought to its maximum strength, and then let an attenuated cloud of chlorid of ammonium be thrown into the beam at the point looked at; the ring system flashes out with augmented brilliancy, and the character of the polarization remains unchanged. This is also the case when phosphorus or sulphur is burned underneath the beam, so as to cause the fine particles of phosphoric acid or of sulphur to rise into the light. With the sulphur-fumes the brilliancy of the colors is exceedingly intensified; but in none of these cases is there any change in the character of the polarization.

But when a puff of aqueous cloud, or of the fumes of hydrochloric acid, hydriodic acid, or nitric acid is thrown into the beam, there is a complete reversal of the selenite tints. Each of these clouds twists the plane of polarization 90°. On these and kindred points experiments are still in progress.†

* Brewster has proved the variability of the position of the neutral point for skylight with the sun's altitude. Is not the proximate cause of this revealed by the foregoing experiments?

† Sir John Herschel has suggested to me that this change of the polarization from positive to negative may indicate a change from polarization by reflection to polarization by refraction. This thought repeatedly occurred to me while looking at the effects; but it will require much following up before it emerges into clearness.

The idea that the color of the sky is due to the action of finely divided matter, rendering the atmosphere a turbid medium, through which we look at the darkness of space, dates as far back as Leonardo da Vinci. Newton conceived the color to be due to exceedingly small water particles acting as thin plates. Goethe's experiments in connexion with this subject are well known and exceedingly instructive. One very striking observation of Goethe's referred to what is technically called "chill" by painters, which is due no doubt to extremely fine varnish particles interposed between the eye and a dark background. Clausius, in two very able memoirs, endeavored to connect the colors of the sky with suspended water-vesicles, and to show that the important observations of Forbes on condensing steam could also be thus accounted for. Bruecke's experiments on precipitated mastic were referred to in my last abstract. Helmholtz has ascribed the blueness of the eyes to the action of suspended particles. In an article written nearly nine years ago by myself, the colors of the peat smoke of the cabins of Killarney* and the colors of the sky were referred to one and the same cause, while a chapter of the "Glaciers of the Alps," published in 1860, is also devoted to this question. Roscoe, in connection with his truly beautiful experiments on the photographic power of sky-light, has also given various instances of the production of color by suspended particles. In the foregoing experiments the azure was produced in *air*, and e hibited a depth and purity far surpassing any thing that I have ever seen in mote-filled liquids. Its polarization, moreover, was *perfect*.

In his experiments on fluorescence, Professor Stokes had continually to separate the light reflected from the motes suspended in his liquids, the action of which he named "false dispersion," from the fluorescent light of the same liquids, which he ascribed to "true dispersion." In fact it is hardly possibly to obtain a liquid without motes, which polarize by reflection the light falling upon them, truly dispersed light being unpolarized. At p. 530 of his celebrated memoir "On the Change of the Refrangibility of Light," Prof. Stokes adduces some significant facts, and makes some noteworthy remarks, which bear upon our present subject. He notices more particularly a specimen of plate glass which, seen by reflected light, exhibited a blue which was exceedingly like an effect of fluorescence, but which, when properly examined, was found to be an instance of false dispersion. "It often struck me," he writes, "while engaged in these observations, that when the beam had a continuous appearance, the polarization was more nearly perfect than when it was sparkling, so as to force on the mind the conviction that it arose merely from motes.† Indeed in the

* I have sometimes quenched almost completely, by a Nicol, the light discharged normally from burning leaves in Hyde Park. The blue smoke from the *ignited end* of a cigar polarizes also, but not perfectly.

† The azure may be produced in the midst of a field of motes. By turning the Nicol, the interstitial blue may be completely quenched, the shining, and apparently unaffected motes, remaining masters of the field. A blue cloud, moreover, may be precipitated in the midst of the azure. An aqueous cloud thus precipitated reverses the polarization; but on the melting away of the cloud the azure and its polarization remain behind.

former case the polarization has often appeared perfect, or all but perfect. It is possible that this may in some measure have been due to the circumstance, that when a given quantity of light is diminished in a given ratio, the illumination is perceived with more difficulty when the light is diffused uniformly, than when it is spread over the same space, but collected into specks. Be this as it may, there was at least no tendency observed toward polarization in a plane perpendicular to the plane of reflection, when the suspended particles became finer, and therefore the beam more nearly continuous."

Through the courtesy of its owner, I have been permitted to see and to experiment with the piece of plate glass above referred to. Placed in front of the electric lamp, whether edgeways or transversely, it discharges bluish polarized light laterally, the color being by no means a bad imitation of the blue of the sky.

Prof. Stokes considers that this deportment may be invoked to decide the question of the direction of the vibrations of polarized light. On this point I would say, if it can be demonstrated that when the particles are small in comparison to the length of a wave of light, the vibrations of a ray reflected by such particles cannot be perpendicular to the vibrations of the incident light; then assuredly the experiments recorded in the foregoing communication decide the question in favor of Fresnel's assumption.

As stated above, almost all liquids have motes in them sufficiently numerous to polarize sensibly the light, and very beautiful effects may be obtained by simple artificial devices. When, for example, a cell of distilled water is placed in front of the electric lamp, and a slice of the beam permitted to pass through it, scarcely any polarized light is discharged, and scarcely any color produced with a plate of selenite. But while the beam is passing through it, if a bit of soap be agitated in the water above the beam, the moment the infinitesimal particles reach the beam the liquid sends forth laterally almost perfectly polarized light; and if the selenite be employed, vivid colors flash into existence. A still more brilliant result is obtained with mastic dissolved in a great excess of alcohol.

The selenite rings constitute an extremely delicate test as to the quantity of motes in a liquid. Commencing with distilled water, for example, a thickish beam of light is necessary to make the polarization of its motes sensible. A much thinner beam suffices for common water; while with Brücke's precipitated mastic, a beam too thin to produce any sensible effect with most other liquids, suffices to bring out vividly the selenite colors.—*Proc. Roy. Soc.*, xvii, 223, Jan., 1869.

2. *Note on the Formation and Phenomena of Clouds;* by JOHN TYNDALL.—It is well known that when a receiver filled with ordinary undried air is exhausted, a cloudiness, due to the precipitation of the aqueous vapor diffused in the air, is produced by the first few strokes of the pump. It is, as might be expected, possible to produce clouds in this way with the vapors of other liquids than water.

In the course of the experiments on the chemical action of light which have been already communicated in abstract to the Royal Society, I had frequent occasion to observe the precipitation of such clouds in the experimental tubes employed; indeed several days at a time have been devoted solely to the generation and examination of clouds formed by the sudden dilatation of the air in the experimental tubes.

The clouds were generated in two ways; one mode consisted in opening the passage between the filled experimental tube and the air-pump, and then simply dilating the air by working the pump. In the other, the experimental tube was connected with a vessel of suitable size, the passage between which and the experimental tube could be closed by a stopcock. This vessel was first exhausted; on turning the cock the air rushed from the experimental tube into the vessel, the precipitation of a cloud within the tube being a consequence of the transfer. Instead of a special vessel, the cylinders of the air-pump itself were usually employed for this purpose.

It was found possible, by shutting off the residue of air and vapor after each act of precipitation, and again exhausting the cylinders of the pump, to obtain with some substances, and without refilling the experimental tube, fifteen or twenty clouds in succession.

The clouds thus precipitated differed from each other in luminous energy, some shedding forth a mild white light, others flashing out with sudden and surprising brilliancy. This difference of action is, of course, to be referred to the different reflective energies of the particles of the clouds, which were produced by substances of very different refractive indices.

Different clouds, moreover, possess very different degrees of stability; some melt away rapidly, while others linger for minutes in the experimental tube, resting upon its bottom as they dissolve like a heap of snow. The particles of other clouds are trailed through the experimental tube as if they were moving through a viscous medium.

Nothing can exceed the splendor of the diffraction-phenomena exhibited by some of these clouds; the colors are best seen by looking along the experimental tube from a point above it, the face being turned towards the source of illumination. The differential motions introduced by friction against the interior surface of the tube often cause the colors to arrange themselves in distinct layers.

The difference in texture exhibited by different clouds caused me to look a little more closely than I had previously done into the mechanism of cloud-formation A certain expansion is necessary to bring down the cloud; the moment before precipitation the mass of cooling air and vapor may be regarded as divided into a number of polyhedra, the particles along the bounding surfaces of which move in opposite directions when precipitation actually sets in. Every cloud-particle has consumed a polyhedron of vapor in its formation; and it is manifest that the size of the particle must depend, not only on the size of the vapor pholyhe-

dron, but also on the relation of the density of the vapor to that of its liquid. If the vapor were light, and the liquid heavy, other things being equal, the cloud-particle would be smaller than if the vapor were heavy and the liquid light. There would evidently be more shrinkage in the one case than in the other; these considerations were found valid throughout the experiment. The case of toluol may be taken as representative of a great number of others. The specific gravity of this liquid is 0·85, that of water being unity; the specific gravity of its vapor is 3·26, that of aqueous vapor being 0·6. Now, as the size of the cloud-particle is directly proportional to the specific gravity of the vapor, and inversely proportional to the specific gravity of the liquid, an easy calculation proves that, assuming the size of the vapor polyhedra in both cases to be the same, the size of the particle of toluol cloud must be more than six times that of the particle of aqueous cloud. It is probably impossible to test this question with numerical accuracy; but the comparative coarseness of the toluol cloud is strikingly manifest to the naked eye. The case is, as I have said, representative.

In fact, aqueous vapor is without a parallel in these particulars; it is not only the lightest of all vapors, in the common acceptation of that term, but the lightest of all gases except hydrogen and ammonia. To this circumstance the soft and tender beauty of the clouds of our atmosphere is mainly to be ascribed.

The *sphericity* of the cloud-particles may be immediately inferred from their deportment under the luminous beams. The light which they shed when spherical is *continuous:* but clouds may also be precipitated in solid flakes; and then the incessant sparkling of the cloud shows that its particles are *plates*, and not spheres. Some portions of the same cloud may be composed of spherical particles, others of flakes, the difference being at once manifested through the *calmness* of the one portion of the cloud, and the *uneasiness* of the other. The sparkling of such flakes reminded me of the plates of mica in the river Rhone at its entrance into the Lake of Geneva, when shone upon by a strong sun.—*Phil. Mag.*, IV, xxxviii, p. 156.

II. GEOLOGY.

1. *Artesian Well at Terre Haute, Ind.;* in a letter from Prof. A. Guyot to J. D. Dana.—I have received, through the kindness of Rev. George Morrison of Terre Haute, Indiana, the following very interesting record of the boring of an Artesian Well at that place, made under the direction and at the expense of Chauncey Rose, Esq. This gentleman deserves the thanks of the geologists for having carried the work to that extent of minuteness with a special view to be useful to science. The knowledge of the nature and succession of strata down to the depth where the geologist has no possible access, is of itself of considerable interest. The value of the record would be much enhanced if accompanied by some fossils, which would enable the geologist to establish the place of each stratum in the regular series of formations. But I

know that it is next to impossible to get any of real value for the purpose of such operations.

The temperature of the water at the bottom of the well, taken with Valferdin's thermometer or some other kind of reliable self-registering instrument, would be of great interest for establishing the rate of increase of the terrestrial temperature downward. As this can still be done I trust the opportunity will not be lost to furnish the science of the globe with one more fact relating to that important question.

Record of the Boring of the White Sulphur Artesian Well at Terre Haute, Indiana, made under the direction and at the expense of Chauncey Rose, Esq., of Terre Haute.

	Feet.	Inches.		
Sand and gravel, first,	150			
Fire clay,	1	6		
Brown slate,	2			
Soapstone,	11			
Coal,	4	00	168	6
Fire clay,	3	6		
Limestone,	2	1		
Fire clay,	3	2		
Brown limestone,	2			
Soapstone,	1	6		
Coal,		6	181	3
Fire clay,	3	2		
Salt water—Blue hard limestone,	2	6		
Hard pan,	8	6		
Soapstone,	10	5		
Coal,	2	00	207	10
Fire clay,	3			
Sandstone,	1			
Blue limestone,	2	4		
Dark blue rock,	2	6		
White sandstone,	3			
Fire clay,	5			
Shale,	2	4		
Soapstone,	2			
Blue limestone,	5	2		
Soapstone,	5			
Black shale,	4			
Blue sandstone,	6			
Black shale,	2			
Fire clay,	5	0	256	2
Gray sandstone,	10			
Coal,		9		
Fire clay,	2	5		
Blue rock,	3	4		
Black shale,	3			
Fire clay,	2	3		
Limestone,	4			
Fire clay,	5	10		
Limestone,	3	6		
Coal,	2	6	293	9
Fire clay,	1			
Sandstone,	28	3		
Fire clay,	7	2		
Blue sandstone,	27		357	2
Slate,	9			
Blue sandstone,	29	1		
White sandstone,	8			
Slate,	36	2½		
Sandstone,	1	7½		
Blue slate,	15	9		
White slate,	10	2		
Salt water—white sandstone,	35	11½		
Soapstone,	43			
Blue slate,	28	7½		
White slate,	7	7		
Hard sandstone,	23	9		
Hard blackstone,	9	6		
White slate,	12			
More salt water and gas, hard sand rock,	127	½	746	5½
White limestone,	4	4		
White fire clay,	3	3		
White limestone,	30			
Hard gray sandstone,	10			
Blue limestone,	6	11	801	3½
Hard white sandstone,		9		
Hard blue sandstone,	3	6		
Blue clay,	3			
Hard gray sandstone,	2	3½		
Hard blue limestone,	3	3		
Hard sandstone,	110	5		
Soft sandstone,	7	3		
Blue slate,	5			
Blue hard sandstone,	411	2		
Blue soapstone,	34	10		
White grit sandstone,	117	2		
Hard blue slate,	48			
Brown sandstone,	89	11		
White coarse sandstone,	10	9		
Dark sandstone,	6	9		
Yellow sandstone,	44	2		
Hard flint,	15	8		
Clay limestone or shale,	70	2	1785	

840 feet, show of oil,
1276 " 9 inches, lubricating oil.
1335 " vein of fresh water.
1629 " 10 inches, oil vein.
1658 " blue sulphur water.
1710 " white sulphur water.
1768 " more white sulphur water.
1785 " large flow of white sulphur water, at the rate of 6,000 gallons an hour.

2. *Prof. W. P. Shimper's work on Vegetable Paleontology.**—This work may be considered as a complement to Prof. Pictet's treatise on animal Paleontology. But it is prepared on a more extensive and complete plan, containing not only the distinctive characters of genera, but also those of species, with critical remarks on most of the genera and species admitted by this justly celebrated author.

No book of this kind has ever been more needed than this admirable treatise; it fills a gap in scientific literature. Since the publication of the *Genera et Species plantarum fossilium* of Unger in 1850, vegetable paleontology has rapidly progressed and the number of species has nearly quadrupled. Moreover, Unger, adopting generally the published species without critically examining them, has given in his work merely brief descriptions which are of little advantage to the student who has not in his possession the publications of the original authors; while Prof. Shimper, in the preparation of his work, has examined and compared from original authors all the species admitted by them, and even has, at a great cost of time and labor, visited the more extensive collections of fossil plants of Europe in order to examine and compare the specimens on which the species were established.

We have moreover in Prof. Shimper's book, not only diagnoses of the genera and species which after examination have been found worth preserving, but also a great number of illustrations of the genera and the more interesting species described by the author.

The study of any branch of Natural History necessitates the use of a number of special works. But every branch is represented by treatises exposing its most essential characters, and serving as points of departure for the student, and at the same time as points of reference for the learned. Botanical paleontology has had no such treatise; and it is hence easily understood why Prof. Shimper's work is so gladly welcomed by European savants and why it should be equally well received by American paleontologists. For it contains the description of most of our American well ascertained species of fossil plants, and fills a want greatly felt among us, where the study of botanical paleontology is discouraged if not prevented by the total want of books on the subject.

The plan adopted by Prof. Shimper is as follows: After the introduction and general remarks, the first part has a chapter giving a historical review of the subject; another on the state of preservation of fossil plants; then one on the distribution of fossil plants according to the geological formations; on the principles to be followed in the determination of the fossil remains of plants; on the change perceivable in the vegetable kingdom since its first appearance until our actual epoch. Then follows a general review of the flora of various ages; a chapter on vegetable paleontology in its application to the climatology of the old world, and another on its application to geology. This, with a general classi-

* Traité de Paléontologie Végétale, 2 vols., large 8vo, with an atlas of 100 plates in large 4to.

fication of the stratified formations forms the first part of the book in 125 pages.

The second and essential part contains the descriptions of genera and species. In the first volume we have the cryptogams from the Fungi to the Filices inclusive. The third volume will contain, after the completion of the descriptions in a third part, a synoptical table of the various floras, indicating the order of their chronological succession and their mode of distribution in the various formations to which they belong; and, in the fourth part, a bibliographical index of vegetable paleontology from the beginning of the century to the present time.*

It would be possible to criticize some of the opinions of the European author, or to point out a few errors in the discrimination of our American species. But Prof. Shimper has come to his general conclusions from a peculiar point of view sustained by an immense array of facts, in whose examination we cannot follow him, and the few omissions and errors of descriptions remarked in his book will certainly be corrected at the end of the work. We have only therefore to thank the author for the benefit his admirable treatise will confer upon paleontological science, especially in our country, where as yet collections of fossil plants and of books on the subject are unattainable.

Prof. Shimper's treatise is written in French, in an elegant style, which though concise, is clear and easily understood. Only the diagnoses of his genera and species are in Latin. L.

3. *On the Physical Cause of the Motion of Glaciers;* by JAMES CROLL, of the Geological Survey of Scotland.†—I have just seen an abstract of a most interesting paper by the Reverend Canon Moseley "On the Mechanical Possibility of the Descent of Glaciers by their weight only," which was read before the Royal Society on the 7th of January last.‡ In that memoir he arrives at the conclusion that, owing to the great resistance offered by the solid ice to *shearing*, it is impossible that glaciers can descend by their weight alone.

"All the parts," he remarks, "of a glacier do not descend with a common motion; it moves faster at its surface than deeper down, and at the center of its surface than at its edges. It does not only come down bodily, but with different motions of its different parts; so that if a transverse section were made through it, the ice would be found to be moving differently at every point of that section. . . . . There is a constant displacement of the particles of the ice over one another and alongside one another, to which is opposed that force of resistance which is known in mechanics as *shearing-force*."

He determines by calculation the amount of shearing-force which must not be exceeded if the displacement of the particles is

* The details on the unpublished volume are translated from the Publishers' notice, L. B. Baillière et fils; adding that Prof. Shimper's treatise is published as marked above and that the price of each volume with fifty plates is 50*fr*.

† From the Philosophical Magazine for March, 1869.

‡ Proceedings of the Royal Soc., vol. xvii, p. 202.

to be effected by the weight of the ice alone. In the case of the Mer de Glace at the Tacul, the shearing-force of the ice must not exceed 1·3193 lb. per unit surface of one square inch, if that glacier descends merely by its weight, at the rate observed by Professor Tyndall. From experiments which he has made, he finds that the actual shearing-force of ice per unit surface is about 75 lbs. Consequently he concludes it is impossible that the motion of the glacier can be due to its weight alone; there must be some other force in addition to the weight impelling the ice forward. And he calculates that the amount of work performed by this unknown force is thirty-four times the amount performed by the weight of the glacier.

This is a most important conclusion. It is quite decisive against the generally received opinion regarding the descent of glaciers by their own weight.

But although it is thus demonstrated that glaciers cannot descend by means of their weight alone in the manner generally supposed, still, I venture to think that, notwithstanding the demonstration, gravitation after all may be the only force moving the ice.

The correctness of the above conclusion, that the weight of the ice is not a sufficient cause, depends upon the truth of a certain element taken for granted in the reasoning, viz: that the *shearing-force* of the molecules of the ice remains *constant*. If this force remains constant, then Canon Moseley's conclusion is undoubtedly correct, but not otherwise; for if a molecule should lose its shearing-force, though it were but for a moment, if no obstacle stood in front of the molecule, it would descend in virtue of its weight.

The fact that the shearing-force of a mass of ice is found to be constant does not prove that the same is the case in regard to the individual molecules. If we take a mass of molecules in the aggregate, the shearing-force of the mass taken thus collectively may remain absolutely constant, while at the same time each individual molecule may be suffering repeated momentary losses of shearing-force. This is so obvious as to require no further elucidation. The whole matter, therefore, resolves itself into this one question, as to whether or not the shearing-force of a crystalline molecule of ice remains constant. In the case of ordinary solid bodies we have no reason to conclude that the shearing-force of the molecules ever disappears, but in regard to ice it is very different.

If we analyze the process by which heat is conducted through ice, we shall find that we have reason to believe *that while a molecule of ice is in the act of transmitting the energy received* (*say from a fire*), *it loses for the moment its shearing-force if the temperature of the ice be not under* 32° F. If we apply heat to the end of a bar of iron, the molecules at the surface of the end have their temperatures raised. Molecule A at the surface, whose temperature has been raised, instantly commences to transfer to B a portion of the energy received. The tendency of this process is to lower the temperature of A and raise the temperature of B. B

then, with its temperature raised, begins to transfer the energy to C. The result here is the same; B tends to fall in temperature, and C to rise. This process goes on from molecule to molecule until the opposite end of the bar is reached. Here in this case the energy or heat applied to the end of the bar is transmitted from molecule to molecule under the form of *heat or temperature.* The energy applied to the bar does *not change its character; it passes right along from molecule to molecule under the form of heat or temperature.* But the nature of the process must be wholly different if the transference takes place through a bar of ice at the temperature of 32°. Suppose we apply the heat of the fire to the end of the bar of ice at 32°, the molecules of the ice cannot possibly have their temperatures raised in the least degree. How, then, can molecule A take on, *under the form of heat*, the energy received from the fire without being heated or having its *temperature* raised? The thing is impossible. The energy of the fire must appear in A under a different form from that of heat. The same process of reasoning is equally applicable to B. The molecule B cannot accept of the energy from A under the form of heat; it must receive it under some other form. The same must hold equally true of all the other molecules till we reach the opposite end of the bar of ice. And yet, strange to say, the last molecule transmits in the form of heat its energy to the objects beyond; for we find that the heat applied to one side of a piece of ice will affect the thermal pile on the opposite side.

The question is susceptible of a clear and definite answer. When heat is applied to a molecule of ice at 32°, the heat applied does not raise the temperature of the molecule, it is consumed in work against the cohesive forces binding the atoms or particles together into the crystalline form. The energy then must exist in the dissolved crystalline molecule, under the statical form of an affinity—crystalline affinity, or whatever else we may call it. That is to say, the energy then exists in the particles as a power or tendency to rush together again into the crystalline form, and the moment they are allowed to do so they give out the energy that was expended upon them in their separation. This energy, when it is thus given out again, assumes the dynamical form of heat; in other words, the molecule gives out *heat* in the act of freezing. The heat thus given out may be employed to meet the next adjoining molecule. The ice-molecules take on energy from a heated body by melting. The peculiar form of motion or energy called heat disappears in forcing the particles of the crystalline molecule separate, and for the time being exists in the form of a tendency in the separated particles to come together again into the crystalline form.

But it must be observed that although the crystalline molecule, when it is acting as a conductor, takes on energy under this form from the heated body, it exists in the molecule under such a form only during the moment of transmission; that is to say, the molecule is melted, but only for the moment. When B accepts of

the energy from A, the molecule A instantly assumes the crystalline form. B is now melted; and when C accepts of the energy from B, then B also in turn assumes the solid state. This process goes on from molecule to molecule till the energy is transmitted through to the opposite side and the ice is left in its original solid state. This is the *rationale* of Faraday's property of regelation.

This is no mere theory or hypothesis; it is a necessary consequence from known facts. We know that ice at 32° cannot take on energy from a heated body without melting; and we know also equally well that a slab of ice at 32°, notwithstanding this, still, as a mass, retains its solid state while the heat is being transmitted through it. This proves that every molecule resumes its crystalline form the moment after the energy is transferred over to the adjoining molecule.

This point being established, every difficulty regarding the descent of the glacier entirely disappears; for a molecule the moment that it assumes the fluid state is completely freed from shearing-force, and can descend by virtue of its own weight without any impediment. All that the molecule requires is simply room or space to advance in. If the molecule were in absolute contact with the adjoining molecule below, it would not descend unless it could push that molecule before it, which it probably would not be able to do. But the molecule actually has room in which to advance; for in passing from the solid to the liquid state its volume is diminished by about $\frac{1}{10}$, and it consequently can descend. True, when it again assumes the solid form it will regain its former volume; but the question is, will it go back to its old position? If we examine the matter thoroughly we shall find that it cannot. If there were only this one molecule affected by the heat, this molecule would certainly not descend; but all the molecules are similarly affected, although not all at the same moment of time.

Let us observe what takes place, say at the lower end of the glacier. The molecule A at the lower end, say, of the surface, receives heat from the sun's rays; it melts, and in melting not only loses its shearing-force and descends by its own weight, but it contracts also. B immediately above it is now, so far as A is concerned, at liberty to descend, and will do so the moment that it assumes the liquid state. A by this time has become solid and again fixed by shearing-force; but it is not fixed in its old position, but a little below where it was before. If B has not already passed into the fluid state in consequence of heat derived from the sun, the additional supply which it will receive from the solidifying of A will melt it. The moment that B becomes fluid it will descend till it reaches A. B then is solidified a little below its former position. The same process of reasoning is in a similar manner applicable to every molecule of the glacier. Each molecule of the glacier consequently descends step by step as it melts and solidifies, and hence the glacier, considered as a mass, is in a state of constant motion downward. The fact observed by Professor Tyndall that

there are certain planes in the ice along which melting takes place more readily than others will perhaps favor the descent of the glaciers.

We have in this theory a satisfactory explanation of the origin of "crevasses" in glaciers. Take, for example, the transverse crevasses formed at the point where an increase in the inclination of the glacier takes place. Suppose a change of inclination from, say, 4° to 8° in the bed of the glacier. The molecules on the slope of 8° will descend more rapidly than those above on the slope of 4°. A state of tension will therefore be induced at the point where the change of inclination occurs. The ice on the slope of 8° will tend to pull after it the mass of the glacier moving more slowly on the slope above. The pull being continued, the glacier will snap asunder the moment that the cohesion of the ice is overcome. The greater the change of inclination is, the more readily will the rupture of the ice take place. Every species of crevasse can be explained upon the same principle.

This theory explains also why a glacier moves at a greater rate during summer than during winter; for as the supply of heat to the glacier is greater during the former season than during the latter, the molecules will pass oftener into the liquid state.

As regards the denuding power of glaciers, I may observe that, though a glacier descends molecule by molecule, it will grind the rocky bed over which it moves as effectually as it would do did it slide down in a rigid mass in the way generally supposed; for the grinding-effect is produced not by the ice of the glacier, but by the stones, sand, and other materials forced along under it. But if all the resistances opposing the descent of a glacier, internal and external, are overcome by the mere weight of the ice alone, it can be proved that in the case of one descending with a given velocity the amount of work performed in forcing the grinding materials lying under the ice forward must be great, supposing the motion of the ice to be molecular, in the way I have explained, as it would be if the ice descended in the manner generally supposed.

Of course, a glacier could not descend by means of its weight as rapidly in the latter case as in the former; for in fact, as Canon Moseley has shown, it would not in the latter case descend at all; but assuming for the sake of argument the rate of descent in both cases to be the same, the conclusion I have stated would follow. Consequently whatever denuding effects may have been attributed to the glacier, according to the ordinary theory, must be equally attributable to it according to the present theory.

This theory, however, explains, what has always hitherto excited astonishment, viz: why a glacier can descend a slope almost horizontal, or why the ice can move off the face of a continent perfectly level.

Canon Moseley suggests that heat passing into the ice might by its mechanical energy, together with the weight of the glacier, be sufficient to account for the motion. But the mechanical energy of heat is not required to push the glacier forward; gravitation

alone, as we have seen, will suffice. Besides, heat entering ice could not produce a mechanical pressure that would move the glacier; for heat produces contraction of volume, not expansion. True, heat no doubt destroys the crystalline structure of the ice-molecule by tearing the constituent particles separate; but nevertheless the volume of the mass is diminished by this process, for ice in losing its crystalline structure, or, in other words, in passing from ice to water, decreases in volume.

4. *On some Reptilian remains;* by Prof. COPE, (Proc. Am. Phil. Soc., xi, 117.)--The fossil which Prof. Cope exhibited was the almost perfect cranium of a Mosasauroid reptile, the *Clidastes propython.* He explained various peculiarities of its structure, as the moveable articulation of certain of the mandibular pieces on each other, the suspension of the os-quadratum at the extremity of a cylinder composed of the opisthotic, &c., and other pecularities. He also explained, from specimens, the characters of a large new Plesiosauroid from Kansas, discovered by Wm. E. Webb, of Topeka, which possessed deeply biconcave vertebræ, and anchylosed neural arches, with the zygapophyses directed after the manner usual among vertebrates. The former was thus shown to belong to the true Sauropterygia, and not to the Streptosauria, of which Elasmosaurus was the type. Several distal caudals were anchylosed, without chevron bones, and of depressed form, while proximal caudals had anchylosed diapophyses and distinct chevron bones. The form was regarded as new, and called *Polycotylus latipinnis*, from the great relative stoutness of the paddle.

He also gave an account of the discovery, by Dr. Samuel Lockwood, of Keyport, of a fragment of a large Dinosaur, in the clay which underlies immediately the clay marls below the lower Green Sand bed in Monmouth county, N. J. The piece was the extremities of the tibia and fibula, with astragalo-calcaneum anchylosed to the former, in length about sixteen inches; distal width fourteen. The confluence of the first series of tarsal bones with each other, and with the tibia, he regarded as a most interesting peculiarity, and one only met with elsewhere in the reptile Compsognathus and in birds. He therefore referred the animal to the order Symphypoda, near to Compsognathus *Wagn.* The extremity of the fibula was free from, and received into, a cavity of the astragalo-calcaneum, and demonstrated what the speaker had already asserted, that the fibula of Ignanodon and Hadrosaurus had been inverted by their describers. The medullary cavity was filled with open cancellous tissue. The species, which was one half larger than the type specimen of *Hadrosaurus Foulkii*, he named *Ornithotarsus immanis.*

5. *Sulphur Deposits of the island of Saba, in the Dutch West Indies*, (from a Report on the Deposit, by N. S. HIGGINS.)—The Island of Saba belongs to the volcanic range of the Carribee or Windward Islands.

A few miles to the south and west of Saba there is an extensive coral reef, upon which soundings vary from 7 to 140 fathoms in depth; between this reef and the island there is practically no bot-

tom. The rock composing almost the entire formation of Saba is trachytic porphyry, which contains glassy feldspar (or orthoclase), and hornblende in crystals, disseminated through a dark reddish colored base. The formation upon the northward portion of the island in which the sulphur deposits exist, seems to have undergone a more rapid and thorough decomposition than upon the southward, or lee side; this is owing probably to its exposure to the trade winds. It is also more bluff, and the mountain sides more precipitous, a feature common to the northern and eastern portions of almost all of the Windward Islands, particularly those belonging to the volcanic series.

The sulphur deposit is located on the northern part of the Island of Saba, and extends from what is called "All too far Ridge" to "Flat Point," a distance of more than a mile along the sea line. Between these points the sulphur stratum can be traced, varying from 15 to 50 feet in thickness. Near "Flat Point" its elevation is probably not more than 45 feet above the sea level, while at or near "All to far Ridge" it has an elevation of about 200 feet from its foot wall.

III. ASTRONOMY.

1. *Prizes for the discovery of Comets.*—The following circular has been issued by the Imperial Academy of Sciences at Vienna.

For several years past there have been remarkably few discoveries of new comets. The cause of this fact, which seems inconsistent with that of the wider distribution of telescopes suitable for such discoveries, may be due to the special attention that has been given to the small planets. It is, however, much to be regretted that there has been such slight increase in our knowledge of the comets, in view of the recently established connection between the shooting stars and the comets. It is exceedingly desirable that we should know more than two or three hundred out of the many thousands of comets which undoubtedly belong to our system, especially as most of those which we know move in parabolic orbits. Were our knowledge of comets more complete we should surely know of more meteor streams and comets belonging one to the other. Mindful of Herr Schumacher's words, "it is natural that astronomers intrusted with the administration of a well furnished observatory should have no time left for sweeping the sky so minutely and so perseveringly as is necessary for discovering these faint bodies, whilst, on the contrary, it seems certain that to the many amateur astronomers who have less extensive means of observation hardly any more useful kind of activity could be recommended," the Imperial Academy of Sciences at Vienna is induced to propose for the discovery of comets during the next three years (from May 31st, 1869, to May 31st, 1872) eight prizes annually, consisting, as the receiver may choose, of a gold medal, or of twenty Austrian ducats representing its value in money.

The award of these prizes will be subject to the following regulations:

1. The prize will be given only for the first eight comets discovered in each of the three years named, and only for such comets as are telescopic at time of discovery, that is, invisible to the naked eye. The comet must not have been before seen by another observer, and must be one whose appearance could not securely be predicted.

2. The discovery must be communicated immediately and without waiting for further observations, to the Imperial Academy of Sciences, by telegraph if practicable; and otherwise by the earliest post. The Academy undertakes to transmit the news immediately to other observatories.

3. The time and place of discovery with the plan and course of the comet must be given as exactly as possible with the first notice. This first notice is to be supplemented by such later observations as may be made.

4. If the discovery should be confirmed by other observers the prize will not be awarded unless the observations of the discoverer suffice for the determination of the orbit.

5. The prizes will be awarded in the general meeting of the Academy held at the end of May of each year. In case the first notice of a discovery arrives between the first of January and the end of May, the final award of the prize will be deferred till the general meeting in May in the following year.

6. Application for the prize must be made to the Academy within five months from the time of the arrival of the first notice. Later applications will not be considered.

7. The Imperial Academy will procure the decision of the permanent astronomers of the Observatory at Vienna as to the fulfilment of the conditions in Nos. 1, 3, and 4.

2. *On the Phenomena of Light, Heat, and Sound accompanying the fall of Meteorites;* by W. Ritter v. Haidinger, For. Mem. R.S., &c.—A particular incident caused me to return to some portions of my earlier studies in regard to meteors and meteorites.

It was the fall of a meteorite at Kakowa on the 19th of May, 1858, that first induced me to bestow some more attention on this department of physical science. A report on the subject I laid before our Imperial Academy of Vienna on the 7th of January, 1859. On the same day also I gave the first list of the meteorites forming the meteorite collection in our Imperial Mineralogical Museum. A series of reports on meteorites followed, as well as a number of catalogues of meteorites, in accordance with the growing riches of the collection, embracing from 137 to 236 numbers of localities preserved up to the date of July 1, 1867.

But the studies relating to the recent fall of Ausson on the 9th of December, 1858, and the ancient fall of the meteoric iron of Hraschina, near Agram, on the 26th of May, 1751, others on the Cape meteorites of 1838, on those of Shalka, 1850, Allahabad, 1822, Quenggouk (Pegu), 1857, Assam, found 1846, Segowlee,

1853, St. Denis-Westrem, 1855, Nebraska, found 1856, but particularly some studies relating to meteorites of Stannern, 1858, and of that most remarkable meteoric iron from Tula, discovered in 1856 by Auerbach, all of them within the period of 1851 to 1860, and then the fall of New Concord, 1860, and of Parnallee, 1857, had forcibly called upon me to draw up, as it were, a general rule of the nature and succession of events which probably might have taken place in the history of their existence, though in each particular case only fragments of that history came to our notice.

A general survey of this kind I had the honor to lay before our Imperial Academy on the 14th of March, 1861, "On the nature of Meteorites, relating to their composition and the phenomena of their fall."* I felt, it is true, that I had rather too boldly ventured to transgress the limits of my former studies; but at the same time, led on by the high interest connected with the subject, I wished to gain some more publicity for it. As to England, I was most kindly and effectively patronized by that energetic promoter of meteoritic science, my most honored friend Mr. R. P. Greg. He laid a notice of mine before the British Association for the Advancement of Science, held that year at Manchester, and accompanied it with several considerations of his own;† then, also, he kindly had the pages of the Philosophical Magazine opened for me, and presented me with an edition of separate copies of a memoir on the subject—nearly a translation, by my honored friend Count A. F. Marchall, of my original communication to our Academy.‡

At the Meeting of German naturalists and physicians at Speyer, my honored friend Dr. Otto Buchner kindly called the attention of the friends of this department of natural science to my memoir, which had been favorably mentioned in the reports.

A note of mine, containing the leading views of my papers, was likewise laid by my honored friend M. Elie de Beaumont before the Paris Académie des Sciences in their Meeting of September 9th, 1861, while I also sent a French translation by my excellent friend Count Marchall, together with a copy of my original memoir.§

Since that time, up to this day, I had frequently, in seve al communications on meteoritic subjects, had an opportunity to re-

* "Ueber die Natur der Meteoriten in ihrer Zusammensetzung und Erscheinung," Sitzungsberichte der Kaiserlichen Akademie der Wissenchaften, der Mathem.-naturw. Classe, 1861, Band xliii. Abth. ii. S. 389–425.

† "An attempt to account for the Physical Condition and the Fall of Meteorites upon our Planet, by W. Haidinger, Hon. Memb. R.S.L. & E. &c.," Report 1861, Transactions of the Sections, p. 15. "Some Considerations on M. Haidinger's Communication on the Origin and Fall of Aërolites, by R. P. Greg, F.G.S.," ibid, p. 13.

‡ Considerations on the Phenomena attending the Fall of Meteorites on the Earth, by W. Haidinger, For. Memb. R.S.L. & E.; and Philosophical Magazine for November and December, 1861.

§ "De la nature des bolides et de leur mode de formation. Lettre de M. Haidinger," Comptes Rendus hebdomadaires des séances de l'Académie des Sciences, etc., t. liii. Juillet–Décembre 1861, pp. 456–461.

fer to these leading papers, and to support the views which they contained. Therefore I had every reason to be astonished when I read, in a recent work on meteorites by M. Stanislas Meunier,* the following assertion;—"We may observe that a great number of particular phenomena occurring in the fall of meteorites have hitherto remained without explanation. Thus the reason of the explosions, and particularly of the repeated explosions, that of the rumblings, that of the incandescence, are still absolutely unknown."†

But I had still more reason to be astonished when I found M. Daubrée himself nearly upon the same level in his views respecting the origin of light, heat, and sound in the fall of meteorites.

I certainly heartily appreciate the high merit of my honored friend M. Daubrée, in regard both to his deep studies on meteorites and his eminent success in forwarding the interests of the Paris Museum of Meteorites; but I at the same time may be permitted to consider my own views, as given in the memoirs quoted, as representing a scientific advance compared with the statements of M. Meunier and those of M. Daubrée himself in his last memoir on the Orgueil fall.‡ Neither M. Daubrée nor M. Meunier had refuted or even objected to my views; they had only passed them over in silence, doubtless because they had escaped their notice.

But I believe I am fulfilling a duty to scientific progress if I endeavor to place the discrepant and even contradictory views on these subjects together, in order once more to excite attention and recommend them to further study on the part of the votaries of natural science; and it was with this view that I prepared a new memoir, to be laid before our Imperial Academy in their approaching period of session, on the light, heat, and sound accompanying the fall of meteorites. I begin with some of the statements put forth by M. Daubrée, as taken from his memoir on Orgueil:—

"Things go on as if the greater part of the mass of the meteor got out of our atmosphere, in order to continue its course, after having left us some particles, the velocity of which, in consequence of the explosion, was reduced."§ M. Daubrée does not admit the arrival of groups or swarms of meteorites as has been asserted.‖ "The carbonaceous meteorites contradict the hypothe-

* Eutde, descriptive théorique, et expérimentale sur les *Météorites*, par M. Stanislas Meunier. Paris, 1857, p. 18.

† "Remarquons qu'un grand nombre de particularités offertes par la chute des météorites sont restées jusqu'à présent sans explication. Ainsi, la cause des explosions et surtout des explosions multiples, celle des roulements, celle de l'incandescence, sont absolument inconnues."

‡ "Complément d'Observations sur la chute de météorites qui a eu lieu le 14 Mai 1864 aux environs d'Orgueil," Nouvelles Archives du Muséum d'Histoire Naturelle, t. iii, pp. 1–19.

§ "Les choses se passent donc comme si la plus grande partie de la masse météorique ressortait de l'atmosphère pour continuer sa trajectoire, n'abandonnant que quelques parcelles dont la vitesse, à la suite de l'explosion, se trouvait amortie."—*Op. cit.* p. 15.

‖ Comme on l'a dit.

sis that the heat of the meteorites is due to the loss of their *vis viva.*"* The sounds, detonations under the name of explosions, remain without explanation.†

M. Daubrée attributes to mere chance the situation of what he calls "scales," or "écailles de météorites," at the moment of an explosion, if they present certain particular seams of crust surrounding their most extended surface, by which, being foremost, they forced their way through the opposing atmosphere. In regard to this position I had long ago advanced that it must have been a necessary result, while the rectilinear movement of the meteorite was in the way of being checked, of part of the force having been expended in producing a rotatory motion perpendicular to the direction of the course. This I did in particular, in a paper on the meteoric iron of Hraschina, on the 14th of April, 1859, then on an aërolite from Stannern on the 22nd of May, 1862, and in other instances.

The above-mentioned quotations of M. Daubrée's views are now compared with the successive periods of progress in the fall of meteorites, nearly in the same words as I proposed them in 1861.

In the arrival of meteorites on our earth:—

1. Single or agglomerated fragments, in their cosmical course, come into contact with our globe.
2. The fragments are arrested by the resistance of atmospheric air.
3. Pressure, in their progress through the atmospheric air, elicits light and heat; rotation ensues, and a melted crust is formed.
4. The white-hot compressed air is spread out in the form of a fireball, closed up behind, and enclosing the fragment, or fragments, and a vacuum-space.
5. The cosmic course is at an end when the fragment, or the fragments, have been arrested by air.
6. Light and heat are no longer generated; the vacuum-ball will collapse with a loud report, or several reports following each other.
7. The cosmic cold within the aërolite assists in reducing the heat of the melted crust.
8. The meteorite falls down upon the earth like any other ponderous body, the hotter the better conducting material it consists of.

In this way I believe it was my duty again to lay before the public the differences of the views newly taken by M. Daubrée from those which I hitherto had advocated.

But while I was engaged in contrasting them I found myself conspicuously supported by a number of recent publications relative to the subject in question. In one of his own papers M. Daubrée had to register the statement of M. Leymerie, of Toulouse, who considered the fall of Orgueil as presenting not one meteoric mass exploded, but a swarm of aërolites arrived at the same moment.

* "Les météorites charbonneuses contredisent l'hypothèse que la chaleur des météorites est due à la perte de leur force vive."—*Op. cit.*, p. 8.

† "Sans explication."—*Op. cit.*, p. 16.

But above all, two reports of the fall of 30th January, 1868, near Pultusk, both of them kindly presented to me by their respective authors, bore ample testimony in favor of a number of my theses, and enlarged them by deeper and more accurate investigation beyond what I formerly proposed.

These are the memoir "On the Course of the Pultusk Meteorite,"* by Professor J. G. Galle in Breslau, and another, "On the Meteorites of Pultusk,"† by Professor G. vom Rath, in Bonn.

In both of them the most evident proofs are given of the actuality of a swarm, consisting of a very great number of distinct aërolites, having entered our atmosphere.

The course of the Pultusk meteor, according to M. Galle, met the horizontal line under an angle of 44 degrees at the place of dispersion, at a height of 25·25 English miles, or $5\frac{1}{2}$ German miles. After its movement was checked, and the force of it expended in the development of light and heat, how would it have been possible that, as it would follow from M. Daubrée's supposition, the great mass of the meteor should have risen again and left our atmosphere to continue its cosmical orbit? Nor could such be the case with the Knyahinya meteor, which pounced upon our earth almost from the zenith of the place, the course making an angle only of 6 degrees with the perpendicular. But even the Orgueil meteor moved in a direction meeting the horizontal line at the point of dispersion under an angle of about 11° 26′, from which position it certainly could not rise again higher up into the atmosphere, and still less leave it altogether.

I availed myself of the circumstance that I had been gratified by several honored friends with a number of important publications closely connected with the subject, to quote some appropriate passages. I would refer especially to that grand 'Atlas of Charts of Meteor-tracks,' by Messrs. R. P. Greg and A. S. Herschel,‡ together with the "Reports of Luminous Meteors for the years 1865 and 1866–1867,"§ and to the recent memoir by M. G. V. Schiaparelli on the astronomical theory of falling stars,‖ kindly

* Ueber die Bahn des am 30. Januar 1868 beobachteten und bei Pultusk im Königreiche Polen als Steinregen niedergefallenen Meteors durch die Atmosphäre. Vom Professor Dr. C. G. Galle, Direktor der Sternwarte zu Breslau. Vorgetragen am 4. März u. s. w. Besonderer Abdruck aus den Abhandlungen der Schlesischen Gesellschaft für vaterländische Cultur. Breslau, 1868.

† Ueber die Meteoriten von Pultusk im Königreiche Polen gefallen am 30. Januar 1868. Von Dr. G. vom Rath. Mit einer Tafel. Besonders abgedruckt aus der Fest schrift der Niederrheinischen Gessellschaft für Natur- und Heilkunde zum 50 jährigen Jubiläum der Universität Bonn.

‡ 'Atlas of Charts of the Meteor-tracks contained in the British Association Catalogue of Observation of Luminous Meteors, extending over the years from 1845 to 1866, &c.' Prepared for the Luminous-Meteors Committee of the British Association by R. P. Greg and A. S. Herschel.

§ Report on Observations of Luminous Meteors, 1865-66, by a Committee consisting of James Glaisher, F.R.S., of the Royal Observatory, Greenwich, Secretary to the British Meteorological Society; Robert P. Greg, F.G.S.; E. W. Brayley, F.R.S.; and Alexander Herschel, B.A. From the Report of the British Association for the Advancement of Science for 1866. The same for 1866–1867.

‖ 'Note e riflessioni intorno alla teori astronomica delle Stelle Cadenti.' From the work 'Memorie di Matematica e di Fisica della Società Italiana delle Scienze fondata da Anton Mario Lorgna,' ser. 3, tomo i, parte 1, p. 153, Firenze, 1867.

sent to me by the late lamented Matteucci. Schiaparelli holds forth that in shooting stars "the *vis viva*, while the meteoric matter is dispersed in the atmosphere, is completely destroyed by being transformed into heat and light."* From Mr. A. S. Herschel's observations with the spectroscope, we learn that the condition of the August meteors is exactly that of a flame of gas in a Bunsen's burner freely charged with the vapor of burning sodium, or of the flame of a spirit-lamp newly trimmed and largely dosed with a supply of moistened salt (*op. cit.*, p. 146). The idea of a diminutive fireball containing the solid mass, although diminutive itself, surrounded by a luminous gaseous case, including a vacuum, till the force of the movement is spent in heat and light, may not be considered inadequate to the subject.

In a most interesting memoir entitled "Contributions to the Knowledge of Falling Stars,"† by Dr. Edmond Weiss, of Vienna, that able astronomer (the representative, together with Dr. Oppolzer and Lieut. Reziha, of the Austrian Navy, of our Austrian expedition for the eclipse of 18th of August at Aden, where they were so hospitably welcomed and kindly supported by the Governor-General, J. Russel, in behalf of the British Government, along with the North-German expedition, composed of Drs. Vogel, Fritsche, Zenker, and Thiele) considers among other subjects the influence of the earth's attraction upon shower-meteors, independently of Schiaparelli's disquisitions relative to the same subject, and points out also the circumstance that some of them may receive such a direction as to leave our solar system altogether, while Dr. Galle insists upon the fact that the Pultusk swarm must have entered it with an independent force of at least from $4\frac{1}{2}$ to 7 English miles (1 to $1\frac{1}{2}$ geographical miles).

My original design was only to offer some appropriate remarks on the subject of the phenomena of light, heat, and sound generated in and accompanying the arrival of meteorites on the earth through our terrestrial atmosphere; but the different departments of natural science referring to meteors and meteorites are of so manifold a nature, that I frequently was obliged to advert to some of them in regard to which I should rather have kept more on the reserve. But the whole range of meteor- and meteorite-science, continually enlarging, more and more clearly presents itself in these four grand sections:—1st, the original formation of meteorites; 2nd, their movement through cosmic space; 3rd, their arrival through the atmosphere upon our earth; and, 4th, the studies instituted on the objects themselves, which fall into our hands and are preserved in our museums. To the third of these sections it is that my particular attention was directed.—*Proc. Roy. Soc.*, xvii, 155.

* "Questa forza viva, dileguandosi la materia meteorica nell' atmosfera, viene completamente distrutta trasformandosi in calore ed in luce."—*Op. cit.* p. 198.

† "Beiträge zur Kenntniss der Sternschnuppen, von dem c. M. Dr. Edmund Weiss. Vorgelegt in der Sitzung am 16. Jänner 1868," Sitzungsberichte der Math.-nat. Classe der Kais. Akademie der Wissenschaften, lvii, Band ii, Abth. 5. pp. 281–342.

3. *Note on the Heat of the Stars;* by WILLIAM HUGGINS, F.R.S. —In the summer of 1866 it occurred to me that the heat received on the earth from the stars might possibly be more easily detected than the solar heat reflected from the moon. Mr. Becker (of Messrs. Elliot Brothers) prepared for me several thermopiles, and a very sensitive galvanometer. Toward the close of that year, and during the early part of 1867, I made numerous observations on the moon, and on three or four fixed stars. I succeeded in obtaining trustworthy indications of stellar heat in the case of the stars Sirius, Pollux, and Regulus, though I was not able to make any quantitative estimate of their calorific power.

After describing the mode of making his observations with an astatic galvanometer, he observes:

The mean of a number of observations of Sirius, which did not differ greatly from each other, gives a deflection of the needle of 2°.

The observations of Pollux $1\frac{1}{2}$°.

No effect was produced on the needle by Castor.

Regulus gave a deflection of 3°.

In one observation Arcturus deflected the needle 3° in 15 minutes.

The observations of the full moon were not accordant. On one night a sensible effect was shown by the needle; but at another time the indications of heat were excessively small, and not sufficiently uniform to be trustworthy.

It should be stated that several times anomalous indications were observed, which were not traced to the disturbing cause.

The results are not strictly comparable, as it is not certain that the sensitiveness of the galvanometer was exactly the same in all the observations, still it was probably not greatly different.

Observations of the heat of the stars, if strictly comparable, might be of value, in connexion with the spectra of their light, to help us to determine the condition of the matter from which the light was emitted in different stars.

4. *The Total Eclipse of August* 7, 1869.—Few astronomical phenomena have probably ever called out a more thoroughly organized system of observation than that arranged for the recent eclipse. The line of total obscuration crossed the North American continent diagonally, entering the territory of the United States at Behring's Straits, in about the 65th degree of latitude, and longitude 90° west of Washington, while it left our shore at the latitude of 34° and the meridian of Washington itself. It traversed a central belt of well-populated territory, yet there seems to have been scarcely a town of any considerable magnitude along the entire line which was not garrisoned by observers having some special astronomical problem in view.

An appropriation was made by Congress, at its last session, for carrying out a series of observations under the direction of the Superintendent of the Nautical Almanac, and Prof. Coffin has succeeded, by the liberal aid of the Navy Department and the very generous and extensive facilities contributed by some of the principal railroads, in providing for an amount of work which for mag-

nitude, variety and thoroughness seems large beyond all proportion to the sum placed at his disposal. Three cities in Iowa, Burlington, Mount Pleasant and Ottumwa, were occupied by astronomical, photographic and physical observers under his direction, and special observers, provided with telescopes and instruments for determining geographical position, were sent by him to the North and South, to fix the limits of the belt of total obscuration.

The Navy Department, besides making other provisions, sent observers to the western shore of Behring's Straits; and the War Department detailed Dr. Curtis, to make special photographic observations at Des Moines, Iowa.

The Coast Survey established parties on the Yaken river in Alaska, at Des Moines in Iowa, Springfield in Illinois, and Abingdon in West Virginia, and perhaps at still other stations,—that at Springfield being amply provided with photographic observers and apparatus.

Most of the principal observatories likewise organized expeditions of greater or less magnitude. From Washington, the several observers arranged independent series of investigations, stellar, spectroscopic, physical and meteorological. From Cambridge a large party went to Shelbyville, Ky., with large photographic outfit and spectroscopic equipments. From Albany a similar party went to Mattoon, Illinois; others from Clinton and Chicago went to Des Moines, from Cincinnati to Sioux City; and the number of private astronomers who established themselves along the central line, with telescopes and other apparatus of investigation, must have been exceedingly large.

The weather for two days preceding had been unpromising, and in many places almost disheartening; but the efforts of the astronomers were at last rewarded by a day of almost cloudless serenity, with an atmosphere much more transparent than usual, in consequence of the copious rains; and so far as we have heard, the sky was favorable every where, unless a slight haze at Des Moines formed an exception.

It is of course too early, as we go to press, to give any general account of the results, which in most cases are not yet elaborated by the observers; but some matters of interest have been already made known.

The beginning and end of the eclipse seem to have been observed a few seconds later, and the beginning and end of the totality about fifteen seconds later than the predictions of the American Nautical Almanac. As regards the exact position of the central line, and of the limits of the total belt, we have as yet insufficient information to determine the degree of accordance with computation. There can be no doubt that materials have been collected capable of improving the adopted values of the moon's diameter and horizontal parallax.

One of the most interesting results is the introduction of a new and accurate method of determining the time of first contact, by observing with a spectroscope the gradual occultation of the bright lines of the chromosphere. This we owe to Prof. Young, of Dart-

mouth College, who formed one of Prof. Coffin's Nautical Almanac party at Burlington. By keeping the center of the slit directed to the point at which the contact is to take place, the observer is forewarned of the approach of the moon's limb, by the shortening of the bright lines belonging to the chromosphere. The line C is well adapted to this purpose, and is seen to grow steadily shorter until it is totally extinguished. The moment of disappearance of the last bright ray is of course that of the first contact, which is thus observed with the same care and accuracy as any other appulsive phenomenon. Although the first contact, as determined in this way by Prof. Young, was noted some five seconds before its recognition by any other observer, it was subsequently found by Prof. Mayer to accord within a small portion of a second with the time as determined by measurement of a series of photographs, taken during the first minute.

Prof. Young also determined the position of nine bright lines during the totality. These corresponded to 694, 1017·5, 1250±20, 1350±20, 1474, 2080, 2602±2, 2796 of Kirchhoff's scale, and the line *h*. (The lines *b* were seen elsewhere, but this region was not scrutinized by Prof. Young.) Of those named, the 1st, 6th, 8th and 9th are the hydrogen lines α, β, γ, δ, respectively; the 2d is near D but are refrangible, and was very bright; the 3d and 4th are new, but faint and their position estimated; the 5th is given by both Kirchhoff and Angström as an iron line; the 7th was also faint, and is new, its place being micrometrically determined from 2796.

Of these Prof. Young states that all but three belong to the protuberances; but the 5th certainly, and the 3d and 4th probably, to the corona only, remaining visible when the image of the protuberances was moved away from the slit, and the other lines disappeared. He also finds that certainly one of the lines in the corona-spectrum, (1474), and probably two others are coincident with auroral lines seen by Prof. Winlock at Cambridge, and reported in the last No. of this Journal.

Prof. Harkness, of Washington Observatory, observed at Des Moines the spectra of five protuberances, no two of which gave the same lines. In the corona spectrum he found no absorptive lines, and but one bright line.

Measures of the protuberances were made by Prof. Rogers, at Des Moines, who found the largest to be nearly a minute and a half high, and observed a peculiar honeycombed or cellular appearance in all of them.

Special search was made for intra-Mercurial planets by Prof. Newcomb, at Des Moines, according to the plan suggested by him in the April No. of this Journal, with two 6-inch object-glasses, having a field of about 20′ each, and previously clamped to the desired position. A similar scrutiny of the ecliptic near the sun was made by Dr. Gould, at Burlington, in connection with Prof. Coffin's party, using a Tolles telescope of five inches aperture and a field of nearly 2°, provided with occulting discs at the focus. But

neither of these observers nor any others engaged in similar research, found any indications of planets nearer than Mercury.

The photographic observations were very numerous and successful. At Burlington eight impressions are reported to have been taken during totality, by the Nautical Almanac party, and several by the parties at Des Moines, Springfield and Shelbyville. The total number during the partial taken must have been many hundreds.

In our next issue we hope to give more accurate and complete accounts, together with original reports. G.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Eighteenth Meeting of the American Association for the Advancement of Science, held in Salem, Massachusetts, Aug.* 18–26, 1869.—The Salem meeting of the American Association, under the Presidency of J. M. FOSTER of Chicago, was well attended from all parts of the country. About two hundred and fifty old members from a distance recorded their names as in attendance, and over one hundred and fifty new members were elected. The number of communications entered upon the daily programmes of the Standing Committee was about one hundred and fifty, a full list of the titles of which is appended. The range of these papers was considerable, and it was found expedient to have sub-sections on Archeology and Microscopy, to facilitate the disposal of papers which could not be reached in the other sections.

The recent total eclipse of the sun, (Aug. 7th), was naturally a prominent subject of interest. The astronomers were present in considerable force, and the whole of Monday, the 23d, was devoted in Section A to the discussion of this subject. For a notice of the main points of interest then brought out, reference may be had to the preceding article on this subject.

The dedication of the Peabody Academy of Science, on Wednesday, the 18th of August, was an occasion of interest, worthy to occupy the attention of the Association at its opening session. This Institution was founded at Salem in the year 1867, by the munificence of George Peabody, with the design of promoting the study of science in his native county of Essex. The first Annual Report of the Trustees of this Academy, made in January, 1869, shows that it is already fully organized, with an able corps of officers and a well ordered museum, library, &c., and the activity of its Director and Curators is evident not only in the extent and fine condition of the collections but in the zeal and ability with which the various publications of the Academy are conducted. Advantage was taken of the present occasion to make the formal transfer of the building of the Museum to the Trustees, and its delivery and acceptance by the Director, F. W. PUTNAM. In an eloquent address the President of the Academy, WILLIAM C. ENDICOTT, Esq., gave the history of the Museum from its foundation, in 1801, as the East India Marine Hall, to its purchase and reorganization in its present form. The Essex Institute, which is well

known by its Proceedings, Bulletin and Historical Collections, is now incorporated with the Peabody Academy of Science.

The address of Dr. B. A. Gould, the retiring President of the Association, was given on Friday evening, (Aug. 20). His theme was the Position of Men of Science in America, and it was treated in his usual felicitous manner.

Every thing which a hearty good will and an intelligent appreciation of science could do was done to promote the happiness and forward the plans of the Association and its members, alike by the city authorities of Salem, the various scientific bodies, and private individuals. The weather was delightful, and every opportunity was embraced for excursions in the neighborhood by land and water. On Saturday the whole Association were the guests of the city government of Salem, on an excursion by steamboat through the bay of Salem and the waters of Boston harbor, visiting the famous Light House built by General Totten on Minott's Ledge, eighteen miles from land, in a situation as perilous and difficult as the famous Eddystone Light;—Fort Warren, notorious as the unwilling home of many prisoners of eminence during the late war,—and Nahant, where ample provisions were made for the entertainment of the numerous guests in pavilions and along the shores.

The sessions closed with a field day, under the auspices of the Local Committee and the members of the Peabody Academy.

The Association stands adjourned to meet on the first Wednesday in August, 1870, at Troy, New York, under the Presidency of WILLIAM CHAUVENET, of St. Louis University.

The following is a list of the papers read at the meeting.*

1. SECTION A. *Mathematics, Physics and Chemistry.*

On the Total Eclipse of Aug., 1869; B. PEIRCE.

On Quintuple Algebra; B. PIERCE.

Determination of the Mechanical Equivalent of Heat, by means of the modern ice and cooling machines; P. H. VAN DER WEYDE.

The Spectral Bands considered as harmonics of one or more fundamental longer waves, lying beyond in the invisible caloric rays; P. H. VAN DER WEYDE.

On the audible transmission of musical melodies by means of the Electric Telegraph; P. H. VAN DER WEYDE.

Electricity not a self-existent fluid, but a mode of motion of matter; P. H. VAN DER WEYDE.

On the Classification and the Atomic Weights of the so-called Chemical Elements, with Reference to Stas' Determinations; G. HINRICHS.

Atomic Volume and Atomic Distances of the crystallized AB_3C; G. HINRICHS.

Molecular Perturbations; G. HINRICHS.

On the Grahamite of West Virginia; H. WURTZ.

Studies in Chemical Geogony, in three parts. Part 1. On the Prozoic Atmosphere and the Ocean of the Zoic Dawn. Part 2. Zoic History from a Chemical View-point. Part 3. Chemical revelations of a Final Zoic Catastrophe; H. WURTZ.

Flame Temperatures; in their Relations to Compositions and Luminosity; B. SILLIMAN and H. WURTZ.

On the Relation between the Intensity of Light produced by the Combustion of Illuminting Gas and the Volume of Gas Consumed; B. SILLIMAN.

On the Composition and Solubility of the Acid Oxalates of Potassium, Ammonium and Sodium; WM. R. NICHOLS.

Classification of the Elements of Matter; C. A. SEELY.

* The titles given above are only those which appeared on the daily official programmes, and some of these were read only by title.

The Volumetric determination of Carbonic Acid; C. A. SEELY.

New Devices for producing and managing Intense Heat; C. A. SEELY.

Phosphoric Acid, Iron and Potassium, constituents of chlorphyle; E. N. HORSFORD.

On some newly discovered properties of Phosphoric acid; E. N. HORSFORD.

A Formula for computing the time of Axial Rotation of any Primary Planet, its Density and the Relative Force of Gravity at its surface being given. Communicated for Ira Wanzer of Lanesville, Ct.; WM. A. ROGERS.

On a New Method of producing by the electric spark figures similar to those of Lichtenburg; E. W. BLAKE, Jr.

Causes of the Failure of Lightning Rods; J. BUSHEE.

Conditions of a Perfect Lightning Rod; J. BUSHEE.

On the demonstration of Euclid's assumption relative to Parallels; A. C. TWINING.

Some results of the discussion of the Boston Dry Dock Tide Observations; WM. FERREL.

On the velocity of the Electric Current over Telegraph Wires; G. W. HOUGH.

On the Total Eclipse of August 7th; G. W. HOUGH.

Notes on the Chemistry of Copper; T. S. HUNT.

The laws of the Deflection of Beams tested by experiment; W. A. NORTON.

The physical theory of the Principal of the Lever; W. A. NORTON.

An improved method of observing Meteoric Showers; D. MURRAY.

Hints toward an explanation of the Corona in Solar Eclipses; D. MURRAY.

Planetary influence on Rainfall and Temperature; P. E. CHASE.

The use of the Thermometer to determine the period of Solar Rotation; P. E. CHASE.

Suggestions on the Theory of the Composition of Forces; F. W. BARDWELL.

On the Ethereal Medium; S. D. TILLMAN.

A self-recording Psychrometer; S. D. TILLMAN.

Some observations on the Solar Eclipse at Montreal, by Dr. C. SMALLWOOD, with Photographs taken by Wm. Notman. Communicated by B. EDWARDS.

A new method of observing contacts at a Solar Eclipse by the Spectroscope; C. A. YOUNG.

The Spectrum of the Solar Prominences and Corona, as observed at Burlington, Iowa, in the last Solar Eclipse, and the coincidence between the bright lines of Corona Spectrum and those of the Spectrum of the Aurora Borealis; C. A. YOUNG.

The Solar Eclipse, and the Outlines of the Corona as observed at Des Moines; T. BASSNETT.

On the Conservation of Force; H. F. WALLING.

Elemental Fibres, illustrated by models; H. F. WALLING.

Remarkable case of Freezing Fresh water Pipes in Salt water; W. W. WHEILDEN.

The Thermodynamics of Waterfalls; A. M. MAYER.

On some further evidence of the existence of a System of Arctic Winds; J. H. COFFIN.

The imperfect Whiteness of Snow; J. E. OLLIVER.

The present condition of Light House Illumination in the U. S.; JOSEPH HENRY.

Chemical and Mechanical Means as a Protection of Life and Property from fire on Railway Cars; J. F. BOYNTON.

The Law of Accidents; G. A. LEAKIN.

A new method of Rendering the Needle of a Galvanometer definitely astatic; M. G. FARMER.

Smith's Vulcanite Electrical Machine, with attached condenser; M. G. FARMER.

The American Compound Telegraph Wire, referred to the British Association units of resistance; M. G FARMER.

On an improved construction of the Holtz Electrical Machine adapted for the analysis of the phenomena of this variety of machine, and for Class-room use; R. E. ROGERS.

The reactive Force of a mass composed of many non-cohering particles or parts; J. D. WARNER.

On the construction of three Maps of Europe, France and North America, in the Gnomonic Projection, with a view to the distribntion of Mineral Wealth and the study of the Earth's figure; F. FOUCOU.

Photographing objects of natural size without a Camera; T. GAFFIELD.
Laws of Trade; E. B. ELLIOT.
The Proper Monetary Unit; J. F. HOLTON.
On the Abolition of Months; J. F. HOLTON.
The Numerical Method of Criticism; T. M. COAN.

2. SECTION B. *Geology and Natural History.*

Comparison of the Coral Faunæ of the Atlantic and Pacific Coasts of the Isthmus of Darien, as bearing on the supposed former connection between the two Oceans; A. E. VERRILL.

On certain Peculiarities in the distribution of marine life on the Sea-bottom of the Bay of Fundy; A. E. VERRILL.

American Phyllopod Crustacea; A. E. VERRILL.

Physical Geography and Geology of Brazil; CH. F. HARTT.

On Brazilian Drift; CH. F. HARTT.

The Homologies and general structural relations of the Polyzoa; A. HYATT.

Observations on a New Genus of Polyzoa; A. HYATT.

New Species of Fishes obtained by Prof. Orton in the valleys of the Maranon and Napo; T. GILL.

On the systematic relations of the Lamarckian Pteroceræ; T. GILL.

On the Cretaceous Age of Silver Deposits in Chihuahua, Mexico; J. P. KIMBALL.

On the Dyestone Fossil Iron Ore in Pennsylvania; J. P. KIMBALL.

On the age and relations of the Metamorphic Rocks of New Brunswick and Maine; G. F. MATTHEW and L. W. BAILEY.

On the Raritan Clays of New Jersey; J. S. NEWBERRY.

On some recent Geological changes in Northeastern Wisconsin. (Communicated by G. R. STUNTZ); J. S. NEWBERRY.

Notice of some new Fossil Plants from Gaspé, discovered by Prof. J. W. DAWSON; J. S. NEWBERRY.

On some points in the Geology of North Carolina; W. C. KERR.

Description of a New Species of Chiton; WM. PRESCOTT.

Laws of Mountain Formations; J. S. GRIMES.

Notice of Fossils from Table Mountain, California; W. P. BLAKE.

Preliminary notice of the Lamellibranchiates of the Upper Helderberg, Hamilton and Chemung Groups; J. HALL.

Note on a phase in the reproduction of a Confervaceous Alga belonging to the genus Œdogonium; A. M. EDWARDS.

On the Classification of the Diurnal Lepidoptera; S. H. SCUDDER.

The Morphology of the Abdominal Appendages of Butterflies; S. H. SCUDDER.

The value of the characters drawn from the external Armature of Lepidopterous Larvæ; S. H. SCUDDER.

A Classification of the Eggs of Butterflies; S. H. SCUDDER.

Two new genera of Extinct Cetacea; E. D. COPE.

On Embryonic characters in American Salamanders; E. D. COPE.

Early stages of Brachiopods; E. S. MORSE.

Discovery of the Ammonoosuc Gold Field; H. WURTZ.

Note upon the Palæotrochis; H. WURTZ.

Notes on the Geology of Hoboken; H. WURTZ.

Studies of the Red Sandstone of New Jersey; H. WURTZ.

The Ammonoosuc Gold Field in New Hampshire and Vermont; C. H. HITCHCOCK.

The Gems of the United States; A. C. HAMLIN.

On the laws which govern the production of Sexes in Plants; T. MEEHAN.

Nature of the Glands in Acacia; T. MEEHAN.

On a remarkable locality of Vertebrate Remains in the Tertiary of Nebraska; O. C. MARSH.

Notices of some new Tertiary and Cretaceous Fishes; O C. MARSH.

Metamorphosis of Siredon into Amblystoma; O. C. MARSH.

On some new Mosasauroid Reptiles from the Greensand of New Jersey; O. C. MARSH.

Homologies of the Palæchinidæ; ALEX. E. R. AGASSIZ.

Remarks on Trichina spiralis; J. B. EDWARDS.

Plumage of Terns, by Miss GRACE ANNA LEWIS; F. W. PUTNAM.
Geology and Physical Geography of a part of the coast of Maine; J. JOHNSTON.
On the Valley of the Amazon; J. ORTON.
Distribution of Coal, Iron and the Precious Metals in China; A. S. BICKMORE.
On the Non-fossiliferous Rocks of New England; N. T. TRUE.
On Surface Changes in Maine indicating the length of time since the close of the Quaternary Period; N. T. TRUE.
Compression as an agent in geological metamorphism, with illustrations of distorted pebbles in conglomerates; G. L. VOSE.
On the Plasticity of Pebbles and Rocks; W. P. BLAKE.
Hints on the Stratigraphy of the Palæozoic Rocks of Vermont; J. B. PERRY.
Summary of results of a late Geological Reconnoissance of Louisiana; E. W. HILGARD.
Geology of Venezuela; R. P. STEVENS.
The Rocky Mountain Alpine Region; C. C. PARRY.
On Norite or Labradorite Rock; T. STERRY HUNT.
On the Geology of Northeastern America; T. S. HUNT.
On ancient erosions in the St. Lawrence Valley; T. S. HUNT.
Post-Glacial Fossils at Hoboken, N. J.; R. P. STEVENS.
Flora and Fauna of the Fresh-water Tertiaries of Oregon and Idaho; J. S. NEWBERRY.
On the relations of the Geology of Ohio to that of the adjoining States; J. S. NEWBERRY.
Trend of the Rocky Mountain Range north of latitude 60°, and its influence on Faunal Distribution; WM. H. DALL.
On new species of Fishes obtained by Prof. Orton in the Valleys of the Maranon and Napo; T. GILL.

3. SUB-SECTION C. *Archeology and Ethnology.*

Indian Migrations. In four sections: Sec. 1. Physical Geography of North America, with reference to natural Highways; and means of Natural Subsistence afforded by its Areas. Sec. 2. Agricultural Subsistence, and the character and extent of Indian Agriculture. Sec. 3. Migrations of Roving and partially Village Indians, deduced from languages, traditions, and known migrations. Sec. 4. Migrations of Village Indians, as deduced from the same sources; L. H. MORGAN.
A conjectural explanation of the uses of the Embankments of the Mound Builders; L. H. MORGAN.
Discovery of the remains of the Horse among the Ancient Ruins of Central America; O. C. MARSH.
Physical Geography among the Aborigines of North America; N. T. TRUE.
On the Arrowheads of the American Indians and Aborigines. Illustrated by specimens; JOHN A. WARDER.
Exhibition of a few interesting implements collected by R. W. HASKINS from Indian graves on the banks of the Ohio, with special reference to the boring of holes in stone implements; F. W. PUTNAM.
Observations on the Languages of South America and the Classification of the Indian Nations thereof; P. C. BLISS.
The Constitution of man as modified by Light, Heat, and Cold; C. ROESEVELT.
On the Botocudos of Brazil; CH. F. HARTT.
The Ainos, or Hairy Men of Yesso, Saghalien and the Kurile Islands; A. S. BICKMORE.
Evidences of high antiquity in the Kjœkkenmœdden Deposits of New England; E. S. MORSE.

4. SUB-SECTION D. *Microscopy.*

Note on a phase in the Reproduction of a Confervaceous Alga belonging to the genus Œdogonium; A. M. EDWARDS.
On the resolution of Microscopic Test Objects; A. M. EDWARDS.
Some remarks on the Infusorial Deposits of North America; A. M. EDWARDS.
On Cleaning Guanos so as to obtain the Microscopic Organisms in them; A. M. EDWARDS.
Some remarks on an "Opaque Illuminator," applied to an Immersion Objective, and an Immersion Objective of Long Focal Distance; E. BICKNELL.

2. *Large Trees in Australia.*—On this subject the government director of the Botanic Garden at Melbourne furnishes some interesting details, as follows:—"The marvellous height of some of the Australian, and especially the Victorian, trees, has become the subject of closer investigation, since of late—particularly through the miners' tracks—easier access has been afforded to the back-gullies of our mountain system. Some astounding data, supported by actual measurements, are now on record. The highest tree previously known was a *Karri-Eucalyptus* (*Eucalyptus collossea*), measured by Mr. Pemberton Walcott, in one of the delightful glens of the Warren river in Western Australia, where it rises to approximately 400 feet high. Into the hollow trunk of this Karri, three riders, with an additional packhorse, could enter and turn in it without dismounting. At the desire of the writer of those pages (Dr. Mueller), Mr. D. Bogle measured a fallen tree of *Eucalyptus amydalina*, in the deep recesses of Daudenong (Victoria), and obtained for it the length of 420 feet, with proportionate width; while Mr. G. Klein took the measurement of a eucalyptus on the Black Spur, ten miles distant from Healesville, 480 feet high. . . . It is not at all likely that in these isolated inquiries chance has led to the really highest trees, which the most secluded and the least accessible spots may still conceal. It seems, however, almost beyond dispute that the trees of Australia rival in length, though evidently not in thickness, even the renowned forest-giants of California, *Sequoia Wellingtonia*, the highest of which, as far as the writer is aware, rises, in their favorite haunts at the Sierra Nevada, to about 450 feet. . . . Thus to Victorian trees the palm must be conceded for elevation."—*Mossman's Origin of the Seasons*, p. 367.

3. *Scientific Collections of Dr. Shumard.*—We would call attention to an advertisement of the library, minerals and fossils of the late Dr. B. F. Shumard of St. Louis. Dr. Shumard was engaged in various geological surveys, and his collections are of great value.

OBITUARY.

Dr. B. F. Shumard, died at St. Louis on the 14th of April, where he has resided for the last sixteen years. We are indebted to Dr. A. Litton for the following brief sketch of his life.

The doctor was a man of science in the highest sense of the term. He loved it, lived for it, devoted himself entirely to its pursuits, and in the prosecution of his favorite study contributed more perhaps than any man now living, to the revelation of the immense resources of the State of Missouri. As a scientific man, his fame was wide-spread, not only in this country, but in Europe. He was President of the St. Louis Academy of Science, and a corresponding member of the Geological Society of London, of the Geological Society of France, of the "Imperial Society of Vienna," of the "Imperial Geological Society of Hermstadt," and of the "Academy of Science" of Philadelphia, of California, of Cincinnati, of New Orleans, and of innumerable other similar societies,

which thus recognized his services to science. As a paleontologist he held a high rank, as his numerous published contributions amply attest. He has been in a declining state of health for about a year, having suffered from hemorrhage of the lungs. A few weeks since he started for New Orleans with a view of benefitting his health, and was on board the ill-fated steamer Ruth when destroyed by fire, and having to walk a long distance, the exertion proved too much for his emaciated frame. He went on to New Orleans, and returned to St. Louis two weeks ago last Monday; from which time he passed into a rapid decline, being conscious from the first that he could not recover.

Dr. Shumard was born at Lancaster, Pennsylvania, on the 24th of November, 1820, and was, consequently, in his 49th year. His father was a merchant, but he inherited his scientific tastes from his maternal grandfather, Mr. Getz, well known as an inventor, and the maker of delicate scales used in the Philadelphia mint. His father afterward moved to Cincinnati, and while living there Dr. Shumard graduated at Oxford, Ohio; returning to Philadelphia, he went through one course in the medical college of that city. His father then moved to Louisville, Kentucky, where young Shumard completed his medical studies in 1846. He then practiced for a short time in one of the interior towns of Kentucky, but subsequently removed to Louisville, where he devoted his leisure to the study of the fossils and shells in the adjacent country. His collection of organic remains was visited by Sir Charles Lyell and Mr. Edward DeVerneuil, when those distinguished savans were in Louisville, and the last named manifested his appreciation by the presentation of his great work on the Geology of Russia.

He was then appointed by Dr. David Dale Owen as assistant geologist in the U. S. Government Survey of Iowa, Wisconsin and Minnesota, for which he had been commissioned by the national government in 1846. He remained in that survey until the fall of 1856. The published reports of this important survey, in which Dr. Shumard took so prominent a part, will remain monuments of the industry, acquirements and ability of their author.

Besides his share in the publication of the reports, Dr. Shumard published a monograph, entitled "Contributions to the Geology of Kentucky," which abounded in original observations and made his name familiar to European geologists.

In 1850, Dr. Shumard was appointed by Dr. John Evans, to aid him in a geological reconnoissance of the territory of Oregon of which he prepared the paleontological report. He spent eighteen months in Oregon and returned to Louisville in 1852, where he occupied nearly a year in making out the reports on paleontology for his brother, Dr. George Getz Shumard, who was employed under Capt. R. B. Marcy, in the Red River exploration.

In 1853 Dr. Shumard came to St. Louis and was appointed Assistant Geologist and Paleontologist of the Missouri Geological Survey, under Prof. Swallow. He labored here until the summer of 1858, when he was appointed State Geologist for Texas, and made a reconnoissance of almost the entire eastern and middle por-

tions of that State, and had just got his specimens collected and arranged, when the war broke out, and he returned to St. Louis. In the survey of Texas he found within the limits of that State the most complete series of geological formations to be found in any State in the Union, ranging as they do from the oldest paleozoic strata, to the latest tertiary, and presenting an aggregate thickness, estimated at not less than ten thousand feet. He succeeded in rescuing his library from Austin at the end of the war, but never returned to prosecute the survey. His extensive collection of specimens is at the Bonham Female Seminary, where it was his intention to have it arranged and labeled under his supervision for the benefit of the people of St. Louis.

Doctor Shumard leaves a wife, and two daughters, one nine and the other four years old.

J. Beete Jukes, the accomplished head of the geological survey of Ireland, and Professor of Geology in the Royal College of Science, died at Dublin on the 29th of July last, aged 58 years. We cite the following notice of this able geologist from the Athenæum of August 14th.

Joseph Beete Jukes was an Englishman. For the last nineteen years he had been on the Irish Surveys. Prof. Jukes graduated at St. John's College, Cambridge, in 1836. He studied geology under Sedgwicke, of whom he was a favorite pupil. After he left college he sailed to and explored the north coast of Australia on board H.M. S. Fly, to which he was appointed as Naturalist. Subsequently he surveyed the island of Newfoundland. After his return from that country he joined the English survey under Sir H. De La Beche, when Mr. Jukes examined some of the most intricate parts of the geology of North Wales. Later he minutely worked out the South Staffordshire coal-field, and wrote a description of it, which was published among the Memoirs of the Geological Survey. In 1850 Prof. Jukes was appointed to the directorship of the Irish branch of the Survey, and in 1853 was elected a Fellow of the Royal Society. The book by which his name is best known is his 'Student's Manual of Geology.' His style as a writer is vigorous, clear and simple,—an exact portrait of the man himself, who by nature was open, straightforward and upright. As a field-geologist few could surpass him; in a moment grasping the key to a country, and being able to explain what others had puzzled over for months. None could generalize as he could; at the same time he did not despise details. He worked out each spot of country with minuteness. Under his acute supervision the igneous rocks of Ireland have been divided up and classified; and if his life had been spared for a few years longer he would have advanced our knowledge of that part of geology, and raised us to an equality with our brethren on the continent. His vigorous mind grasped the geology of Devonshire; and although few yet accept his solution, the final acceptance is only a question of time. His place on the Irish Geological Survey cannot easily be filled, more especially as the solutions of some difficult problems still remain.

V. MISCELLANEOUS BIBLIOGRAPHY.

1. *Machinery and processes of the Industrial Arts, and Apparatus of the Exact Sciences;* by FREDERICK A. P. BARNARD, LL.D., U. States Commissioner, Paris Universal Exposition, 1867. Washington: Government Printing Office, 1869. 8vo, pp. 669.—This is an extremely valuable memoir upon a great number of important topics connected with the Industrial Arts and the applications of mechanical and physical principles, as these were illustrated in the French Exhibition of 1867. These are considered in a systematic and exhaustive manner, in fourteen chapters, of which the general headings are: I. The relation of invention to industrial progress, pp. 1–25; II. Motors, pp. 25–127; III. Transmission of force, pp. 128–150; IV. Accumulation of force, pp. 151–161; V. Measure of force, pp. 162–168; VI. Direct applications of force, pp. 169–218; VII. Meters for liquids and gas; Boiler feeders, pp. 219–236; VIII. Machines and mechanical apparatus designed for special purposes, pp. 237–280; IX. Processes and products, pp. 281–332; X. Diving and Respiratory apparatus, pp. 332–346; XI. Improvements in the application of cold, pp. 346–360; XII. Artificial production of cold, pp. 361–402; XIII. Light-house illumination, pp. 403–416; XIV. Printing and the graphic arts, pp. 417–468. Under each of these general heads we find grouped a great number of most interesting and important matters, about many of which it is impossible to find elsewhere, if at all, so clear and exact statements. The mere enumeration of the topics thus discussed would fill several pages of this Journal.

The just claims of American skill and science are fully stated, with occasional reclamations, among which we are glad to find under chapter XII, a full recognition of Prof. Alexander C. Twining's American Ice Machine of 1850, which is unquestionably the progenitor of all similar machines, and which has been most shamelessly pirated and appropriated by European inventors. In concluding his account of Prof. Twining's apparatus, Dr. Barnard adds—"It cannot be too much regretted that an invention of so much merit and importance, and of which the soundness and commercial value had been so fully demonstrated, both theoretically and experimentally, should, through the apathy or timidity of capitalists, have been permitted to be neglected in the country in which it originated, till foreign enterprize had seized upon it, and developed it into a great industry."

This Report is illustrated by well-executed wood cuts of the most important forms of apparatus discovered, 154 in number, and is correctly and handsomely printed, under the supervision of Prof. W. P. Blake, charged with editing the Reports of the United States Commissioners of the Paris Exposition of 1867.

2. *Proceedings of the American Association for the Advancement of Science. Seventeenth Meeting, held at Chicago, Illinois,* August, 1868. Cambridge: Published by Joseph Lovering. 1869. 372 pp. 8vo.—This volume, elegantly printed at the Essex Institute Press, embraces twenty-six papers on mathematics, physics

and chemistry, and twelve papers on natural history, forming together only about one-fourth part of the papers communicated at Chicago; of the remainder, one hundred and six are given by title only. The address in commemoration of ALEXANDER DALLAS BACHE, by Dr. B. A. GOULD, followed by a list of his published works and the address of Dr. BARNARD, Ex-President of the Association, occupy the first one hundred pages of this volume and would alone give it a character of permanent value.

Inaugural Report of the Director of the Cincinnati Observatory, 30th June, 1868. Annual Report of the Director, 1st May, 1869. 48 pp. 8vo.

First Annual Report of the Trustees of the Peabody Academy of Science. January, 1869. 104 pp. 8vo. Salem. 1869.

First Annual Report upon the Geology and Mineralogy of the State of New Hampshire; by C. H. Hitchcock, State Geologist and Hall Professor of Geology and Mineralogy in Dartmouth College. 36 pp. 8vo.

Prodromus of a study of N. A. Fresh-water Algæ, by Dr. H. C. Wood, Jr. (Proc. Phil. Soc. Philad., vol. xi.) 28 pp. 8vo.

Nature: An illustrated Journal of Science. This new scientific journal, a weekly of 24 pp., the first No. of which is to appear in October, has among its pledged contributors the most eminent physicists, chemists, and naturalists of Great Britain. Macmillan & Co., London, are the publishers.

PROCEEDINGS ACAD. NAT. SCI., PHILADELPHIA, NOS. 3 to 6, June to Dec., 1868.—p. 153, Variations of Epigæa repens; *T. Meehan.*—p. 156, Monœcism of Luzula campestris; *T. Meehan.*—p. 157, Fresh-water origin of certain deposits of Sands and Clays in west New Jersey; *E. D. Cope.*—p. 159, Remarks on remains of Extinct Cetacea, etc; *E. D. Cope.*—p. 160, Descriptions of seven new species of Unio from North Carolina; *I. Lea.*—p. 161, Description of two new species of Unionidæ from Equador; *I. Lea.*—p. 162, Descriptions of Unionidæ from the Lower Cretaceous Formation of New Jersey; *I. Lea.*—p. 165, A Sketch of the Natural Order Liliaceæ, as represented in the Flora of the states of Oregon and Cal.; *A. Wood.*—p. 174, Notice of some Vertebrate Remains from Harden Co., Texas; *J. Leidy.*—p. 177, Indication of Elotherium in California; *J. Leidy.*—p. 177, Notice of Reptilian Remains from Nevada; *J. Leidy.*—p. 178, Notice of Vertebrate Remains from the West Indian Is.; *J. Leidy.*—p. 181, Remarks on Leaves of Coniferæ; *T. Meehan.*—p. 183, Mitchella repens, a dicœcious plant; *T. Meehan.*—p. 184, Second contribution to the History of the Vertebrata of the Miocene period of the U. S.; *E. D. Cope.*—p. 195, Notice of some remains of Horses; *J. Leidy.*—p. 196, Notice of some extinct Cetaceans; *J. Leidy.*—p. 197, Remarks on a jaw fragment of Megalosaurus; *J. Leidy.*—p. 200, Remarks on Conosaurus of Gibbes; *J. Leidy.*—p. 203, The Crocodilian genus Perosuchus; *E. D. Cope.*—p. 205, Notice of American species of Ptychodus; *J. Leidy.*—p. 208, Synopsis of the Extinct Batrachia of North America; *E. D. Cope.*—p. 221, Agaphelus, a genus of toothless Cetacea; *E. D. Cope.*—p. 227, Occurrence of Cupriferous Ores in Texas; *F. A. Genth.*—p. 229, Notice of some American Leeches; *J. Leidy.*—p. 230, Notice of some remains of extinct Pachyderms; *J. Leidy.*—p. 233, Some Cretaceous Reptilia; *E. D. Cope.*—p. 242, The Origin of Genera; *E. D. Cope.*—p. 300, Variations in Taxodium and Pinus; *T. Meehan.*—p. 303, Remarks on the Geology and Mineralogy of Venezuela; *R. P. Stevens.*—p. 305, Sixth Contribution to the Herpetology of Tropical America; *E. D. Cope.*—p. 313, Observations on some extinct Reptiles; *E. D. Cope.*—p. 314, Fruiting of Wisteria; *T. Meehan.*—p. 315, Notice of extinct Insectivora from Dakota; *J. Leidy.*—p. 316, Observations on Reptiles of the Old World, Art. 2; *E. D. Cope.*—p. 323, Notes on some points in the Structure and Habits of the Palæozoic Crinoidea; *F. B. Meek & A. H. Worthen.*—p. 334, Seed Vessels of Forsythia; *T. Meehan.*—p. 335, Remarks on Carboniferous Crinoidea, with descriptions of new Genera and Species of the same, and of one Echinoid; *F. B. Meek & A. H. Worthen.*—p. 359, Descriptions of seven new species of American Birds; *G. N. Lawrence.*—p. 361, Analytical table of the species of Baridius inhabiting the U. S.; *J. L. Le Conte.*—p. 365, Gyrinidæ of America north of Mexico; *J. L. Le Conte.*—p. 373, Species of Agonoderus, Bradycellus and Stenolophus inhabiting America north of Mexico; *J. L. Le Conte.*—p. 383, Annual Reports, etc.

THE

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[SECOND SERIES.]

ART. XXIX.—*Historical and Geographical Notes on the earliest Discoveries in America;* by HENRY STEVENS of Vermont, F.S.A., etc., 4 Trafalgar Square, London.

EXPLANATORY.

IN February last the writer was asked by his brother, Mr. Simon Stevens of New York, President of the Tehuantepec Railway Company, to contribute to his forthcoming book on Tehuantepec, an Historical Introduction on the earliest discoveries in America, and on the routes of commerce of the Old World, tracing their changes, especially so far as they had any direct bearing on his project of Interoceanic Communication by way of the Isthmus of Tehuantepec. The writer accepted the opportunity, not expecting perhaps so much to aid the enterprise as to give shape and expression to certain ideas that had for years been floating and growing in his mind respecting the entanglement, in our earliest charts, of the northeast coast lines of Asia and North America, and the confusion growing out of it, in the early history, geography, and chronology of the new Continent. In reprinting that paper here, with considerable revision and emendation, necessary to harmonize it, he finds it convenient to throw the chief additional matter into an explanatory preface, rather than rewrite the whole.

Recently vast stores of material of American history have been brought to light. Old books and maps have turned up. Bibliography has become an exact science. Documents are scrutinized anew, as they never were before. New historical books have been written, old ones revived, annotated, edited and reproduced, to such an extent that half an American his-

torian's labor, before he begins his narrative, consists in clearing away the rubbish of his predecessors, and in reconciling conflicting authorities. There is something manifestly wrong in this, for the honest Muse of History is not such a muddler. Truth is not so obscured in the other coast lines of this hemisphere.

In 1793 appeared the first volume of Muños' great work. The death of the author prevented its continuation. His manuscripts and his mantle fell to Señor Navarrete, who published in 1825 his first two volumes on the voyages of Columbus, though the learned compiler had been diligently at work in official and private archives since 1789, under the patronage of the Spanish government. Then followed in quick succession, in 1828, a translation into French of Navarrete's volumes, with additions by prominent members of the Geographical Society of Paris. The same year Washington Irving gave to the world his *Life of Columbus*, built confessedly upon Navarrete's foundation. The year 1830 brought forth in London *The History of Maritime Discovery*, followed and cut to pieces the next year by Biddle's *Memoir of Sebastian Cabot*, which in turn was roughly handled in 1832 in Tytler's *Historical View of the Northern Coasts of America.* Finally in 1835–1839, after long and gigantic research, appeared Humboldt's *Examen Critique*, a digest of all that had preceded it respecting the causes that led to the discovery of the New World; the facts and dates of the voyages of Columbus, Vespucci, and others; the earliest charts, etc. This incomparable work was a masterly survey of the whole field of early American geography, and though unfinished has been the parent of innumerable minor productions. The large marine chart of the World by Juan de la Cosa, discovered by Humboldt in 1832, was here used for the first time, and was in many respects the great philosopher's grand card. More recently the labors of Kuntsmann in Munich, of Santarem and Jomard in Paris, of Ghillany in Nuremberg, of Rawdon Brown in Venice, of Bergenroth in Spain, have brought to light valuable original material illustrative of maritime discovery prior to 1492, as well as of the voyages of Columbus, Vespucci, the Cabots, Behaim, and others. Still more recently many subjects of great interest and importance pertaining to our earliest geography have been elaborated by Messrs. LaSagra, Lelewel, D'Avezac, Varnhagen, Major, Peschel, Bancroft, Helps, Parkman, B. Smith, Murphy, Lenox, Asher, Hale, Read, Deane, and not least by Brevoort, until one is ready to exclaim of the old voyagers, Are their ways past finding out? Yet there still exists the old entanglement in the American and Asiatic coast lines and the old confusion in our primitive annals and geography.

A new summing up of North American discovery has appeared in a magnum opus published in April of this year by

the Maine Historical Society, nominally the History of the Discovery of Maine, but really the history of the discovery of the whole eastern coast of North America. This learned work by John G. Kohl, LL.D. is presumed to be the culmination of all that is known and recorded on this vast subject from Adam of Bremen to Kohl of Bremen, and may therefore be held as the present state of the history of North American geography and discovery. There is appended to this volume a remarkable paper on the *four* voyages of John and Sebastian Cabot, by M. D'Avezac of Paris, in which the distinguished French geographer, on several important points, expresses views precisely opposite to those of Dr. Kohl. Both of course cannot be right, but this affords an apt illustration of the present confused condition of our geography. However, whether in all respects the Maine volume will stand the test of criticism or not, the Historical Society of Maine is deserving of high commendation for having so boldly and so honestly put forth this expensive foreign production, amply illustrated as it is with facsimiles (ut vulgo) of no less than twenty-one of the earliest maps. The whole question is now brought down to date and set up between two boards for public view and judgment. No geographer has as yet done the work better, and the only wonder is that Dr. Kohl could have done so much and so well, even from his point of view, in the short time allowed him. But—

Still the writer does not find his cravings for true and exact history satisfied. Eternal may, perhaps, and probably, are the menials of Fiction, seldom of History. Another method of treating our ancient records, he has thought, might possibly throw new light on the old geographical puzzles that have come down to us from and before the Great Discoverer, and reveal the key. The truth is that the history of the early voyages is so bemuddled by recent writers (and the newly discovered old materials seem only to add to the confusion) that nothing short of an entire overhauling of first principles, and resifting of facts, aided by rigid chronology and compound scrutiny, will enable us to take clear observations, to ascertain our bearings and show us whither we have drifted these four hundred years. The writer does not pretend that he is competent to do this himself, though he owns to the consumption of no little midnight petroleum in trying to read old records by the new light. He has attempted, after many years of bibliographical study, to step into the shoes of the old navigators, pilots and cosmographers, to see as they saw, beginning fifty years before, and coming down to half a century after Columbus, taking up the sequence of events as they occurred, and excluding rigidly all subsequent testimony. In the following paper he has given a rapid sketch of some of his observations from this point of view. A few of them are sufficiently startling if true, but require, no doubt,

further elucidation and a full declaration of authorities. These, when space is more abundant. Meanwhile the reader is invited to study well the accompanying photo-lithographic facsimiles of some of the oldest and most important maps and charts pertaining to our coasts. It is not permitted to every one to see and touch the precious originals, scattered and secluded as they are, in various public and private repositories, throughout Europe and America. Not three persons exist probably who have seen them all. The copies here given, imperfect as they are, speak clearly to the eye, and will doubtless repay careful examination, though a few explanations may aid the reader in understanding them.

And *first*, The Portolano, or marine chart of Juan de la Cosa, made by him at Puerto de Santa Maria, near Cadiz, in 1500 [Plate I]. The original, bought at a public sale in Paris about twenty years ago, for the Queen of Spain, against the writer, for 4020 francs, is now preserved in the Royal Library at Madrid. It is on oxhide, five feet nine inches long, by three feet two inches wide, cut square off at the tail, a little beyond the Ganges and Golden Chersonesus, so as to be attached to a roller; and rounded at the back of the neck, so as to be tied with a ribbon when rolled up after the manner of ancient portolani. The whole world is laid down, including the entire 360 degrees of longitude, on a given scale of fifteen Spanish leagues to a degree. The chart is well drawn, in colors and heightened with gold, altogether a work of art of considerable pretention. It is acknowledged by competent judges, to be the earliest, the most important and the most authentic geographical monument relating to the western discoveries that has come down to us. It was not discovered until after Muños, Navarrete, Irving, Biddle and Tytler had written their works, and hence Humboldt used it constantly and with effect in his *Examen Critique*, as well as in his supplemental chapter prefixed to Ghillany's Martin Behaim in 1853. A full sized facsimile was published by M. Jomard, on three double elephant folio sheets, some fifteen years ago. Of the western sheet, or third, not colored, the accompanying reduced facsimile is taken. La Sagra, Lelewel, Ghillany, Kohl and others have used it extensively and described it. All geographers admit its importance, but many raise objections greatly diminishing its authority. These objections have hitherto been deemed unanswerable. They are: *First*, That Cuba is represented as an island in the year 1500, and is misshaped at the western extremity by curving to the south so as to form a kind of gulf, when in fact it was not ascertained to be an island till Ocampo circumnavigated it in 1508, and found it to extend considerably farther to the west than La Cosa's, and having no such curve. *Second*, that the American coast line extending from a point west of Cuba to the *Mar descubierta por Yngleses* gives no proper idea of the Gulf of Mexico, Florida,

New York, Cape Cod and other strongly marked coasts, in fact is mere guess work. *Third*, that the discoveries of the Cabots and Cortereals are not properly laid down, and that the coast line does not resemble that from Cape Race westward. And *fourth*, that "the map has no indication of the degrees of latitude" (Kohl, p. 152) and longitude.

These four objections answered, Juan de la Cosa is vindicated, and his chart becomes *the* authority. Let us look at them. Answer, *First*, that La Cosa, the *Maestro de hacer cartas*, as Columbus styled his chart-maker, did not intend to represent Cuba to be an island (whatever posterity may think of his drawing) is manifest from the following facts. In the spring of 1494 after Columbus, in his second voyage, had sent home from Hispaniola (his Zipangu or Japan) the larger part of his fleet under Antonio de Torres, he resolved with three caravels and about eighty men, to go on an exploring expedition along the south side of Cuba (which he for sometime persisted in naming Juana) supposing it to be continental, or that part of Asia near Mangi. This little fleet reached Cuba on the last day of April at a point named Cabo de Fundabril, first called by Columbus Cape Alpha and Omega, the point where the West ends and the East begins. Proceeding westward they touched at many places, the names of most of which, laid down by La Cosa, can readily be recognized in the narratives of the Cura de los Palacios and Peter Martyr, as well as in later maps. These names are Cabo de Cruz, Cabo del Serpienta, Fumos, Cabo Serafin, Mangni, Mont, Bienbaso, &c. At length they came to a turn in the coast to the southwest. This place Columbus named Cabo de Bienespera, or Cape of Good Hope, a guiding point leading him on toward the Golden Chersonesus, the bourne of his hopes. Here on the 12th of June, 1494, Columbus, being compelled to turn back from shortness of provisions, caused his captains, his pilots, his master of charts, and all his sailors to sign a declaration under oath, that they believed Cuba to be part of the Continent of Asia, near Mangi; and Juan de la Cosa added the further particulars that he never saw and never heard tell of any island 335 leagues long, and hence he believed Cuba to be in Asia. A little further on to the south-southwest, amid shoals and islands, picking his way and grazing the sands, Columbus reached another place which he named Evangelista. Here, from the mast head, one might see coasts to the north, the Bay of Cortes and the Cayos de Indios to the west, and land to the southwest and south, the whole, with islands and keys, appearing continuous so as to form a gulf of considerable extent studded with islets. This body of water Columbus mistook for the Gulf of Ganges! "Indiæ Gangetidis continentem eam esse plagam contendit Colonus," wrote Peter Martyr to Cardinal Bernardino, August, 1495, on the authority of

a letter to him from Columbus himself. This place was the farthest point touched in the expedition, "hanc ultimam existemati continentis oram quam ille [Columbus] attigit, vocavit Evangelistam," again wrote P. Martyr. The Admiral longed to go on down the coast, double the Golden Chersonesus, visit Calicut and Arabia, and so return to Spain, ever going west, but necessity compelled him, the next day, to set his face toward Hispaniola. Here then is the key of this mystery, the parent of a hundred geographical blunders, in later maps. Evangelista is on the west side of the Isle of Pines, the Cape of Good Hope is on Cuba to the N.N.E. near Batabano, and a dash of *green* paint, the conventional color for *terra incognita* in old portolani, marks a "cut-off" and completes the Gulf of Ganges! This simple cut-off shows that all beyond was unknown. Three days more, had Columbus persevered toward the west, would have brought him to the end of Cuba, and dispelled all his grand visions of the Province of Mangi, and the incomparable riches of the Grand Kahn of Cathay. Cuba is then here not an island, but is merely cut off in the usual way by La Cosa himself who was there with the Admiral, and who laid down the track of the whole expedition with marvellous truthfulness.*

The answer to the *second* objection, as to the *American* coast

* Ruysch, seven years later (Pl. 2, No. 3) understood this perfectly, and in his Continental Cuba marked this cut-off more distinctly. He has preserved the "Gulf of Ganges," but has disguised some of the names of places. Cape Seraphin where the white priest was seen, is changed to Cvlcar [c. vicar?] and Evangelista to C. S. Marci, one of the Evangelists. The south side of Cuba is a literal copy of La Cosa's chart laid down from actual survey in company with Columbus himself, but the north side considered as part of Asia beyond Zipangu, is carried up to about 40° N. latitude, above C. Elicontii the same as in Fra Mauro's map of 1457 and Behaim's globe of 1492. The German geographers of St. Dié and Strasburg, (who probably never saw salt water) in their map in the Ptolemy of 1513, probably made as early as 1508, (Pl. 2, No. 1) have copied La Cosa and Ruysch both, making Spaniola and Isabella answer for the Japanese islands, all the names being transferred to their Continental Cuba with most of the names of La Cosa and Ruysch Italianized, and almost obscured in the transfer. Corveo, Anterlinoi, Cvlcar and Lago de Loro of Ruysch become Coruello, G. delinor, C. lurcar, and lago dellodro in the 1513, while C. Elicontii becomes C. delicontir. La Cosa's Mar Oceanus, north of Cuba, becomes C. del mar usiano and is carried up to latitude 54°. The Gulf of Ganges is not only preserved, with all the islands of La Cosa, but the three mouthed Ganges itself is made to empty into the gulf! All this *Terra de Cuba* was thought somehow, to pertain to Asia, for no one yet had dreamed of an intervening continent. The north side of Cuba in La Cosa's chart, west of Rio Mares (the farthest point reached by Columbus in his first voyage, the 31st of October, 1492,) is colored as *terra incognita* having no defined coast line. The very accurate manner in which the whole coast eastward of this point is laid down renders it almost certain that La Cosa accompanied Columbus also in his first voyage as his Maestro de Cartas. If so, considering his subordinate position, may not this be in substance the long lost chart of Columbus? The names written in full are rio Mares, rio Luna, Cabo de Cuba, punta de Mar Nuestra Señora, punta de Santa Maria, Cabo Rico, Puerto Santo, rio de la Vega, Cabolindo and ponta de Cuba, corresponding almost exactly with the log book or journal of Columbus as preserved by Las Casas. It should, however, be mentioned that Senhor Varnhagen, in his valuable work on Vespucci, printed in Lima, in 1865, differs from the writer, interpreting these to be the Mississippi River, the Gulf of Mexico and Florida.

line from the west of Cuba to Bacalaos is simply that La Cosa intended that line for Asia. In 1500 neither he nor anybody else suspected or dreamed of an intervening Continent. La Cosa projected a map of the whole world, the Eastern Asia of Marco Polo and Sir John Mandeville included. Cutting his map off at the Golden Chersonesus, beyond the Ganges, so as to attach it to a roller, how else could he complete Asia and the 360 degress of longitude but by the line he drew on the other side of the globe? Asia and America are not *both* laid down. Which is omitted? If this line be the unknown new Continent, what has he done with the well known part of the old Continent? Furthermore, where are Zipangu and the islands of the Eastern Archipelago described by Marco Polo and so ardently sought by Columbus? If Cuba be Zaiton or Mangi, surely Hispaniola must be Zipangu [Pl. 2, No. 3]. How else could Columbus reason? Let it be borne in mind that there is great similarity in the coasts of Eastern Asia and America. From all this it is apparent that La Cosa and his map are not responsible for erroneous conclusions drawn by modern geographers.

The *third* objection, respecting the coast line of the Cabots and the Cortereals, from Cape Race westward, may be met by the fact that La Cosa has laid down no such line. Cape Race is in latitude 46° 40′, and Cape Sable in Nova Scotia, is 43° 24′. La Cosa's coast line in the north, marked by five English flags, begins at latitude 53° N., that is the Straits of Belle Isle, and extends very nearly west to the meridian of the Virgin Islands. It is, in short, the northern coast of the Gulf of St. Lawrence, pretty accurately depicted. Of course it is to be understood that the Cabots in 1497, as well as La Cosa in 1500, supposed this coast to be in Eastern Asia. This chart carefully compared with Sebastian Cabot's map of 1544 [Pl. 4, No. 1,] and studied with the new material lately brought to light by Mr. Rawdon Brown in Venice, and Mr. Bergenroth in Madrid, will, it is believed, harmonize well, as contemporary documents, and throw into the shade the loose gossip, long after date, reported by Butrigarius and Peter Martyr. The words *Mar descubierta por Yngleses*, instead of *Mar Oceanus*, show it to be a sea or gulf and not the open ocean. If the reader will lay down on La Cosa's chart Newfoundland, Cape Briton Island, Nova Scotia and New Brunswick in their proper latitudes and longitudes, he will doubtless be surprised at the result, especially when he compares it with the map of F. G. in Hakluyt's Peter Martyr of 1587 [Pl. 3, No. 1]. The discoveries of the Cortereals could not have been known by La Cosa in 1500.

The *fourth* objection is answered by simply looking for a moment at the original map, or at M. Jomard's facsimile, and not at the imperfect ones generally in use. The indications of latitude and longitude are abundant, and there is a good scale both

at the top and the bottom of the chart. The equator is given, and the tropic of Cancer, 23½°, and guiding lines or parallels pass through the Straits of Gibralter 36°, and Paris 48° 40′. These fixed points, with the scale, will help the reader to the latitude of any other place. Longitude can be determined in a similar way.

The eclipse that took place in Sept, 1494, immediately after his return to Hispaniola from Cuba, was a most important event for Columbus, because it enabled him to determine the longitude of his discoveries. He found that the middle of Hispaniola was nearly five hours west of Seville, or about 70°. La Cosa's scale marks this distance to be about 68°, sufficiently near, considering the mode of measuring time then, before Copernicus had commanded the sun to stand still. Columbus' mistakes in latitude are difficult to be accounted for, but they do not affect the observations of the Cabots in the north, or those of Vespucci and Ojeda in the south, as laid down by La Cosa.

Now if these objections are fairly answered, La Cosa not only emerges cleared from a vast amount of unjust criticism, but his chart becomes a beacon of light in the early annals of America. It tells posterity, as it is told nowhere else so truthfully, of Columbus, his discoveries and his mistakes, and depicts in honest lines just how far the Great Explorer groped his way blindfolded toward the west. The American historian has no longer any difficulty in tracing the track of Columbus to the very end, and accounting for the true and the false lines in his continental or Asiatic Cuba. He sees how the Asiatic lines grew in the map of Ruysch of 1508, while those of La Cosa remained the same; how also in the maps of Bernard Sylvanus in 1511, of the Gymnasium of St. Dié in 1513, of the Margarita Philosophica in 1515, of Apian and Schoner in 1520, of Bordone in 1521, of Lawrence Fries in 1522, of Orontius Fine in 1531, and of Sebastian Muenster in the Grynaeus of 1532. In all these old maps the geographer can at a glance, now that the key is recovered, trace the true coast lines, for he knows the origin of the false ones, thanks to painstaking La Cosa. Considering the state of grographical, astronomical, and nautical knowledge at that time, and the muddle of the map-makers, it is not to be wondered at that the discoveries of Balboa, of Magellan, of Cortes, of Ponce de Leon and Ayllon, led to some bewilderment, and puzzled even the *cognoscenti* of the Congress of Badajos. Before 1520 the Portuguese began to comprehend better the longitude of the Moluccas and other of their possessions in the East, and geographers began to suspect an intervening space not accounted for. At first strange guesses were recorded as to the extent and direction of the South Sea, by Schoner and others, but after the appearance of the map of Cortes [Pl. 4 No. 7] in 1524, the culmination of absurdity appeared in the elaborate double-hearted projection of Orontius Fine in July, 1531 [Plate 3, No. 3 and 4]. Schoner in describing his own newly improved globe in 1532, exactly describes this map. The South Sea was represented as south of the equator, while Asia was brought forward to Bacalaos. One can readily see how all this grew up, as one can also see how, by slow degrees, their false Asia receded and melted away, for above 200 years, as the western coast of America and the eastern coast of Asia were explored by Spanish, English, French and Russian navigators, till the year 1727, when a strait was opened by Behring, and Asia and America became divorced.

It was the writer's intention to try and trace out the history of the first exploration of the entire coast of the United States, until the last thread of the Asiatic line was expunged by Capt. John Smith before 1614. But that labor, even if he had time and space, is reserved for an abler pen. The Rev. Dr. Leonard Woods, late President of Bowdoin College, has on the anvil as already announced, for the Maine Historical Society's next volume, an original unpublished manuscript of Richard Hakluyt, of the highest historical and geographical interest. It is entitled "A particular discourse concerning the greate necessitie and manifold comodyties that are like to grow to this Realme of Englande by the westerne discoveries lately attempted, written in the yere 1584, by Richarde Hackluyt . . . at the requeste of Mr. Walter Raleigh before the comynge home of his two Barkes [from Virginia]" &c. This invaluable manuscript, consisting of sixty-three large closely written folio pages, was in the possession of the writer for two or three years, having fallen into his hands some sixteen or seventeen years ago by a piece of good luck, after a bibliographical tournament memorable as any recorded by Dibdin. After fruitless

endeavors to find for it a resting place in some public or private library in America, and subsequently in the British Museum, it finally became the property of Sir Thomas Phillipps. So impressed was the writer with its importance that immediately on learning the object of Dr. Woods' mission to England in the autumn of 1867, he called the Doctor's attention to it, and suggested his procuring a copy, if possible, for publication by the Maine Historical Society. He trusts soon to have the pleasure of seeing Richard Hakluyt again in print, not alone because he is an old friend, but because he is likely to render any further discussion of the present subject, on the part of the writer, superfluous.

Historical and Geographical Notes, 1453—1530; by HENRY STEVENS, of Vermont, F.S.A., etc., Trafalgar Square, London.

A retrospect of four centuries, with a rapid glance at the progress of modern discovery, exploration and invention, will probably serve as an appropriate introduction to our projected scheme of Interoceanic Communication by means of the Tehuantepec Railway, and show that the time is near at hand for its accomplishment. Let us, therefore, go back for a moment, and survey the little old world and its inhabitants as they appeared about the middle of the fifteenth century. According to Ptolemy, the best recognized authority, whose geography had stood the test of thirteen hundred years, the then known world was a strip of some seventy degrees wide, mostly north of the equator, with Cadiz on the west, and farthest India or Cathay on the east, lying between the frozen and burning zones, both impassable by man. The inhabitants, as far as known in Europe, were Christians and Mohamedans, the one sect about half the age of the other. Christendom, the elder, that once held considerable portions of Asia and Africa, had been driven back inch by inch, in spite of the Crusades, even from the Holy Land, the place of its birth, up into the northwest corner of Europe; and both in lands and people was outnumbered six to one by the followers of Mahomet. For seven hundred years the fairest provinces of Spain acknowledged the sway of the Moors, and the Mediterranean, from Jaffa to the Gates of Hercules, was under their control. The crescent was constantly encroaching on the cross; while Christendom, schismatic, dismayed, demoralized and disheartened, seemed almost incapable of further resistance.

India beyond the Ganges, from the days of Moses, Alexander, and Aristotle, to say nothing of the geographers Pomponius Mela, Strabo and Ptolemy, was deemed the land of promise, the abode of luxury, the source of wealth, and the home of the spices; but the routes of commerce thither, via Venice and Genoa, by the Red Sea, Egypt, the Nile, Arabia, Asia Minor, the Black and Caspian Seas, through Persia and Tartary, were one by one being closed to Christians. The profits of the overland carrying trade were mostly in the hands of the Arabians, who inherited it from the Romans; but Memphis, Thebes, and Cairo, that flourished by it, had declined as it fell off, and yielded

to Alexandria nearer the sea. Finally, in 1453, Constantinople, the Christian city of Constantine, fell into the hands of the Turks, and with it the commerce of the Black Sea and the Bosphorus, the last of the old trading routes from the East to the West. Christendom for a time was disconsolate, and could only "pray for the conterition of the Turks." The whole of the carrying trade passed into the hands of middle men or agents, who passed goods without news, and India became more a land of mystery than ever; but this apparent misfortune proved to be the beginning of a new and brighter era.

The learned Christians of Constantinople, with nothing but their heads and their books, fled in exile into Italy, and became its schoolmasters. At once began there the revival of learning, which soon extended throughout the West. "Westward the course of empire takes its way." The Medici family of Italy, at Venice and Florence, welcomed these learned Greeks, and bought their precious manuscripts of ancient lore. The gunpowder of Europe had already silenced the Greek Fire of Asia. On the Rhine the young printing press was just giving forth its first sheets. The compass and the astrolabe, recent inventions, began now to give confidence to mariners and teach them that, though the old paths of trade overland were closed, they might venture on new ones over sea. In 1453, in western Europe there was no tea, no coffee, no tobacco, no Indian corn, no potatoes; and many of the necessities of our day were not even known as luxuries. Though the Crusades had failed in their immediate objects, they had exposed the secrets of the India trade, and the vast revenues of the eastern cities. The manuscript travels of Marco Polo and Sir John Mandeville had found their way into the hands of thinking men. Venice was already waning, preparatory to yielding its trade to Portugal, the then most rising and active maritime power. Prince Henry the Navigator had still ten years to live to carry out his great schemes of discovery and exploration of the western coast of Africa. He was an ambitious student of geography, history, mathematics, astronomy, and navigation, and for almost forty years had stood alone. At the early age of fifteen he had a successful brush with the Moors at Ceuta, opposite Gibraltar; and by 1418 had crept down the coast of Africa to Cape Nun, lat. 28° 40′, the southern boundary of Morocco. In 1434 his captains doubled Cape Boyador, and seven years after obtained from Pope Martin V. a grant to the crown of Portugal of all he should discover from this cape to the Indies. In 1442 Rio del Oro was reached, and gold and negro slaves brought back. These were two real stimulants to Portuguese discovery, avarice, pride, and wealth, though the conversion of the infidels to Christianity, was, no doubt, a strong additional motive power. The reintroduction of negro slavery, and the part it soon played in com-

merce and the world's progress, may be ascribed to Prince Henry. He encouraged the traffic, which, with the love of gold and the hatred of the Moors, aroused his countrymen to his projects, and insured the promotion of discovery, in so much that by the time of the fall of Constantinople, his captains had reached Cape Verde, lat. 14° 45′ N., probably a few degrees beyond, and had exploded the old theory of a boiling belt about the equator.

In all ages there had been a prevailing notion that one might sail round Africa; but when once it was demonstrated that Portuguese sailors could cross the equator and survive, Prince Henry's vague idea of reaching the land of spices by this route was confirmed. At all events, he was schooling hardy sailors, and training them for bolder work, so that soon after the date of the fall of Constantinople, Italy and Portugal had reached that turn for adventure and enterprise, which spread like wildfire throughout the other states of Europe, and caused the entire revolution in the commerce of the world.

In 1453, Columbus was a lad of six years at Genoa, Vespucci of two at Florence and John Cabot a youth at Venice. The new learning at once took deep root. When these three Italian boys became men, behold how changed! The sciences of mathematics, astronomy, and navigation had grown with their growth, and developed with marvelous rapidity. The press had spread broadcast the learning of the ancients. The secrets of the earth were inquired into and revealed. Many islands of the Atlantic had been discovered and described, and sailors knew the coasts of Europe and Africa from Iceland to Cape Verde. But above all, the knowledge of the sphericity of our earth was no longer confined to philosophers. Alexander had told Aristotle what he knew of the East, and Aristotle had written down that there was but a small space of sea between Spain and the eastern coast of Asia. Strabo had said that nothing stood in the way of a westerly passage from Spain to India but the great breadth of the Atlantic Ocean; but Seneca said this sea might be passed in a few days with favorable winds. Pomponius Mela and Macrobius put in like testimony, with certain difficulties about passing burning zones, and the earth being shaped like an egg floating in water. All these opinions were rehashed and digested by Ptolemy of Alexandria, in the second century, who first properly reduced the globe into 360 degrees of latitude and longitude. In latitude he was as correct as he was incorrect in his longitude. Roger Bacon, an Englishman, again summarized these theories in his *Opus Majus*, in the thirteenth century; and in the fifteenth century, Pierre d'Ailly, a Frenchman, reviewed the whole question, bringing together the opinions of the ancient writers named, as well as the fathers of the church, including modern philosophers, travelers, and theologians, es-

pecially Roger Bacon, Marco Polo, and Gerson, and gave to the world his well-known *Imago Mundi.* This celebrated work, finished in 1410, was afterward the guide, companion and friend of Columbus. The learned author was for three years Provost of the ancient Ecclesiastical College of St. Dié in Lorraine, away up in the Vosges Mountains, in the remotest corner of France. This was on the very spot where, nearly a century later, in the Gymnasium within the same precincts, a confraternity of some half dozen earnest students, lovers of geography, of whom the poet Mathias Ringman was the soul, in a little work called *Cosmographiæ Introductio*, printed there in the kalends of May, 1507, suggested that the *Mundus Novus* of Vespucci should be named America, after a man, inasmuch as Europe and Asia had been named after women. Thus a little mountain town of France first gave aid and comfort to Columbus and afterwards a name to the New World.

As early as 1474, Paul Toscanelli, a learned physician of Florence, sent to Columbus a Chart made after the narrative of Marco Polo, and was in correspondence with him on these very subjects, showing that even then the plans of Columbus were maturing. In 1478, the great geographical work of Ptolemy, with the twenty-seven beautiful copper plate maps, was printed at Rome, and about the same time many other of the ancient historians, poets, philosophers, mathematicians, and astronomers saw the light. The *Imago Mundi* was printed at Louvain, in 1483, and there still exists at Seville, Columbus' own copy, with manuscript notes said to be his, discovered and described about forty years ago by our countryman, Washington Irving.

Meanwhile, the work of discovery and exploration was earnestly pursued by the Portuguese. In 1454 Prince Henry secured the services of Cadamosto, an intelligent Venetian, well acquainted with the trade of the Mediterranean and the East, and sent him down the coast of Africa, where he reduced the explorations and the trade to order, and pushed southward the discoveries to the Cape Verde Islands by 1460, the year of Henry's death. By 1462 Pedro de Cintra had crept down the coast to some 300 miles beyond Sierra Leone. In 1463 Gibraltar was captured by Spain from the Moors. Kings Alphonso and John continued the African discoveries with so much energy that, after Diogo Cam's passing Congo in 1484, the bold captain, Bartholomew Dias, reached the Cape of Good Hope, and looked beyond it in 1487, thus completing with marvelous perseverance an exploration of some six thousand miles of coast line in seventy years. Bartholomew Columbus was in this last expedition.

Meanwhile King John had sent overland through Egypt Pedro de Covilham, to India and Eastern Africa to gain information and report. In 1487 he reported that he had visited Ormuz, Goa, Calicut, etc., and had seen pepper and ginger, and heard

of cloves and cinnamon. He visited the eastern coast of Africa, went down as far as Sofala, and returning northward, sent a message to King John that he had learned for certain that if Dias should pursue his course round Africa he would reach India over the Eastern Ocean via Sofala. This theoretical discovery of Covilham exactly coincided with the practical one of Dias.

All these events were but leading up to the grandest discovery the world ever knew, but it is difficult to trace the precise origin and the gradual development of the plans of Columbus. We know, however, that at the early age of fourteen he went to sea, educated with small knowledge of Latin and less Greek; and in 1474, at the age of twenty-seven, was in correspondence with Toscanelli, and became the father of Diego, the boy for whom, some ten years later, he begged a night's lodging at the Convent of La Rabida. By the year 1487, when the mystery of a path to India around Africa was solved, he had not only completely worked out his great idea of sailing West to find the East; but had offered his services in carrying it out, first to his native city, Genoa, without success, and had two years before brought it to Spain from Portugal where his proposals had been openly spurned and ridiculed, but treacherously though unsuccessfully tested. It is tolerably certain that much of his time had been spent in active and practical maritime service, for he had been down the coast of Africa as far as El Mina; had resided at Porto Santo, one of the out-lying Portuguese islands of the Atlantic, the daughter of whose first governor had become his wife; had visited England and Iceland, and was acquainted with the whole of the Mediterranean. His brother Bartholemew had been a chart-maker at Lisbon, and was his advocate at the court of Henry VII.

We know from the writings of his son Ferdinand that Columbus was both a practical and a learned mathematican as well as navigator. He had read probably all the compilations named above, and his own experience, together with what he had learned from the Portuguese, had enabled him, with his Marco Polo in his pocket, to sift all the vague and contradictory notions of the ancients as to the Antipodes and the shape of our earth, as well as to cypher out a theory of his own. For seven long years, after being worn out and disgusted elsewhere, he danced attendance on the Spanish court, with no fortune but his idea; sometimes threadbare and barefooted, ever pressing his suit, never flagging in his confidence, questioned and ridiculed by commissions of geographers and scientific men, without ever being able to penetrate the conservative ignorance of the learned and courtly, or, as he complained, to convince any one man how it was possible to sail west to reach the East. But Time was working for him then, as it is now for Interoceanic Communication.

The fortieth year from the fall of Constantinople, the forty-fifth of the age of Columbus, witnessed the death of Lorenzo de Medici; but other suns were rising. Copernicus, in the far north, was in his twentieth year; Erasmus, his twenty-fifth; Cortez, his seventh; and Luther, his tenth. Martin Behaim, the old geographer of the Azores, aged sixty-two, was home on a visit to his native city of Nuremberg, from which the tide of commerce was ebbing. Here, in 1492, he made his famous globe of the whole world, as if to lay down upon it all the knowledge (and all the ignorance) of the geography of the earth, preparatory to the opening of new books. The same eventful year witnessed the expulsion of the Moors from Spain, the opening of the Mediterranean, and the discovery of America. Mohamedanism received its first check, and Christendom received a New World. These three Italian boys had become men. When Columbus had balanced his egg for Spain, it was easy for Vespucci and the Cabots to do it for Portugal and England. Italy, whose noble sons did this in foreign service, never acquired a foot of the newly discovered lands for herself, yet how much of the honor was and still is hers.

In 1493, within three months from the return of Columbus, Alexander VI, a Spaniard, a Pope of not a year's standing, wishing to reward Ferdinand and Isabella, for their struggles in expelling the Moors, divided our globe into two parts, by a line of demarcation passing from pole to pole, one hundred leagues west of the Azores and Cape Verde islands, giving to Spain all she should discover within 180° to the west of it, leaving to Portugal all her African discoveries and the Indies for 180° east of it. But poor Portugal, that had been struggling seventy years in the dark in her circuitous route to India round Africa, jealous of the new short cut of Columbus, which had been offered to her and refused, protested against the position of this meridian. It was finally settled in the treaty of Tordesillas, of June, 1494, with the Pope's approval, that the line should stand at three hundred and seventy leagues west of the Azores. Had the King of Portugal's geographers and pilots advised him to contend for a line farther east instead of farther west, he would have received within his half the Moluccas and the other Spiceries. As some compensation for this geographical blunder, however, he secured a foothold in Brazil. Both nations were now running a race of discovery of India by divers routes. By India is here meant all the East beyond the Ganges, including China, Cathay, Mangi, Japan, and the Spice Islands. The acquisitions of the Spaniards were named the West Indies, while those of the Portugese were called the East Indies.

Never was great discovery more modestly announced. "*A Letter of Christopher Columbus, to whom our age is much indebted,*

respecting the Islands of India beyond the Ganges lately discovered," dated February, 1493. Columbus thought his success complete. He aimed at Zipangu, or Japan, and to his dying day in 1506, believed that he had found it nearly where his calculations had placed it, but never was man more mistaken, and never did mistake produce greater results. Believing our earth to be a globe, Columbus reasoned correctly that by sailing west he would come to the East of Marco Polo, but from want of knowledge of longitude, he, like everybody else, from Ptolemy down, was vastly deceived as to the size of the globe. From Cadiz to the Ganges the distance had been computed from the days of Alexander at about 180°, or half round the globe. From the Ganges to the Corea and Cathay, and thence to Zipangu fifteen hundred miles more, the distance was also exaggerated by Marco Polo. So that, still going east, the distance from Zipangu to Cadiz was calculated to be about equal to the space from Palos to Saint Domingo. Upon this error in longitude hung no doubt the problem of circumnavigating the globe, for had Columbus suspected the real distance to Japan by the west, he would never probably have ventured to penetrate the "sea of darkness," or have found sailors bold enough to accompany him. The actual distance from San Francisco to Hong Kong is nearly one-third more than Columbus had reckoned it from Spain to Japan.

The sensation produced throughout Europe by this discovery of a short and direct route to India was great, but for nearly forty years nobody suspected the truth. The simple letter of Columbus in various editions, in prose and verse, was about all that was published for ten years, but the intelligence gave a new impulse to maritime discovery and commercial enterprise. Columbus, with full honors, sailed in 1493, with a well equipped fleet to explore his Eastern Archipelago. He returned to Spain in June, 1496. Juan de la Cosa, author of the world-renowned portolano of 1500, went with him as Master of Charts in this second voyage. They proceeded directly to Dominica, one of the Windward Islands, thence to Porto Rico, St. Domingo, south side of Cuba, Jamaica, &c.

The Portuguêse now redoubled their energies, and in 1497–98, Vasco da Gama, just ten years after Dias' discovery of the Cape, circumnavigated Africa and reached Calicut. The same year John Cabot under a Patent of Henry VII, dated March 5, 1496, in trying for a short cut to Cathay by the northwest, discovered certain islands, probably in the Gulf of St. Lawrence, and took possession, supposing them to be off China, and erected conjointly the flags of England and Venice, on the 24th of June, 1497. The next year Sebastian Cabot, under a supplemental license dated Feb. 3, 1498, sailed again with the view

of planting a colony and promoting trade, but no contemporary account of the voyage being known, it is difficult to extract any reliable information of this failure from the confused gossiping reports that have come down to us. The discoveries of 1497 were in 1498 reported to the kings of Spain by their vigilant ambassador in London, with the intimation that he had seen John Cabot's chart, and would send home a copy of it. What steps followed it is difficult now to trace, but the result appears to be that Henry VII, never following up the discoveries after 1498, Sebastain Cabot remained quietly at home till after the death of Henry, when in 1512 he took service under the king of Spain, permitting his English and Venetian rights of discovery and plantation to lapse. Thus ended the first English and Venetian attempts to reach Cathay by the northwest.

On the 30th of May, 1498, in his third voyage, Columbus first touched the continent of America in Venezuela, though some contend that Vespucci had anticipated him by nearly one year. The natives called it Paria, and Columbus reasoned himself into the belief that it was Paradise, whence our first parents had been driven. In 1499, Vicente Yañez Pinzon and Alonzo de Ojeda, private traders, with the latter of whom was Vespucci on his second voyage, visited Brazil under Spanish flags; and in 1500 Brazil was discovered accidentally (?) by Cabral, in that great fleet which the success of Gama had called forth. He was blown out of his course on his way to India, and took possession for the Portuguese. Portugal thus gained undisputed possession of Eastern Brazil by rule of ignorance of longitude, claiming it as hers because it was east of the line of demarcation. All the science of Spain at that time could not disprove this, and therefore Pinzon abandoned it to the Portuguese. The same year the Portuguese hearing of the voyages of the Cabots, and probably suspecting irreverence in the English for Papal bull lines of demarcation, sent Gaspar Cortereal to follow in their track, who returned in the fall of 1500. Between May 15 and the 8th of October, 1501, a second voyage with two ships was made by Gaspar Cortereal, and laborers (slaves) brought back to Lisbon, but Gaspar himself never returned. A third voyage was undertaken by Miguel Cortereal from Lisbon to the northwest the 10th of May, 1502, in search of his brother, but no tidings ever came back. Then the king dispatched two more vessels to cruise in search of the missing ones, but they returned without any trace of the lost brothers, and thus ended the Portuguese attempts to reach Cathay by the northwest.

In 1501 New Granada, Darien, and Panama were taken possession of for the Spanish by Bastides, and in 1501–2 Vespucci explored the coast of Brazil for the Portuguese, it is said, as far as 50° S. lat., within two or three degrees of the strait, and in

1502 there was written an account of his expedition, which was soon after printed, under the title of *Mundus Novus.* The years 1502 to 1504 were occupied by Columbus in his fourth and last voyage, in which he was accompanied by his brother Bartholomew, and his son Ferdinando who afterwards wrote a life of his father. He explored the coasts of Central America from Truxillo in Honduras to Darien, still looking for the Ganges and inquiring for the home of the Grand Kahn. An account of this voyage, coming down to July 7, 1503, was printed at Venice in 1505.

In 1502 Valentim Fernandez, a German, attached to the household of the ex-queen of Portugal, edited and printed at Lisbon a collection of voyages in the Portuguese language, comprising Marco Polo, Nicolo Conti, Santo Stephano, &c., with a view of stirring up the people to a more lively interest in the commerce and navigation of the Indies. The success of Columbus and the Cabots is referred to, and the speedy return of Cortereal from the north, from his second voyage, is expected. This magnificent folio volume, the first important book (not biblical) printed in Portugal, must have had a powerful effect in drawing popular attention to the land of spices. It was the first collection of voyages printed in the vernacular tongue, and could be read by all the unlearned who had a penny to venture. It was translated into Spanish, and printed at Seville in 1503. No rarer books are now known to geographers. In May, 1507, the four voyages of Vespucci were published for the first time together, in Latin, at St. Dié, in France, as before stated, as an appendage to a little work on cosmography, a science which now began to assume new and startling importance.

On the third of November, the same year, there was published in Italian, at Vicenza, a most important collection of voyages under the title, *Countries newly discovered, and the New World of Albericus Vespucci*, containing accounts of the voyages of Cadamosto to Cape Verde, in 1454–5; of de Cintra to Senegal, in 1462; of Vasco da Gama, in 1497–1500; of Cabral, in 1500–1; of Columbus (three voyages) 1492–1498; of Alonzo Negro and the Pinzons; of Vespucci (four voyages); of Cortereal, &c. This work was the next year, 1508, printed in Latin and German.

All these new geographical works hitherto printed, it will be perceived, pointed to the same thing, enlightenment of the public as to India beyond the Ganges, and how to go and trade thither. In 1508, for the first time in print, all these discoveries were collected and laid down in a beautiful copper-plate map, by Johann Ruysch, a German who had probably* visited

* Beneventanus says "Joannes vero Ruisch Germanus Geographorum meo judicio peritissimus, ac in pingendo orbe diligentissmus cujus adminiculo in hac lucubratiuncula usi sumus, dixit, se navigasse ab Albionis australi parte; et tamdiu

the new found islands with the Cabots, and knew well what he was doing. It appears in the Ptolemy of 1508, published at Rome, accompanied by *A new Description of the World, and the new Navigation of the Ocean from Lisbon to India, by Marcus Beneventanus.* A careful study of this map and its descriptive text, if we exclude all subsequent publications, and look at the world as seen by the geographers of that day, will greatly aid us in clearing up many apparent inconsistencies.

Ruysch lays down three distinct and independent fields of discovery. First, the Archipelago of Columbus in the center, filling a space of above a thousand miles from north to south, and open to India. This part of the map was no doubt laid down from Columbus' own letter, the only authority, in 1507, existing in print. He had, indeed, coasted along Paria from Trinidad westward, in June, 1498, as Pinzon, Ojeda, and others did subsequently, supposing it to be another large island, or part of the mainland of Cathay, but nothing of this had then been printed. Second, the *Mundus Novus* of Vespucci, being the eastern coast of South America from Darien to Upper Patagonia, one vast Island with an unknown background. The authority for this was what has since been called Vespucci's "Third Letter," first printed at the end of 1502, or probably early in 1503. And third, the discoveries of the Cabots and the Cortereals in the north, represented by them as part of the mainland of Asia. This portion of the map is only Marco Polo's description of Cathay extended considerably to the northeast, and modified by the experience, probably, of Ruysch himself, and the information he gathered from the Bristol men, when he was with them in 1497–8 and the discoveries of the Cortereals.*

quo ad subparallelum ab subæquatore ad boream subgradum, 53, pervenit; et in eo parallelo navigasse ad ortus littora per angulum noctis atque plures insulas lustrasse, quarum inferius descriptionem assignabimus." *Anglicé:* But John Ruysch, of Germany, in my judgment a most exact geographer, and a most painstaking one in delineating the globe, to whose aid in this little work I am indebted, has told me that he sailed from the south of England, and penetrated as far as the 53d degree of north latitude [straits of Belle Isle], and on that parallel he sailed west toward the shores of the East [Asia], bearing a little northward [*per anglum noctis*] and observed many islands, the description of which I have given below.

* The chart of Juan de la Cosa, representing the then known world bearing the date of 1500, is not overlooked, but its significance, so far as the coast line of the United States is concerned, has been so manifestly distorted by every one who has described it, from its discovery by Humboldt in the library of Baron Walckenaer, nearly forty years ago, down to the present day, that the writer hesitates to venture his opinion. But by long study and comparison of this with other early maps, especially with those of Ruysch and Peter Martyr of 1508 and 1511, he is convinced that the coast line, from the most westerly of the five English flag-staffs marking the extent of Cabot's discoveries southward and westward, to a point west of Cuba, precisely like the map of Ruysch seven or eight years later, is laid down as the northeastern coast of Cathay, from the descriptions of Marco Polo. If our Maine friends, therefore, will place behind their red line border, Marco Polo's name *Mangi*, they will see that this territory is farther "down East" than is generally supposed.

Columbus had placed his discoveries in the Indian Archipelago beyond the Ganges, and the world accepted the names he gave to the separate islands. No new general name was required. The discoveries of the Cabots and the Cortereals being also in

being indeed eastern Asia. The word Cuba, instead of *Juana*, the name given by Columbus, and the fact that it is represented as an island have been strenuously objected to by geographers, but both these objections will be answered in another place. [See preliminary preface.]

La Cosa perished in Ojeda's mad expedition in Dec., 1509. He was a clever fellow, and a great favorite, and used to boast that he knew more of the geography of the new lands than did Columbus himself. Indeed, of all others, says Peter Martyr in 1514, his charts were the most esteemed. His knowledge and experience were great, for he had been, between the years 1493 and 1509, on no less than six exploring expeditions, either as Master of Charts or commander, with Columbus, Ojeda, Vespucci, and Bastides, and had visited repeatedly the entire coast, from Paria to Uraba, and thence on his own account, north to the middle of Yucatan, as well as most of the islands in Columbus' vast Archipelago. When with Bastides, in 1501–2, he found that the Portuguese were meddling on the wrong side of the line of demarcation, endeavoring, probably, to find a shorter route to Calicut via Darien, and therefore, on his return to Spain, La Cosa was sent to Lisbon to remonstrate against this enroachment. He was there imprisoned and was not released till August, 1504. Nothing daunted, the next year, 1505–6, he went on an exploring and trading expedition of his own to Uraba and Panama, and on another similar one in 1507–8. On the 11th of November, 1509, he embarked with Ojeda from Hispaniola, and perished soon after. From this it will be seen that he might be in Spain chart-making, from June to October, 1500; from September, 1502 to 1504, autumn, (except when in prison in Lisbon); and again parts of the years 1506–7, as well as parts of 1508–9. He had, therefore, ample time, if necessary, to touch up his great chart of the world, made and dated in 1500, but a careful examination of the whole chart will show that it gives no information later than its date. The date is positive, and there is probably no reason to doubt it. But as his own discoveries and explorations west of Mont San Eufemia towards Uriba, Darien and Panama made from 1501 to 1508 are not laid down, is it not probable that the chart had passed out of the maker's possession, and was therefore beyond his reach for retouching? There are many other points for discussion, but as the writer has never had under his eye the original chart, but judges only from M. Jomard's excellent colored fac-simile on three double elephant folio sheets, he feels that he is treading on ticklish ground. The fac-similes (greatly reduced in size) given by Humboldt, Ghillany, Lelewel, Kohl and others, are in many respects defective, and tend to mislead the student, inasmuch as the coloring, and the lines of latitude and longitude are left out. Some names are misplaced and others are misspelled, while many important ones are omitted altogether. Only the western sheet or third, is given (except by Humboldt). But it should not be forgotten that the chart is intended to represent, on a plain, the entire globe as far as known in 1500. There is a broad green border above and beyond the Ganges, showing that the northeast of Asia is *terra incognita*. But La Cosa had the same authorities up to the Polisacus river and bay, in latitude 52° north that Behaim had for his globe made in 1492. Hence the two works agree remarkably well, but La Cosa, taking advantage of the seven years progress in geography, has attempted to complete Asia by laying down its northeastern coast on the other side of the globe, from somewhere about Zaiton in the Corea, to and some thirty degrees eastward, beyond the Polisacus river and bay, through the kingdoms of Gog and Magog, and thence by a dream line connecting Asia with the discoveries of the Cabots and the Cortereals. The Polisanchiu river of Fra Mauro in 1457 is the Polisacus of Ruysch and the Ptolemies of 1511, 1513, 1535, and 1540. These and the Posacus of Schoner, the Puluisangu of Ortelius, and Pulisangu in later maps, are probably the Amoor river of our day. At all events, the river and bay are in eastern Asia, are about 50° to 52° north latitude, and therefore, America on La Cosa's chart cannot extend further west than the left flagstaff, the meridian of Porto Rico. The three rivers on the three reduced fac-similes are not in the original map of La

the East, were so recognized as they placed them, and required no new general name, but their names of particular localities, such as Terra Nova and Bacalaos, were adopted. But as to the *New World* described by Vespucci, the case is different. This large country was undoubtedly new, and as his was the first description of it printed, his friends of the Vosges Mountains, lovers of geography, sought very properly, in 1507, to compliment him by giving it, instead, the beautiful name AMERICA. This was done without the knowledge of Vespucci, and was never intended to interfere with the just rights and claims of Columbus. The truth is, there was then no other book in print describing Brazil but Vespucci's very simple and interesting letter, written (but in what language it is doubtful) probably immediately after his return in September, 1502. He gave the country he described no name, but the translator into Latin entled his little tract *Mundus Novus*. But time wore on, and the mistakes of the geographers, as well as those of Columbus and Vespucci, are made apparent.*

Cosa, and on Dr. Kohl's fac-simile the important words, *Mar descubierta por Yngleses*, are placed too low down and half an inch too far west, thus conveying the idea that the English had discovered Mangi.

In short, La Cosa's coast line, from Cuba to the first flagstaff, was intended for Asia, and to this day answers better for Asia than America. The student, therefore, who is not clear on these points is liable to get the Polisacus (sometimes spelled Plisacus) Bay, the Gulf of Maine, Rio Gomez, Cathay, Memphramagog, Gog and Magog, Quinsay, Cape Cod, Zaiton, Zipangu, Capes Race and Henlopen, Mangi, Carolina, Ciambu, Florida, Chicora, Cuba, etc., into a beautiful muddle. This is no exaggeration. This utter confusion has been made by compilers and amateur geographers from the times of Hylacomilus, Apianus, Schoner, Laurence Fries, Orontius Fine, and Muenster, to the present day, and no doubt will continue so until geographers look more carefully into the chronology and bibliography of their subjects. With these explanations this map is perfectly intelligible, and is reconcilable with other good maps made since the discovery of the Pacific in 1513, when America first began to stand alone in geography independent of Asia. The question next to be asked is, how far west and south did Sebastion Cabot go in 1497–8? According to La Cosa and Ruysch, as far probably as the extent of the Gulf of St. Lawrence. Compare Hakluyt's map of 1587. Ruysch differs from La Cosa only as he had to record also the discoveries of the Cortereals. The remark of Peter Martyr, in 1515 (after their eyes were opened to the size and shape of the globe by the discovery of the Pacific) about Cabot's reaching on the American coast the latitude of Gibraltar, and finding himself then on a meridian of longitude far enough west to leave Cuba on his left, is simply absurd, dilemmatize it as you will. Such a voyage would have landed him near Cincinnati.

* A little book, hitherto unknown, written by Walter Lud, and printed at Strasburg in 1507, entitled *Speculi Orbis Declaratio*, discovered by the writer in 1862, has been the means of clearing up many unjust aspersions of historians against Vespucci, and explaining the true state of affairs. The book is now in the British Museum. The writer, after unsuccessful endeavors for two years to place it in America, at the end of March, 1864, had the great satisfaction of calling the attention of his friend, R. H. Major, Esq., to it, and pointing out to him the passages referring to the Vespucci books. How well Mr. Major has used these materials his excellent paper on the Manuscript Map of Leonardo da Vinci, printed in the *Archæologia* and his admirable *Life of Prince Henry the Navigator*, abundantly show. The next year the writer called Monsieur Harrisse's attention to it, and in his *Bib. Am. Vet.* it appears, under No. 49.

In 1505–6 northwestern Honduras aud Yucatan were seen by Solis and Pinzon, and in 1508 Juana (henceforth called Cuba) was circumnavigated by Ocampo, thus dispelling the doubt about its being Zipangu, or part of the main land of Asia. It was found to be a long, narrow island, extending east and west, and not north and south, like Zipangu. A strange confusion now began to seize the German geographers of Strasburg and Vienna. They made Cuba an island, and called it Isabella, and then transferred all the names from Isabella to a mainland, named usually, Terra de Cuba, connecting it with Paria (sometimes with and sometimes without a narrow strait) standing bolt upright, and extending to 45° north latitude, with a point like Florida, and a gulf to the west of it. This was still supposed to be part of Asia, the Florida-like projection being the Corea, and the gulf, the sinus Gangeticum, but in reality existed only in the imaginations of the geographers, like Antilla and San Brandan. It holds on their maps about twenty names, some of which are found on Ruysch's large island or main land west of Spagnola, and all of which are found on early maps, especially on a Portuguese portalano compiled by Lelewel under date of 1501–4. It is in the Ptolemy of 1513, extending up to 45° with the three-mouthed Ganges and the Gulf of Ganges, while on the globe of Schoner, of 1520, it reaches 51°, and is separated from Zipangu by five or six degrees of Balboa's newly discovered South Sea which by a strange guess is carried due north to the pole. Off to the northeast, in its proper latitude and longitude, most of these maps have Terra de Corte Real as a large island, extending probably as far as the Cabots and the Cortereals discovered—that is, as far west as the meridian of Porto Rico. Some maps have it Terra de Cuba, others Paria; and one, in the *Margarita Philosophica* of 1515, from a misreading of Columbus' first letter, Zoana Mela. This fancy continent grew in size for nearly a quarter of a century, and was hard to get rid of, but the explorations of Ayllon, Cortez, Gomez, Verranzo, Cartier, and others, finally drove it from our geographies.

In 1513 Florida, up to Chicora, was explored by Ponce de Leon, but it is now certain that it had been discovered two or three years before, probably by private adventurers, but perhaps by Ocampo in his return voyage in 1508. At all events, it appears correctly laid down in the excellent map of Peter Martyr printed at Seville April 11th, 1511, under the designation, *Isla de Beimeni.* This map, exhibiting an unbroken coast line from Cape Santa Cruz, in Brazil, to the middle of Yucatan, with hints of continental lines from Florida northward and westward, and one due north of Yucatan, if studied by the light of Peter Martyr's tenth book of his second decade, dated December, 1514, will foreshadow an approaching eclipse of Spanish enterprise in this direction.

There is little doubt that, at the time of the publication of this most important map, the author was still under the belief that all these new main lands somehow pertained to the continent of Asia. It is true, he informs us that some philosophers, and he leaves us to infer that he was one of them, had their suspicions that Columbus was mistaken in his opinion of its being Cathay, that the globe was larger than Columbus supposed, and that he had not really reached the antipodes, or the kingdom of the Grand Khan. But when Columbus, in his fourth voyage, brought home some poppinjays, and exhibited their brilliant plumage at the court, the good old gossipping letter-writer acknowledged that the great Discoverer was right, that such beautiful birds could come only from the East. Hence, probably on this map the lines west of Beimeni and north of Yucatan are dream lines from Marco Polo. Indeed, Peter Martyr says, in his first decade, finished in 1510 and printed shortly after, that all these provinces of Paria, Cariena, Canehiet, Cuquibacoa, Uraba, Veragua, and others, are supposed to pertain to the continent of India. Florida and Beimini forgotten by Marco Polo, and left out of his report! Shade of Sebastian Cabot!

In 1511 Cuba was settled under favorable auspices, and with Diego Velasquez as governor over well-to-do colonists, it became the base of operations for extensive explorations. On the 8th of February, 1517, Francisco Hernandez de Cordova, accompanied by Bernal Diaz del Castillo, he of the *True History*, and Antonio Alaminos as pilot, who as a boy had sailed with Columbus, set out on an exploring expedition to the west, to look for trade, gold, and the long-sought passage to the land of promise. He went by Cape Catoche, the bay of Campeche, as far as Champoton, and returned. The next year, 1518, on the 5th of April, Juan de Grijalva set out on the same route, with a better fleet and fuller instructions, accompanied by Bernal Diaz, Pedro de Alvarado, and the ever faithful Palinurus, Alaminos. They visited Cozumel, Cape Catoche, Campeche, Rio Tabasco, Potonchan, and named the country New Spain. They went as far as Panuco. Alvarado was sent back with the sick and heaps of gold, but Grijalva himself did not return to Cuba till the 15th of November. The journal of this important expedition, kept by the chaplain, Diez, was first published in Italian by Zorzi, at Venice in 1520, as an appendage to the *Itinerario* of Varthema.

Three days after Grijalva's return, Hernando Cortez, on the 18th of November, 1518, with the instructions in his pocket, which the governor sought in vain to recall after the return and favorable report of Alvarado, embarked on that most wonderful expedition of modern history, but he did not really leave Cuba for Cozumel till the 10th of February, 1519. He followed the courses of Cordova and Grijalva till he reached Vera Cruz. From thence he ascended the Grand Plateau, and what followed

is known to all the world. In his Second Relation, dated 30th October, 1520, Cortes sent to the Emperor a map of the entire Gulf of Mexico, well laid down, which was printed for the first time in 1524, at Augsburg, where Charles V. had resided. This map was incorporated into Orontius Fine's celebrated map of the world dated July, 1531, which, compared with the account of Megellan's voyage, and the third and fourth Relations of Cortes, led the great geographer and astronomer of Nuremburg, Schoner, the next year, 1532, to completely change his mind as to the extent of the South Sea, and place it almost entirely south of the equator, extending Asia to the north of it from the Ganges to Bacalaos, or Newfoundland. On this map of Cortes are the names of all the places at which he touched from Yucatan along the coast as far as Vera Cruz. These are, in order, Santo Anton, Roca Partida, Rio de Grijalva, Rio de la Palma, Rio de dos botas, Caribes, Santo Andres, Rio de Cocuqualquo, Roca partida, Rio de Vanderas, Rio de Alvarado, P. de Sant Juan, Seville, Almera, and San Pedro. The Rio de Cocuqualquo was surveyed for many miles, probably with the hope of finding an opening to the South Sea. In Fine's map of 1531 most of Cortes' names are indiscriminately mixed up with those of Marco Polo. [Pl. III. No. 3 and 4.]

In 1519, Francisco Garay, the Governor of Jamaica, dispatched Alonzo Alvarez de Pineda to explore the keys and coasts of Florida, but owing to the reefs and contrary winds, he directed his way round by the northwest coast by Mobile Bay, and the Mississippi river to Vera Cruz, thus completing a full and careful survey of the Gulf of Mexico. But still the disappointing report to the home government of old Spain was—no thoroughfare. Here was the eclipse. Portugal had gained a strong foothold of eight hundred miles on the coast of Brazil in consequence of removing the Line westward. In this way Spain became hemmed in between two lines of demarcation, the one the breadth of the Pope, the other the Cordilleras of the new hemisphere, the one about as impassible as the other, to the Spanish mind.

Thus all these three fields of discovery had by degrees crept into one vast continent, extending from the Arctic to the Antartic Circles, and, instead of being India, the land of fabulous treasures, it was an impassable barrier to the approach thither by the western route. In 1513, when Vespucci had been in his grave a year, and Columbus seven, Nuñez de Balboa first saw the Pacific Ocean (for many years called the South Sea) from the mountain tops of Panama, and soon after navigators began to realize that the land of spices was beyond another ocean, even more vast than the Atlantic itself. The beautiful name AMERICA now began to swallow up the conjunctives, to spread itself

eventually all over the new hemisphere, by the same law that made the Libya of the Romans succumb to its younger and more beautifully named daughter, AFRICA.

But Spain, with her new Emperor, her Fonsecas, her Corteses, her Pizarros, her Almagros, her Don Quixotes, her affluent mis eries, her newly awakened thirst for gold, her Christian zeal, and her jealous rivalry for possession of the Spiceries, was not the power to bend or break. She redoubled her energies, made laws for the regulation of her half of the world, and pious and unscrupulous as they were, systematized her efforts. She would not permit the Portuguese to seek a passage to their eastern possessions through her half by the way of the Isthmuses of America, and by the same rule she felt a delicacy in using their route by the Cape of Good Hope. Her ambassadors and agents in foreign countries manifested no such scruples.

In 1512 or earlier, Sebastian Cabot was seduced from England, and induced to take service, with his experience, in Spain; and the same year Juan de Solis, exploring the coast of South America, discovered Rio de la Plata. In 1515 he was again sent thither with a view of finding a passage to the South Sea, and thence to the Moluccas. This expedition returned soon after in consequence of the death of Solis, but it led the way to a successful one in 1519, under Magellan, a disaffected Portuguese gentleman who had served his country for five years in the Indies under Albuquerque, and understood well the secrets of the Eastern trade. In 1517, conjointly with his geographical and astronomical friend, Ruy Falerio, another unrequited Portuguese, he offered his services to the Spanish court, At the same time these two friends proposed not only to prove that the Moluccas were within the Spanish lines of demarcation, but to discover a passage thither different from that used by the Portuguese. Their schemes were listened to, adopted and carried out. The Straits of Magellan were discovered, the broad South Sea was crossed, the Ladrones and the Phillipines were inspected, the Moluccas were passed through, the Cape of Good Hope was doubled on the homeward voyage, and the globe was circumnavigated, all in less than three years, from 1519 to 1522. Magellan lost his life, and only one of his five ships returned to tell the marvelous story. The magnitude of the enterprise was equalled only by the magnitude of the results. The globe for the first time began to assume its true character and size in the minds of men, and the minds of men began soon to grasp and utilize the results of this circumnavigation for the enlargement of trade and commerce, and for the benefit of geography, astronomy, mathematics, and the other sciences. This wonderful story, is it not told in a thousand books? The Spanish eclipse was now passed, and America not long after stood boldly out as an independent hemisphere.

Meanwhile the Spaniards were timidly tempting their new ocean. The South Sea shores of Darien, Panama, and Veragua were explored in 1515 to 1517, as they had been a few years before on the north side, with a view of finding a water communication from ocean to ocean. Estevan Gomez, another decoyed Portuguese pilot in the service of Spain, who went with Magellan in 1519 as far as the Straits and there discreditably deserted him, returning to Spain in 1521, reported that, though a strait had been found by the admiral, it was too remote and too dangerous for use. It was resolved, therefore, to seek for the supposed isthmian passage by a more thorough examination of the coasts of the Pacific. Accordingly, in 1522, four vessels having been built at Panama, Avila and the pilot Nino set out to explore the coast from the Bay of San Miguel to the Gulf of Fonseca, expecting to find at the latter place a passage by water through to the Gulf of Honduras.

The same year Cortes, after having subjected the mighty barbaric empire of Montezuma, extending from the Atlantic to the Pacific, with characteristic energy set himself to work exploring to find a natural water passage, or to make an artificial one. He ordered four ships to be built at Zacatula, two for direct trade to the Moluccas, and two to search for the strait. The voyage to the Moluccas was postponed, but the search for the strait was prosecuted so vigorously that, between the expeditions of Avila and his own, every inlet was explored between Colima, in latitude 18½° North, and the Bay of San Miguel, a distance of above 2,500 miles of coast line, but of course without finding any passage. The following year, 1523, Cortes is said to have dispatched five small vessels to reconnoitre the coasts from Florida northward, to seek for the passage connecting the two oceans. His plan was to send another fleet up the western coast that they might meet somewhere north of the German geographer's fancy continent, or sail round it. Of course they never met.

In 1524, Pizarro and Almagro, the future conquerors of Peru, began their approaches thither from Panama, carrying with them always the impossible instructions to seek out the hidden passage, while they were looking for trade and searching for gold.

The Portuguese in India and the Spiceries, as well as at home, now seeing the inevitable conflict approaching, were thoroughly aroused to the importance of maintaining their rights. They openly asserted them, and pronounced this trade with the Moluccas by the Spanish an encroachment on their prior discoveries and possession, as well as a violation of the Papal Compact of 1494, and prepared themselves energetically for defense and offense. On the other hand, the Spaniards as openly declared that Magellan's fleet carried the first Christians to the Moluccas,

and by friendly intercourse with the kings of those islands, reduced them to Christian subjection and brought back letters and tribute to Cæsar. Hence these kings and their people came under the protection of Charles V. Besides this, the Spaniards claimed that the Moluccas were within the Spanish half, and were therefore doubly theirs. Accordingly great preparations were made to dispatch a fleet of six new ships to the Moluccas, to establish and protect trade. The Council of the Indies advised the Emperor to maintain this fleet there, and to take the Spiceries into his own hands, and carry on commerce and navigation thither through his own exclusive channels, either by the strait recently discovered by Magellan, or by some hidden one which *must* soon be disclosed (if any reliance could be placed on the geographers) in a more direct line through some one of the Isthmuses; or, failing that, by opening communication from the coast of the Pacific.

Matters thus waxing hot, King John of Portugal begged Charles V. to delay dispatching his new fleet until the disputed points could be discussed and settled. Charles, who boasted that he had rather be right than rich, consented, and the ships were staid. These two Christian princes, who owned all the newly discovered and to be discovered parts of the whole world between them by deed of gift of the Pope, agreed to meet in Congress at Badajos by their representatives, to discuss and settle all matters in dispute about the division of their patrimony, and to define and stake out their lands and waters, both parties agreeing to abide by the decision of the Congress.

Accordingly, in the early spring of 1524, up went to this little border town four-and-twenty wise men, or thereabouts, chosen by each prince. They comprised the first judges, lawyers, mathematicians, astronomers, cosmographers, navigators and pilots of the land, among whose names were many honored now as then—such as Fernando Columbus, Sebastian Cabot, Estevan Gomez, Diego Ribero, etc. They were empowered to send for persons and papers, and did in reality have before them pilots, Papal bulls, treaties, royal grants and patents, log books, maps, charts, globes, itineraries, astronomical tables, the fathers of the church, ancient geographies and modern geographers, navigators with their compasses, quadrants, astrolabes, mathematical instruments, etc. For two months they fenced, cyphered, debated, argued, protested, discussed, grumbled, quarreled and almost fought, yet they could agree upon nothing.

Whereas in the treaty of 1494 the Portuguese claimed the right of placing the line farther west than 370 leagues from the Cape Verde Islands, while the Spaniards contended rather to carry it farther east than placed in the original bull, both parties now (so much does self-interest sometimes modify arguments of

right) contended for the very opposite to their former arguments. The line, however, had been fixed on and approved by the Pope in 1494, and therefore could not be altered by them. But as there were 150 miles between the most easterly and most westerly of the Cape Verde Islands, they discussed angrily as to which island the line should pass through, each party knowing that every mile the line was moved here to the east or west, it would necessarily have to be moved just so much at the antipodes, the real field in dispute.

The debates and proceedings of this Congress, as reported by Peter Martyr, Oviedo, and Gomara, are very amusing, but no regular joint decision could be reached, the Portuguese declining to subscribe to the verdict of the Spaniards, inasmuch as it deprived them of the Moluccas. So each party published and proclaimed its own decision, after the Congress broke up in confusion on the last day of May, 1524. It was, however, tacitly understood that the Moluccas fell to Spain, while Brazil, to the extent of two hundred leagues from Cape St. Augustine, fell to the Portuguese. The calculation of longitude was the *pons asinorum* of the Congress, the very problem that had deceived Columbus and other experienced navigators a quarter of a century before. At this time let it be remembered, no geographer had given any hint of the fan-like shape of North America, but all maps represent it as a narrow strip of land, like that from Panama to Tehuantepec, with the South Sea itself narrow running up to the west of it.

However, much good resulted from this first geographical Congress. The extent and breadth of the Pacific were appreciated, and the influence of the Congress was soon after seen in the greatly improved maps, globes, and charts. Many doubtful points in geography and navigation were cleared up on both sides of the globe, and the latitude and longitude of many places were defined. Indeed, on the new maps after this, all the discoveries actually made, up to 1524, were tolerably well laid down, but there was a deal of imposition left in the imaginary lines of those parts of the North American coast which had not yet been explored, that is, between Florida and Nova Scotia. These false lines were still used by the pilots of both Spain and Portugal, probably with a view of blinding the eyes of each other, or leading astray the outside barbarians of England, France, and Holland, who, though children of the Father, and given to trade and adventure, had no share in the Papal gratuity. The fact that all the coasts of South America, Panama, Nicaragua, Honduras, Yucatan, the Gulf of Mexico, and Florida, as well as of the Pacific shores from the Gulf of San Miguel to Colima, that had been surveyed by the Spaniards up to this time, were well laid down, both as to latitude and longitude,

proves almost to a certainty that the indefinite coast line of the United States was still imaginary, if not Asiatic. Indeed, the old wood-cut maps of 1513 and 1522 of the German geographers, with their ideal continent, Terra de Cuba, did service, without alteration in the Ptolemies, for a quarter of a century later.

The return of Magellan's ship Victoria in 1522 aroused the spirit of public and private enterprise throughout Spain. Innumerable schemes for developing commerce with the Orient, and making further explorations, were proposed and discussed. Every pilot, whether amateur or practical, had his card of the shortest route to the Indies. Of these schemes no less than six in 1523 and 1524 were adopted by the government, and promoted wholly or in part by public funds; viz., that of Cortes, of Loaysa, of Gomez, of Ayllon, of Cabot, and of Saavedra. The impending conflict with Portugal called together the Congress of Badajos. That being over by the 1st of June, 1524, and resulting practically in favor of Spain, these several plans were matured as fast as practicable.

Cortes, the first and most active, had no sooner conquered Mexico and clenched his conquest than he began his exploration of the coasts of the Pacific. Without delay he sent Alvarado and other captains to the south and southeast, to bring into subjection the chiefs of the Province of Oaxaca and what is now called the Isthmus of Tehuantepec, and, shortly after, proceeded thither himself.

Ships were built on the Pacific side, but with many of the materials carted over from the Coatzacoalcos River. All the details of this scheme, from the 15th of May, 1522, to the 15th of October, 1524, are recorded in Cortes' Fourth Relation to the Emperor, printed at Toledo, October 20th, 1525. This Relation in Spain, with the reports of Alvarado and Godoy attached, gave still another impulse to the new speculations and enterprises, as it showed not only the practicability, but the probability of opening by artificial means a direct route to the Orient in a low latitude and good climate. Cortes was clear-headed and far-sighted enough to see that lines of commerce must be straight lines, and that the curves of the capes in high latitudes are only temporary matters of necessity. Indeed, so sanguine was Cortes on these points, that he planted his personal hopes and private fortune on and near this isthmus, as likely to become the Old World's highway for Oriental commerce. All the lands and private estates selected for himself and his posterity, and confirmed to him in 1529 by the Emperor, were located here in the Valley of Oaxaca, and near Tehuantepec. He was ennobled in 1529, taking his title, Marquis del Valle, from his possessions chosen here. To this day they are called the Cortes Estates, or the Marquisanas. He and his

kinsman, Saavedra, had vast schemes for opening communication, by means of a ship canal or Roman road, for the transportation of merchandise brought hither from the Moluccas and other parts of the East for passage or transhipment to Spain. How unexpectedly this rational scheme was thwarted will appear farther on.

At the end of 1524 or early in 1525, Estevan Gomez, the pilot who had been in the East, had started with Magellan and deserted him, a delegate to the Congress of Badajos, was the first to get off from Spain. He had boasted that he could find a passage to Cathay and the Spice Islands by the north, as Magellan had done by the south. He must have seen at Badajos, if not before, the maps of Ruysch, with the continent west of Spagnola extending to 35° north, and the Hylacomylus map of 1513, carrying the same ideal continent up to lat. 46°, ending with Cape Mar del Oceano, just above Ruysch's Cape Helicon (probably named from the rumored fountains of Florida). Peter Martyr's map of 1511, and Cortes' map of 1520, printed in March, 1524, together with the knowledge that Ponce de Leon, in 1513, and Ayllon, in 1520, had explored the coast of Florida up to 33° 40′, a little above Charleston; and it being known that Ayllon had another commission in his pocket, dated June 12, 1523, to explore still further north of Florida; and his own commission being to find a strait between Florida and Barcalaos; these considerations make it certain that Gomez' field of search lay between 35° and 45°, or between Norfolk and Cape Sable, where, as Peter Martyr expresses it, "he found pleasant and profitable countries agreeable with our parallels." Very little is known about this unimportant expedition, and no authentic maps or papers have come down to us. The contemporary historians give no prominence to it, and very few facts about it. Indeed from what is at present known, it is very difficult to tell whether Gomez sailed up or down the coast, or both, or at what points he touched. So little information did he bring back, that it would not now be a matter worth discussing if the results of the voyage had not been so enormously exaggerated by recent writers.

Let it be borne in mind that Gomez sailed with only a single caravel of fifty tons, with perhaps a dozen men, in the dead of winter, from Coruna, in lat. 43°, the government contribution toward the cost of the fit-out being only 750 ducats, returning in November, 1525, after an absence of about ten months, with some Indian slaves, whom he had kidnapped against a recent law of Spain and the positive instructions of the Emperor, and you have the whole story. Oviedo, writing in 1526, says that he sailed to the northern parts and found a great part of land continuate from that which is called Bacalaos, taking his course

toward the west to 40° and 41°, from whence he brought certain Indians. Would an intelligent pilot sail north with such a craft in winter? Might not New England be the "great part" of land next to Bacalaos; and might not the fine tall natives of Rhode Island have been kidnapped, part being taken to Cuba for sale, the rest taken to Toledo, thus consuming the ten months, without having gone north of Cape Cod? Peter Martyr says, writing also in 1526: "He, neither finding the strait nor Cathay, which he promised, returned back within ten months from his departure. I always thought and presupposed this good man's imaginations were vain and frivolous." Herrera, who wrote three quarters of a century later, is hardly more favorable to this explorer.

The reader is referred, by recent writers, to the manuscript map of Ribero of 1529, now preserved at Weimar, for the result of Gomez' voyage. But the intelligent reader will see with half an eye that this is a partizan map, and intentionally deceptive in the coast line between 33° 40′ and 50° N. The discoveries of the English are thrown into Greenland, and called Labrador, while Bacalaos is given to the Portuguese, and cut off by the line of demarcation. All the rest of the coast is closed up under the names of Gomez and Ayllon, and so given to Spain. There is no room left for the discoveries of Verazzano for the French in 1524. The Spaniards knew of his voyages, for they had been watching him, and caught him, and in 1527 hanged him as a corsair. Indeed, the best that can be reasonably said of the voyage of Gomez is, that it exploded the ideal continent of the German geographers, and, connecting the explorations of Ayllon with New England, showed that the coast of North America trended continually eastward, so as probably to connect it with the discoveries of the Cabots, and thus make the whole coast west of the Line Spanish.

Lucas Vasquez Ayllon, a lawyer, a Senator in Hispaniola, and a man of position, immediately after the survey of the entire Gulf of Mexico under Grijalva and Cortes, sent an expedition up the coast of Florida in 1520, as far as Chicora, exploring beyond the limit of Ponce de Leon, as far, probably, as Cape Fear, seeking for the passage to Cathay. He found a fine country, but to Asia no thoroughfare. The next year he returned to Spain, and was, according to Peter Martyr, in behalf of the Regency of Hispaniola "a long time suitor [to the Council of the Indies] to have leave to depart again into those countries, to build a colony there." At length, after the return of Magellan's ship Victoria with its glorious news, the Council granted his request, and articles of agreement were signed the 12th of June, 1523, giving him permission, at his own expense, to fit out as many vessels as he pleased for the purpose of plant-

ing his proposed colony, but the usual instructions were inserted in his grant, to explore all inlets and islands with a view of finding a passage to Cathay. This license, given by Navarrete, permitted him to explore as far as 800 leagues to the north of Hispaniola. He returned to Hispaniola, built there six fine vessels, and, after many delays, sailed with them and above 500 men and nearly 100 horses, in July, 1526. He went as far north as lat. 33° 40′, found no strait, and met with nothing but misfortunes. The 18th of October Ayllon died, and soon after the few survivors, about 150 out of the 500, returned to Hispaniola, the expedition being a dead failure. Thus ended the attempt to plant a colony near the mouth of Cape Fear River, and thus ended the Spanish attempts to penetrate to the East by the way of the North. Both Gomez and Ayllon had found no gold, and no strait, and even the trees and animals they reported were common in Europe; whereat old Martyr exclaims, "to the south! to the south! for the great and exceeding riches of the equinoxial; they that seek riches must not go unto the cold and frozen north." The whole story is comprehended in Martyr's sentence. North America, by the Spaniards, was never considered of any consequence of itself, and was regarded only as a barrier or a stepping stone to a richer, older and better land. It was necessary, however, to shut it up by a coast line west of the line of demarcation, so that other nations might be deterred from finding a northern passage to India.

The Emperor, considering the verdict of the Congress of Badajos in his favor, lost no time in dispatching his new fleet of six sail and 450 men by the Straits of Magellan, from Coruna, on the 24th of July, 1525, under the command of Loaysa, to the Moluccas and the Spice Islands, with the view, first, to succor the men left there by Magellan's fleet, and then to establish a government bureau and to protect its commerce. The Straits were passed, and four of the six ships reached the Moluccas; but the story of their long, long sufferings is too long to be told here.

In April, 1526, Sebastian Cabot, who had for years been the Pilot Major of Spain—said, however, to have been a better cosmographer than pilot—after long and ample preparations at Seville, sailed for the Moluccas via the Straits of Magellan, with four well-equipped ships, for the purpose of reinforcing and assisting the expedition of Loaysa. This expedition was another dead failure. For some unaccountable reason, Cabot did not deem it prudent to try the Straits of Magellan, but attempted to find a passage through the Rio de la Plata. He penetrated far into the interior of Paraguay, explored many large rivers and fertil provinces, suffered many hardships, lost most of his men and ships, and finally, after four years of toil and disappointment, returned without any favorable results.

Cortes was kept informed of these several expeditions, with a request from the Emperor that he would coöperate with them at the Moluccas, by sending a fleet from the western coast of Mexico. Accordingly he caused three ships to be built on the Pacific, and dispatched them, with 110 men and thirty pieces of artillery, under command of his kinsman, Saavedra, from some port of Southern Mexico, probably Tehuantepec, Huatulco, or Acapulco, on the 31st of October, 1527. This fleet met that of Loaysa in the Moluccas, coöperated with it, found the Portuguese strong and resolute, by no means disposed to abandon the islands, fought them separately, and fought them together for months, nay, for years, never hearing a word from home, being cruelly neglected, yet loyal and true, till reduced to a handful, some few of the survivors, long after Loaysa and Saavedra had died, as well as most of the sub-officers, found their way home after twelve years of unspeakable hardships. Thus all these six hopeful expeditions brought nothing but disappointment. The Straits of Magellan were found so dangerous and remote, that old Peter, had he lived, would no doubt have again exclaimed as before, "To the north! to the north! they that seek riches must not go to the dangerous and frozen south!"

As early as 1526 or 1527, before the extent of these failures was known, it became apparent, if the commerce of the East was to flourish, it must be by some more direct communication. These great difficulties of the extreme North and South determined the Spaniards to explore the Isthmuses yet more thoroughly. All the five routes from Darien to Tehuantepec, were spoken of then as now, with the view of constructing immediately a canal, road, or portage, deeming it safer and cheaper to tranship goods, than to carry them round by the Strait. "There are mountains it is true," exclaimed the old historian, "but Spanish hands, and Spanish enterprise can overcome them." But no Spanish hands could overcome the impolitic blunders of the Emperor. There is little doubt that inter-oceanic communication would have been opened in 1529 or 1530, by means of a ship canal or a turnpike across the Isthmus of Tehuantepec, had not the Emperor, who was greatly in want of money, defeated all the schemes against the advice of the Council of the Indies, by pawning in the treaty of Saragossa to the King of Portugal who had just married his sister, the Moluccas for 350,000 ducats. So the trade of the Moluccas passing for a time out of the hands of the Spaniards, there was no immediate pressure for the completion of this great work. The opportunity then lost of securing an exclusive transit was never recovered by Spain, but it is reserved to us of to-day to make the Isthmus of Tehuantepec the world's highway.

H. S.

May 10, 1869.

ART. XXX.—*Summary of Results of a late Geological Reconnoissance of Louisiana;* by EUGENE W. HILGARD, of the University of Mississippi.

THE geological reconnoissance of a large portion of West Louisiana, the results of which I propose briefly to discuss, was made under the auspices of the New Orleans Academy of Sciences. The means required for outfit and traveling expenses were provided partly by subscription (chiefly among the members of the Academy), partly by an appropriation, made in furtherance of the object in view, by the Board of Immigration for the State of Louisiana. The time at my disposal for the purpose was, unfortunately, limited to thirty days; but in view of the presumable close correspondence of the formations of Louisiana to those of Mississippi, previously well known to me, as well as the information already in my possession as the result of a previous exploration made under the auspices of the Smithsonian Institution, I was led to anticipate that even a rapid reconnoissance would enable me to determine with sufficient precision, the chief characteristics and geographical outlines of the formations. I was accompanied and materially assisted by Dr. J. K. Walker, of New Orleans, a Fellow of the Academy, and Mr. Scott Miller, of the same city, who volunteered to take charge of the pack mule needed to carry specimens. The entire distance traversed on horseback was 625 miles, and the route was so chosen as to cross the presumable strike of the strata, as often as possible, while touching the most important known points of interest. Passing by the interesting chain of islands previously examined by me (Petite Anse, Côte Blanche, etc.), the party proceeded from New Iberia on the Tèche viâ Opelousas to Bayou Chicot, where the border of the older formations was reached; thence west to the Calcasieu river, down that stream to Lake Charles and the sulphur and petroleum wells on the West Fork of the Calcasieu river; thence north to Sabine Town, Texas, thence viâ Manny to Mansfield, La., thence crossing Red river at Coushatta Chute Landing to the salines on Saline bayou, and thence viâ Winfield to Harrisonburg on the Washita river, where, after some excursions in the neighborhood, the expedition terminated.

While the presumption as to a general arrangement of the formations in bands, more or less parallel to the Gulf coast, proved to be substantially correct, yet in consequence of local deflections and differences presently to be discussed, the section obtained on the route just recited was less complete than I had hoped. It has, nevertheless, served to develop pretty fully the

main features of the geology of the whole of Louisiana. The unexplored territory will probably, before the end of the season, have been surveyed by Profs. Lockett and Hopkins, of the Louisiana State Seminary at Alexandria, in pursuance of a small provision made for the purpose by the last legislature.

Before proceeding to details it may be well to recall, briefly, the results communicated at the last meeting, of my examination of the formations of Lower Louisiana. I then stated that the southern outline of the main body of the Orange Sand or southern Drift, extends but little south of the limit of the Grand Gulf group, the latest (fresh-water) Tertiary of the Gulf coast; that, nevertheless, in the direction in which the main pebble-stream, coincident with the axis of lowest depression of the Mississippi valley would strike the Gulf, we find a chain of elevations, formed, apparently, by a nucleus of outliers of the Orange Sand materials, surrounded and overlaid by those of the succeeding swamp, lagoon and estuary formation, which from its prominent development at Port Hudson, I have designated as the Port Hudson group; its geological horizon lying between that of the Orange Sand, and the Loess or Bluff formation. I also stated that the deposits of this age extended at least from the Sabine River to Mobile Bay. In fact, I then suspected, and am now confirmed in the opinion, that most if not all the deposits provisionally thrown together under the head of "Coast Pliocene," on my geological map of Mississippi, are the equivalents of the Port Hudson group.

The Port Hudson group.—East of the Mississippi river, the country underlaid by this group of deposits is level or gently undulating, with a gentle slope S.S.E.; the more fertile portions timbered with oak, while on the whole there is probably a predominance of Long-leaved Pine woods, at times degenerating (as in the coast region of Mississippi) into the wet and sterile "Pine meadow" uplands, where the Pine and Cypress grow side by side, greatly damaged by their mutual concessions as to habitat.*

West of the Mississippi, the topographical features are on the whole similar; but instead of being wooded, the surface is almost altogether occupied by prairies, from the Bayou Tèche to the Calcasieu river, and from the marshes of the Gulf coast to an undulating line laid, in a W.S.W. direction, through Ville Plate in St. Landry parish. In correspondence with the portion east of the river, the general slope here appears to be S.S.W., the Port Hudson bluff having its counterpart in those which, abutting upon the bayou Cocodrie below and above Opelousas, have given to very level regions the seemingly inappropriate names of "Côte Gêlêe" and "Grand Côteau des Opelousas"; which are descriptive of the appearance when first approached

* Miss. Rep., p. 368.

by water, rather than of the nature of the country itself. As may be supposed under the circumstances, outcrops are exceedingly scarce throughout the prairie region. The wells are shallow, remaining usually within the limits of the upper (silt and loam) strata of the Port Hudson profile; since fetid, undrinkable water is obtained at greater depths, in dark colored clays with fossil wood. Nearer the coast, however, marine beds with oysters, "clams" (*Gnathodon*) and gasteropods are also struck not uncommonly, both near the surface and at greater depths, from the Calcasieu to the Pascagoula river. I have been unable to detect any regular stratigraphical relations between these marine beds and the cypress swamp deposits; they appear to be coördinate and substantially coëval, denoting the coëxistence of littoral cypress swamps, marshes, lagoons and estuaries; just such as would naturally result from a gradual depression of the present coast.

The thickness of this formation near the coast seems to be very considerable. In one of the bored wells on the West Fork of Calcasieu, the materials of the Orange Sand were struck at 160, in the other at 354 feet (see profile below). If such is the thickness of the Port Hudson strata at a distance from any great channel, it cannot be surprising that, in the well bored at New Orleans, in the main channel of the Mississippi valley, it should not have been passed through at 630 feet. Nor is it surprising that, in that great continental depression, marine strata should prevail almost exclusively, when it is considered that at one epoch of the period of slow depression, the swamp formation extended as high as near Memphis on the Mississippi, and Shreveport on Red river.

The banks of Red river in the lake country above Nachitoches (and, according to reliable information, at least as high as Shreveport), as seen at low water, consist of materials scarcely distinguishable from those forming the profile of the sea-face at Côte Blanche.*

There are alternations, every few feet, of stiff red, blue, green or brown clays, with sand or reddish loam; often containing calcareous concretions, sometimes even well preserved fresh-water shells; as well as successive generations of cypress stumps. At the present time, neither the material nor the arrangement of the Red river deposits present any similarity to these strata, any more than do the modern Mississippi deposits to those of Port Hudson; while their thickness, regularity and continuity over large areas, as well as the rarity of stratification lines, distinguish them from the comparatively limited cypress swamp deposits of the present time.

The prairies of South Louisiana, underlaid by the Port Hudson group, embrace, especially in their southern and eastern

* Proceed. Am. Assoc., Chicago meeting, 1868, p. 327.

portion, the most fertile uplands of the state ; the region adjoining the Bayou Tèche having, in times past, received and deserved the title of the "Garden of Louisiana" ; not inferior in fertility to the bottom lands, and in point of health and comfort much preferable to the latter. From their exposure to the sea-breeze, their summer temperature is much less oppressive and injurious to health, than is the case on the prairies of the Northwest ; while their bland winter relieves the inconvenience arising from scarcity of wood. Belts of timber, however, border all the streams ; and rapidly growing hedges of the Cherokee rose obviate, in a great measure, the necessity for costly wooden fences. Yet the greater portion of this preëminently agricultural region is now merely a range for herds of cattle. West of the Mentau waters, cattle-raising is almost the only occupation of the inhabitants, except near the coast ; the white "crawfishy" soil, dotted with clumps of pine, being mostly unfit for cultivation—yet very far from being the dreary marsh, accessible only on stilts or in canoes, and peopled by alligators, which our maps represent as covering most of Calcasieu.

The Orange Sand Formation.—I have heretofore stated that this important series of deposits, seems, west of the Mississippi, to skirt the southern border of the highlands of Arkansas, and to be extensively represented in Louisiana. The latter presumption I have found abundantly verified, since it is as characteristically developed in the latter State, as in the corresponding portion of Mississippi. Outside of the river bottoms and adjoining "hommock" flats, and of the prairies of the Port Hudson group, just described, it appears on all the hill lands, especially on the higher ridges ; which are, as usual, capped by rocky knolls of ferruginous sandstone, while slaty fragments of the same strew the slopes. A description of its general features in Louisiana would be, in every respect, a mere repetition of that already given in my Mississippi Report, and other papers since published.* I have, however, to add some facts concerning its general distribution, both horizontally and vertically.

My own observations on this formation have been confined chiefly to the great delta-shaped mass which covers Mississippi, Louisiana, and a portion of the states of Tennessee, Alabama and Arkansas, which bears such obvious relations to the great embayment whose axis is now occupied by the Mississippi river below Cairo, but which was already impressed upon the continent in ante-cretaceous times. Tuomey† and myself,‡

* This Journal, May, 1866; ibid, Nov., 1866, ibid, Jan. 1869.
† Second Report on the Geology of Alabama, p. 146, et al.
‡ Mississippi Report, 1860, p. 27.

however, have early suggested the probable equivalence of these beds with the detrital deposits of the southern Atlantic States, and the universality, in North America at least, of the cause which produced them. No one as yet, has taken up the subject in those States; much as we hear of the Northern Drift, the very existence of the Southern Drift has thus far been studiously ignored in all text-books. Yet it determines the character of the surface, not only of the greater part of five States, above mentioned, and of an important belt along the Atlantic coast, but I have now traced it in its characteristic development, across the Sabine river into Texas, and from scattered observations partly contained in United States and Texas geological reports, partly communicated verbally, I am satisfied that it forms an important feature of the geology of Texas, at least as far south as the Colorado river, and from the escarpments of the Llano Estacado to the Gulf of Mexico. How much farther it may follow the outline of the Gulf—what part, if any, it plays in the Tierra Caliente of Mexico, must hereafter be determined. At all events, its wide distribution alone assigns it a most important place among the formations of the Southwest, and this importance is greatly enhanced by its hypsometrical relations, as I have lately observed them.

I have stated in previous papers, that the depression of the lower Mississippi valley during the "Champlain" epoch cannot have been *less* than 400 feet below its present level—probably, taking into account the depth of water required for the deposition of the materials of the Loess of Louisiana, it must be estimated at fully 450 feet at least. This supposes that the depression commenced from a horizon near the present tide level. But it will be seen by reference to the profile of the Calcasieu bored wells, that in one of them, the Orange Sand had not been passed through at 450 feet below tide level, and near that depth it still contained pebbles requiring for their transportation a considerable velocity of current. The somewhat startling, but inevitable conclusion is, that if the sea level was the same then as now, *the Gulf coast has in late Quaternary times suffered a depression to the extent of at least nine hundred feet* (perhaps more), *and during the Terrace epoch, a contrary motion to the extent of about half that amount.*

The Mississippi river at the present time transports only sand; and were we to construct a general surface level from the northern lake country to the hills of the Gulf border, the fall of water flowing on the surface would still be inadequate to accomplish much more than this. But the nature, both of the surface on which the Orange Sand was deposited, and of

the deposits themselves, prove the action, especially at first, of *violent* currents, capable of transporting pebbles of several pounds weight, hundreds of miles from their original site.* It follows (always provided that the ocean level remained sensibly constant) that the 900 feet change of level, at the mouths of the Mississippi, must have been accompanied by a considerably greater change near its head, one which would more than suffice, at the present time, to establish water communication between the Gulf of Mexico on one hand, and the Gulf of St. Lawrence, as well as (through the ancient channel described, at the Chicago meeting of the Association, by Gen. G. K. Warren) with Hudson's Bay and the Arctic basin on the other; sufficiently great to explain the glaciation of the continent, as well as the succeeding fresh-water flood, whose effects are no less prominent in the southwestern portion of the North American continent, than those of the glaciers are in the northern. And it seems probable that the detailed study of this formation and of its relations to preceding and succeeding deposits, over its wide area of occurrence, is likely to give more important information concerning the geological events immediately preceding our present epoch, than can be gathered from the local accidents of ancient beaches. For while the *presence* of the latter irrefragably proves a *positive*, their *absence* fails to prove a *negative*. Unless absolute continuity is proven, the 30 feet beaches of southern New England cannot be taken as evidence that at Montreal the depression was greater in proportion to the present elevation of its highest beach; or that the (minimum) depression of 450 feet did *not* extend to the Atlantic coast: any more than that highest beach itself can be taken as the mark of maximum depression. Under the rigor of an arctic climate especially, many circumstances might concur to prevent the formation of beach lines, or cause their removal subsequent to deposition. If we assume the glacial epoch to have resulted chiefly or wholly from an uprising of the land, (and perhaps of the sea-bottom also) in northern latitudes, the wide distribution of its effects *there* points to a universality and uniformity of cause, quite analogous to that which seems to obtain in reference to the southern or Stratified Drift, from the Susquehanna to the Colorado of Texas; and (as regards the maximum of reported change of level) from the Gulf of Mexico to the Arctic coast. It is permissible to infer, that these great events were not confined to the Atlantic slope; and that the auriferous gravel beds of California are, in all probability, the strict equivalents of the "Orange Sand" of Mississippi; while the period of time required to cover the pebble

* See Mississippi Rep., 1860, pp. 13, 26, et al.

streams of Louisiana with many hundred feet of swamp and marsh deposits, may well embrace the successive lava streams now overlying the gravel of California.

The Grand Gulf group.—The materials of this formation characterize, more or less, the portion of Louisiana lying northward of the prairies of the Port Hudson era, up to a line laid in a W.S.W. direction, through Cloutierville on Red river; where, at the foot of elevated ridges consisting of Grand Gulf sandstones and claystones, the limestones and marls of the Vicksburg Eocene Tertiary begin to prevail.

The features of the Grand Gulf group in Louisiana are almost absolutely identical with those prevailing in Mississippi.* In the more southerly portion of its area of occurrence, its materials are hard, intractable blue, green or gray, massy clays or clayey sands, appearing chiefly in the beds of streams, and thickly overlaid by the deposits of the Orange Sand; to whose lower portion it has communicated its clayey character, resulting in the formation of excellent potter's clay. On the higher ridges, the ferruginous sandstone of the Orange Sand prevails largely and characteristically.

Farther northward, however, as in Mississippi, gray or white, mostly soft and somewhat clayey, sandstones, alternating with siliceous claystones of various degrees of induration, and gray, sometimes lignitic, but mostly massy clays, themselves constitute the ridges, forming rather barren soils, on which the long-leaved pine and coarse grasses alone can find sufficient nutriment. Yet even here, wherever a particularly prominent ridge or knoll is seen, it is sure to consist of an outlier of Orange Sand, perched on a plateau of Grand Gulf rock and capped by a ledge of ferruginous sandstone.

As regards the general arrangement of the strata, they doubtless dip slightly to the southward; though it is difficult to observe this in any one outcrop. Probably the dip is but slightly greater than that of the average surface of the country, for I have found nothing to indicate that the sand and claystones which form the ridges on the northern border of the formation, underlie the clays found on the southern edge. My impression is that the former have either never been formed in the latter region, or else have been subsequently removed.

My hopes of finding, in the reported limestone deposits on the territory of this group, a clue to its position in the Tertiary series,† have been disappointed. The limestone of St. Landry proves to be a Cretaceous outlier: while that occurring near Harrisonburg, capping the highest hilltops of Sicily Island,

* Mississippi Report, 1860, p. 147; this Journal, Jan, 1867, p. 39.
† This Journal, Jan., 1869, p. 9.

consists of the gnarled and knotted concretions characterizing the Bluff formation ("Loess-puppets"), which contain the Helices usual in that group. Faint and usually irrecognizable impressions of leaves sometimes occur, as is the case in Mississippi; but in the present condition of phyto-palæontology, little can be hoped for from that slender source. In its stratigraphical, lithological and structural characters, it differs widely from all the other tertiary deposits of the Southwest; its slight dip alone proving it to be of comparatively modern origin. Whatever may be the precise epoch of its formation, that event could not have been a local one, due only to a littoral shallowing of the Gulf. The regularity, as well as the uniformity of composition of the strata, from the Escambia river to the Colorado of Texas, alone seems to forbid its being considered, like the Port Hudson deposits, as the representative of a period of swamp and estuarian formations on the border of a marine basin. I have heretofore suggested,* that nothing short of a temporary cutting off of the Mexican gulf from the Atlantic seems capable of accounting for the existence of the Grand Gulf strata; and this impression has been nowise weakened by a more extended acquaintance with this remarkable formation.

While the territory of the Grand Gulf group is on the whole perhaps the least fertile portion of Louisiana. (as is likewise the case in Mississippi), there are some notable exceptions to this rule, in regions where a calcareous clay stratum† comes so near the surface as to contribute to the formation of the soil on the hillsides and in the bottoms. Such is the case on the upper bayou Anacoco (in the "Anacoco prairie" region) as well as in the southern portion of Sicily Island, near Harrisonburg on the Washita. Whether the Avoyelles prairie belongs to the same category, I have been unable to ascertain; but from its position it seems likely that such is the case.

This white clay marl, the building stones occurring in the northern portion of the formation, the potter's clays above referred to, and a pure white and exceedingly refractory, semi-indurate white pipe-clay, occurring near the edge of the Vicksburg rocks in Catahoula parish, constitute the practically useful materials of this group in Louisiana; where on the whole, it yields much fewer waters impregnated with noxious salts, than is the case in Mississippi.‡

The Vicksburg group.—The territory underlaid by the rocks

* This Jour., Jan., 1867, p. 41.

† Probably the same as that which appears on Pearl river, in Marion Co., Miss., at "Barnes' White Bluff," and has been used as a fertilizer (Mississippi Report, 1860, p. 179).

‡ Ibid, p. 187, et al.

of this division of the Eocene Tertiary, forms a band about thirty miles wide, crossing the state in a W.S.W. direction, north of the Grand Gulf group.

The features of the Vicksburg group, where it is crossed by the Washita, seem to agree closely with those given in my general section (p. 140 of the Mississippi Report of 1860). According to the observations of my companion, Dr. Walker (who determined the line between this and the Grand Gulf group, on the Washita), lumps of Orbitoides limestone at the foot of the Grand Gulf sandstone ridges, are the first evidence of the change of formation. Thence northward, lignito-gypseous clays are reported for some distance, while about six miles below Columbia, according to information from residents, there are limestone hills with small shell prairies and marl beds.

Northward of Columbia, calcareous strata corresponding to the Jackson group do not seem to occur on the Washita until we reach "about fifty miles (by water) south of Monroe," the locality from which Dr. Harlan obtained the vertebræ of Zeuglodon described by him in 1832.* Thus far, the section of the marine Tertiary on the Washita corresponds very well to that on Yazoo and Pearl rivers, in Mississippi; only the intervening lignitic stratum, which forms the base of the Vicksburg bluff, is more extensively developed on the first mentioned stream.

On the Sabine river, too, the upper portion of the profile is pretty correctly reproduced. At the base of the Grand Gulf rocks we find, on the bayou Taureau, a seam of shell limestone with Vicksburg fossils. We then pass over lignito-gypseous strata to Sabine Town, Texas, where we see about seventy feet of these, overlying ledges of blue fossiliferous limestone alternating every two or three feet with what would be greensand marl like that of Vicksburg, had not the lime of the numerous shells of which it contains casts, been removed by subsequent dissolution. So far as I have seen, the usual leading fossils of Vicksburg are wanting here; while the greater sandiness of the materials, as well as the prevalence of shallow-sea bivalves, indicates their deposition in shallower water. As we proceed northward from Sabine Town, lignitic clays and lignite alone separate, and sometimes altogether replace, the limestone ledges, which themselves become poorer in fossils, as we approach the northern edge of the formation.

Beyond, we again enter upon lignitic territory, which thenceforth continues with unbroken uniformity, so far as the Tertiary is concerned, to the Arkansas line.

* Trans. Am. Phil. Soc., vol. iv, N. S.

From my own observations farther east, as well as from information obtained from others, it seems that there is a gradual increase of the lignitic clay facies in the Vicksburg strata, as we advance westward from the Washita. The Casatche Hills below Natchitoches are described as consisting of alternating limestone and marl strata, capped by Orange Sand knolls; while the "Grande Ecore" on Red river, a few miles above Natchitoches, exhibits only dark laminated clay and sand. In the flat region between Dugdemona and Red rivers, where I recrossed the Vicksburg territory, there is but little chance for observation; but about the middle of the belt, on the heads of Bear creek, semi-indurate marls with *Orbitoides*, *Pecten Poulsoni* and *Ostrea Vicksburgensis*, are abundant; as well as farther east, the nodular Orbitoides limestone, at the base of the Grand Gulf rocks.

The Mansfield group.—In Mississippi the stages of the marine Tertiary are separated by lignitic clay strata; in Alabama, on the contrary, they are directly superimposed upon each other.* The lignitic bands gradually increase in thickness as we advance westward, but the territory underlaid by them in Mississippi is generally too limited, and the development of the strata too slight, to necessitate their designation by a special name. At Vicksburg, nevertheless, the thickness of the lignitiferous stratum intervening between the Vicksburg and Jackson groups, is not less than 35 to 40 feet, and it underlies a district several miles in width, on the Yazoo bluff.

In western Louisiana, as already stated, none but lignitiferous strata of Tertiary age, occur north of the Vicksburg group, as far north as Shreveport, and so far as I have been able to ascertain, up to the Arkansas line. In fact, the only locality in Louisiana known to me as distinctly of Jackson age, is that already mentioned as the source of Zeuglodon bones, described by Dr. Harlan, about half way between Columbia and Monroe, on the Washita. Nor does the main body of the marine Tertiary seem to extend any farther west in Arkansas, the outcrops mentioned by Dr. Owen being chiefly on Washita and Sabine rivers, in about the same longitude; to the westward of which excepting an outlier of Tertiary limestone in Clark county, the Tertiary epoch seems to be, in both states, represented by lignitiferous, fresh or brackish-water deposits. Nevertheless, the characteristic marine fossils of the Jackson group, according to Buckley† occur abundantly in (southeastern ?) Texas.

Very probably, the equivalents *in time* of all the marine groups exist in the lignitic Tertiary of Arkansas, Louisiana

* This Journal, Jan., 1867, p. 30.

† Prelim. Report on the Texas Geol. Survey, 1866, p. 44.

and Mississippi, their change of character denoting a change in the depth (and consequently in the character) of the waters in which they were deposited. It will be extremely difficult to define the portions corresponding to each of the various marine epochs; meanwhile, I propose to designate as the *Mansfield group*, that portion which, from its geographical position and general uniformity of materials, seems to be the equivalent of the lower portion of the Vicksburg bluff. It is very characteristically developed near Mansfield, La., and there presents a feature foreign to the other lignitic groups I have investigated, viz: a ledge, $\frac{3}{4}$ to 2 feet thick, of an impure, laminated limestone with numerous, but mostly fragmentary, impressions of lignitized stems and leaves. A narrow ($\frac{1}{4}$ to $\frac{1}{2}$ in. wide) band of this rock seems to extend from Mansfield as far as Shreveport, appearing mostly a few feet below the hilltops. Bluish-gray, clayey sands and mouse-colored laminated clays are the predominant materials, with which lignite beds are frequently associated; and near these, well preserved impressions of leaves are not uncommonly found. The surface of the territory occupied by this group is undulating, sometimes (on the rivers) hilly; and as usual, the higher ridges are everywhere capped by the Orange Sand, whose ferruginous solutions have frequently metamorphosed the subjacent Tertiary material into ferruginous shale or sandstone; at the same time forming above the line of contact large deposits of concretionary Brown iron ore,* containing from 40 to 60 per cent of hydrous peroxyd, which will doubtless in time become of considerable practical importance.

Numerous and extensive lignite beds exist in northern Louisiana, the economical importance of which is already beginning to be appreciated.

The limestones of the Vicksburg group at many points yield excellent lime, while the more impure varieties possess in the large amount of glauconite they contain, special advantages for agricultural purposes. Good marls of various kinds also abound. These calcareous materials are the more important in an agricultural point of view, because the soils of the territory, both of the Vicksburg and Mansfield groups have in general a foundation of pretty stiff red clay, derived from the lignitic clays, upon which stimulation produces a great and lasting effect. This red subsoil may almost be considered characteristic of the uplands of northern Louisiana; which are very far from being "Pine Woods," in the sense in which the expression is understood east of the Mississippi; especially where the Vicksburg rocks underlie.

* Mississippi Report, 1860, pp. 23, 24.

The Cretaceous outliers, presently to be mentioned, furnish limestone containing only 1 to 1·5 per cent of impurities, and are sometimes chemically pure carbonate.

The Salines of North Louisiana.—One of the most striking features of North Louisiana is the occurrence of salt springs and licks, usually accompanied by outcrops of limestone, which appear sporadically, but usually near the water courses, mainly near the head of Lake Bisteneau and on the waters of Saline bayou, in the parishes of Bossier, Bienville and Winn.

Brines of considerable strength and purity are obtained in these licks by sinking shallow wells or pits, usually to the depth of 14 to 20 feet. Sometimes brine is obtained in sand, without striking any rock; most frequently, a bed of limestone is encountered, sometimes compact, more frequently coarsely and incoherently crystalline, consisting of more or less horizontal bands or aggregates of white, yellow or black calcareous spar. Beneath this rock, of a few feet thickness, a bed of white or gray granular gypsum of 12 to 20 inches thickness, frequently appears, and beneath this the brine is reached, in a sandy layer.

At several points deep borings have been made in these licks, from 200 to as many as 1,100 feet, whereby an increased and, in some cases, an artesian supply of brine has been obtained. The precise records of these borings have been lost; but in one case at least the pile of borings, in others tradition, testifies that calcareous or gypseous materials were met with all the way. This fact coupled with the lithological character of the latter (which is foreign to all the Tertiary groups known to me), and a "find" of several individuals of *Exogyra costata* and *Gryphœa Pitcheri* in the rubbish of one pit, suggests that we have here, not local Tertiary basins, but rather the peaks of a Cretaceous ridge, projecting through the lignitic Tertiary; whose lithological characters agree closely with those described by Dr. Owen as characterizing a portion of the Cretaceous of Arkansas, and equally corresponding to those observed on the upper Red River, near Fort Washita, by Dr. G. G. Shumard.*

The highly crystalline, non-fossiliferous, horizontally banded limestone which characterizes most of these saline outliers, reappears independently farther south, in the shape of limestone ridges elevated perhaps a hundred feet above the drainage of the country; as near Winfield, and on Saline Bayou below Drake's Salt Works.

It will be observed that the general trend of the body of these outliers is about S.E. and N.W. A continuation of this line strikes the main body of the Cretaceous of Arkansas, in Hempstead county, on the one hand; on the other, a body of

* Marcy's Exploration of Red river, p. 195.

limestone of precisely similar character, near Chicotville in St. Landry parish, La., on the territory of the Grand Gulf group, which in the absence of other evidence, I had previously referred to the latter (see above). Its absolute lithological identity with the limestones of Northern Louisiana, as well as the incongruity with all other materials heretofore observed in the Grand Gulf or other Tertiary deposits, leave little room for doubt that here, within 70 miles of the Gulf coast, we have another Cretaceous summit rising out of the Tertiary. And if we follow still farther the general line of trend, southeastward, we light upon the group of Five Islands, and notably the rock-salt deposit of Petite Anse.

It is perhaps too early to discuss the question, whether the latter coincidence is accidental, or whether this ancient Cretaceous ridge thus forming the "backbone" of Louisiana, has caused, not only the shallowing of the older Eocene sea into marshes and lagoons, but also the eastward deflection of the lower Mississippi, and explains the simultaneous existence of salt both in North and South Louisiana. If rock-salt, however, should be found to form any part of the Cretaceous rocks of the southwest, a Cretaceous outlier at Petite Anse would be scarcely more strange than the limestone outcrop near Chicotville. The presumption is still farther strengthened by the phenomena observed in the wells bored near the West Fork of Calcasieu river, about twelve miles west of Lake Charles in Calcasieu parish.

The Artesian wells of Calcasieu.—These are located on two small islands in the (fresh-water) marsh which forms the head of bayou Choupique, a small tributary of the main Calcasieu river. It was long known that on one of these islands there existed "tar springs" which had formed an asphaltum pavement on a portion of the surface, and continuallv evolved combustible gas; and not long after the close of the war, boring operations were commenced there by the "Louisiana Petroleum and Coal Oil Co.," whose auger had, at the time of my visit, reached a depth of 1,230 feet.

Another bore has been commenced on an island about 700 yards to the westward; the work, now carried on by Dr. Kirkman of Lake Charles, has reached a depth of 450 feet. The following is a comparative profile of both wells.

The data for the following profile are derived, for position and thickness, from the statements of the well-borers; the materials are given from samples of the borings picked from the pile by them in my presence, and I have every reason to think that the facts are faithfully represented.

As regards the interpretation of the formations penetrated,

Profile of Artesian Wells, west fork of Calcasieu river.

Kirkman's Well.			Louisiana Oil Co.'s Well.			Formations.
Depth.	**Thickness.**	**Materials.**	**Depth.**	**Thickness.**	**Materials.**	
Ft.	Ft.	Blue and yellow clay, with some sand strata.	Ft. 160	Ft. 160	Blue clay, sometimes with layers of sand soaked with petroleum.	Port Hudson Group.
	354		333	173	Loose sand and gravel, 138 to 153 ft. very pebbly; 153 to 173 ft. finer material.	Orange Sand Group.
			343	10	Gray laminated clay ("soapstone").	Vicksburg Group.
	96	Sand with clay laminæ, 36 ft. Sand and gravel, 56 ft.	383	40	Blue, sandy, nodular limestone, with marine shells. Petroleum and gas.	
450	-----	Sandy pipeclay, 4 ft.	443	60	Soft, white, crystalline, crumbling limestone; tube driven through.	
			543	100	Pure crystalline sulphur.	Cretaceous Formation.
			690	147	Sulphur and gypsum, alternating. About ⅓ sulphur. 5 ft. Sulphur bed at 650 ft. 10–15 " " 680 "	
				540	Pure gypsum. Dense, granular, and coarsely crystalline, grayish or white.	

there can of course be no doubt as to the identity of the Port Hudson and Orange Sand groups. It is interesting to note, that here as elsewhere the Orange Sand rests on a deeply denuded surface, and has itself suffered subsequent denudation; as is evidenced by its relative levels in the two bores. The pebbles are of the usual character; chiefly chert and siliceous sandstones, still showing impressions of palæozoic fossils; the largest observed weigh about five ounces.

While Kirkman's well has chanced upon a valley of denudation, the Company's well has struck a ridge whose summit has resisted denudation by the aid of a cap of hard clay shale, in which, besides, there was a layer of sandstone. As soon as this was penetrated there was a violent rush of combustible gas, and water mixed with petroleum. The amount of the latter however, never exceeded a few barrels a day, even when the pump was used; and great difficulty was experienced in pene-

trating the stratum of loosely piled, disjointed, rounded lumps of blue limestone, which kept tumbling in from the sides. This is evidently the oil-bearing stratum, and (reports to the contrary notwithstanding) I am satisfied that no fresh supply of oil was found after reaching the underlying white limestone.

The rare shells contained in the blue rock are too ill-preserved to allow of specific determinations; but their very state of preservation, no less than the peculiar lithological character of the rock, suggests at once the correspondence to the base of the Sabine Town bluff; which is, moreover, corroborated by the comparative chemical and microscopic analysis. The lignitic nature of the intervening beds, as well as the occurrence of asphalt in the Vicksburg limestone of Mississippi, are suggestive with reference to the oil-bearing feature. The overlying clay stratum likewise coincides.

As to the underlying white limestone, it is a material utterly foreign to any of the Tertiary groups of the Southwest, while coinciding precisely with some of the limestone of the saliferous cretaceous outliers of North Louisiana; here again, chemical as well as microscopic characters coincide as strikingly as they differ from those of the blue oil-bearing rock.

For the immense *sulphur bed* underlying, we have no direct precedent, unless it be the occurrence of a sulphur-bearing earth in the gypsum formation on Delaware creek, on the southern border of the Llano Estacado, observed by Capt. Pope.* But the interstratification of sulphur and gypsum in the lower bed proves the closeness of their mutual relation, while the enormous thickness of the underlying gypsum bed recalls at once the great gypsum formation of the upper Red river, and the Llano Estacado; faintly represented by the gypsum beds of North Louisiana, and Arkansas.

The age of the great gypsum formation has been the subject of much discussion. It has always seemed to me that the great extent of the area over which the Cretaceous beds and underlying gypsum are known to be coëxtensive, went far to prove that they belonged substantially to the same epoch. Whatever weight may attach to this argument is greatly enhanced when we find the crystalline limestone and underlying gypsum not only reappearing in northern Louisiana, but actually accompanying each other beneath the waters of the Gulf of Mexico. Whether the volcanic agencies which even now so frequently disturb that great basin, have been instrumental in reducing the sulphur, distilling the petroleum, and crystallizing the rock salt of southern Louisiana, may be more profitably discussed

* Report of an exploration of a route for the Pacific railroad, near 32d parallel; Geology, by W. P. Blake, p. 38.

when more extensive excavations shall have given us an opportunity of closer inspection of the facts. As regards the sulphur bed, it seems strange that no such opportunity is as yet foreshadowed in the near future ; although in my view, its practical importance can hardly be over-estimated. Its development requires, it is true, large capital and the best of engineering resources, in view of the depth, and peculiar difficulties of drainage and ventilation. But who that knows the part sulphuric acid plays in modern civilization, the monopoly enjoyed by Sicilian sulphur, the burdens naturally and artificially imposed upon its production in that island, and the inferiority of the acid prepared from pyrites, can fail to appreciate the intrinsic importance of a bed of pure sulphur some 135 feet thick, lying at a depth less than half of that at which some coal mines are profitably worked in Pennsylvania ; and within ten miles of ocean navigation ! The very gangue of the mineral—gypsum —is of sufficient value in agriculture and the arts, to bear shipment for thousands of miles, within the country. Nor indeed, is it likely that beds *of such magnitude* should be confined to a limited area, and not be accessible at more advantageous locations.

As regards the prospect of obtaining petroleum in paying quantities, the inconsiderable thickness of the Vicksburg rocks, and the obvious fact that they are traversed by valleys of denudation, are very unfavorable omens.

The water now flows from the Company's well at the rate of 65 gallons per minute ; rises 12 feet above the surface. It is a *saturated solution* of sulphuretted hydrogen, with a little gypsum and common salt. This stream flows chiefly from the surface of the sulphur bed. Boring operations at this well have been suspended, and a company is now being formed with a special view to mining the sulphur.

ART. XXXI.—*Contributions from the Laboratory of the Lehigh University.* No. 2.—*On certain compounds of Chromium with Iron ;* by J. HAYNES H. CORBIN.

PERCY, in his work on iron and steel (p. 186), describes several crystalline compounds of chromium with iron prepared and analyzed by Mr. Smith under his direction.

These compounds contained respectively the chromium percentages of 4·24, 27·07, 54·63, and 76·58, corresponding to the formulæ $Fe_{19}Cr$, Fe_3Cr, $FeCr$ and $FeCr_3$. The experiments were performed in pursuance of the investigations of Berthier,

who found an alloy of the formula Fe_5Cr, containing 17 per cent of chromium, and another containing as much as 60 per cent of this element. Berthier, Faraday and Stodart observed that the addition of 1 per cent of chromium to steel communicated to this compound great hardness and the quality of acquiring a beautiful damask by the action of dilute acids.

Boussingault has lately published (Chem. News, vol. xvii, p. 267, Eng. ed.) the analysis of a chromiferous wrought iron from Central America, containing 1·95 per cent chromium and 4·40 of combined carbon, which he obtained by a new method proposed by himself, viz: dissolving the powdered iron in a solution of corrosive sublimate.

The American Tool Steel Company of Brooklyn has been engaged in preparing alloys of chromium with steel upon a manufacturing scale. They placed a number of specimens of the various compounds in the hands of Dr. Charles M. Wetherill of this University, under whose instruction I have made the following examination of certain of them in the laboratory of the Lehigh University.

The specimens analyzed consist of:

1. Chrome iron ore from the neighborhood of Baltimore.
2. A specimen of chromiferous cast iron obtained by the reduction of 1.
3. Turnings of No. 1 steel prepared by use of 2.

1. The chrome ore possessed the ordinary character of the mineral, and analyzed by the method of Dr. Genth, gave the following percentage result:

Silica	2·12
Chromic oxyd	40·79
Alumina	4·20
Ferrous oxyd	44·48
Manganous oxyd	trace
Lime	2·32
Magnesia	5·21
Phosphoric acid	trace
	99·12

2. The chromium cast iron is a very hard silver-white metal; apparently a mass of interlacing crystal needles. Hardness of feldspar, but very brittle and of density 7·25. It is attacked with great difficulty by the different acids and was brought into solution for analysis by fusion with potassic bisulphate. On attempting to decompose it by means of the battery, only a partial decomposition ensued; the skeleton of carbon which remained contained a good deal of undissolved and crystalline

metal. The process of Boussingault, already referred to, was used for the determination of the carbon. Although this process worked satisfactorily with Boussingault, whose compound contained a small percentage of chromium, it failed with me to fully decompose this specimen, which contains more than 26 per cent of that metal.

The carbon was weighed as $\mathrm{C}\Theta_2$ in a potash bulb. The compound yielded by the analysis :

	1.	2.	3.
Iron	70·18*	70·12	70·23
Chromium	26·25	----	----
Aluminum	·26	---	----
Calcium	2·16	----	----
Magnesium	·58	----	----
Silicon	trace	----	----
Carbon	1·69	----	----
Phosphorus	none	----	----
Sulphur	none	----	----
	101·12		

By eliminating carbon and supposing the small percentage of other metals than iron and chromium to be replaced by iron, the analysis yields almost exactly the formula $\mathrm{Fe}_5\mathrm{Cr}_2$; which is intermediate between 2 and 3 of Smith's compounds alluded to in the beginning of this article. Since the proportion of carbon in white cast iron varies from 3·5 to 5·75 per cent, this specimen is peculiar in having a much lower percentage of that element.

3. The chrome steel is a compound possessing some peculiar properties, a marked one being that of assuming a highly crystalline structure and cracking badly when tempered at the usual heat for tempering steel ; but at a low red heat, a product of very fine grain is the result. Another property is, that it may be submitted to considerable torsion without breaking. A bar twenty-four inches in length and one half inch square, was twisted while cold by two men at the end of a powerful lever two and one half feet in length, until the lever described three complete circles. The twisted bar was now bent in the shape of an ellipse until the ends touched : on examination no injury to the steel could be detected, as it appeared to possess the same properties after as before the operation. The steel is very hard. The hardness of a tempered specimen is equal to that of quartz, and that of an untempered specimen to that of feldspar. The density of the tempered specimen is 7·79 and that of the untempered one 7·8. The density of the latter,

* Mean of 2 and 3.

however, had been raised by its having been struck with a hammer. Its fracture is white, conchoidal, and very fine in structure. Like ordinary steel it is attacked readily by chlorhydric acid, evolving f tid hydrogen and forming an oily scum. On treating the polished steel, both tempered and untempered, with dilute and strong acids, no damask could be obtained.

The analysis gave :

	1.	2.
Iron	95·92	95·27
Chromium	1·66	2·22
Aluminum	2·38	1·69
Calcium	0·44	
Magnesium	0·12	
Silicon	0·12	
Carbon	0·98	
Phosphorus	trace	
Sulphur	trace	
	101·62	

The carbon was determined as in 2. In analysis 1 the iron, chromium and aluminum were determined from an aliquot part of the oxyds precipitated together, by the addition of ammonia ; while in the second analysis the iron was separated as sulphid, the chromium and aluminum being held in solution by addition of tartaric acid to the alkaline solution. On comparing this specimen with one quoted by Berthier, (Percy, p. 187) containing about the same percentage of chromium, it is found that his specimen by treatment with dilute acid yielded a beautiful damask, while this does not ; from which one would conclude that there is a more thorough incorporation of the chromium throughout the entire mass in this compound, brought about by the process of manufacture, than in Berthier's. This would lead to a more uniformly hard, and probably harder, steel, on account of there being no interstices between crystals of iron and chromium, which, together with the carbon produced the damask in Berthier's specimen. It would seem that the properties of this steel are not due to the replacement of carbon by chromium as is thought by the manufacturers ; for although the presence of the chromium may greatly tend to enhance the value of this compound as a steel, yet we find its content of carbon to be within the limits for producing a good quality of steel.

The extraordinary properties possessed by the chromium steel, may, in a great measure, be attributed to the uniform distribution of a hard uncrystalline alloy of iron and chromium through the mass of steel—so homogeneous, in fact, does this compound appear to be, that there is no veined structure or

damask to be noticed when treated with dilute acid. The almost total absence of the deteriorating elements, phosphorus, sulphur and silicon, has probably much to do with the quality of this steel; for the manner in which it may be twisted when cold, and heated to whiteness without "burning," forged and welded, presents an anomaly in the behavior of steel.

ART. XXXII.—*Contributions from the Laboratory of the Lehigh University.* No. II.—*Examination of a supposed Hercynite*; by CLARENCE A. WOLLE.

THE mineral Hercynite is known only by an analysis of Quadrat (Ann. Ch. Pharm., lv, 357.) A mineral very much resembling it was discovered by Prof. W. T. Rœpper, who kindly gave me the specimen for the following investigation, which was made in the Laboratory of the Lehigh University under the direction of Dr. Chas. M. Wetherill. The locality is near Peekskill, N. Y., and Prof. Rœpper, who visited the spot, describes the mineral as occurring in large isolated masses in syenitic gneiss.

The supposed hercynite is intimately mixed with magnetite, from which it may be freed by digesting the fine powder with hydrochloric acid. It remains unaltered by this reaction and appears, under the microscope, as a transparent greenish crystalline mineral which, when fused with carbonate of soda, is not decomposed. The crystals were boiled with a solution of carbonate of soda to remove silica.

The mineral thus treated when examined under the microscope shows traces of octahedral cleavage and crystallization. It is vitreous on surfaces of fracture, but otherwise possesses a dull luster. The color is greenish to leek-green, becoming greener and lighter when powdered; to the naked eye it is not transparent. Hardness 7·5; specific gravity 3·58; not magnetic.

Before the blowpipe it shows the following reactions:—1. Alone infusible. 2. With carbonate of soda bead it remains undissolved and floats about like silica in a microcosmic salt bead, and on withdrawing from the flame is first green and finally on cooling turns gray. 3. With borax bead, a yellow-green glass, which on cooling assumes on olive-green color. 4. With microcosmic salt, dissolves completely, and forms a greenish-yellow glass, which, when cold, is colorless.

The qualitative analysis shows Al_2O_3, Fe_2O_3 and MgO to be its constituents. 0·8036 gram of the dried substance was taken, according to Rose and Quadrat, and fused with about five to six times its weight of bisulphate of potassa in a platinum crucible

for a considerable time, thereby evolving SO_2. After a perfect fusion the mass when cold was dissolved in water made slightly acid with HCl, and from this solution the Al_2O_3 and Fe_2O_3 precipitated with NH_4O and finally separated by KO, and treated as usual. The Fe_2O_3 after being incinerated weighed ·2364 gram, =29·40 per cent, and the Al_2O_3 weighed ·4885 gram, =60·79 per cent.

The MgO in the filtrate from the first precipitate of Al_2O_3 and Fe_2O_3 was precipitated as phosphate with phosphate of soda, and weighed, after incineration, ·2863 grm. =·1032 grm. MgO =12·84 per cent. The results of the analysis therefore yield—

Fe_2O_3	=	29·40 per cent.
MgO	=	12·84 "
Al_2O_3	=	60·79 "
		103·03

The iron does not all exist as FeO, for such constitution would give the oxygen ratio of $RO : R_2O_3$ as 1 : 2·557 instead of 1 : 3. The hardness and insolubility in acids of this mineral show that it is a spinel. Part of the Fe must therefore exist as Fe_2O_3. A calculation of this Fe_2O_3 in such a manner as would give the oxygen ratio 1 : 3 will yield the following percentage composition:

Ä̇l	F̈e	Ḟe	Ṁg	
60·79	5·26	21·74	12.84	= 100·63

and calculating from the formula—

$$(\tfrac{1}{2}\dot{M}g + \tfrac{1}{2}\ddot{F}e) +)\tfrac{1}{2}\tfrac{9}{0}\ddot{A}l + \tfrac{1}{2}\tfrac{1}{0}\ddot{F}e),$$

we obtain the following percentage composition, which agrees well with the above analysis:

Ä̇l	F̈e	Ḟe	Ṁg	
60·45	4·94	22·25	12·36	= 100

An analysis of a spinel from Tunaberg, by Erdman, gave the following results:—

Ṁg 13·03 F̈e 23·46 Ä̇l 62·95 = 99·44.

From the above analyses and remarks, it will therefore be seen that the mineral is a magnesia-iron spinel, with part of the the Al_2O_3 replaced by Fe_2O_3, and it may be regarded as intermediate between Hercynite and Ceylonite.

Sept. 1869.

ART. XXXIII.—*Contributions from the Laboratory of the Sheffield Scientific School, Yale College.* No. XXII.—*On the proximate Composition of several varieties of American Maize*;* by W. O. ATWATER, Ph.D.

THE four varieties of Indian corn analyzed are as follows:

A. *Early Dutton Corn.*—An early variety, yellow in color, twelve rowed, kernels rather small. Ears medium size. One of the most common varieties of early corn in New England.

B. *The common Yellow Corn* of New England and the eastern States, also called *Canada Corn.*—Eight rowed, kernels and ears of good size.

C. *King Philip Corn*, sometimes called *Rhode Island Corn.*—Brown-red color, eight rowed, ears and kernels often quite large.

D. *Stowell's Evergreen Sweet Corn.*—Specimens are sold under this name, having twelve and sixteen rows, ears short and thick.

Preparation for analysis.—The corn was ground in an ordinary drug-mill. The mill was carefully cleaned by grinding corn therein until the meal came through clean in appearance. For the ash-determinations, a portion of each sort was coarsely crushed in the mill. Another portion was then ground quite fine for the other investigations, in which the result could not be appreciably affected by an amount of impurity from the mill, not detectable by the eye. Considerable care was taken to insure a thorough mixture of the material, it having been noticed on cleaning the mill before the grinding of each specimen that a portion of the finely divided substance adhered to the interior, which portion it was feared might come from the softer and more easily pulverized part of the kernels. In a number of cases it was found necessary to grind the meal still finer with sand in a porcelain mortar. The specimens for analysis were all ground at the same time, and set aside for use in well closed bottles.

Determination of water.—The accurate estimation of hygroscopic water is often attended with difficulties, owing to the extreme slowness with which the last traces of water disappear, as well as to the fact that, from long continued heating there results an oxydation of fatty matters and an alteration and loss of other elements.

At the suggestion of Prof. Johnson, use has been made of the Bunsen pump, and the following method adopted, by which the above difficulties have been obviated, to a great extent. One or two grams of the very finely divided material are weighed off, and quickly transferred to a dry round-bottomed

* Graduating Thesis presented to the Faculty of Philosophy and the Arts, Yale College, July, 1869.

glass flask, of about 75 c. c. capacity. The flask is then closed with a perforated rubber stopper, which has been previously boiled in caustic soda, and is itself closed with a glass rod. This is allowed to stand in the balance for a time, and is then weighed with a similar flask as counterpoise. The stopper is then removed and the flask is partially immersed in boiling water and allowed to remain for an hour. The stopper is now inserted, the glass rod being replaced by a glass tube, bent at right angles, which connects with the Bunsen pump. The exhaustion by means of the latter is made as complete as possible, and the boiling continued for half an hour or an hour. With the proper precautions, an hour's boiling with the flask open, and the same under exhaustion, suffice to bring the flask and its contents to a constant weight.

During the last boiling, moisture is apt to condense in the tube. I have found it well to expel this by heat, or still better, to replace the wet tube with a dry one. A tube, with the horizontal arm 20 cm. long, answers well for this purpose. It is of course essential that the interior of the pump be as dry as possible, otherwise a number of hours may be required for the completion of the process.

After the drying is finished, the tube is removed from the stopper, the glass rod inserted, and the flask set aside in the balance for half an hour or more. The rod is then removed, for a moment, to allow access of air to the interior, and again inserted, when the whole is weighed. The difference of the two weighings is the loss of water. The results accord closely as seen from the subjoined figures.

Water per cent.

A.		B.		C.		D.	
I.	II.	I.	II.	I.	II.	I.	II.
8·09	8·08	10·54	10·51	9·78	9·80	10·75	10·98

A, had been kept for some months in a very dry atmosphere. The others were in the same hygroscopic condition as when taken from the seed-store.

Determination of Ash.—For this purpose two methods have been employed. In each, two, or more generally, three grams of meal were used. By the first, the meal was ignited for from twelve to twenty hours at a low heat in a porcelain capsule over a Bunsen lamp. By this means the corn was without difficulty burned to a light gray or nearly pure white ash. The difference between the weights of the light gray and of the white ash is quite inconsiderable—two trials giving less than half a milligram each.

By the second method the meal was charred, first at a quite low, and then at a somewhat higher heat, for a little time after all empyreumatic odors had disappeared. It was then boiled with water and filtered. The filtrate was evaporated to dry-

ness, and gently ignited, while the filter with its contents was incinerated at a much higher heat, and the residue weighed with that of the filtrate.

I append results of experiments by the two methods.

A 1. 2d method, per cent,	1·52	Soluble,	1·04
		Insoluble,	·48
A 2. " " " "	1·52	Soluble,	1·03
		Insoluble,	·49
A 3, 1st " " "	1·56		
A average of four others,	1·52		
B 1. 2d method, per cent,	1·31	Soluble,	·80
		Insoluble,	·51
B 2. " " " "	1·30	Soluble,	1·01
		Insoluble,	·29
B 3. 1st " " "	1·30		
B 4. " " " "	1·36		

As intimated above, the amount of carbon left unconsumed in direct incineration, with a low and long continued heat, is very trifling; and the comparative results above given confirm the observation of Strecker, that there is no loss of alkali-chlorids in this process.* The ash thus obtained is free from carbonic acid. The amounts of soluble and insoluble ash correspond very closely with the amounts of soluble and insoluble ingredients, as calculated from the average of the best analyses.

Here follow the ash-determinations made in case of A and B by the second method above described, and in case of C and D by the first.

Ash, per cent.

A.		B.		C.		D.	
I.	II.	I.	II.	I.	II.	I.	II.
1·52	1·52	1·31	1·30	1·61	1·58	1·87	1·91

Determination of Fat, &c.†—This substance was estimated by the use of Storch's apparatus,‡ which has proved to be very convenient. The ground corn was triturated with pure quartz sand previous to extraction. Pure ether was the solvent used. Corks, if employed for connectors, need to be purified by pre-

* Compare Fres. Quant. Anal. on preparation of ash of plants for analysis. Also Ann. d. Chem. u. Pharm., lxxiii, 366–8.

† According to Hoppe Seyler, (Med. Chem. Unters., i, 162), a sample of maize examined by him, yielded

Ether-extract	3·770 per cent, which contained
Cholesterin	0·100
Protagon	0·149
Saponifiable fat and yellow pigment	3·521

‡ A modification of the "Extracteur" of Payen; Fres. Zeitsch. f. Analyt. Chem. 1868. S. 68. I have found that a glass tube 13 cm. long, 3 cm. wide at the upper, and 2 cm. at the lower end, answers quite well, especially if the taper be confined to the lower 4 cm.

liminary treatment. Ordinary cotton batting will also need purification. A portion of that which I used, when dried at 100° C. and treated with ether, gave 0·9 per cent of a fatty substance, which on cooling had the appearance of tallow or stearine. Great care and considerable time are required to remove the last traces of ether and moisture from the fat and the flask containing it, before weighing. I have always used, in weighing, a counterpoise flask similar to the one in which the fat was collected. Below are my results:

Fat, per cent.

A.		B.		C.		D.	
I.	II.	I.	II.	I.	II.	I.	II.
5·76	5·58	4·42	4·41	4·52	4·38	7·57	7·75

L. Lenz (Henneberg's Jahresbericht, 1866–7, p. 151), has published examinations of six varieties of maize, in which he finds a small proportion of fat in the endosperm and a large percentage in the chit (*keime*), and expresses the opinion that the fat found in the endosperm really belonged to portions of the chit which escaped separation. To test this supposition, I have made the following experiment:

A number of kernels of common yellow corn, B, were taken, the interior soft portion of each kernel carefully cut and scraped out, and the two portions weighed.

Weight of outer hard portion, endosperm,	30·211 grm.	76·43
" " inner soft " embryo with some endosperm,	9·321 grm.	23·57
Total,	39·532 grm.	100·00

The former portion was ground and the amount of water and fat determined as above, with the following result:

Water,	15·92 per cent.
Fat,	1·37 " "

Lenz found in the endosperm of the maize examined by him from 0·75 to 1·96 per cent of fat, the mean of his six results was 1·32 per cent. The water-content of the endosperm he analyzed was less than the above, viz: from 9 to 10 per cent. The larger percentage of moisture in my sample was due to the fact that the corn had been standing for some time, and was likewise ground in a very damp air. It appears then that while the endosperm is very much poorer in fat than the chit, it is nevertheless not entirely free from this material. The ether-extract from the endosperm had much the same appearance as that from the entire kernel obtained in the ordinary estimations.

Determination of Albuminoids.—The amount of nitrogen*

* The nitrogen determinations gave the following figures:

A.		B.		C.		D.	
I.	II.	I.	II.	I.	II.	I.	II.
1·53	1·54	1·56	1·55	1·88	1·92	1·76	1·79

was estimated by combustion with soda lime, and the result, multiplied by 6·25, was taken for the amount of albuminoids.*

Here follow the results:

Albuminoids, per cent.

A.		B.		C.		D.	
I.	II.	I.	II.	I.	II.	I.	II.
9·56	9·62	9·75	9·69	11·75	12·00	11·00	11·19

Determination of Cellulose.—The cellulose was estimated by alternate extraction with diluted acid and alkali (Peligot's method), after Henneberg's directions, (Versuchs-stationen, vi, 497). As is well known, the methods for cellulose estimation are not entirely accurate, and the results here given are probably somewhat too low.

Crude fiber ash-free, per cent.

A.	B.	C.	D.
I.	I.	I.	I.
2·52	2·40	2·21	2·63

Another trial, no doubt less accurate, from the fact that the material was allowed to stand for some time in the liquid previous to each decantation, gave

A.	B.	C.
II.	II.	II.
1·69	1·60	1·76

And a trial upon the material left from an unsatisfactory attempt to estimate starch, by Dragendorff's method, described in Johnson's "How Crops Grow," p. 66, gave after extracting starch with dilute chlorhydric acid—

Crude fiber ash-free.

B.	C.	D.
1·03	1·34	1·78

Determination of Aqueous Extract, Gum and Sugar.—Four grams of finely ground material were treated with cold water in a beaker for two hours, and then filtered with the aid of the Bunsen pump. The whole operation required three or four hours for completion. In the case of the sweet corn it was found necessary to make the solution of known bulk, and take aliquot parts of the first portion of the filtrate for the estimations, as the filter became, after a time, so clogged as to forbid the passage of the solution, even when under pressure. The filtrate was divided into four equal portions, each representing

* The mean factor 6·25 is that adopted by the *Versuchs-stationen* of Germany. The recent investigations of Ritthausen, Jour. f. Prakt. Chem., cvi, p. 483, give in maize-fibrin 15·58 per cent of nitrogen. Stepf, (same Journal, 76, 90), found 15·6 per cent of nitrogen. The other albuminoid in maize is very near Ritthausen's *Conglutin*, and contains 17·72 per cent of nitrogen, but as it forms but 0·5 per cent of the grain, (*loc. cit.*) we must conclude that 6·4==(100÷15·6) is the proper factor for calculating the albuminoids. This gives the following average percentages:

A.	B.	C.	D.
9·82	9·95	12·16	11·36

one gram of meal. The first portion was evaporated to dryness in a platinum capsule, weighed, ignited, weighed again, and the difference reckoned as aqueous extract, ash-free. From the last weight was subtracted the weight of the capsule and the difference was reckoned as ash. The results are as follows:

	A.	B.	C.	D.
Aq. ext. ash-free,	7·22	7·14	7·85	16·28
Ash,	·74	·88	·68	·97
Total aq. ext.	7·96	8·02	8·53	17·25

When examined qualitatively, the extract gave with iodine a blue tint, indicative of the presence of a small amount of starch, and when ignited in a glass tube with soda-lime, yielded a slight reaction for ammonia, showing that there was a small amount of albuminoid matters likewise present.

In every instance the solution was somewhat turbid, from presence of a trace of suspended fat (?) This was especially true in case of the sweet corn. On boiling, a white substance, probably a coagulated albuminoid, separated from the solution. The quantity was however very small, and its estimation was not attempted. Stepf gives the amount of albumin in the maize he examined at 0·62 per cent.

The researches of von Bibra* indicate the absence of dextrin from the cereal grains, a conclusion which is quite in accordance with my own qualitative examinations. I have therefore considered the aqueous extract to consist of sugar and gum exclusively, so far as its non-nitrogenous ingredients are concerned.

The second portion of the aqueous solution was also evaporated to dryness at near 100° C., treated with alcohol of 66 per per cent, filtered, the filtrate evaporated to dryness, and the residue treated as before. The following results were obtained:

	A.	B.	C.	D.
Dissolved in alcohol,	6·95	7·20	5·53	11·53
Undissolved,	0·27	0·00	2·32	4·75

It is probable that the alcohol of 66 per cent carried gum into solution. In B the albuminoid was also dissolved.

More confidence is to be placed in the results obtained with the third portion of the aqueous extract, by the use of Fehling's solution, as described in Fresenius' Quantitative Analysis. The precipitated suboxyd of copper was collected on weighed filters, and the sugar was reckoned as glucose. I obtained:—

Sugar and Gum, per cent.

	A. II.	B. II.	C. II.	D. II.
Sugar,	3·00	4·78	3·05	11·64
Gum, by difference,	4·22	2·36	4·80	4·64

Want of time cut short my work at this point, and I regard these determinations of sugar and gum as open to revision.

* Die Getreidearten und das Brod, *passim*.

The complete (mean) analyses stand as follows, taking the sugar and gum as estimated with Fehling's solution and reckoning starch by difference:—

	A. Early Dutton.	B. Common Yellow.	C. King Philip.	D. Stowell's Evergreen Sweet.
Water,	8·08	10·52	9·79	10·86
Albuminoids,	9·62	9·72	11·87	11·10
Sugar,	3·00	4·78	3·05	11·64
Gum,	4·22	2·36	4·80	4·64
Starch,	65·40	64·49	62·23	49·58
Fat,	5·67	4·42	4·45	7·66
Cellulose,	2·52	2·40	2·21	2·63
Ash,	1·52	1·31	1·60	1·89
	100·00	100·00	100·00	100·00

Subjoined are the mean percentages of the proximate elements calculated upon dry substance:

	A.	B.	C.	D.
Albuminoids,	10·46	10·86	13·16	12·45
Sugar,	3·26	5·34	3·38	13·06
Gum,	4·59	2·64	5·32	5·21
Starch,	71·13	72·08	68·99	55·62
Fat,	6·16	4·94	4·93	8·59
Cellulose,	2·74	2·68	2·45	2·95
Ash,	1·66	1·46	1·77	2·12
	100·00	100·00	100·00	100·00

In these analyses the percentage of water and ash alone can be regarded as quite correct. The percentage of albuminoids must be considered as a close approximation to the truth. The figures given for "sugar" and "gum" (aqueous extract) are likewise probably not far from right. They include, however, a little of some soluble albuminoid and possibly soluble starch —the "amiduline" of F. Schulze and "amylogen" of Jessen. The cellulose is much lower than most chemists have found. Thus Poggiale, Payen and Polsen obtained respectively 4·5, 9 and 14·9 to 20·4 per cent of fiber. That these figures are erroneous must be concluded from simple ocular investigation. Fresenius, using Peligot's method obtained 1·58 per cent. Bibra rejects Peligot's method as yielding too little cellulose, but the numerous analyses executed by the German Agricultural Chemists within recent years indicate that its results do not vary widely from the truth. The error in the percentage of starch (insoluble), which is determined by difference, cannot probably exceed 2 or 3 per cent.

The only detailed investigations upon Indian corn by American chemists with which I am acquainted, are those of J. H.

Salisbury, Trans. N. Y. State Ag. Soc., 1848, p. 678, and those of C. T. Jackson, U. S. Patent Office Report, 1857, p. 160, and Geology of New Hampshire, pp. 256 *et seq.* These investigations, the former of which, especially, was quite extended, were unfortunately made for the most part by methods too imperfect to yield valuable results. I append an analysis by Salisbury, above report, p. 779, of "Yellow Corn," the same variety as B of the present article, also one of "Rhode Island Sweet Corn," same report, p. 784.

	Yellow Corn.	R. I. Sweet Corn.
Water,	11·18	10·22
Albumen,	6·46	13·00
Casein,	·12	2·64
Zein or gluten,	7·32	3·68
Sugar and extract,	11·87	18·08
Sugar,	·65	2·72
Dextrin or gum,	6·28	12·32
Starch,	42·03	15·16
Oil,	4·35	9·92
Fiber,	9·36	12·80
Matter separated from fiber by weak solution of potash,	·44	·24
Ash,	not given	not given
	100·06	100·78

The following is an analysis by Jackson, Patent Office Report, 1857, p. 161, of King Philip Corn.

Water,	10·0
Gluten or zein,	5·0
Casein and albumen,	2·0
Dextrine and glucose,	1·5
Starch,	54·5
Fat oil,	4·2
Cellulose,	17·3
Undetermined, ash, &c.,	2·0
	100·00

As seen above, Dr. Salisbury found in Sweet Corn 12·32 per cent of dextrin or gum and 13·00 per cent of albumen, and in the article referred to attributes the shrivelling of the kernels to the loss of water in the drying of these bodies. It cannot be doubted that the estimations were erroneous.

In "The Geology of New Hampshire," page 259, Dr. Jackson reports the amount of oil in different varieties of corn as varying from 6 to 11 per cent, the latter amount being found in the Canada Corn (B of this paper). In the same article, p. 257, he states that the oil in this variety as in several others, is con-

fined chiefly to the endosperm, whereas Lenz and myself find it nearly all in the chit. On page 258 Dr. Jackson "is able to prove that the popping of corn" is due entirely to the decomposition of the oil and the formation of carburetted hydrogen gas. But it is a matter of experience that sweet corn which is remarkable for its large content of oil, expands only very slightly in "popping." On page 257, Dr. Jackson mentions "a beautiful and new application of chemistry" by which the use of qualitative tests, "iodine," "sulphate of ammonia," &c., "we may easily cause any grain to point out the extent and precise limits of each of its ingredients and by the eye we can form a pretty correct estimate of their relative proportions in different seeds." It would be ungracious to notice these statements, were it not that they are frequently quoted as a part of our standard knowledge on this subject.

It will be seen from my analyses that the three first varieties of corn which are quite similar in general appearance and in the consistency and structure of the kernel, are almost identical in composition, while the sweet corn is much poorer in starch and richer in sugar and gum as well as in fat. I hope to have an opportunity in the future of extending my investigations in this direction so as to accomplish more perfect separations and also to examine a large number of varieties of American maize.

Art. XXXIV.—*On the Magnetite in the mica of Pennsbury, Pa., in reply to Prof. G. Rose ;* by James D. Dana and George J. Brush.

1. *Note by J. D. Dana.*

Professor Rose, of Berlin, in a paper published in the Proceedings of the Royal Academy at Berlin (Monatsberichte für 1869, p. 339), has pronounced the statement in my Mineralogy (p. 150), that the markings in the Pennsbury mica are due to thin films of magnetite, an error, and has instead called the mineral *hematite*. The first reference of the species to magnetite was made by Prof. Brush, and I therefore leave it to him to mention the observations upon which the conclusion was based. They afford full proof, I feel assured, that the mineral is not hematite, and make it scarcely less certain that it is magnetite.

Professor Rose's arguments are mostly opinions rather than facts or demonstrations. He *infers* from his having seen very minute grains of magnetite, even those obtained in blowpipe reductions, which were not transparent, that the excessively thin transparent crystalline films in the mica are not magnetite.

He infers, from his having observed scales and markings of hematite in *some* micas, that those of the mica in question are probably hematite. Finkener having, at Professor Rose's request, examined the Pennsbury mineral and found in it protoxyd of iron, he infers that this protoxyd is an accidental ingredient, as is true in the case of some hematites, and not evidence that the species is magnetite. Rammelsberg thinking he has reason to believe that the oxyd of iron coloring green bottle glass is magnetite, the inference is drawn that magnetite if transparent would be green, and hence the mineral by its brownish shades shows that it is not magnetite. Such evidence has not great scientific value.

The seemingly decisive fact brought forward, to which the above inferences are added, relates to the color of the mineral. In my Mineralogy the films are said to vary from "colorless to pale smoky brown and black." Professor Rose states that, besides having these colors, it is also sometimes *red* and *yellow*. This was, from the first, observed to be true by Professor Brush and myself. But it was further seen by us that *the red and yellow colors were always a result of alteration ;* and we are sure that if Professor Rose had examined the hundreds of specimens that have been at our disposal, he would not have failed to detect this. He argues from the occasional red color which he observed that the mineral is not magnetite, but hematite ; when in fact the range of colors from colorless to black proves just the reverse, or at least that the species is *not* hematite.

In applying the term *dendrite* to these markings I had reference to the *dendritic forms* they generally present, and not to the time or mode of origin, on which latter point I held the same view with that sustained by Professor Rose.

2. *Note by G. J. Brush.*

The following are the observations which led me to believe that the mineral imbedded in the Pennsbury mica in dendritic forms is magnetite, and which force me still to the same conclusion contrary to the opinion of Professor Rose.

1. From an examination of several hundred specimens it appeared that the mineral was black and opaque where sufficiently thick ; that this color shaded into dark brown ; and this faded gradually into a delicate smoky hue, still retaining the brown color, becoming finally almost colorless.

2. Wherever the mineral had been exposed to alteration, especially toward the edges of the crystals of mica, it was *sometimes* changed to a bright red or yellow color. A large number of specimens, however, showed no evidence of alteration.

3. I found that the mineral was powerfully magnetic, so much so, that a thin film would rise to the magnet, carrying with it a load of mica many times its weight. I also found that *where the film of mineral was red or yellow it was destitute of magnetic properties.*

4. I determined by blowpipe tests that the mineral was an oxyd of iron yielding no reaction for titanium.

5. On heating the blackish brown mineral to redness out of contact of air it retained its color, but heated with access of air it became red. I also found that when the yellow mineral was heated it became red.

From these observations I concluded that the *yellow* mineral was hydrated oxyd of iron; that the *red* substance was sesquioxyd of iron (hematite); and that the *mineral varying from colorless to smoky and blackish-brown* was magnetic oxyd of iron, or in other words *magnetite*; and further, that wherever the specimens were red this was due to oxydation, and the consequent formation of hematite; and where they were yellow it was due to hydration as well as oxydation.

I have made a careful reëxamination of a large number of specimens and have not only confirmed my former observations but have found that the red mineral when rubbed on white porcelain gives a red streak, the yellow mineral an ochre yellow streak, while the blackish brown mineral gives a black streak. This is additional evidence that the red mineral is hematite, the yellow mineral hydrated oxyd of iron, and that the magnetic mineral is in all probability *magnetite.*

Art. XXXV.—*On the probable origin of Albertite and allied minerals;* by S. F. Peckham.

In a paper read at the meeting of the National Academy of Science last August,* I expressed the opinion, that solid bitumens occurring in veins of large extent, of which the Albertite is an example, had not been formed by the inspissation of petroleum, but were the product of a very gradual distillation of bituminous minerals at a minimum temperature resulting from their metamorphosis. In the same paper I showed that petroleums containing paraffine and very little nitrogen, like those of Pennsylvania, were not rendered more dense by oxydation, but by inspissation.

In 1863 Mr. J. P. Lesley expressed the opinion in reference to Grahamite, that, "there seems to be no escape from the conclusion, that the substance filling the vertical vein is a pro-

* Proc. Am. Phil. Soc., x, 457.

duct of the gradual oxydation of coal-oil once filling the open fissure," and further, that "it is not impossible that the lower regions of the fissure are still filled with liquid oil."*

In 1865 in a report made upon Grahamite, Prof. Henry Wurtz states, that the general aspect of the mass, as well as all the results of a minute examination of the accompanying phenomena, lead irresistibly to the conclusion that we have here a fissure filled by an exudation, in a pasty condition, of a resinoid substance derived from, or formed by some metamorphosis of unknown fossil matter, contained in deep seated strata intersected by the fissure or dike."†

In 1865 Prof. Charles H. Hitchcock, State Geologist of Maine, said, "The Albert Coal" (Albertite) "was originally in a liquid state, was injected into vertical fissures, and subsequently hardened into a substance resembling jet."‡

The same year Prof. Hind, of New Brunswick, endeavors to show that Albertite is an inspissated or hardened petroleum."§

In 1868 Prof. Wurtz says, "no doubt can now be held, that the Albertite vein was formed by the injection of a fluid or pasty mass of matter into a fissure or crack in the rocks; that is, in the same way that a dike of volcanic trap or lava is formed."‖

In the recent edition of his System of Mineralogy (1868) Prof. Dana says, "Grahamite occurs in West Virginia, * * filling a fissure (shrinkage fissure), * * and supposed to be like the Albertite, an oxygenated petroleum."

At the time I ventured the opinion that Albertite was not an inspissated petroleum, I had not seen Prof. Wurtz's papers. His views, however, do not appear to be endorsed by Prof. Dana, who refers to these papers and then states the opinion held by a majority of observers, viz: that the minerals are inspissated or oxygenated petroleums. I propose to examine the testimony of those who have written upon this subject, and note some of the difficulties which appear in the acceptance of such a theory.

It appears to me that all true veins of bitumen occurring in the older strata of West Virginia, New York, Canada and New Brunswick may be referred to a common origin. The asphaltum veins of Cuba may or may not be more nearly allied to a hitherto undescribed vein, occurring upon the coast of

* Ibid, ix, 183.

† Rep. on a mineral formation in W. Va. by Prof. Henry Wurtz, to the Ritchie Mineral Resin and Oil Co., Baltimore, Md.

‡ This Journal, II, xxxix, 272.

§ Prelim. Rep. on the Geology of New Brunswick, chap. v.

‖ Coal or Asphalt, an inquiry into the proper classification of the Albertite of New Brunswick.

Southern California, of which I shall speak hereafter. To this also, without doubt, are more nearly allied certain veins said to occur in Miocene sandstones near the junction of the White and Green rivers, Colorado.*

All observers agree that the veins first mentioned are true cutting veins, at, or nearly at, right angles to the planes of the strata which they intersect. In most instances the enclosing rocks present evidences of metamorphosis, in others they are unaltered, and in others still the metamorphosis has obliterated the planes of stratification, the rocks becoming crystalline. It is further their unanimous opinion that the mass was injected, and from below upward; also that the mass was in either a fluid or semi-fluid condition. Prof. Hitchcock believes that the Albertite has been injected at two distinct periods. He also describes "horses" or enclosed pieces of the wall rock, as common in the vein. Prof. Wurtz describes one of these masses as occurring in the Grahamite, but a few feet below the cavity from which it fell. The vein of Albertite has been mined to the depth of a thousand feet without diminishing in thickness; it forms the crown of an anticlinal, the walls pressing against it with sufficient force to granulate the mineral, and crush large sticks of timber as they close behind the miners. In all these veins the lines of demarcation between the "veins" and "country" are clearly drawn, there being no intervening mass of rock more or less completely saturated with bitumen.†

The thickening of *petroleum* to a solid mass, by either evaporation or oxydation, or both combined, is an exceedingly slow process. Even in California, where the change takes place most rapidly, months if not years are required to cause the oil to become asphaltum, even when it is spread out in a thin pellicle and exposed freely to the atmosphere and an unclouded sun. Neither Grahamite nor Albertite could have been derived from oil like those of California, becoming dense from decomposition, as they both yield paraffine, but must have been derived, if derived from petroleum at all, from the more stable class represented by those of Pennsylvania which thicken by evaporation, or from an oil partaking of the characters of those of both regions.

Let the prior existence of a subterranean pool of petroleum be admitted. The fissure is formed and the oil enters it. In the case of the Albertite, what held the walls asunder while the oxydation was in process of completion—a process which

* Annual of Scientific Discovery, 1866–7, p. 257. Proc. Bos. Soc. Nat. Hist., 1866. At the recent meeting of the American Association, Prof. Wurtz stated that the Colorado bitumens resembled Albertite; they are not therefore allied to the California asphalts.

† For authorities, see papers before quoted.

after a solid pellicle was once formed would go on more and more slowly as it proceeded downward? What held the masses of wall rock suspended but a few feet below the cavity from which they fell, while the oxydation was in process? What has become of the remainder of which these enormous masses are *only the residue?*

Is the hypothesis of their derivation from petroleum more acceptable, if it be admitted that the substance entered the fissure in a semi-solid condition? The fissure opened and was filled. The filling could not be gradual by infiltration, else the same questions arise respecting the wall rock and the "horses." The oxydation must then have been completed at a depth of more than a thousand feet below the surface. Through what agency could the oxydation have been effected at that depth? In California, petroleums were found changed by oxydation at a depth of nearly five hundred feet; the change however was only slight; they were still *fluids.* The strata too, in that region are very much broken and porous, wherever the oils are oxydized beneath the surface. If the veins were filled by a residue from the evaporation of petroleum, the evaporation must have taken place at a great depth by internal heat—certainly not by the sun's rays. What then became of the lighter portion, amounting to from ninety to ninety-five per cent? Did the formation contain fissures into which the vapors arose and were condensed? If such is the case why is not Hillsborough Co., New Brunswick, one of the richest petroleum regions in the world? Is it probable that so vast a quantity would have escaped so as to leave only traces at present? In Canada and New York such veins are remote from springs of petroleum, and are usually, if not always, found in metamorphic strata.

This hypothesis presupposes a subterranean sea of petroleum. The quantity must have been vast or the fissure could not have been at once filled with the residue. Its accumulation must have been finished before the distillation began, as it could not have been fed from above downward, as hydrostatic pressure constantly forces oil toward the surface; neither could it have been fed laterally for the same reason; nor could it have been fed from beneath, unless we suppose the mass to represent one product in a system of fractional condensation. Distillation commences; if the cavity were hermetically sealed, enormous pressure is generated, and a corresponding increase of temperature required for further distillation. The pressure increases until the crust of the earth is ruptured, and from ninety to ninety-five per cent escapes as vapor, leaving a perfectly homogeneous mass which is forced by the collapse into the fissure,

and solidifies on cooling. If the cavity were not sealed, and the temperature gradually decreased toward the surface, fractional condensation in the crevices of the rocks must be the result, the heavier portions succeeding the lighter as the descent was made. This latter supposition makes no provision for the ruptured crust and filling of the fissure, nor for the absence of petroleum in the immediate vicinity, of every degree of density.

The first hypothesis—that the veins were ever filled with liquid petroleum—appears to me to be impossible; the second—that they were filled with the material in its present form, a residue from the distillation of petroleum—may be possible but not probable.

The hypothesis first announced by Prof. Wurtz, is at every step in strict conformity with well-known facts, and it is surprising that it should have escaped the attention of geologists and chemists for so long a time. It is remarkable, that Prof. Lesley should have cited the fact that quartz veins cut injected veins of bitumen in the state of New York, as proof of the aqueous origin of the quartz, and not have ascribed the origin of the bitumen to the same cause, acting upon different materials.* Mr. Vanuxem thus speaks of these minerals: "The anthracite of this rock, from its appearance in the form of drops or buttons, and as before noticed, proves that its previous nature was bituminous, its own being infusible; and shows the heat not dry but humid, to which the greater part of the rock had been subjected, and which readily accounts for the numerous siliceous and other products which are common to it."†

It is a fact well known to technologists in coal-oil, that the lower the temperature at which coals or shales are distilled, and the more slowly the process is conducted, the more dense and copious will be the product. So far is an excess of heat to be avoided, that the most improved methods reject the upright retorts which necessitate sufficient pressure to throw the vapors into the worm, and apply the heat at the upper surface with a downward draft, by which the products of combustion are made to pass through the mass to be distilled, and bear away all the volatile products at the lowest possible temperature. Also when the substance to be distilled melts at a temperature below the point at which distillation commences, the use of superheated steam not only increases the quantity of the distillate but also its density. This fact is proved most conclusively, by a comparison of the results first obtained in the manufacture of Albertite itself, with the results of the latest and most improved process.

* Loc. cit. (note.)

† Geology of New York, Pt. III, by L. Vanuxem, p. 34.

It only becomes necessary, therefore, to subject pyroschists like the Albert shales, rich in bituminous matter, to metamorphic action through the agency of aqueous vapor, and the distillation of the volatile matter at the lowest possible temperature becomes a necessity. As time always enters as an element into the operations of nature in sufficient quantity, all the conditions would be present requisite to the production of the most copious and dense distillate which such materials were capable of furnishing. It is impossible to conceive of the metamorphosis of such rocks, containing large cavities in comparatively free communication with the surface, without producing such a result. Without such free communication, pressure and consequently a higher temperature would produce more or less volatile liquids and naphtha springs would be the result. Humboldt speaks of having observed metamorphic rocks near Cumana containing bitumen, and not far distant he also saw naphtha floating upon the sea, into which streams of hot water were injected from subterranean springs, in such quantity as to raise its temperature preceptibly.* In one of the recent numbers of this Journal, the results are given of an analysis of a specimen of mica schist from Sweden containing bitumen.† According to Dr. Taylor the rocks enclosing the asphaltum veins in Cuba are metamorphic slate. The Albert shales forming the wall-rock of the vein of Albertite are metamorphosed. The rocks in which veins of bitumen occur in New York and Canada are metamorphic, in many instances having been subjected to a secondary action, which has rendered the rocks crystalline, and expelled nearly all of the volatile matter, leaving but little more than coke, resembling anthracite.‡ Quartz veins have cut the vein of bitumen during this secondary action. Masses of melted bitumen, have formed the nucleus around which quartz or calcite began to crystallize, and afterward in cooling hardened in botryoidal masses upon the crystals. In a few instances minute drops or irregular fragments, became entangled in the crystals themselves. The idea that petroleum has been inspissated from the center of a geode of quartz, or from an hermitically sealed cavity of calcareous rock, is opposed to all that is known in reference to that substance. The bitumen had ceased to be petroleum before the rocks enclosing it assumed their present form. If the Albert shales were subjected to such action as would render them crystalline, it is probable that all the phenomena witnessed in New York and Canada, would there be observed on a gigantic scale. The fact that the rocks enclosing the Grahamite are

* Travels, i, 198; iii, 113, Bohn's ed.
† This Jour. (II), xlv, 38.
‡ Vanuxem; T. S. Hunt, Geol. Surv. Canada, 1866, p. 262.

unaltered, is no proof that they are unaltered at the point at which the bitumen originated.

Prof. Wurtz mentions two facts as observed in connection with the Grahmite, which renders the supposition impossible, that the fissure was ever filled with a liquid. They are, first, the occurrence of "horses," and second, the fact that the porous wall-rock of sandstone is not penetrated by the bitumen. The occurence of "horses" is equally conclusive proof that the injection did not take place into a previously formed fissure. The determination of the cause which produced the fissure is not essential: its *position* in reference to the subterranean pool of melted bitumen was no doubt determined by the pressure exerted by compressed gaseous hydrocarbons, which accompanied the melted mass. The injection was no doubt caused by the collapse of the subterranean chamber, and partial expulsion of its contents.

The occurrence of asphaltum at La Goleta, (Hill's Ranch) a few miles west of Santa Barbara on the coast of Southern California, is noticed by Prof. Whitney. The wood cuts which accompany this notice, however, are on too limited a scale, to convey an adequate impression of the position and relation of the different masses to each other.*

An injected vein of asphaltic sand occurs here, which appears to the eye to be pure asphaltum, but it really contains nearly fifty per cent of sand. It bears no resemblance to Albertite in its appearance, composition, or in its probable origin. The *injection* of the vein, however, no doubt took place in a manner strictly analogous to the *injection* of the Albertite. The mass of the former is very small in comparison to that of the latter, and this fact, together with the limited area over which the forces have been exerted, renders a study of the phenomena much more exhaustive and satisfactory.

The vein occurs in a slight indentation of the coast, caused by the wearing down of a bluff between two rocky promontories. The bluff at this point is about sixty feet in height above high water, the sand of the shelving beach beneath it, covering the upturned edges of the oil shales, but a few feet in depth. Irregular masses of asphaltum protrude above the water for some distance from the shore, and several irregular veins, some in an horizontal as well as perpendicular position, project from the bluff with here and there lenticular masses of small extent. From the masses last mentioned a sort of talus decends, connecting them with the shales below. The largest vein stands perpendicularly and at right angles with the face of the bluff. It cuts the bluff from the base to the summit, and is wedge-

* Rep. Geol. Surv. Cal., Geol. I, 132.

shaped, thinning out from two and a half feet in thickness at the bottom to six inches at the top.

The bluff is composed of semi-indurated Post-pliocene sandstone. The strata are so slightly curved as to appear horizontal for short distances. A recent deposit a few feet in thickness forms the soil of the plain above. These sandstones rest unconformably upon the edges of the oil shales, which are inclined at an angle of seventy or eighty degrees. From a careful study of the positions of the several masses, it is evident, that since the several veins were filled, not only has the sea advanced a long distance inland, but the entire coast line at this point, has experienced a very considerable elevation. Within the memory of those now living in the vicinity, the bluff extended a considerable distance beyond its present verge, the erosion taking place as marked by the uncovering of the large vein, at the rate of about two and one half feet per year. The elevation of the coast line at a recent geological date, is proved by the presence, a short distance farther west, of old beach lines nearly on a level with the present summit of the bluff. On the borders of this ancient beach irregular masses of asphaltic sand are found, mingled with the shells of bivalves, now found off the same coast. The occurrence of these masses indicates that the springs which yield the maltha, which has been observed floating on the sea in this vicinity for the last hundred years, projected their product into the sea at the time when this beach was at the sea level. The maltha now, as then, becomes dense upon exposure, and is cast upon the beach, where it is rolled and mixed with the sand and gravel until it becomes hard asphaltic sand.

It is evident that this maltha at one time arose and saturated the overlying sand, instead of being projected into the sea. The exact method by which this saturation took place is perhaps beyond conjecture, but the inference that it took place beneath the superincumbent mass which then formed the bluff, cannot be avoided. It is equally obvious that the asphaltic mass entered the fissures in a pasty condition; and also that it entered from beneath. The effects of the disturbance which produced the injection, could not at the time of my visit, be traced below the Post-pliocene formation. This disturbance seemed to have proceeded from a focus about a quarter of a mile from the present beach, and to have lifted and torn asunder the more recent deposit of sixty feet in thickness, which, falling back upon the yielding mass of asphaltum, caught and held a large portion of it in its fissures.

While the matter in which the mass of bitumen collected has not necessarily any direct bearing upon the question of its subsequent injection, the subject is still of much interest.

Twenty-five miles east of this point, upon the coast, an equally interesting and unusual deposit of asphaltic sand occurs. In this instance, the sand is spread out horizontally over a very wide area (many hundreds of acres), and uniformly, about twenty feet in thicknes, so far as is known. This stratum of asphaltic sand lies uncomformably upon the upturned edges of the oil shales, from which the tarry maltha exudes and gradually saturates the sand. Judging from a section of both shales and sand, which appears for nearly a mile along the coast, the saturating process is still in progress.

We have only to suppose this process to take place beneath sixty feet of semi-indurated sandstone, instead of ten feet of sand and soil, and we have the action which preceded the injection of the vein just described. Again, we have only to imagine a metamorphosis of deep-seated bituminous strata, producing a distillate a thousand or more feet beneath Silurian or Devonian rocks, which gathered in their crevices, and we can readily account for the gathering of the mass of Grahamite or Albertite previous to injection. An earthquake, shrinkage, or the expansive force of pent up gasses, may have caused an upheaval and fracture of the superincumbent mass. It makes no difference whether the fractured mass were a thousand, five hundred, sixty or ten feet in thickness, in either case when it fell, it would force a part of the plastic mass into the fissures and hold it there.

At this time only specific names have been given to those bituminous minerals occurring in veins, which are evidently derived from the metamorphosis of bituminous strata. They possess many properties in common, and are essentially unlike the true asphalts, which are derived from petroleum. I think it was Dr. Taylor, of Philadelphia, who several years since proposed the name of "Meta-Asphalt" as a generic name for minerals of this class.

Washington and Jefferson College, Washington, Pa., July 6th, 1869.

ART. XXXVI.—*On a new method of observing contacts at the Sun's limb, and other spectroscopic observations during the recent Eclipse;* by Prof. C. A. YOUNG, of Dartmouth College.

OUR party was one of those organized, and subsidized by Prof. J. H. C. Coffin, Superintendent of the Nautical Almanac; and the one which was so fortunate as to enjoy his personal presence and supervision.

Our station was at Burlington, Iowa, a few miles north of the central line, where the duration of the totality was 2 minutes and 50 seconds. The air was perfectly clear, without cloud or haze; the thermometer during the Eclipse ranged from 76° to 67°, and the barometer from $30^{m}{\cdot}140$ to $30^{m}{\cdot}065$. The wind was from the N.W., but very gentle.

The spectroscopic combination employed, was compiled for the occasion from various instruments belonging to Dartmouth College, and differed so much in the relative proportion and arrangement of its parts from those hitherto used, that a brief description is perhaps neccessary.

The telescope which formed the solar image was a comet-seeker by Merz & Son, of 4 inches aperture and 30 inches focal length. An ordinary Huyghenian eye-piece enlarged the image so that when it fell upon the slit of the spectroscope at a distance of 5 inches, it was $2\frac{1}{8}$ inches in diameter. The use of an eye-piece gave an easy means for securing the accurate focus of the limb at the slit, an adjustment of great importance. The spectroscope proper had telescopes of $2\frac{1}{4}$ inches aperture and $16\frac{1}{2}$ focal length (by Alvan Clark). The eye telescope was provided with an eye-piece magnifying 18 times, and a wire micrometer, constructed from a reading microscope, for determining the position of any new lines in the spectrum by referring them to those already known. This, although a very accurate method, was too slow to be well adapted to eclipse observations, but was the only arrangement I could construct with the time and means at my command.

The collimator had a slit $\frac{1}{8}$ of an inch long and of adjustable width. It was provided with a small prism, which could be turned up so as to throw into half the slit light from an electric spark formed between platinum electrodes by a small induction coil and Leyden jar.

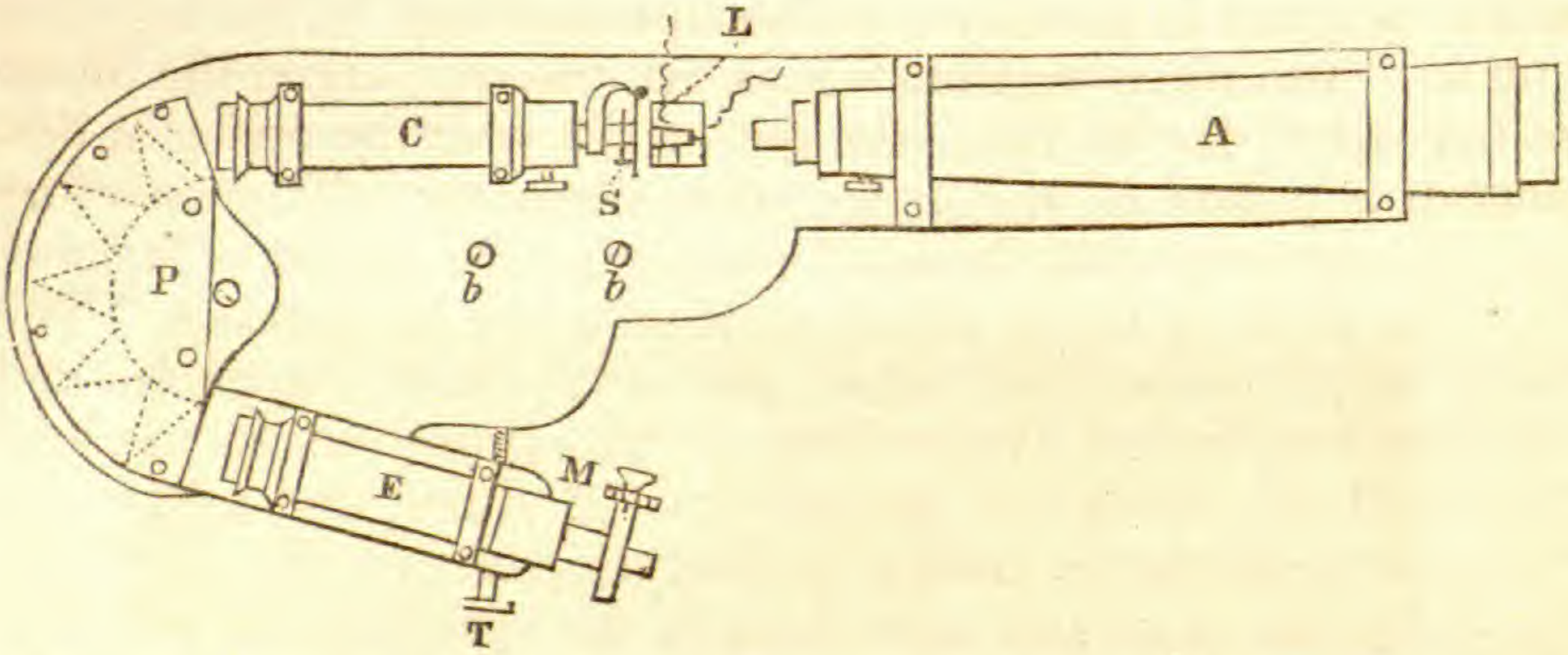
It also carried a thin brass disc about $2\frac{1}{2}$ inches in diameter, placed in front of the slit, with a hole of $\frac{1}{8}$ of an inch in the center. This disc was covered with white paper and graduated into sectors of 10° by lines radiating from the center. This graduated screen, upon which the image of the sun was clearly visible even during the totality, answered the purpose of a finder, and its graduation furnished the means of determining within less than 3° the position of any object observed on the sun's limb, or of bringing any desired portion of the limb to the slit.

The spectrum was formed by a train of 5 prisms of 45° each, with faces $2\frac{1}{4}$ by $3\frac{1}{4}$ inches. They gave a dispersion of about 18° between A and H, with a total deviation of about 165° for the D line. The box which contained them was so connected

by a link with the arm which carried the eye-telescope, that whenever the latter was moved by its tangent-screw along the spectrum the prism box would turn through an angle just half as great. Thus the prisms were kept in the position of best definition for whatever lines were in the middle of the field of view, the extent of which was sufficient to embrace D and E together.

The telescope and spectroscope proper were firmly secured to a wooden framework, and this was mounted equatorially, with slow motion screws in both right ascension and declination. Fig. 1 gives an idea of the appearance of the whole.

1.



A, Comet-seeker; C, collimator of spectroscope; L, camera lucida prism, and platinum electrodes; S, graduated disc immediately in front of slit; P, prism box; E, eye telescope; T, tangent screw for moving telescope across the spectrum; M, micrometer; b, b′, bolts securing the frame-work to the equatorial mounting.

The spectrum was about $1\frac{3}{4}$ inches broad (referred to a distance of 10 inches) and about 45 long. It showed all the lines on Kirchhoff's maps of the spectrum; such lines as the nickel line between D_1 and D_2 being perfectly distinct.

I had seen with the instrument before the eclipse the following six bright lines at the sun's limb, viz: C, 1017·5 K. (near D); 1474 K. (near E); F; 2796 K. (near G); and *h*: on two occasions also I had seen a 7th line at* or near 660 K. a little below C. The line 1474 K. was discovered by me on the 9th of July, and I do not *know* that it was seen by any one else before the eclipse, though quite possibly it is the new line reported by Rayet on the 7th of June, the position of which I have never seen stated. P. S. It was discovered by Lockyer on June 6th.

The scale of my instrument was referred to that of Kirchhoff by repeated and closely accordant measures of 42 intervals be-

* Possibly this may be the 'fainter red flash' already described by Mr. Lockyer, to which Lieut. Herschel alludes in a letter to Mr. Huggins published in the Sept. number of the Chemical News, page 152, American edition. I have not yet seen Mr. Lockyer's notice.

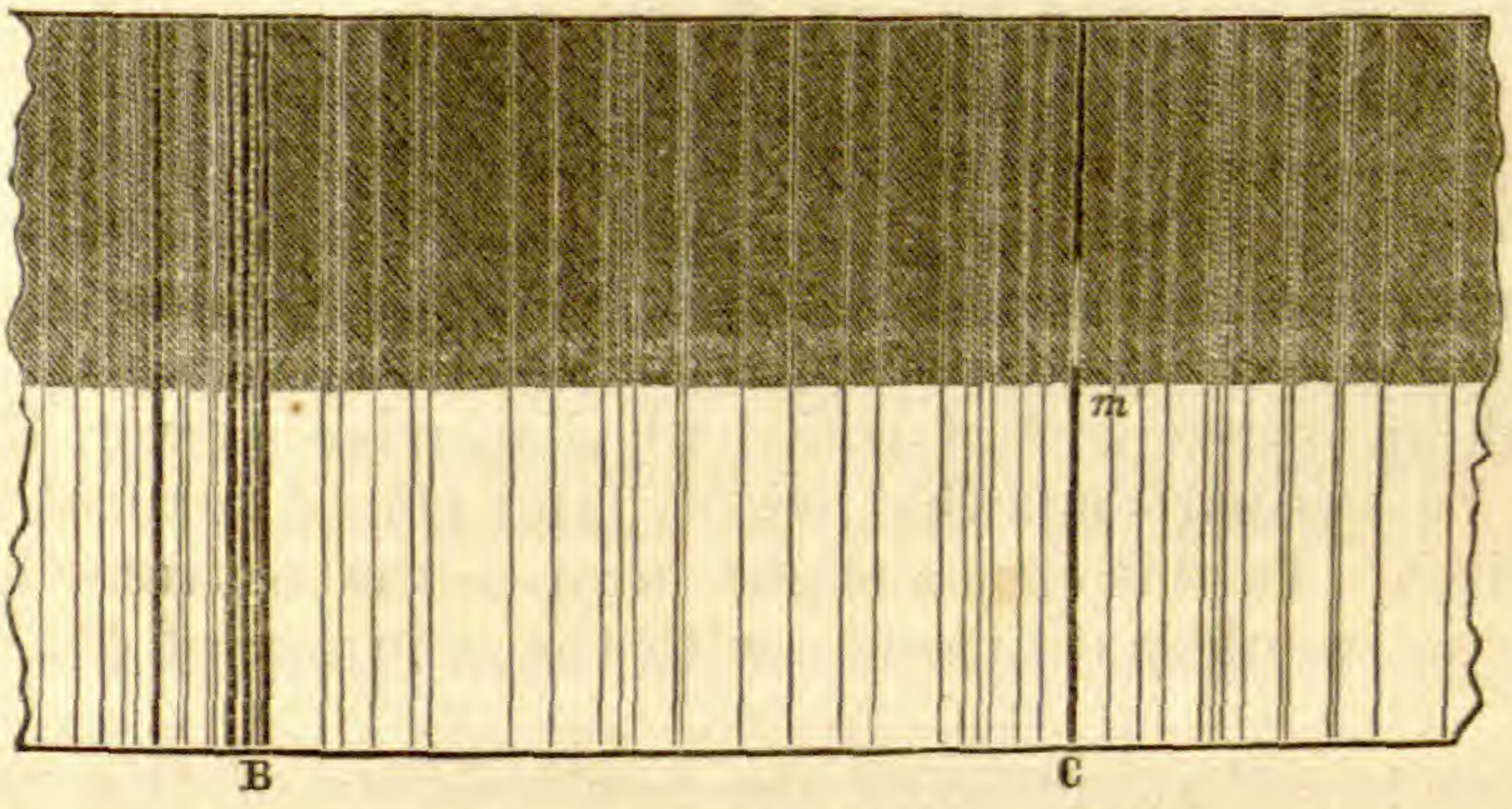
tween important lines, covering the whole length of the spectrum from A to G. Above G, Angström's map was made the basis.

In order to observe the first contact I had provided myself with a solar eye-piece which could be used upon the comet-seeker without disturbing the spectroscope; but about half an hour before the totality the idea presented itself that a more accurate result could be obtained by means of the spectroscope than in any other way—thus:

Suppose that by means of the tangent screws and the position lines on the screen-disc, that part of the sun's limb at which the contact is to take place is brought across the center of the slit and kept there by the slow motion.

Under ordinary circumstances, if the eye-telescope is directed upon the C line, the appearance will be what I have roughly represented in fig. 2. The spectrum will be divided

2.



into two portions by a longitudinal line of demarcation. One half of it, formed by the disc of the sun itself, will be intensely bright; the other half formed mainly by the illuminated air near the sun's limb, comparatively dark. Most of the spectral lines will extend across both portions alike; not so the C line. *A brilliant needle of scarlet light* projects into the dusky spectrum from the end of the *dark line* in the bright portion of the spectrum (at the point marked *m*,) formed by the light from the hydrogen in the solar chromosphere. The length of this needle in my instrument usually ranges from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch, even when the slit is not near any prominence. (The whole width of the spectrum, $1\frac{3}{4}$ inches, was found, with the eye-piece used on the comet-seeker, equivalent to 1′ 55″ of arc, whence the thickness of the chromosphere is easily deduced; it seems to vary from 3000 to 8000 miles commonly).

Now it is evident that as the moon approaches the sun she must first eclipse this chromosphere, and the observer can de-

termine the instant of contact by noticing the extinction of the bright needle.

Similar remarks apply to F, or any other line of the chromosphere spectrum, but C is incomparably the best to observe.

Having arranged my instrument therefore, with the computed point of contact across the center of the slit, I had the unspeakable gratification of seeing everything take place as expected. First, a full half minute before the time of contact, the sharp point of the needle was truncated by the dark edge of the moon, then it grew steadily shorter, (not *less brilliant* what remained of it) until finally its last spark vanished, the C line became exactly like its neighbors, and the contact was effected.

The observation was as easy and definite as that of the transit of a moderately slow star, β Ursæ Minoris for instance. I am confident the observation may be relied upon within a fraction of a second, although it was from 5 to 15 seconds earlier than the time assigned by any of the other observers. I am informed by Professor Mayer, however, who had charge of the photographic operations of our party that it agrees within one third of a second with the time deduced from a preliminary measurement of a photograph taken about 15 seconds after the contact was announced.

With an instrument of sufficient dispersive power, the slit might be opened somewhat widely, and placed *tangent* to the sun's limb. In this case a slight error in the estimated point of contact would not interfere with the accuracy of the observation.

I wish to call attention to the applicability of this method at the coming transits of Venus. It is not possible, perhaps, to predict just how great will be the effect of her atmosphere; but it is difficult to see in what respects this method will suffer from it more than any other. It certainly presents this great advantage, that the observer will perceive and watch the planet's approach long before the instant to be observed, and thus have all the benefit of preparation.

It seems likely also that the instant of *internal contact* will be more easily seized with the spectroscope than with any other instrument. Instead of the rupture of a black ligament, it ought to show the sudden formation of a brilliant line running the whole length of a before dusky spectrum, a phenomenon much more striking than the other.

While the moon was advancing upon the sun, special attention was paid to the appearance of the spectrum lines near her limb. They came up to the edge perfectly square and straight, even when the limb made an angle of only 5° or 6° with the

slit; and the longitudinal line of demarcation, before referred to, between the brilliant and dusky portions of the spectrum was hard and sharp, in striking contrast with the effect of the sun's limb, which under similar circumstances always gives a boundary more or less hazy and indefinite, and this to a degree continually changing from minute to minute. This contrast was beautifully exhibited a few seconds before the totality when the limbs of both sun and moon were on the spectrum together, the width of the visible portion of the sun having become less than the length of the slit. It was at first thought that this appearance was decisive against the existence of a lunar atmosphere however rare: but a little consideration shows that on the other hand it is, if anything, favorable, being a simple consequence of that brightening of the sun's disc near the moon's limb, which is so beautifully evident upon the photographs; and which is most easily accounted for by admitting a slight refraction suffered by that portion of the sunlight which grazes the moon. Possibly, however, it may yet be explained as a case of simple inflection of light.

Before the eclipse began, the existence of prominences on the limb of the sun had been ascertained in the following positions, (reckoning from the north point through the east). A large but faint one near +90°, a small but bright one at +146° (the photographs show *two* here), a long low one at −70°, very near the point of first contact, and an enormous and very bright one at −130°, with several others of small elevation but considerable length on different parts of the limb.

At the beginning of the totality the slit was upon the prominences at +146°; the eye telescope upon C. As soon as totality commenced this line blazed out magnificently, but from the small extent of the prominence did not reach across the spectrum. No line appeared below C, nor any between C and D. The orange line, which for convenience I will call D_3, (1017.5 K) was beautifully bright, but no longer than C. Between it and the next prominent line were two faint lines, situated by estimation at 1250±20 and 1350±20 of Kirchhoff's scale. Then came the 1474 K line, which was very bright, though by no means equal to C and D_3; but attention was immediately arrested by the fact that, unlike them, it extended clear across the spectrum, and on moving the slit away from the protuberance it persisted, while D_3, visible in the edge of the field, disappeared. Thus it was evident that* *this line belonged, not to the spectrum of the protuberance, but to that of the corona.*

* On two or three occasions previously I had been very much surprised at not being able to detect this line in the spectrum of unusually bright prominences. On the other hand I once found it very easy to see at a place on the sun's limb where the other chromosphere lines, usually far more brilliant, were almost invisible.

My impression, but I do not feel at all sure of it, is that the two faint lines between it and D_3, behaved in the same manner, and are also corona lines.*

I may as well confess that my uncertain memory here is due to the fact that just at this time, while my assistant was handing me the lantern with which to read the micrometer head, I looked over my shoulder for an instant, and beheld the most beautiful and impressive spectacle upon which my eyes have ever rested. It could not have been for five seconds, but the effect was so overwhelming as to drive away all certain recollection of what I had just seen. What I have recorded I recall from my notes taken down by my assistant.

By this time the moon had advanced so far that it became necessary to shift the slit to the great prominence on the opposite side of the sun. While my assistant was doing this I suppose I must, in the excitement of the moment, have run my eyepiece over the region of the magnesium lines (*b*), and thrown them out of the field before he had brought any thing upon the slit. At any rate I saw nothing of these lines, which were evident enough to several other observers, and can think of no other way to account for their having escaped me.

The F line in the spectrum of the great protuberance was absolutely glorious, broad at the base and tapering upward, *crookedly*, as Lockyer has before often observed. Next appeared a new line,† about as bright as 1474, at 2602±2 of Kirchhoff's scale. Its position was carefully determined by micrometrical reference to the next line, 2796 K (Hydrogen γ) which was very bright—*h* was also seen, very clear but hardly brilliant. In all I saw 9 bright lines.

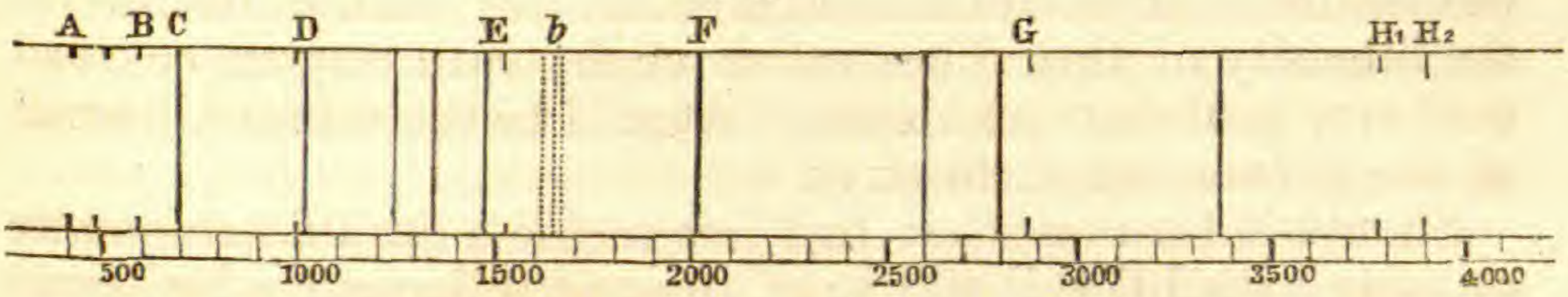
A faint continuous spectrum, without any traces of dark

* A careful examination of the photographs, especially No. 2 of the Burlington totality pictures, somewhat diminishes my confidence in the conclusion of the text as to the nature of these three lines (1250, 1350 and 1474). They certainly *do* not belong to the spectrum of the *most brilliant portion* of the prominences; but around the prominences of the eastern limb, on which the slit of the spectroscope was directed during the first half of the totality, the photograph shows a pretty extensive and well defined nebulosity, evidently distinct from, though associated with, the brilliant nuclei. Now it is *possible* that these lines may belong to this nebulosity, and not to the corona proper; for I cannot recall with certainty whether 1474 retained its brilliance at any considerable distance from the prominences or only in their immediate neighborhood. My strong impression however is that the former was the case, and that the text is correct. I am confirmed in this opinion by Professor Pickering's observation. He used a single-prism spectroscope, with the slit of the collimator simply directed to the sun, and having no lens in front of it. With this arrangement he saw only 3 or 4 bright lines, *the brightest near E* (1474) Now this is exactly what ought to occur, if that line really belongs to the corona, which, from its great extent, furnished to his instrument a far greater quantity of light than the prominences.

† This is undoubtedly the line described by Lieut. Herschel as between F and G, in the letter referred to in a former note, Chem. News, Sept., 1869, p. 152, Am. Ed.

lines in it, was also visible, evidently due to the corona. Its light, tested by a tourmaline applied next the eye, proved to be very strongly polarized in a plane passing through the center of the sun. I am not sure, however, but that this polarization, as suggested by Prof. Pickering, may have been produced by the successive refractions through the prisms. This explanation at once removes the difficulty otherwise arising from the

3.



absence of dark lines. Figure 3 exhibits the position of the lines seen by me, and I have also added the magnesium lines.

My observations decide nothing as to specific differences between the different protuberances, since from the smallness of my field of view, I was obliged to observe a portion of the spectrum on one of the prominences and the rest on another.

I had just completed the measurement of 2602 when the totality ended. This line disappeared instantly, but 2796 was nearly a minute in resuming its usual faintness. I cannot describe the sensation of surprise and chagrin, of wasted opportunity, personal imbecility, and complete exhaustion which overwhelmed me when the sunlight burst out. Many other observers I believe shared in it.

Having for some time entertained the idea that there might possibly be some connection between the Aurora Borealis and the Solar Corona, immediately after the eclipse I examined Angström's map, in which he lays down one bright line in the Aurora spectrum. It plainly did not coincide with 1474. But on my return home I found in the July number of this Journal the positions of five lines observed by Professor Winlock in the spectrum of the Aurora. In numbers of Huggins's scale they are given as follows, viz: 1280 (brightest), 1400, 1550, 1680 and 2640. Now from the data given in Professor Gibbs's recent articles on 'wave lengths by the method of comparison,' we easily find, with a probable error of not more than 2 or 3 divisions, that H 1280 = K 1247; H 1400 = K 1351; and H 1550 = K 1473. I observed in the corona spectrum K 1250, K 1350 and K 1474. These coincidences are certainly very remarkable, especially the last. The positions of the faint lines (K 1250 and 1350) being only estimations, very little weight can of course be given them. But as to the position of 1474 in the corona spectrum there cannot be the least doubt. It

is the reversal of a well marked though not prominent line just below E, put down as *iron* by both Kirchoff and Angström, though not given by Huggins. Whether the position of the apparently coincident Aurora line is as well settled I am not yet certain, but hope to be able to ascertain before very long by a direct comparison between the spectrum of the Aurora and that of the electric spark from iron electrodes. At present it seems pretty likely that the spectra of the corona and the aurora borealis are identical with only such differences in the intensity of their lines as we might naturally expect, and that very probably the identity extends to the essential nature of the phenomena themselves.

Should it turn out that this line in the aurora does actually coincide with 1474, it will be of interest to inquire whether we are to admit the existence of *iron vapor* in and above our atmosphere, or whether in the spectrum of iron this line owes its presence to some foreign substance,—probably some occluded gas as yet unknown, and perhaps standing in relation to the magnetic powers of that metal.

Hanover, N. H., Sept. 13, 1869.

The above article comprises the substance of two papers read at the last meeting of the American Association for the Advancement of Science at Salem.

Art. XXXVII.—*Notes on the Geology of Western Texas and of Chihuahua, Mexico;* by James P. Kimball, Ph.D.

The road from San Antonio, Texas, to Presidio del Norte on the Rio Grande, by way of Fort Clark, Camp Stockton and Fort Davis, traverses the elevated Cretaceous table-land of western Texas which incidentally has been described in the reports of several government expeditions. Following this road, a belt of country reaching some fifty miles on either side of the 30″ parallel comes under observation. As far westward as the Limpia Mts. there is a gradual acclivity of the surface, which at short intervals is channeled by water courses, causing numerous valleys bounded by bold ascarpments of the Cretaceous limestone strata. The approximately level attitude of this formation gives rise to the mesa-top as seen from the valleys, while the mesas themselves, thus separated, rise successively from an altitude at San Antonio of 579 feet above the sea to 4688 feet at the head of the Limpia. In the case of the wide valleys, the streams have repeatedly changed their beds, most of which are dry except in times of heavy rain. The grassy

table-lands all have a basin configuration, there being toward the center a depressed portion usually containing drainage water. From the Limpia Mts. to the Rio Grande there is a gradual descent—the altitude of Presidio del Norte being 2779 ft.; but, unlike the eastern slope of the divide thus formed by the Limpia Mts. or Sierra Diavolo, between the Rio Grande and Pecos basins, the declining surface has no conformability with the stratification.

Orographically, it is true that the Limpia Mts., as described by Mr. Arthur Schott, form a part of a great dividing range between the Pecos and Upper Rio Grande, including the Guadaloupe and Sacramento mountains to the north, and the continuation south of the Limpia Mts. to form not however the Sierra Rica Mts. in Chihuahua, but the Sierra del Carmen, a range farther to the east, and through which the Rio Grande passes farther down near Presidio de San Vincente. My own observations do not justify the assertion that this range is characterized by *igneous* rocks, nor the inference that it is an axis of elevation.* At least on the Presidio del Norte road, the rocks are of a metamorphic aspect where not plainly Cretaceous—their topography being that of erosion. It was upon the evidence of specimens that Prof. Hall asserted the igneous nature of the Limpia range. These he characterizes as compact quartz, "derived doubtless," he says, "from the gelatinous silica produced by volcanic waters, reddish brown porphyry and a coarse granitic aggregate of which adularia forms a large part."†

However it may be in the case of the Guadaloupe and Sacramento mountains to the north, the Limpia Mts. near the 31st parallel are, as I shall proceed to explain, the last easterly development of what appears to be a metamorphic zone next overlying Cretaceous fossiliferous limestone, and probably included within the Cretaceous series, and known in Mexico as *cantera;* and quite overspreading a large portion of the state of Chihuahua—that portion, at least, to the north of the 28″ parallel, and as far west as the Grand Sierras. Within this area it is the surface formation of the eastern slope of the Cordilleras, except where local elevations have lifted, or erosion has bared, lower rocks. I traced it west beyond Cusihuiriachic whose altitude, determined by Dr. Wislizenus, is only 2181 feet less than that of the Cumbres de Jesus Maria—reputed to be the culminating point of the north Mexican Cordilleras (8375 ft.)‡ The peak

* Mex. Bound. Surv., i, Pt. II, p. 4. † Ibid, p. 107.

‡ Pedro Garcia Conde: Ensayo Estadistico sobre el Estado de Chihuahua. Chihuahua, 1842, p. 9. The same authority gives the altitude of the Mineral de Cusihuiriachic as 2362 varas (6564 ft.) above the sea; while the Cerro de Cuiteco is stated by Rémond to be the culminating point of the high Sierras.

of Cusihuiriachic, rising 1,643 feet above the village, and which is made up of this formation, thus exhibits its development so high up the Grand Sierras, as to leave a difference of less than 439 feet of summit altitude between the point where my observations ceased, and the highest point in the Cordilleras of this latitude, 100 miles farther west, which a bad state of the road rendered it impracticable to reach. Its continuation this whole distance indeed, is reported to me as a fact by Mr. John Potts of Chihuahua; as well as by Mr. W. S. Keyes of San Francisco, who entered the sierras from the Pacific side. The late Mr. A. Rémond described a series of what he distinguished as volcanic rocks, disposed in beds, and overspreading the Cretaceous argillaceous shales represented at Arivechi in Sonora, and which he found "extending from the Gulf of California, up to the very summit of the Sierra." The lithological characters and position of these rocks, briefly indicated in the valuable account of his explorations, prepared by Prof. Whitney, bear numerous striking analogies to the so-called *cantera* of the eastern slope.*

Near Hackberry Ponds, Texas, (about 26½° W. long. Wash.) where the rocks which form the body of the Limpia Mts. are first seen on the Presidio del Norte road, the configuration of the country suddenly changes, the arid Cretaceous table land east of that point giving way to grassy plains, bounded by rugged rocks. The gray Cretaceous limestone here passes out of sight, and is covered with a reddish brown, hard, compact rock, presenting the anomalous condition of a dense quartz matrix, colored by brown oxyd of iron, apparently *not feldspathic* itself, but containing minute translucent orthoclasic crystals; and minute irregularly shaped cavities filled with crystalline quartz, and coated with brown oxyd of iron which sometimes colors the quartz segregations. Thus we have the characters, not of a porphyry, but what may be called a *porphyritic quartzite.* It occurs in strata, which are gently undulating, and which rise toward the west by accumulation rather than by elevation, and thus form the Limpia Mts. Wild Rose Pass, by which the road crosses the mountains, and which mainly follows the eroded valley of the Limpia, a tributary of the Pecos, presents bold escarpments of this rock softer than where at first seen, and weathering excessively. This weathering or disintegrating action, due to the ferruginous character of this rock, goes far to produce its peculiar topography throughout its wide development. Nowhere to greater advantage can it be witnessed than in this pass, where the faces of the bluffs are weathered into massive columns, reaching in many cases from their base to top, and,

* Notice of Geological Explorations in Northern Mexico made during the years 1863–65. Proc. Cal. Acad. Sci., iii. (Extract, p. 5).

more or less perfect, fluting their whole surface which is of a dark ochreous color. A similar effect is to be seen in the bluffs back of Fort Davis. The lithological characteristics above noted here likewise prevail, but the rock is still softer than in Wild Rose Pass, and its sedimentary character more positive. A quarry opened by Maj. Gen. Merritt in the base of a high cliff of this rock, exhibits it to great advantage. Here the interior proves an earthy, or soft, fine-grained, alumino-silicious aggregate, containing scattered grains of quartz and minute crystals of pyrites. It is of light reddish and gray tints, quarries soft, and hardens on exposure. Of this material the officers' and other quarters are built. Thus, within a short interval, we find the same formation presenting the two lithological extremes, between which in its wider development it affords numerous varieties. The softer variety has all the characteristics of the *cantera*, of which the better structures of Chihuahua are built, and *which is found in all parts of the state under conditions similar to its occurrence at Fort Davis.* Hence I have adopted the Mexican term, and, as common, applied it to the whole formation. In this connection I may venture to mention, without attempting at present to support, the impression which these and correlative facts have forced upon me, namely, that the metamorphism of this formation consists of chemical and molecular changes under the influence of the atmosphere and percolating waters, and that the range of alteration will be found to be limited to the exposed portions.

The relation of the *cantera* at Fort Davis to the underlying Cretaceous limestone is rendered clear by the fact that a quarry for the supply of a lime-kiln has been opened by Gen. Merritt just below the level of the plain.

The disintegration of the surface formation seems to depend on the degree that it is ferruginous—the broadest plains and thickest soil always being found at the base of ochreous colored cliffs or ridges. This is best illustrated west of the Rio Grande. But by contrast with the neighboring topography of the limestone table-land such phenomena near Fort Davis are unusually marked—especially the distribution of the detritus of ferruginous rocks, and the action of rainwater in the leveling of expansive valleys, or the great grassy plains of this section, and causing the obliteration of former channels, scored out before the water-system had been altered by changes in level of the whole eastern slope of the Sierra Madre. By the rapid drainage of the skirting highlands in heavy rains, the plain is suddenly flooded by a sheet of water which, in its subsidence, carries with it toward the depressed or middle portion the fine sediments. These are continually being renewed, while the

* See a cut in Mex. Bound. Surv., i, p. 88.

plain is widened, by the disintegration of the bordering rocks. Gen. Merritt relates that the parade ground of the post is sometimes suddenly flooded to the depth of a foot, the water subsiding almost as quickly as it comes. The gardens of the post require protection against the loss of their soil by such floods.

Leaving Fort Davis to the north, the road in a few miles begins to desend into the Rio Grande basin, passing through a succession of wide champaign valleys skirted by table-land, capped with the *cantera* of a greenish tinge, as if colored by a silicate of iron—the ochreous coloration, and columnar weathering disappearing near Fort Davis. The prevailing dip, though scarcely appreciable, is toward the northeast, and hence the road, going southwest, is continually getting deeper in the geological section. Passing the water-hole of San Estevan at the base of a cliff of *cantera*, here also a porphyritic quartzite, a conglomerate is seen in the gullies. This is probably a cemented rubble common in Chihuahua at the base of the *cantera*, the cementing material, a carbonate, appearing to be derived from soluble ingredients in superincumbent strata which often are vesicular on weathering. Before reaching the Alamos the road has passed below the *cantera*, the lower portions proving very ferruginous and coarse grained. It disintegrates greatly—hills in all stages of dissolution being seen to have been composed of it. Between the Alamos and Presidio del Norte the road comes down to limestone, in some places saccharoidal and fossiliferous. Some twelve miles from the river, the valley proper of the Rio Grande is reached. In it five or six terraces of gravely material, varying from 20 to 100 feet in height, may be counted on either side. The town of Presidio del Norte is situated on the last one of the west side, or that nearest the present flood-plain of the river. Its altitude, according to the Mexican Boundary Survey, is 2,779 feet. The true valley of the Rio Grande here is from twenty to twenty-five miles wide, its western boundary—the limestone bluffs of the Sierra de las Cuestas.

This range is the continuation to the north of the Sierra Rica. At the base of this range near Nugal, which is twenty miles from Presidio del Norte on the Chihuahua road, and therefore incorrectly laid down on Fleury's map, are good exposures of heavy bedded calcareo-aluminous sandstone, dipping 15° N.W. —intercalated with impure calcareous shales. The former is exceedingly fossiliferous, furnishing the following Cretaceous, forms known in Texas: *Exogyra plicata*, *Scalaria Texana*, *Natica Texana*, *Lima Wacoensis*, together with species of *Ostrea*, *Inoceramus*, *Caprina* and *Ammonites*, and fish teeth. The Sierra Rica is made up of (1) lower calcareous shales and fissile slates; (2) blue limestone containing *Inoceramus*; (3) upper fissile cal-

careous shales; (4) arenaceous limestone, also containing *Inoceramus*, and probably the continuation of the more sandy beds seen at Nugal. This fossiliferous series is conformably capped on the highest mountains by a hard reddish rock of a bedded structure, and forming mesa or flat tops. It is characterized by a granular or aggregated quartz matrix, densely filled with rounded orthoclasic amygdules. Although thus conforming to the qualitative type of the crystalline *cantera*, and occupying its constant position with reference to the fossiliferous series, this rock forms a marked deviation from its common appearance. Local dips in the Sierra Rica are variable, though a prevailing one to the S.W. seems to be marked within the range of my observations, which were limited to a brief stay on account of the presence of hostile Apaches. The Sierra Rica lode, in which the mine of the same name has been opened to a depth of some 400 feet, is encased in the fossiliferous series, its highest outcrop being on the crest of a prong from which the summit quartzose rock of the neighboring mountains has been denuded. The lode has yielded rich sulphurets of silver, associated with sulphurets of the base metals, in a quartz veinstone enclosing breccia from the walls.

On passing out of the Rio Grande valley the acclivity of the surface again becomes appreciable. The Chihuahua road crosses the limestone range by the Cuesta de Gato, a depression in it some four miles beyond the Mula,* thirty-six miles from Presidio del Norte.

Here the limestone is pure, blue and brittle, with a conchoidal fracture. From this elevated pass the road descends immediately to the *jornada*—a great barren plain with a basin configuration, but without water or visible water-courses, and bounded by the mountains as indicated on Fleury's map. In the neighborhood of the road, it is covered with fine limestone detritus, overspread with a thin deposit of silt. The range of mountains to the west, including the Cuchillo parado, and the Sierra del Chupadores, rises some 450 feet above it. This range elevates the same limestone series as the Sierra Rica. But it consists mainly of heavy-bedded white and gray limestone, the upper shales only coming occasionally to view in the road-bed, on entering and leaving the *jornada*.

Passing round the base of the Chupadores, over a slight divide into another, smaller champaign valley beyond, a reddish diluvium is met with, some four miles north of the Gallina pass, the source of which is immediately traced to the development again here of the ferruginous summit rock (*cantera*) which comes in by the sudden pitch to the east of the underlying limestone in the gap, and caps apparently all the mountains to

* Incorrectly laid down on Fleury's map.

the east of the road, bordering the great *jornada*, viz,—the Sierra del Eclusero, Sierra de Encenillas, and the Sierra de las Masteñas, while the limestone range west has undergone no change of aspect. The same stratigraphical conditions prevail all the way to the Conchos. To the east of the road is seen a prominent development of the ferruginous *cantera*, while west the Choreras range, including the Amaragosa Mts., preserves the limestone series in heights of 400 to 600 feet. Within the range of the development of the *cantera* the usual remnants of hills in advanced stages of degradation are seen—a circumstance already indicated as common to this formation, and as going far to produce the peculiar conformation of the surface throughout its development.

The difference between the vegetation of the limestone soil and that resulting from the disintegration of the ferruginous *cantera*, is here marked the same as in the neighborhood of the Limpia Mts., Texas. The former produces the *mesquite* shrub, together with the *mesquite* variety of grass, while the latter is covered with *gramma* grass, and is destitute of mesquite.

The Conchos river flows close to the base, and seems to occupy an anticlinal axis, of what I have designated as the Choreras and limestone range, which extends from near Julimes N.E. to Presidio del Norte. Under the additional erosive influence of its two affluents-—the Rio Sacramento, which joins it at San Diego, and the Rosales at Julimes—great expanse has been given to the bottom of the Conchos. From the Choreras, east, to the Santa Eulalia range, west, it is some twenty-five miles broad. It is covered with a fine, and somewhat ferruginous, calcareous alluvium, which, thoroughly irrigated, is under high cultivation.. It contains several populous towns, and a number of fine ranches. Fuel from the root of the *mesquite* is yet comparatively abundant. The limestone bluffs of the Choreras are the most westerly prominent outliers of the Cretaceous fossiliferous limestone, yet bosses of the same formation along the prolongation of the same axis of elevation, occur at intervals in the sub-structure of mountains for some seventy miles further—as near Carretas and in the Sierra de Magistral.

The famous silver mines of Santa Eulalia are in the midst of the long narrow N. and S. range, of the same name which bounds the great outspread of the Conchos bottom near Julimes, an intermediate range which marks its valley below having been here obliterated. In the body of the range, the limestone has given way to the *cantera*, except in the mining district of some five square miles, where on a prolongation, as above mentioned, of the Choreras axis, a single boss elevates with quaquaversal dips, the limestone again. The limestone, the same as at Sierra Rica, is the seat of the silver deposits,

which are of an irregular description, and probably unique. These will be described in a future number of this Journal. Suffice it to notice at present the frequent occurrence in the silver-bearing beds, of *Radiolites*, *Pecten*, *Inoceramus*, and a characteristic mesozoic coral. All along the limestone range mineral deposits are known. In the Chenati Mts.—its prolongation into Texas—argentiferous galena and stibnite occur. The Cuchillo parado and the Choreras are both reputed mineral localities, as likewise the Sierra de Magistral, as its name implies.

In the Dolores pass, by which the road crosses the Santa Eulalia range, no limestone occurs, the elevations being entirely of *cantera* of various tints, and distinctly stratified. The cemented rubble, to which allusion has been made, is seen in this pass, varying from a coarse to a fine breccia. Such deposits are found throughout central Chihuahua under the diluvium of the plains, and in low places among the mountains. In some places it is indurated, and in this condition might easily be mistaken for a regular, instead of a recent deposit, and be thought to enter into the stratification which it never does.

From the Conchos to Concepcion the mountains and river system are approximately north and south. And the same may be said of the whole eastern slope of the Cordilleras all the way to the Rio Grande, except where the presence of limestone elevations has served to modify the uniform topography of the *cantera*. This uniformity consists in the succession of narrow and continuous north and south ridges with foot hills, separating broad and, longitudinally, remarkably continuous valleys. The whole surface, thus characterized, rises toward the west, while the mountains gain somewhat in height and the valleys in breadth in the same direction. Such is the configuration quite to the summit of the Cordilleras in this latitude, and it is thus almost insensibly reached. The term, Sierra Madre, is for this reason seldom heard in Chihuahua. The western slope in Sonora is rugged and steep.

The cantera of the mountains, while conforming to one qualitative type is presented under various conditions of color, aggregation and structure. Though generally occurring in pretty level beds, it is much jointed, and sometimes exhibits oblique cleavages so continuous as to resemble stratification under a high dip. Such an appearance is produced in the range directly east of the city of Chihuahua, where the Sacramento river passes through it. The champaign valleys, which are filled with the detritus of the more ferruginous *cantera*, generally contain, west of Chihuahua up toward the humid belt, small running streams, or shallow lakes, which fit them for cultivation. Some of these valleys are over a hundred miles in length.

Between the city of Chihuahua and El Paso del Norte the physical and lithological features of the *cantera* still prevail. The road lies over the plain of Encenillas—one of the typical valleys above described, extending, together with its bordering mountains, within twenty miles of the Rio Grande where limestone hills are again met with, forming the bluffs of the valley. This limestone seems to bear the same relation to the *cantera* as the Cretaceous beds at Presidio del Norte below. Hence I must take exception to the determination of this limestone by Dr. Wislizenus as Silurian, especially as this was upon the inadequate evidence of an "injured and imperfect" coral which he refers to *Calamopore*, and a bivalve shell of the genus *Pterinea*. I did not stop to collect fossils at this locality, no question having been present to my mind on the spot as to its equivalency with the Cretaceous as elsewhere observed, and as I was not then acquainted with Dr. Wislizenus's report.* The discrepancy between the lithological terms employed by Dr. Wislizenus and myself proceed from a difference of observation and reasoning. The *cantera*, (which term I have employed for short) whose characteristic and varying qualities have been detailed, and which has been described as a surface metamorphic formation, horizontally bedded and comparatively undisturbed, attaining a thickness of over 1700 feet, where found within the range of my observation least reduced by denudation (at Cusihuiriachic), and overspreading the middle and northeastern part of Chihuahua, and probably also the western part, Dr. Wislizenus designated generally as porphyry, and sometimes as granitic, and again as trachytic. That what he thus terms is really the so-called *cantera*, under its various aspects, is clear from his specifying the building stone used in the city of Chihuahua, from which I have taken its local name, as white porphyry, as well as from the fact that he distinguished as granitic and porphyritic its continuation on either side of the El Paso road. He similarly characterized the rock which forms the mountains of Cusihuiriachic, seventy-nine miles west of the city of Chihuahua. Thus it will be seen that in this respect our observations agree as to the extent and identity of the mountain formation, but that we differ as to its origin and lithological character. The orographic features of the country as phenomena of denudation have not been noticed by this traveler. And the determination of the limestone twelve miles N.E. of Chihuahua (Santa Eulalia) as Silurian upon the insufficient evidence of a simple specimen, received at second hand, containing "some chambers of an *Orthoceras*," cannot be accepted in the light of

* Memoir of a Tour to Northern Mexico, connected with Col. Doniphan's Expedition in 1846–7. Senate Doc., Misc. 26, 30th Cong. 1st Ses. See also Report of Dr. Parry: Mex. Bound. Surv., vol. i, Pt. 2d, 8, 9. On the Silurian in the Rocky Mts., see a notice by Prof. J. D. Whitney, Proc. Acad. Nat. Sc., iii, 307.

the significant evidence above brought forward to prove the Cretaceous age of the same limestone. In the geological sketch given by Dr. Wislizenus, the formations are laid down according to his description.*

The number of Cretaceous fossils collected by myself west of Presidio del Norte, quite disproves the position of Dr. Parry, viz., that the "natural boundaries of this basin (near Presidio del Norte) consist of irregular mountain ranges composed principally of carboniferous limestone similar to that seen above" (near El Paso.)† But Dr. Parry in this matter seems to follow Prof. Hall who referred the limestone of this section to the carboniferous exclusively on the ground of the lithological analogy with the Carboniferous limestone in numerous western localities, of a simple specimen from the rapids of the Rio Grande, in which no fossils could be recognized.‡ With regard to the "compact and vesicular lavas, and volcanic and friable breccias, etc.," thus termed by Prof. Hall, in the collection of Dr. Parry, it is proper to suggest the former to be referable to the *cantera* in some of its aspects of coloration, aggregation, and weathering, and the latter to be the cemented rubble above noticed. The limestone back of Presidio del Norte, unmistakably Cretaceous, is brought to the surface by the Conchos axis of elevation, which is so prominent till cut through at the bend of that river, and which does not finally expire for yet a distance of some seventy miles to the southwest. Topographically as well as stratigraphically, this is the lowest part of the state which I visited, and the only part I found either not overspread with, or bearing on its heights, the *cantera*, which even along the easterly development of this axis, it will be understood, has disappeared but from a narrow belt.

The extension of the fossiliferous Cretaceous so far up toward the summit of the Cordilleras, has an important bearing upon the occurrence of Texas Cretaceous fauna in Sonora, where they were found by the late Mr. Rémond. Prof. Gabb, to whom we owe this identification, calls attention to the discovery as going to show a "water communication between the great Cretaceous sea that covered so much of what is now the central portions of our continent, on the one side, and the Pacific, on the other." The recognition of the Cretaceous near Arivechi in Sonora, according to Mr. Gabb, proved only the second reported locality

* We much incline to doubt whether Fremont, Stansbury or Wislizenus have brought unequivocal Silurian rocks or fossils from several points in the Rocky mountains. See an editorial critique on a geological map by Jules Marcou (this Journal, vol. xvii, p. 202), by him attributed to Prof. Hall (Geol. North America, two reports, etc., 1858, pp. 93 and 98.)

† Mexican Bound. Surv., i, Pt. 2d, p. 50.

‡ *Ibid.* p. 110.

of its occurrence in the whole area of Mexico, the other being in the State of Puebla.*

So important a discovery as the occurrence of rich silver deposits in the *fossiliferous*, as well as the metamorphic Cretaceous of Chihuahua, cannot adequately be treated within the scope of a general article; and I therefore reserve for a subsequent number of this Journal, descriptions of the interesting silver mining localities of Santa Eulalia, Cusihuiricahic and Cieneguilla, of which incidental mention has already been made.† Although the metamorphic Cretaceous is, through the labors of the Geological Survey of California, well known in numerous localities in the Coast Ranges, as a seat of gold deposits; and the Jurassic, east of the High Sierras within the territory of the United States, as a seat of silver deposits, the instances above given of the unequivocal fossiliferous Cretaceous, as well as a probable metamorphic and later zone of the same series, as sources of silver ores, are the first in North America yet reported. The only parallel occurrence yet brought to light, so far as I am aware, is in Chili, where according to Mr. Rémond, calcareous fossiliferous Cretaceous strata carry silver deposits, evidently much in the same way as at Santa Eulalia.‡

New York, Aug. 10, 1869.

ART. XXXVIII.—*Contributions to Zoölogy from the Museum of Yale College.* NO. IV.—*Abstract of a Notice of the Crustacea collected by Prof. C. F. Hartt, on the coast of Brazil in* 1867; by SIDNEY I. SMITH.

THE paper of which the following is a short abstract, was printed during July and August, in the second volume of the Transactions of the Connecticut Academy, but the whole edition, excepting a few copies of the first two signatures which had been distributed, was destroyed by fire in September last. During the delay consequent to the reprinting of the Transactions, this article seemed desirable.

The collection, although quite small, is of interest from the large proportion which it contains of species heretofore known only from Florida or the West Indies. The following is a list of the species with the localities at which they were collected by Prof. Hartt.

* Geol. Surv. of California, Palaeontology, ii, p. 257.

† These three localities have produced during the last 150 years from 200,000,000 to 300,000,000 of dollars, mainly during the last century.

‡ Proc. Cal. Acad. of Sc., iii, 1866; Phillips' Mining and Metallurgy of Gold and Silver, p. 318: Domeyko, Ann. des Mines (4), ix, 22.

Milnia bicornuta Stimp.—Reefs of the Abrolhos.
Mithraculus coronatus Stimp. — " "
Mithrax hispidus Edw.— " "
Xantho denticulata White.— " "
Chlorodius Floridanus Gibbes.— " "
Panopeus politus Smith (Proc. Bost. Soc. Nat. Hist., vol. xii, p. 282, 1869; Trans. Conn. Acad., vol. ii, p. 3, plate i, fig. 4).—Reefs of the Abrolhos.
Panopeus Harttii Smith (Proc. Bost. Soc. Nat. Hist., vol. xii, p. 280; Trans. Conn. Acad., vol. ii, p. 5, plate i, fig. 5).—Reefs of the Abrolhos.
Eriphia gonagra Edw.—Reefs of the Abrolhos.
Callinectes Danæ Smith (Trans. Conn. Acad., vol. i, p. 7; Lupa diacantha Dana; *non* Lupa diacantha Edw., *nec* Calli; nectes diacantha Stimp.).—Pernambuco and Bahia.
Callinectes ornatus Ordway.—Caravellas, Province of Bahia.
Callinectes larvatus Ordway.—Bahia.
Acheloiis spinimanus De Haan.—Bahia.
Acheloiis Ordwayi Stimp.—Bahia.
Goniopsis cruentatus De Haan.—Reefs of the Abrolhos.
Cryptograpsus cirripes Smith (Trans. Conn. Acad., vol. ii, p. 11, plate i, fig. 3).—Rio de Janeiro (Coll. Peabody Acad. Sci.)
This species differs from the *C. angulatus* Dana, heretofore the only known species of the genus, in having the front as seen from above nearly straight instead of deeply bilobed, in the much greater breadth of the carapax between the outer orbital teeth—the ratio of this breadth to the breadth of the carapax being 1:1·43, while in *C. angulatus* it is 1:1·68,—and in having the posterior legs densely ciliated. Length of carapax in a male, 31·0^{mm}; breadth of carapax, 35·6^{mm}.
Uca cordata (Cancer cordatus Linn.)—Bahia.
Cardiosoma quadratum Saussure.—Pernambuco.
Dromidia Antillensis Stimp.—Reefs of the Abrolhos.
Petrochirus granulatus Stimp.— " "
Calcinus sulcatus Stimp.— " "
Clibanarius vittatus Stimp—Caravellas, Province of Bahia.
Clibanarius sclopetarius Stimp.—Caravellas River.
Clibanarius Antillensis Stimp.—Reefs of the Abrolhos.
Scyllarus æquinoxialis Fabr.—Bahia.
Panulirus echinatus Smith (Trans. Conn. Acad., vol. ii, p. 20).
This species is closely allied to *P. guttatus*, but differs from the figures and descriptions of that species, in having the spaces between the spines of the carapax tuberculose and hairy instead of smooth, the third pair of thoracic legs extending beyond the second instead of the second being longer than the third, and the trausverse sulcus of the third abdominal segment interrupted in the middle. In the posterior thoracic legs of

the female, the dactylus is short and armed on the posterior side of the base, with a stout process which closes against a similar process from the extremity of the propodus, both processes being hairy on the outside, and having horny spoon-shaped tips.—Pernambuco.

Alpheus heterochelis Say.—Reefs of the Abrolhos.

Palæmon Jamaicensis Olivier.—Penêdo, Rio Sao Francisco.

Palæmon forceps Edw.—Mouth of the Pará.

Palæmon ensiculus Smith (Trans. Conn. Acad., vol. ii, p. 26, plate i, fig. 2.—Pará.)

Rostrum very long, strongly curved downward for the basal half of its length, the terminal half very slender, nearly straight, but strongly inclined upward, armed above with nine to twelve short teeth of which seven or eight are on the basal portion, and the others near the tip, and below with eight to twelve teeth. Second pair of thoracic legs in the male very long and quite slender, in full grown specimens, the merus reaching beyond the tip of the antennal scale, and all the segments to the base of the fingers closely beset with short spinules; hands cylindrical, not swollen, the fingers slender and sparsely clothed with short, downy pubescence; in the females and young the second pair of legs smaller and much less spinulose. Penultimate segment of the abdomen long and narrow, the length above being twice as great as the breadth; terminal segment narrow and tapering regularly to a very slender and acute point. Length, 65 to 100^{mm}.

Peneus Brasiliensis Latr.—Bahia.

Xiphopeneus Smith, gen. nov., (Trans. Conn. Acad., vol. ii, p. 27).

Carapax much as in *Peneus*, but the rostrum very long and slender, and the gastro-hepatic sulcus scarcely perceptible, while the cervical and branchio-cardiac sulci are distinct. Lamelliform appendages on the inside of the peduncle of the antennulæ very small, not expanded over the eye as in *Peneus*; antennulary flagella very long and slender, the upper ones much stouter and longer than the lower. Antennæ, maxillipeds and the three anterior pairs of thoracic legs nearly as in *Peneus*. Fourth and fifth pairs of legs very long, the terminal segments very slender and flagelliform.

Xiphopeneus Harttii Smith (Trans. Conn. Acad., vol. ii, p. 28, plate i, fig. 1.)—Caravellas, Province of Bahia.

Rostrum as long as, or considerably longer than the carapax, wholly unarmed below, but the basal portion with a thin carina above, which extends back upon the carapax and is armed with six sharp teeth, the terminal portion is subcylindrical, unarmed, and tapers to a very slender point far in front of the antennal scales. Upper flagellum of antennula

about three times as long as the carapax; lower flagellum very slender and half as long as the upper. Thoracic legs of the first pair reaching to the middle of the propodus of the external maxillipeds, slender, beset with stiff hairs along the edges, and the basis armed with a spine on the inside near the articulation with the ischium; second and third pairs of legs successively a little longer, smooth and unarmed; legs of the fourth and fifth pairs smooth and unarmed, all the segments, except the coxal and basal very slender and very much prolonged, the terminal segments being fully as slender as the terminal portions of the flagella of the antennulæ.

Gonodactylus chiragra Latr.—Reefs of the Abrolhos, Caravellas.

Of the 32 species in the foregoing list, 21 are new to the fauna of Brazil; of these 21 species, 6 are described as new, and the remaining 15 are all species previously known from the West Indies or Florida. The 11 species in Prof. Hartt's collection which were previously known from Brazil are all, with the exception of *Callinectes Danæ*, now known from the Caribbean fauna.

The account of Prof. Hartt's collection is followed by a list of the described species of Brazilian Podophthalmia with their geographical distribution. One hundred and five species are enumerated but the actual number of described species is probably somewhat less, as several are admitted on questionable authority and some others will doubtless prove to be synomyms. In this list the following changes in nomenclature are introduced:—

Acheloüs Sebæ=Neptunus Sebæ A. Edw.

Eucratopsis is proposed as a new genus for the reception of *Eucrate crassimanus* Dana, Stimpson, in Boston Journal Nat. Hist., vol. vii, p. 588, having shown from an examination of specimens of *Eucrate crenatus* that De Haan's genus has the male organs, or verges, arising from the coxæ of the posterior legs and therefore belongs to the *Carcinoplacidæ* of Edwards, while in *E. crassimanus* the verges are sternal. The genus thus constituted appears to be nearest allied to *Speocarcinus* Stimpson (Annals Lyc. Nat. Hist., New York, vol. vii, p. 59), but it is quite distinct in the larger orbits, the approximation of the inner margins of the external maxillipeds, and in the much greater narrowness of the posterior part of the sternum.

Trichodactylus (?) *Cunninghami*=Uca Cunninghami Bate.

Pachygrapsus rugulosus=Letograpsus rugulosus Edw.

Petrolisthes leporinus=Porcellana leporina Heller.

Petrolisthes Brasiliensis, sp. nov=Porcellana Boscii? Dana (*non* Savigny).

ART. XXXIX.—*Notice of some new Mosasauroid Reptiles from the Greensand of New Jersey;* by O. C. MARSH, Professor of Paleontology in Yale College.

A STRIKING difference between the reptilian fauna of the Cretaceous of Europe and America is the prevalence in the former of remains of *Ichthyosaurus* and *Plesiosaurus*, which here appear to be entirely wanting; while the Mosasauroids, a group comparatively rare in the Old World, replace them in this country, and are abundantly represented by several genera, and numerous species. Recent explorations in the Cretaceous deposits of the Atlantic border, and in the region west of the Mississippi have resulted in the discovery of many new forms of this peculiar type of reptilian life, and furnished material for a more satisfactory study of its structure and affinities, which have so long remained in doubt. The investigations already made by Professors Leidy, Cope, and others have removed many uncertainties in regard to the true nature of these reptiles, and disclosed affinities with other groups, before unsuspected. The interesting remains of *Mosasaurus* and its allies, which are briefly characterized in the present paper, promise to throw much additional light on this subject, and will be described in full, with illustrations, at an early day.

Mosasaurus princeps Marsh, sp. nov.

This species is indicated by the most important parts of a skeleton which is perhaps the largest hitherto found in this country, as when entire the animal was probably not less than seventy-five feet in length. The remains are in an excellent state of preservation, and among them are the greater portion of the skull, with the maxillary teeth; one perfect quadrate bone; one mandible, nearly complete, with many of the teeth, and the posterior portion of the other; about twenty vertebræ, and several bones of the extremities.

The teeth are smooth or very slightly facetted, and much curved inward and backward, especially in the posterior part of the jaws. The external pedicle of the crown is short, and its surface very concave. The dorsal vertebræ are very cylindrical; the caudals slightly flattened below, and furnished with anchylosed chevron bones. The ribs preserved are most of them cylindrical and slender like those of serpents, but are not hollow. Some of the smaller ones, apparently from the posterior dorsal region, are flattened transversely, and have the articular head nearly round, and slightly convex. The suspensorium of the quadrate bone is clasped by the proötic above, and the exoccipital below, and the squamosal forms the greater part of the glenoid cavity. The

articular faces of the right subarticular and splenial bones are complete, and indicate that the peculiar joint in the lower jaw, characteristic of the Mosasauroids, was, in this species, more adapted for vertical, than for lateral motion, although the latter was to some extent possible.

This species appears to be readily distinguished from those already known, with the exception, perhaps, of *Mosasaurus maximus* of Cope, which has not yet been fully described. So far as it has been defined, however, it presents marked differences from the present species, particularly in the quadrate bone, one of the most characteristic portions of the skeleton. In *M. princeps*, the proximal end of the quadrate forms an open sigmoid, the process at the angle over the great ala is much smaller than that of the external angle, and the knob just within the meatus of the ear is very prominent. There is also a large foramen near the medial line, a little below the center, which is not given in Prof. Cope's figure of the quadrate of *M. maximus*.* The left quadrate of the present specimen is eight inches in length, four and two-thirds inches in breadth from the outer side of the pit near the meatus to the edge of the great ala, and five inches across the articular face of the distal extremity.

The geological position of these remains was in the first or lower bed of Cretaceous greensand, or Marl. They were all found together in July last near Hornerstown, Monmouth county, New Jersey, during the excavation of a ditch by the well known Cream Ridge Marl Company, and, with most of the specimens described below, were presented to the Peabody Museum of Yale College by John G. Meirs, Esq., in behalf of the Company. The thanks of all friends of science are justly due to Mr. Meirs and the other Directors for their intelligent zeal and liberality in preserving such valuable specimens, and rendering them available for investigation.

Mosasaurus Copeanus Marsh, sp. nov.

The remains which at present represent this species are portions of a skull with some of the maxillary teeth, and part of the corresponding lower jaws, including the anterior extremity of the left ramus, and the articular surface of the left splenial bone. They indicate one of the smallest Mosasauroids yet discovered, and one very distinct from any hitherto known. The teeth are slender, compressed, considerably curved, and deeply facetted. They are very pointed, and a sharp ridge, without denticulations, divides the outer from the inner surfaces. The enamel of the crown is remarkably smooth, and quite unlike the usual corrugated dental surfaces of the larger Mosasauroids. The dimensions of a very perfect tooth from near the middle of the left lower jaw are as follows:—

* Transactions of Am. Philosophical Soc., vol. xiv, pl. xi, fig. 7, 1869.

Length of crown and osseous support,	1 inch,	11·	lines.
Length of crown alone,		10·5	"
Antero-posterior diameter of crown at base,		5·25	"
Transverse diameter of crown at base,		4·	"

The fang-like supports of all the teeth are more firmly coössified with the jaws than is usually the case in this family, and most of them contain excavations for the successional teeth. On the outer superior edge of the lower jaws there is a row of pits, round or oval in outline, and alternating with the teeth. In most instances one is situated outside and a little in front of each tooth, and those in the anterior portions of the jaws are deeper than those farther back. They evidently have been excavated by the maxillary teeth, and are adapted for their reception, like the similar cavities in the jaws of crocodiles. Slight depressions, corresponding to these in position, may be seen in the jaws of some of the larger species of *Mosasaurus*, and the unusual depth of the pits in the present specimen is probably due to the more pointed character of the teeth.

Among the pieces of the skull preserved, is part of a symetrical bone, about seven inches in length, which formed the superior, medial portion of the face in front of the orbits. Although no sutures are visible, it is evidently composed of the nasal bone, and portions of the attached premaxillary and frontal bones. Its upper surface is very peculiar in form, and is doubtless quite characteristic of the species. It is slightly concave in front where broken off, flat at its narrowest part between the nasal openings, convex as it becomes broader a little farther back, next flat with regular beveled edges at its greatest width between the apertures, and finally very convex as it again expands before coalescing with the medial frontal. This fragment indicates that the nasal bone was very slender, and, like the premaxillary, undivided; that the superior nasal openings on either side were long and narrow, and that the central line of the face immediately behind them was marked by a low rounded ridge.

This species will be easily distinguished from the Mosasauroids hitherto described, with the possible exception of the *Holcodus accutidens* of Gibbes,* which was founded on specimens including teeth of *Hyposaurus*, and a single dental crown apparently similar in size and general appearance to the teeth here described. The latter, however, appear to all have the crown more unequally divided by the acute edges, and they also have facets at the base of the inner surface in place of the strong striæ which suggested the generic name *Holcodus*.

The present remains indicate an animal about twenty-five feet in length. They are from the lower Cretaceous greensand bed

* Smithsonian Contributions, vol. II, Art. 5, p. 9.

at Marlborough, Monmouth county, New Jersey. The species is named for Professor E. D. Cope, of Philadelphia.

Mosasaurus Meirsii Marsh, sp. nov.

This species is indicated by the crown of a single tooth which was found in the lowest Marl bed, near Hornerstown, New Jersey. It evidently belonged to a Mosasauroid reptile of moderate size, but appears to differ from the teeth of any yet described in being more pointed, and in having the sides very deeply facetted, or grooved. It resembles strongly the teeth of *Mosasaurus Copeanus*, but is more compressed, the enamel of the crown more corrugated, the cutting edges are minutely denticulated, and it evidently belonged to a much larger animal. The crown is an inch and five lines in length, and eight lines in antero-posterior diameter at the base. The facets fade away before reaching the apex, which is nearly smooth.

This tooth is apparently too large for either of the species of *Halisaurus* described below, the remains of which were found in the same immediate vicinity, but it may possibly belong to *Macrosaurus lævis*, or *M. validus*, the teeth of which are unknown. In the absence of any evidence on this point, it may very appropriately be named for the discoverer, Mr. John G. Meirs, who has rescued for science so much valuable material relating to *Mosasaurus* and its contemporaries.

Halisaurus platyspondylus* Marsh, gen. et sp. nov.

Macrosaurus platyspondylus Marsh, American Association of Science, Salem Meeting, August, 1869.

This genus is especially characterized by the great depression of the centra of the vertebræ, which gives the articular ball and cup a very transverse elliptical outline, exceeding in this respect apparently those of any other Reptilia. The vertebræ, so far as known, are also elongate, and without the zygosphenal and zygantral articulation. In the anterior part of the series the cup is deep, thin lipped, and more concave transversely than vertically. In outline it is somewhat concave, and its face is directed slightly downward. The neural arch rests upon the anterior three-fourths of the centrum, and the spine is of medium height. The neural canal is a broad vertical oval. The diapophyses have a general resemblance to those of *Mosasaurus*, but in the anterior part of the vertebral series are more compressed, and extend forward and downward, projecting below the inferior surface of the centrum, like the corresponding pedunculate processes in some of the serpents. The Ophidian affinities of this genus appear to be further indicated by the hypapophysis, which in the posterior cervicals, at least, is wedge-shaped, and

* Ἅλς, *the sea*, and σαῦρος, *a lizard*.

descends vertically from the posterior part of the centrum, resembling strongly the hypapophyses of the medial trunk vertebræ of the constricting snakes, especially the Eocene *Palæophis*, which may, perhaps, yet prove to be a descendant of some of the Mosasauroids. The present genus appears to have its nearest allies in *Macrosaurus* and *Clidastes*, especially the former, which has, however, the dorsal vertebræ more or less compressed. From the latter genus it may readily be distinguished by the absence of the zygosphenal articulation.

The remains on which the species is founded consist of a posterior cervical, and an anterior dorsal vertebra; the right splenial bone with its concave articular face, and a small portion of the base of the skull. A coracoid found near these specimens probably belonged to the same animal, although it is smaller than the other parts of the skeleton would apparently indicate, and differs considerably in form and proportions from the corresponding bone in both *Macrosaurus* and *Clidastes*. The splenial bone differs from that of *Mosasaurus* in the form of its articular face, and in being more overlapped in front of the joint by the dentary. The dimensions of the posterior cervical vertebra are as follows:—

Length of centrum below,	2	inches,	6 lines.
Transverse diameter of articular cup,	1	"	8·5 "
Vertical diameter of articular cup,			11· "
Distance from center of cup to middle of lateral edge,			11· "
Length of diapophyses below lower margin of cup,			5·5 "
Length of hypapophysis below lower margin of ball,			8· "

The dorsal vertebra has no trace of a hypapophysis, and the lower surface of the centrum is remarkably flat. The anterior downward prolongation of the diapophyses still project below the centrum, but they have become obtuse processes, partially separated from the more vertical portion of the diapophyses by a notch. The following are the more important dimensions of this vertebra:—

Length of centrum below,	2	inches,	6· lines.
Transverse diameter of cup,	1	"	9. "
Vertical diameter of cup,	1	"	
Width of neural canal below,			6· "
Width between extremities of anterior zygapophyses,	2	"	3· "
Length of diapophyses below lower surface of centrum,			2· "

These remains, which were recently discovered by Mr. Meirs in the lower Cretaceous Marl bed at Hornerstown, New Jersey,

indicate an animal about thirty feet in length. If the coracoid found near them belongs to the same skeleton, the body was remarkably slender, and the fore limbs possessed comparatively little power.

Halisaurus fraternus Marsh, sp. nov.

This species is established on an anterior dorsal and two posterior dorsal vertebræ, found not far from each other, and probably part of the same series. They are about the same size as those just described, and have many points of resemblance to them, but differ in having the centra less depressed and less elongate. The anterior dorsal has the zygapophyses less expanded, and their articular faces more nearly vertical than the corresponding parts in the previous species. It has also indications of a small hypapophysis, which in form and position resembles somewhat that of *Mosasaurus*. The neural spine is compressed, of moderate height, and directed slightly forward. The posterior dorsals have the centra considerably less depressed than the anterior dorsals, and the neural arch rests upon the anterior two-thirds of the centrum. The diapophyses pass off horizontally, their upper flat surfaces being nearly in the same plane as the floor of the neural canal. At their extremities there is an articular face which is subtriangular. These vertebræ are all much more depressed than those of *Macrosaurus lævis* Owen, or *M. validus* Cope, and indicate an animal smaller than either of those species, probably twenty-five or thirty feet in length. The remains were found at Hornerstown, New Jersey, by Mr. Meirs, at the same locality as those described above.

Yale College, New Haven, Conn., Oct. 20th, 1869.

ART. XL. — *Description of a new and gigantic fossil Serpent (Dinophis grandis), from the Tertiary of New Jersey;* by Professor O. C. MARSH of Yale College.

THE earliest remains of *Ophidia* both in Europe and this country have been found in the Eocene, and nearly all the species from strata older than the Post Pliocene appear to be more or less related to the constricting serpents. Remains of this character are not uncommon in European rocks, but in this country two species only, one founded on a single vertebra, have been described hitherto, and both of these were discovered in the Tertiary greensand of New Jersey. An interesting specimen from the same formation, recently presented to the Museum of Yale College, indicates a third species, much larger than either of the others, in fact superior in size to any known fossil ophidian, and not surpassed by the largest of modern serpents.

This species is represented by a single dorsal vertebra, somewhat injured, but with the neural arch well preserved. The general form of the centrum is elongate, and considerably compressed behind the middle. The articular cup and ball are subtriangular ovate, and their faces are much more nearly vertical than is usual in ophidian vertebræ, the cup looking but very slightly downward. The neural arch is elevated, and massive. The neural canal is broader than high, and its floor depressed posteriorly, with indications of a slight medial epapophysis. The sides of the canal are marked by a sharp longitudinal ridge, which, in connection with the arched roof above, gives a trifoliate outline to a transverse section of the opening, as in some species of *Python*. The floor of the neural canal is somewhat below the plane of the anterior zygapophyses. The zygosphene is much elevated, and its summit concave. It is narrower than the articular cup, a feature which appears to be peculiar to fossil serpents alone. Its anterior surface is deeply excavated, and the lateral margins extend from the base downward and outward to the superior edge of the cup, thus continuing the sides of the neural canal forward. The zygantrum is comparatively shallow, and has its greatest depth on the medial line. Its base extends downward and backward until directly over the superior margin of the ball, protecting also from above the neural canal posteriorly. The neural spine is much compressed, triangular in outline at its base, and does not extend to the anterior margin of the zygosphene. The base of the neural arch is strengthened by a thick rounded ridge, which unites the zygapoyphyses on each side. It begins below the plane of the anterior zygapophysis, and ascending slightly, joins the posterior zygapophysis above the articular face. Remnants of two hypapophyses connected by a prominent ridge exist, and show that the anterior process was much the smaller, and its base somewhat separated from the margin of the cup.

The principal dimensions of this vertebra, which is apparently an anterior dorsal, are as follows:—

Length of centrum from edge of cup to convexity of ball,	14·25	lines.
Transverse diameter of cup,	9·10	"
Vertical diameter of cup,	7·5	"
Distance from top of zygosphene to lower margin of cup,	13·25	"
Vertical diameter of ball,	7·25	"
Width of neural canal in front,	3·75	"
Height of neural canal in front,	2·5	"

The present species is quite distinct from *Palæophis halidanus* Cope, which somewhat resembles it in size. The original specimen on which the latter species was founded is now in the Mu-

seum of Yale College, and a comparison shows that the centrum is much more depressed, the cup and ball more transverse, and the ridge uniting the zygapophyses narrower in proportion, and less rounded. From the vertebræ of *Palæophis littoralis* Cope, which it most nearly resembles in general form, outline of cup, and hypapophyses, the present specimen differs especially, judging from the description and figures,* in having the plane of the anterior zygapophyses above the floor of the neural canal, and the ridge between the zygapophyses not parallel with the centrum. The zygosphene is also more elevated, and the top of the neural canal more rounded in front. The bulk of the present vertebra is, moreover, at least three times that of *Palæophis halidanus*, and five or six times that of *P. littoralis*. It is also considerably larger than any vertebra described by Professor Owen in his valuable Memoir on the Tertiary Ophidia of England,† as well as quite distinct from any of the species there defined.

The present specimen is evidently identical generically with the two species already described by Professor Cope, but in comparing these various remains with typical specimens and figures of the species placed by Professor Owen in his genus *Palæophis*, several marked differences between the two groups will be observed, which would seem to justify their separation. For the reception of the American species, therefore, the genus *Dinophis*‡ is proposed. Among the most apparent differences between this genus and *Palæophis*, to which it is closely related, are the following:—The base of the neural spine in *Dinophis* is not coextensive with the supporting arch, but rises a short distance back of the anterior margin of the zygosphene, as in the existing *Python*. The ridge connecting the anterior and posterior zygapophyses is much more developed, and its continuous crest more rounded. The sloping sides of the arch above the neural canal are more deeply concave, and an obtuse ridge separates the concavity from the anterior zygapophysial notch. The neural canal has a sharp longitudinal ridge on each side, which gives its transverse section a trifoliate outline, as in *Python*. The zygosphene is more excavated anteriorly, and its summit is concave. The zygapophyses are more extended outwardly, and the hypapophysial ridge is more prominent.

The vertebra here described would indicate an animal not less than thirty feet in length, probably a sea-serpent allied to the Boas of the present era. In view of its superior size, the species may appropriately be named *Dinophis grandis*. This interesting specimen was found in the Eocene greensand, near

* Proc. Acad. of Nat Sci. Philad., 1868, p. 234, and Trans. Am. Phil. Soc., vol. xiv, Plate V, 1869.

† Paleontological Society of London, 1850.

‡ Δεινός, *terrible*, and ὄφις, *a serpent*.

Shark River, Monmouth county, New Jersey, and was presented to the Peabody Museum of Yale College by Dr. W. S. Kimball, of Eatontown in that state.

A synopsis of the known American species of fossil *Ophidia* will at present, in accordance with the above determinations, stand as follows:—

Family BOIDÆ. ?

Genus DINOPHIS Marsh.

Dinophis littoralis (Cope).

Palæophis littoralis Cope. Proc. Acad. Nat. Sci. Philad., 1868, p. 147 and 234. Also Trans. Am. Phil. Soc., vol. xiv, 1869, plate v, fig. 1.

Dinophis halidanus (Cope).

Palæophis halidanus Cope. Proc. Acad. Nat. Sci. Philad., 1868, p. 234. Also Trans. Am. Phil. Soc., vol. xiv, 1869, plate v, fig. 2.

Dinophis grandis Marsh.

Am. Journal of Science, 2nd Series, vol. xlviii, 1869, p. 397.

The occurrence of closely related species of large serpents in the same geological formation in Europe and America, just after the total disappearance in each country of *Mosasaurus* and its allies, which show such marked ophidian affinities, is a fact of peculiar interest, in view of the not improbable origin of the former type; and the intermediate forms, which recent discoveries have led paleontologists familiar with these groups to confidently anticipate, will doubtless at no distant day reward explorations in the proper geological horizon.

Yale College, New Haven, Conn., Oct. 25th, 1869.

ART. XLI.—*Discovery of a new Planet, the* 109*th*; by Dr. E. H. F. PETERS (in a letter to one of the Editors).

I WRITE to communicate the discovery made here on Saturday night, of a planet, the 109th of the asteroid group. It is in the constellation of *Pisces*, more properly in the following position:

1869, Oct. 9, $13^h\ 31^m\ 58^s$, Hamilton College mean time. A. R. $=0^h\ 56^m\ 2{\cdot}60^s$. Decl. $= +9°\ 37'\ 10{\cdot}6''$.

Its motion in declination is almost nothing; that in right ascension over a minute per day. In brightness it equals a star of the 10th magnitude.

Litchfield Observatory of Hamilton College, Clinton, N. Y., Oct. 11th, 1869.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS.

1. *Observations on the protuberances of the Sun.*—ZÖLLNER has communicated to the Royal Society of Sciences of Saxony the results of observations of the solar protuberances made by a new method, the details of which are, however, not given in the paper from which this abstract is taken. The author states that by this method the protuberances can be observed with great sharpness and distinctness, and gives a number of figures of much interest, representing various forms of the red eruptive flames. The method of observation employed gives the same protuberance in three different colors at the same time, corresponding to the three homogeneous lines of the spectrum, red, yellow and blue. A marked difference is observed between the yellow and the other two images. The yellow image is very intense near to the edge of the sun's disc where it corresponds with the other images, while at a greater distance the finer details are lost. Zöllner infers from this either that the rays to which the yellow image is due proceed from a gas specifically heavier than hydrogen and, therefore, occupying a lower stratum, or that the increase in the temperature and pressure of the hydrogen near the surface of the sun determines the emission of the yellow rays in question. The author remarks that the red protuberances, as seen by his method, for the most part strongly resemble the various forms of terrestrial clouds, the cumulus type being most distinctly exhibited. There are, however, some exceptions; in certain cases the phenomena resemble those of eruptions of volcanoes or of hot springs. Zöllner suggests that it may hereafter be possible to observe at the same time all the protuberances as in the case of a total eclipse. In conclusion the author mentions another observation of great interest. On the 27th June the slit of the spectroscope was made to approach a part of the sun's disc where the spectral lines of the protuberances were particularly long and bright. At a distance of 3 or 4 minutes above the sun's edge the whole length of the spectrum was crossed by bright linear flashes. These flashes extended over the whole portion of spectrum in the field of view and were so abundant at one point of the sun's edge that it seemed as if the whole spectrum were crossed by the straight paths of rapidly following electric discharges. This phenomenon would be explained by the assumption that small intensely ignited bodies are moving near the sun's surface and sending out rays of all refrangibilities. As the images pass rapidly before the slit of the spectroscope they give a spectrum with flashing lines.—*Pogg. Ann.*, cxxxvii, 624, No. 8, 1869. W. G.

2. *On a method of viewing the solar prominences without an eclipse.*—Mr. HUGGINS has also given a method of observing a solar prominence with a spectroscope. This method consists in placing a narrow slit behind the train of prisms before the object glass

of the observing telescope. This slit limited the light entering the telescope to that of the refrangibility of the part of the spectrum near C. The slit of the spectroscope was then inclined sufficiently to admit the form of the prominence to be seen. The spectrum became then so impure that the prominence could not be distinguished. A piece of deep ruby glass was then introduced so as to absorb light of all refrangibilities differing much from that of C. The prominence was then distinctly seen. When the sky is very clear the colored glass may be dispensed with.—*Proceedings of the Royal Society*, No. 109, 1869. W. G.

3. *Researches on gaseous spectra in relation to the physical constitution of the Sun, Stars and Nebulæ.*—FRANKLAND and LOCKYER have entered upon a special study of the spectra of several gases and vapors, with a view to throw light on the discoveries recently made bearing upon the physical constitution of the sun. In the first place, as regards hydrogen, the authors have as yet failed to detect any line in the hydrogen spectrum corresponding to the yellow line near D, (which might be conveniently denoted by *d*. W. G.), but the experiments are not yet complete. The thickening of the line F proves to be due to pressure and not appreciably, if at all, to temperature *per se*. The authors believe that there is ample evidence that in the higher prominences the gaseous medium is in a state of excessive tenuity, and that at the lower surface of the chromosphere itself the pressure is very far below the pressure of the earth's atmosphere. As the bright line *d* does not appear reversed in the solar spectrum, it follows that, assuming the line to be a hydrogen line, the selective absorption of the chromosphere is not sufficient to reverse it. Frankland and Lockyer remark that the facts observed lead to important modifications of the received theory of the physical constitution of the sun—that proposed by Kirchhoff. According to this theory the photosphere is either solid or liquid, and is surrounded by an atmosphere composed of the gases and vapors of the substances incandescent in the photosphere. Instead of this we find that the outer atmosphere consists mainly of hydrogen and that the photosphere is cloudy or gaseous or both. Thus it has been shown that a gaseous condition of the photosphere is consistent with its continuous spectrum; that the spectrum of the photosphere contains bright lines when the limb is observed, indicating an outer gaseous shell; that a sun spot is a region of greater absorption, and that occasionally photospheric matter appears to be injected into the chromosphere. These facts seem to show that the selective absorption which reverses the bright lines takes place in or near the photosphere. Other and more recently obtained results are as follows:

I. The Fraunhofer line of the solar spectrum named *h* by Angström, which is due to the absorption of hydrogen, is not visible, in the tubes, we employ, with low battery and Leyden jar power; it may be looked upon therefore as an indication of relatively high temperature. As the line in question has been seen by one of us reversed in the spectrum of the chromosphere, it follows that the

chromosphere, when cool enough to absorb, is still of a relatively high temperature.

II. Under certain conditions of temperature and pressure, the very complicated spectrum of hydrogen is reduced in our instrument to one line in the green corresponding to F in the solar spectrum.

III. The equally complicated spectrum of nitrogen is similarly reducible to one bright line in the green, with traces of other more refrangible faint lines.

IV. From a mixture of the two gases we have obtained a combination of the spectra in question, the relative brilliancy of the two bright green lines varying with the amount of each gas present in the mixture.

V. By removing the experimental tube a little farther away from the slit of the spectroscope, the combined spectra referred to in II and III were reduced to the two bright lines.

VI. By reducing the temperature all spectroscopic evidence of the nitrogen vanished; and by increasing it, many new nitrogen lines make their appearance, the hydrogen line always remaining visible.

The authors infer that the temperature of the nebulæ is lower than that of our sun and that their tenuity is excessive. In a previous communication the authors stated that when the vapors of magnesium are injected into the chromosphere the spectral lines do not all attain the same height. Thus the heights of b, b^1 and b^2 are almost the same, but b^4 is much shorter. They now find that when the spark is made to pass in air between two poles of magnesium separated in such a manner that the magnesium spectrum does not extend from pole to pole, but is only visible for a small distance indicated by an atmosphere of magnesium around each pole, the magnesium lines b behave exactly as they do in the sun. The most refrangible of the three lines is the shortest while other lines, not yet discovered in the spectrum of the chromosphere, are still shorter. The authors consider this experiment as fully justifying their assumption that the mass of the absorption takes place in the photosphere and that this and the chromosphere constitute the true atmosphere of the sun.—*Proc. of the Royal Society*, vol. xvii, 288, 453. *Comptes Rendus*, lxix, 264. W. G.

4. *On the physical constitution of the Sun.*—In a letter addressed to M. Dumas and by him communicated to the Academy of Sciences, Mr. Lockyer has given a summary of his observations of the sun from which we extract the following table showing the lines observed in the chromosphere with the dates of their discovery.

Hydrogen.	
C	Oct. 20, 1868.
Near F	" "
D	Dec. 20, "
Near G	" "
M	March 14, 1869.

Sodium.		
D	----------	Feb. 28, 1869.
Barium.		
1989·5	Kirchhoff's scale,--------	March 14, 1869.
2031·2	" " --------	July 5, 1869.
Magnesium.		
b	1, 2, 3, 4,----------	Feb. 21, 1869.
Iron 1474,----------		June 6, 1869.
? 1515·5,----------		" "
A brilliant ray 1529·5, ----------		July 5, "
? 1567·5,----------		March 6, "
? 1613·8,----------		June 6, "
Iron 1867·0,----------		June 26, "
A brilliant line 1871·5,----------		" "
Iron 2001·5,----------		" "
? 2003·4,----------		" "
? Band or lines 2054·0,-------		July 5, "

—*Comptes Rendus*, lxix, 121. W. G.

5. *On the ultra violet Spectra.*—Mascart has examined the spectra of metals with special reference to lines beyond H, employing photography as a means of recording his observations. In this manner he has detected more than 100 new coincidences of iron and solar lines, in addition to the 450 observed by Angström in the visible spectrum. No coincidences could be observed with certainty for cadmium, though six very intense rays appeared also to exist in the solar spectrum. Mascart further calls attention to the occurrence, in different parts of the spectrum, of similar groups of lines belonging to the same element. Thus he observed in 1863 that the six principal rays of sodium observed by Wolf and Diacon are all double, and that the two rays of each group are at about the same distance as those of D. Magnesium, as is well known, gives the group of 3 rays *b*. In the ultra violet spectrum of the same metal there are two other remarkable groups. One, situated near L, can be seen by the eye without difficulty. It consists of 3 rays disposed in the same manner and at about the same distances as the three lines in *b*. These rays also exist in the solar spectrum. The other group is situated between P and Q and is also found in the solar spectrum. It has the same form as *b* but the rays are rather more widely separated. The wave lengths of the least refrangible rays in the three groups are respectively 518·2, 386·4 and 333·5. The author thinks that this repetition of the same phenomenon in different parts of the spectrum cannot be the result of chance, but depend on the molecular constitution of the luminous gas.—*Comptes Rendus*, lxix, 337. W. G.

6. *On the spectrum of the Aurora Borealis.*—In our notice of the spectral lines of the aurora borealis of April 15, 1869, given on p. 123 of vol. xlviii of this Journal, it is stated that 5 lines were seen. For 5 we should read 7, the places on Mr. Huggins' scale being

1280 brightest
1400
1550
1680
Near F
2640
Near G

We are indebted for this correction to Mr. Charles S. Peirce by whom the observations were made.

The brightest line is fully 20 times as bright as any other. The faint lines should perhaps be called bands rather than lines as they exhibit an appreciable breadth. On June 6th 5 lines were seen, the brightest being 1280 of Mr. Huggins' scale. W. G.

7. *On a new element associated with Zirconium.*—The existence of absorption bands in the spectra obtained from light transmitted through certain specimens of zircon was first observed by Prof. Church in 1866 and a notice of his results published in the Intellectual Observer, vol. ix, p. 291. The same bands have been recently observed independently by Mr. H. C. Sorby, who has inferred from them the existence of a new element to which he gives the name of jargonium. The natural silicate of jargonium is almost, if not quite, colorless but gives a spectrum exhibiting more than a dozen narrow black lines more distinct than even those of didymium. The borax bead gives no absorption bands, but by flaming crystals of borate of jargonia are formed, and the spectrum then shows four absorption bands unlike those of any other known substance. Another remarkable property of jargonia is that its compounds may exist in three different crystalline states, giving three wholly different spectra. The spectrum of the borax bead after flaming may easily be seen with the spectrum microscope which thus enables us to detect less than one per cent of jargonia in zircons. The spectrum, however, is different according to the temperature to which the bead has been subjected. Jargons from Ceylon of density 4·70 contain very little jargonia, but those of density 4·20 contain about 10 per cent, in a form which gives hardly a trace of absorption bands. On keeping such a specimen for some time at a high red heat the density increases to 4·60. The mineral then gives a spectrum with 13 narrow black bands and one broader line No such changes occur with zircons from Miask which are free from jargonia. Mr. Sorby and Mr. David Forbes have both succeeded in making an approximate separation of jargonia by purely chemical methods, but their results must be considered only as first attempts and necessarily very imperfect.—*Proc. of the Royal Society*, xvii, 511. W. G.

8. *Additional observations on Hydrogenium.*—When a palladium wire is allowed to occlude hydrogen its length increases and from the corresponding increase in volume Graham determined the density of the occluded hydrogen to be about 2. It is now found, however, that the wire after the expulsion of the hydrogen undergoes a permanent shortening about equal in amount to the

previous elongation. If we assume that the volume added to the wire is represented by both the elongation and contraction the mobility of the palladium particles being determined by the first entrance of the hydrogen, the volume of the hydrogen in the alloy will rise from 4·68 per cent to 9·36 per cent and the density of hydrogenium will fall from 1·708 to 0·854, according to the new calculation. In another experiment the density was found to be 0·872. The alloys of palladium with other metals are also found to absorb hydrogen when the second metal does not much exceed one half of the mixture. The alloys all expand by the absorption and afterward contract but only to the original length of the wire. The following table gives the results of the author's determinations of the density of hydrogenium as deduced from different alloys:

	Density of hydrogenium.
When united with palladium alone,	0·854 to 0·872
" " and platinum,	0·7401 to 0·7545
" " " gold,	0·711 to 0·715
" " " silver,	0·727 to 0·742

The mean of these numbers is 0·733 which may be accepted provisionally as the approximate density of hydrogenium.—*Proc. of the Royal Society*, vol. xvii, p. 510. W. G.

9. *On the properties of fluohydric acid.*—We extract from an extended memoir by Mr. G. Gore, the following account of the properties of pure fluohydric acid, as obtained by heating perfectly dry fluohydrate of fluorid of potassium in a platinum retort. The pure acid at 15·5° C. is a colorless mobile liquid; its density is 0·9879 at 12·7° C., water at the same temperature being taken as 1; it boils at 19·4° C. and remains fluid at −34·5° C. The acid is a most dangerous substance to handle, requiring the utmost care. Dry gaseous fluohydric acid does not attack glass so long as moisture is completely excluded.—*Proc. Royal Society* xvii, p. 256.

W. G.

10. *On a new mode of formation of the nitro-prussids.*—When potassic cyanid is added to a solution of a ferrous salt an orange colored precipitate, as is well known, is formed. Städeler finds that this precipitate has the formula Fe_2Cy_5K, and that with potassic nitrite it yields, on boiling, potassic nitro-prusside, ammonia and ferric oxyd. The equation representing the reaction is here—

$$Fe_2Cy_5K + N\Theta_2K = Fe\Theta + Fe(N\Theta)Cy_5K_2.$$

The ammonia in this case results from the action of the ferrous oxyd upon potassic nitrite, and is, therefore, with ferric oxyd to be regarded as a secondary product. After a careful discussion of the whole subject Städeler arrives at the conclusion that Gerhardt's formula for sodic nitro-prusside is correct; and it therefore contains nitroxyl ($N\Theta$) and not ($N\Theta_2$) as others, and in particular Hadow, had maintained. Städeler agrees with Playfair in deriving the nitro-prussides from a hitherto unknown ferrocyanhydric acid $FeCy6H_2$ which may be termed superferrid-cyanhydric acid. The potassic salt of this acid appears to be formed by the action of

iodine upon ferrid-cyanid of potassium and Städeler promises a further investigation of the subject.—*Ann. der Chemie u. Pharmacie*, lxxv, 1. W. G.

11. *Researches on Vanadium.*—Roscoe has continued his fine investigation of the compounds of vanadium and in the second part of his paper describes vanadium itself and three of its chlorids. Vanadic tetrachlorid is a dark reddish brown volatile liquid obtained when metallic vanadium or the mono-nitrid is burned in chlorine; its density at 0° C. is 1·8584; it does not solidify at −18° C., is decomposed on boiling and even at ordinary temperatures into trichlorid and free chlorine. Water decomposes the tetrachlorid into chlorhydric acid and a blue solution of the tetroxyd V_2O_4. The tetrachlorid does not combine with bromine. Vanadic trichlorid crystallizes in beautiful peach blossom colored scales closely resembling chromic sesquichlorid. It is not volatile in hydrogen, but first loses an atom of chlorine, forming the dichlorid, and afterward, at a higher temperature, loses all its chlorine, leaving the metal as a gray lustrous powder. It is very hygroscopic and deliquesces to a brown liquid. The density of the trichlorid is 3·00 at 18° C. Vanadic dichlorid is also a solid, crystallizing in bright apple-green micaceous plates. It is extremely hygroscopic; when thrown into water a violet colored solution is formed like that of hypovanadous acid and bleaching strongly by reduction. Metallic vanadium, prepared by reducing the dichlorid in hydrogen at a red heat, is a brilliant crystalline metallic mass having a bright silver-white lustre. It does not oxydize or tarnish in the air at ordinary temperatures or even when heated in air to 100° C. When heated quickly in oxygen it burns vividly forming the pentoxyd; but when slowly ignited in air it first forms a brown oxyd, perhaps V_2O, then the black trioxyd, the blue tetroxyd and finally the pentoxyd. The density of the metal at 15° C. is 5·5; it is insoluble in hot or cold chlorhydric acid; strong sulphuric acid dissolves it on heating, giving a yellow solution; fluohydric acid dissolves it slowly with evolution of hydrogen; nitric acid of all strengths acts violently, evolving red fumes and yielding a blue solution. Metallic vanadium burns when heated in a current of chlorine forming the tetrachlorid; heated in a current of nitrogen the mono-nitrid is formed.—*Chemical News*, vol. xx, 37, 38. W. G.

12. *On a new apparatus for the measure of the thermic expansion of solids.*—Prof. J. Müller has made an application of Poggendorff's mirror-arrangement to the measurement of the expansion of solids. The apparatus used for the purpose is described in full, and the details of a measurement in the case of an iron bar are given.—*Pogg. Ann.*, cxxxv, 672. W. G.

Note.—It is not a little remarkable that neither Prof. Müller nor the distinguished editor of the Annalen should be aware of the fact that the above mentioned instrument is not new either in principle or in application. The reflecting pyrometer was invented in 1826 by Mr. Saxton, now of Washington, D. C., and used by him

in adjusting the compensation of a pendulum. It is however first mentioned in print in Prof. Bache's reports on Weights and Measures for 1846 and 1848, and fully described and figured in the report for 1856. It is referred to as having been used to compare the measuring bars for the base-lines in the Coast Survey Report for 1847 and again more particularly in that for 1854, in which the base-measuring apparatus is described and figured. The actual publication from which according to established usage the invention of Mr. Saxton must date is 1856. It is scarcely necessary to say that this note is not intended to dispute Prof. Müller's originality and independence in the invention, but only to assert the prior claims of another. W. G.

13. *On a new Acid of Sulphur.*—Some years ago Schönbein noticed that when an aqueous solution of sulphurous acid is acted upon by zinc for a few moments, it becomes yellow in color, and acquires the property of decolorizing energetically solutions of indigo and litmus. He supposed ozone to be in some way formed, and to act as the bleaching agent. This interesting reaction has been recently studied by SCHÜTZENBERGER, who argued that since the indigo and litmus solutions, thus bleached, regained their color on exposure to the air, the decolorization must be due to a reduction rather than to an oxydation; and since the liquid possessed its activity even after separation from the zinc, the effect could not be due to a simultaneous action of the acid and zinc, but must result from the production of some new and energetic reducing body, which it would be possible to isolate. His preliminary experiments showed him: 1st, that the formation of zincic hyposulphite takes place only after the bleaching power has passed its maximum; 2d, that cupric sulphate gives with the yellow reducing liquid, a precipitate of cuprous-hydrid, which, when the copper salt is in excess is mixed with metallic copper; 3d, that salts of silver and mercury are likewise reduced by this reagent; 4th, that the maximum decolorizing power of the liquid, measured by means of a titred potassic permanganate solution is one and a half times that of the sulphurous acid solution, before putting in the zinc; 5th, that the zinc may be replaced by iron, by manganese, or by magnesium with the same results; and 6th, that no hydrogen is set free during the solution of the zinc in the acid. He observed further, that the effect is immensely increased when a concentrated solution of hydro-sodic sulphite (bisulphite of sodium) is used in place of sulphurous acid, the zinc being in the form of turnings, and the mixture being artificially cooled, the entire operation being conducted out of contact with the air. In half an hour the reaction is finished, and crystals of sodio-zincic sulphite are deposited. The decanted liquid instantly bleaches blue litmus paper, which, on exposure to the air, regains its color, becoming red. By contact with the air, the liquid also loses its properties, and then contains only sodio-zincic sulphite and hydro-sodic sulphite. The zinc turnings left after the decantation, become heated to 55° or 60° C. by the oxydation of the

adhering liquid, evolving visible vapors; the filter too, becomes sensibly hot. The strong attraction of the new body for oxygen is thus very evident. The following is Schützenberger's method for isolating the compound thus active: about half a liter of the active liquid just described, is poured into a flask of two liters capacity, two-thirds filled with strong alcohol, which is then tightly corked. At first, a crystalline deposit is thrown down, composed of the double sulphite mixed with the new product. The clear alcoholic liquid is decanted into a flask, which it should completely fill; this is well closed, and placed in a cool room. In a short time it becomes almost a solid mass of fine colorless needles. These are thrown upon a cloth and rapidly expressed; the solid matter thus retained, though small in amount, is the active substance, the expressed liquid being entirely inactive. Since this crystalline mass heats at once on exposure to the air, it must be immediately placed in the vacuum of an air-pump. On drying, the crystals fall into a white powder permanent in the air, which is soluble in water and dilute alcohol, but insoluble in strong alcohol. It contains a trace of zinc, evidently from admixture with sodio-zincic sulphite, since the impurity may be removed by recrystallization. After oxydation, the powder consists only of hydro-sodic sulphite. Before oxydation its solution decolorizes strongly sulphate of indigo and litmus, precipitates cuprous hydrid from the sulphate, and metallic silver from the nitrate. It has a hot taste, recalling that of hydro-sodic sulphite. Dried in a vacuum and heated in a tube, it gives off a little water, sulphur, and sulphurous oxyd, and leaves a residue of sodic sulphate and sulphid. The numbers obtained on an analysis agree very closely with those given by hydro-sodic sulphite.* And Schützenberger believes that the evolution of water and sulphur during the calcination of the dry salt, shows that this body contains feebly-combined hydrogen which acts as if it were nascent, and thus makes the body active. He maintains that the compound obtained above, is the soda salt of a peculiar acid analogous to hypophosphorous, less oxygenated than sulphurous, and writes its formula $\left.\begin{matrix}S\Theta,H\\Na\end{matrix}\right\}\Theta$, that of hydro-sodic sulphite being $\left.\begin{matrix}(S\Theta)''\\HNa\end{matrix}\right\}\Theta_2$.† Of course the corresponding acid would be $\left.\begin{matrix}S\Theta H\\H\end{matrix}\right\}\Theta$. It is much less stable than its sodic salt, and its formation by the action of the sulphurous acid upon zinc is as follows:

$$(H_2S\Theta_3)_2+Zn=Zn\,S\Theta_3+S\Theta H.H\Theta+H_2\Theta.$$

* [The original statement is: "L'analyse de ces cristaux secs a donné des nombres qui se rapprochent beaucoup de ceux que donnerait le bisulfite anhydre de soude." If this be true, then the formula given cannot be correct. Theory however, would confirm the formula, and look for a qualification of the analytical statement. —G. F. B.]

† [By an evident misprint, this formula is given twice as $\left.\begin{matrix}SO\\HNa\end{matrix}\right\}O$, and once it is called "bisul*fate* de sodium"! So also zincic sulphite is twice printed $(SO_3)_2$ Zn, instead of SO_3Zn; and this error uncorrected, vitiates both the equations in which it occurs.—G. F. B.]

The acid may also be obtained by adding very dilute sulphuric acid, (1 molecule in a liter) to the sodic salt. A beautiful deep orange-yellow liquid, having an intense bleaching power is produced, which soon becomes turbid from the setting free of sulphur, and loses its activity. The decolorizing power of the liquid after the action of the zinc, as measured by permanganate solution, was found to be exactly one-third greater than that of the hydro-sodic sulphite originally:

$$(HNa\,S\Theta_3)_3 + Zn = Na_2\,S\Theta_3 + Zn\,S\Theta_3 + S\Theta H.\,Na\Theta + H_2\Theta.$$

Taking the bleaching power of one molecule of $S\Theta_2$ as unity, and excluding the zinc, the first member of the above equation contains three decolorizing units, the second (by experiment) contains four, an increase of one-third. This accords with the previous statement in regard to the liquid obtained by the action of zinc upon sulphurous acid. The reaction is:

$$(H_2S\Theta_3)_2 + Zn = Zn\,S\Theta_3 + S\Theta H.H\Theta + H_2\Theta.$$

In this case there are two units of decolorizing power in the first member, and three in the second, an increase of one-half as above stated.

Because of the composition and the mode of formation of this acid, Schützenberger proposes to call it *hydro-sulphurous acid*, and its sodic salt, *sodic hydrosulphite*. He has produced it by the action of iron, manganese, and magnesium on sulphite solutions, and, what is more remarkable, by the electrolysis of hydro-sodic sulphite. The nascent hydrogen evolved from the negative electrode—the only one immersed in the solution—being absorbed by the sulphite which becomes hydrosulphite. He finds indeed that when a solution of hydro-sodic sulphite is used in the porous cup of a Bunsen cell, a current is produced but little inferior to that given by nitric acid, and of much greater constancy.—*Bull. Soc. Ch.*, II, xii, 121, August, 1869. G. F. B.

14. *On the use of Thallous oxyd as a test for Ozone.*—In March, 1868, Schönbein proposed to use thallous oxyd as a test for ozone. He impregnated paper with some thallous solution, and exposed it to an atmosphere containing ozone, when the paper became brown from the production of thallic oxyd. Pure oxygen, and air free from ozone were said to be without action. Inasmuch as it was said to remain unaffected in presence of nitrous fumes, it would be invaluable as a test for ozone, if shown to be reliable. For this purpose Lamy undertook an investigation into the relations of ozone to the oxydation of thallium. During an entire year he made numerous comparative experiments with two different kinds of the test-paper, exposing them under the most diverse conditions. In Paris they were placed in the boulevard St. Michel, facing the garden of the Luxembourg; in the open country, they were carried to the Jura, and lastly they were exposed in some of the northern chemical works. The results of these experiments are given as follows: 1st, Thallous oxyd turns brown without being exposed to ozonized air or oxygen; 2d, the sensitiveness of thallous oxyd paper varies

with the degree of concentration of the solutions with which it is prepared, and also with the amount of carbonate present in them; 3d, recently prepared thallous oxyd paper appears to be more sensitive to the oxydizing action of ozone than iodid of starch paper; 4th, the more or less deep coloration of the thallium papers is a certain sign of the presence of ozone only when they are able to turn guaiacum tincture blue; 5th, within the conditions now given, thallous oxyd papers may be used to detect with certainty and rapidity the presence of ozone, even in the midst of a strongly nitrous atmosphere; their employment, however, should be limited to simple confirmations of the presence of ozone, and not extended to a determination of the amount of active oxygen present.—*Bull. Soc. Ch.*, II, xi, 210, March, 1869. G. F. B.

15. *On the preparation of concentrated Iodhydric acid.*—The extensive demand for a concentrated solution of iodhydric acid in the laboratory, particularly as a reducing agent in organic research, has induced VIGIER to make some experiments upon its economic preparation. He employed the usual method, acting upon red phosphorus by iodine in presence of moisture, the operation being conducted in a tubulated retort whose neck was prolonged by a recurved tube, so that the gas as evolved, could be made to pass into a bottle containing distilled water and kept cold by ice. As to the relation between the amounts of phosphorus and iodine used, Vigier finds that for every 1 part of phosphorus, 20 parts of iodine and 15 parts of water are required. An excess of iodine does no harm; but if the phosphorus be used in a less proportion than this, the phosphorous acid formed from the action of water upon the phosphorous iodid, breaks up under the influence of the heat into phosphoric acid and phosphine, PH_3, which phosphine unites directly with the iodhydric acid gas to form phosphonium iodid PH_4I, which condenses in beautiful crystals in the cooler parts of the tube, and may completely close it. The retort is placed in water to keep it cool, the necessary quantity of phosphorus, iodine and water, in the proportions above given, is placed within it—the iodine being added gradually,—and the whole is exposed to a gentle heat, the receiver being kept cool by ice. On repeating the charge, the partially saturated solution of the acid is to be used in place of water. In concluding the operation, the retort may be placed on a sand-bath to expel the last traces of the iodhydric acid gas.—*Bull. Soc. Ch.*, II, xi, 125, Feb., 1869. G. F. B.

16. *A new series of Platinum Compounds.*—SCHNEIDER has studied the action of stannous chlorid upon the salts of platinum. He finds that when a freshly prepared solution of stannous chlorid, moderately concentrated, and containing free hydrochloric acid, is poured into a solution of platinic chlorid, containing 0·01 grm. platinum, the fluid is colored at first dark yellow, then bright brown, and finally becomes so dark brown as to be opaque. If the stannous chlorid be added carefully and in small portions so long as each addition increases the depth of color produced, it will be found that nearly three molecules of the tin salt will be re-

quired for every one of the platinic chlorid. If sufficient acid be present, the fluid remains clear, even on dilution with water. After standing twelve hours in a well closed vessel, the dark brown fluid is cautiously neutralized with ammonia, when there separates a voluminous dark brown, almost black, precipitate, leaving the supernatant fluid colorless. The reaction of the tin salt upon the platinic oxyd, Schneider gives thus:

$$(PtO_2)_2 + (SnO)_6 = Pt_2O + (Sn_2O_3)_3.$$

He views the above precipitate as a compound of the stannoso-stannic oxyd with a hypo-platinous oxyd, containing only half as much oxygen as the platinous compound. That such a stage of oxydation exists, he proves by finding that a platinum solution, reduced by sulphurous acid to the platinous condition, affords the same brown precipitate on the addition of stannous chlorid and treatment with ammonia. On drying this dark brown precipitate over sulphuric acid, it appears as a brilliant brittle mass, easily rubbed to a black-brown powder. On heating in the air, it at first loses some water, but then undergoes no alteration by heating to redness. Heated in a stream of hydrogen, water is given off, and a mixture of metallic tin and platinum is left. In composition it varies slightly, according to the strength of the solutions employed. A carefully prepared specimen afforded on analysis 29·10 Pt, 57·05 Sn, 13·85 O; the above formula, $Pt_2Sn_6O_{10}$, requires 31 per cent Pt, 56 Sn, and 13 of O, a very close approximation. Schneider suggests that this compound has an analogy with the purple of Cassius, and proposes for it the name stanno-platinous stannate. If it be treated while still moist with a very dilute sodic hydrate solution, the greater part of the stannic oxyd is taken up, and a black, pretty dense powder is left, which after repeated treatment with soda, always contains tin. A mean of several analyses gave its composition as follows: 50·0 per cent of Pt, 29·3 of Sn, 6·0 of Na, and 13·5 of O, leading to the formula $Na_2Pt_2Sn_2O_6$, a sodio-platinous stannate. From the stanno-platinous stannate as a starting point, a series of interesting compounds has been made.—*Pogg. Ann.*, cxxxvi, 105, January 27th, 1869.

G. F. B.

17. *Potassio-platinic oxysulphoplatinostannate.*—On fusing together an intimate mixture of 4 parts stanno-platinous stannate, 6 parts pure potassic carbonate, and 8 to 10 parts of sulphur in a covered crucible, and treating the cooled mass with water, the greater part dissolves, giving an intense brown solution, while there remains a cochineal-red crystalline powder, which may be obtained pure by washing with water, in which it is insoluble. Similar crystals are obtained by fusing the stannate with liver of sulphur, or by fusing together 6 parts spongy platinum, 3 parts stannic sulphid, 12 parts potassic carbonate, and 12 parts sulphur, and then extracting with water. Under the microscope the crystals are very beautiful, being six-sided tables, dark garnet-red in color, and having an almost metallic luster. Treated with hydrochloric acid, the color of the powder changes to gray, the potas-

sium being removed as chlorid; no evolution of gas takes place. Out of contact with the air, it may be heated to redness without change. On analysis it yielded: Pt 59·47, Sn 11·86, K 7·76, S 19·35, O 1·79, giving the formula $K_2Pt_3SnS_6O$. Schneider discusses pretty fully the decompositions observed, and from them concludes that the rational formula is

$$\begin{array}{ccccccc} S & - & S_2 & - & O & - & S_2 & - & S \\ | & & \| & & & & \| & & | \\ Pt'' & - & Pt^{iv} & - & K_2 & - & Sn & - & Pt \end{array}.$$

A similar compound of sodium has also been prepared. Analogous bodies of the series the author promises to describe in a future communication.—*Ibid.* G. F. B.

18. *On Potassic and Sodic Ethylates.*—When any one of the alkali metals acts upon alcohol there is formed a body called an ethylate. If sodium be the metal used, crystals are after a time formed which have hitherto been supposed to be pure sodic ethylate, but which according to Geuther and Scheitz, are really a compound of this body with alcohol. Wanklyn has re-examined this substance and finds it to be composed of one molecule of sodic ethylate and three of alcohol, $Na(C_2H_5)O, (H(C_2H_5)O)_3$. It fuses at 100° C. without decomposition, and remains colorless so long as the air is excluded, a very slight exposure to the atmosphere turning it brown. It is scarcely soluble in ether, more soluble in a mixture of acetic ether and ether. On heating this compound in an oil bath to 190° or 205° C., the alcohol is completely expelled and pure sodic ethylate is left, as was proved on analysis, all the sodium being found caustic. Absolute sodic ethylate is a perfectly white amorphous solid, non-fusible, and very light, floating on ether. It is nearly insoluble in ether and may be heated in close vessels to 275° C. without losing its whiteness. It is one of the most stable of organic compounds, suffering a temperature of 290° C. without decomposition. At dull redness, it carbonizes, evolving marsh gas and hydrogen, probably. The residue contains sodic hydrate and carbonate, with some free sodium. On treating sodic ethylate with acetic ether, an interesting isomer of sodic butyrate is produced which Wanklyn formulates thus: $(C_2H_4)Na'''O(C_2H_3O)$. Potassium gives a similar ethylate, which also forms a compound with alcohol.—*Phil. Mag.*, IV, xxxvii, 117, Feb., 1869. G. F. B.

19. *On a new radical, Ethylene-sodium, and its compounds.*—Wanklyn has subsequently more thoroughly investigated the isomer of sodic butyrate mentioned above. He is inclined to regard absolute sodic ethylate as the hydrate of a new radical which he calls ethylene-sodium. He therefore writes its formula $\left.\begin{matrix}((C_2H_4)''Na''')' \\ H\end{matrix}\right\}O$, and believes that by the action of a compound ether upon it, its hydrogen is replaced by the acid radical; so that for example, on treatment with acetic ether it gives ethylene-sodic acetate, $\left.\begin{matrix}(C_2H_4Na)' \\ (C_2H_3O)\end{matrix}\right\}O$. The radical itself has not been obtained free, owing to the many difficulties in the way. In regard to its

chemical constitution, Wanklyn prefers the formula $((\mathrm{C_2H_4})''\mathrm{Na}''')'$, claiming the trivalent nature of sodium from the two compounds sodium-zinc-ethyl and sodium tri-acetyl, and regarding it as the analogue of nitrogen and arsenic, rather than of hydrogen. Beside the acetate, the valerate and benzoate of this radical, and the acetate and valerate of the homologous radical, amylene-sodium, have been prepared by Wanklyn.—*Phil. Mag.*, IV, xxxvii, 175, March, 1869. G. F. B.

20. *On some Acetyl compounds of the Carbohydrates.*—Schützenberger and Naudin have published the results of some interesting researches upon the carbohydrates. When cellulose, either in the form of cotton-wool or Swedish filtering paper, is heated to 180° in close vessels with six to eight times its weight of acetic oxyd (anhydrid) it dissolves to a thick syrup, which, when poured into water, deposits white flocks of triacetyl cellulose, $\mathrm{C_6H_7(C_2H_3O)_3O_5}$. These flocks are insoluble in water, alcohol and ether, are soluble in concentrated acetic acid, and are re-converted into cellulose by alkaline solutions. No higher acetyl compound can be obtained, either by longer heating or by any excess of the oxyd. The authors therefore conclude that cellulose is a triatomic alcohol. They formed also mono-acetyl and di-acetyl cellulose but were not able to obtain them free from each other. Starch, when heated to 140° in presence of an excess of acetic oxyd, swells up strongly, but does not dissolve. On washing the residue with water, a white amorphous mass is obtained, which is insoluble in water, alcohol, and *acetic acid*, and is not blued by iodine. Its composition is $\mathrm{C_6H_7(C_2H_3O)_3O_5}$, and it is decomposed by alkalies, yielding the starch again. If however, the mixture be heated to 160°, the porous mass dissolves, forming an amber-colored syrup, from which water precipitates a white amorphous substance, insoluble in water, alcohol, and ether, but *soluble in acetic acid*, and isomeric with the former. When acted upon by alkalies, it is converted into dextrin; it is therefore tri-acetyl dextrin. Neither starch nor dextrin will permit the substitution of more than three acetyl atoms; these bodies also, therefore, are triatomic alcohols. Inulin affords a tri-acetyl derivative, as also does gum arabic. In the case of the sugars, acetic oxyd attacks them energetically, but to obtain saturated compounds, it is necessary to heat them with an excess of acetic oxyd for twenty-four hours, to 170° in closed vessels. The reconversion into the sugars again, cannot be effected by alkalies, since the sugars are so easily decomposed by them; but it may be readily accomplished simply by heating with water to 160°. Dextrose (grape sugar), heated in open vessels with $2\frac{1}{2}$ parts of acetic oxyd, reacted violently, and gave a solid, colorless soluble product, bitter in taste, and having the composition of di-acetyl dextrose. This, when heated with 2 parts acetic oxyd to 140°, afforded a second derivative, slightly soluble in pure water, but readily soluble in dilute acetic acid, alcohol, and ether, and having the formula $\mathrm{C_6H_9(C_2H_3O)_3O_6}$, tri-acetyl dextrose. Finally, if this compound be heated with a large excess of the oxyd, to 160° for 24 hours, a saturated compound is formed, similar to the last, but in

soluble in dilute acetic acid. If however, the fluid be poured into water, a tenacious precipitate is thrown down, which by washing in water, solution in alcohol, treatment with animal charcoal, and evaporation of the filtered solution, is obtained pure. Analysis gave it the formula $\mathrm{C_{12}H_{14}(C_2H_3O)_8O_{11}}$. Saccharose (cane sugar) affords under similar conditions, a precisely similar saturated body. Lactose (milk sugar) also dissolves when heated with acetic oxyd to 140°, and affords a sticky mass, becoming soon pulverulent, having also the composition $\mathrm{C_{12}H_{14}(C_2H_3O)_8O_{11}}$.

After giving the above facts in his Journal, FITTIG says in a note that these interesting results are in complete accordance with the view of the constitution of these bodies which he has for a long time held. All these carbohydrates are saturated derivatives from hexyl hydrid $\mathrm{C_6H_{14}}$, coming directly from a seven-acid alcohol $\mathrm{C_6H_7(OH)_7}$. This alcohol, because two of its hydryl atoms are united to one carbon atom, is not, probably, capable of existing. On attempting to prepare it, it would, just as in the case of the aldehyd-alcohols (for example, the alcohol $\mathrm{CH_3—CH\begin{cases}OH\\OH\end{cases}}$, when set free from its well known acetic ether $\mathrm{CH_3—CH\begin{cases}C_2H_3OO\\C_2H_3OO\end{cases}}$ decompose into water and its first anhydrid, $\mathrm{C_6H_7\begin{cases}O\\(OH)_5\end{cases}}$. This substance is grape sugar (dextrose). As the conversion of mannite into mannitan ($\mathrm{C_6H_8(OH)_6}$ into $\mathrm{C_6H_8\begin{cases}O\\(OH)_4\end{cases}}$) shows, the polyacid alcohols are very easily converted into anhydrids. If now the grape sugar loses still more water, two results may take place: 1st, two molecules may together lose the water, yielding

$$\mathrm{C_6H_7\begin{cases}O\\(OH)_4\\O\\C_6H_7\begin{cases}(OH)_4\\O\end{cases}\end{cases}}$$

in this case the anhydrid, which is cane sugar, milk sugar, etc.; or 2d, the molecule of water may be taken from a single molecule of dextrose, affording then the triacid alcohol $\mathrm{C_6H_7\begin{cases}O\\O\\(OH)_3\end{cases}}$; this is starch, cellulose, etc. The numerous isomers in these groups are easily accounted for; they have their cause as it would seem, partly in differences in the structure of the hexyl radical no doubt, but chiefly in the variations in the mode of grouping of the O and the OH atoms. According to this view, the formula for the saturated compound from grape sugar, i. e., $\mathrm{C_{12}H_{14}(C_2H_3O)_8O_{11}}$ is much more probable than the $\mathrm{C_6H_6(C_2H_3O)_4O_5}$ which Schützenberger admits to be possible. If this be the true formula, then it appears that grape sugar by the loss of water, is converted into the saturated ether of cane sugar, a reaction which is very interesting.—*C. R.*, lxviii, 814. *Zeitschr. Chem.*, II, v, 264, May 15, 1869. G. F. B.

21. *On the relation of Amylene to oil of Turpentine.*—BAUER and VERSON have succeeded in obtaining from rutylene bromid, by treatment with an alcoholic solution of potassic hydrate, a considerable quantity of a fluid having a boiling point between 156° and 160°, and yielding on analysis the formula $\mathrm{C_{10}H_{16}}$. They noticed that both diamylene and rutylene, but especially the former, absorb oxygen readily from the air, under precisely the same conditions as does oil of turpentine. Hence from this cause, as well as from the formation of compound ethers by the action of the alkaline solution, it was somewhat difficult to obtain a pure product. The new hydrocarbon $\mathrm{C_{10}H_{16}}$ is a clear and brilliant liquid, possessing an odor strongly recalling that of oil of turpentine, which is especially noticeable after a short exposure to the air. It burns with a bright but smoky flame. Cooled to 17° C. the first drops of bromine let fall upon it combine directly without evolution of hydrobromic acid; but a larger quantity acts violently, evolving this gas abundantly. Iodine acts similarly, but less actively. Nitric acid oxydizes it violently, and fuming sulphuric acid dissolves it with a deep brown color. Aqueous, as well as gaseous hydrochloric acid, combines directly with it even in the cold, giving after treatment, a colorless liquid boiling at about 180°, and having the composition $(\mathrm{C_{10}H_{16}})_2\mathrm{HCl}$. No direct union with water could be effected. The authors believe this hydrocarbon to be identical with terebene.—*Ber. Ak. Wien*, lviii. *Zeitschr. Chem.*, II, v, 402, July 3, 1869. *Am. Ch. Pharm.*, cli, 52. G. F. B.

22. *On the products of the oxydation of Paraffin.*—GILL and MEUSEL have succeeded in oxydizing paraffin and in studying the products. The paraffin was recrystallized from $\mathrm{CS_2}$ and then fused at 60°. Sulphuric and hydrochloric acids, even when concentrated, were without action upon it. Bromine in sunlight did not unite directly with it, but formed a substitution product. Hypochlorous acid had no effect on it. The authors place it therefore in the marsh gas series, rather than the ethylene series. Oxydation with chromic acid gave a large quantity of cerotic and acetic acids, with other members of the fatty acid series. Nitric acid gave cerotic acid, but also acetic, butyric, valeric, and œnanthic acids, in the distillate, and a mixture of succinic and anchoic acids in the retort.—*J. Chem. Soc.*, vi, 466, Nov., 1868. *Zeitschr. Chem.*, II, v, 65, Feb., 1869. G. F. B.

II. GEOLOGY.

1. *Geology of Tennessee*, by JAMES M. SAFFORD, A.M., PH.D., State Geologist, Prof. Nat. Sci. in Cumberland University, Lebanon, Tennessee. Published by authority of the General Assembly. 550 pp. 8vo, with a geological map of the State and several lithographic plates of fossils. Nashville, 1869.—In 1855, Prof. Safford published his first and only biennial Report on the Geology of the State, under the title of *A Geological Reconnoissance of the State of Tennessee.* His labors were continued during several

succeeding years, and he was prepared for a final report just before the breaking out of the recent war. He has since continued his investigations, and has, at last, issued the volume, as here announced. Prof. Safford is a faithful observer and able geologist. He has had under study a region unsurpassed for interest in the country, for its position between the north and south, and the east and west, and the great variety of its formations, especially the older, make it geologically a keystone State. Although there is much work yet to be done over the great area to give completeness to the survey, the volume is one of great importance, not merely to the State but to all interested in the geology of the continent. The author describes first the physical geography of the State, in which respect there are some remarkable features; and then passes to the geological structure and the successive formations; the minerals (including ores), and rocks, of special use; and finally the soils and agricultural features. On the question of the age of the "Orange Sands" he differs from Prof. Hilgard, who has an article on the subject on a preceding page of this volume, drawn from extensive examinations of the deposit over regions farther to the south. The plates contain figures of fifteen "new species" of fossil shells and corals, besides others described by Roemer, and several fossil leaves determined and part of them named by Lesquereux. The geological map of the State, which adds greatly to the value of this excellent report, is nearly three and a half feet long with a breadth (from north to south) of about nine inches, and is handsomely and effectively colored.

2. *Geological Survey of Ohio.*—The State Geological Corps of Ohio, Prof. J. S. Newberry, chief geologist, Prof. E. B. Andrews, Prof. Edward Orton, Hon. John H. Klippart and Mr. G. R. Gilbert, assistants, and Prof. T. G. Wormley, chemist, held a meeting on the 5th of October last for comparing and combining the results of the summer's work, and the day was occupied in this and in opening and examining the numerous packages of specimens forwarded to headquarters during the summer.

The survey was commenced on the first of June, with the following organization. Prof. J. S. Newberry, chief geologist; Prof. E. B. Andrews, Prof. Edward Orton and J. H. Klippart, Esq., assistant geologists.

In addition to these officers, appointed by the Legislature, ten additional assistants have been constantly employed on the survey during the last three months. Of these, all but two were volunteers, receiving only the payment of their traveling expenses for their services. The surveying party was divided into four detachments to whom different districts were assigned. Of these, two, operating in the northern half of the state, were under the immediate supervision of the chief geologist; another, under Prof. Andrews in the southeastern quarter, and still another under Prof. Orton in the southwestern quarter of the State.

The first duty assigned to the surveying party was to trace out the geographical extent of the different formations, so that an

accurate geological map could be made, and to gather material for settling the much debated questions of the relations of the rocks of Ohio to those of adjoining States. This part of the work is practically done. An accurate geological map, on a large scale has been made, the doubtful questions in the geology of Ohio definitely settled, and a large amount of interesting material gathered illustrative of our ancient flora and fauna, as well as of our mineral resources—coal, iron, salt, peat, gypsum, clay, water-lime, etc.

The detailed examination of the State by counties has also been begun and careful surveys of Washington and Perry counties have been made, or are in progress, by Prof. Orton, and of Cuyahoga and Erie counties by Prof. Newberry and his assistants.

The specimens already collected, filling more than fifty boxes, will form the commencement of a museum of economic and scientific geology in this city. Sets of specimens are also collected for the principal colleges in the State.

Prof. Newberry's first report will be presented to the Legislature in January next. Including, as it will, the records of the present half year's work and the result of twenty years geological study and collection in Ohio by Prof. N., it cannot fail to contain much interesting and valuable matter. For this report fifty plates are already drawn, and more than one hundred analyses of our useful minerals made at the private cost of the chief geologist. This report will also include special reports on the geology of certain counties, and of regions of peculiar importance as mining and manufacturing.—*Ohio State Journal, Oct.* 6.

The results which have already been obtained prove the connection and equivalence of the Waverly with the Vespertine of Rogers, thus showing that the Waverly is Lower Carboniferous, and settling this vexed question.

3. *Earthquake in New England.*—On the morning (about 6 o'clock) of Friday the 22nd of October last, an earthquake was felt over New England from Connecticut northeastward to Maine, and beyond over New Brunswick and Nova Scotia. It was slight at New Haven and noticed by but few. But at St. John, N. B., the shock was severe, lasted about twenty seconds, and was preceded by a rumbling noise. It is stated that houses were shaken, and many left them from alarm. At Fredericton and other places in New Brunswick, chimneys were thrown down and the walls of houses cracked. In Nova Scotia, it was felt in Halifax, Annapolis and Kentville.

4. *Synthetic Experiments relative to Meteorites;* by M. Daubrée.—Prof. Daubrée has published several papers on the origin of meteorites as illustrated by experiments for the production of the same material in its different meteoric conditions, and has embodied his views in a work of 68 pages, published at Paris in 1868.* The results are of the highest importance to geology as

* Expériences synthétiques relatives aux Météorites; rapprochements auxquels ces expériences conduisent, par M. A. Daubrée, Membre de l'Institut, Inspecteur Gen. des Mines, etc. 1868.

well as to the special department of meteorites; and we are gratified to state that a translation of it has been published in the Report of the Smithsonian Institution for 1868, recently issued.

5. *Substances Minérales*, par A. DAUBRÉE, Membre de L' Institut, Inspecteur Gen. des Mines: one of the "Rapports du Jury International," publiés sous la direction de M. Michel Chevalier. 266 pp. 8vo. Paris, 1867.—This report by the able mineralogist and geologist, A. Daubrée, treats especially of the useful mineral and rock materials that were exhibited at the Paris Exposition of 1867, taking up the subject in the following order: Combustibles; Bitumines; Ores of iron; Ores of other metals; Minerals useful in the chemical arts; Ornamental stones; other useful minerals; collections of rocks, minerals and ores. Under these heads, the materials from the different countries represented are taken up in succession, and along with the descriptions, there are also general remarks on the mines and their productions for each country and for its several mining regions, together with observations of historical, economical and geological interest. The volume is a valuable collection of facts pertaining to many of the mines and useful minerals of the world.

III. ZOOLOGY.

1. *Critical remarks on the Halcyonoid Polyps with descriptions of new species in the Museum of Yale College. No.* 4 *;* by A. E. VERRILL.—Through the kindness of Dr. Albert Kölliker we have recently received a large collection of spicula, prepared by him from authentic and original specimens in various European museums, including many of the types of species described by Esper, Lamarck, Valenciennes, Edwards and Haime, Duchassaing and Michelotti, Mobius, etc. From an examination of these and other species, I am led to make the following observations, relating mainly to genera and species alluded to by me in former articles.

LEPTOGORGIA (sens. mod.) Edwards and Haime, Corall. i, p. 163= Leptigorgia (pars), Gorgonia (pars), Rhipidogorgia (pars), Gorgonella (pars), Verrucella (pars), Pterogorgia (pars), and Lophogorgia Edw. and Haime,=Gorgonia (pars) Kölliker, Icones Hist., ii, p. 139,=Litigorgia Verrill, this Journal, xlv, p. 414, 1868, and Trans. Conn. Acad., i, p. 387, 1868.

In the work of Edwards and Haime the name, *Leptogorgia*, was applied to an incongruous group, comprising 14 nominal species, having scarcely any thing in common, except the slenderness of the branches, lack of prominent cells, and a somewhat thin cœnenchyma. As thus constituted it included representatives of at least five genera, while many species having the closest relations with the more typical species were scattered through several other genera, including even *Gorgonia*. Hence in former articles I proposed two new names for genera, part of the species of which would have been included by Edwards and Haime under *Leptogorgia*. At that time I had not examined several of the species referred by

them to *Leptogorgia*, including the first species, *L. viminalis*, which may be regarded as most typical. Having received from Dr. Kölliker spicula from the original specimen of this and several other species in the Paris Museum, I have found that *L. viminalis* of Edw. and Haime is a *Litigorgia*. The same is true of their 4th species, *L. rosea;* the 7th, *L. Webbiana;* 8th, *L. viminea;* 11th, *L. virgulata;* 13th, *L. virgea*. Their 3d and 10th species belong to our *Gorgonia: G. miniacea* (Esp. orig.) and *G. sanguinea* (Lamk. orig.). The 9th is an *Echinogorgia* (*E. aurantiaca*) and *Gorgonia Sasappo* Pallas belongs also to *Echinogorgia;* the 12th, *L. Boryana*, appears from the spicula to be a *Gorgonella*. Although it might be better, on some accounts, to dismember such a group and drop its name from the system, yet a close adherence to the laws of priority seems to require that the name should be so restricted as to include the first or typical species and congenic forms, and thus be retained in a modified sense. Adopting this view the genus, as modified, becomes equivalent to our *Litigorgia*.

As thus constituted it will include all *Gorgonidæ* having a horny axis; thin cœnenchyma, finely granulous at the surface and composed of very small warty spicula in the form of longer and shorter double-spindles, usually mingled with more or less numerous small heads and double heads; the polyp-spicula long and slender, simple, with few warts. The cells are usually arranged in lateral rows or bands, and may be either flat or more or less elevated on verrucæ.

The following species of which I have personally examined the spicula, and probably several others not yet seen by me, appear to belong to this genus.

A.—Dichotomously or arborescently branched; branches usually numerous, more or less elongated, often virgate, sometimes sub-pinnate.

a.—Cells not raised on prominent verrucæ, flat or slightly elevated.

L. viminalis E. and H. Mediterranean and Canary Isles.

L. rosea (Lam.) E. and H. Loc. (?). Perhaps a variety of the preceding.

L. Webbiana E. and H.* Canary Isles.

L. virgulata E. and H. (+*L. viminea*). North Florida to Cape Hatteras.

L. teres Verrill. "Bay of New York."

L. virgea E. and H. Antilles.

L. Floridana V., sp. nov. Florida.

L. Esperi V. (*G. violacea* Esper, *non* Pall.) V. West Indies (?).

L. festiva V. (Pterogorgia festiva Duch. and M.). Antilles. Perhaps the same as preceding.

* The spicula from the original specimens of this and the two preceding species are very much alike in size and form, and they may well prove to be mere variations of one species; similar variations in color, size and form of branches are constantly seen in *L. virgulata* from Charleston, S. C. The spicula of *L. Webbiana* and *L. rosea* agree most nearly, and both are a little stouter than those of *L. viminalis*.

L. clavata V. (Lophogorgia clavata Horn, Proc. Phil. Acad., 1860, p. 233). Locality unknown.

L. alba (Duch. and M.) Verrill. (Litigorgia lævis V., loc. cit.) Panama to San Salvador.

L. flexilis Verrill (Litigorgia V. op. cit.). Bay of Panama.

L. rigida Verrill, Bulletin M. C. Z., 1864. San Salvador to Cape St. Lucas and La Paz.

L. cuspidata Verrill, 1865. Zorritos, Peru, to Cape St. Lucas.

L. Caryi Verrill (Litigorgia fucosa V., Trans. Conn. Acad., i, p. 404, 1st ed., *non Gorgonia fucosa* Val.). Near San Francisco.

L. Peruana Verrill (Litigorgia, op. cit.). Callao.

L. Californica V. (Litigorgia, op. cit.). Lower California.

L. sarmentosa (Esper) Verrill. (? Gorgonella sarmentosa E. and H.). Mediterranean; Azores.

L. crista V. (Lophogorgia crista Mob.). Africa.

b.—Cells at the summit of distinct verrucæ.

L. pumicea Verrill (Gorgonia pumicea Val., E. and H.). Brazil; Rio Janeiro (U. S. Expl. Exp.).

L. miniata V. (Gorgonia miniata Val., E. and H.). Antilles.

L. ramulus V. (Gorgonia ramulus Val., E. and H.). Zorritos, Peru, to Acapulco.

L. pumila V. (Litigorgia pumila V., op. cit.). Zorritos.

L. diffusa V. (Litigorgia diffusa V., op. cit.). Panama Bay and Corinto, Nic.

L. hebes V. sp. nov. Key West, Florida.

L. radula V. (Gorgonia radula Mob.).

B.—Branches pinnate, bipinnate or tripinnate, spreading usually in a single plane.

a.—Cells scarcely raised on distinct verrucæ.

L. pinnata V. (G. pinnata Linn., ed. x). Gaboon, West Africa.

L. flammea (Ellis) V. (Lophogorgia palma E. and H., *non* G. palma Pallas). Cape of Good Hope.

b.—Cells on prominent verrucæ.

L. Floræ V. (Litigorgia Floræ V., op. cit.). Pearl Islands, Bay of Panama.

L. violacea (Pallas) V. (Pterogorgia petechizans E. and H. (?) *non* Pallas). West Coast of Africa at Sombrero I. (?).

L. sanguinolenta V. (Gorgonia sanguinolenta Pallas; V., Bull. M. C. Z., *non.* Esper; G. petechizans (pars) auct.). West Indies.

C.—Branches wholly or in greater part reticulated, flabelliform.

a.—Cells not raised on prominent verrucæ.

L. stenobrachis Verrill (Rhipidogorgia stenobrachis Val., E. and H.). Zorritos, Peru, to Gulf of California.

L. cribrum V. (Rhipidogorgia cribrum Val., E. and H.). New Zealand.

b.—Cells raised on distinct verrucæ.

L. Agassizii V. (Litigorgia Agassizii V., Tr. Conn. Acad. i, p. 388, 1st ed.). Acapulco to Cape St. Lucas.

L. Adamsii V. (Litigorgia Adamsii V., op. cit.). Zorritos, Peru, to Acapulco.

L. eximia V. (Litigorgia eximia V., op. cit.). Bay of Panama.
L. media V. (Litigorgia media V., op. cit.). San Salvador to Cape St. Lucas.
L. arenata V. (Rhipidogorgia arenata Val., Edw. and H.). New Zealand.

The following species, which Dr. Kölliker refers to his first section of the genus *Gorgonia*, probably belong to *Leptogorgia*, as modified, but I have not examined them.

G. umbella Esp. (Rhipidogorgia E. and H.).
G. venusta Dana (Rhipidogorgia E. and H.).
G. ventalina Linn. (Rhipidogorgia E. and H.).
G. cauliculus K. (Gorgonella Val., Leptogorgia E. and H.).
G. sanguinolenta Esp. (*non* Pallas); Köll., Icones, taf. xviii, fig. 239, (? G. petechizans Pallas).

Two species described by Duchassaing and Michelotti, *L. flavida* and *Gorgonia oblita*, are probably additional species.

Leptogorgia hebes Verrill, sp. nov.

Corallum branching in one plane, subdichotmous. The main trunk is rather stout, upright, giving off rather stout branches from each side subpinnately, at distances of ·25 to ·40 of an inch; the larger branches are somewhat rigid, tapering, dichotomously or subpinnately divided, mostly secund. The terminal branchlets are from one to four inches long, ascending, somewhat rigid. Cells small, arranged in lateral bands, apparently slightly raised, but the specimen is too much rubbed to show clearly the character of the surface. Axis black in the trunk and main branches, dark amber-color and translucent in the small branches, rigid and tapering to the tips. Cœnenchyma bright deep red. Height 6 inches; breadth 5; diameter of axis of trunk ·10; of larger branches ·06 of an inch. Spicula bright red, remarkably short and stout; the longer double-spindles are stout, oblong-oval, blunt, usually with two whorls of large warts on each half, the smaller whorl nearly terminal; stouter spicula scarcely shorter, much thicker, broad oval, each end usually having two close whorls and a terminal cluster of large rough warts. The longer double-spindles measure ·108^{mm} by ·048^{mm}, ·108 by ·036, ·092 by ·048, ·084 by ·040; the stouter ones ·108 by ·060, ·096 by ·060, ·090 by ·048.

Key West, Florida,—Maj. E. B. Hunt. This is very distinct from all other Atlantic species known to me, by the very stout, obtuse spicula.

Leptogorgia pumicea Verrill (*Gorgonia pumicea* Val., Edw. and Haime).

Corallum much branched, the branches slender, irregularly subpinnate; terminal branchlets very slender, ·5 to 1 inch long, scarcely tapering. Verrucæ prominent, rather large, rounded, perforated at summit by the small oval or oblong cell, arranged alternately in two rows on each side of the branches, giving them a somewhat quadrangular appearance. Color deep purplish red. Height 6 or 8 inches; diameter of branches ·06 to ·08; of branchlets ·05; of verrucæ ·03.

Spicula deep red; the longer double-spindles acute at the ends, with about three whorls of crowded warts on each half; stouter ones shorter and thicker, obtuse, usually with two crowded whorls and a terminal cluster of warts on each half. The longer double-spindles measure ·120^{mm} by ·048, ·120 by ·042, ·108 by ·036, ·096 by ·042, ·096 by ·030; the stouter ones ·084 by ·048, ·078 by ·042, ·072 by ·035.

Rio Janeiro,—U. S. Exploring Expedition.

Leptogorgia Floridana V., sp. nov., (L. purpurea Verrill, Bulletin M. C. Z., p. 31, 1864, *non* Pallas).

Corallum dichotomous, dividing chiefly near the base, the larger branches usually dividing only two or three times, at distances of one or two inches. Branchlets slender, virgate, 6 to 12 inches long, round, slightly tapering, ascending and subparallel, cells scattered over the whole surface, except on a narrow median space, rather large, oblong-oval, usually flat, but often raised on low verrucæ, especially on the large branches. Axis blackish in the main branches, horn-yellow, translucent, slender and flexible in the branchlets. Color generally brick-red, or dull dark red, sometimes purplish. Height 15 inches; breadth 5; diameter of larger branches ·10 to ·12 of an inch; of branchlets in middle ·08 to ·10; of their axis ·02 to ·03. Spicula deep red and yellowish red; longer double-spindles slender, acute, with three or four well separated whorls of small, not very close warts; stouter ones shorter, broader, and less acute, with fewer and more crowded whorls of warts; many small, slender spicula have but one or two distant whorls of warts on each half. The longer double-spindles measure ·132^{mm} by ·048, ·132 by ·036, ·120 by ·048, ·120 by ·042, ·120 by ·036, ·108 by ·048, ·096 by ·042; the stouter ones ·096 by ·048, ·090 by ·048, ·079 by ·042, ·079 by ·036; the small ones ·060 by ·030, ·054 by ·030, ·054 by ·024.

Florida Reefs.—G. Wurdemann.

This species externally somewhat resembles *L. virgulata* of the Carolina coasts, but has longer, more terete, and more regular branches. The spicula of the latter are very different, being much larger and longer (the double-spindles from ·144^{mm} by ·030, to ·192 by ·048), and relatively more slender, with five or six whorls of warts on each half. The authentic spicula of *L. virgea* differ widely from those of this species, being much more slender and more distantly warted.

Leptogorgia clavata Verrill (Lophogorgia clavata Horn).

This species is quite distinct from any other known to me. It is peculiar in having short, clavate branchlets. Its color is yellowish red, or light minium-red. The spicula are also quite characteristic. They are light red, mostly stout and rather blunt. The longer double-spindles are usually acute at the ends, with a wide median space, each end with two very unequal whorls of large, well separated warts; the stouter ones are more abundant, short and thick, with blunt or obtuse ends, each half having a whorl of large rough warts and a much smaller whorl at the end blend-

ing with the small terminal cluster; closely warted heads and double-heads also occur; the polyp-spicula are very long and mostly remarkably slender.

The longer double-spindles measure ·108^{mm} by ·036, ·092 by ·042, ·084 by ·036, ·079 by ·036; the stouter ones ·084 by ·048, ·079 by ·042, ·072 by ·042, ·072 by ·054; double-heads ·054 by ·042, ·042 by ·042, ·030 by ·030; polyp-spicula ·192 by ·036, ·168 by ·012, ·132 by ·024, ·132 by ·018, ·120 by ·012.

Locality unknown. (Coll. Phil. Academy.)

Eugorgia aurantiaca V. (E. Mexicana V., this Journal, xlv, p. 415, 1868; Trans. Conn. Acad, i, p. 410. = Lophogorgia aurantiaca Horn, 1860, = Gorgonia bicolor Val. MS., Paris Mus.).

The *Leptogorgia aurantiaca* of Edw. and Haime proves to be an *Echinogorgia*, therefore there is no longer any reason why the present species should not take the same specific name, which appears to be the earliest one published.

We have recently received numerous large and beautiful specimens from the Gulf of California, from J. Pedersen.

Gorgonia Linn. (sens. mod.). = Gorgonia (pars) and Pterogorgia (pars) Ehr.; Pterogorgia (pars) Dana; Leptogorgia (pars), Rhipidogorgia (pars), Pterogorgia (pars), Xiphigorgia, Phyllogorgia, and Hymenogorgia Edw. and Haime.

It has become necessary to restrict this genus to those species having small double-spindles, mingled with small bracket-shaped or crescent-shaped spicula, corresponding to Dr. Kölliker's second section of *Gorgonia*, as suggested by me in a former article (Trans. Conn. Acad., i, p. 386, 1868).

As thus limited the species known to me may be arranged thus:

A.—Flabelliform, branches reticulated and coalescent, with open meshes, (Rhipidogorgia).

G. flabellum Linn. Bermudas; Florida; West Indies.

G. occatoria (Val.) V. Guadaloupe.

B.—Plumose or panicled; the branches regularly pinnate, usually long and slender, with the cells in rows along the sides, (typical Pterogorgia).

G. acerosa Pallas. (*G. setosa* Linn., Ed. xii). Bermudas; Florida; West Indies.

G. turgida (Ehr.) V. Florida; Burmudas; West Indies.

G. Americana Gm. (P. Ellisiana E. and H.). Florida; West Indies.

G. Sloanei (?) (E. and H.) V. West Indies.

G. setosa (? Linn. pars, *non* Esper). West Indies.

C.—Flabelliform; the branches bipinnate, sparingly coalescent, flattened.

G. bipinnata V. (Pterogorgia bipinnata V., Bulletin M. C. Z., p. 37, 1864). Cumana, Ven.

D.—Dichotomous, with elongated, slender branches.

G. miniacea Esper. (Leptogorgia miniacea E. and H.

G. tenella V. (= Gorgonia ceratophyta Esper, tab. xix, *non* Linn. *nec* Pallas). Perhaps young.

G. gracilis V. (Pterogorgia, Trans. Conn. Acad., vol. i, p. 359 1868). Abrolhos Reefs, Brazil.

G. sanguinea Lam. (Leptogorgia sanguinea (pars) E. and H.). Locality unknown.

E.—Dichotomous, often fasciculate; the branches ascending; with the cœnenchyma developed laterally into marginal wings, thus producmg flat or triquetral branches, with the cells in rows along the edges, (Xiphigorgia).

G. anceps Pallas. Florida; West Indies.

G. Guadalupensis (Duch. and Mich.) V. Guadaloupe.

G. citrina Esper. Florïda; Bahamas; St. Thomas.

G. pumila V. (=X. Americana D. and M., Supl., p. 113, Tab., 2, fig. 6, *non* G. Americana Gmel.). Perhaps a variety of the preceding. Antilles.

F.—Foliaceous, the branches slender, not reticulated, but the cœnenchyma laterally developed into broad, frond-like forms, (Hymenogorgia).

G. quercifolia Ehr. West Indies; Guadaloupe, etc.

G.—Flabelliform and foliaceous, the branches reticulated and coalescent, but the meshes closed by the lateral development of the cœnenchyma, (Phyllogorgia).

G. dilatata Esper. Bahia, Brazil.

G. foliata (Val.) V. Guadaloupe.

Several other described species of Gorgonidæ, which I have not seen, appear to belong to this genus, judging from external characters.

Eunicella Verrill, gen. nov.

Gorgonia (pars) Pallas and subsequent authors, (*non* Linn. Syst. Nat., ed. x); Eunicea (pars) Ehrenberg; Gorgonia (pars) Dana; Gorgonia (pars) Edw. and Haime; Kölliker.

Cœnenchyma thin or moderately thick, composed chiefly of small warty double-spindles, but having a distinct external layer of very small, peculiar, club-shaped spicula perpendicular to the surface, which often have one or two whorls of fine spinules toward the larger end. Cells scattered, either raised on prominent verrucæ or perfectly flat. Longitudinal ducts nearly equal, in a circle around the axis. Color, usually white. (Type *Gorgonia verrucosa* Pallas).

In the work of Edwards and Haime the name, *Gorgonia*, is applied to a group of 14 nominal species, of which 5 belong to this genus. Their 1st species is *Muricea vatricosa* Köll.; the 2nd appears to include a *Muricea* and an *Echinogorgia;* the 6th is *Thesea* or *Swiftia exserta;* the 7th, 8th and 9th are *Leptogorgiæ;* while the 10th and 11th also, do not belong to this genus. One of the principal characters of their genus (prominent cells) excludes several true species of *Eunicella.* Moreover the genus appears to belong properly in the *Plexauridæ*, and to be closely allied to *Eunicea* and *Plexaura* in structure. The forms of the spicula are the principal characters for distinguishing it from *Eunicea*, for certain species (*G. palma, G. papillosa*) often have a thicker cœnenchyma than some species of *Eunicea.* It must, consequently, be excluded from the family, *Gorgonidæ*, as now restricted.

Ehrenberg united this group with *Eunicea*, and restricted *Gorgonia* to a group having *G. flabellum* as its type.

Finally, no species of this genus was known to Linné when he first established the genus, *Gorgonia* (Syst. Nat., ed. x), in which

he included *G. flabellum* and other well known species of the same group.

For these reasons I have been led to apply a new and distinctive name to this well-marked genus, and to restrict *Gorgonia* to those species allied to *G. flabellum*, in accordance with a suggestion made by me in a former work,* which, indeed, seems to be the only alternative, if we adopt the generally accepted laws of priority.

As thus defined this genus corresponds with Dr. Kölliker's third section of *Gorgonia*.

The species which I have personally examined are as follows:

A.—More or less flabelliform, much branched; cells prominent,

Eunicella verrucosa (Pallas) V. Mediterranean.
E. venosa (Val.; E. and H.) V. Algeria; Madeira.
E. subtilis (Val.; E. and H.) V. Algeria.
E. tenuis V. (sp. nov.). West Indies. (?)

B.—Branches dichotomous, elongated, slender; cells prominent or flat.

E. graminea (Lam.) V. Mediterranean; Naples.
E. Bertolonii (Lamx.) V. Mediterranean.
E. crinita (Val.) V. Archipelago Bizagos, Africa.

C.—Low, fructicose, branches short and stout; cells prominent.

E. papillosa (Esper) V. Cape of Good Hope.

D.—Palmate, branches flattened, elongated; cells scarcely prominent.

E. palma V.† (G. palma Pallas; G. albicans Köll.). Cape of Good Hope.

Eunicella tenuis, sp. nov.

Somewhat flabelliform, a foot or more high, densely branched, the ultimate branches subpinnate, giving rise to short alternating branchlets, about ·25 of an inch apart. These are about ·3 to ·6 of an inch long, and ·05 in diameter, exclusive of the verrucæ, with the tips dilated and bilobed. The verrucæ are small, but prominent, conical, on the branchlets unequal, alternating on the opposite sides, about their own diameters apart; height of the largest about ·05, diameter ·03 or ·04. Color white. The larger double-spindles are slender, acute, with a wide median space, each half covered with rather distant, small, conical warts, those nearer the center larger and in whorls, the rest scattered, decreasing in size to the ends; clubs very small, short, rather broad, the large end flattened, often winged or triquetral, triuncate or slightly rounded, usually with two or three slight teeth or serrations on each edge, but these are often wanting, the small end surrounded by a close whorl of very small, rough warts, and terminated by one to three small points or papillæ. The longer double spindles measure ·196^{mm} by ·048, ·196 by ·036, ·184 by ·048, ·184 by ·036, ·172 by ·048, ·172 by ·036; the clubs ·072 by ·036, ·072 by ·030, ·066 by ·036, ·060 by ·042, ·060 by ·036.

West Indies (?). (Mus. Yale College and Phil. Acad.).

The spicula of this species do not approach very nearly those of

* Trans. Conn. Acad., i, p. 386, April, 1868.

† Pallas' description applies to this species, and not to *Leptogorgia flammea*.

any other, except *E. subtilis*, which, however, has considerably smaller and more warty spindles.

If the locality be correct, it is remarkable as the only American species of a genus very common on the opposite coasts of the Atlantic.

Psammogorgia fucosa V. (Gorgonia fucosa Val., Voy. de la Venus, Pl. 15 bis, 1846; Plexaura fucosa, Edw. and Haime, Corall., p. 154, *non* Verrill). The spicula from the original example of this species show that it is very distinct from the species that I have hitherto referred to it (*Leptogorgia Caryi*). It appears, judging from the spicula, to be a *Psammogorgia*, allied to *P. teres*, but quite distinct. The figure represents it as 10 inches high and 9 broad, with the branches about ·15 of an inch thick, enlarged at the axils. Several stems arise from one base, as is usual in *P. arbuscula*, the largest trunk being half an inch in diameter. The branches are irregularly dichotomous, the divisions being ·5 to 2 inches apart; the final branchlets are stout, scarcely tapering, obtuse or clavate at the ends, often crooked, ·5 to 1 inch long, ·12 to ·18 of an inch in diameter. Cells small, oblong or oval, flat on the branches, slightly raised on the branchlets. Color dull reddish.

It is remarkable for the great diversity in form and color of the spicula. These are white, yellowish, light red, deep red, and amethystine intermingled. They are mostly stout, blunt, and covered with large rough warts. Among them are various forms of spindles, double-spindles, double-heads, heads, and stout warty clubs, with various irregular forms. The stout double-spindles, which are most numerous, are short and thick, mostly with obtusely rounded ends, sometimes acute, median naked space narrow, bordered by whorls of large, coarse, rough warts, beyond which there are usually one or two whorls of smaller warts and a terminal cluster, but in many cases there are none between the median whorls and the terminal cluster, in other cases the whorls become crowded and thus the forms pass into large, stout "double-heads," in which the ends are rounded and densely covered with rough warts.

Numerous spicula lack the naked median space and are densely covered with large rough warts, some of these are short and rounded, in the form of heads; others are longer, tapering at both ends, and have the form of very stout spindles; others are large at one end, with the other tapering, or club-shaped. The polyp spicula are long, slender spindles, tapering quite regularly to both ends and covered with small warts. The large double-spindles measure ·156^{mm} by ·072, ·156 by ·066, ·150 by ·072, ·144 by ·084, ·144 by ·060; the smaller ones ·120 by ·060, ·108 by ·060, ·072 by ·048; double-heads ·132 by ·096, ·132 by ·090, ·096 by ·084; the heads ·108 by ·084, ·048 by ·048; the stout spindles ·156 by ·072, ·144 by ·072, ·120 by ·072; the clubs ·144 by ·084, ·144 by ·072, ·096 by ·048; the polyp-spicula ·156 by ·030, ·156 by ·024, ·144 by ·024, ·102 by ·024.

Mazatlan,—Voyage of the Venus.

Echinogorgia aurantiaca Verrill (=Plexaura aurantiaca Val.; Leptogorgia aurantiaca E. and H., Corall. i, p. 165).

The spicula of this species show that it is an *Echinogorgia*, pretty nearly allied to *E. sasappo*. The spicula are yellow, mostly large, broad, flattened clubs, or scale-clubs, the smaller end often acute, sometimes blunt, covered with rough warts, the large end usually terminating in one or more broad, flat, irregular, rounded scales, which are often lobed, or even subdivided into sharp, lacerate spinules. With these are many more or less regular four-branched crosses, with rather slender, acute, warty branches; and various forms of irregular, often branched, warty spindles, and compound spicula.

The clubs and scale-clubs resemble those of *E. sasappo* figured by Dr. Kölliker in his Icones Histiologicæ, Taf. xviii, figs. $9_{,1}$ and $9_{,3}$. The scale-clubs measure ·290^{mm} by ·216^{mm}, ·288 by ·204, ·288 by ·156, ·264 by ·192, ·260 by ·168, ·240 by ·156, ·216 by ·156, ·192 by ·132, ·192 by ·084, ·180 by ·084; the crosses ·240 by ·192, ·180 by ·156, ·144 by ·120, ·120 by ·096; the irregular spindles ·336 by ·072, ·288 by ·084, ·252 by ·084.

Callao, Peru. Mus. Paris.

Thesea gemmata, sp. nov.

Corallum flabelliform, much branched; branches long, slender, seldom coalescent. The trunk is roundish, moderately stout, upright, giving off from each side at distances of ·5 to ·75 of an inch numerous very long, flexible, spreading branches, which in turn give rise to numerous secondary branches and branchlets arranged subpinnately, at distances of about half an inch. The terminal branchlets are from two to five inches long, very slender, flexible, covered with a thin cœnenchyma, and bearing large, prominent verrucæ, arranged alternately on opposite sides, at distances of about ·20 to ·25 of an inch; two verrucæ are usually terminal, producing a broad flattened tip, as in many other Gorgonians. The verrucæ are swollen at the base, the edge divided into eight triangular lobes at summit, surmounted by a subconical mass of spicula belonging to the basal portion of the contracted tentacles, which seem to have been incapable of retraction within the cells. Cœnenchyma thin and friable, and like the verrucæ composed mostly of rather slender spindle-shaped spicula, with a superficial layer of very small spicula, giving the surface a granulous appearance under a lens. Axis nearly smooth, with numerous very fine striations, black in the trunk and larger branches, brownish and setiform in the branchlets. Cœnenchyma and verrucæ white.

Height 17 inches; breadth 12; diameter of trunk ·18; of larger branches ·10 to ·12; of branchlets ·03 to ·04; of verrucæ at base ·07 to ·08; at summit ·05 of an inch. The cœnenchyma is chiefly composed of long, slender, rather acute spindles, with small, distant, conical spinules; the superficial layer is composed of small, short, warty double-spindles, double-heads, heads, and oblong spicula with two whorls of conical warts toward the center. The

double-spindles are obtuse and usually bear one whorl and a large terminal cluster of rough warts on each end. The spicula of the tentacles are long, mostly curved or crooked, distantly warted spindles, which are generally shorter and thicker than those of the cœnenchyma, and bear smaller and more distant spindles.

The larger spindles of the cœnenchyma measure ·984^{mm} by ·096^{mm}, ·840 by ·096, ·720 by ·108, ·720 by ·060, ·696 by ·096, ·696 by ·060, ·684 by ·108, ·672 by ·072, ·648 by ·066, ·600 by ·072; the small double-heads and double-spindles of the surface ·108 by ·048, ·090 by ·048, ·084 by ·048, ·072 by ·042; the small oblong spicula ·108 by ·048, ·096 by ·048, ·092 by ·042, ·090 by ·036; the heads ·098 by ·060. The larger spinules from the tentacles ·840 by ·096, ·720 by ·084, ·660 by ·108, ·624 by ·108, ·624 by ·096, ·540 by ·108, ·540 by ·048, ·516 by ·096, ·408 by ·096.

St. Croix, West Indies,—J. Alexander Moore. The specimen was obtained in deep water by a fisherman. Attached to it was a fine *Astrophyton cæcilia* Lutk.

This species resembles in external characters *Gorgonia exserta*, as figured by Ellis and Solander, which Duch. and Michelotti refer to their *Swiftia exserta*, but it has more prominent verrucæ. Its spicula are very different from those of *Thesea Guadalupensis* D. and M., and *Swiftia exserta*. The "*Gorgonia Richardii*" D. and M., Corall. Antilles, Tab. iv, fig. 1 (*non* Lamouroux), bears some resemblance to it in external appearance, but has stouter branches and more cylindrical verrucæ. The latter may, quite probably, be an allied species of *Thesea*.

2. *Note on Hyponome Sarsii, a recent Cystidean; by S. Lovén.** —The general appearance of this very remarkable Echinoderm is that of a small starfish or a Euryalid. It has a disk, convex on the ventral surface, flattened on the dorsal, and five short and broad rays; each of these is divided into two short dichotomous branches, terminating in four very short rounded lobes. As in the recent genera, *Antedon* and *Pentacrinus*, a large, conical, proboscis-like funnel rises in one of the interradial spaces of the ventral surface of the disk; and from a point situated a little before the center of the same surface five narrow channels, protected by marginal scales, radiate and, bifurcating thrice, run out on the rays and their branches, giving off short branchlets to certain sacculate protuberances placed at regular distances. No pinnulæ. On the protuberances and on the rays the channels are open; but upon the disk, between their first bifurcation and their common starting-point, their marginal scales close over them, forming a vault, so that the five channels are converted into covered ducts, converging into a common subcentral aperture, concealed beneath the integument, and not visible from the outside. In the covered parts of the channels I found masses, consisting of microscopic Crustacea, larval bivalves, and other remains of the food of the

* We are indebted to the Author for the communication of this translation from "Forhandlinger ved de Skandinaviske Naturforskeres tiende Möde, i Christiania," July, 1868.

animal, apparently taken through the ends and open parts of the channels, and on its way, through their covered parts, to the concealed mouth. On the rays, near their tips, are seen some few pores, perhaps indicating the existence of retractile organs. The ventral surface is clothed with rather small, thick-set, irregular whitish scales, among which, in certain places, some six or seven larger ones are seen forming a rosette. Between the rays and their bifurcations this scaly covering of the ventral surface extends back on to the dorsal surface, ending there with great regularity in triangular spaces pointing to the center of the disk. The remainder of the dorsal surface of the disk and the rays, which, by this arrangement, assumes the form of a regular star with five broad dichotomous rays, is clothed with a soft and smooth brownish skin. There is no trace of a calyx. In the center of the even dorsal face of the disk is seen a somewhat pentagonal space studded with minute pores.

To have the channels on the disk converted into tunnel-like passages leading to a mouth concealed beneath the integument is a peculiarity hitherto not observed in any recent Crinoid; but it is, as shown by Professor Huxley and Mr. Billings, a characteristic of the palæozoic Crinoids and Cystideans. The absence of any indication of a calyx at once excludes *Hyponome* from the former. Among the Cystideans it recalls the genus *Agelacrinites*, of Vanuxem, by the depressed form of the body, the scaly covering, and the flatness of the dorsal surface, devoid of anything like a stem or peduncle, and also by the absence of pectinated rhombs and of pinnulæ. Branchlets running from the channels to saccular protuberances are found also in the genus *Glyptocystites* of Billings and *Glyptosphœrites* of Johannes Müller; and bifurcations of the channels are met with in *Sphœrocystites* and *Callocystites* of Hall. Lastly, the genus *Hyponome* shares with the surviving type of the Crinoidea the radiated form of the body and the simply conical unprotected funnel.

The specimen described is from Cape York, Torres Strait.—*Annals and Magazine of Nat. Hist.*, Sept., 1869.

3. *New Localities of Artemia;* by A. E. Verrill.—At the late meeting of the American Association at Salem, Prof. Agassiz stated that he had observed an *Artemia* (probably *A. gracilis* V.) several years ago in the salines on Cape Cod. During the meeting Dr G. H. Perkins found a fine colony of *A. gracilis* in a tub of sea-water on the bridge of the Eastern R. R. across Charles River at Charlestown, near Boston. I have recently received specimens with Dipterous larvæ from Great Salt Lake, through S. A. Briggs, Esq., and others from Prof. D. C. Eaton collected by Mr. Sereno Watson. They belong to a new species, more nearly allied to *A. gracilis* than to *A. Monica.* The males have larger and more acute claspers than even in *A. gracilis;* the second joint is broader and very strongly angled outwardly, and between the angle and the point the outline is decidedly concave. I propose to call it *Artemia fertilis.*

4. *Additamenta ad historiam Ophiuridarum*, Part III; by Chr. Fr. Lutken, (Vidensk. Selsk. Skr., 5 Række, naturvid. og mathematisk Afd. 8 B. II, 4to, 109 pp. Copenhagen, 1869).—This important work contains ten critical and descriptive essays on various genera and species of Ophiurians, including many new forms. These are followed by a synopsis of all the genera of true Ophiurians, with Latin and Danish descriptions of each, and a tabular view of the classification adopted; by Latin diagnoses of the new genera and species; and by a résumé, in French, of the whole work. The tenth essay contains a critical review of the various genera of fossil Ophiurians hitherto described.

The new genera are as follows: Ophionephthys (type, *O. limicola* nov., St. Thomas); Ophionema (type, *O. intricata* nov., St. Thomas); Ophioconis (type, *Pectinura Forbesii* Heller); Ophiopsammus (type, *Ophiopeza Yoldii* Lutk.); Ophiochæta (type, *O. setosa* nov., Feejees); Asteromorpha (type, *A. Steenstrupii* nov., loc. unknown), a very interesting new genus, allied to *Astrophyton*, etc., with undivided arms; Ophiarachna is restricted to *O. incrassata* and similar species, while the other species are separated as a very distinct genus, to which the name, Pectinura Forbes (*non* Heller), is restricted.* The following new species are also described: *Amphipholis fissa*, Amour; *Ophiarachna affinis*, Feejee Is.; *Ophiomastix mixta*, Samoa and Feejee Is.; *O. asperula*, Feejees; *O. caryophyllata*, Feejees; *Ophiomyxa australis*, Straits of Bassiano; *Ophiocoma canaliculata*, with the last; *Ophiacantha Pentacrinus*, Antilles, adhering to *Pentacrinus*; *Ophiothrix elegans*, China Sea; *O. trilineata*, Samoa Is.; *O. Capensis*, Cape, on Gorgoniæ. *Ophiactis clavigera* Ljung. is referred to *Ophiacantha* and identified with *Asterias tricolor* Abjd. (Zoolog. Danica, t. 97), and it is suggested that "*Ophiocoma granulata*," found by Wallich at the depth of 1,260 fathoms, may be the same species. The West Indian species, hitherto referred to *Ophiothrix violacea*, is separated as a new species, *O. Caribæa* Lutk. Two species of this genus, *O. echinata* M. & Tr. and *O. quinquemaculata* (d. Ch.) are described from the Mediterranean. *Astrophyton Agassizii* Stimp. is reported from Greenland and Finmark, though not before known north of the Gulf of St. Lawrence. The classification adopted is based chiefly upon the structure of the parts of the mouth. A. E. V.

5. *Synopsis of the Polyps and Corals of the North Pacific Exploring Expedition, under Commodore C. Ringgold and Capt. John Rodgers, U. S. N., from* 1853 *to* 1856. *Collected by Dr. Wm. Stimpson, Naturalist to the Expedition;* by A. E. Verrill. Part IV, Actinaria, with three plates. (From the Proceedings of the Essex Institute, vols. v and vi, 8vo. Salem, Mass., March to October, 1869.)—This final part includes descriptions of the Actinians obtained by the expedition, and also a supplement con-

* The species recently described by me under the name, *O. maculata*, (Proc. Bost. Soc. Nat. Hist., xii, p. 388) belongs to the latter group, and should be called *Pectinura maculata*.

taining corrections and additions to the previous parts, together with geographical lists of all the species. The following new genera and species are described: *Halocampa Stimpsonii*, Cape of Good Hope; *Actinia? timida*, Hong Kong; PARANTHEA (type *P. minuta*, Bonin Is.); *P. armata*, Hong Kong; *Phellia inequalis*, Bonin Is.; *Phellia arctica*, Arctic Ocean; *Cereus Stimpsonii*, Cape of Good Hope; *Cereus Sinensis*, Hong Kong; *Sagartia? Paguri*, China Sea; *Sagartia lineata*, Hong Kong; *Bunodes Japonica*, Island of Jesso; PHYSACTIS (type, *P. multicolor* Stimp. sp., Hong Kong); *Anthopleura Stimpsonii*, Hong Kong; AMPHIACTIS (type, *A. orientalis* nov., Bonin Is.); *Discostoma fungiforme*, Bonin Is.; HOMACTIS (type, *H. rupicola* nov., Hong Kong); STEPHANACTIS (type, *S. Indica* nov., Gaspar Straits).—In the Supplement: EUPLEXAURA (type, *E. Capensis* nov., Cape of Good Hope); *Madrepora microphthalma*, Loo Choo Is.; *Montipora lichenoides*, Loo Choo Is.; *M. exesa*, Gaspar Straits; *M. patula*, Hawaiian Is.; *Turbinaria dichotoma*, unknown; *Pocillipora gracilis*, Loo Choo Is.; *P. Danæ*, Feejees; *P. aspera; P. nobilis;* and *P. frondosa*, Hawaiian Islands. In addition to these many other species previously known only by imperfect or very brief descriptions are described at length, and many changes have been made in their nomenclature.

6. *Review of the Corals and Polyps of the West Coast of America;* by A. E. VERRILL. (From the Transactions of the Connecticut Academy, Vol. I, New Haven; February and March, 1869).—The signatures containing the Order, Actinaria, were published and partially distributed during February and March, 1869. Owing to the late fire by which the entire edition of the incomplete volumes of the Transactions was destroyed, with the exception of author's copies previously distributed, the publication of the balance of this memoir will be considerably delayed. On the west coast the three suborders of ACTINARIA (*Actinacea*, *Zoanthacea* and *Antipathacea*) are represented. In the sub-family, Phyllactinæ, we have described *Oulactis concinnata; Lophacti ornata* (gen. et sp. nov.); *Asteractis Bradleyi* (gen. et sp. nov.). Of the family Actinidæ, we find in the sub-family, Bunodinæ, *Bunodes cruentata* Gosse; *P. papillosa* V. (Lesson); *B. pluvia* V. (Drayton); *B. ocellata* V. (Lesson); *Urticina crassicornis* Ehr.; *Evactis artemisia* V. (gen. nov., type, *Actinia artemisia* Drayton); *E.* (?) *xanthogrammica; Cladactis grandis* V. (gen. et sp. nov.); *Cystiactis Eydouxi; Anthopleura Dowii* nov.; *Phymactis clematis; P. florida*:—in the sub-family, Sagartinæ, are *Metridium fimbriatum* V.; *M. reticulatum; Actinia* (?) *Mertensii* Brandt; *Cereus Fuegiensis* V. (Couthouy); *Calliactis variegata* (gen. et sp. nov., type of genus, *C. decorata* Drayton sp.); *Sagartia impatiens* Gosse; *S. lineolata* V. (Drayton); *S. crispata* nov.; *S. carcinophila* nov.; *S. Panamensis* nov.; *S. Bradleyi* nov.; *S. nivea* V. (=*Actinia nivea* Lesson, *non S. nivea* Gosse=*S. Gossei* V.) *S. Lessonii* V. (=*Actinia bicolor* Lesson, *non* Lesueur); *S.* (?) *Peruviana* V. (Lesson); *S.* (?) *nymphæa* V. (Drayton);

S. (*?*) *rubus* V. (Drayton); *Nemactis primula* E. and H.; *N. Draytonii* E. and H.; *N.* (*?*) *Chilensis* V. (Lesson);—in the sub-family, Phellinæ, *Phellia inornata* nov.; *P.* (*?*) *rubens* nov.; *P. Panamensis* nov.; *P. arctica* V.;—in the sub-family, Actininæ, *Paractis* (*?*) *nobilis* nov.; *Epiactis prolifera* V. (gen. et sp. nov.) Puget Sound; *Anactis picta* Ehr. (Lesson). The suborder, ZOANTHACEA, is represented by *Mammillifera Danæ* V. (LeConte); *M. nitida* nov.; *M. conferta* nov.; *Gemmaria elongata* nov.; *G. humilis* nov.; *G. crassa* nov., (the name, *Gemmaria* having been first employed for a genus of Acalephs by McCready, *Epizoanthus* Gray (emended) should be substituted for it). The ANTIPATHACEA are represented as yet only by *Antipathes Panamensis* nov. *Montipora fragosa* (sp. nov.) from "California" is also described.

All the new species of Actinians, except *Epiactis prolifera*, are from the Panamian Fauna. *Epiactis* is a very interesting form, remarkable for producing numerous lateral buds in a circle around the column, which appear to become free when still quite small, though furnished with mouth, disk, and tentacles. V.

7. *The Butterflies of North America.* Part IV; by WM. H. EDWARDS, (American Entomological Society, Philadelphia, April, 1869).—This beautiful number contains five plates, with twenty-nine figures, profusely illustrating the following species: *Argynnis Leto* Behr., *Colias Eurytheme* Boisd., *C. Keewaydin* Edw. sp. nov., *Thecla Ontario* Edw., *T. strigosa* Harris, *Limenitis Weidemeyerii* Edw. The synopsis of N. American Butterflies contains the remaining species of *Pieris*, *Neophasia*, *Nathalis*, *Anthocaris*, and *Callidryas*. The execution of the plates is admirable. V.

8. *On Remains of the Beaver in New Jersey;* by MASON C. WELD. (In a letter to one of the Editors).—I take the occasion of the recent discovery of a very interesting and novel fact to me to communicate with you. It is the finding of a genuine Beaver meadow, on the very top and near the brink of the Palisades. The edge of the meadow is about 175 paces from the "steep rocks," which are, I suppose, about 500 feet above tide water in the Hudson river, and which rises so abruptly, that a stone may in some places be thrown from the top into the water.

Stumps gnawed off by beavers were found by workmen, getting out swamp-muck on the land of Mr. Charles Nordhoff, and in the rear of his residence. The trench in which they were found (6 or 7 feet below the surface) is about 10 feet deep, and though it was in the midst of the severest drought we had had for many years, water soon flowed into it. An eight foot well on the place has contained a constant supply of water. An excavation made for a fish-pond, within ten rods of the steep rocks, filled up with water to the depth of two or three feet, without receiving a gill from rains or from the surface. Wells, springs and brooks along the western slope and in the valley have gone dry in great numbers, while here and elsewhere along the top of the Palisades, there has been an abundant supply. The beavers must have had permanent water. The size of the meadow is not more than four

or five acres; the depth of the peat variable and uncertain; the bottom of the basin where exposed consists of a fine sandy hard-pan with some small boulders and masses of trap, and the trap-rock in place is occasionally denuded.

To appearance there is an abundance of water along this whole range, which cannot be accounted for by the rainfall, and yet it is isolated by miles of intervening hills and valleys from equally high land. Permanent springs little influenced by the season, or by abundance or dearth of rain are not rare on the western slope of the Palisades, and they are found on some of the highest points; one quite noted one is near Crumm's Rock, the highest point.

Closter, New Jersey, Sept. 19, 1869.

IV. ASTRONOMY.

1. *Observations on the Eclipse of August*, 1869; by Prof. J. Winlock. (Communicated through Dr. Wolcott Gibbs, for this Journal).—In the observations of the solar eclipse of August 7th, made at Shelbyville, Kentucky, a spectroscope of two flint glass prisms by Troughton & Simms similar to the one described by Mr. Huggins, (Phil. Trans., 1864, part II,) was used. It was attached to an excellent equatorial telescope by Merz of $7\frac{1}{2}$ inches aperture and $9\frac{1}{2}$ feet focal length. The chromosphere was carefully examined both before and after the eclipse; only three lines could be seen: C, one near D, and F. During totality only the brightest protuberance on the lower limb of the sun was examined carefully. In the short time occupied in getting into this, nothing was seen but a faint continuous spectrum; but since the observing telescope took in only a small part of the spectrum at once, nothing conclusive can be inferred from the observation as to the non-existence of bright lines in the corona.

During totality eleven bright lines were seen. Besides the three described above, there was a short line at or very near E, the three lines of *b* were bright and very sharp, and there were four lines above F. Although these lines were very bright on a dark ground, all of them but the three seen before the eclipse disappeared instantly on the first burst of sunlight, and the same point in the sun's disk was examined with great care after totality without finding any of the lines but those above described.

The photograph of the corona taken at Shelbyville shows a flattening at the extremities of the sun's axis, and an elevation about the equatorial region. The appearance can be explained by the hypothesis that it is a photographic view of the sun's atmosphere, and the form is that which it would assume from the sun's rotation about its axis, with its upper surface disturbed by the protuberances or flames below, and by large waves which are to be expected in such an atmosphere.

2. *Relations to the Corona of the aureole visible in the photographs of the total eclipse.*—Dr. B. A. Gould in a letter to Prof. Morton, published in the Journal of the Franklin Institute for Oct.

(p. 222), says: "An examination of the beautiful photographs made at Burlington and Ottumwa, by the sections of your party in charge of Professors Mayer and Himes, and a comparison of them with my sketches of the corona, have led me to the conviction that the radiance around the moon, in the pictures made during totality, is not the corona at all, but is actually the image of what Lockyer has called the chromosphere.

"This interesting fact is indicated by many different considerations. The directions of maximum radiance do not coincide with those of the great beams of the corona; they remained constant while the latter were variable; there is a diameter, approximately corresponding to the solar axis, near the extremities of which the radiance upon the photographs is a minimum, whereas the coronal beams in these directions were especially marked during a great part of the total obscuration. The corona beams stood in no apparent relation to the protuberances, whereas the aureole, seen upon the photographs, is most marked in their immediate vicinity. Indeed, the great protuberance, at 230° to 245°, seems to have formed a southern limit to the radiance on the western side, while a sharp northern limit is seen on all the photographs at about 350°, the intermediate arc being thickly studded with protuberances, which the moon displayed at the close of totality. The exquisite masses of flocculent light on the following limb are upon the two sides of that curious prominence at 93°, which at first resembled an ear of corn, as you have said, but which in the later pictures, after it had been more occulted, and its southern branch thus rendered more conspicuous, was like a pair of antelope horns, to which some observers compared it. Whatever of this aureole is shown upon the photographs, was occulted or displayed by the lunar motion, precisely as the protuberances were. The variations in the form of the corona on the other hand, did not seem to be dependent in any degree upon the moon's motion.

"The singular and elegant structural indications, in the special aggregations of light on the eastern side, may be of high value in guiding to a farther knowledge of the chromosphere. They are manifest in all the photographs by your parties which I have seen, but are especially marked in those of shortest exposure, such as the first one at Ottumwa. In some of the later views they may be detected on the other side of the sun, though less distinct. But the very irregular and jagged outline of the chromosphere, as described by Janssen and Lockyer, is exhibited in perfection."

3. *Observations of Prof. Pickering's party upon the Eclipse.*—Prof. E. C. PICKERING who observed at Mount Pleasant, Iowa, concludes his report upon the eclipse as follows (Jour. Frank. Inst., Oct., p. 286): "In conclusion, the new facts elicited may be summed up as follows:—An increase of heat and actinic power is observed in the beginning of the eclipse, caused by an increased brightness of the sun's disc near the moon's limb. The spectrum of the corona appears to be free from dark lines, but may contain

two or three bright ones. Its striæ are spiral rather than radial, and its light is unpolarized. The sky adjoining it, however, reflecting light from the earth, shows strong signs of polarization."

4. *Meteors during the Eclipse.*—Prof. C. F. HIMES in his report speaks thus of certain phenomena (Jour. Frank. Inst., p. 278): "During the progress of the eclipse, Mr. Zentmayer, who examined the ground glass of the camera from time to time to notice the position of the image of the sun, called my attention to an appearance of small luminous bodies like meteors crossing the dark image of the moon from cusp to cusp. Subsequently, they were seen to pass over the ground glass from outside of the field on to the image of the sun, where of course they were lost, always coming from the same side. We were led by this circumstance to regard them as most likely to be optical illusions, perhaps insects with transparent wings or bodies, but the fact that other observers report a shower of meteors between the moon and the earth, which seemed to be, as far as I can gather from a hasty description, identical in appearance with the objects noticed by us, our observation may be of considerable value, especially as Mr. Zentmayer, who saw most of them, is disposed not to regard them as optical illusions, since they must have been caused by objects not less than 2,000 feet distant."

5. *Prof. Mayer's report of the Eclipse.*—Prof. A. M. MAYER and five assistants were stationed by Dr. Morton at Burlington. His full report of instruments, of methods, of work done and of results, is given in the Journal of the Franklin Institute for October. They took 41 photographs, five of them during the totality. From these photographs numerous measurements of the prominences and of the various phenomena of the eclipse have been made for comparison with results from other observers and photographs. In his closing section, he points out "the peculiar value of photography in the observations of the transits of Venus."

6. *Radiation of heat from the Moon.*—The present Earl of Rosse is worthily employing the telescope constructed and so well used by his father. He has recently made a series of experiments upon Lunar radiant heat (Proc. Roy. Soc., 112) with a view of determining in what proportion the moon's heat consists of (1) that coming from the interior of the moon which will not vary with the phase; (2) that which falls from the sun on the moon's surface, and is at once reflected regularly and irregularly; and (3) that which falling from the sun on the moon's surface, is absorbed, raises the temperature of the moon's surface, and is afterward radiated as heat of low refrangibility.

His results suggest to him that the law of variation of the moon's heat will probably be found not to differ much from that of the moon's light. It therefore follows that not more than a small portion of the moon's heat can come from the first of the three sources named.

Also, the greater part of the moon's heat which reaches the earth appears to have been first absorbed by the lunar surface.

From a single series of eighteen readings of the galvanometer for the sun's heat he obtained the ratio of lunar to solar radiation of 1 : 89819.

The amount of lunar heat appears to indicate an elevation of temperature for the moon's surface at full moon of 500° Fahrenheit.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Collections of the Maine Historical Society*, Vol. I.—Having given up so much space in this number of the Journal to the Geographical and Historical Notes of Mr. Stevens, we desire to call the particular attention of our readers to a recent publication which has been in some degree the occasion of this essay, and which is a most comprehensive and convenient summary of the views which have heretofore been commonly received respecting the early discoveries of this continent.

Rev. Leonard Woods, D.D., lately President of Bowdoin College, was commissioned by the Maine Historical Society a short time since, to investigate in Europe the early History of Maine, for the purpose of securing as much as possible of the documentary records. In the course of his inquires, which were fruitful in many ways, he came upon the well known traveler Dr. J. G. Kohl of Bremen, who has spent many years in the study of the Atlantic sea-board, and who was at one time expectant that his researches would be published under the auspices of one of the national establishments at Washington. Dr. Kohl was readily enlisted by Dr. Woods in the preparation of a Memoir on the coast of Maine, regarding Maine not in a narrow or provincial sense, but in a sort of continental comprehensiveness, or in other words as including, in itself and its vicinity, our whole Atlantic sea-board. He has brought together twenty-three plates containing fac-similes of more than thirty maps and parts of maps on which the outlines of America as they were dimly perceived by the navigators, are definitely portrayed by the engravers; and these maps he has accompanied with elaborate and comprehensive illustrative notes and comments, to the extent of five hundred octavo pages. Among the maps transcribed are those of the Italian brothers Zeni dating from 1400, two early Icelandic maps, a part of Martin Behain's famous Nuremberg globe of 1492, de la Cosa's Spanish map of 1500, and so on through French, English, Portuguese, Spanish and Italian maps to the work of Mercator in 1569. After discussing these various charts chronologically, Dr. Kohl gives a general summary, by nations, of the parts performed by the several maritime powers in this work of discovery.

At the suggestion of Dr. Woods, M. D'Avezac of Paris, has reiterated his well known opinions on the Cabots in an appendix to the volume. The entire publication is a great honor to the State of Maine, to Dr. Woods, and to Mr. Willis who is the editor of the series.

2. *Stevens's Historical and Geographical Notes on the earliest Discoveries in America*, Art. XIX, p. 297.—The following are the contents of the maps illustrating this article:—

PLATE I.

CHART OF THE WORLD by JUAN DE LA COSA, dated 1500, the western third, reduced from M. Jormard's uncolored fac-simile. The original is in the Royal library, Madrid, on leather, colored, size 5 feet 10, by 3 feet 2 inches.

PLATE II.

No. 1. OCEANUS OCCIDENTALES SEU TERRÆ NOVÆ, reduced from the Ptolemy of 1513.

No. 2. LA CARTA UNIVERSALE DELLA TERRA FERMA and Isole delle Indie occidentali, canata da due carte da nouicare fatte in Sibilia da li piloti della Maiesta Cesarea. Venetia, 1534. Reduced to one quarter the size of the unique original in the possession of Mr. James Lenox of New York. The two pilots are no doubt Diego Columbus and Ribero whose original charts of 1527 and 1529, or contemporary copies, are preserved in the military library at Weimar, the American portions of which have been extracted and published by Dr. Kohl.

No. 3 Part of the UNIVERSALIOR COGNITI ORBIS TABULA by John Ruysch. Published in the Ptolemy of 1508.

PLATE III.

No. 1. MAP OF THE NEW HEMISPHERE by F. G. Size of the original, dedicated to Hakluyt, and issued in his edition of Peter Martyr's Eight Decades, Paris, 1587, 8vo. It is very rare. Cabot's discoveries are placed north of the Gulf of St. Lawrence and dated 1496. Virginia is here laid down for the first time, and dated 1584. Drake's landing in California is recorded under the date of 1580.

No. 2. HUNTER'S GLOBE dated 1542, three continents terminating alike in the Southern Ocean. *Paria* takes the place of *Terra de Cuba* and is separated from Zipangu by a narrow sea.

No. 3. ORONTIUS FINE'S DOUBLE-HEARTED GLOBE dated July, 1531, slightly reduced from the original in the Paris edition of the *Novus Orbis* of 1532.

No. 4. Part of the above mentioned GLOBE of ORONTIUS FINE of July, 1531, reduced to Mercator's Projection. The best authorities seem to have been used by Fine in compiling this map, but he has so misread them that his production is the culmination of absurdities Yet the best geographers and mathematicians of his day agree with him. Schoner's *Opusculum Geographicum*, 4°, 1532, though intended as descriptions of his own new and improved globes made at Nuremberg, answers equally well for the descriptive text of this map. The names of Marco Polo in Eastern Asia, and of Cortes in Mexico, are mixed up and all laid down in one country. For this admirable reduction to Mercator's Projection the writer is indebted to his friend Mr. J. C. Brevoort, of Brooklyn, who on all occasions has liberally opened to the writer his geographical treasures to use as freely as if they were his own.

PLATE VI.

TEHUANTEPEC RAILWAY COMPANY'S Chart of the World on Mercator's Projection: showing the lines of railway with its connections of steamships and sailing vessels, with the prominent parts of the world.

3. *British Association.*—The meeting of the British Association was held at Exeter, commencing Aug. 1st; on the evening of the same day Prof. Stokes, the President of the meeting, delivered his inaugural address. The next meeting will be held at Liverpool under the Presidency of Prof. Huxley. Prof. Stokes closes his excellent address with the following paragraphs.

"But do the laws of chemical affinity, to which, as I have endeavored to infer, living beings, whether vegetable or animal, are in absolute subjection, together with those of capillary attraction,

of diffusion, and so forth, account for the formation of an organic structure, as distinguished from the elaboration of the chemical substances of which it is composed? No more, it seems to me, than the laws of motion account for the union of oxygen and hydrogen to form water, though the ponderable matter so uniting is subject to the laws of motion during the act of union just as well as before and after. In the various processes of crystallization, of precipitation, and so forth, which we witness in dead matter, I cannot see the faintest shadow of an approach to the formation of an organic structure, still less to the wonderful series of changes which are concerned in the growth and perpetuation of even the lowliest plant. Admitting to the full as highly probable, though not completely demonstrated, the applicability to living beings of the laws which have been ascertained with reference to dead matter, I feel constrained, at the same time, to admit the existence of a mysterious *something* lying beyond—a something *sui generis*, which I regard, not as balancing and suspending the ordinary physical laws, but as working with them and through them to the attainment of a designed end.

"What this *something* which we call life may be is a profound mystery. We know not how many links in the chain of secondary causation may yet remain behind; we know not how few. It would be presumptuous indeed to assume in any case that we had already reached the last link, and to charge with irreverence a fellow worker who attempted to push his investigations yet one step further back. On the other hand, if a thick darkness enshrouds all beyond, we have no right to assume it to be impossible that we should have reached even the last link of the chain; a stage where further progress is unattainable, and we can only refer the highest law at which we stopped to the fiat of an Almighty Power. To assume the contrary as a matter of necessity is, practically, to remove the First Cause of all to an infinite distance from us. The boundary, however, between what is clearly known and what is veiled in impenetrable darkness is not ordinarily thus sharply defined. Between the two there lies a misty region, in which loom the ill-discerned forms of links of the chain which are yet beyond us. But the general principle is not affected thereby. Let us fearlessly trace the dependence of link on link as far as it may be given us to trace it, but let us take heed that in thus studying second causes we forget not the First Cause, nor shut our eyes to the wonderful proofs of design which, in the study of organized beings especially, meet us at every turn. * * * * *

"When from the phenomena of life we pass on to those of mind, we enter a region still more profoundly mysterious. We can readily imagine that we *may* here be dealing with phenomena altogether transcending those of mere life, in some such way as those of life transcend, as I have endeavored to infer, those of chemistry and molecular attractions, or as the laws of chemical affinity in their turn transcend those of mere mechanics. Science can be expected to do but little to aid us here, since the instrument of

research is itself the object of investigation. It can but enlighten us as to the depth of our ignorance, and lead us to look to a higher aid for that which most nearly concerns our well-being."

4. *On the altitude of Kearsarge Mountains, in New Hampshire;* by J. R. EASTMAN, Prof. Math., U. S. Observatory, Washington. (Communicated for this Journal, Oct. 7, 1869).—Finding that the altitude of "Kearsarge" mountain in Merrimack Co., N. H., as given by various authorities, ranged from 2,000 to 3,500 feet, I made in Sept., 1868, a careful measurement of its height above the roadbed of the Northern railroad in the town of Andover.

The instruments used were a theodolite by Troughton & Simms, loaned me by Gen. H. W. Benham, U. S. Engineers, and a two-rod surveyor's chain, which was carefully tested before and after the measurements. For a base line I selected a portion of the road-bed, 2255·66 feet long, in that portion of the town known as "Andover Plain." The western end of the base was 11·55 *south* of, and in a line perpendicular to the central line of the northern rail of the main track, at a point 27·39343 from the southern terminus of the railroad in Concord, N. H. The eastern end of the base was 12·21 feet *north* of the center of the northern rail.

The angle of elevation of the highest point of the peak above the western station was found to be 4° 29′ 42″, which value coincided with the observations at the eastern station made for a check.

With these data and the horizontal angles measured at the two stations, the altitude of the highest point of the mountain above the western station was found, when corrected for height of instrument, curvature and refraction, to be 2111·22. From the railroad surveys I found that the western end of the base was 379·35 feet above the terminus of the road in Concord, and from the railroad surveys between Concord and Boston, and Concord and Portsmouth, the Concord terminus of the Northern road was found to be 236·0 feet above mean half tide.

We make, therefore, the height of the mountain 2726·57 feet above the sea level.

This mountain is an isolated peak, and has already become historic from the fact that it was the namesake of the U. S. steamer that sunk the "Alabama."

5. *Artificial Ice.*—The Louisiana Ice Manufacturing Co. at Jefferson City near New Orleans, have in operation six machines calculated to produce twelve tons each of solid ice in twenty-four hours; and with which some sixty tons a day are actually made. H. C. Millaudon, Esq., the President of the Company, announces, as we find in a New Orleans paper, under date of June 14th last, that the company had become the owner by purchase of the rights of Prof. Twining for their territory in Lousiana, and "is at present working under two combined patents of A. C. Twining of New Haven, Ct., and Armand Carré, of Paris, France." We have had occasion to allude in a previous number of this Journal to the ice machine of Prof. Twining, as being the undoubted progenitor

of all the machines operated in this manufacture in different places and countries of the world.

6. *The occurrence of Laurite and Diamonds in the native Platinum of Oregon.* (A communication from Prof. WOEHLER to Dr. C. F. Chandler, dated Göttingen, July 22d.)—In the native platinum from Oregon, for which I am indebted to you, I have found the new mineral composed of sulphid of ruthenium and sulphid of osmium, which I discovered in the Borneo platinum, and to which I gave the name of Laurite.

The crystals are very small, but by magnifying them fifty diameters it was possible to distinguish them by their peculiar luster from the dull grains of chromic iron. As it was impossible to separate the crystals of Laurite from the other minerals present, a quantity of the entire ore was subjected to chemical examination.

The platinum and gold were dissolved by aqua regia. The chromic iron was separated as much as possible by fusion with bisulphate of potassa, and subsequent treatment with dilute hydrochloric acid. The silica was expelled by treatment with hydrofluoric and sulphuric acids. The residue was then throughly washed.

On examining the material thus purified, under the microscope, it was seen to contain numerous grains of undecomposed chromic iron, beside iridosmine, and different transparent minerals, some colored, some colorless, especially minute crystals of hyacinth, which had hardly been attacked by the hydrofluoric acid.

The mixture was then placed in a glass bulb tube, and ignited in a current of hydrogen entirely free from sulphuretted hydrogen. The formation of sulphuretted hydrogen began as soon as the bulb was raised to a red heat, and continued for some time. I have elsewhere shown* that it is a peculiar property of this otherwise difficultly decomposed mineral, to give up all its sulphur on ignition in hydrogen.

The residue was then treated with hydrochloric acid to remove iron. But although hydrogen was evolved on the application of the acid, the solution contained merely a trace of iron. On adding ammonia to it, a white precipitate was obtained, which by ignition in hydrogen yielded globules of tin.

The ore thus freed from the iron and tin was then treated with aqua regia, when it yielded a brown solution, in which chlorid of ammonium precipitated a small quantity of black double chlorid of iridium and ammonium. The entire solution was then evaporated to dryness with an excess of chlorid of ammonium, and ignited in a porcelain crucible. There remained a grayish black metallic powder, which was fused in a silver crucible with hydrate of potassa and a little nitre. The fused mass dissolved in water, yielding the characteristic orange-colored solution of rutheniate of potassa, and leaving a very small quantity of oxyd of iridium. On adding nitric acid to the solution, a black precpitate of oxyd of ruthenium was produced, and, at the same time was perceived the ozone-like odor of ruthenic acid, and later, the characteristic odor of osmic acid.

* Ann. Chem. Pharm., cxxxix, 116.

In a subsequent communication, dated Göttingen, Aug. 8, Prof. Woehler continues: On examining under the microscope the mineral powder which had been freed from platinum, gold, chromic iron (in part), silica, iron, and tin, and from which the ruthenium, &c., had been removed by aqua regia, besides many grains of chromic iron and beautiful hyacinth crystals, colorless and transparent grains resembling quartz were observed, but besides these, grains resembling rounded diamond crystals were detected. To ascertain whether these crystals were really diamonds, a gram of the powder was ignited in a stream of pure oxygen gas to convert the carbon into carbonic acid. The powder was placed in a freshly ignited platinum boat, in a new porcelain tube, which had previously been ignited while oxygen was passed through it to destroy any dust that it might contain. On igniting the powder and conducting the stream of gas through baryta water, a strong cloudiness was at once produced, but the precipitate soon began to assume a brown color, and a black deposit, probably of oxyd of ruthenium, was deposited in the tube. On pouring hydrochloric acid into the tube, the precipitate was disolved with a visible evolution of gas, which, conducted into baryta water, produced a cloudiness.

I am satisfied, therefore, that besides the laurite, iridosmine, chromic iron, hyacinth, etc., the Oregon platinum contains microscopic crystals of diamonds.—*Chem. News* (Am. ed.), Nov., 1869.

7. *Minerals and a copy of Elliot's Indian Bible of* 1680, *belonging to the late Henry R. Schoolcraft, for sale.*—By letter from Mrs. Schoolcraft, just received, we learn that Mr. Schoolcraft's cabinet was valued by him previous to the war, at a thousand dollars; it is offered now for five hundred. A manuscript catalogue of the minerals accompanies them. There is a copy of Elliot's Indian Bible, which is strongly bound in calf. Besides this work, there are books and tracts in various Indian languages, to be disposed of, and also original letters, as autographs, written to Mr. Schoolcraft by prominent literary men from 1809 to 1864.

Inquiries may be addressed to Mrs. Mary H. Schoolcraft, 256 F street, (between 13th and 14th sts.) Washington, D. C.

8. *Correction.*—The biographical notice of the late Dr. Shumard in our last number, received by us from Dr. Litton and attributed to him, was not written by him. It is from the editorial colums of the "Missouri Republican."

OBITUARY.

Death of George Peabody.—This distinguished philanthropist and patron of science died in London at midnight of Nov. 4th, 1869, having recently returned from the United States suffering under severe disability, the gradual breaking up of a vigorous constitution. Mr. Peabody was born at Danvers, Massachusetts, on the 18th of February, 1795, and was at his death within three months of the completion of his 75th year. Mr. Peabody was in the strictest sense of the term the architect of his own fortunes. Com-

mencing at the early age of eleven years his commercial career, by a life of strict economy, probity and great industry, he laid the foundations of his colossal fortune, aided only by his own virtues and the remarkable intellectual ability which appeared in all his great and varied experiences as a merchant, banker and negotiator. His family, one of the oldest and most honorable in New England, descended from Francis Peabody (Paybody), who was born at Leicestershire, England, in 1614, and who came to America in 1635 and settled in the town of Topsfield, Massachusetts. Thomas Peabody, the father of the great banker, was the fourth generation from the eldest of six sons of Francis. At the early age of nineteen years Mr. Peabody was the head of a commercial firm of which Elisha Riggs was the senior and capitalist, and having removed from Washington to Baltimore in 1815 his management secured such success that branch houses were established in New York and Philadelphia. In 1829 the retirement of Mr. Riggs left Mr. Peabody the head of the house, and during several visits to Europe he conducted with entire success important negotiations for his adopted State of Maryland. For these services he steadily refused all compensation, but he could not decline the unanimous resolves of the Assembly "for his generous devotion to the interests and honor of Maryland"—conveyed to him by the Governor with an earnest assurance of the gratitude of the people. In 1837 Mr. Peabody took up his residence in London, where he continued to conduct the business of Peabody, Riggs & Co. But in 1843 dissolving his connection with that firm he established his well known banking house, designed as he said to be "an American house—a center of American news—and an agreeable place for his American friends visiting London." From this date Mr. Peabody appears as the exponent in Great Britain of American interests, sustaining the national and state finances by liberal purchases of American securities, and by his personal integrity and uprightness restoring confidence in the national faith. Thousands of Americans who visited London during the Great Exposition in 1851 will recall his timely generosity in sustaining the good name of America by discharging the costs of the arrangement of the American department left in a helpless condition by the failure of Congress to make any appropriation for its needs; and Mr. Peabody's banquets, given in singular contrast to the very simple retiracy of his private life in London, were the centers of reunion and enjoyment to all his fellow citizens who were made known to him.

When again Congress failed to make any appropriation for the Kane Expedition in search of Franklin, Mr. Henry Grinnell having furnished the vessel, Mr. Peabody placed ten thousand dollars at the disposal of the managers of the expedition, which enabled them to carry out that important search.

The first of Mr. Peabody's remarkable series of public benefactions was the gift of $20,000, in 1852, to his native town of Danvers on the occasion of the celebration of the two hundredth anniversary of its foundation, for the purpose of building a public

Library and Institute. This gift he subsequently enlarged to an endowment of $300,000.

After an absence of twenty years, in 1857 Mr. Peabody revisited the United States, an honored guest, but with characteristic modesty declining all public demonstration except one in his native town of Danvers. During this visit he laid the foundation of the noble endowment bestowed upon his adopted city of Baltimore, by the gift of $500,000, which sum he has since enlarged to $1,000,000, to furnish a free public library, and an Institute for courses of lectures, an academy of music, and gallery of art.

Returning to London in the same year he began that noble foundation for the benefit of the poor of London, which has placed him at the head of the public benefactors of Great Britain, by establishing a trust with the gift of £150,000, which he has since increased to £350,000, left without restriction except that it should be kept free from sectarian or partisan management. Already several fine squares have been covered in different parts of London with dwellings for the poor, combining features indicated in Mr. Peabody's letter of endowment. Proffers of public demonstration of regard, orders of knighthood he firmly declined, accepting only an autograph letter of thanks from the Queen of England, accompanied by a miniature portrait of herself, set in diamonds and bearing on its golden case the inscription, "Presented to George Peabody, Esq., the benefactor of the poor of London." These memorials of noble deeds are deposited in the Peabody Institute at Peabody, Mass.

In 1866 he again revisited the United States that he might with his own hand bestow still more princely gifts. During that memorable visit he gave $25,000 to the Phillips Academy, at Andover; $15,000 to the Newburyport Library; $100,000 to build a church as a monument to the memory of his mother, in Georgetown, Mass.; $16,000 to a library in the same town; $140,000 to the Academy of Science at Salem; $5,000 to the library at Thetford, Vt., where he spent a year with his grandfather when a boy; $20,000 to the Massachusetts Historical Society; $150,000 to found a Professorship and Museum of American Archæology at Cambridge; the same sum for a Museum of Natural History at Yale College; the last $500,000 of the fund already mentioned for the Peabody Institute at Baltimore; $20,000 to the Maryland Historical Society; $25,000 to the Kenyon College, Ohio; and $15,000 for a library at Georgetown, D. C.; besides the crowning donation of $1,500,000 to build up the cause of education in the Southern States of this Union, to assist schools and popular education without distinction of race or color. This endowment was increased during his last visit the past summer by an addition of one million of dollars, making a fund of $2,500,000 for this most catholic object of popular education.

During his last visit he also gave a liberal donation to Washington University in Virginia, besides distributing, it is said, $1,500,000 among the members of his own family. Mr. Peabody never mar-

ried. The aggregate of the donations bestowed in his lifetime by this most noble man is more than ten millions of dollars. Not the least remarkable or praiseworthy part of these unexampled endowments is seen in the fact that Mr. Peabody had at once the good sense and moral courage to be his own executor!

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Twelfth Annual Report of the Board of Commissioners of the Central Park, New York, for the year ending December* 31, 1868. 8vo, pp. 164.—This beautifully printed and well illustrated document sets forth the present condition and plans of one of the most renowned of public Parks. It is a hopeful evidence of progress in the right direction, that the Commissioners recognize the growing demands made by the public for museums and collections in natural history, that these educational elements are receiving some share of attention, in connection with, and as elements of, the Park. Mr. Waterhouse Hawkins, well known for his spirited restorations of extinct animals at the Sydenham palace, near London, has been engaged during the past year or more in the same direction in the Central Park. The Appendix to this report contains a well written article on the educational department of the Park, together with the correspondence between the Comptroller, Mr. Green, and Mr. Hawkins, and the Report of the latter on the progress of the fossil restorations undertaken by him; and particularly a description of the restored skeleton of the great herbivorous saurian, *Hadrosaurus Foulkii* (Leidy), allied to the Iguanodon of the Wealdon of Sussex. The *Hadrosaurus* occurs in the Cretaceous marls of New Jersey, and the remains from which the restored skeleton are in part composed were discovered at Haddonfield, Camden Co., New Jersey, five miles from Philadelphia, in the autumn of 1858. Mr. Hawkins, after a careful and minute study of the bones of the original specimen in the collections of the Academy of Natural Sciences in Philadelphia, proceeded to model them all, and then to set up the restored original in the Halls of the Academy at his individual expense, as a contribution to the collections of their museum. The restored skeleton of *Hadrosaurus* measures 26 feet in length, and stands on its hinder extremities and tail 13 feet 3 inches high. The great disproportion between the fore and back parts of the body of *Hadrosaurus*, led Prof. Leidy to suspect that the animal ordinarily assumed a position like that of the Kangaroo, sustaining itself like a tripod, on its enormous hinder extremities and powerful tail. This position, favorable to browsing on trees which grew along the shores of the sea, upon which the animal lived, is adopted for that of the skeleton in Mr. Hawkins's restoration. From the moulds made by him in Philadelphia, Mr. Hawkins has prepared a model of the restored animal for the Central Park museum, the first of a group of animals of the former periods of the American continent, which Mr. Hawkins has undertaken to reproduce for the Central Park.

It appears from the catalogues in the Appendix, that living animals in considerable numbers have been presented to the Commissioners of Central Park, from various parts of the world, and these to a considerable extent have been preserved and are now living in the grounds. We understand also that an extensive museum has been projected and the first steps taken toward its establishment. The park will thus become a means of national entertainment and of instruction, in fact a great center of knowledge for the people.

2. *Report on the Filtration of River Waters, for the supply of Cities, as practiced in Europe, made to the Board of Water Commissioners of the City of St. Louis*, by JAMES P. KIRKWOOD, Civil Engineer. Published by permission of the Board. 178 pp. 4to. Illustrated by thirty engravings. New York, 1869. (D. Van Nostrand, publisher, 23 Murray St. London, Trübner & Co.)—Fully one half the bulk of this volume is made up by the numerous well engraved plates, most of them double, giving in plan and sections the various methods adopted in Great Britain and Continental Europe for the filtration on a great scale of the waters used for metropolitan supply. The plans adopted as the result of Mr. Kirkwood's studies, and after an inspection of the best European methods, for the city of St. Louis, are also given. This is an important subject, deeply concerning the health and welfare of all metropolitan communities, and it is nowhere of greater importance than throughout the whole internal drainage system of the United States, upon all the affluents of the Mississippi river, where the only adequate supply is by pumping water from rivers which are at all times more or less turbid and are periodically liable to floods which surcharge them with mud and slowly settling sediments.

Mr. Kirkwood's system for St. Louis embraces both subsiding or settling reservoirs, reservoirs for unfiltered water after the great bulk of foreign matter has been removed by standing for twenty-four hours in the settling reservoirs, and finally wells and conduits for the filtered water. The agents used for filtration are of the simplest description. The filter beds are formed as follows, commencing above, viz:

Fine washed sand,----------	18 inches.
Coarse sand, ----------	12 "
Gravel, pea size,----- -----	12 "
" nut size,----------	12 "
Broken stones,----------	24 "
Drain pipe,----------	12 "
Puddle bottom.	

The rate of filtration through such a series of beds is found to be 75 imperial gallons per day for each square foot of filtering surface exposed, or half a cubic foot per hour. The size of the filter beds proposed for St. Louis has been assumed to be 260 by 156 feet, giving an area of 37,440 square feet, yielding at the rate above named 3,360,847 United States gallons in twenty-four hours. To supply 12,000,000 U. S. gallons daily required by St. Louis, five

filters of this sort are required, leaving one always out of use for cleaning the surface of the filter bed of the accumulated sediments.

Mr. Kirkwood's researches extended not only to the great works of London, York, Liverpool, Edinburgh and Dublin, but he also studied those of Hamburgh, Altona, Berlin, Tours, Angers, Nantes, Lyons, Toulouse, Marseilles, Genoa, Leghorn and Wakefield. For all these he gives detailed drawings and many statistics which are not to be found elsewhere, and he adds in an Appendix valuable data as to the 'duty' of the London pumping engines. Mr. Kirkwood's report will be highly esteemed by his engineering brethren, and must serve a most important end in convincing city councils elsewhere of the great importance and early practicability of delivering to consumers only limpid waters purged of sediments and rendered fit for human use. The work is printed in the style which has rendered Mr. Van Nostrand a favorite publisher of engineering and scientific books in the United States.

3. *Report of the Superintendent of the United States Coast Survey, showing the progress of the survey during the year* 1866. Washington: Government printing office, 1869.—The present report was made by Mr. Hilgard, assistant in charge, and contains in the Appendix a report, by Assistant C. A. Schott, of the connection of the two primary base lines in New York and Maryland by a series of 45 primary triangles. There are also three papers by Mr. Schott upon the methods in use in the Coast Survey in observations of time, of latitude, and of azimuth. In the previous Report there was a similar treatise upon the use of the plane table, the general aim being to gradually embrace the whole range of subjects so that a collection of the articles will form a complete *Coast Survey Manual.*

In this volume are also reproduced all the articles of general scientific interest of the octavo reports previous to 1852, excepting the table of geographical positions in the report for 1851. This is reserved for a time when the cardinal longitude shall be permanently settled. This will make the quarto reports complete as to papers of scientific interest published by the Coast Survey.

4. *The progress and condition of several departments of Industrial Chemistry;* by J. Lawrence Smith, U. S. Commissioner to the Paris Universal Exposition, 1867. 146 pp. with vii plates. Washington, 1869.—The subjects selected by Dr. Smith for this Report are discussed under the following heads: Chap. I, The manufacture of sulphuric acid; Chap. II, Soda and salts of soda; Chap. III, Potash and its compounds; Chap. IV, Ammonia, baryta, magnesia and alumina; Chap. V, Chlorine, fluorine, manganese, and carbonic acid; Chap. VI, Industrial production of oxygen, hydrogen, and other elements; Chap. VII, Manufacture of illuminating gas from coal, and the utilization of the waste products; Chap. VIII. Stearic acid industry; Description of the plates. The clear and common sense manner of Dr. Smith's discussion of the topics selected by him, leaves a sense of regret that the distinguished author has not extended his researches to other depart-

ments of this extended subject so full of interest as well to scientists as to those engaged in technical pursuits. A greater degree of fullness also upon some sections of the topics discussed would have been highly acceptable and a much better reference to the text of the literature of many subjects would have given the report additional value. The very full and detailed plans for an extensive sulphuric acid works given by Dr. Smith supply a want which many technical chemists will be glad to have supplied, especially what relates to the pyrites furnaces.

The interesting chapter on Illuminating Gas gives us some important data respecting the Paris system, but leaves us hungry for more. So in the chapter on oxygen, hydrogen and other elements, it is satisfactory to know that Dr. Smith has "no doubt of the ultimate success" of Tessié du Motay's process for the industrial production of oxygen from manganate of soda; but this confession of faith is sustained by no details, and we are left without any further information accessible to most American readers, as to the practical operation of Tessié's method than come to us from the rose-colored statement of the promoters of his patent.

Technists will glean from the perusal of Dr. Smith's report numerous important hints and suggestions which cannot fail to attract attention and stimulate inquiry.

5. *Report on Excisions of the Femur for Gunshot Injury;* Circular No. 2, War Department, Surgeon General's Office, Washington, Jan. 2, 1869.—During the late war, the Surgeon General's office at Washington accumulated vast stores of statistics in the reports returned by the medical staff of the army, and amassed an unequaled museum of specimens illustrative of injuries and diseases. The office is discharging an obvious duty, and at the same time rendering a great service to medical science, in the use which it is making of this invaluable material.

"Circular No. 2" of the Surgeon General's office for the current year is one of a series of important monographs issued during several years past. It is a report on excisions at the hip for gunshot injury, by Asst. Surg. and Bvt. Lt. Col. George A. Otis, and is a complete and exhaustive study of that interesting surgical topic. Like its predecessors from the same pen, it shows the marks of unwearied labor, and of an intelligent and discriminating use of statistics which in careless or ignorant hands might prove a snare and a delusion.

This report and several other of the recent issues from the same Bureau, notably the great "Catalogue of the Army Medical Museum," are worthy of mention for the beauty of their mechanical execution; some of the best specimens of American wood engraving are to be found in their pages. F. B.

6. *Fownes's Chemistry: A Manual of Elementary Chemistry, Theoretical and Practical;* by GEORGE FOWNES, F.R.S. From the tenth revised and corrected edition, edited by George Bridges, M.D., Prof. of Chemistry in the Philad. College of Pharmacy; With 197 illustrations. 857 pp. 12mo. Philadelphia, 1869. (H. C. Lea.)—

The London edition of this popular and excellent manual, from which this American reprint is taken, was edited by H. Bence Jones and Henry Watts in 1868, who have re-written almost entirely the organic chemistry and the chapter on chemical philosophy, besides making considerable additions to all other parts of the work, and explaining the atomic weights and notation almost universal now among the chemists. Enough of the old structure remains however to give to the work a familiar look to its early friends, with many of whom it deservedly holds a high place among elementary books on chemistry. Its comparative fullness of detail and general simplicity of style render it convenient and attractive as a book of reference for both teachers and students, especially medical students; while for the purposes of a drill book in class room instruction, its very fullness is a bar to its usefulness for that purpose. In the hands of an expert teacher, however, who is master of the science, it is an admirable book, and equally so to the student who wishes faithfully to review the teachings of the chemical lecture-room.

7. *Weisbach's Mechanics: A Manual of the Mechanics of Engineering and of the Construction of Machines, with an Introduction to the Calculus*, designed as a text-book for Technical Schools and Colleges, and for the use of Engineers, Architects, etc.; by JULIUS WEISBACH, Ph.D., Oberbergrath and Professor at the Royal Mining Academy at Freiberg; member of the Imperial Academy of Sciences at St. Petersburg, etc. In three volumes. Volume First—Theoretical Mechanics, with 902 wood cuts in the text. Translated from the fourth augmented and improved German edition, by Eckley B. Coxe, A.M., Mining Engineer. 576 pp. 8vo. New York, 1870. (D. Van Nostrand).—An English translation of the first edition of this work, published in two volumes over twenty years ago, though poor as a translation, has yet been so extensively used, and, of late commanded so high a price, as to show conclusively the very great excellence of the work itself in the estimation of Teachers and Engineers. All who have known either the original or the translation named will be glad to learn that the new translation, the first half volume of which is now before us, besides being made from the fourth greatly enlarged and improved German edition, is also, as a translation, a great improvement on the old one, and, in some respects, is an improvement on the original itself, being made under the author's sanction, and embodying the latest corrections of both author and translator. This part, issued in advance of the complete volume to meet the immediate demand for it as a text book, includes the four sections: 1, Simple Motion; 2, Mechanics, or the Physical Science of motion in general; 3, Statics of Rigid Bodies; and 4, the Application of Statics to the Elasticity and Strength of bodies; together with a preliminary introduction to the Calculus. The use of the Calculus in this edition has involved the recasting of large portions of the work, as, especially, in the 4th section of this part. The entire work will, like the original, fill three octavo volumes of ten or

twelve hundred pages each. Though too extensive, perhaps, and difficult, for many besides special students and professional engineers, it will still, we hope, meet with such favor as to remunerate the enterprising publishers for undertaking to place before the country this invaluable Thesaurus of Theoretical and Applied Mechanics.

8. *On a Method of predicting by graphical construction Occultations of Stars by the Moon, and solar Eclipses, for any given place, together with more rigorous methods of reduction for the accurate Calculation of Longitude;* by FRANCIS CRANMER PENROSE, F.R.A.S. 50 pp. folio, with three plates and sets of skeleton forms. 1866. Macmillan & Co.—The title of this volume explains very well its scope. It is designed to furnish the amateur astronomer, the sailor, and the traveler with such facilities as will make the use of occultations for the determination of longitude easy and attractive.

Three charts contain scales of use in the graphical constructions, and fourteen tables are added to facilitate the reductions. Ten or fifteen minutes of labor in making the extracts, completing the computations, and working upon the chart, suffices to bring out for any given latitude and longitude, a prediction differing not more than three minutes from the truth.

9. *Smithsonian Report for* 1868.—Prof. HENRY here reviews the explorations of the continent which have been in recent progress, some of which have received assistance from the Smithsonian Institution. He dwells particularly on the efforts going forward in the country toward the collection of specimens in archeology and ethnology, and mentions also the work done under the direction or auspices of the Institution in natural science and meteorology, and for the enlargement of the National library. The list of "Smithsonian meteorological stations and observers from 1849 to 1868," which follows, occupies 34 pages. The "General Appendix" containing important papers, mostly translated from foreign journals, covers 340 pages of the Report, and gives it great scientific value. Among them are memoirs of Cuvier, Oersted, Schönbein, Encke and Eaton Hodgkinson; memoirs on the mechanical theory of heat, by J. Müller; Radiation, by Tyndall; Synthetic experiments, relative to meteorites by Daubrée; catalogue of meteorites of the Yale College collection; on the electric resonance of mountains: experiments on Aneroid barometers at the Kew Observatory; and many others.

10. *Synopsis of the extinct Batrachia, Reptilia and Aves of North America;* by EDWARD D. COPE. Transactions of the American Philosophical Society, Philadelphia, August, 1869. Part I, 4to, with 12 plates.—The author regards the Batrachia and Reptilia as distinct classes. The latter he divides into the orders: *Ichthyopterygia*, *Archosauria*, *Testudinata*, *Pterosauria*, *Lacertilia*, *Pythonomorpha*, *Ophidia*. The prominent structural features are well expressed in his synopsis. The present part includes the Batrachia, the *Ichthyopterygia*, and that portion of

Archosauria included in *Sauropterygia*, *Streptosauria*, *Thecodontia*, *Crocodilia*, *Dinosauria*. Two recent species of *Crocodilia*, *Perosuchus fuscus*, and *Osteolæmus tetraspes* Cope, are redescribed and figured. Mr. Cope mentions the following as the most important general results of his investigations of extinct Reptilia: 1st, that the *Dinosauria* present a graduated series of approximations to the birds, and possess some peculiarities in common with that class, standing between it and the *Crocodilia*; 2nd, that serpents exist in the Eocene formations of this country; 3rd, that the *Chelydra* type was greatly developed during the American Cretaceous, and that all the supposed marine turtles described from it, are really of the first named group; 4th, that the Reptilia of the American Triassic are of the *Belodon* type; 5th, the discovery of the characters of the order *Pythonomorpha*; 6th, the discovery of the characters of the order *Streptosauria*; 7th, the development of the characters of numerous members of the Batrachian suborder *Microsauria* in the United States.

The illustrations accompanying this memoir are profuse and well executed. V.

11. *Bulletin of the Museum of Comparative Zoology. No.* 9,—*Preliminary Report on the Echini and Star-fishes dredged in deep water between Cuba and the Florida Reefs, by L. F. de Pourtales, Assist. U. S. Coast Survey;* prepared by Alexander Agassiz.—I, Catalogue of the Echini; II, On the young stages of Echini; III, Bathymetrical and geographical distribution; IV, List of the star-fishes.

No. 10,—*Preliminary Report on Ophiuridæ and Astrophytidæ;* prepared by Theodore Lyman.—I, General remarks; II, Descriptions of new genera and species, with critical remarks.

No. 11,—*List of the Crinoids obtained on the Coasts of Florida and Cuba by the United States Coast Survey Gulf Stream Expeditions, in* 1867, 1868, 1869; by L. F. de Pourtales.

No. 12,—*List of Holothuridæ from the Deep-sea dredgings of the United States Coast Survey;* by L. F. de Pourtales.—These important and interesting papers were received too late for suitable notice in this number. They contain descriptions of numerous new and remarkable genera and species, together with tables of the distribution of the species in depth and geographically. The observations of Mr. Agassiz on the structure and development of numerous young Echini are particularly important. V.

12. *The Academy, a monthly record of Literature, Learning, Science and Art.*—The first number of this new London monthly, a quarto of 28 pp., was issued by the publisher, John Murray, on the 19th of October. It promises to be a journal of fair and learned criticism, and to some extent a repository of new discoveries in its several departments. Price 6d; or stamped, 7d.

13. *Nature, a Weekly illustrated Journal of Science.* Published by Macmillan & Co., London. No, 1, November 4th. 22 pp., between 8vo and 4to, exclusive of advertisements. Price fourpence.—Devoted to discoveries in all departments of Nature-

science, as the title indicates, and advocating the views of Darwin. It includes among its contributors many of the most eminent men of science in Great Britain, and promises to be an able and spirited journal. The first number opens fittingly with the aphorisms on nature by Goethe, translated by Huxley. Then follows an article on the fertilization of winter-flowering plants, containing new results, as a sequel to Mr. Darwin's observations, by A. W. Bennett. Other subjects are—the recent eclipse of the sun, by J. Lockyer; Science-teaching in schools; the late Professor Graham; Triassic Dinosauria, (under which, Mr. Huxley gives good reason for regarding the Thecondontosaurs as true Dinosaurs, and adopts Prof. Cope's conclusions that the Bathygnathus of Prince Edward's Island is Dinosaurian); others, on a few topics in chemistry and physics, besides notices of new works, and of the Proceedings of some prominent Societies.

Allgemeine Musiklehre. Ein Hülfsbuch für Lehrer und Lernende in jedem Zweige musikalischer Unterweisung; von Adolf Bernhard Marx. 8th edition. pp. 436, 8vo. Leipzig, 1869. (Breitkopf & Härtel).

Des Tortues Fossiles conservés dans le Musée Teyler et dans quelques autres Musées; par F. C. Winckler. 152 pp., 8vo, 33 lithographic plates. Harlem, 1869.

Die Vegetationsverhältnisse von Croatien; von Dr. August Nielreich. 8vo. Wien, 1868.

Mélanges Orthoptérologiques; par Henri de Saussure. II Fascicule. 145 pp. 4to, 2 plates. Genéve et Bale, 1869.

Uber Thal- und See- Bildung. Beiträge zum Verständniss der Oberfläche der Schweiz; von Prof. L. Rütimeyer. 96 pp., 4to. Basel, 1869.

Archives du Musée Teyler. Vol. I, Fasc. 4. Harlem, 1868. Vol. II, Fasc. 1, 2, 1869.

Memoirs on the Bryozoa, by F. A. Smith. Mr. Smith, of Stockholm, has issued his important memoirs on the Bryozoa, published in the years 1864 to 1867, in an octavo volume. They are illustrated by many beautiful plates.

Journal Acad. Nat. Sci., Philadelphia. Vol. VI, Part 4.—p. 303, New Unionidæ, Melanidæ, etc., chiefly of the United States; *I. Lea.*—p. 345, An Attempt to ascertain the Average Weight of the Brain in the different Races of Mankind; *J. B. Davis.*—p. 369, On Brevoortia; *A. Wood.*

Proceedings American Philosophical Soc. Vol. XI, No. 81.—p. 3, Indian Sculpture; *Boyd.*—p. 4, The Maya Language; *Brinton.*—p. 15, Mylodon annectens; *E. D. Cope.*—p. 16, Cretaceous Tortoises; *E. D. Cope.*—p. 17, Philadelphia Life Tables; *P. E. Chase.*—p. 25, Notes on the Geology of Wyoming and Colorado Territories, No. 2; *F. V. Hayden.*—p. 57, The Geological Age and Equivalents of the Marshall Group; *A. Winchell.*—p. 83, Relics from Vera Cruz; *J. Marston.*—p. 85, Obituary Notice of Mr. Bancker; *Cadwalader.*—p. 91, Longitude of San Francisco; *Davidson.*—p. 92, Specimens of Silver Ore; *Dubois.*—p. 94, Periodicity of the Solar Spots; *D. Kirkwood.*—p. 103, Cosmical Relations of Light to Gravity; *P. E. Chase.*—p. 107, Boring Records in the Anthracite Basin; *P. W. Scheafer.*—p. 111, Aurora of April 15.—p. 113, Rain Curves; *P. E. Chase.*—p. 114, The Arawak Vocabulary of Shultz; *Brinton.*—p. 117, New Mosasauroid Reptile; *E. D. Cope.*—p. 118, Human Osteology; *H. Allen.*

Proceedings Boston Soc. Nat. Hist., Vol. XII.—p. 1, Annual Report.—p. 78, The Crocodile in Florida; *J. Wyman.*—p. 78, On a Chick with Supernumerary Legs; *E. Coues.*—p. 83, American Lepidoptera, Geometridæ; *C. S. Minot.*—p. 85, Male of Lemenitis Proserpina; *C. P. Whitney.*—p. 86, Observations on the Marsh Hare; *E. Coues.*—p. 93, Notice of a Cyclopean Pig; *E. Coues.*—p. 100, Notes on Beaver Dams; *A. Agassiz.*—p. 104, on the Habits of a few Echinoderms; *A. Agassiz.*—p. 108, On a New Species of Pedipes from Florida; *R. E. C. Stearns.*—p. 109, Molluscan Fauna of New Haven, part I, Cephalopoda and Gasteropoda; *G. H. Perkins.*

TRANSACTIONS AMERICAN ENTOMOLOGICAL SOCIETY. Vol. II, Nos. 2, 3.—p. 115, On the Synonomy, etc., of certain species of American Lepidoptera; *A. R. Grote.*—p. 122, A new Hesperian; *W. H. Edwards.*—p. 123, Catalogue of Coleoptera from South Western Virginia; *G. H. Horn.*—p. 129, New species of Coleoptera from the Pacific District of the U. S.; *G. H. Horn.*—p. 141, Synopsis of the Scolytidæ of America North of Mexico; *C. Zimmermann* and *J. L. Le Conte.*—p. 179, Descriptions of American Lepidoptera, No. 4; *A. R. Grote* and *C. T. Robinson.*—p. 207, On a Remarkable variety of Papilio Turnus, and Descriptions of two species of Diurnal Lepidoptera; *W. H. Edwards.*—p. 211, Catalogue of the described Tenthredinidæ and Uroceridæ of N. A.; *E. Norton.*—p. 243, Synonymical notes on Coleoptera of the U. S., with descriptions of new species from the MSS. of the late Dr. C Zimmermann; *J. L. Le Conte.*—p. 260, Descriptions of two new species of Arotes; *E. T. Cresson.*—p. 261, Notes on American Tortricidæ; *C. T. Robinson.*—p. 289, List of the N. A. species of Anthrophora, with descriptions of new species; *E. T. Cresson.*—p. 293, Notes on Cuban Hymenoptera, with descriptions of new species ; *E. T. Cresson.*—p. 299, Biological Notes on Diptera; *R. Osten Sacken.*—p. 305, New species of Orthoptera; *S. H. Scudder.*—p. 307, Structural characters of Polyommatus Tarquinius; *A. R. Grote.*—p. 308, New genus of Noctindæ allied to Dyops, with remarks on certain species of Agrotis; *A. R. Grote.*—p. 310, American Butterflies referred to the genus Charis by Doubleday; *A. R. Grote* and *C. T. Robinson.*—p. 311, Descriptions of certain species of Diurnal Lepidoptera found in the U. S.; *W. H. Edwards.*

APPENDIX. *Note by Prof.* YOUNG *to his paper*, Art. XXXVI, p. 370.—Having just received the volume of the Comptes Rendus of the French Academy of Sciences for the first half of the current year, I find that I have been anticipated by M. Faye in respect to the method of observing the contact of an opaque body with the disc of the sun by means of the spectroscope. At the session of Monday, January 11th, 1869, in a discussion upon the observation of the coming transit of Venus, he proposed essentially the same use of the spectroscope which I have described in the foregoing article.

It is unnecessary to say that until to-day I was not aware of the fact.

Hanover, Nov. 16, 1869.

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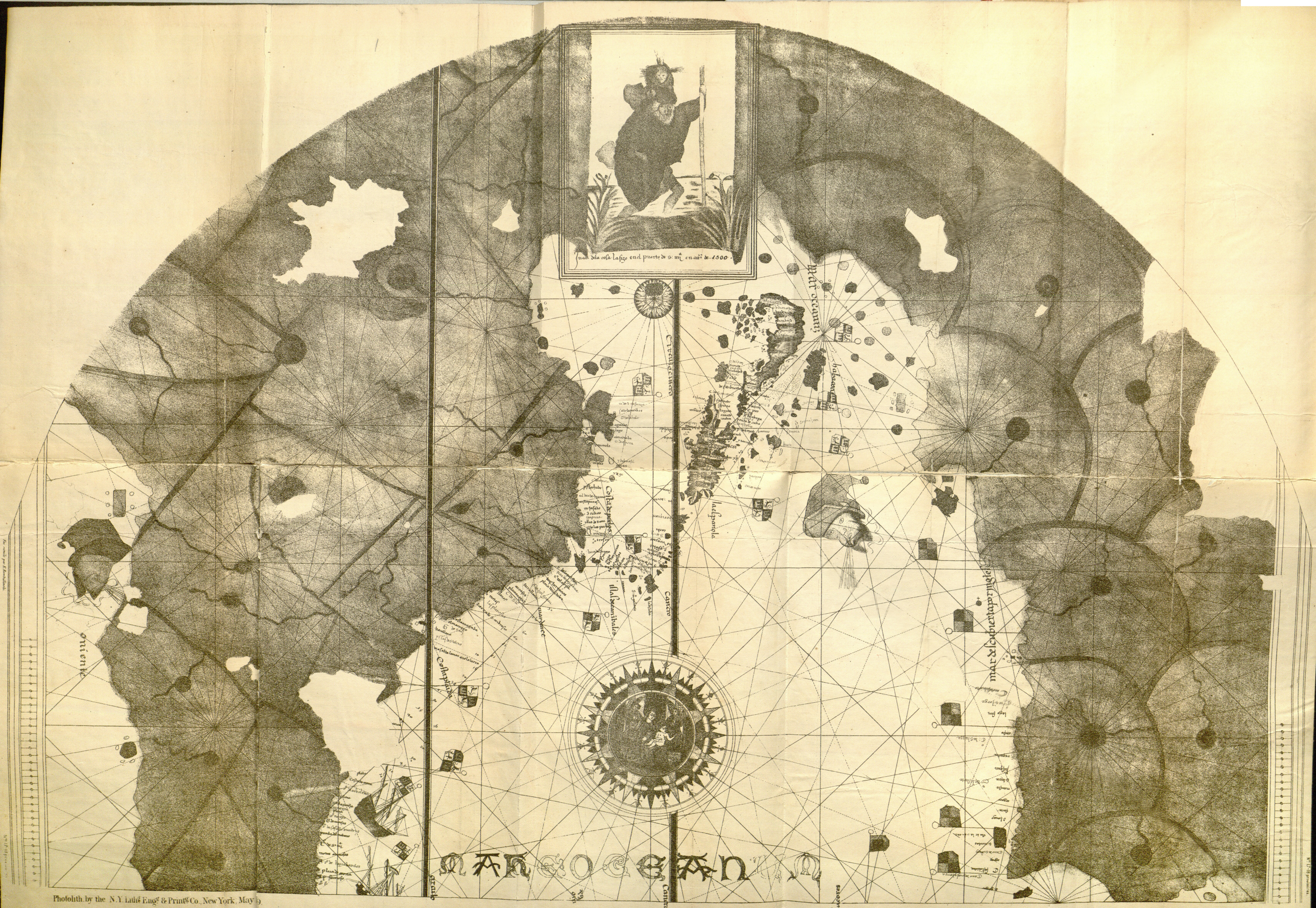

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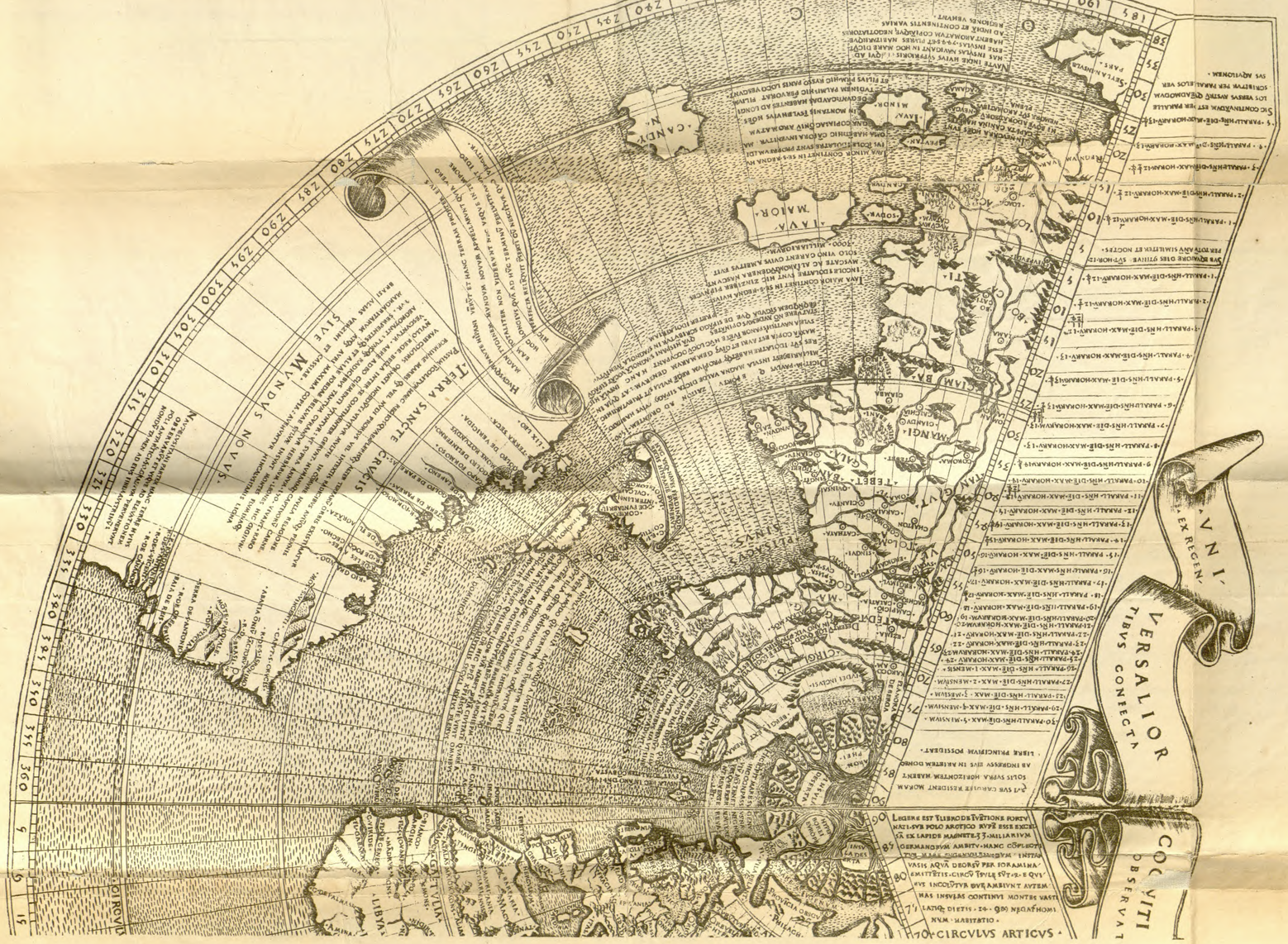

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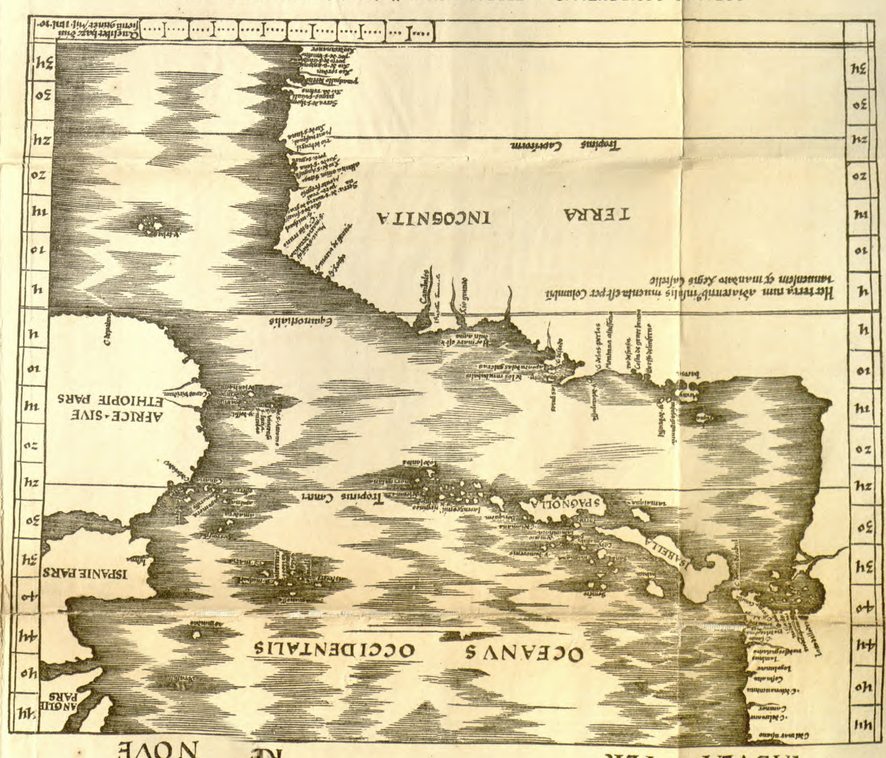

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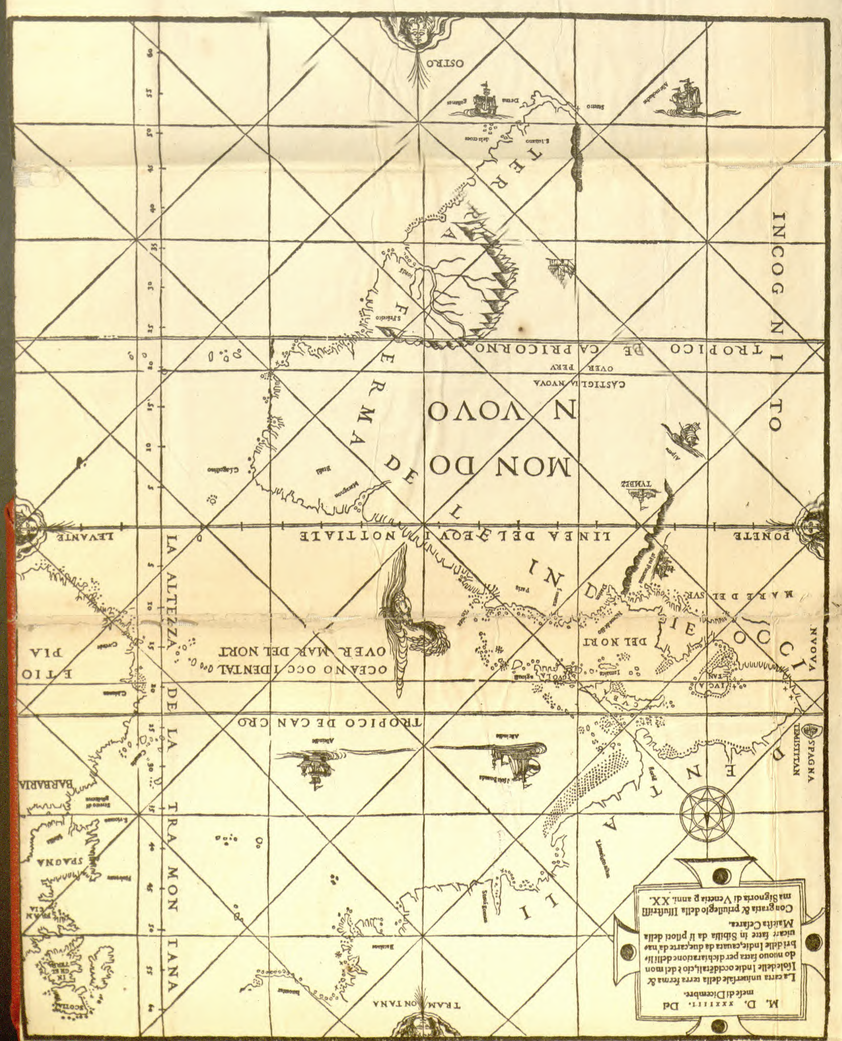

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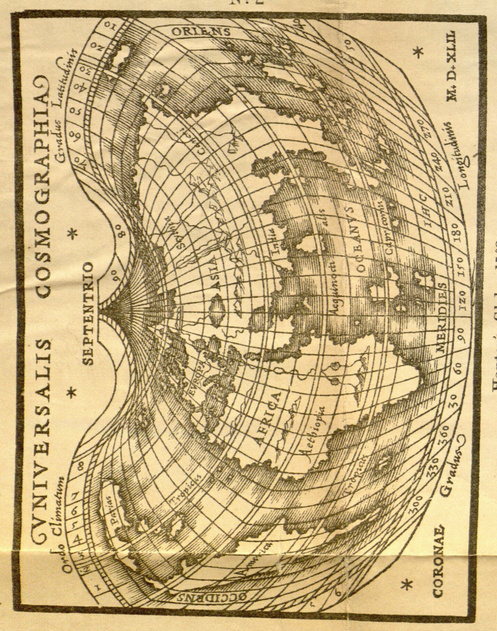
Map from Hakluyt's Edition of Peter Martyr 1587.

№2

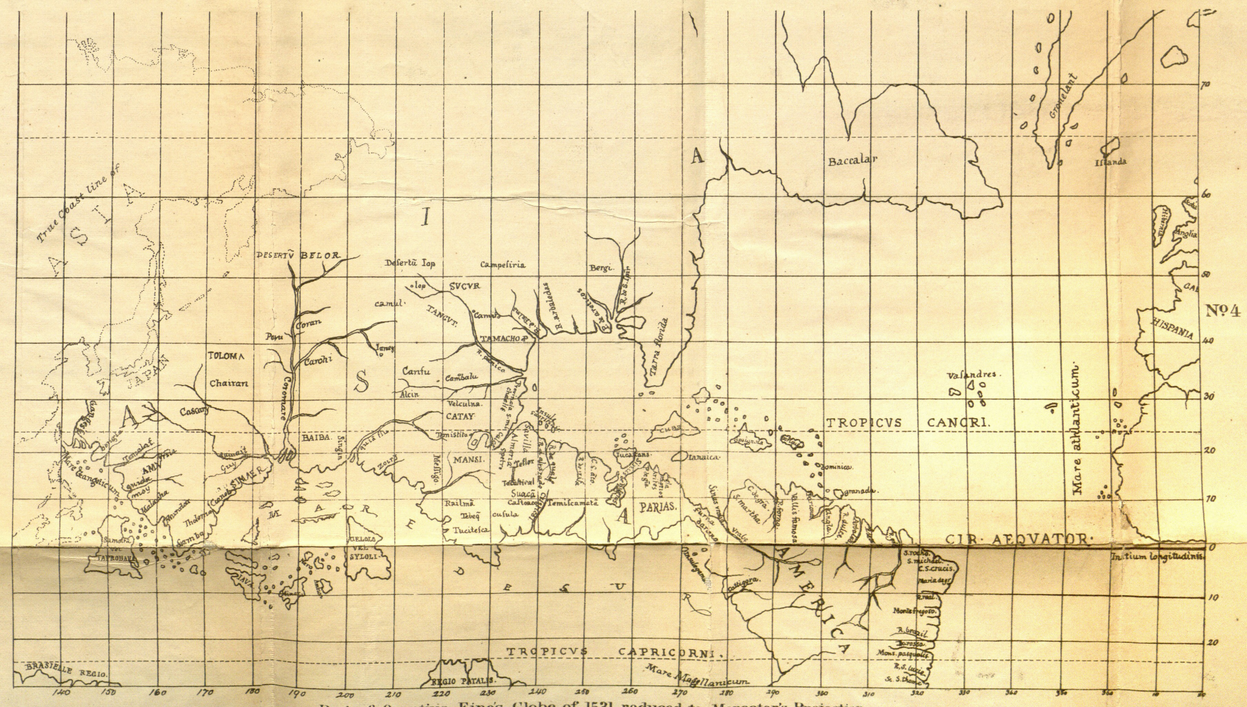


Honter's Globe 1542.

№3

Orontius Fine's Globe, slightly reduced 1531.

№4



Part of Orontius Fine's Globe of 1531, reduced to Mercator's Projection.

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