TRANSACTIONS

OF THE

WISCONSIN ACADEMY

OF

SCIENCES, ARTS, AND LETTERS.

VOL. III. 1875—76.

Published by Authority of Law.

MADISON, WIS.:
E. B. BOLENS, STATE PRINTER.
1876.

CONTENTS.

TITLES OF PAPERS PUBLISHED IN THIS VOLUME

Department of the Natural Sciences.

Department of Letters.

Department of the Social and Political Sciences.

GENERAL OFFICERS OF ACADEMY.

PRESIDENT:

DR. P. R. HOY, *Racine.*

VICE-PRESIDENTS:

DR. S. H. CARPENTER, - - - - -	*Madison.*
PROF. T. C. CHAMBERLIN. - - - - -	*Beloit.*
REV. G. M. STEELE, D. D. - - - - -	*Appleton.*
HON. J. I. CASE, - - - - - - -	*Racine.*
REV. A. L. CHAPIN, D. D. - - - - -	*Beloit.*
DR. J. W. HOYT, - - - - - -	*Madison.*

GENERAL SECRETARY:

PROF. J. E. DAVIES, M. D., *University of Wisconsin.*

TREASURER:

GEO. P. DELAPLAINE, ESQ., *Madison.*

DIRECTOR OF THE MUSEUM:

E. T. SWEET, ESQ., *Sun Prairie.*

LIBRARIAN:

CHARLES N. GREGORY, *Madison.*

COUNSELORS EX-OFFICIO:

HIS EXCELLENCY THE GOVERNOR OF THE STATE.
THE LIEUTENANT GOVERNOR.
THE SUPERINTENDENT OF PUBLIC INSTRUCTION.
THE PRESIDENT OF THE STATE UNIVERSITY.
THE PRESIDENT OF THE STATE AGRICULTURAL SOCIETY.
THE SECRETARY OF THE STATE AGRICULTURAL SOCIETY.

OFFICERS OF THE DEPARTMENTS

Department of Speculative Philosophy.

President Ex-Officio—THE PRESIDENT OF THE ACADEMY.
Vice-President.—S. H. CARPENTER, LL. D., *State University.*
Secretary.—REV. F. M. HOLLAND, *Baraboo.*
Counselors.—PRESIDENT BASCOM, *State University*, PROF. O. AREY, *Whitewater*, and REV. A. O. WRIGHT, *Fox Lake.*

Department of the Natural Sciences.

President Ex-Officio.—THE PRESIDENT OF THE ACADEMY.
Vice-President.—PROF. T. C. CHAMBERLIN, *Beloit.*
Secretary.—PROF. J. H. EATON, *Beloit.*
Counselors—PROF. W. W. DANIELLS, *State University*, PROF. J. C. FOYE, *Appleton*, and PROF. THURE KUMLEIN, *Albion College.*

Department of the Social and Political Sciences.

President Ex-Officio.—THE PRESIDENT OF THE ACADEMY.
Vice-President.—REV. G. M. STEELE, *Appleton.*
Secretary.—E. R. LELAND, *Eau Claire.*
Counselors.—DR. E. B. WOLCOTT, *Milwaukee*, REV. CHARLES CAVENRO, *Lombard, Ill.*, and PROF. J. B. PARKINSON, *Madison.*

Department of the Mechanic Arts

President Ex-Officio.—THE PRESIDENT OF THE ACADEMY.
Vice-President.—J. I. CASE, *Racine.*
Secretary.—PROF. W J. L. NICODEMUS, *State University.*
Counselors.—CHAS. H. HASKINS, *Milwaukee*, HON. J. L. MITCHELL, *Milwaukee*, and CAPT. JOHN NADER, *Madison.*

Department of Letters.

President Ex-Officio.—THE PRESIDENT OF THE ACADEMY.
Vice-President.—REV. A. L. CHAPIN, D. D., *Beloit.*
Secretary.—PROF. J. B. FEULING, *State University.*
Counselors.—PROF. W. F. ALLEN, *Madison*, PROF. EMERSON, *Beloit*, and HON. L. C. DRAPER, *Madison.*

Department of the Fine Arts.

President Ex-Officio.—THE PRESIDENT OF THE ACADEMY.
Vice-President.—DR. J. W. HOYT, *Madison.*
Secretary.—HON. J. E. THOMAS, *Sheboygan.*
Counselore.—J. R. STUART, MRS. S. F. DEAN, and MRS. H. M. LEWIS, *Madison.*

DEPARTMENT OF

The Natural Sciences.

TITLES OF PAPERS READ BEFORE THIS DEPARTMENT.

---

1. Kaolin in Wisconsin. By ROLAND IRVING, A. M., E. M.
2. Oconomowoc and Other Small Lakes of Wisconsin. By I. A. LAPHAM.
3. Fish-culture. By P. R. HOY, M. D.
4. Notes on the Geology of Northern Wisconsin. By E. T. SWEET, M. S.
5. On the Rapid Disappearance of Wisconsin Wild-flowers; a Contrast of the Present Time with Thirty Years Ago. By THURE KUMLEIN.
6. On the Ancient Civilization of America. By W. J. L. NICODEMUS, A. M., C. E.
7. Extent of Wisconsin Fisheries. By P. R. HOY, M. D.
8. Leveling with the Barometer. By JOHN NADER, C. E.
9. On Kerosene Oil. By E. T. SWEET, M. S.
10. Improvement of the Mouth of the Mississippi River. By JOHN NADER, C. E.
11. On the Catocalæ of Racine County. By P. R. HOY, M. D.
12. Copper-tools found in the State of Wisconsin. By Prof. J. D. BUTLER, LL. D.
13. Report of Committee on Exploration of Indian Mounds in Vicinity of Madison.

Department of Natural Sciences.

ON KAOLIN IN WISCONSIN.

BY ROLAND IRVING, A. M., E. M.
Professor of Geology, etc., in the State University.

I.—NATURE, ORIGIN, AND OCCURRENCE OF KAOLIN.

Origin of the word "kaolin."—The word *kaolin* is a corruption of the Chinese *kao-ling** or *kau-ling*,† meaning "high-ridge," the name of a place near Jauchau Fu, in China, where for many centuries the Chinese have obtained the material for the manufacture of their famous porcelain. According to Von Richthofen,‡ however, the Chinese material is not the same as that to which the term *kaolin* is applied in Europe and America, but is on the contrary a solid rock, which is exported in a pulverized condition under the name of *kao-ling*. The application of this name to the European porcelain-clay by Berzelius, was, according to Von Richthofen, made on the erroneous supposition that the white powder which he received from China occurred naturally in that state.

What is kaolin?—However this may be, since Berzelius, the word has been applied in Europe to a white clay-like substance which, from its peculiar composition and freedom from any ingredients tending to lessen the whiteness of the wares burnt from it, or its refractoriness to heat, is especially adapted to form the base of the finer kinds of pottery known as porcelain, whence its name of

---

* Baron Von Richthofen, American Journal Science, "On the Porcelain Rocks of China," III i 179. Comp. also Percy's Metallurgy, volume on Fuels, p 92.

†Dana's "System of Mineralogy," p. 75—S. W. Williams' "Middle Kingdom," vol. II, p. 116.

‡ Loc. cit.

"porcelain-clay." An exact statement of the geological and chemical application of the term is not so easily given. Geologists have commonly designated as kaolins only those clays resulting directly from the disintegration of felspar-bearing rocks in place, as distinguished from the bedded or sedimentary clays. It is true that most all of the kaolins used for porcelain making are obtained from deposits of the former nature, but it is equally true that beds, or patches in beds, of sedimentary clays have the same composition and properties as the ordinary kaolins. It has long been noticed that clays possessing these properties tend to approach a type composition, and that they are frequently separable by a process of levigation into a fine white scaly clay, and a sand composed of particles of quartz and undecomposed felspar. The white clay thus separable has always a definite composition, and, as shown by Messrs. Johnson and Blake,* is seen under the microscope to consist of translucent or transparent, rhomboidal or hexagonal plates, which are flexible and inelastic, isolated or aggregated in prismatic, curved, or fan-shaped bundles, and referable to the orthorhombic system. The bases of these scales are marked with lines arising from the edges of super-imposed laminae. The hardness varies from that of talc to about midway between that of selenite and calcite. The mineral whose existence is thus rendered certain, has been designated as *kaolinite* by these gentlemen, from the *kaolin* in which it is most commonly found. These crystalline scales are however found to occur, not only in the real kaolins, which they chiefly make up, but also in small quantities in many ordinary sedimentary fire-clays, or even in common brick-clays. In these, however, they appear to be associated with other silicates of alumina, or at least with an excess of silica over the amount necessary to form kaolinite, which cannot be proved to exist in the free state. The ordinary clays cannot therefore as yet be regarded as having a base of kaolinite. The composition of kaolinite, Messrs. Johnson and Blake showed to be as follows:

	P. cent.
Silica	46.3
Alumina	39.8
Water	13.9
	100.0

*"On Kaolinite and Pholerite." Am. Jour. Sci. II. xliii. p. 351 et seq, as quoted in Percy, p. 92 volume on Fuels etc.

These figures correspond to the formula $Al_2 O_3$, $2 Si O_2 + 2 H_2 O$, one deduced by Forchhammer for kaolin as long ago as 1830, from a comparison of a series of analyses of crude and washed articles.

We may then designate as kaolin any native hydrated silicate of alumina having the above percentage composition, or any native material composed of a mixture of such a silicate with quartz fragments, and fragments of undecomposed rock. Some of the raw kaolins are almost pure kaolinite, whilst others contain as much as fifty to sixty per cent. of foreign matter.

Origin of Kaolinite.—The mineral kaolinite, when considered as the base of large clay masses, appears always to have resulted from the decomposition of minerals of the felspar group. In very small quantities, it is true, the same substance is known to be an alteration product of other minerals than the felspars, e.g. beryl, staurolite, leucite; still all of the large kaolinite masses have originated by the alteration of some of the felspars. This alteration may have been caused by several agents, by far the most important of which has, however, been carbonated water, or water carrying carbonic acid in solution. The felspars are silicates of alumina with an alkaline ingredient, which may be either potash, soda, or lime. Obtaining carbonic acid from the atmosphere, and to some slight extent from direct organic decay, the surface waters, thus reinforced, infiltrating through the seams of the felspar-bearing rocks, (granite, gneiss, porphyry,) act gradually upon the alkaline silicates, forming first carbonate of lime, if lime be present in the rock, which dissolving as bicarbonate in the carbonated water, is carried away. More slowly are taken up and leeched out the alkalies as carbonates, or as silicates, if the amount of carbonic acid is only small, which will be the more usual case. Part of the silica thus set free always remains as colloid or hydrated silica, and may be detected in samples by its solubility in alkali. The amount of colloid silica† remaining will depend directly on the supply of carbonic acid, being greater as the carbonic acid is more plenty. Still remaining after the leeching process are now certain proportions of alumina and silica, to which is added a certain proportion of water. These three combining and crystallizing, form the hydrated silicate of alumina, kaolinite. The theoretical change from orthoclase felspar

* Dana's Mineralogy—under orthoclase, p. 361.
† Bischof Chem. Geol. Vol. II, p. 183.

to kaolinite is well shown by the following figures, which are percentages by weight, calculated on the original orthoclase:

Constituents.	Orthoclase.	Removed.	Remain.	Added.	Kaolinite.
Silica	64.6	43.1	21.5	....	21.5
Alumina................	18.5	....	18.5	....	18.5
Potash................	16.9	16.9	....	....	....
Water................	....	....	....	7.4	7.4
Total.............	100.0	60	40	7.4	47.4

The last column corresponds to the composition already given for kaolinite, viz., silica, 43.3; alumina, 39.8; water, 13.9. The change may also be conveniently indicated from the formulae as follows:

Orthoclase - - - - - -	$6K_2O+6Al_2O_3+36SiO_2$
Removed - - - - - - -	$6K_2O+\quad 24SiO_2$
Left - - - - - - -	$6Al_2O_3+12SiO_2$
Which corresponds to - - -	$Al_2O_2 2SiO_2$
Added - - - - - - -	$2H_2O$
Resulting Kaolinite - - - -	$Al_2O_3,2SiO_2+2H_2O$

These calculations are made on the assumption that the alumina is not removed. It appears however in some cases to be partially removed.* The soluble substances resulting from this decomposition, the carbonates and silicates of potash and soda, and the bicarbonate of lime, pass off with the infiltrating waters, and reaching the surface again, give rise to mineral springs, or add to the solid contents of the drainage waters of the region. The felspar may alter so as to produce certain zeolites when all of the protoxyd bases are not removed,† and if the infiltrating waters carry magnesia in traces a steatitic change may result. These are however much rarer changes, and do not affect the object of the present paper.

Should the felspathic rock be contaminated with iron pyrites, its decay may be much hastened.‡ This may be in part due to a direct action upon the silicate by the acid waters resulting from

* Dana, loc. cit.
† Bischof. Chem. Geol., p. 211—Dana, loc. cit.
‡ Dana's Mineralogy, p. 360. Geology of New Jersey, p. 68.

oxydation of the sulphid, but is rather due chiefly to the disintegration of the rock produced by this oxydation, which leaves it more easily permeable to the carbonated waters.

The felspars which appear especially to have given rise to kaolin masses are orthoclase and albite, the potash and soda felspars. This must be attributed rather to their greater abundance as compared with oligoclase and andesite—the soda-lime felspars—since these latter change much more easily to kaolin, whilst orthoclase changes with the least readiness of any of the felspars, being found often unaltered, when oligoclase occurring in the same rock is completely kaolinized.* Labradorite does not commonly alter to kaolinite.†

Origin of clay deposits in general.—All clays and indeed most shales (clay shales) may be said to have resulted primarily from the alteration more or less completely carried out, of the felspar of felspar bearing rocks. The disintegrated material resulting from this alteration may either have remained where formed, still occupying the position and retaining the lamination of the original unchanged rock, or may have been subsequently removed by the ordinary eroding forces and deposited elsewhere as a bedded clay. This removal, if merely for a short distance, may have been unaccompanied by any assorting of the clay and rocky materials; as for instance is observed in the "kaolin" of the Cretaceous beds of eastern New Jersey. Such an assorting appears however most commonly to have taken place, the clay having been washed out from the quartz and undecomposed rock fragments accompanying it, having had more or less of foreign material mingled with it during the process of sedimentation, and having thus resulted in a bed of ordinary clay. Again in other cases the action of eroding forces on the unaltered felspathic rocks may have resulted in a sediment of powdered felspathic material which by subsequent alteration has become a clay. In some one of these ways all true clays would seem to have been formed. Fragments of felspar still remaining in many of them, and the alkaline ingredients shown by analyses, testifiy to this general origin. Of course bedded clays may have been again and again removed and redeposited, mingled with various impurities, or introduced as impurity into other sedi-

* Dana, p. 348.

† Dana, p. 361.

ments—*e. g.* limestone—by whose subsequent solution and removal the clay may be left alone and pure.

Whatever the exact origin, we may then group all clays conveniently into the *bedded clays*, and the clays accurring as *disintegrated rocks in place.* In both of these ways kaolin occurs. A brief consideration of each mode of occurrence will be of interest in the present connection.

Kaolin as a disintegrated rock in place.—Most kaolin of commerce comes from this kind of a deposit. Gneissic and other felspathic rocks, frequently placed with their bedding planes vertical, admit of deep penetration by the surface carbonated waters. Their felspathic ingredient being thus decomposed, the whole rock is converted into a soft admixture of kaolinite, quartz fragments, particles of partly decomposed, and entirely undecomposed felspar, and more or less altered particles of mica. This alteration has been noticed to as great a depth as seventy feet and over. The gneissic rocks of the Blue Ridge in Virginia, North Carolina, and Georgia, are found altered to this depth over considerable areas, retaining still their original lamination and highly inclined position.* Similar changes and to much greater depth are reported from Brazil.† In such cases the once quartz veins are often seen occupying their original position as great sheets in the soft clay.

Should now the felspar be a largely predominating constituent of the rock, or should the mica be present in inconsiderable quantities only, there will result on decomposition a mixture of a very pure white kaolinite with more or less quartz sand and undecomposed felspar fragments, which can readily be removed by levigation, and a valuable article obtained. Should, on the other hand, the mica be largely present, or should there be any quantity of hornblende or pyrite in the rock, the resulting clay will be largely contaminated with non-separable alkalies from the mica, or oxyd of iron from the mica, hornblende or pyrite, and will be a mere red brick-clay of no value. Thus it happens that whilst many localities of disintegrating granite are known, but few of them yield good kaolin. In the case of much pyrite or other ferruginous constituent in the rock, the weathering and leeching by the carbonated waters, may result in the formation of deposits of the hydrated sesquioxyd of iron, in the shape of "bog iron ore." Such Dr.

* Am. Jour. Sci. III. vii p. 60.

† Hartt as quoted by Hunt, Loc. cit.

T. S. Hunt* regards as having been the origin of some of the bog-ore deposits in the vicinity of the disintegrating gneissic rocks of the Southern States. I allude to this here since it is a fact that bog-ores of considerable value occurs in the Wisconsin kaolin district and may be supposed to have had a similar origin.

In as much as the decomposition of the felspar in such a process is hardly ever so completely carried out as to leave none of it unaltered, it results that the kaolins used in the arts show either in their crude or washed state almost always a certain amount of alkali on analysis. This alkali may be present partly as entirely undecomposed felspar fragments, in which state it can be completely removed by levigation, and partly as felspar in different degrees of change. All of the latter cannot be separated.

Many of the best kaolins aspear to have resulted from the decomposition of a rock consisting chiefly of felspar with as small admixture of quartz and no mica, known as *pegmatite*.† These, from their great richness in felspar, tend to produced an especially pure kaolin. The ordinary gneisses and granites on the other hand, by their decay yield a very coarse sandy clay, which may be quite impure from foreign admixtures, or if free from any hurtful impurity, so largely mingled with quartz, as to be very lean in pure kaolinite. In some regions it is noticed that those granitic or gneissic layers more largely composed of felspar than the adjoining beds, tend to alter whilst the rest stand firm. Since these alternating beds are always inclined at high angles, their outcropping edges strike across the country in groups of narrow parallel bands. Thus it comes that kaolin is sometimes found following long straight lines, having a constant bearing. This fact may be made use of in "prospecting" for kaolin.

Examples of the occurrence of kaolinized rock.—Most of the authorities that I have been able to consult agree in describing the Chinese kaolin. used many centuries before porcelain-making was introduced into Europe, as a result of the disintegration of a granitoid rock, though I have not seen any detailed account. A recent paper‡ by Baron Von Richthrofen, as already said, gives a different account of the nature of the Chinese article. He says: "I visited * * * * the famous King-te-chin, where the Chinese have made nearly all their porcelain for almost three thousand years. I

* Loc. cit. † Von Cotta's Lithology p. 206, English Ed. ‡ Am. Jour. Sci., cit.

examined the places from which they take the material. * * * I have to record the unexpected fact that the material from which the porcelain of King-te-chin is made, is taken from certain strata intercalated between these slates, and occurring at several places, separated [from each other laterally, i. e., at right angles] with the strike of the rocks. It is a rock of the hardness of felspar (inferior kinds are not so hard) and of a green color, which gives it to some extent, the appearence of *jade* to which the Chinese too, compare it. The rock is reduced by stamping to a white powder, of which the finest portion is ingeniously and repeatedly separated. This is then moulded into small bricks. The Chinese distinguish chiefly two kinds of this material. Either of them is sold in King-te-chin in the shape of bricks, and as either is a white earth, they offer no visible differences. They are made in different places by pounding hard rock, but the aspect of the rock is alike in both cases. For one of these two kinds of material, the place "Kaoling" was in ancient times in high repute, * * * * and the Chinese still designate by the name "kaoling" the kind of earth which was formerly derived from there. * * * * The second kind of material bears the name pe-tun-tse, ("white clay.") S. W Williams, in his "Middle Kingdom," speaks* of the kaolin as a disintegrated granite, which is almost all felspar—and of the "pe-tun-tse" as nearly pure quartz—but his account does not appear to be based on personal inspection.

One of the most famous kaolin localities of Europe is that at St. Yrieix-la-perche, near Limoges, in France. Here is obtained the material for the famous Sevres porcelain manufactory.† The kaolin occurs as a result of the disintegration of masses of pegmatite partly interstratified with the gneiss and partly intersecting it in cross veins. The gneiss is also decomposed, but to a red clayey mass of no value. The pegmatite, consisting chiefly of felspar, wherever decomposed has given rise to an excellent kaolin, moderately free from quartz and rocky particles, these forming only about ten per cent. of the whole.

Another famous European occurrence of kaolin is that of the vicinity of St. Austle in Cornwall. This is a weathered mixture of orthoclase and quartz, chiefly on Tregoning hill near Helstone,‡ in

* Vol. II, pp. 116, 117.
† Dana's Mineralogy, p. 475; Knapp's "Chemis'y Applied to Arts," vol. ii, p. 230.
‡ Wagner's Chem. Technol. Eng. Ed.

various stages of decomposition. The kaolinite portion is removed from the weathered rock by allowing streams of water to run over it. The clay thus washed out settles in a series of large catch-pools. The weathered rock itself is used to a considerable extent in the ceramic arts in England, under the name of *Cornish stone.*

At Aue in Saxony the source of the kaolin was a rounded mass of granite very much decomposed on the surface and surrounded by the kaolin as by a cap.* The deposit is exhausted. At Mionia in Saxony, the kaolin is decomposed porphyry, and is used in the Dresden manufactories.† At the Einigheit mine near Freiberg, Saxony, it is in nests in gneiss.‡ The kaolin of La Bresse, France, is an altered andesite.‖ That of Bayonne, France, is a graphic granite in every stage of decomposition.¶ At Passau the occurrence is exactly like that of St. Yrieix in France.§

The following are analyses of crude European kaolins:**

Place.	Rock residue.	Silica.	Alumina.	Water.
St. Yrieix	9.7	41.9	34.6	12.2
Cornwall	19.6	46.5	24.0	8.7
Devonshire	4.3	44.1	36.8	12.7
Aue	18.0	35.9	34.1	11.0
Passau	4.5	46.4	37.0	12.8
Mort near Halle	43.8	26.0	22.5	7.5

A few occurrences of kaolinized rock are known in the United States, of such a nature as to supply a good article. An excellent material is found in the graphic granite of Brunswick, Maine, and also at Haddam, Connecticut. At each place the rock is a coarse mixture of very pure quartz and felspar. At the latter locality it has been of late mined and broken up for making kaolin for white ware at Williamsburg, N. Y.†† Near Trenton in New Jersey the gneissic rocks are more felspathic than usual in the region, and the felspar is entirely changed to kaolin, which is dug to be used in making fire-brick.‡‡ This clay contains zirconia.

Kaolin as a bedded clay.—As a bedded clay kaolin is known in

* Knapp, vol. II, p. 230.
† Wagner Chem. Technol, p. 230.
‡ Percy's Metallurgy, Vol. on Fuels, p. 96.
‖ Ure's Dictionary, Vol. 1, p. 427.
¶ Knapp, Loc. cit.
§ Dana's Mineralogy, p. 348.
** Wagner, Loc. cit.
†† Appleton's Encyclopedia, Art. Clay.
‡‡ Geology of New Jersey, p. 323.

two occurrences: (1) as a coarse admixture of felspar, kaolinite etc. removed but a short distance from where it resulted by disintegration; and (2) as a fine-grained clay washed from its coarse material, and not directly traceable to its origin. In New Jersey the great thicknesses of plastic clays, forming the lowest member of the Cretaceous series, stretch in a wide band south westward across the state from Staten Island Sound to the Delaware River. In places these clays come into contact with the gneisses of the Archaean belt crossing the state from northeast to southwest, and have evidently derived their material from the wear of the previously disintegrated gneissic rocks. In these clay beds kaolin-like clays occur both in the assorted and unassorted conditions. The coarse or unassorted kaolin * is dug at several places on both the main land and island sides of Staten Island Sound. The bed is from two to twelve feet thick, and is composed of coarse angular fragments of quartz mingled with decomposed felspar and mica scales. It is interstratified with other clay and sand layers, and lignite. The finer New Jersey clays of the same series are largely used for making fire-brick and the rougher kinds of pottery. Some of them appear to be sufficiently pure for the manufacture of porcelain.† Ordinary stoneware, porcelain knobs etc. are extensively manufactured at Trenton.‡ The purity of these bedded clays as compared with most others would appear to be directly due to their derivation from the disintegration of the gneissic rocks of the region, and deposition near by where first formed.

A recent discovery in Indiana has brought to light what appears to be a valuable bedded clay, occurring under peculiar circumstances. The kaolin bed lies at the base of the coal measure conglomerate, in Lawrence county, Indiana, having a thickness of five to six feet, one of which is pure white kaolin, the remainder being more or less stained with iron and manganese oxides. Immediately beneath the clay is a bed of limonite iron ore. This clay appears to replace a bed of limestone which has been dissolved away by the action of carbonated waters. It has almost exactly the composition of kaolinite. With it are found lumps of the mineral allophane, another hydrated silicate of alumina, with a larger percentage of water than kaolinite.

* Geology of New Jersey p. 249. † Geology of New Jersey loc. cit.
‡ Geology of New Jersey p. 685.

A similar occurrence to the one just described is mentioned by Jukes* as existing in the tilted bottom-beds of the Carboniferous Limestone, on Cork Harbor, Ireland. Here, over a small area, the limestone has been almost entirely removed, leaving the clay-like substance behind. This clay has been used considerably in the English potteries. The following are analyses of those of the Indiana and New Jersey bedded clays, which approach to kaolinite in composition:

Constituents.	I.	II.	III.	IV.
Silica	43.20	45.30	45.90	47.05
Alumina	39.71	37.10	40.34	37.14
Water	14.25	13.40	13.26	15.55
Oxide of Manganese	....	....	....	0.03
Sesquioxyd of Iron	0.74	1.30	....	......
Potash	.37	1.30	....	....
Magnesia	....	0.22	....	} 0.03
Lime	....	0.17	....	
Zirconia	1.40	1.40	....	....
Total	99.67	100.19	99.50	99.80

I. is a fine white clay from Burts Creek, near South Amboy, New Jersey, analysed just as it came from the pit. II. is a kaolin-like clay analyzed after washing to free from particles of quartz, mica, and feldspar. It is from Trenton, New Jersey. III. and IV. are the Lawrence county, Indiana, kaolin, analyzed without washing.

II.—KAOLIN IN WISCONSIN.

Geographical position of the kaolin district.—The fact of the existence of kaolin in Wisconsin has been known for many years. The material has however only very recently attracted much attention and become the object of actual exploitation. The first published mention I find of it is in the report of Dr. J. G. Norwood in Owen's Geological Survey of Minesota, Iowa, and Wisconsin.† He says, in describing the last Archaean exposure seen in descending the Wisconsin River: "Above the granite at the old mill-dam,‡ is a bed of ferruginous argillite four feet thick, succeeded by five feet of decomposed felspar, above which is a bed two feet thick of well digested kaolin, or porcelain clay, with * * * * quartz disseminated through it in veins and containing a notable quantity of

*Jukes and Geikie's Manual of Geology, p. 130. † P. 289.
‡ Near Point Bass, Wood county.

pyrites. Then succeeds a variegated white and yellow sand-stone * * * *." In this account Dr. Norwood conveys the erroneous impression that the kaolin of the Wisconsin occurs as a bedded clay, which it does not do.

The various localities at which kaolin has been noticed in the state, so far as my knowledge extends, all occur in a belt of country about fifty miles in length and fifteen in breadth, stretching eastward from Black river in Jackson county to the Wisconsin, in the vicinity of the city of Grand Rapids, in Wood county. This district includes more or less of townships 21, 22, and 23 north, and ranges 1, 2, 3, 4 west, and 1, 2, 3, 4, 5, 6, 7 east, of the meridian. It is crossed from north to south by three streams of considerable size; Black River on the west, the Wisconsin on the east, and Yellow River towards the centre. The kaolin discoveries have, I believe been made almost entirely in the vicinity of these streams.

Geology of the kaolin district.—The district thus described, lies for most of its extent just south of the main boundary-line between the Potsdam sandstone, which underlies so large an area to the south, east, and west, and the Archaean rocks, which form the sub-structure of all the region to the northward. In places the boundary, which is a very irregular one, lies within this district. The country in this part of the state is generally level, with a gradual rise to the northward. In the more southern portion of the belt, the sandstone is nearly everywhere the surface rock, except along the beds of the rivers, where the strata of Archaean gneiss granite and diorite are laid bare. The sandstone is therefore, where it occurs, only a very thin covering over the crystalline rocks, and indeed these occasionally rise through it in bold isolated bluffs of granite and quartzite, which, though sometimes as much as two hundred feet in height, cover but a small area. Interspersed with these are other bluffs of similar height and dimensions, of horizontal sandstone, bearing witness to the great thickness of that rock which has suffered denudation. Further north, the gradual rise of the country seems to be due in some measure to the shape of the surface of the underlying Archaean rocks, which finally rise from beneath the sandstone and become the surface formation. The boundary between the two terranes is traced with great difficulty. Barometrical elevations are no guide at all, for the sandstone having once covered the region so deeply may be found at the very highest levels, whilst the irregular upper surface of the gneissic rocks is apt to bring them up through the sandstone at any place. A geological map, including Portage, Wood, Clark, and Jackson counties, would show on the south the sandstone as the surface formation, on the north the crystalline rocks, whilst where the two meet they would be shown dovetailing into each other, the Archaean extending many miles south in the stream beds, the sandstone penetrating as far north on the divides. As we trace the rivers southward towards where the last crystalline rocks are seen, these are found confining themselves more and more closely to the vicinity of the streams until they are finally restricted to their beds, the sandstone forming the banks. Thus the Wisconsin River, for ten miles above Point Bass, and the Black for a greater distance above the falls, present strips of crystalline rocks only as wide as their own currents.

Another feature in the geology of the kaolin district seems worthy of notice in the present connection. I refer to the fact that the boundary line between the "driftless" area of the south western quarter of the State, and the "drift-bearing" area to the north and east, crosses the district in a nearly east and west line from Grand Rapids to Black River Station, on Black river.

Nature and mode of occurrence of the Wisconsin kaolin.—The Wisconsin kaolin occurs entirely as "kaolinized" rock. As already stated it has been noticed only in the vicinity of the large streams. This is so because elsewhere the crystalline rocks are for the most part covered by the sandstone. Nearly always it occupies exactly the original position, retaining sometimes even the minute structure, of the unaltered rock. A few cases were noticed immediately on the river banks, where the structure of the clay seemed to have been modified slightly by water action. The rocks from which the kaolin has been formed, and into which it can frequently be traced throush every degree of alteration, are beds interstratified with the series of Archæan strata which have over wide areas a common strike. Only the out-cropping edges of these beds are decomposed, and as a consequence it follows that the resulting kaolin forms narrow bands crossing the country in straight lines parallel to the general strike. It is exceedingly common to find overlying the kaolin a few layers of sandstone, sometimes a few inches only, at others, a score or so of feet. In such cases the purer kaolin is found immediately below the sandstone, next below a partially kaolinized rock, and next below again the entirely unaltered rock. Such sections are common in the district.

The kaolin localities appear to be almost entirely within the driftless area, or at least where the drift is very thin and the glacial action has been insignificant. This fact becomes a significant one, when we consider that over all the great Archaean region of the north half of the state, which is drift covered, no occurrence of kaolin is known; all the known occurrences being confined to that comparatively small district where the Archaean rocks are found within the driftless area. I am inclined to attribute this absence of kaolinized rock in the northern portion of the state to the denuding agency of the drift forces, following Dr. T. S. Hunt, who has made the same suggestion* in explanation of the non-disintegrated condition of the gneissic rocks of the Blue Ridge in the northern Atlantic States, the same rocks further south being constantly found decomposed to considerable depths.

Where and how to search for kaolin in Wisconsin.—If it be a fact that the drift forces have removed all kaolinized rock they have encountered, then at once we may conclude that search at any considerable distance north of the drift limit is not likely to be rewarded with success. An exception to this might be where the kaolin has been formed underneath protecting masses of sandstone. Within the thus restricted district, moreover, the labor of the search may be much lessened by the recognition of a few simple guiding facts. The explorer should visit the known outcrops of kaolin, note the rock from which it has decomposed, measure carefully its strike and then follow the line thus obtained until other patches are found. Having once noted the kind of rock tending to produce the kaolin, (in this region usually a pinkish felspathic gneiss or granite,) by following the strike of any similar bed kaolin will probably sooner or later be found. The search would be best made with a boring-tool of some simple kind. Should sandstone be struck in the boring the kaolin may yet underlie it. The explorer should at the outset divest himself of the idea that the kaolin occurs in a continuous horizontal bed.

Kaolin on the Wisconsin River.—The best known kaolin deposits in Wisconsin are those that occur on and near the Wisconsin Riv-

* Loc. cit.

er, in the vicinity of the city of Grand Rapids, in Wood county. The Archaean gneissic rocks here occur chiefly in the bed of the stream, which for many miles makes bold rapids over their upturned edges. Elsewhere they are mostly covered with sandstone. The predominating gneissic rocks have associated with them both interbedded, and clearly intrusive granite and diorite. Of the gneiss and granite there are many varieties, according to the predominance of one or other mineral ingredient, both rocks being formed sometimes of a largely predominating pinkish felspar. These beds are the ones most commonly weathered, though some of the dark micaceous kinds show the same tendency. All of the beds strike between N. 50° E. and N. 80° E. with a dip of about 50° either S. E. or N. W.

On the southwest quarter of section 5, town 22, range 6 east, on the land of Mr. Garrison, considerable digging has been done in borrowing for the road-bed of the railroad near by. The removal of about two feet of earth has exposed the kaolin in a number of places extending along the railroad for some rods. The clay is here in some places quite white, in others much stained with iron sesquixoyd, the stained portions being those nearest the surface. Much of it appears to have lost all sign of the original rock structure, whilst in many places the spade turned up masses as distinctly laminated as any of the gneiss in the vicinity. All of the kaolin here is quite gritty from the presence of quartz and undecomposed felspar fragments, a statement which will apply to all of the Wisconsin kaolins that have come under my notice. Scales of silvery mica appear to be largely present. Average samples of the whiter clay, selected by the writer, yielded Mr. Sweet, of the State Geological Survey, by whom all the analyses of Wisconsin kaolins quoted in this paper were made, the following results:

Constituents.	I.	II.	III.
Silica	78.83	49.94	92.86
Alumina	13.43	36.80	2.08
Sesquioxyd of Iron	0.74	.72	.74
Lime	0.64	trace	.96
Magnesia	0.07	....	.10
Potash	.37	.51	.28
Soda	.07	.08	.05
Carbonic Acid	.01	....	....
Water	5.45	11.62	2.53
Total	99.60	99.67	99.60
Specific Gravity	2.52	2.522	2.749

I. is the clay just as it came from the pit, after drying at 100° C. II. is the fine or kaolinite portion of I. washed from the coarse matter by repeated decantation and stirring. The separation is not perfect, but imitates what would be done in washing on a large scale. III. is the coarse residue from this washing, its composition being calculated from the two preceding analyses after finding that it constituted 67.1 per cent. of the whole clay. The carbonic acid remains as a silent witness of the agency by which the clay was formed. The following show II. and III., calculated in percentages on the original unwashed clay, and indicate how the various ingredients distribute themselves between the fine clay and coarse residue:

	II.		III.		I.
Silica	16.33	+	62.50	=	78.83
Alumina	12.03	+	1.40	=	13.43
Sesquiox. Iron	.24	+	.50	=	.74
Lime	.00	+	.64	=	.64
Magnesia	.00	+	.07	=	.07
Potash	.12	+	.25	=	.37
Soda	.03	+	.04	=	.07
Water	3.75	+	17.0	=	5.45
Total	32.50	+	67.10	=	99.60

The fluxing ingredients, iron oxide, lime, magnesia, potash, soda, very small in the original clay, have thus been removed largely (five-sixths) by washing. The following are other determinations made on samples from the same locality, all in the raw state:

Constituents.	IV.	V.	VI.	VII.
Sesquioxyd of Iron	1.69	2.3	....	....
Potash	....	....	.78	2.14
Soda	....	....	.03	3.21
Water	....	....	....	.56

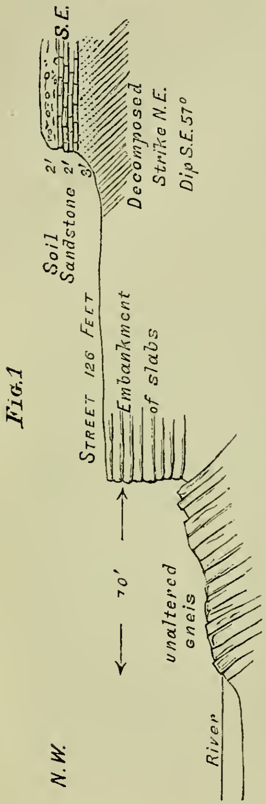
IV. is the bright yellowish clay from near the surface; V. is somewhat less yellow but apparently more ferruginous. It is the most abundant kind. VI. is white clay, still retaining, to a marked degree, the lamination of the original rock. It would appear, however, to be much more thoroughly decomposed than much of the more homogeneous clay of the region. VII. is a highly micaceous weathering granite from the river bank near by the kaolin pits.

On the northwest quarter of the southwest qnarter of section 4, town 22, range 6 east, on the east side of the Wisconsin river, near the centre of the section, kaolin occurs overlaid by ten feet of friable sandstone. Most of it has lost the rock structure, though this appears very distinctly in places. This clay is one of the whitest looking noticed. It has been used for making hearth at the Grand Rapids foundry. The following are Mr. Sweet's analyses of samples from this place:

Constituents.	VIII.	IX.	X.	XI.
Rocky residue	42.59	....	....	....
Fine portion	57.41	....	....	....
Potash	....	0.38	1.21	.87
Soda	....	0.08	0.46	.00

VIII. is the raw clay; IX. the same washed. X. is raw clay taken from the box at the foundry, and said to come from the same place; XI is the fine portion of X. The removal of alkalies by washing is here evident.

In digging for the turn-table at the Green Bay and Minnesota depot, at Grand Rapids, a few layers of compact sandstone were first penetrated, this giving place suddenly to a white kaolin through which piles had to be driven five or six feet (?) before becoming firmly placed.



Immediately north of the Rablin House, at Grand Rapids, kaolin is exposed in the cut made for grading the street, which here runs immediately along the river bank. The following section was obtained at this point—Fig. 1—:*

The decomposed rock is in most places quite firm, though often a soft clay. It is all whitish, and without any appearance of the unaltered rock except the lamination. A specimen of the former kind yielded:

	XII
Potash	7.56
Soda	5.03
Water	3.55

The decomposition had not yet removed much of the alkalies, although the rock was quite white.

On lot 5, section 24, town 22, range 5 east, on the west side of the river, on the land of Mr. L. P. Powers, kaolin occurs in the river bank. The clay has been dug here to a considerable extent. It shows here as elsewhere every degree of decomposition. The pure white is of inconsiderable thickness before a firmer rocky kind is reached. At the waters edge below are seen ledges of unchanged rock. At the time of my examination the locality had been less developed than since that time; but the several outcrops along the river bank indicated a considerable quantity. From this place all of the clay that has been shipped away from Grand Rapids has been taken. Places were noticed here where bunches of highly ferruginous clay

* The engraver has omitted the word "kaolin," in Fig. 1, underneath "sandstone," and also the word "gneiss" after "decomposed." "Unaltered gneis" should read, "unaltered gneiss."

occurred in the midst of the whiter kind. The following are analyses of samples from this place:

Constituents.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.
Silica	70.83	....	....	....	70.25	....	69.34
Alumina	18.98	....	....	....	17.68	....	19.19
Sesquiox. Iron	1.24	....	2.30	....	2.32	....	1.75
Lime	0.24	....	....	....	0.33	....	0.44
Magnesia	0.02	....	....	....	1.49	....	0.31
Potash	2.49	1.22	2.30	1.96	1.69	2.33	3.30
Soda	0.10	trace	trace	0.05	0.39	.10	2.43
Carbonic acid	0.02	....	....	....	trace	....	....
Water	5.45	8.84	....	....	5.61	....	2.67
Total	99.31	10.06	4.60	2.01	99.76	2.43	99.43

XIII. is the raw clay from the exposure furthest down stream. It was averaged from an apparent thickness of three feet. XIV. is the fine portion of XIII. XV. is the raw clay from the next exposure above along the river bank. It represents an approximate thickness of two and a half feet. XVI. is the fine portion of XV. XVII. and XVIII. are the raw and washed clay from the exposure furthest up stream, still showing the rock structure. XIX. is only partly kaolinized rock from the same place. These analyses nearly all indicate the material lessening in percentage of the alkalies effected by levigation.

On the west side of the northeast quarter of section 26, town 22, range 5 east, on Mr. Canning's land, several pits and a well have been sunk into kaolinized rock. The decomposition did not appear to extend to any great depth. The following are analyses:

Constituents.	XX.	XXI.	XXII.	XXIII.
Silica	....	....	....	54.87
Alumina	....	....	....	28.87
Sesquioxyd of Iron	1.95	....	....	1.54
Protoxyd of Iron	....	....	....	.95
Lime	....	....	....	1.62
Magnesia	....	....	....	.99
Potash	1.84	2.65	2.95	2.57
Soda	0.27	.21	.83	.07
Water	....	7.29	....	9.48
Total	4.06	10.15	3.78	100.56

XX. and XXI. are crude and washed clay from Mr. Canning's well. XXII. and XXIII. are both washed samples, from different pits. XXIII. was 43.39 per cent. of the unwashed clay. All of these clays are very white, but appear to be much charged with alkali even after washing.

On the northwest quarter of section 10, town 21, range 5 east, on the land of Mr. Moses M. Strong, on the west bank of the river, kaolin occurs underlying sandstone. The clay shows at a number of places at different levels above the water, but these do not probably indicate a continuous mass. Two samples were taken from the opening at this place, one at a higher level than the other. The following are analyses:

Constituents.	XXIV.	XXV.	XXVI.	XXVII.
Potash	1.25	2.18	1.51	1.54
Soda	0.08	trace.	0.81	0.22

XXIV. and XXV. are the same clay, before and after washing, taken from the upper portion of the opening. XXVI. and XXVII. are crude and washed clay from a lower level. The percentage of alkalies does not appear to be lessened by washing.

About half a mile below this place the last Archaean rocks are seen in the bed of the stream, and resting directly upon them the sandstone. Sections showing the exact junction of the two terranes are common in this vicinity. A detaiied section across the river was taken at one place, the water being very low. It is an interesting one, and I have condensed it in Fig. 2.

Kaolin on Yellow River.—Kaolin is reported in quantity on Yellow River. The localities are above Dexterville in Wood county. The Archaean rocks are exposed finely for many miles along the bed of the stream. They show everywhere a tendency to weather, consisting largely of a pinkish felspar. In places I noticed the weathering carried to the condition of clay, but did not see any of the white clay that is said to exist.

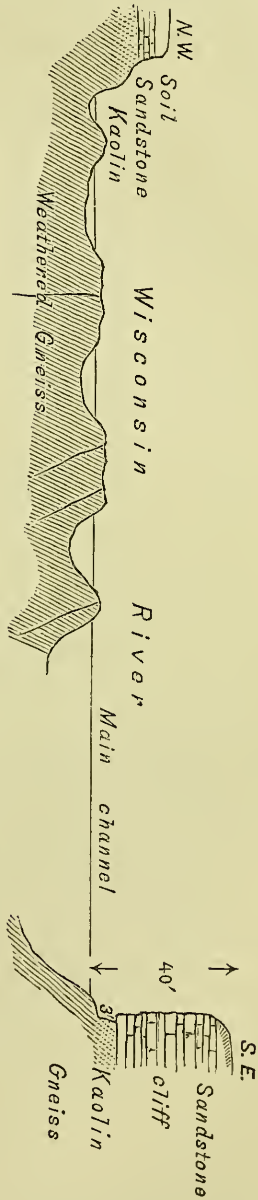
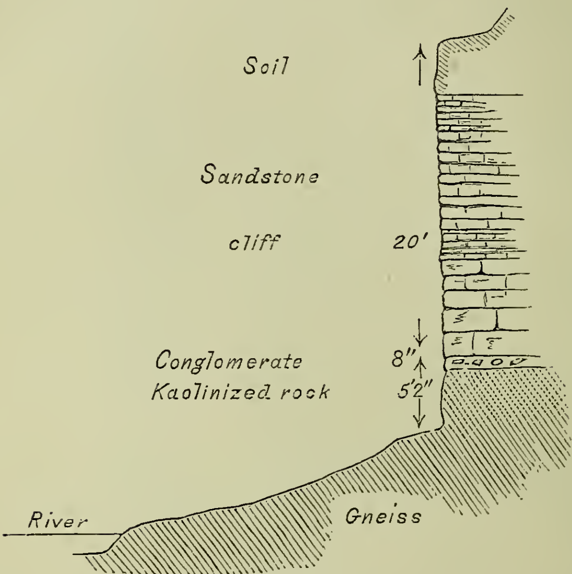


FIG. 2

Kaolin on Black River.—On this stream, in Jackson county, kaolin occurs between Black River Falls and Black River Station. As on the Wisconsin, the Archaean rocks are found here forming the bed of the stream, the sandstone overlying them in the banks. In many places the gneissic rocks are decomposed. At the lower end of the rapids at the town of Black River Falls, the gneisses disappear beneath the sandstone. A section very like that on the Wisconsin, at Point Bas, occurs here; and exhibits the mode of formation of the kaolin handsomely.

On the west bank of the river at Ledyard's old mill, is a high cliff of sandstone overlying gneiss, (Fig. 3.,) the exposures of both rocks extending several hundred feet. The surface of the gneiss is irregular, its depressions being filled by the overlying sandstone. The gneiss is very distinctly seamed—the seams striking north 37 degrees west, (magnetic,) and dipping southwest about sixty degrees—is moderately coarse, micaceous, and has much pinkish orthoclase felspar, which occurs sometimes in nests of some size. Near the water-level the gneiss is but little changed, but as as it is traced up to the sandstone it is found getting more and more decomposed, until it becomes a soft, greyish kaolin, retaining most markedly the laminated structure of the gneiss.

FIG. 3



Quantity of kaolin obtainable in Wisconsin.—Taking the whole district together, a very large amount of kaolin undoubtedly exists. There is no reason why what has been seen should be all there is. It must always however be expected that any one deposit will vary much in character, both as to purity, and as to thickness. Numbers of instances came to my notice where boring showed two feet of kaolin, and no kaolin at all, within a few feet of one another. The fact that the kaolin is apt to occur in continuous lines will however counter-balance the disadvantage of its lack of uniformity, since it can be searched for with assurance of success. In my opinion the indications are such as would warrant the outlay of money in exploitation.

III.—USES OF KAOLIN.

Having thus shown the existence of kaolin in Wisconsin in quantity, it becomes pertinent to ask what it is good for. Its chief use has always been in the ceramic arts. It is also used to make fire-brick and refractory vessels, and to some extent in making alum. The two former of these uses are the important ones.

Use of kaolin in the ceramic arts.—For making the finer kinds of pottery the important qualities of the kaolin are its color after burning; plasticity; and capacity of hardening well under heat without fusion. The plasticity is necessary for the moulding, the last named property for the perfect retention of the moulded form. Pure kaolinite is almost absolutely infusible under heat, simply losing its water and becoming an anhydrous silicate of alumina. This refractory property is lessened by the addition of any other bases; least by magnesia, more by lime, still more by iron oxyds, and most by the alkalies. The table of analyses of foreign clays given below, will serve to indicate how the Wisconsin clays rank in this regard.

The many kinds of clay-ware may be grouped conveniently into the *dense* and *porous* kinds,* according to the internal texture of the mass. Certain kinds of the dense wares are the ones for which kaolin is chiefly used. The ordinary "true" or "hard" porcelain consists of (1) a body of previously washed kaolin, and (2) a fusible binding material, which by its fusion fills the pores of the baked clay and thus renders the ware homogeneous and translucent. This binding material, or "flux," is composed chiefly of felspar, to which are added other ingredients, such as quartz, gypsum, etc. In general, the three ingredients of porcelain are kaolin, felspar and quartz. True porcelain has usually no external glaze placed upon it, its glaze being imparted by the flux which renders it translucent. To give an idea of the amount of kaolin needed in making porcelain, I select the following admixtures used at some of the famous European manufactories:†

* Wagner's Chemical Technology.

† Knapp. Chem. app. to Arts p. 229

Constituents.	Berlin ornamental.	Berlin common.	Dresden common.	Dresden ornamental	Vienna.	Sevres.	St. Petersburg.	Munich.	Copenhagen.
Kaolin	75	76	72	37	72	48	50	65	40
Felspar	15	24	26	......	12	.. .	25	....	27
Quartz	10	....	....	37	12	....	25	21	33
Lime	....	....	....	17½	....	....	....	....	....
Gypsum	....	....	....	......	4	. ..	.. .	5	....
Chalk	....	....	....	......	.. .	4	....	....	....
Broken ware	....	....	2	8½	....	....	....	5	....
Sand separated from kaolin	....	....	....	......	....	48	....	4	....
Total	100	100	100	100	100	100	100	100	100

Kaolin is used to a considerable extent also for other dense wares than true porcelain. In the manufacture of the so called English or "tender" porcelain are used kaolin, plastic clay, "Cornish stone," burnt bones, and steatite. The "Cornish stone" is the partially weathered granite, which by its complete kaolinization affords the famous kaolin of Cornwall.

Preparation of kaolin for porcelain making.—The crude kaolin is always first washed to free it from quartz and felspar fragments. This is effected by simply breaking up the clay, stirring in water, and decanting the suspended matter. The coarse residue from this washing is frequently of value, since it contains two essential ingredients of the porcelain, viz. felspar and quartz.

Use of kaolin as a refractory material.—As a fire clay or for making fire-clay articles, I cannot find that kaolinized rock has been much used. The chief difficulties in the way of such use appear to lie in the lack of uniformity so characteristic of this kind of deposit, and in the fact that where of fine quality the material is too valuable for other purposes. The use of kaolinized rock from near Trenton, New Jersey, as an ingredient of fire-bricks, has already been alluded to. The only other instance I find recorded is that of the so-called "Lee Moor Porcelain Brick," made in Devonshire, England, by mixing a small quantity of inferior kaolin with an excess of the coarse residue obtained from washing the same kaolin. This residue consists chiefly of angular fragments of quartz. The bricks are reported as of extraordinary refractoriness, and are even compared with the famous Dinas silica bricks.

Practical suggestions as to the use of the Wisconsin kaolin to make fire-brick.—There appears to be every reason why a kaolin brick, if properly made, should be of unusual value. A few suggestions are given here as to its manufacture. First, then, the clay must be *selected* in the pit, the red and bluish portions being rejected. The pure white are the best kinds, whilst some of the yellowish kinds are much better than they appear at first sight. After selecting, the kaolin should always be *washed*, to free it from felspathic particles, which contain a large amount of fluxing alkalies. The raw clay will never prove uniform in its capacity of withstanding heat. This is what theory would teach, and, as I am informed by Mr. J. J. Hagerman, of the Milwaukee Iron Works, is found in practice to be the chief obstacle in the way of using the Wisconsin clay. The fine clay obtained by washing should next be mixed with a large excess of tolerably coarse angular quartz, for which might be substituted in part, fragments of fire-brick. The mass should now be moulded or baked carefully. In this way I am persuaded that an unusually good quality of brick might be prepared. It will not do to make brick from this clay as the ordinary fire-brick are made, on account of its extraordinary shrinkage on heating. Prepared in the manner I have suggested the kaolin brick would far excel ordinary fire-brick for all purposes, save where contact with a highly basic slag is necessary, when it would be inapplicable on account of its high content of free silica. I might say in this connection that a number of places exist in Wisconsin where the quartz for mixing with the kaolin might be obtained. I am informed that since my examination of the Grand Rapids localities, a number of fire-brick have been made without great success, the clay being used raw and mixed with wood-ashes as a counter-shrinkage ingredient. No worse admixture, of course, could be imagined, since the ingredient most desirable to avoid is thus directly introduced into the clay.

IV.—TABLES OF ANALYSES OF WISCONSIN AND FOREIGN KAOLINS AND FIRE CLAYS.

These tables are given so that a comparison between the Wisconsin clays and the already well known clays of Europe and the

United States may be readily made. The analyses in Table I of Wisconsin kaolins are those already given, and have the same numbers as before.

In Table II., analyses I., II., III., IV., V., VI., and VII., are taken from the "Geology of New Jersey, pp 683–688. I. is the average composition of the best white clay of the Cretaceous, near South Amboy, analyzed just as taken from the pit. II. is the clay from Trenton, New Jersey, analyzed after washing to free from quartz sand, also Cretaceous. III. and IV. are clays imported from Coblentz, Germany, for making glass-pots. V. and VI. are the St. Louis, Mo., glass-pot clay, raw and prepared. VII. and VIII. are New Jersey potters-clays (Cretaceous), and undergo some vitrification on burning. Analyses IX. to XIX. are taken are taken from Percy's Metallurgy, Volume on Fuels, p. 99. IX. is a true kaolin from Pool, Dorsetshire, used in making Cornish crucibles. X. is also a true kaolin, from Ireland. Small crucibles made from it were kept for hours with melted steel in them, without changing form. XI. is also an Irish kaolin. XII. and XIII. are the finest Cornish kaolin, analyzed by different chemists—washed before analyzing. XIV, is the best Stourbridge fire-clay; XV. a poorer kind of Stourbridge clay. XVI. is the best Dowlais clay; XVII. a poorer Dowlais clay. XVIII. is a greenish kaolin, with red spots, from Newcastle, Delaware; used for making glass-pots and porcelain saggars. Analyses XIX. to XXV. are from the Indiana Geological Report for 1874. XIX., XX., and XXI. are the Lawrence county, Indiana, porcelain clay, analyzed raw. XXII. is from Golconda, Illinois; occurs in pockets in the Carboniferous rocks. XXIII, is washed Chinese kaolin. XXIV. is washed kaolin from St. Yrieix, France. XXV. is Missouri "ball clay." XXVI. and XXVII. are kaolins from Saarau, Silesia, analysed raw and washed; quoted from the second supplement to Watt's Chemical Dictionary p. 354. In comparing the Wisconsin clay with these foreign clays it should be borne in mind that for porcelain making the qualities desired are whiteness after burning and refractoriness to heat; and for making firebrick refractoriness only. The coloration will increase directly with the content of oxyds of iron. The refractoriness will decrease* with the increase of the ratio of fluxes (iron protoxyd, lime, magnesia, pot-

* Watt's Chem. Dictionary, Second Supplament, p. 354.

ash, and soda) to the silica and alumina together, and with the decrease of the proportion of the alumina to the silica. Of the fluxes the alkalies are the most, the alkaline earths the least harmful.

TABLE I.—*Wisconsin kaolins.*

(Analysed by E. T. Sweet, M. S.)

Constituents.	I.	II.	IV.	V.	VI.	VIII.	IX.	X.
Silica	78.83	49.94	......	......	......	......	......	......
Alumina	13.43	36.80	......	......	......	......	......	......
Sesquioxyd of Iron	0.74	.72	1.69	2.30	......	......	......	......
Lime	0.64	Trace	......	......	......	......	......	......
Magnesia	0.07	......	......	......	......	......	......	......
Potash	.37	.51	......	......	.78	......	0.38	1.21
Soda	.07	.08	......	......	.03	......	0.08	0.46
Water	5.45	11.62	......	......	......	......	......	......
Protoxyd of Iron	......	......	......	......	......	......	......	......
Carbonic acid	.01	......	......	......	......	......	......	......
Total	99.60	99.67	......	......	......	......	......	......
Coarse sand	67.30	......	......	......	......	42.59	......	......
Fine-clay	32.70	......	......	......	......	57.41	......	......
Total	100.00	......	......	......	......	100.00	......	......

Constituents.	XI.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.
Silica	......	70.83	......	......	......	70.25	......	69.34
Alumina	......	18.98	......	......	......	17.68	......	19.19
Sesquioxyd of Iron	......	1.24	......	2.30	......	2.32	......	1.75
Lime	......	0.24	......	......	......	0.33	......	0.44
Magnesia	......	0.02	......	......	......	1.49	......	0.31
Potash	.87	2.49	1.22	2.30	1.96	1.69	2.33	3.30
Soda	.00	0.10	Trace	Trace	0.05	0.39	0.10	2.43
Water	......	5.45	8.84	......	......	5.61	......	2.67
Protoxyd of Iron	......	......	......	......	......	......	......	......
Carbonic acid	......	0.02	......	......	......	Trace	......	......
Total	......	99.37	......	......	......	99.76	......	99.43
Coarse sand	......	......	......	......	......	......	......	......
Fine-clay	......	......	......	......	......	......	......	......
Total	......	......	......	......	......	......	......	......

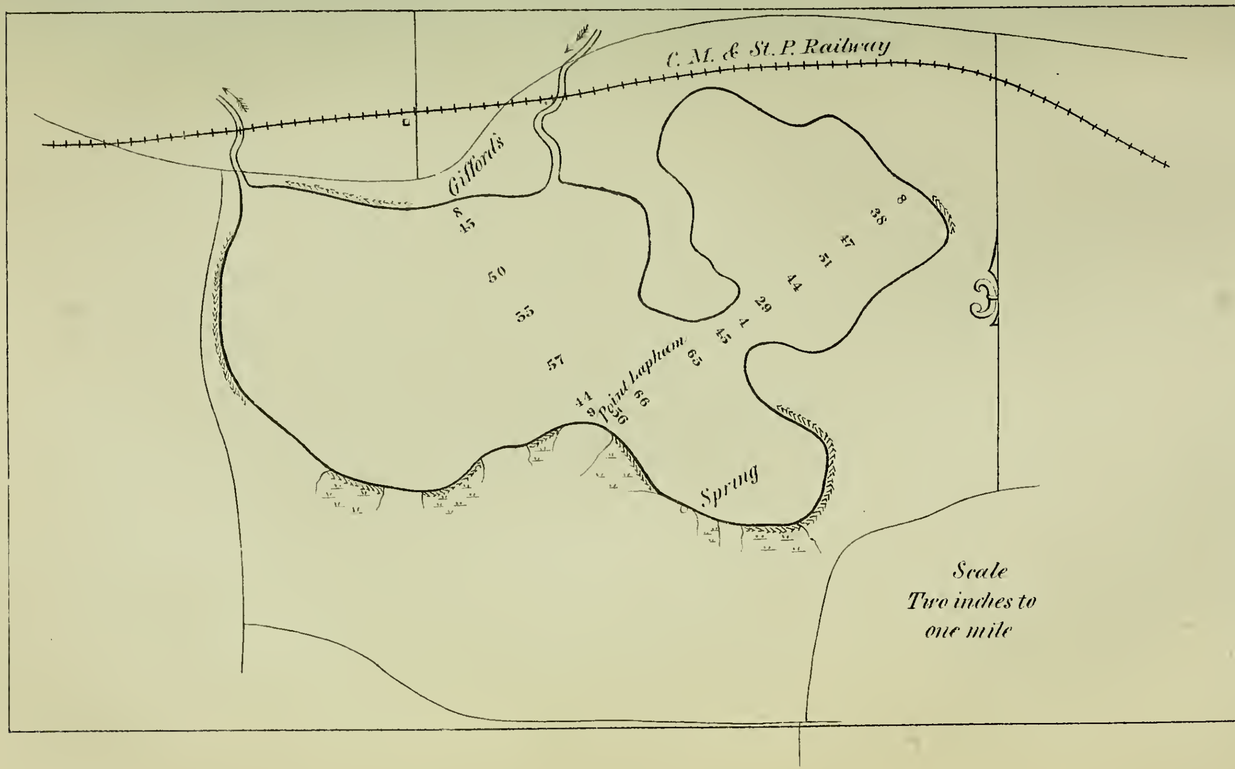
Constituents.	XX.	XXI.	XXII.	XXIII	XXIV.	XXV.	XXVI.	XXVII
Silica	......	......	......	54.87	......	......	......	......
Alumina	......	......	......	28.87	......	......	......	......
Sesquioxyd of Iron	1.95	......	......	1.54	......	......	......	......
Lime	......	......	......	1.62	......	......	......	......
Magnesia	......	......	......	.99	......	......	......	......
Potash	1.84	2.65	2.95	2.57	1.25	2.18	1.51	1.54
Soda	0.27	.21	.83	.07	0.08	......	0.81	0.22
Water	......	7.29	......	9.48	......	......	......	8.69
Protoxyd of Iron	......	......	......	.95	......	......	......	......
Carbonic acid	......	......	......	......	......	......	......	......
Total	......	......	......	100.56	......	......	......	......
Coarse sand	......	......	56.61	......	......	......	......	......
Fine-clay	......	......	43.39	......	......	......	......	......
Total	......	......	100.00	......	......	......	......	......

TABLE II.—*Fire-clays and kaolins from various localities.*

Constituents.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Silica	43.20	45.30	50.20	51.20	61.02	59.60	71.80	65.62	48.90
Alumina	39.71	37.10	34.13	30.03	25.64	26.41	19.95	20,88	32.11
Sesquiox. Iron	9.74	1.30	......	1.50	1.70	1.61	1.31	1.23	2.34
Lime	......	0.17	0.30	1.60	0.70	1.00	0.31	......	0.34
Magnesia	......	0.22	......	0.18	0.08	0.07	0.79	0.30	0.22
Potash	0.37	1.30	0.39	0.89	0.48	0,29	0.61	1.95	3.31
Soda	......	......	......	......	0.25	0.19	......	......	......
Water	14.25	13.30	13.70	13.90	10.00	10.36	6.08	8.16	......
Protox. Iron	......	......	0.87	......	......	......	......	......	......
Zirconia	1.40	1.40	......	......	......	......	......	......	......
Sulphur	......	......	......	0.45	0.33	......	......	......	......
Phosphoricacid	......	......	......	......	......	......	......	......	......
Sand	......	......	......	......	......	......	......	......	......
Combin'd water	......	......	......	......	......	......	......	......	9.63
Hygros'pic wa'r	......	......	......	......	......	......	......	......	2.33
Organic matter	......	......	......	......	......	......	......	......	......
Total	99.67	100.19	99.59	100.00	100.32	99.88	99.95	98.08	99.36

Constituents.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
Silica	78 40	74.44	46.32	46.29	65.10	50.20	67.12	44.25	72.23
Alumina	12.25	19.04	39.74	40.09	22.22	32.59	21,18	34.75	16.75
Sesquiox. Iron	1.30	0.61	......	......	......	3.52	1.85	3.41	1.29
Lime	0.50	,0.45	0.36	0.50	0.14	0.36	0.32	0.34	2.00
Magnesia	......	0.27	0.44	......	0.18	0.44	0.84	1,18	0.07
Potash	......	2.07	......	......	0.18	2.32	2.02	1.58 }	......
Soda	......	......	......	......	......	......	......	...... }	......
Water	......	......	......	......	......	......	......	......	......
Protox. Iron	......	......	0.27	0.27	1.92	......	......	......	......
Zirconia	......	......	......	......	......	......	......	......	......
Sulphur	......	......	......	......	......	......	......	......	......
Phosphoricacid	......	......	......	......	0.06	......	......	......	......
Sand	......	......	......	......	......	......	......	......	......
Combin'd water	5.20	5.71	12.67	12.67	7.10	9.69	4.82	8.56	6.34
Hygros'pic wa'r	......	......	......	......	2.18	......	1.39	2.89	1.14
Organic matter	......	......	......	......	0.58	......	0.90	3.17	......
Total	98.65	100.59	99.80	99.82	99.66	99.12	100.44	100.13	100.32

Constituents.	XIX.	XX.	XXI.	XXII.	XXIII.	XXIV.	XXV.	XXVI.	XXVII
Silica	45.90	47.05	47.13	42.28	50.50	48.37	65.69	19.99	45.39
Alumina	40.34	37.14	36.76	43.05	33.70	34.95	24.87	17.31	39.34
Sesquiox. Iron	......	trace	trace	......	1.80	1.26	2.54	0.56	1.28
Lime	trace }	0.03	0,04	trace	0.80	......	......	......	......
Magnesia	...... }								
Potash	......	......	......	......	1.90	2.40	......	0.46	1.04
Soda									
Water	13.26	15.55	15.13	14.66	11.22	12.62	16.60	5.70	12.95
Protox. Iron	......	......	......	......	......	......	......	......	......
Zircouia	......	......	......	......	......	......	......	......	......
Sulphur	......	......	......	......	......	......	......	......	......
Phosph'ric acid	......	......	......	......	......	......	......	......	......
Sand	......	......	......	......	......	......	......	55.89	......
Combin'd water	......	......	......	......	......	......	......	......	......
Hygros'pic wa'r	......	......	......	......	......	......	......	......	......
Organic matter	......	......	......	......	......	......	......	......	......
Total	99.50	99.77	99.07	99.99	99.92	99.60	99.70	99.91	100.00


C. M. & St. P. Railway
Giffords
Point Lapham
Spring
8
15
50
55
57
44
9
56
66
65
45
4
29
44
51
47
38
8
Scale
Two inches to
one mile

OCONOMOWOC LAKE, AND OTHER SMALL LAKES OF WISCONSIN, CONSIDERED WITH REFERENCE TO THEIR CAPACITY FOR FISH-PRODUCTION.

BY I. A. LAPHAM.

The Oconomowoc Lake in Waukesha county, on the line of the Chicago, Milwaukee and St. Paul Railway, is one of those beautiful sheets of clear, cold water that may be taken as a type or representative of hundreds of others within the State of Wisconsin. A few facts and observations in regard to this lake may therefore be of interest to the Fish Commissioners, and to all who desire to encourage the increase of fish-production.

As shown upon the plats of the government land surveys, it has a length of two miles; breadth, three-fourths of a mile; a shore line of six and a half miles; covering an area of 830 acres, or one and three-tenths square miles.

Its elevation above Lake Michigan, as ascertained many years ago, in making the survey of the Milwaukee and Rock River Canal, is two hundred and eighty-two feet. Its irregular form can best be seen by reference to the accompanying chart.

The Oconomowoc River, a small stream which is the outlet of several other lakes, enters it on the north shore and leaves it at the northwest corner. So irregular is the shape of this lake that it might be taken to illustrate geographical terms, as gulf, bay, point, cape, promontory, peninsula; it has also straits, channels, bars, shoals and its coast-line.

The banks of the lake consist mostly of high grounds which are selected as sites of beautiful, often costly residences, which, especially when duplicated by reflection from the smooth surface of the water, form landscapes worthy of the pencil of the painter.

The lines of figures on the accompanying chart show the depth of the water as measured in 1875. They indicate three principal depressions, the deepest being 66 feet,* the mean of all the soundings is 39 feet.

* The greatest depths measured in other lakes in the vicinity were:

	Feet.		Feet.
Nagowicka	100	La Belle	45
Upper Nashotah	55	Silver Lake	40
Lower Nashotah	50	Upper Genesee	39
Pewaukee	50	Lower Namahbin	34

There are several shoals with from two to six feet depth of water.

There is no deposit of mud or sand brought into the lake by the river; the water-supply both from the river and from the numerous springs on the shore, being always clean and pure. One of these springs on the south shore, known by its Indian name Minnewoc, (place of waters,) has been analyzed by Mr. G. Bode, of Milwaukee, Chemist of the Wisconsin Geological Survey, with the following result:

Chloride of sodium	0.129
Sulphate of soda	0.627
Bicarbonate of soda	1.041
Bicarbonate of lime	9.638
Bicarbonate of magnesia	6.138
Bicarbonate of iron	0.129
Alumina	0.067
Silica	0.879
Total (grains in one gallon)	18.648

It will be seen that the chief ingredients, as in most Wisconsin waters, are lime or magnesia, derived doubtless directly from the magnesian limestone rocks and pebbles buried beneath the soil. This analysis also shows that the water does not differ essentially from those having great reputation for their medicinal virtues.

The lime from the springs is deposited, under favorable circumstances, upon the bottom of the lake forming beds of pure white marl; a process which is materially assisted by the secretions of mollusks aud aquatic plants, especially the chara and algæ.

The temperature of the water, being an important item in fish culture, was taken at different times near the surface, where it had considerable depth, with the followiug result:

In May	41° Fahr.
In June	63 "
In July	72 "
In August	72 "
In September	72 "
In October, 1874	53 "

An attempt was made to find the temperature at the bottom in deep water and resulted in showing at some times no differences, at other times one or two degrees warmer or colder; though the deep water is popularly believed to be much colder than that at the surface.

The strong wind blowing over the lake causes a surface current which must be balanced by a counter current below, and thus by a constant interchange of water equalizes the temperature. If the day is warm with but little wind, the surface water will become the warmest; at night the surface cools down so that in the early morning it is colder than at the bottom.

The deep-water fishes do not, therefore, seek that locality on account of diminished temperature.

One lake is said to have remained open nearly all winter; the cold weather having been accompanied by high wind, which prevented the water from freezing.

When the surface is once covered with ice the currents cease, and ice is formed of great depth and of crystal transparency and purity.

The temperature of the spring-water along the shores remain nearly uniform throughout the year, varying from 47 to 49 degrees, which is not far from the mean temperature of this locality.

The currents caused by the wind blowing over the surface of the lake, act upon the bottom and shores, causing abrasious at some places and accumulations at others, very much as by the larger currents of the ocean. This is quite apparent at two points on the channel between the lake and the large bay at the northeast angle. The current flowing into the bay from the lake causes an eddy at these points from which are deposited long narrow bars projecting from the shore. This channel it will be seen is quite narrow and the water in it shallow.

These currents also cause accumulations of beach sand and gravel at certain points along the shore; separating and assorting the material upon a small scale, precisely as is done on a larger scale by the currents in the great lakes, and in the ocean.

While white shell marl is accumulating in some portions of the lake, soft muck resulting from the annual decay of aquatic vegetation is accumulating in others. Some of the lakes, especially those not connected with a stream of running water, are thus becoming rapidly filled with marl and peat, causing changes that become apparent after long intervals of time. Some small shallow lakes have thus been changed to meadows within the recollection of the first settlers of the county only 38 years ago.

The government plats represent some lakes in 1835, which are now only known as marshes or wet meadows. One called "Soft Water Lake," was a clean sheet of water only four years ago, but is now nearly covered with the leaves of the yellow pond lily (Nuphar) and other water plants. Soon it will cease to be known as a lake.

There are also some changes of the level of some of these lakes, indicating a less amount of water than formerly. Sand bars formerly covered with water are now dry, and in one case the bar extends quite across the lake, thus dividing it into two. Another proof of a diminished supply of water is afforded by the occurrence of ancient beaver dams in places where no pond could be formed at the present time, for want of running water.

The time may come when by the use of some simple, easily worked dredge, the marl, and muck may be removed from the bottom of some of the more important of these lakes, to be used as a fertilizer of the neighboring farms; especially as the beauty of the lakes would be increased by deepening the water, and by the consequent removal of the unsightly vegetable growth along their shallow margins.

Ice ridges are formed at certain places around the shore, some of them double, or triple, and varying in height up to ten feet. These ridges are formed by the expansion of the ice during the winter, pushing the materials of the beach in-land. They consist of sand, gravel, or boulders; in the latter case they constitute the so-called "walled lakes." If the banks are high and steep at the edge of the water, no ridge can be formed, but wherever low grounds or marshes approach the lake, they may be looked for. Where springs enter the lake, no ridges are formed, the water remaining above the freezing point all winter. Trees are often found with their roots crowded inland by the ice-expansion; their tops leaning over the water. These ridges make excellent road-beds, and are often used for that purpose.

The ancient mound-builders, that mysterious people who preceded the present Indian races, once occupied the banks of these lakes as is clearly shown by their numerous works; and they probably derived no inconsiderable portion of their subsistence from fish. No shell-heaps have been found to indicate their use of the abundance of Unio and Anodons found in these lakes. The works of the mound-builders are rapidly disappearing, being levelled by the plow of the farmer.

Besides the Unios, these lakes abound in other bivalve and univalve mollusks; crustaceans and worms, and the larvæ of insects appear in wonderful numbers. These, with the innumerable minnows found in shallow waters, afford at all times an abundant supply of food for the larger fishes. Loons, geese, ducks, gulls, plover, and many other birds swim upon the waters or wade along the margin.

Among the fishes to be found are the following:

PERCH, Perca flavescens, Cuvier.

WALL-EYED PIKE, Lucoperca americana.

STRIPED BASS, Roccus chrysops, Girary.

ROCK BASS.

STONE-ROLLER, Etheostonia.

BLACK BASS, Micropluas nigricans, Agassiz.

SUN-FISH, Pomotis.

PUMPKINSEED.

SHINER.

SHEEPHEAD, Haploidonotus grunnieus.

STICKLE-BACK, Applissinconstans, Kirtland.

PICKEREL, Esox, Lesueur.

SISCO, Argysosomus sisco, Jordan Am. Nat., 1875, p. 135, Ind. Geol. rep. 1875, p. 190.

SUCKER, Catastomus.

RED-HORSE, Plychostonus.

CAT-FISH, Amiurus catus, Cuvier.

BULL-HEAD.

BILL-FISH, Lepidosteus oxyurus, Rafinesque.

The Salmon and Brook-trout are reared artifically, and have been introduced into some of the lakes.

Young salmon (Salmo salar) and the brook-trout (S. fontinalis,) have been introduced into this lake, but so far as known they have not increased.

From the data given above one will be able to decide whether it would be advisable for the State to attempt to stock this lake with fish; and if so, the kinds best adapted to the conditions named.

The natural supply of fish has been drawn upon so heavily that the present yield is quite small, compared with what it was a dozen or more years ago; and hence the necessity of some effort for the restoration of the supply of the better kinds.

FISH-CULTURE.

BY P. R. HOY, M. D., RACINE.

It is of the first importance to ascertain the nature of the water which we desire to stock with fish, its depth, temperature and chemical character; also, the nature of the bottom, and of the shore, how supplied, and what becomes of the surplus water; what species of fish, crustacea, mollusks, annelida, and insect larvae are found in the water and in the mud of the bottom; what aquatic plants are found growing in the water, and on the margin of the lake, pond or stream. An intelligent answer to these several interrogatives would furnish data, that will enable us to escape the danger of certain failure. For it is evident to the most careless, that these conditions should agree with the instincts, habits, and way of life of the animals to be developed there. The neglect to observe, or properly appreciate these natural conditions has, in many instances, been the cause of total failure of fish culture, even when in other respects, the men have been skillful pisciculturists. All our lakes should be surveyed in the most careful manner, under the supervision of men fitted for such investigations. The paper prepared by the lamented Dr. Lapham, on Lake Oconomowoc, is a model in almost all points. It only remains for us to dredge the bottom in order to secure the lower forms of life, to ascertain their species and abundance, so that in all future time it can be known to a scientific certainty what valuable species of fish will thrive in its waters.

What species of fish are best to cultivate in order to stock our hundreds of small inland lakes? This is a question of great moment, and one that should be answered with caution in any given case. I will however in a general way state a few of the species that will be suitable for many of these charming sheets of water.

White-fish.—The genus Coregonus includes the true white-fish of the great lakes. They may be known by their blunt nose and short underjaw. These fish are, undoubtedly, superior as an article of diet to any other fresh-water fish. They feed on small crustacea and occasionally on the larvæ of insects. Whether this fish will thrive in any of these smaller lakes is still doubtful. However, it is worth the trial surely. The genus Argyrosomus includes those smaller species of whitefish, having a sharp nose and projecting underjaw. There are at least four species known, three of them are found only in the largest lakes. The fourth, the Sisco, inhabits several of the smaller lakes. There is at least one species, the Lake-herring, *a. clupeiformis*, that can be transferred to all of those lakes where the Sisco is now found. All of these small whitefish take the baited hook at certain seasons of the year. The other two species inhabit the profound depths of Lakes Michigan and Superior, and will not flourish if taken from these waters. The Salmon trout—*Salmo namaycush* is one of the largest and best of the fresh water salmon; a species that is one of the easiest to propagate artificially, the egg being large and hardy. We have many lakes, undoubtedly, where this great gamefish would multiply and be at home. Why should we be running after strange gods, when we have such a treasure at home? At Racine and Milwaukee the egg can be procured in any numbers desired.

The so-called brook-trout *(Salmo fontinalis)* are just the thing for ponds supplied by free flowing springs of pure cold water. For this purpose they have no equal, bnt it is probable that it would be hardly expedient to use this species for stocking public waters. There is a species of salmon that has lost the instincts of its distant relation, the *salmo salor,* so that it has no longer a desire to visit the ocean. The " land-locked salmon" *(Salmo sebago)* is not quite one half as large as the salmon trout, but is an excellent game fish; one that will thrive in a number of the lakes. We have quite a number now in the State of Wisconsin, and hope soon to be able to stock some of the lakes with this fish. The black bass *(Micropterus nigricans and M. Salmoides)*, are excellent fish, but difficult to propagate in consequence of their eggs having a mucous coat that causes them to adhere in packets. There is an interesting paper published in the U. S. Fish Commissioners Report, for 1872 and 1873, on page 567, by Rudolph Hessel, of Germany, " On methods of treating adhesive eggs of certain fishes in artificial propagation." Hessel, it is hoped, has struck the right method, and we hope that in a short time we shall be able to propagate bass, and especially the European Carp, *(Cyprinus carpio and other species)* which deposits her eggs on the underside of submerged aquatic plants, only an inch or two under the surface of the water. The Carp is extremely tenacious of life, but flourishes in shallow lakes with muddy bottom and partly filled with vegetation. We have numerous lakes of this discription where the bass will not thrive, but where all the conditions are favorable for the healthy development of the Carp. I look with great hope in that direction. Prof. Baird will secure abundance of Carp spawn as soon as it is proven that we can manage them artificially. When you can go with hook and line and bag ten pound specimens of that most desirable fish, the carp, then you will feel like thanking the men who have so persistently persevered in investigating every condition that can secure benefits so great. These waters that now produce so slender a supply of ordinary fish, then will teem with the best; such as but few men can now afford to eat.

NOTES ON THE GEOLOGY OF NORTHERN WISCONSIN.

BY E. T. SWEET, M. S.
Assistant on the Geological Survey of Wisconsin.

During the summer months of 1873 and 1875, I was occupied, mainly in northern and northwestern Wisconsin, assisting in the prosecution of the field-work of the State Geological Survey. The greater part of the season of 1873 was devoted to an examination of the Penokie Iron Range, including incidental observations upon the geology of Ashland county, under the direction of Professor Irving. Late in the season I received instructions from our lamented chief geologist, Dr. Lapham, to examine and report upon the "Copper Ranges" of Douglas county. My visit to the northern part of the State during the season of 1875 consisted of a reconnoisance of northern Wisconsin, under the direction of Dr. Wight, the State Geologist. Canoe-trips were made from St. Croix Falls, nearly to the source of the St. Croix river; from the head of the Chippewa river to Chippewa Falls; from Jenny up the Wisconsin and Pelican Rivers, and from Post Lake down the Wolf River to Shawano. The total distance traveled by the party, during two months, mainly upon these streams, was about 700 miles.

The main results obtained in Ashland and Douglas counties the first season, have already been made public by Professor Irving, through the second volume of the Transactions of the Academy. I wish to call particular attention to the Professor's paper on "Some Points in the Geology of Northern Wisconsin," and to the conclusions reached by him; for, in many respects, this paper may be considered merely a supplement to that. His general conclusions will be accepted and quoted without reiterating the proof upon which they are based. Several points alluded to in his paper, I wish to still further elaborate in connection with the presentation of facts which were observed for the first time during the reconnoissance. In this paper I shall especially discuss the main features in the geology of the region immediately bordering the St. Croix river from St. Croix Falls to the head of that stream, and shall also frequently refer to other localities in northern Wisconsin and Michigan, in order to present new facts, or to quote those already known, which bear upon points in the geology of the above mentioned district.

Four great geological formations are represented in northern Wisconsin.

1. Granitic and gneissic rocks supposed to be the equivalents of the Canadian *Laurentian.*

2. The *Huronian* magnetic schists, quartzites slates and diorites.

3. A great variety of rocks lithologically distinct, among which are diabase, melaphyres, porphyries, conglomerates, shales and sandstones, known as the *Copper Bearing Series.*

4. The *Lower Silurian Sandstones.*

Of these formations, the Laurentian and Huronian are not known to occur in the vicinity of the St. Croix River. The first probably will not be found nearer than twenty-five or thirty miles to the St. Croix, while the existence of the second, as shown below, may be proven much closer to that stream.

1. *Laurentian.*—The rocks of this, the most ancient geological age of which we have any knowledge, although very interesting to the geologist, are in northern Wisconsin of comparatively little importance. In this state we have no evidence of the occurrence of useful minerals in these rocks, in anything like workable quantities. Gold, however, has been reported in very small quantities from Oconto county. Professor Irving reports traces of gold and silver in quartz from Clark county, which is probably of this age. The Laurentian rocks are usually granites, passing through the fine and medium grained to very coarse grained varieties. Rocks of this age, with a single exception, were found to occur the entire distance passed over in the reconnaissance of the Chippewa, Wisconsin, Pelican and Wolf Rivers. Upon the Chippewa and and Wisconsin Rivers, numerous exposures of syenitic and hornblende rocks occur interstratified with granite and gneiss rocks. The bedding of the strata along these streams can usually be determined with a great degree of certainty. A remarkable uniformity in the strike of the rocks of this region has been proven to exist. There is scarcely an exposure along the banks of the Chippewa or Wisconsin upon which the strike can be made out, that does not fall within the arc included between north sixty degrees east and

east and west. The dip is always at a high angle either to the north or south.

The Laurentian rocks of Wolf River are very uniform in character. From Post Lake to Keshena, a distance of about seventy-five miles, the rocks are all exceedingly coarse grained feldspathic granite. The crystals of orthoclase are often several inches across. Biotite, a variety of black mica, appears to be a characteristic of these rocks. At localities it is the exclusive variety of mica found. At Post Lake dam, on section 9, town 33, range 12 east, a ledge of hornblendic schist gives a strike of north, fifty degrees east. With this exception no undoubted strike or dip was observed in the rocks in the vicinity of Wolf River. A few miles above Keshena the surface of the granitic fields has been worn by glacial action into knolls and knobs which present the characteristic appearance of "Roches Montonnees." Large boulders of uniform, coarse grained granite are of frequent occurrence in the channel of Wolf river from Post Lake dam to Keshena. Many boulders also, of immense size have been transported from this region, far to the southward, and deposited in Waushara and adjoining counties.

Huronian.—Several new and interesting points showing the relationship between the Laurentian and Huronian formations were observed at Penokie Gap, by Mr. C. E. Wright, of Marquette, Michigan, and myself, during the season of 1875. We spent nearly three days at the "Gap" and succeeded in making several important additions to the geological section of the "Range," taken two years before at that point, by Professor Irving and myself. The section referred to accompanies Professor Irving's manuscript report on the Penokie Range now in the office of the Secretary of State. It extends from the fine grained white quartz and siliceous slates on the south to the massive diorites on the north, a distance across the formation, at right angles to the dip, of about four thousand feet. Mr. Wright and myself extended this southward a short distance to the Laurentian gneiss and granite, and northward over two thousand feet, probably to the lowest member of the Copper-Bearing Series.

The junction between the Laurentian and Huronian is in the southern part of section 14, town 44, range 3 west. At this point Bad River passes through a narrow gorge having nearly vertical walls on either side. In the left or northern wall of the gorge, fine grained white quartz with a vitreous coating and slaty siliceous schist occur, showing a strike nearly east and west, and dip of sixty-six degrees to the north. The quartz represents the lowest member of the Penokie system examined by the party in 1873. Upon examining the opposite wall of the gorge siliceous marble was discovered for the first time to be one of the beds of the Penokie system, lying below the iron bearing beds.* A similar arrangement has long been known to exist in the Huronian of the Marquette district, which has led to the suspicion of its existence in Wisconsin. The thickness of the siliceous marble is about fifty feet. It is usually fine grained and grayish in color. Small crystals of calcite and dolomite however can be observed irregularly disseminated. An analysis of a specimen taken from the ledge afforded me the following result:

	Per cent.
Carbonate ot Lime	50.52
Carbonate of Magnesia	33.41
Insoluble Matter	13.85
Oxide of Iron	1.70
Undetermined	.52
Total	100.00

The analysis shows that the proper name for the rock is siliceous dolomitic marble. In the Marquette region the Morgan furnace limestone but very little purer than this has been extensively used as a flux. One hundred feet southeast from the exposure of siliceous marble, there is a large ledge of gneissoid granite showing a well defined dip ot seventy-seven degrees to the south, and strike of north, seventy-five degrees west. In following the strike west, one passes within twenty-five feet of the outcrop of siliceous marble which has a northerly dip. Between one and two hundred feet south, on the line of the railroad, other large exposures of gneissoid granite are found having essentially the same bedding as that mentioned above. When the railroad cut is completed at this locality, the absolute junction of the Laurentian and overlying Huronian will doubtless be exposed. There can be no doubt of the unconformability of these formations, approaching each other as

* I will say in this connection that the facility for making observations at this locality have been greatly increased since Professor Irving's examination of the "Gap." Excavations have been made at the gorge for a railroad bridge and the earth and roots which formerly overhung the face of the wall removed. The rocks are now plainly exposed and are easily accessible.

they do with a persistent opposite dip and somewhat different strike. Unconformability has been shown to exist between the Laurentian and Huronian in Michigan, but this is the first time that it has been proven in Wisconsin. Northward from the granites the section has been completed for over sixteen hundred feet. In this space are included two "magnetic ore" beds, the southern one hundred and thirty and the northern over five hundred feet thick. Directly above or north from the northern "ore" bed there is a space of fourteen hundred feet upon which exposures have not been found. Above this blank, recent railroad excavations enabled Mr. Wright and myself to subdivide and extend the belt of four hundred feet, supposed to be the uppermost member of the Penokie system, into: a. siliceous schists, one hundred feet; b. blank, (Bad River,) seventy-five feet; c. contorted black slate, two hundred and fifty feet; d. diorites, seventy-five feet; and e. black porphyritic slates, fifty feet.

Owing to the heavy deposits of drift we were unable to find exposures for thirteen hundred feet north from the black porphyritic slates.

We then found what are probably the latest beds of the Huronian formation, g. black slate, forty feet, h. quartzite, about two hundred and fifty feet, i. slaty amygdaloid seventy-five feet.

The thickness of the formation, I estimate at something over five-thousand feet. The dip is about sixty-six degrees to the north showing entire conformability throughout.

It will be observed from this brief outline of the geological section at Penokie Gap, that there are two important belts left blank. There is no attraction of the needle upon either, which would lead one to suspect the presence of magnetic deposits. But the red or hematite ores have no influence on the magnetic needle, they are soft and easily worn away, and never outcrop naturally in the Marquette region. Consequently although not exposed on the Penokie range they may yet be found in one of these blank spaces. Representatives of most of the beds of the Marquette system occur at Penokie gap. This is a strong argument in favor of the existence of the soft or hematite ores in the unexplored belts of the Wisconsin Huronian.

An accurate geological section ought to be constructed entirely across the Penokie Range at some point from the granites on the south to the undoubted Copper-Bearing Series on the north, even should it be found necessary to do a little testpitting in order to expose representatives of each member of the system.

A new quartzite locality was discovered on section 6, town 32, range 6, west, during the descent of the Chippewa. It forms a hill about three hundred feet in height, and three or four miles in circumference. The lowest stratum of the formation is reddish metamorphic conglomerate, having a thickness of three hundred feet. The pebbles are seldom over an inch in diameter and are either jasper or amorphous quartz. The matrix consists of reddish grains of quartz. Above the conglomerate is a bed of reddish quartzite four hundred feet thick. The grains of quartz of which the layers are composed are much more distinct than in specimens of quartzite from the Baraboo Hills of Sauk county. Also the rock has a much deeper red color than most of the Sauk county quartz. A depression in the side hill one thousand feet across, comes in above this quartzite upon which exposures were not found. The space is probably occupied by some softer rock than quartzite. Above this arises the main hill of quartzite. In every respect the rock is similar to that mentioned above. The entire thickness of the formation is not far from five thousand feet. Both the conglomerate and quartzite are distinctly and heavily bedded. The strike is north twelve degrees, west, and the dip sixty degrees to the west. Careful observations were taken with the dip compass, and also with the magnetic needle, with a view to discovering magnetic ore deposits. No undue attraction, however, was observed.

One and three-quarters miles from the exposures of quartzite, syenitic granites which may be assumed Laurentian in age, were found in the banks of the Chippewa striking north, fifty degrees east, and dipping high to the north. From the persistency of the strike here and at Little Falls, two miles below, it may be assumed that the quartzites and conglomerates unconformably overlie the Laurentian granites and syenites.

No evidences were observed along the Wolf River, of the crossing of that stream by the Huronian.

3. *Copper-bearing series.*—The only examinations upon the Copper-Bearing Series during the reconnaissance, were made in the ascent of the St. Croix River. At St. Croix Falls there are several well defined ridges of Copper-Bearing rocks trending east north east. It is not known, however how far to the eastward they ex-

tend. Neither has their relationship to the Lake Superior Copper-Bearing System yet been made out. The bedding, if it exists, is very indistinct. Across the formation at right angles to the apparent strike, the distance is between four and five miles. In lithological character the rock differs from any I have noticed in the Lake Superior region. It is usually very fine grained, dark gray in color, and is apparently made up of feldspar, hornblende and quartz. Some varieties are porphyritic, other amygdaloidal. At the falls and dalles of the St. Croix these rocks are largely exposed. A mine at Taylor's Falls, near the dalles, has been worked to a considerable extent in this rock for metallic copper. It is said encouraging results have been obtained.

After leaving the St. Croix Falls range, nothing more is seen of the copper-bearing rocks along the river to a point thirty miles north from the Falls. A short distance north of the mouth of Snake River Cupriferous rocks again come in. They are mainly melaphyrs and amygdaloids, and are overlaid by horizontal beds of light colored Potsdam sandstone. A few miles to the north, conglomerates and reddish shales conformably overlie the Cupriferous strata. The dip, so far as can be made out, is slight, and to the northwest. The conglomerate is heavily bedded, but does not cover the melaphyrs and amygdaloids at all points. It appears rather to fill pockets and depressions in the underlying rocks than to be intrstratified with them. The pebbles of the conglomerate are usually very large, some of them being over a foot in diametor. They have all evidently been derived from the underlying Cupriferous rocks. The matrix consists of reddish grains of quartz, similar to the Lake Superior sandstone. A short distance above the mouth of Kettle River, the most northern exposure of the Kettle Kiyer range is found. Across the formation at right angles to its trend, the distance is four and one half miles. Copper has been discovered and locations have been marked upon this range near the St. Croix River. The conglomerates and shales associated with the melaphyrs and amygdaloids of the Kettle River range occupy the same stratigrapical position, and are in every respect, except in the degree of inclination, similar to those of the copper range of Ashland county, exposed on Bad River at the mouth of Tylers' Fork. On Bad River the dip is nearly vertical to the northwest, while on the St. Croix it is but a few degrees in the same direction. Between these localities the upper conglomerates and sandstones accompanying the Copper-Bearing series have not been seen. For asserting that they are the representatives of each other—I have among others, the following reasons:

1. Cupriferous strata have been traced uninterruptedly from the extreme end of Keweenaw Point to Long Lake in Bayfield county, a distance of over 200 miles. The apparent thickness of the formation is never less than 20,000 feet, and is often even 60,000 feet. Fifteen miles west from Long Lake, Dr. Wight found the Cupriferous series represented at the Eau Claire Lakes. From here, in the same general southwesterly direction, the distance to the out-crops on the St. Croix is about 60 miles. Exposures of "trap-rocks," have been reported by explorers at numerous localities between the two points. There can be no doubt then, that the Kettle River Range is merely a westward prolongation of, and is directly connected with, the "mineral range" of Keweenaw Point, upon which the most famous copper mines of the world are located. From facts which have been obtained mainly from explorers, and also from Dr. Owen's report, I am satisfied that the range extends forty or fifty miles into Minnesota before it is covered by later strata.

2. The region has been very little examined, and the conglomerates might escape observation.

3. There is probably a gradual thinning out of the conglomerates towards the west. At the mouth of the Montreal River, the conglomerates and interstratified sandstones and shales have a thickness of 10,000 feet, while on Bad River, but eighteen miles to the west, the exposed thickness is but a few hundred feet. On the St. Croix River the thickness is still less. Owing to this thinning out they have been largely removed by erosion.

Northeast from the Kettle River range there is a space of forty miles along the St. Croix River, although only about four miles at right angles to the trend of the formations, upon which rocks in place were not observed. At Sawyer's dam, on section 16, town 42, range 14, west, southward dipping sandstones and shales were found. For fourteen miles along the stream, in a southeast direction, the strike and dip are very persistent. The strike corrected for variation is north sixty degrees east, and the dip fourteen degrees to the southeast. The greatest horizontal distance across the formation is three miles. A trigonometrical calculation therefore gives 3,949 feet for the thickness of the bed. The sandstone is reddish, fine grained and argillaceous. Flakes and concretions of indurated reddish clay are of frequent occurrence in the layers. The most northern exposure is near Chase's dam on section 36, town 44, range 13, west. Above here, on the St. Croix, no rock in place has been found. Two localities of southward dipping sandstone are known in Ashland county—the first at Lehigh's, on Bad River, where the thickness is 2,000 feet, and the second twelve miles southwest from Lehigh's—at Welton's, on White River—where only a few hundred feet are exposed. Owen, in an old executive document, reports southward dipping sandstone, at the head of White River, twenty miles still farther southwest. From here it is only 32 miles in the direction of the general trend of the formation to the southward dipping sandstones of the St. Croix, at Chase's dam. It is therefore probable that the bed extends entirely across the State from the St. Croix River to Lake Superior, entering the Lake at the mouth of the Montreal River. Owen reports southward dipping sandstones in Minnesota, on Kettle River, six miles above the falls of that stream. These exposures may be a westward continuation of the same bed.

The southward dipping sandstones and shales, form with the northward dipping sandstones, shales and conglomerates, a synclinal extending entirely across the State, the opposite edges of which approach on the west within four miles of each other, but on the east are separated by eight or nine miles. From this fact and others to be given, the conclusion may be assumed that the northward and southward dipping beds are the equivalents of each other. As both are largely represented on Bad River, and, moreover, as it was upon that stream that the southward dipping bed was first observed, I propose the name of *Bad River sandstone* for these, the upper beds of the copper-bearing series.

4. *Lake Superior sandstone.*—This term is generally employed to designate the reddish aluminous sandstones which nearly everywhere border the south shore of Lake Superior. They also form the basement rock of the Apostle Islands. They have never been found in a tilted condition. The interesting question of their age has been ably discussed by numerous writers upon the geology of Lake Superior. Without commenting upon the opinions which have been advocated upon this subject, some referring them to the

Triassic, others to the Potsdam, we may regard the question as definitely settled by the investigations of Dr. Rominger, of the Michigan Geological Survey, and others, that they are the downward continuation of the light colored Potsdam sandstones of the Mississippi valley. No fossils have ever been obtained from these sandstones. In the eastern part of the upper peninsula of Michigan they are found directly underlying light colored sandstones and Calciferous strata. A large area of Lake Superior sandstone extends southwesterly from Keweenaw Bay nearly to the Montreal River. The distance from the western end of this area to the exposures of horizontal red sandstone on the Wisconsin shore of Lake Superior is about 30 miles. From their proximity to each other, and also from a similarity in lithological characters, and in stratigraphical relations to the underlying formations, it may be asserted that the red sandstones skirting the lake shore from near Ashland to the St. Louis River, at the western end of the lake, and those of the Apostle Islands, are of the same age as those east of Keweenaw Point.

Upon the St. Croix River the Lake Superior sanestone does not occur. Only the light colored Potsdam and Bad River sandstones are represented upon that stream. It has been shown by Professor Irving that the dipping sandstones, shales, and conglomerates, associated with the Cupriferous rocks, very much ante-date the horizontal sandstones of Lake Superior in age. This being the case no satisfactory evidence can be drawn of the age of the horizontal sandstones from the stratigraphical relations which occur in the vicinity of the St. Croix River. The conclusions of Dr. Owen upon the "Age of the Lake Superior Sandstones," are based mainly upon the fact that the Bad River sandstones dip beneath, and are overlaid by light colored Potsdam sandstones. He did not realize that there is a vast difference in age between these and the true Lake Superior sandstone. There is no known locality west of Keweenaw Point, where the Lake Superior sandstone and Potsdam of the Mississippi valley are not separated by many miles.

The Lake Superior sandstones usually contain a large per cent., of alumina and sesquioxide of iron, which it has been observed were derived from the wearing down of the highly aluminous and ferruginous Copper-Bearing rocks.

The following analyses, made by me for the State Geological Survey, show at a glance, the change in chemical composition which has taken place in the process of the formation of the sandstones from the Cupriferous rocks:

	No. 1.	No. 2.	No. 3.	No. 4.
Gravity	2.92	2.69	2.43	2.18
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Silica	48.28	53.69	69.78	87.02
Alumina	17.35	22.10	15.43	7.17
Peroxyd of Iron	11.43	8.53	7.93	3.91
Protoxyd of Iron	4.02	3.65	....	....
Lime	6.27	4.31	.49	.11
Magnesia	6.58	2.09	1.17	.06
Potassa	1.14	1.39	2.64	1.43
Soda	1.83	1.99	2.42	.22
Water	2.66	2.61	Trace	Trace
Total	99.56	100.36	99.86	99.92

No. 1. (239, of the survey collection) is a fine-grained greenish gray diabase, from the Fond du Lac copper mine, Douglas county. It contains a trace of metallic copper. No. 2, (40 of the collection), is brownish-black melaphyre from the Ashland copper mine, near the mouth of Tyler's Fork, Ashland county. No. 3, (44) is coarse grained, reddish, Bad River sandstone, from Lehighs, Bad River. Crystals of feldspar can easily be distinguished in the specimen. No. 4. Typical Lake Superior sandstone from a large quarry on Basswood Island, Lake Superior. It is extensively used as a building stone. The material for the walls of the Milwaukee courthouse was obtained from this quarry.

5. *Potsdam sandstone.*—At St. Croix Falls, Potsdam sandstones, characteristic of the light-colored Primordial sandstones of the Mississippi valley, come in contact with the Cupriferous rocks at numerous localities. At the Falls they are usually fine-grained, and are also of ten aluminous and somewhat shaly. The shaly beds are often highly fossiliferous. Dr. Owen states that at St. Croix Falls, "the oldest Palaeozoic fossils of this continent, if not of the world, are found." At the western end of the old St. Croix dam about one half mile above the village of Taylor's Falls any number of shaly slabs may be obtained almost entirely made up of

large Lingulas. Fossils are also numerous at other localities. At Osceola, six miles from the Falls, trilobite fragments are especially abundant. Among others, I was able to detect the following: *Conocephalites binodosus. C. diadematus*, *Illaenurus quadratus, Agnostus disparilis,* and *Dikelocephalites osceola.* Associated with them is a very large gasteropod, believed to be new to science..

Dr. Owen, whose observations only have been published upon the geology of the St. Croix, considered the crystalline rocks at the Falls and Dalles of the St. Croix, of igneous origin, and of more recent age than the contiguous sandstones. I submit the following reasons for differing with him upon the question of age:

1. So far as can be determined, the sandstones are perfectly horizontal, and show no signs whatever of ever having been subjected to igneous or metamorphic action, or even of ever having been in contact with highly heated rocks.

2. Horizontal layers of fossiliferous sandstone occur a few feet from Cupriferous rocks, and in two instances perfect specimens of *Obolella polita* and *Lingulepis pinnaeformis* were found in a film of sandstone, not over one eighth of an inch from the absolute base of the formation at those points. In other instances shells were obtained from sandstone largely made up from the unaltered grains of the underlying formation. These shells certainly would have been destroyed, thus near highly-heated rocks.

3. Depressions and pockets in the surface of the Copper-Bearing rocks are often found filled or partially filled with horizontal layers of sandstone.

4. Grains from the crystalline rocks appear in the layers of sandstone at a distance of several rods from ledges of the former, thus showing that part of their material at least was derived from the Copper-Bearing rocks. The layers of sandstone were deposited therefore after the Cupriferous strata had assumed nearly their present condition.

Occasional outcrops of the Potsdam occur along the banks of the St. Croix for nearly forty miles above the Falls. A short distance below the mouth of Kettle River, on section 16, town 39, range 19 west, the most northern exposures of light colored sandstone were found. The outcrops are in the banks of the stream from ten to forty feet above the surface of the water. They are underlaid by melaphyrs, amygdaloids, conglomerates and fragments of aluminous red sandstone. Owing to the haste with which the expedition moved, the actual junction was not observed.

The Lake Superior Synclinal.—Foster and Whitney first painted out the existence of a synclinal between Keweenaw Point and Isle Royale. Professor Irving has suggested that this extends into Ashland and Bayfield counties. I think it has been pretty satisfactorially shown in this paper that it extends uninterruptedly westward, entirely across the state of Wisconsin, and enters the state of Minnesota. A general geological section across the formations represented upon the upper St. Croix, is very similar to one from Lehigh's, on Bad River, extending southeasterly across the formations to the Penokie Range. Starting from Chase's dam on the St. Croix, and from Lehigh's, on Bad River, the formations to the south are as follows:

1. A bed of southward dipping sandstones. About four thousand feet are exposed on the St. Croix, and two thousand on Bad River.

2. Trough of the synclinal; four miles across at the St. Croix, and about nine, in the vicinity of Bad River. Lake Superior sandstone may fill the trough of the syuclinal. At present only one small exposure of horizontal red sandstone is known to occur in it.

3. Northward dipping sandstones, shales and conglomerates. On the St, Croix they are but a few feet thick; on Bad River probably 1,000 feet are exposed; at the mouth of the Montreal the thickness is fully 10,000 feet.

4. Amygdaloids, melaphyrs, porphyries, etc. On the St. Croix the dip is slight to the northwest. Across the belt, the distance is four and one half miles. At the Montreal River the distance across the formation is about ten miles, and as the dip is nearly vertical, the apparent thickness is, in round numbers, 50,000 feet. If the rocks are of igneous origin, it is not difficult to account for this seemingly enormous thickness.

In Douglas and Bayfield counties, the Copper-Bearing strata have a dip to the south, and probably conformably underlie the southward dipping Bad river sandstone. If this is the case they are the representatives, in the northern edge of the synclinal of the Ashland and Burnett county copper series. The distance across the formation in Douglas county is about 30 miles; allowing a dip of fourteen degrees, which is that of the sandstones on the St. Croix, the thickness is not far from 40,000 feet.

The dimensions of the Lake Superior Synclinal, as thus made out, are simply enormous. It is over 300 miles in length, and from 30 to 50 miles in width. Over 4,000 square miles of territory are occupied in Wisconsin alone, by rocks belonging to its northern or southern edge. It can only be compared to an extensive, inverted range of mountains.

Westward extension of the Penokie range.—The Penokie system lies directly below, or geographically, south, from the Copper-Bearing series. The two formations are intimately connected, the strike and dip conforming throughout. The eastern end of the Penokie Range is near Lake Gogebic, in Michigan, nearly 100 miles from the famous Marquette iron region. It extends westerly without break to a point seven miles west from Penokie Gap. In Ashland county it forms a bold, high ridge, over thirty miles in length, and never more than two miles in width. In the western part of the county the range appears to break down and become lost for a distance of ten miles, when it appears again at two localities near Atkins Lake. The question of its westward extension from Atkins Lake, is one of great economic as well as of scientific importance. The country between the supposed end of the range and the St. Croix River has never been visited by a geologist. On account of its poverty in pine, it is comparatively unknown to woodsmen and explorers. That the formation does extend westward, probably to the vicinity of the St. Croix, I have strong presumptive evidence, but of course not absolute proof. I do not intend to assert that the Huronian belt extends uninterruptedly from the Penokie Range to the St. Croix. On the contrary, it has doubtless been subjected to extensive denudation, and large portions of it may no longer remain. Large sections of it are probably buried deep beneath accumulations of drift. The space of ten miles between the western end of the main range and the outcrops near Atkins' Lake, has been largely removed by erosion. but it is more than probable that below the deposits of drift the downward extension of the members of the system may still be found. The arguments in favor of the westward continuation of the Huronian schists in a more or less interrupted belt, are the following:

1. The westward extension, to the St. Croix River, of all the formations found north of the Penokie Range to Lake Superior.

2. If the iron bearing belt extends westward, it doubtless follows the southern boundary of the Cupriferous formation. It would therefore cross the St. Croix River some distance below the mouth of Snake River. Then, in the neighborhood of a line drawn from the mouth of Snake River to Penokie Gap, one would expect to find indications of the Huronian magnetic schists. Iron ore is reported in place, at several localities in the vicinity of this line. Explorers report its occurrence near the southern end of Long Lake, also on section 18, town 43, range 19 west, and from the northern part of Burnett county. On the original survey plat of town 38, range 19 west, I find on section 19, topographical lines indicating a ledge, and the words "iron ore." The locality has not been examined by members of the Geological Survey.

3. The non-occurrence of ranges or marked ridges in the St. Croix country may be cited in this connection, and reasons given why they should not be expected. In the eastern part of Ashland county the high ridge formed by the Penokie range is due to the nearly vertical dip of the strata. As the formation of northern Wisconsin extend westward the dip gradually decreases and they more nearly approach horizontality. Brooks reports the dip of the Huronian schists in the vicinity of Black River in Michigan, sometimes as great as 90°. At the gorge of Tyler's Fork I found the dip 75° to the northwest. At Penokie Gap the dip is 66° while at Atkins Lake the inclination is only 45° to the northwest. The upper members of the Copper-Bearing series, which have an almost vertical dip on the Montreal River and at the mouth of Tyler's Fork, have only a slight dip to the northwest on the St. Croix River. At Lehigh's, on Bad River, the southward dipping sandstones incline 38° to the southeast. At Welton's the dip is 25°, while on the St. Croix it is but 14° to the southeast. *As the formations approach the St. Croix they do not form bold ridges, but cover a much wider extent of territory than in the eastern part of the State*, and consequently the opposite edges of the synclinal are found much closer to each other than farther eastward.

4. The occurrence of small angular boulders of magnetic rock and iron ore in the drift at numerous localities in Polk and Burnett counties.

In Michigan, and in all regions where magnetic ore is found much reliance in exploring is placed upon magnetic surveys. Valuable mines have been discovered by noting the abnormal deflection of a delicate magnetic needle in crossing the formation at right angles to its trend. This method often succeeds when the dip compass fails. Although magnetic surveys have not been made in the region under consideration, linear surveys have, and the variation at several points upon each section recorded upon the township plats. In the township through which the Huronian belt is supposed to pass, the difference between the maximum and mimi, mum deflection of the needle from the magnetic meridian is much greater than in townships known to be distant from local magnetic influences. For instance, in township 37, range 20 west, the difference is 5 degrees, 30 minutes. Numerous other examples might be mentioned. The fluctuations of the needle from a fixed point under ordinary circumstances, and in ordinary townships, is not usually over one or two degrees. Investigations with a dip compass, and with an instrument for making accurate magnetic surveys, will certainly settle the question of the western prolongation of the magnetic schists. It will be necessary to go over a considerable portion of Burnett county, the southwest of Ashland, and southeast of Bayfield, and possibly the northern part of Polk very carefully. It is an important question, worthy of thorough investigation, and one which should be definitely decided as soon as possible by the Geological Corps.

ON THE RAPID DISAPPEARANCE OF WISCONSIN WILD FLOWERS; A CONTRAST OF THE PRESENT TIME WITH THIRTY YEARS AGO.

BY THURE KUMLEIN.

For the last thirty-two years I have resided in the vicinity of Lake Koshkonong, in Jefferson county, Wisconsin, and have during that time paid some attention to the Fauna and Flora of that locality, and have collected somewhat extensively in nearly all the branches of Natural History, particularly Ornithology and Botany.

When first I came here in 1843, a young and enthusiastic naturalist, fresh from the university at Upsala, Sweden, the great abundance of wild plants, most of them new to me, made a deep impression on my mind, but during these thirty-two years a large number of our plants have gradually became rare and some even completely eradicated.

When first I visited the place where I now live, the grass in the adjoining low-lands was five and six feet high, and now in the same locality, the ground is nearly bare, having only a thin sprinkling of June grass, Juncus tenuis and J. bufonius, Cyperus Castaneus, here and there a thistle or a patch of mullein and in the lowest with parts some Carices. As the land gradually became settled, each settler fencing in his field and his stock increased, some plants became less common, and some few rare ones disappeared; Lupinus perennis, among the first. But when all the land was taken up by actual settlers, and each one fenced in all his land and used it as fields or as pastures for as many cattle, horses, sheep, and hogs as could live on it without actual starvation, botanizing in this vicinity became comparatively poor.

In the oak openings, besides grasses of several species there were an abundance of other plants of which I will mention only some Orchids from a small piece of opening-land near my residence: Pogonia, pendula, Goodyeara pubescens, Corallorhiza odontorhiza, Aplectrum hyemale, Liparis lilifolia, Orchis spectabilis and Plalanthera bracteata, of these only one or two can be found in the same locality now.

In the thick timber along the Koshkonong Creek, there is now but one lot of about 40 acres where the plants can yet be found nearly as abundant as formerly. There can yet be had Phlox divaricata, Laphami. Allium tricoccum, Erythronium albidum, Dentaria laciniata, Asarum canadense and many other interesting plants. A Tamarack marsh held out the longest; it was not visited by cattle till, for want of pasture elswhere they were obliged to cross its miry borders. In this marsh, or on its borders, were formerly growing, Microstylis ophioglossoides, Liparis lœselii, Gymnadenia tridenta, Platanthera leucophoea, lacera and orbiculata, Arethusa bulbosa, Pogonia ophioglossoides, Calopogon pulchellus, Cypripedium pubescens, Parviflorum candidum and spectabile, Tofieldia glutinosa, Drosera linearis, Lobelia kalimi, Ophioglossum vulgatum, Schoenus albus, Schenchzeria palustris, Triglochin palustre, and many Carices among which Carex oligosporma. Now of all these and many other interesting plants formerly growing in this marsh or near it some have become very rare and some are totally eradicated.

On a small prairie, too stoney and gravelly for cultivation, there can yet be found Geum triflorum, Aster obtusifolius and ptarmicoides, Lithospermum hirtum and longiflorum, Castileja sessiiflora, Linum boothi, Gentiana puberula, Ranunculus rhomboideus, Hieracium longipilum, Draba caroliniana, Arubis lyrata, Arenaria, stricta, Mich. and Diplopappus which on gravel hills grows only two to three inches high, with leaves very stiff and narrow, but the flower large, having somewhat the aspect of an Alpine plant. A list of the plants of this vicinity, giving the plants of to-day, would be a comparatively meagre one and nearly useless, as their number is lessening every year, and a list of the plants of thirty years ago would perhaps have no other than a small historical value.

These observations, though made in only this locality, do probably apply to all the settled portions of the State.

ON THE ANCIENT CIVILIZATION OF AMERICA.

BY PROF. W. J. L. NICODEMUS, A. M., C. E.

The ancient works divide themselves into three great geographical divisions, viz., South America on the west coast between Chili, and the second degree of north latitude; Central America and Mexico, and the valleys of the Mississippi and Ohio.

The ruins of ancient Peru, which form the first division, are found chiefly on the elevated table-lands of the Andes, between Quito and Lake Titacaca, but they can be traced five hundred miles further south to Chili and throughout the region connecting these high plateaus with the Pacific coast. The entire district extends north and south about two thousand miles.

Before the Spanish conquest the whole country was the seat of a populous and prosperous empire, rich in its industries and far advanced in civilization. It is now accepted that the Peruvian antiquities represent two distinct periods in their ancient history, one being much older than the other, one before and the other after the first Inca. Among the ruins which belong to the older civilization are those of Lake Titicaca, old Huanaco, Tiahuanaco, and Gran-Chimu, and probably the roads and aqueducts were originated by it. On Titicaca Island are the ruins of an edifice supposed to be a palace or temple. It was built of hewn stone, and had doors and windows, with posts, sills, and thresholds of stone. At Tiahuanaco, a few miles from Lake Titicaca are what are supposed to be the oldest ruins in Peru. They are described by Cieca de Leon, who accompanied Pizarro. He mentions great edifices "that were in ruins," two stone idols resembling the human figure, and apparently made by skillful artificers." These idols were great statues, ten or twelve feet high. He describes large gateways with hinges, platforms, and porches, each made of a single stone, some of which were thirty feet long, fifteen high, and six thick. Along the whole length of some above the stone ran a cornice covered with sculptured figures. "The whole neighborhood," says Mr. Squier, "is strewn with immense blocks of stone, elaborately wrought, equalling, if not surpassing in size, any known to exist in Egypt or India."

At Cusco, about two degrees north of Lake Titicaca, are the ruins of buildings that were occupied until the rule of the Incas was overthrown. The Temple of the Sun was surrounded by a great wall built of cut-stone. Near by this is the extensive ruins of the palace of the Incas. The objective points to notice about both these periods of ancient civilization are, the absence of inscription; little or no decoration; method of building peculiar; their constructions including cities, temples, palaces, other edifices of various kinds; fortresses, aqueducts, (one, four hundred and fifty miles long,) great roads, (extending the whole length of the empire,) and terraces on the sides of mountains, built of cut-stone laid in mortar or cement, sometimes ornamented, but generally plain in style and always massive.

The Peruvians were highly skilled in agriculture and in some kinds of manufactures. They excelled in the arts of spinning, weaving, and dyeing. They had great skill in working metals; especially gold and silver. They excelled in the manufacture of articles of pottery. They had some knowledge of engineering as evidenced by their roads and aqueducts. They had some idea of astronomy. They divided the year into twelve months; and are supposed to have had something in the form of a telescope for studying the heavens, as a silver figure of a man holding a tube to his eye, has been discovered in one of the old tombs.

MEXICO AND CENTRAL AMERICA.

We now come to our second geological division, Mexico and Central America. Here we trace four distinct eras of civilization, which we will mark by describing a ruin belonging to each era. In the order of antiquity comes Quirigua. It is situated on the right bank of the River Motagna, in the State of Guatemala. It covers a large area of ground. We have described a pyramidal structure with flights of steps, and monoliths larger and higher than those at Copan. Though the sculptures are in the same general style, they are in lower relief and hardly so rich in design. One of the obelisks is twenty feet high, five feet six inches wide, and two feet eight inches thick. The chief figures carved on it are a man and woman on the front and back, while the sides are covered with inscriptions similar to those at Copan. Other obelisks are higher than this. The ruins of Copan that mark the second era are situated in the extreme western end of Honduras. Owing to the hostility of natives these ruins have not been very carefully explored. A stone wall from sixty to ninety feet high is described as running along the River Copan six hundred and twenty-four feet, in some places fallen and in others entire, which supported the rear side of the elevated foundation of a great edifice. It was made of blocks of cut stone six feet long, well laid in mortar or cement. The chief peculiarity of Copan was the number of sculptured inscribed pillars. In speaking of these, Mr. Squier says the ruins of Copan are distinguished by singular and elaborately carved monoliths, which seem to have been replaced at Pelenque by equally elaborate basso relievos, belonging, it would seem, to a later and more advanced period of art. Palacios, who described these ruins three hundred years ago, speaks of an enormous eagle carved in stone, which bore a square shield on its breast carved with undecipherable characters; of a stone giant; a stone cross; a plaza circular in form surrounded by ranges of steps or seats, as many as eighty ranges remaining in some places. This plaza was paved with beautiful stones, all square and well worked.

The next era is represented by the ruins of Palenque situated in the northern part of the Mexican State of Chiapa. The largest known building is called the "Palace." It stands near the River Chacamas, on a terraced pyrmidal foundation, forty feet high and three hundred and ten feet long, by two hundred and sixty broad at the base. The edifice itself is two hundred and twenty- eight feet long, one hundred and eighty wide, and twenty-five feet high. It faces the east, and has fourteen doorways on each side, with eleven at the ends. It is built of hewn stone laid in mortar of the best quality. It has four interior courts, the largest being seventy by eighty feet in extent. These are surrounded by corridors, and the architectural work facing them is richly decorated. Within the building were many rooms. The piers around the courts are covered with figures in stucco, or plaster. There is evidence of painting being used for decoration, but the architectural effect of the stone-work and the beautifully executed sculptures, particularly strike attention. The walls and piers are covered with ornamentation. Mr. Stephens thinks that the sculptured human figures, fragments of which are found, must have approached in justuess of proportien and symmetry, the Greek models.

The ruins of Uxmal represent the fourth and last era of the ancient civilization of Mexico and Central America. This brings us down to the time of the Spanish conquest. At that time it had begun to be a ruin which was complete in 1673.

The most important edifice was named by the Spaniards "Casa del Gobernador." It is 320 feet long, and was built of hewn stone, laid in mortar or cement. The faces of the walls are smooth up to the cornice. There follows on all four sides, one solid mass of rich, complicated, and elaborately sculptured ornaments, forming a sort of arabesque.

Before leaving this geological division, mention should be made of the astronomical monument, described by Captain Dupaix. In the Mexican State of Oaxaca, near the village of Mecamecan, is an isolated granite rock, which was artificially formed into a kind of pyramid, with six hewn steps facing the east. The summit of this structure is a platform, well adapted to observation of the stars on every side. It is supposed that this very ancient monument was devoted to astronomical observations. On the south side of the rock are sculptured several hieroglyphical figures, having relation to astronomy. The most striking figure in the group is a man in profile, standing erect, and directing his view to the rising stars in the sky. He holds to his eye a tube or optical instrument. Below his feet is a frieze divided into six compartments, with as many celestial signs carved on its surface.

Our third geographical division, the valleys of the Mississippi and Ohio Rivers, includes the remains of the ancient people called the Mound-Builders. Their ruins are the most numerous in the south, extending from the Gulf of Mexico, to West Virginia, Ohio, Michigan, Wisconsin, Nebraska, and probably further west. They consist of mounds and inclosures. In these mounds have been found ornaments and implements made of copper, silver, obsidean, porphy, and greenstone, finely wrought. Also, axes, single and double; adzes, chisels, drills, or gravers, lance-heads, knives, bracelets, pendants, beads, and the like, made of copper; articles of pottery, elegantly designed and finished; ornaments of bone, mica from the Alleghanies, and shells from the Gulf of Mexico. Porphyry is a very hard stone and could only have been worked with tools made of the hardest material. Obsidean is of volcanic origin and much used by the Peruvians and Mexicans for arms and cutting instruments. It is found in its natural state no nearer the Mississippi Valley than the Mexican mountains of Cerro Gordo. The art of spinning and weaving was known to them as evidenced by the cloth found in the mounds.

Before any evidence of ancient mining was discovered in the Lake Superior copper region, pieces of copper with blotches of silver appearing to be welded to it but not alloyed with it, had been dug from mounds. As this condition is peculiar to the Lake Superior copper, it was supposed that the Mound-Builders were acquainted with the art of mining. This was proven to be so in 1848. The modern mining works are mostly confined to that part of the copper region known as Keeweenaw Point. This is a projection of land extending into Lake Superior. It is about eighty miles in length, and at the point where it joins the main-land, about forty-five miles in width. All through this district, where-ever modern miners have worked, remains of ancient mining works are abundant; and they are extensive on the adjacent island, known as Isle Royale.

The area covered by the ancient works is greater than that which includes the modern mines, as they are known to exist in the dense forests of other district where modern mining has not as yet extended. Their mining was chiefly surface work; that is, they worked the surface of the veins in open pits and trenches. The mounds differ greatly in size. At Grave Creek, West Virginia, there is one 70 feet high and 1,000 feet in circumference. One at Miamisburg, Ohio, 68 feet high and 852 feet in circumference. Another at Cahokia, Illinois, is 700 feet long, 500 wide, and 90 feet high. They range generally from 5 to 30 feet in height. It is supposed that the lower mounds were used for the same purposes as the mounds in Mexico and Central America, for the foundation of their principle buildings. But these buildings, having been built of wood, soon perished, leaving no trace behind them save this earthen base. The high mounds are pyramidal in shape and have level summits of considerable extent, which were reached by stairways on the outside as those at Miamisburg, Ohio, and Grave Creek, West Virginia, which resemble the great mounds at Chichen, Itza, and Mayapan, in Yucatan, the first 75 feet high and the last two each 60 feet high. These Yucatan mounds were evidently constructed for religious uses as upon the summits of the first two are the ruins of stone temples. On the third the edifice has disappeared, as in all probability those upon the high mounds in this division, being built of the same material, wood.

In one of the mounds of the Ohio Valley there were found the timber-walls of two chambers and arched ceilings, with overlapping stones, precisely like those in Central America.

The Natchez Indians, on the lower Mississippi, had temples and sacred buildings, in which the "perpetual fire" was maintained. They were sun-worshipers, their chief claiming descent from the sun. Their traditions connected them with Mexico. By some they are classed as the Nahuatl, or Toltec race.

According to the Central American books, the Toltecs came from "Huehue Tlapalan," a distant country in the northeast, long previous to the Christian era. Here they dwelt in a high state of civilization for a long period, were overthrown by the Aztecs, who in turn were conquered by the Spaniards.

All indications aeem to warrant the conclusion that the mound-builders and the palace-builders, if we may be permitted to use this term, of Mexico and Central America, belonged to the same race. They must have left the United States on or before the advent of the wild Indians. This emigration south may have been voluntary to seek a more congenial clime, or may have been forced by the savages from the north. Fragments would seem to have been incorporated with the Indiâns, as for instance the Mandan Indians, a supposed branch of the Dacotahs. They differed in many respects from the other Indians, being of lighter color and peculiar in manners and customs. We suppose the mound-builders came to the United States from the south, entering the country near the Gulf of Mexico, where they were the most populous, and then gradually throwing out colonies, extended their sway, with sparser population to the northward.

They were eminently an agricultural people. Maize is supposed to have been their chief grain. Having fulfilled their mission here, they returned to Mexico and Central America.

The time of their disappearance is estimated to be about two thousand years ago. The appearance of the wild Indian is located at or after this time. In him we find an original barbarian with no signs of ever being connected with civilization. Besides, his traditions connect him with the northwest, from which direction he is supposed to have entered North America.

A strong fact in support of this view is that there are several tribes, the nomadic Koraks and Chookchees, found in Eastern Siberia, throughout the region that extends to Behring's Strait, who have a strong resemblauce to the wild Indian, and may well represent the common parent stock.

A few words in regard to the points relied upon to establish the antiquity of the mound-builders.

1. As no mounds are built upon the lowest formed of the river-terraces, it is presumed the mounds were built prior to their formation. These rivers show four successive terraces in their subsidence to their present channels. It is not possible to say what antiquity this would indicate, but at least a great one.

2. Sound and well preserved skeletons known to be two thousand years old have been taken from burial places in England and other European countries, less favorable to their preservation than the burial places of the mound-builders. Hence, it is supposed that the decayed skeletons taken from the mounds are more than two thousand years old.

I. The great age of the mounds are shown by their relation to the forests which must have sprung up after the disappearance of this eminently agricultural people. In conclusion, I will merely add that many theories, some plausible and others very absurd, have been invented as to the origin of the ancient civilization of Central America, and Peru. Authorities differ as to whether these two are distinct and if not which is the oldest. The weight of authority inclines to the opinion that they were originated by the same people and that of Central America is the most ancient.

Mr. Baldwin, an eminent writer on Archæology, after reviewing the principal theories as to the origin of this ancient civilzation, arrives at the conclusion that it was an original civilization. This is certainly a very safe theory and till more light is thrown upon this subject, seems to have as much to be said in its favor as any other hypothesis.

ON THE EXTENT OF THE WISCONSIN FISHERIES.

(An abstract of notes sent by Dr. P. R. Hoy to the President of the Acadamy.)

There are thirty-six locations on Lake Michigan, and two or three on Lake Superior, which are merely headquarters for the fishermen for a large extent of shore, in the vicinity of the Apostle Islands, and the shore immediately east of Duluth.

In these regions there are employed about 148 pound-nets, 48 bearing gill-net stocks, and 212 lighting gill-net stocks, valued, at a low estimate, at $200,000.

To carry on fishing, there are proprietors and men, but a small proportion of the number of men on wages—about 800 men.

The production of the Wisconsin nets, it would be difficult for me to separate from the total Michigan, Wisconsin, and Illinois fisheries; *Chicago sales of lake fish amount to over a half million of dollars,* of which, of course, a large quantity come from Wisconsin, as they recover into Milwaukee dealers, the whole of the Lake Superior catch, on the Wisconsin shores. Milwaukee inspection reports have reached about 17,500 half-barrels of lake-fish, worth $87,500. Other points in Wisconsin, placing salt-fish on the eastern market, would swell the amount to about $40,000 more. The interest of the fisheries, probably brings into the State every year about $350,000. These estimates are made with the figures in my possession of statistics of the lake receipts of fish, for 1872, including the handling of fish in the markets, which has never been compiled before.

The evidences are very apparent, and universally acknowledged by fishermen, that the food fishes of the lakes are decreasing to an alarming extent.

The purpose of the United States Commission was first to investigate the decrease, its causes, and the remedies to be applied to arrest the decrease, and restore the fishes to their former numbers; in other words, to increase the product of the fisheries of the United States.

From careful investigation, it is evident that the first and principal means is artificial propagation, with judicious protective laws as an auxiliary.

The State commissions have given special attention to propagation, with the most encouraging results. The shad, in the Connecticut River, where they had been nearly exterminated, are now more plentiful than in the period of 70 previous years. Last season there was a large increase in the Hudson River, the result of the successful work of Seth Green, three years ago. In Canada, Samuel Wilmot, the government breeder, has restored the salmon in large numbers. Experiments have been made by three prominent fish culturists in the propagation of the white-fish, and their efforts are now crowned with complete success. Mr. N. W. Clark, of Clarkston, has carried three-quarters of a million of eggs beyond the stage of danger, and Seth Green has a large quantity hatched and is distributing them to inland lakes in large numbers. Seth Green has been equally successful with lake-trout.

The advantage of artificial culture is in the fact, that almost the entire number of eggs are hatched, while in a state of nature, but a very small proportion are hatched. This is especiallly true in the lakes, where there are so many species of fish who make the ova of fishes their food, and where the continual stormy weather, at certain seasons, carries the sediment from the clay-banks, outward, and deposits it on the spawning beds.

A bill has passed in the State of Michigan, providing for a fish commission and making an appropriation for the expenses of their work.

The State of Michigan has enacted that:

"It shall be the duty of the governor, to appoint three commissioners of fisheries, whose terms of office shall be, respectively, two four, and six years, and their successors appointed, two years thereafter."

(As I cannot follow the detail of the bill, from memory, I will give the character of the different sections.)

The duties of the commissions were provided for in the second section *i. e.*, to propagate white-fish, and such other food-fishes as they saw fit,providing for two breeding-establishments, one in the eastern and one in the western portion of the State.

The third section provides that they should have the privilege of taking in any manner any fish they choose, for the purposes of propagation or scientific purposes.

Another section provides that the pay should be three dollars per day and necessary traveling expenses, for expenses actually incurred, and for time actually employed. The pay should be drawn on a properly sworn voucher, from the auditor of the State. A clause gives the governor authority for directing concurrent action with other States. It has been drawn as conciosly as possible, and embraces nothing but the provision for commissioners work, as it was deemed best to let the bill stand on its own merits, and not involve protective legislation or anything else.

LEVELING, AND USE OF THE BAROMETER.

BY JOHN NADER, C. E.

The term leveling is used to denote the art of determining the difference of level between two objects or of one object with reference to some fixed or known object.

Leveling is one of the most difficult branches of surveying, in as much as it is impossible to detect or correct an error as may be done in some other branches without again repeating the whole work.

The term level is also applied to the position of an apparent horizontal plane. The object desired may be attained in various ways depending upon the purpose of the work and the amount of accuracy required, and also upon the instruments which may be available.

The art of leveling is based upon invariable natural laws, *i. e.*, the horizontality of a body which yields to the fullest extent to the force of gravity, such as a liquid under favorable circumstances, or a body freely suspended and submitted to the action of gravity.

It would hence be an easy matter to assume a horizontal plane and refer objects to the same were it not that a number of influences come to bear upon the results which often differ widely from the truth.

The principal influences are the following: Mechanical imperfections; errors of observation; effects of temperature; curvature of the earth and atmospheric refraction.

I will here notice the latter. When an object is viewed obliquely through a transparent medium of any nature whatever, it does not occupy the position in which it appears, the rays being bent by refraction. If the medium be of a uniform density throughout the ray will pass through in a straight line, but if the density of the medium is variable, the line will be irregular, and as in the case of the atmosphere, whose density is as its height, the line of refraction will be a curve, and since the denser medium will have the greater refractive power the rays become bent more and more as they approach the earth, and the curve as a rule will be concave towards the earth.

It would appear an easy matter to determine this curve, but in attempting to do so we at once find a complication and uncertainty arising from accidental causes; a variation of temperature and of the amount of moisture held in suspension, will both separately and combined, cause a variation in the density of the atmosphere, and especially affect Barometric Leveling and often render the results uncertain and unreliable.

According to "Bessel" the atmospheric refraction amounts to nearly thirty-five minutes of arc at the horizon and diminishes towards and becomes nil at the zenith.

Cases may occur where the refraction is negative, *i. e.*, when the curve is convex towards the earth. This happens when the higher strata are condensed, while the lower recieve the heat previously absorbed by the earth or ocean. I have had the opportunity of observing some remarkable cases of negative refraction. In the one case the exhaust of the high-pressure engine of a tug-boat, distant about two miles, stood up distinctly like a row of columns from forty to sixty feet high apparently, at the same time the scraggy cedars four or five miles off appeared like great poplars. In another case the full moon, rising from the horizon of the ocean, presented a remarkable phenomenon; it came up depressed on its upper edge, and continued to rise with its sides perpendicular until the whole disc should have been above the horizon, then it began to assume the form of a balloon until the disc should have been about one-fourth its diameter above the horizon at which time the lower edge left the water, and the disc assumed its usual circular form. This occurred in August, 1867, after a very hot day, the atmosphere, from some cause or another was very much reduced in temperature in the evening, while at the same time the sea was giving out the heat absorbed during the day.

A singular case occurred to one of the assistants of the Lake Survey. While engaged in taking soundings with two boats within speaking distance, his second boat, seen and spoken but shortly before, suddenly disappeared; upon arising, the boat was plainly visible, whilst sitting it could not be seen. I will not attempt to explain this phenomenon, but I have it from a gentleman of veracity

In leveling operations where great accuracy is required, there is occasional need of correcting for curvature of the earth and atmospheric refraction. The curvature amounts to about eight inches per mile, and increases as the square of the distance; the refraction is dependent on the distancc, and, as will appear from previous remarks, will vary with different conditions of the atmosphere. Since refraction as a rule makes objects appear higher than they really are, it serves to reduce the errors due to curvature, and according to Bessel's coefficient of 0,0685, it amounts to a little more than one-seventh of the curvature.

As the earth is not a true sphere its diameter cannot be equal in all places, yet this will make no practical difference in most operations, but it would be well in all cases to give the basis upon which tables are computed. I give the following tables for corrections for curvature and refraction for a mean diameter of 7925,646 statute miles, or 41,847,247 feet. The quantities are computed to six and seven places of decimals and corrected for second differences:

$$\text{Formula } C = 0{,}4315 \frac{e^2}{r}$$

Distance *e*.	Curvature *h*.	Refraction *f*.	*h*—*f*=*C*.
	Feet.	*Feet.*	*Feet.*
100 yards	0.0021	0.0003	0.0019
200 yards	0.0086	0.0012	0.0074
300 yards	0.0194	0.0026	0.0167
400 yards	0.0344	0.0047	0.0297
500 yards	0.0538	0.0074	0.0464
600 yards	0.0774	0.0106	0.0668
700 yards	0.1054	0.0144	0.0909
800 yards	0.1376	0.0188	0.1188
900 yards	0.1742	0.0238	0.1503
1,000 yasds	0.2151	0.0295	0.1856
1.100 yards	0.2602	0.0356	0.2146
1,200 yards	0.3097	0.0424	0.2673
1,300 yards	0.3635	0.0498	0.3137
1,400 yards	0.4215	0.0577	..3638
1,500 yards	0.4839	0.0663	0.4176
1,600 yards	0.5506	0.0754	0.4752
1,700 yards	0.6215	0.0851	0.5364
1 mile	0.6662	0.0913	0.5749
1¼ miles	1.0409	0.1426	0.8983
1½ miles	1.4989	0.2053	1.2936
1¾ miles	2.0402	0.2795	1.7607
2...miles	2.6648	0.3650	2.2997
3...miles	5.9957	0.8213	5.1744
4...miles	10.6591	1.4601	9.1989
5...miles	16.6548	2.2815	14.3734
6...miles	24.9829	3.2853	20.6976

The object sought viz: The difference of altitude of objects may be attained in various ways depending upon the degree of accuracy required and the instruments at hand.

The masons level, the builders level, and the surveyors level all serve their purpose in their respective places. The construction and value of these instruments varies with their real worth as compared with their requirements.

The Theodolite and Sextant are sometimes used in leveling, in such case it is nothing more or less than a vertical triangulation and is treated and computed as such.

In connection with the sextant there is used an artificial horizon. This is simply a reflecting liquid by means of which the direct and reflected images of an object are brought in contact in the horizon glass of the sextant and the angular distance measured, the angle as a matter of course is double the angle of elevation above the apparant horizon. Mercury is most generally used, but oxidises rapidly when in contact with air, and although a very dense substance is most easily disturbed by the slightes breeze. Oil, colored with lamp-black or molasses, are about as convenient and reliable as anything for the purpose, and being inexpensive can be renewed whenever desirable.

In measuring great differences of altitude recourse is had to the barometer. It is not reliable for small differences as its motion is but one-tenth of an inch for altitudes of from 96 to 110 feet and is moreover affected by every change of temperature and the consequent change of density of the atmosphere.

Operations with the barometer are based upon the principle of the Torricellian vacuum which is simply a measure of the weight of the atmosphere. If now according to Marriot's law "the density of one and the same quantity of air is proportional to its tension." we have at once a means of measuring the difference of heights by the tension of the atmosphere, for as we ascend, the density decreases as the column.

This motion as before stated is so gradual (one inch for 1,000 feet) and affected by so many contingencies that the barometer has always, and now is, looked upon as a very uncertain and unreliable leveling instrument.

This, however, will vanish with experience, and with proper care and application the barometer will be found very useful and quite reliable. The distrust generally arises from an insufficient acquaintance with the instrument and its defects. For instance, a mercurial barometer may be taken from one temperature to a higher, and instead of rising as it should do the mercury may fall; everything else being correct, the vacuum cannot be perfect, a small quantity of air is above the mercury which expands according to Gay Lussac's law with the increase of temperature and hence instead of rising, as the mercury should from expansion, it falls.

The barometer consists of two parts; a tube and a basin. The tube is first filled with mercury and then the open end is inserted into the basin of mercury, the other, or upper end, being closed in the manufacture. The mercury in the tube will now descend until the height of the column measured from one surface to the other, is just in equilibrium with the weight of the atmosphere. It makes no difference how long the tube may be, whether three feet or three hundred, the difference of level will measure the weight of the atmosphere. If the tube is inserted deeper into the basin a corresponding rise will take place in the tube. Such being the case, how does the expansion of the mercury have an influence on the height of the column as we have seen that the quantity has nothing whatever to do with the same; this will be accounted for from the fact that the mercury has lost in specific weight, in other words, has brcome lighter and the atmosphere is consequently enabled to support a correspondingly greater column of equal weight. I would here remark that the greatest distrust to the barometer may probably arise from too many observations being made indoors, for although the detached thermometer would indicate a dilation of the atmosphere, yet this local dilation does not affect the tension but acts merely as a cushion. Cases may occur, however, where the atmosphere of a room may be in an abnormal condition, that is when the heat currents are such as to carry small objects as though supported by a denser medium.

I have under such circumstances found a difference of temperature between the upper and lower ends of the instrument amounting sometimes to as much as ten degrees. At such times the barometer is very seriously affected and is entirely unreliable.

In making observations for heights, the same should be made simultaneously at both stations, as the density sometimes changes as much as 200 feet in a few hours; the instruments should be carefully compared before starting, one remaining at the lower station while the other should receive sufficient time to reach the upper, the observations to begin at a certain time and repeated at intervals previously agreed upon, and continued until it is certain that the distant party may have had time to make the necessary repetitions. When not too distant a gunshot may answer for signal, if beyond hearing distance the smoke from a fire may answer the purpose, the signals applicable will generally depend upon the situation.

Repetitions are necessary for several reasons. An imperfect contact of the vernier scale or local and wave-like disturbances may all tend to make the observation doubtful unless repeated, or the apparatus may not yet have partaken entirely of the local temperature. After carefully adjusting the index of the vernier to the top of the column, the scale should be read, recorded, and the vernier displaced, a second or third reading may verify the first, or one another. The barometer requires two thermometers, one attached to show the temperature of the mercury, (it being impossibe to insert the attached thermometer into the mercury, it is only necessary to place the same under as nearly as possible the same conditions,) and one detached which should be moved about to give the temperature of the atmosphere. Above all it appears necessary to be well supplied with instruments when starting for a different altitude. Assistant Edwards, of the coast survey, started for the top of a mountain in California with six barometers and arrived at his station with one, one of the original syphons of which he carried the mercury in a flask in his pocket.

It may be observed that valleys and abrupt inclinations should be avoided, and isolated stations chosen where the atmosphere appears undisturbed.

For reducing the observations the formula published in the United States Coast Survey reports is most convenient in ordinary cases, this is arranged for a mean temperature of fifty-five degrees Fah., and is the product of the constant 55,000 multiplied by the quotient of the difference of the Barometer readings divided by their sum, $\left(55000\ \frac{B-b}{B+b}\right)$ and differs but little from the truth.

When we desire to make more accurate measurements, we find the matter proportionately complicated. If we assume that the atmosphere is of a uniform temperature, we may take the difference of level of any two stations according to the equilibrium of elastic fluids equal to a constant 60200 (at 32°) multiplied by the difference of the logarithms of the readings in inches, thus:

$$(x = k\ (\text{Log. B.} - \text{Log. b});)$$

Since the height of the mercury is affected by temperature, it is necessary to reduce the observations to a common temperature.

Mercury expands at 32° Fahr., about .0001 of its bulk for every degree of heat, the rate of expansion varies, but this will not be sensibly felt under ordinary circumstances. It is most easy, and hence most proper to reduce the temperature of one reading to that of the other, rather than to reduce both to a normal, and it will be most convenient to reduce that which has the lowest temperature, which, as a rule, is at the highest station.

The difference of temperature which will affect the height of the mercury by expansion, will also affect it further by affecting the density of the atmosphere.

Air expands about .0021 of its bulk for every degree from 32° Fahr., and although this rate is not regular, it is safe to assume it as such when applying to mean temperature.

Where the distance between stations is great, or that the latiude differs much from 45°, a correction must be made on account of the difference of the force of gravity. Taking one practical example and applying the two formulæ before mentioned, the first gives an altitude of 6143.50 feet, and the second 5960.1622 feet, both of which are fair approximations.

Example.

Stations.	Barometer.	THERMOMETERS.		Latitude.
		Detached.	Attached.	
N. lower......	B.=28,94 in.	T=76°	T′=68	44°–40′
V. upper......	b=23,12 in.	t=47°	t′=53	45°–10′

$$\frac{T+t}{2} - 32° = 29.5°;\quad T' - t' = 15°;\quad 2\text{ Lat.} = 89°.50'$$

$$\text{1st. } 55{,}000 \left(\frac{B-b}{B+b}\right) = 6143{,}50.$$

$$\text{2d. } 60200\ (\text{Log. B} - \text{log. b}) = 5960,\ 1622.$$

Taking the 2d formula and correcting b the upper reading for difference of temperature of mercury by $(1 + 0{,}0001.\overline{T'-t'})$ gives 5831.014 feet, here we have lost, as we have reduced by the difference of temperature of mercury which was lower at the upper station, and consequently indicated a greater altitude.

If now a correction for dilation of atmosphere is made by

$$1 + 0{,}0021 \left(\frac{T + t}{2} - 32.\right);$$

we obtain 6192.21 feet, this correction necessarily increases the difference of the readings and consequently the altitude. The third correction of 1—(0.0028 Cos. 2 Lat.) reduces the result only one hundreth of a foot. This example gives 106.5 feet for every one-tenth of an inch of difference of barometers, and it will be observed that the result differs by but 0.78 feet in one hundred from the first formula, which is arranged for a mean of 55° Fah. and by 3.70 in one hundred from the second, which is for a mean of 32° Fah.

The complete formula with three corrections reads:

$$x = k \log \frac{B}{b(1+0{,}0001.(T'-t'))} \times 1 + \left(0{,}0021\left(\frac{T+t}{2} - 32\right)\right) \times 1 - (0{,}0028 \text{ Cos. } 2 \text{ Lat.}),$$

The following form is convenient:

B=28,94 - - - - - - -		log.=1,461499
b=23,13 - - - - - -	log.=1,363988	
1+(0,0001×15°)=1,0015 - - -	log.=0,000650	
	Sum=	1,364638
	Difference=	0,0096861
Difference=0,096861 log= - - - - - - -		$\bar{2}$,986148
k=60200 log.= - - - - - - - -		4,779596
1+(0,0021×29,5°)=1,06195 log.= - - - - -		0,026102
1—(0,0028×Cos. 89° 50′)=0,99999 log= - - -		$\bar{1}$,999999
x=6196,20 feet from sum of logs.= . - - - .		3,791844

The aneroid barometer is coming into general favor perhaps more from convenience than any other reason, as it is imposible to read as small fraction from the index as from the vernier of the mercurial barometer.

From observations made in two different rooms at temperatures of 54° and 65° respectively, a difference was found amounting to ten feet, but since this was eqnal to the probable error of observation of the scale of the instrument used, the result might be taken as a test of the accuracy of the formula.

Whenever observations are made in a room of moderate temperature, the detached thermometer should be placed in the open air in a sheltered place, and from the temperature obtained the corrections for dilation may be made with accuracy, for expansion of mercury, the temperature as shown by the attached thermometer must necessarily be taken for corrections of the same.

The barometer is subject to regular periodical oscillations in consequence of variable temperature of the earth and the consequent air currents. A very small diurnal barometric wave exists which may be traced with great accuracy. The laws which control the regular motions will soon be thoroughly understood from the results of a recording apparatus in use for the several years by which a diagram is photographed which gives an accurate continuous record day or night.

The thermo-barometer and other useful and interesting matter is omitted for want of the time necessary to prepare the same.

ON KEROSENE OIL.

BY E. T. SWEET, M. S.

The introduction of kerosene as an illuminating agent has became so general, that the leading charicteristics of a safe and valuable oil, should be well understood by consumers. It was with this idea in mind that I commenced the preparation of the following paper. As the sources of information in regard to the methods of detecting dangerous burning fluids, are exceedingly limited, I shall, after briefly referring to the manufacture of kerosene, and summing up the results of a number of evperiments made at the University of Wisconsin, in January, 1878, upon different samples of commercial kerosene, particularly refer to the proper manner of testing oils. While nothing original is claimed for this article it is thought that its perusal will give general knowledge of the principles of testing burning fluids, and may awaken an interest in the subject, and indirectly lead to the consumption of a higher grade and safer kerosene than is at present in use.

The fire-test is the only efficient method of distinguishing between a safe and a dangerous hydro-carbon oil. Experiment shows that but very few samples of commercial kerosene will stand the tests required by law. Consequently instead of perfectly safe burning fluids, as dealers nearly always represent, immense quantities of inferior oil are sold, which are liable to become ignited at any moment, when heated a few degrees above the temperature of an ordinary room.

Crude petroleum as it comes from the earth is a dark colored fluid, consisting of many hydro-carbons, compoundsof hydrogen and carbon. It has a density of about .880, water being 1,000.

The raw or crude material is placed in immense iron retorts, holding from fifteent to twenty thousand gallons each, and distilled. The distillation is eminently destructive, for it "cracks' or breaks up the oil into lighter hydro-carbons, which have different boiling points, and consequently pass off in vapor at different temperatures. The vapors are condensed in an iron coil passing through water and collected in separate reservoirs. The products of the distillation taken in order, as they are driven off, are as follows:

Name.	Gravity.	Boiling point.
		° F.
Gasolene	.665	120
Naptha	.709	180
Benzene	.721	216
Kerosene	.804	350
Mineral sperm oil	.857	425
Lubricating oil	.883	575

Rhigolene is a very volatile hydro-carbon, produced by the repeated distillation of gasolene. In consequence of its rapid evaporation, its boiling point being but 65° F., it is used in surgery for producing "local anæsthesia." Paraffine, another product of petroleum, is a solid. It is used principally in the manufacture of candles, chewing gum, and water-proof cloth.

About ten per cent. of the native petroleum consists of gasolene, naptha, and benzene. They pass from the still first, and are nearly valueless, being sold for from five to ten cents per gallon. All readily ignite at ordinary atmospheric temperature, therefore are highly dangerous for illuminating purposes. After the light hydro-carbons have been driven off, the remaining fluid in the still is generally transferred to smaller retorts, the temperature raised, and safe kerosene distilled. A heavy black residue remains, which is principally manufactured into paraffine and lubricating oil. On account of the poor market for the light oils, and as they afford even a more brilliant flame than safe kerosene, there is a strong tendency on the part of unscrupulous manufacturers to commence the collection of burning fluid before the less dense oils have entirely passed off. This is the primary cause of the many fatal accidents that yearly occur from the use of kerosene.

Kerosene oil has no constant composition. Like petroleum, it consists of a great number of liquid hydro-carbons. Most of the higher combinations of these elements found in kerosene, have a low specific gravity, and are very volatile. They pass off in vapors at comparatively low temperatures. As a burning fluid contains a large or a small proportion of these volatile compounds, it is said to be a light or a dense oil; those known as light being regarded dangerous, while the heavy oils are called safe. But the specific gravity of kerosene, as shown below, is not an invariable indication of its purity.

Soon after the introduction of kerosene as a burning fluid, a method called the "fire-test" was devised for the detection of dangerous oils. It consists in determining the temperature at which an inflamable vapor is evolved, or the "flashing point;" and also the temperature at which the fluid becomes ignited from the flash of the vapor and continues to burn, or the "burning point." The flashing point is determined by inserting the bulb of a thermometer half an inch below the surface of the fluid to be tested, and gradually raising the temperature from sixty or seventy degrees, to the point at which a pale blue flicker is observed to pass across the surface upon the approach of a small flame or lighted match. The burning point is usually from ten to fifteen degrees above the flashing point.

If an oil gives off a combustible vapor, or flashes, at a low temperature, there is danger of forming a very explosive mixture with about four volumes of atmospheric air, especially in a confined space. This mixture is often formed in a kerosene lamp, containing a small quantity of oil, in attempting to refill it while still burning. It is also formed if the temperature of a partially filled lamp is suddenly lowered by changing it from a warm to a cool room, or by allowing a cold draught of air to come in contact with it. In these cases a part of the vapor above the oil condenses, air rushes in to fill the partial vacuum, the flame has a tendency to descend and an explosion is apt to take place. The oil itself never explodes, it is a mixture of vapor and atmospheric air that bursts the lamp and kindles the flame, hence the necessity of keeping lamps well filled and uniform temperatures.

Laws have been enacted by several State legislatures, and a special act was passed by congress March 2, 1867, which however, has since been declared unconstitutional, fixing the temperature at which hydro-carbon oil may be deemed safe and merchantable, at not less than one hundred degrees Fahrenheit, for the flashing point, nor below one hundred and ten degrees Fahrenheit for the burning point. An oil which will stand these tests may be regarded as perfectly safe. The results of my observations show that such a burning fluid in the ordinary market is of rare occurrence. Of twenty-seven samples of kerosene collected in this city, and examined, but two were found to stand the test required by law. The following are the results of the examinations referred to:

No.	Brand.	Flashing point.	Burning point.	Specific gravity.
		Deg. F.	*Deg.* F.	
1	Kerosene	71	92	.797
2	....do	83	100	.799
3	....do	84	94	.798
4	....do	85	94	.797
5	....do	85	100	.797
6	....do	86	98	.796
7	....do	86	102	.799
8	....do	86	102	.739
9	....do	88	94	.800
10	....do	89	100	.798
11	....do	90	96	.798
12	....do	90	102	.788
13	....do	90	102	.799
14	....do	88	98	.799
15	....do	90	106	.799
16	....do	92	107	.800
17	....do	92	106	.796
18	....do	92	107	.800
19	....do	92	109	.802
20	....do	92	109	.800
21	....do	94	104	.801
22	....do	97	106	.799
23	....do	97	106	.799
24	....do	98	106	.793
25	....do	99	107	.800
26	....do	100	118	.810
27	....do	103	127	.806
28	Head-light oil	156	158	.802
29	....do	158	172	.800
30	Mineral sperm	258	296	.841

In order to determine the proportion of contaminating fluids contained in the oils, several samples were subjected to a fractional distillation, which gave the following important results:

Number.	Brand.	Gasolene, naptha, and benzene.	Burning fluid
		P. Ct.	*P. Ct.*
1	Kerosene	12	88
9	....do	5	97
15	....do	4	96
52	....do	3	97
30	Mineral Sperm	0	100

It will be observed from these results that but two of the twenty seven samples of kerosene may be regarded as safe burning fluids. Of seventeen samples of kerosene tested in the city of La Crosse, by myself, in December, 1873, but one was found to answer the requirements of law.

Headlight-oil was originally manufactured for lanterns used on locomotives.

Mineral Sperm oil owes its name to the odor and color of the fluid. The process of manufacturing it was discovered in 1872, by Mr. Joshua Merrill, at the Downer Oil-Works, in Boston, Massachusetts. In the notice of its discovery Mr. Merrill says: "Flames of considerable size, such as a large ball of wicking yarn saturated with oil and ignited, when plunged beneath the surface of this oil, previously heated to the temperature of boiling water are extinguished at once."

It is estimated that about one-fourth of the production of petroleum may be manufactured into this beautiful and safe illuminating agent. No danger, whatever, need be anticipated from mineral sperm or headlight oil, even though a lamp containing either should be accidentally broken while in use. The flame at the end of the wick would probably be extinguished, but if circumstances the most favorable should happen for igniting the oil, fire could not possibly be communicated to it until the temperature of the surrounding fluid became raised to its vaporizing point. The flame would then gradually spread over the surface of the oil in an enlarging circle, and no sudden flash would be observed, as in the case when a lamp is broken containing oil heated above the temperature at which it evolves a combustible vapor. It is certainly to be hoped that these perfectly safe oils will soon come into general use. The lamp in which kerosene is burned, often has an important bearing upon the temperature of the oil which is contained in it. I can not better convey an idea of the effect of the lamp upon the temperature of the oil, than to quote from a report upon the subject, submitted to the Metropolitan Board of Health, in 1870, by Professor C. F. Chandler, of Columbia College, and chemist to the board. He says, "in continuing the investigation with regard to dangerous kerosene, it was thought a matter of importance to ascertain the temperature to which the oil is heated in lamps while they are burning, as a knowledge of this point is obviously a preliminary to the establishment of a proper standard for safe oil. To this end twenty-three ordinary lamps were purchased. Eleven were of metal, mostly brass; twelve were of glass. They were filled with the same oil and allowed to burn for seven hours; the temperature of the room during the experiment was nearly constant, varying from 73° to 74° Fah. The temperature in the eleven metal lamps varied from 76° to 100°, the average being 86° Fah. The temperature in the twelve glass lamps varied form 76° to 86°, the average being 81° Fah. The average temperature of all the observations on all the lamps was 83° Fah.

These experiments show, that an oil which does not give off an inflammable vapor below 100° F., may be regarded as perfectly safe. They also show that the average temperature of the oil in the lamp is about 8° above the temperature of the room in which it is burning, hence if the temperature of a room in which an oil is burning is 74°, and the flashing point of the oil is 80°, a vapor is constantly passing off, and there is danger, upon suddenly cooling the lamp, of an explosion.

Testing the oil is a very simple operation. A rough method of detecting dangerous kerosene is to pour out a small quantity of the oil into a saucer, and attempt to ignite it with a lighted match. If the flame is not at once extinguished, on being plunged beneath the surface of the fluid, the oil is highly dangerous, and should at once be consumed. By this means cheap burning fluids, usually bearing fancy names, as "Eureka," "Sunlight Oil," "Danforth's Fluid," "Non-explosive Chemical Spirit," etc., may easily be detected. When a thermometer is at hand the temperature of the oil may be raised by cautiously heating the saucer over a stove, and for every two or three degrees rise, a lighted match may be passed rapidly across the saucer, one-fourth of an inch above the surface of the fluid. If the oil becomes ignited, a slight puff of the breath will extinguish the flame. Of all the methods devised for testing kerosene, the most approved is that used by the British government in applying the "fire-test" to hydro-carbon oil. The only apparatus required, is a tester, thermometer and spirit lamp or candle.

The tester consists of a tin vessel four and one-half inches deep, with the same diameter. A cover fits this, which supports another small vessel of tin, two inches in depth and two inches in diameter. When the cover is placed in position, the small vessel descends into the larger vessel. The cover also has an elevated rim about the circumference, one-fourth of an inch in height. Stretching across the top of the rim is a wire, which passes over the center of the small vessel containing the fluid to be tested. Water at 60° or 70° is placed in the large vessel and slowly warmed from underneath by the flame of a lamp or candle. The cover, containing the small vessel filled with oil, is put on, and the bulb of a thermometer is introduced one-half inch below the surface of the fluid. For every rise of two or three degrees in the mercury, a minute gas-flame, or lighted match, is passed along the wire a quarter of an inch above the surface of the oil, which is repeated until a pale blue flicker is observed to pass across the surface of the fluid, when the flashing point is reached. The temperature is then increased until the oil will take fire from the flash and continue to burn. The temperature of this is the burning point.

IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER.

BY JOHN NADER, C. E.

The improvement of the mouth of the Mississippi, the free and unobstructed outlet of a great national highway equal in extent to that which forms the subject of this paper, can certainly not be over-estimated. A number of important producing States depend mainly upon this highway to dispose of their productions, and also to obtain through the same those imports which are necessary for manufactures, arts, and comforts of life. The river, very properly denominated the father of rivers, flows in a north and south line through a fertile tract of country, partaking of varieties of climate and embracing the extremes of latitude of the United States. Its tributaries are numerous, and some are of considerable magnitude; its productions embrace the extremes, its commerce concerns the world at large, and the national character of this great highway demands free and unobstructed passage for the largest ships sailing the ocean.

Before entering upon any plan of improvement, we will first examine the physical and hydrological conditions of the river in question.

The Mississippi River is one of the great working-rivers of the world, and compares with the "Nile," the "Po," the "Rhone," the "Danube," and others. By working-rivers, we understand those rivers which deposit large quantities of alluvium in deltas at their outlets to the ocean or seas.

The working of rivers is due only to natural forces, and in order to remedy any resulting difficulties it is necessary to amend these forces, but in order to master the forces of nature and to use them to our advantage, the first condition is that we should well understand them.

In examining a map of portions of the Mississippi valley, we can conclude, by observing the form of sloughs, bayous and annular lakes, that the river which occupies a very inconsiderable portion of the valley, has at some time occupied in turn nearly every portion of the same. The matter is very plain when we observe the present working of the river; an abrasion takes place on one side, while a corresponding accretion takes place on the other, and in this manner a constant lateral motion takes place which may continue in one direction for an indefinite period, until from some cause or other the motion is changed.

It is not difficult to comprehend the movement of an island down stream, or the shifting of the point of bifurcation. The upper end of the island is worn away by the current, while at the same time the lower end grows by deposits which take place in the still water. The movement of bends, on the other hand, partakes of an entirely different nature; these must be destroyed before they can reform. The peninsula like portion of land projecting into the bend is abraded on both the upper and lower side, until it is finally cut off, the old river bed is abandoned and a new one is formed; the regimen of the river thus disturbed, at once seeks to readjust itself and hence the fearful inroads consequent upon a natural or artificial cut-off. The causes are plain, the absolute slope, and consequently the velocity is increased, while at the same time the reciprocity of curves is broken, and a new bend must result. The remedy in this case is plainly the preservation of the natural bends.

My object in dwelling upon the foregoing, although foreign to the subject, was simply to illustrate the source of the material requisite to form the delta. The material which is carried along by the action of the current, will be found to differ very materially along the course of the stream, on the upper portions it is composed of sand and gravel, this will be found reduced by attrition as we descend the river, until it is finally reduced to impalpable mud; decomposed vegetation is added by the draining of the forests, and of this composition the delta is formed. I can give no better illustration of the delta than the following from a translation of a work by " Reclus." He says:

"These narrow embankments of mud, brought down into the open sea by the fresh water, present a striking spectacle. In several places these banks are only a few yards thick, and during storms the waves of the sea curl over the narrow belt of shore, and mingle with the river. The soil of the banks becomes perfectly spongy; it is not firm enough to allow even willows to take root, and the only vegetation is a species of tall reed, the fibrous roots of which give a little cohesion to the ooze, and prevent its being dissolved and washed away by the succession of tides. Farther down the reeds disappear, and the banks of mud form, are washed away and form again, wandering, so to speak, between the river and the sea, at the will of the winds and tide. On the left bank of the southwest passage, which is used for the largest ships, the plank built huts of a small pilots village have been fixed as delicately as possible. These constructions are so light, and the ground that carries them is so unstable, that they have been compelled to anchor them like ships, fearing that a hurricane might blow them away; still, the force of the wind often makes them drag on their anchors. Below, the banks of the Mississippi are reduced to a mere belt of reddish mud, cut through at intervals by wide cross streams; still farther down even this narrow belt comes to an end, and the banks of the river are indicated by nothing but islets, which rise at increasing distances from one another, like the crests of submarine dunes. Soon the summits of these islets assume the appearance of a thin, yellow palm floating on the surface of the water. Then all is mud; the land is so inundated with water that it resembles the sea, and the sea is so saturated with mud that it resembles the land. Finally, all trace of the banks disappears, and the thick water spreads freely over the ocean. After getting clear of the bar, the sheet of water which was the Mississippi preserves, during floods, the yellowish color by which it can be distinguished for about twenty miles, but it loses in depth all that it gains in extent, and, gradually depositing the earthy matter which it holds in suspension, becomes ultimately mingled with the sea."

This beautiful illustration gives one at once an idea of the difficulties of navigating the Delta, which in storms and dark weather becomes uncertain and dangerous even with the assistance of expert pilots. Now, in connection with the above, if we consider the insufficient depth of channel, our problem at once becomes manifest. Before however entering upon the solution of the problem, we will examine the working of rivers, and the means applied to remove the resulting obstruction in the deltas and mouths of rivers.

The amount of alluvion brought down and deposited in the gulf annually is estimated equal to a mass one mile square and 268 feet high. The "Hoangho," which probably carries more alluvium than any river in the old world, has formed a deta which extends over a space of over 90,000 square miles, and constitutes one of the most important provinces of China. It is estimated that the alluvion of this river would in the course of sixty days, form an island a mile square and over 100 feet in depth. According to Rennell, the Ganges conveys from five to six cubic yards per second, or from forty to fifty thousand cubic yards per day. The Nile, scarcely comparing with rivers of an inferior class, advances but slowly, yet its Delta measures nearly 200 miles on its front and increases over seventy acres in a year.

The "Po" is considered one of the most remarkable working-rivers in the world, although a constant subsidence is taking place; the river is nevertheless continually encroaching upon the Adriatic, its deposits being estimated at over 15 million cubic yards every year.

The Rhone deposits an estimated mass of 22 million cubic yards every year.

I have here given a fair idea of the enormous amount of work done by rivers, in order to show what we have to deal with.

Considering the enormous masses which form the obstructions which we wish to remedy, it may be well to examine the manner in which they are disposed of by nature, and how these obstructions, are formed. I will here return directly to the river in question—the Mississippi.

It will be observed that two parallel banks, confining the river, stretch out into the gulf over 60 miles; these finally become irregular, and the stream is divided into numerous branches and outlets. It is asserted that the Delta proper commences only at the head of the *passes*. I would, however, consider the entire projection as belonging to the same. The first formation was on the shallow coast of the gulf, removed from the destructive force of the ocean waves; the river here asserted its rights and pushed boldly on, every freshet increasing and fortifying the narrow causeways forming its banks, which the waves would, in my estimation, only tend to solidify by impact and by incorporating denser substances eroded from the gulf-shores.

The west side of these advancing banks is by some considered part of the gulf shore, whereas it appears to me to be an accretion, formed by the littoral current, such as would occur in the case of a jettee'. In fact it appears that at one time the Delta was being forced to the east, as may be observed at Bird Island, where the motion must at some time have been decidedly east. As soon, however, as the delta had advanced far enough to stop the erasion of the shores, the accretion ceased, and the shoals produced by the previous easterly motion gave a tendency to a contrary motion. During freshets the alluvion is precipitated on the banks which thereby continue to rise and to assume a more substantial consistance.

In building a dyke, or causeway of earth, the same is self-sustaining to a considerable height; even in shallow water the same can be formed, but when the saturated portion becomes considerable, it finally loses the cohesion necessary to support the superincumbent weight and partakes of a lateral motion, or in other words, spreads out, until the submerged portion attains sufficient resistance to produce an equilibrium.

The alluvion of the delta after reaching deep water, and not being fortified by any material denser than its own impalpable mud, must necessarily spread out until the lateral resistance would prevent motion. The river also would become wider, and lose in depth what gains in extent. Now, considering the foregoing facts, it is not at all surprising that the delta of the Mississippi encroaches on the gulf and presents the difficulties with which we are already familiar.

The estimated discharge of alluvion of the South Pass is about 22,000,000 cubic yards per annum, and the advance of the delta is put at 100 feet.

As the delta advances, its progress will decrease in proportion as the depth of the gulf increases; the difficulties of navigation would increase in the same ratio in this wide-spread bed of alluvion. In order to estimate the result of this progressive motion, we must consider that the discharge of a stream is the product of two quantities, viz., the cross-section and mean velocity, $(Q = F. V_o)$ and that the latter depends principally upon the absolute slope;

$$\left(h = \frac{v^2}{2g}\right)$$

hence the lengthening of the river would diminish the slope, and since the natural supply must of necessity be discharged, the slope must of necessity adjust itself for the performance of the work.

It is for this reason that we find that the Mississippi, which at first most naturally flowed in the lowest portion of the valley, is now at places over fifteen feet above the abjacent flood plains. On the improvement of the Rhine, the entire river has been lowered as much as six feet in places by increasing the slope by means of cut-offs, and large tracts of land have been reclaimed which had become entirely worthless.

On the majority of "working-rivers," we find very little difference in the ultimate result, unless they are interfered with by artificial contrivances, or that the natural forces find a new field of operations. After what has been observed, I will endeavor to review what has been done up to the present time to remedy the difficulties arising from the detritus deposited at the mouths of rivers.

The first, and most natural conception, was to endeavor to improve the natural outlets of the rivers, but this plan has been attended with varied results, and in some cases the very action of nature suggested the contrary.

In the case of the Vistula, every attempt to improve the mouth failed; a new outlet was formed and the old channel was converted into a canal which gives the necessary water to Dantzic. At the mouth of the Danube the Jetties gave success, but they were applied to the "Soulina Pass," a comparatively new branch of the river, far removed from the actual delta. The Jetties were carried out into the sea to a point where a current passes from north to south in the Black Sea; this current receives and carries all the alluvium brought down by the river, and prevents the formation of a bar. The channel has been deepened from nine feet, to sixteen and one-half feet by this means, since the works were constructed. It is very properly presumed that the encroachment of the whole delta will have the effect of crowding the current farther into the sea, and finally a bar will form as heretofore.

The improvement of the mouth of the "Adour" was accomplished by means of Jetties, but this river differs very materially from what we consider "working-rivers." The difficulty in this case was, that the obstructions cast up by the Atlantic forced the river in a direction parallel to the shore until its banks were no longer able to contain it; at such times the river would break out and form a new mouth. The mouth below "Bayonne" was improved precisely upon the plan of our own lake shore harbors. Parallel dykes are carried out to a depth where the action of the waves cease to disturb the bottom, which is in about eighteen feet, the channel is cleared by dredging and the natural current of the river maintains the same, the detsitus moved down by the river is carried off by the littorral current into deep water. The question as to how long these artificial structures will serve their purpose, is a matter not yet determined. Operations were carried on for many years at the mouth of the Rhone by dykes and jetties, which plan had finally to be abandoned. It was hoped that by closing the lateral outlets, and by confining the channel between contracted banks that a sufficient depth might be obtained, but the works were not carried out to a sufficient depth, and the mass of alluvium carried down, left the outlet in about the same condition as it was before the improvement. Finally, a canal was constructed to the "Gulf de Fos" so called from a former canal constructed by Marius. This canal (St. Louis) is entirely sufficient for the requirements of commerce. In connection with this canal there is a very extensive basin to serve the purpose of trans-shipment to the steamers navagating the shallow portions of the river.

It appears that a system of jettees is the plan that has most generally been resorted to by engineers for the improvement of the mouths of rivers. In some cases they have been attended with partial success, and in others the enormous expense involved did not warrant the completion of the experiment.

An attempt was made about 1857 to improve the Southwest Pass of the Mississippi, but a tempest swept away a jettee of over a mile in length.

In reviewing the subject, we may safely conclude that the jetty system would give but temporary relief in working rivers, although the plan has succeeded admirably in the majority of our inland harbors where the same was applied.

Returning directly to our own subject, we find the Mississippi one of the most active working-rivers in the world. The South Pass increases at the rate of one hundred feet annually, and the other principal passes even more.

From the manner in which it is brought before the public we know that it is obstructed to a great degree and requires a remedy. For years the government has been engaged, and with considerable success, in improving the Delta. The method applied has been a peculiar kind of dredging. Boats of considerable power were provided with a movable propeller, which could be lowered to the required depth. The boat was run down stream into the bar, the excavator was agitated, and the alluvion was given to the current. This process most naturally required constant repetition, but on the whole was not of sufficient capacity to satisfy commerce. I am reliably informed that the depth of water maintained in the Southwest Pass at present varies from fourteen to eighteen feet, rarely, however, less than sixteen feet. But that, on account of this lack of sufficient water, many of the larger sailing vessels and steamboats have been withdrawn from the trade, and my informant says: "I believe that one German line has been discontinued on account of the difficulties, dangers, and delays at the mouth of the Mississippi."

Now, when we consider the foregoing, together with the fact that for the past twelve months the port of New Orleans reports a total export in cotton, tobacco, grain in bulk, sugar, and sundries of $100,000,000, and total imports, foreign and coastwise, of $60,000,000, notwithstanding the many drawbacks, we no longer wonder that the nation calls for improvements.

Now, the question arises, as to the kind and extent of improvement to satisfy the requirements of commerce. Although the Government, with an annual expenditure of about $100,000, has failed to maintain a reliable 18-feet channel, while commerce demands at least 24 feet, still the problem is one that must and can be solved. There are however other difficulties of a local nature which I would wish to exhibit. Captain C. H. Howell, of the Corps of Engineers, makes the following statement in his report for the fiscal year ending June 30, 1873:

"Even the popular prejudice against dredging has been overcome, and the people of New Orleans most interested to-day acknowledge the good done. So far, so well; but there is a powerful monopoly, known as the Tow-boat Association, domiciled in New Orleans, controlling its commerce, opposed to the improvement of the channels across the bars at the mouth of the Mississippi, and having in its power at any time to render valueless any improvement attempted. This association has, time and again, willfully and maliciously retarded my work, and damaged and destroyed its fruits."

This monopoly really forced the dredges from the Southwest Pass to Pass a l'Outre, in April of 1873, according to the engineer's report. Science may overcome the natural difficulties, but those just mentioned can only be overcome by prompt and positive legislation.

From what we know of this matter, it appears that the nation is prepared to do the work; the only question has been as to the plan which would, with the greatest certainty of success, and at a warrantable cost, satisfy the wants of commerce, and which could be maintained with a reasonable expense.

A board of engineers was appointed in compliance with an act of Congress of June, 1874, to examine and report a plan with estimates for obtaining and maintaining sufficient depth of water to tne Mississippi for purposes of commerce. The plan to be either a canal, or the improvement of one or more natural outlets.

The board has completed its labors and has reported in favor of the Jetty-system, according to the idea of Captain Eads, (of St. Louis bridge fame,) with this difference, that they reccommend the South instead of the Southwest Pass. In this connection I agree with the committee, as the South Pass is several miles the shortest and debouches, into deeper water than the others, although some work will he required at the head of the passes to make a sufficient depth to the entry of the pass. The committee discussed several canal plans, the Fort St. Philip plan receiving the preference, but on account of the greater cost was rejected, and the improvement of the south pass by means of Jettees and dredging was finally recommended.

The estimated cost of construction and maintenance of this plan is $7,942,110, and the estimate for the Southwest Pass is $16,053,124, and that of the Ft. St. Philip Canal $11,514,200. Now as to the relative merits of the different plans without regard to cost of construction or maintenance, the improvement of the South Pass would open the Delta in the middle and vessels going either way would not be obliged to make a detour, while at the same time it is the shortest and most direct route to the river; on the other hand Capt. Eads may have counted on the more stable bottom of the Southwest Pass to support the Jettees. In either case it would require a large annual expenditure to lengthen the Jettees as the delta advanced, and to dredge out the bars.

If we should now consider the Jetty-system to succeed, the danger of entering is still not removed. It will be necessary, in a storm, to find an entrance to a gap of only 300 yards among mud-lumps and mud-banks, none of which are more than three feet above still water, and although the channel may be boyed and marked and lighted, still more than ordinary skill would be required, while at the same time the entry would be subjected to the severest storms and waves of the ocean.

As reported, one member of the board concurred only in so far as the selection of the south pass for the *trial* of the Jetty-system if that be adopted, as the chances of success of the improvement of the natural outlets do not in his judgment justify recommendation; and since the canal plan offers reasonable chances of success, he gives this his preference.

New Orleans being the second city for value of her exports and sixth in the value of her imports in the United States and promises fair to improve with sufficient navigation, it is important that the plan offering the greatest chances of success should by all means be the one to be adopted.

From the quotation which I have used to give a general idea of the appearance and consistence of the delta, and by examining a map of the same, the difficulties to be encountered are very apparent. Placed, I might say, in an open sea, a hundred feet deep of mud, of insufficient consistence to sustain itself, ever seeking an equilibrium, some sinking, some rising, moving, oozing, never at rest; volumes at times lashed into foam by the fury of the ocean waves.

Considering the unstable foundation upon which we would have to construct, and the fact, that the Jetty-plan has been attended with success in only a few and special cases, it is but proper that we should adopt some other and more certain method to obtain the end in view.

The plan known as the Fort St. Philip Canal, has always appeared to me to be most reliable method of opening the Miss. The river at this point is deep and safe; the banks, although not more than a few feet above the level of the river, have assumed sufficient stability to admit of constructions; the whole length between extremes of excavtion will be about six miles; the river at this point never rises more than seven feet above the level of the gulf, and is seldom lower than the same. The gulf-end is sheltered by the arms of the delta, and by a number of islands, and will give a safe outlet of 26 feet, which is sufficient to admit the largest class of sea-going vessels. Several locations of canals have been advanced, but all seem to be encumbered with the same objections excepting the Fort St. Philip Canal.

One plan has been to leave the Pass a l'Outre six miles inside of its bar and reach deep water to the north; another, of leaving the Southeast Pass about six miles above its bar and make deep water towards the east. Both these plans have this disadvantage; although the slope is inconsiderate, yet without locks, there is a possibility of the canals becoming a branch of the Delta; on the other hand, it may be that the stability of the banks is insufficient to support the construction of locks, or resist the pressure during freshets.

Another plan has been considered, which is the closing of the head of the South Pass by means of a dam, and entering the Pass through a channel from the Southwest Pass. In this case the difficulty would be the keeping open of the mouth of the pass by dredging away the bar which would be thrown up by the ocean waves. It appears to me, that the plan of the Fort St. Philip Canal is the most reliable plan of producing uninterrupted navigation to the Mississippi, and the only plan which promises positive success. This canal would be in the extreme six and one-half miles long and should be 300 feet wide at the bottom, with sloping banks of not less than two horizontal to one perpendicular. The lift to be overcome would never exceed seven feet; the locks should be of the greatest capacity, say 500 feet long and 80 feet wide, so as to enable the largest class of vessels to enter without difficulty, or to pass a fleet of small vessels at the same time. I would recommend at least two locks, in order not to impede navigation in the least degree; at the same time if one lock should in any manner be impaired, commerce would not be impeded.

I have not the slightest doubt that such a canal could be constructed at a cost not to exceed that estimated for the improvement of the South Pass, say $8,000,000 in round numbers with a certainty of success which no other plan promises. An annual expenditure of $25,000 or $30,000 may be required to maintain the work, still this is no comparison to the $100,000 or $300,000 required to extend the jetties per annum, provided that science and determination should exist in sufficient abundance to produce the same on the ground which would have to be occupied, and of sufficient stability to escape the fate of the jettee of 1857.

ON THE CATOCALÆ OF RACINE COUNTY.

BY P. R. HOY, M. D., RACINE.

There is an interesting group of large showy Lepidoptera, belonging to the great family of Nocturnidac, included in which is the genus Catocala. The larvæ feed on the leaves of various shrubs and trees. In the United States this genus is largely represented. The accomplished entomologist Augustus B. Grote, has catalogued sixty-four species. Many more undoubtedly remain to be caught and described. There has not yet been a locality discovered where Catocalas are so numerous as they are in the vicinity of Racine. During the summer and fall of 1874, there were taken within a space, bounded on the north by Ninth street, on the south by Evergreen Cemetery, on the east by the Lake shore, and west by College Avenue, being one and a half miles long by forty rods wide, no less than six hundred specimens, belonging to forty species. The abundance of insects found in the vicinity of Racine College, may be accounted for by the numerous and great variety of plants, shrubs, and trees cultivated, as well as the scarcity of summer birds.

The birds have been driven off by the boys belonging to the college, who for several years past robbed, indiscriminately, every birds' nest found, and their sharp lookout leaves very few undiscovered.

The consequence of this egging mania has directly diminished the number of birds, and indirectly vastly multiplied insects.

The following catalogue includes only those taken at Racine, all captured with two exceptions within the past year, (1874.)

CATOCALÆ, Epion, *Drury.*
" insolabilis, *Guen.*
" residna, *Grote.*
" obscura, *Streck.*
" viduata, *Guen.*
" desperata, *Guen.*
" retecta, *Grote.*
" Flebilis, *Grote.*

CATACOLÆ, relicta, *Walker.*
" unijuga, *Walker.*
" Meskei, *Grote.*
" Briseis, *Edw.*
" parta, *Guen.*
" coccinata, *Grote.*
" ultronia, *Hubn.*
" concubens, *Walker.*
" amatrix, *Hubn.*
" nurus, *Walker.*
" cara, *Guen.*
" ilia, *Cramer.*
" inubens, *Guen.*
" Var. scintillans, *Grote and Robison.*
" cereogama, *Guen.*
" neogame, *Guen.*
" subnata, *Grote.*
" piatrix, *Grote.*
" palaeogama, *Guen.*
" Var. phatanga, *Grote.*
" habilis, *Grote.*
" consors, *Abb. and Smith.*
" ponderosa, *Grote and Robison.*
" badia, *Grote and Robison.*
" antinymptha, *Hub.*
" levettei, *Grote.*
" serena, *Edwards.*
" nuptialis, *Walker.*
" polygama, *Guen.*
" grynea, *Cramer.*
" nuptula, *Walker.*
" fratercula, *Grote and Robison.*
" androphila, *Guen.*

ON A MASTODON FOUND IN RACINE COUNTY.

Everything relating to those great animals that in the distant past inhabited this country, is of interest. This paper is presented for the purpose of recording the facts and conditions under which the bones of a mastodon were found on the farm of H. Hoffman, southwest quarter of section 68, in the town of Dover, Racine county, Wis., on the 12th day of November, 1874. These remains were exhumed by F. Wells and F. S. Perkins, of Burlington. I am indebted to Mr. Perkins for a minute account of the soil and condition in which the bones were found. They excavated a piece of ground 15x20 feet, to the depth of four feet from the surface. They passed through first fifteen inches of peat, then through a bed of yellowish sand quite compact and hard, of a uniform thickness of six inches. Below this stratum of sand is a bed of light-colored deposit, of sticky clay, intermingled with fine sand, all of which was of the consistency of soft putty. The depth of this deposit was not ascertained, as they could not reach bottom with an iron rod ten feet in length.

The most superficial of these bones was found only six inches below the sand—twenty-seven inches from the top af the peat.

The greatest depth at which any were found was four feet from the surface. They procured many fragments of broken ribs, several vertebræ, the right scapula, a fibula and two tusks. All the bones were much decayed, and of little value. However, by the exercise of great care and skill, one of the tusks was taken out and so prepared, that it is now the most perfect specimen I ever saw. There is not a fraction wanting. Even the sharp edge of that portion entering the socket in the jaw is complete.

This tusk is four feet eight inches in length and fifteen inches in circumference. No teeth were found. All the lower bones were found in great disorder; the tusks were separated ten feet apart, and each resting on fragments of ribs.

The peat-swamp, in which the bones were found, is 200 feet wide, by 800 long, surrounded by high ground with the exception of a narrow outlet. This marsh was undoubtedly once a small lake, now filled with the wash from the adjacent elevated grounds.

The scattered condition in which the bones were found may be accounted for by the agency of ice. The water freezing to the bottom would include the skeleton. Then when the ice broke up it would transport the bones to various parts of the lake. Possibly, however, animals, or even man, have had to do with separating the various parts of the skeleton.

COPPER TOOLS FOUND IN THE STATE OF WISCONSIN.

BY PROF. J. D. BUTLER, LL. D.

Implements of unalloyed copper are among the most rare and curious of archæological findings. The exhibit of these articles now made at the Philadelphia Centennial comprises the largest collection ever brought together. The copper age proper, in distinction from the age of bronze, forms a link in the chain of human development which according to Sir John Lubbock, "is scarcely traceable in Europe." The only European museum known to that distinguished archæologist which contains any copper tools is the Royal Academy at Dublin. The number there was thirty till within a year or two, when five were received from Gunjera—a province in India north of Bombay.

The articles now on view at the Centennial are as follows: In the Government building, from the Smithsonian Institution, seventeen real tools, besides casts of several others, and various copper trinkets. In the same building two articles, much corroded, owned in the State of Vermont.

In the mineral annex. From Ohio eight implements; from Michigan nineteen, and from Wisconsin, *one hundred and sixty four.* The whole number from all quarters is two hundred and ten.

I made notes regarding all the exhibits, but having lost them; can only describe the shows from Wisconsin. But the coppers from that State are nearly four times as many as all the rest of the world has sent to Philadelphia, and they surpass others in size, variety, and perfection of preservation, as much as in number. The only instrument from any other source, not represented among Wisconsin Coppers, is a crescent about six inches long—perhaps intended for a knife, though it has no handle.

Among the varieties in the Wisconsin exhibit—which is made by the State Historical Society—are the following:

Ninety-five spear-heads. Of these the larger number are what some antiquarians called "winged," that is the sides of the base are rolled up towards each other so as to form a socket to receive a shaft. Some of these sockets are quite perfect, and all are ingeniously swaged. Sixteen of them are punched each with a hole, round, square, or oblong, for a pin to fasten the shaft, and one of the copper pins still sticks fast in its place. Twenty-three of the spear-blades swell on one side something like bayonets, the rest are flat. Three are marked with seven dents apiece, and one with nine; indentatious which have been fancied to indicate the number of beasts, or men, the weapons had killed. Nine spear-heads have round tangs which are so long, smooth and sharp, that they may well have been used as awls and gimlets. The blades of these nine spears swell in the middle of each side. Their shape is a beautiful oval. The largest specimen of this class is about a foot in length. In the middle of its blade there is a hole as large as a pipe-stem, which may have been drilled for putting in a cord to recover the spear when it had been thrown into the water. One spear has a unilateral barb. This, meeting with unequal resistence, will not go straight in water, so we think it of an absurd pattern. But the truth is that if aimed at a fish where he looks to be, it will hit him where he is—though, owing to the refraction of light in water, he is not where he looks to be. One barb is then better than two, and we are the fools after all. Spears of a similar pattern, though of other material have been exhumed in France and California, and are still used in Terra del Fuego. Specimens in bone from Santa Barbara may be seen in the Smithsonian exhibit. Thirteen spears have flat tangs to thrust into shafts. Six of these tangs are serrated or notched like the necks of flint weapons for binding about with sinews. They seem to mark the very point of transition from one material to another—from mineral to metal.

There are fifteen knives. Most of these were intended to be stuck in handles, but one of them has a handle rolled out of the same piece of copper with its blade. Another has its copper handle bent into a hook. There are several gads, or wedges, to be driven. There are three adzes—tools beveled only on one side of their edges, and with broad sockets for handles. There are eleven chisels, some as heavy as those we now use. There are twelve axes, one weighing three and three-quarter pounds is exactly the weight of those common among Wisconsin lumbermen to-day. Another, which is a pound heavier, is the largest specimen of wrought copper that has ever been brought to light. There is one hook, and a square rod. There are more than half a dozen borers of various sizes. One may be called an auger, being sixteen inches long and three in circumference. There is a dagger ten inches long with a blade an inch wide. These, with various anomalous articles, complete the catalogue.

For the conservation and display of this unique copper treasure the State of Wisconsin has set apart one of the towers of the Capitol in Madison. There they will be daily open for inspection, and will no doubt be a magnet attracting to themselves other curiosities of like nature.

The question is always asked, "Where did these coppers come from?" It cannot be so definitely answered as is to be desired. Nevertheless something is known in respect to the finding of them. They were all discovered within the limits of Wisconsin—while the Smithsonian specimens—less than one eighth as many, were gleaned from eight different States. Nearly all of them have come to light in eleven southeastern counties of Wisconsin. Only in those counties has much search been made.

Most of the Wisconsin coppers were brought together into one collection by the zeal and perseverance of one single man, Frederick S. Perkins of Racine county. Five years ago this gentleman, though he had long been forming a museum of stone implements, had never seen one of copper. On the 25th of November, 1871, he was first shown such an antique. It was a large spear-head that had been exhumed three miles north of his residence in Burlington, Wisconsin. That November date marks the birthday of his interest in copper—or his transition from the stone to the copper age. His enthusiasm which had been great for the former became greater for the the latter. He had leisure—or he made it, to ride over county after county on every road, waylaying every pedlar, calling at every school, every store, at almost every house. He advertised in newspapers, he threw tempting baits abroad on all waters. He found what he sought, where no one else would have looked for such a prize, and where many proved to him that it could not be found. He has recorded the name and residence, by county and town, of one hundred and twenty-one persons from whom he obtained pre-historic coppers, as well as of three hundred and twenty-five others who furnished him stone antiques, but had no coppers to furnish. This record shows how thorough and wide-spread were his researches. Indeed, although the Wisconsin Historical Society has bought the bulk of his findings, some of them are scattered far and wide. Five of them are in the Central Park museum, others in the Metropolitan in New York, others I think have enriched the Smithsonian. A further question which must occur to every investigator, is, where were these implements obtained by those from whom Mr. Perkins obtained them? On this point my information is more scanty than it would be were not Mr. Perkins now in Europe, and than it will be on his return. Large numbers of the tools were turned up in plowing or hoeing. Others at greater depth in digging foundations of houses or sinking wells. Not a few have come to light in burial mounds close by skeletons. In one such mound at Prairie du Chien an axe weighing two and seven-sixteenths pounds and eight inches long was discovered lying on a large flint spade, fourteen feet below the top of the mound, and seven feet below the level of the earth around, and among human bones. Another axe, with other coppers, was taken from a similar mound in Barron county. The only socket spear-head which shows its rivet still in its place, was found on a knoll in plowed land by James Driscoll in May, 1874, at Lake Five, Waukesha county. One knife was dug out of a mound by a dog while hunting, in 1860, in Troy, Waukesha county. One chisel was met with ten feet below the surface in cutting a road through a bluff at Cedarburg, Ozaukee county, in 1871. One of the most remarkable articles, a sort of copper pike, was dug up three feet under ground on the bank of Pike Lake, Hartford, Washington county, by Samuel Mowry in 1865. One massive celt, at first turned up in Merton, Waukesha county, a pedlar had preserved for twenty years. Several knives and other implements found near lakes and rivers appear to have been washed out of their banks. A lance-head found at Rubicon, Dodge county, in 1869, has a lump or stud of silver on one side of it.

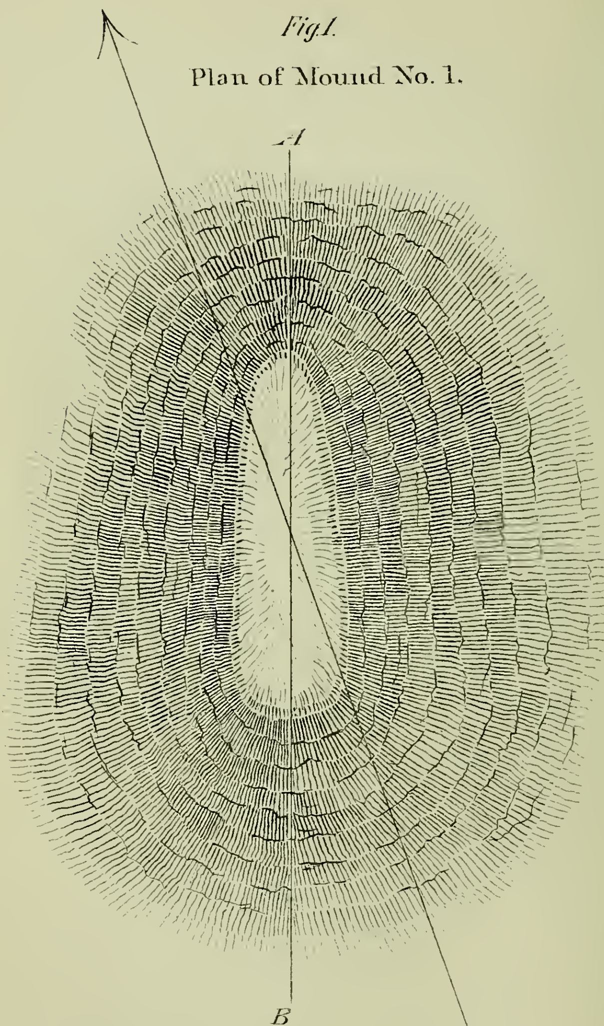
But we cannot fail to ask, "who made these copper instruments? was it Indians or some pre-Indian race?" It has been argued that they are of pre-Indian origin because the skeletons with which they are discovered in burial mounds are not of the Indian type, but of a very different cranial development. Again, as the mounds, multitudinous and often of vast size, are beyond Indian industry, so the tools seem beyond Indian ingenuity. Most of them indeed, are hammered, and so show copper used rather as a mineral than as a metal. Others of the coppers betray no marks of hammering, no laminations or flaws. Practical foundrymen detect on them mould-marks where the halves of a flask united, and so declare them smelted. Others they hold were run in a sand-mold. These indications of casting are plainest on the largest piercer and on one of the chisels, except perhaps on certain implements which Mr. Perkins has carried abroad for the conversion to his views of trans-Atlantic skeptics regarding our pre-historic metallurgy. All proofs that our coppers were cast, tend to show that they are not the handiwork of Indians.

Our early annals indicate that our copper implements were a pre-Indian manufacture. They testify that the earliest travelers in Wisconsin found the Indians using copper, if at all, only for trinkets and totems, but not for implements either of war or of peace. Thus La Salle on his last expedition through this region, well nigh two centuries ago, says of the Indians: "The extremity of their arrows is armed, instead of iron, with a sharp stone or the tooth of some animal. Their buffalo-arrow is nothing else but a stone or bone, or sometimes a piece of very hard wood." Charlevoix, writing about 1720, mentions Indian "hatchets of flint which take a great deal of time to sharpen, as the only mode of cutting down trees." "To fix them in the handle," says he, "they cut off the head of a young tree, and make a notch in it in which they thrust the head of the hatchet. After some time the tree by growing together keeps the hatchet so fixed that it cannot come out. They then cut the tree to such a length as they would have the handle." "Both their arrows and javelins," he adds, "are armed with a point of bone wrought in different shapes." According to Hennepin about 1680, (2.103) "the Indians, instead of hatchets and knives, made use of sharp stones which they fastened in a cleft piece of wood with leather thongs, and instead of awls they made a certain sharp bone to serve." The Jesuit Father Allouez, writing about 1660, says: I have seen in the hands of the savages, pieces of copper weighing from ten to twenty pounds. They esteem them as divinities or as presents made them by the gods. For this reason they preserve them wrapped up with the most precious things, and have sometimes kept them time out of mind." In none of these or other early chronicles do I find any mention of any copper tool whatever. Pre-historic mines about Lake Superior are a proof that our copper implements are not Indian work. No tradition of such mines was brought to light by early adventurers among Indians. But if excavated by them to such an extent as we see them, and for ages, how could they have been given up and even forgotten? On the whole the evidence now before us tends to show that our copper tools are the work of some pre-Indian race. The success of Mr. Perkins in unearthing coppers in unlooked for numbers should raise up a legion of copper-hunters. For encouraging such investigators still more, my last words shall be regarding the greater harvest than has crowned his labors which seems to me ripe for their sickles.

Indications are not wanting that our past prizes in copper-hunts, are all as nothing to what is in store for us. Pre-historic mining-pits honeycomb Isle Royal all over. Along the south shore of Lake Superior they are frequent for a hundred miles. They were every one rich pockets. Their yield of copper must have been many times enough for sheathing the British navy. What has become of this copper? It cannot have vanished like iron in oxidizing rust. It must still exist, and lurk all around us. At Assouan the quarries prove to a stranger that Egypt must be rich in granitic monoliths, for there we see the rock whence they were hewn. Spanish treasure-ships sunk in the Carribbean ages ago, still teach divers where to ply their sub-marine machinery for richest spoils. In Greece, the Styx, and other catabothra, or lost rivers—emptying into subterranean abysses, suggested to the ancients streams that girdled the whole under-world. So our mining shafts sunk time out of mind are a prophecy and an assurance of copper bonanzas for explorers in the future so vast as will make us utterly forget whatever has been discovered. All hail such a ressurrection of the copper age. The longer it has been lost the more welcome will it be when found again.

Fig.1.

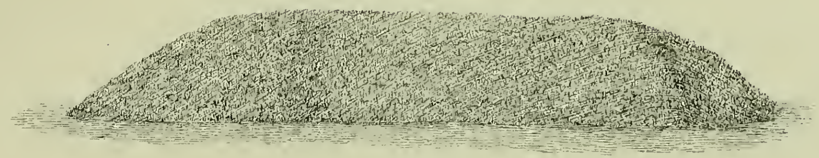
Plan of Mound No. 1.



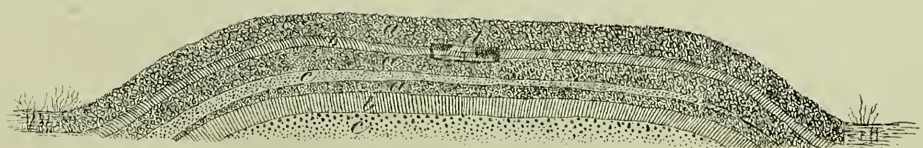
Scale 20 ft. to 1 inch.

Fig. 2.

Elevation and Section of Mound No. 1.



on line A.B.



Scale 20 ft. to 1 inch.

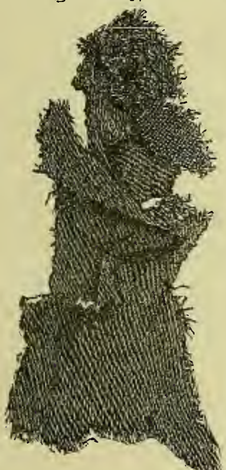
Surveyed by W. J. L. Nicodemus C.E. 1874

REPORT OF COMMITTEE ON EXPLORATION OF INDIAN MOUNDS.

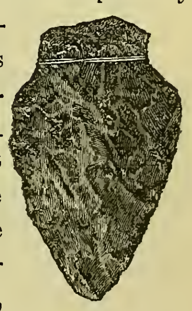
The committee, on exploration of Indian mounds in the vicinity of Madison, Wisconsin, have the honor to report, that they have explored three mounds.

These mounds are situated upon the crest of the peculiar ridge of glacial drift, which separates Lakes Monona and Wingra, known as Dead Lake Ridge.

Mound No. 1 is pear-shaped, and runs east 30 degrees north, by west 30 degrees south, being in this direction 78 feet long and in a line through center, perpendicular to this, 55 feet.



Beginning at center and proceeding inward, alternate layers of mould and clay, very dry and compact, were penetrated to a depth of six feet, then a layer of gravel, a foot thick in center, gradually reducing to four inches in thickness at the base, having the natural slope of gravel thrown down at center. To this succeeded alternate layers of clay and mould to a depth of nine and one-half feet from the surface to the natural surface, (see Figs. 1 and 2;) a. represents mould, b. clay, and c. gravel. The penetration was carried three feet below the natural surface through layers of boulders and coarse gravel. A fire-place, 2x2½ feet, with a layer of charcoal and ashes four inches in thickness, was found at a depth of five feet. In this was a piece of cloth partially burnt, which for the most part crumbled to powder on exposure to the air. A small piece was preserved. Both on the north and south sides, fragments of bones occurred at three to five feet from surface in an advanced stage of decomposition. A chert arrow-head was found three feet below surface opposite the center on the north side. In the center at two feet above natural surface were obtained, nearly broken down by decomposition, the femurs, tibiæ and fibulæ of a single skeleton corresponding to a height of six and one-half feet in the living subject.



Mound No. 2, (see Figs. 3 and 4,) is a round mound 40 feet in diameter, and sloping to the base of No. 1. The line joining their centers runs east 30 degrees south, by west 30 degrees north, and is 64 feet long. In opening this mound obscure alternations of mould and clay were pierced to a depth of 8½ feet.

Two fire-places were found, one at 3 feet, and the other at 5 feet below surface. Dimensions the same in each, 3 by 6 feet. In the lower one was partially burnt bone in the ashes. At 6 feet were found some pieces of pottery and a bundle of bones, consisting of fragments of four or more skeletons in a tolerably good state of preservation, corresponding to heights from 5 feet 8 inches to 6 feet 6 inches in the living subject. Photographs are transmitted herewith, which give forms of two crania secured.

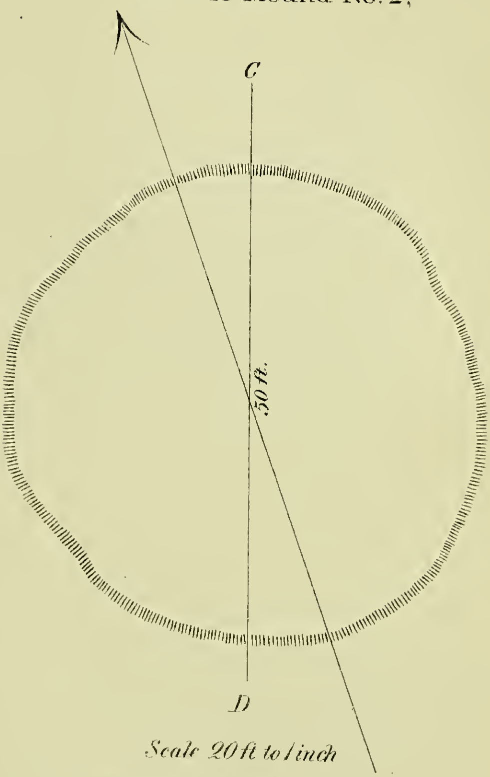
Mound No. 3 is a low mound about 200 yards south of No. 2, on the same ridge, forming a mere swell upon the surface. About 2 feet below the surface, in the center, occurred partially decomposed bones of a single skeleton. Below that the mould and clay of natural surface.

Comparative measurement of crania, above referred to, as being found in Mound No. 2.

Description.	No. 1.	No. 2.
Longitudinal diameter..	6.4	6.5
Inter-parietal	5.2	5.4
Vertical	5.5	6.0
Frontal	4.2	4.5
Inte-mastoid arch	14.9	15.0
Inter-mastoid line	4.1	4.2
Occipito-frontal arch	12.0	12.5
Horizontal periphery	19 6	20.2
Facial angle..	70°	75°
Internal capacity	81	85

Fig. 3.

Plan of Mound No. 2,

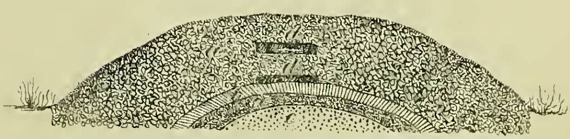


Scale 20 ft to 1 inch

Fig. 4.

Section of Mound No. 2,

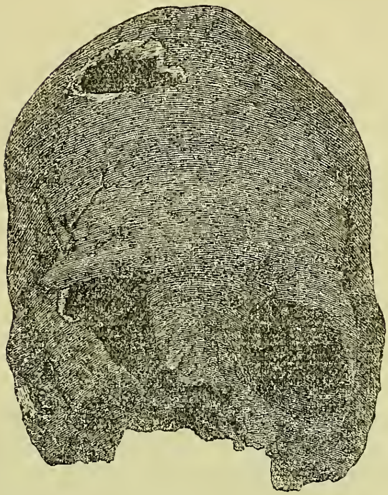
on line C. D.



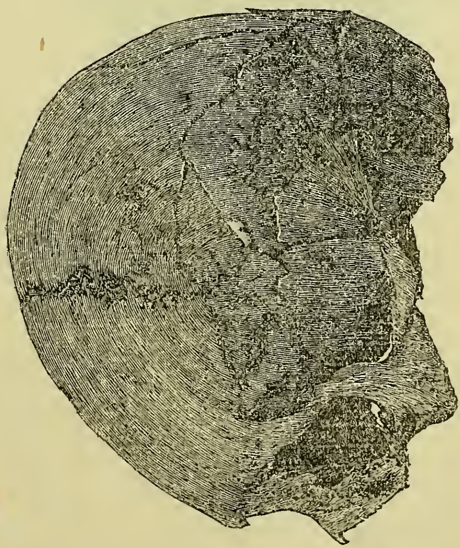
Scale 20 ft. to 1 inch

Surveyed by H. J. L. Nicodemus C. E. 1874

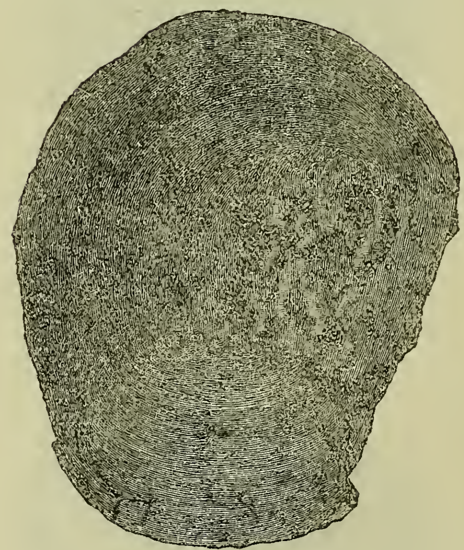
(Crania No. 1.)



(Crania No. 1.)



(Crania No. 2.)



The committee have not thought it advisable to do more in this report than to state the mere facts of the exploration, leaving to individual members of the academy the opportunity of pointing out the bearing of these facts.

The thanks of the committee are due Messrs. Delaplaine and Burdick, on whose lands the explored mounds are located, for permission to open them, to Mr. James R. Stuart, artist, for assistance in superintending the exploration, and to Mr. N. B. Van Slyke, chairman of the executive committee of the Board of Regents of the State University, for furnishing tools and workmen from the university farm.

Photographs of the arrow-head, cloth, pottery, and crania, two of the pottery and three of the others, with four drawings of mounds Nos. 1 and 2, and an account of expenditures are herewith transmitted, as also the specimens of the first three articles named.

Respectfully submitted.

W. J. L. NICODEMUS,
J. B. FEULING,
ROLAND D. IRVING,
I. A. LAPHAM,
G. P. DELAPLAINE.

Madison, Wis., Nov. 18, 1874.

THE LAW OF EMBRYONIC DEVELOPMENT—THE SAME IN PLANTS AS IN ANIMALS.

BY I. A. LAPHAM, LL.D.

It is now generally admitted that there is a law in the animal kingdom, that the young or embryonic state of the higher orders, of animals resemble the full grown animals of the lower orders.

As examples of this law we have the tadpole, which is a young frog with gills and a tail, resembling the fishes which stand lower in the scale than the reptiles; and the caterpillar, which has the characteristics of a worm, but which is the immature state of the higher class butterflies.

The discovery of this important law, and its application to particular cases, has been one of the causes of the recent rapid progress in the study of the animal kingdom; it has enabled naturalists to determine the proper place of certain species in the grand scale of beings, and thus to correct their systems of classification; it has enabled geologists to decide upon the relative age of rocks in some otherwise doubtful cases. It has also given occasion for much speculation, which may have its use in directing the attention of men to the wonderous works of the Creator.

It is the purpose of this letter to show, as briefly as possible, that the same law of resemblance between the immature of one order, and the mature of a lower order of animals, is equally true in the vegetable kingdom, where its study may hereafter lead to results of equal importance.

To understand what follows it will be necessary to recall certain facts respecting the growth, development, organs, etc., of plants of the higher orders.

They grow from seed planted in the ground, have roots, stem, branches, leaves; they produce flowers with calyx and corolla, and the more essential organs—stamens and pistils; they bear fruit with seed after their kind, which, when planted, swell and become other plants.

The stamens have, at the top, a sack, (the anther,) completely filled with grains, (Fig. 2,) nicely packed; each of which proves on examination to be a smaller sack, (the pollen,) filled with a viscous fluid matter, in which is floating exceedingly small grains, called fovilla.

These are all essential organs in the re-production of plants, and must perform their functions before the seed can be matured. We may increase and multiply plants by layers, cuttings, budding, etc., but to re-produce a new plant, the agency of the stamens, pollen, and fovilla, as well as of the seed, is needed.

Under a good microscope this fovilla may be seen in any ripe pollen-grains, but the particles are among the most minute things we are called upon to examine, requiring the higher powers of the instrument even to see them; and what seems truly wonderful, these minute particles are found to have a proper motion of their own. They move forward, backward, or side-ways, but never make much progress in any direction; the motion appears to be objectless, like that of an animal seeking food.

The cause of this motion is not known; it is called molecular motion, and may be the effect of some chemical action, but is more probably due to the mysterious vital force.

From the bottom of ponds of stagnant water, and from springy places, we may bring up plants so minute that no unaided human eye has ever seen them; they consist of a single cell; they are the smallest and the very lowest grade of plant-life, the Desmideœ, and yet they are full-grown plants. They never grow to be anything else; they are only Desmideœ, and nothing more. They are true plants, and not animals, as was once supposed.

These minute, though full-grown plants, will be found actually moving forward and backward and sidewise; making no progress; appearing to have no aim, no object; precisely like the little particle of fovilla from the pollen-grains of the highest orders of plants.

Here, then, we have the first proof of the existence of the law in the vegetable kingdom; the wonderful motion, both of the full-grown plant of the lowest vegetable race, and of the particles, which may be regarded as one of the first steps toward the reproduction of the plants of the highest type.

Arctic and Alpine travelers report the snow as sometimes red, and we know that our stagnant waters are sometimes green. These colors are found, upon close examination, to be owing to other minute one-celled plants, called Protococcus.

They are little sacks or cells, containing particles of a brilliant

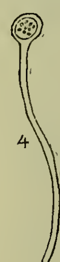
carmine red, or a beautiful green color. Each particle within the cell is destined to become a new plant, and then again to give origin to others.

The analogy between these full-grown plants of an exceedingly low grade and the pollen-grains of a rose, standing at or near the head of the plant-kingdom, is at once apparent. They contain particles (fovilla) destined to the same office of reproduction. One wood-cut serves to represent both.

The Botrydium (Fig. 3) may be deemed a plant only a little

higher than the Protococcus. It consists like that of a single cell; but this cell sends down a tube which is often branched, extending off in various directions, very much like roots in search of vegetable food. The cell proper is filled as usual with the reproductive particles, and some of the branches become enlarged, (as shown in the figure,) develop other particles, and soon separate to form new plants of the same kind.

In this, and in many similar full-grown plants of the lower orders, there is a very striking correspondence with the pollen-grains after they have fallen upon the stigma, and developed the pollen-tubes, (Fig. 4.) In both cases we have a cell with a tube extending downwards from one side, with the vegetable particles and fovilla; and in both, these minute bodies are supposed to pass down the tube to perform their office of originating a new plant.

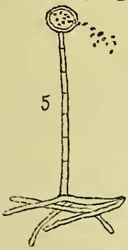


Here, again, the full grown Botrydium corresponds with the embryonic pollen-tubes of higher plants, and we have a third proof of the existence of the law.

Fungi are plants of a higher grade than the Algæ, the Protococcus, and Botrydium. Instead of a single cell, they consist of an aggregation of cells; and they produce a number of little cases or sacks, filled with grains called spores.

Fig. 1. Protococcus. Fig. 2. Pollen-grain.
Fig. 3. Botrydium. Fig. 4. Pollen-tube.

Here (Fig. 5) is a figure of the mould that grows upon bread in


5

a damp cellar. It consists of a single stem, made up of cells placed one upon another, and a single globular spore-case at the top. The spores are liberated when ripe, and blown to the four quarters of the world, by the wind. Wherever they alight, (circumstances being favorable, as bread in a damp cellar,) they grow and become mould again.

Compare this, which is one of the lowest of the fungi, with a stamen (Fig. 6) growing in one of the most perfect of flowers. It has its filament (stem) supporting a case or sack (the


6

anther) filled with pollen-grains, (which I compare with the spores of the fungi,) and which, when fully mature, are liberated and scattered about by the wind, or are carried by insects. Under favorable circumstances (falling upon the stigma) they also grow and become new plants.

These examples are sufficient for the present purpose; they show clearly the existence of this important law in the vegetable as well as in the animal kingdom.

Many similar analogies might be found throughout the whole course of vegetable life, had we time to pursue the subject.

We have here one more connecting link between the two great kingdoms of organized nature; and another proof of the unity of design of the Creator.

Fig. 5. Mucor, (mould.)

DEPARTMENT OF

LETTERS.

Titles of Papers read before this Department

Studies in Comparative Grammar, by J. B. Feuling, Ph. D., Professor of Comparative Philology, in the University of Wisconsin.

Department of Letters.

STUDIES IN COMPARATIVE GRAMMAR.

BY J. B. FEULING, Ph. D.,

Professor of Modern Languages and Comparative Philology, in the University of Wisconsin.

1.—SOME WEAK VERBS IN THE GERMANIC DIALECTS.

A few weak verbs in the 1st class in *ia (j)* present some peculiarities due to euphonic changes, on account of which most grammarians class them with the "irregular" verbs, or place them with the modal auxiliaries (praeterito-praesentia) in the *mixed conjugation*, because "they unite in themselves something of the features of the *strong* and *weak* verbs." See Earle, Philology of the English Tongue, p. 246. Dr. F. A. March classifies correctly those of the Anglo-Saxon dialect in his A. S. Grammar (209), though following tradition he mentions them again among the so-called irregular verbs, (216). They are also correctly classified by Dr. S. H. Carpenter, in his "Introduction to the Study of the Anglo-Saxon Language." In the "Transactions of the American Philological Association, 1872, (Article IX, 'Some irregular verbs in Anglo-Saxon") Dr. March has given an explanation of these verbs. A comparison with the other dialects shows not only the correctness of Dr. March's views, but also the fact that there is nothing anomalous in the conjugation of these verbs. All dialects have in common the syncope of the derivative *j* (*i*, *e*) in the preterite, and the letter-changes incident to this syncope are in harmony with the euphonic laws of the respective dialects.

In *Gothic* these verbs are: *briggan* for *braggjan*, to bring; *brûkjan*, to use, want; *bugjan*, to buy; *kaùpatjan* for *kaùlpatjan*;

vaúrkjan, to work; *thagkjan*, to think; *thuggkjan* or *thugkjan*, videri. The *d* of the preterite-suffix *da* can only stand after *n*, *r*, *l* and *z*, (the only exceptions are: *gahugds*, *ajukduths*); it changes to *t* after *t* which becomes *s*, and after *k*, *g* which become *h*, hence *gd* and *kd*=*ht*, *td*=*st*. The nasal *g* (*n*) disappears before *h*, which causes the lengthening of the preceding vowel. The preterite of these verbs is, therefore, as follows: *brâhta* <*braghta* <*braggda* <*braggida; brûhta* <*brûkta* <*brûkda* <*brûkida; baúhta* <*bugta* <*bugda* <*bugida*, short *u* before *h* (*r*) has the breaking *aú; kaúpasta* <*kaúpatta* <*kaúpatda* <*kaúpatida; vaúrhta; thâhta* <*thâkta* <*thâkda* <*thag(n)kda* <*thagkida; thûhta* for *thugkida*> *thugkda*, etc. The consonant-changes are due partly to assimilation, partly to dissimilation. In *briggan* (root *brag*, cf. fra-n-go), the *i* is a weakening of the original *a*. In the other dialects the derivative *j* (*i*) caused *Umlaut* in the present which remained after the *j* had disappeared (after stems long by nature or position) by syncope as in Old High German, or by assimilation as in the Anglo-Saxon. But in the preterite *Rück-umlaut* takes place on account of the syncopated *j*, which vowel-change, in addition to the consonant-changes, forms the peculiar characteristic of these verbs. This vowel-change is not the *Ablaut*, as some grammarians teach.

Old High German—prenkan (prinkan), pret. *prâhta*, p. p. *prâht*. This verb belonged originally to the strong conjugation, (Class XII, Grimm), for we find the following forms: *prank, prunkumês, prunkan;* in the Gothic documents strong forms do not occur. Its present stem was formed with the infix -*na*-, shortened -*n*-, which was originally a suffix. This verb is an example of a primitive verb in the transition-period to the weak conjugation, and Language remained conscious of its primitive character in retaining the strong form which occurs for the pret. participle in the dialects of New High German. *Denchan (thenkan)*, pret. *dâhta*, p. p *dâht* and *denchit; dunchan*, *dûhta*, *dûht; furhtan* or *forhtan*, *forhta*, *forht* and *furhtit; wurchan (wirchan)*, *worhta*, *worht* and *wurchit (wurht).* Old High German rejects the Umlaut of *u; forhta* and *worhta* have weakened *u* into *o* on account of the following *a,* but when the succeeding syllable has *i*, the original *u* reappears in the root, hence *furhtit* and *wurchit.*

In *Middle High German* the vowels *i* and *u* are sheltered by the liquids *m* and *n,* followed by another consonant. While the Umlaut *ü* is unknown in Old High German, it appears in Middle High German without excluding entirely *u* (*o*); we observe therefore a fluctuation between *u* (*o*) and *ü*. *Bringen*, *brâhte*, *brâht;* the strong forms *brang*, *brungen* are occasionally found in documents of the twelfth century. The strong pret. participle *ge-brunge(n)* by the side of *gebrocht* for *gebracht* is found in dialects of New High German. *Denken*, *dâhte*, *ge-dâht (gedenkt*, New High German patois); *dunken*, *dûhte (dunkte)*, *gedûht (gedunket)*; *vürhten*, *vurhten*, *vorhten*, pret. *vorhte*, p. p. *gevorht*, *gevürhtet*, *gevorhten;* the *o* flattened into *ä* (*ö*), continues in New High German patois. *Würken*, *wurken*, *wirken*, pret. *worhte*, *(warhte) wurhte*, p. p. *geworht*, *gewurht*, *gewürket*.

In *Anglo-Saxon* the *a* has weakened into *i*, as in *Gothic*, e. g. *bringan*. The *i*, not only original, but also weakened, passes into *e*, hence the form *brengan*, by the side of *bringan;* the *e* in *brengan* might be considered as the Umlaut of the original *a*, on account of the syncopated derivative *i*. I prefer, however, to take *e* as a weakening of *i*, because this verb does not seem to have established itself entirely as a weak verb, as indicated by the existence of the strong forms *brang*, *brungon*. It forms the preterite *brôhte*, not *brohte*, as the comparison with other dialects shows. Although the *Anglo-Saxon ô* is identical with the Gothic *ô*, it corresponds here to the Gothic *â;* an interchange between *ô* and *â* is peculiar to Anglo-Saxon (Low German.) In *bycgan* the *y* is Umlaut of the original *u*, which passes into *o* in the preterite. The consonant combination *cg* represents the gemination of *g*, which takes place before a syncopated *j* according to *Holtzmann*, *Altdeutsche Grammatik*, p. 212, 5. But it is preferable to assume an assimilation of the derivated *j* to the preceding *g: bygjan> byggan> bycgan.* This derivative *g* (assimilated *j*) is dropped before the suffix of the preterite, which causes the reappearance of the original *u*=weakened *o* : *boc(g)-de> boc-te>boh-te;* the sonant *d* is assimilated to the surd *c*, and "when two mutes come together, one of them often becomes continuous for more easy utterance." Of *hycgan <hygjan* we should expect, after the analogy of *bohte*, the preterite *hohte*, but we find *hygde* or *hogde*. It formed the preterite from the unassimilated *hyg-jan* either *without* Rück-umlaut *hygde*, or *with* Rück-umlaut *hogde (hugde);* in either case it dropped the derivative *j*, being treated as a stem long by position. If it had formed the pre-

terite from the assimilated *hycgan*, we would have *hycde*> *hycte*> *hyhte*, which could not have been distinguished from *hyhte*, the preterite of *hyhtan*, to hope. It is evident that *hogde* with the Rück-umlaut is a later form than *hygde*, if not, there is no reason why we should not have *hohte*. The cognate *hogjan* (Class II.), pret. *hogôde*, may have been the cause, that *hygde* adopted Rück-umlaut. In *thyncan* the *y* is Umlaut of *u*; in the preterite Rück-umlaut takes place; *thûhte* <*thûcte* <*thuncte*. In *wyrcan* the *y* is Umlaut of *o*, weakened from *u*; as *y* and *i* are interchanged, we find sometimes *wircan*, which has the breaking *weorcan*, but *wircan* and *weorcan* are bad spelling, for while *y* might always replace *i*, the reverse could happen only after it had been forgotten that *y* was the Umlaut of *u* (*o*). In the preterite the original vowel reappears regularly, as *worcte*>*worhte;* the *o* is therefore not the effect of the *h*, as Dr. March assumes in the article above mentioned, (p. 112, 3); for the original *y*=*i* would have the breaking *eo*. The *lecgan* and *secgan* arise through assimilation and umlaut from *lagjan* and *sagjan*. As the derivative *j* (*g*), Anglo-Saxon *e*, disappears in the preterite of stems long by nature or position, which causes Rück-umlaut,—the preterite of these verbs is **lagede*,**sagede* >*laegde*, *saegde*, contra., *laēde*, *saēde; ae* is the regular weakening of *a*. The *e* in *segede*, *legde* is bad spelling for *ae*.

In *Old Norse* we observe similar euphonic changes, e. g. *soekja* from *sôkja*, *oe* (*ae*) being umlaut of *ô*, forms the preterite with Rück-umlaut *sôtta*. We should expect *sôkta*, for *kt* never assimilates into *tt*, as Helfenstein says; but as *k* represents an original *h*, which with *t* assimilates into *tt*, the form *sôtta* is entirely regular. In *Old Swedish* we find *sôkt* by the side of *sott*. In *yrkja* *y* is the umlaut of *o* (*a*); its preterite is *orta* and *orkta (varkta)*. Of three consonants one is sometimes dropped, cf. *mart* for *margt; morni* for *morgni*, *apni* for *aptni; thykkja* or *thykja, kk*=*nk*, pret. *thôtta* from *thôhta*< *tkok(n)hta*; *thekkja*, *e* is the umlaut of *a*, pret. *thâtta* from *thâhta*<*thok(n)hta*.

2.—THE USE OF THE INFINITIVE OF MODAL VERBS INSTEAD OF THE PRETERITE PARTICIPLE IN NEW HIGH GERMAN.

Fred. Münch, a well known German-American writer, advanced lately the opinion that it was a blunder to say, "ich habe es tun können," instead of "ich habe es tun gekonnt." In reference to this construction I found in Professor Whitney's German Grammar, p. 109, the following note: "This is a simple grammatical anomaly, an original blunder of construction, though now sanctioned by universal use; it was apparently caused by the influence of the other neighboring infinitive, which attracted the auxiliary into a correspondence of form with itself." It will appear from the following remarks, that the *infinitive* is *not* an "original blunder of construction," but represents the ancient *preterite participle.*

1. The prefix *ge* was originally not a necessary element in the formation of the Germanic preterite participle. Afterwards some dialects used or omitted it as special prefix to the pret. part. It is a characteristic feature of the German and English languages, that Middle German developed the tendency to adopt this prefix, and Middle English (1100 to about 1250) to drop it, after it had been weakened to *i* (*y*); yet it continued to hold its ground for some time; cf. Corson's Note to "The Legende of Goode Women," Prol. v. 6. In the Nibelungenlied the participles *brâht*, *komen*, *laszen* (*lân*) never take *ge*, so that in M. H. German the context decides, whether *komen*, etc., stand in the infinitive or in the pret. participle.

2. The verbs *dürfen*, *können, mögen*, *müszen, sollen*, *wollen* are originally strong preterites, but later used as presents, after their own present had been lost (praeterito-praesentia). The strong pret. participle took the place of the infinitive and was replaced by the formation of a weak participle. It is probable, that the dialects, those faithful wardens of ancient forms of speech, retained the original participle with the former freedom to omit the prefix *ge*, as often as an infinitive preceded it, so that in the sentence, "ich habe es tun können," *können* is *not* the *infinitive*, but the old participle. Cf. Grimm, D. W, vol. v., p. 74.

3. Owing to a false analogy the verbs *hören*, *lehren*, *lernen*, *laszen*, *heiszen*, *sehen*, employ the infinitive instead of the participle, when preceded by another infinitive. The last three verbs could easily be "attracted" by the neighboring infinitive, because their participle, the prefix *ge* being omitted, is identical with the infinitive. It is, however, a better usage, to employ the participle of the verbs *lehren* and *lernen* in such a construction.

DEPARTMENT OF

Social & Political Sciences.

TITLES OF PAPERS READ BEFORE THIS DEPARTMENT.

---

1. United States Sovereignty; whence derived and where vested. By W. F. ALLEN, A. M., Professor of History and Latin in the University of Wisconsin.
2. Formal Commendation of Government Officials. By J. W. HOYT, M. D.
3. Industrial Education. By Rev. F. M. HOLLAND, Baraboo.
4. The People and the Rail Roads. By Rev. C. CAVERNO, Lombard, Illinois.
5. The Boa Constrictor of Politics. By Rev. F. M. HOLLAND.
6. The Revolutionary Movement among Women. By Dr. J. W. HOYT, President of the Academy.

Department of Social and Political Science.

UNITED STATES SOVEREIGNTY—WHENCE DERIVED, AND WHERE VESTED.

BY W. F. ALLEN, A. M.,

Professor of History and Latin in the University of Wisconsin.

The late war brought to an end the long and fierce controversy as to the nature of the Federal Union. What argument had not been able to decide, was decided by arms; and the United States are recognized as a Nation, possessed of sovereignty. With the determination of this controversy, however, another question has come into prominence, as to the origin of this sovereignty. Before the war it was commonly held that the act which severed the colonies from the mother country had as its effect the creation of thirteen independent and sovereign States; and that it was not until the formation of the Federal Constitution that sovereignty was conferred upon the central government. This doctrine, however, of the original sovereignty of the States, has been thought to afford some foundation for the doctrine of Secession. Some of the most ardent advocates, therefore, of the national and sovereign character of our Union, have, since the war, brought into great prominence the theory that the Nation was not created by the States, but the States by the Nation; that the States were never, in any true sense of the term, sovereign, but that the act of independence created at once a sovereign Nation. This view has been most fully elaborated in a series of articles in the first volume (1865) of the *Nation*, by Hon. Geo. P. Marsh, United States minister to Italy; it is presented also by Professor Pomeroy in his "Introduction to Constitutional Law." In this work the authority of Hamilton, Jay, Marshall, Story and Webster is claimed for this theory. I do not think, however, that Marshall and Webster can fairly be cited as its adherents. Mr. Pomeroy has given no citations in support of his view, and on the other hand both these jurists have expressed themselves unequivocally in favor of the original sovereignty of the States. Webster says, of the Confederation: "it was a league, and nothing but a league."* Chief Justice Marshalls' language is: "it has been said, that they [the States under the Confederation] were sovereign, were completely independent, and were connected with each other only by a league. This is true."†

Admitting, therefore, that the one theory has in its behalf the authority of Jay, Hamilton, Story and Kent, the other has the equally high authority of Marshall, Madison and Webster. We may, therefore, where authorities disagree, proceed to examine the arguments with perfect freedom from bias. The question is eminently an historical one—that is, a question of facts, not of theory, Sovereignty being the supreme power to command, it is simply a question of fact what organization was found in possession of this power, when it ceased to be exercised by Great Britain.

It requires no argument to show that before the Revolution the colonies were absolutely dependent upon Great Britain; whatever powers of government they severally possessed was in virtue purely of sufferance or explicit grant, on the part of the mother country. It is equally clear that the colonies were connected with one another by no organic bond. There was no government of the united colonies; each colony had its own government; and if sometimes, for the convenience of administration, two or more colonies were united under the same royal governor, this was simply an administrative union—one official managing two independent governments at a time, not a single government resulting from the fusion or union of two individual ones. There were thirteen organized communities, standing in a condition of coequal dependence upon the government of Great Britain. This tie of dependence was severed by the Declaration of Independence, July 4, 1776, sustained, as this act was, by armed force.

Two points fall here under consideration: first, the power which severed the tie; second, the logical effects of the act of severance.

*Speech on "The Constitution not a Compact," Works, iii. 454.
†Ogden vs. Gibbons, 9 Wheaton, 187.

First, the power that performed the act of severance was the Continental Congress. But by what authority, and in virtue of what delegation of power did the Continental Congress act? Was the Congress the organ of the several States, or of the "people at large" (to use Mr. Marsh's expression)?* To answer this question, which rests at the bottom of the argument, we must trace briefly the history of this Congress.

In the year 1764, upon motion of James Otis, the General Court of Massachusetts passed a resolution proposing to the other colonies to form a union for the purpose of resisting the acts of the British government. This proposition was accepted, first by Virginia, then by the other colonies. The Congress met the next year (1765), and shortly afterward, as a result of the spirit thus manifested, the Stamp Act was repealed. The Second Continental Congress met in 1774, called in a precisely similar manner. In both cases the members of the Congress were elected by the several colonies, and in both cases it was only a portion of the colonies—nine the first time, twelve the second—that were represented. Now so long as Georgia staid away, it is clear that not "the people at large of the United States," but only the people of twelve colonies, were engaged in formal acts of resistance. In the assembly thus composed of delegates from the several colonies, the colonies voted *as such*; no measure was adopted by a majority of votes, as would have been the case if they had been considered to represent the people at large; a majority of the *colonies* must always decide. It was by colonies that the Declaration of Independence was passed, and in this document the several colonies are declared to be "free and independent States."

Let us pause a moment upon this word "State," which thus makes its appearance in our political vocabulary. The great convenience of having a different term to denote the units which compose our federal government from that which designates the federal government itself, has established, in American constitutional law, a fundamental difference in the meaning of the respective terms. By *State* we understand a political organization inferior to the *Nation*. But this distinction is peculiar to American public law. The two terms are originally identical in meaning, or rather in application; being applied indifferently to the same object, but from different

* The Nation, No. 23.

points of view. A State is, in public law, a Nation, regarded from the point of view of its organization; a Nation is a State, regarded from the point of view of its individuality. We must not, therefore, suppose that when the colonies, in 1876, declared themselves to be free and independent States, they attributed to the word State the same inferiority which we now associate with the word. They understood by it, a sovereign political organization. That they selected this term, rather than Nation, is no doubt partly due to its expressing more distinctly the idea of organization; partly, I am ready to admit, to the feeling that *Nation* was a larger term, and that a higher organization, which should embrace all these individuals in one whole, was destined to result. Nay, we meet the term Nation very early, as applied to the united body.

That the Congress considered itself as acting as the organ of the colonies or States, and not of the people at large, appears manifest from the language habitually used. On the tenth of May, 1776 Congress resolved to "recommend" to the "respective assemblies and conventions of the United Colonies," to form permanent governments. August 21, of the same year, it made use of the expression: "All persons not members of, nor owing allegiance to any of the United States of America,"—showing that allegiance was regarded as due to the several States. Its constant title for itself was "the United States in Congress assembled"—a term which plainly recognizes that the United States, as an organized body, has no existence except in the Congress, which Congress, as we have seen, acted purely as the organ of the several States.

I pass now to the nature and effect of the act of severance. This act was in the first place purely negative in its intrinsic character. It simply put an end to a certain previously existing relation—that by which the colonies individually depended upon the British sovereignty. The relations of the several colonies to one another could not be affected by it. If before the act they formed a united, organized body, this united body, in virtue of the act of independence, succeeded to the sovereignty surrendered by the mother country; if they were individual and disconnected before, they remained so after the act, and each individual passed into the full enjoyment of sovereignty.

Now I have shown first, that before the revolution the colonies had no organic connection with one another, but only with the mother country; second, that the union which they formed for purposes of resistance professed to be nothing but a voluntary, incomplete and temporary association, with only limited and temporary aims, possessing none of the essentials of a permanent government, capable, it is true, of developing into a complete sovereignty, but in all its acts and words appearing as not itself an organic body, but the representative of certain organic bodies. "The United States in Congress assembled," made no claim to individual or independent existence, but acted avowedly as a mere intermediary or instrument of joint action for organisms which did possess individual existence. And this practical independence accrued to the several colonies simply from the fact that, upon the severance of the tie which connected them severally to the mother country, each was left standing legally alone; and, standing alone, having no legal superior, but possessing a complete and adequate organization of its own, each colony passed into the undisputed enjoyment of sovereignty.

Neither before nor after the commencement of the revolution, therefore, did there exist any united organic body which could supersede the several colonies, and assert a claim to the lapsed sovereignty of Great Britain. And if this is true for the period of inchoate nationality which intervened between the first acts of resistance and the practical establishment of independence, still more is it true for the ensuing period of the Confederation. It needs no argument to show that the States were at this time recognized as fully and exclusively sovereign; its Articles explicitly provide "that each state retains its sovereignty and power which is not by this Confederation expressly delegated to the United States in Congress assembled." All that can be said in opposition to this view is that this was a "palpable usurpation,*" set on foot during this "embryonic or inchoate period†"; and their arguments plainly imply that they understand the Articles of Confederation to represent a different phase of national life from the Declaration of Independence, and as requiring therefore to be construed from a different point of view; they were adopted by Congress sixteen months later than the other act, (Nov. 15, 1777.) and in this period of time, it is hinted, the "flow of enthusiasm," under which the united act of independence had

*Pomeroy, p. 48. †Mr. Marsh, in the Nation, No. 1.

been accomplished, "receded," and selfish and local prejudices took its place. Now, if the Articles of Confederation were really drawn up a year and a half after the Declaration of Independence, this reasoning would have much weight. But the date here given is only that of the *adoption* of the articles by Congress. They were reported to Congress July 12, 1776, just a week after the Declaration—the preliminary steps, indeed, were taken in June, before the passage of the act of independence. It is therefore perfectly legitimate to interpret the act of independence in the light of the government which was established after it. The two acts were to all intents and purposes parts of one and the same act. In the very act of declaring their independence, the States formed themselves into a Federal Union; and in this Union the several States were explicitly declared to be independent and sovereign; from which it necessarily follows that the Union thus formed, was, in Webster's words, "a league and nothing but a league."

It will be seen that the whole controversy turns upon the period between the suspension of the royal authority and the establishment of the confederation. While the royal authority continued to be recognized, sovereignty of course belonged to Great Britain; after the establishment of the Confederation, it as manifestly belonged to the several States. Was there an interval during which it was possessed by the United Colonies? Mr. Marsh says:* "it was not for a moment imagined that the sovereignty was in the interim lodged anywhere except in the whole people of the United Colonies." But he brings no facts to prove this assertion.

At the beginning of this discussion it was remarked that the question was essentially an historical one, and must find its decision in historical facts—that is, in the series of events by which the sovereignty was transferred from Great Britain to the United States; and I think I have shown that, as a matter of fact, this transfer was not made at one stroke, but that the sovereignty was actually possesed for a while by the several States, before it was transferred by a deliberate act to the nation. There remain, however, some theoretical objections to this view, which it will be necessary to consider.

Mr. Pomeroy states these theoretical objections in the following strong terms: "Grant that in the beginning the several states

* The Nation. No. 21.

were, in any true sense independent sovereignties, and I see no escape from the extreme positions reached by Mr. Calhoun."* No arguments are presented in support of this startling assertion, except the doctrine that among the attributes of sovereignty, "the one which underlies all others, and is, in fact, necessarily implied in the very conception of separate nationality, is that of supreme continued self-existence. This inherent right can only be destroyed by overwhelming opposing force; it cannot be permanently parted with by any constitution, treaty, league, or bargain, which shall forever completely resign or essentially limit their sovereignty, and restrain the people from asserting it." There is no attempt made to prove this doctrine; it rests simply upon Mr. Pomeroy's assertion, backed by references to the works of half a dozen European publicsts. According to this doctrine Texas was never annexed; if the United States had conquered her, and forced her into the Union, her status would have been a legal one; but as she came in voluntarily, surrendering her sovereignty and individual existence, the act was null and void. According to this doctrine the act of union by which, in 1706, England and Scotland surrendered their individual sovereignty, and united into the new sovereignty of Great Britain, was an impossible act; and Scotland might now, if she chose, re-establish her Parliament at Edinburgh, and crown a Presbyterian King at Scone. Again; on this theory, what are we to do with Rhode Island and North Carolina in the interval between the establishment of the Federal Government, and their accession to it? They were certainly not members of the new Union; which made no claim to extend its power over them. The Confederation of which they had been members, no longer existed. There is but one answer to the this question. They were independent, sovereign States, as independent and as sovereign as Costa Rica, or San Marino, or the Free City of Hamburg.

In arguing for the original sovereignty of the States, I would not be understood to advocate the modern doctrine of State Rights. I hold with Marshall, Webster and Story, with Mr. Marsh and Mr. Pomeroy, that the United States form a nation, and possess full powors of sovereignty. But I hold that this sovereignty was formally and voluntarily conferred upon them by the States in the act of forming the Federal Constitution. The doctrine advanced by Mr.

*p. 39

Pomeroy* as to the relation of the States to the United States, which is essentially that of Mr. Austin, I fully accept. "The people of the United States, as a nation, is the ultimate source of all power, both that conferred upon the General Government, that conferred upon each State as a separate political society, and that retained by themselves." Only, by "ultimate source," I do not understand historical filiation, but legal authority, under the constitution; the States—meaning by that the people of the several States—formed themselves, by this act, into "the People of the United States;" and this sovereign people, as organised in States, exercises its sovereign powers by the two-fold instrumentality of the National Government and the States' Governments, distributing these powers between these two instrumentalities as seems most expedient. Thus the States are as much sovereign as the Nation; but in truth neither is sovereign, but each is an organization for the exercise of a certain definite portion of the powers of government. The sovereignty is not divided between States and Nation, because sovereignty is indivisible and absolute; but the functions of government, in which consists the exercise of the powers of sovereignty, can be divided, and are divided between these two organizations.

---

* Page 23.

ON THE FORMAL COMMENDATION OF GOVERNMENT OFFICIALS.

J. W. HOYT, M. D.

It has been customary in all countries, and in all ages, for both people and government, in extraordinary cases, to take formal notice of distinguished services in the public interest. Sometimes by statue or monument, after death, as a means of perpetuating the memory of noble deeds through succeeding generations; sometimes by commendation of him who rendered the service, through decree of sovereign or vote of parliament, congress, or legislature, while yet living.

There has been, of course, no prescribed rule of action in any time or country, for the guidance of sovereign or people in such matters. In general, however, the distinctions have been conferred for cause so patent and so sufficient that the thing done amounted to a demand that left no room for question.

Commendation of the kinds mentioned have perhaps been more common under monarchies, where the sovereign is not always free from the motive of strengthening himself by the accession of faithful supporters, than in a republic, where titles of nobility are forbidden and decorations are unknown. But even there, they are usually confined to cases where the recipient has, in matters of public moment, transcended the line of mere official duty, doing more than could of right have been expected, or has made voluntary contributions of an important character to the welfare of his country or the general progress of mankind.

In the early days of American history, there was a severity of practice in these regards that comported well with the stern virtues and high moral standards of the heroic people who planted the colonies, defended them so grandly against foreign encroachments, and finally founded the Republic, now closing its first century.

In the light of more recent times, and at the distance we now stand from the leading actors in those great events of American history, one is even ready to wish there had been a less exacting standard for our early heroes. For, if ever men deserved the formal and cordial commendation of a people by resolutions or otherwise, it was they who, in the face of so great a personal and common peril, pledged "their lives, their fortunes, and their sacred honor" to the establishment and maintenance of American Independence. Nobly in the great drama of the Revolution, and no less nobly in the founding of the Federal Government, they played their part. Yet, where are recorded the thanks of the Federal Congress, or of legislative assemblies in the States whereon they shed the lustre of their names?

What, then, does it mean that to-day, in face of this example of the Fathers, ere the close of the first hundred years of our national existence, and ere the completion of the only national monument to the Father of his country, we hear of legislative resolutions thanking the Chief Magistrate of a nation, second in resources and power to none other on the face of the earth, and his Secretary of the Treasury, with others of lower official rank, for that. in the fulness of time—when all honest patriots are alarmed, if not appalled at the corruption seen and suspected on every hand; when venality, theft, and robbery stalk abroad and threaten a universal disgrace as well as national ruin;—they, the President and a high cabinet officer of his appointment, have shown a disposition to bring the villains to justice? It means a demoralization of the public sentiment, the cause of which, and the remedy *for* which demand a most serious consideration.

A people may very properly, even in the most formal manner, as by legislative resolution or enactment, express their grateful appreciation of an important public service, when such service illustrates a superior wisdom supported by an exalted virtue. An occasion for such expression is furnished when, in the time of public danger or national trial, an officer charged with discretionary authority, steadily holds his intellectual powers to the forming of just judgments and lofty purposes, uninfluenced by personal prejudice or popular clamor, and bravely leads his countrymen and kind to take new steps on the road to a higher civilization. But surely an occasion is *not* furnished when a public officer merely fulfills his sworn duty as the executor of a plainly written statute of the land, whether it be a law against frauds on the ballot-box or on the public revenues. A vote of thanks by the representatives of the people for such a cause proves one of two things: that the popular idea of duty has become wofully debased, so that not to wink at crimes against the general weal is evidence of superior virtue on the part of the highest officers of the government; or, that the political parties of the country have grown so corrupt and reckless that for mere short-lived partisan advantage they are willing to at once poison the fountains of virtue for the youth of the land, and put a tarnish upon the national honor.

Accepting either alternative, there is ground of anxiety for the future. There is need of a resolute purpose among honest citizens everywhere to stem the swift current of immorality and to raise up the old, or yet better, standards of both public and private virtue.

It should be settled at once and forever that no public officer, be his rank as low as the lowest, should be formally commended by the people or their representatives for doing, however thoroughly and well, what was a manifest duty, what not to have done would have justly subjected him to condemnation and punishment.

And it should also be settled as a principle, and deeply engraven on the hearts of the people both young and old, that such commendation of an officer whose duties are of so grave a character that *honor* is the only security demanded for their fulfillment, is a reflection upon those who offer it, and an imputation upon that integrity and high sense of honor which, in the public mind, should be inseparable from every public trust.

INDUSTRIAL EDUCATION.

BY F. M. HOLLAND, BARABOO.

This is a topic peculiarly appropriate here, in an association which is the pinnacle of the State temple of public instruction, Our public school system is enlarging its field of force so rapidly, that it is well to enquire if the improvement in quality keeps pace with that in quantity.

We shall probably soon imitate the example of the States that have established compulsory, or as it might better be called, guaranteed education, a measure for which there need be given no other argument than Professor Huxleys, "If my neighbor brings up his children untaught and untrained, to earn their living, he is doing his best to destroy my freedom by increasing the burden of taxation for the support of jails and work-houses for which I have to pay."

The force of this argument, however, depends on the extent to which the children are really trained to earn their living in the public schools. And so does much of the force of all arguments for public schools at which attendance is voluntary. The fact that we are taxed to keep up these schools gives us a right to require that the instruction be made as practically useful and generally valuable as possible.

Of course, the whole aim of the public school should not be to teach children to earn their living, but this is certainly a part of the legitimate aim and might be largely developed in harmony with other parts, as is actually the practice in Europe.

No knowledge of any kind can be acquired without increasing all the powers of usefulness, but some kinds of knowledge do immensely more than others to develop particular powers. A law student would learn more in a theological seminary than in a factory, but not so much in a year as he would in a law school in a single month. Neither law school nor theological seminary would particularly increase the skill of the mechanic. These seem truisms, but just consider how much better fitted our public schools are to prepare men to be law and theological students than to be farmers or mechanics. It is these branches of manual labor that most of the boys are to go into, but their schooling does not teach them how to use their hands and muscles. but rather their brains.

Our public school system would be practically perfect, provided all the pupils were going to be clergymen, lawyers, doctors, or teachers. Indeed, the village schools under my own observation seem to aim mainly at turning out school teachers. Every girl, at least, who graduates, tries immediately to get a school, for her training has exactly fitted her to earn her living in just that and no other way. No wonder teachers wages are low, when the number of teachers is thus continually increased.

In view of this lowness of wages, as well as the pressing demand for skilled workers in many other fields, it seems to me that something might be done in our public schools to fit pupils to earn their living in other ways. If our schools are merely going to educate teachers, and these to educate still other teachers, the whole system might be compared to a grist mill. of which the wheel is so large and the stones so heavy that the force of the stream is spent in turning them around, without grinding any grist.

Even if the aims of the public school are legitimate enough, there seems to me much room for improvement in the choice of means. Let me quote from Dr. Bartol, who says; "He that can sketch an object with a pencil understands it better than he who recites all its titles in the epoch of every tribe under the sun.

Possibly we have yet to learn what education is beyond a series of tasks in sentences and mathematical figures. Was Horatio Greenough educated, when glued to the bench for a Latin recitation, or loath to demonstrate the sum of degrees in a triangle, and not when he picked up a piece of plaster in the streets to carve the head of a Roman Emperor?

Michelet says a man always clears his mind by doing something with his hands. The poor girl goes to school with the rich, and learns to scorn her mother who cannot read, to envy her mates' costlier dress, and to steer for means of like adornment into temptation in the course of study. The education is a curse that puts notions into her head but no skill into her hand. Taught to create value, she would disown the tempter." (Rising Faith, p. 177.)

The possibility of making Wisconsin a great manufacturing State gives peculiar importance to the immense results achieved in Europe by Industrial or as it is sometimes called, "Technical Education." For instance the great iron works of Creuzat. France, which in 1867 employed 10.000 workmen and turned out $3,000,000 worth of products annually, rose from small beginnings through the systematic training of laborers in schools opened for this purpose more than thirty years ago.

When the first International Exposition was held in London, in 1851. English workmen excelled in ninety departments out of one hundred; but, in the Paris Exposition of 1867, England carried off 10 per cent. instead of 90 per cent. of the honors. The introduction of drawing into the public schools, with the opening of special schools in all the great centres of industry in France, Germany, Switzerland and Austria. had made these countries equal to Great Britain where she had hitherto reigned supreme. The British Government took the alarm, and made general inquiries, to which the Birmingham Chamber of Commerce replied that every trade in Birmingham suffered from lack of technical education. Similar answers came from Sheffield, Kendall and Staffordshire, except that the potteries in the last district were found to be kept up by the importation of properly educated foreigners.

Active exertions have since been made in Great Britain to recover the lost sceptre by imitating the course adopted on the continent, but the Swiss, French and German workman are still superior in training, not only to the British but to the American ones, according to the report of the Massachusetts Commissioners of Education for 1873. These Commissioners report that in Pennsylvania the great body of skilled artisans are foreigners. Mr. Stetson, in a work on Technical Education, published during the year 1874, declares "it is not the pauper labor but the educated labor of Europe which America has good reason to fear." A country, nineteen twentieths of whose artisans are unable to work from drawings, has good reason to dread the rivalry of countries where a mechanic who cannot draw is a rare exception.

When we consider, further, that as good a judge as Mr. Russell, the builder of the Great Eastern, declares that if in Great Britain, one-half the laborers were as highly skilled as one-quarter of them are at present, the change would be worth 50,000,000 pounds sterling, or onr quarter of a billion dollars a year, as it would enable the mechanical power of the kingdom to be used to three or four times as great advantage as at present, we can imagine what a mine of wealth lies almost unbroken at our feet. And again from the fact that in this conntry the highly skilled worker earns $3 where the utterly unskilled laborer earns $1, we can see how immensely the condition of our laboring classes is capable of being improved at little cost.

One of the principal means has been already mentioned; this is drawing, knowledge of which helps a mechanic to work from plans, and trains eye and hand to act in union. Four or five years ago this branch was introduced into the public schools of Massachusetts, New York and Connecticut, and the example is being generally followed all over the country. The lack, however, not only of properly qualified teachers, but of sufficient public interest, often prevents the instruction from being much better than nominal. We are very far behind the French practice of teaching every scholar seven years old, to draw and write simultaneously, so that each of the two acquirements may help the other. The Swiss and German primary schools also give to drawing a prominent place. So small a part of the primary school session in this country is spent in actual study, that not only drawing but object lessons and Kindergarten exercises, as well as needle work for the girls, might be introduced for two or three hours a day without hindrance to the present instruction, and with immense gain not only to the discipline but to the intellectual spirit of the school.

Enough free hand drawing should be taught in the primary schools to enable the pupils in the grammar schools to use drawing instruments, draft plans, and copy geometrical solids, and it is very important that they should be restricted to these and similar branches of purely industrial drawing; otherwise the desire to make a show at exhibitions, to get something pretty to hang up in the parlor, and to amuse oneself with little efforts, will tempt both pupils and teachers into giving their attention almost exclusively to fancy drawing of too little industrial value to be paid for justly out of the school fund. And in the grammar schools might also be given some knowledge of the practical teachings of chemistry, such as would be of assistance not only to the bleacher, dyer, founder, miner, and machinist, but to every farmer and housekeeper. The high school should continue the instruction in chemistry and drawing, and add the study of perspective, descriptive geometry and mechanical proportion. Of course these high school studies should be electives, alternatives with Latin and Greek perhaps.

It would also be possible for instruction in one or two trades to be given to a few of the most skillful pupils in every high school. One teacher in the girls' high school of Boston has introduced the study of photography, mainly at her one expense. Other trades which might be taught with advantage, are telegraphing, wood-carving, engraving, stenography, dress-making, watch-making, pharmacy, designing and painting. I mean of course not artistic but industrial painting; not painting pictures, but furniture and signs, and I speak particularly of this branch because it might be taught with advantage to the community in most of the village high schools.

The industrial course in our public schools would then be: Primary School, drawing, sewing, and kindergarten lessons; Grammar School, mechanical drawing and chemistry; High School, chemistry, drawing, perspective, geometry, and some special trade.

The pupils, who need this teaching most, would not, however, be able to go through the high school course, and special trade schools should be opened to allow them to pass through the whole course in two or three years after leaving the primary school.

The same teachers could carry on the instruction in drawing and other industrial studies in the common schools and also in the trade schools, where the training could be made extremely practical. One of the highest class of trade schools, which might well be imitated in America, is that for the French watchmakers at Besancon. The course is three years; first year mechanical drawing and general principles of the trade; the second year adds geometry, designing various parts of the watch and modelling the tools used; the third year adds the study of mechanics and practice in modelling various parts of the watch, mechanical drawing and designing being continued. Among the industrial schools especially worthy of note, are those for carpenters and builders held in the large cities of Germany for four or five months, beginning with the first of November, and giving instructions in "elements of physics and knowledge of materials, details of the art of building, plotting, geometrical and ornamental drawing and modelling" and other practical studies, described at length on page 124 of the report on education made in 1870 by Dr. Hoyt, who wisely recommends the opening of such schools in all the cities of the United States. Similar schools might be opened at the same season for the improvement of farmers. There are also many laborers who cannot attend any day school, even an industrial one, but who would go to an evening school gladly. The workman who is too tired to study anything else has been found able to learn drawing in such a school with great advantage.

A State which has so many German and Scandinavian inhabitants as Wisconsin really seems to me also bound to give the men and women some such facilities for perfecting their knowledge of the English language. Allow me to suggest further, that in a great railroad centre, like Madison, evening schools should be opened to teach railroad hands, and workers in machine shops, mechanical drawing, modelling, the use of every part of the steam engine and all the scientific principles involved in the running of railway trains and the manufacturing of cars and locomotives. The gain merely to the morals of the pupils, by removing them from temptation, would fully justify all the outlay necessary. I am glad to hear that twenty-nine evening schools for adults are in successful operation in Philadelphia, and hope the time will come when similar statistics can be furnished by Chicago, Milwaukee and Madison.

In one point we are already wiser in America than they are in Great Britain, or on the continent of Europe. Scarcely any industrial schools for women have been opened there, or seem likely to be. Of what little has been done in the United States, woman has had her full share. A prominent place in the Boston public school system is occupied by what are called the "designing young ladies;" and the philanthropic women in that city are attempting to follow the example of their sisters in New York, who have for the last two years been giving instruction in running sewing machines, housework, sewing of all kinds, laundry work, cooking, book-keeping, proof-reading and other useful employments with great success.

Of the many female colleges springing up all over the land, none deserve more praise than that already founded by John Simmons, of Boston, who bequeathed $1,400,000 "to provide for the teaching of medicine, music, drawing, designing, telegraphing and other branches of art, science and industry best calculated to enable the scholars to acquire an independent livelihood."

Among the branches in which women might engage with advantage are those pursued by decorators of glass, porcelain, and china, artificial flower makers, feather colorers, retouchers of photographs, wood carvers, fan and toy makers, watchmakers, jewelers, lapidaries and cameo cutters, workers in wax, plaster and ivory, glass cutters and grinders, piano tuners, designers, engravers, telegraph operators, compositors, druggists, photographers, florists, dentists and journalists. Indeed all the arts in which a good eye for color is needed, seem to be especially suited for women.

And let me here suggest that our State University, having shown its enterprise in establishing departments of law, military science, agriculture, civil engineering and mining and metallurgy, should give similar attention to the industrial education of the "better half" of its pupils, by opening one or more departments especially adapted for training women in some of the occupations just mentioned. In closing I would say that no industrial training is complete without artistic culture, which, though never its equivalent, should always be its inspiration.

THE PEOPLE AND THE RAILROADS.

BY REV. C. CAVERNO, LOMBARD, ILL.

The following are *some* views connected with the railway question. It is not pretended that there are not other views, but these lie near the base of the subject, and cannot be disregarded.

The transportation question is one to which we must in the future give close attention, if we would properly discharge our duties as American citizens. Whether we are to exist as a united nation or not, may depend upon our views and practice respecting rights and rates of transportation.

Macaulay says that of all modern inventions, those which abridge distance are of first civil and social import. The South failed to detach the West from the East in the rebellion because the men of the West had come from the East. But generations are to come after us who were not born at the East. Whether the sympathies of the various sections of our country are to flow together in time to come will depend upon the amount of communication there is between them. That will depend upon facilities and rates of transit. We shall be a united people if we are a *traveling* people.

It is a patriot's duty to see that the conditions are supplied which will create mutual interest and sympathy between all sections of the Republic. Once there was but one name for stranger and enemy. The fact is of deep significance. Given no strangers under the government flags, and there will be no enemies. Among isolated people springs up the tendency to rebel.

The question then before us touches not alone the pocket; it touches the heart as well. It is a question not merely of rates on exchange of *produce*, but one of rates on *social* exchange—an exchange of ideas.

Just now the item of *freight* is the one uppermost in the public attention. But if we look deep enough we shall see that the matter of *passenger* rates is one of tremendous import.

Just where we are in the whole matter can best be brought out by the statement of a single fact. A few weeks ago the telegraph informed us that the Freight and Passenger Agents of the various main lines of railroad running across the country, were in Pittsburg in consultation upon the rates of freight and passenger transit over those lines. It was stated that they were sitting with closed doors.

That is something which happens once or twice a year. Considered as a telegraph report that makes but a small item. But think what it means. Think of all the vast interests that centre around the matter of freight and passenger communication between the Mississippi valley and tide water. It is a matter of as much concern to the people of the nation as the question of the currency, or the right to declare war and make peace. In fact the currency question is one *subordinate* to the transportation question. We are interested in the currency only as a subsidiary agent in transportation. Currency is of value only as it helps persons and property to change place. Yet the subsidiary question goes to an open congress of the nation—the main question to irresponsible corporation clerks who sit with closed doors.

We convulse the nation in our politics on some issue of tithing mint, anise and cumin, while we neglect the weightier matters of the law.

It would seem fair that the public should have some voice in fixing rates since they are the one factor out of whom rates are to be raised. A matter of such importance ought to be open for discussion and settlement before representative men of the nation.

The men who actually sit upon it are not even the representative men in their various corporations. They are the mere mandataries of the few capitalists who control the corporations. No questions of public right or interest are ever submitted to them. As mathematicians, they cipher in aid of the schemes of the stock operators who control the roads.

Rates of transportation are a tax upon the people.

Unquestionably the people ought to pay some tax—a righteous tax for transportation. But that a body of irresponsible and unknown men, the mere agents of a few private capitalists, should have the right, in secret session, to levy this tax on the whole American people is an anomaly in the practice of this nation, before which, one may well stand in blank astonishment.

This nation declared its independence and fought to its liberty on the foundation. "No taxation without representation." But here is taxation, and that too without representative voice in it before which, that against which the patriots of the Revolution fought, pales into nothingness.

We never could have come where we are in respect to the matter of transportation, had we not practically lost sight of one of the most fundamental principles of common law.

The right of the people to transit was a right that the common law always asserted and protected. It said the rivers should be the people's free highways. It has kept them open up to to-day.

The common law was always a jealous protector of the right of private property in land. But beyond any right which a man might have in his acres, it asserted the right of the people somehow and somewhere to find transit over them as their needs might require.

Behind every individual right lay the public right of eminent domain for the purposes of transit. The river was open to the people; any man might put his boat thereon and go up or down the stream at his pleasure. The road was open to the people; any man might put his carriage thereon and go whither he would.

In the development of human industry and art a new method of transit has come into use which supercedes both the old methods.

The simple question at issue is, *whether the people are to preserve any of their old rights of transit in this new mode of transportation, or whether they are all to be swallowed up in the private interests of the capital that built and manages the roads.*

Have the masses at large any rights in the new inventions which revolutionize modes of communication and commerce? Did Watt think out the steam engine in the interests of capital only? Did the old vegetation of the coal measures "suck the fire of forgotten suns" only to lodge in the hands of a fortunate few the power to obliterate one of the most cherished rights of the people.

It is no answer to this inquiry to say that the river and the road are still open to the people, and they can travel on them as of old. The new mode of transit has rendered the old compartively useless. The humblest living cannot be earned without making use of the new system of communication. The right of the people to transit it a right inhering in them as to all modes of transit.

If the river and the road were theirs they have the right to the new method of accomplishing the ends they executed on river and road.

The practical point is to find a way of asserting the rights of the people—to put into practical shape the old right of eminent domain for transit under the new method of locomotion. So long as private corporations are concerned with the business of transportation as they now are, it is hard to see how the public can realize any of its ancient right except it have some voice in the determination of *rates* of transportation.

From the nature of the new mode of locomotion a man must travel or put his freight in such vehicles as the companies may provide and at such times as they may designate. He may not put his own conveyance upon railway track as he formerly might put his boat on the stream or his carriage on the road.

Now if the officers of the corporation may say, "you may have transportation but only at such rates as we choose to fix" the old right of eminent domain which was maintained to secure free communication among the people is annihilated.

The people travel no longer on any right of their own but simply on the mercy of the corporation. The selfishness of corporations may be enlightened enough not to fix rates that will prohibit travel. That does not alter the fact that it is by their will alone, practically, that travel by the new mode of transportation exists.

If a private corporation makes a railway bed, and puts upon it rolling stock, it is but just that the people using the method of conveyance provided should pay proper charges therefor. *But it is unjust that in or about the rates collected there should not be some element which should represent the old right of the people to locomotion.* The right of transit is of as high order as any right of property in road-bed or vehicles of transit. *The right of the public to a voice in respect to the rates of transportation is at least equal to the right of the corporation for moneys expended.*

The recent legislation of the Western States may, in fact, be unjust. If so, it must and it will be made just. It would be strange if the first attempts at regulation in a matter so immense and so novel, had hit the exact line of justice. *But this legislation is correct in theory.* In attempting to regulate *rates* of transportation, it asserts, in the only practical way, the people's right to transportation—the right to it in the freest way—in the cheapest way consistent with justice to the capital invested in transportation enterprise.

We are in our present imbroglio, in respect to railroads, because we have lost sight of the fact that there are two distinct interests vested in them.

The people have not heretofore asserted their rights; and, of the people's rights, the railroad corporations have been willingly ignorant.

The railroad position, at least in the northwest to-day, is that of denial of all public right in the railways and of defiance of all control over them.

The open contempt exhibited by the railway companies for the recent legislation of the people, and the tone and import of the latest reports of the presidents of the leading railroad companies is the sufficient evidence of this fact. The issue is joined on this plain question—*whether railroads are a private concern entirely.* The people maintain that the railroad corporations stand in a relation of trust to themselves to whom they must give account of the deeds done in their corporate body, as well as the operators who manipulate their stocks. The people maintain that railroad property is not private property, like a farm or a stock of goods in a store. Whatever of private property there is in them *is property laid down on the foundation of a public use as no other property is.* It is property laid down over an old time right of the people—a right that permeates it everywhere.

De Witt Clinton's idea was that transportation was wholly a public business. It would be instructive to have the history of our unfortunate departure from the principles and practices of De Witt Clinton. Our recent legislation is charged in certain quarters with being an unjustifiable attack on the rights of private property.

The Hon. David A. Wells says that objection to that legislation is founded ultimately on the command "thou shalt not steal." It ill becomes those who are attempting to convert an old time common law right of the people to their own especial use and behoof, to talk about theft.

As between the obliteration of a right and the regulation of a rate it does not require much ability to decide where the most wanton meddlesomeness lies.

The people mean no injustice to property invested in railroads. It is that which is *not* invested that they desire to make some inquiries about. They want to know what the fictitious elements are which they sustain by taxation levied in the shape of rates. In Illinois there are roads that cost but $16,000 per mile on which rates are collected on a basis of cost at $32,000 per mile.

When we want to get to tide water if we go over the New York Central, or Erie, or the Pennsylvania Central, we have to pay rates to support stocks that represent an average cost of $107,000 per mile on those roads. It is well enough known that not one-half of that amount per mile was paid to build and equip those roads.

The people have no desire to convert private property into a public use, but they do not want to be taxed from year to year to make that property which is no property.

It is "watered stock," stock, that represents no money advanced, that the people are at war with. If a farmer had the privilege of taxing the community to make up to himself any sum which he might name, he would only be doing as the railroads have had the privilege to do in "watering" their stocks and in issuing stock dividends. No wonder that railroad operators have become rich men.

It may be difficult even impossible at this date to eliminate this no property element. But that is no reason why we should not look steadily at it till we know what it is, and till we find out where it came from. It is an element, that beginning with credit mobilier contracts in the construction of roads, has by various modes of "watering" and mortgage "loading" increased, till it may be roundly stated as constituting half of the burden against which the people lift, in the payment of rates of transportation. If the past cannot be rectified the future can be secured. If it cannot, then, farewell to the prospects of honest industry.

Everything cannot be swallowed up by the men who do not earn but invent property.

Besides being property laid down on the foundation of a public right as no other property is, railroads should be subject to the public control for the reason that they are supported by public taxation as no other property is.

The President of one of our railway companies in a recent report maintains, that the railway companies should have a right to the increased value of their property. Certainly, if they want to sell it. But certainly not if they want to make that increased value a basis for levying rates upon the people. No farmer has the right to tax the community to make good to him a dividend on the increased value of his farm. When holders of other property can have this right it will be time enough to grant it to the railroad corporations.

If new property appears on a railroad it got there either by the earnings of the road which have been raised out of rates assessed upon the people, or it is there because loaned money has put it there, the interest upon which, and ultimately the principle of which, is paid by rates assessed upon the people. It is not right that the people should be again taxed upon property which they have already paid for. The owners of no other species of property have yet found out a way to derive an increased value of their property while they themselves retained possession of it.

We cannot build new railroads all over the country to compete with those which already exist. The people are not driven to that resort. They have their rights and they should prosecute them in those roads which already exist.

The farmers movement will not rectify the situation. The Grange may be of value to the farmer in many directions. Possibly it may be an element helpful in the solution of this problem, but it can only be subsidiary at best.

New times and new conditions demand new measures. Courts and legislatures, as now constituted, are inadeqnate to the solution of the railroad problem. We need commissioners, State and National, with legislative and law powers ample enough to meet the demands of the situation. The constant increase of the transportation business will make such commission a permanent necessity.

Those who control the private interests invested in railroads are at all times alert to their interests. The people should have what would be equivalent to an always open court and ever sitting legislature to attend to their interests in the roads. These commissions should have full powers of instant action. We have not exhausted the resources of society in the establishment of a Circuit Court and a State Legislature. When a new business attains to such gigantic dimensions as the transportation business has reached, there ought to spring up a new tribunal to attend to it—a tribunal that should stand on its own basis, not being the mere creature of some other department.

Our Commissioners ought to be the courts of last resort in railroad matters, and no more amenable to the State Legislature than the judiciary is now. Mr. Windom's proposition for a Railroad Bureau is in the right direction, but it is not radical enough as he has up to this time developed it. The first work of such a commission would be an investigation of all the elements which figure in the sums on which it is claimed dividends should be paid out of the rates assessed, and the remorseless rejection of all the no-property which is now confounded with property, when such rejection can with justice be done. Then a proper basis will be laid for a just assessment of rates. We have long been running a reckless race, careless how we lost our rights, or who picked them up. It will be a long way back to the correct position. But courage, persistence and honesty will take us there.

THE BOA CONSTRICTOR OF POLITICS.

BY REV. F. M. HOLLAND, BARABOO.

Recent elections show how generally our politics are believed to be corrupt. But merely changing the party in power will not purify them. Great as is the need of civil service reform, we can no more expect either party to be the first to refuse to favor its followers, than we can expect an army to spike its cannon before it goes into battle.

We may blame the practice of passing by wisdom and purity to nominate popular mediocrity or unprincipled brilliancy, but it is plain that the policy of nominating only the most popular candidate would have the same advantage over that of preferring men, whose height of principle and intellect excited enmity, which the Prussian needle-gun had over the Austrian musket. And for any party to dismiss an able and popular leader on account of private immorality would, to borrow President Grant's comparison, be like relieving a general under the fire of the enemy. And so will a party that forbids any severe criticism on its leaders within the ranks, meet one that permits it, just as an army meets a mob. Popular enthusiasm may give the mob the victory, but only exceptionally. On the whole, the more a party is like an army, the stronger it will be, and therefore party success requires that the management be centralized in a few men of experience, enough to set up the platform, and candidates most likely to catch votes. "The ring" has a terrible sound, but a party without a "ring" would be pretty apt to be beaten by any party with one. Indeed a party without a "ring" is like a barrel without a hoop.

These facts are not pleasant ones, but we need to keep them in mind in order to see that to purify politics we must change our system so deeply as to lessen the power of parties, and no longer enable the one, which happens to gain even the smallest majority, from sweeping all the presidential electors, members of congress, state legislatures, judges, and county officers into its jaws and swallowing them as completely as a boa-constrictor engulphs a rabbit. And, as a rabbit, shut up with two such monsters, can simply flee from one to the other until it is taken, so third parties have to choose by which of the two stronger ones they will be devoured, before the larger one shall swallow up the other, or, in other words, carry the state.

There is only too much evidence to show how far we fall short of Lincoln's ideal of a government of the people, by the people, and for the people. In both the Forty-second and Forty-third Congresses, whose successive sessions extend over the four years closing March 4, 1875, the Republicans have had more than two-thirds of the representatives, though they polled but little more than one-half the votes, so that a majority of 35 or 36 per cent. in the House has been gained by one of 7 or 8 per cent. at the polls; and this injustice is not lessened by the fact that no delegates to the Forty-third Congress were sent by the supporters of the administration in Kentucky or Texas, but it is much increased by the allotment of not a single delegate to its opponents in Iowa, Kansas, Louisiana, Maine, Massachusetts, Michigan, Minnesota, South Carolina and Vermont. This disproportionate strength of the Republican party increases the apparent magnitude of the change in 1874, when no Republicans were elected to the Forty-fourth Congress, either by the Republicans of Arkansas, Georgia, Maryland, Missouri, Texas or Western Virginia, who cast 351,764 votes, or by the Democrats of Maine, Rhode Island, Florida and Minnesota, who cast 104,510; and when of the 265 delegates from 28 states, all then voting except Louisiana and the four one-member states, 97 represent 2, 30,300 supporters of the administration, and 168 represent 3,410,535 of its opponents, whereas the former are really entitled to 122, and the latter to but 143. The democrats have thus obtained nearly two-thirds of the House by little more than one-half the votes, or more exactly, 64 per cent. of these 265 members by 59 per cent. of the votes, a majority of 28 per cent. in the House representing one of 8 per cent at the polls. These estimates are from the Tribune Almanac for 1875, and in some cases only approximative, though it is sufficiently plain that the members of one party or the other in sixteen of these twenty-eight states will be virtually unrepresented in this Congress, since the Republicans have three members less than their share in Tennessee and Virginia, two less in Kentucky, North Carolina and Alabama, besides being wholly unrepresented in the six states above mentioned; and their opponents three members less than their share in Iowa, besides being unrepresented in four states as mentioned. In a seventeenth state, Wisconsin, the party actually in the majority was able to elect but one third of the State Assembly and but three out of the eight Congressmen, while the republican minority claims to have carried the state and may yet succeed in getting a sixth Congressmen. In Florida, where the parties are almost balanced, the majority gets both the Congressmen, but has a minority in the state legislature, a double injustice. In New York, Massachusetts and Kansas the assembly men are unfairly distributed, so there are but two states among the twenty-eight where the elections did justice to both parties, Vermont and Illinois, in the latter of which a new system has been introduced as we shall soon see.

Three presidents, Taylor in 1848, Buchanan in 1856, and Lincoln in 1860, secured large majorities in the electoral college, though none of them had one half of the popular vote. In 1864, indeed, Lincoln got a little more than half the votes and this gave him ten-elevenths of the electors, but if McClellan had received 35,000 of the votes given to Lincoln he might have gained the majority of the electors and become president, though he would still have been in the minority at the polls.

It is plain that the people are very imperfectly represented and that neither party gets its fair share of the power. It is also plain that corruption is much facilitated by the extreme difficulty of setting aside the nominations of either party except in favor of those of the other, perhaps equally bad. Parties would be slow to nominate men who oppose civil service reform or lack character and ability, or are mere tools of the ring, if such candidates could be defeated easily. This can now be done only when the bolters form the majority of the district, and many a patriotic statesman, who has friends enough to send him to Washington if they could act together, stays at home because he cannot carry the district where he resides. What we want is a system of voting which will give a fair share of power not only to each party but to every combination of independent voters, so that, for instance, of the one hundred members of the assembly, in Wisconsin, forty, fifty, or sixty would come from each party according as it polls forty, fifty or sixty per cent. of the votes, and any independent candidate would be elected who gets his one per cent.—more indeed than is now requisite, so that the voting districts must be enlarged greatly to enable any one to obtain it. This system is meant to give no special favor to individuals or minorities, but only such justice to all the candidates, that its proper name is not Personal or Minority, but Proportional Representation.

There are several plans for doing this, the best known being the cumulative, advocated by Horace Greeley twenty years ago, and now in use in Illinois, as well as in England, where, as the London *Times* says, "it has made its way by its inherent justice." In Illinois it was enacted in 1870 that the 153 legislative districts, formerly sending each a representative to the legislature, should be consolidated into 51, with three members each. Each voter casts three votes, which he can concentrate on one candidate or distribute among two or three, as he prefers. This plan was first tried in 1872, when, as Mr. Medill stated in the *Cincinnati Commercial*, of December 2, 1872, "for the first time each party is represented from every part of the State, and the aggregate representation is exactly in preportion to the numerical strength of each party. For the first time since the Republican party was organized in Illinois (1854), have the Democrats secured a representation from Northern, or the Republicans from Southern, Illinois, with rare exceptions. The bitterest Democratic districts down in Egypt now, for the first time in the history of existing parties, elected Republicans." The *Chicago Tribune* adds: "On the whole, it has worked admirably; it has secured the great end sought, and has enabled the people, in many instances, to defeat the objectionable candidate," which is a fulfillment of the prediction of John Stuart Mill, that "those who would be favored by the cumulative vote would generally be the persons of the greatest real or reputed virtue or talents." (Thoughts on Parliamentary Reform.)

It was further noticed that in thirty-three of these fifty-one districts, the republicans were in the majority, so that by the usual, or as the Chicago Times aptly called it, the "jug handle" method, there would have been ninety-nine of one party to fifty-four of the other, whereas the estimated proportion was eighty-five to sixty-eight, and the actual result nearly the same, eighty-six to sixty-seven. At the last election in 1874, when the old plan would have elected fifty-four republicans to ninety-nine of their opponents, the new one gave seventy of the former to eighty-three of the latter, of whom indeed there were twenty-seven independents and fifty-six democrats, almost exactly the allotment justified by the vote.

Seven of the districts, however failed to get their exact share, most of these discrepancies being due to the voters scattering their ballots among too many candidates. In England, however, at an election of the Birmingham school board, the Liberals, though slightly in the minority, tried to elect all the fifteen members and so got in only six, while really entitled to seven. Such failures of this method can be prevented only by strict party discipline, though they would be much less frequent if no voter were allowed to vote for more than the majority of the candidates, or indeed, where their number is even, for more than one half of them. Thus no voter in Illinois should be allowed to vote for more than two of his three representatives, and the one hundred assembly districts in Wisconsin might well be consolidated into ten, in each of which there would be ten candidates to be elected, and five votes to be distributby each citizen.

All the essential advantages of the cumulative plan would thus be preserved, and it would become still better fitted for electing members of congress than the form recommended by Senator Buckalew in 1869, which, for instance, would give each New Yorker thirty-three votes for representative, whereas he would have exactly as much power if he had but seventeen, and any independent candidate getting above three per cent. of the vote would be equally sure of election under either arrangement. It would, however, be better still to have three districts, each sending eleven delegates and allowing six votes.

This restriction of the number of votes would lessen immensely the difficulty of counting them, and the distribution by the individual would be much easier when the parties were equally balanced, while the labor of marshalling the voters of a party largely in the majority, so as to get all the benefit of them, would not be increased.

Neither form of cumulative vote would be likely to abolish the caucus, which indeed can scarcely be spared, but either form would restrain its abuse, by the facility it would offer for defeating its candidates, and electing those nominated by boards of trade or mass meetings called by leading newspapers. This is most easily done when the districts are the largest, hence the advantage of the proposed restriction, which makes the distribution and counting of votes but one-half as laborious as would be the case where the same number of voters were to choose the same number of representatives by the ordinary form or the cumulative vote.

A further restriction of each voter to one vote would indeed make counting them still easier, but render the distribution, when the number of candidates is large, extremely difficult and precarious. Either of these plans might, however, be used in choosing directors of corporations and stock companies, and thus enable the holders of a comparatively small quantity of stock to have their own representative to protect their interests. In such elections comparatively few votes would probably be thrown away; but at the polls there is great risk, not only of the votes being too much scattered, but of their being too much concentrated.

Thus the Democrats, in two of the Illinois districts in 1874, gave all their votes to one man when they might have elected two, and at an election of the Marylebone school board, in England, Miss Garrett got more than twice as many votes as she needed, and more than half of them were thrown away. Now if Miss Garrett's friends could have placed her on a ticket with several other of their candidates, and could have had every vote not needed by her transferred to her associates, they would have been much more fairly represented.

A plan which would have done this, and which is known as the preferential method, has actually been in use for twenty years in Denmark, and was several times employed in the nomination of overseers of Harvard University. Many English liberals favor it, and John Stuart Mill places it among the very greatest improvements yet made in the theory and practice of government, "and therefore of civilization." Mr. Thomas Hare, after whom this plan is often named, says: "In framing this system I have always looked forward to its reception by the American people with an anxious hope. Surpassing all other people in the arts of peace as they minister to the universal comfort and well being, attaining a not less distinguished though unhappy eminence in the arts of war, a nobler work remains to them * * * that they become the leaders of mankind in the far greater art of government."

This plan is sometimes called too difficult, but Mr. Mill declared that it is as easy as the multiplication table. The voting is easy enough. Miss Garrett's friends would have deposited ballots on which her name was marked, "First choice," while those candidates would be named as second or third choice, etc., to whom that vote should be transferred if not needed for her election. The votes are first counted so as to show the full number, which divided by the number of candidates to be elected, gives the quota required for the election. Then the ballots are recounted for the first choice. As soon as Miss Garrett had reached her quota, her name would have been cancelled on all the other ballots of her friends, and these votes would be counted for the second choice, and if that candidate also gained the quota, for the third. The same process being applied to all the ballots, it would have happened in this case as in most others, that there would be a vacancy or two left to be filled from among candidates, none of whom had the quota. Mr. Hare's last decision seems to be, that in such cases the name having least votes be cancelled, and these ballots redistributed until the quota is reached. Other authorities are in favor of giving the preference in such cases to the plurality, or of getting a smaller quota by methods, of which it is enought to say that they would much prolong the labor of counting the votes, a task already so difficult as to give great opportunity for fraud.

Indeed there is one case in which dishonesty would be peculiarly easy and justice almost impossible.

Suppose these Illinois Democrats and Liberals, who elected one representative when they might have got two, had used Hare's plan, and all of them made Brown their first choice, while, for the second choice, the ballots were divided between Jones and Robinson. Now if Jones' votes were counted first, Brown would be elected and his name cancelled on all other ballots, which would thus elect Robinson also, whereas if the Robinson ballots were counted first the choice would be Brown and Jones. Either Jones or Robinson coull secure the seat by persuading the inspectors of the votes to shuffle them, so that his name would be counted last while if these officers were too honest for this, their decision would be merely a matter of chance, and either chance or fraud might elect Jones, when he had less than half as many votes as Robinson. The Hare plan should not therefore be adopted, if we can find any other which could not be so perverted, but which would be equally likely to prevent any vote from being lost.

The true plan should always make as exact an apportionment as Hare's can ever do, work as simply as the cumulative method, and have the additional advantage over both these plans of always appointing in advance, for every vacancy during the term of office, a substitute representing the same constituency. Such a plan was actually invented in 1866, by M. Morin, of Switzerland, in which country it is termed the the "free list," though American writers call it the independent or list system. It is really Hare's plan simplified. The ballots are very similar, namely, lists of names arranged in order of preference, but marked list number one, two, *i e*, according to the order in which they have been recorded. The quota is obtained in the same way, but there is only one counting of the vote, of which the number cast for each list is ascertained, at the same time as the whole numbers of votes polled. It is then only necessary to divide the number cast for each list by the quota, to know how many of the candidates on that list are elected, the names being taken in order as they stand.

By this system, if the list containing three names headed by Miss Garrett had obtained three times the quota, all three would have been elected. In the States of Kentucky and Tennessee, each of which now has ten representatives in Congress, the quota would be ten per cent. of the vote polled. Any party would have three, four or five representatives according as it had thirty, forty or fifty per cent. of the vote, and any independent candidate would be elected who got his ten per cent. This way of reckoning would give the Republicans three from the former and four from the latter State, instead of one member in each actually elected to the forty-fourth Congress.

This method favors independent candidates even more than the cumulative, for there is much less danger of votes being thrown away. There is the same probability as under Hare's plan, that every ballot will count, but not the same possibility of the interference of chance or fraud. The imaginary votes for Brown, Jones and Robinson would be classed as so many for list one, Brown and Jones, and so many for list two, Brown and Robinson, and the second man would be taken from the list best supported, while the few cases of an exact tie could safely be referred to the legislature.

With this slight exception. the results would be quickly made known and easily verified. If a member of Congress dies in office his successor would be the first man left on the list from which he was taken constituents would continue to be represented by a candidate of their own choice.

Under the list system the nominating power of the caucus would be the same as with the cumulative or preferential plan, except that its advocates have proposed a restriction which might well be incorporated with any method of election, even the boa-constrictor one, namely, the condition that all the nominations should be recorded and published long enough beforehand. to give the citizens time for independent action. There is some difference of opinion as to how long the time should be, and how great should be the possibility of offering and altering lists by individuals. It seems to me that it would be best to provide that any list, signed by the secretary of any convention of delegates or any mass-meeting, or by one hundred voters individually, and sent at least thirty days before the election, should be numbered, registered, and published at once; that lists signed by any citizen and wholly made up of names already presented should be received, numbered and published as above, until fifteen days before the election; and that all ballots should be counted according to the registered number; alterations being disregarded and unregistered lists treated as blanks. I think such restrictions would simply exclude scattering votes and chances of mistake in the count. But these details are of little importance and may easily be adjusted.

It will be seen that this method is peculiarly adopted to the choice of members of Congress and presidential electors, while the cumulative plan works best in districts where the number of candidates and of votes is small.

Still more complete representation of the whole people than at present, would be attained, if either system were employed in electing committees who should take the place of the President's Cabinet, and form, with him, a national council; whose unanimous vote should be necessary for the appointment of judges, ministers and heads of departments, while other high officials might be appointed by a two-thirds vote, which should also be requisite for vetoes, suspension of the *habeas corpus* act, etc. It would be easy to change our civil service from a partisan to a national bulwark, if all minor officials were under the control of supervisors appointed and retained in office by such a council, while not only the leaders of both parties, but the great men outside of party lines could thus take their rightful places beside the President. It will easily be seen that State and city councils might be formed on the same plan.

Some may think these changes too radical; but every reader will see the advantages, in other respects, of the list system over any other method of proportional representation, though any of these methods would be an immeasurable improvement over the present plan, by which a party but slightly in the majority, or perhaps not having a majority of votes, but only one of districts, can crush and swallow up its opponents in true boa-constrictor fashion.

NOTE.—A member of the last Constitutional Convention of Missouri, to whom I sent a copy of this essay, informs me that its main principles have been "adopted n private corporation elections."

ON THE REVOLUTIONARY MOVEMENT AMONG WOMEN.

BY JOHN W. HOYT, A. M., M. D., LL. D., PRESIDENT OF THE ACADEMY.

I.

The work of civilization is the work of individualization. The problem of the ages in the interest of mankind is the problem of the soul at work in its own consciousness. Man's service to man in attempt to harmonize universal need is not greater, nor is it other than this—the attempt of the individual to find himself his proper place. The accomplishment of this by the few is that which makes any advancement possible, and it is the accomplishment of it by all that must merge the mission in the fulfilment of civilization.

But the unit man is able to open the eyes of his fellow men to this greatening of power and privilege only as he is able to help them to a like experience of it. Soon it is found that thought-level and class-level coincide—that one cannot at once get beyond the charter or the decree, and that progress is chronicled by caste and special end.

This parcelling out the rights of the individual has had the effect to make advances slow and partial; for in the same breath that makes the declaration, "thus far will we come!" there is heard the limitation, "we and no others!"

There are two thoughts that run along so parallel to any retrospect made of the progress of the race that they seem a part of all other thought upon this subject. They are distinctly these: that whatever has been gained has been wrung from those withholding as long as it was possible to do so, and that these gains have been so generally in the interest of man, that woman has remained outside of any considerable advantage. And yet, after all these generations of steady advancement for man, the burden-bearer of the world, how little he is advanced, at the best of his aspirations and means! The marvel that he has not been goaded to a fuller conquest of all barring the way to his rights of manhood and possible achievement stands face to face with that of woman, now moving in her own interest to the most complete and far-reaching revolution the world has yet seen.

That man, with his constitutional aggressiveness, his aptness for organization, the clear field with nothing but himself to oppose, should up to this hour have missed so much, is not more surpristhan that woman, unaggressive by nature, unsuited to organization and with universal history, precedent, and prevailing philosophy against her, should have undertaken at one move, the sum of all revolutions. And yet there it stands, the most conspicuous fact of the times touching either a moral or a political future for society.

A demand for rights of one kind and another—in the home, in the schools, in the occupations and professions, with a more equal control of property, and lastly, use of the ballot, as covering all these—has characterized this movement from the beginning. The wholeness of this demand makes the requisite reconstruction easy. Could anything be more simple? The half of society claiming to speak for the whole population, and hitherto exercising that prerogative have but to draw a pen across a few prescribing words in statute and constitution, and there is freedom for the whole people to be and do, each according to capacity and power. To the thoughtful and just man, it is strange that in the countries most enlightened, especially in our own the very essence of whose institutions is freedom without partiality, this sublimest act of emancipation that history can ever record should be so long delayed. For what can be more profoundly moving to the justice and sympathy of the universal mind than the spectacle of one-half of the great people, through sheer force of muscle and ruder force of brain, withholding from the other its dearly purchased and most sacred immunities?

All things considered, the success of the movement, at last begun, is next to the fact of it noticeable. It has acquired a respectable, not to say remarkable frontage in literature, on the rostrum, and in the halls of legislation. For thirty years, from pulpit, press and platform, in club and in social circle, it has had the benefit and hindrance of approval, protest and discussion; enlisting the dignity of conversation, the brilliancy of wit, the contempt of sarcasm, the repartee of humor, and all the vicissitudes of a question so much at home among the people as to be equally everybody's and nobody's business. And yet, should the history of this movement be attempted, the details would be found unsatisfactory, its methods unattractive and its results vaguely defined.

II.

Of the causes moving to this unrest and protest among women, the difficulty of finding suitable and remunerative employment is conspicuous. Here, as in the beginning of human effort, the question for woman is first one of shelter and sustenance, and without the world before her, as it has ever been before man; for the great highways of occupation are either positively or practically closed to feminine industry; and in those open to women it is the almost universal rule that they are met with less wages for the same work.

The best argument for this inequality of compensation is based upon the usual responsibility of man for the family maintenance. This leads to the question, How, then, when a woman receives from one-fourth to one-half of that paid a man for the same service, is she to maintain a family left to her care? It seems very unsatisfactory to be told that such persons are exceptions to the rule of generally provided-for married women, and the case must be met in some other way than that of labor and compensation for it;"* or that, "women left without natural protectors, must take upon themselves the pursuits of men in order to live at all," and that, "for these aberrations from general law special arrangements must be made." So far from staying this revolt, women are not even pausing to press the old question, "Gentlemen, what is this other way, and when are those special arrangements to take effect?" but are moving upon results with the apparent purpose of making their own arrangements.

*"Social Science and Women Suffrage." By Rev. C. Caverno, Academy Transactions, Vol. I.

There is not a more pitiful proposition in the list of social impracticabilities than that of a mother turning to the occupations of men and asking bread and education for her children. So far as I am aware, the consideration of this struggle for existence among dependent women has not advanced much beyond the admission that it is a case to be considered. And I would here suggest, as a step toward something known, if not done, in this regard, that through this organization for the advancement of knowledge and social amelioration the Government be asked at the taking of the next census, to inquire how many women there are in the United States dependent upon themselves for support; and how many, in addition to their own support, are charged with the maintenance of children, aged parents or family relations dependent upon their labor, with the occupations followed and the means accruing therefrom. This, with the number, sex, and age of children and other statistics relating to the family, and a statement of such partial means as have been left by deceased or are furnished by incompetent natural providers, would throw much light upon related questions, while bringing this one of compensation for labor with a new significance before the social philosopher who answers the inquiry, "Ought not the compensation of one person to be equal to that of another for the same work?" by asking, "Ought not families to be supported?"*

The question before us is not a divided one, but inseparable by virtue of a higher law no political economy can permanently resist. That "the laborer is worthy of his hire," stands denied by Christian, as by Pagan communities, to the multiplication of poorhouses and jails under sound of the Sabbath bells of all Christendom. This is no mere figure of speech; the logic of statistics proving that in the so-called most Christian nation upon which the sun shines, the pauper list, because of unremunerated employment, is greater than that of any other country in the world. And what is pauperism? Pauperism is the result of uncompensated labor; and labor uncompensated is that the wages of which do not furnish the means of keeping in repair the instruments of it. Science and experience show that man, as a laborer, must receive wages in advance of keeping himself in repair, or the instrument he leaves to take his place must be a deteriorated one. This, be-

* Social Science and Woman Suffrage, by Rev. C. Caverno. Vol. I. Academy Transactions.

cause, while he labors he also becomes the father of children. This deterioration, going on with each generation, at last reaches the point where pauperism becomes a settled condition rather than an occasional and temporary result.

This monstrous evil, this unconvicted crime, of labor without adequate wages, it is plain to be seen, falls most heavily upon the laboring woman who, least of all, is responsible for it. The interests of industry and the instincts of virtue unite in the condemnation of such barbarism.

This question of family maintenance rests upon an arrangement far below the righteous or unrighteous usages of society. In the nature of things, the duty of maintenance belongs to that parent, be it father or mother, best fitted for the fulfilment of it. Shall the little one of any household in the Kingdom of Christ go less suitably fed, clothed and educated because the burden of this providing falls upon the mother, whose more brooding care and greater tenderness more fully symbolize those of the All-Father for the child Humanity? Not always. Nor need the majority-man, upon whose shoulders this burden usually falls, fail of courage because of this concession. He will find the problem most easily solved by the rule of equal compensation. Women do not go into the occupations of men, competing for wages, save from necessity; remaining there the shortest possible time, and finding themselves, when there, at disadvantage of natural and acquired unfitness. Nevertheless, it is true that women, thus thrust out of their own into new and distasteful occupations, often accomplish as much and as good work as men trained to its pursuit. This putting of themselves so completely into their work, to secure this result, must be exhausting beyond that of masculine services of the same sort. For this reason, and for other very good reasons, when women do go into the occupations of men for wages, they ought to have at least as much, since in respect of need they have the same—that of having others to support—and, in addition, this: the care of the household, in cooking, sewing, nursing, and the general responsibility of administering the affairs of the home. This is so much extra burden laid upon the average laboring woman beyond that performed by the average laboring man.

But the great reason, covering all classes and all conditions of each class is this—*that women are not able to labor so continuously* *as men.* The disabilities that cut a man off from compensation for labor he is not able to perform are possible and occasional; while those thus hindering a woman are inevitable and periodical. And this, most certainly, at that period of life when family maintenance, if left to her, would, from the youth of her children, be the heaviest. That physiology which stands with its protest at the ballot-box may well take the initiative of protection for woman against this iniquity of more work for the same wages. For a woman to do as much, and as good work as a man, at any continuous employment, involves the using of her life-forces at the rate of self-destruction. And for society to compel, or even permit, this is to legalize by stronger than statutory provision the abrogation of that law of self-preservation, and that duty of equal protection, for the enforcement of which society was formed.

Another and most prolific source of discontent is the want of appreciation which everywhere meets women in the performance of the ordinary and ever-recurring duties of domestic life.

This want of appreciation is apparently grounded, not so much upon a depreciation of woman, herself, as of her occupation. It is as wide-spread as domestic life, and a source of bitterness among all classes not exempted from personal care in affairs of the house by exceptional exaltation of rank. It is found equally among the intelligent and the illiterate—a prevailing low estimate of home duties. Strange as it may seem, this estimate steadily lowers as the intelligence and pursuits of class advance; finding its ultimate in the disdain of gentlemen of the best circles.

The fact that women do not complain of this very much, or that, to many, it is not distinctly formulated in thought, is all the more to the argument of its being a great wrong and working serious injury. Indeed, next to the fact itself, that it finds so little expression is the worst of it. It is a skeleton with a shadow for every homely joy, dragging the body of its death, through the weary round of woman's life.

The depreciation of whatever industry, art, or gift belongs to the furtherance of purely domestic ends, such as thrift, organization, and device in the household, has gone so steadily on since the days of King Lemuel, that, taking it up as a cause of revolution among women is, as if in obedience to the command, "Open thy mouth for the dumb, in the cause of all such as are appointed to destruction."

I am not unaware of the speculative nature of the theory that measures the decay of woman's interest in home by that of man's estimate of business, but I appeal to both to say whether as the world enlarges to the one the home is not belittled to the other. The house increases in dimensions, for there must be room for the conveniences of art and a retinue for the service of means. But the home atmosphere is dying out. In the language of one whose celestial philosophy often touches practical life, "it is not known any more what it is, or even that it is." What is there in the well-furnished modern home? Everything to make it comfortable but comfort. Man, with his energy and skill, brings everything there but an appreciation of what woman does to convert material into beauty and use. Ignoring that the home contains in microcosm every element of power with which he wrested from the world the right to call it his own, with additional force of finesse and spirituality of which he has little conception, he seats himself so in the midst as to leave her pretty much out. How to organize the forces, that there may be ordered without restraint; to harmonize the restlessness of the child with the rest of the adult; to adjust the duties and privileges of servants, the entertainment of friends, the courtesies of society, the calls of religion and charity, maintaining through all her own individuality, and things, if possible, more precious,—the saving from themselves of dearer ones by the conservation of all the powers through which the thoughtful woman knows how to build with stones that need no smiting,—she knows through what an incarnation of soul and sense these have come. He does not. So far from this, he really thinks they have cost him so much money. Are not these the receipts?

There is nothing more common than for the wife to discover that her husband wonders what has become of her time. The masculine judgment that money and hired service are sufficient to the results a woman knows have commanded, not her time and freshness only, but as high an order of talent as was ever employed in money-making or in State administration, is driving the wife of price beyond rubies out of the home and out of the world.

There is no mistaking either the fact or the effect of this. In regard to the highest of these home duties, the care and training of children, notwithstanding the theoretical value placed thereon, they fall into the rut of a uniformly low estimate of what is properly considered a woman's work. Evidence of this is found in the fact of no provision made for the development of any practical efficiency for their performance in the home, and in the placing of children under charge of the most incompetent and poorly paid teachers in the schools.

Not until the best institutions that can be established make ready the devoutly impressed and richly furnished young women to become mothers will women believe there is any honest conviction behind the complimentary speech with which this branch of home service is taken out of the category of contempt. From the gridiron and clothes line to the best possible administration of the home, it is against this grinding sense of undervaluation of her employments that woman makes her way through life.

Of education, as a cause of the present revolutionary movement, it is more difficult to speak. I refer now to that wrong and inadequate education, of which girls get so much that women find themselves practically without any. It commences early and continues long, in that indirect tutelage found in the home, in institutions, laws, literature and society, and which, between repression and stimulation, becomes an almost systematic procedure for baffling nature and substituting the standards of art. And what do we see? Hearty, happy little girls? We see very little, any more, of that phase of female loveliness. Preferences and tendencies are no longer tolerated unless of clear becomingness, according to estimates as changing as the unreliable qualities they foster. To atone for this ever present repression in regard to food, frolic and devices of taste, an enervation of indulgence sets in, with corresponding results to body and mind.

The law of nature, which is development and not hindrance, is thus stimulated to over-activity among boys by the constant assault upon its application to the girls of the household. Thus the hard and aggressive nature of boys becomes harder and more aggressive than nature intended, resulting in injury to the female organism. Reference is had to that sort of injury upon which the discovered relations of physiology and psychology begin to throw some light, and which is due to the more complete wholeness of woman's structural development at any given time, and at the earliest time, making the endurance of repression or the excess of simulation more hurtful to the childhood of girls than of boys.

The pernicious doctrine that women are made for sacrifice, with the stimulus of making this sacrifice wholly acceptable has been the root and front of all falsity in relations between the sexes. It begins in the family, teaching to the least of them that brothers are to become whatever they can make themselves through their gifts and opportunities, and that sisters are to become what is neither in the way of nor unacceptable to their brothers. This subordination of one sex to the other teaches inferiority and breeds the pride of some sort of rivalry. The field of this is soon found, there being much help to it; and the aim is fixed to be a pleasure to the brother, as he is a power to her. If this were all, little harm would come of it; since, at its height of art and purpose, it is the gift of God—*this art of a woman wholly pleasing a man.* But the end being presented, with no incentive beyond it, the aim soon touches its depth of demoralization, through the notion that methods are of less consequence than results, and forgetting the purpose of appearing to be what she is not.

There is little room to doubt that this is a legitimate result of early indirect training, and a fountain of that insincerity which is so dark a shadow on female character. The affectation, instead of the cultivation of gracious quality in the plastic years of childhood often remains but an affectation, to the wormwoodand gall of other lives and latest years. It is because of exceptional nurturing of truth and womanly quality, that society is saved from the full penalty of the teaching that women are bound to please; and, pleasing, it matters but little how. Grave as this charge seems, it is as true as when made a quarter of a century ago by that illustrious friend of man, Horace Mann, that, "Through all time women have been assiduously taught that the garniture of the body was more precious than the vesture of the spirit; and in no age nor portion of an age, in no country nor segment of a country, has woman ever been elevated for her reflex power of elevating others."

Under the conditions, it is not surprising that woman should seize upon material ornamentation as accessory to the purpose of making the most of herself; or that, as the sense of her moral responsibility is lowered, she should rely more and more upon these allies of personal attractiveness. The surprise is, that, with any moral sense left, she should not repudiate the putting of things beautiful and appropriate, as aiding the expression of intrinsic beauty and worth, in the place of these. Nevertheless, this is done, and to such an extent that, just as the connection between taste and morals disappears in modern feminine apparel, it reappears in the spectacle of a very low standard of personal appreciation, expressing itself in the deformities of fashion. It is not merely the empty head of the votary of conventional extremes that measures the folly and wickedness of training up childhood to such maidenhood; it is in the exhibition of moral unfitness superinduced upon womanhood itself, and finding its moral expression in her attire, where the womanly art of decoration becomes artifice.

As life advances, the position and language of institutions reaffirm to woman the humiliating proposition of her youth. At the threshold of all higher power and privilege, she is met with the denial of right, or the denial of capacity. There is not an institution, of the highest grade of its kind, in the world where a woman can go for instruction, upon an equality with man; and in those approximating this rank, where she finds admission, it is also to find the atmosphere and hindrance of his supercilious toleration.

In the language of the law, she finds herself ranking first in the list of natural and convicted incapables—"women, children, criminals, idiots and slaves." Moses placed her in the category of substance—property—and there she remains. Not long since I saw in an American newspaper an advertisement of the escape of a wife who had been left as security for the payment of money, with notice of penalties for harboring her. The property and the husband are one, and not the husband and wife; for does not their relation terminate upon the death of either, while the husband and his horse go on together beyond the solemn event?

In regard to the ownership of children, not the slave-mother alone, but Cæsar's wife may miss the infant from her side and Cæsar make no answer. Moses inaugurated this also, and time has meddled but little with the policy.

In literature it is the same, and yet worse of the kind. The voice of institutions and of law can be somewhat escaped, invading the home but occasionally. But literature, which is a woman's refuge, with its treasures of new and old, its enchanting fabrications in story and verse, and its record of all that has been done, and hoped, and failed,—it is here that woman finds herself in the full habiliment of her subordination. It is not the bold avowal of her inferiority and the scorn of her sphere, of which there is no lack; it is not the meaningless paraded recognition of her charms and gifts, as the decorator and subserver of his leisure, nor yet the vows and homage accorded her as ministering angel of the house and purifier of society; it is that inexpressible tone and spirit pervading the whole, as she turns its pages, announcing everywhere to woman the measure of her esteem among men. Out of literature proper she is eased down into society—where the virus of all takes most fatal effect—by the newspaper press. There is nothing more offensive, and nothing more damaging to the moral sense of the average reader, of either sex, than the manner in which woman is distorted and bemeaned by the newspaper craft. Woman, the scandal of the double-leaded column, the gist of every well-told tale, the butt of the best joke, the glint of sarcasm, the ridicule of domestic discontent and diabolism, and the unknown quantity of all innuendo and suspicion. And woman not at her best, or half best of admitted worth, but at her worst of disadvantage.

In society, the attitude and the speech of man to woman is most decorous; for it is here, in the presence of her physical charms, that the fascinations of her intellectual and spiritual beauty unite in appeal from the decrees of his calculating intellect. And yet it is here that woman brings the largess of an unreserved sacrifice—her time, labor, means, capability, her health, herself.

As a last cause distinctively considered, we have the direct education furnished in schools for girls. And it may be that here will be found the chief cause of the attempt of women to revolutionize public sentiment in their interest, since the language of positive education is the plainest possible statement to woman of the inferiority of her duties and of herself.

The rule of less compensation for labor may come in part from a mistaken judgment as to the number of dependent women; the depreciation of home duties from an imperfect knowledge of domestic economy; and much of indirect teaching may be the half unconscious growth of a belief that, things being as they are, it is best to make the most of conditions found. Even the injustice of her legal status may be glossed over by the assumption that the responsibilities of equality would overbalance its additional security. Such conclusions are compatible with a rather fair estimate of women taken out of the intricacies of relations which it is difficult to estimate. But that direct education, which is neither for public nor professional service, comes to woman with a denial of the right to it or capacity for it. If one could lay upon the page, or place before the eye, a picture representing the hemispheres of time occupied by men and women respectively, and touch them with light and shade, according to the measure of education that has been furnished each, the eye might help the mind in gaining a conception of the extent to which woman has been denied a knowledge of herself and of the world in which she lives. But Art has not the gift, as eloquence has been in vain, to arouse man to the wrong of denying to woman an equal share in whatever education can give as a preparation for life. Because there is a difference between the present and the practice of earliest times, it is not to be lost sight of that the difference in the opportunities afforded young men and women respectively, has not been diminished in proportion to general educational advancement; so that it remains, to the dishonor of all time and countries. Using again the language of Horace Mann, "In estimating the number of heroic souls who have languished out their lives in dungeon cells, or fallen beneath the axe of the oppressor, we count by hundreds and by thousands; in summing up the multitudes whom conquerors have subjugated and enslaved, we count by nations and races of men; but, in enumerating the women whom man has visited with injustice and persistent wrong in the rights of education, we express ourselves by a unit, but that unit is the world. And this, notwithstanding that human reason seeks in vain for a reason why there should be this difference of education and no education between the sexes."

It is incredible that women have not been taking note of these things through much time of both experience and retrospect; and that they are not more moved to protest and revolution to-day, in the flush of modern enlightment, than when abiding in the thicker darkness of the past. Nor is it wonderful that this revolution, having its root and furtherance in the English-speaking countries, where progress has done the most for men, should find just here, where their education has most advanced, most bitter cause of complaint.

III.

Of the aims and methods there is but time for the most general mention.

The aim is to take woman out of the condition of subordination to one of equality with man. As an aim it is all that it could be —a whole, a wise, and a just one.

Of the methods, it must be said, they have often been mistaken ones, hindering the cause. But they are explained as being the only ones furnished as models—the means used by man in furtherance of similar objects.

IV.

The supposed results being the hydra-headed confusion and desolation of the social scheme, it is well to look a little carefully at what they would probably be. And, first, they must appear in woman herself more than in man. The mere fact of equality before the law would vitalize her intellectual being, through an added sense of power, not likely to awaken at once a corresponding sense of responsibility. This has been the history of all class advancement, and especially when advancing upon privileges long withheld, and it cannot be doubted that the entire body of women, I mean all classes of them, would be thus affected—first by the privileges, rather than by the duties, of the new position. Nor could this fail to bring about great social injury, involving the neglect of children and homes, domestic industries and charities, differences between husbands and wives, and disaster to private and public business. As the direct result of the independence of woman, this would be bad enough; but it would undoubtedly be followed by the darker shades of increased licentiousness among both women and men. Political power, and political power alone, as furnishing the means of protecting himself against the inflictions which may come of it, has been the bulwark of man's prerogative and practice of vice. It has done more and worse than this; it has compelled, whenever his interests were subserved thereby, a participation by woman in his vice, while meeting out direst penalties for the same when it did not so subserve his purposes.

The revulsion from all this, with co-ordinate power and privilege, will most assuredly work to the debasement of female character, checked only by her natural superiority of instinctive virtue, and by the increased security against temptation found in her enlarged material independence. The tendency to this growth of vice among men would also find restraint in their increased respect for women, *because* of their independence, and in the elevation of sentiment inspired by them through better culture and the consequent ability to turn the excess of masculine passion into virtuous and useful channels.

Another powerful, and, it may be, more immediate check to either the ordinary or increased licentiousness of men would be the alarm seizing upon all but the most depraved circles of society, at the spectacle of woman becoming the instrument of so appalling a measure of retributive justice. Nor can it be doubted that this spectacle would become a measure of extraordinary enlightenment to him concerning the whole nature of the sexual passion and of the non-sexual character of morality *in extenso.*

An increase of divorce legitimate to this state of things would ere long be corrected by enabling women to enter upon marriage more considerately than now; while marriage itself would be steadily gaining in dignity and security, as the elevation and responsibility of enfranchised women began to take effect upon the general quality of men, as well.

This movement, would, however, beyond all question, show itself to have been a great and just movement in the result of better educated women. Through the independence of equality in education, better women; and after that a better race of men, better rearing, better society, better government, and a nobler civilizaotin.

That women desire an equality with men to the end of entrance upon public life, or of competing with them in the affairs of business, is as far as possible from the truth. There is much apprehension as to the subversion of social order, while insisting upon obedience to the law of nature in the parcelling out of duties and relations between men and women; and yet the entire proceeding of the civil structure of man in this regard is as if nature had furnished no law not in need of the sanction of his enforcement. But if there is one law of the intellectual constitution of sex more clearly defined than another, it is this: That man is intended for massing himself with his fellows in organization, and woman for abiding in the unity of self-hood. Man for openly aggressive, and woman for silent, power is the *law* of power; each after its fitness and its destiny. Since the world was, man has appeared best in activity, woman in repose. Instance the testimony of all marble and canvas, as well as of literature, and observe it in the daily round where the self-blinded eyes of men begin to see this open secret of the social disorder.

Women do not crave a public career, nor would they remain long in public life if its paths were fully open to them. They do not seek the ballot to this end. Even the majority of the leaders of this movement desire nothing so much as the protection a domestic sphere and home-life theory promise them. As before the Magi of the old, a woman stands to-day before the law maker of this new time questioned as to what most pleases woman. And thus has she always stood, answering in the language of the myth, "To be loved, to be studied by her husband, and to be mistress of the house."

The difference between the women of that and this time is in the manner of the response. The Persian representative of her sex stood in the twilight of the world, asking for a veil behind which to hide from even the gods, who held in their keeping such precious gifts, her sacred joy in anticipation of their bestowal; while the representative-movement woman of to-day stands on platform and in press in the emphasis of her determination to have something better than the *promise* of these good things.

To be loved, to be studied, and to be mistress of the home where strength and honor are her clothing, this has always been and always will be the joy and crown of woman. By the laws of her physical and spiritual being, as well as by intellectual preferences, she is wedded to her motherhood. But she never has been, and never can be, true to it under the imposition of conditions dependent upon the will of man.

Ideal freedom, which is the birthright of every human soul, is more necessary and more possible to woman than to man, if any comparison can be made. Alone with herself, in the unity of that mysterious bond which binds a finite to an infinite being, woman becomes a power for baffling evil and furthering good. But under the ban and surveillance of her master, she is not able to realize, much less to find, her place.

V.

The final cause of this movement is that of all real progress, and in the nature of things it cannot fail. That women will accept less than the obliteration of the last jot and title of man's ungraciousness to her is not possible, as it is not possible for a law to be and not to be at the same moment. Ways and means are nothing, as condition and precedent are nothing. Through folly and through wisdom, through strength and through weakness, moves on the perfect plan to perfect ends.

DEPARTMENT OF

Speculative Philosophy.

Titles of Papers read before this Department.

---

1. Were the Stoics Utilitarians? By Rev. F. M. Holland, Baraboo.
2. An Examination of Prof. S. H. Carpenter's Position in regard to Evolution. By Herbert P. Hubbell, Winona, Minn.

WERE THE STOICS UTILITARIANS?

BY F. M. HOLLAND, BARABOO.

The practical value of Stoicism was long ago fully demonstrated in the energy, justice and philanthropy with which, for more than eighty years after the death of its worst enemy, Domitian, five of its pupils successively ruled the Roman Empire. It is well to ask if the philosophy, for which Nerva went into exile at the same time as Epictetus, in which the latter, with Dion Chrysostom and Arrian, instructed Trajan, Hadrian and Antoninus Pius, and of which Marcus Aurelius made himself the grandest embodiment, has still a place among living systems of ethics.

The few writers who have tried to find such a place for the Stoics differ widely. Mr. Lecky and Miss Cobbe labor to array them among the transcendentalists, the History of European Morals asserting that of "the two rival theories, one is generally described as the stoical, the intuitive, the independent or the sentimental—the other as the epicurean, the inductive, the utilitarian, the selfish," (vol. i. p. 3,) while the Essay on Intuitive Morals frequently appeals to the authority of the Stoics, in quotations, for the most part mistranslated, as is especially that from Lucan, ix., 573, (Am. Ed., page 120,) which owes its significance wholly to the words, "inborn precepts," which are rightly italicized by Miss Cobbe, for they are not contained in the original Latin printed beneath them. This liberty, like the similar ones with Marcus Aurelius, I. 13; and V. 27, was undoubtedly taken in the firm belief, that the real views of the authors were thus fully manifested. Even J. S. Mill so far agrees with his two antagonists, as to speak of "every writer, from Epicurus to Bentham, who maintained the theory of utility," and to say "let utilitarians never cease to claim the morality of self-devotion as a possession which belongs by as good a right to them, as either to the Stoic or to the Transcendentalist." (Utilitarianism, Ch. II.) Everybody knows Jeremy Bentham's hatred of "the sort of trash which a set of people used to amuse themselves with talking, while parading backward and forward in colonnades called porches," but everybody does not know that Alexander Bain, who is, except Herbert Spencer, the ablest living advocate of utilitarianism, declares that "Stoicism and Epicureanism are both included in its compass." (Moral Science, Am. Ed., p. 16.) Mr. Bain, however, gives no evidence for this statement, and takes little pains to show the proper place of the Stoics among the happiness moralists.

These differences of opinion make it necessary to examine carefully the statements of Stoicism, made by its principal teachers, Seneca, Epictetus and Marcus Aurelius, as well as the accounts of the opinions of still earlier authors by Diogenes Laertius and Cicero. Such an examination will show that the Stoics never were led by their belief, that every soul is a part of the Supreme and All-pervading Intelligence, to suppose themselves thus endowed with an infallible moral guide, and raised above the necessity of learning what is right and wrong by observation and experience.

Seneca, in his 120th letter, says: "Nature could not teach us the first ideas of goodness and virtue. She gave us the germs of knowledge, but not knowledge itself. Our philosophy holds that these ideas come by observation and comparison of our daily deeds, and that goodness and virtue are known by analogy."

Epictetus devotes the eleventh chapter of the second book of his Discourses to proving that we are not so well provided with innate ideas of good and evil, as to be able to distinguish right from wrong without some rule, balance or standard, such as philosophy alone can give, the knowledge of which inability he calls "the beginning of wisdom." (See pages 124, 5, 6 of Higginson's spirited translation.")

He complains not only that "the governing faculty of a bad man is faithless," but that people not instructed in philosophy are ignorant of "the essence of good and evil, and act rashly and by guess;" "that contradiction among the generality of mankind, by which they differ concerning good and evil," showing that moral knowledge can be acquired only by tuition, as was also the opinion of the earliest Stoics.*

The fundamental distinction, however, between the intuitionalists and their rivals, is that the former believe the moral sentiment to be innate, independent and incapable of analysis, while the latter are satisfied that it can be analyzed into simpler elements, and therefore claim the title of derivative moralists, a name which the

* See Higginson's Epictetus, pp. 48, 62, 65, 74, 76, 83, 101–2, 145–53, 175–6, 185–6, 208, 224, 245–7, 299, 315, 335, 345, 354. Diogenes Laertius, Zeno LIV, p. 292, Bohn.

Westminster Review decidedly prefers to that of utilitarian.* In this respect it is very significant that the founder of Stocism introduced a new word for duty, *kathekon*, containing a preposition denoting relation or derivation, and that the last defender of the Portico gives a similar term, *katorthoseis*, for those actions "which proceed by the straight path from a kindred principle to the end appointed."†

Cicero,‡ however, considers that the preposition in these terms for right actions, denotes simply their accordance with nature.

Nature was, indeed, the supreme authority of the Stoics, whose favorite precept, "follow nature," did not mean "follow conscience," as Miss Cobbe asserts on pages 142–3 of Intuitive Morals, where she imagines that she proves it by a remarkably incomplete quotation from Diogenes Laertius, who makes much more reference. than in her extract, to universal nature, an oracle to which the Epicureans appealed as constantly as their stern rivals, without ever attempting to receive its revelations intuitively. The philosophers of both schools agreed with most of their contemporaries in "acknowledging, as the ultimate source of right and wrong in morals, and therefore in institutions, the imaginary law of the imaginary being, Nature." (Mill on Comte, p 65.) And this fallacy was accepted as the ultimate analysis by nearly every moralist who sought any for fifteen centuries after the death of Marcus Aurelius. Indeed, the error still shows itself in the current loose talk about natural rights and desires, unnatural conduct, etc. The fact that the Stoics lived in what Mill calls the abstractional, or ontological, and Comte the metaphysical period of ethics, should not prevent our recognizing them as faithful followers of the derivation method according to their light, as is proved by the following quotations, some of which even show that their authors were in advance of the age and almost anticipated the discoveries of modern Utilitarians, while other passages indicate a habit of estimating the morality of an action according to its tendencies and usefulness.

"In order to distinguish good from evil you should consider not whence it comes, but whither it tends.

"Whatever makes life happy is good by its own right and cannot become evil." (Seneca,Ep.44,section 6.) "Only that which makes

* See the article on the Natural History of Morals, published October, 1869, in Vol. XCII, p. 237, 52. Am. Ed.

† See Diogenes Laertius, Zeno LXII, p. 293, and Marcus Aurelius, V. 14.

‡ *Kata physin*. See De Finibus, III, 14.

us happy is good." (do 85, 20 and 115, 15.) "In being useful the soul moves according to nature." (do 109, 12.) "Whatever is good is always profitable. If it be not profitable, it is not good; if it be it is so." (do 117, 27.) "Utility is the standard of necessity," (or conformity to nature, do 39, 6.) "Public and private utility are inseparable." (do 16, 10.) "The only proper aim of the giver is the advantage of the receiver." (De Benificiis iv, 9, 1.) "Our duty certainly is to be useful to other human beings and to as many as possible, for in doing good to others we perform the common work." (De Otio iii, 5.) "Punish without anger, not as if revenge were sweet, and only so far as it is useful." (De Ira, Lib. ii, 33, 1.) "All men seek what is useful and according to nature." (Epictetus, Discourses, i. 18.) "No one can think anything really useful and not choose it." (do i, 28.) "When therefore any one identifies his interest with those of sanctity, virtue, country, parents, and friends, all these are secured, but whenever he places his interest in anything else than friends, country, family, and justice, then these all give way, borne down by the weight of self-interest. For wherever I and mine are placed, thither must every living being gravitate." do ii, 22, Higginson p. 174.) "Why did Agamemnon and Achilles disagree? Because they did not know what is useful and what is useless." (do ii, 24.) "Consider the antecedents and the consequences of every action." (do iii, 15, also in the Eucheiridion, xxix.) "Every creature is formed by nature for pursuing and admiring the things which appear beneficial." (Ench. xxxi.) When you imagine any pleasure, don't be carried away by it, but wait awhile. Then think how you will grieve and blame yourself for enjoying it, and how you will rejoice and please yourself for having abstained." (Ench. xxxiv.) "This above all is the business of nature, to correct and apply the active powers to what appears fit and beneficial." (Fragment lxiv in Higginson's Epictetus, lxix in Didot's, Paris, 1842.) *

NOTE.—The first ninety-one of these fragments, as Higginson gives them, and some later ones are from Stobaeus, who lived about 300 years after Epictetus, but who shared his vsews so far, and has received such general confidence, that I quote all he furnishes of importance. Others are from Maximus and contain nothing to the purpose. The rest are from Antonius Melissa, a work in the dark ages, some 600 or 1000 years later than than the philosopher whom he quotes at second hand, through the untrustworthy medium of the church fathers. To his extracts I shall make no further reference except to mention that one passage (Higginson cv.;) is decidedly derivative and may fairly be paired off with another, (Higginson xcii,) which is the only expresssion of intuitionalism I have found among the sayings ascribed to Epictetus.

"Don't consider what others say, do or think, unless it is very necessary and for the common good." (Marcus Aurelius, Commentaries, iii, 4.) "Never labor without regard to the general interest." (do iii, 5.) "Choose the better part. But that which is useful is the better part." (do iii, 6.) "Let no act be done without a purpose." (do vi, 2, Long's translation.) "Do only what is useful to men." do iv, 12.) "Turn the present to profit by aid of wisdom and justice." (do iv, 26.) "How cruel it is not to allow men to strive after what seems to them natural and useful." (do vi, 27.) "Whatever I can do, ought to be directed to this end alone, usefulness to the community." (do vii, 5.) "A rational nature goes on its way well when it directs its movements only to actions universally beneficial, etc. (do viii, 7.) "Repentance is a kind of self-reproof for having neglected something useful." (do viii, 10, Compare Darwin, Descent of man I, 87.) "Let every action be a complete part of social life. Every act of thine, which has no immediate or ultimate reference to a public end, tears thy life asunder." (do ix, 23.) "Let there be effort and exertion resulting in acting for the common good, for this too is according to thy nature.") do ix, 31.) "If I remember that I am a part of the whole I shall do nothing unsocial, but shall turn all my efforts to the common interest." (do x, 6, Long, abridged.) "Thy charge is to provide in every way what is useful to the State." (do xi, 13.) "Our object should be the good of the State, and of mankind also." (do xi, 21.) "First, do nothing inconsiderately, nor without a purpose; Second, make thy acts refer to nothing else than a social end." (do xii, 20, Long.) "And anything which is useful to the universe, is always good and in season." (do xii, 23, Long.)

"The Stoics say that men are created for the sake of mankind, to be useful to each other. Thus we are commanded to follow nature in being mutually and universally useful." (Cicero de Officiis, i, 1, 5.) "Those in charge of public business should look at the advantage of the citizens, and consult that in all they do, forgetting their own interests. A public trust should be administered for the benefit of those giving it, not of him to whom it is given." (do., i, 25, 1 and 2.) "True philosophers have not neglected the advantage and interests of mankind." (do., i, 54, 1.) "Nothing does more to deprave human conduct, than the belief that anything is virtuous which is not virtuous." (do., ii, 3, 3.) "The

Stoics agree that whatever is virtuous is useful, and that nothing is useful which is not virtuous." (do., iii, 3, 4, and 4, 15.) "Panætius taught that virtue ought to be cultivated because it is the cause of utility, that it is never at variance with real but only with imaginary utility, that nothing is useful which is not also right, or right which is not also useful, and that no worse disease has ever invaded human life, than the theory which disjoined these two ideas." (do., iii, 3, 5, and 7, 6.) "The law of nature watches over and holds together the interests of mankind." (Do., iii, 6, 14.) "Duty is always performed when the advantage of mankind is consulted." (Do., iii, 6, 15.) "Although nothing is so contrary to nature as depravity, yet nothing is so much in accordance with nature as utility, and certainly depravity and utility cannot be found together." (Do., iii, 8, 2.) "This is the law of nature which you should obey and follow, that your interest is the universal, and the universal one your own." (Do., iii, 12, 7, and 6, 1.) "He is a good man who benefits as many people as possible and harms nobody." (Do., iii, 18, 9.) "Those who separate utility and morality overthrow the fundamental principles of nature. We all seek utility, are carried away by it, and cannot do otherwise. For who flees away from what is useful? Who does not rather pursue it most diligently?" (Do., iii, 28, 1, 2.) "Whatever is useful is virtuous, though it does not at first seem so." (Do., iii, 23, 9, and 30, 10.)

These quotations show how fully the Stoics recognized utility as the inseparable and characteristic result of virtue; though their position cannot be further explained, until we have considered their language about happiness and pleasure.

The following passages are in harmony with the two about happiness, already quoted from Seneca.

"All men wish to live happily but cannot discern the proper way." (Seneca, De Vita Beata, I. 1.) "To live happily is the same as to live according to nature." (do, do, 8, 3, also 3, 3, and Ep. 124, 7.) "He has reached the perfection of wisdom, who does not place his happiness in another's power." (do, Ep. 23, 2.) "Make yourself happy." (do Ep. 31, 9.) "All men seek happiness. In what do they err? In taking its conditions for itself." (do Ep. 44, 7.) "He who is not happy, has not attained the supreme good." (do Ep. 71, 18.) What is the business of virtue? A life truly prosperous." (Epictetus, Disc. I, 4, Higginson, p. 14) "Suppose then, I should prove to you that you are deficient in what is most necessary and important to happiness, and that hitherto you have taken care of everything rather than your duty." (do ii, 14, Higginson, p. 137.) "Show me some one who is always happy, for I long to see a Stoic." (do ii, 19) "You were not created to be degraded or miserable with others, but to be happy with them. For God made all men to enjoy happiness and peace." (do iii, 24, 1.) "Be contented with a sound mind and a happy life." (do iii, 24, 118.) "Our struggle is for prosperity and happiness itself." (do iii, 25.) "You have applied yourself to philosophy only in name, and have disgraced her principles, as much as you could, by showing that they are unprofitable and useless to those who study them. You have never made peace, tranquillity and equanimity the object of your desires." (do iii, 26, 13.) "What is the object you should seek except a happy life?" (do iv, 4, 4.) "Be mindful, morning, noon and night, that the only way to happiness is this." (do iv, 4, 39.) "Meditate upon your actions. What have I omitted that is conducive to happiness? What have I done contrary to the interests of my friends or of my race? (do iv, 6, 35.) "It is better that your servant should be bad than you unhappy." (do Enchiridion xii, Higginson, p. 379.) "To be happy is a good object and in your own power." (do Fragment, xix Didot.) "It is better to contract yourself within the compass of a small fortune and be happy, than to have a great one and be wretched." (do Frag. xxiv, Didot, xxi, Higginson.)

In the original of the last passage the verb is the one translated be of good cheer, or be merry, in our Bible, (Acts xxvii, 22 and 25; James v., 13.) and corresponding to the adverb rendered cheerfully (Acts xxiv., 10), as well as to the noun selected by Democritus, as the mark of the system thence called Euthumism by Miss Cobbe, (Essay on Intuitive Morals, p. 221.) and signifying "the pursuit of virtue for its intrinsic *i. e.* moral pleasure." In the other quotation from Stobæus, and in all those from the third book, the terms are those familiar ones, whose use by the ancient advocates of Utilitarianism, leads Miss Cobbe to call that system Eudaimonism, meaning "the pursuit of virtue for the sake of the extrinsic, affectional, intellectual and sensual pleasure resulting from it" (do. p. 219). In other passages, however, is found a word peculiar to the Stoics, who thought so much of happiness that they invented for it a new term, *Euroia.* Their views of this favorite idea appear nowhere more clearly than in a long passage of Epictetus (Discourses, book II, ch. xvii., Higginson, p. 151), where the student, who has learned to desire nothing but freedom from passion and trouble, is said to have passed through the first class in philosophy, whence he enters the second class in his desire to know his duties to foreigners, his country, his parents and the Gods. Thus the first degree in Stoicism was to make one's self happy, and the second to be useful to others; which second and higher degree is that mainly dwelt on by Cicero and Marcus Aurelius, as has been already shown.

The Tusculan Disputations and De Finibus of Cicero state at some length, that the Stoics agreed with the Peripatetics, Epicureans and other acknowledged Utilitarians, in honoring happiness as the greatest good and highest aim of man, and differed from them mainly in declaring that the sole and sufficient means of acquiring it was virtue, or, in other words, both active and submissive obedience to the commands, prohibitions and decrees of nature, their favorite watchword being "*sustine et abstine.*"

The peculiar bitterness of the controversy between the Stoics and Epicureans was partly due to the attempts made by the latter, to overthrow the established opinions about theology, politics and metaphysics, and partly to their assertions, that pleasure was not only the means but the synonyme of happiness, that the virtues are chosen for the sake of pleasure and not on their own account.*

It does not appear from Lucretius, Diogenes Laertius, or Cicero, that regard to any happiness but our own was ever inculcated by the Epicureans, and it is certain that they committed the dangerous error of using Greek and Latin terms for pleasure which have an extremely sensual signification, hedone being rightly translated lust in our New Testament, (Titus III, 3, James IV, 13,) and *voluptas* being used in a sense even grosser than that of our derivative voluptuous. Mr. J. S. Mill does not "consider the Epicureans to have been by any means faultless in drawing out their scheme of consequences from the utilitarian principle" (Utilitarianism p. 11;) Professor Bain "cannot but remark that the title or formula of the theory was ill chosen, and was really a misnomer,"

*See Diogenes Laertius, p. 470—3.

(Moral Science, p. 120.) Bishop Cumberland, one of the earliest modern advocates of the greatest happiness principle, attacks Epicurus and his followers vigorously, and two of the best known among the ancient expounders of that principle, Aristotle and Theophrastus, take similar ground, the former denying that pleasure is the chief good or synonyme of happiness and warning his disciples against snares, (Ethics II, 9, and X, 3,) while the latter speaks so strongly of the peculiar guilt of sins committed with pleasure, that his language is quoted with hearty approval by Marcus Aurelius (II, 10.) We should not therefore infer that the Stoics were not Utilitarians, because they opposed Epicureanism, which system indeed had become, before any exposition of their views now extant was written, little else than a cloak for indolence, servility, profligacy, and indifference to the claims of patriotism and philanthropy, as indeed the lives and writings of the best known of the successors of Epicurus prove only too plainly.

Marcus Aurelius, Epictetus and Seneca saw these facts so clearly, and loved practical morality so faithfully, as often to speak of pleasure with unqualified aversion. Seneca, however, frequently distinguishes the voluptas which is brevis, tenuis, corporalis, vana, nimia, poenitenda ac in contrarium abitura, from that which is vera, stabilis, naturalis, necessaria, in animo, etc., (De Vita Beata iv, 2; vi, 1; Ep. 18, 10: 21, 11; 78, 22;) and Epictetus uses hedone with similar caution (Disc. iii, 7.) These two terms are also employed in some remarkable passages which may be regarded as foreshadowing the discovery, now the bulwark of utilitarianism, that pains are the correlatives of actions injurious to the organism, while pleasures are the correlatives of actions conducive to its welfare. "Pleasures are the incentives to life-supporting acts, and pains the deterrents from life-destroying acts. (Herbert Spencer's Psychology, Ed. of 1872, Vol. i, p. 279-284.) With these statements should be carefully compared the following:

"Nature has mingled pleasure with necessary actions, not in order to have us seek after it, but that what we cannot live without may with this addition, become more attractive." (Seneca Ep. 116 3.) Pleasure is the companion, though not the leader, of a virtuous will. When virtue leads, pleasure follows like a shadow." (do, de Vita Beata, viii, 1 and xiii, 5.) "Our nature is to be free, noble and modest. And pleasure should be subjected to these virtues, as a servant and assistant, and sustain us in doing what is commanded by nature." (Epictetus, Discourses iii, 7, 23.) "We do not think that pleasure is commanded us by nature, but that it is a result of what is so commanded, namely, justice, temperance, and freedom." (do Fragment lii, Didot.)

Philosophers who speak thus cannot be charged with ignoring the value of pleasure, which indeed they sometimes acknowledge even more freely.

"Our pleasure is doing good." (Seneca, De Beneficiis iv, 13, 2.) "We shall not have any the less pleasure for giving virtue the precedence, but shall be its masters and governors." (do De Vita Beata xiv, 1.) "It is a great pleasure for me to think of the character of Scipio." (do Ep. 86, 5.) "I permit you to enjoy pleasures, which will come to you more plentifully if you rule them than if you obey them." (do Ep. 116, 1.)

Usually, however, terms, which denote only mental pleasure, like *gaudium*, *lætitia* and various forms and derivatives of the verbs *chairo* and *euphraino* are preferred, of which common practice a few instances will be given.

"He has reached the height of wisdom who knows what to rejoice in. Learn this, first of all, O Lucilius." (Seneca Ep., 23, 2.) "I am not depriving you of many pleasures" (voluptates) "but desiring that joy may never fail you." (Do. Ep., 23, 3.) "Nothing which is not right can please anybody always." (Do. Ep., 20, 5.) "You can see that you are not yet sufficiently wise; for the wise man is always joyous. Joy belongs to him alone, and this is the reason that you should wish for wisdom." (Do. Ep., 59, sec. 2, 14 and 16.) "The wicked find a fleeting pleasure in what gives the wise man enduring joy." (Do. Ep., 59, 24.) "It is right and natural for the good man to be joyful." (Do. De Ira, II, 6, 5.) "Enjoy the present and accept all things in their season." (Epictetus' Disc. IV, 4, 45.) "Take continual pleasure in passing from one philanthropic action to another, thinking of God." (Marcus Aurelius VI., 7.) "What remains, except to enjoy life by joining one good thing to another, so as not to leave even the smallest interval between." (Do., XII, 29. Long. See also VIII, 26, and X 33.)

The reader may charge the Stoics with self-contradiction in their language about mental pleasure, but he can find none in their refusal to admit bodily pleasure as a legitimate motive or as any part of happiness. Here, indeed, they differed from the Epicureans, but they agreed fully with the keen-sighted Peripatetics. The philosophers of both these schools were wise enough to know that the best way to be happy is to disregard bodily pains and pleasures, and cultivate self-control, kindness of heart, and nobleness of though. It was also characteristic of both Stoics and Peripatetics, though not of the Epicureans, to aim at universal. and not merely personal happiness, and to believe that virtue should be practised for its own sake, that is simply on account of its conformity with the laws of nature. Indeed, the Peripatetics charged the Stoics with stealing all their teachings, merely altering the terms, as thieves do the ear-marks of stolen cattle.*

The position that virtue is sufficient for happpiness, however, was confined to the Stoics, who further differed from the Peripatetics as did the Epicureans also, in refusing to accept the judgment of the wisest as the moral standard, and surpassed all other philosophers, not only in teaching disinterestedness, but in importing that regard for all the interests of their race which has since been called the enthusiasm of humanity.

Stoicism is thus seen to have preferred universal to individual happiness, disregarded bodily pleasures, demurred to accepting even mental ones as motives, believed in following virtue for her own sake, and placed morality on a disinterested basis, scarcely any of which views would be thought compatible with being utilitarian by those who, like Mr. Lecky, consider that term as a synonyme of selfish. Even he, however, makes some discrimination in favor of what he calls "the refined sensuality" of the Mills, Tucker and Austin, while Miss Cobbe distinguishes plainly between the two schools of Private and Public Eudaimonists, as she styles them, in a description much confused by her taking, as the representative of the last named class, Jeremy Bentham, who really belongs, with Paley, the French naturalists of the last century, and the Epicureans, among what we may call the self-regarding or individualistic Utilitarians, who did not believe in disinterestedness or in caring for others' happiness except as a condition of one's own. No wonder that Stoicism appeared trash to a man who finally discarded the last four words of his own famous formula, "the greatest hap-

* See Ac. Quaest. II 5. De Finibus II, 23, 27. III, 3. IV, 26, 28. V, 13, 16, 17, 25, 26, 29.

piness of the greatest number," and who, if we may trust the Deontology so far, even declared that "A man can no more cast off regard to his own happiness, meaning the happiness of the moment, than he can cast off his own skin."

The progress of psychology is rapidly destroying the arguments on which these egotists rested, and showing that the real representatives of Utilitarianism are those who, like Bain, Mill, Spencer and others of its most recent advocates, plant themselves on disinterested social sympathy so firmly, and teach regard to universal happiness so plainly, that they deserve no worse epithet than that of humanitarian or philanthropic. Their position is so little understood, that a few characteristic passages must here be quoted from the little book, called "Utilitarianism," by John Stuart Mill, published in 1863, and since reprinted among the Dissertations and Discussions.

"This it is, which, when once the general happiness is recognized as the ethical standard, will constitute the strength of the utilitarian morality. This firm foundation is that of the social feelings of mankind, the desire to be in unity with our fellow creatures, &c., (p. 45).

"Few but those whose mind is a moral blank, could bear to lay out their course of life on the plan of paying no regard to others except so far as their own private interests compels" (Do. end ch. iii., p. 50.) "The utilitarian standard is not the agent's own greatest happiness, but the greatest amount of happiness altogether" (Do. p. 16). The happiness which forms the utilitarian standard of what is right in conduct, is not the agent's own happiness, but that of all concerned. As between his own happiness and that of others, utilitarianism requires him to be as strictly impartial as a disinterested and benevolent specator. In the golden rule of Jesus of Nazareth, we read the complete spirit of the ethics of utility," (p. 24). "Utilitarianism could only attain its end by the general cultivation of nobleness of character" (p. 16). "It maintains not only that virtue is to be desired, but that it is to be desired disinterestedly, for itself" (p· 53). "Readiness to serve the happiness of others by the absolute sacrifice of his own, is the highest virtue which can be found in man" (p. 23). "Virtue in those who love t disinterestedly is desired and cherished, not as a means to happiness, but as a part of their happiness" (p. 53–4). "Virtue, above all things important to the general happiness" (p. 56).

With the above passages should be cited these two from the articles on Comte. "No one, who understands any morality at all, would object to the proposition that egoism is bound, and should always be taught to give way to the well understood interests of enlarged altruism. It is an error often, but falsely, charged against the whole class of utilitarian moralists" to require "that the test of conduct should also be the exclusive motive to it" (p. 125–6 of the Reprint).

Sir James Mackintosh also maintained (according to Bain's Moral Science, p. 264), that "the utility is the remote and final justification of all actions accounted right, but not the immediate motive in the mind of the agent."

These passages give, with but incidental differences, the views not only of Bain and Spencer, but of Hume, Locke and Cumberland, and with these philanthropic utilitarians, the Stoics and Peripatetics would have agreed much more readily than the Epicureans. The Stoical literature is especially rich in passages honoring the social feelings and teaching universal philanthropy.

"Nature endears man to man," (De officiis I. 44.) "Nothing is more natural to man than kindness," (do I, 14, 1.) "All men are plainly in union with each other," (do I, 16, 5.) "Knowledge is empty and isolated, unless accompanied by love of all mankind, and of universal brotherhood," (do I. 44, 8.) "The brotherhood of the whole human race is especially in accordance with nature." (do III. 5, 2.) They say that we should love our fel ow citizens, but not foreigners, destroy the universal fellowship of mankind, with which would perish kindness, benovolence and justice," (do III. 6, 6.) "The same law of nature joins us all together," (do III. 6. 3) "Care for other men and serve the human brotherhood," (do III. 12, 7.) "Nature has inclined us to love our fellow men, and this is the foundation of the law." (De Legibus 1, 15.) "Nature so endears us to each other that no man should ever be unfriendly to another, simply because he is a man," (De Finibus III. 19.) "Nature bids us prefer the general advantage to our own; for all the universe is one common city of men and gods," (do do.) "We are impelled by nature to benefit as many people as possible, born for human brotherhood, and joined together in one great community," (do 20.) "The aim of the Stoic is to be useful, not to himself alone but to all men, both collectively and individually,"(Seneca, De Clem. II. 5, 3.) "Guard religiously the bond which unites man to man and establishes the common rights of all the race," (do ep., 48, 3.) "Philosophy teaches reverence for the gods and love of man, (do ep., 90, 3.) "This is the rule of duty. Nature has made us kindred, implanted in us mutual love, and made us kindly affectioned, so that it is more painful for us to injure than to be injured. She bids our helpful hands be ever ready. Have this verse ever on your lips and in your heart. 'I am human, and I think no other man a stranger.' We are born to live together. Humanity is an arch which falls unless each part sustains the rest," (do ep. 95, 52, 3.) "The wise man thinks himself the citizen and soldier of the universe, and labors as if under orders." (do ep. 120, 12.) "I owe more to the human race than to any individual, (do De Ben., VII. 19, 9.) "Men by nature endeared to each other," (Epictetus III, 24. Higginson, p. 266.) "Man's nature is to be gentle and sociable, and to do good," (do IV. 1. 122, 6.) "I would have death find me doing something benovelent, public-spirited, noble. (do IV 10, 12) "Nothing is nobler than magnanimity, meekness, and philanthropy," (do Fragment LI.) "I would lay aside all self love, (Marcus Aurelius, II. 5.) "Rational creatures exist for each other," (do IV. 3.) "The sole fruit of this earthly life is a pious disposition and philanthropic activity, (do VI. 30.) "Only what is useful to Rome and to the universe is useful to me," (do VI. 44.) "One thing here is of great worth, to live in fellowship with truth and justice, and yet be benovelent to liars and unjust men." (do VI. 47.) "It is peculiarly human to love even those who do wrong," (do VII. 22.) "Love mankind," (do VII. 31. "Benevolence to our fellow men is peculiarly human," (VIII. 26.) "It is not fit that I should give myself pain, for I have never given pain intentionally to anyone else," (do VIII. 42.) "Among the properties of the rational soul is love of one's neighbor," (do X. 1, 1.) "Have I done anything for the general interest? I have had my reward," (do XI. 4.)

No wonder that J. S. Mill calls the commentaries of Marcus Aurelius "the highest ethical product of the ancient mind." Indeed the writings of these two philosophers are admirably in harmony, like their lives.

It is true that before the discovery, but little more than a century ago, of the doctrine of association of ideas, so little was known of the process by which we rise, from desiring certain qualities, as means to happiness, to desiring them for their own sake, and recognizing them as virtuous, that the Stoics were obliged to content themselves with sometimes enjoining disinterestedness, but not giving any adequate reason, and sometimes demonstrating the tendency of virtue to produce happiness without showing how knowledge of this is compatible with the duty of being disinterested. Similar ignorance of the fact, perhaps never yet made sufficiently prominent, that no happiness can be universal, except that which consists mostly in the enjoyment of the higher pleasures, because these are the only ones which can become objects of common desire, without exciting general strife, compelled the defenders of the Portico to maintain that virtue was the only means of happiness, though they occasionally admitted that mental pleasure can become felicity. In the same way their lack of knowledge of the full psychological value of pleasure, as an indication of utility, as well as of the distinction afterwards made by Mill and Mackintosh, between taking utility as a test or as a motive, forced them either to deny as stoutly that it is the best motive as to disparage its value as a test, or else to use it as a test so inconsiderately as almost to sanction it as a motive. They stated all the facts in turn of the Utilitarian theory, as held by its most advanced modern advocate, but without being able to see the relations of these parts so accurately as to present the whole truth. Their zeal for practical moral culture and universal progress in virtue was another chief cause of these inconsistencies, which, indeed, in that age could scarcely be avoided, except either by the recklessness with which the Epicureans declared pleasure to be the best of motives as well as tests, and even in its grossest forms the equivalent of happiness, or by the insipid understatements which prevented the Peripatetics, despite the consummate genius of their mighty founder, from leaving any deep imprint, except his own, on either literature or history.

The fact that only one school of ancient philosophy was able to produce a crowded series of noble patriots and philanthrophists, among whom Tiberius Gracchus, Cato, Portia, Thrasea, Epictetus, Dion Chrysostom, the younger Pliny, Trajan, Antoninus Pius, and Marcus Aurelius are merely the best known instances, shows that stoicism was able to do the practical work of utilitarianism with a success so peculiar as scarcely to be compatible with serious defects in theory. But these heroes became martyrs so commonly, and uniformly struggled against tyranny and profligacy with such self-denial and self-devotion, as necessarily gave the Stoics a peculiar tendency to asceticism, which, indeed, never hindered their being studious, patriotic and philanthropic beyond comparison, but which often prevented them from weighing the worth of pleasure with scientific accuracy.

Of these struggles and martyrdoms, Mr. Lecky has given us so beautiful, and, despite mistakes, like calling Brutus a Stoic, so valuable a narrative in his History of European Morals, that it is all the more remarkable that he did not see how completely he has answered his own arguments against the value of utilitarianism, which fill a large part of his first volume, by showing, in the remainder of it, what a noble work was done by the obnoxious theory, in the ethical elevation and influence of the most zealous of its ancient advocates. Failure to see the resemblance of stoicism to utilitarianism is, however, to be expected from a writer who so far ignored the position of Mill, Bain, and Spencer, as to call the system, of which they were the leading expositors, selfish. And this failure was much more excusable in works written, like Miss Cobbe's essay on Intuitive Morals, before the broad school of happiness moralists had gained its present prominence. How early in life J. S. Mill accepted Epicurus as the first utilitarian in preference even to Aristotle, we need not inquire, nor how far this view was imbibed from Jeremy Bentham.

The common misunderstanding of the true relationship of the Stoics has been much promoted, among other causes, by the fact that, like other ancient philosophers, they paid such regard to what they called Nature, as to satisfy themselves with appealing to her fancied authority instead of pushing derivative analysis to the last results. Evidence has, however, already been offered to prove that in following Nature the Stoics not only conformed to the principal precepts of the most enlightened Utilitarians, but even used their method, so far as to call only useful qualities and actions natural, a term by which, indeed, they meant little more than that the origin of the claims of utility was a sacred mystery. Indeed, modern science has been obliged to exert all her powers in order to solve this mystery so far as to show that the enlargement and ennoblement of human happiness is the realization of all our finest impulses, dearest wishes and highest hopes.

Ancient philosophers, however, were so blinded by this illusion, as well as so ignorant of the real value of pleasure, that perhaps none of them can, in strictness, be called utilitarian, and it is scarcely worth our while to consider whether the title of founder of the greatest happiness theory should be given, on acount of priority of time, to Aristotle, rather than to either Epicurus or Zeno, or whether his claim also should yield to that of Socrates, whose regard for utility appears in many passages of the Memorabilia.

It is enough to say that the Stoics, despite their noble inconsistences, maintained the most important principles of Utilitarianism in such purity and power, that they must hold the highest place among its forerunners, if not among its originators. Recognition of this fact would not only encourage the use of their writings as introductions, and even in some respects as supplements to those of Mill and Spencer, but would help us value justly the system of philanthropic Utilitarianism by showing how much was done for moral culture by one of its rudimentary forms.

AN EXAMINATION OF PROF. S. H. CARPENTER'S POSITION IN REGARD TO EVOLUTION.

BY HERBERT P. HUBBELL, WINONA, MINN.

If we were called upon to define the position occupied by Dr. Carpenter, in his paper before the February meeting of the Academy of Science, Arts and Letters, we should say that he was an Evolutionist but not a Darwinian.

To make this distinction plain, and to show more clearly his position, we should say that an evolutionist, as generally understood, is one who believes in evolution as taught by Spencer; that is to say, that matter, inorganic and organic, has arrived at its present degree of complexity by evolution from a simple state through a series of differentiations governed by some unknown law. That countless facts in nature substantiate this position, and that whilst recognizing the present state of nature as forming one extreme of the series, it finds, at present at least, in nebulous matter the other extreme.

Starting as it does with matter in its highest state of complexity it pursues it, by a process of strict inductive reasoning through its ever-varying phases of decreasing complexity until the mind loses itself in an an illimitable expanse of nebulous matter. Darwinism is an attempt to show that in so far as *organic* nature is concerned, evolution is dependent upon some *occult law of generation* co-operating with those conditions in nature necessary to its developmen. Evolution and Darwinianism, then, are in one sense materialistic; they deal wholly with the facts of nature and look to material causes to produce material effects. But Dr. Carpenter does not do this. Though he believes that in nature there is an evolution of matter, the recognition of this fact does not suffice: he goes *beyond* matter, beyond its nebulous state and finds there a Supreme Intelligence "which is the highest generalization of which matter and mind are capable of." This Intelligence, like all intelligences, must be, and is, governed by the laws of rationality, and must in its mental action, proceed either inductively or deductively. Constituting as it does the *highest* generalization, it is debarred from mental activity in the *inductive* direction, and is, consequently, obliged to manifest itself *deductively*. But mind is subjective. It can only manifest itself objectively, and hence, *matter* is such objective manifestation. Matter, therefore, on this hypothesis becomes nothing but the symbol of thought. The Supreme mind manfesting itself according to deductive laws proceeds in a series from the simple to the complex. Hence, matter symbolizing this thought will proceed in the same manner. Differentiations then in matter are not due to generative forces residing in the organism but to thought existing in the supreme mind. And thus it is that Dr. Carpenter is an Evolutionist but not a Darwinian.

The key-stone of Dr. Carpenter's logic is found in a Supreme Intelligence,—not the Supreme Intelligence as generally conceived, but as specially conceived by men, that is to say, as being the highest possible generalization—as governed by the same rational laws that govern us—and as manifesting his thoughts in material forms. It is evident that the surest way to weaken this logical structure will be to weaken this conception.

Let us grant that the mind must proceed either deductively or inductively, the question arises which process has precedence. Is it possible to reason deductively before we have inductively arrived at our deductive stand point, or to reason inductively before we have deductively reached our induction stand point? or in other words do we reason naturally from the particular to the general or from the general to the particular? A moments consideration will inform us that before we can reason deductively, we must have reasoned inductively. The growth of the child's mind is the natural growth, and it is from the individual to the general. The individual facts begin to form into groups of animate and inanimate, and these into subordinate groups, and these into others; there is in fact a constant sinking of individual characteristics into those that are specific, and of these latter into those that are generic, and of these into broader divisions, and thus, step by step, the highest generalization of which matter is capable is reached, which is, as Dr. Carpenter truly says, the highest knowledge. No deductive standpoint, therefore, can be reached save only through induction; but once attained through the instrumentality of a *few* facts, we may use the deductive method to discover the *many*.

"Complete generalization is complete knowledge" not because the generalization contains the *potential* attributes necessary to constitute individualities, but because it is the generalization *stripped* of its individualizing attributes. The individual must exist before the genus, there can be no generalization unless there be a preceding individualization. The individual is lost in the species, the species in the genus, the genus in the order, the order in the class, and the class in the kingdom. The two kingdoms, vegetable and animal, have properties in common which classify them as organic. Organic and inorganic bodies have elements in common which unite them under the head of matter. Matter has weight and density and dimension; if we rise in our generalization we must in some measure eliminate these properties—these individualities. In order to do this we conceive of matter reduced to a state of the greatest rarity—as filling all space—as being, in fact, a homogeneous, illimitabie, imponderable, chaotic mass. But let our conceptions be at their best we must still think of matter as having limits, elements and a degree of density. Our highest generalization is reached when we think of matter as existing in this nebulous state.

Now, conceive a Supreme Intelligence, and what is the effect in our mind? Immediately, our conceptions from being most indistinct and general, are concentrated upon one object having many attributes. For we cannot think of intelligence apart from mind, of mind apart from body, of body apart from members and of members apart from functions. In what sense then can the Supreme Intelligence be considered the "highest generalization," surely not in a logical one, for instead of widening our generalization it narrows it. Following the strict rules of inductive reasoning we *must* stop with *nebulous matter*. A Supreme Intelligence is *not* a higher generalization. If sought by reason at all it must be *teleologically* and not by the rules of induction.

Assuming, however, that the Supreme Intelligence exists and that it is absolutely the highest generalizatiou possible, are we to consider it as a generalization containing *potential* individualizations, or as a generalization *stripped* of its individualizing attributes? It is evident from Dr. Carpenter's reasoning that he considers it the former, whereas, if it could be reached by a process of inductive reasoning, as he assumes, it is equally evident that it would be the latter. Can we conceive of a *Supreme* intelligence as being subject to the laws of mental growth—of being wiser to-day than yesterday? Is not the wisdom infinite, and the same yesterday, to-day and forever? How then can we conceive of *potentialities?* Or on the other hand can we think of any attributes which could be added to it? Is not the Divine mind perfect in all things so far as our conceptions go? How, then, if we can conceive of nothing which can be added to it, can we conceive of it as existing *stripped* of attributes? The Supreme Intelligence is not a generalization, but is, on the contrary, so to speak, *a strongly individualized human intelligence.* Every mental faculty which we possess we conceive as being held by the Divine Mind in a perfected state. Wisdom, knowledge, justice, in infinite completeness go to make up our conception of God. If we increase in wisdom, knowledge and justice, we advance towards him; that is to say, the more strongly individualized our minds become, the nearer do we approach in likeness unto God. But if God were the "highest generalization" the more individualized we became the farther would we be from Him, and this is doubtless a result which Dr. Carpenter would be among the last to desire.

"If the Supreme Intelligence is to communicate with man," says Dr. Carpenter, "it must be in obedience to the laws which control our mental activities. The divine thought must then, like human conceptions, be communicated by means of physical symbols." The error, (for we think there is one,) which lurks in this assumption is the error of all theologians, and forms the basis of all their reasonings and of all their conceptions; viz: That man is the *object* of creation—the *end sought* through the formation of matter, and that the Supreme Intelligence is desirous of conveying his thoughts to the consciousness of man. Dr. Carpenter had just been speaking of the purely subjective nature of the conceptions of the artists, and that it was necessary before those conceptions could be communicated to others, that they should, through the instrumentality of the canvas or the marble, seek an objective expression, and to follow this remark with that above quoted is to place the Supreme Intelligence in the artist's position with conceptions to communicate, and implies, before they can be communicated, an objective medium and another consciousness to which the communication is to be made. If man is the highest product of matter—of creative forces—and if we assume a Supreme Intelligence, then the *object* of creation, if discoverable at all, is discoverable by man, or at least it is complete in him. But if, taking the other view, we look upon man as but a link in the chain of being—if we conceive of the forces of nature which in the past have evolved a higher type of matter as working for the same end to-day, our thoughts cease to dwell upon the present, and project themselves into a distant, but ever-perfecting future. The imperfections which surround us and which are the stumbling-blocks in the way to our conception of a *perfect* God, fade out, in the evolving ages, and the mind rests in the thought of a coming time when the divine idea shall be accomplished and when the mysteries which now shroud all things shall have passed away and the "glory of the Lord" shall be revealed.

Prof. Carpenter admits an evolution of matter; he even admits that man is the highest product of evolution; he believes that the supreme intelligence existed alone in his own consciousness, and that before he could exist in any other consciousness he must seek an *objective* material medium through which to express himself. If the supreme intelligence is purely *subjective*, as Dr. Carpenter claims, then anything external to and apart from that intelligence must be *objective*. Man, then, whether considered as matter or mind, is objective. The object of creation, according to Dr. Carpenter, is to communicate subjectivity to subjectivity through objectivity, or in other words the divine conceptions to consciousness through matter. But human consciousness, as we have just seen, is objective to the divine consciousness; hence, the object of creation is not to communicate subjectivity to subjectivity, but subjectivity to objectivity through objectivity, which is nothing more than saying that man is but one of the nicer touches from the hand of the painter; one of the finishing strokes from the hand of the sculptor; one of the pages from the book of the thinker. God is the artist, the universe, the canvas, and man but a pigment which, with other material, goes to further the divine conception.

If matter is objective and the expression of thought, then man, being matter, is objective and an expression of thought. If he is an expression of thought he stands in the same relation to the supreme intelligence that any expression of thought stands. Every object in nature, on Dr. Carpenter's hypothesis, is an expression of thought. Man, then, bears to the supreme intelligence the same relation that any animal or any plant bears. That relation is inscrutible, and so is the relation of man.

We believe in a Supreme Intelligence, and we believe in Evolution. We also believe that evolution in nature exists because the Supreme Intelligence has willed that it should exist; but we cannot believe with Dr. Carpenter that it exists, because there was no other way by which the Supreme Intelligence could manifest itself. For this would be to prescribe bounds for that which is infinite. It is true that we cannot think of God as a rational being without thinking of him as governed by the laws of rationality, nor can we think of Him as a just God. without being governed by the laws of justice, nor can we think of Him as possessing any mental attribute without thinking of the law governing the manifestation of it. Yet these conceptions of God ,are but human, they are efforts of the finite to measure the Infinite, and taking them at their best, our reason tells us that they fall far short of God himself. It is true that in nature there is such an orderly sequence of events, that in recognizing it, we call it law, but to say that this law exists because God designed it, and to say that it exists because a rational God cannot manifest himself in any other way, are two very different things. Nor can we see, if the Supreme Intelligence is governed by the law of rationality, and if it manifest itself in material form, why there should be such enormous intervals of time between the different steps in the divine consciousness as is evidenced by the physical symbols. For if evolution in matter is but the reflection of evolution in the Divine mind, as Dr. Carpenter teaches, then evolution in both is simultaneous. There could, consequently, have been no conception of *man* in the Divine consciousness before his advent physically—for his advent physically is but the reflection of an evolved conecpt in the Divine mind. There could, therefore, have been no *plan* of creation embracing man, for man is the *last* of the series—is the complex as opposed to the simple—the particular as opposed to the general. But the last term in a deductive series must be reached by the law of rationality, that is to say, it must be derived from the first term by a differentiating process, consisting in the addition af attributes not found in the preceding terms. According to Dr. Carpenter, if man had been conceived by the Divine consciousness it must have been by some rational process and such process would have been immediately symbolized in matter. But because it was *not* thus symbolized we are bound to believe that no conception of man existed in the Divine mind until the time of his physical advent.

But we cannot assent to this conclusion; we prefer to believe that before the nebulous mist arose, there existed in the Divine Consciousness a perfect conception of creation—the end to be compassed, and the means to accomplish it. That when the fiat went forth, matter became endowed with certain principles which, acting constantly and uniformly, have evolved the countless forms that people the universe; and that they will continue to be evolved until the divine conception is wrought out. We recognize the *genetic* force as one of those principle; we recognize the tendency of organisms occasionally to depart slightly from their parent forms as the natural result of this principle; we can believe a departure from this departure as natural; and if we recognize two variations, we can recognize a third—a fourth—and any number. We can conceive it possible that a departure, and a continual redeparture from the parent form might give rise to varieties so different as to be classed as species; we can conceive of species varying to such a degree as to constitute genera; and we can conceive of this "functional impulse" working through countless ages with ever varying effects, as redounding more to the wisdom and glory of God than any number of *successive creations*, be they of the nature of distinct fiats, or the symbols of evolution in the Divine Consciousness.

SECTION OF THE

Mathematical and Physical Sciences.

Title of Paper read before this Section

Recent Progress in Theoretical Physics. By John E. Davies, A. M., M. D. Professor of Physics in the University of Wisconsin.

RECENT PROGRESS IN THEORETICAL PHYSICS.

BY JOHN E. DAVIES, A. M., M. D.,
Professor of Physics in the University of Wisconsin.

The present paper is the first of a series intended to give, in a collected and condensed form, the results of recent *theoretical* advances in the Physical Sciences. The researches by which these advances have been made are partly experimental and partly mathematical. Some of them are most lucidly presented by Prof. P. G. Tait in his "Recent Advances in Physical Science," while those which I shall present are only briefly mentioned by him, or else are omitted altogether. Prof. Tait, however, alludes to those which he does mention, in such terms as to imply that he regards them, nevertheless, as of the greatest importance, and to be omitted chiefly on account of want of time.

A complete review of these researches would include Clausius' remarkable theorems upon the mechanics of a great number of molecules, and Boltzmann's results in the same direction, together with their application to the theory of heat; the studies of Helmholtz and Thompson upon the vortex motion of fluids and their analogues among magnetic forces and electric currents; Thompson's explanation of the magnetic rotation of the plane of polarization of circularly polarized light, first experimentally shown by Faraday; the experimental researches of Jamin, Rowland, Stoletow, Bouty, and others, in magnetism; Rankine's hypothesis of molecular vortices; Clerk Maxwell's wonderful electro-magnetic theory of light, with the experimental researches thereon by Boltzmann and others; the explanation of anomalous dispersion by Ketteler of Bonn; the mathematical relations of vibratory and translatory motions in fluids, by Challis; the explanation of the blue color and polarization of the sky by Lord Rayleigh; as also his remarkable results upon Resonance and Sound generally; the mathematico-physical discoveries of Kirchoff; the Kinetic Theory of Diffusion, Conduction and Radiation by Maxwell; the thermo-electrical researches of Tait; and many other researches as well, all tending to the simplification and unity of the Physical Sciences, by showing a probable similarity or identity of cause for the most diverse phenomena.

In the present paper I shall merely *begin* with certain remarkable relations between the formulæ of electro-magnetism and those of fluid motion, first pointed out, so far as I know, by Helmholtz.*

VORTEX MOTION.

In magnetism we have the following formula for the value of V the SCALAR POTENTIAL of a magnet of finite dimensions

$$V=\iint \frac{\sigma}{r}dS+\iiint\frac{\rho}{r}\,dxdydx \qquad \text{A.}$$

x, y, and z, being the coordinates of any point of the magnetic mass,

σ, being what is called the surface density of the magnetic matter, and,

ρ, the volume density of the same.

The surface density σ, is the resolved part of the intensity of magnetization in the direction of a normal to the surface of the magnet, and the volume-density ρ, is what Maxwell has designated as the "convergence" of the magnetization at a given point within the magnet.

This expression for V is similar to that for the *electric* potential at any point, due to the electrification of a body on whose surface there is electricity of density σ, and within its substance a bodily electrification whose density is ρ. In both cases, V satisfies Laplace's equation for points outside of the electrical or magnetic mass, and Poisson's equation for points inside of the same. That is, for the first case,

$$\frac{d^2V}{dx^2}+\frac{d^2V}{dy^2}+\frac{d^2V}{dz^2}=0 \qquad \text{B.}$$

* In the paper as read before the Academy, a somewhat complete synopsis was given of Thompson's explanation of Faraday's experiment on the Magnetic Rotation of Polarized Light; of Clerk Maxwell's Electro-magnetic Theory of Light; and of the Hypothesis of Molecular Vortices. Many points, also, only briefly summarized in this printed paper were elaborated by oral explanations and diagrams, and the terms used in the paper were for the most part carefully defined.

and, for the second case,

$$\frac{d^2 V}{dx^2} + \frac{d^2 V}{dy^2} + \frac{d^2 V}{dz^2} = -4\pi^* 9 \qquad \text{C.}$$

The ordinary magnetic and electric forces are derived from these potentials by the application of Hamilton's operator,

$$\nabla = i\frac{d}{dx} + j\frac{d}{dy} + k\frac{d}{dz};$$

that is, to find the magnetic or electrical attraction or repulsion along a line, we take the differential coefficient of the potential (magnetic or electrical) with reference to the direction of that line. For ordinary magnets the potential V, is single-valued for any given point of space; for electro-magnets V is many-valued like $\tan^{-1}\frac{y}{x}$ having, in fact, an infinite series of values at any given point; these values differing by $4\pi^* i$ where i is the intensity, or strength of the electric current in the electro-magnetic wire.

Carefully to be distinguished from V is another quantity, which, in the case of *solenoidal* distributions of magnetism at least, also fulfills Laplace's Equation. This quantity may be designated by I.

I is a quantity so related to the magnetization that, calling the components of the latter in three directions at right angles to each other, A, B, and C, we have

$$A = \frac{dI}{dx}, \qquad B = \frac{dI}{dy}, \qquad C = \frac{dI}{dz}. \qquad \text{D.}$$

I, which determines the *magnetization (not the magnetic force)* at any point, is called the Potential of Magnetization.

But, besides the SCALAR (or *non-directed*) POTENTIAL, V, and the Potential of Magnetization, I, mentioned above, we have, when considering not only the magnetic *force* but likewise also the magnetic *induction*, a VECTOR (or *directed*) POTENTIAL. The magnetic *induction* is derived from this VECTOR POTENTIAL in a precisely similar manner to the derivation of the magnetic *force* from the SCALAR POTENTIAL, namely: by the application of Hamilton's operator ∇.

If three quantities F, G, and H, be regarded as the components, in three directions, at right angles to each other, of the *scalar*

*Owing to the want of Greek type the printer has placed this letter n to represent 3.1416 the ratio of the circumference of a circle to its diameter.

potential V, then these quantities will satisfy the following conditions:

$$\frac{dH}{dy} - \frac{dG}{dz} = 0; \quad \frac{dF}{dz} - \frac{dH}{dx} = 0; \quad \frac{dG}{dx} - \frac{dF}{dy} = 0. \qquad \text{E.}$$

But if F, G, H, be taken to represent the components of the *vector-potential*, they will satisfy the conditions

$$\frac{dH}{dy} - \frac{dG}{dz} = \mathrm{a}, \quad \frac{dF}{dz} - \frac{dH}{dx} = \mathrm{b}, \quad \frac{dG}{dx} - \frac{dF}{dy} = \mathrm{c}, \qquad \text{F.}$$

where a, b, c, are the components of the magnetic induction. In words, the line integral of the *vector-potential* round a closed curve representing any circuit, is numerically equal to the surface-integral of the magnetic induction over a surface, bounded by the curve representing the circuit.

We have also, if **a**, **b**, **c**, represent components of magnetic force, and u, v, w, components of electric current,

$$4\pi^* u = \frac{d\mathbf{c}}{dy} - \frac{d\mathbf{b}}{dz}$$

$$4\pi^* v = \frac{d\mathbf{a}}{dz} - \frac{d\mathbf{c}}{dx} \qquad \text{G.}$$

$$4\pi^* w = \frac{d\mathbf{b}}{dx} - \frac{d\mathbf{a}}{dy}$$

as the equations of electric currents: or, in words, the line-integral of magnetic force *round* a closed curve is numerically equal to the current *through* the closed curve multiplied by $4\pi^*$.

The values of F, G, H, are also given by the following equations

$$F = \frac{1}{\mathrm{M}} \iiint \frac{u}{r}\, dx\, dy\, dz$$

$$G = \frac{1}{\mathrm{M}} \iiint \frac{v}{r}\, dx\, dy\, dx \qquad \text{H.}$$

$$H = \frac{1}{\mathrm{M}} \iiint \frac{w}{r}\, dx\, dy\, dz$$

where M is the quantity known as the *specific inductive capacity* of a medium, or its *permeability* to magnetic lines of force.

*The letter π is put for 3.1416.

The components of the vector-potential are related to those of the scalar-potential as follows:

$$\frac{dH}{dy} - \frac{dG}{dz} = -\frac{dV}{dx} = \mathbf{a}$$

$$\frac{dF}{dz} - \frac{dH}{dx} = -\frac{dV}{dy} = \mathbf{b} \qquad \text{I.}$$

$$\frac{dG}{dx} - \frac{dF}{dy} = -\frac{dV}{dz} = \mathbf{c}$$

a, **b**, **c**, being as before the components of magnetic force, derived from the scalar-potential V by differentiation along x, y, z.

The components of the electric current, u, v, w, are known to satisfy the condition

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0.$$

The components of magnetic induction a, b, c, also satisfy a similar equation

$$\frac{da}{dx} + \frac{db}{dy} + \frac{dc}{dz} = 0.$$

On a careful study of these formulæ, which have been deduced for the potentials and forces of ordinary magnets and electro-magnets, we are impressed with their similarity to the formulæ that express the ordinary motions of an incompressible frictionless fluid. For example, in fluid motion, where u, v, and w, represent the component velocities of an element of the fluid in three rectangular directions, and D represents the density of the fluid, we have the following so-called "Equation of Continuity" of the fluid:

$$\mathrm{D}\left\{\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz}\right\} + \frac{d\mathrm{D}}{dt} + \frac{d\mathrm{D}}{dx}.u + \frac{d\mathrm{D}}{dy}.v + \frac{d\mathrm{D}}{dz}w = 0. \qquad \text{J.}$$

This equation is proven for ordinary motions of fluids, in all works upon the dynamics of fluids. It is merely an analytical statement that in all motions of fluids, however they may expand or contract, and move about in currents or otherwise, there is no change in the *mass* of the fluid caused by such motions. If the fluid be incompressible, there can also be no variation in its *density*, caused either by its own motions or by the lapse of time. Then, the total differential of D in the preceding equation, will be *zero*, and there will be left

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0, \qquad \text{K.}$$

which is the simplified form of the "equation of continuity" for in-incompressible fluids. Equation (K), is an equation of condition which all incompressible fluids are required to fulfill.

If u, v, w, be made to depend upon the variations of a quantity Q, such that

$$u = \frac{dQ}{dx}; \qquad v = \frac{dQ}{dy}; \qquad w = \frac{dQ}{dz}; \qquad \text{L.}$$

we may call Q the *velocity potential* of the velocities u, v, and w; because it is a quantity the first differential co-efficient of which along a line, x, y, or z, gives the velocity of the fluid along that line. This quantity Q, must, in incompressible fluids, which, since u, v, w, as has been said, satisfy Equation (K), therefore also give

$$\frac{d^2Q}{dx^2} + \frac{d^2Q}{dy^2} + \frac{d^2Q}{dz^2} = 0; \qquad \text{M.}$$

or, in other words, like the scalar magnetic and electric potential V, or the potential of magnetization I, it must satisfy Laplace's equation.

Returning to magnets, and electro-magnets, we have seen that the general expression for the value of the *potential* of any magnet of finite dimensions, at any point in space whose co-ordinates are x', y', z', is, designating the potential by V,

$$V = \iint \frac{6}{r} d\,S + \iiint \frac{9}{r} dxdydz$$

where the surface part of the integral extends over the whole *surface* of the magnet, designated by S, and the solid part of it (every element of which $= dx$, dy, dz) extends to all portions *within* the surface.

$r =$ the distance from the magnet to the point, x^1, y^1, z^1, where the value of V is taken;

$I = lA + mB + nC$ *i. e.*, the intensity of magnetization *normal* to the surface of the magnet; because

A, B, and C, represent the intensities of the magnetization, along the three co-ordinate axes; and

l, m, n, are the direction-cosines with reference to these axes, of a normal to the surface.

6 is often called, as was said before, the surface-density of the magnetic matter; and

9 = interior-density of magnetic matter;—9 is also

$$= \left(\frac{d\,A}{dx} + \frac{d\,B}{dy} + \frac{d\,C}{dz}\right) = 0,$$

when the magnetization is *solenoidal.*

Now, since A, B, C, are the *components of the magnetization* of the magnet, if we take a quantity I such that

$$\frac{d\,\mathrm{I}}{dx} = \mathrm{A}\,; \qquad \frac{d\,\mathrm{I}}{dy} = \mathrm{B}\,; \qquad \frac{d\,\mathrm{I}}{dz} = \mathrm{C};$$

then, also, as was said before, I may be called the *potential of magnetization*, and it is evident that when the magnetization is *solenoidal*, we shall here also have the condition

$$\frac{d^2\mathrm{I}}{dx^2} + \frac{d^2\mathrm{I}}{dy^2} + \frac{d^2\mathrm{I}}{dz^2} = 0 \qquad \mathrm{N}.$$

as in the case given above, [Equation (M)], of the *velocity potential* of fluid flow.

Hence the velocities u, v, w, in the case of fluid flow in incompressible fluids, are the analogues of the electric and magnetic forces in free space, and of the *components of magnetization* in the case of solenoidal magnets. At least, all three sets of quantities are subject to the same analytical conditions. I the Potential of Magnetization gives,

$$\frac{d^2\mathrm{I}}{dx2} + \frac{d^2\mathrm{I}}{dy^2} + \frac{d^2\mathrm{I}}{dz^2} = 0.$$

Q, the Velocity Potential of an incompressible fluid, gives

$$\frac{d^2Q}{dx^2} + \frac{d^2Q}{dy^2} + \frac{d^2Q}{dz^2} = 0.$$

V, the electric potential gives

$$\frac{d^2V}{dx^2} + \frac{d^2V}{dy^2} + \frac{d^2V}{dz^2} = 0.$$

In magnetic and electric distributions, the rate at which V varies along a line, determines the electric or magnetic force in free space along that line.

In magnetization, the rate at which I varies along a line, determines the intensity of the magnetization, at any given point within the magnet, in the direction of that line.

In fluid motion, the rate at which Q varies along a line, determines the velocity of the fluid, at any given point, in the direction of that line.

In the case of ordinary fluid motion, moreover, if the conditions

$$u = \frac{dQ}{dx}; \qquad v = \frac{dQ}{dy}; \qquad w = \frac{dQ}{dz}; \qquad \text{O}$$

hold true, then also we have the conditions

$$\frac{du}{dy} - \frac{dv}{dx} = 0; \qquad \frac{dv}{dz} - \frac{dw}{dy} = 0; \qquad \frac{dw}{dx} - \frac{du}{dz} = 0; \qquad \text{P}$$

as is well known.

We have seen [Eqs. (D) and (E] that precisely similar conditions obtain in the case of ordinary distributions of electricity and magnetism, so long as we confine ourselves to the space outside of that which contains the so-called magnetic or electric matter.

The motions of fluids heretofore discussed in treatises on the dynamics of fluids are such as fulfill the conditions imposed by equations (O) and (P.) They are motions of translation, or of expansion and contraction; oscillatory movements being merely periodic movements of translation, of greater or less extent. All such motions have assumed for them a *velocity potential*, the differential coefficients of which with reference to the coordinates, are the component velocities of the fluid in the direction of the coordinates.

The assumption of a velocity potential necessitates the set of conditions given above in equations (O) and (P.)

But Helmholtz in a remarkable memoir on "Integrals Expressing Vortex Motion" to be found translated by Prof. Tait, in the Philosophical Mag., for 1867, has shown that these conditions *do not hold* if there be some of the elements of the fluid in rotation. In such cases if w^1, w^2, w^3, represent the angular velocities of the rotating fluid element about the coordinate axes, then we have

$$\begin{aligned} \frac{du}{dy} - \frac{dv}{dx} &= 2w^3 \\ \frac{dw}{dx} - \frac{du}{dz} &= 2w^2 \qquad \text{Q} \\ \frac{dv}{dz} - \frac{dw}{dy} &= 2w^1 \end{aligned}$$

For these cases there is *no* velocity potential. "It is only when there is no velocity potential that some fluid elements can rotate and that others can move round along a closed curve in a simply-connected space."

Helmholtz calls the motions that have no velocity potential, generally, *vortex motions.*

He shows that in a frictionless fluid, these vortices when once instituted in the fluid, have a wonderful tenacity of existence; that they may go on widening, changing their form under the influence of other vortices, moving about, attracting and repelling each other in consequence of combining their motions; and that they may play amongst themselves all sorts of fantastic games, yet preserve unchanged their identity and living force (i. e. their kinetic energy) so as to be the very types of the unchanging atoms of matter, which are never destroyed.

One simple instance of Helmholtz' results I will state, to make the matter plain. If there be, for example, a single circular vortex ring set up in an indefinitely extended fluid, the center of gravity of the section of the ring (section supposed small) will have from the commencement an approximately constant and very great velocity parallel to the axis of the ring, and this will be directed toward the side *to which* the fluid flows through the ring.

Two ring-formed vortex-filaments having the same axis would mutually affect each other, since each, in addition to its own proper motion has that of its elements of fluid as produced by the other. If they have the same direction of rotation, they travel in the same direction; the foremost ring widens and travels more slowly, the pursuer shrinks and travels faster, till finally, if their velocities are not too different, it overtakes the first and penetrates it. Then the same game goes on in the opposite order, so that the rings pass through each other alternately. If they have equal radii and equal and opposite angular velocities, they will approach each other and widen one another. So also one will widen on coming to a fixed wall. "The motions of circular vortex rings can be studied by drawing rapidly for a short space along the surface of a fluid a half immersed circular disk, or the nearly semi-circular point of a spoon, and quickly withdrawing it. There remain in the fluid half-vortex rings whose axis is in the free surface. These vortex rings travel and widen when they come to a wall, and are widened or contracted by other vortex rings exactly as deduced from theory."*

In this memoir it is also demonstrated that *the product of the velocity of rotation into the cross section of a vortex-filament is constant throughout the whole length of the filament.* Moreover, that a vortex-filament can never end within a fluid, but must either return ring shaped into itself within the fluid, or reach to the boundaries of the fluid.

Precisely similar theorems had been announced by Sir Wm. Thompson in a paper on the Mathematical Theory of Electro-Magnetism in 1847.† Thompson, in this paper, designates the *strength* of an electric current by C‡, and then says: "In a continuous current this quantity is of course *the same for every section;* and, as it is impossible that a continuous stream of electricity can emanate from one body, and be discharged into another, the current must be *re-entering*, or every continuous current must form what is called "a closed circuit." It is found by experiment that whatever be the dimensions or material of the different parts of the conductor along which the current flows, provided always the dimensions of the section be small compared with the distances through which the electro-magnetic action is observed, the quantity C has the same value for all parts of it; and even in the places where the electro-motive force operates, as has been shown by Faraday, as in the liquid of any ordinary galvanic battery, or in a conductor in motion in the neighborhood of a magnet, the electro-magnetic effects are observable, and, probably to exactly the same degree; so that it would probably be found that a galvanic circuit, consisting of a battery of small cells, arranged in a circular arc, and a wire completing the circuit by joining the poles, would produce the same electro-magnetic effects at all points symmetrically situated with reference to the circle, irrespectively of the part of the circuit, whether the cells or the wire; provided always, that the distances considered be great, compared with either the dimensions of a section of the wire, or of any of the cells made by planes perpendicular to the plane of the circle, through its center."

* Professor Tait's book on "The Recent Advances in Physical Science" has two figures, one showing how these vortex rings can be produced, and the other what the directions of rotation and movement will be in a ring once formed.

† See Thompson's "Reprint of Papers on Electro-Statics and Magnetism"—p. 409 et seq.

‡For current strength Thompson uses the Greek letter *gamma*.

The precise character of the movement within the wire, is also shown to be entirely irrelevant in this estimate of the current strength. For "in the theory of electro-magnetism it is unnecessary to adopt any such hypothesis as this [that the electric current consists of matter flowing,] however probable or improbable it may be as an ulterior theory; and all that we could introduce as depending upon it is that, for a linear circuit of varying section or material, the quantity C is the same throughout the circuit, and that all finite circuits possessing continuous currents are necessarily closed; two facts which cannot be assumed *a priori*, but which are in reality established by satisfactory experimental evidence."*

C, the current strength here alluded to, is the product of the so called *intensity* of the current, into the area of the cross-section of the conductor. It may be measured of course by the work it will do in a definite time, either as electrolysis, heat, or other form of work. Helmholtz' angular velocity of the vortex-filament in a fluid, affords a means of forming a mental conception of intensity of current, in electricity, by assimilating it to the rotatory energy in a vortex-filament, which is far superior to any of the illustrations ordinarily used; and this without in any way necessarily implying that the electric current actually involves such rotating elements, although this may really be.

As a linear electro-magnet is completely specified when the form of the closed curve of the current, and C, the strength, are given; so also a vortex filament is completely specified when the form of its axis and the product of its angular velocity into the area of its cross section are given.

In electro-magnetism we have $iA=i'A'$ for the same circuit. In vortex filaments $qA=q'A'$ for the same filament; q being the angular velocity; $A, A,'$ areas of cross sections; i, i', current intensities. In electricity, magnets are known to circulate around current-conducting wires, and wires reciprocally around magnets. In fluids, vortex-filaments that are straight circulate around each other and their mutual center of gravity; vortex filaments that are circular also revolve around each other, as is shown by the peculiar action described above where the rings alternately pass through each other, by contracting and accelerating their speed, and then widening and moving slower, while the one following contracts and passes through in turn.

* Reprint—p. 410

Helmholtz further shows, in the memoir above alluded to, how to find the velocities, u, v, w, of any portion or element of the fluid when we know w^1, w^2, w^3, the angular velocities of a vortex-filament established in it, by the following method:

Let there be given within a mass of fluid which includes the space S, the values of w^1, w^2, w^3, satisfying the "equation of continuity"

$$\frac{dw^1}{dx}+\frac{dw^2}{dy}+\frac{dw^3}{dz}=0. \tag{1}$$

Also, u, v, and w, must satisfy a similar equation,

$$\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}=0. \tag{2}$$

And likewise also, these conditions,

$$\frac{dv}{dz}-\frac{dw}{dy}=2w^1;\quad \frac{dw}{dx}-\frac{du}{dz}=2w^2;\quad \frac{du}{dy}-\frac{dv}{dx}=2w^3. \tag{3}$$

The conditions for the bounding surface S are supposed to be given according to the particular problem. a, b, c, can be taken as the three angles made with a normal to the surface S; q as the *resultant* angular velocity of the three components w^1, w^2, w^3; T, the angle between the normal to the surface S and the axis of the rotating filament; then we shall have

$$w^1\cos a+w^2\cos b+w^3\cos c=q\cos. T=0.$$

over the whole of this surface S, or if this surface S cuts any of the vortex-filaments, over the whole of some larger surface S', which includes all the filaments, and their continuations, if there be any in the first surface S.

Now we can find values of u, v, and w, satisfying equations (2) and (3), if

$$\begin{aligned} u&=\frac{dP}{dx}+\frac{dN}{dy}-\frac{dM}{dz}\\ v&=\frac{dP}{dy}+\frac{dL}{dz}-\frac{dN}{dx}\\ w&=\frac{dP}{dz}+\frac{dM}{dx}-\frac{dL}{dy}\end{aligned} \tag{4}$$

and if the functions L, M, N, and P, be taken so as to satisfy also within the larger space S′, the conditions

$$\frac{d^2L}{dx^2} + \frac{d^2L}{dy^2} + \frac{d^2L}{dz^2} = 2w^1$$
$$\frac{d^2M}{dx^2} + \frac{d^2M}{dy^2} + \frac{d^2M}{dz^2} = 2w^2 \quad (5)$$
$$\frac{d^2N}{dx^2} + \frac{d^2N}{dy^2} + \frac{d^2N}{dz^2} = 2w^3$$
$$\frac{d^2P}{dx^2} + \frac{d^2P}{dy^2} + \frac{d^2P}{dz^2} = 0$$

The analogy of these equations (5) to Poisson's equation (C) is at once apparent if

$$-\frac{w1}{2\pi}{}^*; \qquad -\frac{w2}{2\pi}; \qquad -\frac{w^3}{2\pi};$$

be each taken equal to ρ. L, M, N, are quantities which satisfy the same equations as the *vector potentials* of electric currents. They stand in the same relation, in vortex fluid motion, to the angular velocities of the *core* of the vortex filament, as do in electricity the vector-potentials of electric currents, to what might guardedly be called the *mass* of the currents which give rise to these potentials; thus again showing the help we may derive in our notions of electrical strength, mass, density, or whatever we choose to call it, by comparing the "current-penetrated space," to the *core* of a vortex filament. It moreover prominently calls our attention to what may be going on in the space outside the wire, as well as in the substance of the wire itself. Indeed, if r be the distance of a point a, b, c, from a point x, y, z, on the axis of a vortex-filament; and if w_a^1, w_a^2, w_a^3, be the values which w^1, w^2, w^3, have at this point, a, b, c, then we will have

$$\text{L} = -\frac{1}{2\pi}{}^* \iiint \frac{w_a^1}{r} dadbdc$$
$$\text{M} = -\frac{1}{2\pi}{}^* \iiint \frac{w_a^2}{r} dadbdc \quad (6)$$
$$\text{N} = -\frac{1}{2\pi}{}^* \iiint \frac{w_a^3}{r} dadbdc$$

* π represents the ratio 3.1416.

Equations which are analogous to equations (H), and which suggest that, since $-\frac{1}{2\pi}$* here takes the place of $+\frac{1}{M}$ in those equations, M, or the *magnetic permeability*, may be equal to w^1, w^2, w^3, divided by 9, generally, while here definitely equal to the constant 2π*.

That equation (2) *is* satisfied by the values of u, v, and w given above in equations (4) is shown by differentiating equations (4) and adding; we thus get

first $\quad \frac{du}{dx}=\frac{d^2P}{dx^2}; \quad \frac{dv}{dy}=\frac{d^2P}{dy^2}; \quad \frac{dw}{dz}=\frac{d^2P}{dz^2};$

then, on adding

$$\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}=0.$$

That equations (3) are likewise satisfied, is also shown by differentiating equations (4), and then making the necessary subtractions; noticing the values $2w^1$, $2w^2$, $2w^3$, given by equations (5).

We thus get:

$$\begin{aligned}
\frac{dv}{dz}-\frac{dw}{dy}&=2w^1-\frac{d}{dx}\left\{\frac{dL}{dx}+\frac{dM}{dy}+\frac{dN}{dz}\right\}\\
\frac{dw}{dx}-\frac{du}{dz}&=2w^2-\frac{d}{dy}\left\{\frac{dL}{dx}+\frac{dM}{dy}+\frac{dN}{dz}\right\} \qquad (7)\\
\frac{du}{dy}-\frac{dv}{dx}&=2w^3-\frac{d}{dy}\left\{\frac{dL}{dx}+\frac{dM}{dy}+\frac{dN}{dy}\right\}
\end{aligned}$$

which, if the second terms of the second members are zero, show equations (3), and likewise equations (Q), to be completely satisfied.

That these second terms *are* zero is shown by first differentiating equations (6) with respect to x, y, and z successively; thus getting results of the form

$$\frac{dL}{dx}=+\frac{1}{2\pi^*}\iiint\frac{w_a^1\,(x-a)}{r^3}\,da\,db\,dc$$

for each coordinate. And then, on integrating these latter results by parts, we get the following three equations:

$$\begin{aligned}
\frac{dL}{dx}&=\frac{1}{2\pi}\iint\frac{w_a^1}{r}\,db\,dc-\frac{1}{2\pi}\iiint\frac{1}{r}\cdot\frac{dw_a^1}{da}\,da\,db\,dc\\
\frac{dM}{dy}&=\frac{1}{2\pi}\iint\frac{w_a^2}{r}\,da\,dc-\frac{1}{2\pi}\iiint\frac{1}{r}\cdot\frac{dw_a^2}{db}\,da\,db\,dc \qquad (8)\\
\frac{dN}{dz}&=\frac{1}{2\pi}\iint\frac{w_a^3}{r}\,da\,db-\frac{1}{2\pi}\iiint\frac{1}{r}\cdot\frac{dw_a^3}{dc}\,da\,db\,dc
\end{aligned}$$

*The letter π represents the ratio 3.1416.

which, if added, and dS be put for the element of surface, give

$$\frac{dL}{dx}+\frac{dM}{dy}+\frac{dN}{dz}=\frac{1}{2\pi}\iint\left[w_a^1 \cos. a + w_a^2 \cos. b + w_a \cos. c\right]dS$$

$$-\frac{1}{2\pi}\iiint\frac{1}{r}\cdot\left[\frac{dw_a^1}{da}+\frac{dw_a^2}{db}+\frac{dw_a^3}{dc}\right]da\,db\,dc.$$

In the second member of this last equation the factors in parentheses in each of the two terms, are known to be equal to zero; consequently,

$$\frac{dL}{dx}+\frac{dM}{dy}+\frac{dN}{dz}=0.$$

Therefore the equations

$$\frac{dv}{dz}-\frac{dw}{dy}=2w^1;\qquad \frac{dw}{dx}-\frac{du}{dz}=2w^2;\qquad \frac{du}{dy}-\frac{dv}{dx}=2w^3;$$

give correctly the relations between the angular velocities of the core of a vortex-filament, and the velocities in the fluid at points outside of, but surrounding the core.

The values of L, M, N, taken from equations (6), being substituted in equations (4), give certain results, the interpretation of which will appear from the next paragraph. These results are

$$\Lambda u\,(x-a)+\Lambda v\,(y-b)+\Lambda w\,(z-c)=0, \tag{9}$$

indicative of a right angle with r;

$$w_a^1\Lambda u+w_a^2\Lambda v+w_a^3\Lambda w=0, \tag{10}$$

indicative of a right angle with the axis of the rotating filament;

$$\sqrt{(\Lambda u)^2+(\Lambda v)^2+(\Lambda w)^2}=\frac{dadbdc}{2\pi r^2}\cdot q.\sin V; \tag{11}$$

and

$$qr.\cos V=(x-a)w_a^1+(y-b)w_a^2+(z-c)w_a^3 \tag{12}$$

Where q is the resultant of w_a^1, w_a^2, w_a^3, and V the angle which q makes with the radius-vector r.

Now it is proven in works on electricity and magnetism* that "the vector-potential *at a given point*, due to a magnetized particle placed at the origin of co-ordinates, is numerically equal to the magnetic moment of the particle, divided by the square of the radius vector to the point, and multiplied by the sine of the angle between the

* Clerk Maxwell's "Electricity and Magnetism," Vol. ii., p. 28.

axis of magnetization and the radius vector; and the *direction* of the vector-potential is perpendicular to the plane of the axis of magnetization and the radius-vector, and is such that to an eye looking in the positive direction along the axis of magnetization, the vector-potential will be drawn *in the direction of rotation of the hands of a watch.*" The results just referred to above, show that the distance-action of vortex-filaments is similar to the electro-magnetic action of current-conducting wires; for they prove that "*each rotating element of fluid* (a) *implies in each other element* (b) *of the same fluid mass, a velocity whose direction is perpendicular to the plane through* (b) *and the axis of rotation* (a). *The magnitude of this velocity is directly proportional to the volume of* (a), *its angular velocity, and the sine of the angle between the line* (a) (b) *and that axis of rotation, and inversely proportional to the square of the distance between* (a) *and* (b)."

Thus the vector-potential of the electric-current, in free space surrounding the wire, has for its analogue the velocity of the fluid element, due to a vortex-filament supposed to occupy the place of the current.

Many other curious analogies between vortex-motions in fluids and the action of magnets and electric currents have been pointed out by Sir Wm. Thompson.*

Of course it is possible that these analogies may be merely formal, and that they arise from the fulfillment of similar mathematical conditions by both the electric current and vortex-motion in fluids.

But whether the relationship shall or shall not ultimately be found to consist in a closer connection than mere formal analogy, one thing is certain. The discovery of the laws governing vortex-motion in fluids constitutes an era in physical science. The differential equations of the motions of fluids although handled by such masters as LaGrange, LaPlace, Euler, and Green, had only been integrated on the special assumption of a velocity-potential; which condition we have seen to hold only in the space outside of those portions of the fluid which are in rotation. It remained for Helmholtz to make the next great step by integrating these equations under the supposition that no velocity-potential exists; and to show that while the establishment of vortex-motion in fluids, is, on the one hand, a consequence of fluid friction, on the other, that when vortex-fila-

* Sir Wm. Thompson's "Papers on Electrostatics and Magnetism."

ments are once set up in a frictionless fluid they are absolutely indestructible save by the power that originated them. Only an infinite power can set up vortex movement in a perfect fluid without friction, and only an infinite power can destroy such motion when once set up. On this idea Sir Wm. Thompson has based his famous speculation that the *atoms* of matter are merely so many vortex-rings of variable but definite shape for each elementary kind of matter. Such rings possess all the qualities usually attributed to the atoms of matter, being absolutely impenetrable, and possessing when set in vibration that characteristic periodicity of vibration which the spectroscope shows to be the case with the atoms of the elements of matter. As Professor Tait says, "not only can these vortex-rings in a perfect fluid not be cut, but we cannot even so much as get at them, to try to cut them." They rebound from the sharpest edge.

Thus it will be seen that there is at least *an analogy* between vortex-filaments in a perfect fluid and magnetism caused by electric currents. The equations of the electro-magnetic field show this, when compared with the equations of vortex filaments. But this is by no means all.

In Faraday's beautiful experiment of the rotation of the plane of polarized light when passing through a medium which is under the influence of magnetic strain, we have a means of *testing* whether anything of the nature of rotation of small elements, either of gross matter or of some incompressible frictionless fluid be going on in the magnetic field. For, if the magnetic force be in any way the consequence of such minute rotations, we might expect *a priori* that the minute motions which cause light, at least those circular oscillations that constitute circularly polarized light, could in some way be compounded with the minute rotations involved in magnetic phenomena, and be influenced by them. And thus, although we could not directly observe these vortex movements by the senses, we yet might have the means of exploring the magnetic field, by an agent of almost superhuman delicacy in the shape of the oscillations of light. The possibility of the compounding of the magnetic rotations with those of circularly polarized light, which constitutes the explanation Thompson gives of the Magnetic Rotation of Polarized Light, I will take up next.*

* This subject was fully treated in the paper as read before the Academy, but its publication is delayed until cuts can be prepared to illustrate it, and Greek type obtained for the formulæ.

PROCEEDINGS

OF THE

ACADEMY,

SINCE

FEBRUARY, 1874.

Report of the President.

His Excellency Harrison Ludington,

Governor of Wisconsin:

Sir:—Since the date of my last report, the Wisconsin Academy of Sciences, Arts, and Letters has steadily advanced in prosperity. It has not made large additions to its permanent fund, nor greatly increased the list of its working members. But the very considerable number of scholars and scientists holding memberships, have devoted themselves with increased zeal to the work of the work of the Academy in original investigation, and have produced papers embodying the results of their inquiries which are of considerable value, and must yet more favorably commend the Academy to the respect and confidence of the literary and scientific public.

The Academy is no longer an experiment. The past six years have demonstrated; first, that Wisconsin embraces a large number of persons both competent and experienced as laborers in various fields of research and investigation; and secondly, that it is posible and easy, through such an organization as this, to hold them together in systematic and profitable oc-operation, for the advancement of the arts and sciences, as well as for the intellectual and social progress of the commonwealth.

The present volume of transactions will be found to consist largely of papers in the Department of the Natural Sciences. While all are interesting and valuable, it will appear upon examination that some of these are the fruit of extensive observations in the field, as well as of laborious investigations in the laboratory. Since it is this department which so directly touches the material progress of the State, and which would also especially contribute to the establishment of advantageous relations with kindred organizations in all parts of the world, it will be to the friends and patrons of the academy a ground of satisfaction that its development has been characterized by so strong a bent in this particular direction.

In the other departments there have been fewer laborers. Still, it will not escape observation that many of the best thinkers and investigators of the State have given to the Academy the results of careful and protracted inquiry in the several fields embraced within the broad domain of the Academy.

In this country, Speculative Philosophy finds comparatively little recognition as a means of scientific progress, and is therefore without the cultivation it merits. Nevertheless, it is not without creditable representation in this, as it was not in our last volume of Transactions.

The Department of Social and Political Sciences embraces so vast a range of subjects for inquiry, and appeals so directly and strongly to the public mind that a more rapid growth of it might reasonably have been expected. It is not wanting in activity, however, and gives promise of more substantial progress in the future, through the reinforcements likely to come to it from the learned professions and from special students of Social Philosophy, and of statesmanship.

The Department of Letters is also in need of reinforcements. The contributions heretofore made have been both interesting and valuable, however; some of them justly insuring commendation from distinguished European savans.

At the late annual meeting, the department of the arts was divided into the "Department of Practical Arts" and the "Department of the Fine Arts." Neither of these has yet received much development. Still it is believed that the creation of separate departments will prove advantageous. There are numerous inventors, scientific artizans and practical observers and experimenters in Wisconsin, who, if brought together within the pale of a department of the Academy exclusively devoted to the progress of the useful arts, would make it eminently successful. So, too, there are artists and cultivators of art in sufficient number, if united, to make the Department of the Fine Arts at once a means of mutual advantage, and of increasing art culture in the State, as well as of initiating the formation at the seat of the Academy, and in joint connection with it and the State University, of a Gallery of Art, coupled with an Academy of Design.

Leaving out of view the present paucity of artists within our own State, and the difficulty, supposed to be necessary, of finding adequate patronage outside of the cities, there could hardly be found anywhere in this country, a more suitable or more desirable spot for an institution of the kind suggested. And even the objection alluded to would affect only such artists as are limited to one or two of the several branches of art. The landscape painter, the historic artist, and the idealist in either painting or sculpture, would each find themselves happily placed here, in an exceptionally pure atmosphere, in a region remarkable for its healthfulness, and in the midst of scenery unparalled for beauty. As this is a matter in which the Academy, the State University, artists of the Northwest, and the friends of Art generally, must all feel an interest, we are not without hope that practical results of some importance will follow the effort thus systematically begun.

The Library of the Academy is under the management of a competent and zealous librarian, through whose efforts it must make steady, if not rapid growth. As was stated in my first report (for 1870–'72) it has not been, and is not now, the purpose of the Academy to build up a general library, separate and distinct from that of the State Historical Society, which is fast becoming the great general library of the State, but rather to supplement the forces therein at work by efforts to make collections especially rich in the publications of learned, scientific and other kindred societies and associations of all countries, and in works generally which properly belong to the several departments embraced within the Academy, and which are not likely to be supplied otherwise. Large results in this direction have not been accomplished, but the agencies are at work, and will yield fruits more abundant as the years go on. Regarding the Academy from this standpoint, it is quite desirable that its Transactions should be published annually, instead of biennially; for such more frequent publication would render it easier to effect exchanges with other institutions of like character, as well as with the periodical press of the world.

The Museum of the Academy is making more growth than outwardly appears. For, owing to the connection of several of the members most active in making collections, with the Geological Survey, now in progress, much of the material which would otherwise have come directly to the Museum, has very naturally and properly gone to the State Geologist, for classification, and has not as yet reached its final destination under the law creating the survey, which provides that specimens of all the material collected during its progress shall be deposited with the Academy. It may also be remarked that the officers of the Academy are yet expecting that large contributions will soon be made to the Museum from the considerable number of private collections heretofore formed within this State.

The report of the treasurer, herewith incorporated, sets forth the financial transactions of the Academy for the years 1875 and 1876, together with the condition of its funds at the date of the last annual meeting, just concluded:

WISCONSIN ACADEMY SCIENCE, ARTS AND LETTERS,
TREASURER'S OFFICE,
MADISON, *February* 13, 1877.

HON. J. W. HOYT, *President:*

I have the honor to report the financial condition of the Academy, as follows:

Total amount of fees and dues received from 58 members	$778 25
Total fees received from 10 life members	1,000 00
Interest on loan	370 00
	2,148 25
Total amount disbursed in payment of warrants to date	777 97
Balance in treasury	1,370 28

GEO. P. DELAPLAINE,
Treasurer.

The following is a list of the papers read since the date of our last publication:

"Views connected with the Railroad Question," by Rev. Chas. Caverno.

"On Industrial Education," by Rev. F. M. Holland.

"A Mastodon found in Racine County," by Dr. P. R. Hoy.

"A Turtle Mound found in Beloit," by Prof. Eaton.

"The Improvement of the Mouth of the Mississippi River," by Capt. John Nader.

The "Elementary Stratification of the Lower Silurian Rocks in South-Central Wisconsin," by Prof. R. D. Irving.

The "Hibernation of the Striped Gopher," by Dr. P. R. Hoy.

"The Law of Embryonic Development the same in Plants as in Animals," by Dr. I. A. Lapham.

"Were the Stoics Utilitarians?" by Rev. F. M. Holland.

"On the Ancient Civilization of America," by Prof. Nicodemus.

"An Account of Recent Examinations of the Ancient Earthworks in Rock county, Wis.," by W. P. Clark, Esq.

"Drift-notes," by Prof. Eaton.

"Minority or Proportional Representation," by Rev. F. M. Holland.

"On the Fishes best suited to stock the small lakes of Wisconsin," by Dr. P. R. Hoy.

"Oconomowoc Lake," by the late Dr. I. A. Lapham.

"On United States' Sovereignty; whence derived and when vested," by Prof. Allen.

"The Barometer in Leveling," by Capt. Nader.

"On River Engineering," by Capt. Nader.

"The Instrument of Exchange," by President G. M. Steele.

"The Inter-convertible Note Scheme," by E. R. Leland, Esq.

"The Kaolin of Wisconsin," by Professor Irving.

"The Revolutionary Movement Among Women," by Dr. J. W. Hoyt.

"An Account of the Aid Rendered by Various Governments to Science and Education," by James D. Butler, LL. D.

"Geological Reconnoisances in Northern Wisconsin," E. T. Sweet, M. S.

"The Encouragement of Art Culture by the State," by Dr. J. W. Hoyt.

"Some new and Remarkable Features of the Lower Magnesian Limestone, and St. Peter Sandstone in Eastern Wisconsin," by Prof. T. C. Chamberlain.

"The Origin of the Present-Infinitive-Passive in Latin and Greek," by Prof. Feuling.

"The Significance of Faraday's Experiment upon the Magnetic Rotatory Polarization of Light; and upon Helmholtz Paper on the Integrals of Vortex Motion; also upon the Theory of Magnetism," by Prof. Davies.

"On Duplex Telegraphy," by Chas. H. Haskins.

In the confident belief that the Academy has before it a career of great usefulness. and that to this end it will be more and more encouraged by an intelligent public, as well as liberally fostered by the State, I have the honor to be, in its behalf,

Very respectfully,

JOHN W. HOYT,
President.

Madison, February, 1876.

Report of the Secretary.

SPECIAL MEETING OF THE ACADEMY.

September 16, 1874.

The members of the Academy met in their rooms at 7½ P. M. The following resolutions were passed:

Resolved, That we sincerely lament the death of John Y. Smith, in whom our Society has lost an active and honored member, and the science of political economy one of its most devoted and useful followers.

Resolved, That the President of the Academy be requested to appoint a member of the Academy to prepare a sketch of his life and works

Resolved, That these resolutions be published in each of the daily papers of this city, and that the General Secretary be requested to forward a copy of these proceedings to the family of the deceased.

The President of the Academy eulogised highly the merits of the deceased member.

The death of Prof. Peter Engelman, of Milwaukee, was announced by Dr. I. A. Lapham, who pronounced a high elogium upon the scientific character of the deceased.

The following resolutions were also passed:

Resolved, That in the death of Prof. Peter Engleman the Academy has lost a valued member, and the cause of education one of its most active promoters.

Resolved, That the President of this Academy is hereby requested to appoint some member to prepare, for the next regular meeting of the Academy, a memoir of his life and labors.

Resolved, That these resolutions be published in the Proceedings of the Academy.

The Treasurer of the Academy, G. P. Delaplaine, Esq., called the attention of members to a remarkable mound, supposed to be very ancient, in the vicinity of the city of Madison.

Prof. Nicodemus, of the State University of Wisconsin, Dr. I. A. Lapham, of Milwaukee, Geo. P. Delaplaine, Esq., of Madison, and Prof. Irving, of the University, were appointed a committee to investigate the mound and furnish to the Academy a report thereon, at an expense to the Academy not exceeding $25.00.

JOHN E. DAVIES,
General Secretary.

FIFTH REGULAR ANNUAL MEETING.

First Session.

ACADEMY ROOMS, Feb. 9, 1875, 7½, P. M.

The fifth annual meeting of the Academy was commenced in their rooms on Tuesday evening, February 9, 1875, at 7½ o'clock; there being a large attendance of members and citizens; the President, Dr. J. W. Hoyt, in the chair; the Secretary, Prof. J. E. Davies. absent by reason of severe illness.

In the absence of the secretary, Prof. James Eaton, of Beloit College, was appointed secretary *pro. tem.*

The treasurer's report was read and referred to an auditing committee consisting of Prof. Nicodemus, Dr. Hoy, and Elisha Burdick, Esq.

The librarian's report was read and accepted.

The rules were suspended and Messrs. E. T. Sweet, R. H. Brown, J. T. Dodge, and Charles N. Gregory were elected annual members.

The first paper of the meeting was read by the Rev. Charles Caverno, on "Views connected with the Railroad Question."

Twenty-three members were present at this meeting of the Academy.

Second Session.

FEBRUARY 10, 9.45 A. M.

During the absence of the President, the chair was occupied by I. A. Lapham, Vice-President of the Academy.

The report of the secretary was read.

The following papers were read and discussed:

On "Industrial Education," by Rev. F. M. Holland, of Baraboo.

"A Mastodon found in Racine County," by Dr. P. R. Hoy, of Racine.

Dr. Holland called attention to a number of bones of a Mastodon found in Baraboo thirty years ago.

A paper was read on "A Turtle Mound in Beloit," by Prof. Eaton of Beloit.

E. R. Leland, of Eau Claire, read a memoir upon the late Peter Engelman, of Milwaukee, a member of this Academy.

Adjourned till 2:30, P. M.

Third Session.

FEBRUARY 10, 2:30, P. M.

The Academy met pursuant to adjournment, with a large attendance.

Dr. I. A. Lapham, Vice-President, in the chair.

Papers were read as follows:

On the "Improvement of the Mouth of the Mississippi River," by Capt. Nader.

On "The Elementary Stratification of the Lower Silurian Rocks in South-Central Wisconsin," by Prof. Irving.

On "The Hibernation of the Striped Gopher," and on "The Catocalae of Racine County," by Dr. Hoy, of Racine.

On "The Law of Embryonic Development, the same in Plants as in Animals," by Dr. I. A. Lapham, of Milwaukee.

The committee appointed to audit the Treasurer's Report gave in their report, which was read and accepted.

The meeting then adjourned till 7:30, P. M.

Fourth Session.

FEBRUARY 10, 7:30 P. M.

The Academy met pursuant to adjournment; with a full attendance.

Prof. S. H. Carpenter, Vice President in the chair. Papers were read as follows:

"Were the Stoics Utilitarians?" by Rev. F. M. Holland of Baraboc.

On "The Ancient Civilization of America," by Professor Nicodemus, of the University of Wisconsin.

"An account of Recent Examinations of the Ancient Earthworks in Rock county, Wisconsin," by W. B. Clark Esq.

"Drift notes" by Prof. James Eaton.

SIXTH ANNUAL MEETING.

First Session.

ACADEMY ROOMS, Feb. 8, 1876, 7:30 P. M.

The sixth annual meeting of the Academy was convened in their rooms on Tuesday evening February 8th, 1876, at 7½ o'clock; there being a large attendance of members and citizens of Madison; the President, Dr. J. W. Hoyt, in the chair.

The minutes of the last previous meeting were read by the Secretary and approved.

After a few remarks by the President of the Academy, on the general progress and success of the Academy during the year, the reports of the Secretary, Treasurer, and Librarian of the Academy were read, accepted and referred to appropriate committees.

The President of the Academy announced that the Hon. George H. Paul, of Milwaukee, Railroad Commissioner for Wisconsin had consented to donate $100 to the Academy, and thereby become a Life Member.

The following gentlemen were elected members.

For Corresponding Members.—Dr. Joseph Buchanan of Louisville, Ky., and S. W. Burnham Esq., Chicago, F. R. A. S. London.

For Annual Members.—E. E. Woodman, Esq., of Baraboo, Wis.; Prof. W. C. Sawyer, of Appleton, Wis.; Hon. Peter Doyle, Secretary of State for Wisconsin; C. H. Haskins, Esq., of Milwaukee, Gen'l. Supt. Northwestern Telegraph Co.; Right Rev. E. R. Welles of Milwaukee, Protestant Episcopal Bishop of Wisconsin; Hon. Harlow S. Orton, of Madison; Gen. E. E. Bryant, of Madison; Hon. S. U. Pinney, of Madison; Hon. J. C. Gregory, of Madison; Rev. John Wilkinson, of Madison; Samuel Shaw, Esq., Principal of High School, Madison; J. W. Wood, Esq., Baraboo; J. O. Culver, Esq., Madison; S. G. Lapham, Esq., of Milwaukee; E. S. Searing, Esq., of Madison; Hon. I C. Sloan, of Madison; Josiah E. Cass, Esq., of Eau Claire; E. A. Birge, State University; T. G. Atwood, Esq., Albion, Wis; J. W. Stuart, Esq., of Madison.

Dr. P. R. Hoy, of Racine, Chairman of the committee appointed to prepare a sketch of the life and character of Hon. I. A. Lapham, LL. D., late Vice President of the Academy, read an exceedingly interesting paper upon the general life and scientific labors of Dr. Lapham. Dr. Hoy feelingly referred to a friendship prolonged for over thirty years. He summed up the important labors of Dr. Lapham by reading the following letter from Prof. Joseph Henry:

SMITHSONIAN INSTITUTE,
Washington, Feb. 3, 1876.

DR. P. R. HOY, Racine, Wis.:

DEAR SIR: Your letter was received during a great pressure of business, and I now embrace the first opportunity to give it a reply.

The action of Congress in regard to the signal service was due to the immediate exertions of Mr. Lapham through the member of Congress from his district, General Payne, in setting forth the advantages of the system to the commercial interests of the great lakes.

Yours very truly,

[Signed.] JOSEPH HENRY.

Secretary.

E. R. Leland, Esq., of Eau Claire, spoke very eloquently of the virtues, public and private, of the deceased Vice-President, whom he had known intimately for many years.

Remarks were also made by Prof. T. C. Chamberlain, of Beloit, Dr. Lapham's successor as Director of the Geological Survey, of the State, and R. D. Irving, Professor of Geology in the University of Wisconsin.

Dr. S. H. Carpenter, Professor of Logic and English Literature in the University of Wisconsin, read an admirable review of the life, mental characteristics, and writings of the late Hon. John Y. Smith. Dr. Carpenter showed him to be a man of unusual power of mind and great clearness of thought. Prof. W. F. Allen, Professor of Latin and History in the University of Wisconsin, also added his testimony to the statements made in Dr. Carpenter's paper.

A paper upon "Minority or Proportional Representation," by Rev. F. M. Holland, of Baraboo, was then read by Prof. Allen.

Adjourned till Wednesday morning, 9 a. m.

Second Session.

WEDNESDAY MORNING, 9½, o'clock, February 9, 1876.

The Academy met pursuant to adjournment; the President Dr. J. W. Hoyt in the chair. The following papers were then read:

"On the Pre-Historic Copper Implements found in Wisconsin," by James D. Butler, LL. D., of Madison." This paper was read by Professor W. W. Daniells, of the State University of Wisconsin.

"On the Fishes best suited to stock the small lakes of Wisconsin, by Dr. P. R. Hoy, of Racine. Dr. Hoy also read a paper on the Oconomowoc Lakes," prepared by Dr. I. A. Lapham, just before his death.

"United States Sovereignty—whence derived and where vested," by Professor W. F. Allen, of the State University."

"The Barometer in Leveling," by Captain John Nader.

"On River Engineering," a translation from the German, by Captain John Nader, of Madison.

Adjourned till 2½ P. M.

Third Session.

WEDNESDAY AFTERNOON, 2½ P. M.—Feb. 9, 1876.

The Academy met pursuant to adjournment, the President Dr. J. W. Hoyt in the chair. The following papers were then read and discussed:

"On the Instrument of Exchange," by G. M. Steele, DD., President of Lawrence University.

"The Interconvertible Note Scheme," by E. R. Leland, Esq., of Eau Claire.

"On Kaolin in Wisconsin," by Professor R. D. Irving, of the University of Wisconsin.

The Academy then adjourned until 7½ o'clock P. M.

Fourth Session.

FEBRUARY 7th, 7½ o'clock P. M.

The Academy met pursuant to adjournment, the president Dr. J. W. Hoyt in the chair.

Dr. P. R. Hoy then made some popular remarks on the "General Classification of Animals."

Dr. J. W. Hoyt then read a carefully prepared paper on "The Revolutionary Movement among Women."

Adjourned 9 A. M.

Fifth Session.

THURSDAY, February 10, 9 A. M.

The Academy met pursuant to adjournment. The President Dr. J. W. Hoyt in the chair. The following papers were then read and discussed.

"An Account of the aid rendered by Various Governments to Science and Education," by James D. Butler, LL. D.

"Geological Reconnoisances in Northern Wisconsin," by Mr. E. T. Sweet, Assistant on the Geological Survey.

"The Encouragement of Art Culture by the State," by Dr. J. W. Hoyt.

"On some new and remarkable features of the Lower Magnesian Limestone, and St. Peter's Sandstone in Eastern Wisconsin, by Prof. T. C. Chamberlin, Director of the Geological Survey.

Adjourned till 2 o'clock P. M.

Sixth Session.

MONDAY, February 10, 2 o'clock P. M.

Academy met pursuant to adjournment. President J. W. Hoyt in the chair. The following papers were then read and discussed.

"The origin of the Present-Infinitve-Passive in Latin and Greek." by Prof. J. B. Feuling Ph. D., of the University of Wisconsin.

"The Significance of Faraday's Experiment upon the Magnetic Rotatory Polarization of Light," by Prof. J. E. Davies, M. D., of the State University.

"Helmholtz' Paper upon the Integrals of Vortex Motion; and the significance of these Integrals in the theory of Magnetism," by Prof. Davies.

"On Duplex Telegraphy," by Charles H. Haskins, General Superintendent of the Northwestern Telegraph Company, Milwaukee.

The reading of the papers prepared for this meeting having been concluded, the Academy prepared to ballot for the election of officers for the next three years.

The following gentlemen were unanimously elected.

For President, P. R. Hoy, M. D. Racine.

For General Secretary, J. E. Davies, M. D., Madison.

For Vice President of Department of Speculative Philosophy, S. H. Carpenter, LL. D., Madison.

For Vice President of Department of Natural Science, Prof. T. C. Chamberlin, Beloit.

For Vice President of the Department of Social and Political Sciences, Rev. G. M. Steele, D. D. Appleton.

For Vice Presidentof the Department of the Mechanic Arts, Hon. J. I. Case Racine.

For Vice President of the Department of Letters, Rev. A. L. Chapin, D. D. Beloit.

For Vice President of the Department of the Fine Arts, Dr. J. W. Hoyt, Madison.

For Treasurer Geo. P. Delaplaine, Esq., Madison.

For Director of Museum E. T. Sweet, M.E., Sun Prairie.

For Librarian, Charles N. Gregory, M. S., Madison.

After the transaction of other minor business, the Academy adjourned *sine die*.

JOHN E. DAVIES,
General Secretary.

Report of the Librarian.

To the President of the Wisconsin Academy of Sciences, Arts and Letters:

SIR:—I have the honor to report the receipt of the following contributions to the library of the Academy, which have been forwarded by the courtesy of the Smithsonian Institute, Washington D. C.

Bremen Natural Science Society.—Vol. 3, parts 1 and 2, 1872, Vol. 4, part 4, 1875. Vol. 4, part 1, 1876. Supplement No. 4, 1874–5, Supplement No. 5, 1876.

Amiens Linnean Society of the North of France.—Monthly bulletins from May, 1875 to June, 1876, inclusive.

Munich Royal Bavarian Academy of Science.—Transactions for 1875, parts 1 and 2. Two pamphlets on Chemistry. One pamphlet on Schelling.

Harlem Netherlands Society for the Fostering of Industry.—Transactions for 1874, transactions for 1875, and six pamphlets.

Lyons Academy of Science, Belles-Letters and Arts.—Memoirs Volume 16, for 1874–5.

Dresden Society of Natural History.—Transactions for 1875.

Vienna Imperial Royal Zoological and Botanical Society.—Transactions Volume 25, for 1876.

Brunn Natural Historical Society.—Proceedings Volume 13, 1875. Catalogue of Library 1874.

Halle Journal of the Natural Sciences by Dr. Giebel.—Volumes 11 and 12, 1875.

Bern, Swiss Society of Natural History.—Proceedings for 1876. Memoirs.

Bern, Society of Natural Science at Bern.—Transactions 1874, 1875.

London Royal Society.—Volume 23, of Proceedings. Nos. 153 to 163 inclusive. "On the Tides of the Arctic Seas," from Philosophical Transactions of Royal Society.

Neuchatel, Society of Natural Science.—Bulletin received March 1876.

Natural Historical Society of Prussian Rhineland and Westphalia.—Transactions for 30th year 1874, and 31st year 1875.

Konigsberg. Publications of Society of Physical Economy.—Parts one and two, 1873 and 1874.

Gottingen, Royal Society of Learning etc.—Transactions for 1875.

Harlem, Archives of the, "Musee Teyler"—Vol. 1, 2 and 3, and 1st part of vol. 4.

Amsterdam, Royal Academy of Science—Publications from 1865 to 1876 inclusive, in 21 pamphlets.

Belgium, Royal Society of Botany—History of Roses, by Francis Crepin; extract from Bulletin.

Danzig, Natural Historical Society; Transactions—Vol. 3, part 4.

Freiburg, Society of Natural History; Transactions—Vol. 6, part 4.

St. Petersburg, Physical Central Observatory—Annals for, 1874.

Instructions for Meteorological stations, by H. Wilde.

Andennatt, Swiss Society of Natural Philosophy—Report 1874 and 1875.

Bamberg, Society of Natural Philosophy—Tenth report, 1874 and 1874.

Stockholm, The Royal Swedish Academy of Science—Memoir by S. Loren on "Echinoidea," 1875. Transactions for 1872. 11th volume of Synopsis of Transactions, 1875 and 1876. Appendix to Transactions, volume 3, part 1. List of Swedish and Norse members May, 1876.

I have also received, by the kindness of Professor Alexander Agassiz,

Cambridge, Mass., Museum of Comparative Zoology at Harvard College—Bulletin Volume 3, Nos. 11 to 16; volume 4, No. 10.

Also from the State Library of New York,

87th Report of the Regents of the State of New York.

Report of New York State Library for 1875.

Report of New York State Museum of Natural History.

Biographical sketch of Increase A. Lapham, read before the Old Settlers Club; by the kindness of Mr. Seneca Lapham, of Milwaukee.

All of which is most respectfully submitted.

With great respect,

CHARLES N. GREGORY,

Librarian.

List of Officers and Members

OF THE

ACADEMY, 1876.

GENERAL OFFICERS OF ACADEMY.

PRESIDENT:

Dr. P. R. HOY, *Racine.*

VICE-PRESIDENTS:

Dr. S. H. CARPENTER, - - - - -	*Madison.*
Prof. T. C. CHAMBERLIN. - - - - -	*Beloit.*
Rev. G. M. STEELE, D. D. - - - - -	*Appleton.*
Hon. J. I. CASE, - - - - - - -	*Racine.*
Rev. A. L. CHAPIN, D. D. - - - - -	*Beloit.*
Dr. J. W. HOYT, - - - - - -	*Madison.*

GENERAL SECRETARY:

Prof. J. E. DAVIES, M. D., *University of Wisconsin.*

TREASURER:

GEO. P. DELAPLAINE, Esq., *Madison.*

DIRECTOR OF THE MUSEUM:

E. T. SWEET, Esq., *Sun Prairie.*

LIBRARIAN:

CHARLES N. GREGORY, *Madison.*

COUNSELORS EX-OFFICIO:

HIS EXCELLENCY THE GOVERNOR OF THE STATE.
THE LIEUTENANT GOVERNOR.
THE SUPERINTENDENT OF PUBLIC INSTRUCTION.
THE PRESIDENT OF THE STATE UNIVERSITY.
THE PRESIDENT OF THE STATE AGRICULTURAL SOCIETY.
THE SECRETARY OF THE STATE AGRICULTURAL SOCIETY.

OFFICERS OF THE DEPARTMENTS

DEPARTMENT OF SPECULATIVE PHILOSOPHY.

President.—S. H. Carpenter, LL. D., Madison.
Secretary.—Rev. F. M. Holland, Baraboo.
Counsellors.—Dr. John Bascom, President University of Wisconsin; President Oliver Arey, Whitewater, and Rev. A. O. Wright, Fox Lake.

DEPARTMENT OF NATURAL SCIENCES.

President.—Prof. T. C. Chamberlin. Beloit.
Secretary.—Prof. James H. Eaton. Beloit.
Counsellors.—Prof. W. W. Daniells. of the University of Wisconsin; Prof. Foye, of Appleton, and Prof. Thure Kumlein, of Albion.

DEPARTMENT OF SOCIAL AND POLITICAL SCIENCES.

President.—Rev. G. M. Steele, D. D. Appleton.
Secretary.—E. R. Leland, Esq., of Eau Claire.
Counsellors.—Dr. E. B. Wolcott, Milwaukee; Rev. Charles Caverno, Lombard, Ill., and J. B. Parkinson, of Madison.

DEPARTMENT OF THE MECHANIC ARTS.

President.—Hon. J. I. Case, Racine.
Secretary.—Prof. W. J. L. Nicodemus, of the University of Wisconsin.
Counsellors.—Charles H. Haskins, of Milwaukee; Hon. J. L. Mitchell, of Milwaukee, and Capt. John Nader, of Madison.

DEPARTMENT OF THE FINE ARTS.

President.—Dr. J. W. Hoyt, Madison.
Secretary.—Hon. J. E. Thomas, of Sheboygan.
Counsellors.—Mrs. S. F. Dean, Madison; J. R. Stuart Esq., Madison, and Mrs. H. M. Lewis, Madison.

DEPARTMENT OF LETTERS.

President.—Rev. A. L. Chapin. D. D., Beloit.
Secretary.—Prof. J. B. Feuling, of the University of Wisconsin.
Counsellors.—Prof. W. F. Allen, of the University of Wisconsin; Prof. Emerson, Beloit College, and Hon. L. C. Draper, Madison.

MEMBERS OF THE ACADEMY.

ANNUAL MEMBERS.

Allen, W. F., A. M., Professor of Latin and History in the University of Wisconsin.

Arey, Oliver, A. M., President State Normal School, Whitewater, Wis.

Atwood, T. G., Esq., Albion, Wis.

Bascom, John, LL. D., President of the University of Wisconsin.

Bashford, R. M., A. M., Madison, Wis.

Ballentine, W. G., Ripon, Wis.

Butler, J. B., LL. D., Madison, Wis.

Bryant, E. D., Hon., Madison, Wis.

Birge, E. A., A. M., Instructor in Zoology in the University of Wisconsin.

Carpenter, S. H., LL. D., Professor of English Literature and Logic, in the University of Wisconsin.

Chamberlin, T. C., A. M., Professor of Natural History Beloit College, and Director of the Geological Survey of Wisconsin.

Caverno, Charles, Rev., Lombard, Ill.

Chapin, A. L., D. D., President Beloit College, Beloit, Wis.

Charlton, E. A., A. M., President State Normal School, Platteville, Wis.

Cole, Theo. L., M. S., LaCrosse, Wis.

Copeland, H. E., Whitewater.

Conover, O. M., A. M., Madison, Wis.

Cass, Josiah E., Eau Claire, Wis.

Daniells, W. W., M. S., Prof. of Chemistry in the University of Wisconsin.

Davies, J. E., A. M. M. D., Prof. of Astronomy and Physics in the University of Wisconsin.

Delaplaine, Geo. P., Madison, Wis.

De La Matyr, W. A., Mazomanie, Wis.

Dudley, Wm, Madison, Wis.,

Durrie, D. S., Librarian Wisconsin State Historical Society.

Doyle, Peter Hon., Secretary of the State of Wisconsin.

Eaton, James H., Ph. D., Prof. Chemistry Beloit College, Beloit, Wis.

Feuling, J. B., Ph. D., Prof. Comparative Philology and Modern Languages in the University of Wisconsin.

Foye, J. C., A. M., Prof. Physics, Lawrence University, Appleton, Wis.

Gregory, J. C., Madison, Wis.

Gregory, Chas. N. A. M., Madison, Wis.

Holland, F. M. Rev., A. M., Baraboo, Wis.

Hauser, J. L. Rev., A. M., Milwaukee, Wis.

Hawley, C T., Milwaukee, Wis.

Holton, E. D. Hon., Milwaukee, Wis.

Hoy, P. R., M. D., President Wisconsin Academy Sciences, Arts, and Letters, Racine, Wis.

Hoyt, J. W., M. D., Madison, Wis.

Haskins, C. H., General Superintendent Northwestern Telegraph Company, Milwaukee, Wis.

Irving, R. D., A. M. M. E., Prof. of Geology and Mining in the University of Wisconsin.
Kumlein, Thure, Prof. Albion College, Albion, Wis.
Kingston, J. T., Necedah, Wis.
Kerr, Alex., A. M., Prof. Greek in the University of Wisconsin.
Leland, E. R., Eau Claire, Wis.
Lapham, S. G., Milwaukee, Wis.
Marks, Solon, M. D., Milwaukee, Wis.
Mason, R. Z., LL. D., Appleton, Wis.
Nicodemus, W. J. L., C. E., Prof. of Civil and Mechanical Engineering in the University of Wisconsin.
Nader, John, C. E., Madison, Wis.
Orton, Harlow S., Hon., Madison, Wis.
Parkinson, J. B., A. M., Madison, Wis.
Pradt, J. B. Rev., A. M., Madison, Wis.
Preusser, Charles, President Natural History Society, Milwaukee, Wis.
Pinney, S. U., Hon., Madison, Wis.
Reed, Geo., Hon., Manitowoc, Wis.
Roby, H. W., Milwaukee, Wis.
Reade, E. D., C. E., Milwaukee, Wis.
Steele, Rev. Geo., M., D.D., President of Lawrence University, Appleton, Wis.
Shipman, S. V., Chicago, Ill.
Smith, Wm. E. Hon., Milwaukee, Wis.
Searing, Edward, A, M., Superintendent of Public Instruction for the State of Wisconsin.
Sawyer, W. C., Prof. Lawrence University, Appleton, Wis.
Shaw, Samuel, A. M., Principal of High School and City Superintendent of Public Schools, Madison, Wis.
Stuart, J. R., A. M. Madison, Wis.
Sloan, I. C. Hon., Madison, Wis.
Whitford, W. C., A. M., President of Milton College, Milton, Wis.
Wright, A. O. Rev., Fox Lake, Wis.
Welles, E. R., Rt. Rev. S. T. D., Episcopal Bishop of Wisconsin.
Wilkinson, John, Rev. A. M., Madison, Wis.
Wood, J. W., Baraboo, Wis.
Woodman, E. E., Baraboo, Wis.

CORRESPONDING MEMBERS.

Andrews, E. B., LL. D., Prof. Marietta College, Ohio.
Andrews, Edmund, A. M. M. D., Prof. Chicago Medical College, Chicago, Ill.
Blossom, T., M. E., School of Mines, Columbia College, New York.
Bridge, Norman, M. D., Chicago, Ill.
Brinton, J. G., M. D., Philadelphia, Pa.
Buchanan, Joseph, M D., Louisville, Kentucky.
Burnham, S. W., F. R. A. S., Chicago, Ill.
Carr, E. S., M. D., Superintendent Public Instruction, California.
Ebener, F., Ph. D., Baltimore, Md.
Freer, J. C., M. D., President Rush Medical College, Chicago, Ill.
Gatchell, H. P., M. D., Kenosha, Wis.
Gilman, D. C., President John Hopkins' University.
Gill, Theo., M D., Smithsonian Institution, Washington, D. C.
Hopkins, F. V., M. D., Baton Rouge, La.
Haldeman. S. S., LL. D., Prof. University of Pennsylvania, Chickis, Pa.
Horr, Asa, M. D., President Iowa Institute of Arts and Sciences, Dubuque, Iowa.
Harris, W. T., LL. D., St. Louis, Mo.

Hubbell, H. P., Winona, Minn.
Jewell, J. S., A. M. M. D., Evanston, Ill.
Morgan, L. H., LL. D., Rochester, Ill.
Marcy, Oliver, LL. D., Prof. Northwestern University, Evanston, Ill.
McCabe, L. D., D. D., Prof. Wesleyan University, Delaware, Ohio.
McAllister, J. H., Philadelphia, Pa.
Newberry, J. S., LL. D., Prof. Columbia College, New York.
Orton, E., A. M., President Antioch College, Yellow Springs, Ohio.
Porter, W. B., Prof., St. Louis. Mo.
Le Barron, Wm., State Entomologist, Geneva, New York.
Safford, T. H., Director of the Astronomical Observatory of the University of Chicago.
Shaler, N. S., A. M., Professor Harvard University, Cambridge, Mass.
Schele, De Vere M., LL. D., Prof. University of Virginia, Charlotteville, Va.
Thornton, J. Wingate, Boston, Mass.
Trumbull, J. H., LL. D., Hartford, Conn.
Verrill, A. E., A. M., Prof. Yale College, New Haven, Conn.
Van De Warker, Eli, M. D., Syracuse, N. Y.
Watson, James, A. M., Director of the Astronomical Observatory at Ann Arbor, Michigan.
Whitney, W. D , Prof. Yale College, New Haven, Conn.
Winchell, Alex. LL. D. Chancelor Syracuse University, Syracuse, N. Y.

LIFE MEMBERS.

Case, J. I., Hon., Racine, Wis.
Dewey, Nelson, Ex-Governor of Wisconsin, Madison, Wis.
Hagerman, J. J. Esq. Milwaukee, Wis.
Hoyt, J. W., M. D., Madison Wis.
* Lapham, I. A. LL. D, Milwaukee, Wis.
Lawler, John, Esq , Prairie du Chien, Wis.
Mitchell, J. L., Hon., Milwaukee, Wis.
Noonan, J. A. Esq., Milwaukee, Wis.
Paul, G. H., Hon., Milwaukee, Wis.
Thomas, J. E., Hon. Sheboygan Falls, Wis.
Thorpe, J. G., Hon., Eau Claire, Wis.
White, S. A., Hon., Whitewater, Wis.

MEMBERS DECEASED SINCE THE ORGANIZATION OF THE ACADEMY IN 1870.

Rt. Rev. Wm. E. Armitage, S. T. D., Bishop of Wisconsin, and late Vice-President of the Academy of Sciences, died December 7, 1873.
Prof. Peter Engelmann, Milwaukee, Wisconsin.
J. W. Foster, LL. D., late Professor in the University of Chicago, Chicago, Ill.
I. A. Lapham, LL. D., Milwaukee, Wisconsin, First Secretary Wisconsin Academy Science Arts and Letters.
Wm. Stimpson, M. D., late Secretary Chicago Academy of Sciences, Chicago, Illinois.
Hon. John Y. Smith, Madison, Wisconsin.
Hon. A. S. McDill, M. D., Madison, Wisconsin.

---

* Deceased.

CHARTER, CONSTITUTION AND BY-LAWS

OF THE

Academy of Sciences, Arts and Letters,

OF WISCONSIN

With the Amendments thereto, up to February, 1876.

CHARTER.

AN ACT TO INCORPORATE THE "WISCONSIN ACADEMY OF SCIENCES ARTS AND LETTERS.

The people of the State of Wisconsin, represented in Senate and Assembly, do enact as follows:

SECTION. 1 Lucius Fairchild, Nelson Dewey, John W. Hoyt, Increase A. Lapham, Alexander Mitchell, Wm. Pitt Lynde, Joseph Hobbins, E. B. Wolcott, Solon Marks, R. Z. Mason, G. M. Steele, T. C Chamberlin, James H. Eaton, A. L. Chapin, Samuel Fallows, Charles Preuser, Wm. E. Smith, J. C. Foye, Wm. Dudley, P. Englemann, A. S. McDill, John Murrish, Geo. P. Delaplaine, J. G. Knapp, S. V. Shipman, Edward D. Holton, P. R. Hoy, Thaddeus C. Pound, Charles E. Bross, Lyman C. Draper, John A. Byrne, O. R. Smith, J. M. Bingham, Henry Bætz, Ll. Breese, Thos. S. Allen, S. S. Barlow, Chas. R. Gill, C. L. Harris, George Reed, J. G. Thorp, William Wilson, Samuel D. Hastings, and D. A. Baldwin, at present being members and officers of an association known as "The Wisconsin Academy of Sciences, Arts, and Letters," located at the city of Madison, together with their future associates and successors forever, are hereby created a body corporate by the name and style of the "Wisconsin Academy of Sciences, Arts, and Letters," and by that name shall have perpetual succession; shall be capable in law of contracting and being contracted with, of suing and being sued, of pleading and being impleaded in all courts of competent jurisdiction; and may do and perform such acts as are usually performed by like corporate bodies.

SECTION 2. The general objects of the Academy shall be to encourage investigation and disseminate correct views in the various departments of science, literature and the arts. Among the specific objects of the academy shall be embraced the following:

1. Researches and investigations in the various departments of the material, metaphysical, ethical, ethnological and social sciences.
2. A progressive and thorough scientific survey of the State, with a view of determining its mineral, agricultural and other resources.
3. The advancement of the useful arts, through the applications of science, and by the encouragement of original invention.
4. The encouragement of the fine arts, by means of honors and prizes awarded to artists for original works of superior merit.
5. The formation of scientific, economical and art museums.
6. The encouragement of philological and historical research, the collection and preservation of historic records, and the formation of a general library.
7. The diffusion of knowledge by the publication of original contributions to science, literature and the arts.

SECTION 3, Said Academy may have a common seal and alter the same at pleasure; may ordain and enforce such constitution, regulations and by-laws as may be necessary, and alter the same at pleasure; may receive and hold real and personal property, and may use and dispose of the same at pleasure; *provided*, that it shall not divert any donation or bequest from the uses and objects proposed by the donor, and that none of the property acquired by it shall, in any manner, be alienated other than in the way of an exchange of duplicate specimens, books, and other effects, with similar institutions and in the manner specified in the next section of this act, without the consent of the legislature.

SECTION 4. It shall be the duty of the said Academy, so far as the same may be done without detriment to its own collections, to furnish, at the discretion of its officers, duplicate typical specimens of objects in natural history to the University of Wisconsin, and to the other schools and colleges of the State.

SECTION 5. It shall be the duty of said Academy to keep a careful record of all its financial and other transactions, and, at the close of each fiscal year, the President thereof shall report the same to the Governor of the State, to be by him laid before the Legislature.

SECTION 6. The constitution and by-laws of said Academy now in force shall govern the corporation hereby created, until regularly altered or repealed; and the present officers of said Academy shall be officers of the corporation hereby created, until their respective terms of office shall regularly expire, or until their places shall be otherwise vacated.

SECTION 7. Any existing society or institution having like objects embraced by said Academy, may be constituted a department thereof, or be otherwise connected therewith, on terms mutually satisfactory to the governing bodies of the said Academy and such other society or institution.

SECTION 8. For the proper preservation of such scientific specimens, books and other collections as said Academy may make, the Governor shall prepare such apartment or apartments in the Capitol as may be so occupied without inconvenience to the State.

SECTION 9. This act shall take effect and be in force from and after its passage.

Approved March 16, 1870.

CONSTITUTION.

NAME AND LOCATION.

SECTION 1. This association shall be called "The Wisconsin Academy of Sciences, Arts and Letters," and shall be located at the city of Madison.

GENERAL OBJECTS.

SECTION 2. The general object of the Academy shall be to encourage investigations and disseminate correct views in the various departments of Science, Literature and the Arts.

DEPARTMENTS.

SECTION 3. The Academy shall comprise separate Departments, not less than three in number, of which those first organized shall be:

1st. *The Department of Speculative Philosophy—*

Embracing:
- Metaphysics;
- Ethics.

2d. *The Department of the Social and Political Sciences—*

Embracing:
- Jurisprudence;
- Political Science;
- Education;
- Public Health;
- Social Economy.

3d. *The Department of the Natural Sciences—*

Embracing:
- The Mathematical and Physical Sciences;
- Natural History;
- The Anthropological and Ethnological Sciences.

4th. *The Department of the Arts—*

Embracing:
- The Practical Arts;
- The Fine Arts.

5th. *The Department of Letters—*

Embracing:
- Language;
- Literature;
- Criticism;
- History.

SECTION 4. Any branch of these Departments may be constituted a section; and any section or groupe of sections may be expanded into a full department, whenever such expansion shall be deemed important.

SECTION 5. Any existing society or institution may be constituted a Department, on terms approved by two-thirds of the voting members present at two successive regular meetings of the Academy.

SPECIAL OBJECTS OF THE DEPARTMENTS.

SECTION 6. The specific objects of the Department of Sciences shall be:

1. General Scientific Research.
2. A progressive and thorough Scientific Survey of the State, under the direction of the Officers of the Academy.
3. The formation of a Scientific Museum.
4. The Diffusion of Knowledge by the publication of Original Contributions to Science

The objects of the Department of the Arts shall be:

1. The Advancement of the Useful Arts, through the Applications of Science and the Encouragement of Original Invention.
2. The Encouragement of the Fine Arts and the Improvement of the Public Taste, by means of Honors and Prizes awarded to Works of Superior Merit, by Original Contributions to Art, and the formation of an Art Museum.

The objects of the Department of Letters, shall be:

1. The Encouragement of Philological and Historical Research.
2. The Improvement of the English Language.
3. The Collection and Preservation of Historic Records.
4. The Formation of a General Library.

MEMBERSHIP.

SECTION 7. The Academy shall embrace four classes of governing members who shall be admitted by vote of the Academy, in the manner to be prescribed in the By-Laws:

1st. Annual Members, who shall pay an initiation fee of five dollars, and thereafter an annual fee of two dollars.

2d. Members for Life, who shall pay a fee of one hundred dollars.

3d. Patrons, whose contributions shall not be less than five hundred dollars.

4th. Founders, whose contributions shall not be less than the sum of one thousand dollars.

Provision may also be made for the election of Honorary and Corresponding Members, as may be directed in the By-Laws of the Academy.

MANAGEMENT.

SECTION 8. The management of the Academy shall be entrusted to a General Council; the immediate control of each Department to a Department Council. The General Council shall consist of the officers of the Academy, the officers of the Departments, the Governor and Lieutenant Governor, the Superintendent of Public Instruction, and the President of the State University, the President and Secretary of the State Agricultural Society, the President and Secretary of the State Historical Society, Counselors *ex-officiis*, and three Counselors to be elected for each Department. The Department Councils shall consist of the President and Secretary of the Academy, the officers of the Department, and three Counselors to be chosen by the Department.

OFFICERS.

SECTION 9. The officers of the Academy shall be: a President, who shall be *ex-officio* President of each of the Departments; one Vice-President for each Department; a General Secretary; a General Treasurer; a Director of the Museum, and a General Librarian.

SECTION 10. The officers of each Department shall be a Vice-President, who shall be *ex-officio* a Vice-President of the Academy; a Secretary and such other officers as may be created by the General Council.

SECTION 11. The officers of the Academy and the Departments shall hold their respective offices for the term of three years and until their successors are elected.

SECTION 12. The first election of officers under this Constitution shall be by its members at the first meeting of the Academy.

SECTION 13. The duties of the officers and the mode of their election, after the first election, as likewise the frequency, place and date of all meetings, shall be prescribed in the By-Laws of the Academy, which shall be framed and adopted by the General Council.

SECTION 14. No compensation shall be paid to any person whatever, and no expenses incurred for any person or object whatever, except under the authority of the Council.

RELATING TO AMENDMENTS.

SECTION 15. Every proposition to alter or amend this constitution shall be submittted in writing at a regular meeting; and if two thirds of the members present at the next regular meeting vote in the affirmative, it shall be adopted.

AMENDMENTS TO THE CONSTITUTION.

Amendment to Section 3: "The Department of the Arts shall be hereafter divided into the Department of the Mechanic Arts and the Department of the Fine Arts." Passed February 14, 1876.

BY-LAWS.

ELECTION OF MEMBERS.

1. Candidates for membership must be proposed in writing, by a member, to the General Council and referred to a Committee on Nominations, which Committee may nominate to the Academy. A majority vote shall elect. Honorary and corresponding members must be persons who have rendered some marked service to Science, the Arts, or Letters, or to the Academy.

ELECTION OF OFFICERS.

2. All officers of the Academy shall be elected by ballot.

MEETINGS.

3. The regular meetings of the Academy shall be held as follows:

On the 2d Tuesday in February, at the seat of the Academy; and in July, at such place and exact date as shall be fixed by the Council; the first named to be the Annual Meeting. The hour shall be designated by the Secretary in the notice of the meeting. At any regular meeting, ten members shall constitute a quorum for the transaction of business. Special meetings may be called by the President at his discretion, or by request of any five members of the General Council.

DUTIES OF OFFICERS.

4. The President, Vice-President, Secretaries, Treasurer, Director of the Museum and Librarian shall perform the duties usually appertaining to their respective offices, or such as shall be required by the Council. The Treasurer shall give such security as shall be satisfactory to the Council, and pay such rate of interest on funds held by him as the Council shall determine. Five members of the General Council shall constitute a quorum.

COMMITTEES.

5. There shall be the following Standing Committees, to consist of three members each, when no other number is specified:

On Nominations.
On Papers presented to the Academy.
On Finance.
On the Museum.
On the Library.
On the Scientific Survey of the State; which Committee shall consist of the Governor, the President of the State University, and the President of this Academy.
On Publication; which Committee shall consist of the President of the Academy, the Vice-Presidents, and the General Secretary.

MUSEUM AND LIBRARY.

6. No books shall be taken from the Library, or works or specimens from the Museum, except by authority of the General Council; but it shall be the duty of said Council to provide for the distribution to the State University and to the Colleges and public Schools of the State, of such duplicates of typical specimens in Natural History as the Academy may be able to supply without detriment to its collections.

ORDER OF BUSINESS.

7. The order of business at all regular meetings of the Academy or of any Department, shall be as follows:

Reading minutes of previous meeting.
Reception of donations.
Reports of officers and committees.
Deferred business.
New business.
Reading and discussion of papers.

SUSPENSION AND AMENDMENT OF BY-LAWS.

8 The By-Laws may be suspended by a unanimous vote, and in case of the order of business a majority may suspend. They may be amended in the same manner as is provided for in the Constitution, for its amendment.

Report of the Council.

Since the last Report of the Council on February 11, 1874, the Academy has lost by death three of its most active members: Hon. I. A. Lapham, LL. D., of Milwaukee, late Chief Geologist of Wisconsin, Prof. Peter Engelman of Milwaukee, and Hon. John Y. Smith of Madison, the latter noted for his sound views and able writings in Political Economy.

A short account of the life and character of Dr. Lapham, by E. R. Leland, Esq., of Eau Claire, also one by P. R. Hoy, M. D. President elect of the Academy will be found at the end of this volume.

A sketch of Prof. Peter Engelmann, by Mr. Leland will also be found in the same place.

An account of the life of Hon. John Y. Smith, will be found in the Wisconsin State Historical Society's Report for 1876.

IN MEMORIAM.

PROF. PETER ENGELMANN.

BY E. R. LELAND, ESQ., OF EAU CLAIRE.

Peter Engelmann was born on the 24th of January, 1823, and on the 17th of May, 1874, he died, before he had completed his fifty-second year. The object of this memoir is to give a slight sketch of this existence which was so suddenly cut short at the moment of bearing its best fruit.

It is due to his memory that I should disclaim my fitness for this task, which was only undertaken upon the assurance that else it would remain undone. Without other qualification than the admiration and respect resulting from a rather limited acquaintance—with but meagre details of his life at my command, I shall attempt no adequate biographical sketch, but simply try to declare what the *man was.*

His birthplace was the village of Argenthal, in Rhenish-Prussia. His parents were farmers, as were his elder brothers, and of him they desired to make a farmer also; but in farm life he felt little interest even in boyhood, while, as soon as he could read, he was hungry for books, and eager in his search of knowledge. But social lines are drawn with rigor in Germany, and distinctions of caste observed almost as scrupuously as they are in India, and it was only through the intervention of a fortunate circumstance that he was enabled to escape from the irksome pursuit of the plow and follow his natural bent for learning. The Protestant clergyman of the village, and the superintendent, interested in the boy, on account of his rapid progress under inferior instruction, pursuaded his parents to send him to a better school. To this they finally consented, in the hope to see their son gain the pulpit—than which they had for him no higher ambition—and he was sent to the "Hochere Buergerschule" at Simmern. He went there from his ninth to his fifteenth year, walking a distance of four miles each way every day. When he reached home after his four-mile walk he had his "chores" to do, and then to get his lessons. But he had energy and dilligence enough to overcome these disadvantages, and he received the highest certificates as to his proficiency.

At this time he had no other aim than to gratify the pious ambition of his parents; but this was not to remain the case very long. In 1838 he was—thanks to the aid of his teachers at Simmer, of whom he always spoke with tenderness and gratitude—fitted to be received in the secunda of the gymnasium, at Kreuznach. It was while here, although all his surroundings were calculated to impress his mind with religious faith, that he felt constrained to give up the plan of becoming a pastor; the critical bias of his intellect constantly prompting him to question theologians and demand explanation of the contradictions in their teachings, until finally the old mystic creed of his fathers, lost every title of its influence and authority, and he ceased then, and forever after, to be swayed by its absurd hopes or childish fears.

After studying at Kreuznach for the four years necessary to go through the Secunda and Prima, he passed a successful examination in 1842. The study of history and the natural sciences only served to strengthen his convictions, and, ever frank and outspoken, he found himself in antagonism to his bound-to-be-pious teachers. They could not, however, help giving him in his certificate the most excellent notes in regard to diligence, progress, moral character and good nature. The theologian, inserted the admonition that "he must not forget that nature and her laws are not higher than their Creator."

He went away to the Universities. Of his life there I know little. He joined a secret revolutionary society; but neither revolutionary zeal nor the temptations of student life diverted him from his work. There is evidence that his course was marked by the same good conduct and steadfast industry; for there, as at Kreuznach he was the object of high praise. The certificate given him at Berlin where he studied three years, after one year at Heidelberg, contains twenty notes from various professors, among them Encke, Poggendorf, Dove, Ehrenberg, and Dirichlet, all unanimous in commendation.

On leaving the University there were two courses open to him. One was to choose Astronomy as his calling, which he had studied theoretically and practically under Encke, but this he had not the means to pursue without aid, and he would not as he wrote in his journal "beg protection." The other was to become a teacher at some gymnasium. He decided to apply for a State teacher's examination and passed successfully, though he looked forward to it with apprehension, several of his friends having failed but a short time previously. The theologian among the examiners, to whom he frankly confessed his unbelief, while giving him credit for his knowledge, decided that "he could not teach religion because he did not accept the bible as the source of truth. Royal commissioners in Prussia are very anxious to see that the youth are not misled by unbelieving teachers. Fortunately the result depended, not upon the theologian, Mr. Teressen, but mainly upon Schellbach, Rose, and Ehrenberg, and so he was granted the "facultus docenti."

He then went to the Kreuznach Gymnasium, where he taught for a year and a half with marked success. Here again his frankness stood in the way of his preferment —his outspoken declarations for republicanism preventing him from being regularly installed as a teacher.

When in February 1848 the revolution broke out in France, he hailed it with enthusiasm, and with all the fervent zeal and energy of his nature agitated for the republican idea among the people of Kreuznach. Jointly with some friends he founded a Turn-verein (gymnastic society) and a Buergen-verein (citizens' society) and wrought a radical change in the public opinion. He was given to understand that if he would "hush" he should have a desirable situation, and the Chief Director of Education of the Rhenish Provinces summoned him to an interview and advised him to desist. His answer was an increased revolutionary activity. With a few friends of the cause he founded a democratic club and began publishing a revolutionary paper. The first editor was soon compelled to flee. Engelman succeeded him in February 1849 and conducted the paper till May, when he too, had to leave his Fatherland to escape the dungeon. Another of the friends then continued the paper until it was suppressed by Prussian soldiery.

In August, 1849, Englemann reached New York in a destitute condition. He joined an acquaintance to try "Latin farming" near Marshall, Michigan. The result was as discouraging as might have been expected. One of his first acts was to take out his naturalization papers, for he burned with impatience to "renounce forever his allegiance to the King of Prussia," and to become a citizen of the Republic. After working for awhile as a farm-hand. he went to Milwaukee, and thence to Oshkosh. At the latter place he was taken sick, and lay prostrate for eight weeks, without friend or farthing. Returning to Milwaukee, he was again taken sick; and without money for support, or a single acquaintance, his situation and frame of mind may be more easily imagined than described.

When partially restored, he was engaged by a farmer, three miles from Milwaukee, to instruct two boys for his board. Soon after, he was engaged as teacher for a district school. His success as a teacher soon became manifest, so that children were sent from the city to partake of his instruction. After the close of the term, although the district sought to retain him at double his former salary, he went back to Milwaukee to seek a more extended field for his educational work. Then it was that the German and English Academy was founded. It commenced school July 1, 1851, giving its director a salary of $25 per month. Here he remained until death closed his arduous and unselfish duties.

His plans were far more comprehensive than his achievements. He was not to be permitted to carry them out, but he lived to see his academy advance in members and educational results until it gained the reputation of being one of the best schools of its grade in the Union, a result which it is no exaggeration to say was due to his labors. Engleman was one of the pioneers in the United States of modern rational pedagogy, as opposed to the old school routine of memorizing and reciting; his aim was more to educate and train the young mind for self-instruction, than to cram with undigested knowledge. His methods were based upon the ideas of Pestalozzie and Froebel—though he was a routine follower of no man's lead. It had long been his intention to publish a number of hand-books for the use of schools, among them one of Universal History, and he was about to prepare a teachers manual for mathematics. In this respect his premature death is a serious loss to the cause of education, for his metnod, based upon his rational views, have proved highly satisfactory and successful. In moral teachings he avoided making them repugnant to the pupils by dry catechism, but taught them to love virtue by examples taken from history which were emphasized by his own excellent example.

He introduced natural sciences more largely than is common, that his scholars might learn how to observe—how to read and question the works of nature for themselves, and to apply the scientific methods of investigation to all things; and lastly, he ever sought to transplant his own humane sentiments; his own chivalrous love for liberty and justice into the minds of the embryo citizens entrusted to his care. One of the good results of his school was the elevation—by a spirit of emulation—of the standard of the public schools of Milwaukee, to a much higher level than they would have otherwise attained.

But the care of this Academy, absorbing as it was, by no means bounded the sphere of his activity. He and his friend Dr. A. Luning, were the principal founders ot the Natural History Society of Wisconsin, and he the Curator of its now very valuable museum from the beginning. He bestowed a great amount of labor upon it; zealously collecting himself, and inciting others to follow his example. Whoever might be lukewarm; he was not. He never wearied of the work; he shrank from no drudgery connected with it. Much, perhaps most of his leisure was given to the work of determining, labeling and arranging specimens. Nor was he niggardly of his precious time to either the mere curiosity gazer, the inquiring young student, or the amateur dabbler in science. The courtesy and kindly interest with which he welcomed all comers, I have occasion to gratefully remember. Since his death, the museum bears his name.

In spite of this exhausting and absorbing professional work, he found time to write many articles for liberal papers, and to give numerous lectures before radical and scientific societies, always without pay, and often illustrated by experiments at his own expense. In short, he sought knowledge, not for the personal gratification which it affords, but to the end that he might aid in its general diffusion, or make some practical application of it for the good of his fellows, and he carried these disinterested labors to an extreme that many of his thrifty countrymen could not understand, and they were, some of them, inclined to call him visionary and a fanatic. He was neither. He had sterling good sense, and he rode no hobbies. His motives lay upon the surface, and if men could not read them aright it was their own oblique vision that was at fault. His whole life was given to the advancement of the race, to liberty of thought, of speech, of life—with a devotion that most men will admire and few have the courage to imitate.

His last illness was a sharp attack of congestion of the lungs, under which he sank very rapidly, retaining consciousness to the last. He died, as he had lived, bravely and calmly; without fear or regret. With characteristic modesty he directed that his funeral should be free from formal obsequies. There were none of the conventional forms, but hundreds followed him to his grave and hid it with flowers as a last feeble tribute to his worth, and, few indeed are the men who have a place in the tender memories of so many hearts as this self-sacrificing teacher. The future of his beloved enterprises—concerning which he had many and ambitious hopes—is now in other hands. They may not suffer, but it will be a long search to find one man who can fill his place.

This, in brief, and most imperfect outline. was the life of Peter Engelmann. It was not, as we have seen an eventful one. His name never became famous, for his were not the qualities which gain fame—as the world goes. Self abnegation, honest steadfastness of purpose, devotion to principal, are prized and valued but are not loudly praised. It is the bold dogmatist, the skilled rhetorician. the sagacious trimmer of sails to the breeze of public opinion, that wins applause.

This modest pedagogue knew none of these tricks of success. With rare rectitude he, in early manhood, put aside a brilliant scientific career, because he prized independence, self-respect, the approval of his conscience, more highly than place and profit and fame; and from his devotion to principle the very nature of his religious belief, removed all taint or suspicion of selfishness, even of the most refined and spiritual sort, for he was an uncompromising materialist.

Forced to the conclusion, that so far as human reason, arguing from the facts of life, can form any judgment on the subject, a self-conscious existence hereafter is an impossibility; he declined to follow those who assume that there is a higher mode of apprehending these facts than *reason* supplies. He would allow no attributes—cherish no hopes that demanded the sanction of something higher than his understanding; and whatever may be our private beliefs, it is difficult to see how the logical soundness of this position can be assailed.

His belief gives the clue to his aims and his labors. Feeling that the assumptions of the so-called, higher modes of cognition were gratuitous and mischievous, he worked so far as he could for their downfall—but he did not stop here, he was not a mere iconoclast. He saw, what all must see, that there is a growing disposition to question these assumptions, and he was not blind to the dangers of states of transition. He could use no other than the materialistic formula, but with that he did what in him lay to revolutionize and humanize political and social life, so as to fit it to a higher creed. He worked to the end that when men should no longer obey, through fear or hope, the mystical, external commands, that they should already be, through a love of goodness for itself, obedient to the higher, internal commands.

He apprehended no danger to morality, for he well knew that morality is not the fruit of any creed, but the sum of human experience. His last work in this direction, was an answer to an attempt, by one Pastor Streissguth, to *prove* that materialism was error and tended to immorality. The pamphlet has been published since his death, by the Wisconsin Union of Liberal Societies; he therein refutes by unanswerable arguments, as he had by his pure and blameless life, the silly and inconsequent slander, that the morality which flows from scientific materialism can be comprehended in the words, "Let us eat and drink, for to-morrow we die." If a man believes that his sentient existence is restricted to the three-score years on earth, will he therefore anticipate the nothingness of the future by becoming a sot in the present? or will he use his best endeavor to husband this handful of years and make them yield to him the greatest measure of spiritual life?

To say nothing of the many good and able men who cannot base their theory of life upon a belief in a future individuality; there are outside the limits of Christendom millions of human beings who look forward to forgetfulness, and whose lives are by no means marked by a devotion to the grosser pleasures of the world. The assertion, or rather the inference—for it oftenest comes in that shape—that a man will be good only in proportion as he has a lively sense of the pleasures of a coming heaven, or the pains of an inevitable hell, is a rank calumny upon our moral nature. It is safe to assert that no man of noble instincts, pure aspirations, or high moral principle will be demoralized by the contemplation of a limited existence; nor will the brute be ennobled by the prospect which the church presents to his debased imagination.

I will make no apology for thus lamely intruding these truisms. There is need of their occasional reiteration.

No good and pure man lives without divinities—and Engleman's were; humanity, progress, a realization of the high ideals to which his philosophy pointed. Brave and outspoken in uttering his convictions when need was, he was never dogmatic. He did his work in a spirit of true humanity—a humanity that was content cheerfully to accept the place which he believed he held in nature, that of a stepping-stone—one of the myriads by which the race is to gain a glorious future. But he had none of the assumed, servile, oriental abjectures that leads man to revile himself as a worthless worm of the dust, and in the same breath demand, with sublime egotism, why he was created, with his lofty purposes and high aspirations, if he is to *have* a glorious and an undying future? That leads him to deem himself defrauded if, with his matchless intellect, he is not to know a state of being far transcending anything which earth affords, more or less ineffable and gorgeous as his ideas are spiritual and his imagination vivid.

The man who holds and promulgates ideas that are in opposition to the popular beliefs of his age, can scarcely live a bright and cheerful life; but it may contain much of nobleness that compensates for the loss of worldly pleasures. Engelmann was a serious but not a sad man. He bore a burden common to many, but he stood upright under it. He answered the question which man is ever asking "What am I?" by saying "my consciousness is a mere resultant of force acting upon matter and at the death of the flesh it will revert to its former conditions, as sounds revert back to the air in which they were born." We may answer it differently, but we cannot demonstrate that he was mistaken; and we must admire his attitude when brought face to face with a great problem.

It was with eyes open and head erect—true to his creed to the last—hugging no delusive dreams—his highest conception of truth upon his lips. No man can meet death better!

He is at peace, and if it be that the universe holds greater possibilities than were acknowledged in his philosophy, we may be sure, as has been said of one whom in many things he resembled:

"Wherever there is knowledge,
Wherever there is virtue,
Wherever there is beauty,
He will find a home."

INCREASE A. LAPHAM, LL. D.

BY P. R. HOY, M. D., RACINE.

PRESIDENT OF THE ACADEMY.

It becomes my duty, as chairman of the committee appointed for the purpose, ot report on the life and labors of I. A. Lapham, LL. D., one of the organic members and the first Secretary of our Wisconsin Academy of Sciences, Arts, and Letters.

I perform this duty with greater willingness, and, indeed, with a mournful pleasure, remembering Dr. Lapham as a long and well-tried friend. Engaged in similar scientific pursuits, there sprang up between us a close friendship, cemented by sympathy, which lasted nearly thirty years, until his death.

I shall not attempt a complete chronological history of his life, as that has already been so well done by S. S. Sherman for the Old Settlers' Club of Milwaukee, but shall speak principally from personal knowledge, merely introducing a short sketch of his early life by way of preface.

Increase Allen Lapham, whose memory we wish to honor. was born of Quaker parents, in Palmyra, Wayne Co., N. Y., on the 7th of March, 1811. After receiving a common school training he began the study of Engineering under his father's instructions.

When but sixteen years of age he went to Louisville and was employed on the ship canal around the Falls of the Ohio.

At this early date he began the study of Botany, Conchology, and Geology, which he prosecuted as a youthful lover of nature with the enthusiastic zeal which characterized his work during all the years that followed, up to the hour of his death.

While in Louisville he wrote his first scientific paper entitled, "A Notice of the Louisville and Shipping-Port Canal, and the Geology of the Vicinity," which was published in the American Journal of Science and Arts.

This first offering contained many new facts and was highly commended by the elder Silliman as a valuable contribution, coming as it did from a mere boy, what might not be expected from the pen of riper years, wider experience and greater knowledge?

When the canal was completed, young Lapham became assistant engineer of the Ohio canal, which position he held until his appointment in 1833 as Secretary of the State Canal Board of Commissioners, when he moved to Columbus. Here he found time to devote to his specialty, Botany, and formed the acquaintance of many eminent scientific men, among them Prof. J. B. Kirtland.

In the spring of 1836 he landed at the straggling village of Milwaukee, in the then Territory of Michigan, where he continued to live and study for the remaining thirty-nine years of his active and useful life.

My first acquaintance with Dr. Lapham was in 1846, when one morning there landed from the steamer Sultana a small man with a huge collecting box hanging at his side.

He came from Milwaukee and intended returning on foot along the lake-shore in order to collect plants and shells, no easy journey, encumbered, as he soon would be, with a well filled specimen box He spoke lightly of the undertaking, saying he had performed similar feats before Truly where the heart is in the work and the mind is fully occupied, labor becomes mere play, and what otherwise would seem drudgery is performed with ease and pleasure.

In after years we were often together, studying the mounds, quarries, forest trees etc., near Racine, and my first impressions of his energy, perseverance, enthusiasm, accuracy and extent of information were all deepened by our subsequent meetings.

He was a quiet unassuming gentleman, benevolent and most hospitable, as both strangers and friends can abundantly testify. He had not the advantages of commanding presence, and was not gifted in public speaking, and being modest to a fault, always inclined to underrate his own abilities and labors, he often did not receive that recognition which his knowledge demanded and which would have been quickly yielded had he possessed more self-assertion or a more combative temperament. Yet, his light could not be hidden, though he succeeded sometimes in shadowing it, and he soon became *the* authority on all scientific subjects, and was often appealed to from city, state and country for information which he alone could furnish.

His politeness and patience under the infliction of ignorant question-askers who often trespassed upon his valuable time with matters of little importance, and his rule of always answering letters asking information, no matter how trifling, show his kind heartedness and unselfishness.

No one could doubt his industry who saw his large, valuable, and well used library, and his extensive and systematically arranged collection of minerals, fossils, shells and antiquities; or who examined his Herbarium of three thousand specimens—the finest in the Northwest—and then remembered in connection with all this his work in other directions. His idea of rest was characteristically shown by his once cataloguing my hundreds of insects for future use in some publication, at a time when he visited me under his physicians' orders to take a needed rest and abstain from business.

He was no politician and never sought office. Such offices as he held sought him.

Among the many services he has rendered to science not the least, is his work in establishing the Signal Service, which has already worked such good in saving wealth and precious lives. As his connection with this enterprise seems to have been enveloped in doubt with some, I wrote to Prof. Henry, Secretary of the Smithsonian for information. In reply I received the following:

"The action of Congress in securing the Signal Service was due to the immediate exertions of Dr. Lapham through the member of Congress from his district, Gen. Payne, in setting forth the advantage of the system in the commercial interest of the Great Lakes." So this matter is settled as Prof. Henry is the end of the law in meteorological affairs,

Was Lapham a self-made man?

Yes, all men are self-made, in one sense, for there can be no unusual attainments without close and persistent study. Lapham, however, never had the advantages of a college education. But was not the book of nature ever open to impart instruction to this student who knew how to read its pages with delight and profit? To his extensive reading and close observation of nature we must not omit to add as an educational element in his life, scarcely to be overestimated, his long continued correspondence with such men as Henry, Baird, Leidy, LeConte, Haldeman, Cassin, Hall, Morton, Kirtland, Agassiz, Gray, Eaton, Silliman, Rogers, Hitchcock, Torrey, Harris and a host of others eminent in science and arts. Another means of improvement, not neglected by Dr. Lapham, was attendance of meetings of societies devoted to the discussion of his loved studies, and where mind comes in contact with mind, with mutual benefit. He was a member of most of the scientific associations of the country, and gave them many valuable written contributions. Some of his articles are published by the Wisconsin Academy, in the Wisconsin and Illinois Agricultural Reports, Agricultural Department of the Patent Office, Historical publications, Smithsonian Contributions to Knowledge, Proceedings of the American Association for the Advancement of Science, American Naturalist, Geological Reports, etc., etc. Besides, he published many pamphlets and maps, both topographical and geological. His writings were brief, clear and devoid of high-sounding words used for effect—he was above such trickery.

In order to judge correctly of men, we must know them under those circumstances and in that place where nature and education have best fitted them to act. To know Dr. Lapham, we must go with him to his workshop—the great out-doors. We stroll out on the prairies. He pulls up the grass and discourses familiarly of the spikes and spikelets, the rachis and glume, inspects the roots, digs down and examines the soil from which they spring. His tongue is unloosed, and he becomes eloquent in spite of himself. We go into the forest. He talks of the various species of trees, the vines that clamber up their trunks and nestle in their branches. He inspects the lichens that grow on the rough bark, examines the moss that adheres to the roots, and unearths a tiny helix that has found a home there. We go to the rapids, and he immediately interests himself in the rare ferns that festoon the rocks with their graceful fronds; or clambers among the quarries, marks the stratification of the Silurian rocks, and chips out rare forms of Crinoids and Trilobites—those wonderful representations of the ocean fauna of the dim past. We seek the mounds—those records of a pre-historic race—dig beneath their foundations and wrest from them their secrets. The position of the bones is carefully noted, their rude pottery restored, the curious stone implements treasured up, and 128 mounds are surveyed and mapped. We stand upon our lake shore and he discourses of the force of the waves, and describes the ingenious contrivance by which he detected the lake's minature lunarwaves. He talks of the force of the winds and their velocity and direction and then looks up the clouds and tells their indications, and speaks of the annual rainfall and of the average temperature of the seasons for the last thirty years, during which time he had kept a faithful record of these phenomena.

His last paper, "Oconomowoc and the Small Lakes of Wisconsin," was prepared for me. The ink was scarcely dry before his soul passed over to the "Shining

Shore," that lovely day, September 14, 1875, was the last of earth to Dr. I. A. Lapham.

The State has lost the service of one who knew more of her Geology, Topography and Botany than any man living, and one who contributed largely to her early prosperity. Milwaukee has lost one of her oldest and best citizens, an upright and honest man. His children have lost a loving father and his accquaintances a devoted friend.

ADDITIONAL TRIBUTE TO THE MEMORY OF DR. LAPHAM.

BY E. R. LELAND, ESQ., EAU CLAIRE, WIS.

MR. PRESIDENT:—I cannot let this occasion go by without trying to pay some tribute to the memory of our lamented and revered fellow-member, whom it was long my privilege to call a friend.

Known to the world as an able scientist; to the many who casually met him, as a modest, manly, cultured gentleman; by the few he was honored and beloved as it falls to the lot of few men to be, for virtues that were not worn upon his sleeve—for a nobility that intimacy alone could reveal.

I do not, however stand here as his eulogist. I should feel that to be a sort of impertinence in me—even if the work had not already been done far better than I could hope to do it.

I desire only to make some acknowledgement of the obligation—now never to be discharged—which Dr. Lapham has laid upon me by many acts of kindness and assistance through all the years since I first knew him. An obligation which, I think many others must share with me, for he was ever ready with kind and helpful sympathy for all. The merest tyro in natural history was sure of warm welcome and encouragement at his hands, and his collection, his library, and above all his valuable time and experience were placed freely at the disposal of the seeker for knowledge.

And he taught wisely; for his nature had nothing of the pedant, his spirit nothing of dogmatism. His was the open mind; ready to learn from all sources, not prone to theorizing nor swift to draw conclusions. He had learned to wait—and there was in his attitude no posturing, nor bidding for popular applause in anything which he did. He toiled for science, from a love of science, but with a thorough and intelligent comprehension of the great possibilities that lie in this field of research.

And it has always seemed to me that when he came to die, the manner of his death was a serene and most fit ending of a life thus spent. No prolonged, distressful struggle, no whispering, crowded room; there were bending over him no beloved faces, agonized with a grief which he could do nothing to assuage. No doctor came,

"With phrase and fame,
To shake his sapient head and give
The ill he could not name;
* * * * * * *
No brother doctor of the soul,
To canvass with official breath,
The future and the viewless things,
Which one who fe ls death's winnowing wings,
Must needs read clearer, sure, than he!"

He was alone and face to face with Nature, whose life-long lover he had been. Fanned by her softest airs, lulled by her gentlest song, his last conscious act, perhaps, a fresh effort to trace her endless clue, and he passed on, with swift and pangless transition, to the solution of the wonderful mystery which envelops all.

TRANSACTIONS

OF THE

WISCONSIN ACADEMY

OF

SCIENCES, ARTS, AND LETTERS.

Vol. IV. 1876-77.

Published by Authority of Law.

MADISON, WIS.:
DAVID ATWOOD, STATE PRINTER.
1879.

CONTENTS.

TITLES OF PAPERS PUBLISHED IN THIS VOLUME.

PROCEEDINGS OF THE ACADEMY.

LIST OF OFFICERS AND MEMBERS.

CHARTER, CONSTITUTION AND BY-LAWS.

IN MEMORIAM.

DEPARTMENT OF SOCIAL AND POLITICAL SCIENCES.

PEASANT COMMUNITIES IN FRANCE.

By WILLIAM F. ALLEN,

Professor of Latin and History in the University of Wisconsin.

The investigations into the system of collective property in land, which have recently thrown so much light upon the early history of institutions, have been for the most part confined to the Teutonic and Slavonic nations of Europe. Among these nations, collective property in land has been found to have been nearly universal in early times, and in many of these, clear traces of it exist to the present day. In regard to the nations of southern Europe, the field has hardly been explored at all. Mr. Maine, in his last work, "The Early History of Institutions," says, in relation to France, that "this darkness has recently given signs of lifting" (p. 5), and that "M. Le Play and others have come upon plain traces of such communities in several parts of France." Bonnemère, in his "Histoire des Paysans," devotes a chapter to these communities; La Chavanne, in his "Histoire des classes agricoles," discusses them at some length; and Laveleye, in his "Primitive Property," describes them in two or three very interesting chapters. Nevertheless, there has been no systematic and exhaustive examination of this subject for France, such as the works of von Maurer and Thudichum for Germany, and of Nasse for England.

Some light may perhaps be thrown upon this inquiry by an examination of such registers of seignorial estates as are accessible, to ascertain whether any traces are discernible in them of a systematic organization of the peasantry, such as is manifest to the most superficial glance in England. I have, in former years, read to this society the results of an examination of such English documents of this class as I had within reach, from which it appeared that the peasantry, down to the fourteenth century, fell into regular organized classes, holding their lands in a precise manner and in uniform parcels. As a modest contribution to the investigation, I propose to present the results of a similar examination into such French documents as have come within my reach.

It should be remarked at the outset, that the probabilities are against any such uniformity, whether in France or in any other of the countries occupied by the so-called Latin nations. The Teutonic and Slavonic nations are on the whole homogeneous in race, and as a rule have occupied the territories where they are now found from the very beginning of our historical knowledge of them. The population of France, on the other hand, is not only mixed, but has been subjected at several times to violent and sweeping revolutions. It was, no doubt, practically a homogeneous people when conquered by the Romans 2,000 years ago. The Gauls, a Celtic nation cognate to the Gaels of Scotland, are found in clans somewhat similar to those of Scotland — clans which appear to rest upon a common origin, either real or assumed, like the original subdivisions of most primitive peoples. But this primitive and homogeneous people, with its primitive and uniform institutions, has been at different times subdued by at least two great conquests: first by the Romans, then by the German tribes. It has changed its language, its religion and its customs, and it is fair to assume that it has modified its internal organization and its mode of holding land as well. Assuming, as we are perhaps entitled to do, that the Gallic tribes in Cæsar's time held their land in common, it is still probable, first: that this tenure of land was not held in village communities, like the Germans and Slavonians, but in clans, like the Celts of Britain; and secondly, that even this degree of community of tenure was broken up in a large degree by the shock of successive conquests. Wherever, on the soil of France, we find a Germanic colonization on a large scale, we may expect to find village communities; elsewhere, we may expect an irregular and unorganized peasantry, the result of disturbing influences from without — precisely as similar cases have now at length brought about a similar irregularity and unorganized tenure of the soil in Germanic countries. It confirms this expectation, that the greater part of the village communities, described by Bonnemère and La Chavanne, as existing in France, are found in the essentially Teutonic portions of France, like Franche Comté; but it would not militate with this view if such communities were found sporadically in every part of France, because there were, as a matter of fact, extensive settlements of Germans scattered all over France.

The documents which I have been able to examine in this investigation belong entirely to the ninth, tenth and eleventh centuries: to a period, that is, before the full establishment of feudalism, and in which, therefore, we may expect, if anywhere, to find the primitive organization of the community.

Of these documents, the first is the most important and instructive for my point of view. It is the Polyptichum of the Abbot Irmino; a register of the estates belonging to the Abbey of St. Germain des Près in the time of Charlemagne. In the fullness and minutetness of this survey, we are reminded of the greatest medieval work of this character, the Domesday Book of William the Conqueror; but this Polyptichum is confined to only a small part of France, all within forty leagues of Paris. Moreover, Domesday Book is a public document, drawn up for the use of the government, while this is a private register of the estates belonging to a religious corporation.

The first point that strikes one on examining this register is that the estates are not enumerated according to public divisions of the territory, but are grouped into what are called *fiscs*: in this grouping, there is the greatest irregularity,* bits of land scattered here and there in different villages, being combined merely for purposes of administration. Now, in English documents of this nature, we find the public divisions uniformely observed, even in reference to private estates. What is of even more importance, is that tenures of land in England are always given in hydes or aliquot parts of the hyde — the hyde being the part of land falling to a full member of an organized community; in the French

*Prolegomena, p. 30.

documents, on the other hand, estates are given by their dimensions, which vary very greatly.

For example:* Erlenteus and his wife Hildegarde hold one *mansus* (peasant's holding) containing six *bunuaria* about [five acres] of arable land, three *aripenni* [thirty-six rods] of vineyard, and two and one half of meadow; besides this, he has of allodial property three *bunuaria* of arable land, and one *aripennus* of meadow. And so throughout: land is held not in uniform and equal portions, but always in specified and varying amounts. In ten holdings, for example, in *Theodaxium*,† the *bunuaria* of arable land range from two to twelve; the *aripenni* of vineyard from two and one half to four and one half the *aripenni* of meadow from one and one half to two and one half.

Nearly contemporary with this document in date, is the Polyptichum of the Abbey of St. Remi, at Rheims. In this register we find a totally different system. Each estate is given under the term *mansus*, and the size of the *mansus* is not described. It is a natural inference, therefore, that that *mansi* were of uniform extent, corresponding, therefore, to the English *hyde*. Now these lands, being in the neighborhood of Rheims, at a considerable distance to the east of Paris, may very easily have been settled under a different system. Moreover, being near the German frontier, there was in all likelihood a larger proportion of German population than in the neighborhood of Paris. However this may be, we find, in the dissimilarity of these nearly contemporaneous records, a confirmation of the *a priori* probability that the tenure of land in France would be irregular or heterogeneous.

Appended to the Polyptichum of St. Remi are fragments of a rather later date, of the description of some estates in the neighborhood of Treves, still further east, and in a country of nearly pure German population. Here, as might be expected, we find a complete uniformity in the tenures, so far as the incompleteness of the documents permits us to form a judgment. The *mansi* are spoken of as being themselves definite and uniform quantities of land, like the English *hyde;* and their extent, in acres, *bunuaria* or *aripenni*, is not alluded to.

*Book XXV. 8. †Book XIV.

There remain two documents considerably later and far less complete in this respect than the two Polypticha, but which completely support the view already taken, that there is not likely to be found any near approach to uniformity in the peasants' holdings. In the Cartulary of the Abbey of St. Père de Chartres there is a complete lack of uniformity. Grants of land are, to be sure, usually stated in *mansi*; but *mansus* has not necessarily, like *hyde*, the meaning of a definite share in a village community, but means a peasant's property of whatever extent. And when we come to the detailed description of estates, there is hardly a vestige of uniformity as between the several estates. This description is very meagre in amount, and is copied into the Cartulary from some old papers, the copyist himself professing himself unable wholly to understand them. The date of these document is assigned by the learned editor, Guèrard, to some time before A. D., 1000.

In one or two of the estates there are to be sure some indications of uniformity in the condition of the peasants of the same estate: e. g., in Cavanuis Villa (p. 37), are given the names of twenty-one peasants (*agricolæ*), all of whom paid the same dues to the convent; nothing is said as to the size of their holdings. In Cipedum there are ten peasants, all paying the same dues. But next follows Comonis Villa, with four peasants, two holding five *bunuaria* and paying three measures of corn; two holding six *bunuaria* and paying four measures. On the next page, Abbonis Villa has thirty-three peasants; twenty-one of these paid one shilling, and the rest sums varying from six pence to three shillings. On page 40 begins the enumeration of seventeen holdings, paying ten different sums, varying from six pence to fifteen shillings. Only two of these, to be sure, are called *mansi*, but these two pay respectively two and five shillings, and one *mansellus* three shillings.

There remains the Cartulary of the Monastery of St. Bertin at St. Omer, in the extreme north of France, therefore in a territory largely settled by Germans. The date of these registers is about the middle of the ninth century. Here we find, as might be expected, a uniformity almost as great as in England. The estates are regularly stated in some such manner as this: "*Mansa XV per bunaria XII, et ille dimidius per bunaria VI*" — "fifteen *mansi* of twelve bunuaria each, and a half one of six bunuaria." The size of the *mansus* varies exactly as that of the virgate in English manors*; that is, it is generally uniform in the same villa, but ranges in the different villas from ten to twenty-four *bunuaria*, with sometimes, however, two or three different standards in the same villa. For example, in Pupurninga there are ten *mansi* of twenty-four *bunuaria*; ten of twenty; ten of fifteen; seventeen of thirteen, and one-half *mansi* of eight. We find also a large number of peasants with independent holdings, not given as *mansa*, and very irregular in amount; like the freeholders of England.

The result of this inquiry, which embraces all the documents relating to France which I have been able to examine, is completely to confirm the expectations which appeared probable on general grounds. We find here and there, especially in those provinces which had a considerable German element in the population, decided indications of uniformity in single villages or estates, sometimes even on a larger scale. But as a whole, uniformity is not the rule but the exception; the communities, if they were such, appear to have been isolated and scattered amid a population which was prevailingly irregular and heterogeneous.

*See Transactions, Vol. II, p. 223.

THE ABOLITION OF THE JURY SYSTEM.

BY CHARLES CAVERNO.

Lombard, Du Page County, Ill.

It may seem a bold project to advocate the abolition of the jury system. We have been taught to regard the writ of habeas corpus and the trial by jury, as little less than gifts of Divine inspiration. The writ of habeas corpus may still stand. The Time Spirit has not passed adversely upon that, and is not likely to.

But candid examination will hardly be able to resist the conclusion that, in this country, trial by jury has outlived its usefulness.

The history of trial by jury will here be treated of only incidentally. Sources of information respecting the history of the jury system are in the hands of the legal profession, and lie open to all. Few other institutions have undergone so many changes as this. To speak of trial by jury is to speak of something whose content of meaning depends upon time. The institution has taken on a new phase and parted with an old one, in almost every century since the Norman conquest.

Jurors were originally summoned to aid a court in a matter of dispute, by a declaration of facts within their own knowledge. Now it is legally a disqualification for a man to know anything about the case in hand — practically, a disqualification for him to know anything else. When the court could put men of the vicinage on oath, to help it with a statement of the facts they knew, there was life and health in the jury system. Later, when this group of witnesses took on the further function (that out of which the grand jury grew), of suggesting to the court matters in their vicinage, connected with the public weal or the public peace, which they thought the court should look after, there was life and health in the system.

But when now the court has to inform the jury of the facts, and then tell them substantially what facts they shall hand back to it, as found by them, it is apparent that we have an institution which has little setting in reason and, as matter of fact, has little respect with those familiar with it in practice.

In trial by jury to-day we have a marked instance of an institution, sapped of its strength by the growth about it of a multitude of petty restrictive details. Force that does not go to stalk, goes to shoot, till life is smothered by its own abnormities.

IN CIVIL CASES.

That trial by jury in civil cases is not an essential element of civilization, and is not necessary to industry and commerce, is apparent when the fact is known that jury trial in such cases has never had place on the continent of Europe, was not in fact introduced into Scotland till a period within the memory of men still living.

Lord Mansfield, toward the close of his illustrious career at the end of the last century, advised against the introduction of the jury in civil cases into Scotland.

Lord Campbell said that the principles underlying Mansfield's objections were unfortunately overlooked when jury trial in civil cases, in 1807, was introduced into Scotland. He further adds, "The experiment, I am afraid, has proved a failure, and Lord Mansfield's objections been fatally verified."

While as much as this would not be allowed by all Scotch lawyers to-day, yet the claim is distinctly made, that all the advantages which have arisen in Scotland with the introduction of the jury system are not due to that system at all, but are due to a contemporaneous rectification of the Scotch system of pleadings.

Trial by jury in civil cases is distinctively English in origin and limited in practice to England and the colonies — Scotland being allowed for as above stated.

Great Britain and America do not transact all the business of the world. There has been done and is doing a vast deal of business on the continent of Europe. If all this business has been transacted without the jury system in legal matters, we may at least conclude that that system is no social necessity.

If there has been and is no call for the establishment of the system on the continent, by the commerce there located, then we may judge that the system, in such cases, is not even of apparent social convenience. But the argument against the system is only partially made when you look at continental commerce. In England itself the tendency has been, in the growth of legal practice to wrest department after department from under the incubus of the jury system. Just think how much business is covered by equity, probate, and admiralty. Yet they are exempted from the jury system.

Lord Mansfield said that equity grew up in England to rectify abuses resulting from the jury system. This statement at once explains why it is that England and her colonies are the only countries where law and equity have been divided and assigned to separate courts. The jury system was only adapted to coarse, crude business. Anything requiring care or nice discrimination had to be sent to another court, which, significantly enough, was called a court of equity, as though something like even justice might be there expected. How important the equity side of law is, lawyers understand. The stretch of equity over legal business must increase more and more with the growing complexity of civilization.

Take probate business; as a rule, that is exempt from the jury system. The statutes sometimes commit special matters to juries, or they are found by way of appeals to other courts. But what a reach there is to probate business. All the property of a country passes through probate, generation by generation. Yet the difficulties of this huge business are normally met without the intervention of a jury. The value at stake in matters passed upon in common law actions cannot compare with the values that are adjusted in probate, nor do such common law actions present problems of greater interest or intricacy.

To admiralty in England, and usually in this country, the jury system is not applied. "Britannia rules the waves." The jury system is peculiarly a British institution, yet Britain has taken good care that the right arm of her power and prosperity should not be fettered by the jury system. She has followed the adage, "*Ne entor ultra crepidam.*"

Trial by jury may be a palladium of British liberty, but Britain has had wit enough not to trust her invaluable marine interests to landlubber juries. It is readily apparent why this exception is made. The ordinary citizen cannot pass understandingly upon matters so technical and peculiar as maritime business involves.

But then, is it not apparent that all business is rapidly tending to infold the same difficulty? Can marine affairs present any greater difficulties to an ordinary jury than arise out of the industries we are now plying on land? If it is undesirable to have juries pass upon shipping interests, how comes it desirable to have them pass upon cases which spring out of railway business, out of manufacturing, patents, telegraphy, banking?

Is not commerce by land becoming as technical and peculiar as commerce by sea?

If there were no objections to the character of juries as ordinarily raised, yet the tendency of all business to what Herbert Spencer would call greater "heterogeneity," is reason enough for the abolition of the jury system in all civil cases.

The lot cannot any longer be expected to select a man for a juror who can in any wise be of any assistance to a court or to parties litigant. Originally the jury was called not only to aid the court with information which they possessed, instead of being instructed by the court, as now, by the impartation of both fact and law, but for generations it was only upon one kind of matter of dispute that the aid of a jury was sought.

Questions respecting titles to land called into existence the institution of the jury. The expression, "a jury of the vicinage," preserves to us a reminiscence of the day when the sole business of a jury was to give the court information in respect to possession and reputed title to land in their vicinage.

In the commotions consequent upon the Norman conquest, questions of this kind were frequent.

Titles rested not in record but in possession. Twelve men from the vicinage could tell the court who had been in possession of a certain piece of land, or along what line of descent it was reputed among them that possession came. That was a simple office, easily discharged. In England, and in this country, wherever the old common law forms are used, the writs summoning juries still preserve the direction to summon men from *the vicinage*, when knowledge of matters naturally consequent upon being of the vicinage disqualifies the juror for the very service to which he is impliedly called, and sends him from the jury panel to the witness box. It is a long tale to tell how legal practice wandered from that to this. Is it to severe too say that there was sense in that, but that reason has dropped out by the way to this?

But the argument against juries in civil cases can be strengthened by still other considerations.

There is a constant endeavor to escape them by trials by the court alone or by references from the court. Generally, it may be stated that a jury is the terror of a good cause and the hope of a bad one. A case that wants a jury usually has an eye to possible aid from that peculiar character — the twelfth juryman. Arbitration is growing more and more frequent as a means of escape from the jury system. Various guilds and associations in the industries and in commerce, make as part of their constitution, provision for the settlement of disputes that may arise among their members. With higher moral culture, more and more will be made of the principle and practice of arbitration. Where juries are preserved, ultimate confidence in no case is placed in them. Provision is always made to review their work by another tribunal. It is not worth while for society in any civil matters to preserve so cumbrous and expensive a system in which after all it puts so little trust.

It is good theory to say that the province of the court is to pass on law and that of the jury on fact. But it is often a question of law what facts shall be taken into consideration, and often a question of fact what the law is.

This division between fact and law is one which can rarely be clearly made in practice.

Alexander Hamilton says: "Though the true province of juries be to determine matters of fact, yet in most cases legal consequences are complicated with fact in such a manner as to render a separation impracticable." When the court gives the law to the jury, the court has already inferentially found the facts, and when the jury find the facts they inferentially apply the law. *Fact and law are so involved that they belong to one mind.*

There is a constant tendency for fact to pass up into the order of law. A few facts make a custom, and custom is law. It is hard to say where fact leaves off and law begins. The tendency of civilization is to make law at the expense of fact. In the subdivision of labor in law, lawyers do not attempt to cover all the realm included in their profession. One devotes himself to the law of Patents, another to the law of Railways, another to the law of Real Estate. Yet we take indiscriminately from the mass of the people juries to sit indifferently, now on the delicate interests involved in one of these great departments, and the next moment on those of another. We set a hod-carrier to pass upon facts (as, for instance, upon those which constitute negligence) upon which a lawyer would give no opinion unless he had made them a life study.

We have no need here to discuss the character of our jury service. The service itself, as we practice it in civil cases, is inherently absurd.

IN CRIMINAL CASES.

Trial by jury in criminal cases, at various dates within a century, has been introduced into many of the nations on the continent of Europe. It came in, in several instances, as a result of the political commotions of 1848.

The popularity of trial by jury is in its application to criminal cases. But a little study detects the fact, that this popularity has arisen out of one peculiar class of cases.

When Hallam eulogizes Magna Charta, especially the clause which is supposed to establish the right of trial by jury, he lets us see from what quarter the popularity of this institution has come. He calls it "The Keystone of English Liberty," and says that it is one of "the bold features which distinguish a *free* from a *despotic monarchy.*"

It is because of its *political* service in monarchical or aristocratic governments that the jury system has come by its high reputation.

Tocqueville sees this and says, that "trial by jury is emphatically a *political* institution."

You detect the ring of *political* intent in the speeches of the continental orators advocating the introduction of trial by jury into their several countries.

It is easy to see how this comes about. Monarchies and aristocracies often make political crimes out of what men of progressive and democratic tendencies consider the liberties of the citizen.

The jury becomes popular because, taken from the people, it naturally will be a defense against conviction of these political crimes.

But in this country, we are expected yet to glorify an institution which has lost all significance and appreciation as a protection of liberty. We have no monarch to declare the liberties of the citizen political crimes. We have no ranks in society who can make crimes out of encroachments by the lower orders upon the claims of privilege. The ballot has taken the wind from the sails of trial by jury as a defense of liberty, and left it as

> "Idle as a painted ship
> Upon a painted ocean."

Trial by jury has not had a cargo to carry in the interest of liberty since the government was founded, and it cannot get one.

The social conditions in this country are such that trials like the famous state trials in England — Horne Tooke's and Hone's for example — can never arise; and if they should, the ballot will always be the swiftest instrument to cut the knot which they present. Political rights with us find their solution in suffrage, not in jury trials. Politics settles political rights, courts assenting or dissenting. As long as the courts are in the hands of the people, politics may be trusted to take care of political rights. If it could be shown that courts have stood in the breach for liberty, it will be found that any effective service has been rendered by courts of last resort, where juries never come.

In this country, then, trial by jury, considered as a bulwark of political liberty, is serviceless. The only remaining function of the jury is to do justice in cases of accusation of universally acknowledged crime. We are to inquire whether it is fulfilling that office. It is high time we looked this institution straight in the face — high time that we stripped it of the glamour in which it is clothed, brought from other ages and other circumstances. There is one plain question to be asked of it, *is it protecting society in cases of crime?* If it is not doing that, its sole occupation is gone.

We have few statistics to help us to a judgment on this matter, and from the nature of the case, if we had, they could never be conclusive. There must be a problematical element in all our judgments on the subject.

Quetelet gives us one set, however, that are very suggestive.

In 1830, on the introduction of trial by jury into Belgium, the ratio of acquitted to accused in that country was found to be just doubled. Now no man can demonstrate that this result made against social protection, and did not make in favor of protection of innocence; but one familiar with the history of criminal trials in this country for the last quarter of a century will judge that this result did make against social protection and in the interest of crime.

Common fame may be trusted for the assertion that for a generation there has been a substantial failure of justice in this country in criminal trials. The rule is that great criminals escape.

Jury trial has come to protect criminals and not society. If a criminal fails to be protected, it is simply because the resources offered by the jury system have not been well worked — wit and money fail him, not opportunities for their successful use.

Look along the line on which the criminal can operate. If we had arranged it with special eye to the disaster of society and the defense of crime, we could scarcely have done better. Juries take their rise in boards which, in the large cities, have been delivered to "the bondage of corruption."

Out of the same board of supervisors came forth the Tweed frauds and juries. In such extremity of virtue, if crime does not find its opportunity, it is modest. When we are star-gazing, we bring up in pit-falls at our feet. We can see jobbery in congress, but we stumble heedlessly over it in our primary representative bodies. The original constitution of the jury in the great centres of population is in low, bad hands. Judges *have* been found with self respect enough to dismiss whole panels as unfit and unsafe for public service. The whole list often fills Horne Tooke's bill against a jury list in his day — "a basket of rotten oranges from which one has his choice." No rational account can be given of some juries, but that they are of the criminal class, put in by the criminal class, for the benefit of the criminal class.

Then comes the facility of tampering with juries through the sheriff's office. The reputation of that office is not immaculate. No office in the gift of the people lies so open to temptation from rascality. It is a place of peculiar attraction to the "rough" element. They furnish more candidates for this office than for any other, and succeed usually in having some representative in it. That element will serve itself and its own. A great outlay of effort is not required. A shrug of the shoulder or a wink, and there is a dead lock in the jury.

Then society breaks its own center in the provision for summoning talesmen. The men who are anxious to serve somebody are always on hand. The old jury soldier is a well known character. Whether he is one of the devil's poor or a poor devil, he is equally open to the use of artful crime.

Finally, add the technics of judicial procedure, especially as they find expression in the ignorance and indifference, (qualifications in some states now abolished by express statute), by which jurymen are secured who are too ignorant to know of crimes committed about them in society, and too callous, morally, to express any opinion concerning them if they do, and there seems to be no special reason why crime should not secure immunity and society fail to be protected. The system, as we have it, is a standing peril to society.

If it be said that the service must be reformed, the reply is that all attempts at reform will necessarily be partial, spasmodic. The line is too long to guard, and then it is not worth guarding. Society has lost interest in the institution. The attitude of business men toward jury service plainly shows that the system has outlived its usefulness. Judges scold and fine, yet business men slip through their fingers, and the old soldiers take their accustomed seats. It is not worth while to try to reform an institution whose service is so universally distasteful to men of character and occupation. The only question deserving consideration is, whether practical injustice would be likely to result to those accused of crime from the abolition of the trial by jury.

Presentment by grand jury was once thought to be as essential to the protection of those accused of crime as final trial by petit jury. Yet the grand jury has gone by the board in many states, to nobody's damage. The petit jury might follow it with as little injury. Any man accused of crime could find security enough in the ordinary course of law without the jury system. He can have as many new trials as he can show reason for. If capital punishment were abolished in all of the states, as it is in many, then we could say that in all cases, as long as natural life might last, courts would be open to applfcation for new trial on the ground of newly discovered evidence.

Granting these privileges, society would be likely to mete justice as evenly and unerringly as is possible to man.

Why should everything about crime be adapted to and managed in the interest of criminals? Is not society's right to protection as high as the individual's right to protection?

An individual has no right as against society to that which practically leaves it defenseless. It is an incidental matter but I cannot forbear to mention the probable influence on the bar of the abolition of jury trials.

The morals and manners of equity practice are certainly heaven-high over those *nisi prius* or of criminal courts. There is no reason why the attempt to get at facts in cases civil and criminal cases should corrupt the manners and morals of the bar any more than the attempt to get at law, and yet every body knows that it does. The cause of it is in the standing temptation there is in the jury.

A good illustration of the nature of this temptation and of what it can lead lawyers to do is well set forth, in a few words of Sir Nicholas Throckmorton, who was tried for high treason in 1554.

"MASTER SERJEANT, I know how by persuasions, enforcements presumptions, applying, implying, inferring, conjecturing, dedu-' cing of arguments, wresting and exceeding the law, the circumstances, the depositions, and confessions, unlearned men may be enchanted to think and judge those that be things indifferent or at the worst oversights, may be great treasons. Such power, orators have, and such ignorance the unlearned have."

But the processes that win with a jury are powerless with the court. It would be a happy result for the bar if all possible temptation to such processes were removed.

We have instances enough to show that a master of rhetoric *can* convince a jury that it is perfectly natural for men to unjoint their heads and carry them under their arms during a shower. But whether it is worth while for society to tax itself heavily to support an institution for the sake of giving such rhetoricians exercise, is or is not much of a question, according as it is viewed.

The jury system has indeed such age as it has to recommend it.

But, as Forsyth well says: "A better reason for the continuance of an institution must be given than that it has been handed down to us by our forefathers."

Professor Christian has expressed the opinion that the rule of unanimity in verdicts could not have been introduced in any age by deliberate act of the legislature.

If it were an original question with us, whether to introduce jury trial as we have it, either in civil or criminal cases, the proposition would fail to find respectable support.

POSTSCRIPT.

The abolition of term sentences in criminal cases, recommended by the governor of Wisconsin, Hon. W. E. Smith, in his first annual message, has a bearing upon the abolition of the jury system in such cases, to which attention is invited.

The board having the charge of criminals must always have before them the question of the actual guilt of a prisoner, as well as the equities existing in case of clearly ascertained crime. Such board would always be in position to pass upon a question upon which a jury can pass only once, and at once.

Those accused of crime, and against whom a prima facie case is made out before a judge, have in such a board the benefit of a *standing* jury.

The abolition of term sentences is a step in the right direction; but, once taken, it reduces the jury system to the position of the fifth wheel to the social coach.

Jan'y 21, 1878. C. C.

THE ORIGIN OF THE FREEHOLDERS.

BY WILLIAM F. ALLEN,

Professor of Latin and History in the University of Wisconsin.

[This is a portion of a paper read at Racine, July 11, 1877, revised and enlarged.]

The accepted view at present as to the origin of the class of freeholders is, that they represented the old village community, and that their court, the Court Baron, represented the old village assembly. Sir Henry Maine says (Village Communities, p. 137): "We cannot doubt that the freeholders of the Tenemental lands correspond in the main to the free heads of households composing the old village community." Prof. Stubbs speaks (Constitutional History, Vol. I, p. 399) of the "court baron, the ancient gemot of the township." And Mr. Digby says (Introduction to the History of the Law of Real Property, p. 38): "There can be little doubt that tenure in socage [that is, freehold] is the successor of the allodial proprietorship of early times." And again (p. 43): "The manor court is the successor of the ancient assembly of the village or township."

In opposition to this view, I undertook to show in a previous paper * that the so-called customary tenants, who were as a rule serfs, were the representatives of the old village community; and suggested that the tenants in socage, or freeholders, were "specially privileged *villani*." I propose at present to develop this last point further, and show that free socage was in its nature a feudal tenure and that the freeholders as a class had a feudal origin.

First, it should be noted that free tenure was of two kinds: by chivalry or knight's service, and by socage or agricultural service; and that the two classes of tenants, although differing widely in the form of their services and in social position, formed neverthe-

* See Transactions of the Academy, Vol. II, p. 220.

less legally one class. The lists of free tenants, *libere tenentes*, always begin, as is natural, with the most honorable class, the tenants by knights' service, and then continue without a break with the tenants by socage. And all the freeholders, *omnes libere tenentes*, composed the court baron of the manor, and owed suit to the court of the hundred and the shire. Now, as the two categories of freeholders composed but one class in law, it is natural to suppose that they had the same origin. The tenants by chivalry were of course a purely feudal class, holding their estates by the strictly feudal tenure of military service. The tenants by socage, it is natural to suppose, may have had a similar origin.

As a matter of fact, the two classes came into existence at the same time. Tenure by chivalry was, as a matter of course, introduced when the feudal system was introduced. The precise time and manner of this is still a matter of uncertainty. What is certain is that feudalism, in its complete form, did not exist in England at the time of the Norman Conquest (1066), but that it is found completely developed at the accession of the House of Anjou (Henry II.), in 1154. Now this interval of about a hundred years is precisely the time in which the tenure by free socage and the class of tenants by socage made their appearance.

Even as late as Domesday Book (1086) there was no freehold (except by military tenure), and no class of rural freeholders. But the Boldon Book (1183), and the Abingdon Cartulary, of about the same time, contain lists of freeholders of both the military and the agricultural class, and standing above the mass of servile tenants. It is therefore *a priori* probable that the tenure by free socage and the class of free socagers came into existence in connection with the establishment of feudalism, and as a part of this process. It is true, as I pointed out in a former paper,* that there is a large class of *sochemanni* enumerated in Domesday Book; but, first, this class is confined to a few counties in the east of England; and, secondly, it appears to have been a class of persons, not a category of tenure; — there were *sochemanni*, but no *socagium*. There was likewise found in the eastern counties a class of freemen, *liberi homines;* but they appear to have been

*Transactions, Vol. I, p. 167.

allodial proprietors, not free *tenants*.* Whatever, therefore, the origin and status of these two classes may have been, they could have had no *historical* connection with the later freeholders. Even the county of Kent, where villenage in its proper form is said never to have existed, had neither *liberi homines* nor *sochemanni* in Domesday Book.

I will now take up in succession the several features in which the free socagers stood related to the manor and its lord.

First, their tenure was in its form strictly feudal. They were formally enfeoffed with their lands, by "livery of seisin," were subject to most of the feudal incidents, and were regarded as having a definite legal interest; while the serfs or customary tenants held their lands by prescriptive title, and were in strictness of law only tenants at will, not being "regarded as having any legal interest in the land at all." Their estates, as I have shown on another occasion, were exceedingly variable in size and nature; but often they were regular portions of the customary lands, which they held upon the performance of the customary services, or a part of them.† It was not uncommon for one of the customary tenants to have also a freehold.‡

Next to the tenure of land comes the manorial court, in which the jurisdiction of the manor was exercised. This was known as the Court Baron, and its judges were the free tenants of the manor, whether by chivalry or by socage. The constitution of the court was strictly feudal.§ Every feudal lord had his feudal court, composed of his immediate vassals, those, that is, who were peers of one another. The feudal court required, for its mainten-

* "It is characteristic of the growth of tenure that in Domesday (if the index is correct) we hear of different classes of tenants, but not of different species of tenure; of *liberi homines*, but not of *liberum tenementum;* of *milites*, but not of tenure *per militiam;* of *sochemanni*, but not of *socagium;* of *villani*, but not of *villenagium*." Digby, p. 40, n. 1.

† "The tenure of a certain number of these fields is freehold."— Maine, Vill. Comm., p. 137.

‡ In the manor of Ledene, out of nine customary tenants, each holding a virgate of fifty acres, six also had freeholds, varying from one to thirteen acres.— Gloucester Cartulary, iii, 126.

§ The *liberi homines* are almost confined to Norfolk and Suffolk; the *sochemanni* to these counties and Nottingham, Northampton, Leicester and Lincoln.

ance, a minimum of tenants. Now the Court Baron of the English manor fell if there were not at least two freeholders to take part in it. It followed, moreover, the feudal rule, that the judgment, both as to law and to fact, was given by the tenants, the suitors or peers of the court—the lord or his steward only presiding. The name, moreover, Court Baron, is hard to explain by English etymology; but, as the French manorial court was called *Cour de Baronnie*, it is easy to suppose that the name was introduced along with the feudal system itself. On the other hand the customary tenants, the compact and organic body of the peasantry, had no function in this court, except that of lookers-on. They had their own court — the Customary Court — whose powers were "administrative rather than judicial," † in which, therefore, they had no real power, such as the freeholders had in the Court Baron, being hardly more than witnesses.

This was, in short, such an assembly as that of the members of a corporation might be expected to be after the corporation had lost its effective powers; we may, therefore, consider it to represent the assembly of the mark or village community, reduced to a servile status. The freeholders, it should be remarked, "are not, generally speaking, suitors at the Customary Court," from which it follows, almost of necessity, that they did not, *as freeholders*, have any share in the administration of the community, but only in so far as they held customary lands.

In the next place, the rights of the two classes in the waste differed: each had the right of common appendant to his arable land, but that of the copyholder or customary tenant was by the custom of the manor, while that of the freeholder was "by virtue of his individual grant, and as incident thereto."* This would show that here too the customary tenants represented immemorial antiquity, the freeholders a special and recent grant.

It remains to supplement these general arguments by special examples of the genesis of freehold. This is not easy to do, inasmuch as the period of the development of this class, the century following the Norman Conquest — is very barren in docu-

† Digby, p. 216.

*Digby, p. 215. Williams, Law of Real Property, 467, compare, 483.

ments of the required character. When we begin to meet with rent-rolls and other records of the manors, the freeholders are already a large and recognized class. There are, nevertheless, a few statistics which appear fully to prove the point in question.

The manor of Beauchamp, in Essex, was the property of the Chapter of St. Paul. At the time of the Exchequer Domesday (1086) it contatned twenty-four *villani*, ten *bordarii* and five *servi*; no freeholders. In 1222, in the document known as the Domesday of St. Paul, there were thirty-four *libere tenentes.* This class, therefore, had come into existence in this interval. Now it so happens that for this manor we have the fragment of a record, of the year 1181, known as the Domesday of Ralph of Diceto. Its importance can be judged from the fact that this is the only manor I have been able to find, of which there is a rent-roll in existence at two different periods; by means of this we are able to compare the condition of the manor at an interval of forty-one years. Unfortunately the list of the *operarii* (as the customary tenants are here called) is incomplete; the *libere tenentes* are eighteen in number. From this it appears that the class of freeholders was not merely a new class, originating in the century after the Norman Conquest, but that it was a class that was steadily added to, having more than doubled its numbers in less than fifty years. Nor was this wholly by dividing the estates; for the lands held by them were, during this period, increased from 667 acres to 744.

The continuousness of the tenures is shown very clearly by these lists; more than half of the estates of both classes can be traced from father to son, or other relative, even after the long space of forty-one years. In only one case is the same tenant found. Robert, son of Wlurun, a customary tenant, held, in 1181, an entire virgate of land. In 1222, he appears as holding only a half virgate of customary land; but his name stands also in the list of new freeholders, as holding another half virgate. Evidently being one of the richest and most prominent of the serfs, he had been converted into a freeman and a freeholder by being enfeoffed with half of his customary estate, the other half remaining in villenage. Lambert Gross, in 1181, held two half virgates of customary land. In 1222, his widow, Alice, held one half virgate by the same tenure, and his son William the other half, as a freehold. Here are two clear cases of the conversion of serfs into freemen, and of customary tenure into freehold.

It would appear, therefore, to be proved that the freeholders, or tenants by free socage, were, as a class, the creation of feudalism; that the feudalization of England was accompanied, or rather accomplished in detail, by the creation of a body of immediate tenants to the lords of the manors, who, without these, would have had no complete jurisdiction. The tenure itself would appear to be simply the French *censive*, or agricultural fief, which is in its nature and form wholly analogous with the fief proper; it may also have had some analogy to the tenure by which the *sochemanni* of the eastern counties held their land, and from this to havereceived the name *socagium*. If this view is correct, it would follow that the feudalization of the township, its conversion into the manor, consisted in the introduction of this new class of tenants, holding by a new tenure. For this purpose leading villeins would naturally be selected, and the cases of Robert son of Wlurund and Lambert Gross show very clearly the process. That this class, new and of foreign and feudal origin, became the most valuable and characteristic of the English institutions, is due to the strong vitality and power of assimilation of the English constitution, whose trial by jury was also of foreign origin, and which even turned an exceptionally despotic royalty into an instrument of freedom.

THE DUTY OF THE STATE IN ITS TREATMENT OF THE DEAF AND DUMB, THE BLIND, THE IDIOTIC, THE CRIPPLED AND DEFORMED, AND THE INSANE.

BY R. Z. MASON.

In the progress of modern civilization, the state has come slowly to a recognition of certain duties and obligations to these unfortunate classes. At present we take up the subject in the interests not only of humanity and of sound political philosophy, but also in the interests and light of modern science. Perhaps we shall commit a grave mistake in venturing to draw our conclusions solely from the cold suggestions which the teachings of the most advanced investigators in science might supply. Humanity certainly has claims upon us which the dictates of our spiritual natures must respect. Shall we adopt the modern theories of evolution and the language of Herbert Spencer, "the fittest shall survive," and be induced thereby to turn out the unfortunate idiot, the insane or the deformed cripple, with nothing but his own resources to depend upon, to compel him to struggle for a precarious existence by battling with the relentless forces of nature, and sharp competition with the fierce selfishness of individual life? Would this course be in accordance with the instincts of man's better and higher nature? Whatever theories we may adopt as to our origin, we cannot ignore the fact that we belong now to a cultured race, to those whose gentle humanities are to be as much regarded as the mere elements of physical strength or intellectual acumen. If we did spring from the brute, we cannot afford to act quite like him. But the subject has another phase which it is proper we should carefully examine. The question arises, whether the state shall expend its hundreds of thousands of dollars per annum in the almost hopeless effort to correct congenital malformations, to subdue the frantic manifestations of insanity, to counteract the subtle forms of organic disease, and to educate the feeble-minded and still allow these pre-natal and constitutional disorders to flow on through countless generations of the unborn. Of course we assume in our argument, that it is the province of the state, acting from considerations of the highest political economy, to care by systematized and organized effort, for such of the unfortunate as cannot care for themselves, or whose wants friends cannot supply. The insane can, not unfrequently be rendered happy and useful, but even sane. The idiotic can, by skillful treatment of the educator be developed into the *self-reliant, self-sustaining* intelligent being. The orthopedic surgeon can bring beauty out of deformity, and can so change those flexures that deform and weaken the physical anatomy, as to bring nature to her true and original lines, and impart a new strength and vitality.

But the prosecution of all these lines of experiment and modes of rendering the combined skill of the civilized world available, require large outlays of time and money. And is it not vastly better that the state, acting in her organic capacity as the agent of human society, should encourage and aid by her own means, the foundation of institutions for such purposes, rather than to leave the large numbers of these unfortunate people to the ill-directed and uncertain efforts of poor, and often unintelligent families, to get along with their herculean difficulties as best they may? Is it not better, therefore, that the state should tax herself a little to help the blind to become an intelligent, self-sustaining member of society, or to cure a child of some *dwarfing* deformity or some *smiting* paralytic stroke, rather than tax herself much by and by in maintaining these victims of relentless misfortune in poor-houses in the long years of their future? Such a question can, I apprehend, have but one answer.

But above and beyond all this, the state has another and more important duty to perform to society, than that of merely taking care of such as have come into the world under the blight of some terrible misfortune. This other and higher duty is so to modify its legislation as to prevent the propagation of congenital idiocy, deforming insanity and organic disease. I know that in venturing to discuss this subject by treating it as a function properly belonging to the state, I may be assuming what will not be readily conceded. To prevent, if possible, these serious misfortunes, is unquestionably the duty of somebody. Or must we admit that man, intelligent and immortal, is such a creature of blind and reckless passion, that he must be permitted to go on through the vast æons of the future as he has done in the past, reproducing himself, depraved and demoralized as he is, transmitting his anatomical defects, his physiological *idiosyncrasies*, his organic imperfections, in the most marked manner, in order that posterity may have the opportunity to cultivate the moral virtues by taking humane care of the insane, the blind, the deformed and the idiotic. It is not too early in the history of man, I more fear it is too late, to ask the question, should a radically defective organization be allowed to perpetuate itself by reproduction? To this I would answer, that for the good of the race it should not. This must be our conclusion unless we are prepared to adopt the modern school of Euthanasists, who take the ground, that when a human being cannot live and be happy, he has the right to claim of society the boon of death, legally administered. I would modify the proposition by saying rather, that such an unfortunate had a right not to be born; yet, having been born, perhaps the Euthanasist may say that he has the right to ask the privilege of an early, painless death. Yet the original question still recurs, What is the duty of the state towards this large and constantly increasing class of incurables and unfortunates?

First, I answer as to those in existence. Let them be taken care of in the most economical and best systematized way which science, art and experience can devise. Let alms-houses, the insane hospital, the deaf and dumb, and blind asylums, still stand as monuments of the generous and humane spirit of the age. Let the crippled and deformed have ready access, if need be, by public charity, to all sources of relief which the world's best wisdom can supply. It is better that the state pay the expense of putting a man in a condition so that he can take care of himself, than to tax the public through an entire generation for the support of a cripple in the poor house. But secondly, I propose to show a rational answer, it may be *imperfectly* and *impractically*, to the second branch of this question, to wit: the duty of the state to the unborn generations, with which our successors will have to deal The state establishes a state board of health, to whom it commits the various questions concerning the public health. It requires the individual to conform to such sanitary regulations as are found necessary to protect life, health and property. But is there any more reason why the state should see that offensive and mephitic vapors and gases should be promptly neutralized by chemical agents, why nuisances should be abated or removed from civilized communities, than there is why the state should interfere to arrest the descent, through long lines of generations, of the germs of incurable diseases, which are sure to become the object of the world's pity when allowed to develop into the full proportions which we witness in our hospitals and public alms houses? Should it be the province of a state board of health to tell me that my sewers need chloride of lime or carbolic acid, and not be their function to tell me that my posterity will be smitten with incurable insanity, provided a contemplated marriage is consummated? Should he be allowed to intrude into my back yards and order me to remove the offal, which carries on its *wings* the pestilence and plague, and yet must not be allowed to have at least some voice in arresting, by counsel or by law, the descent of those congenital disorders, that prey at an earlier or later date on half the population of the civilized world.

We take remarkable pains in selecting and crossing breeds of the domestic animals. Here at least we try to study and harmonize with the laws of nature. The royal and aristocratic families of Europe are very strict in the marriages of their sons and daughters. We recognize the universal law that physical qualities, character, breeding and education begin long anterior to birth. But unfortunately for the ruling classes of Europe, the primary principle on which their intermarriages are based, is not in respect to the laws of nature. Their idea is a purely conventional one, and their society is purely artificial, where nature and her economy in the processes of reproduction, are as much ignored as with the bulk of mankind elsewhere. Their intermarraiges come from rank, based on wealth, and on freedom from the restraints of law and labor; a condition of things best calculated to deteriorate what there is good in any generation of men. If the doctrine is true, that the fittest only should live, then it follows as a rational corollary that, in a society of rational men, where the interests of a race capable of indefinite development are blended, that "the fittest only should be born." To reproduce and fill the world with posterity is not always a duty. Certainly not always a privilege. The law makes it a crime where the parties have not taken the legal steps to provide, as far as may be for the protection, the education and general wellbeing of future offspring. Why should not the law adopt the sound maxim, that no person has the right to throw upon the charities of the world, his diseased, deformed and insane offspring.

The laws of generation are now sufficiently well established so that good scientific and medical authority can determine with tolerable certainty the probable issue of a given marriage, so far as health is concerned. Yet, even this generation continues to introduce into the world, children marked with these congenitial defects, as if it were a matter of the slightest concern whether children were well or ill born. Society should here erect an impassable barrier, so that no person, man or woman, who failed to present the requisite credentials of a sound mind in a sound body, free from all forms of congenital and organic disease, no matter what social standing or wealth might distinguish them, should become the head of a family of children. This is the aristocracy of nature. No man is well born who inherits the appetite of a drunkard or the feebleness and frailties of a consumptive. No person is ill born who comes into the world with all his mental and physical faculties bright with the bloom of health and vigor. All theories of progress and true social development are useless and abortive unless these ends are first secured.

But should our legislators see practical difficulties in the way of a system of legislation so radical and revolutionary in the social life and economy of the people as the above programme would indicate, still the least it can do is to introduce these biological remedies to the attention of the public, in the education of the young. It is ignorance that has destroyed us in generations past. It is ignorance of the functions of life and of the laws of reproduction that destroys us to-day. We cultivate with more skill even the grapes and grains than we do the propagation and reproduction of our own species. Marriage is a hap-hazard affair, the result of caprice or fancy, instead of being the result of judgment and knowledge of the fundamental laws of being. Science and the public law, are alone, perhaps insufficient to do justice to this noble cause. They invoke the aid and co-operation of the pulpit and of the public teacher. A wise supervision of this subject is indispensable to the future wellbeing of the race. False standards of delicacy must be set aside. Morbid sentimentalism must give way to the suggestions of common sense and a rational philosophy.

DEPARTMENT OF ARTS.

ART AS EDUCATION.

BY ALFORD PAYNE.

INTRODUCTION.

Having been asked to prepare a paper for this scientific assemblage, I have chosen as a subject, Art as a means of Education. But why comes one, unpractical, unscientific, into this learned body? The answer is, he comes in all sincerity to commend to popular notice, through the prestige given by your academy, a class of truths, as educational, which he thinks are not valued as they should be.

Are we not generally liable, if not to overestimate our own special lines of study, at least to undervalue the departments of knowledge which we have not much considered? Rare is the man, who, with Lord Bacon can make all departments of knowledge his province. The clergyman is thought to live too exclusively in dogmatic theology; the lawyer sees this, and listens with a critical sharpness based on a conviction of the immense value of a knowledge of jurisprudence, coupled with thorough legal training; and he may, perchance, undervalue theology, for, like the physician in Chaucer, his study may be "but little in the Bible." We may trace this tendency in all classes of men, even, it may be, amongst students of physics and artists, and so on till we find it illustrated in the shoemaker who *knew* there was *nothing like leather*. Realizing this tendency in myself, but earnestly desiring to value every department of knowledge justly, and feeling that in this regard, I could ask no better or fitter audience, I ask your attention to Art as a means of Education.

Of the mechanic arts, admirable as are their results, we do not now speak. But our concern on this occasion is with those arts which are called *par eminence* Fine Arts, or more commonly "Art." These serve not for mere material uses, for our comfort, or convenience, or for the facilitation of business; not to sustain the natural life, or even to promote in any way mere physical well-being; but they speak directly to the intellectual and moral nature of man, adding to his stock of knowledge, educating or leading forth his noblest powers, conducting him both onward and upward, by inciting to love and delight in the beautiful and good. How necessary is this moral elevation, we realize from the words of the poet, "unless above himself he can erect himself, how *mean* a *thing* is man!" Art, so understood, is the embodiment or utterance of those ideas modified by the imagination, whose nature it is to awaken sensibility or emotion.

Then how wide the realm of art! Every object in nature, every fact in history, every truth in science, and nearly all such have their poetic aspects, whose tendency it is to awaken feeling, may become the subject of art. Nay, the realm of art extends above and beyond nature; every thought and imagination concerning the mind of man, and its relations; concerning the supernatural; concerning other states of existence; concerning God himself, is the legitimate subject of art. Still more, every influence given to these thoughts and imaginations by our moods and feelings becomes in itself poetic.

The chief elements of art are the sublime, the beautiful, the characteristic, the humorous, the fantastic and the grotesque.

The particular modes of manifestation of art-feeling, or language of art, are poetry, painting, statuary, music, and architecture.

Poetry is art in articulate language; painting, in color, form, light and shadow; statuary, in form only; music, in sound; and architecture is art in the application of beautiful and grand forms to uses, in the construction of buildings.

Having defined art *generally*, let us now look more particularly at art-ideas as differenced in *kind* from truths of science. Scientific truth is statement of that which *is*; it derives its character as truth by virtue of its agreement with things as they really exist.

Art-truth is statement always with regard to these *qualities* of things, which have power to move our affiections. Scientific truth is the actual food of the mind. Being appropriated and assimilated, it becomes actually a part of our intellectual being. By it we grow. By it we advance. By it the world indeed moves. Nearly all scientific truths, have, as before said, their poetic side, and, so considered, become art truths.

The function of truths, of art, is especially to *elevate* the mind and to develop or educate its powers. But the value of art generally, and of art ideas particularly, can only be properly estimated by those who have the noblest and most exalted conception of the human soul and its interests. We wish to be in the highest de gree practical; and to be so, we must exalt those truths which tend to the greatest good. Alas! many, who are often considered practical, value those truths only which serve merely as the *means* of life, and entirely ignore or despise that higher class of truths which concern intimately the *objects* of life, the very purpose of existence. "These men speak," as Ruskin says, "when they speak from their hearts, as if houses, and food, and raiment, were alone useful, and as if sight, and thought, and admiration were all profitless; men who insolently call themselves utilitarians, and, if they had their way, would turn themselves and their race into vegetables; men who think, as far as such can be said to think—that the meat is more than life, and the raiment than the body; who look to the earth as a stable, and to its fruit as fodder; and so comes upon us that woe of the preacher, that though God hath made everything beautiful in his time, also he hath set the world in their hearts so that no man can find out the work that God maketh from the beginning to the end."

Now, that is most practical, which is most useful; and that is most useful, which best serves the purposes of existence; and all admit that those purposes are best served by the most perfect education. This most perfect education is the leading forth, the fullest development of all our powers, and pre-eminently of the noblest powers of our whole nature.

This education, art claims as its direct function. To man alone, of created beings, does art speak.

> "In industry thou'rt mastered by the bee;
> The worm more skillfulness than thine hath shown;
> Thy knowledge, all high spirits share with thee,
> But Art, Oh! man, hast thou alone."

Man has the mind possessed by the animals, and he has more. He has powers far removed from theirs and different in kind. He has an understanding trammeled and limited by the senses, as they have; and he has a judgment which uses the senses for its expression, which is not limited by them, but which makes its affirmations positively, independently, and often in opposition to their dictation.

Sharing the judgment in common with the lower animals, where shall we find the distinction between us and them? Shall we not find it in this, that we possess a *moral* sense, or the power of conceiving right and wrong abstractly as principles; that we possess imagination, that high imagination which "bodies forth the forms of things unknown," as essential to the man of science as to the poet, to a Lord Bacon, as to John Milton; and above all, that power of affirming principles or laws, so surely that we never question them; principles which are the grounds of all mathematical, metaphysical and ethical science; that power whose assertions are as postive and undeniable as that "God liveth."

These faculties we know we possess, and we have as yet no reasons for supposing they pertain to inferior creatures.

Plato taught that in the mind of the Creator, there existed ideas which were the types or patterns of all his creations. Also that human souls are so formed in the Divine image, and so partake of his nature, that they also perceive and delight in these divine forms. Here we have the source of all transcendental philosophy. It accords also with scriptural teaching, for we are told that man was made in the image of God, and this image must have been of the Divine mind. The adoption of this conception underlies the philosophy of a majority of the greatest minds which have been vouchsafed to us. That this faculty of intuition, or direct beholding of essential truth, does exist in us, was held also by Lord Bacon, Dr. Ralph Cudworth, Kepler, Luther, Hooker, Pascal, Leibnitz, Fenelon, Immanuel Kant, Sir Wm. Hamilton, Cousin, Wordsworth, Coleridge, Mrs. Browning, and a host of other minds most influential. Coleridge says, "it is evident that there is an intuition, or immediate beholding, accompanied by a conviction of the necessity and, universality of the truth so beholden, not derived from the senses, which intuition gives birth to the science of mathematics; and when applied to objects supersensuous or spiritual, is the organ of theology and philosophy.

This higher power is the source of all art; and to this faculty all art is addressed. So, the radical meaning of the word poet is, *maker*, and the art faculty is universally called the *creative faculty*. Goethe sings—

> "Oh that the true creative power
> Through all my sense were ringing,
> Like juices ready for the flower,
> From out my fingers springing."

It is apparent that all the forms of musical art, all the sublime conceptions of the great masters, are purely creations. They seem the most spiritual of all the forms of art; there is in them no fitness to awaken emotions either painful or unpleasant; they serve only to elevate and delight us. This is indeed the true end of all art. It may be depraved, as may all things pure; it may even be forced into the service of vice; but the association is so incongruous, that to the reflecting mind, evil is made only the more revolting. It is a question whether any subject which is to a greater extent painful than otherwise, should ever be embodied in art; for example, Landseer's "Death of the Stag," and the group of the Laocoon, and only the beauties developed in their treatment can reconcile us to them.

The scientific man compares truth with truth, fact with fact, and, by a process of induction, arrives at general propositions, or laws; he uses the judgment in accordance with sense, in observing and comparing, and he uses the higher faculty of his reason, in establishing principles. The artist observes particular objects in nature, forms in his mind a general conception of his proposed subject, selects, arranges, modifies, and refers all to the standard in his mind, which is his ideal of beauty, or grace, or power, or whatever quality he may require, and so forms a perfect whole, based indeed *on* nature, conforming *to* it, but which is *not nature*, not imitation, not reproduction, but, as far as it is art at all, *is his creation.* Intimately concerned in this creation is the principle we call *taste.* Taste is the power of perception of those qualities, which, inhering in thoughts and things, render them fit subjects for art. This taste is not judgment, we must carefully avoid this notion, but by it the mind affirms directly and positively. It is to the mind in regard to qualities in truths, what the bodily senses are in regard to sensible qualities of material things, such as flavors, odors, and the like.

We pronounce as positively and independently of judgment, concerning the beauty of a flower, the grace of a musical melody, or the grandeur of a thought, as concerning the sweetness of sugar, or the sourness of vinegar.

To all it is not given to perceive these qualities in the same variety, and with equal accuracy; just as we may vary in perceiving *sensible* qualities. Yet, these qualities remain, and do not vary; sweet is sweet, and sour is sour; and hence, from the unvarying nature of these qualities, arises truth or untruth in the expression of them. Hence, we have truth of beauty, of humor, of power, or of any other element of art.

Possessed with this thought, hear Schiller—

The truth which had for Centuries to wait,
The truth which reason had grown old to find,
Lay in the symbol of the *fair* and *great*,
Felt from the first by every child-like mind.

T'was virtue's beauty made her honored so:
A finer instinct shrunk back, when it saw,
The ugliness of sin, ere Solon made the law,
Forcing the plant unwillingly to grow.

Long ere the thinker's intellect severe
The notion of eternal space could win,
Whoever gazed up at yon starry sphere,
That did not feel it prophesied within!

A glory of Orion round her head,
  Behold her in her majesty!
Her keen glance all but purer Demons dread,
  Consuming where she looks, she rides on high.

Above the stars, upon her sunny throne,
  Urania — the stately, the severe!
But she has laid aside her blazing crown,
  And stands — in Beauty's form, before us here.

She puts on loveliness' enchanted belt,
  Becomes a child, is hailed by simplest youth.
What here as *Beauty* we have felt,
  Shall one day come to us as *Truth.*

Now let us consider briefly, the influence of art in educating and elevating the mind. An artist, gifted with a soul alive to all the influences of sight, and sound, and thought, around and within him, produces a work: it may be an Oratorio; Handel's Messiah; a statue, The Night, or the Day, of Michael Angelo; a painting, The Last Supper, by Da Vinci; a temple, The Parthenon; a poem, or any one of the myriad works which make up the true wealth of the world! In the production of such a work, the artist, by his innate love for, and sympathy with the elements of which we have spoken, perceives them intuitively in objects of nature or in thought, or from his own mind creating these qualities, clothes the thoughts he presents with them, and thus we, who of ourselves might not perceive these poetic qualities, or create them, have them forced upon us, and the art faculty is gradually awakened and developed within us.

And the great art-work which has served us, once created, lives forever. Lives to delight and quicken the souls through all the ages.

That the art sense is so gradually produced, that this is the general process of art-education is I think, the experience of all artists, and we have upon it the testimony of so consummate an artist as Goethe, who gives as his own experience

"For when I think how, year by year,
  This sense hath kept unfolding;
Where once the barren heath spread drear,
  Now springs of joy beholding."

This sense, he speaks of in the verse just preceding, as the "Creative power." And this sense is not unfolded, and these springs of joy are not disclosed, except to the earnest humble votary who waits upon the oracle within. This also, Goethe shows in his enigmatic —

PARABLE.

Poems are colored window-glasses!
Look into the church from the market-square:
Nothing but gloom and darkness there!
Shrewd Sir Philistine sees things so:
Well may he narrow and captious grow,
Who all his life on the outside passes.

But come, now, and inside we'll go!
Now round the holy chapel gaze;
'Tis all one many colored blaze;
Story and emblem, a pictured maze,
Flash by you: — 'tis a noble show.
Here feel as sons of God baptized,
With hearts exalted and surprised.

Art does not only awaken this art-power, but with this awakening comes constantly delight, admiration, love, and all the nobler emotions, purifying and lifting the whole being. Coleridge says of poetry (and what is true of poetry is true of all forms of art), "poetry has been to me its own exceeding great reward; it has multiplied my enjoyments, it has soothed my affections, it has endeared solitude, and it has given me the habit of wishing to discover the good and beautiful in all that meets and surrounds me."

De Quincy divides all literature into two classes; one is of *information*, the other is of *power*. The one speaks to the understanding; the other, to the higher faculty we have been considering, and always through affections of pleasure and sympathy. "Remotely it may travel towards objects in the Lumen Siccum, a phrase of Lord Bacon for the pure reason, but proximately, it must act, or it loses its character as literature of power, in and through that humid light, which illuminates the mists, the irridescent hues, and the glittering points of human passions, desires, and genial emotions," Lord Bacon speaks thus of the influence of poetry: "Poetry serveth and conferreth to magnanimity, and therefore it was ever thought to have some participation of divineness, because it doth raise and erect the mind, by submitting the shows of things, to the desires of the mind. Milton speaks of, "our sage and serious poet Spencer, whom, he adds, 'I dare be known to think a better teacher than Scotus and Aquinas.'"

Nothing has yet been said of the *extent* of the influence; its nature only has been noticed; but where does it not extend, it is every where; we cannot excuse art's influence. It is in our books, our periodical literature, the ornamentation of clothing and furniture, the decoration and refinements of our homes, in music, all rural adornments, in the beautiful commingling of exquisite buildings and gardens, with natural scenery in the suburbs of cities. It is in all architecture, from the most primitive, through the simple but sublime forms of Egyptian art, the chaste and classic elegance of Grecian, to the wonderful variety and exquisite beauty of the finest Gothic cathedrals.

Even the art of past ages, which has been long buried, is being constantly exhumed for us; and as the Palimpsest, or old parchment, from which the original treatise has been obliterated to give place to the chronicles of after times, and to which, art can restore the original writing, so almost all the habitable earth has in it, concealed by the deposition of ages, the life and art of a by-gone world. And these are being constantly revealed to us by exhumation, in Rome, in Greece, in Pompeii, in Egypt, in Assyria, etc., and most recently on the site of ancient Troy, by the wonderful "finds" of Dr. Schlieman.

All this *influence* is *education.* The perception of truth in the simplest forms of art always gives enjoyment, and the realization of the various truths of beauty, grace, and power, which combine in any perfect work, carries the mind beyond delight, to gratitude, admiration, and even adoration. And the "human soul is in the most exalted position, when it reverences; when it adores." This is the education art accomplishes for us; what do we for art?

How long has it, or any branch of it been considered an essential part of an educational course? Thirty years ago, the most done in this direction was through the professorship of Belles lettres in our colleges. This comprised instruction in Rhetoric, and on English authors of all classes; but without any consideration of literature as educational, or any recognition of the value of art in mental development. In the English universities, there was a professorship of poetry, but regarded mostly as a sinecure. In some select schools, young ladies seminaries, etc., claim was made to an art department, because young ladies were there misled and corrupted in their *natural* feeling for art, by exercises in water-colors, Grecian painting, scratching off marble dust, and other puerile quackeries. In our cities the rudiments and practice of vocal music have been not uncommon; but there never yet has been, and there is not now, any practice or teaching of the principles and value of any form of art, in our common schools, in any part of this land, except in a very few instances, which shall soon be noticed. More than this, the most astonishing ignorance prevails generally, not only with the advanced scholars, but among the teachers. It is frequently the experience of artists, that visitors to their studios, occupying high place in the professions, show a wise modesty in the expression of judgment, or show that modesty would have been wise. Critics generally get no farther than to think close imitation the best art; and tell of the birds plucking at painted grapes. Yet this proves not that the art was good, "but," says Goethe, "that the critics were only poor birds."

Too often our critics look into the church from the market-square; they do not step within.

With the teaching of Ruskin a "new departure" is taking place. Schools of design, with special reference to art in manufactures, and ornamentation have been put in operation in several English cities. A professorship of art has been established in Oxford, which is filled by Mr. Ruskin; who teaches the cultured young men of England, the supreme value of the arts in all the refinements of life, and in that development of the intellect and the moral natnre, for which alone life is given, as has never before been done in the history of the world.

In this country, three or four years ago, Walter Smith from London, England, was appointed "state director of art-education for maps, in the common schools of the state." A manual of his system has been published, which consists of graded exercises in ornamental and symmetrical forms. These forms are to a great extent idealized forms of natural objects, or as he calls them, conventionalized forms. He has taught many of the teachers, and is still directing *their* teaching. Some of his pupils are now engaged in introducing his system in the larger cities of the Union, when they can find favor in the eyes of boards of education, as lately in the city of Chicago.

This teaching, as a beginning, I regard as of inestimable value in disciplining the hand and eye, and awakening the mind to the perception of beauty in line and form. Yet in this system, the "picture element" is almost entirely excluded. Light and shadow color, composition, expression and most of the essentials of pictorial art are not at all studied. All this must follow, and this leads me to consider lastly the best means of bringing this wealth of knowledge and feeling home to the minds and hearts of the people; and in this connection, the universality of the faculty to receive it.

Time was, when all science was mystery, and secret guilds monopolized the arts. The philosopher was in league with the evil one. The church said, "thus far shalt thou go, and no farther." All research was unpractical. "What nature hides within," O thou philistine! No finite mind can know.

> "Now that for sixty years I've heard repeated,
> And oft' as heard, with silent curses greeted,
> I whisper o'er and o'er this truth eternal:—
> Nature doth freely all things tell;
> Nature hath neither shell nor kernel.
> Whole everywhere, at each point thou canst learn all;
> Only examine thine own heart,
> Whether thou shell or kernel art."

Where is the kernel of nature? say, but in man's heart.

This element of sincerity with one's self is the first requisite for progress, either in science or art.

Not long since, no one could sing without some special gift.

Now, all can learn to sing, except some rare individual with imperfect organ of hearing or voice. Not long since, no one could learn to draw, without a *special* gift, and now, if a boy shows some aptitude to imitate nature, the fond parents and friends say, "what a gift the boy has!" What a genius he is! Because, perhaps he has drawn a cat or a candlestick so that one may almost immediately say that it was not intended for either a cow or a capstan. A few years back, John. S. Chapman, artist, uttered the truth, that "any one who can learn to write, can learn to draw." And this we now begin to understand. Of course we require gifts; and thank God we have, all of us; and one of the best gifts we have, is the love of beauty, beauty in all its manifestations, in flowers, animal life, in trees and rocks, in streams and skies, in form, and sound, and thought, and *life is full* of it. And the power of enjoyment — which means the art-faculty is as universal as the material provided for it.

"I know I could never be an artist." No, sir, you do not. "I know I have not the gift." Dear Madam, you are full of gifts. You do not know what gifts you have; and your knowledge of them can come only by your development of them.

Of course, these gifts vary in power, as do other gifts, which are presumed to exist in all; the judgment, memory, power of comparison, etc. It often happens, however, that the person most gifted, your genius, will be satisfied with mediocrity, and the humble, slow, but earnest seeker for excellence will go far beyond him. "Nothing" says Sir Joshua Reynolds, is ever denied to well directed effort. When Domenichino was called "the ox," by his fellow students, for his slowness and lack of gifts, his master, Annibal Carracci said, "he is an ox who will till well the field he plows," and he surpassed them all.

What is needed, in my judgment, to make our system of education more complete, so that we may be less onesided, and our powers may be symmetrically developed, so that, as men and women, we m y be rich with wealth, which long lay in us all unconsciously is, 1. To introduce generally in our primary and graded schools, such system of drawing, as that of Mr. Walter Smith, supplemented by simple picturesque designs, with some effect of light and shadow; slight artistic sketches of natural objects. 2. In higher schools, practice on more complex designs from nature, and on good copies from antique and modern statuary; this should be accompanied by some instruction in the first principles of art, and the connection between the arts in their nature and influence. 3. Connected with every state system of education, should be an art professorship. The incumbent should devote all his time to the duties of his office, instructing teachers in the cities, and students in the normal schools, visiting them periodically, lecturing on the elements of art, and directing them in their practice. He should also attend all educational conventions within the limits of his state, and create and continue an interest on this important matter; and, 4. In each of our colleges and universities, should be an Art Department, supplied with a museum of works of art, of all kinds; these should be added to constantly, by gifts from all sides, and the collection would grow with the institution. Each institution should support a professor of the history and principles of art; and lectures and systematic teaching of the history of schools and styles should be given, and of the philosophy of all the arts, illustrated by specimens always at hand, in the museum.

When this state of things exists, the reproach of such general ignorance will pass away; and this will be the smallest gain. Then love of art will be sincere, and intelligent; and love of nature also will increase. Then will beauty come to us as truth. Then will we feel and know the truth, that —

"Freely through Beauty's morning gate,
Canst thou to knowledge penetrate;
The mind, to face truth's higher glances,
Must swim sometime in Beauty's trances;
The heavenly harping of the muses,
Whose sweetest trembling through thee rings
A higher life into the soul infuses,
And wings the upward to thee soul of things."

THE HARMONIC METHOD IN GREEK ART.

BY MR. J. R. STUART.

A great deal is said in a vague way of the ideal in Greek art, as if that ideal were a fixed form or pattern, by which the artist worked out his statues. Were this possible, the art would become a manufacture and we should have statues turned out by the lot, like so much furniture, of the correct pattern. Whereas, the work of the Greek sculptors was the result of constant, earnest study and observation. A lifetime was sometimes devoted to a single work, and, among the thousands of statues produced, there was an infinite variety in the model. The massive muscle of Hercules, the superhuman grace and greatness of Apollo, the matronly Juno and lovely Venus are each a distinctive type. To combine these types, to place the head of Hercules on the body of Apollo, for instance, we feel at once would produce a monster. Each statue must be in harmony with itself, and this leads us to what Walker, in his 'Analysis of Beauty,' has called the "*harmonic method*" of the Greeks.

There are certain general, proportional measures used by artists in constructing their figures, such as eight heads to the whole height, which was sometimes varied as low as seven and a half heads. Six feet (lengths of the foot) to the height, as Vituvius tells us, was the practice of ancient artists. A man standing with arms extended; the extreme extent of his arms is equal to his height. So, also, the measure from the centre of one mamma to the centre of the other, equal to the distance from each to the pit above the breastbone.

There is something needed, however, beyond these rules of general application, and we now approach the chief difficulty, which evidently found a stumbling block to even Leonardo da Vinci. That harmonic method which, strange as it may appear, will be found to afford rules that are at once perfectly precise and infinitely variable. Says Walker. The harmonic method of the Greeks — that measure which Leonardo called "the true proportion;" "the proportion of an individual in regard to himself.;" "which should be different in all the individuals of a species," but in which "all the parts of any animal should be compared to the whole;" and which, as Bossi adds, "Varies in every figure, according to the age, circumstances and particular character of each." In short, this method for the harmony of parts in each distinct individual; this method, presenting rules perfectly precise, yet infinitely variable, has, in all its elements, been clearly laid down before the reader (though not enunciated as a rule) in the *locomotive*, *nutritive* and *thinking* systems, or, generally speaking, of the *limbs*, the *trunk* and the *head*, and in the three species of beauty founded on them.

These, it is evident, present to the philosophic observer, the sole means of judging beauty by harmonic rule, the great object of Leonardo da Vinci's desires and regrets. They present the great features of the Greek method, if that method conformed to truth and nature, as it undoubtedly did. This will be rendered clearer by a single example.

Thus, if any individual be characterized by the development of the nutritive system, this harmonic rule of nature demands, not only that, as in the Saxon English, the Dutch and many Germans, the trunk shall be large, but consequently that the other two portions, the head and the limbs shall be relatively small. That the calvarium shall be small and round and the intellectual powers restricted; that the head shall nevertheless be broad, because the vital cavities of the head are large, and because large jaws and muscles of mastication are necessary to the supply of such a system; that the neck shall be short, because the locomotive system is little developed; that it shall be thick, because the vessels which connect the head to the trunk are large and full, the former being only an appendage to the latter. That the lower limbs shall be both short and slender; that the calves of the legs shall be small and high; that the feet shall be little turned out, etc. So, also, if any individual be characterized by the locomotive system, the harmonic rule demands not only that the limbs shall be large, but consequently that the other two portions, the head and trunk, shall be relatively small; that the calvarium shall be small and long, and the intellectual powers limited; that the head shall be long, because the jaws and the muscles are extended.

Again, likewise, if any individual be characterized by the development of the thinking system, the harmonic rule demands, not only that the head shall be large, but consequently that the other two portions, the trunk and limbs, shall be relatively small; that the head shall not only be large, but that the upper part, the calvarium, shall be largest, giving a pyramidal appearance to the head; that the trunk and limbs, however elegantly formed, shall be relatively feeble, the former often liable to disease, the latter to accident.

It must be borne in mind, however, that there may be innumerable combinations and modifications of these characteristics, certain greater ones, nevertheless, generally predominating.

The following are some of the principal rules, which, either by intuition or distinctly defined, guided the practice of the ancient Greeks:

First, in regard to the thinking system. In the head, in particular, may be observed *character*, or a permanent and invariable form, which defines its capabilities and *expression* or temporary and variable forms, which indicate its actual functions. As character is permanent and invariable, it depends fundamentally on permanent and invariable parts, the *bones*. And as expression is temporary and variable, it depends on the shifting and vital parts, the *muscles*.

The suggestion of the bony structure, then, giving character, and of the action of the muscles, giving expression, we find always represented in a masterly manner by the Greeks, minuter forms which are universal, and without which nature is imperfectly represented. These are details of the highest order, because the means of expressing intellect, emotion or passion. Between these intellectual means, these higher details and those of a lower order, the great artists of Greece distinguished. The lower details, such as wrinkles and folds of the skin, projecting veins, peculiarities of the hair, beard, etc., these have always characterized inferior artists and decadent art.

When the ancient artists increased the facial angle beyond eighty degrees, they believed that an increase of intelligence corresponded to that conformation. By increasing the angle beyond eighty-five degrees they impressed upon their figures the grandest character, as in the Apollo, Venus and others, whose facial angle extends to or exceeds ninety degrees.

Observing the nature of the angle, we perceive that it tended in no way to raise the forehead, but to throw it forward or to lengthen it. Whence the expression of long head for wise head, which has not yet given place to broad head, preferred by German craniologists in compliment to their own organization. The general rule was, that the forehead's height should equal the space from the forehead to the bottom of the nose, or from the nose to the bottom of the chin.

The next rule is in regard to the *form* of the nose, in nearly the same line with the forehead, and with very little indentation between the parts.

The nose is the inlet of vital emotion or pleasure, the eye of mental emotion, while the passions depend on the mouth and ear. The emotional, the higher faculties, were expanded by this raising of the junction of the forehead and nose, while the lower faculties of passion, the mouth and ear were relatively decreased. While developing the higher organs of emotion all impassioned expression was suppressed, and thence the bestowal of that calmness and simple grace, which is the highest quality in all representation. In inferior beings, however, when passion is expressed, the features are varied by the Greek artists, as they are in nature. Such are the great ideal rules for the head and functions of thought.

As regards the *nutritive system*, the vital and reproductive, the Greeks similarily idealize. The Venus of Milo may be taken as the type of this system. The head and torso are all that is visible of the body. The head presents all the loftier qualities already discribed in the intellectual and emotional, but calm, sweet and self-poised, while in the torso, the nutritive system is perfectly developed in the full expansive forms and exquisitely rounded costumes. A representation of eternal perfected womanhood and feminine loveliness.

Next of the *locomotive system* and the ideal rules for *its* treatment by the Greeks.

Of the works of ancient art which have been preserved, the Apollo Belvidere is conceded to possess the highest qualities. In this statue we find all of these principles developed and combined. The full intellectual brow, the thin, quivering nostril and fine yet sensitive lips, the column-like throat, the well developed limbs and trunk, but the last subordinated to the first, the higher faculties of the intellect.

The Antinous is unsurpassed among ancient statues for grace and beauty. But in comparing the Antinous with the Apollo we find, that, when the former fills us with admiration only, the Apollo strikes us with surprise. To, at least, as much grace and beauty as is found in the former, there is a superaddition of greatness, an appearance of something more than human, which one is at a loss to describe. This is the more surprising when we find, that the legs and thighs are too long and too large for the upper parts.

Now, Hogarth suggests that this has been done with a purpose, and that this greatness is really owing to what has been considered a blemish. The Apollo is greater in size than the Antinous, but if we consider a moment, we feel that were the Antinous enlarged to the Apollo's height, this would not produce the superiority of effect. Says Hogarth: "The Antinous being allowed to have the justest proportion possible, let us see what addition, upon the principle of quantity can be made to it, without taking away any of its beauty. If we imagine an addition of dimension to the head, we shall immediately conceive, that it would only deform. If to the hands or feet we are sensible of something gross and ungenteel. If to the whole length of the arms, they would be dangling and awkward. If by an addition of length or breadth to the body, we know it would appear heavy and clumsy. There remains then only the neck with the legs and thighs to speak of. To these, we find, that not only certain additions may be admitted without causing any disagreeable effect, but that thereby, greatness, the last perfection as to proportion is given to the human form, as is evidently expressed in the Apollo."

This is well done by Hogarth (says Walker). It requires but little anatomical knowledge to see the reason of this. The length of the neck, by which the head is further detached from the trunk, shows the independence of the higher intellectual system upon the lower one of mere nutrition and the length of the limbs shows, that the mind had ready obedience in locomotive power. Here again we find the expansion of the higher faculties and the subordination of the lower.

This principle that all the parts of any animal should correspond to the whole, is the same adopted by comparative anatomists in their constructions. But in representing the human form, the Greeks had an insuperable advantage over the modern. Now only were the opportunities for observation and comparison infinitely better, from the habits and costume of the people, but the Greek man himself was undoubtedly developed to a far higher state of perfection, than has been done either before or since by any other people. Jaine has given in his art in Greece a very exhaustive treatise on the mode of life and training which produced such results, the perfect model and thence the perfect statue. It is probable that we can never equal them in their particular branch of sculpture, but by following the method practiced by them, our own work will certainly be more perfect.

We have something analogous to it in the training and improvement in the breeding of horses. The heavy Clydesdale or Norman horse with massive limbs and muscles, at once suggests his fitness for the laborers of Hercules, to whom he is analogous in form, while the lithe form, clean limbs, broad front and quivering nostrils of the English thoroughbred, or the Arab of the Nedjid, suggests the warrior and hunter, the very Apollo of horses. Without doubt, as our jockeys are connoisseurs in the points of horse flesh, so were the ancient Greeks in the points of man flesh, and the method of their artists was based upon such knowledge, cultivated by centuries of observation and experience.

DEPARTMENT OF LETTERS.

LETTERS AN EMBARRASSMENT TO LITERATURE.

By PROF. W. C. SAWYER, of Lawrence University.

Without letters there could be no literature; but with them, its development must be in proportion to the facility with which they symbolize and record our thoughts. Intellectual activity is stimulated through the eye quite as readily as through the ear, and recorded thought stirs the soul only less potently than the human voice.

The utterances of the tongue — not the traces of the pen and the impressions of the types — constitute language. Speech is made up of the symbols of thought; literature, of the symbols of speech, and is, accordingly, two removes from the energies of the soul itself. The tones of the voice, however, travel but a short way and perish before they have reached more than a few thousand ears — not allowing for the possibilities of the telephone — while the recorded words and deeds of buried generations will perpetuate their memory, in many lands and literatures, to the end of time.

There are some reasons for supposing that the present advantage of writing, over speech, may be increased tenfold with the increasing facilities for the production, distribution, and consumption of literature. The chief obstacle to the growth and perfection of our literature is in the mechanical difficulty of writing, together with the consequent evil effects upon reading and general culture.

Leibnitz has said, "Give me a good alphabet and I will show you a good language." The world has been suffering for centuries from the vain endeavor to form good languages — or literatures rather, for the languages have almost formed themselves — without the least regard to the sort of alphabet used. A single language exhausts our score and six letters, and the next is forced to fit this same garment to its altered proportions.

Human speech is made up of the various phonetic effects of the air passing through the mouth and nose, as modified by the tongue, the teeth, the lips, the uvula, and the vocal chords. We know, by the physical laws of phonetic change, that every modification of these physiological organs must produce a distinct sound. No language uses nearly all the possible voice modifications; but each one employs a certain definite number of them — our own using about forty — and makes up for the deficiency of symbols by arbitrarily assigning some group of letters to represent the phonetic elements of each word of the language. One result of this practice is, that in different languages, different powers are given to the same letter. This is rapidly becoming a greater and greater evil, as the study of the languages, especially the modern, becomes more general and more necessary. It is not easy to overcome the power of a fixed habit and give a new sound to a familiar letter. Especially is this difficult when the new power of the letter differs but little from the old, as when, for instance, we learn the continental *o* — a simple sound — or when a student from the Continent learns our *o* — a diphthong. I set this fault of the alphabet among the chief reasons why we come so far short of mastering the orthoëpy of foreign languages. The importance of this feature of linguistic study cannot well be overestimated.

The fact that there are less letters in the alphabet than there are elementary sounds in our language leads to the fatal necessity of employing the same letter in different capacities. This unsettles the powers of the alphabet, and disturbs the logical order of education, even for the children in our common schools. Unfortunately the confusion thus necessitated does not stop with the limit of the necessity. The demoralization consequent upon the unsystematic use of letters with variable powers has greatly increased the burden of a common education. The first letter of the alphabet is given, by some careful orthoëpists, nine distinct sounds, as in *ale*, *any*, *care*, *pan*, *pass*, *arm*, *idea*, *what* and *all*. The same uncertainty attends all the vowels, though the variations are most numerous in the case cited. This leads to the extraordinary phenomenon of representing about fifteen elementary vowel sounds in about forty-seven different ways in the same language. The consonants afford but little relief, the simple surd palatal sibilant being represented in twenty-two ways, requiring in all forty-seven letters. The language affords many examples of sounds variously represented by dissimilar characters, among both vowels and consonants. The habit of representing simple sounds by digraphs like *ph*, *sh*, *th*, *ng*, *wh*, *ah*, *aw*, etc., is very expensive and by no means luxurious. The various spellings of the same syllables, as in *tion*, *sion*, *cion* and *shun*; the various pronunciation of the same combinations of letter, as *ough* in *though*, *through*, *bought*, *plough*, *cough* and *enough*; and the hundred and twenty-four silent letters out of every thousand in an average book, constitute a material and moral burden that the age can ill afford to carry.

Our alphabet could be employed to far better advantage than at present; but its crudeness discourages all refinement in its use. It is barbarous in both its origin and its character. It mingles surds, sonants, gutterals, dentals, labials, and vowels and consonants in such perfect confusion that to inquire for their principle of arrangement could be understood only as a jest.

A startling statement has been made by Mr. James W. Shearer, that only five words in the English language are pronounced as they are spelled. The word *no* is among the number. It has a consonant that is nearly, though not quite, uniform in its use. But the vowel *o* as heard in this word, represents two elementary vowel sounds — the first being the exact contenental *o* and the other a short vanishing *u*, like the vowel of *moon*. This combination corresponds with the name of the letter and its popular "long" sound.

In this word, the sound of *o*, which Mr. Shearer, in all probability, has set down as the proper sound occurs, according to Professor Whitney's table of frequency, only one hundred and seventy-six times in ten thousand words, while "short *o*," as in *not*, occurs two hundred and fifty-nine times. Strictly speaking, there is no knowing when a word *is* "pronounced *as spelled*" in our language, though we can generally be sure that our words *are not* pronounced as spelled.

* * * * * * * * * *

One of the chief elements of elocution is orthoëpy. A careful and correct articulation marks refinement and scholarship everywhere. Nothing is better established in philology than the universal indolence of the organs of speech. This is attested by all forms of assimilation, as well as by the dropped syllables of all the uncultivated Teutonic and other dialects. It is not for euphony that we say *collateral* for *con-lateral*, but for economy of articulation. The *n* contact, of the whole tongue with the hard palate, completely obstructing the passage of the breath by the mouth, is unlike that of *l* by only a part of the contact, the sides of the tongue being withdrawn from the palate or teeth, while the lips remain as before. To save the effort of this slight variation of the position of the tongue, we assimilate the *n* to the *l*. This disintegrating tendency is a force that operates perpetually against the correctness of our pronunciation. Some of the corruptions of utterance are attended with corresponding changes of orthography; but these changes have been capricious, and spelling and pronunciation have become so completely divorced that no rules can longer account for all the disagreements between orthography and orthoëpy.

If the symbols of our writing were exact, all the tendency of reading would be toward purifying, instead of corrupting, our utterances. A distinct symbol for every sound in our speech, with its power fully described and thoroughly practiced in connection with learning the forms of the letters, would correct every error of pronunciation Every written or printed word would then suggest and impress its proper sounds, and reading and elocution could not fail to make the most rapid advance. The orthoëpy of our language is demoralized by its barbarous alphabet, and, till that is reformed, it cannot expect to recover any fair standing.

One of our literary disabilities which we charge, with some asperity of feeling, to our orthography, is the difficulty of rapidly reading, or skimming, books to gain their leading thoughts, or to discover their views upon some special subject. Even under its present difficulties, this method enables a student to make a far wider acquaintance with literature, and to give a better authority to his authorship, than if he should read altogether by the deliberate examination of every page and word.

The mechanical difficulty of rapid writing also, troublesome in every literary pursuit, is peculiarly so in the higher education. The use of lectures, in university instruction, is embarrassed so much by the necessarily slow and burdensome process of writing out the lectures of the professors that we cannot afford to make that use of lectures which is so popular in Germany, and which, but for this obstacle, might be very useful in our own educational methods.

Only five or ten years ago, spelling reform was looked upon as the impracticable notion of a few dreamers. At present, it has the support of the leading philologists of England and America. Indeed, the only work in this interest which is likely to abide, has been done by our foremost linguistic scholars. Reports very favorable to this reform have been made by committees of both the *American Philological Association* and the *National Educational Association.* Some special organizations have been formed, both in this country and in England, to promote this same end. The Germans also have taken active measures to correct the comparatively few and slight orthographic defects of their language. The Royal Commission, appointed by Minister Falk, reported such modifications as violate the historic spelling just about as often as they violate phonetic principles. Such a compromise, though now the law of the Empire, could not hope for great popularity; but it is noteworthy that the complaint that reaches our ears is chiefly on account of the half-way character of the reform, rather than because the sacred order of the letters has been disturbed. Under such sentiments, a Reform League has been formed in Germany aiming to complete the reform, and introduce it into common use. They make a forcible showing of some of the advantages of the reform, in the following mathematical fashion:

"If, after the adoption of phonetic spelling, each child at school were to save only one lesson in spelling every week, that, for sixty millions of Germans, would amount to a saving of five million years. Each child would save forty-eight hours in a year, which, if we reckon each day as consisting of twelve working hours, would give four days in a year, or thirty-two days during the eight years spent at school. Each child would therefore save about one month at school, twelve children one year, sixty millions of German children five millions of years. These might be applied to some better purposes than to find out whether we should write *libe* or *liebe*."

These same considerations apply in English with tenfold more force. If, therefore, the Germans will not tolerate even a moiety of the few phonetic defects of their orthography, what satisfaction can we expect from a half-and-half reform of our own? But our reformers are inquiring not how little change will satisfy the people, but how much they will suffer. They put too low an estimate upon the public intelligence, and are far too sensitive about being compared with Josh. Billings and other gentlemen who spell better in jest than other people in earnest. Fortunately the public is conservative enough to cling to the old system till a better one is found. A reform that needs reforming must always be unsatisfactory. Several systems of spelling by the aid of the old alphabet, with or without modifications, are now before the public. They exhibit evidence of careful study and economy almost heroic. But economy, carried to the pitch of saving a few new symbols at the expense of saddling upon unborn generations another irrational method of writing, becomes a groveling parsimony.

Mr. Bell's system of "Visible Speech" is the most thoroughgoing attempt yet made to form a simple, exact, and universal system of phonetic rotation. This was never intended for general use, and, as Prof. W. D. Whitney has shown, is not perfectly adapted to replace the alphabet; but it has demonstrated the grand possibilities of phonetic symbolism.

Thanks to such men as Mr. Bell, Mr. Ellis, and Profs. Haldemann, March, and Whitney, we have at last a rapidly maturing phonetic science, which is both the indispensable condition, and the sure promise, of a rational alphabet.

DEPARTMENT OF SPECULATIVE PHILOSOPHY.

MR. SPENCER'S SOCIAL ANATOMY.

By H. M. SIMMONS, of Kenosha.

The ancient and hackneyed simile comparing social to animal structure, at length assumes scientific form in Herbert Spencer's last volume ("Principles of Sociology"). His comparison is very ingenious. Individuals are the cells of the social structure; although not in physical contact like animal cells, still through language and various influences they become virtually in contact. The earliest social organizations are small and loose groups where each individual retains a large measure of independence; like a cluster of vorticellae or a sponge, where each cell retains its separate life. But with advancing society the organizations grow larger, population like animal tissue grows denser, and the individual like the cell becomes more dependent on the aggregate, as the differentiation of structure and function advances. A savage tribe, like a rhizopod, is homogeneous, each part serving for any kind of work at demand. But with advance society separates into classes, with increasing division of labor, just as rising animal structure shows its increase of organs.

The first differentiation in Mr. Spencer's analysis is between outside and inside. In the animal, outside hardens and assumes organs of defense and attack, while inside becomes stomach and varied alimentary system. So society separates into an outer class of masters, warriors, and rulers for protection, and an inner class of slaves and laborers for procuring and preparing sustenance. Between inside and outside must be another system to distribute the sustenance when prepared. This becomes circulation in the animal and commerce in the state. Finally in the outer layer of the animal arises a varied nervous system, with organs of sense and will for the regulation of the whole; so in the dominant class in the state arises government with its varied means for obtaining information and executing orders for the regulation of the whole. So in social as in animal structure, Mr. Spencer traces three systems: first, the inner sustaining system, — alimentation in the animal, and productive industries in the state; second, the distributing system, — circulation in the animal and commerce in the state; third, the regulating system, — the nervous structure of the animal and the government in the state.

Mr. Spencer traces the analogies in detail. As the simple alimentary canal becomes divided into organs for mastication, disintegration and the various processes of digestion; so the rude industries of a savage tribe grow diverse in the arts of civilization, with the same method. As for instance, the liver originating in separate bile-secreting cells scattered along the intestine, becomes at length concentrated in a viscus with direct and ramifying branches; so an industry commencing with separate workmen scattered through the community, gradually becomes concentrated in factories and a great manufacturing center.

The distributing system shows still more remarkable parallels. Commerce commences with shifting paths through forests and prairies, like the unwalled and changing lacunæ in animal tissue. But with advance the paths grow straight, and fixed in fenced roads, like the walled blood vessels; and culminate in the double-tracked railroads separating the outgoing and incoming currents, — the arteries and veins of the social structure. These great channels of distribution in their ever-ramifying divisons grow smaller in roads and lanes, and end in unfenced cart-tracks across the fields, — the capillaries of commerce. As circulation commences in the lower animals feeble and irregular, but culminates in the steady pulse of the mammal; so commerce commences in feeble barter, and rising through the irregular fair, comes at last to the steady pulse of the daily market. Here and there a manufacture, like a secreting gland, draws from the current the crude material, which it works over into more refined products and then returns to the circulation. So in the animal and social economy alike, the sustenance is carried where needed.

The regulating system shows a like parallel in details. The lowest tribes are nearly without government, as the lowest animals without nerves. Then comes the rude chief, like a simple ganglion. Then comes the union of tribes, with one and its chief raised to a kind of leadership, like the lower articulate with segments partially subordinate to the head. Then comes monarchy, with its king controlling all subordinate rulers and members, like a vertebrate with its nervous system fully centered in the brain. But, as in the rising nervous structure, cerebrum and cerebellum, the deliberative centers, imperceptibly arising, come to overshadow and control the sensory centers; so in the state, deliberative assemblies, imperceptibly arising, come to overshadow and control the personal will of the monarch, and government becomes constitutional instead of autocratic, reasonable instead of impulsive and passionate. Finally, as in the animal, the internal functions are regulated by the sympathetic and vaso-motor systems acting automatically; so the internal functions of the state, its industry and commerce, come to be self-regulating, and need no interference from the government.

These comparisons, doubtless, seem fanciful to many. But if life is one, as we are learning, then such resemblances are natural. Of course such parallelisms must not be pressed to details of structure; but in functions, they are not only natural but necessary. Society, like any other living thing, must have its sustenance and distribution, and its organs for these functions; and Mr. Spencer's analysis seems in general not only ingenious but true.

But, on a few points, Mr. Spencer seems open to criticism. The animal digestive system seems to correspond not to all the productive industries of the state, but only to the manufacturing industries. Digestion, like manufacture, takes the raw materials of nature second-hand and prepares them for use. Hence digestion is only part of the sustaining function. Beyond the secondary process of preparing the sustenance lies the primary process of getting it. Outside the animal digestive system are organs for gathering food for digestion; and outside of manufactures are the various agricultural, mining, lumbering, and other industries, for gathering from nature the material for manufacture. All these processes, of course, belong to the sustaining system. So the sustaining system is not all inside, as Mr. Spencer makes it, but partly outside. It is outside before it is inside. The protozoon is sustained by absorption through the surface, before stomach cavity arises; and a savage tribe is sustained by the external industries of fishing and hunting before manufactures arise.

This criticism does not injure the parallel, but helps it. In this external part of the sustaining system, we may also trace the analogies between the animal and social structures. As the sustaining system of the rhizopod is a mere surface folding around the food coming in its way; so the lowest savages merely absorb the uncooked roots, berries and molluscs that chance brings them. But with the beginnings of stomach come cilia to entrap and absorb food, and tentacles to range through the water at random and capture prey; so with the beginning of domestic life and the arts, some men become hunters and fishers, the tentacles of the tribe roving at random to entrap and capture game. With advance in the animal, the external organs become fierce with appendages for fighting; so advancing society produces its warrior class to win sustenance by attack and plunder, — the claws and fangs of the social body, growing more deadly as they become pointed with bronze and steel. But as in the rising animal scale, fierce claws at length give way to supple hands and cunning fingers, gathering a better sustenance; so in the social body, the military class in time give place to the industrial, and what was once the claws of the state become the productive hand of civilization, peacefully gathering from field, forest, earth and sea a far richer sustenance than war can steal.

Again, one is forced to ask why Mr. Spencer has said nothing of the *respiratory* system. Respiration is the function most characteristic of and most essential to animal life. The sustaining and distributing systems of which he says so much are purely vegetative, — belong to a tree as much as to a man. But one of the chief differences separating the animal from the vegetable is respiration. The animal absorbs oxygen, and the higher he is in the scale, the more perfect his organs for absorbing it. In the lowest animal the oxygen is absorbed from the water through the general surface of the body; then through specialized places on the surface, which in time fold and branch into gills; finally it is absorbed more rapidly from the air through the perfect lung of bird and mammal. Respiration seems the special mark of the rising animal, and comes to be the most important function of all. Eating may be omitted and the sustaining system lie idle for days; but not breathing. Consciousness may be suspended and the regulating system deranged; but the respiration must go on. From respiration, too, come the warmth and energy of higher life. The contrast between the torpid reptile and the frigate bird which, as Michelet says, "takes his breakfast on the Senegal and dines in America," comes largely from the contrast in breathing powers. Even that higher life we call spiritual is as closely linked with the breath as its name implies. Foul air dulls and fresh air quickens the thought. Even moral excellence seems somewhat dependent on good breath. "Let everything that hath breath praise the Lord," says the Psalmist, and probably nothing else will. The old fabulists were wise to figure Satan as a dragon, — a poor-lunged creature, perhaps one of the extinct gilled halisaurians. High life comes with breathing. To the sustaining and distributing systems of the vegetable, must be added a respiratory to make the animal; and it seems strange that Mr. Spencer should have omitted this from his parallel.

We may not be able to trace the social gills and lungs or any details of the respiratory structure, but the respiratory function is plain in society. Respiration means consumption. Breathing is burning, and the different methods are only so many ways of keeping the fire. Gills furnish a poor draft; perfect lungs show pipes, chimney, and heaving bellows at the bottom, and keep the animal well burnt out. Stomach and lungs balance each other. Stomach feeds and lungs eat; stomach accumulates and lungs consume. The tree gathers and keeps, and so grows bigger every year; the animal gathers and spends itself, turns its fiber into force, warmth and action, and so after a little does not grow bigger, but grows better, ever burning out the old and keeping itself renewed. Respiration means consumption of old tissue.

Society shows this process,— not the mere consumption of which the political economist speak, but the deeper consumption of the social tissue itself. Men whose work is done are removed like worn-out cells from the body. As even the older and solider framework of the body is slowly removed, and our very bones change; so even the older and more fundamental institutions are slowly consumed and renovated in a healthy state that breathes and lives. As this process of consumption works in nerve and brain more rapidly than anywhere else; so in a healthy society, thought and opinion show still more rapid change, as old errors are abandoned and new knowledge gained. This respiration in society as in the animal, brings higher life by removing the effete and poisonous elements from our institutions. Buckle said the best work of legislators had been in undoing the work of their predecessors. Advancing knowledge and thought do, indeed, eat away old opinions as oxygen consumes the brain, but like that, for good. No need to restrict thought. There may, indeed, be social stages to which knowledge is fatal, as free air is to fish. But we need not on that account restrict thought, any more than we enact laws to keep fish in the water. Few men are too eager to come out into the higher air, and whoever will, let him. Some think this is the way lungs have come. It is safe for society to absorb its gills and develop lungs as fast as it will. Knowledge and thought do indeed, like oxygen, burn out old errors; but like that, respect life, and harm nothing good. In state and body alike the organism's own vitality is ever renewing the wasted tissue, and giving us better than we lost. The respiration which consumes is yet the breath of life.

With all these parallels between the animal and social structure, we should note one contrast, to which Mr. Spencer refers. Consciousness does not become centralized in the state. There is no social sensorium. In the social body, unlike the animal, consciousness is retained in each individual cell. So much does individualization seem to be one of the ends of nature. Constituting one body, we yet remain separate persons. Growing ever more organized in one social structure, we become ever more personal too. These two processes go on side by side, — the organization of the whole and the perfection of the parts.

NATURE AND FREEDOM.

BY JOHN J. ELMENDORF, S. T. D.,

Professor in Racine College.

Problems which concern the will have always been favorite questions with American psychologists. There has seemed to be a special fascination in the problem of reconciling the thought of an infinite, omnipotent Being with what men know, or think that they know of freedom in themselves? I do not hope to add anything towards the solution of the question; on the contrary, I only allude to it because I desire, as far as possible, to exclude it, in order to consider the relations of man to nature, of the free thinker to that phenomenal world which is one of the most attractive objects of his contemplation and study.

I notice at present a wide divergence between philosophy in its strictest sense, as based on analysis of the necessary thought of the free *ego*, and sciences of nature; i. e., of the world of phenomena which are observed, classified, and made the objects of induction, along with an attempt at founding a philosophy upon them exclusively.

The spheres of the two seem to me to be far apart, and their methods, though each involving the other, essentially different. On the one side is the domain of intelligence, freedom, will, consciousness, morality, duty, activity. Here is an intelligence so absolute that it hardly seems to be individual, because its note is an absolute oneness in all men; here is a will, an activity, which is identified with our own personality which attends to and observes all outward phenomena, all inward states, seeks to find their unity and their laws, and demands the *how* and the why in all things. It criticises itself, and sits in judgment on its own faculties. To understand it, our method is necessarily introspective, and analytic of any concrete act of volition or of intelligence.

On the other side is a world of phenomena in which apparently rule blind necessity, unvarying, inflexible order. We are sensitive, but passive beings in their presence. It is the realm of effects which we are regarding, effects transferred, transmuted, but, so far as we can discover, unalterable. We see how, conditions varying, the consequent varies, and therefore can conceive of unlimited change. But because nothing is self-moved, we must regard this phenomenal world as passive. (If we apply to it the term activity, we merely mean the transfer of an impulse received, not self-produced, and measure the result by the antecedent.) Its characteristic note is individuality; generality, law, is the mind's discovery, and what the mind reads on that printed page of nature. If we seem to find intelligent will any where, there we know or assume a second *ego* like ourself.

Our method is inductive from these phenomena. Analysis, if employed, is for reducing the complex to the simple, nothing more; we group and classify, and, by induction, construct our chain of antecedents and consequents. Further than this we cannot go, and even the very validity of our inductive process itself carries us out of this phenomenal sphere into the other on which it rests.

Here then are these two spheres so unlike to be received. What is their unity? How shall the man who is exclusively devoted to one of them "s' orienter," by getting a fairer and fuller view of the truth. Can the scientist reconcile himself with the philosopher; the believer in human freedom, morality, divine law of conscience, intelligence, obligation, the student of metaphysics, the "science of the sciences," with the strictly scientific observer whose mind looks outward at phenomena reflected in impressions on himself? The problem opened is a wide one. I desire to offer only a few matters of thought.

But, as preliminary to the discussion, it may be well to notice the wide difference in the very nature and habits of men themselves, in the tendency of different eras. One man; and such will be a leading representative of our own age, is a most acute observer of natural phenomena; from earliest childhood he has been observing, collecting, comparing, trying experiments; and his whole end is given to his noble work. Bring before him a new fact, a trifling variation in a familiar species, the prospect of some new discovery in nature, and to the eagerness of a child is added the prompt grasp, the far-reaching vision of the scientist of our day. But try him with some philosophical theorem, the very one, it may be, which he himself is unconsciously assuming; it glides off from the surface of his mind, making no impression there; or, if he venture on philosophical statement at all, it is of the crudest, most disjointed, or even inconsistent nature. He would not be the true scientist, which he is, if he were equally prompt and clear in the sphere of metaphysics. On the other hand, there have been certain periods when men would have found these remarkable facts about the moons of Mars, or the fossils of the far West, the most barren or trifling topics for a rational man's interest, and viewed with a smile or with pity the busy triflers who so wasted their time. Instead of the fact, they could have demanded the universal, the idea. Until they had found that, they would seem to themselves to have no place on which to plant their feet, and would totter as on quicksands. We must willingly accept these differences, cheerfully grant to each class its sphere and only desire that each should kindly recognize the other. Let the scientist, like the shoemaker, "stick to his last," see where the limits of his science are, wide enough, indeed, for any mortal man, but that outside of them lies a "science of the sciences," which criticises, regulates, judges his conclusions, so far as they can be abstracted from the particular facts where he alone is supreme.

I begin with a brief

HISTORICAL RETROSPECT.

In the Nicomachean ethics the profoundest thinker of antiquity only incidentally touches the question before us, while seeking to ground the principles of virtue and vice, of responsibility, of rewards and punishments, on the free, active principles in man, because the passive, i. e., impressions, sensitiveness, "nervous shocks," as Spencer calls them, are not in our own power, and they therefore contain no foundation for responsibility. With his strong, good sense, Aristotle simply regards as voluntary what we know in consciousness to have an intrinsic principle of action, and consciousness is accepted as an ultimate criterion in all knowledge, without any attempt to discriminate between the conceivable, and the objectively true. We originate our own neutral action or energy. Whatever be the motives, or "con-causes," the mind is known in consciousness to be active; and not, as it might appear from another point of view, the merely passive recipient of impressions coming from without, which it in turn communicates, as a sort of electric telegraph.

The involuntary is found where the passive predominates, i. e., where the principle of motion is from without. Aristotle also makes a distinction, instructive enough, between (1) will, as above described, seeking an end prescribed by nature, an end necessarily sought, i. e., a will, "determined;" (2) will, *βούλησις*, which adds hope of obtaining that end, (3) deliberate preferences *προαίρεσις*, which is the intelligent choice of particular means for getting that end, the intelligent action of a rational man knowing what he wills, and selecting the means, which can be clearly distinguished from irrational desire in man and brute, which pushes equally both of them towards an end, with apparently the same determined necessity as the unknown force by which a crystal is shaped into one form and cannot take another.

This being the free man, as Aristotle views him, his reason which is hardly personal and individual in his proper self, discerns certain necessary principles, apodeictic truths, no matter how he got them, assumed in every thought. They are not derived from any special science, but underlie all sciences. They admit of investigation, analysis, rigid statement not of proof. They constitute the first philosophy.

In Aristotle's physical treatises, we find the objective world, as far as the thinking mind, had then explored it. Thus, the problem is opened; Epicurean and Stoical morals, necessarily touched the question before us; I am not aware that any step further was made towards an answer.

Christian dogmas necessarily give an added importance to the question, and it is prominent enough, from St. Augustine's time, through the middle ages; but the aim was, not to reconcile freedom and nature, but to find how the infinite and absolute stand, towards the finite and relative. The question of determinism and liberty, of indifference, which I have said is not before us, otherwise Aristotle's analysis of will, rules eighteen centuries; to move voluntarily, is to move, *a principio intrinsico ;* man judges of the means to attain ends, which he understands, and selects those means.

But when the tendency of thought began to desert the "Gnothi seauton" the one aim of so many ages, and to attend to the phenomena of an outer world, revealed in consciousness through our senses, phenomena, so strangely undervalued, by many leading minds before ; then necessarily arose a new impulse to thought, concerning nature and freedom. I regard Hobbes, as the representative thinker of the new era. It is well to place him with reference to his age and circumstances. He is secretary to the Lord Chancellor, who collects "centuries" of observations on sounds, fruits, plants, etc., and who without discovery or original thought, gives a new impulse to empirical science, showing us the "promised land," which he did not enter, and calls metaphysics, a spinning of spiders' webs out of the thinker's brain. Kepler was dead only some ten years. Galileo, was just buried. The Royal Society, itself, just founded, along with other such societies throughout Europe, is the clearest indication of men's minds, outward to the phenomena of nature. A philosophy for their science was indispensable, and Hobbes provided it, the "patriarch of positive philosophy," as Comte calls him. We know only, says he, phenomena and their chain of sequences. Contrast this, with the previous philosophy of which Dante is the popular representative. Proceeding to nature from what is known in consciousness of the active *ego*, and reasoning by analogy, there would be nothing unphilosophical in the assumption, that natural phenomena are caused by the active and productive power of spirits like us ; and this is Dante's theory. How different with Hobbes ! The phenomena of the active *ego*, are by him, little regarded. The mind is almost or altogether a passive thing, moved as other passive things are moved. So it takes its place in nature's chain of many links, pull on any one, the whole is moved ; or rather, this chain pulls itself ; freedom has disappeared.

And yet the opposite aspect of the truth obtrudes itself once more, under the name of "force," only there is no honest analysis of the meaning of that convenient symbol; no strict interrogation of consciousness, no straightforward endeavor to ascertain what it is, of which we are conscious; what phenomena, what processes, what results. The belief that our thought, our mental act, the force we exert is free, is itself a phenomenon the most constant of all phenomena; it requires to be accounted for. If our consciousness is false here, it may be false in any thing. "I will," "I will not," a child's word, clearly distinguishable from, "I want to etc," "I do not want to, etc.," raises three questions to which Hobbes, gives no answer. 1. What does it mean? 2. Where did the reality it expresses begin? 3. How, by introspection, do we become aware of it, and try to account for it? While Hobbes fails us here, it may be doubtful whether his method, though developed, has since yielded a better or a different result.

Locke, with his analysis of power, as "a simple mode, whose idea is derived from choice or determination," evidently seems to be reinstating freedom once more. But the mind is regarded as passive in the formation of ideas, and Hume's subtile criticism causes it to disappear altogether. So the question of its freedom necessarily vanishes with it; and as for metaphysics, the best synonym for them, is a want of common sense. We owe to two men, it seems to me, deliverance from this excessive preponderance of the phenomenal, the passive, as a factor in thought — to Reid and Kant. The latter, perhaps will give an impulse to thought, in which objective nature will once more disappear, remaining only as modes of the *ego*, so that we shall merge the objective in an extreme idealism; but the sharp distinction in self, of desire, from rational will, the clear discrimination of the empirical, both as object and as method, the domain of the sciences, from the universal; the domain of philosophy with its own special method of analysis, of institutions and interrogation of consciousness, these, if once grasped, are an anchorage amid these fluctuating waves of thought.

But to Reid's strong Scotch common sense, albeit somewhat superficial, we owe some principles which we are not likely to lose:

1. Already intimidated by Locke, that active power is conceivable only in a being possessed of will and intelligence. Whence came the ready inferences; *a*, that sciences of practice, deal only with a series of consecutive phenomena; *b*, that cause, either efficient or final, is not an element of those sciences; *c*, that in such sciences, force is a mere abstraction, an unknown, undiscoverable; force necessarily assumed throughout, since we are studying its effects, but left as an unknown quantity without inquiring what more it means than what we see; and *d*, that Prof. Tyndall, has made a mistake when he wandered from heat, sound and glaciers, which he understands, to dabble in philosophy, and will prove himself a true scientist by confining himself to his proper work, where he will have all the honor and success which he so justly deserves.

2. We have learned through Kant and Reid, that law or will in nature, is fundamentally different from cause or force; the one, which J. S. Mill has so well analyzed, the invariable sequence of phenomena; the other, a thing incapable of definition, perhaps, as being an ultimate principle, yet, found everywhere in language, because, in its concrete reality, it is in all men's thoughts and experience.

3. That free choice is directed to an action willed, being the choice of means to an end, while desire is of an end.

4. That will, by repeated actions, creates habits, not instinct, which is a name for another unknown x in the sphere of nature, not of consciousness. I mean that a certain series of effects are seen in brutes, and something like them in men. Not knowing any more, we group them and then call their unknown cause instinct.

5. As the result of all these, that metaphysics, philosophy, has its own sphere, as the sciences have theirs, and we shall do well to separate them.

Finally, to conclude our historical retrospect, we have Spencer, with his American disciple, Fiske, endeavoring once more to construct a philosophy of the phenomenal in aid of contemporary science. That both of these writers fail to give an account of the phenomena of consciousness is a verdict which cannot here be justified. That the problem of nature and conscious freedom is not to be solved by annihilating one of its factors, I will not repeat; but will only ask that an analysis of mind, whose ultimate point, is element of mind equals nervous shock, even if it allow Mr. Fiske to substitute "psychical shock" must necessarily fail to satisfy many who earnestly seek for truth. For it leads us to ask,

1. What are elements of mind in *me*, whose self is known, if known at all, as an enduring, invisible unit; at least that is what I mean when I say "I," and you must first prove that I am wrong; and in doing it, you also will use the same word, and I shall understand the same enduring, indivisible unit in you.

2. What one-sided tendency led a writer on psychology to employ nervous shock as the ultimate element of mind?

3. Call it psychical shock, and what is the thing that is shocked, not known apart from its shocks; but known as shocked? Or, if the question be relegated to the unknowable, how is a shock of self related to a perceived shock of the air, or the inferred shock of an electrified body? A figure of speech settles nothing in philosophy or science. One of the above is a fact of consciousness referred to self; the other, to something outside of *ego;* the air, when the brain is shocked.

4. Granting that Spencer and Fiske have rendered some account of the passive factor in phenomena, what is to be said of the active, which our consciousness reveals and Mr. S., we presume, employed in finding out his explanation?

An historical retrospect is instructive as showing the tendencies of thought, and giving some account of opinions now prevailing. I come to the

PRESENT STATE OF THE QUESTION,

Is any reconciliation possible where there is such wide divergence? Only, I maintain, when we acknowledge and keep steadily in view the dual aspect of the truth. This is not by any means a fundamental dualism, from the metaphysical point of view. But sciences of phenomena, as the accidents of true being, may be separated by their objects and methods, from the science of true being with its proper method; whether we are dualists or *monists*, while we still recognize the mutual dependence of the two spheres of knowledge which necessarily involve one another. Entire disregard of either side, subjective, or objective, active or passive, phenominal or real, material or formal, to employ the old phraseology, widens the gulf of separation. Frank acceptance of different methods in different spheres for different ends may aid both parties in reaching the common meeting place.

Nature is all around us, and reflected within us, inviting us to investigate, to master it. Phenomena are to be carefully observed, experimentally produced, classified, and referred to general laws. This is the objective, the passive, which the free conscious thought of man is reducing to order within him by discerning the order in it, and without him. Thence come to us the notions of constraint, of necessity, of energy communicated to something which is passively removed, and of invariable sequence. And this is all that the mind thus knows. It knows no power, no cause; but only a transfer, merely of sensible effects, whose resultant always remains the same, and it arrives at that consumation of physical discovery, the conservation of energy. Thus far I believe all are agreed, for the analysis of the empiricist himself finds nothing more than this in cause or force. The mind indeed requires an attraction called "force" to account for these effects, because the free soul demands that they shall be accounted for. But it will only confuse language and thought, to confound such an assumption, giving unity to sensible results, with intelligent will in ourself as a name for our spontaneous activity which we know in exercising it, or with cause as expressing a notion derived from our own spontaneous and productive activity; which also we know in exercising it.

Let one travel on the road of the senses as far as he may, he is still at an infinite distance from the infinite form which christians call God, and from his own free self. For no aggregate of phenomena is any more than an aggregate, even when it vanishes in the indefinite, which we are so apt to confound with the infinite; this indefinite sum of phenomena has not led us a step towards active being, finite or infinite.

Beside nature, then, is this active *ego* of ours, attending by its intelligent will, to this wonderful world of phenomena; conscious that itself chooses to regard, now this one, now that one of its own passive sensations and feelings; that it actively moves from within to meet influences which it does not produce, and intelligently applying rational laws to their investigation. The free soul is conscious, indeed, of motives to ends which it cannot help desiring; but it intelligently chooses means to reach those ends. In concrete application, it were folly to deny this. It is only the abstract and universal form of it which the student of nature may ignore or oppose. Here there are facts of a different order from those phenomena, from even those phenomena of sensibility, which also consciouness reveals to the attending mind for its scientific inductions, inductions which themselves are based on those higher truths.

To develop this point may delay us a moment. And avoiding as far as I may, any metaphysical question connected with the will, I offer, as a test of the distinction between nature and self-freedom, our intelligent consciousness of motives and of purposes in our mental action. It is evidently possible to overlook the very starting point of investigation, which is that, in mind, as a unit are the willing, the motive, and the purpose. While even so subtle a thinker as Edwards, analyzing what is essentially one, may put motives on the one side, the *ego* on the other, and calculate the force which one part of an indivisible entity exerts on another, as if he had a problem in mechanics to solve, and may easily prove that the movable part is moved in the direction of least resistance, or strongest repulsive force. But "determinism" is not our subject. The facts given in consciousness are these. We know what end we seek, i. e., we know our motive; we choose the means with deliberation, in our own purposes look forward to the future, and determine our future acts. Language informs us that other men do the same.

But pass to the sphere of nature, of objective phenomena, and internal, passive states. It is necessarily present. Its past is in memory, in our mind. Its future only prophetically there. There is no possible induction which can put motives or purposes there, until we introduce the notion of an intelligent being ruling nature. Anthropomorphically, poetically, or philosophically, if you will, it may be affirmed, but no *inductive science* can inclose conscious intelligence within a crystal or an art, as certainly as we know our own in considering our motives. For who pretends that when a Colorado beetle lays its eggs on a potato leaf, it has in view the prospective comfort of future larvæ?

Motives, then, may be regarded as "con-causes," as conditions of natural action, for this intelligent *ego* of ours acting, but not acting towards anything or for anything, is inconceivable; it is nonsense. And we know also that we do not create the ends which we seek. But, on the other hand, to consider motives without regarding the mind's assent would contradict our continual experience. We may, if we will, ask what causes the assent; but we shall find no answer. To transfer physical associations to the facts of self-consciousness would be unscientific. We can have no induction from phenomena, because the very concept of power of cause is not in them. Experience simply tells us that we will, assent, move mentally, and then something outward follows. But it is a universal experience that when we do not assent, we do respect, when we assent, it is mental motion, when we energetically assent, we act energetically.

I work, finally, to obviate some possible misapprehension, and anticipate some objections. In the appeal to consciousness, nothing is said of the sphere of the unconscious in its relations to mind, because the question belongs to philosophy; the inductive sciences as such have nothing to do with it. Neither is a dualism in the sphere of being either maintained or denied, but only the contrast between inductive sciences based on a series of consecutive, and, so far as we see, inseparable phenomena, and the philosophy of the free self, its thought, its intelligence, its relations to nature on the one side, and the Infinite and Absolute on the other.

1. We hear much of the universality of law. But, on finding by our analysis, as an ultimate factor of consciousness a free self, energizing from within, we do not find its freedom to be an exemption from law. Büchner, in his "Matter and Force," most unjustifiably assumes this. The error is like that in theology of

assuming that the miracle is a violation of law. If this were the case, then the contrast between the free subject, and the passive object in which we always discover law, would be greater. But exemption from law would be irrational, immoral, blind chance, precisely what the soul is not. But this freedom is consciously and intelligently taking to one's self a law which, as the "categorical imperative," is reason's universal law, this free self-discovery. It is by this that we are brought into due relation to the world of rational beings, and freely take our place among them, citizens, not slaves, in that illustrious commonwealth.

It is *ego*, also, which discerns law in nature, and, by assenting puts its free self under that, using nature's laws for its own ends and purposes. Because freedom is not in nature, we could not think of advising crystals how to form, nor of counseling the society of bees, nor of exhorting the birds; though we may separate and combine the energies of these slaves of nature to serve our plans. But because we believe that other men also have self-freedom, and language utters free thought, we speak of rights, justice, counsel, advice for free men. If sciences of nature have no place for these, and I do not see that consistently they have any, then empirical, inductive sciences are not exhaustive of truth; and, instead of awkward attempts to insert them where they do not belong, it would be better frankly to acknowledge the two-sided aspect of the truth.

2. It may be objected that if a man's character, if all his antecedents, circumstances, motives, were known, his actions could be infallibly predicted, and, consequently, he is a part of nature, and his mind wholly an object of scientific induction.

But I reply:

1. That this proposition itself is not a scientific induction from observed facts. For these are only of the present; the past is retained by mind; the future is not given at all. Neither in this case can we verify our prophecies, and so confirm our hypothesis, since all turns upon an *if.* The subjective sphere to which the objector refers is only known in our own consciousness; so he either begs the question, or asserts only that self, under these conditions can predict its own acts.

2. If the objection states a fact, it means only that self-freedom is moral and rational, logical and orderly, and so *ego* freely assents to and follows its own laws. If we knew the order, and could look forward through the aims and intentions, i. e., if we were the very individual in question, we could predict his course, presuming him to be as rational as ourself. How this resembles the prediction of an eclipse, where the phenomena are objective, are before the eyes of all, I fail to see.

3. Lastly, it may be said that, after all, the problem is not solved. I do not say that from the metaphysical standpoint, consciousness spans the gulf between mind and matter; between subject and object. It is sufficient for my purpose, in pointing out the limits of the sciences of nature, that those sciences being purely inductive from phenomena, whether of external sense, or of internal sensibility, must regulate these critical questions to philosophy as being out of their sphere. The moment we regard the results of will in our own limits, we have passed into the sphere of nature and the sciences; we are to search for the invariable antecedents of the lifting of our arm, and may, possibly have a regret *ad inf.* in the transmutatious of energy. We find no production; action and reaction are equal. Perhaps a molecular vibration in the brain is transmitted into motion in the fingers, which vibration has also its antecedent, loosely called, its cause. But what we know in the mental spheres, is pure and true activity. We not only desired to move our arm for rational ends, we willed it. Experience only has shown its result in the outward sphere, etc., that the arm moved. We might have willed and no such result have followed. But, the antecedents being there, we expect the consequent, and even introduce that strange word necessity, the consequents *must* follow, which surely the experience does not contain.

Consciousness does not span this gulf; the objection is admitted; yet as a known fact, the free self directs its act towards this other phenomenal world, even in examining it, classifying its phenomena, and reasoning upon them. How, then, can he who explores the heavens, ignore the existence of his telescope? In other words, how can the devotee of nature ignore his own mental existence, while in every word, he is declring his own spiritual activity and freedom?

Consciousness may not tell us how we pass from subject to spirit; from mind to matter, though it may clearly reveal the fact; but to make the *ego* convertible with a nervous shock or any part, or the whole sum of sensible or conceivably sensible phenomena is spanning the gulf by ignoring one side of it. Spencer and Fiske try to translate the force, the active, into the passive, the externally necessitated; the proportion, I act, I am acted upon; and so thought becomes confusion, language, empty babble. We know not how to argue with certain thinkers; for we find ourselves carried back to the premises which we, with the rest of mankind, have assumed as not needing proof. Premises are treated as assumptions, till finally nothing remains admissible except individual impressions, "psychical shocks," and we do not know why we should admit these, since there is nothing left to be shocked, or what to infer from them, since we ourselves, the observer and the reasoner, are only a series of these shocks.

In summing up then, I find the position of Reid, for the scientist, a sufficient and practical foundation. In nature, causes so called, J. S. Mill, has well enough analyzed, as invariable sequences. I see no occasion for controversey, if we understand our terms. But the constant use of such words as "causes," "force," in different sense, seems to me to aid the old logomachy. Causes, in the sense of efficient and productive power, or purposes intelligently aimed at *i. e.*, final causes we see not in nature. But consciousness goes along with our observations; consciousness of voluntary attending, generalizing, inferring; *ego* a mirror reflecting the objective, but arriving at results in another sphere than that of images, and attaining ends which we aim at or produce. From language we cannot elminate this side of the truth; "I make," "I produce," "I cause." Something sensible, indeed may follow, but "I will this volition" is an ultimate fact, admitting of no further analysis, except it be that of Des cartes' "*cogito.*" If it be itself, an effect, no consciousness declares it to be so, therefore we have no object of scientific inductions, the subject-matter belongs to philosophy. Motions are not causes; neither of them are invariable sequences. The two former are in the mind, as aspects of the active self, and by its own laws referred to other beings, as similar activities: the latter are in the mind as observers of passive results which it only observes.

As there has been a senseless irrational antagonism between science and the christian faith, whose methods and spheres differ so widely, so these may seem to be between the empirical road, the broad high-way of the science, and the narrow, difficult path of metaphysics. But the antagonism is not real. The aims are different, the mental powers employed are distinct, the method, consequently, is different. The instrument of the one is induction, of the other analysis. The scientist has sometimes vexed us, sometimes provoked a smile, by the assumption that all things in heaven and earth are subject to him. But we have looked again, and there was speaking another free, proud self, like us; he has been taking for granted what we wished to understand, or, at least, to investigate more closely by asking, how he knew, and with what, and by what does he know anything, and so we only smiled at him, and said, let us both go our several ways, and do the best we can for the truth.

DEPARTMENT OF NATURAL SCIENCES.

NOTES ON CLADOCERA.

By EDWARD A. BIRGE, Ph. D.

During the past three years I have collected Cladocera at intervals. The group has been little studied in this country, though thoroughly worked up in Europe. I have found several new forms, including one new genus, and now publish a synopsis of the work hitherto done by me.

I give only the more important references under the synonymy The works most useful for reference on this group are:

O. F. Müller, Zoologiæ Danicæ Prodromus. 1776.

" Entomostraca. 1785.

Jurine, Hist. d. Monocles qui se trouvent aux environs de Genève. 1820.

Liéven, Branchiopoden der Danziger Gegend. 1818.

Baird, Natural History of the British Entromostraca. 1850.

Fischer, Ueber die Crustaceen aus den Ordnungen der Branch. und Entomos. 1851.

" Ergänzungen, Berichtigungen und Fortsetzung zu der Abhl. ü. d. in der Umg. von St. Petersburg vorkommenden Crustaceen. 1854.

Liljeborg, De Crustaceis ex ordinibus tribus; Cladocera, etc. 1853.

Koch, Deutschlands Crustaceen, etc. 1835.

Schödler, Neue Beiträge zur Naturgeschichte der Cladoceren. 1863.

" Die Cladoceren des frischen Haffs. 1863.

" Zur Naturgeschichte der Daphniden. 1877.

Leydig, Naturgeschichte der Daphniden. 1860.

P. E. Müller, Danmarks Cladocera, 1868..

Kurz, Dodekas neuer Cladoceren. 1874.

Weissman is now contributing some very valuable papers on structure and physiology to the Zeitschrift für Wissenschaftliche Zoologie.

In my notes, all the above papers are cited by the name of the author, or, if necessary, by adding to his name a single word.

SECTION 1. CALYPTOMERA. Sars.

Family 1. Sididæ.

GENUS 1.

SIDA. Strauss, 1820.

SIDA, Strauss, 1820. (Mem. sur les Daph. Mem. Nat. Hist., VI, 157.) Liéven, Liljeborg, Leydig, Baird, Schödler, Sars, P. E. Müller, Kurz.
SIDÆA, Fischer.

SPECIES 1.

SIDA CRYSTALLINA. O. F. Müller.

DAPHNE CRYSTALLINA, O. F. M. Zool. Dan. Prod., 2405.
For the long synonymy of this species, see P. E. Müller, Danmarks Cladocera, p. 101–2.

There appears to be no well marked difference between our species and that of Europe. I wish to notice only one or two points with regard to it. Claus (Zeit. Wiss. Zool. Vol. XXVII) asserts that he has seen a second maxilla in Sida. I have looked for it carefully, and under most favorable circumstances, but have failed to find it. I am inclined to question its existence. The appendage has been seen by no other observer, not even G. O. Sars.

The projection on the inside of the basal joint of the legs ("processus maxillaris," Sars), is triangular in shape, with ten stout spines and a large number of setæ. This may be homologous to the "appendix interior" (P. E. Müller) in Pollyphemus.

Cambridge and Southampton, Mass.; Madison, Wis. Quite plenty everywhere.

GENUS 2.

DAPHNELLA. Baird, 1850.

DAPHNELLA, Baird, Schödler, Sars, P. L. Müller, Kurz.
DIAPHANOSOMA, Fischer.

SPECIES 1.

Plate II. Figs. 1–4.

DAPHNELLA EXSPINOSA. sp. nov.

Length, circ. 0.85. mm.; height, 0.4 mm.
Length of head, 0.25 mm.; of valves, 0.60 mm.
Diameter of eye, 0.07 mm.

Length of head less than half that of the valves. Antennæ reaching only about two-thirds the length of the valves when bent backward. Post-abdomen without caudal teeth. Eye large.

The valves are marked only by the ends of the "stutz-balken." Their edges bear numerous small, movable spines (0.0013 mm. long). The shape and general proportions resembles those of D. brachyura (Liéven). There are, however, marked differences in details.

The indentation between head and body is greater than in D. brachyura. The post-abdomen has no caudal teeth. The terminal claws have three teeth and are not serrate. The appendages of the male, in which the vasa deferentia open, do not reach so far as the base of the terminal claws. In D. brachyura they reach beyond the claws. The vas deferens opens, not near the heel of the foot-shaped termination, but below the instep. The antennules of the male are longer proportionately.

Southampton, Mass., 1878. Common.

Family 2. Daphnidæ.

GENUS 1.

MOINA. Baird, 1850.

SPECIES 1.

MOINA BRACHIATA. Jurine.

For synonymy of genus and species, see P. E. Müller, pp. 132–133.

Pool beside railroad, near Yahara river, Madison, Wis., July, 1877. Present in immense numbers.

GENUS 2.

CERIODAPHNIA. Dana.

CERIODAPHNIA, Dana. U. S. Expl. Ex. Crustacea, Vol. II, p. 1265.
" Sars, P. E. Müller, Kurz.

SPECIES 1.

Plate I. Figs. 1–2.

CERIODAPHNIA DENTATA. sp. nov.

Head angulated in front of antennules. Shell reticulated with hexagonal meshes. Terminal claws with a row of teeth on outside and finely serrate inside.

The head is prolonged, and is distinctly angulated in front of the antennules. The shell of the head and body is reticulated with hexagonal meshes. The lines of reticulation vary from almost imperceptible to very strongly marked, in different specimens. The shell may be transparent or opaque. There is a distinct projection at the junction of the dorsal and posterior margins, almost a spine. The fornices are broad and projecting, but are smoothly rounded over and have no angular projection. The post-abdomen is of moderate size, truncate, with seven or eight caudal teeth on each size, and with scattered, very fine hairs. The terminal claws are armed with from 0 to 8 (usually 6) teeth on the outer side. The teeth vary much in size, are often exceedingly fine, and rarely altogether absent. There is also a row of very fine teeth extending to the tip of the claw. This is only to be seen in good specimens and with a high power ($\frac{1}{5}$ Wales), and sometimes, though rarely, cannot be seen at all. The abdominal process is rather blunt, and has fine hairs scattered upon its surface, as has also that part of the abdomen behind it. Cambridge. Southampton and vicinity, Mass.; Madison, Wis. Male not seen. C. reticulata (Jurine) has the terminal claws provided with teeth, but in this species the fornices are "permagnæ et valide prominentes" (P. E. M.), and have a sort of triangular projection in front. The fornices in this species are of medium size, and have no such projection. C. reticulata has the head "obscure angulatum" in front of the antennules; this is manifestly so. Finally, C. reticulata has no fine teeth on the terminal claw. C. nitida (Schödler) (= quadrangula, Leydig) has the armature of the terminal claws, but is reticulated with quadrangular meshes. The name is given on account of the teeth on the terminal claws.

SPECIES 2.

Plate I. Figs. 3-4.

Ceriodaphnia Consors. sp. nov.

Length circ. 0.5 mm.

The head is prolonged, rounded at the apex, not angulated in front of the antennules. The shell of the body is large, round, or square with rounded angles, but with a more or less prominent angle behind, as in the preceding species. The shell is strongly marked with a reticulation of hexagonal meshes. The fornices project moderately, but are rounded and smooth. The post-abdomen is broad, not narrowed toward the apex, but is obliquely truncated, so that the caudal teeth lie on the lower margins. There are about eight of these moderately large, recurved teeth on each side. The terminal claws are large and smooth. The color is transparent or opaque, passing through a reddish brown to nearly black. A variety has the areas of the meshes marked by little rounded prominences. Male not seen. Madison, 1877, with the preceding species, in pools of tolerably clear water; not common.

The shape of the post-abdomen distinguishes this species from all but C. rotunda, Straus. It is plainly not that species, as that has the shell of the head bent into a right angle below the eye, and ornamented with spines. The specific name is given from its habit of associating with the preceding species. I have never found it alone.

SPECIES 3.

Plate II. Figs. 8, 9.

CERIODAPHNIA CRISTATA. sp. nov.

Length, circ. 0.7 mm.

Head not angulated in front of antennules. Post-abdomen with a dorsal row of teeth. Valves with irregular meshes around the edges and perpendicular striæ across the middle, as in Simocephalus.

In general shape this species resembles C. dentata. The head is rounded regularly over in front, not angulated in front of the antennules. The valves are marked much as in Simocephalus.

The post-abdomen is broad, somewhat truncate below, with large, smooth terminal claws, and four teeth on each side of the arms. The dorsal margin of the post-abdomen is produced into a crest which bears eight or nine teeth, largest at the distal end of the row. The apices of these teeth are directed upward. This feature curiously recalls the teeth of the post-abdomen in Eurycercus.

The eye is very large; the macula nigra is of moderate size, and is angular.

The name is given on account of the crest on the post-abdomen.

Southampton, Mass., 1878. Rare.

GENUS 3.

SIMOCEPHALUS. Schödler, 1858.

SIMOCEPHALUS, Schödler, Branch. der Umg. von Berlin, p. 17.
" Sars, P. E. Müller, Kurz.

SPECIES 1.

Plate I. Fig. 6.

SIMOCEPHALUS AMERICANUS. sp. nov.

Length, 1.5-2.5 or 3.5 mm.

Head angulated in front, with three or more teeth at the angle.

Terminal claws long and slender, with a row of fine teeth on each side. Teeth of equal size in each row. Macula nigra rhomboidal.

The head is separated from the body by an obvious depression. Its upper margin curves pretty regularly downward to the point where the fornices approach it more closely, where it bends downward abruptly, and after a short distance is bent again, so as to form almost an acute angle with the front margin. At this angle are three or more short teeth. The fornices project considerably. The superior margin of the valves is arched, serrate, and produced into a short spine behind. In old animals the back is so much arched as to bring the spine near the middle of the hinder edge. In the young it is near the top of the hinder edge. The posterior and part of the ventral margins are serrate. The anterior margin is concave. The valves have the markings characteristic of the genus. The abdomen has two blunt, weak processes.

The post-abdomen is broad, compressed and truncate. Its greatest width at the top is often greater than its length to the insertion of the terminal claws. These are long and slender, with a row of fine teeth on each side. The teeth are of equal size in both rows, and are about 0.01 mm. long. There are eight or nine caudal teeth in each row, geniculate, and bearing a row of fine setæ. Besides these, there are often five or six other very fine teeth, completing the row across the post-abdomen.

The antennules are freely movable, slightly curved, shaped like a truncated cone, and ornamented with several short cross rows of fine teeth. The antennæ and their branches bear the same ornament, and on the basal joint are a pair of short, two jointed setæ, projecting upward from a slight elevation, and a similar seta near the insertion of the branches.

The macula nigra, as seen from the side, is rhomboidal, with the upper angle sometimes a little prolonged.

A rudimentary haft-organ is found in young animals, but disappears in the adults.

The male resembles in general the young female. The testicle is very large, extending the whole length of the body. The vasa deferentia open on both sides of the post-abdomen, at the angle opposite the insertion of the terminal claws. They thus cross the intestine in their course.

Color, corneous to opaque yellow. Calcareous concretions are sometimes, though rarely, found in the valves.

Everywhere common.

This species combines the characteristics of several European species. In general appearance it resembles S. serrulatus (Koch). The post-abdomen is more like that of S. exspinosus (Koch), as is also the macula nigra. The serration of the terminal claws resembles that of S. vetulus (O. F. Müller). It thus differs from S. serrulatus in two of its characteristic peculiarities — the shape of the macula nigra and the serration of the terminal claws.

SPECIES 2.

SIMOCEPHALUS VETULUS.. O. F. Müller.

DAPHNE VETULA. O. F. Müller, Zoöl. Dan. Prod., N. 2399.
DAPHNIA SIMA. Liéven, Fischer, Liljeborg, Leydig.
" VETULA. Baird, l. c., p. 95, P. X, fig. I.
SIMOCEPHALUS VETULUS. Schödler, Branch, p. 18.
" " P. E. Müller, l. c., p. 122, Pl. I, figs. 26–27.
" " Kurz, l. c., p. 29.

Very common everywhere, with the preceding species. Both species are almost always taken at the same time, but the number of individuals of S. Americanus is usually greater.

GENUS 4.

SCAPHOLEBERIS. Schödler, 1858.

SPECIES 1.

Plate 1. Fig. 7.

SCAPHOLEBERIS MUCRONATA (?) O. F. Müller.

DAPHNE MUCRONATA, O. F. Müller. Zool. Dan. Prod. No. 2404.
MONOCULUS " Jurine. Monocles, etc., p. 137.
DAPHNIA " Liéven. l. c., p. 30, T. VII, fig. 1–2.
" " Liljeborg. l. c., p. 44, T. III, fig. 6.
SCAPHOLEBERIS " Schödler. l. c., p. 23.
DAPHNIA " Leydig. l. c., p. 187.
" " P. E. Müller. l. c., p. 124.
" " Kurz. l. c., p. 28.

Length, 0.7–0.8 mm.

I give references for the variety "fronte lævi" only, since

Schödler (Zur Naturgeschichte der Daphniden, 1877, p. 24) is very positive in his statements that the variety "fronte cornuto" is a distinct species. All the specimens which I have seen want the horn.

P. E. Müller says of the genus, of which he has seen only this species, "Antennæ immobiles." So Liéven, "Die Tastantennen kommen mit denen dieser Art. (D. pulex) überein." Other authors are silent on the subject, though it might possibly be inferred from Fischer's figures that he considered the antennules to be movable. They are always free in the specimens which I have seen. The correspondence in other respects with S. mucronata is so great that I do not like to make this a new species. It is, at least, a marked variety, to which the name "fusca" might be appropriately applied.

My specimens have all the different markings which, in different European localities, are considered characteristic of the species. Thus Müller says, "Areis hexagonalibus reticulata." Schödler says: "Eine reticulirte Cuticula ist nur auf dem Kopfe, namentlich um den Rüssel herum, deutlich wahrzunehmen: der Schalenklappen entbehren derselben, sind aber in der vorderen Partie leistenartig gestreift. Diese Leisten verlaufen in ziemlich gleicher Richtung mit dem Vorderande, und gehen, namentlich gegen den Unterrand, mehrfach in einander über. Die Mitte der Schalenklappen aber lässt nur eine feinkörnige Cuticula unterscheiden." I have seen specimens from the same pool which exhibited markings agreeing with both these descriptions, and other specimens which showed still other variations.

SPECIES 2.

Plate I. Figs. 8, 9, 10, 10*a*.

SCAPHOLEBERIS NASUTA. sp. nov.

Length, circ. 1 mm.

Rostrum pointed, antennules large and movable. Shell of valves covered with pointed elevations.

The head is separated from the body by a marked depression. The lower margin of the head is slightly concave. The rostrum is prolonged into a rather sharp beak, at whose apex the continuations of the fornices unite. The beak does not project downward, as in S. mucronata, but backward, and in its natural position lies between the valves. The valves closely resemble in shape those of S. mucronata. The shell of the head is reticulated, as is also that of the area *a* (Plate I, Fig. 9). The area *b* has a few strong striæ and a few cross markings connecting these. There are only one or two striæ parallel to the lower edge of the shell, and occasionally, in large specimens, two or three parallel to the hinder edge. The rest of the valves bear numerous small pointed projections. The " mucro " is short and blunt. The antennules are much larger than in S. mucronata, though they do not project beyond the rostrum. They have a flagellum and a cluster of knobbed sense hairs, and are freely movable. The rami of the antennæ are never opaque. The macula nigra is long and large, and somewhat resembles that of Simocephalus vetulus. The post-abdomen has the same general shape as that of the preceding species, but is not opaque. The terminal claws have several fine teeth on their outer sides.

The male has the continuation of the fornices prolonged into a rounded projection on each side of the rostrum. These protect the large curved antennules, which are abundantly provided with sense hairs. The vas deferens opens close behind the terminal claws.

Color greenish white, varying to opaque, but usually quite transparent.

In antennules and macula nigra this species resembles Simocephalus much more closely than does the preceding species. Embryos very closely resemble those of Simocephalus.

GENUS 5.

Daphnia. Schödler, 1858.

Daphnia, Schödler. Branch. der Umg. von Berlin, p. 10.
" Sars, P. E. Müller, Kurz.
" and Hyalodaphnia, Schödler. Cladoceren des frischen Haffs, p. 16.

Daphnia, as thus limited, forms a very natural group. It contains the crested forms of the Daphninæ, and thus recalls the genera Acroperus and Camptocercus, among the Lynceidæ. Like those genera, too, the members of this group are transparent, and their post-abdomen is narrow and elongated, although by no means to so great an extent as in the Lynceid genera.

No subsequent writer has agreed with Schödler in distinguishing Hyalodaphnia from Daphnia. And with good reason, since the sole characteristic of the genus is the absence of the macula nigra ; and as this structure is small or rudimentary in all the species of Daphnia, its absence does not form a generic difference.

Daphnia is not a genus typical of the sub-family Daphninæ, but is rather an extreme form. Moina is the least specialized.

SPECIES 1.

Plate I. Fig. 11.

Daphnia Pulex. De Geer, var. denticulata. var. nov.

For the long synonymy of this oldest and best known of Cladocera, see Baird, British Entomostraca, and P. E. Müller, Danmark's Cladocera, p. 110.

In size, shape and markings, this animal agrees with D. pulex. There are, however, some differences. The lower margin of the head is not so convex as in D. pulex. The abdominal processes are very slightly hairy, or not at all so, instead of being covered with hairs. The terminal claws, like those of D. pulex, are armed with teeth at their base, but have besides a row of very fine teeth extending along the whole length of the claw. The number of abdominal teeth is greater than has been noted in D. pulex, being 18–20 instead of 15, the highest number noted in D. pulex (P. E. Müller, T. I, fig. 4). On these grounds I make it a distinct variety, named from the teeth on the terminal claw.

Cambridge, Mass.; Madison, Wis.

I have seen a blind specimen of this species. The eye-capsule was ruptured, and the lenses and pigment scattered in the cavity of the head. The optic muscles and ganglion were in great part absorbed. It was a large and healthy animal and lived nearly a week in captivity, when it was eaten by a neuropterous larva accidentally put into its glass. It had a marked peculiarity in its motion. It frequently turned four or five somersaults in rapid succession, and invariably went through similar gyrations on coming in contact with any object. The eye was probably ruptured while moulting, as deformities of the head from this source are not uncommon. I have seen a deformed Simocephalus, in which the eye had evidently been destroyed by the same cause, which had elongated and compressed the head.

This is perhaps the species found in Lake Superior, and noted by S. I. Smith (Fish Commission Report, 1872–3, p. 696).

SPECIES 2.

Plate II. Figs. 5–7.

DAPHNIA LÆVIS. sp. nov.

Length, 2–3 mm, exclusive of spine.

Transparent, crested, head rounded in front, not prolonged into an angle. Terminal claws smooth. Abdominal processes separate. Macula nigra present.

The spine may be as long as the body in young animals, or short and blunt in old individuals. The outline of the head is angular in embryos and young animals, but is regularly curved in adult specimens. A marked crest, more prominent in young than in old animals, runs along the front and top of the head. Below, the outline of the head is nearly straight, sometimes a little concave in the middle, prolonged behind into a sharp rostrum, whose apex lies close to the edge of the valves. The outline of the valves is on the whole elliptical, nearly resembling that of the preceding species. The spine, however, is attached at about the middle of the distance from the dorsal to the ventral edges. The spine has two rows of teeth, one above and one below. Exceptionally, there may be also a row on each side. The lower margin has a row of short spines. The markings of the valves, the antennules, antennæ and post abdomen, resemble the corresponding parts of D. pulex. There are about nine caudal teeth in each row. The terminal claws are smooth. The abdominal processes are not united. The macula nigra is small. The hepatic coeca are quite small, often rudimentary, being greatly reduced in size, their cavity obliterated and their tissue degenerated. Specimens of every age, except very young, may show this peculiarity. The "haft-organ" is wanting in adults, though found in embryos.

The male resembles in shape the new born female. The antennules are movable, short and stout, with a flagellum, and a cluster of sense-hairs, not on the end of the antennule, but a little proximad. The "haft-organ" is present.

So far as I know, this is the only crested species with a macula nigra in which the terminal claws are smooth. The name is given on account of this peculiarity.

I found this very beautiful species only in a small, muddy pool near Mt. Auburn Station, Watertown, Mass., 1875. It was present in great numbers, and with a copepod formed the entire crustacean life of the pool.

Sub-family 2. Lyncodaphninæ.

GENUS 1.

Lathonura. Liljeborg, 1853.

Lathonura, Liljeborg. l. c., p. 55.
" Schödler, Sars, P. E. Müller.
Pasithea, Koch, Leydig, Liéven.
Daphnia, e. p. O. F. Müller.

SPECIES 1.

Lathonura Rectirostris. O. F. Müller.

Daphnia rectirostris, O. F. Müller. Entomostraca, p. 92, Tab. XII, fig. 1–3.
Pasithea " Koch. l. c., H. 35, Tab. XXIV.
" " Liéven. l. c., p. 42, Tab. XI, fig. 1–3.
Lathonura " Liljeborg. l. c., p. 57, Tab. IV, fig. 8–11; V, 2; XXIII, 12–13.
" " P. E. Müller. l. c., p. 139.

The male of this species I have once seen. It is smaller than the female, being about 0.5 mm. in length, while the female may be 0.8 mm. Its back is less arched than that of the female and its ventral margin more convex. The valves gape widely below. The testicle has a thick coat of muscular fibres, both circular and longitudinal, and the vas deferens opens just in front of the anus. The antennules of the male resemble those of the other sex, and the feet of the first pair have a moderately large hook, but no flagellum or a rudimentary one.

Cambridge, Mass., 1876. Rare.

GENUS 2.

Macrothrix. Baird, 1843.

Macrothrix, Baird. Ann. Mag. Nat. Hist., Vol. XI, p. 87, 1843.
" Liljeborg, Schödler, et al.
Echinisca, Liéven.

SPECIES 1.

Plate I. Figs. 12–13.

Macrothrix Rosea. Jurine.

Monoculus roseus, Jurine. l. c., p. 150, Tab. XV.
Echinisca rosea, Liéven l. c., p. 31, Tab. VIII, figs. 3–7.
Macrothrix " Baird. Brit. Ent., p. 104.
" " Liljeborg. l. c., p. 47, Tab. IV, figs. 1–2; Tab. V, fig. 1.
" " P. E. Müller, p. 136, Tab. III, figs. 1–4.

My specimens agree closely with Müller's description. He says, however, "Der findes et lidet udviklet Hefteapparat paa samme sted og af samme Bygning som hos Eurycercus." In these specimens it is considerably larger than in Eurycercus, and lies decidedly further back.

I have seen one male of this species. It is about 0.3 mm. long. The antennules are curved as in the female, and besides, curved outward toward the base, and again inward toward the apex, so as to appear somewhat bow-shaped, as seen from the front. They have five cross-rows of stout, short, black hairs on the outside of each antennule, and a rather long flagellum near the base. The sense-hairs are short and curved inward. The first feet have a very long hook, stout at the base, its apex projecting from between the valves and bent inward toward the median line, so that the ends of the two hooks are almost in contact when at rest. The ends are covered with fine teeth. The post-abdomen has the same general shape as that of the female. The hairs on it are finer, hardly perceptible. There are no terminal claws, and the post-abdomen is prolonged into an elevation about 0.05 mm. long, on whose summit the vas deferens opens.

Madison, Wis., 1877. Not rare in shallow and weedy water.

Sub-family 3. Bosmininæ.

GENUS 1.

Bosmina. Baird, 1850.

SPECIES 1.

Bosmina Longirostris. O. F. Müller.

Lynceus longirostris, O. F. Müller. Entomostraca, p. 76, Tab. X, figs. 7-8.
Bosmina " Sars, l. c., p. 153.
" " Schödler. Cladoceren des frischen Haffs. p. 45, figs. 16–17.
" " P. E. Müller. l. c., p. 146, Tab. III, figs. 8–9.
" " Kurz. l. c., p. 29.

Length, circ. 0.39 mm.

These specimens agree with Bosmina longirostris in all respects except size, which is considerably greater in our form.

Cambridge and Southampton, Mass.; Madison, Wis. Rather rare.

SPECIES 2.

Bosmina Cornuta. Jurine.

Plate 11. Fig. 10.

Monoculus cornutus, Jurine. l. c., p. 142, Tab. 14, figs. 8–10.
Eunica longirostris, Koch. l. c., H. 35, Tab. XXIII.
Bosmina cornuta, Sars. l. c., p. 280.
" " Schödler. Clad. fr. Haffs. p. 49, Tab. III, figs. 18–22.
" " P. E. Müller, l. c., p. 147.

Specimens belonging to this species were found at Easthampton, Mass., Aug., 1878. Length, 0.3 mm.

FAMILY 3. LYNCEIDÆ.

Sub-family 1. Eurycercinæ.

Sole genus and species.

EURYCERCUS LAMELLATUS. O. F. Müller.

For the synonymy of this species, see P. E. Müller, l. c. p. 162. Fischer's L. laticaudatus is the only instance where the animal has been described under a specific name different from Müller's.

I wish to note only a few points in the anatomy of this species. The ventral margin of the valves is set with short, stout, movable spines. These bear near near the base a row of backward projecting hairs. The antennules have a crown of long teeth around the apex, from within which rise the sense-hairs. On the basal joint of the antennæ, about the middle of its hinder side, is a large tubercle, covered with short, stout, black spines. The anterior margin of the valves is strongly convex, and the lower loop of the shell-gland is prolonged into the convexity, thus making an open loop, whose long axis is parallel to that of the body. Leydig's figure of the animal is quite incorrect in this particular, and indeed, his figures in general, so excellent in other respects, are little to be trusted in this. His figure of the legs of this species is very accurate.

Sub-family Lynceinaæ.

GENUS 1.

PLEUROXUS. P. E. Müller, 1868.

LYNCEUS. e. p. autorum.
PLEUROXUS ET PERACANTHA. Baird.
" " ET RHYPOPHILUS. Schödler.
" " Sars, Kurz.

SPECIES 1.

Plate I. Figs. 19–20.

PLEUROXUS PROCURVUS. sp. nov.

Length, 0.5 mm.

Rostrum bent forward and upward at tip. Hinder margin and anterior margin armed with teeth. Valves striate around edges.

The shape in general is oval. The dorsal margin is high, arched, sloping steeply toward the posterior margin, with which it forms a sharp angle, almost a tooth. The posterior margin is short, straight, and has seven or eight teeth. Of these, the first upper tooth points obliquely upwards, the succeeding two also upwards, though less steeply, and the rest either outward or slightly downwards. The posterior margin joins the ventral in a rounded angle. The ventral margin is concave, and has somewhat sparse, abundantly plumose, setæ. The forward margin is strongly convex, and has numerous small teeth on its lower half. These point downward or backward. The valves are marked by striæ, which are very plain around the edges. At the upper part of the posterior margin they are parallel to the back, gradually changing their course so as to become perpendicular to the ventral margin about its center. The succeeding striæ incline backward, and become at last parallel to the anterior margin. There is an area in the center of the valves which is either obscurely reticulated or smooth. The rostrum is long, stout, and abruptly bent outwards into a hook at its tip. The post-abdomen is long, laterally compressed, truncated, with a dorsal row of teeth, consisting of a cluster of four or five stout and long spines at the lower corner, and eight or ten teeth following these, arranged somewhat in pairs. In this and all other cases of a dorsal row of teeth, which I have seen, except in Eurycercus, the teeth are not exactly on the dorsal margin of the post-abdomen, but are set on the sides, usually each alternate tooth on the same side, so that there are really two rows of teeth. The keel of the labrum is somewhat tongue-shaped, running into a long, rounded projection behind. The ephippium forms on the rear upper part of the shell. It contains one egg. Two summer eggs are produced at one time. The color is yellowish, but remarkably transparent. The male was not seen.

Glacialis, Cambridge, Mass., two specimens, 1875. Southampton, Mass., 1878; common. Madison, Wis., July and August, 1877; common.

The teeth on the posterior and anterior margins of shell at once distinguish this species from all others with recurved rostrum. It combines the general appearance of Pleuroxus with the rostrum of Rhypophilus, and the anterior and posterior marginal teeth of Peracantha. The name is given from the shape of the rostrum.

SPECIES 2.

Plate II. Fig. 11.

PLEUROXUS STRAMINIUS. sp. nov.

Length, circ. 0.6. mm. Height, 0.35 mm.

Post-abdomen slender, its dorsal side concave. Valves marked by hexagonal meshes.

The dorsal margin is not greatly arched. It forms a short but well marked projection at its junction with the posterior margin. A similar projection, not a tooth, is seen at the junction of the posterior and ventral margins. Rarely, a very small tooth is present there. The valves are marked by elongated, hexagonal or irregular meshes. The rows run obliquely downward and backward. The surface is also marked by the "stütz-balken" and by minute striæ. These last are confined to the meshes and do not cross the lines of reticulation. The post-abdomen is long, slender, somewhat curved, truncated at the end, with a large number of fine, slender teeth on the dorsal row. The terminal claws have the usual two spines, and are serrate. This last characteristic is not always to be seen. The antennules have six or eight sense-hairs besides the flagellum. The eye is much larger than the macula nigra.

The rostrum of the male is much shorter than that of the female, the post-abdomen is more slender, and the terminal claws are very slightly removed from its ventral edge. The vas deferens thus opens between or slightly above the terminal claws. Except for the regular sexual difference, it otherwise resembles the female. Color, straw-yellow, opaque.

P. straminius is most nearly allied to P. hastatus (Sars). The females are nearly the same. They differ in proportions, hastatus being higher proportionately. The lines of reticulation are horizontal in P. hastatus, oblique in straminius. The former is "eine der durchsichtigsten Species" (Kurz), while the latter is just the reverse. The valves differ widely. In P. hastatus the head is very small, the rostrum slender and strongly curved, and the post-abdomen tapers gradually to a point. In P. straminius the head is longer, the rostrum short, blunt, not much curved, and the abdomen shorter and truncated at the end.

Cambridge, Mass., 1875; common. Not found in Madison, Wis., where its place seems to be taken by P. procurvus and P. denticulatus, which are far more common there than in Cambridge.

The name is given on account of the color.

SPECIES 3.

Plate II. Fig. 12.

PLEUROXUS INSCULPTUS. sp. nov.

Length, circ. 0.27 mm. Height, 0.18 mm.

Valves strongly marked by hexagonal reticulations. One tooth at lower posterior angle of valves.

This is by far the smallest species that I have seen. The dorsal margin is little arched, so that the hinder margin is not much shorter than the height of the valves. At the junction of the posterior and ventral margins, there is a strong tooth formed by a semi-circular incision in the posterior margin. Sometimes there is a second very small tooth above it. The ventral margin of the female is very slightly concave, the concavity lying in the rear half of the margin. The shell is marked as in the preceding species, but the lines are much more distinct. At first sight only the diagonal striæ are manifest. Closer inspection discloses the true nature of the sculpture. The rostrum is rather short, the fornices quite broad. The post-abdomen is short, broad, truncated, with a dorsal row of eight or ten teeth. The terminal claws are serrated and have the usual two basal spines. The last (eighth) seta of the antennæ is not always to be found. The eye is quite large; the macula nigra much smaller. The male is narrower proportionately. Its rostrum is short and "stumpy." The post-abdomen is strongly concave below, dorsally; with about the same number of teeth as in the female. The end is somewhat rounded. The terminal claws have very small basal spines and no serration.

The name is given on account of the deeply cut reticulations.

Cambridge, Mass. Glacialis, 1876. Rather scarce. Southampton, Mass., 1878. Not uncommon.

SPECIES 4.

Plate I. Fig. 21.

Pleuroxus Denticulatus. sp. nov.

Length, 0.5–0.6 mm. Height, 0.35–0.45 mm.

Anterior margin of valves armed with small, backwardly projecting teeth. Rostrum not bent forward.

The dorsal margin is very convex, descending rapidly to the posterior margin, which is consequently relatively short. At the junction of the posterior and ventral margins, there are two, three or (usually) four teeth, or in young specimens none. Of these, the upper tooth curves upward, the others outward, or the lowest a little downward. There is a series of fine teeth on the lower part of the anterior margin, directed downward or backward. These lie inside the row of setæ. The shell is marked as in P. procurvus. There are also striæ on the head, of which the lower run parallel to the edge of the fornix, the upper parallel to the outline of head. The rostrum is long, pointed, and curves backward. The post-abdomen resembles almost exactly that of P. procurvus. There is often a black pigment deposited in its lower part. The male has a shorter rostrum, hairs instead of teeth on the post-abdomen, whose lower angle is rounded. Color, greenish or yellowish.

Glacialis, Cambridge, 1876. In muddy or clear water. Madiison, 1877. Common.

This species is allied to P. trigonellus (O. F. Müller), from which it differs in shell markings, and very greatly in the male. (Vid Kurz, Pl. III, fig. 2.) P. Bairdii, Schödler (= P. trigonellus, Baird) has the striæ all parallel and extending over the shell, a rounded and gibbous post-abdomen, and other differences. It differs from these and all other species of Pleuroxus, in its limited sense, by the possession of teeth on the anterior margin. From this fact, I have named the species P. denticulatus.

SPECIES 5.

Plate I. Fig. 22.

Pleuroxus Unidens. sp. nov.

Length, 0.85 mm. Height, 0.46 mm.

Shell little arched on dorsal margin. Lower posterior corner of valves rounded. A tooth just in front of the corner. Valves marked by striæ.

In its proportions, this species approaches P. straminius, the back being comparatively little arched, so that the height is about one-half the length. In the shape of the front part of the animal, there is also a close resemblance to P. straminius, and in the relative length of the post-abdomen. There are, however, great differences. The upper posterior angle is prolonged into a projection, quite characteristic, seen, I believe, in no other species. The lower corner is rounded, not angulated. Some distance before it is placed a single minute tooth. From this peculiarity, the species has received its name. The bristles of the lower edge are much larger in front. They become very small behind, and seem to be smooth there instead of plumose. The valves are marked by striæ. One set occupies the upper half of the valves and runs approximately parallel to the back. A second set runs nearly parallel to the lower edge. The upper stria of this set is complete, and those of the upper set run into it where their curvature will not permit them to reach the posterior margin without meeting it. At the front part of the valve is a set parallel to the forward edge. These meet the second set in an area which is irregularly reticulated. The striation is very plainly marked. The post-abdomen is long and stout. The hinder end is truncated, but the corner is slightly rounded off. There are two rows of 18 or 20 pointed, rather long, caudal teeth. The terminal claws have the usual two basal spines, and are serrate. There are two small projections (one of which is shown in the figure) on the abdomen, which can hardly be anything else than a rudimentary sixth pair of legs, although they are situated some way back of the fifth pair. It was wanting in one of the dozen specimens which I examined, or at least I could not find it. If it is a rudimentary sixth leg, this is the first case in which this structure has been found in the Lynceinæ. It confirms the opinion which I had formed on other grounds, that Pleuroxus is the genus which stands as the most generalized type of this sub-family. Color, yellowish, transparent. Male not seen.

Lake Wingra, Madison, Wis., Sept., 1877. Rare, only about fifteen specimens found.

This is the largest species of Pleuroxus yet seen, and P. straminius seems to be the next in size.

SPECIES 6.

Plate II. Figs. 13, 14.

Pleuroxus Hamatus. sp. nov.

Length, 0.4–0.45 mm. Height, 0.21–0.25 mm.

General shape like that of P. unidens. Valves marked by oblique striæ, and by short, irregular, horizontal striæ.

In general shape this species approaches closely to P. unidens, though the back is somewhat more arched. The posterior margin of the valves is concave, the lower angle rounded, and entirely without teeth. The valves are marked by striæ running as in P. denticulatus, and by short, faintly marked striæ, which run nearly horizontally. These cross the oblique striæ, and are found all over the shell of valves and head. The species is, in markings, the third of a series. P. unidens has only striæ, and those continued quite across the valves. P. denticulatus and P. procurvus have striæ at the edges and irregular markings in center, while the present species has striæ around the edges of valves, and also the short markings all over them.

The post-abdomen closely resembles that of P. denticulatus.

The feet of the first pair in the female are furnished with a tolerably stout hook, of which a sketch is given in Pl. II, fig. 14.

This is, I think, the only case where this distinctively male appendage is found in the female.

Southampton, Mass., Aug., 1877. Not rare.

SPECIES 7.

Plate II. Fig. 15.

PLEUROXUS ACUTIROSTRIS. sp. nov.

Length, 0.35 mm. Height, 0.22 mm.

Beak, long, pointed, and bent backward at the tip. Teeth of post-abdomen very fine. Bristles of lower margin of valves stout and plumose.

In general shape this species closely recalls P. hamatus. It is readily distinguished by the long, pointed rostrum, whose apex nearly meets the valves when in its natural position. The valves are reticulated as in P. insculptus, although not so plainly. There are no teeth on their ventral margin.

The post-abdomen is broad, compressed, truncated, with numerous fine caudal teeth. The terminal claws have only one basal spine.

In rostrum this species closely approaches Harporhynchus (Sars), as also in the single basal spine of the terminal claws. In general, however, the species is so thoroughly Pleuroxus-like in appearance, that I keep it under that genus for the present.

Southampton, Mass., July, 1878. Very rare.

GENUS 2.

CHYDORUS. Leach. 1816.

CHYDORUS, Leach. Sup. Brit. Encyc., Art. Annulosa.*
" Baird, Schödler, Sars, Kurz, P. E. Müller.

SPECIES I.

Plate II. Fig. 19.

CHYDORUS SPHÆRICUS. O. F. Müller.

One of the oldest and best known species of Cladocera For

*Teste P. E. Müller.

synonymy, see Kurz (l. c., p. 77). The mandibles are articulated, not where the fornix joins the valve, but behind this point. This fact is noted by Kurz in C. ovalis, and his figures show that the same is true of C. globosus; although his description of C. globosus would imply otherwise. A chitinous ridge runs from the the point of articulation of the mandible, above the junction of the fornix and the valve, along the under side of the fornix to the rostrum. It does not stop at the junction of fornix and valve, as figured by Kurz in C. ovalis.

This species is common wherever I have collected, and is present in dense swarms near the surface of the water on bright, warm, calm days. It is one of the earliest of the Lynceinæ to appear in the spring.

SPECIES 2.

Chydorus Globosus. Baird.

For synonymy, see Kurz (l. c., p. 18).

One specimen from Lake Wingra, Madison, Wis., Sept., 1877.

GENUS 3.

Crepidocercus. gen. nov.*

The head is immovable. The rostrum is sharp, but does not extend downward for more than half the distance between the articulation of the mandible and the ventral edge. The dorsal margin is much arched, and rounds evenly over, terminating behind in a somewhat sharp angle. The posterior margin is sinuate, concave above, then convex. Just in front of the junction of the posterior and ventral margins is a single strong, recurved tooth. The ventral margin is slightly concave and the anterior margin strongly convex. The valves are marked by the "stützbalken," as in all Cladocera, and by an obscure reticulation of irregular hexagonal meshes, most clearly marked in the hinder portion of the valves, where the longer axis of the meshes runs obliquely downward and backward.

* From κρηπίς, shoe, and κέρκος, tail.

The upper part of the dorsal margin of the post-abdomen is prolonged, and runs nearly parallel to the posterior margin of the valves, while the lower part is parallel to the ventral margin, and makes nearly a right angle with the upper part. The apex is rounded and bears two small terminal claws, each of which has a small basal spine.

The general shape of the post-abdomen is like that of a shoe, whence the generic name. It is much compressed laterally, and its armature consists of numerous bristles scattered somewhat irregularly over its surface.

The usual pair of setæ project backward from the post-abdomen; and the ventral margin of the valves is fringed with somewhat long, plumose setæ.

The antennules are of moderate size, do not reach to the end of the rostrum, and have a flagellum and eight to nine sense-hairs. The antennæ are about as large as in Pleuroxus, and bear eight setæ $(\frac{3\ 0\ 0}{3\ 1\ 1})$ and three spines $(\frac{1\ 0\ 1}{1\ 0\ 0})$. The keel of the labrum is somewhat prolonged backward, as in Pleuroxus, but not to so great an extent.

The eye, macula nigra, intestine, anal coecum and shell-gland present no points of especial interest.

The shape from above is an elongated oval, broadest through the fornices. The valves gape considerably below.

The animal moves by strong and sudden blows of the antennæ. With a single stroke it darts for a short distance, and then returns to rest, ordinarily not moving again until disturbed. It may, however, swim for a considerable distance by repeated strokes of the antennæ, but on the whole is decidedly sluggish, remaining for hours at rest. The extreme suddenness with which it starts into motion is very remarkable. The antennæ are ordinarily bent downward along the anterior margin of the valves, and I have never been able to see them raised preparatory to a saart. It passes instantaneously from rest to motion, and, without any warning, is gone from the field of view in the microscope. It can also move slowly, as I have noticed, by strokes of the abdominal feet upon the cover of the live box in which it is kept. The post-abdomen does not seem to be employed as an aid to locomotion.

SPECIES I.

Plate I. Fig. 18.

CREPIDOCERCUS SETIGER. sp. nov.

Length, 0.4–0.5 mm. Height, 0.27–0.32 mm.

Measurements from one specimen.

Length, 0.37 mm. Height, 0.25 mm. Length of hind margin, 0.12 mm. Length of spine of ventral margin, 0.017 mm. Length of setæ of ventral margin, 0.02–0.04 mm. Diameter of eye, 0.028 mm. Diameter of macula nigra, 0.01. Length of antennule, 0.044 mm. Length of post-abdomen from "heel" to "toe," 0.11 mm. Length of terminal claw, 0.016 mm. This specimen was rather below the average in size.

The color is yellow, rather opaque. The specific name is taken from the setæ with which the post-abdomen is armed. Madison, Wis. Rare. Male not seen.

This species is to some degree intermediate between Alona and Pleuroxus. It resembles the first in the size of the rostrum and the single basal spine of the terminal claws. In general shape and markings it recalls Pleuroxus. Graptoleberis is the only form whose post-abdomen at all resembles that of Crepidocercus. The mode of motion is quite peculiar.

GENUS 4.

GRAPTOLEBERIS. Sars, 1867.

GRAPTOLEBERIS. Kurz.
ALONA, e. p. Baird, Schödler, P. E. Müller.
LYNCEUS, e. p. Leydig, Liljeborg, Fischer et al.

SPECIES 1.

Plate I. Fig. 17.

GRAPTOLEBERIS INERMIS. sp. nov.

Length, 0.6–0.8 mm. Height, 0.30–0.35 mm.

There is no indentation at the junction of head and thorax, but the dorsal margin rounds regularly over from the point of the rostrum to the posterior margin. The junction here is not well marked, and at the lower corner the posterior margin does not form a sharp angle with the ventral. The corner is rounded, but on it are two strong teeth like those of G. testudinarius (F.scher). The ventral margin is straight. The front half bears long, straight, closely set, plumose setæ, while those on the hinder part are shorter and more scattered. The meshes of the reticulation are mostly hexagonal on the head, quadrangular or irregular on the body. The lines of the network in the front and lower part of the valves radiate from the junction of valve and fornix. The first few rows run to the ventral margin. The succeeding rows bend and run parallel to that edge. Those on the upper half of the valves are parallel to the dorsal margin, and there are one or two imperfect rows in the middle of the valves where the two sets meet. The upper set are continued on to the head, running around parallel to the edge of the fornix. The lower, dorsal, margin of the post-abdomen bends upwards just below the anus, and thus makes the apex pointed. There are about eight clusters of three or four hairs each, on each side. The terminal claws are small and unarmed. The eye is only of moderate size, smaller proportionally than in Alona. While in Alona the diameter of the eye, in an average specimen may equal $\frac{1}{15}$ of the total length, in G. inermis, it equals only $\frac{1}{21}$–$\frac{1}{28}$ of the length. The macula nigra is about two-thirds as large as the eye, a little smaller than in Alona. Male not seen.

This species resembles G. testudinarius in most particulars (see the excellent description of this species, Kurz, l. c., pp. 50–53). The differences are, the eye in this species is small instead of large; its shape is rounded, not " nearly triangular;" the macula nigra is not greatly smaller than the eye; the terminal claws are smooth and not "ornamented with teeth;" there is no trace of an elevation on the back, where the outline of the head meets that of the back; the posterior lower corner is rounded, though armed with teeth, and not prolonged into a sharp angle.

The outline in general more closely resembles that of G. reticulatus than that of G. testudinarius. In most respects, however, it more closely approaches the latter species.

Cambridge, Mass., 1876, two specimens.
Madison, Wis., Sept., 1877, Third Lake. Rare.
Southampton, Mass., 1878. Rare.

GENUS 5.

ALONA. Sars, 1862.

This genus was first established by Baird, 1850, but was limited to a small portion of its former extent by Sars. I am not sure that Alonella should have been separated from Alona, but on the whole, prefer to keep the genus as Sars left it.

SPECIES 1.

Plate II. Fig. 16.

ALONA ANGULATA. sp. nov.

Length, 0.4 mm. Height, 0.25 m.

Shell marked by rectangular meshes.

The dorsal margin is considerably arched, terminating in a more or less obvious angle at the hinder corner. The hinder edge is convex, as is also the front margin. The ventral margin is provided with plumose setæ. The rostrum is pointed, as seen from the side, and extends down nearly to the ventral edge of the shell. The fornices are broad, the distance between their edges being nearly equal to the greatest distance between the valves. They are extended forward to the end of the rostrum. The shell is obviously striated, the striæ running obliquely downward and backward. Close inspection discloses a set of cross markings, making the shell reticulated with oblong meshes. The post-abdomen is broad, and truncated at the end. It has a row of about twelve teeth on each side, inserted a little way from its lower, dorsal, edge, and their points project behind it. Along the middle of the post-abdomen, on each side, runs a row of very small scales furnished with clusters of short hairs. The antennules are rounded at the end, and the sense-hairs are set around the end, not upon it. They have besides a flagellum. The basal joint of the antennæ reaches about to the edge of the fornix, the branches nearly to the lower edge of the shell. They have $\frac{3\,0\,0}{3\,1\,1}$ setæ and $\frac{1\,0\,0}{1\,0\,0}$ spines. The last seta is, as usual, very much smaller than the others. The macula nigra is much smaller than the eye, about one-third as large in diameter. Two young are produced at once. A very young specimen showed no striæ. In the adult, these are about 0.025 mm. apart.

The male is somewhat smaller than the female and of slightly different proportions. It is 0.35 mm. long and 0.2 mm. high. The rostrum projects farther forward and not so far downwards. The post-abdomen is rounded at the end, without teeth, but with a row of fine hairs. The vas deferens opens below the terminal claws. The body behind the heart rises up to the top of the cavity of the valves. This position makes the abdomen hang down nearly perpendicularly when at rest. The coils of the intestine are larger than in the female, and the testicle lies immediately on them. The front legs have the usual hook. The cross markings of the sculpture are scarcely to be seen; otherwise it resembles the female.

The reticulation of this species excludes it from all others of this genus except A. guttata (Sars, Crust. Clad. i Omgn. of Christiania, p. 287). In that species, however, the rostrum is shorter, the macula nigra much larger ("oculo parvo minor," Müller), the post-abdomen "apice rotundato," and its teeth much smaller. The general outline, too, is different, and the reticulation, instead of running obliquely across the valves, is horizontal. It is also one-fourth larger: 0.5 mm. instead of 0.4. A. reticulata (Schödler, Neue Beitr., etc., p. 25), if not identical with A. guttata, is even more unlike the present species.

Cambridge, Mass., 1876. Not rare.

SPECIES 2.

Plate I. Fig. 16.

Alona Porrecta. sp. nov.

Length, 0.34 mm. Height, 0.19 mm.

Anterior portion of valve with a sinus. Lower angle of post-abdomen acute. Shell striated with horizontal lines.

This and the following species will be more briefly described. There is no evident angle at the junction of the dorsal and posterior margins. The lower edge bears setæ and has no sinus. The front edge has a very slight sinus, or none at all. The valves are marked by faint horizontal striæ. The rostrum does not extend so far downwards as in the preceding species. The post-abdomen has its usual claws, each with its basal spine, which is not serrate. The teeth of the post-abdomen are about twelve in each row; three or four at the end are larger than the rest. There is besides, a row of hairs above the row of teeth. The lower angle of the post-abdomen is not rounded. The male is of the same general shape as the female. Length, 0.34, height, 0.18 mm. In the armature of the post-abdomen this species approaches nearest to A. tenuicaudis (Sars); but in other respects, e. g. shape of shell, and especially of post-abdomen, is quite different.

Cambridge, Mass., 1876.; Madison, Wis., July, 1877. Not common.

SPECIES 3.

ALONA GLACIALIS. sp. nov.

Length, 0.3 mm. Height, 0.19 mm.

Anterior margin of valves without sinus. Valves horizontally striated. Lower corner of post-abdomen rounded.

This species differs from the preceding chiefly in the post-abdomen. This is rounded at the lower angle, and the teeth, about fourteen in number, are of equal size. There is also a second row of hairs. The forward edge of valve is strongly convex, otherwise much like A. porrecta. This species approaches perhaps most nearly to A. lineata (Fischer). There are, however, great differences. The size of A. lineata is nearly twice as great. The post-abdomen has, according to Müller and Schödler, only one row of teeth and no hairs. According to Kurz, it has hairs, but a deep incision in the lower end. In either case the dtfference is well marked. The shape is also different. A. glacialis is relatively much broader behind than A. lineata (vid. Schödler).

Glacialis, Cambridge, Mass., 1876.; rare. Male not seen. The specific name is taken from the pond in which it was chiefly found.

SPECIES 4.

ALONA SPINIFERA. Schödler.

ALONA SPINIFERA. Schödler (Neue Beiträge, p. 18, Pl. I, fig. 17-22).

Specimens belonging to this species were scantily found in Madison, Wis., and were quite common in Southampton, Mass.

SPECIES 5.

ALONA OBLONGA. P. E. Müller.

ALONA OBLONGA. P. E. Müller, l. c., p. 175, Pl. III, fig. 22–23.

Length, 0.9 mm.

One specimen, closely agreeing with Müller's description, was found in Merrill's Springs, near Lake Mendota, Madison, Wis., Sept., 1877.

On the front side of the second joint of the outer antennary branch was a cluster of spines. In this it differed from Müller's description.

SPECIES 6.

ALONA TUBERCULATA. Kurz.

ALONA TUBERCULATA. Kurz, l. c., p. 51, Tab. II, fig. 3.

The chief difference between my specimens and Kurz's, seems to be that mine have a greater number of rounded elevations than his.

The shape of the post-abdomen does not appear to be identical, but so brief is his description that I am not sure of any difference. I therefore prefer to leave it under that species for the present.

Southampton, Mass., 1878. Rather common.

GENUS 6.

ALONOPSIS. Sars, 1862.

ACROPERUS, e. p. Schödler.
ALONOPSIS. P. E. Müller, Kurz.

SPECIES I.

Plate I. Fig. 14–15.

ALONOPSIS MEDIA. sp. nov.

Length, 0.55 mm. Height, 0.35 mm.
Length of male, 0.4 mm.

Rostrum prolonged and shell sharp, somewhat quadrangular in shape, marked by striæ.

The dorsal margin is convex, the hinder margin nearly straight. Its lower angle is rounded and without teeth. The lower margin is concave, and has long, plumose setæ. The front margin is strongly convex. The post-abdomen is long and slender, resembling that of Camptocercus, and is notched at the distal extremity. It has two rows of fine teeth and some small scales above them. The terminal claws are long, slender, with a basal spine, a spine in the middle, and are serrated. The antennules are long and slender, but do not reach to the end of the rostrum. They have each a flagellum and sense-hairs. The antennæ are small and have eight ($\frac{3\,0\,0}{3\,1\,1}$) setæ and two ($\frac{1\,0\,0}{1\,0\,0}$) spines. The labrum resembles that of A. leucocephalus, but is slightly prolonged at its apex. The intestine, coecum, and color resemble those of Acroperus. There is a trace of a keel present on the back.

This species is in some retpects intermediate between A. elongata (Sars) and A. latissima (Kurz). In general shape, rostrum and marking of valves, it most nearly approaches the former, while it approaches the latter in the post-abdomen, its shape, teeth and armature of terminal claws. Hence I call the species A. media.

GENUS 7.

Acroperus. Baird, 1850.

Acroperus, e. p. Schödler.
Acroperus. Müller, Sars, Kurz.

SPECIES 1.

Acroperus Leucocephalus. Koch.

Lynceus leucocephalus, Koch. l. c., H. 36, Pl. X.
? A. harpæ. Baird, l. c., p. 129, Pl. XVI, fig. 5.
L. leucocephalus. Fischer, Ergänzung, u. s. w., 1854, p. 11, Pl. III, fig. 6–9.
A. leucocephalus. Schödler, Müller, Kurz.

Cambridge, Mass., Madison, Wis. Common.

Kurz says: "Die Acroperus-arten sind die besten Schwimmer unter den Lynceiden." This is not true of our species, which is far inferior in strength and rapidity of motion to both Crepidocercus and Pleuroxus. The same is true of Alonopsis and Alona.

The last genus, indeed, is given to haunting the bottom of the water, and often is found resting among the debris at the bottom of the jar in which it is kept.

GENUS 9.

Camptocercus. Baird, 1851.

Camptocercus. Baird, Sars, Schödler, P. E. Müller, Kurz.

SPECIES 1.

Camptocercus Macrurus. O. F. Müller.

Length, about 1 mm.

Lynceus macrurus.	O. F. Müller, Prod. No. 2397.
" "	Liljeborg, l. c., p. 89, Pl. VII, figs. 2, 3.
Camptocercus "	Schödler, Neue Beitr., p. 35, Pl. II, figs. 39–41.
" "	P. E. Müller, l. c., p. 164, Pl. III, fig. 12.

Cambridge, Mass., Madison, Wis. Not common.

SECTION II. GYMNOMERA. Sars.

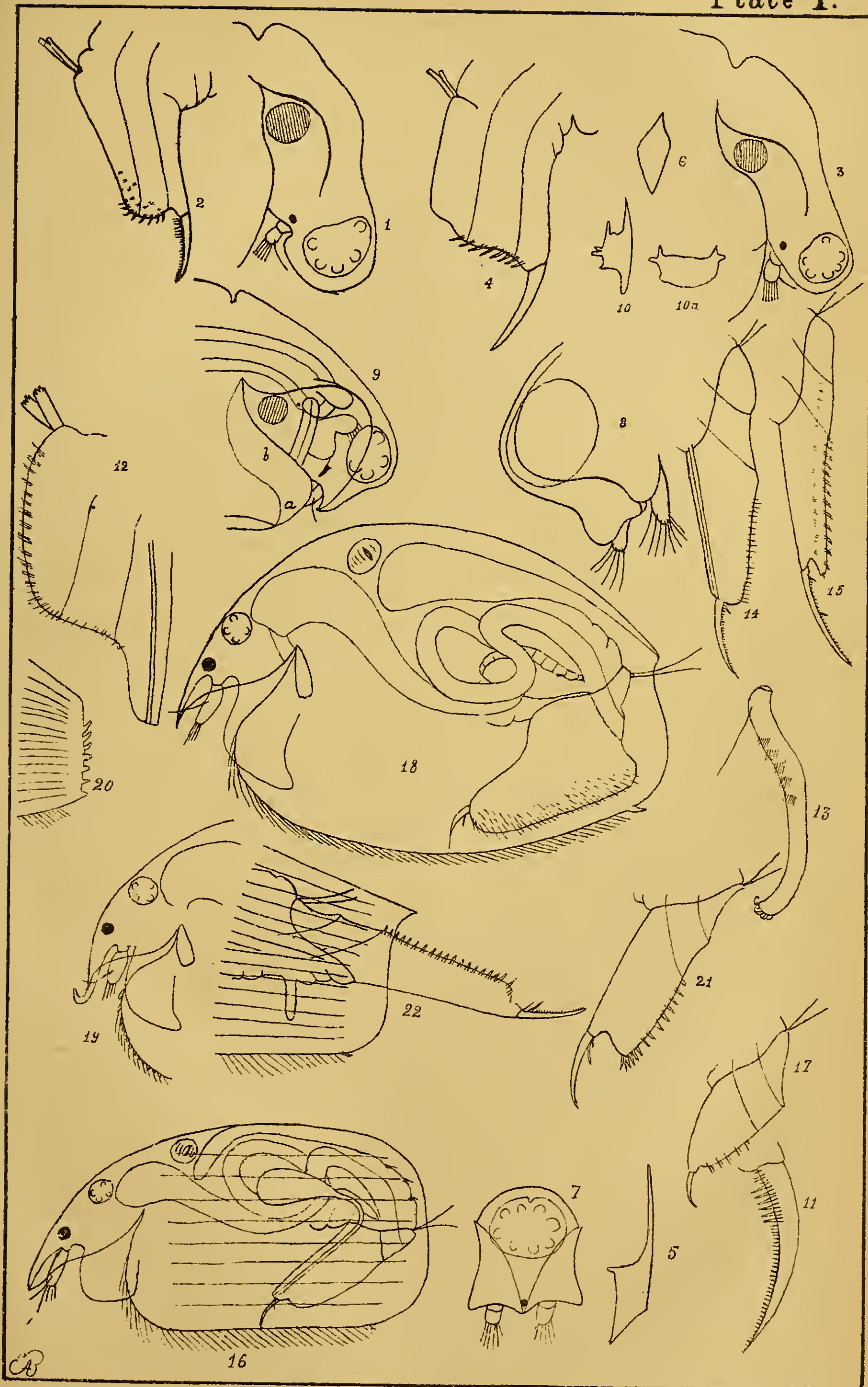
Polyphemus Pediculus. De Geer.

One specimen only. Cambridge, Mass., Oct., 1876.

EXPLANATION OF PLATE I.

Fig. 1. Ceriodaphnia dentata, fem. Head × 80.
2. " " " Post-abdomen × 130.
3. " consors, " Head × 80.
4. " " " Post-abdomen × 130.
5. Simocephalus vetulus, " Macula nigra × 260.
6. " Americanus, fem. Macula nigra × 260.
7. Scapholeberis mucronata, fem. Head from below × 160.
8. " nasuta, male. Head seen obliquely from below × 260.
9. " " fem. Head × 80.
10, 10 a. " " fem. Macula nigra from side and from below × 260.
11. Daphnia pulex. Terminal claw.
12. Macrothrix rosea, male. Post-abdomen × 260.
13. " " " Antennule × 260.
14. Alonopsis media, " Post-abdomen × 160.
15. " " fem. " × 150.
16. Alona porrecta, male. × 150.
17. Graptoleberis inermis, fem. Post-abdomen × 150.
18. Crepidocercus setiger, fem. × 148.
19. Pleuroxus procurvus, fem. Front part of animal × 150.
20. " " fem. Hind part of valve × 150.
21. " denticulatus, fem. Post-abdomen × 150.
22. " unidens, fem. Hind part of body and valves × 95.

Plate I.

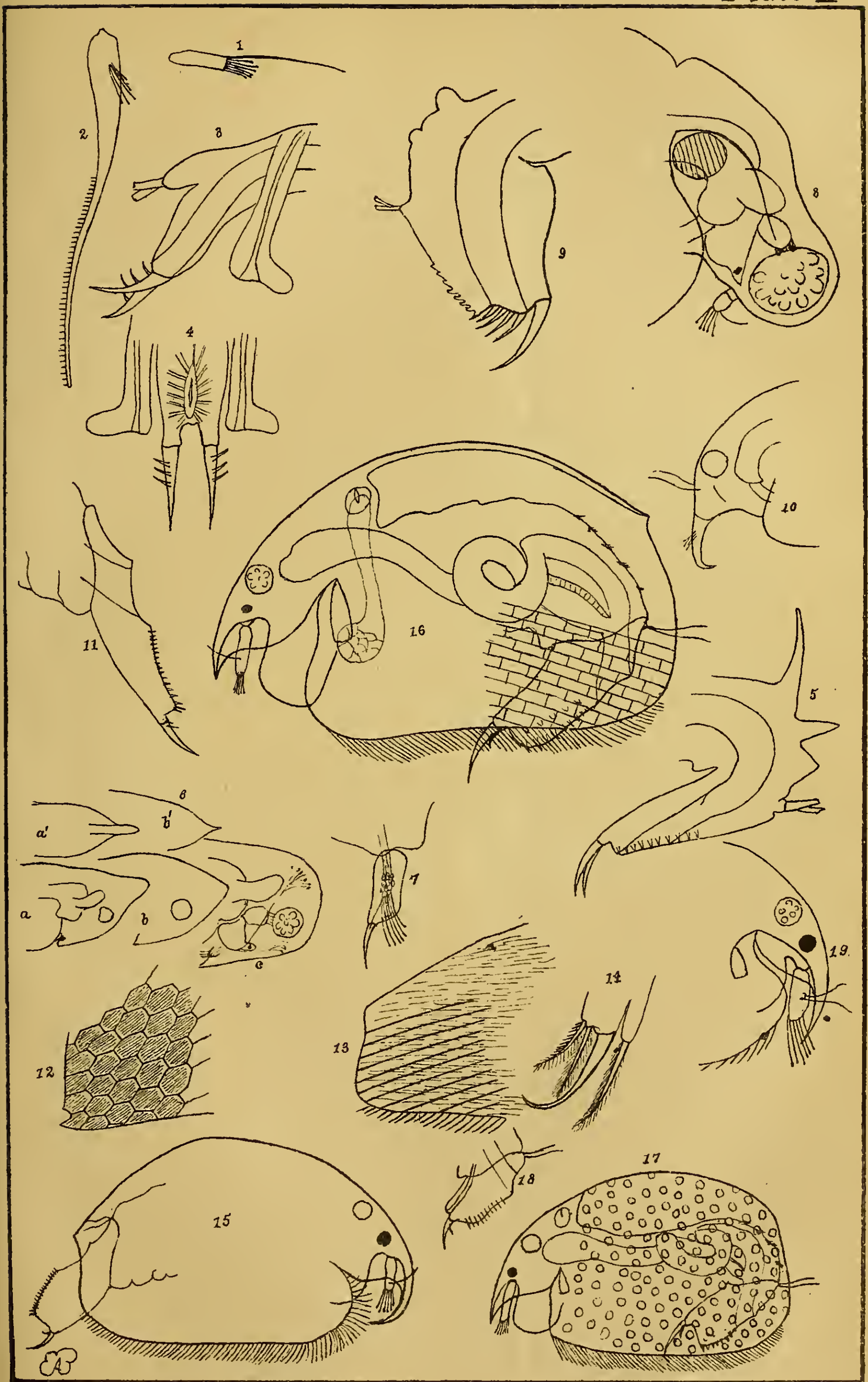


THE HELIOTYPE PRINTING CO. 220 DEVONSHIRE ST BOSTON

EXPLANATION OF PLATE II.

Fig. 1.	Daphnella exspinosa, fem.			Antennule × 140.	
2.	"	"	male.	"	"
3.	"	"	"	Post-abdomen × 140.	
4.	"	"	"	"	"
5.	Daphnia	lævis,	fem.	"	"
6 a, á.	"	"	"	Embryo, outline of head.	
6 b, b′.	"	"	"	Young,	"
6 c.	"	"	"	Adult,	"
7.	"	"	male.	Antennule × 140.	
8.	Ceriodaphnia cristata, fem.			Head × 130.	
9.	"	"	"	Post-abdomen × 130.	
10.	Bosmina cornuta, fem.			Head, etc., × 150.	
11.	Pleuroxus straminius, fem.			Post-abdomen × 140.	
12.	"	insculptus,	"	Details of marking.	
13.	"	hamatus,	"	"	"
14.	"	"	"	First foot × 148.	
15.	"	acutirostris	"	× 135.	
16.	Alona angulata, fem.			× 135.	
17.	"	tuberculata, fem.		× 135.	
18.	"	"	male.	Post-abdomen × 140.	
19.	Chydorus sphæricus, male.			× 150.	

Plate II.



THE HELIOTYPE PRINTING CO. 220 DEVONSHIRE ST BOSTON.

ON THE FAUNA OF THE NIAGARA AND UPPER SILURIAN ROCKS AS EXHIBITED IN MILWAUKEE COUNTY, WISCONSIN, AND IN COUNTIES CONTIGUOUS THERETO.

BY F. H. DAY, M. D.

Wauwatosa, Wis., Dec. 27, 1877.

It is stated as an axiom by high paleontological authority,—that "Since rocks are identified more by their fossil contents, than by their lithological character, a name descriptive of the latter is of less importance than formerly, when fossils were the subordinate characters of a mass;" and although paleozoic characters have assumed the supremacy over all others in distinguishing sedimentary strata, "still the lithological terms must not be overlooked; for if properly understood, they will be unerring guides in tracing the condition of the surface, for more than hundreds of miles in extent."

Changes in the lithological features of a rock which may render observations unsatisfactory, are accompanied by greater or less variation in the nature of the fossils. It is therefore of the highest importance in the examination of sedimentary rocks to be governed by three essential facts, which are:

1st. The lithological character.

2d. The order of the superposition.

3d. The contained characteristic fossils.

By an observance of such precepts geologists have been enabled to form a reliable and a systematic geological history, which is arranged into natural distinctions of ages, periods, epochs, and eras, with the capability to trace from one portion of country to another, through all intricate phases, types and characters, the rocks containing remains, images or casts of paleozoic life.

It is thus we determine the first appearance in the world's history of organized beings, as exemplified in the commencement of the Silurian age — usually termed the Lower Silurian, where by successive layers or strata of calcareous or siliceous sedimentary matter, we trace each order of life through distinctive periods, and epochs, until progressive organization culminated in the era of man.

The nomenclature adopted by tacit consent of paleontologists, to be applied to rocks, is that of the locality where the exposure of a specified rock exists in its best state of preservation and can be carefully examined and studied.

In this manner are the terms derived, Canadian, Trenton, Niagara, Salina, Lower and Upper Helderberg and Hamilton, with the subdivisions of Quebec, Galena, Waukesha, Racine and St. Claire.

But it is the three principal periods: the Trenton, Niagara and Salina which particularly interest a paleontologist when making collections of paleozoic remains from the eastern portions of Wisconsin, and therefore the foregoing explanatory observations seemed to be necessary to elucidate what seemed to befog or deter some of our leading state geologists in arriving at definite satisfactory conclusions.

For if you examine the strata of rocks, with their fossiliferous contents, as exhibited in various exposures by quarrying or from other causes in Milwaukee county within a radius of twenty miles, it is difficult to apply the foregoing mentioned, or geological axioms. In a single quarry containing a coralline limestone near Wauwatosa I have obtained several thousand specimens within the past twenty years, and from among them I can show you representative fossils delineated and described as belonging to the commencement of the primordial time or Lower Silurian age, intermingled with many fossils characteristic of the Upper Silurian, the Guelph and the beginning of the Devonian age. However, "Prof. Dana asserts that there is no evidence that a species existed in the latter half of the Upper Silurian, that was alive in the latter half of the Lower Silurian." The fossils of the Niagara fauna being mostly casts of the interior, it is more of an exception to find the shell or testaceous covering in a perfect state of preservation thereby making our investigations accompanied with many difficulties, nevertheless Eastern Wisconsin has a fauna which in variety, beauty, perfection and numbers cannot be excelled by a similar collection, within the same extent of country on either hemisphere.

Could the distinguished Prof. L. Aggasiz have examined our corals, Echinoderms, Brachiopoda, Lamellibranchs, Gasteropoda, Cephalopoda and Trilobita, no doubt he would have exclaimed, "why sir, the sight of this display would make an eastern naturalist crazy."

On one occasion after a recent excavation by blasting at Schoonmacker's quarry, I measured a coral disk about twenty feet in diameter, three feet in height, and more than sixty feet in circumference. The surface was made up of beautiful concentric layers, like the flattened whorls of a gasteropod, and were covered by very pretty Heleolites.

Cruising around such coral eminences, were the "lords of the invertebrates," the Orthoceratites, the straight variety of Cephalopoda, measuring over twelve feet in length and twenty inches in circumference, and having siphuncles so peculiar in shape and expansion, that Prof. H. A. Ward, notwithstanding his large experience and observation, declared these different from any species he had seen in the old or new world, because the pyrimidal-cone-shaped siphuncle of the base, or last chamber, resembled much the contour of a Belemnite.

Here also was the gigantic *Phragmoceras* having a base twenty one inches in circumference, six inches deep, and a seven inches latitudinal aperture, and extremely *macrochcilus* or long lip, for perfect specimens collected of five species of Phragmoceras make Prof. Hall's description of a single specimen of our species, comparatively a myth, and his *Phragmoceras nestor* is simply a description of a mutilated specimen of a *Phragmoceras macrocheilus*. Prof. Hall's *Gomphoceras septoris* has the curvilinear figure of a *Phragmoceras*, or *Cyrtoceras*, and in general aspect much resembles a *Phragmoceras callistoma* (Barrande), delineated in Woodward's Modern and Fossil Shells. Of the four varieties of *Gomphoceras*, one may prove to be *G. scrinium* or *G. Marcyi* of Winchell.

The gasteropoda of the Lower and Upper Silurian and Hamilton cement are found much larger and in a more perfect condition than those pictured and described in reports of previous geological surveys. A magnificent and perfect *Pleurotomaria perlata* five inches in diameter, found in the Niagara shale, and also in the Guelph or Gault, a *Trochoceras, Gebhardii*, six inches in diameter, from the cement rocks, besides many others, claim honorable mention. In no other place are such unique lamellibranchiata to be found, particularly the *Moceraunas* and *Amphicelia*, *Ambonychia*, and *Paleocardia*. I have quite a number of perfect specimens, retaining the whole or parts of their beautiful striated shells.

It is in Schoonmaker's Quarry that several distinct species of trilobites belong which are not found elsewhere—in any fossiliferous formation.

Prof. J. Hall, in his description of the fauna of Wisconsin, was often obliged to make use of imperfect material, and in resorting to the very unsatisfactory mode of delineating restored parts, or "supposed differences," he would naturally be much disappointed and mortified to find his opinions erroneous upon the subsequent discovery of perfect specimens, which were heretofore entirely new, or but little known. On this account it is questionable whether Hall's synonyms for fossils like the *Illœnus*, *Sphœrexochus*, *Phragmoceras*, et cetera, when perfect specimens prove them to be so radically different from Hall's descriptions, should be "saddled" with the names he intended should be applied to them, especially when his opinions are based upon a single part or fragment of a perfect specimen, and also when the synonym is foreign to the idea suggestive of its character. For example, the pygidium of the *Illœnus cuniculus* is confounded with the Bridgeport and Waukesha *Illœnus armatus*, which is probably an adult specimen of *Illœnus insignis*, or *Illœnus Worthmanus* of Winchell, or *Illoenus Springfieldensis*, of Meek. There are other species of the *Illœnus*, or *Asaphus*, to which the glabella has a slight resemblance to Hall's description, but otherwise are totally different.

The pygidium of Hall's *Sphoerexochus Romingeri* is simply a mutilated specimen of a pygidium of *S. mirus* of Beyrich. I am induced to make these assertions after a careful comparison with perfect specimens in my cabinet. Allow me, also, to state that I have never seen a single specimen of *Illoenus ioxus*, found in Schoonmaker's Quarry, notwithstanding Prof. Hall's mention that it is of frequent occurrence, and Prof. T. C. Chamberlain identifies it as belonging to this quarry.

A nearly perfect head and pygidium of an *Acidaspis Danai* make the specimen quite different from Winchell's *Acidaspis Ida*.

Extraordinary sized *Ceraurus insignis* are occasionally found and well marked parts of *Bronteus Acmas*, *Harpes*, *Lichas*, *Dalmania*, new species of *Illœnus*, *Asaphus*, besides quite a number of as yet undetermined varieties of trilobites, which are "new or but little known."

Fine specimens of *Illoenus ioxus* are found in Waukesha and and Greenfield, but it is in the Racine quarries that the grand patriarchial *ioxus* assumed his supremacy. Specimens of heads over five inches wide and three inches deep, and joined to thoracic segments, and pygidium will make full-sized specimens, more than one foot in length. The *Acidaspis* and several other very remarkable varieties of trilobites are also found, beautiful as well as unique, and unsurpassed. But it is in the the Wauwatosa quarries that the best documents are produced to illustrate the comparative anatomy and physiology of the trilobite. A critical examination of fossil specimens of this invertebrate animal reveals a bundle of contradictions on account of its possessing many attributes belonging to several orders, which cause the trilobite to assume as uncertain a position among the invertebrates as a Cheiroptera does among vertebrates "which can claim a habitation neither with birds or beasts."

All the parts of the trilobite, as found at Wauwatosa, being "casts of the interior," reveal an internal mechanism which requires no more stretch of the imagination to localize and impute certain actions to different parts, than for an anatomist to explain definitely and intelligently the properties and powers pertaining to the skeleton of a vertebrate.

Precisely in similar manner do the casts of the trilobite illustrate its organism, habits and locomotion. Like some species of Entromostracans, it was capable of being dismembered into several parts and had the attributes of Crustaceans, Mollusks and Worms. Its ambulatory movements were performed in a similar manner to the larvæ of insects, but its exterior covering of crustaceous segments, united by chitine, enabled it to move rapidly in the water similar to the molluscan *Chiton.* It also possessed the same natatory powers as the Crustacean Macrurans. or it could assume a spherical form like an Isopod, or lepidoptera hairy larva. By the action of its extension or flexor muscles, the trilobite was enabled to elongate or contract its size from several inches in length to one-third its longitudinal extension capacity, and did not possess a single attribute of an arachnoid. If a name were required for such an organization, it would be one suggestive of three orders of genera, combined in one, indicative of an annelid, a Mollusk, and a Crustacean. Such a proposition is the result of a careful examination of many thousand specimens of several genera and species of trilobites, and I am induced to believe that this peculiar invertebrate lived, at certain distinct periods of time, so well defined, as to indicate a sufficient reason for making a change in the ages of Geological History. For instead of classifying the Silurian age as one of Mollusks, and the Devonian as one of Fishes, substitute a Trilobite age. For Mollusks existed through all ages, and fishes first appeared in the later part of the Silurian, and assumed a prominence in subsequent ages, like the Devonian, Carboniferous, etcetera, but the Trilobite is identified at the commencement, and became extinct at the close of paleozoic life. In a paper like this, treating of a miscellaneous fauna, I can only thus give a brief synopsis of the component parts of Trilobite, which, like the Crustacea, by aid of muscular action could be "sessile or stalked eyed," and its having a chitine carapace united by sutures, was provided with processes, and sinuses for the attachment and action of muscles, and it could be readily dismembered at its dissolution into cheeks, glabellæ, hypostoma, thoracic segments and pygidium, that were held in proper position by a chitinous bond of union, which enabled the trilobite to perform its wormlike motions by expansion, adhesion and contractions, or to fold its extremities together as the caterpillar larva, or wood louse when alarmed, or if attacked as a means of defense, or could move swiftly through the water, like the Molluscous *Chiton* or Crustacean crawfish.

After many years of patient research and with the aid of largely magnifying optical instruments, I have been unable with the single exception of the seta filaments at the extremities of the thoracic segments of *Calymene* — to discover any apppearance having the slightest resemblance to the strong jointed legs; characteristic of the limulus group.

Since preparing this society paper, I have received from Mr. C. D. Wolcott, Curator State Museum Natural History, Albany, N. Y., two pamphlets on the organism of the trilobite, entitled "a preliminary notice of the discovery of the natatory and branchial appendages of the trilobite," also an explanatory letter from the author respecting the uncertanty of his discoveries, but hopeful of a final satisfactory result.

A copy of the twenty-eighth Regents' New York Report by Prof. Hall, with reference to plate 34, fig. 14, illustrating points of attachment for supposed natatory organs, also fig. 13, which might be a sub-section in conjunction with other parts of a folded specimen, could be readily construed into a semblance of strong jointed legs, resembling the limuloid species. Mr. Wolcott's theories are formed from incised specimens of "casts of the exterior," while my conclusions are the result of examinations made of "casts of the interior."

In our investigations, Mr. Wolcott and myself may be in a chameleon sense, right or wrong, as to the opinions we may form, being largely influenced by the circumstances which govern our actions in a similar manner — as several years ago — a diversity of opinion existed between Professors Billings, Woodward, Verrill and Dana.

Permit me to simply state that I think I have conclusive evidence, that "trilobites did *not* swim on their backs," they did not have *stout jointed legs,* they did *not* rest with their dorsal surface downwards, and they did *not* belong to the higher order of entromostracans. But more extended and fully explanatory views concerning the trilobite, will appear in a work I am now preparing for the press.

But whatever the result may be of our persevering labors, natural science will no doubt be benefited by our efforts to solve what have been so long problematical statements.

It is said to be a trite saying of the Icelander, that the "sun shines on no country equal to his own." In like manner we may boast or as Virgil, "sing praises," not of "men and arms," but of the richness and variety of the "paleozoic treasures of Milwaukee County, and other counties contiguous thereto," for a naturalist will examine with ecstatic delight, the unexcelled crinoids, as found in the quarries of Racine, Waukesha, Bridgeport and Greenville. Probably in no other fossiliferous localities are there to be found such rich collections of Silurian echinodermata. Quite a number of them are delineated and described in part 3 of Hall's Paleontology of Wisconsin, 1871.

But since the publication of that work, more perfect specimens and new genera and species have been added to private collections, like that of our worthy president, Dr. P. R. Hoy.

If I claim to have unravelled some of the many perplexing and doubtful theories concerning the organism of the trilobite, President Hoy can claim equal success as regards the habits and internal structures of Wisconsin Niagara Echinoderms.

Although a large proportion of the crinoidea may be found at Racine, a majority of the Cystidea are found in Waukesha and Milwaukee counties.

For Racine, besides her unsurpassed Echinoderms, has a wonderful genera, and species of other paleozoic fossils, trilobite heads and pygidia, equal to the largest size yet published or described. Specimens are found of the very peculiar *Acidaspis*, *Dalmanites*, *Bronteus*, *Lichas*, *Sphæroxochus*, *Illænus*, *Calymene* and *Asaphus Harpes*.

Exquisitively beautiful is the internal structure of several varities of Cephalopods, that of the *Orthoceras abnorme*, with a siphuncle, having a central siphuncle, composed of minute cylindrical ramifications which reach to the outer walls of the siphon. Also several varities of the *Orthocerta*, like the O. *angulatum*, O. *columnnre*, O. *crebescens*, O. *Laphami*, on account of their peculiarly constructed chambers, bases or siphuncles, have some resemblance to *Endoceras*.

Quite a number of the Gasteropods claim our attention, as the *Pleurotomaria occidens*, *Trochoceras costatum*, *Tremanotus*, *Tremanotus alphenus*, *Pleurotomarial Hoyi* and *P. Halli*.

Principal among the Brachiopods are the *Osotus conradi*, *Spirifer nobilis*, *Spirifer plicatella*, *Strophodonta paofunda*, *Pentamarella ventrecosus*, *Pentamarus oblongus*. In an inspection of the fossils of Eastern Wisconsin, it is naturally expected by every votary of natural science, that an identity of fossiliferous bearing rocks should be established with some age or period.

But it appears from the published expressed opinions of those appointed to execute the geological state surveys, that there are many complications and difficulties intervening, in localizing, in accordance with established rules and methods, definite ages and periods, for the strata of rocks as exhibited in Eastern Wisconsin.

In 1862, the first plausible or rational theories were published by Wisconsin legislative enactments concerning the parallelism of New York paleontology, with the same fossiliferous bearing rocks of the northwestern states, — more particularly the eastern portions of Wisconsin, — especially Milwaukee, Racine and Waukesha counties.

Notwithstanding the conclusions reached were far from satisfactory, still some system was established, which enabled the student of Paleontology to profit by his investigations, and may have been the means of stimulating such inquiries and experiments, as resulted in establishing a great commercial and profitable branch of industry, which may give to Milwaukee a reputation for hydraulic cement products, second to none in the Union, and eventually first in the world.

No doubt this most gratifying success was accomplished through the suggestions and persevering investigations of the late Dr. I. A. Lapham, one of the chief pioneers of natural history.

SCIENCE IN WISCONSIN.

Yet, a certain amount of credit is due to the Superintendent of the Geological Survey of Wisconsin (Prof. James Hall) of 1862, for the opinions he expressed in that work, and also for the theories similarly advanced in Vol. III, Paleontology of New York, and part 3d, Paleontology of Wisconsin, 171, in the introductory chapters, having reference to the hydraulic cement character, of the calciferous formations of the Upper Silurian age of rocks, as exhibited in the vicinity of Milwaukee.

Prof. Hall, also in his statements in Vol. I, Geology of Wisconsin, represents the strata of rocks lying above the Niagara, as the equivalent of the Salina or Onondaga Salt group of New York, or the Guelph, or Gault, of Canada, and the Le Claire, of Iowa. Notwithstanding, he was unable to trace the characteristic fossil, Eurypterus remipes of the Water-Lime Group. Similar views are expressed by him in his prefatory remarks in his paleontology of Wisconsin, also see Paleontology of New York, Vol. III. Likewise what are called, on page 72, Vol. I, Geology of Wisconsin, the upper Helderberg and Hamilton groups, have proved to be what is Geology of the Hamilton cement, of Devonian age, in Vol. II. of now termed Wisconsin.

An analytical examination of the expressed sentiments of the authors in Volumes first and second of Geology of Wisconsin, concerning the lithological character of the rocks containing the fauna of Wisconsin, especially its eastern portion, shows no very marked distinction or discrepancy, for their final summation respecting the area, the age, and periods, embracing the characteristic epochs, as generally admitted in American Geology.

To the general student of Natural History, the previous classification established by Hall, on 447 page, of Vol. I, of Geology of Wisconsin, comprehensively covers the synonymous terms of Mayville and Byron beds, and upper and lower coral beds, lying below the Waukesha limestone. For the Hamilton cement, the Le Claire, the Racine and Waukesha limestones, embrace all the fauna belonging to that portion of the Upper Silurian, equivalent to the Salina, Lower Helderberg and Hamilton.

Such an increase of synonyms has a tendency to embarrass the student in his study of paleozoic life, notwithstanding. Prof. Chamberlin, while reiterating the ideas advanced by Prof. Hall, has invested them, in a fuller and more interesting phraseology. But some facts concerning the quarries in Milwaukee county do not substantiate the correctness of Prof. Chamberlin's views, that the three classes of limestone, Mayville, Waukesha and Racine, lying above the Trenton period of rocks, were formed simultaneously.

If we examine the lowest depths of the sole of Schoonmaker's quarry, we find the same characteristic rock, containing the *Terebratulous fossil*, *Gypidean occidentalis*, belonging to the Byron division of the Mayville bed. This formation was quarried to some extent, and formed dressed stones, for bases to grave-stones, and window caps and sills.

This stratum terminated abruptly in an ancient river bed, the bottom of which is smooth and polished, grooved and scratched by the drift of the glacial action or era, for huge granite boulders were excavated during the process of quarrying.

Above this stratum, are regular even layers of a glazed, compact, metalic ringing, cherty limestone, of several inches in thickness, which is quarried in regular rectangular forms, and is utilized as a durable pavement on the side walks, or macadamized streets of Milwaukee and Waukesha. This formation was covered with animal life, similar to that, so extensively intermixed in the strata or groups overlying it, and is well exhibited at every exposure of this rock, in all the quarries in Milwaukee, Racine and Waukesha counties. But the fauna which covered the surface of the Waukesha limestone, at Cook's, Hadfield's and Pelton's, in Waukesha county, or Trimbone's, Swan's, Busack's, Schwackhart's and Story's in Milwaukee county; or Ives', Horlick's and others, in Racine county; or Cook and Mc'Henry counties in Illinois, are in an exceedingly compressed stratum, and in many instances the fossils are in such a state as to be but little better defined, than well marked outlines of the original plant or invertebrate animal. In several of the quarries, as Story's, Schewickhart's, Busack's and Cook's, the Bryozoa, Cephalopoda, Gasteropoda, Brachiopoda and Crustacea, are so intensely compressed and distorted and glazened as often to give the appearance of different genera or species.

In seeking an elucidation of the age and character of the dolomitic formations in eastern Wisconsin, and in taking into consideration the totality of their surroundings, a plausible, perhaps a correct theory is established from these facts. Adopting the axioms, that the predominating fossil contents of rocks determine their age and character, we find lying above the regular stratified rocks of the Niagara period, and termed the Waukesha limestone, soft, porous, and in places, easily disintegrated coral formations, termed by Profs. Hall and Chamberlin, coral reefs, which were formed on the top of sedimentary rocks, less than one hundred feet deep, in an ancient sea.

That these coral reefs extended from the south of Kewaunee, Wisconsin, in a southerly direction, below Bridgport, Illinois; a distance of more than two hundred miles, and westerly, to Le Claire, Iowa.

That at certain points in Milwaukee, Waukesha, and Racine, these coral reefs became more prominent and formed, as termed by Prof. J. Dana, atolls, bordering on lagoons, which upon the receding of the ancient sea, formed the fiords vallies, now occupied by the numerous rivers of Wisconsin.

Subsequently in the vicinity or same direction of these fiord vallies, glacial vallies were formed at frequent intervals for long lines of granitic boulders, of the Archean age are found, some measuring many tons, in size and weight; they no doubt had an agency in producing the grooves, scratches and polished surface, exhibited on the tops and sides of the ledges of the compact and fine grained limestone. The compressed condition of the fossils appears to be due to an upward pressure from an upheaval at the era of Silurian eruption, from which the same cause may have changed portions of the sedimentary dolomitic strata, either by igneous action or by solution into metamorphic beautiful calcite, or strontianite. Such a theory would account for the extraordinary compressed condition of fossil Cephalopoda, and other genera, and calcite crystals in the Waukesha limestone, and at the quarries in Wauwatosa, Racine and elsewhere in the state. An equally plausible theory is, that by a gradual submergence, or subsidence; and also from erosion, by the waves and currents of the ancient sea upon portions of the foundation or base of the coral reefs, certain parts were undermined, causing the superior portion of the rocks to tilt over and slide down in huge blocks, which give the appearance, upon exposure by quarrying, of an upheaval of the strata. Such causes, explain somewhat, the deep vertical fissures and seams, which permeate every portion of the Wauwatosa reefs, and this situation is taken advantage of by workmen, in the process of quarrying, by blasting and excavating.

In certain parts of the reefs are coves, or pockets, which contain remains of distinct colonies of paleozoic life. For in one cove, you will chiefly find Foraminifera and Zoophyta. In another cove, the Brachiopoda; in another the Crustacea, and so on with each class and species of fossils. A similar state exists in other of the coral reefs; for the trilobites of Wauwatosa are not found at Waukesha. The magnificent and peculiar Echinoderms of Racine, are not found in other reef formations; and the trilobite species, *Illænus imperator*, *Illænus armatus*, are found in the southerly reefs of Burlington, Bridgeport and Algonquin.

From the foregoing considerations, aided by geological axioms and other published opinions of accepted paleontological authority, we offer these suggestions, as an effort to supply the "missing links" in our research, as to the age, period and epoch, wherein once lived, moved and had a being, "the fauna of Niagara and Upper Silurian rocks, as exhibited in Milwaukee county, Wisconsin, and in counties contiguous thereto."

DISCOVERIES ILLUSTRATING THE LITERATURE AND RELIGION OF THE MOUND BUILDERS.

BY EDMUND ANDREWS, A. M.. M. D.,

Prof. of Surgery in Chicago Medical College.

Looking back into the dawn of American history, we see certain figures stalking dim and phantom-like across the horizon. So unreal do they appear, that were it not for the massive earthworks they have left behind them, we might well disbelieve their existence.

Little by little we have gained information respecting them. They were miners and coppersmiths of considerable skill, but apparently wrought their metal solely by hammering, yet they occasionally had molten bronze chisels, which they probably imported from Mexico. They possessed shells from the sea, plates of mica from the Alleghanies, and Obsidian from the Rocky Mountains. They probably sent copper to Mexico, and in the graves of Yucatan have been found heads of their Lake Superior chlorastralite. They were farmers, and cultivated broad fields with hoes and spades made of flint and wood. They wove cloth, made pottery, and erected earthworks of such enormous size and number as to astonish even the white men who now occupy their deserted cities. Their skeletons often exceed six feet in height, their skulls, which are generally brachycephalic, are flattened at the occupit like those of the modern Indians, but enclosed a large sized brain. This comprises nearly all that we have hitherto known about the vanished races.

The exploration of the interiors of their mounds has generally been conducted in a very slovenly and inefficient way. It would seem that in sacrificial mounds, the builders were accustomed to deposit sacred records inscribed on stone, but so incomplete have been our examinations, that hitherto only a few of them have been disinterred, and these more by accident than by any real skill of the discoverers.

The first one that came to my knowledge was found in a township called Savannah, on the Tennessee river, in the state of Tennessee. A mound existed here so broad that a company of cavalry and all their horses, in the late war, encamped on its summit. Subsequently the men removed their tents from it and systematically dug away the whole structure. A small slab of stone was found with a drawing upon it representing an altar with the body of some animal upon it enveloped in flames, while the sun was depicted above. It evidently represented a sacrifice to the deity residing in that luminacy. I have not yet succeeded in securing a copy of this stone.

The second was near Rockford, Illinois. A large mound was examined there, and yielded a small stone of crystalline marble containing a figure of the sun supported as if on a pedestal, with a column of hieroglyphics on either side consisting of twelve characters, in all. A fac simile marked No. one, is transmitted with this paper. The left hand column shows at the top a segment of a circle. Next below is a triangle, next a snake, a lizard, and last a flower. The right hand column consists of a sigmoid line, a line like the letter U, a minute cross, head of a rabbit, two objects whose significance I am unable to make out, and a fish. The disk of the sun has a human face drawn on it, and on the forehead of the face is the disk of a crescent moon, with as much of an imitation of a face on the latter as there was room to portray. It may be remarked here that the Aztecs, according to Prescott, (Conquest of Mexico, vol. 1, p. 122), understood the agency of the moon in producing eclipses, and portrayed these events by drawing a moon on the disk of the sun. This stone, therefore, may be the record of an eclipse. It is not possible yet to translate the twelve hieroglyphic signs upon it.

The third discovery of this sort also occurred near Rockford. There were hieroglyphics found on some stones excavated from a mound, but I have not yet succeeded in obtaining a copy.

The fourth inscribed object was an ornament of shell found in a Mound Builder's grave, near East St. Louis. It contained only four characters.

The fifth discovery was made last month at Davenport, Iowa, by the Rev. Mr. Gass, a trustworthy Lutheran clergyman, with his friends. Fac similes ha e been sent me by Mr. Pratt, Secretary of the Davenport Academy of Sciences, and copies are sent herewith, numbered two, three and four. Numbers two and three are on opposite sides of the same stone. The drawing is excessively rude and far inferior to the work of some modern Indians. It is a sacrificial scene, taking place on the summit of a mound. At the bottom is the mound itself, on it blazes a large fire, and near it lie the bodies of three human victims. Around it stand a circle of worshipers clasping each others hands, while the smoke curls upward from the flame. Above at the right hand is the sun; at the left hand is the moon, with a human face portrayed on its disk, and between are the stars, over all arches the sky. On the upper part of the slab are about one hundred characters, which are evidently a record of something which we at present cannot read. (The irregular line from the top to the bottom represents only a fracture in the stone).

The opposite side of the same slab seems to be a rude representation of a wooded country, full of game of every description, which a few lucky hunters are killing with the greatest ease. There are deer, bears, buffaloes, fish, birds, and nondescript animals, possibly intended for a musk ox and a turtle. As the opposite side was a sacred scene, this side is probably a religious delineation also, and may, perhaps, represent the famous "happy hunting grounds" of departed souls. Two-thirds of the way up the slab, a line of hieroglyphics runs across it containing, like the Rockford stone, twelve characters, four of which are identical with those on the Rockford stone. It is to be observed, also, that the two lines of characters carried along the arch of the sky on the other side of the slab, each contain twice twelve characters, and in fac similie number four, we again find twelve hieroglyphics, so that this number seems to have some special significance in their system.

Number four shows a central round spot, surrounded by four concentric circles. Between the two outer circles are ranged very regularly the twelve hieroglyphic characters just mentioned. They are very hastily drawn as if the priests had long been familiar with them and only felt it necessary to slightly imitate the forms. Above are two round spots, intended, perhaps, to signify the sun and the moon. It seems difficult to avoid the impression that this inscription is some sort of a calendar. The stones lay one on the top of the other at the bottom of the mound, on the original surface of the ground, and were surrounded by a circle of small rounded stones, each about four inches in diameter.

No one can inspect these fac similies without the conviction that we have before us rude specimens of literature, which some future investigation may yet translate. Meantime the sacrificial mounds should be ransacked in every part, instead of being carelessly dug into, for the only hope of being able to translate these inscriptions rests on the discovery of more of them for comparison and study.

In concluding this paper I desire to call attention to some neglected evidences, which seem to indicate that the Mound Builders are not extinct, as popularly supposed, but still exist among our Indian tribes.

Squier, after investigating carefully the mounds of western New York, found himself driven very unexpectedly to the conclusion that "they were erected by the Iroquois, or their western neighbors."

Purchens, writing two hundred and fifty years ago, said "The Iroquois have no Townes: their dwellings and Forts are three or foure stories high, as in New Mexico."

Greenhalgh, one hundred years ago, made a statement about the commercial houses of the Senecas, which shows them to have been somewhat like those of New Mexico in plan.

Foster is of the opinion that the mounds thirty miles southwest of Natchez, were erected by the Natchez Indians, and states that the trees on them were younger than on the adjacent grounds.

Lasalle, nearly two hundred years ago, visited the Natchez Indians, and his companion, Touty, says their town was surrounded by a strong earthwork, defended by stakes, on which were stuck the skulls of enemies sacrificed to the sun. They also kept a perpetual fire burning on a mound forty-five feet high. They, therefore, made use of mounds and earth fortifications and sacrificed human victims to the sun, like the Mound Builders of Davenport. In fact they were Mound Builders themselves.

The Smithsonian Reports state that at the bottom of a mound, near Savannah, an iron sword was found with an oak handle, indicating communication with white men.

Bartram (Antiq. Southr. Indians, p. 131), says that in his day the Choctaws erected mounds over the collected bones of their dead, and that the chief, To-mo-chi-chi, pointed out the large mound in which were the bones of a chief who had entertained a great white man with a red beard, who came into Savannah river in a ship.

It is well proved that the southern Indians, like the Mound Builders, possessed the art of weaving cloth, which Foster erroneously attributes to the Mound Builders alone.

I have just received a letter from the Rev. A. L. Riggs, a missionary among the Nebraska Indians, respecting the use of earthworks among the western tribes. He says:

"Along the Missouri river, at least from Sioux City to its head, are many remains of villages and fortifications. They are all traceable to tribes now in existence, chiefly to Poncas, Rees, and Mandans, and were built within two hundred and fifty years. The large circular dirt houses still to be seen at Fort Berthold, among the Mandans and Gros-ventres, were once built by the Poncas, also.

"I remember the site of an old fort on the Minnesota river, near the Yellow Medicine. It was on the edge of the western bluffs. Three sides had been protected by a ditch, and probably by palisades. It enclosed, as I remember, an acre. This fort was said to have been built by the Pawnees, or else the Omahas. This was before the Dakotas occupied the country."

It appears, therefore, that a considerable number of tribes still exist, and some of them are now well civilized, who were Mound Builders when the white men first met them. These facts may destroy some of the poetry of the mounds, but we must look at things as they are. The theories of ethnology have grown too much under blue glass, swelling to an unhealthy size, which cannot be maintained under white sunlight. We shall get on faster, if we move slower.

The next grand effort should be to disinter more of this buried literature, and see whether by the study of it, some genuine knowledge of the past can be made to rise from these tombs. It is also necessary to make a thorough study of the dialects of those tribes, who seem to be descended from the Mound Builders, for they will furnish a necessary stepping stone to the interpretation of the inscriptions, just as the study of Coptic was an essential pre-requisite to the translation of the Egyptian hieroglyphics.

No. 6, Sixteenth street, Chicago, Feb. 8, 1877.

HOW DID THE ABORIGINES OF THIS COUNTRY FABRICATE COPPER IMPLEMENTS.

BY P. R. HOY, M. D., President Wisconsin Academy of Sciences.

I propose to consider the manner in which the ancient inhabitants of this country fabricated those curious copper implements which the plow and spade turn up all over Wisconsin and the adjacent states. These copper tools are objects of great interest to the archaeologist, and it is a matter of pride that the Wisconsin Historical Society has the largest and best collection to be found in any state.

A few of the specimens, upon a superficial examination, seem to be cast. This point will first be considered: Did these prehistoric people possess the skill and intelligence requisite to cast articles of pure copper?

Before a cast can be made, it is necessary to have an exact copy moulded, either in sand, plaster, clay, metal, or other suitable substance. The formation of sand moulds is by no means so simple an affair as it seems at first thought. It requires long practical experience to overcome the disadvantages attendant upon the materials used. The moulds must be sufficiently strong to withstand the action of the fluid metal perfectly, and at the same time to permit the egress of the gases formed by the action of the metal on the sand. If the material is air-tight, then danger would come from pressure, arising from the rapidity of the generating of the gases, and the casting would be spoiled, and probably the operator injured. If the gases are locked up within the mould, the general result is what moulders term *blown casting*, that is, the surface becomes filled with bubbles of air. The preparation of sand and loam used in forming the mould must be carefully considered. The greater the quantity of sand the more easily will the gases escape and the less liability is there of fracture of the casting. On the other hand, if the loam predominate, the impression of the pattern will be better, but a far greater liability of injury to the casting will be incurred from the impermeable nature of the moulding material. In moulding an accurate pattern must be made, generally in two or more parts. Pattern making involves much knowledge and skill.

I enumerate these difficulties in order to show that it was not likely that a rude people possessed that amount of knowledge and skill adequate to overcome these obstacles.

I pass over all other modes of forming moulds, and speak only of those formed in stone. Almost all savage tribes possess the skill to fashion stone into various tools, and we are forced to admire the workmanship displayed in working the hardest materials, such as flint, quartz, granite, greenstone, etc. In contemplating these evidences of patient toil, we are assured that they could readily work out suitable moulds in stone in which castings might be made.

Copper is a refractory metal, which melts at from 2200 to 2600 degrees, a temperature that can be reached only in a furnace, assisted by some form of coal and an artificial blast. We must have good evidence before we assert that these dwellers by the lake possessed these indispensable auxiliaries to successful working in metals. "Copper, when melted, is thick and pasty, and without the addition of some other metal, will not run into the cavities and sinuosities of the mould."

In consulting with an intelligent and skillful brass-founder, I was shown a hammer weighing three pounds, cast of pure copper, and was assured that this was the smallest casting he could make of this metal. The addition of one pound of zinc to ten of copper makes an alloy that will melt at less than half the temperature of copper, and will flow freely.

In casting in copper it is positively necessary to put the materials in a crucible, and that the surface of the melting mass be covered with a flux in order to effectually defend the melting metal from the action of the atmosphere.

A word about crucibles. The manufacturing of good crucibles, such as will withstand the heat necessary to melt the more refractory metals, involves such a degree of knowledge, that for many generations the entire civilized world was dependent on a small section of Germany; and even now Hessian crucibles are unsurpassed. In England there are now several manufactories which turn out excellent articles, one in London which makes the celebrated Plumbago crucible. It will sufficiently indicate the difficulties involved, when I state that America, to-day, is dependent upon Europe for the immense number of crucibles used in this country. I am aware there is a manufactory established in Connecticut, but the quality is so inferior that they are only used for the more easily fused metals. I experimented with fragments of pottery taken from the ancient mounds near Racine, in order to determine the degree of heat they would stand. The result was they were melted long before the copper was fused.

A majority of copper implements found have specks or points of pure silver scattered over their services. I am prepared to prove by the best authority in America, James C. Booth, and Thomas H. Garrett, U. S. assayers at Philadelphia, that one single speck of pure silver, visible even with the microscope, is positive evidence that the specimen was never melted.

Copper unites intimately with nearly all metals, thus forming homogeneous alloys — with zinc forming brass, with tin, bronze, and so on. The only apparent exception to this law is where large masses are fused and at rest for a long time. In these cases the heavier metals gravitate and separate more or less, but *never perfectly*. When large brass cannon are cast, in consequence of the great quantity of metal fused, together with the additional circumstance that the mould is made in the earth and hence requires days to cool, "blotches of lighter color are occasionally found on the surface of the guns, indicating a *segregation* of the metals. A fibrous texture is another evidence that these implements were hammered or rolled out. This fibrous quality is well exhibited by the action of strong acids on the specimens. On articles that are cast, the acid acts in a uniform manner, revealing no *striae* or hard bands. The absence of the slightest indication of a *sprue* — the opening where the metal is poured — is also, to say the least, suggestive. We certainly would expect to find indications of this necessary blemish in specimens so carelessly finished that the mould marks remain conspicuous. If these projections are the remains of the imprint of the mould, the specimen is of recent casting, for it is evident that these delicate marks would be the first to be corroded by the tooth of time.

I make a short extract from a paper entitled "The Ancient Men of the Great Lakes," read by Henry Gilman at the Detroit meeting of the American Association for the Advancement of Science. Mr. Gilman is a close observer, and an accomplished archaeologist, and has made the ancient mines of Lake Superior a specialty. He says: "I cannot close, however, without expressing my wondering admiration of a relic, which, taken in connection with our former discoveries, affords some of the most important evidences of the character of the ancient miners, the nature of their work, and the richness of the mineral field selected for their labors, at Isle Royale. On cleaning out of the pit the accumulated debris, this mass was found at the bottom, at the depth of sixteen and one-half feet. It is of a crescent-like shape and weighs nearly three tons, or exactly 5,720 pounds. Such a huge mass was evidently beyond the ability of those ancient men to remove. They could only deal with it as best they knew how. And as to their mode of procedure, the surroundings in the pit, and the corrugated surface of the mass itself, bear ample testimony. The large quantities of ashes and charcoal lying round it show that the action of fire had been brought to bear on it. A great number of the stone hammers, or mauls, were also found near by, many of them fractured from use. With these the surface of the mass had evidently been beaten up into projecting ridges and broken off. The entire upper face and sides of the relic present repeated instances of this; the depressions, several inches deep, and the intervening elevations with their fractured summits covering every foot of the exposed superficies. How much of the original mass was removed in the manner described, it is of course impossible to say. But from appearances, in all probability it had at least been one third larger. Innumerable fragments of *copper chips* lay strewn on all sides, and even the scales of fish, evidently the remnants of the meals of the miners, were recovered from the pit."

Mr. Gilman was asked if there were in or about any of these ancient mines any indications of the copper having been melted. He replied: "Not the least." And now, were not these innumerable copper chips that were strewn on every side additional evidence that these ancient men know nothing about casting in copper? Those fragments would have been the most suitable to melt, as in all metals the smaller the fragments the more easily they melt. It is evident that those chips, being too small to make any form of their implements, were abandoned as useless.

Finally, How were they made if not cast? I believe that I have the *key*, and can fabricate any form of these ancient implements so exactly as to deceive *even* my learned friend, Dr. Butler.* These ancient Indians, for I believe they were Indians, used fire in their mining operations. The vein-rock was made hot by building a fire on or against it; then, by dashing on water, the rock would not only be fractured, but the exposed pieces of copper be softened, so that it could be beaten into shape. Then the metal became hard, in consequence of its being pounded; it was again heated and plunged into cold water; for copper is, in this respect, the opposite of steel; the one is softened, while the other is rendered hard. In this way copper was fashioned simply by pounding.

In addition to the hammering process, cylindrical articles were evidently rolled between two flat rocks, which is the manner in which several of the articles in the historical collection might be made. Some of those implements that have been supposed to be cast, were, I think, swedged; that is, a matrix was excavated in stone, into which the rudely fashioned copper was placed, and then by repeated blows the article would be made to assume the exact shape of the mould. Nearly all those plano-convex articles could be made in this manner. Of twenty axes taken from mounds near Davenport nearly three-fourths were of this pattern. I will repeat a few lines of an interesting paper read at the Detroit meeting of the American Association, by R. H. Farquharson, on "Recent Explorations of Mounds near Davenport, Iowa."

"The Davenport collection of copper implements consists, at present, of twenty axes, six of which were more or less covered with cloth, four copper awls or borers, over one hundred beads, and a curiously spoon-shaped implement. The axes are all of two forms, one plano-convex, the other with flat sides. They are

*Dr. Butler, who was present, has held strongly for the *casting* of these copper tools.—Ed all cold-wrought by hammering. Some retaining the original scales or lamina on the surface; none of them show signs of use, and are notably harder on the edge than elsewhere."

All of these interesting implements are figured in the proceedings of the American Association at the Detroit meeting, page 304.

We can learn more from this Davenport collection than from any other, because of the perfect condition of the specimens, being unused and in some degree protected by their coverings.

Besides this half swedging process, I am persuaded that, in a few instances at least, there was a complete mould worked out in halves, on the face of two flat stones, so that by placing a suitable piece of copper between them and giving it repeared heavy blows the copper was made to fill the mould accurately.

Last September, while watching some workmen engaged in filling the cribs of the harbor pier with stone, my attention was directed to a slight excavation on the face of a large granite boulder. On careful inspection I found that it was undoubtedly the work of man; although but a part of the excavation was left, the rock having suffered fractures, there was enough, nevertheless, to enable me to make out the original form. We attempted to chip off the specimen with a heavy stone hammer, but failed, as the cleavage was in the wrong direction, and the mould was obliterated. I however worked out a pattern as nearly accurate as I could, representing the excavation. I took this pattern to a stone cutter, for the purpose of having a mould cut in granite. Upon consultation it was decided that the mould would have to be cut in halves in large granite boulders in order to insure success, which would be costly and inconvenient, and for the purpose of illustrating the subject it would be as well to have a mould cast in iron. This was done, and a beautiful ax swedged out of cold native copper was the result. This cylindrical specimen* was made out of a piece of float copper, hammered with a stone ax into partial shape, and then finished by rolling between heavy flat stones.

(The author exhibited plain convex and double convex hatchets, as well as a long cylindrical implement tapering regularly from the centre to the point, that were fabricated by him in the manner stated).

*The specimens referred to was exhibited to the Academy.

REMARKS ON THE DESCENT OF ANIMALS.

BY PROF. H. OLDENHAGE, MILWAUKEE.

Whether species are constant and have been created with the same specific characteristics they now possess, or whether they are variable and have desended from common ancestors, is the point at issue between the defendants of special creation and the evolutionists. Since Linne first introduced the idea of species into Botany and Zoology, many attempts have been made to define in an exact manner, what we are to understand by the term species; but when a systematizer underakes to apply these definitions, it is at once seen that they are either glittering generalities, or unmeaning phrases. Among the most recent, and no doubt the ablest of these attempts, is Agassiz's "Essay on Classification," the dogmatism and fulitity of which, Hæckel has so thoroughly exposed in his "Generelle Morphologie."

"Even before the appearance of Darwin's work on the 'Origin of Species,'" says Oscar Schmidt, "Carpenter, in the course of his researches on the Foraminifera, arrived at the conclusion, proved in special instances, that in this group of low organisms, which secrete the most delicate calcareous shells, there could be no question of "species," but only of "series of forms." Forms which the systematizer, had reduced to different genera and families, he beheld developing themselves from one another" (Descent and Darwinism., p. 92). But as these Foraminifera are "so simple in structure, and so little is known of their individual development, the defenders of the persistency of species might claim, that Carpenter's series of forms are mere varieties, and only prove that the true 'species' have not yet been found." To determine this point, however, the researches of Oscar Schmidt and Hæckel, on sponges, have been of the greatest importance. Oscar Schmidt shows, that "we arrive gradually at the conviction, that no reasonable dependence can be placed on any 'characteristic;' that with a certain constancy in microscopic constituents, the outward bodily form, with its coarser distinctive marks, varies beyond the limits of the so called species and genera; and that, with like external habits, the internal particles which we looked upon as specific, are transformed into others, as it were under our hands." "Any one," thus concludes this section of Schmidt's work on the Fauna of the Atlantic Sponges, "who with regard to sponges, makes his chief business the manufacture of species and genera, is reduced *ad absurdum*, as Hæckel has shown with exquisite irony in his Prodrome to the Monograph in the Calcareous Sponges."

"In my specific researches," continues Schmidt, "I confined myself essentially to the siliceous sponges, and by thousands of microscropic observations, by measurements, by drawings, by facts and inferences, have produced evidences, which acute opponents of the immutability of species had not brought forward before me, that in these sponges, species and genera, and consequently fixed systematic unities in general have no existence. The other division of the same class, the calcareous sponges, had been treated with unrivaled mastery by Haeckel in his monograph."

Hæckel was not only able to confirm Oscar Schmidt's statements, "but, owing to the smaller compass and the greater facility of observing the groups selected for study, to advance with more sequence and continuity, from the observation of details to the whole, to portray its morphology, physiology, and evolutionary history, with the utmost completeness." He sums up his conclusions as follows: (Preface to American Edition of History of Creation, p, 15.) "For five consecutive years I have investigated this small but highly instructive group of animals in all its forms in the most careful manner, and I venture to maintain that the monograph, which is the result of these studies, is the most complete and accurate morphological analysis of an entire organic group, which has up to this time been made. Provided with the whole of the material for study, as yet brought together, and assisted by numerous contributions from all parts of the world, I was able to work over the whole group of organic forms, known as the Calcareous Sponges, in the greatest possible degree of fullness, which appeared indispensable for the proof of the common origin of its species. This particular animal group is especially fitted for the analytical solution of the species problem, because it presents exceedingly simple conditions of organization; because in it, the morphological conditions possess a greatly superior, and the physiological conditions are inferior, in part, and because all species of the Calcispongiæ are remarkable for the fluidity and plasticity of their form. With a view to these facts, I made two journeys to the sea-coast (1869 to Norway; 1871 to Dalmatia), in order to study as large a number of individuals as possible, in their natural circumstances, and to collect specimens for comparisons. Of many species, I compared several hundred individuals in the most careful way. I examined with the microscope, and measured in the most accurate manner, the details of form of all the species. As the final result of these exhaustive and almost endless examinations and measurements, it appeared that 'good species,' in the ordinary dogmatic sense of the systematists, have no existence at all among the Calcareous Sponges; that the most different forms are connected, one with another, by numberless gradational transition forms; and that all the different species of Calcareous Sponges are derived from a single exceedingly simple ancestral form, the Olynthus. If we take for the limitation of genera and species, an average standard, derived from the actual practice of naturalists, and apply this to the whole of the Calcareous Sponges at present known, we can distinguish about 21 genera with 111 species. I have however, shown that we may draw up, in addition to this, another systematic arrangement, which gives 29 genera and 289 species. A systematist, who gives a more limited extension to the ideal species, might arrange the same series of forms in 43 genera, and 381 species, or even in 113 genera and 590 species; another systematist, on the other hand, who takes a wider limit for the abstract "species," would use in arranging the same series of forms, only 3 genera, with 21 species, or might even satisfy himself with 2 genera and 7 species. This appears to be so arbitrary a matter, on account of endless varieties and transitional forms in this group, that their number is entirely left to the subjective taste of the individual systematist."

"In point of fact," he continues, "I have a right to expect of my opponents, that they shall carefully consider the exact 'empirical proof' here brought forward for them, as they have so eagerly demanded. May they, however, spare me the empty, though by even respectable naturalists the oft repeated phrase, that the monistic nature-philosophy, as expounded in the 'General Morphology,' and in the 'History of Creation,' is wanting in actual proof. Precisely that exact form of analytical proof, which the opponents of the direct theory demand is to be found, by anybody who wishes to find it, in the 'Monograph of the Calcareous Sponges.'" "This mutability of the Spongiadæ" adds Oscar Schmidt, "affords the extremely important evidence that, so to speak, an entire class has even now, not attained a state of comparative repose." But to prove the variability of species satisfactorily, "the transition of the forms succeeding one another historically in the strata of the earth" must be shown.

The researches of Waagen, Zittel, Neumayr and Würtenberger have proven, in the most conclusive manner, "at least with respect to the important division of the Ammonites, the utter impossibility of separating them into species." "Neumayr is such a cool and cautious observer, that he allows nothing to pass current, but that which is absolutely certain." It is true he holds it to be "extraordinarily probable, that in *all* forms these gradual transitions have taken place, yet in one case only does he demand unqualified assent; namely, that he has proven 'that Perisphinctes aurigerus of the Bathoniaus, and Perisphinctes curvirostris of the zone of the Cosmoceras Jason, are connected in such a manner by intermediate occurrences that it is impossible to draw a limit.'"

Würtenberger's studies were applied to thousands of specimens from the groups of the Planulate Ammonites, with ribbed shells, and of the Armate Ammonites with prickly shells. In summing up his results he says: "In groups of fossil organisms, in which, as in the present case, so many connecting links between the most extreme forms are actually before us, that the transition is regularly carried on, the species is far less susceptible of apprehension than in the organic forms of the present world, which at least denote the existing limits of the great pedigree of the organic world.

With respect to these fossil forms, it is fundamentally indifferent whether a very short, or a somewhat longer portion of any branch be honored by a special name, and looked upon as a species. The prickly Ammonites, classified under the name Armata, are so intrinsically connected, that it becomes an impossibility to separate sharply, the accepted species from one another. The same observation applies also to the group of which the manifold forms are distinguished by their ribbed shells, and termed Planulata.

This is sufficient to show why modern inquiry "sets aside the phantom of 'species,' and to judge what series of observations are opposed to the assertion, that in no single case has evidence been given of the transition of one species into another." "The fact is," says Huxley, "that if the objections which are raised to the general doctrine of evolution were not theological objections, their utter childishness would be manifest even to the most childlike of believers.' "

"Scarcely a single fact," says that most careful observer Neumayr, "speaks more decisively in favor of the correctness of the theory of descent, than the existence of series of forms in the manner in which they have already been proved in many cases, and will, no doubt, be now found more frequently, since attention has been called to this point.' "

But it is not only among the lower animals that these transition forms have been found. Even among vertebrates, and what is the more important, between those classes, orders and families, which at present are separated very widely from one another, these connecting links multiply almost daily, bearing in mind, of course, the great imperfection of the geological record.

"The class of birds and reptiles as now living," says Prof. Marsh, of Yale College, to whom palæontology owes so many important discoveries, "are separated by a gulf so profound, that a few years since it was cited by the opponents of evolution as the most important break in the animal series, and one which that doctrine could not bridge over. Since then, as Huxley has clearly shown, this gap has been virtually filled by the discovery of bird-like reptiles and reptilian birds.' "

In 1860, shortly after the appearance of Darwin's "Origin of

Species," a remarkable bird was found in the lithographic slates of Solenhofen, Bavaria, the head of which was unfortunately crushed beyond recognition. Recently, however, another specimen has been found in the same formation, at Eichstadt, Bavaria, with a well preserved head. The celebrated comparative anatomist, Owen, of London, described this bird and called it Archaeopteryx. "There is this wonderful peculiarity about this creature, that so far as its feet are known, it has all the characters of a bird, all those peculiarities by which a bird is distinguished from a reptile. Nevertheless, in other respects, it is unlike a bird and like a reptile. There is a long series of caudal vertebrae. The wing differs in some very remarkable respects from the structure it presents in a true bird. In a true bird the wing answers to the thumb and two fingers of the hand, the metacarpal bones are pressed together into one mass, and the whole apparatus, except the thumb, is bound up in a sheath of integument, and the edge of the hand carries the principal quill feathers. It is in that way that the bird's wing becomes the instrument of flight. In the archaeopteryx, the upper arm bone is like that of a bird; the two forearm bones are more or less like those of a bird, but the fingers are not bound together — they are free, and they are all terminated by strong claws, not like such as are sometimes found in birds, but by such as reptiles possess; so that in the archaeopteryx we have an animal which, to a certain extent, occupies a place midway between a bird and a reptile. It is a bird so far as its foot and sundry other parts of its skeleton are concerned; it is essentially and thoroughly a bird, in the fact that it possesses feathers; but it is much more properly a reptile, in the fact that what represents the hand has separate bones resembling that which terminate the fore-limb of a reptile. Moreover, it had a long tail with a fringe of feathers on each side. From this description it is seen that the archaeopteryx is about three-fourths bird and one-fourth reptile."

Prof. Marsh has found during the last few years very remarkable forms of birds in the Chalk of Kansas. In the Hesperornis, "says Marsh," "we have a large aquatic bird, nearly six feet in length, with a strange combination of characters. The jaws are provided with teeth set in grooves; the wings were rudimentary and useless, while the legs were very similar to those of modern diving birds. Ichthyornis, a small flying bird, was stranger still, as the teeth were in sockets, and the vertebrae biconcave, as in fishes and a few reptiles."

"It is obvious," says Huxley, "that the contrast between the crocodile's leg on the one hand, and the bird's leg on the other, is very striking. But this interval is completely filled up when you study the character of the hinder extremities of those ancient reptiles which are called the Dinosauria. In some of these, the bones of the pelvis, and those of the hind limb, became extraordinarily similar to birds, especially to those of young or foetal birds. Furthermore, in some of these reptiles, the fore-limbs become smaller and smaller, and thus the suspicion naturally arises, that they may have assumed the erect position. That view was entertained by Mantel, and was also demonstrated to be probable by your own distinguished anatomist, Leidy, but the discoveries of late years show that in some of these forms the fact was actually so; that reptiles once existed which walked upon their hind-legs as birds now do. The Compsognathus longipes (Wagner) must assuredly have walked about upon its hind-legs, bird fashion. Add to this feathers, and the transition would be complete."

It is now generally admitted by biologists "who have made a study of the vertebrates," continues Marsh, "that birds have come down to us through the Dinosaurs, and the close affinity of the latter with recent struthious birds will hardly be questioned. The case amounts almost to a demonstration, if we compare with Dinosaurs, their contemporaries, the Mezozoic birds. Compsognathus and Archaeopteryx of the old world, and Ichthyornis and Hesperornis of the new, are the stepping-stones by which the evolutionist of to-day leads the doubting brother across the shallow remnant of the gulf, once thought impossible."

Although this kind of evidence is far weightier than that upon which men generally base their conclusions regarding important propositions, it is not that kind of evidence which might be called demonstrative. That is to say, it might be demanded "that we should find the series of gradations between one group of animals and another in such order as they must have followed if they had constituted a succession of stages, in time of the development of the form at which they ultimately arrive." In short, it would have to be shown, that, with reference to birds and reptiles, for instance, "that in some ancient formation reptiles alone should be found; in some later formations birds should first be met with; and in the intermediate strata we should discover in regular succession the forms which are intermediate between reptiles and birds."

Precisely this kind of evidence has of late years been accumulating rapidly respecting many groups of the animal kingdom. The development of the horse offers us, perhaps, the best illustration of this kind of evidence, and I give the substance of "these thoroughly and patiently worked-out investigations of Prof. Marsh," in his own words. He says: "I have unearthed with my own hands not less than thirty distinct species of the horse tribe, in the tertiary deposits of the west alone.

"The oldest representation of the horse at present known is the diminutive *Eohippus*, from the lower Eocene. Several species have been found, all about the size of a fox. Like most of the early mammals, the ungulates had forty-four teeth, the molars with short crowns, and quite distinct in form from the premolars. The ulna and the fibula were entire and distinct, and there were four well-developed toes, and the rudiment of another on the fore-feet, and three toes behind. In the structure of the feet and in the teeth, the Eohippus indicates unmistakably that the direct ancestral line to the modern horse has already separated from the other perissodactyles. In the next higher division of the Eocene, another genus (Orohippus) makes its appearance, replacing Eohippus, and showing a greater, although still distant, resemblance to the equine type. The rudimentary first digit of the fore-foot has disappeared, and the last premolar has gone over to the molar series. Orohippus was but little larger than Eohippus; in most other respects very similar. Near the base of the Miocene, we find a third closely allied species, Mesohippus, which is about as large as a sheep, and one stage nearer the horse. There are only three toes and a rudimentary splint bone on the fore-leg, and three toes behind. Two of the premolar teeth are quite like the molars. The ulna is no longer distinct, or the fibula entire, and other characters show clearly that the transition is advancing. In the upper Miocene Mesohippus is not found, but in its place a fourth form, Miohippus, continues the line. The three toes in each foot are more nearly of a size, and a rudiment of the fifth metacarpal bone is retained. All the known species of this genus are larger than those of Mesohippus, and none pass above the Miocene."

"The genus Protohippus of the lower Pliocene is far more equine, and some of its species equalled the ass in size. There are still three toes on each foot, but only the middle one, corresponding to the single toe of the horse, comes to the ground. In the Pliocene we have the last stage of the series before reaching the horse, in the genus Pliohippus, which has lost the small hooflets, and in other respects is very equine. Only in the upper Pliocene does the true Equus (horse) appear and complete the genealogy of the horse, which in the post-tertiary roamed over the whole of South and North America, and soon after became extinct. Besides the characters I have mentioned there are many others in the skeleton, skull, teeth, and brain of the forty or more intermediate species, which show that the transition from the Eocene Eohippus to the modern horse has taken place in the order indicated, and I believe the specimens now at New Haven will demonstrate the fact to any anatomist. They certainly carried prompt conviction to the first of anatomists (Huxley), whose genius had already indicated the later genealogy of the horse in Europe, and whose own researches so well qualified him to appreciate the evidence here laid before him."

Basing his conclusion on these facts, Huxley says: "The doctrine of Evolution at the present time rests upon exactly as secure a foundation as the Copernican theory of the motion of the heavenly bodies. In fact, the whole evidence is in favor of Evolution, and there is none against it."

Another class of facts, considered equally conclusive in favor of the Theory of Descent, are the results of Embryology.

NOTE.—Prof. Oldenhage had only written thus far when he was seized with an illness which speedily terminated a most promising life.

WHY ARE THERE NO UPPER INCISORS IN THE RUMINANTIA?

BY P. R. HOY, M. D., PREST. ACADEMY.

In studying the anatomy and physiology of animals, we become intensely interested in the various modifications of parts, so as to exactly fit them, to perform the office assigned them. In other words, the structures are so altered as to correspond to the mode of life which the animal pursues.

Perhaps no part of vertebrates is as significant as the apparatus of the mouth, for obvious reasons, as it performs an important part in nutrition, the function which strikes at the very foundation of life.

Every vertebrate has his *bill of fare* written in indelible characters on his teeth. They not only indicate the food on which the animal subsists, but with few exceptions, the mode of procuring that food, as well.

All those animals having no incisors in the upper jaw, and provided with eight placed obliquely outward in the lower jaw, have evenly divided hoofs, complicated stomachs, and chew the cud. I am satisfied that there is a deep meaning conveyed in the absence of upper incisors in ruminantia, if the fact is correctly interpreted.

In the first place, all true ruminants have a prehensile tongue. We will take one of the most familiar examples, the cow, and what is true of this domestic animal, will apply equally well, not only to the entire *boss family*, but with slight modification, to the entire ruminantia. The tongue is large and muscular, weighing from three to five pounds, the upper surface, *dorsum*, is covered with a dense, almost horny skin, especially at the point; the mucous coat, covering the tongue and lingual glands, pours out an abundance of mucus and saliva to keep the organ moist and pliable. It is capable of being thrust out beyond the lips to the distance of from six to eight inches. In protruding the tongue it is pressed firmly against the hardened gum of the upper jaw, then it is coiled around the morsel, the tongue curves upwards bringing the food into the mouth rasping, as it were, the upper jaw.

In grazing, the tongue is lapped around a wisp of grass, which is brought into the front of the mouth, and held in its grasp against the upper jaw, when by a quick motion of the head, the sharp chisel-teeth in the under jaw, clip off the herbage. In these motions we see the great advantage of the outer direction of the under incisors.

In studying these movements of the tongue, we become convinced that upper front teeth would not only seriously interfere with its motion in protrusion by lacerating its upper surface, but would positively arrest the morsel against the upper incisors, if there were any, and thus impose a barrier against the use of the tongue in prehension.

In the deer tribe, *cervidae*, the tongue is longer in proportion to its weight, than in the ox. Deer are mostly browsing animals, feeding on leaves and branches of shrubs and small trees; for this purpose the long flexible tongue is especially well adapted. Deer have the longest tongue of any of the ruminants, if we except the giraffe, whose tongue is simply enormous. With its extensive tongue, and long neck, this singular animal is enabled to reach branches of considerable elevation.

Antelopes, for the most part, have moderately sized tongues, yet not a few have the organ largely developed; in fact the tongues vary nearly as much as do these ill-assorted animals themselves. For the genus antelope is a kind of zoological retreat for the reception of those outcast hollow-horned ruminants which do not belong, either to the ox, sheep, or goat species.

Goats have a moderately developed tongue, fully capable, however, of procuring food in the same manner as the preceding tribes.

Sheep have this organ less developed than in any other of the true ruminants. It is capable of being protruded not over three inches beyond the lips. In grazing on short pasturage, the point of the tongue is only used to fix the short grass to the upper gum, while the under teeth are made to sever the herbage. In our wild sheep of the Rocky mountains, *ovis montana*, the tongue is more developed than in the domestic animal. Is it not more than probable that the domestic sheep, having been confined to short pasture for a long series of generations, have lost, in length, a portion of their tongues?

In the camels, including the lamas, there is a wide departure from the typical ruminants. In fact anatomically, the camel family show a marked affinity to the pachyderms. They stand on the border line of the ruminants where they join the pachydermata, possessing characteristics of each. Their lips are large and fleshy, the upper one cleft. Their dentition is peculiar, the young possessing a full set of incisors in the upper jaw, which fall out as the animal approaches maturity, save the two latter ones, which are permanent.

We have here perfect corresponding relations between the imperfect set of upper front-teeth and the partly prehensile tongue which they possess. The lips and tongue are nearly equally useful in seizing and conveying food to the mouth.

On the lowest round looking up towards the ruminants, stand the kangaroos. These herbivorous marsupials do chew the cud, though imperfectly, as they possess saculated stomachs approaching the multiple condition of the typical ruminants. It is interesting to find that these wonderful animals, of a wonderful country, do not possess a prehensile tongue, but have instead, a full, strong set of incisors in the upper jaw. Here we have then, one of the best proofs that the use of the tongue regulates the presence of incisors.

Insectivorous edentata, embracing the armadillos, and ant-eaters of South America, and the Panoglins and Ard-vark of India and Africa — in these quadrupeds, the tongue is long and cylindrical, and is protruded directly forwards, so that front teeth in either jaw, would interfere with the necessary rapid motions of the tongue in feeding. Hence, the total absence of front teeth in either jaw, and in fact the ant-eaters have no teeth whatever, being strictly edentate. These animals furnish us with another proof that prehensile tongues are antagonistic to front teeth.

If a prehensile tongue be cylindrical, then we will have a total absence of front teeth; if flat and coiled upward in using, then we will find incisors only in the under jaw.

May it not be true that the absence of upper incisors in the ruminants, and the total want of front teeth in the edentata, are the result of long ages of disuse, accompanied with the almost constant friction and presure against them, which might injure and ultimately destroy the germs of the useless teeth, until their absence becomes an hereditary peculiarity, as a final result?

BOILER EXPLOSIONS.

BY CHAS. I. KING,

Superintendent University Machine Shop.

In considering the subject of Boiler Explosions, I am aware that it has heretofore received the attention of many able theorists and mechanical engineers who do not agree in their conclusions. That such diversity of opinion exists, is natural from the various conditions of the matter discussed.

What is here prepared may not be new, but the subject is of such vast importance, that even repetition may be pardonable.

If we for a moment consider the field, we find that its extension precludes comprehending the whole in one short paper, which covers thė subject proportionally, as the hand might cover a table. That the astonishing developments, attained by the use of steam in the various industries throughout the country, must be ascribed to its universal success as a moderately cheap prime mover none can deny; and the facility with which it can be employed in any section of the land enables the manufacturer to locate his mills wherever desirable, and then transport to them the mo tive power.

Without it, he must be content with the water courses wherever they may be found, and ever after transport the material of manufacture to and from the market.

Without it many of our large cities and manufacturing centers could not exist to-day. Only while it is considered less dangerous or less expensive than other agents, can steam maintain its now prominent position of principal motive power for nearly all branches of manufacture, transportation, etc.

There are considerations in connection with the present methods of utilizing steam, which, looked upon from every point, would indicate clearly that we are justified by no means in accepting it as the most economical prime mover obtainable. Many unsuccessful attempts have been made to discover a substitute for steam as a source of power, there always having been found insurmountable obstacles, inseparably connected with the use of all other agents; difficulties which science and the best mechanical skill have failed to overcome. Quite a number of years will probably yet elapse, ere these hindrances are pushed aside by the spirit of investigation and invention which pervades the age in all civilized countries. But supposing the successful employment of a more suitable and economical motor might be rendered practicable, during the coming week, month or year, the expense necessary to secure the change would preclude its rapid adoption by many using the present devices. It would in fact be so long before the present arrangements could be superseded that it must still be worth our time to strive for improvements in the manner of employing the power we now have, and to gain some knowledge in which direction, further improvement in its safe and economical use may tend.

Practical experience has taught us, in the past twenty-five years, that there was no economy in the "old time practice" of using steam at a low temperature and pressure for all purposes. The direct advantages accruing from its use at high pressure, securing high piston speeds, and expanding the steam to nearly zero, have been very large. This change came gradually. Many improvements were necessitated, but now the six to fifteen pound pressures of forty-five years ago, and large unsightly engines are supplanted by pressures of fifty to two hundred pounds, and engines of half the size which give the same equivalent of work. As the economy of the higher temperatures becomes generally appreciated, the greater the demand will be for them.

The principal impediment still existing to progress in this direction is due to the limited strength of the present forms of the steam generators. The boilers of the future must be improved so that safety may be insured, being either constructed in sections, or of material with greater strength, also not complicated in design and of moderate cost. That the most important of these requirements have not been realized, is only too apparent from the many accidents continually occurring in different sections of the country. That some boilers will explode is perhaps inevitable. The increase in the number of those accidents is, in a measure, owing to the increase of the number of boilers in use, and to the greater demand made of them in sustaining high pressure. The inference is plain, that improvements in manufacture have not kept pace with this demand. That all boiler explosions are due directly to the inability of the vessel to retain the enormous pressure generated just prior to the rupture, all will admit, but indirectly there are many primary causes traceable. Of the vast number of boilers in use, but comparatively few explode; fortunately they are the exceptions. Something certainly enters into the conditions where explosions occur different from those in which they do not. Boilers are in use under so many varying circumstances, that two explosions are seldom traceable to exactly the same causes. Instances are known where boilers have been in constant use tor twenty years, and almost without repairs, while others fail in as many weeks or months. This difference must be due to material, workmanship, quality of water, and the attention they receive. We know that certain causes produce certain effects, and that neglect and carelessness have no business in mechanical matters at all, much less should they be seen about our steam generators. It is simply astounding to know the extent to which ignorance and incapacity are placed in charge of these agents of the public service, which, in the hands of incompetent men, are about as dangerous as a package of dynamite. That all boiler explosions are due to carelessness and ignorance we do not mean to assert, but that about nine-tenths of them are, is beyond question.

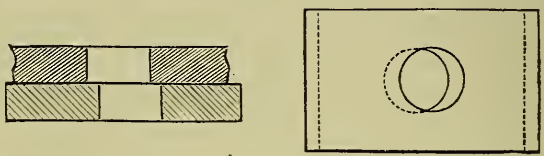
People are accustomed to think that any thing constructed of iron should "endure forever," merely because made of iron. Well, such an hypothesis may answer in some cases. Experience in the past year alone, however, has taught us, that it is an exceeding unsafe one in connection with steam boilers. That so many incompetent men are found in charge of so many boilers and engines, is principally owing to the fact that they are cheap. Cheapness seems to be the only required qualification. The scale balances up and down like the beam of a steelyard, intelligence and suitable compensation usually being found at the upper end. Possibly some employers prefer this class of help lest they might learn some disagreeable truths concerning their steam generators. There is, however, one very important point in this connection which is usually lost sight of. There seems to be an inexorable law in force in these cases as in many others. There is a minimum cost in the management of machinery, which cannot be reduced even by machinery. And if the steam user will employ incompetent labor because it is cheap, then the difference between its cost and that of a higher grade of intelligence must certainly be given to the boiler-maker and machinist by way of repairs, and to the coal dealer for extra fuel, as a skillful fireman will save from five to twenty per cent. over an untrained one. I call to mind a striking illustration of the case, that of a manufacturer in an eastern state, who, though a most successful business man otherwise, possessed a remarkable faculty for utilizing every piece of old iron he could obtain, and the extra work on which, in putting it in suitable condition, always cost him more than the new material. His annual loss from breakage and wear, making no account of time when the machinery was idle, due to the employing of a one dollar man where a two dollar one was required, was at least three times the difference in cost of one or two reliable men. A very common practice, and one most reprehensible withal, is that of employers compelling their engineers and firemen (often these consist of but one man) to do their legitimate work and that of two or three others, frequently being called to distant parts of the building. No man can attend to too many duties well; it is in the nature of things that some will be forgotten, and under these circumstances it is just as likely to be the most important as any other.

Boilers are constructed from a great variety of designs. Those found in more common use are of the locomotive type, and the plain cylinder with closed ends. The material usually is from 1-4 to 3-8 inches thick. As a conductor of heat, iron stands low in the scale, gold being as 1000, copper 898, and iron but 347. Now with iron but 1-4 inch in thickness, a great amount of heat is lost in boilers, owing to the inability to transfer all the heat produced to the water. Hence it is seen we cannot gain security by use of heavier material without a sacrifice of fuel. Small boilers, as a rule, are safer than large ones, if built in proportion, as they have a less number of square inches exposed to pressure. Taking a hasty glance at some of the practices in vogue in the construction of boilers, one of the most objectionable features in this as in many other things, is the too general tendency to obtain our goods at a price below a fair market value, and the custom of letlng these contracts to the lowest bidder often works to the disadvantage of both parties. In this business, of all others, the custom should be discontinued. It is fair to assume that boiler makers are as fallible as any other class of business men. Men do not do business for nothing, as a rule, neither for pleasure. "Each trade has its trick," and the purchasing party who obtains his boiler for less than the market rate, may seek consolation in the fact that he has been "sold" somewhere in his purchase.

In my own experience, I have known boilers constructed under these conditions of so poor material, that the plates did not have the manufacturers' brand on their surface. It may not be out of place to add that the builders of those boilers have had no less than four explosions of boilers of their construction in the past five years. From the time the boiler material is placed in the hands of the workman, it is constantly growing weaker, until thrown aside as old iron. The width of the iron in common use is three feet. Along each edge and across the ends, holes are cut or punched for rivets, after which the sheets are rolled to an approximation of a cylinder. When these cylinders are slipped together, all of the rivet holes should coincide. That they do not is a source of much trouble. The positions of these holes are marked through a wooden templet, which will be about three inches wide by 1-2 in thickness, and of such length as each particular case may require. Along the edges of this templet holes are bored, one set answering for the inside cylinder and the other for the outside. In spacing these holes, about six times the thickness of iron is allowed for difference in length, and the same number of holes must appear in each sheet, only in the short ones they are nearer together. The operation of punching the holes is a rather haphazard one at best, so far as accuracy is concerned.

There are two chances for error by the time the plates are rolled. First. The holes will not all be made exactly where marked; if one whole is punched slightly one side of its mark, and the one which it should match the other way, the error is

Fig. 1.



multiplied. Moreover, it is quite impossible to produce these plates and have them perfectly homogeneous. There will be hard and soft places. The great pressure from the rolls in making the plates cylindrical will cause changes in distance between some of the holes, as the temper of the plate varies. When the cylinders are placed together for riveting, many holes will shut past

Fig. 2.

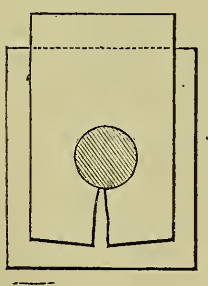


Fig. 3.

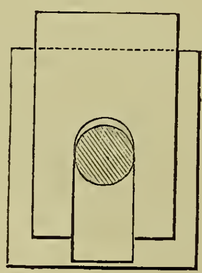
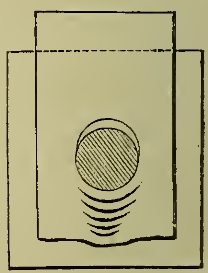


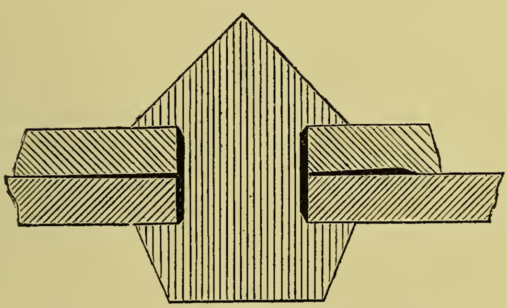
Fig. 4.



one another from 1-16 of an inch to 1-2 or 2-3 their diameter. This, in itself, is objectionable enough, but the case is aggravated. The overlapping metal should all be removed by the reamer and the hole filled by a suitable rivet. If the overlapping of the holes is not such as to compel the use of the reamer, a most objectionable resort is the tool known in shop parlance as a "drift pin," which is nothing more than a steel pin, slightly tapering, and when well oiled can be driven in with such force that the solid iron is often compressed and cracked, and pieces of the plate may be forced out. Fig. 1 is intended to illustrate the overlapping holes, and figs, 2, 3 and 4 the effects of the use of the "drift pin." Another difficulty here presents itself, arising chiefly from carelessness and poor workmanship. Often the sheets do not come in contact, and especially at the heads or ends of the boilers, on which the flanges are turned, is this the case, and also on internal fire-box work. When the rivets are driven, the iron acts as a spring, and vibrates back and forth from the blows of the hammer. The rivets too, will "upset" in between the plates if much apart.

Rivets driven in this way can never be made tight, neither will the caulking chisel remedy the defect, for when the caulking is done, the iron is driven back between the plates forming a thin narrow ridge under which the pressure will soon force the water or steam, Fig. 5, is a fair illustration of the case.

Fig. 5.



To this defect are due, many of the mysterious leaks in new boilers, when but a short time in use. Often rivets are improperly supported or "backed" when being riveted, which causes leaks; or riveted when too cold, causing crystalization to such an extent that often a slight jar will cause the heads to drop off. The outer corner of the outside cylinder must be chamfered to an angle of about fifteen degrees, thus leaving a sharp edge where the cylinders join, for caulking. In many large shops this is done by machinery before the plates are rolled, in others before the cylinders are placed together. In many, it is done after the riveting, and thus the lower sheet is more or less cut by the corner of the chisel, the greatest care cannot prevent it. With many boiler-makers, this is of minor consideration, but the fact that many exploded boilers have given way at this point should draw attention to it. The following account of an experiment made at the University machine shop shows well the effect of cutting through the outside of the iron. A piece of common five-eighths square iron was cut on the four sides with a cold chisel, so that it was well marked. A slight blow from the hammer caused it to break, the ends showing crystalization. A second piece was marked on but one side, which on being broken, was crystalized about half through, the rest showing the fibre undisturbed, and tearing out the iron for half an inch up the bar. It has been claimed that the principal strength of iron is destroyed by cutting through the "skin," yet, a piece of this same bar marked as in the first instance, was placed in the lathe and the marks turned out, after which it was bent to more than ninety degrees before breaking.

It is estimated that about forty-four per cent. of the original strength of the material has been destroyed by the time a boiler is ready for riveting. The axiom that the "strength of any structure must be estimated from the weakest point," is a good one. By these various operations, six per cent. more will be of questionable value. Repeat them at every joint in a boiler twelve to twenty-four feet long, and who will tell where the weakest point may be? Imagine if you can a boiler so constructed of any flexible material, it would contain more kinks and puckers and gathers than a fashionable dress. New boilers are often submitted to the hydraulic test, which consists of forcing in cold water to a certain pressure, and then assuming it safe to carry one-third or two-thirds as much steam pressure. I believe it a questionable method and an unsafe assumption. If there are blisters or imperfect welds in the plates it may develop them. A careful inspection would probably accomplish the same result. But in these tests the boiler is subjected to strains under conditions which do not occur in actual use. The water and iron are both cold, stay rods and braces are loosened which do not again come tight of their own accord. Further, most boiler iron, as demonstrated by the experiments of the Franklin Institute Committee and Fairbairn, a noted English mechanical engineer, has a greater tensile strength with an elevation of temperature, some proving stronger at 600° Fahrenheit, than at any lower point. Now it is quite certain that testing with cold water has not rendered the weakest point of the vessel much stronger..

As soon as a boiler is in use, the agents of destruction incident thereto begin their work. Probably chief among these, is the steam itself. The unit of elasticity, by which the expansive force of elastic fluids is measured, is for popular use, one pound on one square inch of surface. We glance at a steam guage and the little hand may indicate fifty. Let us ascertain what that means. If a boiler is twelve feet long and three feet in diameter (very common dimensions) and contains thirty-four three inch tubes, the two heads with tube surface deducted have remaining 1,864 square inches. The cylinder of the boiler contains 16,280, equaling in all 18,150 square inches which, multiplied by fifty pounds pressure, give a total of nearly one million pounds, or a fraction over 450 tons, continually tending to rend the cylinder. Boilers are made round or approximately so, for two reasons. It is the cheaper form and one naturally self-supporting. I say approximately round, for they are not a true circle and cannot be made so owing to the lap of the longitudinal seams. Now this enormous pressure, tends to force the shell of the boiler to a true circle. The pressure is never constant. Great and unequal strains are produced along the under edge of the lap, which vary from time to time according to the different degree of pressure. In effect it is similar to bending a piece of iron back and forth in the hands, only on a more minute scale. In time the same result will be effected, destruction of the fibre of the iron.

Many purchasers of these steam generators commit the serious mistake of selecting boilers of insufficient capacity, simply because one or two hundred dollars cheaper. In so doing, the door is opened through which many dollars will pass in the way of fuel without an adequate return. But when a boiler has just the capacity to supply the demand by forcing the fires, a nearly full opening of all passages to the engine will result. The steam flows rapidly through them, twice at every revolution of the engine, this flow is suddenly and positively checked. While so checked, there is a rapid accumulation of steam from the forced fires. The boiler expands to the greatest limit in retaining the increasing pressure. The opening of the passage way again affords a temporary relief. Thus the boiler dilates and contracts to such an extent that the movements are sometimes visible to the eye, and they have been compared to the breathing of some large animal.

With this slow and continuous change, there is no wonder that boilers eventually "give out." If there is any mystery in the case, it is that they last so long and serve so well as they do.

That steam and water in pipes not properly drained have great percussive action, may be readily seen from the jumping and snapping of the pipes under these conditions, and many serious accidents have occured from pipes and fittings bursting, even loss of life resulting in some cases. With these facts before us, great care should be exercised, not to open the steam passages from the boiler, too suddenly, on account of the danger arising from relieving the pressure on the water.

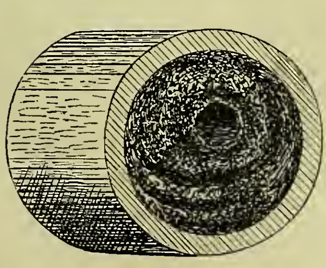
What effect might be caused by such lack of care, may be seen in the following deduction.

The heat required to raise one pound of water through one degree of temperature is termed a unit of heat, or its equivalent, 100 pounds of water through one-tenth of a degree, or one-tenth of a pound through 100 degrees. This quantity of heat possesses the same amount of power as would be required to raise 772 pounds, one foot, or one pound 772 feet. This is termed the mechanical equivalent of heat. Now if the addition of one degree of heat to one pound of water, be such an accession of force, the addition of 100 degrees to 500 pounds of water is an equivalent of a half million times that force. In practice, the combustion of a pound of coal imparts to the water in a good boiler about 10,000 units of heat, and evaporates eight or nine pounds of water of usual temperature. With all the losses and disadvantages considered, a pound of coal exerts about one-fourth of a horse power per hour, fifteen horse power for a minute or 900 for one second. The heat absorbed by 5,000 pounds of water in raising it through 100 degrees, is really twelve and a half horse power for an hour, 750 for a minute or 45,000 horse power for a second. The amount of heat absorbed by 5,000 pounds of water in raising it through 100 degrees, is but a small portion of the quantity in any boiler in common use, yet fifty pounds of coal are required to cause it, and the imparted heat is equal to the amount expended to convert about 430 pounds of water at common temperature to steam. By a too sudden release of pressure, this latent heat might all be released in one or two seconds, and thereby cause an explosion. The idea quite generally prevails that all boiler explosions are due to low water. That might cause such a disaster, but that alone I think seldom does. Often, no doubt, boilers are seriously injured by the plates being burned. Burned plates lose about one-half their strength. Repeat the operation often enough and it is only a question of time, and a rather limited time, too, when the boiler will be ruined.

Several years since, the United States government squandered about $100,000 at Sandy Hook and Pittsburg, trying to determine the cause of boiler explosions. The experiments were under conditions which were almost totally different from those under which boilers are used. Hence, practically, they were nearly failures. Two things were discovered, however; one, that a boiler will not explode when you want it to, and that water, pumped in on plates red hot, would all run out through the seams, which were caused to open from the rapid contraction, or else escape through the safety valve as steam. This operation was repeated three times to produce an explosion.

Boiler plates are burned oftener from incrustation than from low water. Wherever this formation is thick enough to prevent the water from coming in close contact with the iron, that must be the result, and if from this cause the plates when in use become sufficiently hot to weaken the tensile strength in a place of any large area, a rupture will surely follow. Fig. 6 shows a section of a feed pipe filled with lime in the short space of three months. A few years since I had an opportunity to examine a case of this kind. The boiler was of the locomotive type, and was not under cover. The plate over the fire had been forced

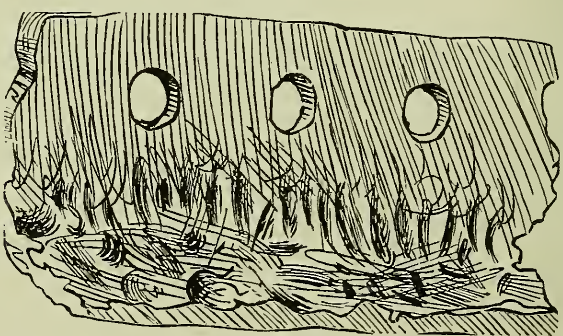
Fig. 6.



down gradually, and in shape like the bottom of a wash-bowl, becoming thinner at the lowest point until finally breaking open, it left rough, ragged edges and a hole about eight inches in diameter. The whole weight of three and a half tons was raised about thirty feet and thrown over back, striking the ground at an angle of about thirty degrees, and sliding along, tore off every particle of the engine.

These deposits in boilers are the most difficult matters steam users have to contend with, but its formation to a dangerous thickness can be prevented by frequent cleaning out, also by frequently letting out a little water through the day when the boiler is under pressure. It is a bad practice, and, of course, a common one, to let the water all blow out of the boiler, after the fires are out and before sufficiently cooled. The heat retained in the metal and

Fig. 7.



surrounding walls will cause the deposit to bake to the iron so that nothing less than a hammer and chisel will remove it. Care should be exercised in setting boilers so that they may be examined at different times, and to keep them in places as dry as possible. Iron wastes away fast enough at best, and if leaks occur where the boiler is in contact with brick and mortar, corrosion goes on so rapidly that the best boilers may be rendered unsafe in a year or two. When leaks are discovered they should be considered signs of wearing out, and should receive attention at once. Usually, however, because it is small or does not let out the water faster than it can be replaced, it is allowed to go. It is treading on a dangerous path.

Fig. 8.

Often, when very impure water is used, boilers are attacked by internal corrosion. Usually it is found at the edge of the sheets, along the seams and around the rivet heads. Sometimes different plates in the boiler will be corroded, while others will be found in good condition.

With all this evidence of the dangerous processes going on both without and within a boiler, it seems very plainly indicated, that too much care and attention cannot be given them. Marine boilers are of the most dangerous class, but they seldom explode. The reason is evident. First-class men, and none others, are placed in charge of them. The statistics show that in the decade from 1865 to 1875, there was an average of about one explosion every three days, and it would seem that the public had the right to demand some system whereby a little higher grade of intelligence could be placed in charge of these, now, indispensable agents of the public service.

From the use of impure water results a process called "pitting." Small holes quite near together are eaten into the plates, and often a pitted plate and a sound one will be found side by side. This is probably due to a chemical difference in the iron, and the pitting may be caused by galvanic action. Pitted plates resemble very much the partly consumed zincs from a battery. Experiments were made with pieces of iron cut from pitted plates, and those which were not, taken from the same boiler and placed in a bath of acidulated water, when connected with a galvanometer, the pieces excited sufficient action to sensibly deflect the needle.

Fig. 7* shows a case of pitting, and fig. 8 represents a corroded brace or stay rod, so much of which is destroyed that it became entirely useless.

*Figs. 7 and 8 are taken from Reports of Hartford Boiler Insurance Company.

MIND IN THE LOWER ANIMALS.

BY J. S. JEWELL, M. D.,

Professor of Mental and Nervous Diseases in the Chicago Medical College, and Corresponding Member of the Wisconsin Academy of Sciences, Arts and Letters.

My subject is that of "*the evidences of mind in the lower animals.*" The first thing to be done, in a case like the present, is to define the meaning of the leading terms. This is one of the golden rules of discussion. Then, what is mind? Before trying to answer this question, which, by the way, is not a new one, I should tell you that it was not my plan to determine, except in a superficial sort of way, what mind really is. It would require more than one lecture to deal adequately with that question. For my present purpose, it is sufficient to assume the existence of something, which may be called mind, whether motional or immotional, the presence and action of which is known usually by certain *signs*, by which beings possessed of mind are commonly distinguished from those that do not have it. It is with these *signs*, rather than the mind itself, that I am to deal. But once again, what is mind? It is much easier to ask this question than it is to answer it. You all know it has been, and at this hour it would be answered very differently by various persons, who have given themselves (following different methods) to its study.

But taking all these answers together, aside from unessential particulars, they may be divided into two principal classes, which are susceptible again of division into sub-classes. But I am to call your attention to the two principal classes mentioned. They may be described as follows:

In the one case, the phenomena called mental are not attributed to any other agent or source than the material organism itself. In this view there is no such being as a mind numerically different from the body of the animal, neither before nor after death. The word mind is simply a name for the aggregate of functions of the nervous system, at any rate of its higher functions. There is no actual proof of the existence of any such immaterial, immortal entity, as that usually designated by the terms, mind, soul, spirit. Mind is simply brain action. When the brain is disordered, mind is disordered. When the brain is healthy, the mind is healthy. When the brain is imperfect in its development and structure, as it is in idiots, then the action of the mind is hopelessly imperfect. But when, on the contrary, its development and structure are the most perfect, uniformly its action is the most perfect.

Moreover, when the brain perishes as it does after death, all mental action ceases, or at least all evidences of it. In short, all that we knew as mind before the death of the individual, perishes with the brain. Any opinion that there is a being so distinct from the body, as to continue to survive after its death, is a mere creation of the fancy, at the dictates of the baseless aspirations or traditions of mankind.

Mind is, hence, absolutely dependent on the body, and without it has no existence. It is simply a combination of physical forces, which return to their primitive condition after death, ready to enter into new combinations of any or all kinds. Such, in outline, is one class of opinions as to mind. They are what have been called *materialistic.* If this class of opinions were true, there could hardly be any difference among thinking people as to whether the lower animals are possessed of minds, as well as man. In point of fact, persons who hold to the view just described, generally admit that animals share in the possession of mind with men.

By the other class, mind is regarded as something substantially different from the physical organism, or body, though closely associated with it during the corporeal life of the individual, from which, however, it becomes separated in what is called death, of which this supposed separation is held to be the principal event. After this, the organization of the body indeed perishes, but not so the mind ; for the latter is believed to continue to exist, as mind, in some other state. It is farther conceived, that the mind is an imperishable existence, possessed always of the same faculties of knowledge which distinguished it while yet connected with the body, but deprived, perhaps, of the means of mechanism furnished by the latter for obtaining a knowledge of the physical world, as well as for manifesting its own existence, or its invisible states or acts, as depicted or represented in the changes of the body. It is also held to be not simply *numerically* different from the body, but *radically* different in substance. The body is said to be material, the mind *immaterial.* It cannot, therefore, possess the properties of matter. If not, then it cannot, by the terms of the case, be made cognizable by the senses, since they appear to be fitted to reach only to material impressions. Mind therefore, as mind, cannot be submitted to physical tests or examination, though the body can be. Its acts and states cannot be directly made known by such means. They can only be made known to other minds by certain signs, or in other words, certain acts and states of the body which is regarded in a certain sense as an instrument of the mind. But these signs would be without any significance whatever, if it was not for certain modes of interpretation possessed by animals, and in various degrees of perfection.

The only way, so far as is known, that they have for finding out the meaning of these signs, is by their own experience. They find by observation that the mutual acts and states are more or less invariably associated with certain states or acts of the body. So when they observe other animals in the same bodily states, or performing the same acts, they infer the corresponding *mutual* states that they have found connected therewith, in their own experience. In this indirect way alone can they discover the mental condition of other animals.

One mind cannot, so far as we know, commune directly, unless under rare circumstances, with another, during the continuance of physical life. But ordinarily, each individual mind may know directly, without the intervention of such signs, many, if not most, of its own states and acts. They take place in what is called *self-consciousness,* which is, in my opinion, the chief, if not the only kind of consciousness we have. These mutual states and acts then, though they cannot be directly reached by physical tests, and are not open to sense observations as physical objects are, may nevertheless be submitted to the tests of immediate self-observation. We can secretly know often what passes in our own minds, and with the utmost clearness, while the observer, who looks upon our bodies from without, cannot many times so much as suspect what is passing within us. There are two ways then of studying mind. One of them is applicable to ourselves alone, and is confined to the states and acts of our own mind. This is the method of introspection, or of looking within our own minds, to directly observe our own mental acts and states, and not the signs of them. The other method is also in a measure applicable to our own bodies. It is the objective method. It is from first to last directly compared with the *signs* of mental states and acts. It is the only method by which we can study the mental states and acts of other individuals, whether man or animals. And the only way in which we can make our observations useful or intelligible is, by a recurrence to our own internal experience, our self observations, which have taught us in various degrees of fullness and perfection, that certain internal, and hence invisible, mental states and acts, are either preceded or followed by certain bodily conditions and signs. The key of the interpretation lies within. If this is true, then it may happen that we would be liable to be deceived by persons who in some way exhibit the signs of thought or feeling, and yet do not truly experience the states or the mental acts, which in a truthful experience the signs represent. And this is sadly too true, as nearly all can testify. Hence, it happens that a mask, a statue, a picture, may exhibit the *signs* of feeling, for example, so perfectly as to excite the same state in ourselves, notwithstanding the object has *only* the signs, and not the fact of thought or feeling. This, I say, is the only method applicable directly to the study of the minds of other beings. It is the one that must therefore be applied to the study of animals. All we can do is to observe them, under varying conditions, and see how they act, or what they do, and then interpret their actions by appeals to our own personal experience in similar conditions. And this, as I have said, is the way in which one must study other men.

But to return from this partial discussion. By persons of this second class, mind is held to be the invisible, intelligent energy, with which, in connection with the body, we truly feel, will, and think, and which permeates the body, possibly only the brain, and uses it, for sake of illustration, as the invisible magnet force, which inheres in a visible portion of magnetic ore, or of steel, causes movements of the same. In short, mind is the immaterial, imperishable, sensitive, intelligent being, which feels, and wills, and thinks, suffers and enjoys, within the body, which though living, would be an unintelligent, or unthinking, possibly unfeeling organism without it.

Now in the sense that it is held and understood by this class, do the lower animals have minds? In relation to this question, and for various reasons, persons differ widely in opinion. Some think they have, others think they have not. And it is to the possession of mind, at any rate, or rather the signs of it in this sense, by the lower animals, that I wish to call your attention this evening.

I know as well as I can ever know, that it is a serious question with many, whether even man possesses mind in the sense just indicated. But I wish for the time, to assume without controversy, as a hypothesis, if you please, that they do, and my present inquiry, I repeat, is whether the lower animals show clear signs of having the same; and if this is refused, I wish to inquire what we are to include as to the mental natures of the lower animals, or how we can explain the phenomena which they present to any intelligent observer. By the phrase "lower animals" I should say, in passing, I mean the whole animal kingdom. I do not include simply the higher vertebrates, but the entire class. For, as we shall see perhaps, even the humbler types of the animal kingdom present us with striking exhibitions of intelligence.

In dealing with this matter, it might be expected that I would lay out some division of the faculties of the mind, as a scheme under which examples from among the lower animals might be ranged. But it is deemed the best way to proceed at once to adduce suitable and well authenticated instances of phenomena, which show in fair measure whether or not animals do possess minds. In doing this, the trouble is not to find such examples, but out of the mass of such cases to make a selection. I have collected from various works under my hands many hundreds, and I might truthfully say, thousands of cases of interest. I might occupy hours detailing and discussing my own personal observations. But I do not have time to do either the one or the other.

But to begin, take this case: A naturalist friend of mine was one day walking along a road, and saw as he walked one of those familar road beetles, rolling its ball of compost. He stopped and watched it for a few moments, and then with a pin, made the ball fast to the ground. The beetle seemed surprised at this turn in its affairs, but soon recovered itself, and endeavored as before to push its ball; but it was not able to do so. It crawled over and round it, and appeared to carefully inspect the situation, and at the same time made strenuous efforts from all points to move its ball; still it could not move it. It then climed up on its ball, and sat there for a few moments, quietly moving its antennæ as if in a sort of reverie, and then rose on its wings and flew away. The gentleman much interested in what he saw, thought he would tarry a while and see what would come to pass. He had not waited many minutes, until he heard the familiar hum of two beetles. They circled about, as is their custom, and finally they both alighted near the ball. One of them was recognized as being the same beetle that had been first observed. It was known by a speck on one of its wing cases. The two immediately went to the ball and united their efforts to move it, the one pushing, and the other pulling, But after various trials, they ceased, and literally putting *their heads* together, they *seemed* to be in consultation. During this time the gentleman quietly removed the pin and left the ball free. They at last went back to the ball, and tried to move it, and of course succeeded. Whereupon beetle number two rose up on its wings and disappeared, while beetle number one rolled its ball along without farther interruption. Now I am quite well aware that this is a simple story, but it is none the less interesting to one who will consent to think on it without prejudice. A hundred histories of this kind would really not be any better than one.

Let us examine this case a little more closely. It might be said, with more or less propriety, that the beetle formed its ball as a nidus for its young, and then sought a proper place in which to bury it away, guided solely by instinct. But I do not think it could be maintained successfully that many of the later performances of the creature were in the proper sense of the word instinctive. It *seemed* as if, when it found itself unable to move its ball, — I say it *seemed* to stop and deliberate as to what should be done. It *seemed* to have found a place of securing aid from some other beetle. For, after a short absence, it returned with a companion. It *seemed* to have gone purposely to find it. It *must* have communicated in some way a knowledge of its wants, for the other beetle seemed to understand the case. They had a common purpose, as was evidenced by their united action toward the same end. They *seemed* to consult, when they found themselves unable to move the ball. They seemed by common consent to conclude to make another effort. When the ball was found movable again, beetle number two *seemed* to know that it was needed no longer, and probably returned to its own occupations. Certainly this cannot have been all due to instinct. It has the plain mark of the presence and action of mind, no less so because the signs of purposive acts were done by beetles instead of men. The *signs* of mind are much the same as they would have been under similar circumstances among men.

As has been already intimated, one case well studied is as good as a hundred. But though this is so, I shall now proceed to advance other examples from the animal kingdom, apparently involving mental action.

For example, let us consider points in the history and doings of ants, as we have given much observation and study to these most singular little creatures. On one occasion, as I was passing along a road, my attention was attracted by a company of large, pale red ants hurrying across the way, the whole company following what seemed to be a leader, who was much in the advance. I stopped and followed them through the grass and weeds for full fifty yards, when they suddenly came to a halt, and collected in a circle in the space beneath the bending spires of grass. mmed iately one of the ants disappeared in a hole in the ground, only to be followed with every appearance of precipitation by one after another of the company. At this moment a smaller ant, but of a similar color, entered on the scene, and rushed for the hole in the ground, but it was instantly seized by one of the marauders, and a fierce struggle ensued, which was not terminated while I watched them. But in a few seconds, as I watched the hole down which most of the company had disappeared one by one, I saw an ant come struggling out, in a state of great excitement. It was of a smaller kind than those which I had watched cross the road. Presently it was followed by another of the same kind, in (as I was about to say) much the same excited state, and as time passed on these two were joined by others. The place evidently belonged to them. They ran violently about the hole, and even up to the top of the blades of grass, and then jumped off to the ground in a distracted and reckless manner. At times two of them would meet and, *apparently*, stop for a hurried exchange of ideas, and then they would run about in the same frantic manner. Meantime all the larger ants had gone down into the hole. In a few moments, however, these latter ants began to reappear, one by one, each bearing a white egg not far from hatching, as the outline of the young ant could be seen through the cuticle. But no sooner had these latter ants reached the open day with their booty than they were ferociously attacked by the smaller ones, to whom the eggs properly belonged. And here began a series of struggles of the most animated and interesting character — one set of ants striving, by might and main, to get away with their booty, the other set striking for their altars and fires. But after some time had been spent in this way, the larger and stronger got away, each one, on his own hook, traveling with great speed, on the back track, bearing an egg in its jaws. But now began a scene of evident distress among the smaller ants whose home had just been robbed in so miserable a manner. They ran round and round, in helpless bewilderment, meeting and consulting (apparently) and passing each other, and diving into their den, and then out again. And in this distressing condition I left them. I followed on after the marauders, and found most of them already across the road. At last, fully sixty yards from the scene of the robbery, they came to their own den, and carried the eggs down into a special chamber, as I afterwards found. After the eggs had been deposited below, the ants of the expedition came up, and with a *seeming* air of satisfaction at their exploit, passed their time in rubbing off their bodies, cleaning and polishing their limbs and mandibles. This was an instance of the doings of slave-making ants.

In this case, there can be no reasonable doubt but that one of the party which composed the expedition had made a discovery of the colony that was to be raided. The ant returned to its companions, reported its discovery, a party was organized, led by the discoverer, the colony was robbed, a conflict ensued, and finally the spoils were carried home.

This whole performance looks very like what men have done in all ages. But when done by men such actions are not ascribed to instinct, but to mind. But let them be done by even one of the higher animals, not to say an ant, and they are loosely attributed to instinct. But why so, where the *signs* are essentially the same?

But I have not done with the history of the singular doings of ants, which seem to indicate the presence of mind. To do this fully would require several lectures. I have watched ants on the hunt for colonies of aphides or plant lice. I have watched them after discovering such a colony. They station guards over them, to dispute the entrance of any other ants, on their domain. They carefully tend the aphides, as a shepherd would his flock. If one of the clumsy creatures of their charge gets off its plumb, and is in danger of falling, a guardian ant takes and tenderly places it in position. The ants step around, among and over the members of their flock with every sign of care. But why? Let any one see. They do not do that to feed on them, but they use them in a sense as men use cows. An ant will stand astride of, or behind the plant louse, and with its pointed feet will seize the little *aphid* underneath the abdomen, and by a motion of combined pressure and tickling, induces it to issue amethystine drops from its back, from a little bag. The ant watches for this, and when it appears, stoops and drinks it with apparent gusto, and then goes his way. The only ants that have this privilege are those which belong to the colony — they alone have the passport.

Ants have armies, commanded, it seems, by officers who seemingly issue their orders, insist upon obedience, and will not permit any of the privates to stray from the ranks. There are some ants which till the ground, plant the particular grain on which they feed, cut it when ripe, and store it away in subterranean granaries. There are ants which bury their dead. There are ants who have slaves, as already intimated, and compel them to labor while their masters live on its proceeds, just as we have known of man. How can we attribute all these things to instinct? If so, let us call the whole thing instinct, and so end it.

Take the case of the bee. It has required a small volume in which to record the doings of these little creatures, which, to say the least, are curious. Take the case of weak hives, which on that account are liable to the incursions of more powerful neighbors, who are ever ready to appropriate the works of the thrift of their less powerful neighbors. In such cases, it has been frequently observed that the weaker colony casts up a cross within the entrance or hallyport to their hive, a wall of wax, etc., called, I believe, a *traverse*, in engineering parlance. Upon entering, the bee is at once confronted by this traverse, and is obliged to turn either to the right or left to enter the hive proper. But in so doing it must pass a very narrow way at either end of the traverse. By this means a few bees can defend a hive against the assault of a very large number of marauding bees. But all hives do not have this traverse, and why not? Is it made in obedience to a blind tendency, such as an instinct is ordinarily held to be? If so, why do not all hives have the traverse? It seems to me, the only natural way is to admit that such doings are an evidence of the possession of mind.

Sometime since a gentleman was struck by a happy thought, viz.: one in which he could utilize bees. He formed the design of exporting a number of hives to the island of Hawaii, where there are flowers all the year round. His thought appears to have been that, as bees gather honey guided solely by a blind tendency or an instinct, that they would work all the year round, and hence make honey all the year, and if so, become a source of no small profit. If they gathered honey wholly from a mere blind impulse, his expectations would have been fulfilled. But in the course of a few years the bees learned somehow that it was unnecessary to lay up honey as in climates where flowering plants exist only a part of the year, and they became valueless from an economical point of view. Was this due to instinct, or to education? If to the latter, is mind involved in the case? I must confess, it seems so to me.

Take the following anecdote from many hundreds of others of various kinds, in respect to dogs:

"There is a water mill on the Tweed in Scotland called Maxwellhaugh, by the road between Kelso and Trovist. It is driven by a sluice of water from the Trovist, just before it joins the Tweed, and consists of two flats. The upper flat, or story, is on a level with the public road, and is called the "upper mill," while entrance to the lower story was reached by a lath road descending from the highway. The first thing the miller did in the morning was to unchain the dog. The dog immediately placed himself across the upper doorway, while the miller proceeded with his work in the lower mill. As soon as the miller had finished his work there, and removed to the upper mill, the dog, without being told, set off to the miller's house, and in two journeys brought his master's breakfast, — namely, milk in a pitcher and porridge in a 'bicker,' tied up in a towel.

"On one occasion, when the Trovist and the Tweed were in a flood, a little dog ventured incautiously into the Tweed, and was carried rapidly down the stream, struggling and yelping as it was hurried along. It so happened that the miller's dog, while carrying his master's breakfast to him, saw the little dog in distress. He immediately put down his burden, and set off at full gallop down the stream. When he had got well below the drowning dog, he sprung into the river, swam across, and so exactly had he calculated the rapidity of the river and his own speed, that he intercepted the little dog as it was being helplessly swept down the current, and brought it safely to land.

"When he got his burden safely on shore, the dog, instead of displaying the least affection for it, cuffed it, first with one paw and then with the other, and returned to the spot where he had deposited his master's breakfast and carried it to him, as usual.

"How is it possible," says the author of the anecdote, to 'refer the proceedings of this animal to mere instinct? Had a negro slave performed them, we should have used them (and with perfect justice) as arguments, that so intellectual and trustworthy a man ought not to be the property of an irresponsible master.'

"The whole behavior of the dog is exactly like that of a burly, kindly and rugged barger, possessed of cool judgment and rapid action, willing to risk his life for another, and then to make light of the whole business.

"The process of reasoning that took place in the dog's mind is as evident as if the brain had been that of a man and not a dog. The animal exhibited self-denial, presence of mind, and forethought. Had he jumped into the water at once, he could not have caught the little dog; but by galloping down the stream, getting ahead of the drowning animal, and then stemming the current until it was swept within his reach, he made sure of his object; and no man could have done better if he had tried to save a drowning child?"

There are hundreds of cases, from among not only the almost innumerable species of lower animals, but also, so to speak, of the higher, such as birds of many kinds, cats, dogs, horses, elephants, and monkeys. But, manifestly, I cannot refer to them to-night; nor, indeed, is it necessary to do so after what has been said, and when it is remembered that it is probably true that there is not one person present but has had opportunities for making interesting personal observations bearing on this question.

Contenting myself, therefore, I will pass at once to a discussion of the subject in various of its aspects. For my own part, I am led to hold to the position provisionally, that the lower animals are possessed of minds, the same in kind as those of men. I have said, this is my *provisional* opinion, for it has become, after much endeavor, a habit of mine to adopt opinions with care, and if not well founded, to try and *remember* that they are not well founded. Such opinions I try to be ready to drop at the first occasion which seems truly to require me to do so, even if I am left without opinions, as, indeed, I have come to be, in relation to many things. I will now proceed to give you some of the reasons which seem to me to justify me in adopting the opinion to which I have here given expression.

1. One strong proof of this position is to be gained from such facts as I have been relating in your hearing. An unprejudiced and attentive examination of the mental phenomena of lower animals, shows them to have in some measure most, if not all, the mental capacities or faculties which distinguish men. But let us for a moment go even back of this. The nervous system, the admitted instrument of mind, in its intimate structure, is essentially the same ; even the *brain* of man and the lower animals agree so closely as to render all but futile the elaborate attempt of Prof. Owen to establish a separate class, the *archencephale*, of which man is held to be the sole member. The agreements in general, and even in details, are surprisingly close, whether in gross form or in minute texture, between the brains of men and the anthropoid apes. Then the lower animals have the same extrinsic means for acquiring a knowledge of the outer world that man has. But why have they the sense apparatuses of vision, hearing, touch, taste, smell, the muscular sense, etc., unless for the same purposes that they subserve in men? But to come nearer. The lower animals experience sensations both agreeable and the contrary, they enjoy sense-perception, and in many cases far beyond what is true for man. They have frequently as perfect, and often a more elaborate muscular system than man, which is exercised and controlled by means of the same kind of nervous mechanism, and is devoted to similar purposes. They have often well marked and very tenacious memories, so far as we can tell, the same as that which belongs to man. They can reason also, or compare the perceptions they have or have had, and many times in a surprising degree. They have most certainly a will, and hence power to choose from among alternatives, the story of Buridan's ass to the contrary notwithstanding. They display all the principal qualities and passions which belong to man, such as parental affection, jealousy, anger, fear, courage, constancy, fidelity, friendship, ill-temper, hope, despair (for animals have been known to commit suicide), pride, self-importance, caution, trickery, maliciousness, etc. examples of all of which it would be easy to give and of many

of them to multiply. They can certainly *learn* and improve, even in many such actions as have been called instructive. They even show abuse of humor and fun, some appreciation of the beautiful, and would appear in some instances to have a knowledge of right and wrong. It is admitted that the moral sense, if developed at all in the lower animals, is very rudimentary. But the same may be said with some degree of seriousness of many human beings, especially of young children and idiots. A young child, if arrested in its moral development at an early period, would, so far as signs can show, be a mere human animal, not equal perhaps to an intelligent monkey. It might be expected *a priori*, that if the lower animals should fail anywhere in a comparison with man, it would be in respect to the higher faculties. And this is found to be actually true. But if the lower animals show but little, if any evidence of possessing a moral and especially a religious sense and capacity, let it be remembered, as already said, that some time elapses in the human being before the conscience is developed so as to beget what is called *accountability.* A young child is not held to be accountable for its acts, when they lead to bad consequences, any more than is a mere animal. So after all, it would seem from the confessedly superficial view of the case, we cannot refuse to admit that the lower animals have minds similar to men, at least in *kind*, on the score of radical difference in their mental phenomena.

2. Then to what shall we ascribe the mental phenomena exhibited by the lower animals, if not to mind? It has been the custom to refer them to what has been called *instinct.* But what is instinct? When an act is performed by an animal without having *learned* to perform it, as when a bird builds a nest without ever having *learned* to do it, or when a bee builds its cell of a certain geometrical figure without any previous instruction or demonstrable plan to follow, or when a pig will begin twenty-four hours before an approaching storm to gather materials for a bed, and in making which, it will heap them up on the side from which the storm is to approach, etc., such actions are called *instinctive* or *automatic.* The animal does them *without purpose or design.* Many such actions are performed like the leaping of a headless

frog, when, according to ordinary experience, the mind would seem to have been removed. But take the case of a bird building its nest. This is said to be instinctive. If this means anything, it means that the animal is fitted prior to experience, and independently of all knowledge, to build its nest. It is created from the start with a nest-building tendency, which is the soul so to speak, of a nest-building mechanism, which at some peculiar conjunction in its affairs impels and guides the bird, it knows not how or why, to build the nest, which it is under the necessity of building on account of the fixed conditions and modes of action of its nest-building apparatus, and in a certain way and none other. Hence the individual members of the same species will build their nests after a peculiar pattern or of peculiar materials, so much so, that it is enough for the observant naturalist simply to see the nest, in many cases, to name the bird. But the case is, or seems to be different, with the architect who plans and builds a house, as every one knows. But let us look more closely at this instinctive act of nest building. One thing is certain, there must be a *plan* somewhere, consciously or unconsciously followed, for the nests of the same species are made alike, or after a common type or plan. The only possible places (so to speak) in which the plan can inhere, are either just in the mechanism or organism of the bird itself, in which case it would have to be assumed that it was constructed to work of itself, in the absence of a mind. It would work then, for example, like a watch, or better yet, if you please, like a pin or match machine, which is fitted to take the raw material at one end, and give out at the other the finished product. It cannot in the nature of its case make anything but tacks. *Any* power which can set it in motion, no matter from what source, may, through the agency of the mechanism, bring about the result; or the plan may inhere in the mind of the animal, as well as the apparatus to which the mechanism corresponds. Why should we deny the presence of mind, in a given case, because it works through an apparatus, even if the latter is automatically perfect from the outset? Can *mind* not work through such mechanism as well as through one which for certain reasons is imperfect at the start, and has to be developed by purposive use? In the latter case the evidence of mind may be clearer, but in the other, is it absent? Or, finally, the act called instinctive may be attributed to the immediate presence and action of the Divine mind. But in some form or other, mind must be present, and we cannot escape it, as some seem to imagine they do by calling certain cases in which it seems to be present, *instinctive.* The bird must *choose* a place in which to build her nest. Is this instinctive? Think of it a moment. How should a bird be *prearranged* to select, from thousands of places in which her nest might be securely built, the one she does select? Does she not look about, and after considerable search and consideration, at last fix upon the spot which, upon the whole, she *likes* best. Then again, is her search for and choice of materials a blind one, in which she follows, mechanically, the unvarying conditions of a fated or at any rate a fixed mechanism? No, it must be that however perfectly the material organism is prearranged for action, under favoring conditions, that it has within it a mind, which, it is true, has a less sphere of spontaneity than belongs to man, and which works therefore under more rigid conditions than in man; but still mind is there. By the limitations of its automatic organism, it is made unnecessary for it to go the round of experience to learn, for it begins where man ends, or tends to end; that is, with an organism, embodying an organized experience prior to the fact. By this means, the lower animals whose lives are short, are enabled to begin their life-work at once, and from the first to avoid mistakes as a rule. But coupled with this freedom from errors in their acts, is the corresponding inability to perceive or correct them when they have been made. Just in proportion as automatic action prevails, does spontaneity and inventive capacity and adaptability disappear. Hence, these latter elements are found in the greatest measure in man, and in the least in the lower animals. But this is to be remembered, that by attributing the actions of the lower animals to instinct, we do not therefore exclude the mind, though this is commonly supposed to have been done in such a case. Even in view of those actions, then, which are most clearly automatic, mind is probably present, and hence by this mode of reasoning we cannot exclude the lower animals from participating in it, in common with man.

Then again there is the question of the *immortality* of the minds of the lower animals. It has been thought if the admission is made that the lower animals have minds, that this will oblige us to concede to them immortality, equally with man. But why not do this? What harm could come of such an admission? What forbids it? Would it be contrary to scripture, to reason, to the true interests of men present or to come, or would it conflict with any well authenticated facts? Would it be degrading to men, or cheapen future existence? But if we refuse it, what shall we do with the intelligent principle, whatever it may be, which feels, and thinks, and wills, and suffers, and enjoys, and remembers, in the lower animals? What is it in them that appeals in hunger and distress, or is the spring of pride or joy, or satisfaction, or fidelity, that devises expedients, draws conclusions, etc.? If it perishes with the body, on what logical grounds can we refuse to surrender the mind of man to a similar fate? If we can do all the things done by the animals by means of a perishable combination of physical and vital forces, why not join in with the so-called materialists, and do the same for mind in man? If not, why not?

But suppose the ground is taken, that we must attribute all the phenomena bearing the marks of mind exhibited by the lower animals to the immediate presence and action of the Divine mind, how shall we reclaim the human mind from being swallowed up in the Divine mind, thus destroying all except the shadow or pretense of individuality? Hence, on such grounds as these, it seems hardly possible to refuse to the lower animals the possession of mind in the same sense, but not necessarily in the same degree as in man.

Of course there are many other reasons which may be used in support of the position that the lower animals have minds, but I cannot refer to all of them, or indeed to any, except in a brief way.

But I will call your attention to two or three of the stronger reasons that may be urged against this view. I will state and briefly discuss them before I close.

One of the objections which may be raised is to this effect:

1. That there is no real proof that animals possess immortal spirits, or minds. Without a revelation we could not really know, except on the grounds of a frail inference, that the mind of ani-

mals survives the destruction of their bodies. But we have no clear revelation on this subject. The Bible, the only pretended source of authority on such subjects, so far as revelation is concerned in them, makes no statement bearing on it, at least none equaling in clearness those made in respect to the future existence of the spirits of men. It would seem not unreasonable, that if the spirits or minds of the lower animals are endowed with immortality, that it would have been for some *purpose*, probably a moral one. And since men and the lower animals sustain to each other such close relations in this life, the purpose in conferring immortality on the souls of the beasts would probably have some relation to man, and hence, would naturally find some expression in the Bible, which has so much to say of the hereafter of men. But no such statements occur. By a mere observation of animals, and a simple scientific study of the phenomena they present, it is not possible to arrive at clear and logical conclusions on this subject, unless, perhaps of a kind unfavorable to the view which affirms their immortality. It is true, such modes of reasoning do not prove that animals do not have immortal souls, but it at least raises a reasonable presumption against such a view.

2. Again it is said, that the mental phenomena of lower animals do not require the agency of mind to explain them, for they have been referred almost by common consent, from the earliest times, to *instinct*. Men and animals differ, as regards their actions and their knowledge, chiefly in this: Animals do not as a rule *learn* to do, or to know what their modes of existence require them to know, or do what they need to do, and their actions therefore are usually as well performed at first as at last. Their actions are automatic, or they are done without purpose or *foresight* of the animal. It is thus with the walking of animals when first born, with their breathing or their sucking. A chicken, not yet out of its shell, will peck at, and swallow a fly; a serpent, when it first escapes from its egg, will on the instant, seek a retreat under a stone, or stick, or clod, if there is any show of violence or danger.

The bee builds its cell, the bird its nest, the spider weaves its web, just as perfectly at first as at last. All these things and thousands more are done by these and other animals prior to experience. They were never learned. In one sense the animal does not *know* how to do them, viz.: in the sense of having *learned* to do them. It does them moved by an *impulse*, rather than determinate thought. It obeys a mere blind, but cogent *propensity*, rather than a rational conclusion, viz.: one deduced by logical processes from ascertained and definite premises. These mere propensities arise in, and then reach on, are apparatus, or mechanism, which is often perfect at birth, or before it. In such cases as those, in which the animal does not begin the performance of certain acts or to manifest certain tendencies until late in life, the reason is to be found in the lateness of development of the appropriate mechanism through which the acts in question are accomplished. The case is in nowise different from that in which the apparatus is perfect at birth. No matter how late in life it is that the animal begins to do what it does, this much is clear, that the apparatus was not developed by *educative* processes, as is so generally the case in man. To all appearances the development is spontaneous. The animal seems to acquiesce, without purpose, and hence unconsciously its capacities to do. It does whatever it does as a rule, from the first, with automatic precision. But while this is the rule with the lower animals, the contrary is true of man. He has the smallest possible stock of instinctive or automatic acts to begin with, and those few of the lowest and simplest kind. Whatever *he* does or knows he has to *learn* to do or know as a rule, by or through slow, *educative processes*.

The point in this case is as follows: As respects the lower animals, they are provided by their Creator from the first with complete mechanisms, fitted to reach in a determinate way to various stimuli, external and internal, while the development and perfection in structure and working of the nervous mechanisms in man are conditional on their *determinate purposive use* or *education*. If not so used, or, in other words, *educated*, they are never developed. Hence we may have ignorant and incapable men, as compared with each other, but not ignorant and incapable animals, as compared with their kind. Hence arises a *duty* on the part of men to *develop themselves*, and if they do not discharge that duty we *blame* them, as in the scripture parable of the talents. But not so in the lower animals. But why these remarkable differences between men and animals if they both have minds of the same kind? The only way in which they may be explained is to admit that in the one case there is a *rational mind or spirit*, which can feel and know, and can use the mechanisms with which it stands connected, so as to lead to their development in many ways and degrees, and in varying propertions to each other, while in the lower animals, the nervous and other mechanisms are developed as a rule in some other way than by their *use*. They are devel oped prior to or *independently of use*, but not so in man, as a rule. In the one case there is a mind to use the imperfect apparatus, and, according to the degree and kind of the use, to develop it in various ways and degrees; but in beasts this is not so, only in a low degree. Hence animals of the same kind are more nearly equal in their development, and men less so. Hence man is in a measure the master of his own higher development, and is, therefore, charged with a duty in this connection; but not so the animals below him. Out of such considerations, if time permitted, it would seem that quite a presumption could be raised up in favor of the view that the lower animals do not have minds as men do. But to pass on, it may be urged,

3. That any necessity which might seem to arise for admitting the lower animals to have mind with man, may be met, or at least justly avoided, by certain distinctions which have been long recognized by many writers. It has been maintained by many, from the time of Aristotle, that in man we may discern at least two forms of mind. The one is conveyed with the objects of sense, and our relations in space and time. To it belongs the sense of perception, the capacity for comparing sense perceptions, or to think on them, and also our nerve propensities, and certain emotions not ordinarily classed with propensities or appetites. This, it is admitted, is possessed in kind by animals as well as men. It has been called the *psyche*. The other is superior to the *psyche*, and has relations not only to the *psyche*, but also to the body. It is that form of mind by which we become related to God, and which is the seat of conscience. By it we are enabled to discern right from wrong, good from evil, the beautiful from its contrary, and by this

we obtain motives to action, not only for the present but the distant future, not only in accordance with, but often in opposition to the mere teachings of sense, or the mere impulses of appetite or of the bodily passions, in obedience to which the lower animals act. This is the home of the reason, of even the "Pure Reason" of Kant, of the *moral sense*, and the true seat of the religious life, to all of which the lower animals are strangers. This form or part of mind is called the *pneuma.* It is the possession of this part which chiefly distinguishes men from the lower animals. It is this part which it may be most truly offered is immortal, without contesting for the immortality of the *psyche*, which the lower animals possess in common with man. This latter part may perish possibly, and if so, we need not trouble ourselves about the question as to whether the mind of animals may continue to survive after the death of their bodies. But that these two forms of mind may be separable from each other would seem to be possible from the fact, as they may be assumed to be, that the lower animals have what corresponds to the *psyche* without the *pneuma* in man, and from the fact, that forms of mind seem to relate to wholly different objects, and from the further fact, as it seems to be in the moral and religious history of mankind, that the *pneuma* may be either dead or alive to the proper moral and spiritual objects and relations, without involving any corresponding or other change in the *psyche.* This is the part of a man's nature which seems of all others the most susceptible of cultivation and expansion, and which the advance of age, which seems to involve so seriously the *body* and the *psyche*, does not often affect. It is *par excellence*, the *progressive* part of man, the most human-like, nay, God-like, part of man; that it is within its domain that these aspirations take their origin, which at once imply and demand a life hereafter, as the only one which does not mark them, and in which alone it would seem possible for them to find satisfying objects. By making some such distinction as has been hinted at, it would seem possible to admit a form of mind as common to man and animals, the admission of which would be perfectly compatible with a denial of its immortality, or at least with a doubt on this subject, and also with a claim for man of a form of mind which, so far as the signs go, may be denied to the lower animals.

4. But finally, it may objected that it cannot be sustained on the score of *utility*. Of what use would a hereafter be to creatures who do not show any signs of needing or wanting it, and who show so little capacity for improving it, to be of any good end? Notwithstanding the acknowledged possibility of educating certain animals, yet the great fact remains, that the lives of all the lower animals are almost wholly automatic. Their lives are not spent in struggles after the practical attainments of ideals, and in an apparent sacrifice of the present for the future, in a purposive exercise of will, to the end of the chastening and subjection of their sensual natures, and the elevation, expansion, unlimited refinement and development of their higher faculties — faculties which, indeed, they do not have as compared with men — in the pursuit of moral and esthetic good, which often have their final object concealed, either in the immediate future or even in another state of existence, and in a rational sacrifice of self for others. I say the great fact remains, that the lives of beasts are not open to any such way, but in following out the dictates of mere propensities, and these are usually, though not always, selfish. Their lives and faculties are developed for them, rather than by them. Of what use would a future life be to such creatures? It is true there may be a use for them hereafter which we do know of, but we are not permitted to go outside of our knowledge for positive purposes. We should never permit ourselves to use a mere negation in a positive manner; we cannot properly use our ignorance as against our knowledge, however imperfect that knowledge may be. We do not know, as compared with men, that the lower animals show no *signs* of desiring a future life, only at best a desire for a continuance of the present one, and they do not show any considerable capacities for improvement or rational enjoyment. But it has been and is different with men in all ages. We all have, I hope, a desire to live hereafter, that is, after death; and as a rule men have in their average estate shown capacities for the acquisition and use of knowledge and for enjoyment which are too vast for the short and uncertain measure of this life.

But why, if there is no hereafter? This desire which men have for immortality, which is shown in so many ways, and which must have an object somewhere, has its birth in the *pneuma* rather than the *psyche*; and hence, if the distinction between these two forms of mind is admissible, and men and animals participate in the *psyche*, but not in the *pneuma*, we can see why animals should not have this desire.

Such are a few among the many reasons which may be offered for refusing to admit the view that the lower animals have minds the same in kind as men, differing only in degree of development.

The reasons that have been given have been selected rather than others, because it was supposed their discussion would prove the most *suggestive.* I say *suggestive*, because my opinion is, that if what is said on such an occasion as this is said only to convey mere information, rather than to provoke and direct thought, we come together for little purpose.

But it is impossible in one short discourse to adequately state, much less discuss, in a satisfactory manner, such a theme as this.

As a result of my studies, which have been long turned in this direction, I have been led to admit that the lower animals, even the lowest, have minds generally the same in *kind* as men, but with important differences.

In the lower animals, the mental faculties involved in perception and memory, and the instincts and propensities, and the lower phases of moral sentiment, may be compared with men, in the natural state, viz.: with the savages. But in the higher provinces of mind, especially those which are the seats of the esthetic, moral and religious activities, the lower animals are separated from man by a vast difference in degree of development, if not of kind. It is on these latter grounds that the distinction is the most profound as between men and the lower animals when compared mutually.

Why should we deny that animals have minds? Why deny that they are immortal? By admitting these positions no harm is done, so far as I can see, and we avoid thereby a host of uncomfortable questions and inferences, which we can neither answer nor parry in a rational manner, and many of which strike at the heart of the immortality of the human soul. Whether the spirits of animals, if they are immortal, will be with us hereafter as at present, or will be somewhere else, is a question about which no one knows anything, and about which no one need concern himself. It may be that the old and yet living doctrine of the transmigration of the spirits of animals points to the true solution of this question.

THE ANTIQUITIES AND PLATYCNEMISM OF THE MOUND BUILDERS OF WISCONSIN.

BY J. M. DE HART, M. D.

The vast difference that has been found to exist between the mounds of Wisconsin and those of other parts of the United States, both in their form and variety of structure, have led many archæologists to infer that they were constructed by a different race; but such eminent authority as the late Dr. Lapham, has dispelled these views, and finds in them sufficient evidence to prove that they are of a common origin. The animal mounds, located a few miles west of the four lakes, near Madison, were first described by Squier and Davis, in their contributions to the Smithsonian Institution, in 1848, and also by R. C. Taylor, in Silliman's Journal.

Dr. Locke, in the Geological Report of Iowa and Wisconsin, furnished information which greatly increased our knowledge of these structures; but Dr. Lapham, in his contributions to the Smithsonian Institution and American Antiquarian Society, has done more than any other writer, in furnishing evidence of their conformation and general character.

Most of these mounds consist of imitations, on a gigantic scale, of animate objects, which were characteristic of the region, such as the bear, buffalo and deer, among the mammals; of the turtle and lizard, among the reptiles, and the night hawk and eagle, among the birds; and, in a few instances, of the human form. The animal mounds seldom exceed five feet in height, while some of them were only one or two feet high, above the surrounding ground. From the fact that the mounds were nearly always located near the great rivers, and in the vicinity of the lakes, we are led to infer that the mound-builders availed themselves of the natural advantages of the country — ready access to living water, natural highways, streams abounding with fish, and the adjacent forests with game.

Many of the mounds are built on high bluffs, from which an extensive view may be obtained of the surrounding country, diversified by wooded steeps and rolling prairies, with, in many instances, a broad river meandering through the landscape, or a beautiful lake, with its placid waters ever abounding with fish in great quantity.

Fig. 1.

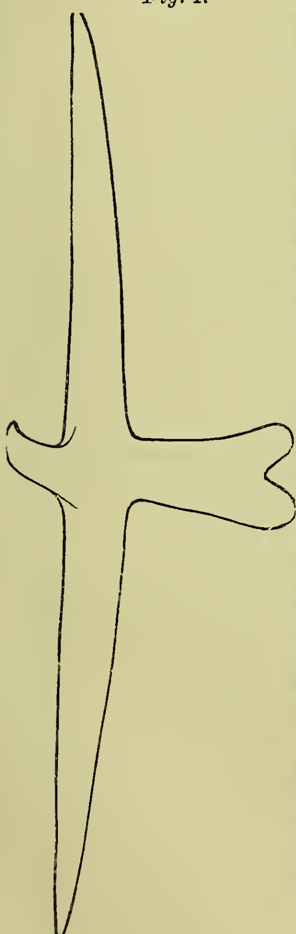


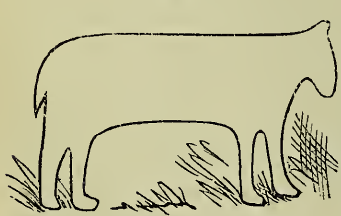
Fig. I represents an eagle, with a body 100 ft. long, and wings expanded 300 ft. on either side of it. It has a well-defined beak, and a tail 40 ft. wide.

Peschel of Leipsic, in his "Races of Man," says that in North America the aborigines made dome shaped tumuli, round, flat topped mounds and circular earth works; some of them contain graves and covered passages. These are very scarce in the New England states, and are rarely found west of the Mississippi, but extend from the upper course of the Missouri and the great lakes, to the south, on both slopes of the Alleghanies, as far as Florida. Most archæologists have ascribed them to an extinct race of Mound-builders, who are supposed to have migrated from Mexico. The builders of these mounds were, therefore, the predecessors of the Indians, and these latter were supplanted by Europeans. W i s c o n s i n furnishes many evidences of the existence upon its soil of a prehistoric race, known as the Mound-builder. Along the northern shore of Lake Mendota, many mounds may be found. The animal mounds found in this vicinity represent a bear, deer, squirrel, and other mammals now extinct; while a few of the mounds are made in the form of birds, some of which are very large, and three of them are located in close proximity to one another, and resemble an eagle with expanded wings. The largest of these birds has a body 100 ft. long, whose expanded wings measure 300 feet on either side of his body, while the tail is 40 ft. wide. The head is quite perfectly formed, so that the outline of the beak is 15 ft. in length. [*Fig.* 1.] The form of a deer, about three feet high, is found near the left wing of the gigantic bird. The body of the deer measures 65 ft. and the legs are 14 ft. long; the head measures 12 ft. from the tip of the nose to the origin of the antlers. These latter are each 10 ft long, and have a branch extending at right angles from their center. [*Fig.* 2.] Near the left wing of the other bird there is the form of a bear, with a well defined body, head and legs. [*Fig.* 3–4.]

Fig. 2.

Fig. 2. represents a deer, whose body measures 65 ft., with legs 14 ft. long. The antlers are each 10 ft. long, with branches from each.

Fig. 3.



Near Grand river, in Green Lake county, there is a collection of about one hundred mounds, mostly of a conical or circular form. One of these resembles the form of a man, with arms of an unequal length. The head points to the south, and towards a high hill, called Mt. Moriah. As these mounds are composed of a sandy soil, they do not preserve their form as well as the mounds in other localities, which are composed of adjacent soil and clay.

In the vicinity of Fox river there are several mounds, some of which resemble racoons and bears, while the remainder are oblong and circular mounds. One mound in this vicinity represents an animal whose genus and species could not be ascertained.

Fig. 4.

While many animal mounds are found near Lake Mendota, there are also circular and oblong mounds. On the following page there is a diagram showing the location and elevation of eight ancient mounds on the northern shores of this lake. Their elevation varies from 93 to 96 feet above the lake, and on some of them trees are growing, measuring five and a half feet in circumference. [*Fig.* 5.] The largest circular mound of this group measures 188 feet in circumference, and 35 feet from the base to its summit. It is the highest mound in this group, and from its elevated position, could have been used for observation, and as a means of communication by signal with other mounds in the adjacent country. From its summit you have an extended view of the surrounding country for many miles in all directions.

This mound was the first one of the series explored, and on the following page a diagram of the manner of exploration is given, together with the location of the skeletons and other relics found therein. [*Fig.* 6.]

In commencing the work, it was thought best to sink a perpendicular shaft, about six feet square, through the centre of the mound, from the apex to the bottom of the tumulus. After removing the surface, a black earth, similar to what is found on the shore of the lake when muck accumulates, or on the prairie bottom, was removed to the depth of five feet. At this depth, and on the western side of the shaft, a group of stones, consisting of magnesia limestone, yellow and red sandstone were found. Some of these stones were flat, while others were irregular in shape, and bear indications of having been obtained from the limestone quarry along the shore of the lake, where the water had worn away portions of them. Underneath this course of earth there was a layer of yellow clay, about four feet in depth, through which a similar course of stones, arranged in a semi-circular manner, and passing off to the opposite side of the shaft, were encountered. Another layer of black earth was found underneath this course of yellow clay, about five and a half feet in depth, after removing two feet of this deposit, ashes, charcoal, and decayed wood, with small pieces of flint were discovered. A few stones were removed directly below these, and the earth underneath was so hard and dry, that it had the appearance of having been baked, another foot of earth was then removed, when the skeleton of an adult mound-builder was discovered in a sitting posture, at the southeastern corner of the shaft, several pieces of the cranium, vertebra, the body of the inferior maxillary, with the alveolar process quite complete, ribs, and bones of the extremeties were found, but none of them were wholly perfect.

Where the cranium had lain, there was a perfectly formed mould, but only a few pieces of the bones were found. Had I thought to measure this mould I could have obtained some idea of the dimensions of the skull. The vertebra were very large and indicated the existence of a race larger than the Indian; of the bones of the upper extremity that were found, that of the humerus presented a feature which is regarded as characteristic of the ancient Mound-builder. There was a perforation through its inferior extremity, as shown in the accompanying illustration. In all instances where the inferior extremity of the humerus has been found in mounds, this perforation has been observed to exist, and hence it may be called a natural communication existing between the olecranon depression on the one side and the coronal and radial depression on the opposite side, in the humerus of the Mound-builder. This perforation is found to exist in the chimpanzee, ape and other animals, who go about on all four of their extremities.

As shown in the accompanying illustration, the specimen found

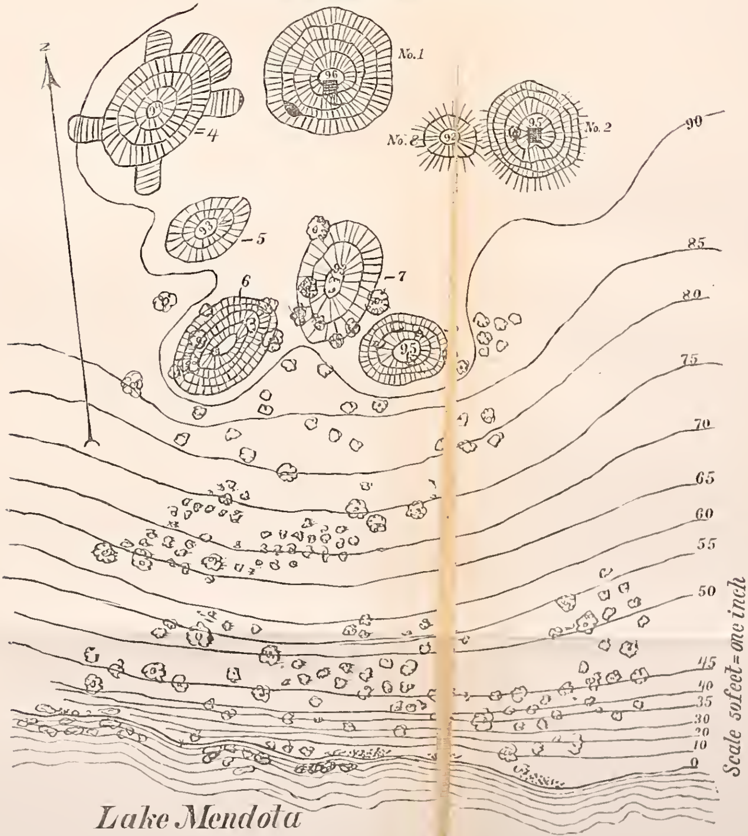
Fig. 5.

DIAGRAM

SHOWING THE

LOCATION AND ELEVATION OF THE MOUNDS AND THEIR ELEVATION ABOVE LAKE.

No. 1. The Mound first examined × 96 above the Lake.
No. 2. The second Mound examined × 95 above the Lake.
The other six Mounds have not been examined.
No. 4. Represents an animal of some kind, probably a Turtle.



Represent Magnesian Limestone.

Represent a bed of gravel.

Represent a few trees on the Mounds and bottom. No Mounds and Lake.

These marks the elevation above the Lake.

Fig. 6.

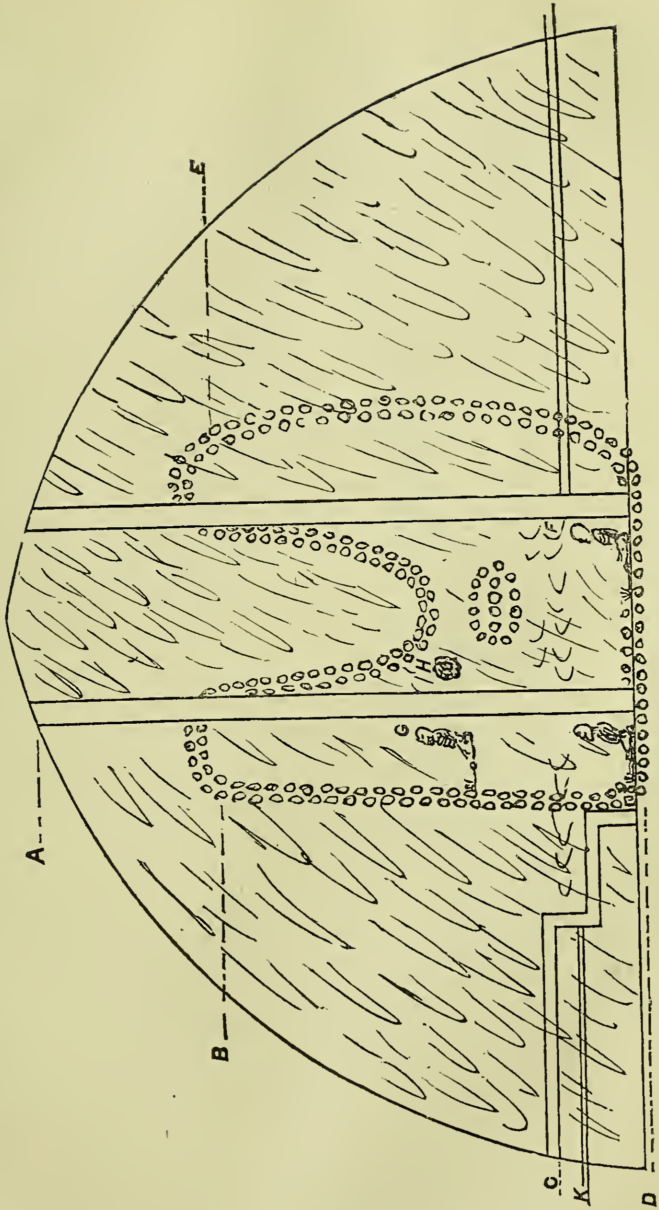
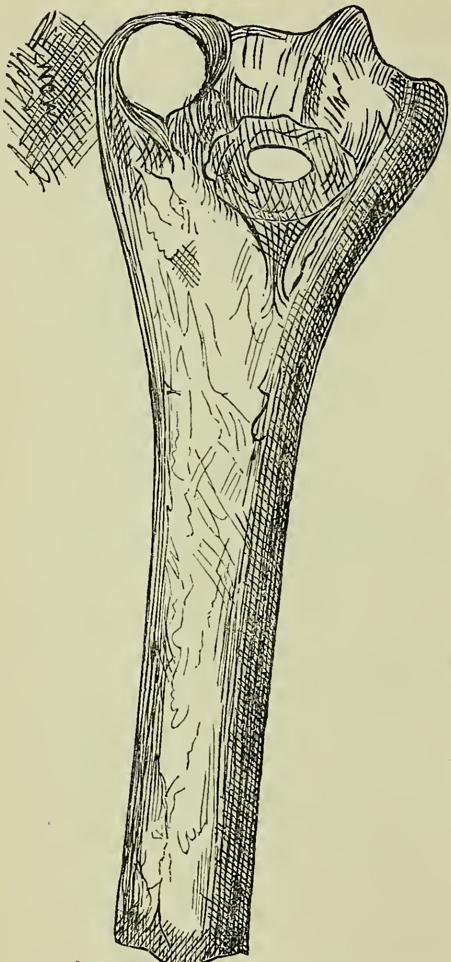


Fig. 7.



in this mound, presents on its anterior surface a perforation, which is surrounded by a gradually receding margin, which is not so great as that surrounding the perforation on the opposite or posterior surface, of the same bone. In the human subject, the anterior surface of the inferior extremity of the humerus presents a ridge of bones, which separates the coronal and radial depressions.

This bone is, no doubt, of great antiquity and was very much decayed, the superior extremity having disappeared. In no case did I find any of the long bones of the extremities wholly perfect, but all of them were broken near the center of the shaft, the other extremity not being found. It is hardly probable that this is due to decay, in every instance, but it may point to some superstitious rite or custom, connected with the sepulture of the dead, among the ancient Mound-builders.

This was the only humerus found, with either extremity nearly perfect.

The shafts of two tibias, found in this mound presented another characteristic of the Mound-builder. They were both remarkably flat, and this peculiarity is termed Platycnemism. In the Smithsonian Annual Report of 1873, Mr. H. Gilman, of Michigan, furnishes six comparative tables, which give the dimensions of some forty specimens of Platycnemism, and in these tables the tibias found in the mound near Rogue river, Michigan, present the greatest amount of flatness. In comparing the specimens found in this mound near Lake Mendota, with those reported by Mr. Gilman, I find that while his measure forty-eighth one hundredths of an inch in comparing their antero-posterior diameter with the transverse diameter, my specimens measure fifty-two one-hundredths and fifty-four one-hundredths of an inch respectively, in comparing the same diameters. This flatness of the tibia has been recognized in the skeletons found in many ancient mounds, not only in this country but also in England and Wales, and might, therefore, be justly regarded as another characteristic feature of the osteology of the Mound-builder.

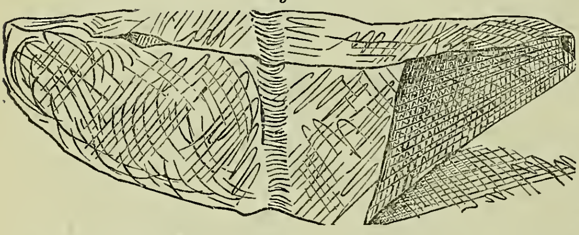
Prof. Buck regards Platycnemism as being characteristic of remote antiquity.

Prof. Gilman says further, that it is impossible to give the correct age of the mounds in Michigan, but from an examination of the trees growing on them, it was evident that they were either planted, or had taken root there, from 750 to 1,000 years ago. It was, therefore, beyond his observation to give anything like an aproximate age of the mounds, because they existed before the trees grew.

Beneath the skeleton of this Mound-builder, there was a few inches of earth, and then a course of stones similar to those previously described, resting upon a bed of yellow clay. As there were no evidences that this had ever been disturbed, and it being one and a half feet below the level of the surface, it was not thought best to sink the shaft any deeper.

As shown in fig. 6, a drift was then made into the side of this mound, three feet above the level of the surface, and about eight feet wide. After the removal of several feet of earth, a similar course of stones, was found, which could be traced to the group of stones on the west side of the shaft. These were removed, and large quantities of ashes, charcoal, and pieces of flint were found near them. On continuing the drift towards the center of the tumulus, and near the shaft, the skeleton of a young Mound-builder, was discovered in a sitting posture. He was probably not more than six years of age, judging from the condition of the bones, a few pieces of the cranium, several vertebra, portions of the long bones of the extremities, and the superior and inferior maxillary were removed; several teeth were still in the alercolar process of the superior maxillary, several pieces of flintshell beads, two large teeth, of some animal, and small arrow heads were found in close proximity. Quite near these remains, three pieces of ancient pottery were discovered; the largest piece measuring four and a half or five and a half inches, and about a quarter of an inch in thickness. It was smooth on its internal surface, and marked externally by raised lines running obliquely across it, such as are frequently seen upon ancient pottery found in

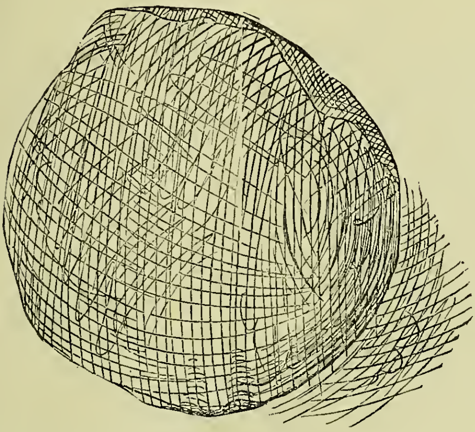
Fig. 8.



mounds. I give an illustration of this piece of pottery, together with a stone implement, resembling a hammer, found in this mound. The drift was carried forward as far as the shaft, and then downwards to the natural bed of yellow clay. Just before striking the shaft, and near the bottom of the tumulus, the skeleton of a second adult was found, only a very few pieces of the cranium and two pieces of the femur were discovered. After removing some very dry and hard earth another course of stones were removed, which bore evidences of having been exposed to fire. Ashes, charcoal, and decayed wood in quite large pieces, one foot long by four inches thick, and plants were found quite near the stones. Many of the stones crumbled to pieces on handling. On removing the pillar of earth formed by the junction of the drift with the perpendicular shaft, a flat disc of stone, quarter of an inch in thickness and four inches in diameter was, found. Similar stone dics were found by Squier and Davis, and were called by them discoidal stones. They have been found in the other parts of the northwest, and were supposed by them to have been used by the Mound-builders in playing games.

Another mound circular in form, and located a few yards from number one, and marked number two in the diagram, on page 7, was that examined. This mound was about five feet high and 125 feet in circumference. A drift was made into the side of this mound on a level with the surrounding ground, and six feet in width. A section of this mound, with the mode of exploration is given on the opposite page. After removing the surface a layer of gravel one foot in depth, and on the summit a course of sand dipping downwards into the layer of earth beneath it, was found. The layer of black earth was three feet deep, and this was followed by another course of gravel and then a layer of earth one foot deep. A thin stratum of gravel was removed, which was followed by finding ashes, charcoal, decayed wood, and flint. These lay upon an altar of stones, composed of limestone, yellow and red sandstone, resting upon a bed of yellow clay. This altar was about one and a half feet below the surrounding surface, and measured three and a half feet in length by one and a half feet in height and two feet in width. The excavation was continued downwards to the depth of three feet, but nothing was found.

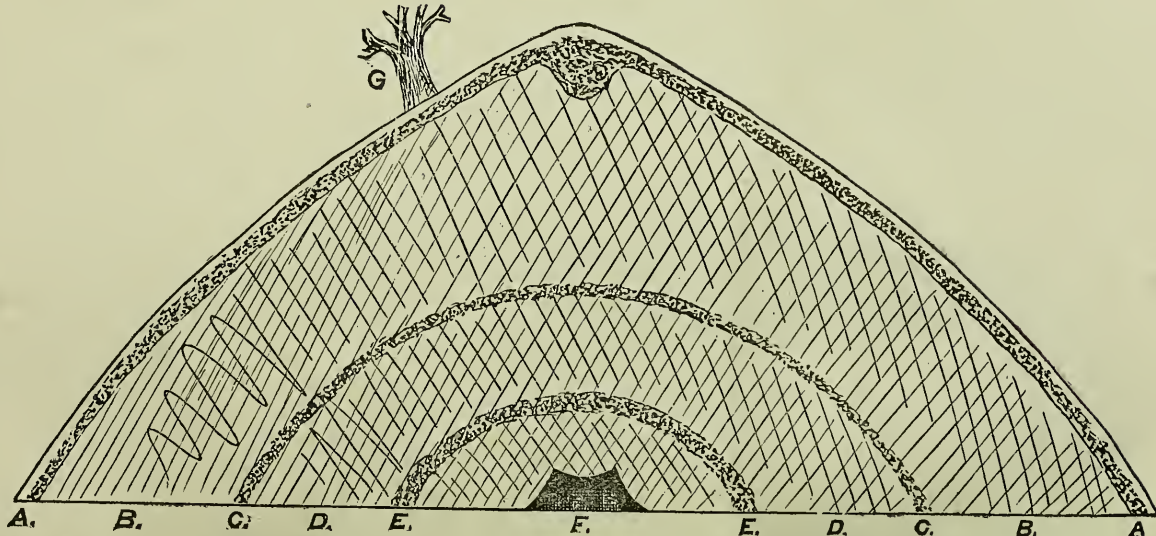
Fig. 9.



Two feet from the summit of this mound, there was a tree growing which measured five feet in circumference. In the side of this tree, and fastened in the back, was a stone pestle, which had undoubtedly been carried upward through the mound, during the growth of this tree. This pestle was composed of granite, with a layer of quartz running through it. It measured six by eight inches.

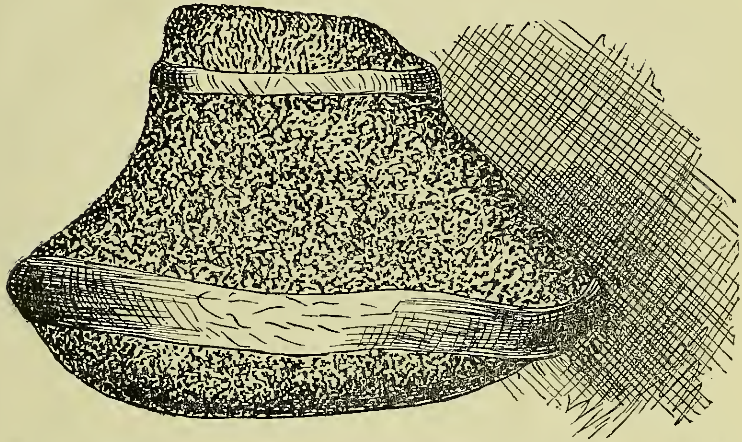
Owing to the approach of winter no further explorations were made of these mounds, but next spring it is my intention to con-

Fig. 10.



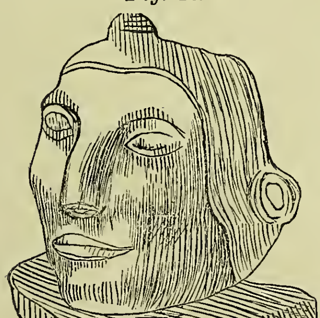
tinue the examination of them, and hope to find on them more evidences of the Prehistoric race, known as the Mound-builder.

Fig. 11.



The question has, no doubt, occurred to many archæologists and antiquarians, who have examined these ancient land-marks, as to who were the people, or what race, built them; but, so far, no possible knowledge has been obtained as to their origin. The Indian tribes, who have lived in the vicinity of them for the past few centuries, know nothing of them.

Fig. 12.



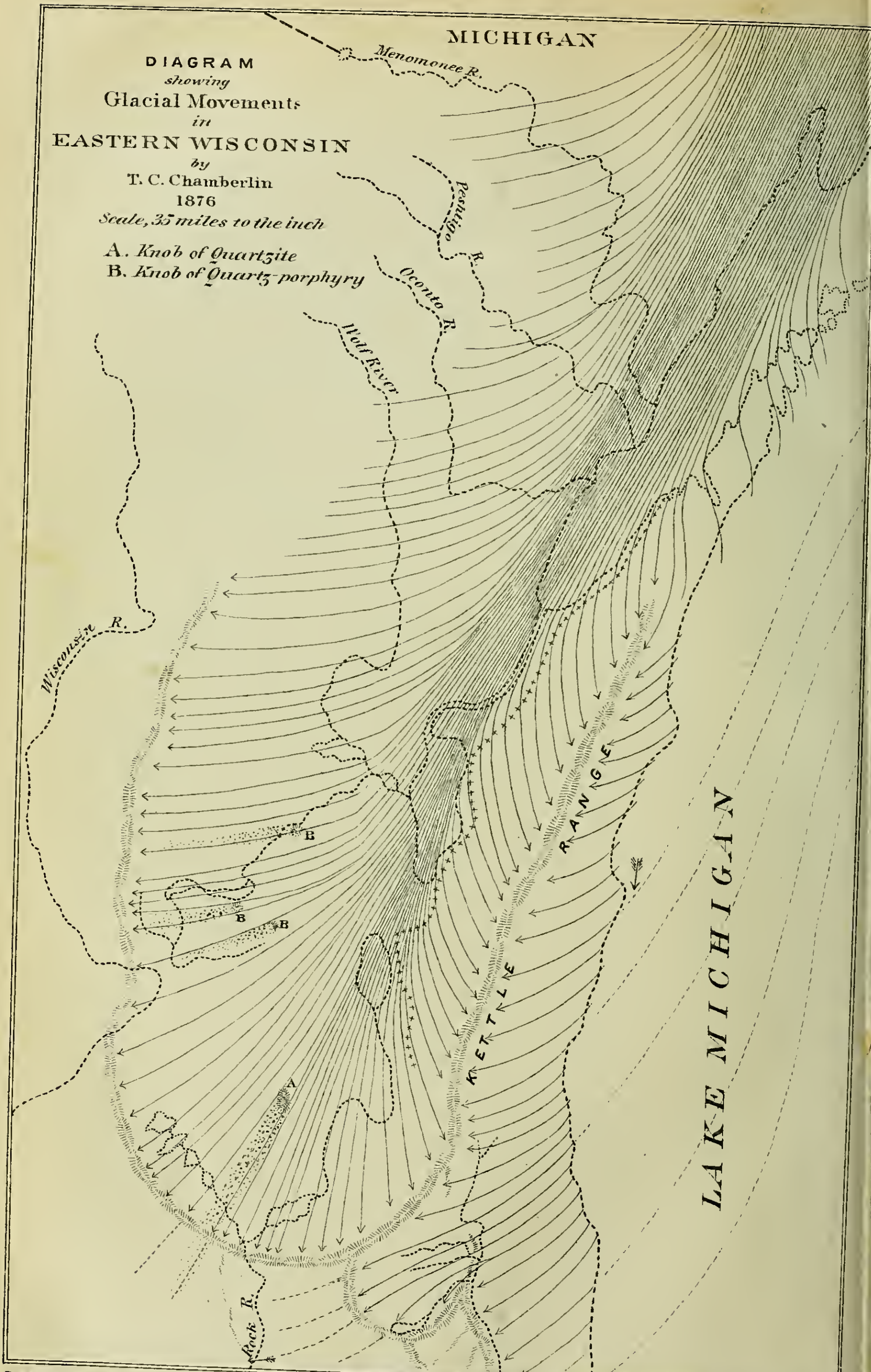
The Winnebagos, who were the last Indian occupants of the Ancient Works at Aztalan, in Jefferson county, would always answer in the negative by a significant shake of the head, when asked if they could tell who erected them.

While Nott and Glidden, in their work, the "Indigenous Races of the Earth," refer to the Mound-builders, as belonging to a race far higher in civilization than the hunting tribes of America." They call them Mound-builders, from the regular fortifications, which they have erected, in several of the Western and Southern States. The Natchez, destroyed by the French of Louisiana, in the last century, seem, in fact, to have belonged to them.

Among the many relics of this ancient race, which were found by Squier, during his explorations of the valley of the Mississippi, was a most characteristic head, made of red pipe clay, the workmanship of these unknown builders, which exhibits the peculiar Indian features.

He says further, " that this discovery proves that these 'Mound-builders' were American Indians, or type; that time has not changed the type of this indigenous group of races; and that the 'Mound-builders' were probably acquainted with no other race, but themselves. In every way proving the views of author of Crania Americans."

Fig. 12 represents above overturned head, formed by squares.



The Milwaukee Litho. & Engr. Co.

DEPARTMENT

OF THE MATHEMATICAL AND PHYSICAL SCIENCES.

ON THE EXTENT AND SIGNIFICANCE OF THE WISCONSIN KETTLE MORAINE.

By T. C. CHAMBERLIN, A. M.,

State Geologist, and Professor of Geology in Beloit College [1]

At the meeting of the Academy, three years since, I took the liberty of occupying the attention of the members by the presentation of some observations and conclusions in reference to a peculiar series of drift hills and ridges in eastern Wisconsin, known as the Kettle range, and the views then advanced afterwards found a place in my report on the geology of eastern Wisconsin.[2] Similar observations were subsequently made by Professor Roland D. Irving, of the Wisconsin survey, and his conclusions are in perfect agreement with my own.[3]

In neither case, however, was any attempt made to show the full extent of the formation outside of the districts reported upon, or to point out its theoretical significance, the chapters being intended only as contributions to local geology, made under somewhat severe limitations as to space.

It is not now possible to map, or even safely conjecture, the complete extent and limitations of the formation; but it is the purpose of this article to add such trustworthy observations as have since been made, and to gather such evidence as may justify a provisional mapping of the range, where it has not been actually

[1] I have taken advantage of the interval between the date of reading and the printing to introduce new matter. T. C. C.

[2] Geology of Wis., Vol. II, 1877 (revised edition 1878), pp. 205–215.

[3] Geology of Wis., Vol. II, 1877 (revised edition 1878), pp. 608–635.

traced. A portion of the paper will, therefore, relate to well ascertained facts, while other portions will be in various degrees hypothetical. If care is taken to distinguish between these portions, no harm can arise from their association; while the provisional mapping will, it is hoped, prove of service in both stimulating and guiding further investigation. The extent of the range is likely to prove too great for the immediate time and means of a single observer; while the broad and irregular, and sometimes obscure, character of the belt is such that it is likely to be overlooked, as a continuous range, as experience has shown, unless attention be called to it, or the observer be keenly alive to distinctions in drift topography. It is believed, therefore, that the presentation of some things that are only probable, not certain, will not be without value.

It will be advisable to consider first, somewhat critically, the character of the formation. The following description, which is based upon careful observation, relates more specifically to the moraine in Wisconsin, where it is usually well developed, and may require some modification in its application to the range where sub-aqueous deposits overlap or encroach upon it, and in other special situations.

Surface Features.— The superficial aspect of the formation is that of an irregular, intricate series of drift ridges and hills of rapidly, but often very gracefully, undulating contour, consisting of rounded domes, conical peaks, winding and, occasionally, geniculated ridges, short, sharp spurs, mounds, knolls and hummocks, promiscuously arranged, accompanied by corresponding depressions, that are even more striking in character. These depressions, which, to casual observation, constitute the most peculiar and obtrusive feature of the range, and give rise to its descriptive name in Wisconsin, are variously known as "Potash kettles," "Pot holes," "Pots and kettles," "Sinks," etc. Those that have most arrested popular attention are circular in outline and symmetrical in form, not unlike the homely utensils that have given them names. But it is important to observe that the most of these depressions are not so symmetrical as to merit the application of these terms. Occasionally, they approach the form of a funnel, or of an inverted bell, while the shallow ones are mere saucer-like hollows, and others are rudely oval, oblong, elliptical, or are extended into trough-like, or even winding hollows, while irregular departures from all these forms are most common. In depth, these cavities vary from the merest indentation of the surface to bowls sixty feet or more deep, while in the irregular forms the descent is not unfrequently one hundred feet or more. The slope of the sides varies greatly, but in the deeper ones it very often reaches an angle of 30° or 35° with the horizon, or, in other words, is about as steep as the material will lie. In horizontal dimensions, those that are popularly recognized as "kettles" seldom exceed 500 feet in diameter, but, structurally considered, they cannot be limited to this dimension, and it may be difficult to assign definite limits to them. One of the peculiarities of the range is the large number of small lakes, without inlet or outlet, that dot its course. Some of these are mere ponds of water at the bottom of typical kettles, and, from this, they graduate by imperceptible degrees into lakes of two or three miles in diameter. These are simply kettles on a large scale.

Next to the depressions themselves, the most striking feature of this singular formation is their counterpart in the form of rounded hills and hillocks, that may, not inaptly, be styled inverted kettles. These give to the surface an irregularity sometimes fittingly designated "knobby drift." The trough-like, winding hollows have their correlatives in sharp serpentine ridges. The combined effect of these elevations and depressions is to give to the surface an entirely distinctive character.

These features may be regarded, however, as subordinate elements of the main range, since these hillocks and hollows are variously distributed over its surface. They are usually most abundant upon the more abrupt face of the range, but occur, in greater or less degree, on all sides of it, and in various situations. Not unfrequently, they occur distributed over comparatively level areas, adjacent to the range. Sometimes the kettles prevail in the valleys, the adjacent ridges being free from them; and, again, the reverse is the case, or they are promiscuously distributed over both. These facts are important in considering the question of their origin.

The range itself is of composite character, being made up of a series of rudely parallel ridges, that unite, interlock, separate, appear and disappear in an eccentric and intricate manner. Several of these subordinate ridges are often clearly discernible. It is usually between the component ridges, and occupying depressions, evidently caused by their divergence, that most of the larger lakes associated with the range are found. Ridges, running across the trend of the range, as well as traverse spurs extending out from it, are not uncommon features. The component ridges are themselves exceedingly irregular in height and breadth, being often much broken and interrupted. The united effect of all the foregoing features is to give to the formation a strikingly irregular and complicated aspect.

This peculiar topography, however, finds a miniature representative in the terminal moraines of certain Alpine glaciers. Most of the glaciers of Switzerland, at present, terminate in narrow valleys, on very steep slopes, and leave their debris in the form of lateral ridges, or a torrentially washed valley deposit. A portion of them, however, in their recently advanced state, descended into comparatively open valleys of gentle decline, and left typical, terminal moraines, *formed from the ground moraines of the glaciers*, and only slightly obscured by the medial and lateral morainic products, which have little or no representative in the Quaternary formations. The Rhone glacier has left three such ridges, separated by a few rods interval, that are strikingly similar in topographical eccentricities to the formation under discussion, save in their diminutive size. The two outer ones have been modified by the action of the elements, and covered by grass and shrubs, while the inner one remains still largely bare, and, as they have been cut across by the outflowing glacial streams, they are exceedingly instructive as to glacial action under these circumstances. The inner one graduates in an interesting way into the wide-spread ground moraine, which occupies the interval between it and the retreating glacier, where not swept by floods, and which presents a different surface contour, illustrative of Till topography. The two Grindelwald glaciers have left similar moraines; those of the upper one, being the more massive, and being driven closer together, present an almost perfect analogy to the Kettle ranges.

The Glacier du Bois, the terminal portion of the Mer de Glace, the Argentière, and, less obviously, the Findelen, and others, so far as their situation favored, have developed similar moraines, and indicate that this is the usual method of deposit under these conditions. Reference is here made *only* to the terminal deposit of the *ground moraine*, eliminating, as it is quite possible to do, for the most part, the material borne on the surface of the glacier.

The Material of the Formation. —This topic, which is one of primary importance in determining the origin of the deposit, readily divides itself into three subordinate ones, all of which need discriminative attention; (1) the *form* of the constituents, (2) their *arrangement* as deposited, and (3) their *source.*

(1) Premising that the Kames, and those deposits which have been associated with them in the literature of the subject, are described as composed mainly of sand and gravel, it is to be remarked, in distinction, that *all* the four forms of material common to drift, viz.: clay, sand, gravel, and boulders, enter largely into the constitution of the Kettle range, in its typical development. Of these, gravel is the most conspicuous element, *exposed to observation.* This qualification is an important one in forming an adequate conception of the true structure of the formation. It is to be noticed that the belt, at many points, exhibits two distinct formations. The uppermost —*but not occupying the heights of the range* — consists almost wholly of sand and gravel, and lies, like an irregular, undulating sheet, over portions of the true original deposit. This superficial formation is confined mainly to the slopes and flanks of the range, and to depressed areas between its constituent ridges; though, when the whole belt is low, it often spreads extensively over it, so as sometimes to be quite deceptive. But, where the range is developed in force, this superficial deposit is so limited and interrupted, as to be quite insignificant, and not at all misleading; and, at some points, where it is more widely developed, excavations reveal unequivocally its relationship to the subjacent accumulations. In such cases, the lower formation shows a more uneven surface than the upper one, indicating that the effect of the latter is to mask the irregular contour of the lower and main formation. Notwithstanding this, the upper

sands and gravels are often undulatory, and even strongly billowy, and the bowls and basins in it commonly have more than usual symmetry. A not uncommon arrangement of this stratum is found in an undulating margin on the flank of a ridge of the main formation, from which it stretches away into a sand flat or a gravel plain.

Setting aside this, which is manifestly a secondary formation, it is still true that gravel forms a large constituent of the formation. Some of the minor knolls and ridges are almost wholly composed of sand and gravel, the elements of which are usually very irregular in size, frequently including many boulders. But, notwithstanding these qualifications, *the great core of the range*, as shown by the deeper excavations, and by the prominent hills and ridges, that have not been masked by superficial modifications, *consists of a confused commingling of clay, sand, gravel, and boulders, of the most pronounced type.* There is every gradation of material, from boulders several feet in diameter, down to the finest rock flour. The erratics present all degrees of angularity, from those that are scarcely abraded at all, to thoroughly rounded boulders. The cobble stones are spherically rounded, rather than flat, as is common with beach gravel, where the attrition is produced largely by sliding, rather than rolling.

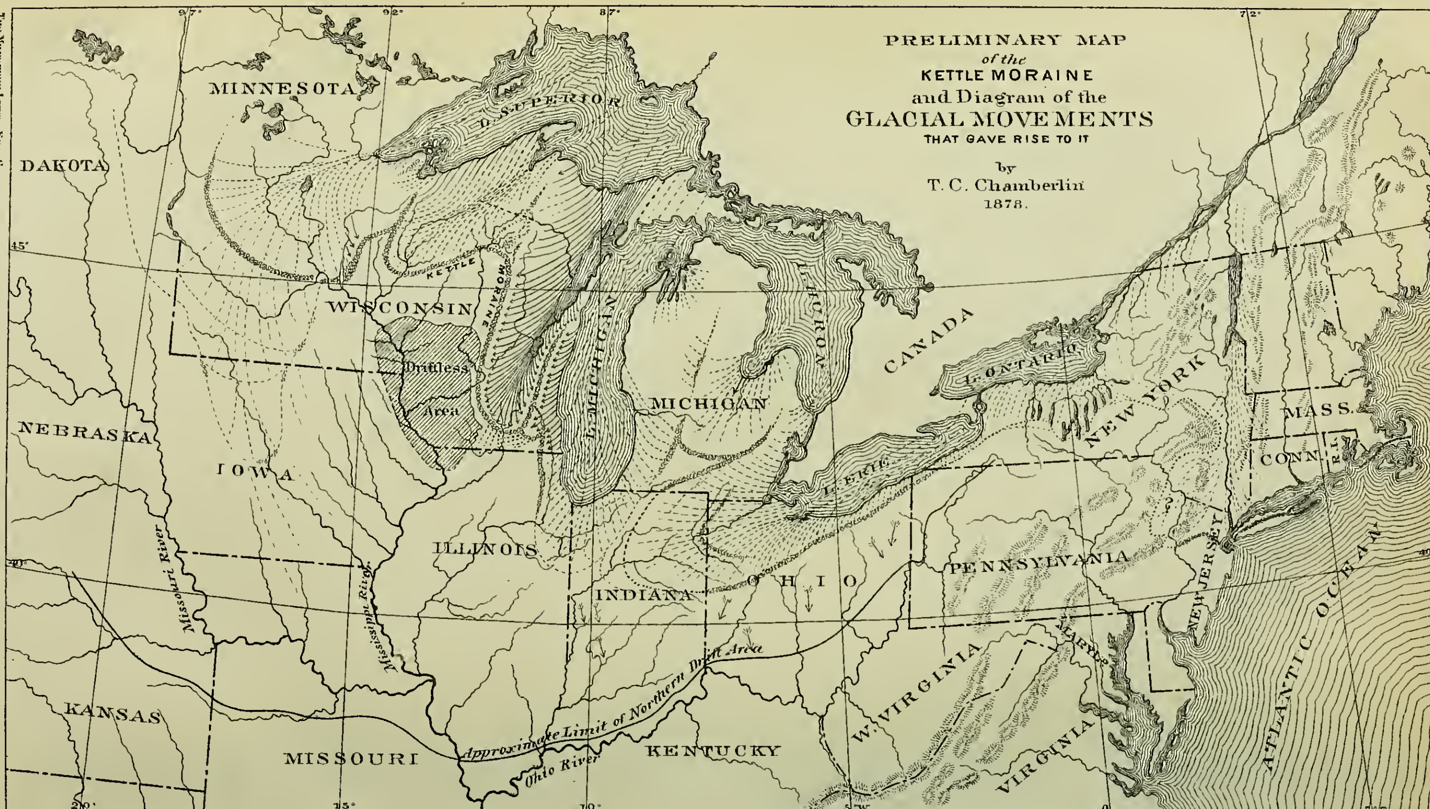
Stratification. — As indicated above, the heart of the range is essentially unstratified. There is, however, much stratified material intimately associated with it, a part of which, if my discriminations are correct, was formed simultaneously with the production of the unstratified portion, and the rest is due to subsequent modification. The local overlying beds, previously mentioned, are obviously stratified, the bedding lines being often inclined, rather than horizontal, and frequently discordant, undulatory or irregular.

The Source of the Material. — This, so far as the range in Wisconsin is concerned, admits of the most unequivocal demonstration. The large amount of coarse rock present renders identification easy, and the average abrasion that has been suffered indicates, measurably, the relative distance that has been traveled. The range winds over the rock formations in a peculiar manner, so as to furnish fine opportunities for decisive investigation. Of the many details collected, there is room here for a single illustrative case only. The Green Bay loop of the range surrounds on all sides, save the north, several scattered knobs of quartzite, porphyry and granite, that protrude through the prevailing limestones and sandstones of the region. These make their several contributions to the material of the range, *but only to a limited section of it, and that invariably in the direction of glacial striation.* Any given segment of the range shows a notable proportion of material derived from the formation adjacent to it, in the direction of striation; and a less proportion, generally speaking, from the succeeding formations that lie beyond it, backward along the line of glacial movement for three hundred miles or more. It is undeniable, that *the agency, which produced the range, gathered its material all along its course for at least three hundred miles to the northward, and its largest accumulations were in the immediate vicinity of the deposit.* For this reason, as the range is traced along its course, its material is found to change, both lithologically and physically, corresponding to the formation from which it was derived.

These facts find ample parallel in the moraines of Switzerland. The marginal portion of the great moraine of the ancient expanded glaciers, on the flanks of the Juras, is composed, very largely, of boulder clay, derived from the limestones that lie in its vicinity, while the quantity of material derived from the more distant formations of the Alps is quite subordinate. Of the more recently formed moraines, those derived from the Bois, Viesch, Rhone, Aar, and other glaciers, which pass over granitic rocks, consist quite largely of sand, gravel, and boulders, clay being subordinate, while those glaciers of the Zermatt region, that pass mainly over schistose rocks, and the Grindelwald glaciers, that, in the lower part of their course, traverse limestone, give rise to a decided amount of clay. The moraines, previously referred to as miniature kettle ridges, are composed of commingled unstratified debris, in the main, but there are instances of assorted and stratified material. The inner moraine of the upper Grindelwald glacier presents much fine assorted gravel and coarse sand, heaped up, very curiously, into peaks and ridges, in various attitudes on the summit and sides of the moraine.

Relations to Drift Movements. — This is manifestly of most vital consideration. The course of drift movement may be determined, (1) by the grooving of the rock surface, (2) by the direction in which the material has been transported, (3) by the abrasion which rock prominences have suffered, (4) by the trend of elongated domes of polished rock, and, (5) less decisively, by the arrangement of the deposited material and the resulting topography. Recourse has been had to all these means of determination, in that portion of the range that has been carefully investigated, and their individual testimony is entirely harmonious, and their combined force is overwhelming. Exceptional opportunity for positive determination is afforded by the protruding knobs of Archæan rocks before alluded to, from which trains of erratics stretch away in definite lines, continuous with the striation on the parent knobs, and parallel to that of the region, as well as concordant with the general system. The united import of all observations, in eastern Wisconsin, testifies to the following remarkable movements, which may be taken as typical, and which are here given, because they have been determined with much care. Between Lake Michigan and the adjacent Kettle range, the direction was obliquely up the slope, as now situated, southwestward, towards the range. On the opposite side, between the Green Bay valley and the range, the course was, after surmounting the cliff bordering the valley, obliquely down the slope, southeastward, toward the range. In the Green Bay trough, the ice stream moved up the valley to its watershed, and then descended divergingly the Rock river valley. Between the Green Bay valley and the Kettle belt on the west, the course was up the slope, westward, or southwestward, according to position. These movements, which are imperfectly shown on the diagram, exhibit a remarkable divergence from the main channel toward the margin of the striated area, marked by the Kettle range.

Much of the data relating to the movements, outside of Wisconsin, has been derived from a study of publications relating to the geology of the several states, to whose authors I am indebted,



The Milwaukee Litho. & Engr. Co.

but who should not be held responsible for the special collocation presented in the accompanying diagram, which, in some of its details, may prudently be held as somewhat tentative, until more rigorously verified. But the grand features of these movements, which may be confidently accepted, are very striking, and are very singularly related to the great basins of the lake region. The three main channels were the troughs of the great lakes, Superior, Michigan, and the couplet, Erie and Ontario, while between these lay three subordinate ones in the basins of the great bays, Saginaw, Green and Keweenaw.

The divergence of the striations from the main channels toward the range, in the case of the Green Bay valley, and, so far as the evidence goes, in other troughs, was an unexpected result, developed by combining individual observations; but, when the method of wasting and disappearance of a glacier is studiously considered, appears not only intelligible, but a necessary result, and one which finds partial illustration among existing glaciers.

Topographical Relations and Distribution. — The topographical relations of the formation are an essential consideration, but may be best apprehended in connection with its geographical extension, which now claims our attention. If we start with the northern extremity of the long known Potash Kettle Range, in Wisconsin, we find ourselves about midway between the southern extremity of Green Bay and Lake Michigan, and on an eastward sloping, rocky incline. The base of the range is here less than 200 feet above Lake Michigan, and is flanked on either side by the lacustrine red clays of the region; and seems, in some measure, to be obscured by them. From this point, it stretches away in a general south-southwestward direction, for about 135 miles, ascending gradually, and obliquely, the rocky slope, until it rests directly on its crest.

When within about twenty miles of the Illinois line, *it divides*, one portion passing southward into that state, and the other, which we will follow, curves to the westward, and crosses the Rock river valley. A profile of the rock surface across this valley, beneath the range, would show a downward curve of more than 300 feet. The range should not, perhaps, be regarded as sagging

14

more than half that amount, however, in crossing the valley, as the canon-like channel of the pre-glacial river, seems to have been filled without much affecting the surface contour of the drift. But the fact of undulation to conform to an irregular surface, produced by erosion, and not by flexure of the strata, is a point to be noted, as it is a serious obstacle in the way of any explanation that is only applicable on the supposition that the formation was in a horizontal position when formed, as the view that it was produced by beach action, or the stranding of icebergs.

After crossing Rock river, the range curves gradually to the northward, passing over the watershed between the Rock and Wisconsin rivers, "descends abruptly 200 feet into the low ground of the valley of the Wisconsin,"[1] crosses the great bend of the river, sweeping directly over the quartzite ranges, according to Prof. Irving, with a vertical undulation of over 700 feet, after which it gradually ascends the watershed between the Mississippi and St. Lawrence drainage systems, until its base reaches an estimated elevation of 700 to 800 feet above Lake Michigan. From thence it has been traced across the headwaters of the Wisconsin river, by Mr. A. Clark, under my direction.[2]

Within the Chippewa valley, it has been observed by Prof. F. H. King, of the Wisconsin Survey, and I have observed it in the vicinity of the Wisconsin Central railroad. This region is covered by an immense forest, mainly unsettled and untraversed, even by foot paths, so that geological exploration is difficult and expensive, and, as no industrial importance attaches to it, and the rock below is deeply concealed by it, I have not deemed it sufficiently important to trace the belt continuously to justify the large expenditure of time and means requisite, especially as I entertain no serious doubts as to its continuity and general position. The observations made, indicate that it descends obliquely the east-

[1] Prof. Irving, Geol. of Wis., Vol. II, 1877, page 616.

[2] To the eastward of the range, as thus traced, Col. Whittlesey describes (Smithsonian Contributions, 1866) a similar formation in Oconto county. I have observed the same at several points. Mr. E. E. Breed informs me that it occurs on the watershed between the Wolf and Oconto rivers, but it has not yet been traced through the wilderness, to any connection with the main range, and it is uncertain whether it is so connected or constitutes a later formation, as such later moraines have been observed at other points.

ern slope of the Chippewa valley, and crosses the river below the great bend (T 32, R. 6 and 7), near which the Flambeau, Jump, and several smaller streams gather themselves together, in a manner very similar to that of the branches of the Rock and Upper Wisconsin rivers, just above the point where they are crossed by the range. From this point the belt appears to curve rapidly to the northward, forming the western watershed of the Chippewa. It is joined in eastern Burnett county by a portion of the range coming up from the southwest, the two uniting to form a common range, analogous to that of eastern Wisconsin. The conjoint range thus formed, extends along the watershed of the Chippewa and Nemakagon rivers, to the vicinity of Long and Nemakagon lakes, on the watershed of Lake Superior. This part is given mainly on the authority of Mr. D. A. Caneday, who visited a portion of the formation with me, and whose discrimination can, I think, be trusted. Mr. E. T. Sweet, of the Wisconsin Survey, describes[1] a kettle range as lying along the axis of the Bayfield peninsula, but it has not been ascertained that this is connected with the belt under consideration.

Returning to the junction of the two ranges in eastern Burnett county, I have traced the belt thence southwestward through Polk and St. Croix counties to St. Croix lake, on the boundary of the state. The lower portion of this has also been studied by Prof. L. C. Wooster, of the Wisconsin Survey. The southeastern range of the belt may be conveniently seen on the North Wisconsin railroad, near Deer Park, and on the Chicago, St. Paul & Minneapolis line, to the west of the station Turner, but only in moderate force.

If a good surface map of Minnesota be consulted, it will be seen that there lies along the watershed, between the Upper Mississippi and the conjoint valleys of the Minnesota and Red rivers, a remarkable curving belt of small lakes. Along this line, lies a chain of drift hills, known in its northwestern extension as the Leaf hills. In the Sixth Annual Report of the Geological Survey of Minnesota, received just as this article is going to the printer,

[1] Manuscript report on Douglas and Bayfield counties, to form a part of Vol. III, Geol. of Wis.

Prof. N. H. Winchell, speaking of the great moraines of the northwest, says: "There are two such that cross Minnesota, the older being the Coteau and the younger, the Leaf hills. Corresponding to the latter, the Kettle Range in Wisconsin seems a parallel phenomenon."[1] I have seen this belt, west of Minneapolis, and concur in Prof. Winchell's opinion. I have also observed, hastily, what I regard as portions of it — dissevered by the river channels — on the peninsula formed by the bend of the Mississippi and the Minnesota, south of St. Paul, and on the similar peninsula between the Mississippi and Lake St. Croix; and this seems to be the line of connection between the Wisconsin and Minnesota ranges. It appears to me, therefore, well nigh certain, that the Leaf hills of Minnesota are not only analogous to the Wisconsin Kettle range, but are portions of the same linear formation.

The multitude of small lakes, found in Wisconsin, lie almost exclusively either along the Kettle belt itself, or in the area within, or north of it. The surface outside has a much more perfect system of drainage, and is almost entirely free from lakelets. The Kettle range constitutes the margin of the lake district. But in Minnesota, south of the Leaf hills, there is an extensive lake region stretching southward in a broad tongue, nearly to the center of Iowa, though the lakes are not very numerous in the latter state. The question naturally arises, whether this lake district is likewise bordered by similar drift accumulations, and this question, though not essential to the present discussion, has much interest in connection with it. In respect to this, I can only give some detached observations and quotations. As already stated, accumulations of this character occur south of St. Paul. Still further to the southward, in the town of Aurora, Steel county, there is a moderate exhibition of gravelly boulder-bearing hillocks and ridges, accompanied by shallow basins and irregular marshes, much after the manner of the formation in question. From the descriptions of Prof. Harrington,[2] these features appear

[1] Sixth Annual Rept. Geol. & Nat. Hist. Sur. Minn., p. 106. The R. R. profiles crossing this belt furnish valuable data. See Ann. Rept. for 1872, pp. 53 and 57, and Sixth Ann. Rept., pp. 47 and 156.

[2] Geol. and Nat Hist. Sur. Minn., Ann. Rept. 1875, pp. 103 *et seq.*

to characterize the county somewhat widely, especially in the southern part. Near Albert Lea, in the adjoining county, on the south, and only a few miles from the Iowa line, there is a more prominent development of similar features, the ridges having a southwestward trend. Dr. C. A. White, in the Geology of Iowa, describes a terrace in the northern part of the state, which, in its eastern extension, "becomes broken up into a well marked strip of 'knobby country.' Here it consists of elevated knobs and short ridges, wholly composed of drift, and usually containing more than an average proportion of gravel and boulders. Interspersed among these knobs and ridges, are many of the peat marshes of the region."[1] One knob he estimates as rising 300 feet above the stream at its base. This area lies in the line of the preceding localities, and near the Minnesota border. Between this "knobby country" and the Algoma branch of the C., M. & St. P. R. R., and stretching southwestward from the latter, there is a broad belt of low mounds and ridges, some of which show the structure and composition common to the Kettle moraine, while others present externally only a pebble clay, similar to that which characterizes the level country to the west of it. The whole presents the appearance of a low range modified by lacustrine deposits.

Near the center of the state, Dr. White describes a second range under the name of "Mineral Ridge,"[2] as consisting, "to a considerable extent, of a collection of slightly raised ridges and knolls, sometimes interspersed with small, shallow ponds, the whole having an elevation, probably, nowhere exceeding 50 feet above the general surface, but, being in an open prairie region, it attracts attention at a considerable distance." Both these ridges, Dr. White classes as probable moraines.

This Mineral ridge lies south of the lake district, and may be regarded as forming its margin in that direction. On the western border, Dr. White describes "knobby drift," in Dickinson county, which, however, is "without perceptible order or system of arrangement."[3] To the northwest from this, we soon encounter the

[1] Geol. of Iowa, 1870, p. 99. [2] Loc. cit. [3] Geol. of Iowa, Vol. II, p. 221.

morainic accumulations of the "Coteac de Prairie,"[1] and the "Cobble Knolls" and "Antelope Hills."

These observations do not indicate a continuous, well defined range, but seem rather to point to a half-buried moraine, that only here and there, along its course, protrudes conspicuously, and this is the impression gained from an inspection of the formation. It is to be noted, as supporting this view, that, at least so far as the eastern side is concerned, this supposed moraine is flanked on the *exterior* by level plains, of smooth surface, often underlaid by sand and gravel, that seemingly owe their origin to broad rivers or lakes that fringed the border of the glacier, in its advanced state, when it probably discharged its waters over the moraine at numerous points, rather than at one, or a few, selected points, as would more likely be the case during its retreat, when accumulations of water could gather along its foot, within the moraine, and large areas be discharged at some single favorable point. But on the inner side of the moraine, the surface, although nearly level, in its general aspect, undulates in minor swells and sags, and the drainage is imperfect. The substratum, instead of being gravel, sand, or laminated clay, is generally a pebble or boulder clay. *Outside* of the moraine, the existing surface contour was formed in the presence, and, to some extent, under the modifying influence, of a fairly established drainage system. But on the *interior*, the drainage system has not, even yet, become fully established, much less impressed itself upon the surface configuration, except in the vicinity of the main rivers.

The terrace-like ridge mentioned by Dr. White, and some of the lines of hills described by Prof. Winchell in Minnesota, as running in a similar direction, may be perhaps regarded as minor morainic lines, stretching across the glacial pathway and marking oscillations in its retreat, analogous to some quite clearly made out in Wisconsin.[2]

This southern morainic loop is, of course, presumed to be older than the Kettle range, and is here discussed because of the inter-

[1] See note of Prof. Mather, Nat. Hist. Sur. 1st Dist. N. Y., p. 193. See also 2d Annual Report Geol. and Nat. His. Sur. Minnesota, by N. H. Winchell, pp. 193 to 195; also *loc cit.*, *ante.*
[2] Geol. of Wis., Vol. II, 1876, p. 215 *et seq.*

esting way in which it is associated with the latter formation, and the suggestions it may contribute to the final solution of the main problem, to which the special one under discussion is only a tributary, viz.: the definite history of the Quatenary formations.

Returning to the branching of the range in southeastern Wisconsin, we find the left arm, or that nearest Lake Michigan, striking southward into Illinois. If we lay before us Prof. Worthen's geological map of that state, and attentively observe its topographical features and its drainage systems, it will be observed that nearly all the lakelets, the greater part of the marshes, and most of the region of abnormal drainage may be included in a curving line, rudely concentric with the shore of Lake Michigan, starting near the center of McHenry county, on the Wisconsin line, and ending in Vermillion county, on the Indiana border. It may also be observed, on a similar inspection of Indiana, that nearly all the lake district lies north of the Wabash.

In Wisconsin, as already stated, we have found this area bordered by the Kettle range, which is itself notably lake-bearing. The range continues to sustain this relationship in Illinois, so far as I know it to be directly continuous. It exhibits a progressive broadening, and flattening, as it enters upon the level country that encompasses the head of Lake Michigan. The pebble clay deposit — not coarse boulder clay — that characterizes the flat country, and which, to the north, has been separated from the range by a belt of coarse boulder clay, here approaches, and appears, to some extent, to overlap the range, and to be one cause of its less conspicuous character. From what I have seen of the region south of Lake Michigan, and from all I can find in geological reports relating to the region, I gather that the range, so far as it escaped the destructive action of the floods issuing from the Lake Michigan basin, both while occupied by ice, and subsequently, is, to a large extent, buried beneath later deposits, or so modified as to be inconspicuous. Whatever the correct interpretation, it remains a fact beyond question, that the belt becomes very obscure, compared with its development to the northward. Dr. E. Andrews says: "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."[1] The members of the geological corps of Illinois did not recognize it distinctively, in the sense in which it is now considered, but Dr. Bannister, in his report on Lake county, says: "In the western part of the county, near the Fox river, we find the ridges, in some places, to be largely composed of rolled limestone boulders. The same character has been observed further south along the same stream and remarked upon in the chapter on Cook county."[2] In respect to McHenry county he says: "In the vicinity of the Fox river, the same kind of gravel ridges are met with as those which have been described as occurring in the western part of Lake county."[3] This lies in the belt identified by me, from personal observation, as belonging to the Kettle range.

Concerning the district farther south, he says: "Boulders of granite, quartzite, greenstone, and various other rocks are abundant in various localities on the surface of the ground, and are frequently met with in excavations for wells, etc., and large deposits of rolled boulders, chiefly of limestone from the underlying Niagara beds, similar to those already described in the report on Cook county, occur in the drift deposits of the adjoining portions of Kane and Du Page counties."[4] Concerning the topography, the same writer says: "Along some of the principal streams, and especially the Fox river in Kane county, the country is more roughly broken, and can, in some parts, even be called hilly, although the more abrupt elevations seldom exceed eighty or one hundred feet above their immediate base."[5] This broken country, if we may judge from what is true of the rough country along the same river to the north of this, it not due so much to the drainage erosion of the river as to the original deposition of the drift. The same features are said to continue into Kendall county, next south, which brings us to the vicinity of the ancient outlet of Lake Michigan, where, of course, the moraine is locally swept away. Still farther south, in Livingston county, Mr. H. C. Freeman mentions a ridge running southeast-

[1] On Western Boulder Drift, Am. Jour. Sci., Sept., 1869, p. 176.
[2] Geol. Sur. of Ill., Vol. IV, p. 130.
[3] Loc. cit., p. 131.
[4] Geol. Surv. of Ill., Part IV, p. 113.
[5] Geol. Surv. of Ill., Part IV, p. 112.

erly from a point in La Salle county, to near Chatsworth, a distance of about forty miles. "This is gravelly and sandy, giving it a distinctive character as compared with the adjacent prairie."[1] This is quite too meager to base an identification upon, but I have thought it worthy of quotation here. At Odell, which lies near this ridge, the drift is said to be 350 feet deep.[2]

On the railroad line from Chicago to Kankakee, there is no recognizable indication of the formation under consideration. Southwestward from Kankakee, on the line to La Fayette, Ind., there are a few mounds and ridges that bear a somewhat morainic aspect, but they are isolated in a generally level tract of lacustrine, rather than glacial, topography. They are, perhaps, remnants of a formation that has been largely eroded or buried. Near Fowler, in Benton county, Indiana, there is a belt of low mounds and ridges, accompanied by shallow depressions, that quite closely resemble the Kettle range in its more modified phases. Boulders appear upon the surface, and, in the more immediate vicinity of the village, are large and numerous. This is probably a portion of the "stream of boulders two miles wide," which Mr. F. H. Bradley mentions as extending through the eastern part of Iroquois county, Illinois, and the central part of Benton county, Indiana,[3] and which he attributes to floating ice. He does not, however, mention the associated topography or underlying drift formation. South of this low range, the country again becomes level, or gently undulating, as far as the Wabash."

The Indiana geologists have not yet critically examined the heavy drift region in the northern part of the state, through which the moraine might be supposed to pass, but in such preliminary inspection as has been made, they have not recognized any prominent moraine-like accumulation. The superficial expression of the region is quite monotonous, and presents to view deposits of sand, gravel, lacustrine or pebble clays, but more rarely the coarse boulder clay or mixed material, that I regard as the unmodified ground moraine. The modifying agencies which produced this phase of the deposits, would be antagonistic to

[1] Geol. Surv. of Ill., Vol. IV, p. 227. [2] Geol. Surv. of Ill., Vol. VI, p. 237.
[3] Geol. Surv of Ill., Vol. VI, p. 236.

ridge-like morainic accumulations, and their presence, in sharp outline, is not to be expected. In the vicinity of Ligonier, in Noble county, there is a feeble, but somewhat characteristic development of some of the features of the formation. So also, in the vicinity of Rome and La Grange to the northeast. Between La Port and Otis there is a kindred, though somewhat peculiar formation, but I am in doubt as to its true character.

On entering Michigan, we find the formation more unequivocally developed. Just north of Sturgis, which is near the southern line of the state, the formation appears in marked development. It does not attain a great altitude, but presents the peculiar strongly undulating and hummocky contour, and the coarse, mingled material, characteristic of the deposit. It may be seen to advantage on the line of the Grand Rapids & Indiana R. R. To the northeast in the vicinity of Albion, it may be seen from Springport on the north, to Condit on the south. It is here broad and flat, and superficially composed of gravel, for the greater part, but some of the deeper excavations reveal the characteristic coarser material. On the Michigan Central R. R., the formation may be observed between Jackson and Dexter, the most prominent portion being between the stations Francisco and Chelsea. It is not very prominent on the immediate line of the road, which was doubtless selected to avoid it, but in the vicinity it rises into prominent hills and ridges. Some of these, on the north, are conspicuous objects at considerable distances. Still farther to the northeast, my friend, Dr. D. F. Boughton, whose identifications I have elsewhere verified, informs me that the range is well developed in Oakland county, and is finely exhibited near the line of the Flint & Pere Marquette R. R., between Plymouth and Holly. Still farther to the northeast, it may be seen at great convenience and advantage, along the Detroit & Milwaukee R. R. from Birmingham, below Pontiac, to Holly. On the flanks, its features are subdued, the hills and ridges being rather low, with more or less level surface between them, and the superficial sands and gravels are prevalent; but from Waterford to beyond Clarkston, the range has a fine, though irregular development. The hills rise with characteristic contours, to an estimated altitude of 200 feet or more above the surface of the beautiful lakelets embosomed at their base. The deep cuts near the latter station, amply exhibit the coarse, commingled material, characteristic of the core of the range.

Putting the foregoing observations together, they seem to establish beyond reasonable doubt the existence of a broad, massive belt stretching northeastward on the highland between the Saginaw and Erie basins.

If we return again to the southwestern part of the state, we are informed by Dr. Boughton that we shall find a similar accumulation at, and in the vicinity of, Kalamazoo. To the north-northeast, in Barry county, the Thorn Apple river cuts across this range between Sheridan and Middleville. This belt here, though broad, presents a more prominent and ridge-like aspect, with better defined limits than elsewhere observed in Michigan. To the north of this, opposite Saginaw bay, there occurs, near Farwell, broken, rough country and abundant coarse drift, that probably belongs to the belt in question, but my opportunity for observation was unsatisfactory. Beyond this point, I have no definite information, but I deem it highly probable that the moraine will be found extending some distance farther, on the highlands of the Peninsula.

The lake survey charts show that Grand Traverse bay has the remarkable depth of over 600 feet. This great depth, together with its linear character, and the form and arrangement of the associated inlets and lakes, has suggested that it may have been the channel of a separate minor glacier, analogous to that of Green Bay on the opposite side of the great lake, but I have no direct evidence that such was the fact.

In the reports of the geological survey of Ohio, a formation of nearly, or quite, identical characteristics is carefully described by the several writers whose districts embraced it. In the second volume,[1] Dr. Newberry gives, under the name of "Kames," an excellent summary of its leading features. These harmonize very nearly with those of the Kettle belt. The main points of differ-

[1] Pages 41–47. See also "Surface Geology of Northwestern Ohio," Proc. Am. Assoc. Ad. Sci., 1872, by Prof. N. H. Winchell, under heads of St. Johns and Wabash Ridges.

ence are the less conspicuous character and massiveness of the Ohio range, and the greater prevalence of assorted and stratified material; in other words, its features are the same that the Kettle range presents in its more subdued aspects, especially where it is formed in a comparatively smooth country, and is flanked by pebble clays, with level surface, instead of coarse boulder clay, with ridged, or mammillary, contour. I cannot turn aside, here, to define, with sufficient circumspection, the distinction between these clays, further than to indicate my belief that the former are sub-aqueous, and the latter sub-ærial, or, if you please, sub-glacial, deposits.[1]

Where I have seen the Ohio formation, it presents almost precisely the characteristics that are exhibited by the Kettle range in northern Illinois, where it is similarly related to plane topography and pebble clays, and it is also very similar to the same formation opposite Green Bay, where it is bordered on both sides by red lacustrine clays of later date. Dr. Newberry quite clearly recognizes the parallelism, but perhaps not the identity, of the formations.[2] Col. C. Whittlesey, in his article on the "Fresh Water Glacial Drift of the Northwestern States,"[3] classes the formations together as identical in character, though he does not seem to have considered them members of a continuous formation, and could not well do so with the prevalent view, which he somewhat emphasizes, that it is peculiarly a *summit* formation. It very often does occupy the summit of a rock terrane, and it sometimes *forms* a watershed by its own massiveness, but it likewise occupies slopes and crosses valleys, as shown in detail in the Wisconsin report. Prof. Andrews of the Ohio survey, in a personal communication, adds his conviction that the Ohio and Wisconsin deposits are parallel formations. It would seem, then, that the only question relates to the *continuity* of the belts. Unfortunately there intervenes the Wabash valley, the ancient drainage channel

[1] I have mapped these formations separately in Eastern Wisconsin. See Atlas accompanying Vol. II, Geol. of Wis., 1877, [Plate III, Map of Quaternary formations. See, also, p. 225 of the volume.

[2] Geol. Surv. of Ohio, Vol. II, pp. 4. 5, and 43. Dr. Newberry's views as to the origin of the Ohio "Kame" belt are at variance with those here presented.

[3] Smithsonian Contributions, 1866.

of the Erie basin. Absolute continuity undoubtedly does not exist. If my views are correct, this was the great — not exclusive — channel of discharge of the glacial floods, at the very time the moraine was being formed, where it could be formed, and, for that reason, the debris was swept away or leveled. In addition to this, the region has been subjected to the vicissitudes of erosion, of a reversal of drainage systems, and of lacustrine and fluviatile accumulation. It is to be presumed, therefore, that a portion of the range, where once formed, has been lost, leveled, or buried. Some remnant indications of the range, on the upper slopes, might, however, rationally be presumed to exist. But, awaiting a critical examination of the region, we must confess a want of direct evidence. The belt stretches entirely across Ohio and enters Indiana, but has not been traced farther.

In the line of indirect testimony, however, some facts may be noticed. Prof. N. H. Winchell describes in the Ohio reports[1] six ridges running parallel to Lake Erie, and Mr. G. K. Gilbert has described that portion of these which lie in the more immediate Maumee valley.[2] Two of the inner ones are conceded to be lake beaches. The two outer ones are members of the "Kame," or Kettle belt, according to Dr. Newberry.[3] The one next within, the St. Mary's ridge, Prof. Newberry distinguishes, apparently, with justness, from both the other classes. Mr. Gilbert gives a clear and discriminating description of this, and expresses the conviction that it is "the superficial representation of a terminal glacial moraine, that rests directly on the rock bed and is covered by a heavy sheet of Erie clay, a subsequent aqueous and iceberg deposit."[4] The views of Professors Newberry and Winchell, while they each differ somewhat, agree with this in the only point essential to the present discussion, viz.: *that this ridge represents the margin of the glacier at the time it was formed.* This shows the glacier to havebeen a tongue or lobe of ice, differentiated from the supposed continental glacier, and having its axis coincident with the Maumee valley, and, withal, capable of forming a morainic accumulation on both sides. The St. Mary's ridge crosses the

[1] See also Proc. Am. Assoc. Ad. Sci., 1872.
[2] Geol. Surv. Ohio, Vol. I, pp. 537 *et seq.*
[3] Geol. Sur. Ohio, Vol. II, pp. 56 and 57.
[4] Loc. cit.

Maumee - Wabash valley — the glacial trough — and, recurving upon itself, bears away to the northeast, approximately parallel to the Kettle belt already described in southeastern Michigan. This wing of the St. Mary's ridge bears the same relation to the Kettle belt bordering the Erie basin on the Michigan side, that the opposite wing does to the "Kame" belt on the south side. The force of this relationship is not easily escaped.

If my views are correct, that this Michigan belt was formed along the right hand margin of the Erie glacier (conjointly with the Saginaw glacier), just as the "Kame" belt was formed on the left hand margin, then its composition should give evidence of the fact. In the case of the Green Bay glacier, I have shown that the lines of striation and transportation diverge from the main axis toward the margin,[1] and, so far as the paths of other glaciers lie within Wisconsin, the observations made upon them, imply the same method of movement, and this habit finds partial exemplification among the glaciers of the Alps — partial, because their contracted valleys and steep slopes afford little opportunity to deploy in this fashion. If this manner of movement holds true with the Erie glacier, material from its trough will be found to have been transported westward and northwestward toward the moraine. Thirteen years ago, in an article in the American Journal of Science, entitled, "Some Indications of a Northward Transportation of Drift Material in the Lower Peninsular of Michigan,"[2] Professor Alexander Winchell called attention, with much detail and precision, to a large mass of evidence, which finds, for the first time, so far as I am aware, satisfactory explanation in the view now presented, and, in return, has the force of confirmatory evidence. It appears that immense, and often but slightly eroded masses of Corniferous limestone, have been borne in the direction indicated, and scattered over the areas of the Hamilton group, the Marshall sandstone, and the Subcarboniferous limestone; that similar blocks of Hamilton rock have been deposited over the two last named formations and even beyond; that the Marshall sandstone has likewise been borne on to the Carboniferous limestone, and that this transportation has

[1] Geol. of Wis., Vol. II, pp. 199 *et seq.* [2] Am. Jour. of Sci., Vol. XL, Nov., 1865.

been from lower to higher levels, as the strata now lie, and are presumed to have lain, since the basin is one of excavation and not of flexure. These phenomena, in all their details, are precisely what we should expect from the action of a glacier advancing through the Erie valley, and moving in a manner analogous to that of the Green Bay glacier. That a glacier moved through this valley has been abundantly shown by the Ohio geologists. The only labor of this article is to show that it was an individualized stream, forming the Ohio "Kame" belt on one side, and the Michigan on the other, simultaneously, and that they are collateral members of a common moraine.

Eastward from Ohio, there has been, so far as I am aware, no definite attempt to trace out the extent of the belt. In western New York, Prof. Hall mentions, as one of the three general aspects of the superficial deposits, a surface "broken into irregular hills or ridges, with deep bowl-shaped depressions, or long valleys, which often communicate in more extensive ones, or are enclosed on all sides by drift,"[1] but he does not definitely locate the formation, or indicate whether it assumes the form of a belt, or otherwise. In central New York, Prof. Vanuxem says: "There is another class of deposits, well defined as to position, but irregular as to composition, which are worthy of note. They occur in the north and south valleys, which are on the south of the Mohawk river, or the great level." "The whole of these deposits have a common character. They are in short hills, quite high for their base and are usually in considerable numbers." "They consist of gravel, of stones also of greater size, sand and earth."[2] These, he says, greatly resemble the "deluvial elevations" noticed in the survey of Massachusetts,[3] the description of which is perfectly applicable to the formation under consideration. Furthermore, Prof. F. H. King, of the Wisconsin survey, has examined the same deposits in the vicinity of Ithaca, and recognizes their identity in kind. Neither of these observers, however, discern a definite belt, although Prof. Vanuxem destroys the force of his apparent limitation of the formation to the valleys, by stat-

[1] Nat. Hist. Surv. 4th Dist., Geol., Pt. IV, pp. 320, 321.

[2] Nat. Hist. Surv. N. Y., 3d Dist., p. 218. [3] Geol. of Mass., E. Hitchcock, 1833, p. 144.

ing that there are numerous points where it has formed over the hill sides, and by associating in mention with it accumulations on the "heights, apparently in no regular order."[1] As these are deep, canon-like valleys, they would probably modify in some degree, the comparatively thin margin of the glacier, giving it a somewhat digitate outline, and the greatest accumulations would take place near the extremities of the tongues, in the valleys, so far as drainage permitted; while the connecting chains would form retreating lines, and be less conspicuous, and might, therefore, escape observation not definitely turned to the subject. This, at least, is suggested by some observations of my own in similar situations. Such valley accumulations, however, do occur at the extremities of linear glacial lakes that are unconnected with a definite belt, as in the case of Green Lake, Wisconsin.[2]

On the line of the Erie R. R., along the small tributary of the Delaware river that is followed up, westward, from Deposit, I have observed winding Osar-like ridges, parallel to the valley, and Kame-like hills upon the slope, up to the watershed of the Delaware and Susquehanna; likewise in the valley of the latter, at and near the village of Susquehanna, but I have no knowledge of their intimate structure, extent, or relations.

In the southeastern district of New York, Prof. Mather recognizes the distinctive aspect of this class of accumulations.[3] He cites several instances of its occurrence on the east side of the Hudson, leaving the impression that they are local features. But on Long Island, it forms "an elevated ridge, called by some, 'Green Mountains,' and by others, the 'Backbone' of the island."[4] This he describes in detail and maps, showing that it branches at the east, one chain extending along the southern peninsula to Montauk Point, and the other, along the northern to its extremity, and, theoretically, to the islands beyond.

Professors Cook and Smock have recently examined this, and have shown its connection with a similar moraine, that stretches across the northern part of New Jersey, from Perth Amboy to

[1] Loc. cit., p. 219.

[2] Geol. of Wis., 1877, Vol. II, p. 138.

[3] Nat. Hist. Surv. N. Y., 1st Dist., Pt. IV, p. 212.

[4] Loc. cit., p. 161.

the Delaware river, below Belvidere.[1] The descriptions of this range tally quite perfectly with that of the Kettle moraine. This range, however, lies on the margin of the area of northern drift, while the western one is medial in position, and at some points is quite distant from the margin. It will be observed, nevertheless, that this distance is greatest, in general, at the west, and that in Ohio it becomes very greatly reduced, so that the fact of coincidence on the Atlantic coast, presents no reason for supposing the ranges to be distinct. But, whether distinct or not, is a matter to be settled by observation, and it is to be hoped that it will not long remain undecided for want of it. The extension of the New Jersey moraine westward has not, so far as I can learn, yet been traced, but the survey of Pennsylvania, in progress, will, doubtless, soon leave nothing to be desired, so far as that State is involved.

To the eastward, Mr. Warren Upham has recently been engaged in studying its probable continuation in southeastern Massachusetts. In a personal communication he writes: "A very clear line of terminal moraine extends along the chain of the Elizabeth islands southeast of Buzzard's Bay; thence it bends to the northeast and north as far as to North Sandwich, when *it turns at a right angle* to the east, and extends through Barnstable and other towns to Orleans, running along the east and west portion of Cape Cod, and terminating at its east shore." "This terminal moraine, like the 'Kettle moraine', is not at the outmost limit reached by the ice-sheet; for hills, in series nearly parallel to the moraine already described, and similarly composed of glacial drift with many boulders, occur on Martha's Vineyard and Nantucket islands, corresponding, perhaps, to the terminal moraine which forms the 'backbone' of Long Island. * * The moraine of the Elizabeth islands and Cape Cod has a length of about 65 miles." It may be suggested that the range along the Elizabeth islands may correspond to the northern branch of the Long Island moraine described by Prof. Mather, and that, as Mr. Upham suggests, that of Martha's Vineyard and Nantucket corresponds to the southern.

[1] Ann. Rept. of State Geologist, N. J., 1877, pp. 9 *et seq.*

Dr. E. Hitchcock refers to these accumulations in his report on the geology of Massachusetts,[1] and classes with them "diluvial elevations and depressions," occurring at other points in that and adjoining States. It would appear, from the geological reports of the Eastern States that analogous, though not certainly identical formations, occur locally, more frequently than in the interior, and this, from the mountainous nature of the country, is not strange; but no continuous massive range seems to have been discerned, except the southern one already described.

In the interior, so far as yet ascertained, the drift limit is not marked by any such persistent ridge-like accumulation, but gradually dies away or is buried by later deposits, so that the precise limit of glacial advance is not easily determined. The only approach to an exception to this, known to me, is the case of the Kettle moraine in Central Wisconsin, where it lies near the border of the driftless area. Elsewhere around that area, the drift thins out very gradually, so as to render the mapping of its margin a work of close inspection; and, as the region presents no evidence of subsequent submersion, or any other special modifying agency, except the usual meteorological forces, this would seem to represent approximately the original form of deposit.

It is evident from the foregoing sketch that much observation remains to be made before the complete geography of this formation is determined. The conjectural lines on the map are only theoretical suggestions, preliminary to observation.

Summary.— It may be helpful at this point to summarize, and bring into close juxtaposition, in thought, the leading characteristics of this remarkable formation.

1. Its linear extent is very great, whatever its final limits may be found to be.

2. It has a width of from one to thirty miles.

3. Its average vertical thickness can only be very roughly estimated, but may, very prudently, be placed at 200 or 300 feet.

4. Its surface configuration is peculiarly irregular, and denotes an extraordinary origin.

[1] Geol. of Mass. 1833, pp. 144 *et seq.*

5. It is a complex range, the component ridges being often arranged in rude parallelism.

6. A distinction is usually to be observed between the superficial and lateral portions of the deposit on the one hand, and the central, underlying one on the other, the former being chiefly sand and gravel, the latter complex commingled debris.

7. The superficial sands and gravels are usually stratified in various attitudes, but the core of the range is mainly unstratified.

8. The irregularities of the range are most conspicuous where the superficial sands and gravels are least abundant.

9. The material was derived, in part, conspicuously so, from the vicinity of the range, and, in part, from the formations lying backward along the line of drift movement for at least 300 miles.

10. A portion of the material is spherically rounded, a part is scratched and polished, and some is little affected, though sometimes soft or friable, the latter being usually from adjacent formations.

11. The range is tortuous in its course, but sustains a remarkable and significant relationship to the great lake basins.

12. It undulates over the face of the country, varying at least 800 feet in its vertical oscillations.

13. It does not sustain any uniform relation to present, or what are presumed to have been, preglacial drainage systems in their details. In some portions, it occupies water-partings; in others, lies on slopes; and in still others, stretches across valleys.

14. It crosses, in its course, all the indurated formations, from the Laurentian to the Coal measures, but exhibits no specific relation to their strike or dip.

15. It sustains a definite and most important relationship to the lines of general drift movement.

16. The range is frequently flanked on its southern, or outer edge, by level areas of sand and gravel, of greater or less extent. These also occur between the component ridges of the belt, and on the inner flank, but less frequently.

17. The surface contour of the adjacent region within, or north of, the belt, usually, though not invariably, has a less perfect drainage system, and exhibits less noticeably the effects of superficial modification, than the outer side.

Origin.— Waiving, for the present, some further generalizations, it is thought that the foregoing phenomena present a *specific combination* which points unequivocally to a morainic origin. To the writer, familiar with the multitudinous details, that cannot here find a place, and having studied recent moraines with special reference to this formation, they have a force little less then demonstrative. The range is confidently regarded as a moraine formed at the margin of a group of glaciers — which may be regarded as a single lobate one — and marking a definite stage of their history. A more vivid and graphic view of the outline and movements of these glaciers, than can be given in words, may be obtained from the accompanying map, from which it will appear that through each of the great lake troughs there poured an ice stream, attended by minor currents through the lesser channels.

Its Medial Position.— It has already been remarked that, in the interior, this moraine does not mark the extreme limit of glacial advance. Numerous striations, and other evidences of glaciation, occur on the south side of it. A line has been drawn on the map intended to indicate the approximate limit of northern drift, based on several authorities.[1] How nearly this shows the limit of actual glacial progress, in distinction from other means of transportation, is not, I think, as yet definitely ascertained, but the general fact of progress, to a considerable distance beyond the Kettle moraine, is sufficiently established. The moraine was, therefore, formed *after the retreat of the glacier had commenced, and marks a certain stage of its subsequent history.*

Glacial Movements before the Formation of the Moraine.—It becomes an interesting question to ascertain whether the glacial movements were the same before the formation of the moraine, as afterwards. Fortunately, in southern Wisconsin, we have very definite and specific evidence bearing on this question. In the towns of Portland and Waterloo, which lie within the area of the Green Bay glacier, and from twenty-five to thirty miles distant from the moraine, there are several domes of quartzite that rise through the horizontal sandstones and limestones, which occupy the surrounding region. These domes are glacially abraded and grooved in a direction S. 30° W., and trains of quartzite boulders

[1] Tesley, Newberry, Cox, and assistants, Worthen, Swallow, and Mudge.

stretch away in that direction to the moraine, and, mingling with it, pass onward to an equal distance beyond. At the same time there is abundant evidence from the material of the drift, from the surface contour and from striation, recently observed by Mr. I. M. Buell, that the westerly movement of the Lake Michigan glacier, near the Illinois line, extended to the west side of Rock River, and that the line of junction of the two glaciers was on the west side of that stream. It appears then, that in this region, the movements were in the same general direction before and after the formation of the moraine, but that there were changes in the details, and that the relative size and position of the glaciers were somewhat different, the Green Bay glacier being relatively smaller in the earlier epoch. Testimony of similar general import, but less specific, may be gleamed from the reports of the other states involved.

Method of Formation.— If, then, the glacial movements were the same, in general, before and after the formation of the moraine, and yet the minor movements and relative size of the glaciers somewhat different, how was the moraine formed? A halt in the retreat of the glaciers, by which their confluent margin should remain stationary for a period, would doubtless cause an unusual accumulation of debris, but this would fail to account for the varying width or irregularities of the moraine. The structure of the range seems to indicate an alternating retreat and advance of the ice mass. During the former, debris was thrust out at the foot of the melting mass, which, when the glacier advanced, was plowed up into immense ridges. If this process be repeated several times paralled ranges will be accounted for, and the irregularities incident to such advance and retreat will explain the complexity of the range. Where the later advances were equal to the earlier ones, the accumulation of drift material would be forced into a single massive ridge. Where any advance failed to equal a former one, an interval between the accumulations of the two would result, giving rise to a depression whose form would depend upon the relations of the two accumulations, but would in general be more or less trough-like in character. Where tongues of ice were thrust into the accumulated material an irregular or broken outline would be the result. If masses of the ice became incorporated in the drift, as has been suggested, their melting would give rise to depressions, constituting one form of the kettles that characterize the range. The suggestion just made, with reference to the irregular advance of the ice mass, accounts for other forms, and, at the same time, for the irregular hills, mounds, and hillocks. Certain of the kettles may be due to underdrainage, through the action of strong underground streams that occasionally flow, as full brooklets, from its base. The drainage of the glacier, while it was advancing and pushing the debris before it, was probably quite general and promiscuous *over* the moraine, and this would give rise to the stratified sands or gravels, and other evidences of the action of water, among which may perhaps, be reckoned some of the minor mounds, ridges and depressions. The changing attitudes, which the debris would be likely to assume, as it was forced along, would, perhaps, give peculiar force to torrential effects.

The gaps in the range, attended by plains, or long streams of gravel and sand, appear to represent the more considerable points of discharge of the glacial floods. When the surface about the margin of the glacier permitted the accumulation of water, the moraine would doubtless be much modified by it and present a subdued aspect.

The Alpine moraines, above referred to, are regarded as miniature exemplifications of the process by which the Kettle moraine was formed.

But, in addition to the structure of the range, the change in the relative position of the Green Bay and Lake Michigan glaciers, already alluded to, affords evidence of an exceedingly interesting character, which has a significance much beyond what can be here indicated. It appears that the junction between the Green Bay and Lake Michigan glaciers at the last observable stage, preceding the formation of the Kettle moraine, was about twenty-five miles farther west, than at the time of the latter's formation, or, in other words, there is an abrupt easterly shift of the line of junction. It appears, also, that the width of the ante-morainic Green Bay glacier, measured just south of the Kettle moraine, was only half that of the post-morainic glacier, north of it, measured at a distance just far enough to escape the terminal curvature. An inspection of the outline of the Green Bay glacier shows that this eastward shift of the junction of the two glaciers was not due simply to encroachment on the Lake Michigan stream, nor to a common movement of both in that direction, for the opposite margin of the Green Bay glacier lay close upon the borders of the driftless region, demonstrating that there was no eastward swaying on that side. Indeed, the indenture of the outline of the driftless area strongly suggests actual encroachment on that side also, and this view is not without independent support.

In harmony with these phenomena are the fiords of the Green Bay peninsula, which indicate that the Green Bay ice stream overflowed into the basin of Lake Michigan. These facts, taken altogether, seem to warrant the belief that both glaciers retreated sufficiently far to the northward, and within their respective basins, to allow time and opportunity for the change in the relative size and position of the two ice streams, and that, under slightly changed conditions that favored the Green Bay glacier, they advanced to the position of the Kettle moraine, and, after a series of oscillations, retreated permanently. This view seems also to be demanded by certain details in the distribution of the drift material that are otherwise enigmatical, but whose discussion would too much extend this article.

Significance.—As forty-five years have passed since Dr. Hitchcock called attention to some of the phenomena under consideration, or, at least, to some distinctly related to it, and yet, the matter has received so little consideration, that our present knowledge is limited to such a degree, that I lay myself liable to the charge of undue temerity in attempting to correlate the observations, I may be pardoned in attempting to indicate, briefly, something of the significance and importance the foregoing conclusions, if sustained, have in relation to the Quaternary history of the region involved. The moraine constitutes *a definite historical datum line*, in the midst of the glacial epoch, and becomes a basis of reference and correlation for adjacent formations. It is an historical rampart, outlining the great dynamic agency of the period, at an important stage of its activity, and separating the formations on either hand by a chronological barrier. It is manifest that the true Boulder Clay, or ground moraine, south of the belt, must have been formed earlier than that north of it, and that the two portions are not at all synchronous. In sedimentary formations synchronism is found in horizontal strata, but in glacial deposits it is to be sought in linear belts, concentric with the margin of the glacier. This fact finds illustration, and emphasis, in the demarcation introduced by this singular corrugation of the wide-spread glacial sheet. It is difficult to limit the value of such a determinate line, in the midst of the complex drift formations, if fully established, and should similar belts be found to mark other stages of glaciation, there would be opened a definite line of investigation that promises much assistance in unraveling the gnarled skein of Quaternary history.

While it does not follow, necessarily, that all formations overlaying the true glacial clay, south of the Kettle moraine, are older than those occupying similar relations to the newer Till, north of it, it is clear, that similarity of stratigraphical sequence is not, by any means, sufficient ground for assuming chronological equivalence. It is evident, that all endeavors at correlation between the superficial deposits, on the opposite sides of the moraine, should be attempted with much circumspection.

These suggestions have especial application to the discussion of the vegetal deposits, so frequently found in the later Quaternary formations. By many writers, the various deposits of this kind, in the Mississippi basin, have been, very naturally, in the present state of our knowledge, grouped together without reference to the necessary discriminations above indicated, and, as a result, beds of diverse age are referred to a common stratum. A general discussion of these deposits is not sufficiently germane to our subject to be fittingly introduced here, but it is appropriate to point out the fact that some of the vegetal strata sustain such a relation to the Kettle moraine, that they must be widely separated from others, in the date of their accumulation and burial. Some of these organic strata lie at the immediate foot of the moraine, beneath fluviatile and lacustrine deposits that, I am confident, began to be accumulated during the accumulation of the moraine, and through the agency of glacial floods; while it is even more certain, that other vegetal deposits accumulated much subsequently, as those found in the red clays of Wisconsin, which are lacustrine deposits of the great lakes formed after the recession of the glacier. It would be too much to assume that all plant remains, found south of the moraine, antedate its formation, but it is safe to affirm that, with only phenomenal exceptions, e. g., such as escaped glacial abrasion, all north of it are more recent.

The bearing of these definite determinations of the glacial outlines and movements upon the question of the origin of the remarkable driftless area of Wisconsin, Minnesota, Iowa and Illinois (see map) was early perceived, and it was clearly foreseen that this line of investigation promised a *demonstrative* solution of the problem. The driftless area manifestly owes its origin to the divergence of the glaciers through the Lake Superior channel, on the one hand, and that of Green Bay and Lake Michigan, on the other, and to the obstacle presented by the highlands of northern Wisconsin and Michigan. This obstacle the glacier surmounted, and passed some distance down the southern slope, but apparently not in sufficient thickness to overcome the melting and wasting to which it was subjected, and so it terminated midway the slope. But the deep, massive ice currents of the great channels pushed far on to the south, converging toward each other; and, if they did not actually unite, at least commingled their debris south of the driftless area.[1] An instance closely similar to this, considered from a dynamical point of view, may be seen, at the present termination of the Viesch glacier, and illustrations of the general principles involved in the explanation may be seen in connection with several other Alpine glaciers.

If the evidence adduced to show that the Kettle moraine was due to an advance of the glaciers be trustworthy, then, to the extent of that advance, whether much or little, the moraine marks a secondary period of glaciation, with an interval of deglaciation

[1] Compare N. H. Winchell in An. Rep., Geol. of Minn., 1876, and R. D. Irving, Geol. of Wis., Vol. II, 1877, whose views are closely analogous to the above and each to the other but are not strictly identical. See, also, J. D. Dana, Am. Jour. Sci., April, 1878.

between it and the epoch of extreme advance. Its great extent indicates that whatever agency caused the advance was very wide spread, if not continental in its influence. The moraine, therefore, may be worthy of study in its bearings upon the interesting question of glacial and interglacial periods.

It will also furnish definite data bearing upon the somewhat mooted question of the origin of the Great Lakes, as well as other questions involving both perglacial and postglacial topography.

DEPARTMENT

OF THE

MATHEMATICAL AND PHYSICAL SCIENCES.

ROTATION AS A FACTOR OF MOTION.

By Professor J. G. McMURPHY, Kenosha.

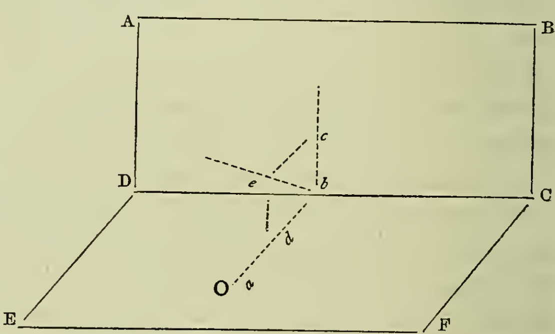
When an elastic ball is thrown against a plane surface it rebounds from that surface according to certain fixed laws. Its position at any moment will depend on certain conditions. The elasticity of the ball, the angle of projection, the rotation of the ball on its own axis, the velocity, will all of them affect the rebounding of the ball. Velocity and elasticity affect the distance to which it will rebound; the angle of projection and angular motion will affect the direction of rebounding.

A ball projected perpendicularly against a plane surface will rebound in the same line, making due allowance for the attraction of gravitation, which finally comes and controls its motion. The resistance of the air is no inconsiderable factor. (In point of fact, it is the latter only which is opposed to the force with which the ball rebounds, for gravity acts at right angles to this force and is not opposed to it.)

If the ball, without rotation, is projected against the plane surface at any angle, excepting ninety degrees, it will rebound so that the angle of reflection shall be equal to the angle of incidence; modified, of course, by gravitation and the resistance of the air.

Let us add another factor and examine the result. Given a horizontal plane surface in front of the vertical plane. Let the ball be placed upon it and propelled perpendicularly against the vertrical plane by a blow, which takes effect above its center of gravity. Such a blow will impart to the ball a rotary motion, together with an onward motion or translation. When the ball reaches the vertical plane its *rebounding force*, due to translation, will tend to make it retrace its path, while the force due to its rotation will tend to make it climb the vertical plane. It is actuated by the resultant of these two forces, and rebounds through the air, in the plane of those forces following the diagonal of the *rectangle* of forces.

The following diagram* may serve to make the explanation more apparent: Let A, B, C, D, be the vertical plane; C, D, E, F, the horizontal plane; Let a be the point from which the ball d is propelled on a-b; the ball having a forward rotary motion; b-d the distance the ball would rebound by virtue of its rectilinear motion; b-c the distance it would climb by virtue ot its angular motion. Then will it be found somewhere on the line b-e. Being a rectangle of forces, the resultant may be expressed by the formula $b\text{-}e = \sqrt{(b\text{-}c)^2 + (b\text{-}d)^2}$.

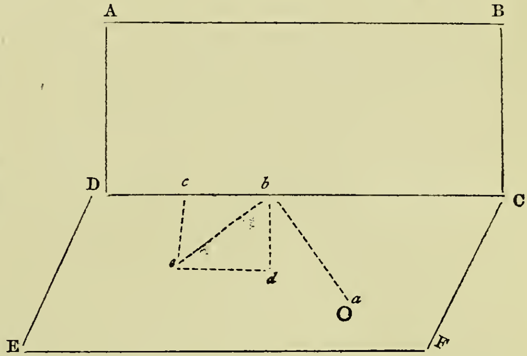


If the ball is propelled from a point to the right of its center of gravity, and constrained to keep the same perpendicular course, it will have a negative or left-hand rotation; when it strikes the vertical plane it will not return in the same path, but will be reflected to the right, so that the angle of reflection is not equal to the angle of incidence. But just as before, the path of the returning ball is the resultant of two forces acting at right angles to each other. If the angular velocity is very great, compared

*No cuts having been furnished by the author, the printer has been obliged to construct the accompanying figures, which are necessarily very imperfect.

with the velocity of translation the deflection from a perpendicular will be very great and vice versa.

When the ball is propelled against the vertical plane at any other angle than a right angle with a rotary motion besides, the problem becomes somewhat more complicated. Let the ball be propelled from *a* with a positive rotation. By its motion of translation it ought to rebound in the path which makes the angle of reflection, equal to the angle of incidence But by its rotation against the fixed point, *b*, it would tend toward *c*; hence it will take the direction *b-e*, and be measured by the diagonal parallelogram of forces, represented by *b-a* and *b-c*. Here it is plain that the angle of reflection is much less than the angle of incidence. If the rotation be a negative or left-hand rotation from the same point, *a*, following the same path, *a-b*, the resultant will be nearer a perpendicular — that is, the angle of reflection will be greater than the angle of incidence.



If a ball be thrown perpendicularly against a vertical plane surface with a positive rotation it will rebound to the left, if the rotation be negative it will rebound to the right, if the rotation be forward the ball will rise, if backward it will fall. If the ball be thrown obliquely to the left, with positive rotation, the angle of reflection will be less than that of incidence. If thrown obliquely to the right, with same rotation, the angle of reflection will be greater than that of incidence. The combinations are almost infinite, and afford a variety of valuable observations.

There are some very curious and interesting experiments in compound direct motion. If a ball lying upon a plane surface be struck by a mallet so as to produce translation with forward rotation on its horizontal transverse axis, and at the same time a rotation about a vertical axis, the ball will neither rotate upon the one nor the other, but upon a new axis intermediate between the vertical and horizontal axes, pointed out by the resultant of the parallelogram of angular forces. This is the principle illustrated by the Gyroscope. The ball will describe a curve upon the plane in the same way that a truck rolled upon the ground when the axes cease to be level, begins to curve its path; of course the two cases are quite different, because the curve made by a ball is much less marked than that made by a truck or wheel.

There is something of a similar nature seen when a ball is projected from a gun or cast from the hand. Since the middle of the sixteenth century, it has been known that the path of a projectile is a parabola, if no account is taken of the resistance of the air. *Templehoff* was the first to take into consideration this element in calculating for projectiles. The resistance of the air increases with the square of the velocity until the velocity exceeds 1,300 feet per second, when the resistance is much greater.

In experimenting with smooth-bored guns, it was found that rotation had much to do with the motion of the projectile from the muzzle. The only rotation which aided in aiming the gun, and in making calculations reliable, was the axial rotation, which was attained by grooving the interior of the barrel.

In the practice of gunnery with a smooth-bored gun there was allowed enough space around the ball for free and easy motion. It was called windage. This windage allowed the ball to ballot slightly from side to side as it passed through the barrel. At each point of balloting the ball received a rotary motion by being retarded on that side next the tangent barrel. The last touch imparted the final rotation, or that which continued through the space traversed by the ball. If the last ballot was upon the right side of the barrel the ball received a right hand rotation. It also received an impulse toward the left of the mark aimed at by the touch on the right side. But while the left side of the ball is moving forward at a much greater velocity than the center on account of the right hand rotation, the right side is moving much slower than the center on account of the same rotation. The left side, therefore, encounters a greater resistance than the right side. The air in front and to the left is compressed, and accumulated resistance finally throws the ball to the right. If the ball had balloted on the left side last, in leaving the muzzle, it would have been deflected to the right by touch and afterwards to the left by resistance and reaction of the compressed air. Thus it is possible with a smooth-bored gun to "shoot round" a nearer object in direct line and hit a more remote object behind it.

I wish to give but one more instance of the effect of rotation on direct motion. It is vulgarly called "curved ball." It may be witnessed in any good base-ball match. The pitcher desires to elude the strokes of the batter; after delivering a few balls in simple parabolic curves or with axial rotations, he will deliver the ball from the hand in such a way that when the ball leaves the hand the fingers touch it from below, causing the underside to be retarded while the upperside moves forward. Then the ball rotates upon a horizontal transverse axis, relative to its motion of translation. The greatest resistance from compressed air is in front and above the moving ball. The ball seeks a path of less resistance, preserving its plane of rotation and drops enough to form a depressed curve. By a skillful adjustment of rotation and translation, the pitcher is able to produce about such a curve as he wishes. To the batter the ball seems coming toward a point it is destined to fall short of. Again, by delivering the ball from the hand with the fingers touching above, a backward rotation is produced on the top of the ball and a forward motion to the under side. Such a ball continues its course until accumulated resistance of air from ahead and below throws it upward. So the batter sees the ball coming toward a point it is destined to pass clearly above. By skillful manipulation the right side of the deliverer the ball may be retarded, and the ball will curve to the right, and by retarding the left side it will curve to the left. The amount of curvature is variously estimated by different persons. With the rotation or twist of the best pitcher, it is no uncommon thing to make a ball curve a yard from its direct path, while many cannot effect any curve.

This purports to be only the outline of a subject worthy of much greater investigation, in its relation to great scientific problems.

Mr. President, members of the academy and others, my subject does not admit of a brilliant introduction nor of a grand peroration. It is the simple statement of the effect of rotation as an element of curvelinear and rectilinear motion.

REPORT ON RECENT PROGRESS IN THEORETICAL PHYSICS.

By J. E. DAVIES, A. M., M. D.,
Professor of Physics in the University of Wisconsin.

Part II.

THE MAGNETIC ROTATORY POLARIZATION OF LIGHT.

It is a well known fact that a ray of plane polarized light, vibrating in any azimuth, will, on passing through a lamina of quartz, have the azimuth of that vibration changed by an amount depending upon the thickness of the lamina, and the wave length of the particular kind of light employed. The direction, right or left, of this rotation of the plane of vibration depends upon the

---

Note to Previous Paper on "Vortex Motion."

For the production of large-sized vortex rings, the device shown in Fig. 1 is used by Prof. Tait. It is an ordinary wooden box, with a large circular hole cut out of one end, and the other covered tightly with elastic cloth. It can be filled with smoke from a couple of retorts, one containing Ammonia and the other Hydrochloric Acid. This will give copious clouds of chloride of Ammonium, which are driven out in vortex rings, on striking the elastic cloth. It has been objected that the rings thus produced do not behave as Helmholtz' mathematical results imply. It is not to be expected that they should; for Helmholtz' investigation upon vortex motion expressly assumes that the medium in which the rings are formed is a *frictionless* fluid, which air is not. The rings are truly air rings, the accompanying smoke merely serving to make them visible. This is finely shown by sending air rings from a second box against the smoke rings already formed. The invisible air rings are made manifest by the jostling of the smoke rings as they are struck by them. The suddenness of this movement is often very striking.

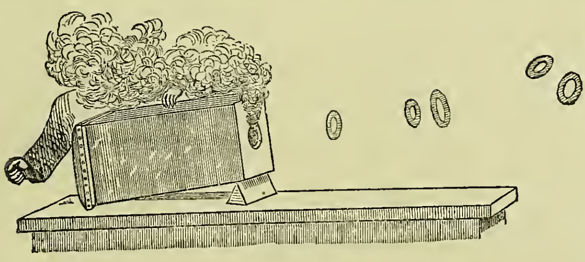


Fig.1

quartz employed, some being right-handed and some left-handed. Certain substances such as quinine, turpentine, tartaric acid, cane

---

Fig. 2, shows the direction of the motion at each point around and close to the core, or circular axis of a vortex ring. Fig. 3, shows the relation between the direction of motion of the entire ring and the direction of rotation around the core. It is seen to be in a direction "perpendicular to the plane of the ring, *towards* the side towards which the rotatory motion carries the *inner* parts of the ring." The *direction* of the motion of the fluid in which the vortex ring exists, at different distances from the *axis of the ring*, both within the ring and without it, corresponds to the *direction* of the lines of magnetic force around a circular conductor in which an electrical current is maintained, (like the ring of a tangent galvanometer, for example,) and the *velocities* of the fluid in various parts, will be in proportion to the *intensities* of the magnetic forces around this circular conductor, in various parts of the magnetic field, which is due to the electric current passing through the conductor.

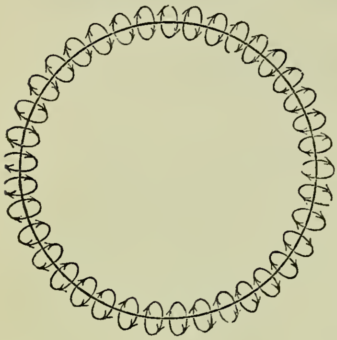


Fig. 2.

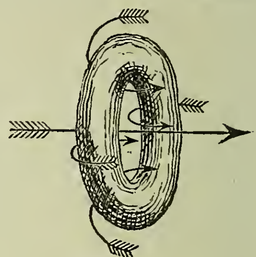


Fig. 3.

The directions of these lines of magnetic force, surrounding a circular conductor are shown in Fig. 4, taken from Prof. Clerk Maxwell's admirable treatise upon Electricity and Magnetism. The small circle represents a section of the circular conductor conveying the electric current, while the oval lines represent the lines of magnetic force surrounding it. Were the conductor merely a straight wire, the lines of magnetic force would be circles surrounding it.

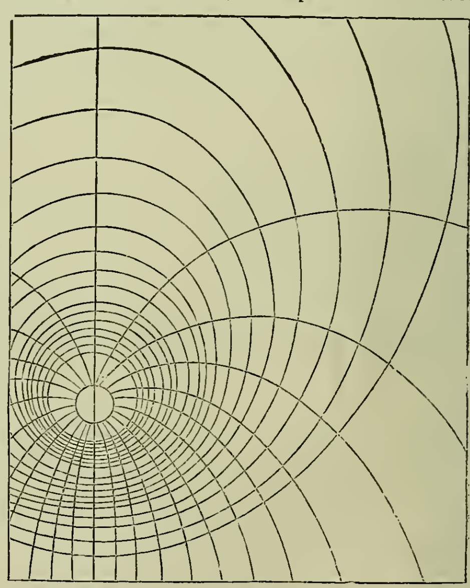


Fig. 4.

and other sugars, are also known to possess this property to a greater or less degree.

Here the conductor is supposed to be bent in a ring placed vertically, and the plane of the paper, a section through it. The section and lines of one side only are shown. These lines would therefore represent the directions of the lines of flow in the fluid surrounding a vortex ring of which the small circle is a section of the core. The intensity of the magnetic force at any point of one of these lines would also be proportional to the velocity of the fluid at a corresponding point around the vortex.

Perhaps Figs. 5 and 6 will help to a better under standing of the relations contemplated.

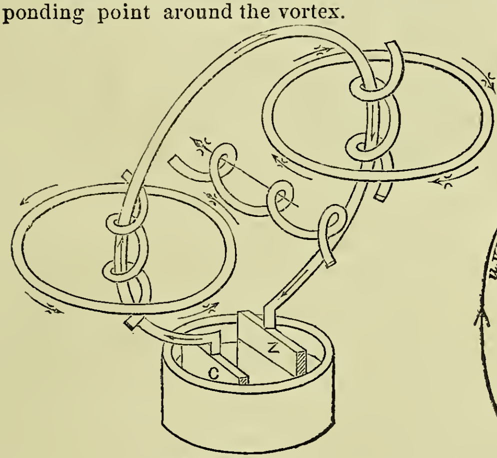


Fig. 5.

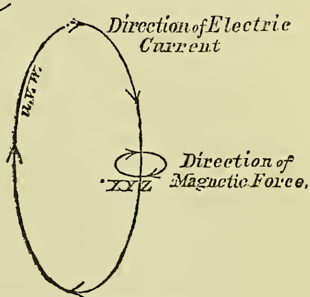


Fig. 6

The behaviour of two vortex rings gyrating in the same or in opposite directions, in a frictionless fluid, are shown for rings gyrating in the *same* direction by Nos. 1, 2, 3 and 4 of Fig. 7;

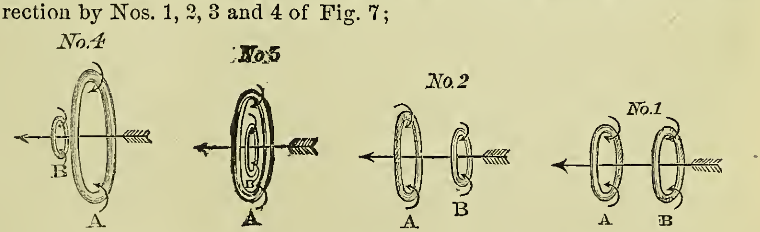


Fig. 7.

and for rings gyrating in *opposite* directions by Nos. 1, 2 and 3 of Fig. 8.

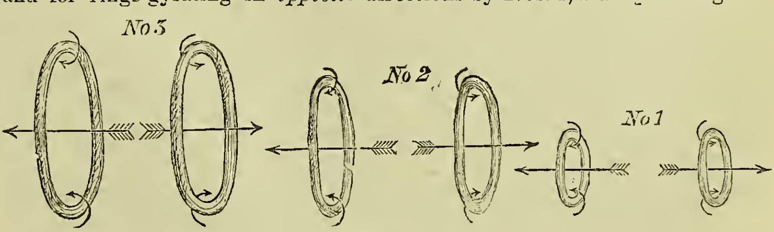


Fig. 8.

Faraday, in 1845, showed that this rotation of the azimuth of vibration could also be produced in substances not otherwise possessing it, by subjecting them to strong electro-magnetic influence, something after the manner shown in Fig. 9, where N is the polar-

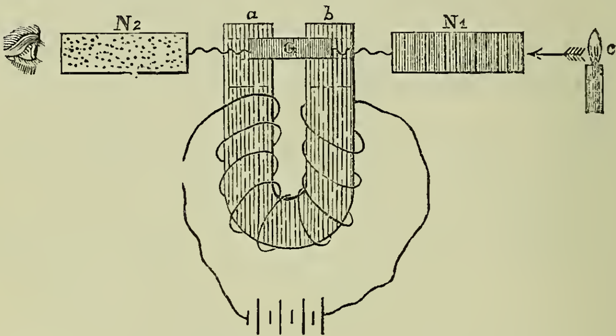


Fig. 9.

izer which reduces the vibrations to a definite azimuth; G is the substance subjected to electro-magnetic strain; *a* and *b* are the

"Where the rings have equal radii and equal and opposite angular velocities, they will approach each other and widen one another; so that finally when they are very near each other, their velocity of approach becomes continually smaller and smaller, and their rates of widening faster and faster. If they are perfectly symmetrical, the velocity of fluid elements midway between them, parallel to the axis, is zero, and here we might imagine a rigid plane to be inserted, which would not disturb the motion, and so obtain the case of a vortex ring which encounters a fixed obstacle. If the rings have the same direction of rotation, they travel in the same direction; the foremost widens and travels more slowly, the pursuer shrinks and travels faster, till finally, if their velocities are not too different, it overtakes the first and penetrates it. So the rings pass through each other alternately."

In Fig. 7, No. 1 represents the rings rotating in the same direction at starting; No. 2 shows the forward ring, *A*, slackening its speed and dilating; No. 3, the *B* ring contracting, accelerating its speed and passing through. Ring *B* then slackens its speed, and dilates in turn, while *A* contracts.

In Fig. 8, the gradual approach of the rings gyrating oppositely is not well shown. The long arrows are intended to show the direction in which the rings *would* move, in virtue of their respective rotations, *were they not influenced by each other.*

The motions of the fluids at various points surrounding a vortex filament in the shape of a ring, are best traced by means of Elliptic Integrals of the two poles of the electro-magnet, bored through for the reception of the substance and the passage of the light, and N_2 is the analyzer by which the position of the azimuth of the light reaching it is determined. When G is a determinate length of "heavy glass" (a silico-borate of lead), the analyzer requires a rotation of 6° on producing the electro-magnetism, in order to be placed in the same relation to the azimuth of vibration of the light reaching it, as it was in, before the circuit was closed. That is, if the position of the analyzer is such before the electro-magnetic circuit is closed, that the field is dark, on closing the circuit, and thus placing the glass in a strong field of magnetic force, the azimuth of the polarized light is so changed that a perceptible amount gets through, and the analyzer must be rotated 6° in order to again cut it off and render the field dark as before. This angle through which the light is turned, is, however, in addition to the length of the stratum of the medium through which it is compelled to pass, directly proportional to the strength of the current producing the magnetism (or rather to that resolved part of the magnetic force produced by the current, which is in the direction of the ray). The amount of the rotation also depends upon the refractive energy of the medium subjected to the magnetic strain. The relation is sometimes stated thus: "The angular rotation of the plane of polarization is numerically equal to the amount by which the magnetic potential increases from the point at which the ray enters the medium to that at which it leaves it, multiplied by a coëfficient, which, for diamagnetic media (like glass), is generally positive."—Maxwell.

---

first and second kind. An elementary discussion of the principal features of vortex motion, involving only the simplest Quarternion notions, is given in Prof. Clifford's recently published "Elements of Dynamics — Part I," page 191, *et seq.* Sir Wm. Thompson has also published an extensive paper in the Trans. of the Royal Soc., Edin. Vol. 8 for 1869, in which many new theories are established and many illustrations of vortex motions in fluids are given, by means of real or or ideal electro-magnets variously arranged. A summary of several of these theories and analogies will be found in Thompson's "Reprint of Papers on Electro-statics, and Magnetism."—London, 1872. An earlier paper, suggesting the idea of *vortex atoms*, was published in Vol. 34, p. 15, of the Phil. Mag., 1867. London, Dublin and Edinburgh.

Under the same circumstances, where "heavy glass" would produce a rotation of 6°, Bisulphide of Carbon would produce a rotation of 3°; flint glass, 2° 8′; rock salt, 2° 2′; water, 1°.

The behavior of a large number of substances under the simultaneous influence of magnetism and circularly polarized light of different colors was examined by Verdet in 1863. He found the results of his experiment to agree very well with the formula:

$$\theta = mc\gamma \frac{i^2}{\lambda^2}\left(i - \lambda \frac{di}{d\lambda}\right) \ldots\ldots\ldots (1.)$$

where θ is the angular rotation of the plane of polarization; m a constant (the coëfficient of *magnetic* rotation of the medium); γ the intensity of the magnetic force resolved in the direction of the ray; c the length of the ray within the medium; λ the wave length in air, of the particular kind of light employed; i its index of refraction in the medium.

For Creosote there was considerable deviation from the formula. On account of the mixed nature of Creosote, being an aggregate of Carbolic Acid and several other substances, this might have been expected, even if the above were the true formula representing the relation between the rotation, magnetic force, wave length, and refractive index.

Verdet has summed up his results as follows:

1st. "The magnetic rotations of the planes of polarization for light of different colors are approximately as the inverse square of the wave length of the light employed.

2nd. "The *exact* law is that the product of the rotation of the square of the wave length, increases from the least refrangible to the most refrangible end of the spectrum."

3rd. "The substances for which this increase is most sensible are also those which have the greatest dispersive power."

The formula (1) may be derived from the following more general formula

$$\theta = - c\gamma \frac{dq}{d\gamma} = \frac{4\pi C}{v\rho} c \sqrt{\frac{i^2}{\lambda^2}}\left(i - \lambda \frac{di}{d\lambda}\right) \frac{1}{1 - 2\pi C\gamma \frac{i^2}{v\rho\lambda}} \ldots (2.)$$

which Prof. Clerk Maxwell has shown to be a consequence of Sir Wm. Thompson's assumption that the only dynamical explanation possible for the magnetic rotation of the plane of polarized light is that, in magnetization there must be molecular electrical currents, and that the components of these currents can be dynamically compounded with the angular velocity acquired by an element of the medium, during the passage through it of a ray of circularly-polarized light.

On making in formula (2), $m = \frac{4\pi C}{v\rho}$, and neglecting $2\pi C\gamma \frac{i^2}{v\rho\lambda}$, because it is very small, being essentially the amount of the rotation of the plane of polarization after passing through a thickness of the medium only equal to half a wave length of the light employed, we have formula (1).

Before showing the manner in which formula (2) is derived by Maxwell, from Thompson's explanation of the magnetic rotation of the plane of polarized light, it may be best to recall one or two elementary propositions relating to polarized light, and also to circular motion. In the first place, *experiment* shows that two rays of light circularly polarized in opposite directions, and of the same intensity, become, when united, a plane polarized ray, the plane of polarization of which will depend upon whether the periods of the component circular vibrations are the same or not. If, from any cause, the phase of one of the circularly-polarized rays is accelerated, then the plane of polarization of the resultant ray, is turned round through an angle equal to half the angle of acceleration of the phase.

So also in certain cases, such as reflection from metallic surfaces, or total reflection in glass at certain angles, as in Fresnel's rhombs, or in the passage of light through thin laminæ of double refracting crystals, as in quarter-wave laminæ of mica, two plane vibrations may give rise to one circular one, right handed or left-handed, according as one or the other plane component is advanced in phase by a quarter of a complete oscillation.

This is only what might be expected from the well-known theorem in pure motion, that "two uniform circular vibrations of the same amplitude, having the same periodic time and in the same plane, but revolving in opposite directions, are equivalent, when compounded together, to a rectilinear vibration. The periodic time of this plane vibration is equal to that of the circular vibrations, its amplitude is double, and its direction is in the line joining the points at which two particles describing the circular vibrations, in opposite directions round the same circle, would meet."

The theorem may be illustrated as follows:

If, in any space like that represented in Fig. 10, we have a great number of *spins*, more or less completely filling the space enclosed by the larger circle, and about axes perpendicular to the plane of the paper, the resultant will be equivalent to a spin of definite magnitude about some single axis likewise perpendicular to the to the plane of the paper; the magnitude of this *resultant spin* being determined by the intensity, relative distances, and number, of the component spins which go to make it up. Regarding this resultant spin only, the velocity of a particle at any distance from the axis can be decomposed into component velocities, as in Fig. 11, where the uniform circular motion of F, from X to Y, can be decomposed into $\xi = r.\cos\theta$ and $\eta = r.\sin\theta$, in such a manner that the motion of D, to and fro on the line X, and the motion of E to and fro on on the line Y, correspond constantly in position to the motion of F around the circle. In such a case, we say that the *circular* harmonic motion of F is compounded of two *rectilinear* harmonic motions along X and Y, of equal periods and amplitude, but differing by

Fig. 10.

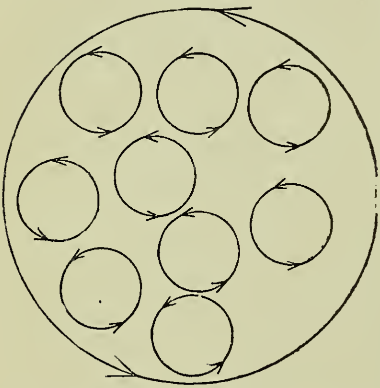
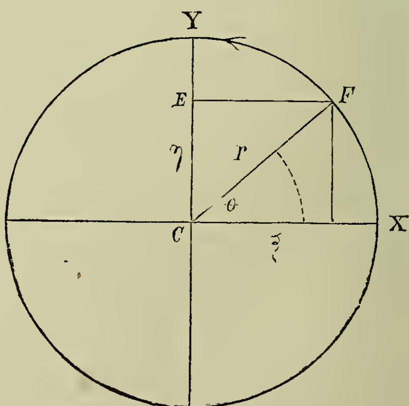


Fig. 11.



a quarter of a complete oscillation. If there be two equal and opposite tendencies operating upon F, one to carry it toward Y, and the other toward X, the result will be, that the tangential tendencies at F will neutralize each other, while the normal components will coincide and carry the particle towards *C* along *r* (Fig. 11), and a rectilinear motion will be the result, as in Fig. 12 or Fig. 13. Thus two tendencies to gyrate in opposite directions may result in mere rectilinear vibrations. If one of these tendencies be stronger than the other, so that of itself it would produce a more rapid rotation in *its* direction, than the other component in its, then the motion will be elliptical in an orbit of which the major axis changes at each complete oscillation by some angle θ, the magnitude of which will depend upon the excess of velocity in one direction over that in the opposite. This is easily seen by reference to Figs. 14 or 15, where the motion would be along *ab*, were both circular components equal, whereas the

Fig. 13.

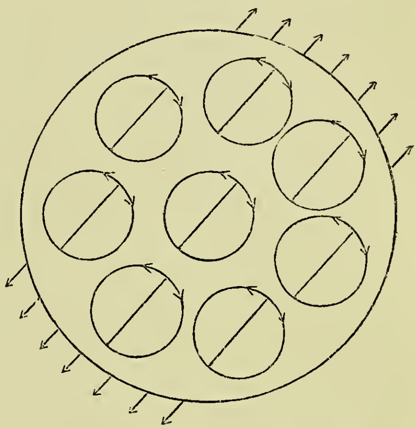


Fig. 12.

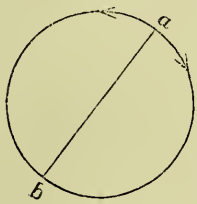


Fig. 15.[1]

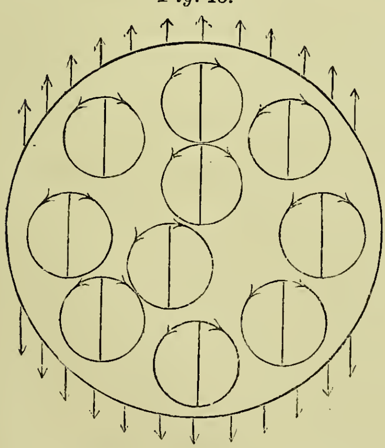
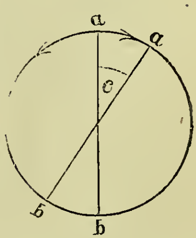


Fig. 14.[2]



[1] The engraver has very imperfectly copied the original drawings for this as for some of the other figures.

[2] For *c* in the figure, read θ, and for *a* and *b* at the extremities of one of the diameters, read *a'* and *b'*, respectively.

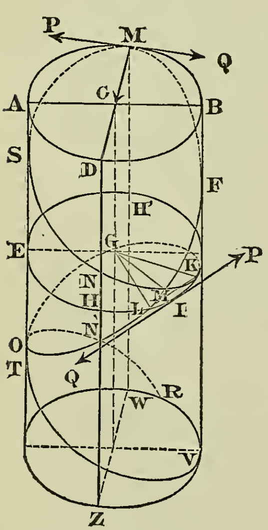
excess of that towards a' carries towards a' during the first part of the virtual motion along ab, and towards b' during the part from θ to b; that is, on account of the shorter time required to complete an oscillation in the direction from a' to b', around the circle, than in the opposite direction, there is an acceleration of phase in that direction. Hence, as long as the tendency to increased rapidity of one component over that of the other continues, so long will there be a change in the position of the line ab.

The application of these principles to the rotation of the plane of polarization as it occurs in quartz, will be clearly shown by the following extract and diagram, taken from Prest. Barnard's excellent "Lectures on the Undulatory Theory of Light," Smithsonian Annual Report for 1862.

After a general discussion of circular and elliptical polarization *by reflection*, Prest. Barnard says:

" We are now perhaps prepared to understand the reason of the rotation of the plane of polarization of a ray transmitted along the axis of a crystal of quartz. We have seen that Fresnel, by an ingenious combination of prisms, succeeded in demonstrating the existence within the crystal of two circularly polarized rays, gyrating in opposite directions. And we have seen that the resultant effect of two opposite gyrations, is to produce a movement in a plane. The gyratory movements within the crystal are then not *actual* but *virtual* — in other words, there are forces constantly tending to produce these gyrations, which hold each other *in equilibrio*, or at least nearly so. We must consider these forces as successively traversing all azimuths within the length of each undulation. If the wave were of the same length in both gyrations, the forces being presumed equal, the molecular movement would be constantly rectilinear, and the plane of polarization would not change. But, as the plane does in fact change, we are led to infer

Fig. 16.



that the undulation lengths for the two rays are *not* equal. The annexed figure may serve to illustrate the mutual action of these rays. Suppose M A D B, to be the orbit in which a force P tends to urge a molecule M, to revolve around the center C, to which it is drawn by the force M C. Suppose the equal force Q to urge the same molecule to describe the same orbit in the opposite direction. These forces holding each other *in equilibrio*, the molecule will follow the direction of the third force, M C.

Now suppose the force Q suspended, the molecule will take the direction of the circle A D B, and will continue to revolve in it so long as the force P (supposed always tangential) continues to act. But its movemehts will impart to the molecule next below it a similar motion, and that to the next, and so on; so that, as these successive molecules take up their movements later and later, there will be a series in different degrees of advancement in their several circles, forming a spiral; and when the molecule M shall have returned to its original position, the series will occupy a position like the curve M F L N′ O R. If, now, P be supposed to be in turn suspended, while the force Q continues to act, the effect of Q will be to produce a contrary spiral, which may be represented by M S K T V. If M D be a diameter of the circle M A D B, drawn from M, and D H N′ be a line parallel to the axis C G of the cylindrical surface, which is the locus of the spirals, then, if the undulating lengths are the same for both movements, the two spirals will intersect D H in the same point, the intersection marking the completions of a half undulation for each. But if these lengths be unequal, the intersection with D H will take place at different points as N and N′.

Let now a plane intersect the cylinder at any distance below M A D B, as at E, parallel to M A D B. It is conceivable that this plane may be made to pass through the point where the spirals intersect each other. If I mark the point of intersection, and we draw the tangents I P′ and I Q′ in the plane of the circle E H I, then there will be a molecule at the point I which will be in the circumstances of the molecule in [Fig. 12 at the point *a*] — that is to say, solicited by three forces, of which two, I P′ and I Q′ are equal and opposite, and the third is directed in the line I G towards the center. The molecule will, therefore move in this line, and not in a circle; and if the plane of the circle E H I H′ be the bounding surface of the crystal, or the surface of emergence of the light, I G will mark the azimuth of the molecular movements of the emergent ray.

But if the planes of E H I H′ do not pass through the point of intersection of the spirals it must cut each spiral in a different point. The figure is drawn to represent this more general case, the points of intersection with the spirals being severally L and K.

By joining L K and drawing the radius G I perpendicular to it, G I will bisect the angle G L K and M′, at the intersection of G I and L K will be the position of the molecule in the plane E H L I K, which, if the tangential force P only were acting, would be at L, and if the tangential force Q only were acting, would be at K. The tangential forces acting at the moment on this molecule will not be represented by I P′ and I Q′, but will be tangents at K and L.

Now, as D H, the distance between the planes A D B and E H I, is a larger part of the length of an entire turn of the spiral M S N K than of the spiral M F L N′, the line G I will fall on the right of G H, the position it would occupy if the two undulations were equal in length. We may therefore say, as before, that if the plane E H I were the surface of emergence of a ray from a crystal, in which it had been subject to the action of the forces supposed, its plane of polarization, G I, would be turned towards the right from its original azimuth. The plane of polarization turns, therefore, in the direction of the *winding* of the closest spiral, or of the ray of shortest undulation; but it turns in the direction of the *gyration* of the ray of longest undulation.

This rotation of the plane, thus demonstrates that the two rays advance with unequal velocities in the axis of quartz — a remarkable fact which is not true of any crystal which produces plane polarization only. It also enables us to determine the relative velocities, or to ascertain the *index* of rotatory polarization. For since G I bisects the angle between the points K and L, which mark the relative degrees of advancement of the two rays in their respective rotations, if we take a thickness θ, which produces a rotation of 90°, we know that the difference of phase is then one-half an undulation. If λ denote the length of the longer undulation, and λ', that of the shorter, then --

$$\theta = m\,\lambda = (m + \tfrac{1}{2})\,\lambda'\,; \text{ or } \frac{\lambda}{\lambda'} = \frac{m + \frac{1}{2}}{m} = \frac{2m+1}{2m}$$

As $\frac{\theta}{\lambda} = m$, and λ may be determined by experiments in refraction, the value of m is known when θ is measured. By pursuing this method, Mr. Babinet found the value of $\frac{\lambda'}{\lambda} = 1.00003$; a value which, small as it is, is the largest known for [non-magnetic] rotatory polarization."

The first mathematical explanation of rotatory polarization as it occurs in quartz, appears to have been given by MacCullagh, in 1836 (Trans. R. Irish Acad., XVII). He succeeded perfectly in explaining the phenomena as they occur in uniaxial crystals, by introducing into the ordinary equations of vibratory motion in fluids, terms of the form $c\,\frac{d^3\eta}{dz^3}$. So that the equations become:

$$\frac{d^2\xi}{dt^2} = b^2\,\frac{d^2\xi}{dz^2} + c\,\frac{d^3\eta}{dz^3}$$

$$\frac{d^2\eta}{dt^2} = b^2\,\frac{d^2\eta}{dz^2} - c\,\frac{d^3\xi}{dz^3}$$

Cauchy also appears to have furnished similar equations to M. Jamin, at the request of the latter, who compared them carefully with experiments, and found a perfect agreement so far as uniaxial crystals are concerned (Verdet–Lecons D'Optique Physique, Vol. II, p. 323). For biaxial crystals Verdet says: "*La methode de MacCullagh est tres-remarquable : c'est un bel exemple de ce qu' on peut faire quand on est réduit à de simples conjectures.*"

The matter has since been treated by M. Briot in an "*Essai sur la theorie mathematique de la lumiere.*" He supposes a forced distribution of the ether in rotatory crystals, so that the lines of ethereal molecules are arranged in elliptic helices. This supposition introduces into the differential equations of vibratory movement, differential coefficients of odd orders, the presence of which indicates the rotatory power.

Airy has suggested similar equations for the rotation produced by *magnetism*, "not as giving a *mechanical explanation* of the phenomena, but as showing that the phenomena may be explained by equations, which equations appear to be such as might possibly be deduced from some plausible mechanical assumption, although no such assumption has been made."

This explanation of what rotatory polarization is, as it occurs in bodies which of themselves rotate the plane of polarization, may help to an understanding of the manner in which an electric current, circulating around a medium through which circularly polarized light is passing, may possibly affect the velocity of either circular component of the polarized light, and thus, according as the direction of the current is *with* a circular component, as in Fig. 16, or *against* it, as in Fig. 17, produce a right-handed or a left-handed rotation, according to the direction in which the current circulates around the medium.

Fig. 16.

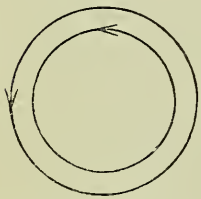
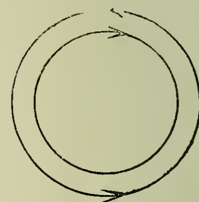


Fig. 17.



Of this latter, Sir Wm. Thompson, in 1856, made the important observation,[1] which Prof. Clerk Maxwell has elaborated into the

[1] "The magnetic influence on light, discovered by Faraday, depends on the direction of motion of moving particles. For instance, in a medium possessing it, particles in a straight line parallel to the lines of magnetic force, displaced to a helix round this line as axis, and then projected tangentially with such velocities as to describe circles, will have different velocities, according as their motions are round in one direction (the same as the nominal direction of the galvanic current in the magnetizing coil) or in the contrary direction. But the elastic reaction of the medium must be the same for the same displacements, whatever be the velocities and directions of the particles; that is to say, the forces which are balanced by centrifugal force of the circular motions are equal, while the luminiferous motions are unequal. The absolute circular motions being therefore either equal or such as to transmit equal centrifugal forces to the particles initially considered, it follows that the luminiferous motions are only components of the whole motion; and that a less luminiferous component in one direction, compounded with a motion existing in the medium when transmitting no light, gives an equal resultant to that of a greater luminiferous motion in the contrary direction compounded with the same non-luminous motion. I think it is not only impossible to conceive any other than this dynamical explanation of the fact that circularly-

fundamental equation with which we began this article, and which the experiments of Verdet so remarkably corroborate.

"The disturbance which constitutes light, whatever its physical nature may be, is of the nature of a vector, perpendicular to the direction of the ray. This is proved from the fact of the interference of two rays of light, which, under certain conditions, produces darkness, combined with the fact of the non-interference of two rays polarized in planes perpendicular to to each other. For, since the interference depends on the angular position of the planes of polarization, the disturbance must be a directed quantity or vector, and since the interference ceases when the planes of polarization are at right angles, the vector representing the disturbance must be perpendicular to the line of intersection of these planes, that is, to the direction of the ray.

The disturbance, being a vector, can be resolved into components parallel to x and y, the axis of z being parallel to the direction of the ray. Let ξ and η be these components; then, in the case of a ray of homogeneous circularly-polarized light,

$$\xi = r \cos \theta, \qquad \eta = r \sin \theta, \tag{1}$$

where

$$\theta = nt - qz + a. \tag{2}$$

In these expressions, r denotes the magnitude of the vector, and θ the angle which it makes with the direction of the axis of x.

The periodic time, τ, of the disturbance is such that

$$n\tau = 2\pi. \tag{3}$$

The wave-length, λ, of the disturbance is such that

$$q\lambda = 2\pi. \tag{4}$$

The velocity of propagation is $\frac{n}{q}$

The phase of the disturbance when t and z are both zero is a.

The circularly-polarized light is right-handed or left-handed according as q is negative or positive.

---

polarized light transmitted through magnetized glass, parallel to the lines of magnetizing force, with the same quality, right-handed always or left-handed always, is propagated at different rates, according as its course is in the direction or is contrary to the direction in which a north magnetic pole is drawn; but I believe it can be demonstrated that no other explanation of that fact is possible. Hence it appears that Faraday's optical discovery affords a demonstration of the reality of Ampere's explanation of the ultimate nature of magnetism." — Sir Wm. Thompson.

Its vibrations are in the positive or the negative direction of rotation in the plane of (x, y), according as n is positive or negative.

The light is propagated in the positive or the negative direction of the axis of z, according as n and q are of the same or of opposite signs.

In all media n varies when q varies, and $\frac{dn}{dq}$ is always of the same sign with $\frac{n}{q}$.

Hence, if for a given numerical value of n, the value of $\frac{n}{q}$ is greater when n is positive than when n is negative, it follows that for a given value of q, given both in magnitude and sign, the positive value of n will be greater than the negative value.

Now this is what is observed in a diamagnetic medium, acted on by a magnetic force, γ, in the direction of z. Of the two circularly-polarized rays of a given period, that is accelerated of which the direction of rotation in the plane of (x, y) is positive. Hence, of two circularly polarized rays, both left-handed, whose wave-length within the medium is the same, that has the shortest period whose direction of rotation in the plane of (x, y) is positive, that is, the ray which is propagated in the positive direction of z from south to north. We have, therefore, to account for the fact that when in the equations of the system q and r are given, two values of n will satisfy the equations, one positive and the other negative, the positive value being numerically greater than the negative.

We may obtain the equations of motion from a consideration of the potential and kinetic energies of the medium. The potential energy, V, of the system, depends on its configuration, that is, on the relative position of its parts. In so far as it depends on the disturbance due to circularly-polarized light, it must be a a function of r, the amplitude, and q, the coefficient of torsion, only. It may be different for positive and negative values of q of equal numerical value, and it probably is so in the case of media, which of themselves rotate the plane of polarization.

The kinetic energy, T, of the system, is a homogeneous function of the second degree of the velocities of the system, the coefficients of the different terms being functions of the coordinates.

Let us consider the dynamical condition that the ray may be of constant intensity, that is, that r may be constant.

Lagrange's equation for the force in r becomes

$$\frac{d}{dt}\left(\frac{dT}{d\dot{r}}\right)-\frac{dT}{dr}+\frac{dV}{dr}=0. \qquad (5)$$

Since r is constant the first term vanishes. We have therefore the equation

$$-\frac{dT}{dr}+\frac{dV}{dr}=0. \qquad (6)$$

in which q is supposed to be given, and we are to determine the value of the angular velocity $\dot{\theta}$, which we may denote by its actual value, n.

The kinetic energy, T, contains one term involving n^2; other terms may contain products of n with other velocities, and the rest of the terms are independent of n. The potential energy, V, is entirely independent of n. The equation is, therefore of the form

$$An^2 + Bn + C = 0. \qquad (7)$$

This being a quadratic equation, gives two values of n. It appears from experiment that both values are real, that one is positive and the other negative, and that the positive value is numerically the greater. Hence, if A is positive, both B and C are negative; for, if n_1 and n_2 are the roots of the equation,

$$A(n_1 + n_2) + B = 0. \qquad (8)$$

The coefficient B, therefore, is not zero, at least when magnetic force acts on the medium. We have, therefore, to consider the expression Bn, which is the part of the kinetic energy involving the first power of n, the angular velocity of the disturbance.

Every term of T is of two dimensions as regards velocity. Hence the terms involving n must involve some other velocity. This velocity cannot be $\dot{r}$ or $\dot{q}$, because, in the case we consider, r and q are constant. Hence it is a velocity which exists in the medium independently of that motion which constitutes light. It must also be a velocity related to n in such way that when it is multiplied by n the result is a scalar quantity, for only scalar quantities can occur as terms in the value of T, which is itself scalar. Hence this velocity must be in the same direction as n, or in the opposite direction, that is, it must be an *angular velocity* about the axis of z.

Again, this velocity cannot be independent of the magnetic force, for if it were related to a direction fixed in the medium, the phenomenon would be different if we turned the medium end for end, which is not the case.

We are therefore led to the conclusion that this velocity is an invariable accompaniment of the magnetic force in those media which exhibit the magnetic rotation of the plane of polarization.

We have been hitherto obliged to use language which is, perhaps, too suggestive of the ordinary hypothesis of motion in the undulatory theory. It is easy, however, to state our result in a form free from this hypothesis.

Whatever light is, at each point of space there is something going on, whether displacement or rotation, or something not yet imagined, which is certainly of the nature of a vector or directed quantity, the direction of which is normal to the direction of the ray. This is completely proved by the phenomenon of interference.

In the case of circularly-polarized light, the magnitude of this vector remains always the same, but its direction rotates round the direction of the ray so as to complete a revolution in the periodic time of the wave. The uncertainty which exists as to whether this vector is in the plane of polarization or perpendicular to it, does not extend to our knowledge of the direction in which it rotates in right handed and left-handed circularly-polarized light respectively. The direction and the angular velocity of this vector are perfectly known, though the physical nature of the vector and its absolute direction at a given instant are uncertain.

When a ray of circularly-polarized light falls on a medium under the action of magnetic force, its propagation within the medium is affected by the relation of the direction of rotation of the light to the direction of the magnetic force. From this we conclude that in the medium, when under the action of magnetic force, some rotatory motion is going on, the axis of rotation being in the direction of the magnetic forces; and that the rate of propagation of circularly-polarized light, when the direction of its vibratory rotation and the direction of the magnetic rotation of the medium are the same, is different from the rate of propagation when these directions are opposite.

The only resemblance which we can trace between a medium through which circularly-polarized light is propagated, and a medium through which lines of magnetic force pass, is that in both there is a motion of rotation about an axis. But here the resemblance stops, for the rotation in the optical phenomenon is that of the vector which represents the disturbance. This vector is always perpendicular to the direction of the ray, and rotates about it a known number of times in a second. In the magnetic phenomenon, that which rotates has no properties by which its sides can be distinguished, so that we cannot determine how many times it rotates in a second.

There is nothing, therefore, in the magnetic phenomenon which corresponds to the wave-length and the wave-propagation in the optical phenomenon. A medium in which a constant magnetic force is acting, is not, in consequence of that force, filled with waves traveling in one direction, as when light is propagated through it.

The only resemblance between the optical and the magnetic phenomenon is, that at each point of the medium something exists of the nature of an angular velocity about an axis in the direction of the magnetic force.

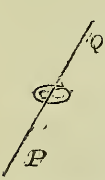
ON THE HYPOTHESIS OF MOLECULAR VORTICES.

The consideration of the action of magnetism upon polarized light leads, as we have seen, to the conclusion that in a medium under the action of magnetic force something belonging to the same mathematical class as an angular velocity, whose axis is in the direction of the magnetic force, forms a part of the phenomenon.

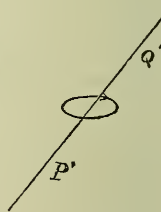
This angular velocity cannot be that of any portion of the medium of sensible dimensions rotating as a whole. We must, therefore, conceive the rotation to be that of very small portions of the medium, each rotating on its own axis. This is the hypothesis of molecular vortices.

The motion of these vortices, though, as we have shown, it does not sensibly affect the visible motions of large bodies, may be such as to affect that vibratory motion on which the propagation of light, according to the undulatory theory, depends. The displacements of the medium, during the propagation of light, will produce a disturbance of the vortices, and the vortices, when so disturbed, may re-act on the medium so as to affect the mode of propagation of the ray.

It is impossible, in our present state of ignorance as to the nature of the vortices, to assign the form of the law which connects the displacement of the medium with the variation of the vortices. We shall therefore assume that the variation of the vortices, caused by the displacement of the medium, is subject to the same conditions which Helmholtz, in his great memoir on Vortex-motion, has shown to regulate the variation of the vortices of a perfect liquid.



Helmholtz's law may be stated as follows: — Let P and Q be two neighboring particles in the axis of a vortex, then, if in consequence of the motion of the fluid these particles arrive at the points P' Q', the line P' Q' will represent the new direction of the axis of the vortex, and its strength will be altered in the ratio of P' Q' to P Q.



Hence if α, β, γ denote the components of the strength of the vortex, and if ξ, η, ζ denote the displacements of the medium, the value of α will become

$$\left.\begin{aligned} \alpha' &= \alpha + \alpha \frac{d\xi}{dx} + \beta \frac{d\xi}{dy} + \gamma \frac{d\xi}{dz} \\ \beta' &= \beta + \alpha \frac{d\eta}{dx} + \beta \frac{d\eta}{dy} + \gamma \frac{d\eta}{dz} \\ \gamma' &= \gamma + \alpha \frac{d\zeta}{dx} + \beta \frac{d\zeta}{dy} + \gamma \frac{d\zeta}{dz} \end{aligned}\right\} \qquad (1)$$

We now assume that the same condition is satisfied during the small displacements of a medium in which α, β, γ represent, not the components of the strength of an ordinary vortex, but the components of magnetic force.

The components of the angular velocity of an element of the medium are

$$\left.\begin{aligned}\omega_1 &= \tfrac{1}{2}\frac{d}{dt}\left(\frac{d\zeta}{dy} - \frac{d\eta}{dz}\right),\\ \omega_2 &= \tfrac{1}{2}\frac{d}{dt}\left(\frac{d\xi}{dz} - \frac{d\zeta}{dx}\right),\\ \omega_3 &= \tfrac{1}{2}\frac{d}{dt}\left(\frac{d\eta}{dx} - \frac{d\xi}{dy}\right).\end{aligned}\right\} \qquad (2)$$

The next step in our hypothesis is the assumption that the kinetic energy of the medium contains a term of the form:

$$2\,C\,(a\omega_1 + \beta\omega_2 + \gamma\omega_3). \qquad (3)$$

This is equivalent to supposing that the angular velocity acquired by the element of the medium during the propagation of light is a quantity which may enter into combination with that motion by which magnetic phenomena are explained.

In order to form the equations of motion of the medium, we must express its kinetic energy in terms of the velocity of its parts, the components of which are $\frac{d\xi}{dt}, \frac{d\eta}{dt}, \frac{d\zeta}{dt}$. We therefore integrate by parts, and find

$$2\,C\iiint(a\omega_1 + \beta\omega_2 + \gamma\omega_3)\,dx\,dy\,dz$$

$$= C\iint\left(\gamma\frac{d\eta}{dt} - \beta\frac{d\zeta}{dt}\right)dy\;dz + C\iint\left(a\frac{d\zeta}{dt} - \gamma\frac{d\xi}{dt}\right)dz\,dx$$

$$+\;C\iint\left(\beta\frac{d\xi}{dt} - a\frac{d\eta}{dt}\right)dx\;dy + C\iiint\left\{\frac{d\xi}{dt}\left(\frac{d\gamma}{dy} - \frac{d\beta}{dz}\right)\right.$$

$$\left.+\;\frac{d\eta}{dt}\left(\frac{da}{dz} - \frac{d\gamma}{dx}\right) + \frac{d\zeta}{dt}\left(\frac{d\beta}{dx} - \frac{da}{dy}\right)\right\}dx\;dy\;dz. \qquad (4)$$

The double integrals refer to the bounding surface, which may be supposed at an infinite distance. We may, therefore, while investigating what takes place in the interior of the medium, confine our attention to the triple integral.

The part of the kinetic energy in unit of volume, expressed by this triple integral, may be written

$$4\pi C\left(\frac{d\xi}{dt}u+\frac{d\eta}{dt}v+\frac{d\zeta}{dt}w\right), \tag{5}$$

where u, v, w are the components of the electric current.

It appears from this that our hypothesis is equivalent to the assumption that the velocity of the particle of the medium whose components are $\frac{d\xi}{dt}, \frac{d\eta}{dt}, \frac{d\zeta}{dt}$, is a quantity which may enter into combination with the electric current whose components are u, v, w.

Returning to the expression under the sign of triple integration in (4), substituting for the value of α, β, γ, those of α', β', γ', as given by equation (1), and writing

$$\frac{d}{dh} \text{ for } \alpha\frac{d}{dx}+\beta\frac{d}{dy}+\gamma\frac{d}{dz}; \tag{6}$$

the expression under the sign of integration becomes

$$C\left\{\frac{d\xi}{dt}\frac{d}{dh}\left(\frac{d\zeta}{dy}-\frac{d\eta}{dz}\right)+\frac{d\eta}{dt}\frac{d}{dh}\left(\frac{d\xi}{dz}-\frac{d\zeta}{dx}\right)+\frac{d\zeta}{dt}\frac{d}{dh}\left(\frac{d\eta}{dx}-\frac{d\xi}{dy}\right)\right\} \tag{7}$$

In the case of waves in planes normal to the axis of z the displacements are functions of z and t only so that $\frac{d}{dh}=\gamma\frac{d}{dz}$, and this expression is reduced to

$$C\gamma\left\{\frac{d^2\xi}{dz^2}\frac{d\eta}{dt}-\frac{d^2\eta}{dz^2}\frac{d\xi}{dt}\right\} \tag{8}$$

The kinetic energy per unit of volume, so far as it depends on the velocities of displacement, may now be written

$$T=\tfrac{1}{2}\rho\left\{\frac{d\xi}{dt}+\eta^2+\zeta^2\right\}+C\gamma\left\{\frac{d^2\xi}{dz^2}\frac{d\eta}{dt}-\frac{d^2\eta}{dz^2}\frac{d\xi}{dt}\right\}, \tag{9}$$

where ρ is the density of the medium.

The components, X and Y, of the impressed force, referred to unit of volume, may be deduced from this by Lagrange's equations

$$X=\rho\frac{d^2\xi}{dt^2}-C\gamma\frac{d^3\eta}{dz^2dt}, \tag{10}$$

$$Y=\rho\frac{d^2\eta}{dt^2}-C\gamma\frac{d^3\xi}{dz^2dt}, \tag{11}$$

These forces arise from the action of the remainder of the medium on the element under consideration, and must in the case of an isotropic medium be of the form indicated by Cauchy,

$$X = A_0 \frac{d^2\xi}{dz^2} + A_1 \frac{d^4\xi}{dz^4} + \text{etc.} \qquad (12)$$

$$Y = A_0 \frac{d^2\eta}{dz^2} + A_1 \frac{d^4\eta}{dz^4} + \text{etc.}, \qquad (13)$$

If we now take the case of a circularly-polarized ray for which

$$\xi = r \cos (nt - qz), \qquad \eta = r \sin (nt - qz), \qquad (14)$$

we find for the kinetic energy in unit of volume

$$T = \tfrac{1}{2} \rho r^2 n^2 - C\gamma r^2 q^2 n; \qquad (15)$$

and for the potential energy in unit of volume

$$V = r^2(A_0 q^2 - A_1 q^4 + \text{etc.}) = r^2 Q, \qquad (16)$$

where Q is a function of q^2.

The condition of free propagation of the ray given in equation (6), is

$$\frac{dT}{dr} = \frac{dV}{dr} \qquad (17)$$

which gives

$$\rho n^2 - 2C\gamma q^2 n = Q, \qquad (18)$$

whence the value of n may be found in terms of q.

But in the case of a ray of given wave-period, acted on by magnetic force, what we want to determine is the value of $\frac{dq}{d\gamma}$ when n is constant, in terms of $\frac{dq}{dn}$, when γ is constant. Differentiating (18)

$$(2\rho n - 2C\gamma q^2)\, dn - \left\{ \frac{dQ}{dq} + 4C\gamma q n \right\} dq - 2Cq^2 n d\gamma = 0. \qquad (19)$$

We thus find $\frac{dq}{d\gamma} = - \frac{Cq^2 n}{\rho n - C\gamma q^2} \frac{dq}{dn}$. (20)

If λ is the wave-length in air, and i the corresponding index of refraction in the medium

$$q\lambda = 2\pi i. \qquad n\lambda = 2\pi v.$$

The change in the value of q, due to magnetic action is in every case an exceedingly small fraction of its own value, so that we may write

$$q = q_0 + \frac{dq}{d\gamma}\gamma,$$

where q_0 is the value of q when the magetic force is zero. The angle, θ, through which the plane of polarization is turned in passing through a thickness, c, of the medium, is half the sum of the positive and negative values of $q\ c$, the sign of the result being changed, because the sign of q is negative in equations (14). We thus obtain

$$\theta = -c\gamma \frac{dq}{d\gamma} = \frac{4\pi C}{v\rho} c\gamma \frac{i^2}{\lambda^2} \left\{ i - \lambda \frac{di}{d\lambda} \right\} \frac{1}{1 - 2\pi C\gamma \frac{i^2}{v\rho\lambda}}$$

which is the complete form of the equation for determining the angle, through which the plane of polarization has been turned by the magnetic force while passing through a thickness of the medium equal to c, and is, in its modified form the one with which Verdet's results have been compared. From this comparison of the consequences of assuming the motions of light to be capable of composition with the motions caused by electric currents, with what experiment shows to be true of bodies conveying circularly polarized light when also placed under magnetic strain, we have probably good evidence for the opinion that some phenomenon of rotation is going on in the magnetic field, that this rotation is performed by a great number of very small portions of matter each rotating on its own axis, this axis being parallel to the direction of the magnetic force, and that the rotations of these different vortices are made to depend on one another by means of some kind of mechanism connecting them. The problem of determining the mechanism required to establish a given species of connection between the motions of the parts of a system always admits of an infinite number of solutions. Of these some may be more clumsy than others, but all must satisfy the conditions of mechanism in general."— MAXWELL — *Electricity and Magnetism*, Chap. xxi.

NOTE.— On page 246 the radical sign ($\surd$) should be the Greek letter gamma (γ), in formula No. (2).

PROCEEDINGS OF THE ACADEMY

SINCE FEBRUARY, 1876.

REPORT OF THE PRESIDENT.

To His Excellency, WILLIAM E. SMITH,

Governor of the State of Wisconsin:

SIR:—It affords me great pleasure to be able to report that the Wisconsin Academy of Sciences, Arts, and Letters is in a flourishing condition, steadily gaining in membership and usefulness.

Every college and educational institution of high grade in the state is now represented in the Academy; thus bringing together many of the ablest men in science, literature and art. The summer meetings held in Racine and Milwaukee were well attended and were instrumental in exciting a lively interest in the society and its aims. We are satisfied that in inaugurating this summer migratory meeting, the society acted wisely, and that these sessions will be productive of good.

At the Milwaukee meeting, a number of ladies were elected members, several of whom are not unknown to science and literature. In electing these ladies, the Academy has gained valuable working members and has added not a little to its well-being, intellectually as well as socially. The society acted on the broad principle that science and letters, have neither country, color or sex. The straight-jacket of superstition and bigotry no longer cramps and cripples investigation in any department of knowledge.

The report of the librarian shows the extent and value of our exchanges from this and foreign countries.

We have already formed the nucleus of a valuable library. The finances are in a healthy condition, the funds are not large, but sufficient for the workings of the society, aside from the publishing of the proceedings, which is justly done by the state.

We are in need of suitable rooms to accommodate the society, We want space sufficient to display and securely keep a cabinet such as will certainly come into our possession as soon as we have permanent accommodations.

The usefulness of the Academy will be greatly enhanced by the possession of suitable rooms for cabinet and library.

Very respectfully,

P. R. HOY, *President.*

PROCEEDINGS OF THE ACADEMY.

[Since February, 1876.]

REPORT OF THE SECRETARY.

Rooms of Wisconsin Academy of Science, Arts and Letters,
Capitol, Madison, Wisconsin.

SEVENTH ANNUAL MEETING.

Held at Madison, Wisconsin.

FIRST SESSION.

February 13, 1877.

Academy met at 7:30 P. M. Usual routine of business. Prof. Davies, General Secretary, called attention to the many valuable exchanges received from foreign and American societies, and the urgent necessity of providing proper rooms and cases for them. Prof. Allen, Prof. Chamberlin and Gen. Delaplaine were appointed a committee for such purpose.

Remarks were made by Prof. Carpenter upon the death of Prof. J. H. Eaton, of Beloit, and a committee consisting of Dr. Chapin, Prof. Chamberlin, of Beloit and Dr. S. H. Carpenter, of Madison, were appointed to draw up an account of the life and work of Prof. Eaton.

A very interesting paper on a mode of illustrating Phylotaxis, by means of a model, was read by E. A. Birge, Esq., of the University of Wisconsin.

Dr. P. R. Hoy, President of the Academy, read a paper upon an elephant's tooth containing an iron bullet. He explained how the bullet sank into the pulp and appeared in another part of the tooth three feet off.

Profs. Chamberlin and Allen, and Gen. Delaplaine were appointed a committee to memorialize the Governor in regard to more ample room for the accommodation of the books and specimens of the Academy.

SECOND SESSION.

February 14, 1877.

Academy met at 9:30 A. M., President Hoy in the chair. On account of the unavoidable absence of the secretary, Hon. E. E. Woodman, of Baraboo, was chosen Secretary *pro tem.*

On motion of Prof. Davies, the following gentlemen were chosen annual members:

Dr. Clark Gapen, of Madison, Wis.
Mr. W. A. P. Morris, of Madison, Wis.
Dr. E. W. Bartlett, of Milwaukee, Wis.

W. F. Bundy, Esq., of Sauk City, read a paper on the "Crustacea of Wisconsin." Mr. James R. Stuart, of Madison, read a paper on "Art Instruction."

Prof. Davies showed the "Application of Fourier's Theorem to the Phenomena of Composite Sounds."

Adjournment, to meet at 2:30 P. M.

THIRD SESSION.

February 14, 2:30 P. M.

Gen. Ed. E. Bryant read a paper on the "Cost of Government." Dr. Clark Gapen read one on "Hereditary Insanity," which was discussed at great length by President Bascom, Prof. S. H. Carpenter and Dr. Gapen.

Prof. Wright, of Fox Lake, read a paper on "The Philosophy of History."

FOURTH SESSION.

7:30 P. M.

Mr. E. A. Birge read a finely illustrated paper upon the the habits and structure of the "Cladocera, a minute crustacean of our fresh water lakes." Many points of its structure were shown to be exceedingly curious.

Hon. E. E. Woodman, of Baraboo, read a valuable paper on "The Pipestone of Devil's Lake."

Dr. E. Andrews being detained at Chicago by important surgical cases, his paper was read by Prof. Davies. It gave a history of the present descendants of the mound-builders, considering the latter as still *not entirely extinct.* The paper elicited a great deal of discussion by Dr. Hoy, Prof. Butler, Mr. Woodman *et al.*

FIFTH SESSION.

February 15, 9:30 A. M.

Mr. E. T. Sweet read a valuable paper containing results of analysis of the Milwaukee brick clay.

The following business was then transacted: First, the summer meeting for July, 1877, was appointed to be held at Racine on the third Tuesday of July; the autumn meeting being entirely set aside for the future.

F. H. Day, M. D., of Wauwatosa, Wis.
Prof. George W. Peckham, of Milwaukee,
Prof. W. Bundy, of Sauk City,
Hon. W. C. Allen, of Racine,
Rev. H. M. Simmons, of Kenosha,

were elected as annual members.

John W. Barrow, of No. 313 E. Seventeenth street New York city was elected a corresponding member.

The following amendments to the By-laws were offered for one year's consideration, according to the provisions of the constitution. By-law No. II to be amended so as to read as follows: "The regular annual meeting to take place hereafter on the last Wednesday and Thursday of December, at Madison and the summer annual meeting to be held on the third Tuesday in July, at such place as shall be fixed upon at the regular annual meeting in December.

Special meetings may be called by the President at his discretion, or by request of any five members of the council.

By-law, Art. I, sec. 7, to be amended to make the fee of annual members three dollars in place of two.

The resignation of the Librarian was accepted, and the Secretary was requested to act as Librarian until the next election of officers.

The Department of Fine Arts was regularly organized.

Hon. Joseph Hamilton, of Milwaukee, was elected an Honorary member of the Academy. Hon. J. C. Ford, of Madison, an annual member.

The report of the treasurer was then read as follows:

WISCONSIN ACADEMY OF SCIENCE, ARTS AND LETTERS,
TREASURER'S OFFICE, *Madison*, Dec. 13, 1877.

Hon. P. R. HOY, President:

I have the honor to report the financial condition of the Academy as follows:

Total amount of fees and dues received from 58 members........	$778 25
Total fees received from 10 life members........................	1,000 00
Interest on loan	370 00
Total amount disbursed in payment of warrants, to date..........	777 97
Balance in treasury	1,370 28

Signed, GEORGE P. DELAPLAINE,
Treasurer.

The Academy then adjourned. to meet at Racine upon the 10th of July following.

FIRST SUMMER MEETING.

Held at Racine, Wisconsin.

FIRST SEMI-ANNUAL MEETING.
July 10, 11 and 12, 1877.

W. A. Germain, Acting Secretary.

FIRST SESSION.

Racine, July 10, 7:30 P. M.

The Academy met at 7: 30, P M., President Hoy in the chair.

Dr. Meachem, mayor of the city, delivered an address of welcome. Rev Dr. Steele, of Appleton, responded.

Prof. Chamberlin then read a Eulogy on the late Prof. James Eaton, of Beloit, which was ordered printed in the transactions.

Rev. Dr. James DeKoven, Pres't Racine College, then read a paper on "Religion as an Element in Education."

The Academy adjourned to meet next morning at nine o'clock.

SECOND SESSION.

July 11, 9:00 A. M.

Academy met pursuant to adjournment. Minutes of the last annual meeting read.

Prof. Butler called attention to the fact that notice of Prof. Wright's paper on "Philosophy of History," had been omitted. Correction was made by the Acting Secretary.

Attention was called by President Hoy to the amendments offered at the last regular meeting.

To amend sec. 3 of the by-laws so as to read:

1. The regular annual meeting to take place on the last Wednesday and Thursday of December, at Madison, and the summer annual meeting to be held on the third Tuesday of July at such place as shall be fixed at the regular annual meeting in December.

2. Special meetings may be called by the President at his discretion, or by the request of any five members of the council.

3. Article I of sec. 7 of the constitution to be amended to make the fee of annual members three dollars in place of two dollars.

Prof. Allen moved the adoption of the amendments.

Dr. Steele moved to amend so as to read, in place of "the regular annual meeting shall take place, etc.," the following:

"The regular annual meeting shall take place during the last week of December, the days to be appointed by the council."

Amendment carried.

The resolutions were then adopted unanimously as amendments to the by-laws.

The following persons were then elected as annual members:

Rev. J. L. Jones, Janesville, Wis.
Rev. S. A. Griffith, Milwaukee.
Rev. A. P. Meade, Racine.
Rev. Dr. James DeKoven, Racine.
Prof. J. J. Elmendorf, Racine.
Prof. H. F. Oldenbage, Milwaukee.
Prof. F. W. Falk, Ph. D., Racine.
Dr. E. H. Merrell, Ripon.
Rev. G. E. Gordon, Milwaukee.
Hon. Edward Martin, Kenosha.
Prof. G. D. Swezey, A. M., Beloit.
Prof. Peter Henrickson, Beloit.
Prof. G. R. Kleeberger, Whitewater.
R. W. Reynolds, La Crosse
W. A. Germain, Delafield.
Prof. C. A. Kenaston, Ripon.
Prof. W. M. Hailman, Milwaukee.
Prof. G. W. Gerry, Ripon.
Prof. J. McMurphy, Kenosha.
Frank Head, Esq., Kenosha.
Prof. J. P. Marriett, Kenosha.
Hon. J. H. Howe, Kenosha.
Dr. J. G. Meachem, Racine.
Dr. J. G. Meachem, Jr., Racine.

As Corresponding members:

Dr. C. C. Abbott, Trenton, New Jersey.
Alford Paine, S. T. D., of Hinsdale, Ill.

As Honorary member,

Prof. Spencer Baird, M. D., LL. D., of Washington, D. C.

Prof. Allen, chairman of the committee appointed to see about securing rooms for the Academy, reported that the rooms of the Railroad Commissioners could be secured in December. The report accepted, and the committee continued. Prof. Allen then read a paper on "Early Form of Land Tenure."

Dr. Falk made extended remarks on Prof. Allen's paper, and gave a review of the feudal relations in Germany.

Prof. McMurphy read a paper on "Rotation as a Factor of Motion."

The President then read the following communication from Captain Nader, C. E., on "The Balloon in Meteorology."

MADISON, Wis., June 20, 1877.

DR. P. R. HOY, Racine, Wis.:

DEAR AND RESPECTED SIR: Your very kind note of invitation of the 7th instant was duly received, and while I regret very much that I shall be unable to partake of the proffered hospitality of the people of Racine, I feel very thankful for your kind remembrance.

My duties here render my time uncertain, and occupy my attention so much that I shall not be able to attend the meeting, which no doubt will be pleasant and instructive. I shall be unable to produce anything in time. I was preparing a letter to you, when I received your note, on a subject which may be interesting, and which I will now give you as briefly as possible.

It is but a short time since an idea occurred to me which I believe to be novel, and perhaps of scientific import, and should you consider it of sufficient importance, I beg you would please present the same for discussion at the meeting.

The object is to explore the atmosphere, so far as may be practicable, without the risk of life and limb. This I propose to do in the following manner: In the first place, I resort to a gas balloon to carry up my apparatus, and since there is no danger of any irreparable damage, the same may be constructed as light as possible, even frail, I may say; and since the charge is not required to endure very long, small leaks need not be noticed, and I believe such a balloon may be constructed at a nominal cost.

Each cubic foot of gas of specific gravity, say 0.6, will displace about 530 grains of air, and deducting its weight, 32 grains, will support a weight of 498 grains, so that 1,000 cubic feet will carry about 70 pounds weight, which is the displacement of a balloon of less than 13 feet diameter.

The balloon is allowed to rise at pleasure by means of a cord of sufficient strength to support considerable more than its own weight, of the desired length or height. The lateral motion, while rising, will indicate the direction of the currents; the height is computed at any time by its position.

The principal apparatus will be that for recording the temperature and barometrical changes. This is done by a clock-work arrangement carrying a strip of highly sensitised paper, with a regular motion, so that the condition of both instruments is photographed at each instant of time. The observation having commenced, it is only necessary to note the time and corresponding altitude, and obtain the corresponding phenomena when the apparatus is recovered. Under favorable circumstances, the balloon may be brought to rest at different altitudes, in order to give the instruments time to assume local conditions. To the apparatus is attached a parachute, so that the same may be recovered in case of collapse or other accident. I have thought some of adding a magnetic apparatus, but have not had time to develop the idea.

This might possibly throw some light on the possibility of aerial navigation, and also be worthy of consideration in other respects.

Hoping you will have an interesting and pleasant meeting, I remain, most respectfully, your obedient servant,

JOHN NADER.

THIRD SESSION.

July 11, 2.30 P. M.

Rev. H. M. Simmons read a paper on "The Social Organism."

Prof. Hailman delivered a lecture on "The Kindergartens"

Judge Allen then read a paper prepared by Dr. Mason, on the "Duty of the State to its Unfortunate Classes."

Prof. Butler read a paper on "American Pre-Revolutionary Bibliography."

FOURTH SESSION.

7.30 P. M.

Prof. Jewell, of Chicago, read a paper on "Mind in the Inferior Animals."

Academy adjourned to attend a reception given by Mayor Meacham in honor of the members.

FIFTH SESSION.

9:30 A. M.

The Academy met pursuant to adjournment.

Prof. Luther, of Racine, was elected an annual member.

Dr. Hoy, President of the Academy, delivered a lecture on the "Disappearance of Large Animals in Wisconsin."

Rev. C. Caverno read a paper on "Abolition of the Jury System."

Dr. Elmendorf read a paper on "Nature and Freedom."

SIXTH SESSION.

2:30 P. M.

Prof. Stuart read a paper on "Harmonic Method in Greek Art."

Prof. Butler then read a paper on "The Mosque of Omar at Jerusalem."

Mr. A. Paine, read a paper on "Art as Education."

The following resolutions were then proposed by Prof. Butler, and seconded by Prof. Caverno, and unanimously adopted:

"*Resolved*, That the Wisconsin Academy of Sciences, Arts and Letters begs to tender its grateful acknowledgments to the mayor of Racine for his cordial greeting in the Court House, and reception at his mansion, as well as to the citizens of the city for their generous hospitalities, and for their attendance on the sessions.

"*Resolved*, That the Wisconsin Central, and Western Union railroads, which have facilitated our convening in the interest of science, are hereby thanked for their kind courtesies.

"*Resolved*, That the sheriff and county commissioners, by placing at our disposal their new and noble court house, have done a service to science and shall be remembered by us with gratitude.

"*Resolved*, That the hearty thanks of the Academy are hereby presented to Dr. DeKoven, as well as the Professors of Racine College and other gentlemen for their able lectures, with which they have honored, entertained and instructed our Association.

"*Resolved*, That these resolutions be presented to the newspapers of this city for publication."

Prof. Perkins, in behalf of the Association, expressed the sincere thanks of the Academy to Dr. Hoy, President, for his earnest efforts to promote its interests.

The Academy then adjourned to meet in Madison on the 26th of December following, according to the change in the by-law regulating the time of the Regular Annual Meetings.

EIGHTH REGULAR ANNUAL MEETING,

Held at Madison, Wisconsin, December 26th, 27th and 28th, 1877.

WEDNESDAY, Dec. 16, 1877.

The Eighth Regular Annual Meeting was opened at 2:30 P. M., there being a large attendance.

Dr. Hoy, President of the Academy, in the chair.

The minutes of the Racine Semi-annual Meeting were read, and the amendments to the Constitution and the By-laws then made, commented upon and formally ratified.

The Secretary gave notice that a complete catalogue of all books and pamphlets thus far received by the Academy was completed, and would be published in the forthcoming Vol. IV of the Transactions.

The Treasurer made the following report:

TREASURER'S OFFICE,
Wisconsin Academy of Sciencies, Arts and Letters,
MADISON, Dec. 26, 1877.

P. R. HOY, M. D., *President of the Wisconsin Academy of Sciences, Arts and Letters:*

I have the honor to report the financial condition of the Academy, as follows:

Total amount of fees and dues from 62 members	$817 25
Total fees from 10 life members	1,000 00
Total interest on loan	440 00
	$2,259 25
Total amount disbursed in payment of warrants to date	$855 17
Balance in treasury	$1,402 08

(Signed) G. P. DELAPLAINE, *Treasurer.*

The Treasurer urged greater promptitude on the part of members in the payment of their dues. Only 62 members out of about 200 have paid any dues whatsoever thus far.

The following papers were read and dicussed during the session:

How Did the Aborigines of this Country Fabricate the Copper Implements? By P. R. Hoy, M. D., President of the Academy.

Some Remarks on the Descent of Animals. By Prof. Oldenhage, of Milwaukee.

Why Have the Ruminants no Upper Incisors. By P. R. Hoy, M. D., President of the Academy.

Boiler Explosions. By Chas. I. King, Superintendent University Machine Shop.

Antiquities and Platycnemism of the Mound Builders. By J. N. De Hart M. D.

Extent and Significance of the Wisconsin Kettle Moraine. By T. C. Chamberlin, A. M., State Geologist.

The German, French, English and American Press. By Hon. Joseph Hamilton, of Milwaukee, Honorary Member of the Academy.

The Ethical Bearings of the Doctrine of Evolution. By Rev. Jenk. Ll. Jones.

Mr. C. H. Haskins, of Milwaukee, gave a very interesting description of the Bell Speaking Telephone, illustrating his remarks by experimental demonstrations.

A paper on the Fauna of the Niagara and Upper Silurian rocks in Milwaukee county, by F. H. Day, M. D., was read by title only, not being received in time to be read in full.

The death of Prof. Oldenhage of Milwaukee was announced and his paper read by Prof. Peckham.

Profs. Peckham, Rogers and McAllister, of Milwaukee, were appointed a committee to present a memoir of Prof. Oldenhage, for publication in Vol. IV of the Transactions of the Academy.

The following gentlemen and ladies were elected annual members of the Academy:

J. S. Westcott, Superintendent of City Schools, Racine.
J. T. Lovewell, Female College, Milwaukee.
Albert Hardy, Principal High School, Milwaukee.
Rufus B. Smith, Madison.
Willett S. Main, Madison.
Geo. B. Smith, Madison.
P. B. Parsons, Madison.
B. E. Hutchinson, Madison.
Mrs. S. F. Dean, Madison.
Mrs. H. M. Lewis, Madison.
Miss Ella Giles, Madison.
J. N. DeHart, M. D., Madison.

J. J. Saylor of Cleveland, Ohio, was elected a corresponding member of the Academy.

Academy adjourned to meet in Milwaukee, at a time to be specified by the President of the Academy after consultation with the officers of the Scientific Club.

SECOND SEMI-ANNUAL MEETING.

Held at Milwaukee, Wisconsin.

Female College,
Milwaukee, July 23, 1878.

Pursuant to a notice given by the Milwaukee Scientific Club, the second semi-annual (or summer) meeting of the Wisconsin Academy of Science, Arts and Letters was convened in the Female College, Milwaukee, at 7:30 o'clock, P. M. President P. R. Hoy, of Racine, in the chair. Hon. Harrison C. Hobart, acting mayor of the city of Milwaukee, delivered an address of welcome. P. R. Hoy responded.

Prof. J. J. Elmendorf, S. T. D., of Racine, then read a paper on the "Popular Epics of the Middle Ages as Aids to Historic Study."

THURSDAY, July 24, 1878.

Academy met at 9 o'clock A. M. President P. R. Hoy in the chair, Prof. J. E. Davies, acting as Recording Secretary.

The following persons were elected annual members of the Academy. The president of the academy prefacing the ballot with the remark that " science knows no distinction of race, color, or sex: "

Mrs. Laura J. Wolcott, M. D., 471 Milwaukee St., Milwaukee, Wis.
Mrs. Charles Farrar, 614 Milwaukee St., Milwaukee, Wis.
Miss Brooks, 614 Milwaukee St., Milwaukee, Wis.
Miss Marion Stewart, 469 Marshall St., Milwaukee, Wis.
Mrs. Emery McClintock, 507 Astor St., Milwaukee, Wis.
Mrs. George Gordon, Humboldt Av., Milwaukee, Wis.
Miss Frank Whitnall, Humbolt Av., Milwaukee, Wis.
Mrs. A. M. Thomson, 459 Cass St., Milwaukee, Wis.
Mrs. A. W. Bate, 320 Terrace Av., Milwaukee, Wis.
Mrs. Celia C. Wooley, Sec. Philosophical Society, Chicago, Ill.
Mrs. P. Abbott, cor. Jackson and Division Sts., Milwaukee, Wis.
Mrs. Lewis Sherman, 171 Wisconsin St., Milwaukee, Wis.
Mrs. Dr. Marks, Prospect Av., Milwaukee, Wis.
Mrs. Carl Dœrflinger, 707 Jefferson St., Milwaukee, Wis.
Mrs. Matilda F. Anneke, 269 Ninth St., Milwaukee, Wis.
Mrs. Julia Ford, 375 Greenbush St., Milwaukee, Wis.
Mrs. N. H. Adsit, 268 Knapp St., Milwaukee, Wis.
Mrs. R. C. Spencer, 275 Prospect Av., Milwaukee, Wis.
Mrs. Edward P. Allis, 381 Prospect Av., Milwaukee, Wis.
Mrs. D. A. Olin, Racine, Wis.
Mrs. Frackleton, 469 Marshall St., Milwaukee, Wis.
Mrs. Olympia Brown Willis, Racine, Wis.
Mrs. J. G. McMurphy, Racine, Wis.
Mi s Jenny Hoy, Racine, Wis.
Miss Mary J. Lapham, Summit, Wis.
Prof. Robert C. Hindley, Racine College, Wis.
Mr. Eugene B. Winship, Racine College, Wis.
Mr. Charles Mann, Milwaukee, Wis.
Mr. Wm. P. Merrill, Milwaukee, Wis.
Dr. G. A. Stark, Milwaukee, Wis.
Mr. James S. Buck, Milwaukee, Wis.
Mr. George Gordon, Milwaukee, Wis.
Dr. Thomas A. Green, 146 Martin St., Milwaukee, Wis.
Prof. Charles A. Farrar, Milwaukee College, Wis.
Mr. H. S. Durand, Racine, Wis.
Mrs. H. S. Durand, Racine, Wis.
Miss Frankie Durand, Racine, Wis.
Rev. F. S. Luther, Racine College, Wis.
Dr. R. M. Byraness, Cincinnati, O., was elected corresponding member.

At the suggestion of Prof. J. J. Elmendorf, a resolution was framed and adopted to the effect, that all books that are now in the possession of the Academy, may be loaned, for one year, to any of the members desiring them.

A request was also made by Prof. J. E. Davies, that all members contemplating reading papers notify him of the same, for the purpose of facilitating the arrangement for the annual meeting.

An invitation was received from Dr. Day, soliciting the members to visit his cabinet at Wauwatosa.

A committee, consisting of Prof. S. H. Carpenter, Prof. Allen, and Prof. J. E. Davies, was appointed, to report, at the next meeting, a suitable memoir of the late Dr. Feuling.

Judge W. C. Allen, of Racine, then read a paper entitled, "The Accountability of Public Officials."

President Chapin, of Beloit College, read a paper on the "Nature and Functions of Credit."

This was followed by an extempore history of credit in Wisconsin, by Mr. Chapman.

At the afternoon session, the following papers were read:

"Drinking Water," by Dr J. G. Meacham, of Racine.
"Mental Hospitality," by Miss Ella Giles, of Madison.
"Scientific Housekeeping," by Mrs. A. W. Bate, of Milwaukee.
"The Origin of Certain Constellations," by the Rev. H. M. Simmons, of Kenosha.

The Academy then adjourned to attendat the invitation of the resident members and committee of arrangements, a banquet given in the evening at the Plankington House.

The following account of the banquet is taken from the Milwaukee News, of Thursday, July 25th, 1878:

"By invitation of the committee of arrangements, W. P. McLaren acted as President of the evening. At his right, sat President Chapin, of Beloit College, and at his left Dr. Hoy, president of the Academy. President Chapin asked Divine blessing on the gathering, after which an unusually long time was spent in disposing of the long and palatable list of dishes on the bill of fare. Mr. McLaren finally called the gathering to order and, in a neat and well-timed speech, introduced the first sentiment on the programme, "The State of Wisconsin." It was expected that the Hon. George H. Paul would respond to this, but, in Mr. Paul's absence, Judge Allen, of Racine, was called. The Judge gave a highly interesting account of the growth and progress of the state from the small beginnings of forty years ago, when he first came into this section of the country.

To the second toast, "The City of Milwaukee," the Hon. E. D. Holton responded, drawing parallels from history and from the present condition of cities in other parts of the world, to show the great advantages which Milwaukee possesses and the magnificent promises of the future. Dr. Hoy responded for "The Wisconsin Academy of Sciences, Art and Letters," very briefly sketching the objects and work of the society. To the fifth sentiment, "American Science," it was expected that Dr. Kempster would respond. But that gentleman was not present, and Prof. Davies, of our State University was called upon. Prof. Davies' speech was short, but full of the most interesting matter, and clothed in well-chosen words.

One of the best speeches of the evening was that of ex-Superintendent MacAllister, who answered for "Our Public Schools." President Chapin responded in an eloquent and logical manner to the seventh toast, " Arts and Letters." M. Almy Aldrich spoke for "The Press," and the regular sentiments closed with "Our New Associate Members," to which Mrs. Amelia Bate responded in a manner that elicited the heartiest applause and warmest commendations on all sides. Brief speeches followed by the Rev. Messrs. Gordon and Livermore, Dr. Wight, Dr. Elmendorf, Mr. Buck and others; and the gathering broke up about 11 o'clock.

Fourth Session, JULY 25, 1878.

Academy met at 9 o'clock A. M. President P. R. Hoy in the chair, Dr. J. E. Davies acting as recording secretary.

A resolution offered by Prof. Elmendorf, that in the appendix of the transactions shall be printed a list of the public and private collections of books within the state, as available for the use of members, to aid in the work of the society, was referred to Prof. Elmendorf and Prof. W. C. Allen, for further consideration.

A motion made by Mr. Peckham, that the secretary of the society be allowed to expend one hundred dollars ($100) for binding pamphlets belonging to the academy, was unanimously carried.

Dr. J. N. De Hart, of Madison insane asylum, then read a paper on the "Microscope and its Benefits to Science."

Rev. C. Caverno, of Lombard, Ill., read a paper entitled " Savings Banks and the Industrial Classes."

A paper entitled " The Relics of a Prehistoric Race," prepared by Dr. De Hart, was read by Rev. G. E. Gordon, as Dr. De Hart was suffering from a severe cold.

Mr. A. R. Sprague, of Evansville, Wisconsin.
Mr. W. P. McLaren, Milwaukee, Wisconsin.
Dr. D. W. Perkins, Milwaukee, Wisconsin,

Were elected annual members of the Academy.

After the morning session the members adjourned to meet at the Plankington House at 3 o'clock P. M., where the resident members of the Academy and citizens of Milwaukee had provided carriages for a drive around the city. The members were taken through the handsomest residence streets of Milwaukee, were shown the elegant grounds and conservatory of Mr. Alex. Mitchell, and then taken to the National Soldier's Home near the city, where they were introduced to Genl. E. W. Hincks, commandant of the Home, who gave them a most cordial welcome. They were then returned to the Plankington House, having spent a most enjoyable afternoon.

Academy adjourned, to meet in Madison on the 26th and 27th of December, 1878.

J. E. DAVIES,
General Secretary.

REPORT OF THE LIBRARIAN.

To the President of the Wisconsin Academy of Sciences, Arts and Letters:

SIR: At the suggestion of the General Secretary, Dr. Davies, I have made a complete revision of the library of the Academy. This work has been of considerable difficulty, owing to the fact that the bulk of the library consists of pamphlets, and the unbound publications of the various scientific associations in our own and foreign countries. Many of these are exceedingly valuable. Many of them contain the summation of the life-long investigations of specialists in their particular department of the vast field of science. Owing to their not being sufficiently well bound, few of these are at present available to the members of the Academy — a thing to be deeply regretted, since these publications are to be found in no other library of the State, that of the Academy filling a distinct and separate purpose, being, to a large extent, supplementary to the State Historical Library. Taking these things into consideration, it seems advisable that a certain sum should be set aside annually for the purpose of preserving these various publications in a more substantial binding.

The library of the Academy contains seven hundred and forty-four volumes, including pamphlets. Under the present system of exchange, it is rapidly growing. I herewith transmit a complete catalogue, embracing all publications received up to the present time (June 15th, 1878). The greater part of those from foreign societies have been forwarded by the courtesy of the Smithsonian Institute, at Washington, D. C.

W. A. GERMAIN, *Acting Librarian.*

PUBLICATIONS OF LEARNED SOCIETIES.

Now in the library of the Wisconsin Academy of Sciences, Arts and Letters.

EUROPEAN.

BELGIUM.

Musee Teyler — Archives —

Vol. I, Pts. 1, 2, 3 and 4.
Vol II, Pts. 1, 2, 3 and 4.
Vol. III, Pts. 1, 2, 3 and 4.
Vol. IV, Pts. 1 and 2.

Hainaut Academy of Science, Arts and Letters —

Memoirs for 1871, 1872, 1873, 1874, 1875, 1876 and 1877.

FRANCE.

National Academy of Caen,—

Memoirs, Vols. I, II, III, IV, V, VI and VII — 1871-6.

Academy of Bordeaux —

Acts de L'Academie, 3d Series, 1872-3.

Acts de L'Academie, 3d Series, 1872.

Academy of Lyons —

Memoirs, Vols. XV, XVI, XVIII, XIX — 1870-75.

Academy of Metz —

Memoirs — 1871-2, 1872-3, 1874-5, 1875-6.

Tables Generales de l' Academie, 1819-71.

Montpellier Academy of Science, Arts and Letters —

Transactions, Vols. IV, V, VI, VII and VIII — 1868-76.

Agricultural and Scientific Society of the Sarthe —

Bulletins, Vol. XIII, Parts 1, 2 and 3, 1871-2.

" " XIV, 1872-3.

" " XV, 1875.

" " XVI, 1876-7.

Amiens Linnean Society of the North of France —

Monthly Bulletins, from May, 1875, to December, 1877.

ITALY.

Royal Institute of Lombardy —

Transactions for 1873, Vol. VI; 1874, Vol. VII; 1875, Vol. VIII; Memoirs, Vols. XIII, XIV and XV.

Academy of Modena —

Memoirs, Vol. XVI.

Royal Geological Commission of Italy —

Bulletines, Nos. 1 to 12, 1874.

Publication of 1875.

NETHERLANDS.

Nederlandsch Meteorologroca.

id Jaarboeck, 1868.

id Jaarboeck, 1871.

Royal Academy of Amsterdam —

Transactions, Vol. I, P'ts 1, 2, 3 and 4, 1865-7; Vol. II, P'ts 1, 2 and 3, 1867-8; Vol. III, P'ts 1, 2 and 3, 1868-9; Vol. IV, P'ts 1, 2 and 3, 1869-70; Vol. V, 1871; Vol. VI, 1871-2; Vol. VII, 1873; Vol. VIII, 1874; Vol. IX, 1875; Vol. XIII, 1874; Vol. XIV, 1875; Vol. XV, 1875.

Year Book, 1873 and 1874.

Catalogue of the library of the Academy, 1877.

Netherland Society for the Encouragement of Industry —
Records, 1873, 1874, 1875 and 1876.
Proceedings, 1874, 1875 and 1876.

Amsterdam Royal Society of Physical Science —
Transactions, Vols. I, II, III, IV, V, VI, VII, VIII, IX, 1868–76.

Holland Society of Science —
Transactions, 1873, 1874, 1875, 1876 and 1877.
Catalogue of members, 1877.

Provincial Society of Arts and Sciences —
Publications, 1872, 1873, 1874, 1875 and 1876.

Royal Netherland Meteorological Institute —
Meteorological Observations, 1873.
Year Books for 1868, 1871 and 1874.

RUSSIA.

Royal Academy of Sciences of St. Petersburgh —
Repertorium of Meteorology, 1874, 1875 and 1876.

Royal Academy of Finland —
Natur och Folk, 1871, 1872, 1873, 1874 and 1875.

Imperial Physical Observatory —
Dorput Publications, Vols. I, II and III.
Annalen, 1875 and 1876.

SWEDEN AND NORWAY.

Kongliga Swenska Vetanschaps Academensis.

The Royal Swedish Academy —
Transactions, Vol. III, 1874.
Memoirs, 1875, 1876 and 1877.

University of Upsala —
Meteorological Observations, Vols. IV, V and VI.

Royal Society of Upsala —
Transactions for 1874, 1875 and 1876.

Royal Academy of Science of Christiana —
Enumeratio Insectorium Norvyicorum, 1874, 1875, 1876 and 1877.

University of Christiana —
Publications for 1873, 1874, 1875 and 1876.
Physiological Studies, by J. W. Muller.
Researches in Egyptian Chronology.
Official Statistics of Norway, 1870, 1871, 1872.

GERMANY.

Academy of Natural Sciences of Munich —
Transactions for 1871, 1872, 1873, 1874, 1875 and 1876.

Gottingen Royal Society —
Transactions for 1875, 1876 and 1877.

Royal Observatory, near Munich —
Annals, XX. Vol.

Mannheim Academy of Natural Sciences —
Transactions for 1870, 1871, 1872, 1873 and 1874.

Academy of Sciences of Heidelberg —
Transactions for 1874, 1875, 1876 and 1877.

Silesian Society, Breslau —
Transactions for 1873 and 1874.
51st Annual Report, 1873.
52d Annual Report, 1874.
53d Annual Report, 1875.
54th Annual Report, 1876.

Academy of Natural Science — Bremen —
Transactions for 1872–1873 and 1874.
Tables, etc., 1873, Parts I and II; 1874, Parts I and II, Vol. IV. Proceedings, Part I, 1876.
Supplement to same, 1876.

Rhenish Prussia and Westphalia Society of Sciences —
Transactions — 9th year, 1872.
" 10th " Part I, 1873; Part II, 1873.
" Part I, 1874; Part II, 1874.
" Part I, 1875; Part II, 1875.
" Part I, 1876.

Giessen Society of Science, Arts and Letters —
Transactions for 1876 and 1877.

Halle Journal of Natural Science — Berlin —
Transactions — Vols. IX to XIV, 1874-5 and 6.

Natural History Society of Dresden —
Transactions for 1876.

Isis Academy of Natural Science — Dresden —
Transactions for 1874, 1875, 1876 and 1877.

Polytechnic School at Hanover —
Programme for 1874, 1875, 1876 and 1877.

Natural Science Society of Freiburg —
Transactions, 1874, 1875 and 1876.

Academy of Eldena —
Transactions for 1870.

Royal Phys.-Econ. Society of Konigsberg —
Publications for 1873, 1874, 1875 and 1876.

Natural Science Society of Gorlitz —
Transactions, XV. Vol., 1875.

Society of Naturalists, Dantzig—
Publications for 1872, 1873, 1874, 1875 and 1876.

Munich Royal Bavarian Academy of Science —
Transactions for 1875, Parts I and II.; 1876, Part I.

SWITZERLAND.

Zurich Academy of Natural Science —
Transactions for 1873–1874, and 1875.

St. Galle Natural Science Society —
Transactions for 1874 and 1875.

Natural Science Socicty of Basel—
Transactions for 1874, 1875, 1876, 1877 and 1878.

Natural Science Society, Neuchatel —
Transactions for 1875, 1876 and 1877.

Natural Science Society of Berne —
Transactions for 1873, 1874, 1875, 1876 and 1877.

Natural Science Society of Schaffenhausen —
Transactions for 1872 and 1873.

Natural Science Society of Chur —
Transactions for 1873 and 1874.

Natural Science Society of Luzerne —
Transactions for 1876.

Academy of Vaudoise —
Transactions, Vols. XIV and XV, 1877–8.
Bulletin for 1877.

ENGLAND.

Philosophical Society of Manchester —
Memoirs, Vols. XII, XIII, XIN, XV — 1872–6.
Catalogue, 1875.

London Royal Society — Proceedings —
Vol. XXII, Nos. 153–155; Vol. XXIII, Nos. 156–163; Vol. XXIV, Nos. 164–170; Vol. XXV, Nos. 171–179; Vol. XXVI, Nos. 179–183.

DENMARK.

Royal Society of Denmark —
Transactions for 1874, 1875, 1876 and 1877.
Bulletin for 1877, No. I.

Royal Academy of Copenhagen —
Bulletins foı 1876, Nos. I and II.

AUSTRALIA.

Public Library of Melbourne —
Mines and Min. Statistics of New South Wales.
Treatise on New South Wales.
Nat. Industrial Resources of New South Wales.
Ann. Rept. of the Dept. of Mines.

MEXICO.

Natural Museum of Mexico —
Annals, Vol. I, 1877.

SPAIN AND PORTUGAL.

Royal Academy of Lisbon —
Transactions for 1875.

SOUTH AMERICA.

Venezuela Monthly Gazette for 1877 and 1878.

ISLAND OF MAURITIUS.

Academy of Mauritius —
Transactions, Vol. IX, 1876.

IRELAND.

Royal Dublin Society —
Journal for 1870–1875.

AUSTRIA.

Academy of Natural Sciences of Vienna —
Transactions, 1872, 1873, 1874, 1875 and 1876.

Royal Zoological and Botanical Society of Vienna —
Publications, 1872, 1873, 1874, 1875, 1876 and 1877.

Emden Natural-Philosophy Society —
Transactions for 1872, 1873, 1874, 1875, 1876 and 1877.

Society of Natural History, Brunn —
Transactions, Vols. XII and XIII, 1873.
Catalogue of the Library, 1874.

AMERICAN SOCIETIES.

Boston Society of Natural History —
Proceedings — Vol. 17, Parts II, III and IV, 1874.
Vol. 18, Parts I, II, III and IV, 1875–6.
Vol. 19, Parts I and II, 1877.

Buffalo Academy of Natural Science —
Bulletin — Vol. I, No. I, 1873.
Vol. I, Nos. II, III and IV, 1874.
Vol. II, Nos. I, II and III, 1874.

Museum of Comparative Zoölogy — Harvard University —
Bulletin — Vol. II, Nos. 1–10, 1876.
Vol. III, Nos. 11–14, 1876.
Vol. III, Nos. 15–16, 1876.
Annual Report of Trustees, 1874.
Annual Report of Trustees, 1874.

St. Louis Academy of Science —
Vol. III. Nos. I, II, III, IV, 1873–1875–1876–1878.

Quarterly Journal of Conchology —
For 1874, 1875 and 1876.

Philadelphia Academy of Natural Science —
Proceedings. Parts I and II, 1877.

New York State Museum of Natural History —
Twenty-fifth Annual Report of Regents.

American Academy of Science — Proceedings —
Vol. IV, from May, 1876, to May, 1877.

Kansas Academy of Science —
Vol. IV, 1875.
Vol. V, 1876, Birds of Kansas (Snow), 1875.

American Association for the Advancement of Scieace — Proceedings —
Buffalo, 1876.

Cleveland Academy of Science —
Proceeedings, 1845–1859.

BOUND VOLUMES AND MISCELLANEOUS PAMPHLETS.

Wells, Walter, Water Power of Maine.
Durrie, D. S., Cat. State Hist. Society, Vol. I, 1873.
Durrie, D. S., Cat. State Hist. Society, Vol. II, 1873.
Driunellette, P. S., Epistola.
Museum of Natural History of New York.
Munsel, J., Chronology of Paper Making.
Dudley Observatory, Annals of, Vol. II.
Cabinet of Natural History, New York.
Munsel, J. Manual of the Lutheran Church.
University of the State of New York, 85th Rep't, 1872.
Noye, W. Maxims of the Laws of England.
Ill. R. R. Commissioner's Rep't, 1871.
Department of Agriculture, Washington, Report, 1871.
Smithsonian Report, 1871.
Land Office Report, 1870.
DeCosta, B. F., Hudson's Sailing Directions.
Tophographic Survey of Adriondic Wilderness.
Natural History and Geology of Maine for 1863.
University of State of New York, 1873.
R. R. Commissioner's Report, Ill., 1872.
Same for 1873.
Transactions of the Wisconsin Agricultural Society, 1869.
Transactions of the Wisconsin Agricultural Society, 1870.
Transactions of the Wisconsin Agricultural Society, 1871.
Transactions of the Wisconsin Agricultural Society, 1872–3.
Transactions of the Wisconsin Agricultural Society, 1873–4.
Transactions of the Wisconsin Agricultural Society, 1874–5.
Transactions of the Wisconsin Agricultural Society, 1875–6.
Public Libraries of the United States, Part I, 1876.
Report Speciale Sur l'Immigration, 1872.
Raymond — Min. Resources West of the Rocky Mountains, 1872.
Raymond — Min. Resources West of the Rocky Mountains, 1873.
Finance Report of 1876.
Compendium of the United States Census, 1870.
Memoirs Manchester Phil. Society, Vol. V.
Mines and River Resources of New South Wales, 1875.
Report of the Chief of Statistics, Washington, 1876.
Commerce and Navigation, Washington, 1876.

Wisconsin Agriculture, 1876-7.
Hayden — U. S. Geological Survey, Washington, 1877.
Birds of the Northwest — *Coues.*
Museum of Natural History, New York, 1872.
New York State Library, 57th Report.
Patent Office Report, Vol. I, 1869.
Patent Office Report, Vol. II, 1869.
Patent Office Report, Vol III, 1869.
Report of Commissioner of Education, Washington, 1871.
Explorations in Nevada and Arizona.
Ninth Census of the U. S.
Hayden, F. V., Geological Survey, Vol. II, 1875.
Hayden, F. V., Geological Survey, 1867-8-9.
Hayden, F. V., Geological Survey, 1870.
Hayden, F. V., Geological Survey, 1871.
Hayden, F. V., Geological Survey, 1872.
Hayden, F. V., Geological Survey, 1873.
Hayden, F. V., Geological Survey, 1874.
International Exhibition, London, 1862.
Powell. B P., Geology of the Uinta Mts.
Hayden., U. S. Geol. Survey, 1874.
Hayden, U. S Geol. Survey, 1876.
Hayden, U. S. Geol. Survey, 1876.
Powell, B. P., Colorado River Exploraitions, 1873.
Memoriam — Increase A. Lapham.
New England and the English Commowealth.
Fur-bearing Animals of the Northwest — *Coues.*
Powell, J. W., American Ethnology.
Hayden, F. V., U. S. Geol. Survey,,Vol. XI.
Hayden, F. V., U. S. Geol. Survey of 1875.
Memoirs, Vol. I, 1875.
Memoirs, Vol. II, 1875.
U. S. Geol. Exploration of 9th Par., C. King, 1875.
Department of Agriculture, 1875.
Department of Agriculture, 1876.
Commercial Relations, 1875.
Messages and Documen's U. S., 1871.
Commerce and Navigation, Part I, 1876.
Commerce and Navigation, Part II, 1876.
The Electoral Count of 1876.
Leading Cases in International Law (Digest).
Western Review of Science and Industry. Theo. S. Case, Kansas City, Mo. Vols. I and II.
Medical Investigator, 1873 to 1878.

REPORT OF THE COUNCIL.

Since the last report of the Council, on February 13, 1876, the Academy has lost by death the following members:

James H. Eaton, Ph. D., for many years Professor of Chemistry in Beloit College, and one of the most valuable contributors to the Transactions of the Wisconsin Academy of Sciences, Arts and Letters. A memoir of Professor Eaton, contributed by his colleague, Professor T. C. Chamberlin, will be found at the end of this volume.

H. E. Copeland, A. M., Professor of Natural Sciences in the Whitewater State Normal School. No memoir of Professor Copeland has yet been presented.

John B. Feuling, Ph. D., Professor of Comparative Philology and Modern Languages in the University of Wisconsin, a memoir of whom, by his colleague, Professor S. H. Carpenter, will be found at the end of this volume.

Stephen H. Carpenter, LL. D., Professor of Logic and English Literature in the University of Wisconsin, whose sudden death has taken place while the last pages of this volume were in press. A brief sketch of his life, taken from the Wisconsin State Journal, will be found at the end of this volume.

J. E. DAVIES,
General Secretary.

LIST OF OFFICERS AND MEMBERS

OF THE

ACADEMY, 1878.

GENERAL OFFICERS OF THE ACADEMY.

(Term expires Dec. 27, 1878.)

PRESIDENT:

DR. P. R. HOY, RACINE.

VICE-PRESIDENTS:

DR. S. H. CARPENTER, - - - - -	MADISON.
PROF. T. C. CHAMBERLIN, - - - -	BELOIT.
REV. G. M. STEELE, D. D., - - - -	APPLETON.
HON. J. I. CASE, - - - - -	RACINE.
REV. A. L. CHAPIN, D. D., - - - -	BELOIT.
DR. J. W. HOYT, - - - - -	MADISON.

GENERAL SECRETARY:

PROF. J. E. DAVIES, M. D., UNIVERSITY OF WISCONSIN.

TREASURER:

GEO. P. DELAPLAINE, ESQ., MADISON.

DIRECTOR OF THE MUSEUM:

——— ———

LIBRARIAN:

——— ———

MEMBERS OF THE COMMITTEE EX-OFFICIO:

HIS EXCELLENCY THE GOVERNOR OF THE STATE.
THE LIEUTENANT GOVERNOR.
THE SUPERINTENDENT OF PUBLIC INSTRUCTION.
THE PRESIDENT OF THE STATE UNIVERSITY.
THE PRESIDENT OF THE STATE AGRICULTURAL SOCIETY.
THE SECRETARY OF THE STATE AGRICULTURAL SOCIETY.
THE PRESIDENT OF THE STATE HISTORICAL SOCIETY.
THE SECRETARY OF THE STATE HISTORICAL SOCIETY.

GENERAL OFFICERS OF THE ACADEMY.

* Term expires Dec. 27, 1881.

PRESIDENT:

A. L. CHAPIN, Beloit.

VICE PRESIDENTS:

Prof. R. D. IRVING, A. M., M. E.,	Madison.
Hon. G. H. PAUL,	Milwaukee.
G. M. STEELE, D. D.,	Appleton.

GENERAL SECRETARY:

Prof. J. E. DAVIES, A. M., M. D.,
University of Wisconsin.

TREASURER:

Hon. S. D. HASTINGS, Madison.

DIRECTOR OF THE MUSEUM:

Prof. G. W. PECKHAM, M. D., Milwaukee.

LIBRARIAN:

E. A. BIRGE, Ph. D., Madison.

* Owing to the unusual delay in the publication of the present volume of Transactions, it was thought advisable to print the above list of General Officers of the Academy, who were elected at the Regular Annual Meeting, held at Madison, Dec. 27, 1878.

OFFICERS OF THE DEPARTMENTS.

Department of Speculative Philosophy.

President Ex-Officio — THE PRESIDENT OF THE ACADEMY.
Vice-President — S. H. CARPENTER, LL. D., *State University.*
Secretary — REV. F. M. HOLLAND, *Baraboo*
Counselors — PRESIDENT BASCOM, *State University*, PROF. O. AREY, *Whitewater*, and REV. A. O. WRIGHT, *Fox Lake.*

Department of the Natural Sciences.

President Ex-Officio — THE PRESIDENT OF THE ACADEMY.
Vice-President — PROF. T. C. CHAMBERLIN, *Beloit.*
Secretary — PROF. J. H. EATON, *Beloit.*
Counselors — PROF. W. W. DANIELLS, *State University*, PROF. J. C. FOYE, *Appleton*, and PROF. THURE KUMLEIN, *Albion College.*

Department of the Social and Political Sciences.

President Ex-Officio — THE PRESIDENT OF THE ACADEMY.
Vice-President — REV. G. M. STEELE, *Appleton.*
Secretary — E. R. LELAND, *Eau Claire.*
Counselors — DR. E. B. WOLCOTT, *Milwaukee*, REV. CHAS. CAVERNO, *Lombard, Ill.*, and PROF. J. B. PARKINSON, *Madison.*

Department of the Mechanic Arts.

President Ex-Officio — THE PRESIDENT OF THE ACADEMY,
Vice-President — J. I. CASE, *Racine.*
Secretary — PROF. W. J. L. NICODEMUS, *State University.*
Counselors — CHAS. H. HASKINS, *Milwaukee*, HON. J. L. MITCHELL, *Milwaukee*, and CAPT. JOHN NADER, *Madison.*

Department of Letters.

President Ex-Officio — THE PRESIDENT OF THE ACADEMY.
Vice-President — REV. A. L. CHAPIN, D. D., *Beloit.*
Secretary — PROF. J. B. FEULING. *State University.*
Counselors — PROF. W. F. ALLEN, *Madison*, PROF. EMERSON, *Beloit*, and HON. L. C. DRAPER, *Madison.*

Department of the Fine Arts.

President Ex-Officio — THE PRESIDENT OF THE ACADEMY.
Vice-President — DR. J. W. HOYT, *Madison.*
Secretary — HON. J. E. THOMAS, *Sheboygan.*
Counselors — J. R. STUART, MRS. S. F. DEAN, and MRS. H. M. LEWIS, *Madison.*

MEMBERS OF THE ACADEMY.

LIFE MEMBERS.

Case, J. I., Hon., Racine, Wis.
Dewey, Nelson, Ex-Governor of Wisconsin, Madison, Wis.
Hagerman, J. J., Esq., Milwaukee, Wis.
Hoyt, J. W., M. D., Governor of Wyoming Territory.
Lawler, John, Esq., Prairie du Chien, Wis.
Mitchell, J. L., Hon., Milwaukee, Wis.
Noonan, J. A., Esq., Milwaukee, Wis.
Paul, G. H., Hon., Milwaukee, Wis.
Thomas, J. E., Hon., Sheboygan Falls, Wis.
Thorpe, J. G., Hon., Eau Claire, Wis.
White, S. A., Hon., Whitewater, Wis.

ANNUAL MEMBERS.

Adsit, N. H., Mrs., Milwaukee, Wis.
Allen, W. C., Hon., Racine, Wis.
Allen, W. F., A. M., Professor of Latin and History in the University of Wisconsin.
Bartlett, E. W., M. D., Milwaukee, Wis.
Bascom, John, LL. D., President of the University of Wisconsin.
Bashford, R. M., A. M., Madison, Wis.
Bate, A. W., Mrs., Milwaukee, Wis.
Birge, E. A., Ph. D., Instructor in Zoology in the University of Wisconsin.
Bryant, Ed. E., Hon., Madison, Wis.
Buck, James S., Milwaukee, Wis.
Bundy, W. F., A. M., Sauk City, Wis.
Butler, J. D., LL. D., Madison, Wis.
Cass, Josiah E., Eau Claire, Wis.
Caverno, Chas., Rev., Lombard, Ill.
Chamberlin, T. C., A. M., Professor of Natural History in Beloit College, and Director of the Geological Survey of Wisconsin.
Chapin, A. L., D. D., President of Beloit College, Beloit, Wis.
Conover, O. M., A. M., Madison Wis.
Daniells, W. W., M. S., Professor of Chemistry in the University of Wisconsin.

Davies, J. E., A. M., M. D., Professor of Physics in the University of Wisconsin.
Day, F. H., M. D., Wauwatosa, Wis.
Dean, S. F., Mrs., Madison. Wis.
DeHart, J. N., M D., Madison, Wis.
De Koven, James, Rev. Dr., Racine, Wis.
De La Matyr, W. A., Spring Green, Wis.
Delaplaine, Geo. P., Madison, Wis.
Doerflinger, Carl, Mrs., Milwaukee, Wis.
Doyle, Peter, Hon., Secretary of State of Wisconsin.
Draper, L. C., Hon., Madison, Wis.
Dudley, Wm., Madison, Wis.
Durand, H. S., Racine, Wis.
Durand, H. S., Mrs., Racine, Wis.
Durand, Frankie, Miss, Racine, Wis.
Durrie, D. S., Librarian Wisconsin State Historical Society, Madison, Wis.
Elmendorf, J. J., S. T. D., Professor in Racine College.
Emerson, Prof., Beloit College, Wis.
Falk, F. W., Ph. D., Professor in Racine College, Racine, Wis.
Farrar, Chas. A., Prest. Milwaukee College, Milwaukee Wis.
Farrar, Chas., Mrs., Milwaukee, Wis.
Ford, J. C., Hon., Madison, Wis.
Ford, Julia, Mrs., Milwaukee, Wis.
Foye, J. C., A. M., Professor of Physics in Lawrence University, Appleton, Wis.
Frackleton, Mrs., Milwaukee, Wis.
Gapen, Clark, M. D., Madison, Wis.
Germain, W. A., Delafield, Wis.
Giles, Ella, Miss, Madison, Wis.
Gordon, Geo., Milwaukee, Wis.
Gordon, Geo., Mrs., Milwaukee, Wis.
Gordon, G. E., Rev., Milwaukee, Wis.
Gregory, Chas. N., A. M., Madison, Wis.
Hailman, W. M., Milwaukee, Wis.
Hardy, Albert, Principal High School, Milwaukee, Wis.
Haskins, C. H., General Superintendent Northwestern Telegraph Company, Milwaukee, Wis.
Hastings, S. D., Hon., Madison, Wis.
Hawley, C. T., Milwaukee, Wis.
Henrickson, Peter, Prof., Beloit College, Beloit, Wis.
Holland, F. M., Rev., A. M., Baraboo, Wis.
Holton, E. D., Hon., Milwaukee, Wis.
Hoy, P. R., M. D., Racine, Wis.
Hoy, Jenny, Miss, Racine, Wis.
Hutchinson, B. E., Hon., Madison, Wis.
Irving, R. D., A. M., M. E., Professor of Geology and Mining Engineering in the University of Wisconsin.

Jones, Jenk. Ll., Rev., Janesville, Wis.
Kenaston, C. A., Ripon, Wis.
Kerr, Alex., A. M., Professor of Greek in the University of Wisconsin.
King, Chas. I., Superintendent Machine Shop, University of Wisconsin.
Kingston, J. P., Necedah, Wis.
Kleeberger, G. R., Whitewater, Wis.
Kumlein, Thure, Prof., Albion College, Albany, Wis.
Lapham, Mary J., Miss, Summit, Wis.
Lapham, S. G., Milwaukee, Wis.
Leland, E. R., Eau Claire, Wis.
Lewis, H. M., Mrs., Madison, Wis.
Lovewell, J. T., Professor in Female College, Milwaukee, Wis.
Luther, F. S., Rev., Racine College, Racine, Wis.
Mann, Chas., Milwaukee, Wis.
Marks, Solon, M. D., Milwaukee, Wis.
Mason, R. Z., LL. D., Appleton, Wis.
McLaren, W. P., Milwaukee, Wis.
McMurphy, J. G., Prof., Racine, Wis.
Meacham, J. G., M. D., Racine, Wis.
Meacham, J. G., Jr., M. D., Racine, Wis.
Merrill, Wm. P., Hon., Milwaukee, Wis.
Morris, W. A. P., Hon., Madison, Wis.
Nader, John, C. E., Madison, Wis.
Nicodemus, W. J. L., A. M., C. E., Professor of Civil and Mechanical Engineering in the University of Wisconsin.
Olin, D. A., Mrs., Racine, Wis.
Orton, Harlow S., Hon., Judge of Supreme Court of Wisconsin, Madison, Wis.
Parkinson, J. B., A. M., Professor of Civil Polity and Political Economy in the University of Wisconsin.
Parsons, P. B,, Madison, Wis.
Peckham, Geo. W., Professor of Natural Science in the Milwaukee High School, Milwaukee, Wis.
Perkins, D. W., M. D., Milwaukee, Wis.
Pinney, S. U., Hon., Madison, Wis.
Pradt, J. B., Rev., A. M., Madison, Wis.
Preusser, Chas., President of Natural History Society, Milwaukee, Wis.
Sawyer, W. C., Professor, in Lawrence University, Appleton, Wis.
Shaw, Samuel, A. M., Principal High School, and City Superintendent of Public Schools, Madison, Wis.
Shipman, S. V., Chicago, Ill.
Simmons, H. M., Rev., Kenosha, Wis.
Sloan, I. C., Hon., Madison, Wis.
Smith, R. B., Attorney at Law, Madison, Wis.
Smith, Wm. E., Governor of Wisconsin.
Sprague, A. R., Evansville, Wis.
Stark, G. A., M. D., Milwaukee, Wis.

Steele, Geo. M., Rev., D. D., President of Lawrence University, Appleton, Wis.

Stuart, J. R., A. M., Madison, Wis.

Swezey, G. D., A. M., Professor in Beloit College, Beloit, Wis.

Whitford, W. C., A. M., Superintendent of Public Instruction of the State of Wisconsin.

Wilkinson, John, Rev., A. M., Madison, Wis.

Willis, Olympia Brown, Mrs., Racine, Wis.

Winship, Eugene B., Racine College, Racine, Wis.

Wolcott, E. B., M. D., Milwaukee, Wis.

Wolcott, Laura J., Mrs., Milwaukee, Wis.

Wood, J. W., Baraboo, Wis.

Woodman, E. E., Baraboo, Wis.

Wright, A. O., Rev., Fox Lake, Wis.

CORRESPONDING MEMBERS.

Abbott, C. C., M. D., Trenton, New Jersey.

Andrews, Edmund, A. M., M. D., Professor in Chicago Medical College, Chicago, Ill.

Barrow, John W., No. 313 East Seventeenth street, New York city.

Bridge, Norman, M. D., Chicago, Ill.

Brinton, J. G., M. D., Philadelphia, Pa.

Buchanan, Joseph, M. D., Louisville, Ky.

Burnham, S. W., F. R. A. S., Chicago, Ill.

Byrness, R. M., M. D., Cincinnati, Ohio.

Carr, E. S., M. D., Superintendent Public Instruction, California.

Ebener, F., Ph. D., Baltimore, Md.

Gatchell, H. P., M. D., Kenosha, Wis.

Gill, Theo., M. D., Smithsonian Institute, Washington, D. C.

Gilman, D. C., President John Hopkins' University.

Haldeman, S. S., LL. D., Professor in University of Pennsylvania, Chickis, Penn.

Harris, W. T., LL. D., St. Louis, Mo.

Hopkins, F. V., M. D., Baton Rouge, La.

Horr, Asa, M. D., President Iowa Institute of Arts and Sciences, Dubuque, Iowa.

Hubbell, H. P., Winona, Minn.

Jewell, J. S., A. M., M. D., Professor in Chicago Medical College, Chicago, Ill.

Le Barron, Wm., State Entomologist, Geneva, New York.

Marcy, Oliver, LL. D., Prof., Northwestern University, Evanston, Ill.

Morgan, L. H., LL. D., Rochester, Ill.

Newberry, J. S., LL. D., Prof., Columbia College, New York.

Orton, E., A. M., President Antioch College, Yellow Springs, Ohio.

Paine, Alford, S. T. D., Hinsdale, Ill.

Porter, W. B., Prof., St. Louis,Mo.

Safford, T. H., Director of the Astronomical Observatory of Williams College, Williamstown, Mass.

Schele, De Vere M., L. L. D., Prof. University of Viriginia, Charlotteville, Va.

Shaler, N. S., A. M., Prof. Harvard University, Cambridge, Mass.

Trumbull, J. H., LL. D., Hartford, Conn.

Verrill, A. E., A. M., Prof. Yale College, New Haven, Conn.

Van DeWarker, Eli, M. D., Syracuse, New York.

Watson, James C., A. M., Director of the Washburn Astronomical Observatory at Madison, Wis.

Whitney, W. D., Prof. Yale College, New Haven, Conn.

Winchell, Alex., LL. D., Chancelor of Syracuse University, Syracuse, N. Y.

HONORARY MEMBERS.

Baird, Spencer, F. M. D., LL. D., Washington, D. C.

Hamilton, Joseph, Hon., Milwaukee, Wis.

NOTE — Members of the Academy will confer a favor upon the secretary by communicating to him their full postoffice address, and by giving him timely notice of any permanent change of residence on their part; also by pointing out any corrections needed in the foregoing lists of members.

MEMBERS DECEASED

Since the Organization of the Academy in 1870.

Wm. Stimpson, M. D., Late Secretary Chicago Academy of Sciences, Chicago, Ill.

J. W. Foster, LL. D., late Professor in the University of Chicago, Chicago Ill. Died June 29, 1873.

Rt. Rev. Wm. E. Armitage, S. T. D., Bishop of Wisconsin, and for a term Vice President of the Academy of Sciences. Died Dec. 7, 1873.

Hon. John Y. Smith, Madison, Wis. Died May 5, 1874.

Prof. Peter Englemann, Milwaukee, Wis. Died May 17, 1874.

I. A. Lapham, LL. D., Milwaukee, Wis. First Secretary of the Wisconsin Academy of Sciences, Arts and Letters. Died Sept. 14, 1875.

Hon. A. S. McDill, M. D., Madison, Wis. Died Nov. 12, 1875.

Prof. H. E. Copeland, Whitewater State Normal School, Whitewater, Wis.

James H. Eaton, late Professor of Chemistry in Beloit College, Beloit, Wis. Died Jan. 5, 1877.

J. C. Freer, late President Rush Medical College, Chicago, Ill. Died April 12, 1877.

Thos. Blossom, M. E., School of Mines, Columbia College, New York. Corresponding member of the Academy.

Prof. H. F. Oldenhage, Milwaukee High School, Milwaukee, Wis.

J. B. Feuling, Ph. D., late Professor of Modern Languages and Comparative Philology in the University of Wisconsin. Died March 10, 1878.

J. Wingate Thornton, Boston, Mass. Corresponding member of the Academy. Died June 6, 1878.

S. H. Carpenter, LL. D., late Professor of Logic and English Literature in the University of Wisconsin. Died Dec. 7, 1878.

COMMITTEES OF THE ACADEMY.

By-law No. 5, states that there shall be the following Standing Committees, to consist of three members each, when no other number is specified:

1. On Nominations.
2. On Papers presented to the Academy.
3. On Finance.
4. On the Museum.
5. On the Library.
6. On the Scientific Survey of the State; which committee shall consist of the Governor, the President of the State University, and the President of this Academy.
7. On Publication; which committee shall consist of the President of the Academy, the Vice-Presidents, and the General Secretary.

Under this by-law it has been customary to appoint, on the first committee, three members of the Academy present at the beginning of the regular meeting, at which the nominations are made.

The President and General Secretary of the Academy constitute the second.

The committee on Finance, to whom is referred the report of the Treasurer, consists of three members of the Academy, appointed by the President at the regular annual meeting in February or December.

The committee on the Museum at present consists of Professors T. C. Chamberlin, R. D. Irving and J. C. Foye.

The committee on the Library consists of Prof. W. F. Allen, Gen. Geo. B. Delaplaine and Gen. Ed. E. Bryant.

CHARTER, CONSTITUTION AND BY-LAWS

OF THE

ACADEMY OF SCIENCES, ARTS, AND LETTERS,

OF WISCONSIN

With the Amendments thereto, up to February, 1878.

CHARTER.

AN ACT TO INCORPORATE THE "WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS.

The people of the State of Wisconsin, represented in Senate and Assembly, do enact as follows:

SECTION 1. Lucius Fairchild, Nelson Dewey, John W. Hoyt, Increase A. Lapham, Alexander Mitchell, Wm. Pitt Lynde, Joseph Hobbins, E. B. Wolcott, Solon Marks, R. Z. Mason, G. M. Steele, T. C. Chamberlin, James H. Eaton, A. L. Chapin, Samuel Fallows, Charles Preuser, Wm. E. Smith, J. C. Foye, Wm. Dudley, P. Englemann, A. S. McDill, John Murrish, Geo. P. Delaplaine, J. G. Knapp, S. V. Shipman, Edward D. Holton, P. R. Hoy, Thaddeus C. Pound, Charles E. Bross, Lyman C. Draper, John A. Byrne, O. R. Smith, J. M. Bingham, Henry Bætz, Ll. Breese, Thos. S. Allen, S. S. Barlow, Chas. R. Gill, C. L. Harris, George Reed, J. G. Thorp, William Wilson, Samuel D. Hastings, and D. A. Baldwin, at present being members and officers of an association known as "The Wisconsin Academy of Sciences, Arts and Letters," located at the city of Madison, together with their future associates and successors forever, are hereby created a body corporate by the name and style of "The Wisconsin Academy of Sciences, Arts and Letters," and by that name shall have perpetual succession; shall be capable in law of contracting and being contracted with, of suing and being sued, of pleading and being impleaded in all courts of competent jurisdiction; and may do and perform such acts as are usually performed by like corporate bodies.

SECTION 2. The general objects of the Academy shall be to encourage investigation and disseminate correct views in the various departments of science, literature and the arts. Among the specific objects of the academy shall be embraced the following:

1. Researches and investigations in the various departments of the material, metaphysical, ethical, ethnological and social science.
2. A progressive and thorough scientific survey of the state, with a view of determining its mineral, agricultural and other resources.
3. The advancement of the useful arts, through the applications of science, and by the encouragement of original invention.
4. The encouragement of the fine arts, by means of honors and prizes awarded to artists for origiual works of superior merit.
5. The formation of scientific, economical and art museums.
6. The encouragement of philological and historical research, the collection and preservation of historic records, and the formation of a general library.

SECTION 3. Said Academy may have a common seal and alter the same at pleasure; may ordain and enforce such constitution, regulations and by-laws as may be necessary, and alter the same at pleasure; may receive and hold real and personal property, and may use and dispose of the same at pleasure; *provided*, that it shall not divert any donation or bequest from the uses and objects proposed by the donor, and that none of the property acquired by it shall, in any manner, be alienated other than in the way of an exchange of duplicate specimens, books, and other effects, with similar institutions and in the manner specified in the next section of this act, without the consent of the legislature.

SECTION 4. It shall be the duty of said Academy, so far as the same may be done without detriment to its own collections, to furnish, at the discretion of its officers, duplicate typical specimens of its objects in natural history to the University of Wisconsin, and to the other schools and colleges of the state.

SECTION 5. It shall be the duty of said Academy to keep a careful record of all its financial and other transactions, and, at the close of each fiscal year, the president thereof shall report the same to the governor of the state, to be by him laid before the legislature.

SECTION 6. The constitution and by-laws of said Academy now in force shall govern the corporation hereby created, until regularly altered or repealed; and the present officers of said Academy shall be officers of the corporation hereby created until their respective terms of office shall regularly expire, or until their places shall be otherwise vacated.

SECTION 7. Any existing society or institution having like objects embraced by said Academy, may be constituted a department thereof, or be otherwise connected therewith, on terms mutually satisfactory to the governing bodies of the said Academy and such other society or institution.

SECTION 8. For the proper preservation of such scientific specimens, books and other collections as said Academy may make, the governor shall prepare such apartment or apartments in the capitol as may be so occupied without inconvenience to the state.

SECTION 9. This act shall take effect and be in force from and after its passage.

Approved March 16, 1870.

CONSTITUTION.

NAME AND LOCATION.

SECTION 1. This association shall be called "The Wisconsin Academy of Sciences, Arts and Letters," and shall be located at the city of Madison.

GENERAL OBJECTS.

SECTION 2. The general object of the Academy shall be to encourage investigations and disseminate correct views in the various departments of Science, Literature and the Arts.

DEPARTMENTS.

SECTION 3. The Academy shall comprise separate Departments, not less than three in number, of which those first organized shall be:

1st. *The Department of Speculative Philosphy* —

Embracing:
- Metaphysics;
- Ethics.

2d. *The Department of the Social and Political Sciences* —

Embracing:
- Jurisprudence;
- Political Science;
- Education;
- Public Health;
- Social Economy.

3d. *The Department of Natural Sciences* —

Embracing:
- The Mathematical and Physical Sciences;
- Natural History;
- The Anthropological and Ethnological Sciences.

4th. *The Department of Arts* —

Embracing:
- The Practical Arts;
- The Fine Arts.

5th. *The Department of Letters* —

Embracing:
- Language;
- Literature;
- Criticism;
- History.

SECTION 4. Any branch of these Departments may be constituted a section; and any section or group of sections may be expanded into a full Department, whenever such expansion shall be deemed important.

SECTION 6. Any existing society or institution mey be constituted a Department, on terms approved by two-thirds of the voting members present at two successive regular meetings of the Academy.

SPECIAL OBJECTS OF THE DEPARTMENTS.

SECTION 6. The specific objects of the Department of Sciences shall be:
1. General Scientific Research.
2. A progressive and thorough Scientific Survey of the State, under the direction of the Officers of the Academy.
3. The formation of a Scientific Museum.
4. The Diffusion of Knowledge by the publication of Original Contributions to Science.

The object of the Department of the Arts shall be:
1. The Advancement of the Useful Arts, through the Application of Science and the Encouragement of Original Invention.
2. The Encouragement of the Fine Arts and the Improvement of the Public Taste, by means of Honors and Prizes awarded to Works of Superior Merit, by Original Contributions to Art, and the Formation of an Art Museum.

The objects of the Department of Letters, shall be:
1. The Encouragement of Philological and Historical Research.
2. The Improvement of the English Language.
3. The Collection and Preservation of Historic Records.
4. The Formation of a General Library.

MEMBERSHIP.

SECTION 7. The Academy shall embrace four classes of governing members who shall be admitted by vote of the Academy, in the manner to be prescribed in the By-Laws:

1st. Annual Members, who shall pay an initiation fee of five dollars, and thereafter an annual fee of two dollars.

2d. Members for Life, who shall pay a fee of one hundred dollars.

3d. Patrons, whose contributions shall not be less than five hundred dollars.

4th. Founders, whose contributions shall not be less than the sum of one thousand dollars.

Provisions may also be made for the election of honorary and corresponding members, as may be directed by the by-laws of the Academy.

MANAGEMENT.

SECTION 8. The management of the Academy shall be intrusted to a general council; the immediate control of each Department to a Department Council. The General Council shall consist of the officers of the Academy, the officers of the Departments, the Governor and Lieutenant Governor, the Superintendent of Public Instruction, and the President of the State University, the President and Secretary of the State Agricultural Society, the President and Secretary of the State Historical Society. Counselors *ex-officiis*, and three Counselors to be elected for each Department. The Department Councils shall consist of the President and Secretary of the Academy, the officers of the Department, and three Counselors to be chosen by the Department.

OFFICERS.

SECTION 9. The officers of the Academy shall be: a President, who shall be *ex-officio* President of each of the Departments; one Vice-President for each Department; a General Secretary; a General Treasurer; a Director of the Museum, and a General Librarian.

SECTION 10. The officers of each Department shall be a Vice-President, who shall be *ex-officio* a Vice-President of the Academy; a Secretary and such other officers as may be created by the General Council.

Section 11. The officers of the Academy and the Departments shall hold their respective offices for the term of three years and until their successors are elected.

Section 12. The first election of officers under this Constitution shall be by its members at the first meeting of the Academy.

Section 13. The duties of the officers and the mode of their election, after the first election, as likewise the frequency, place and date of all meetings, shall be prescribed in the By-Laws of the Academy, which shall be framed and adopted by the General Council.

Section 14. No compensation shall be paid to any person whatever, and no expenses incurred for any person or object whatever, except under the authority of the Council.

RELATING TO AMENDMENTS.

Section 15. Every proposition to alter or amend this constitution shall be submitted in writing at a regular meeting; and if two-thirds of the members present at the next regular meeting vote in the affirmative, it shall be adopted.

AMENDMENTS TO THE CONSTITUTION.

Amendment to Section 3: "The Department of the Arts shall be hereafter divided into the Department of the Mechanic Arts and the Department of the Fine Arts." Passed February 14, 1876.

BY-LAWS.

ELECTION OF MEMBERS.

1. Candidates for membership must be proposed in writing, by a member, to the General Council and referred to the committee on Nominations, which committee may nominate to the Academy. A majority vote shall elect. Honorary and corresponding members must be persons who have rendered some marked service to Science, the Arts, or Letters, or to the Academy.

ELECTION OF OFFICERS.

2. All officers of the Academy shall be elected by ballot.

MEETINGS.

3. The regular meetings of the Academy shall be as follows:

On the 2d Tuesday in February, at the seat of the Academy; and in July, at such place and exact date as shall be fixed by the Council; the first named to be the Annual Meeting. The hour shall be designated by the Secretary in the notice of the meeting. At any regular meeting, ten members shall constitute a quorum for the transaction of business. Special meetings may be called by the President at his discretion, or by request of any five members of the General Council.

Amended at Racine, July 10, 1878, as follows:

The regular *Annual* Meeting of the Academy, shall be held as follows:

On the last Wednesday and Thursday in December, at the seat of the Academy; and the regular *Semi-annual* Meeting shall be held in July, at such time and place as shall be determined upon at the previous regular Annual Meeting in December. The hour shall be designated by the Secretary in the notice of the meeting.

Special meetings may be called by the President or the General Secretary, at their discretion or by request of any five members of the General Council.

DUTIES OF OFFICERS.

4. The President, Vice-President, Secretaries, Treasurer, Director of the Museum and Librarian shall perform the duties usually appertaining to their respective offices, or such as shall be required by the Council. The Treasurer shall give such security as shall be satisfactory to the Council, and pay such rate of interest on funds held by him as the Council shall determine. Five members of the General Council shall constitute a quorum.

COMMITTEES.

5, There shall be the following Standing Committees, to consist of three members each, when no other number is specified:

On Nominations.
On Papers presented to the Academy.
On Finance.

On the Museum.
On the Library.
On the Scientific Survey of the State; which Committee shall consist of the Governor, the President of the State University and the President of this Academy.
On Publication; which Committee shall consist of the President of the Academy, the Vice-Presidents, and the General Secretary.

MUSEUM AND LIBRARY.

6. No books shall be taken from the Library, or works or specimens from the Museum, except by authority of the General Council; but it shall be the duty of said Council, to provide for the distribution to the State University and to the Colleges and public Schools of the State, of such duplicates of typical specimens in Natural History as the Academy may be able to supply without detriment to its collections.

ORDER OF BUSINESS.

7. The order of business at all regular meetings of the Academy or of any Department, shall be as follows:

Reading minutes of previous meeting.
Reception of donations.
Reports of officers and committees.
Deferred business.
New business.
Reading and discussion of papers.

SUSPENSION AND AMENDMENT OF BY-LAWS.

8. The By-Laws may be suspended by a unanimous vote, and in case of the order of business a majority may suspend. They may be amended in the same manner as is provided for in the Constitution, for its amendment.

IN MEMORIAM.

IN MEMORIAM.

PROF. JAMES. H. EATON, Ph. D.

Late Professor of Chemistry and Physics in Beloit College.

By T. C. CHAMBERLIN.

Once and again, a seventh time and an eighth, has our Society been called upon to lament the departure of an esteemed and honored member.

An Armitage, an Engleman, a Foster, a Lapham, a Stimpson, a Smith, and a McDill have passed in turn from our number and have left vacancies we may not hope to fill, losses we may not hope to repair. Esteemed and mourned, as these have been, the more esteemed and the more lamented as we have known them the more intimately, our sorrow is no less profound, our bereavement is even yet sadder, as we realize the loss of a younger and no less earnest co-laborer, the devoted Eaton.

The 21st of June, 1842, marked the beginning, and the morning of the 5th of January, 1877, beheld the close of the life of Prof. James H. Eaton, a span of thirty-four years — twenty-five years of preparation, nine years of work.

To his father, at once a scholar, a teacher and an author, he owed much of that firm intellectual foundation upon which he erected so true and trustworthy a scholarship. His early training was received in earth's best and truest university, the home, a cultured, Christian home. To this was added the vigorous discipline of Phillip's Academy, the wider culture of Amherst College and the technical training of Göttingen University. The fruitage of these rare opportunities was everywhere manifest in the mental acquisitions of Prof. Eaton. His academic scholarship was thorough and accurate, firm and solid. There was no weakness or unsoundness in the foundation. We could admire the symmetrical shaft, the ornate capital, and the chaste entablature of the intellectual column, with no misgiving lest a weak or crumbling pedestal should work its ruin.

His culture was broad and catholic. Because he was a chemist, he did not find it necessary to despise the linguist. Because he traced and taught the history of an atom, he did not deprecate the merits of those who taught the history of man, or of his institutions. Because he could give visible demonstration of the laws of the physical elements, he did not disparage the more occult sanctions of civil, moral and religious laws. Because he dealt with the material, he did not scorn the spiritual.

While not an omniverous student, the bounds of his special investigations did not constitute for him the horizon of truth. He believed in the rotundity of the intellectual world; that, to whatever eminence, as an explorer of truth, he might climb, and however much his vision might thereby be amplified, there was yet beyond a wider circumference, and, however antipodal some phenomena might seem, they were still embraced in the sphericity of truth. How often in our judgment of truth do we forget that the completeness and perfection of the whole involves contrast and antagonism of the parts.

These enlarged views found expression in the opinions and efforts of Prof. Eaton as an educator. While an enthusiastic devotee of science, thoroughly impressed with its value as an educational agency, he at the same time fully recognized the importance of co-ordinate literary, ethical, and æsthetical culture. He extended neither sympathy nor fellowship toward the educational one-ideaism that finds expression in the average scientific course. It was largely due to his influence that the so-called Scientific course of Beloit College was abolished, while he gave a hearty support to the broader and more symmetrical Philosophical course, which is producing so much richer fruit. As an educator he despised narrowness, whether it were vertical or horizontal whether it arose from building upon a constricted foundation or from the tenuity of superficial diffuseness, and so he stood opposed alike to efforts to confine education to a single or a few lines of thought, on the one hand, and attempts, on the other hand, to spread the curriculum over the whole surface of knowledge without giving thorough or adequate instruction in any department of it.

One of the most prominent characteristics of Prof. Eaton, as a scientist and as a man, was his perfect sincerity and scrupulous conscientiousness. A worshiper of the truth, he spurned hypocrisy. A firm believer in the potency and permanence of truth, he scorned to erect a fabric of fallacy for personal or politic purposes. If error marked his views, it was the error of mistake, and not the aberration of guile. If, as all original investigators do, he gathered misconceptions, mingled with his gathering of facts, they were no sooner discovered than cast aside, however much they may have been interwoven with the fabric of his thought, and however much his personal feelings may have been involved by their publication. It requires courage and a conscience to do this.

His mental vision was marked by clearness and accuracy, the outgrowth in part of native endowments, and in no small part, we judge, of that consci entiousness we so much admired. How easy it is to deflect our intellectual sight and warp the native integrity of our judgment. The rays of truth have come to few through purer and clearer lens or one kept more perfect by conscientious care.

Patient industry marked all his endeavors and secured for him honors as a student, respect and confidence as a teacher, and esteem as a scientist. Painstaking preparation for every undertaking was a conspicuous trait. The summation of his life is but a type of his daily habit — twenty-five years of preparation, nine years of work.

To these mental and moral characters there was added religious belief and religious culture. He seemed to us to exemplify in an eminent degree the true attitude of faith and science. They appeared the right hand and the left hand of his being; set over against each other, indeed, antagonizing each other's action in a sense, yet both working together in mutual confidence and love for the good of the whole being.

His religious views never seemed to hamper his scientific conceptions, nor his science circumscribe the domain of his faith. He never seemed to hope or fear that his crucible would analyze the human soul, but in quiet and courageous trust he lived a true scientist and a true Christian.

His scientific labors have been so interwoven with the history of this Society that they do not need formal memorial here. We but repeat the spontaneous judgment of those most intimately associated with his investigations, as well as those who have listened to his productions, when we characterize them in terms of high esteem and admiration.

JOHN BAPTIST FEULING, PH. D.

BY STEPHEN H. CARPENTER, LL. D.

Professor of Logic and English Literature in the University of Wisconsin.

Dr. John Baptist Feuling, Professor of Modern Languages and Comparative Philology in the University of Wisconsin, died at Fayette, Iowa, March 10, 1878, after a lingering illness of more than six months.

Dr. Feuling was born in the classic city of Worms, Germany, February 12th, 1838. He attended the public school until his tenth year. In 1848 he entered the Gymnasium, from which he graduated nine years after, in 1857, with a first degree, and entered the University at Giessen to study Philology. His studies at the University were interrupted by being called to serve in the army, but after two months' service, he returned, and passed his public examination in 1860. While at the University he gave private instruction, and after leaving, he accepted a position in the Institute of St. Gowishausen, on the Rhine, as teacher of Latin and Greek. During 1861 he spent six months at the Bibliotheque Imperiale, at Paris, mainly in the study of Philology, and in acquiring a conversational mastery of the French language.

He came to this country in 1865, landing at Portland, Maine, April 14th. He went directly to New York, where he remained some time. He then spent a year at Toledo, Ohio, where he opened a French and German Academy. Not succeeding in this enterprise, he came west, and was employed for a time at Racine College in giving instruction in the classic languages, from which place he was called by President Chadbourne to the chair of Modern Languages and Comparative Philology, at the University of Wisconsin, in the spring of 1868 — which position he filled at the time of his death. Shortly after his accession to his professorship here, he was invited to the Professorship of Ancient Languages in the University of Louisiana, at Baton Rouge, and visited that place on a tour of inspection. The position was held open for him one year, when he finally declined it, preferring to remain here, although his preference was for the chair of Ancient Languages.

Dr. Fueling was married November 21st, 1868, to Miss Laura H. Aldrich, whose care and devotion have smoothed his dying pillow, and ministered to every want.

In 1876 he visited his old world home on a brief tour, but returned heartily in sympathy with American ways, and our systems of education, after having had the opportunity of comparing the two systems with his matured judgment. Indeed, he remarked to the writer of this sketch that his views as to the expediency of adopting the German method in this country had undergone a complete change — that while the German system carried a few students further, the American system carried the mass of students to a practical education unknown to the German system. The word "university" not designating the same grade of institution here as in Germany, it took him some time to adjust himself to the wants of the students that he here met, but during the last years of his life he was thoroughly in sympathy with his work and with the students under his charge.

The published works of Dr. Feuling are few. Shortly after coming to Madison he published an edition of the *Poema Admonitorium* of Phocylides, prefacing the Greek text with an introduction written in fluent Latin. This was dedicated to the American Philological Association, of which he was an active member, and before which he read several papers. He was also a member of the Wisconsin Academy of Sciences, Arts and Letters, and contributed several philological papers to its transactions. He has left several works in manuscript — "The Homeric Hymns," with notes; Montesquieu's "Considerations," with notes and a glossary, intended as a French Reading Book, which is nearly ready for the press; also "An Historical Outline of Germanic Accidence," which was nearly completed at his death. All these works show on every page his profound and thorough scholarship, and leave no room for doubt that had he lived he would have gained a lasting reputation in his chosen field of study. With him, teaching was not a drudgery; he felt proud of his profession, and discharged his duty with a conscientious fidelity.

As a man, he was genial, companionable and trustful. With an ardent temperament, his likes and dislikes were strong, and sometimes strongly expressed, but withal, he was free from baseless prejudices. He was as prompt to acknowledge a fault as to forgive a wrong. He had warm friends, and this is one of the best tests of manhood.

As a Christian, he kept the faith. He was brought up in the Roman Catholic Church, but on coming to this country he identified himself with the Episcopal Church, of which he was a constant communicant until his death. He died in Christian charity towards all, and let the living exercise the same charity towards whatever faults in human fraility he may have had. He died in the Christian's hope of a blessed immortality.

In the summer of 1877 he felt the premonitions of the fatal disease to which he finally succumbed. It appeared first as a paralysis of the right hand, which he naturally attributed to excessive use of his arm in writing, but the steady advance of the paralysis soon left no doubt that the disease was seated in the brain, and that no human agency could arrest its progress. For some three weeks he attempted to carry on his work, but was then forced to cease his labor in the hope that rest and quiet would restore his health; but disease had too firm a hold upon his system, and he steadily failed. In January he was removed to Fayette, Iowa, the residence of his wife's parents, in the faint hope that a removal from the scene of his labor would lessen the irritation that a man of his active temperament must have felt at being laid aside from duty; and, that care and quiet and the constant medical attendance of his wife's father might have a beneficial effect. But all was in vain, he failed; struggled with disease, and rallied, only to fall back beaten by his powerful antagonist. The disease of the brain steadily progressed, extinguishing one after another of his faculties; his speech gradually failed; then his sight; and at last he gave no signs of consciousness; and so life ebbed away, and death baffled all human effort. Love could not hold him, but Love can cherish the memory of his life.

His remains were brought for interment to Madison, where he wished to be buried. On a bright spring-like day a large concourse of mourners, composed of the Faculty and students of the University, and a large number of personal friends, gathered at his late residence, and followed his remains to the Episcopal church, where the solemn but hopeful and impressive service of the churce he so loved was held by Rev. Mr. Wilkinson, assisted by Rev. J. B. Pradt, after which his body was laid to rest in Forest Hill Cemetery, in sight of the city that he loved as his earthly home, and of the University, the scene of the labors of his active life; and there he rests, awaiting the resurrection of the just. *Requiescat in pace!*

NOTE. — It was Prof. Carpenter's intention to have completely re-written and extended the above notice of the life and death of Dr. Feuling, and he had promised the Secretary of the Academy to do so, only a few days before he was himself seized with the illness which so suddenly terminated his own life. "In the midst of life we are in death."

DEATH OF PROFESSOR S. H. CARPENTER.

[*From the State Journal (Madison) of Dec.* 7, 1878.]

Professor Stephen Haskins Carpenter, of the University of Wisconsin, died at half-past five o'clock on the morning of December 7, 1878, at Geneva, N. Y., of diphtheria, which had already proved fatal to his brother and nephew, a few days before.

Professor Carpenter's death is one of the saddest events we have ever been called on to chronicle. He was widely and favorably known, not only in this state, where he had devoted the best part of his life to the State University, but throughout the literary and educational circles of the country. As an educator he stood among the foremost, and in all matters pertaining to that avocation, his large experience and sound judgment stamped his opinions with unquestioned authority. He was devoted to the University, and rejected many tempting offers from other colleges, that he might retain his chair in her Faculty and continue to labor for her. He had seen the University grow from a mere academy to a great and prosperous institution, and this growth was due in a large part to his devotion to her, and to his zeal in her behalf. The institution with which he, with others, had so long been identified, is a memorial of his and their services and devotion. In everyday life, Professor Carpenter took a busy part; his acquaintance was large, and he was connected with other interests than the University. He was esteemed by all who met and knew him in these outside interests. But by the hundreds of students whom he has taught for so many years past, he was peculiarly loved. His associates have not failed to receive the respect of the students, but perhaps none have ever attained that position in their affection which Professor Carpenter has always held; and the announcement of his sudden death was received with exquisite sorrow by the *alumni* of the University, who had learned to love him while under his instruction, and by the undergraduate students from whom he parted but a week before his death.

Professor Carpenter was born August 7, 1831, at Little Falls, Herkimer county, N. Y., and his early education was obtained at his own home, his preparation for college being obtained at Munro Academy, Elbridge, N. Y. In 1848, he entered the Freshman class of the Madison University, at Hamilton, N. Y., where he remained two years, when he entered the University of Rochester, from which he took the degree of A. B. in 1852; A. M. in 1855, and in 1872, the degree of LL. D. was conferred upon him by his *alma mater*. He came to Wisconsin in 1852, and held the office of tutor for two years in its University. From 1858 to 1860 he was Assistant Superintendent of Public Instruction, and did much towards systematizing that office. In 1860, he was elected Professor of Ancient Languages in St. Paul's College, Palmyra, Mo., which position he held until the rebellion broke up the institution. He then returned north, taught select school one winter, and afterward worked at the printer's trade, devoting his spare time to literary pursuits. He held the office of city clerk of Madison from 1864 to 1868, but was all the time engaged in educational enterprises, as County Superintendent of Schools and member of the City Board of Education. In 1866, he was appointed by the Regents of the University to the chair vacated by Prof. Read, who had been called to the presidency of the Missouri University; in 1868, he was elected Professor of Rhetoric and English Literature, since which time his connection with the University has been continuous, but the title of his professorship was changed to that of Logic and English Literature. In 1875, he was elected President of Kansas University, but declined.

As a writer, he has contributed very largely to the religious and educational periodicals of the country. Ten of his educational addresses have been published and highly commended by literary authorities. His lectures, twelve in number, on the evidence of Christianity, were published a few years since, and have been well received. He has also been quite a translator from the French language, of which he was master. His articles on metaphysical subjects published in the Transactions of the Wisconsin Academy of Sciences, Arts and Letters, have attracted a good deal of attention, and been favorably reviewed in the periodical reviews of the country. But what has contributed most to his fame as a scholar and an educationist, is his proficiency in the Anglo-Saxon and early English languages. In 1872, he published a book, entitled "English of the Fourteenth Century," containing a critical examination of the English of Chaucer. In 1875, he published "An Introduction to the Study of the Anglo-Saxon," as a text-book, which has passed through several editions, and which the London School Board *Chronicle* has noticed in the most complimentary terms. His "Elements of English Analysis" published in 1877, is already in its second edition. His literary and scholarly abilities were of constant growth, and his fame was far from having reached its zenith.

The loss to the Wisconsin University, in his death, is an irreparable one, and the world of letters has been bereft of one of its most brilliant writers and thinkers. No words are adequate to offer solace to the bereaved wife — the balm of a religious hope, the consolations of a gospel, which he sincerely believed and ably defended, and the hope of a blessed reunion in a brighter and better world, must supply what nothing earthly can do.

ERRATA.

Page 188, for "J. M. De Hart," read "J. N. De Hart."

190, 14th line from bottom, for "[*Fig.* 3–4]" read "[*Fig.* 3.]"

193, under the figure insert:

A. Shaft six feet square.

B. E. Groups of stones.

C. Drift into side of the tumulus.

D. Bottom of tumulus.

F. Skeletons of adults.

G. Skeleton of child.

H. Fragment of pottery.

K. Surface of adjoining ground.

196, 5th line from top, for "alercolar" read "alveolar."

196, 5th line from bottom, for "dics" read "discs."

197, 2d–3d line from top, for "on page 7" read "opposite page 192."

197, 3d line from top, for "that" read "then."

197, 3rd line from bottom, after "inches," insert "(*Fig.* 11)."

198, under the figure insert:

A. Layer of gravel one foot thick.

B. Course of dark loam three feet thick

C. Layer of gravel.

D. Loam.

E. Gravel.

F. Stone altar three feet high.

G. Tree growing from the mound.

200, 2d line from bottom, for "Americans" read "Americana."

200, last line, for "above overturned" read "cast of," and for "formed by squares" read "found by Squier."

201, heading—"Department of the Mathematical and Physical Sciences,"—should be omitted.

235, after name of author, for "Kenosha" read "Racine."

246, 7th line from top, for "experiment" read "experiments."