THE

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EDINBURGH NEW PHILOSOPHICAL JOURNAL,

EXHIBITING A VIEW OF THE

PROGRESSIVE DISCOVERIES AND IMPROVEMENTS

IN THE

SCIENCES AND THE ARTS.

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In the Number for July 1856, page 172, line 7 from the bottom, it ought to have been stated that the list of Algæ, furnished by Mr Hennedy, had previously been communicated to the Natural History Society of Glasgow.

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On the Tribual Government of the Ruder Nations. By LOUIS K. DAA, of Christiania.

The object of the following remarks is twofold.

1. Certain facts connected with the tribual organization of the ruder varieties of mankind will be shown to be much more general than is usually supposed.

2. Certain inferences will be drawn from their existence explanatory of some of the more remarkable phenomena connected with the great diversity of language and tribe within the narrow limits of a small population.

The system under notice is, perhaps, found at its *maximum* amongst the North American Indians; amongst whom we find—

First, The division into tribes or clans.

Secondly, The habit of each tribe having a sort of armorial bearing called the Totem.

Thirdly, The regulation that no man shall marry within his own clan, *i.e.* with a female of the same totem.

It is sufficiently obvious, that in these three facts we have elements of no small importance in the natural history of the savage state.

The form which these institutions take in America is shown by the following extract from Gallatin, in his Synopsis of the Indian Tribes. The italics are the present writer's.

" They will hardly submit to any restraints; and it is well known that the nominal title of chief confers but little power, either in war or peace, on their leader, whose precarious authority depends almost entirely on their personal talents and energy. Yet we find the nominal dignity of Chief, Sachem, Mingo, or King, to have been, with but few exceptions, amongst all the Indians, not only for life, but hereditary. But another institution, belonging to all the southern, and of which traces may be found amongst the northern nations, deserves particular consideration.

"Independent of political or geographical position, the division into families or clans has been established from time immemorial; but at what time, and in what manner, the division was first made, is not known. At present, or till very lately, every nation was divided into a number of clans, varying in the several nations from three to eight or ten, the members of which were respectively dispersed indiscriminately throughout the whole nation. It has been fully ascertained, that the inviolable regulations by which those clans were perpetuated amongst the southern nations were, first, that *no man should marry in his own clan; secondly, that every child belongs to his or her mother's clan.* Among the Choctaws there are two great divisions, each of which is subdivided into four clans; and no man can marry in any of the four divisions belonging to his division. The restriction amongst the Cherokees, the Creeks, and the Natches, does not extend beyond the clan to which the man belongs.

"There are sufficient proofs that this division into clans, commonly called tribes, exists amongst almost all the other Indian nations. But it is not so clear that they are subject to the same regulations which prevail among the southern Indians."

Having produced the testimonies of Charlevoix, Johnston, and Heckewelder, for the tribual divisions of the Algonkin and Iroquois nations, he continues: "Whether the *Totem*, or family name of the Chippeways, descends in a regular manner, or is arbitrarily imposed by the father, has not been clearly explained. But Dr James informs us, that no man is allowed to change his *Totem;* that it descends to all the children a man may have; and that the restraint upon intermarriage, which it imposes, is scrupulously regarded. They profess to consider it highly criminal for a man to marry a woman whose *Totem* is the same as his own ; and they relate instances where young men, for a violation of this rule, have been put to death by their own nearest relations." (Tanner's Narrative, p. 313.) But the Chippeways and kindred tribes are in this manner much more subdivided than the other Indians into clans. Dr James gives a catalogue of eighteen Totems, and says that many more might be enumerated.

"The most direct testimony we have of the similarity of the institution amongst the northern and southern Indians is that of Loskiel, in his history of the Moravian Mission (Part i. ch. v.) 'The Delawares and Iroquois never marry near relations. According to their own account, the Indian nations were divided into tribes for no other purpose than that no one might ever, either through temptation or mistake, marry a near relation, which at present is scarcely possible, for whoever intends to marry must take a person of a different tribe.'

"That a similar division existed amongst the Sioux tribes had escaped former observers. But Dr Shaw, who resided several weeks amongst the Omahaws, informs us, that they are divided into two great tribes, &c. Dr Say in another place says, that even a very remote degree of consanguinity is an insuperable barrier to the marriage union."

We need not repeat Mr Gallatin's observations on the great influence of this institution in regulating the wars and settling the disputes of the different nations. Although his attention has been principally fixed upon the beneficial results of the system, and the peculiar sort of federal government it easily introduces, the tribes mutually preserving an hereditary rank, yet he gives proof that the general tendency of this practice was far from promoting tranquillity and peace.

"The Indians who cultivate the soil are perpetually exposed to the attacks of the wandering tribes. Those of the Missouri had also for enemies the *Sauks* and *Foxes*, who have acted too much in that quarter the same part as the *Five Nations* on theirs ; but they had also continual quarrels, often degenerating into actual hostilities between themselves. These originated in encroachments on hunting grounds, elopement, or carrying off of women, and stealing of horses. The enemies wounded in battle are killed on the spot. The prisoners carried home are neither tortured nor put to death. The women are made slaves; the men are considered as servants, and generally employed in taking care of the horses, and in other menial offices, but not in raising corn, that being women's work. The children are almost always adopted into the nation."—P. 130.

Mr Castrén, without being aware of the existence of this institution amongst the Americans, has amply proved that exactly the same laws of tribual government and of marriage originally belonged to all the *Finnic* nations, and that they still continue in force amongst the uncultivated tribes of Siberia.

In his lectures on Finnic Mythology he especially investigates the origin and the conjectures that have been started as to the signification of the lately discovered epic of Finland, the Kalevala. This poem, which evidently is very old, or at any rate describes a state of things anterior to the introduction of Christianity, and which continually carries the reader into the misty regions of witchcraft and Shamanism, has been held by its many patriotic admirers to be a profound allegory, according to the example set by German scholars in expounding the Eddas, Vedas, and the classical mythology. Mr Castrén's opinion on this Iliad of the Fins, which is unquestionably a very important historical document for the illustration of their original manners, as they were thought and embellished by themselves, runs thus, p. 258:—

"If these songs are considered without prejudice, everybody must, without doubt, be brought to the conviction that they, at least for the greater part, rest upon an historical foundation. This circumstance may be proved of all those cantos that describe the travels of courtship of the three heroes *Wäinamöinen*, *Ilmarinen*, and *Lemminkäinen*, and to this class belong most of those that are found in the *Kalevala*. The contents of by far the greater number of the heroic ballads that still exist among our remoter and nearer tribual relations, the *Ostjaks*, the *Samoyedes*, the *Tartars*, are all similar.

These nations also preserve certain manners and institutions, which clearly illustrate the origin and signification of all such songs. One of these institutions is, that every nation is divided into a greater or smaller number of clans, who always stick closely together, but live in the strictest seclusion from other clans not related to them. Formerly, the relation between the several clans was very hostile, and they made predatory expeditions against each other. Even in later days, it has cost the Russian government a great deal of trouble to keep the savage tribes in awe, and to stop their mutual hostilities. At present, it is certainly not said that they commit the more flagrant acts of violence, yet the old hatred is not quite extinct, but shows itself in some way or other, and prevents the different clans from entering into any closer contact with each other. Only when a matrimonial alliance is to be concluded, they must, with or without their will, enter into reconciliation, because, from time immemorial, the law is still preserved, that no matrimony can be concluded in the same clan ; but it is a general tradition that every young man must, with certain exceptions, seek for his bride in a strange clan. Even now, she is not to be obtained except for a considerable bridal price, which must be paid from the bridegroom to her parents or tutors. Formerly, this price was probably still greater, on account of the violent hostility that existed between the clans ; and it seems even that the hand of the maiden, because of this enmity, was sometimes not to be had at any price. The great difficulties which then lay in the way of matrimonial alliances, often tempted the young man to conquer the hand of the maiden by the strength of his own valour,—a custom that is not yet quite out of use among the savage or half savage nations of Siberia. It is exactly this subject that is treated in most of the heroic ballads of these nations, and the greater part of the cantos of the *Kalevala* are of the same import. Thus it is sung in one of these *Runes*, how the brave *Lemminkäinen* violently obtained the beautiful maiden of *Saari*, *Kylliki*. In another canto, the younger daughter of *Pohjola* is carried off by *Ilmarinen*," &c. &c.

" There are also found in the *Kalevala* several other proofs that a courtship by the ancient Fins was connected with great expense and many adventures. The reason cannot have been any other than that this custom also prevailed among our ancestors (the Fins of the Grand Duchy of Finland), never to take a wife from your own, but always from a strange clan, to which you generally stood in an inimical relation."

In *Castrén's Reise-Erinnerungen aus den Jahren* 1838–44, further accounts are given of the effects and the prevalence of this custom, p. 278. " The husband, among the *Zyrjanes*, lays upon the shoulders of his wife every thing that he ought to carry himself, and treats his consort like a slave. The small consideration of the *Zyrjanes* for women is also shown in the mutual relation in which the bridegroom and the bride, even at the nuptials, entertain to each other. Here the bride must, in the presence of all the guests, sing a song, in which she asks the bridegroom, with tears and bows, to feel compassion with her defenceless position, and consider her as his legitimate wife. Of course it is thereby expressed that she is to consider herself as a humble servant. For the same reason, the bride must, after the wedding, undress her consort. In a *Zyrjane's* marriage, also, other customs are practised that show the oppression and deep degradation of woman. Instead of them I will give some of the songs that are sung by the bride and her maids at the nuptials."

These poems, which are translated by Mr Castrén, describe, in forcible language, and with no small amount of poetical naïveté, the bride's feelings of misery on quitting a free life among loving parents for the drudgery and abject position in a strange house, her doleful lamentations being such as might, with the greatest propriety, be employed by a person that is sold or carried off into actual slavery. She even upbraids her brothers that they did not defend her from this misfortune, and asks her parents if she has deserved it by any act of disobedience to them.

And yet the *Zyrjanes*, being converted to Christianity, living in Europe, and interspersed with Russians, whose habits and way of living they have adopted, must be considered as the Finnic tribe that, next to the nations at the Baltic, have assimilated themselves most to European manners. The *Zyr-*

janes also treat their northern neighbours, the *Samoyedes*, as savages, and successfully encroach upon them by the superiority of their half civilization.

P. 286.—" Like the Samoyedes, the Ostjaks are divided into a great number of small clans, each of which forms a small state, or rather a large family. Among the Ostjaks who have adopted Christianity, this division has already ceased, because they are governed by Russian magistrates, and according to Russian laws. Only the Obdorskian Ostjaks still keep up this patriarchal institution which preserves the people in concord and peace, keeps up morality, and prevents many crimes. The power which, in such a community, conducts to virtue, is the love of the whole clan. Every clan consists of a number of families, who have a common origin, and consider themselves as mutually more or less related. There are among the Ostjaks, and especially among the Samoyedes, such clans consisting of several hundreds, or even thousands of individuals, among whom the majority is no longer able to prove their original relation; yet they consider themselves as kindred, enter intono marriages with each other, and consider it a duty to render mutual assistance. Generally those families which are of the same clan keep close together on their nomadic expeditions; and a common practice obtains, that in such a community of families, the rich is to divide his property with the poor. It is evident that in a society thus constituted, disputes must be of rare occurrence. Yet every clan has its elder, whose duty it is to preserve order and harmony in the clan. If two persons belonging to the same clan get into a quarrel that cannot be settled amicably, the case is brought before the elder, who directly gives his judgment without any legal formality. With this result the parties are generally satisfied ; if not, the case may be brought up to the Appellate Court, that is the Prince. A number of clans, living near together, from time immemorial acknowledge a common chief, who has the title of a prince. The principal duty of the prince is to preserve harmony among the different clans, and to settle the disputes arising amongst individuals of different clans about their grounds of pasture, fishing, hunting, &c. The elders are subordinate to him."

P. 297.—" As among the Samoyedes, so among the Ostjaks, the wife is a servant in the strictest signification of the word. Yet this is not enough; she is also considered as an unclean being, and lives in the deepest degradation. Her wishes, if she dare to have such, are never expressed when her heart is given away to the highest bidder by her father, her brother, or any other relative. She is treated as an article of trade. To be sure she is not offered for sale at markets, yet it is the highest bidding that settles her future fate. The price of a young girl is different in different districts. In Obdorsk the daughter of a rich man is sold for fifty or a hundred reindeer; a poor man sells his child for twenty or twenty-five reindeer. The cause why the daughter of the rich man is more valuable than that of the poor one is said to be that the future husband expects to receive assistance and support from his father-in-law, not to mention the greater marriage-portion which the daughter receives immediately. Yet the bridal price is not considered as a deposit that is afterwards to be returned, but in fact as a payment for received goods. Nothing is more just, according to the ideas of the Ostjaks, than that the father or guardian of the girl should receive such payment. The daughters are given away at an age when they are fit for work, and only to a complete stranger. But how could the unknown stranger expect that anybody should bring up and support a woman that is to be for her whole life afterwards his slave or servant? The father might retain the daughter in his own house, and then she might, by the work of her mature years, repay the costs of her childhood. In case of the death of the bride before the marriage is consummated, the bridal price is paid back, or the bridegroom receives another daughter. Polygamy is allowed, but of rare occurrence.

" The low state of women among the Ostjaks and other savage nations of Siberia shows itself also in this, that a woman never receives an inheritance. The husband inherits nothing by his wife, and the widow receives nothing after the death of her husband."

Again, the Votjaks in Russia still keep up this clannish system tolerably perfect. (Latham (from Müller), *Native Races of Russia*, p. 55.)

It is evident that this division into clans, and the singular law of marriage connected with it, must exert such an influence upon the whole state of a savage community that it deserves to be regarded as a fundamental law. Whether this enactment be a result of a certain state of manners, or is to be considered as the cause that has produced them, may be doubtful, as is the case with all investigations into human actions and opinions. At any rate, the effects of these institutions must be most powerful in keeping up and preserving every peculiarity which the savage appreciates as a benefit, or makes his boast and glory. It explains circumstances which have appeared incomprehensible to those observers who have merely compared them with the opinions of civilized nations.

1. It is evident that, according to this state of things, the drudgery and the slavery of married women among the savages of Siberia and North America is as natural, and as strictly legal, as the slavery of the negroes in the plantations of the same western continent: the wife of the free savage is a chattel quite as much as the negro of the independent democrat; they are both either bought at a fair price or made prisoners in war. She is a stranger in the house where she serves, as well as the black man is among the whites.

2. Both Castrén and Gallatin admit, although not without self-contradictions, that these enactments must be an everlasting cause of war and hostilities amongst the tribes and clans. The young warrior of course considers it much more chivalrous to take a bride by force than to buy her as a chattel. The old father has lost the recollection of the code of honour according to which he perhaps acted himself when he was young. Hence the abduction is taken up as an insult, that is to be avenged by murder, pillage, and burning, and for these acts, again, there is to be had retaliation (the exact numbers, in making up every account, always being neglected).

3. These wars of course will lead to an endless transformation of clans into tribes, and of tribes into nations, or rather to an expansion or multiplication of the several communities, on the same principle as when bees separate from the common hive. If a nation consist of a certain number of tribes,

it is possible that one of these may, by repeated injuries of this kind, be driven to secede from the community. Thus the Assiniboins seceded from the Dakotas. They received the nickname *Hoha* (rebels) in commemoration of the event (Gall. *Synopsis*, p. 123). Another clan may be expelled by its brother tribes. In a distant district these exiles must establish their community according to the sacred principle, by subdividing their nation into tribes, or raising its clans into the order of tribes, and forming fresh clans out of their smaller families.

The action of this principle, then, will tend continually to diminish the aggregate number of individuals, or to keep down population, at the same time increasing those rather genealogical than political divisions into which the savages are separated or split up.

Thus we see that the endless subdivision of the Americans into separate nations, with different languages or dialects, is not confined to mountainous parts and secluded valleys, where local circumstances produce a stoppage of communication with neighbours, and thus create a natural diversity of habits, and, in the course of generations, also of language. In America the diversity of speech is quite as great, and the tribes almost as small, on the open prairies and along the navigable rivers. In such localities (*e.g.*, in the broad valley of the Mississippi) the breaking up of clans and tribes must be a result of social causes. The ways in which the diversity has been produced must be the reverse of those means that have been employed in the Old World by founders of the great empires, and by the proselytizing religions, which have tended to make one nationality, and a single language, prevalent over an immense area. These mighty and civilized communities have been formed by amalgamating all the members of the society into one family or clan, and by the keeping up a continual peaceful communication between them. In the life of a savage there never were introduced any such general ideas as could connect and combine, while the contrary process of dispersing was going on continually.

This subdivision into endless varieties of language is not peculiar to America, but obtains quite as much among those

Finnic tribes in the Old World who preserved the same institutions.

The Samoyedes differ so much in language from all their neighbours, that they have, in Klaproth's *Asia Polyglotta*, been considered as a peculiar subdivision of the human race. Castrén's great discovery that they are a Finnic tribe of course is not to be understood thus, that their language should be comprehensible to any other population of Fins. The difference is more remote perhaps than between English and German.

These very Samoyedes are subdivided into five dialects, which are described in Castrén's Grammar. They are so very different in words, terminations, and pronunciation of letters as to form in fact five languages, not easily intelligible to the brother tribes who speak them. Each of their principal dialects, again, is subdivided into several minor discrepancies. Yet all these Samoyedes are only a very small number of wanderers in their immense deserts.

But the same observation is made by observers of the manners of the Fins who are settled as agriculturists in fertile open countries, centuries after their conversion to Christianity, and after they have been for ages subjected to the rule of a strong foreign government, that kept all their clans in peace, and promoted the habits of trade and travelling.

The Estonians, in Estonia and Livonia, are a Finnic nation, numbering about 630,000 individuals, and have existed under such altered circumstances for about six centuries. Their country is, as a sea-border, even more easily accessible than the surrounding Russian territories, which are noted for the uniformity of their population. About the language of these "Estonians" there is an article by a native of the country, Julius Altmann (Erman's *Archiv für Wissenchaftliche Kunde von Rusland*, vol. xiv.) According to this author "the Estonian language is divided into two principal dialects, the Dorpatian and the Revalian: both are again equally subdivided into many sub-dialects or *kirchspielismen* (parish dialects). The harsh enmity that exists between the Estonians and their neighbours the Lets, who have a completely different language and origin, also often prevails in adjoining circles and parishes in Estonia itself. It is subdivided into innumerable communities and localities that do not admit of any friendly intercourse or amalgamation, as if with the desire of preventing communication by the destruction of the unity of language. There are in Estonia closely adjoining districts where idioms are spoken that make the mutual understanding, if not impossible, yet exceedingly difficult. What trouble did it not cost me to understand the dialect of Allatzkiwoi, and when I had succeeded in mastering it, how difficult were not then the dialects of the adjoining Tornea and Dorpat, and how hard to investigate the mode of speech in *Haanhof, Rauge,* and *Fellin?* The causes that have occasioned this intentional isolation and breaking up of languages and communities among the Estonians must be deeply hidden in the darkness of remote centuries. Yet they must always prevent the Estonians from enjoying even the dawning of a common literature and nationality."

Castrén's and Gallatin's observations about the clannish institutions formerly prevailing among the petty nations of the North of America, Asia, and Europe, seem, however, quite sufficient to explain any amount of diversity and enmity between the closest neighbours.

4. The singular phenomenon that has puzzled all travellers and grammarians, who have described the language of the American Indians, that women and men had different words for many objects, and pronounce certain letters of the whole language in a different way (Fabricius tells us, that the females in Greenland pronounce *k* in the end of words, as *ng,* and *t* as *n*) is easily accounted for, the two sexes belonging, in fact, to two different clans.

5. No law amongst men was ever introduced that contained an unmixed evil to all those that were subject to its influence, or which did not favour the interests of anybody. That the continual warfare of savages tends eminently to keep down their numbers, has been amply proved by Malthus in his treatise on population. That it is conducive to the welfare of a nation, subsisting merely on the natural productions of the land, that its numbers should not exceed their means of subsistence is philosophically evident enough. Yet it is hardly to be credited, that a deliberate system should be adopted by savages over a great part of the world, that had

no other object than to preserve a remote posterity from starvation. This might be prevented quite as effectually, and in a much more patriotic way, by murdering their neighbours, than by putting obstacles in the way of the multiplication of the tribe itself. The plausible reason, that made this law appear as divine wisdom to the untutored ancestors of mankind, must have been its tendency to prevent a more immediate and personal evil, or to introduce a benefit nearer to the interests of everybody.

This will be found, if we consider that the children of the tribe are brought up naked, and that they continue, in most instances, to spend their whole lives in circumstances that would facilitate the utmost licentiousness amongst the sexes. Many families often sleep together in the same room, or live close together in the same village. To this early development of vice, there was put an effectual stop, when all the young people in the clan were to consider themselves as brothers and sisters, between whom every improper conversation was regarded as incestuous, and punished with death. If the married females further were regarded as a property, belonging to the husband, of course their chastity also was kept under the control of individual dominion or tyranny, powerfully assisted by religious fear.

Thus, it may be admitted, as Castrén and Gallatin remark, that the clannish institution preserves savage society from one vice, dearly purchased at the price of many. It has also been observed by several travellers, that the manners of the Indians on the opposite side of the Rocky Mountains, are completely contrary. The accounts that have now been quoted refer to the hunting tribes along the Atlantic coast, and in the valley of the Mississippi. Concerning the Indians on the coast of the Pacific, in Oregon, Vancouver Island, &c., it is stated by Hales (*Ethnography of the United States' Exploring Expedition*), that the distinction of clans and totems is quite unknown among the Indians of Oregon and California. These tribes are grossly libidinous; their women are not slaves, "but, on the contrary, have much authority and consideration, and their work is in a manner considered as their property; for instance, the roots they dig up and prepare" (p. 207).

But this peculiarity is not confined to America. According to the excellent account given by the old German naturalist, Steller, of his sojourn among the Kamtshadales, with whose manners he became intimately acquainted, they were quite as bad as their opposite neighbours in America. Other Russian travellers describe the inhabitants of the Aleutian Islands much in the same way.

Thus, we see, that these manners are not instinctive faculties, or qualities of all savages, but really civil institutions, adopted by some of them, while a contrary polity is the rule amongst others.

Why this difference? Geography will answer, that the nations of the interior country and the forest are hunters, and that the last mentioned, on both the coasts of the Pacific, are chiefly fishermen. The difference in these two modes of subsistence, both in tempting to war and murder, and in promoting sociable life, seems to be great. The fishing Indians always are collected in great bands, and live in large houses or caves, containing more families than one.

Yet this does not account for the whole difference in morals and manners. The Laps in Norwegian Finmark have always been divided into two different sets, fishermen on the coasts, living in fixed habitations, and herdsmen of reindeer, wandering on the mountainous plateaux. Yet no considerable difference has been observed in their morals. Likewise, the Athabascans and Eskimos in America are more dependent for their subsistence upon the produce of the sea, than that of the land. Yet the manners of these same Eskimos and Athabascans seem to approach most closely to those of the hunting tribes.

However, this exception is not at all general on the Pacific coast. The Russian missionary, Wenjaminow, expressly states that the powerful Kolosh nation is divided into the Raven and Wolf clan, and that a Kolosh never marries a woman of the same clan (Erman, *Archiv.*, v. iii., and ii. p. 492). Mr Marchand also mentions the Bear, Eagle, and Porpoise clans. (*Trans. Amer. Eth. Society*, vol. ii., p. 149.) This statement is corroborated in the more minute account of Holmberg (*Ethnogr. Skizzen von Russ. Amerika*, Helsingfors, 1855). The principal divisions of the Kolosh (or Thlenkith) the Raven and Wolf, are again subdivided into more families, also named after animals. Mr Holmberg mentions five of the first, and six of the second tribe; and each of these again subdivided into local divisions.

This system would eminently facilitate the formation of new nations out of the old, without disturbing the clannish principle in any way.

The institution of tribes and clans yet exists among a great number of nations in every quarter of the globe, and, according to historical evidence, it was still more frequent formerly.

In Australia, we find the very same institutions as in America and Siberia, viz., that each clan has his *kobong*, corresponding to the American totem, as a sort of armorial emblem, and that nobody is to marry a woman of his own family-name (Latham, *Varieties of Man*, p. 237). Also, among the Kaffres of Africa (Latham, *Ethnol. of British Colonies*, p. 81).

In the Journal of the Asiatic Society for 1852, Captain Macpherson states, concerning the *Khonds*, "That intermarriage between persons of the same tribe, however large or scattered, is considered incestuous, and punishable by death."

As the Khonds are a remarkable specimen of the original inhabitants of India, before they were mixed with any conquerors of the Japetian stock, and as they have not been led to change their primitive simple religion and manners, this also proves that the caste system is the result of conquest, and not even in India the oldest social form. But a coincidence still more striking is what Sir John Bowring in the *Athenæum*, 17th November 1855, states, "That this same extraordinary law of intermarriage also is preserved by the 400 millions of the Chinese people."

"The strict laws which prohibit marriage within certain degrees of affinity (they do not, however, interdict it with a deceased wife's sister) contribute to make marriages more prolific, and to produce a healthier race of children. So strong is the objection to the marriage of blood relations, that a man and woman of the same *Sing* or family name cannot lawfully wed."

We see here the American Totem and Australian Kobong under the Chinese name Sing. The effect is exactly the same.

Thus the same law may be traced from Mexico along the whole continent of North America, along the north of all Asia and Europe, and along the eastern coasts of the Pacific, through China, down to Australia and Africa. The circumstance that a custom which evidently was adopted in the darkest age of barbarism should be equally preserved by the few savages that still continue in the primæval simplicity and by the millions of the Chinese empire, having attained almost the very opposite extreme of super-civilization, shows, in a most striking manner, the mummy-like preservation of trivial and arbitrary forms and manners by the Celestials. The same article of Sir John Bowring supplies another quite as striking analogy. After having described the omnivorous habits of the Chinese, who do not even reject the most disgusting food, he continues:—"The only repugnance I have observed in China is to the use of milk, an extraordinary prejudice, especially considering the Tartar influences which have been long predominating in the land, but I never saw or heard of butter, cream, milk, or whey, being introduced at any native Chinese table."

Exactly this same prejudice was observed among the Californian Indians by a gentleman who had been for years in daily connection with them, and it was related to me before he had the slightest idea that it also was a peculiarity of the Chinese, and this unreasonable disgust might involve an interesting connection dating from thousands of years.

This prejudice will seem to be derived from the hunting state, when the only milk to be obtained was that derived from the breast of woman, which it might be considered a sort of cannabalism in an adult person to taste. It is also to be observed that the word for milk and breast (bosom) seems to be the same in many Mongolian languages.

Breast,	Samoyede,	*sudo, suso.*
,,	Lapp,	*ćidźe.*
,,	Ostjak,	*esem.*
,,	Lesghian (Ćari),	*chudii.*

Milk,	Samoyede,	*süt.*
,,	Ćeremis,	*śür.*
,,	Wogul,	*syrtai, surut.*
,,	Ostjak,	*tüti, tjuti-jink,* esem-jink.*
,,	. . (Andi)	*śiu.*
,,	Ćersessian,	*ćeh, śeh, ćchŭ.*
,,	Turkish,	*süt, sjot, sjut, sut.*

* *Jink* means water.

Breast,	Tungus (Mańcu,)	*tungen, ćećen.*	Milk,	Tungŭs (Mańcu),	*śun.*
,,	Korjak, .	*maćo*	,,	Jukagir,	*iwi-ći.*
,,	Ćukći, .	*ća inka.*	,,	Jeniseian,	*süt.*
,,	Mongolian,	*upzü, opsu.*	,,	Mongolian,	*sŭ.*
,,	Aino. .	*do, to.*			
,,	Korea, .	*ko, dźani.*		Korea,	*kmit.*
,,	Chinese, .	*źu.*			
	IN AMERICA.				
,,	Ojibbeway,	*totosh.*		Ojibbeway,	*totosh-abo.**
,,	Greenland,	*sikkik, sakkiek.*	,,	Caddo, .	*tsotso.*
			,,	Chocta, .	*jushuk chi.*
	IN AUSTRALIA.				
,,	Kowrarega,	*susu.*			

Compare the English *teat,* German *zitze,* Norwegian dialect *tisse.*

This absurd prejudice against the milk of animals has then been kept up by the Chinese during and after their transition to the agricultural state of society. The nomadic state they never went through, and the breeding of domestic animals is even now the most neglected part of Chinese husbandry.

A great distinction between the manners of the Celtic nations and the Teutonic, as well as the Slavonic, seems to have consisted in the paramount importance of clan or sept, in ancient Gaul and the British Isles, and the almost total absence of this division in Germany, Scandinavia, and Russia. The influence of this principle upon the formation of large states, or the continuation of a turbulent anarchy, upon the estimation of the female sex, and upon the development of a chivalrous humanity, must here only be alluded to.

What has been remarked may prove the extreme tenacity with which the Mongolian nations preserved the clannish division, even after the formation of great empires; after the development of considerable commerce; and after the adoption of religion having a tendency to promote a common feeling of brotherhood.

It is certain that the tribus or φυλη among the Græco-Roman population was a genealogical, and not a local institution. Of course these divisions were either clans or castes. How they were preserved separate, although forming an integral

* *Abo* means water.

part of the common state or confederacy, has not been handed down from the darkness of ages, because the Hellenic civilization very soon succeeded in obliterating most of the traces of this institution of barbarism. Yet the Roman history has preserved the following facts, that bear upon this very question.

Between some tribes or little nations there existed *connubium*, so that their members might contract a legitimate marriage; between others this connection was unlawful, as in the oldest times between the Patres and Plebeii; marriages were concluded *per coemptionem*, by sale.

When Romulus and his band of lawless *Latin* youths wanted to acquire wives in a more chivalrous fashion, they did not rob them from their own tribe, but from the *Sabines*. This fact is completely Siberian or American. But are we to guess there was a time when the practice of buying or robbing women from a collateral clan was considered obligatory, as well as permitted, among some of the barbarous tribes in Europe?

Unheard of it cannot have been in antiquity, since we find it preserved even to this day by one nation at least, viz., the Albanians or Arnauts, by whom the manners of their barbarous ancestors, the Greek heroes, are kept up in all but the antique and pure originality. Among their manners Hahn (*Albanesische Studien*, 1854) remarks, "That being divided into many clans, intermarriage is prohibited within the same clan (p. 153). The bride is bought by the bridegroom at rather a high price" (p. 180). The concomitants that attend this system among the natives of America and Siberia, internal wars, family feuds, hereditary for generations, are sufficiently known to flourish to perfection both among Christian and Mahomedan Albanese, quite as much among the believers in a heathen Shamanism or witchcraft. Although Mr Hahn denies it, it also seems, from the facts he states, that this peculiar nicety in the selection of wives is perfectly reconcilable with the grossest licentiousness, or may perhaps even produce it by excluding men from the society of women.

The strength of these savage principles is strongly illustrated in this instance, where they have been able to resist for centuries the opposite doctrines of two such powerful religions, the Christian and the Mahometan.

This clannish institution, unnatural as it is, cannot have preserved its sacred character and been kept up as such but with a corresponding care. We have alluded to the horrid systems of initiation, and the peculiar costumes by which the different clans are distinguished.

Among the ways of dressing the hair that distinguish the American Indian is his mode of shaving or cutting all the scalp short, except a tail left in the middle, a practice considerably inconvenient in a variable climate. Yet the arbitrary practice agrees completely with the costume of the Japanese and Chinese in Asia. Among the latter, however, it is a comparatively new absurdity, having been imposed on the nation two hundred years ago by the Mantchou conquerors, because it was their national or clannish badge.

If from the system of clans among the Mongolians we pass over to the castes of the old Japetian nations, we observe in India exactly the contrary law of marriage. Here every man who marries out of his caste loses all his social privileges derived from it. This shows that the castes consider themselves as naturally or originally not only strangers or enemies, but also inferior and superior, as conquerors and vanquished. The nations subject to the totemic system even in their implacable hatred acknowledge the equality of their neighbours.

We find social divisions, founded upon a common origin, existing in the nomades of Arabia, and among all the mountainous countries of Asia. The old history tells us the like among Jews, Egyptians, Greeks, Romans, and Celts. Which of these stood in the same relation of barbarous equality to each other as the Mongolian clans, and which represent superior and inferior grades of society (castes) based upon conquests?

The intimate connection of the clannish institution with the law of intermarriage, and with the regulations of the sexual intercourse, is best shown by the details of the ceremonies and customs by which it is kept up.

The nations, tribes, clans, and families, are distinguished by the totem, or certain marks representing a sort of armorial bearings. Among the more savage and antique tribes these consist not only in a peculiar cut of the dress, the hair, &c., but especially in the different patterns of the tattooing, in horrid mutilations of the body, &c. Thus the Kolosh and Konjag will make one immense or perhaps six smaller holes in the ears, the nose, and the lower lip, and insert in them large pieces of wood, or the teeth of animals, that completely distort the face.

It is expressly stated that these operations are chiefly performed upon young people when they arrive at the marriageable state, and are combined with long and cruel superstitious ceremonies, generally called initiations (Holmberg, p. 21). The effect of these practices will be to impress upon the mind of the young a horrid reverence for this fundamental principle of the savage society and the laws connected with it, also to increase the intimacy of the relations between the members of the tribe that are joined by this community of religious suffering, and implant prejudices and hatred against those that are excluded from the holy community.

It is probable that the origin of circumcision among the African tribes must be viewed in the same light, the more so as its relation to the intercourse of the sexes is more apparent.

On the Animalcules and other Organized Bodies which give a Red Colour to the Sea. By M. Camille Dareste. (Translated from Annales des Sciences Naturelles.) (Continued from vol. iv., p. 287.)

§ VIII. *Colourings produced by Baccillaria.*

These colorations were observed by Captain James Clark Ross, during his celebrated voyage to the Antarctic regions, upon the coast of the new lands which had been discovered a year before by Dumont Durville. Captain Ross' observations were made repeatedly and in different circumstances, some upon the water itself, others upon the ice or snow; but both appeared produced by the same cause. The coloured water was observed by him on 31st December 1842, in lat. 64° S., and long. 55° 28′ W., 30 miles S.E: of the Gulf Mount Erebus and Terror, in a locality where the sea was very deep and much frequented by whales. Captain Ross caused some of the mud to be collected from a depth of 207 to 270 fathoms, and on his return to Europe he sent it to M. Ehrenberg for examination. Its colour was green, and it contained 53 species of microscopic animals, of which the predominant species were Baccillaria, belonging to the genera *Coscinodiscus*, *Fragilaria*, and *Hemiaulus* (the latter being a new genus). A great number of these animals were still living, and M. Ehrenberg discovered in their interior a kind of green grains which he considered to be eggs, an opinion which has not yet been generally adopted. Those who are engaged in the study of infusoria know perfectly well how, among these animals, the green and red colour pass easily the one into the other.

Coloured ice has been found in still more southern latitudes.

"15th February 1841, in lat. 76° 03′, and long. 166° 12′ E., we perceived several fields of ice; we changed our course southwards in order to avoid them, and as we coasted the shore, we met with a great quantity of brownish-yellow coloured ice. We collected a small quantity of it, and placed it under a powerful microscope, but could not determine the true nature of the colouring matter. Many among us believed that it proceeded from the fine ash from Mount Erebus, which was about eight miles to the south. At 11 P.M. the weather was very calm; we found, in sounding, thirty-eight fathoms, and we collected a greenish clayey mud."

Similar observations of coloured ice were made during the same expedition; on the 17th February 1841, in lat. 76° 35′ S. and long. 165° 21′ W., and the 18th December of the same year in lat. 63° 50′ S. and long. 147° 25′ W. Captain Ross adds that this coloured matter has been found in the stomachs of the Beroes and Salpa, very abundant in these localities.

The water coming from below this ice having been filtered, and the residue sent to M. Ehrenberg, that observer discovered in it a number of microscopic animals. The coloured matter, as in the preceding observation, contained an abundance of the *Coscinodiscus* and *Fragilaria*, and among the latter some *Fragilaria pinnulata*.

§ IX. *Colours produced by Protococcus.*

This colouring matter was observed by M. De Freycinet and M. Turrel upon the coasts of Portugal; and M. Montagne, to whom a bottle of the coloured water was sent, is satisfied that it is produced by a very small microscopic alga, which he refers to the genus *Protococcus*, to which the red snow belongs, and describes under the name of *Protococcus atlanticus*.

"3d June 1845, about 2 P.M., the corvette 'la Créole' was near the coast of Portugal, opposite Cape Spichel, about eleven kilometres from the mouth of the Tagus, and going towards Cape Rocca. There was observed before the ship an isolated colouring in the water of the sea, of a deep red, varying in intensity and shade between brick-red and blood-red. As far as the eye could reach, the sea preserved this tint, although it was not uniform throughout, but exhibited here and there gradations of shade. The places where the water was deeper formed new patches in the middle of the general colouring. Their extent in a north and south direction appeared to be about 150 metres, but their greatest breadth, which was from W.N.W. to E.S.E., could not be attained with certainty by M. De Freycinet. That officer, however, estimated that the phenomenon passed over a field of about eight kilometres or six miles. M. Turrel asserts that he proved the presence of six coloured zones of 400 to 500 metres each, and affirms, moreover, that these bands were prolonged in the direction of the currents produced by the waters of the river, that is to say, from N.W. to S.W., to an extent of about five kilometres. What the estimate may be of the limits of this phenomenon can only be conjectured; at half-past 3, the corvette got beyond *all* intense colour, and great attention was necessary, to observe the faint rosy tint which it still presented."

§ X. *Colour produced by Biphores.*

This fact was observed by MM. Quoy and Gaymard during the voyage of the "Uranie."

"About 100 leagues from the Cape of Good Hope, in lat. 36° S., we saw upon the sea long zones of reddish-brown colour, of which we sometimes could not ascertain the extent. Some at first supposed that it must be fish spawn ; but having crossed several of these bands, the net intended to collect sea animals gave us an opportunity of recognising that they were composed of myriads of small *Biphores* from two to three lines in length, living and sailing in company. Their numbers must have been very great to reflect a colour so marked, as their nucleus was not larger than a grain of millet. What surprised us most was seeing, that, in spite of the movement of the waves, they preserved their affinity to each other, so much so that the lines which they formed were perfectly sharp. Another time, the same phenomenon was observed between the Marianne and Sandwich Islands."

It is to be regretted that these two naturalists have not indicated the species of *Biphores* which produced this colour. It is impossible to make them out from the short description which I have quoted.

§ XI. *Colour produced by undetermined animals, but which are probably larvæ of inferior animals or of Infusoria.*

The most complete observation of this kind with which I am acquainted was made by M. Quoy during the first voyage of the "Astrolabe."

"17th December 1828, at 3 o'clock in the evening, being in the sound of the "Bay of Aiguilles," in sight of land, opposite to Algoa Bay, we saw at intervals the sea become brown-red in large spaces and in zones. On casting a net, we found that this colour was produced by an enormous quantity of small animals, about one or two lines in length, quite white, except the head, on which there was a reddish spot.

"The body of this animal is eel-shaped, flat and pointed at the extremity, where it is furnished with a fin which appeared to us notched. Its middle is traversed by a canal, in which, or rather upon the sides of which, there are white granulations belonging most probably to the organs of generation. The part which belongs to the head is surmounted by a very delicate fringed membranous hood. . . . It is there that the red point is placed, partly surrounded with yellow. These animals being in perpetual motion, from the vibration which they impart to their body, the examination of them becomes difficult; they seem to wish to divest themselves of this hood. They quickly spoil the water which contains them, and in half-an-hour they are dead. Their bodies are then bent into different shapes, the head below; they become opaque, of a dim white, and their organization can no longer be distinguished."

M. Quoy says that he has several times met with these animals, but he does not give the localities. He at first made a genus of them under the name of "*Fretillaria;*" but afterwards, on his return to France, thought he discovered in them the characters of the singular, and still enigmatical animal, which Chamisso has described under the name of *Appendicularia*, and Mertens under that of *Oikopleura Chamissonis.* He adds, however, that these animals may possibly be larvæ. And though we cannot decide from such an incomplete description, this latter opinion of M. Quoy appears very probable. The numerous works which have appeared of late years upon the embryo of molluscs can hardly leave a doubt on this point, because we may very easily recognise in M. Quoy's description the hood of the embryo of *Branchiferous gasteropodes* (*Opisthobranches* and *Prosobranches* in M. Milne-Edward's classification), or of the shell-bearing Pteropodes. Unfortunately we can go no further, or determine in a more exact manner the genus to which these remarkable larvæ ought to belong.

As for the identity of these larvæ with the *Oicopleura* of Mertens, it appears to us much less certain. Although Mertens' description is very incomplete, it points to a very different animal to that of M. Quoy, which no doubt presents something analogous to the two-lobed hood of the larvæ of Gasteropodes, but is much larger in size (more than 3 centimetres), and differs from it by the singular property which it possesses, of secreting a sufficient quantity of mucus in order to shut itself up entirely. Besides, this animal has only as yet been found in a very different locality from that where it has been noticed by M. Quoy, Behring Straits and the north of the Pacific Ocean. As to its organization, the observations of Mertens, made with the aid of a simple magnifying glass, are much too imperfect to carry any certainty from them.

Analogous phenomena are often mentioned on the coasts of Chili, but appear to be produced by larvæ quite different from the first, or perhaps by *infusoria.*

The first observation is due to two Spanish captains, Don Jorge Juan and Don Antonio d'Ulloa, who, in the last century, had accompanied to Peru the French commission charged with measuring the meridian, composed of Bouguer, Condamine, Joseph Jussieu, and Godin : it was in May 1735.

"Having embarked in the French frigate 'la Délivrance,' and being in lat. 36° 54′, and 2° 24′ east of the island of Santa Maria, half an hour after having observed it we suddenly found ourselves upon a ridge of yellow water; which gave us a great fright, and obliged us to leave the table, where we were at dinner, and run upon deck, more troubled still as there was no time to tack. The frigate was in the middle of this colour, which appeared to be that of a shoal, and extended in length nearly two leagues from N. to S., and in breadth about 600 to 800 fathoms from E. to W. The colour of the water was so yellow, that after having crossed it, and being at a great distance from it, it was still very easy to distinguish it. Not having been able to sound, owing to the lead not being ready; and, fearing that we had got upon a sand-bank, as all believed, and that in certain points there would be very little water, we never dreamt of putting the ship back in order to learn the depth. There were some places where the water was more yellow, appearing as if it were shallower, and others where the yellow water was replaced by the gulf or greenish water. Every chart does not indicate it, and some of the pilots have never seen it, which is very strange, considering that voyages in this direction are so common. This fact ought to be a warning to all navigators to be on their guard when passing this place."

This observation, very curious in many respects, and particularly in having produced such an error in two able sailors, who were also distinguished naturalists, is explained by the observations of Pœppig and Mr Darwin.

Pœppig remarks :—

"12th March, about mid-day, we were not a little surprised by a cry of alarm from the deck, and the immediate command to bring to. The dirty red colour of the sea had made us suppose that we had got upon a shoal, but the lead found no bottom at 130 fathoms. From the top-gallant mast the sea appeared, quite to the horizon, of a dark red colour, more particularly in a current of which the length was estimated at six English miles, and which divided to the right and left, in short lateral branches. Continuing our voyage, we found that the colour changed into a brilliant purple, so much so that the foam in front of the ship was of a rosy-red. It surprised us that this purple band was easily distinguished from the blue of the sea ; a circumstance which we the more easily recognised, as our track made us cross the band, which extended in a north-east direction. The water brought up in a bucket appeared quite transparent, but a faint purple shade was perceived, when some drops were put upon a china plate, and gently moved from side to side in the sunlight. A magnifier showed numerous small red points, visible to the naked eye with great attention, and consisting of infusoria of a spherical form, which did not possess any external organ of locomotion. Their very quick movements were only up and down, and always in a spiral line. The want of a powerful microscope prevented me from pursuing this delicate research ; and all the attempts made to preserve these animals on paper, by the aid of the filtration of a drop of water, failed, because under these circumstances the drop of water seemed to evaporate. They were above all sensible to nitric acid ; a single drop in a glass vessel containing this animated water, terminated almost instantaneously the existence of millions of these little beings. We sailed about four hours, with a rapidity of at least six English miles, across this band, the length of which was about seven miles, before reaching its boundary. Its surface was, consequently, about 168 square miles English measure. And, if we suppose these organized atoms to be distributed in the upper stratum of water to the depth of only six feet, their number must be infinitely beyond all that human reason can conceive. . . . . This phenomenon of the colouring of the water of the sea has already been several times observed in other regions; but it is rare upon the coast of Chili. In the southern part of the Pacific Ocean, near the Equator, particularly in the Gulf of Panama, and even at a short distance from California, it is very frequently presented. Among the very many sailors who trade along the coasts of Chili and Peru, and whom I questioned during two years upon the subject of this phenomenon, there is only one to be found who had observed it, in similar states and nearly at the same time of year, upon the coast of Valdivia."

The observation of Pœppig was made on the 12th March 1827, about lat. 36°, about two degrees below Cape Pilares.

It is very probably the same phenomenon which was observed by Mr Darwin upon the coasts of Chili.

November 14th 1764.

"On the coast of Chile, a few leagues north of Conception, the Beagle one day passed through great bands of muddy water; and again, a degree south of Valparaiso, the same appearance was still more extensive. Although we were nearly fifty miles from the coast, I at first attributed this circumstance to real streams of muddy water brought down by the river Maypo. Mr Sulivan, however, having drawn up some in a glass, thought he distinguished, by the aid of a lens, moving points. The water was slightly stained as if by red dust; and after leaving it for some time quiet, a cloud collected at the bottom. With a lens, of one-fourth of an inch focal distance, small hyaline points could be seen darting about with great rapidity, and frequently exploding. Examined with a much higher power, their shape was found to be oval, and contracted by a ring round the middle, from which line curved little setæ proceeded on all sides, and these were the organs of motion. One end of the body was narrower and more pointed than the other. According to the arrangement of Bory St Vincent, they are animalculæ, belonging to the family of Trichodes. It was, however, very difficult to examine them with care, for almost the instant motion ceased, even while crossing the field of vision, their bodies burst. Sometimes both ends burst at once, sometimes only one, and a quantity of coarse brownish granular matter was ejected, which cohered very slightly. The ring with the setæ sometimes retained its irritability for a little while after the contents of the body had been emptied, and continued a riggling, uneven motion. The animal an instant before bursting expanded to half again its natural size; and the explosion took place about fifteen seconds after the rapid progressive motion had ceased; in a few cases it was preceded for a short interval by a rotatory movement on the longer axis. About two minutes after any number were isolated in a drop of water, they thus perished. The animals move with the narrow apex forwards, by the aid of their vibratory ciliæ, and generally by rapid starts. They are exceedingly minute, and quite invisible to the naked eye, only covering a space equal to the square of the thousandth of an inch. Their numbers were infinite; for the smallest drop of water which I could remove contained very many. In one day we passed through two spaces of water thus stained, one of which alone must have extended over several square miles. What incalculable numbers of these microscopical animals! The colour of the water, as seen at some distance, was like that of a river which has flowed through a red clay district; but under the shade of the vessel's side, it was quite as dark as chocolate. The line where the red and blue water joined was distinctly defined. The weather for some days previously had been calm, and the ocean abounded, to an unusual degree, with living creatures. In Ulloa's voyage an account is given of crossing, in nearly the same latitude, some discoloured water, which was mistaken for a shoal; no soundings were obtained, and I have no doubt, from the description, that this little animalcule was the cause of the alarm."—*Darwin Jour.* III., p. 17-18.

It is very difficult for us to establish here, as we have done from the preceding observations, the true nature of these little animals. Mr Darwin, in the first edition of his voyage, there saw some infusoria of the genus *Trichoda* of Müller, a genus from which Bory de St Vincent has withdrawn a certain number of species, to make the genus *Oxytricha*. There is a species of *Oxytricha* which is coloured red, observed by M. Ehrenberg in the Baltic, and also by M. Dujardin ; but these naturalists did not find it in quantities sufficient to change the colour of the water. May we not believe, however, that these phenomena are produced by the larvæ of *Annelides*, or naked *Pteropodes*, or perhaps also by certain larvæ of *Asteria* or *Holothuria*, which move freely in the ocean, by means of their circles of vibratile cilia ?

The colouring observed by Lesson, from the 26th February to 4th March 1823, in the roads of Callao, lat. 12° 3′ 9″ S , and long. 79° 33′ 45″ W., during the voyage of La Coquille, is probably due to *Infusoria*.

" A phenomenon which appears to occur frequently on the coasts of Peru, is that of the bright red colour of the sea, in patches more or less limited. We were once deceived into bringing to and sounding, taking that for a shoal, which was simply the result of a prodigious quantity of animalcules which coloured the sea a deep red. In order to assure ourselves of their nature, we took some of the water in a place where the sea was of a blood-red tint, and this water put into a glass preserved its natural colour. In examining some drops of this water with a strong lens, we discovered millions of little red points which, like shrimps of extreme tenuity, moved with great quickness. This water filtered left a deposit upon the paper of about 2 centigrams of a red mucous matter, which formed, when drying upon the filter, a pellicle which changed into green. Were these eggs ? Their very quick movements do not allow us to suppose it. Were these allied to zoophytes, or rather to microscopic crustacea ? This is what we must conclude."

Incomplete as this passage may be, the change of colour from red to green, observed among these little beings, leads us to think that they belonged to the class Infusoria, where phenomena of this kind have been frequently observed. It is not possible to go further.

I presume that it is also to some species of infusoria that the observation of Scoresby, the indefatigable explorer of the Arctic regions, refers; but it also is too imperfect to enable us to give a satisfactory explanation of it. It was made on the 10th July 1823, in lat. 71° 15′, and long. 17° 20′ W.

§ XII. *Colours of which the nature is unknown, but which appear to be produced by matter brought down by the Rivers.*

Some similar facts have been repeatedly remarked; but their nature is not yet known, and even their existence is not always proved.

It is from a cause of this kind that the colour of the Yellow Sea, "Hoang-Hai," is supposed to be produced. At least, in all geographical works it is attributed to the mud brought by the Yellow River ("Hoang-Ho" of the Chinese, or "Kara-moran" of the Mongols).

We have neither positive observations upon the colour of the Yellow Sea, nor upon the cause of it. In my first memoir I have advanced the opinion that this colour might be produced by algæ of the genus *Trichodesmium*, founded upon the observation of a shower of sand which fell at Shanghai, and in which were found vegetable remains. The question is at this moment as undecided as ever, because I do not know of any direct observations upon the fact in question. However, I ought here to refer to an opinion given by Dr Macgowan in a memoir published in 1850, with which I was unacquainted at the time my first paper was drawn up.

In this work, Mr Macgowan gives a description of a shower of sand, formed by an imperceptible dust of a yellow colour, which he observed in China. He adds that this phenomenon is very frequent, and that it seems even to be one of the causes of the fertility of the soil, because this sand would assist to separate the stiff soil of the alluvial lands of China. This sand would come from the desert steppes of Northern China, which form the deserts of Gobi or Shamo. Mr Macgowan thinks that it is these showers of sand, which give to the Yellow River, and consequently to the Yellow Sea itself, the colour which geographers attribute to them. I can only mention this opinion here, without pronouncing either for or against it myself. It appears, besides, to agree with what we know of the Yellow River, that it only takes this colour, peculiar to it, after having crossed the Steppes of Mongolia. The Chinese annals relate that the Yellow River having at one time become clear this phenomenon was followed by a famine. If, as Mr Macgowan says, the fertility of the soil is due, in China, to the showers of sand, it is easily explained how the famine and the transparency of the water of the river would be produced at the same time.

The colour of the Gulf of California, or "Mer Vermeille" (Mar Vermeio of the Spaniards, Vermilion Sea of the English), is likewise still an undecided question. In many geographical works it is attributed to the mud carried down by the Rio Colorado. But, for some time, a very different opinion has been announced on this subject. Thus, in "l'Histoire des Navigations aux terres Australès," of the President of Brosses, we find this sentence, the original of which I have never yet been able to find:—"On rapporte que, dans le Golfe de Californie, la mer est couverte de vers rouge."

The coloration of the sea, by substances carried down by the rivers, would still be a hypothetical fact, if it had not been proved to a certain extent by a particular case, although upon a very limited scale. The fact is, besides, very interesting in many respects, therefore I believe it worth relating with some detail.

It is that of a little river in Syria, named *Ibrahim-Nahr*, which flows into the Mediterranean, near the small town of *Djibaïl*, or *Gebel*, at a short distance from Beyrout, and which, in every year, at a certain season, was coloured red, and communicated this colour to the sea to a certain extent.

What is so remarkable in this fact is, that it was known to the ancients, and connected with the worship of the Phœnician god *Adonis*, *Adonaï* or *Thammuz*, of which Biblos, now Gebel, was the principal seat in Syria. There is a very exact notice of it in the following passage of the work of Lucian, "Sur la Deesse de Syrie":—

"There was still another marvel in the neighbourhood of this town, a river which flows from Mount Libanus and falls into the sea. The name given to it is Adonis. Every year it becomes bloody, and, after having lost its natural colour, it throws itself into the sea, which becomes red to some extent, thereby intimating to the inhabitants of Biblos the time when they ought to begin their mourning. It is said, in short, that it is in these days that Adonis is wounded on Mount Libanus; that his blood, which flows into the river, changes the colour by mixing with it, and gives it the name of Adonis. This is what the multitude relate; but a man of the country, who appeared to me to speak the truth, explained to me in another way the causes of this phenomenon. 'The river Adonis, oh stranger, traverses the Libanus, a mountain composed of a very red earth. Violent winds, which regularly arise at certain periods, carry into the river this earth, charged with much vermilion; this is what gives to the water that colour of blood, for it is not really blood, as is said; the nature of the soil is the cause of this phenomenon.' This is what the man of Biblos told me."

Lucian is the only author of antiquity who speaks of this fact, though there are in a great many Greek and Latin authors numerous allusions to the worship of Adonis, which, from the Chaldean and the Phœnician, spread by little and little into Greece. But this remarkable coloration of the river takes place in our days as well as in the time of Lucian, having been observed,on the 17th May 1697, by H. Maundrell, and in 1798 by another English traveller, named Browne, but he contents himself with merely mentioning it, without adding any detail.

It would be very interesting to know this colouring matter, which thus seems to be reproduced every year about the same time. Unfortunately, the observations of this phenomenon are much too insufficient to prove, I do not say to inform us completely, but even to put us on the way of solving this question. M. Ehrenberg, who quotes the passage from Lucian in his beautiful "Mémoire sur le vents alizés, les pluies de sang et la poussière metéorique," observes that there are only white or gray calcareous soils in the Libanus, and that consequently, the opinion brought forward by the man of whom Lucian speaks may be unfounded. He thinks that the phenomenon may be produced by a red-coloured meteoric dust, which, driven by the whirlwinds of the Sirocco, falls every year in Syria. He refers on this subject to a very curious passage from the "Liber Regum," where mention is made of a spring suddenly becoming red. I can here only refer to this explanation, without either pronouncing for or against it. I content myself by only remarking that there existed in Syria some soil formed almost entirely of red sand, and that that may account for the opinion of Maundrell, and also the man of whom Lucian speaks.

In concluding this memoir, I think it right to say that I do not pretend to have collected all the facts regarding the colouring of the sea mentioned by navigators, nor even to have enumerated all the localities where similar facts were observed. I have thought it best, under all circumstances, not to pronounce myself upon the causes of these colourings, or at least only to express a very reserved opinion; and I would not have published this memoir if I had not thought that in all scientific questions it is often necessary to collect and compare the results obtained, in order the better to know in what direction we ought to turn our researches. I have, besides, followed here the example of M. Ehrenberg, who, in an admirable series of memoirs on analogous questions, has endeavoured to show the advantage that may be derived by the union of science with historical and bibliographical knowledge.

It is for navigators to complete this work, by collecting, as much as possible, exact records of the circumstances under which these colourings are produced, and the organized beings by which they are caused.

Note upon the Phenomena described by Mariners under the name of the Sea of Milk, and which are occasioned by the presence of Phosphorescent Animalcules.

Having been obliged, in studying the colourings of the sea, to read a great number of narratives of voyages, I have there met with many observations referring to a white colour which gives to the water the appearance of milk; and although I have not made a special study of this question, I may, nevertheless, point out some general consequences which appear to result from the comparison of these particular facts.

These phenomena are very frequent, much more so than red; in fact, there is scarcely a narrative of a voyage which does not make mention of them; and I believe that the number of these observations on record is three times as great as those of red colourings.

It is especially in the intertropical seas that these phenomena are produced; and they appear to be chiefly abundant in the Gulf of Guinea and in the Arabian Gulf, the most part of the observations referring to these two localities. In the latter the phenomenon was known to the ancients more than a century before the Christian era, as may be seen from a curious passage from the geography of Agatharchides: "Along this country (the coast of Arabia) the sea has a white aspect like a river; the cause of this phenomenon is a subject of astonishment to us."

An explanation of the phenomenon may possibly be found in the beautiful experiments upon the phosphorescence of the sea, which have been made at Boulogne in 1850 by M. Quatrefages. This naturalist has discovered that the *Noctilucæ* which produce that phenomenon do not always give out clear and brilliant sparks, but that, under certain circumstances, which he has studied with much care, this light is replaced by a steady clearness, which gives in these animalcules a white colour. We may thus understand how, when these animals are in considerable masses, they may present this steady clearness, and colour the sea white to a great extent. *Noctilucæ* do not appear to be the only animals which possess this property. Thus, in an observation of M. Grafton Chapman, the animalcules, producing the white tint and phosphorescence, were probably gregarious animals, of the genera *Salpa* and *Pyrosoma*.

These white colours, like the red, appear frequently, though I dare not say always, in the same localities. I will only quote one example which has been observed in the neighbourhood of the Cape de Verd islands: it is taken from the narrative of the voyage of the "Vénus," by M. Dupetit-Thouars.

"On the 13th January 1837, at two o'clock, having perceived that the sea had changed colour, we sounded, and did not find a bottom at 300 fathoms. The changed colour of the water did not then seem to be attributable to the quality of the bottom, but more truly to the presence of little animalcules or molluscs, named "*Squid*" by the English. These waters which appear coloured, do not change their place to any sensible degree, in fact in several voyages I have met with them in the same position; but, not wishing to content myself with only quoting what I have met with myself, I will say that in this track we found them in lat. 21° 29′ 39″ N., and long. 21° 45′ 30″ W. of Paris; that Frésier, in his 'Voyage to Chili' in 1712, found them in lat. 21° 21′ N., and long. 21° 39′ W.; and the American Captain Fanning met with them, on the 12th July 1797, in lat. 21° 48′ N., and long. 23° 50′ Greenwich. All these observations go to prove that those coloured waters are limited, and it seems to me that they must be the same as those which were seen in the voyages which we have quoted, since the positions are nearly identical."

An attempt to determine the Average Composition of the Rosedale, Whitby, and Cleveland Ironstones. By W. Crowder, Esq.

Some few months ago I communicated to the *Edinburgh New Philosophical Journal* a paper on the Cleveland Ironstone, in which I endeavoured to show the composition of that district by a series of analyses of the beds, taken in regular sequence from the mines at Hutton Low Cross, near Guisboro. Since that paper was written, I have had occasion to inquire more particularly into the average yield of iron, and general character of this and similar stones, and believing the question to be one of great local, if not national importance, have undertaken a series of analyses which, it is hoped, will suffice to set the matter at rest. In making an examination of the minerals of any district, it frequently happens that the results of experiment differ widely from those obtained in practice. This discordance arises not so much from any defect in the analyses themselves as from want of a sufficient *number* of experiments, to show the fluctuations in composition; for it frequently happens that within a very small compass large masses of ore will yield results which differ materially from each other, so that by adopting any single analysis, very erroneous impressions and mischievous results may be the consequence.

If this view be correct, it will follow that in attempting to arrive at the average composition of any stratified beds, that examination would give the best results, and be nearest the truth, which gave the greatest number of analyses of the mineral taken from the greatest number of places. Minuteness of analysis would here be of secondary value, whilst repetition would be of the highest importance.

In the present communication I have endeavoured to carry out this principle, believing that it is only by a continued repetition of analyses of the beds, under a variety of circumstances, and derived from a number of independent sources, that any general conclusions can be deduced. A large number of specimens about to be noticed have been collected by myself, during a tour through the district a few months ago, whilst the remainder have been derived either from the owners of the mines or from other undoubted sources. The whole have been selected with the greatest care, and it is hoped that the present will form a contribution of some value to our knowledge of the mineral resources of Yorkshire.

Whilst endeavouring to multiply observations, I have not overlooked the value of minute analysis, and have given a complete examination of as many specimens as my time and opportunity have allowed.

The ironstones principally examined are—

1*st*, Those from Rosedale Abbey, about 10 miles from Pickering.

2*d*, Those found in the neighbourhood of Whitby.

3*d*, Those from the Cleveland Hills, which are perhaps the most important deposits.

It will be seen that these three classes of stone differ widely from each other, not only in the chemical constitution of different localities, but at the same place, thus exemplifying at once the necessity for systematic repetition and investigation.

Before proceeding to the subject more immediately under consideration, it will be as well to make some few observations upon the mode in which the following analyses have been conducted.

The silica, lime, and magnesia, were determined in the usual way. Protoxide, and peroxide of iron, were determined in all cases by standard solution of permanganate of potash by the usual method. The strength of the solution was such that 100 graduations oxidized about 5 grains of iron. Alumina was determined by precipitation along with the iron in the filtrate from silica, by deducting the quantity of iron (as obtained by the permanganate process) from the alumina and iron, the quantity of alumina was obtained. If phosphoric acid was present, the quantity of this ingredient was deducted from the alumina.

Sulphur was determined by oxidation with nitric acid and precipitation with nitrate of baryta, and the sulphuric acid determined in a separate portion, and deducted from the total quantity of sulphate of baryta.

Phosphoric acid was determined by one of two methods: 1*st* method—After burning off the precipitate of iron and alumina (which contains the phosphoric acid) it was dissolved in hydrochloric acid; tartaric acid, sulphate of magnesia, and ammonia were added, and the phosphoric acid determined. Or: 2*nd* method—20 grains were dissolved in hydrochloric acid, and boiled. The fluid, which contains the iron principally as *protoxide*, was treated with an alkaline carbonate in the cold till a precipitate was about to form, acetate of potash was then added, and the fluid boiled. The phosphoric acid comes down with only a small quantity of iron; the remainder of the iron, which is still in the state of protoxide, passes through the filter. After washing the precipitate with boiling water, it is dissolved in hydrochloric acid; tartaric acid, sulphate of magnesia, and ammonia added, and allowed to stand 24 hours.

The precipitate of phosphate of magnesia and ammonia is then dissolved and re-precipitated.

Water was determined by heating 20 grains in a tube, and collecting the water in a chloride of calcium tube.

Carbonic acid was either determined by the usual method (viz., by the loss sustained after adding acid and evolving the gas), or, by fusing 20 grains of the ore with 60 or 80 grains of dry borax, and noting the loss, which consisted of water and carbonic acid. By deducting the water in the preceding experiment, the quantity of carbonic acid is obtained. This method has the advantage of being both rapid and accurate, when a good heat can be obtained. There is, however, a great drawback, which led to the abandonment of the process. I found that the platinum crucibles in which the experiment was conducted were rapidly corroded, losing from 0·50 to 0·70 gr. in weight at each experiment.

In some instances the carbonic acid was determined by loss on the analysis. By careful experiments on several of the Cleveland stones, I found that I was able to rely upon this plan in a large number of instances.

Rosedale Ironstone.—In my former communication I gave the analysis of two or three samples of ironstone from Rosedale, but at that time I was not aware that there were two localities of the same name. Since then I have found that there is a place called Rosedale on the sea-coast, at which a large quantity of iron ore is raised and shipped ; and I have now no doubt that the two samples stated to contain 36·82 and 27·93 per cent. metallic iron were obtained from that place, and not from Rosedale Abbey, which is many miles inland. The whole of the present specimens were taken by myself at the mines near Rosedale Abbey about three months ago, and great care was taken in their selection to insure an average result. Much of the stone occurs in large nodular masses, encased in a kind of shell, called scrap by the workmen. It is very variable in composition, depending upon its stage of decomposition.

The outer coverings appear to have originally had the same composition as the inner portion, which is a carbonate of iron—and has, by decomposition, being converted into hydrated peroxide.

There are several places already opened out for working this stone, but the best quality appears at present to be confined entirely to one spot.

It is here obtained by open quarrying into the face of the hill, the thickness of the stone being upwards of 20 feet. Whether this will be lost as the work proceeds remains to be seen; at the present moment it would perhaps be premature to give a decided opinion. The colour of the stone at this place is dark blue, bordering on black, and it occurs in thin slabs, constituting the cases of the inclosed nodule. This blue-black stone is by far the richest in quality, but there is a great quantity of a light blue colour, occurring more particularly at a drift which has been made in the hill-side near the quarry; this latter is quite different from the blue stone.

There is also, at the crest of another hill about 1 or 2 miles from this place, a drift pushed about 20 feet into the hill-side, where a large quantity of the light blue nodules are found incased in a series of coverings, the analysis of which I have given, to show the gradual changes that have taken place. These nodules and scraps lie embedded in a soft friable matrix of ironstone of brown colour, which constitutes the principal bulk of the ore at that particular locality.

For distinction, I shall call the three different places—

The Quarry, from whence the dark blue stone is obtained.

The Shaft and Drift, from whence the light blue stone is obtained.

The Drift, 2 miles away, from whence light blue and brown stone is obtained.

The Quarry.—Description and analysis of the dark blue stone:—

A. Mass of dark blue-black stone very compact.
B. Do. slightly altered by exposure to the air.
C. Do.
D. Do.
E. Dark blue stone streaked with rust-red layers.
F. Do.
G. Do. altered by exposure to air.
H. Do.
I. Do. with wide streak of rust-red colour.
K. Do. altered by exposure.

The following are the quantities of silica and iron in each stone. I may mention that this is a kind of magnetic iron ore, and appears to contain about equal proportions of protoxide and peroxide of iron:—

	Silica.	Peroxide of iron.	Metallic iron.
A, . .	8·60	61·86	43·30
B, . .	7·75	55 00	38·50
C, . .	8·90	49·65	34·75
D, . .	7·30	56·02	39·21
E, . .	7·15	70·45	49·31
F, . .	8·70	68·77	48·14
G, . .	6·70	57·37	40·15
H, . .	8·55	63·40	44·38
I, . .	6·20	71·12	49·78
K, . .	6·80	62·73	43·91
10 samples, average	7·66	61·63	43·14
Maximum, .	8·90	71·12	49·78
Minimum, .	6·20	55·00	34·75

Annexed is the analysis of an average sample of this stone made in the laboratory by my pupil Mr George Steward. I also append an analysis of a specimen of this substance by my friend Mr John Pattinson, chemist to the Clarence Iron Works, Middlesboro', who kindly communicated the result, and which fully confirms the correctness of the other examination in nearly every particular.

This close agreement is exceedingly interesting, when it is considered that the samples were obtained through entirely different sources, and analyzed independently, without any intention of comparing the results with one another.

Analysis of Two Samples of Rosedale Ironstone, Dark-Blue Magnetic.

	Steward.	Pattinson.
Protoxide of iron, . . .	33·55	33·85
Peroxide of iron, . . .	31·40	32·67
Alumina, ...	16·05	3·15
Lime, ...	2·35	2·86
Magnesia, ...	1·29	1·59
Potash, ...	...	Trace.
Carbonic acid, . . .	10·26	10·36
Silicic acid, ...	4·50	6·95
Sulphuric acid, . . .	...	Trace.
Sulphur, ...	...	0·03
Phosphoric acid, . . .	...	1·41
Carbonaceous matter, . .	...	0·84
Water, ...	1·34	3·76
Protoxide of manganese, . .	...	0·69
	100·74	98·16
Metallic Iron, . . .	48·07	49·17

The Shaft and Drift near the Quarry.—I have examined several samples of the stone which is obtained from this place. It is of a light-blue colour, and is, when first taken from the mine, both soft and friable. On exposure to the air it becomes red, from conversion into peroxide, and much resembles externally the matrix in which it is embedded.

No. 1. A thin scrap, blue on the inner side, and brown outside.

No. 2. The light-blue nodule inclosed in No. 1.

No. 3. A thick scrap made up of a series of brown layers streaked with thin blue layers.

No. 4. A light-blue nodule inclosed in No. 3.

Analysis.

	Silica.	Peroxide of iron.	Metallic iron.
No. 1, . .	6·70	64·25	44·97
No. 2, . .	7·40	53·89	37·72
No. 3, . .	8·90	50·17	35·11
No. 4, . .	7·85	64·25	44·97

The Drift about two miles from the Quarry.—I spent some time in examining this spot, as the changes that appeared to be going on between the air and the light-blue stone were very marked; and it afforded a good opportunity of studying the manner in which these curious concretions are undergoing alteration.

On minutely examining one of these nodules *in situ*, the first envelope had some similarity in appearance to the mass which it surrounded—that is, it had the appearance of blue and brown stone intermixed.

The next covering had lost all appearance of light-blue, and was reddish-brown.

The outer casing of all was very similar to the preceding.

Each of the specimens were taken separately and analyzed, with the following results :—

Analysis of Section showing the Composition of a Light-Blue Nodule and its surrounding Scraps. By Mr E. C. Northcott.

	A. The Nodule.	B. 1st Scrap.	C. 2d Scrap.	D. Outer Scrap.
Silica,	9·65	8·20	10·95	8·20
Protoxide of iron,	35·25	4·97	1·24	...
Peroxide of iron,	12·22	50·63	54·65	60·05
Alumina,	14·10	18·70	14.22	15·45
Lime,	2·38	Trace.	0 48	1·15
Magnesia,	3·95	1·41	0·27	0·72
Sulphur,	Trace.	Trace.	Trace.	Trace.
Sulphuric acid,	Trace.	Trace.	Trace.	Trace.
Carbonic acid,	16·25	Trace.	Trace.	Trace.
Water,	4·80	15·50	17·50	15·40
Proto and peroxide equal to	98·60	99·41	99·31	100·97
Metallic iron,	35·94	39·30	39·22	42·03

A glance at the quantities of protoxide of iron in these specimens will show the changes that have taken place from a carbonate to a hydrated peroxide of iron.

In order that the quality of this stone should be thoroughly tested, I collected five samples taken one foot apart from top to bottom of the drift. These were tested separately for silica and iron, and equal weights of each sample were mixed together and analyzed. An average valuation of the entire stone was thus obtained, whilst the determination of silica and iron in all the samples exhibits its maximum and minimum quality.

Analysis of Five Samples of Brown Ironstone from the Drift two miles from the Quarry.

	Silica.	Peroxide of iron.	Metallic iron.
A,	15·00	50·15	35·10
B,	11·50	54·30	38·01
C,	11·00	57·05	39·93
D,	13·00	51·30	35·91
E,	8·70	55·50	38·85
Average,	11·84	53·66	37·56
Maximum,	15·00	57·05	39·93
Minimum,	8·70	50·15	35·10

Analysis of the Average of Equal Parts of the above Five Samples.

Silica,	12·20
Protoxide of iron,	2·50
Peroxide of iron,	51·50
Alumina,	14·50
Lime,	1·95
Magnesia,	1·15
Sulphur,	Trace.
Sulphuric acid,	Trace.
Carbonic acid,	1·70
Water,	11·50
	97·00
Metallic iron,	38·01

It will be seen that this stone is of considerable value, containing, as it does, on an average, about 38 per cent. of metallic iron. It is very free from sulphur, and contains only a very moderate quantity of silica.

There are many other places in this locality where ironstone of good quality may no doubt be obtained, but, my time being limited, I had not the opportunity of more fully exploring the district.

There is still an insuperable objection to working this stone, viz., the want of railway communication. At present the nearest point to the Whitby and Pickering line is at Pickering, ten miles distant, and the conveyance of the stone by carts, in consequence of the great expense of transit, renders its attainment a matter of secondary importance.

Recently some surveys of the district have been made with a view to the projection of a line to the spot, but the contortions of the strata rendering the loss of the seam of stone a matter of possibility, will no doubt make such an undertaking peculiarly hazardous as a monetary speculation.

The Whitby Ironstone Beds.—In proceeding along the sea shore, from Whitby northwards towards Redcar, the rocks forming the coast line contain a number of beds of ironstone varying in composition, but consisting, at the places where I have examined them, either of carbonate of protoxide or hydrated peroxide of iron. The latter, so far as my own observations go, is the most frequently found, but beds of carbonate of iron are obtained of considerable thickness in places.

The stone is obtained by drifting into the cliff, and is conveyed to ships by means of jettys thrown out towards the sea.

I have not had so many opportunities of investigating the locality as could be desired, but have principally confined myself to one or two mines, where a large quantity of this material is obtained.

It is of a dark brown colour, friable, and consists of hydrated peroxide of iron, mixed with variable proportions of sand. Along with the preceding is a stone of much lighter colour and more sandy appearance, and which occurs in considerable quantity. From a letter that I have lately received from the proprietor of one of those mines, I understand that they have come upon a bed of stone, a sample of which I have seen, and which is a carbonate of iron, apparently similar to the stone I shall have to speak of presently, viz., the Sleights Bridge and tunnel stone. The specimens are obtained from the Raithwaite mine, which is the first drift in the cliff after proceeding northwards from Whitby. Part of these were taken by myself, and part have since been sent to me by the proprietors.

It will be seen that the specimens taken by myself are, on the whole, not so favourable as those sent by the parties themselves, but I must in fairness state that I was cautioned at the time I took the samples that I had selected the worst of the stone.

The two collections must therefore be considered as one, and the value of the stone judged of by the average result. I may, however, state that some of the samples that I took were from the waggons on the jetty, which were *of course* about to be unloaded into ships.

The following are the analyses of those samples which were taken by myself from the mine and from the waggons :—

	A	B	C	D	E
Silica, ...	44·75	68·85	58·15	49·45	32·45
Metallic iron, .	22·09	16·69	22·60	29·72	34·70

Description.

A, . . .	Light-coloured sandy stone.		
B, . . .	Do.	do.	
C, . . .	Snuff-coloured	do.	very rotten.
D, . . .	Do.	do.	do.
E, . . .	Do.	do.	do.

The following are the analyses of those samples sent to me by the proprietors of the Raithwaite mines :—

	1	2*a*	2*b*	3	4	5	6
Silica,	36·35	21·00	37·20	18·35	14·00	12·45	18·00
Metallic iron,	25·69	34·26	32·27	34·09	41·86	45·25	33·60

External Characters.

No. 1, . .	Light-coloured sandy stone.
No. 2*a*, 2*b*, .	Ditto.
No. 3, . .	Dark snuff-colour, with many shells.
Nos. 4 and 5, .	Dark rust-red rotten stone, irregular fracture.

On looking over these analyses, the quantity of silica obtained in the first set will be seen to be very high, compared with what is found in many iron ores in the same neighbourhood, and a careful distinction between the good and bad will have to be made if the material is to maintain a good name among ironmasters.

It would appear that the light-coloured stone is much inferior both in yield of iron and proportion of silica to the dark, and the quality of the dark-coloured stone would become much deteriorated by the admixture of any considerable quantity of the light.

Since the specimens A, B, C, D, and E, were analysed, I have ascertained that the siliceous portion of the stone is thinning out, its place being supplied by that of which 2 *a* and 2 *b* are examples. No. 6, I understand, is about 2 ft. 6 in. in thickness. I have made no average analysis of these stones, as their quality and chemical composition are so variable that it could lead to no useful result; but it may be stated generally, that the best appears to contain from 34 to 45 per cent.

A stone differing much in composition and appearance to those already mentioned occurs in large quantity, and is extensively worked, at a few miles from Whitby.

In proceeding from Whitby, in a south-westerly direction by the Whitby and Pickering Railway, a large number of iron mines are observed. Some of this stone has been worked for years, whilst in other cases the drifts have only lately been opened. I have reason to believe that the seams found at

Raithwaite mines are also to be found extensively here, but my object is more especially to illustrate the composition of that stone which appears here, and does not often occur on the sea-shore. It is much more uniform in composition than the preceding, and I understand is obtainable in very large quantities.

The locality has the great advantage of railway communication, in fact the railway passes completely through the district, and sidings run direct from the main line to the mouths of the mines. The stone occurs as far as Grossmont, which is about the fourth station down the line.

I have selected the stone from two places, and append analyses of that found at Sleights Bridge and at the tunnel.

The following are the quantities of iron and silica ;—

Analysis of Sleights Bridge Stone.

	Silica.	Peroxide of Iron.	Metallic Iron.
A, ...	10·00	41·20	28·84
B, ...	9·00	43·55	30·48
C, ...	8·50	42·20	29·54
D, ...	11·60	43·55	30·48
Average, . .	9·80	42·62	29·83
Maximum, . .	11·60	43·55	30·48
Minimum, . .	8·50	41·20	28·84

Sleights Bridge Ironstone.—Analysis of Equal Weights of the preceding Stones.

Silica, ...	9·35
Protoxide of iron, ...	38·56
Peroxide of iron, ...	Trace.
Alumina, ...	12·15
Lime, ...	4·85
Magnesia, ...	4·40
Sulphur, ...	Trace.
Sulphuric acid, ...	Trace.
Carbonic acid, ...	28 00
Water, ...	2·50
Peroxide equal to	99·81
Metallic iron, ...	29·99

The following are the determinations of silica and iron in the stones from the tunnel:—

Analysis of Tunnel Stone.

	Silica.	Peroxide of Iron.	Metallic Iron.
A, ...	15.70	36·75	25·72
B, ...	12·20	45·50	31·85
C, ...	15·50	45·15	31·60
D, ...	17·00	36·05	25·23
Average, . .	15·10	40·86	28·60
Maximum, . .	17·00	45·50	31·85
Minimum, . .	12·20	36·05	25·23

Tunnel Stone.—Analysis of Mixture of Equal Weights of the preceding.

Silica, ...	15·00
Protoxide of iron, ...	35·55
Peroxide of iron, ...	1·80
Alumina, ...	12·30
Lime, ...	5·35
Magnesia, ...	2·10
Water, ...	2·30
Carbonic acid, ...	27·00
Protoxide and peroxide equal to . . .	101·40
Metallic iron, ...	28·91

This stone, in appearance and composition, seems to be the same as that found in the Cleveland Hills, in fact I believe it is considered (geologically) identical. The colour, hardness, and presence of the little oolitic concretions would immediately strike an unpractised eye, and the chemical composition leaves no doubt that this is the same bed of ironstone.

Cleveland Ironstone.—I have been induced to enter into an extended and minute examination of this stone, from the great importance of an exact knowledge of its chemical composition, it being now so extensively smelted in the district where it is raised.

In Cleveland its yield of iron has been a matter of some discussion, whilst the iron made from this stone alone is said to be somewhat inferior in quality, requiring the use of Cumberland hæmatite, in variable quantities, to impart strength, tenacity, and fluidity.

The proportion of iron has generally been judged of by the quantity obtained in the smelting operations ; but it will be evident that this, although the best test in the hands of a skilful manufacturer, would be most fallacious in the hands of an indifferent operator.

In conjunction with the present investigation, I have therefore instituted an inquiry into the chemical composition of the slags of the blast furnaces and the iron produced simultaneously. The results of these experiments will shortly be published, and I shall then have occasion to direct attention to a number of singular circumstances connected with the slag and corresponding iron produced.

The principal mines whence this stone is obtained are those of Eston, Hutton Low Cross, Normanby, and Upleatham. There are other places besides the above named, but I have preferred to analyse these minutely rather than examine a number of places superficially.

In the analysis of the Cleveland stones previously published, I did not determine the quantity of water and carbonic acid separately, and in most instances the phosphoric and sulphuric acid were omitted, whilst I contented myself by stating the iron to be equal to so much peroxide. In the present instance I have, in nearly all cases, determined every constituent separately. The carbonic acid forms the only exception. This latter has, in most instances, been determined by loss on the analysis. It was, however, performed in a sufficient number of cases to establish the correctness of the method, as may be seen by referring to *E* and *F* in the Hutton, *A* and *B* in the Upleatham, and in the Normanby stone analyses.

This stone is exceedingly free from sulphur; in nearly all cases little more than traces can be detected; but phosphoric acid seems to be almost invariably present in considerable quantity.

It will be observed that the stone is a carbonate of protoxide of iron; but there is always a small quantity of peroxide present, generally about 2 or 3 per cent. The stone varies very much in general appearance; but the characters of each bed are so distinct that the different varieties may be recognised without difficulty. Some of the specimens taken from one mine, when compared with those from another, appear so similar as almost to belong to the same piece.

The following are the analyses of the mines enumerated:—

Eston Nab Main Seam.—This seam is from 12 to 17 feet in thickness; solid; not divided by any seam or band of other matter, if the samples marked A to F are taken from a section of the seam,—A being the top of the seam and F the lowest part, and the letters intermediate in the order of their sequence.

G is from a part of the mines where the ironstone is abundantly filled with marine shells, which is not the case everywhere. It will be seen that this stone (G) contained a much smaller percentage of iron and larger percentage of lime than any of the others, which may be accounted for by the proportion of shells in the specimen.

Analysis of Ironstone from Eston Nab (main seam).

	A.	B.	C.	D.	E.	F.	G.
Silica, ...	10·90	11·95	6·00	7.65	7·55	19·90	1 95
Peroxide of iron, .	3·55	6·73	3·95	1·20	...	1·55	2·45
Protoxide of iron, .	39·01	39·05	40·85	43·35	41·22	39·50	24·93
Alumina, . . .	10 62	13 83	12·66	9·88	14·28	17 87	12·72
Lime, ...	1·70	2·52	traces	0 58	trace	1·56	8.56
Magnesia, . . .	3.19	2·72	3·19	5·35	5·48	2·31	1·80
Sulphur, ...	trace	trace	trace	0·09	trace	0·13	0·10
Phosphoric acid, .	2.08	1·02	2·49	3 87	1·02	2·50	1·88
Carbonic acid, . .	25·26	16·38	26·16	22·96	25·32	5·54	41·54
Water, ...	3·69	5·80	4·70	5·07	5·13	9.14	9·07
Proto & Peroxide eq. to	100·	100·	100·	100.	100·	100·	100·
Metallic iron, . .	32·83	35·10	34·54	34·54	32·06	28·73	21·10

	Phosphoric acid.	Silica.	Metallic iron.
Average, ...	2·39	11·98	31·27
Maximum, ...	3·87	19·95	35·10
Minimum, ...	1·02	6·00	21·10

External characters of the stone:

A, cinnamon coloured stone, made up of oolitic grains.
B, C, } blue green-stone, full of oolitic grains.
D, the same, but *dark* blue-green colour.
E, the same, but still darker colour.
F, hard compact stone; olive-green colour; no fossils.
G, dirty-green colour; highly fossiliferous.

Analysis of the Stone from Hutton Low Cross.

	A.	B.	C.	D.	E.	F.	G.	H.	I.
Silica,	20·90	12·80	16·55	15·65	13·00	7·20	12·60	10·40	15·65
Protoxide of iron,	35·55	40·36	37·41	35·75	38·39	40·86			
Peroxide of iron,	1·70	2·41	...	1·80	5·16	4·25			
Alumina,	3·79	3·71	9·86	4·95	3·79	3·44			
Lime,	4·20	2·70	3·08	7·39	3·00	3·80			
Magnesia,	1·12	0·49	trace	2·98	4·80	3·70			
Phosphoric acid,	2·66	1·92	0·67	5·05	2·01	0·96			
Carbonic acid,	25·18	32·72	26·32	23·47	28·40	32·50			
Sulphur,	trace	trace	trace	trace	0·05	1·60			
Sulphuric acid,	trace	0·31	trace	0·07	0·02	0·30			
Water,	4·90	2·58	6·11	4·89	1·45	1·45			
Proto and Peroxide equal to	100·	100.	100.	100·	100·07	100·06			
Metallic iron,	28·84	33·46	29·10	27·45	33·46	34·75	28·88	26.29	28·65

	Phosphoric acid.	Silica.	Metallic iron.
Average,	2·21	13·86	30·09
Maximum,	50·5	20·90	34·75
Minimum,	0·67	7·20	26·29

External characters of the stone:

A, B, E, F, — Colour gray; hard, compact, and high specific gravity, with very few oolitic grains—all alike.

C, D, G, H, I, — Softer stone; fracture uneven; many oolitic grains—all alike.

Analysis of Upleatham Ironstone.

	A.	B.	C.	D.	E.	F.
Silica,	17·49	20·50	14·35	12·95	7·80	7·45
Protoxide of iron,	41·00	34·00	33·37	38·43	38·25	38·25
Peroxide of iron,	trace	7·00	3·50	2·10	6·50	5·80
Alumina,	6·00	12·15	8·10	18·00	11·20	12·20
Lime,	3·35	1·40	7·55	2·80	3·35	5·00
Magnesia,	3·70	3·15	3·45	2·10	2·80	2·40
Sulphuric acid,	traces	traces	traces	traces	traces	traces
Sulphur,	traces	0·06	traces	traces	traces	traces
Phosphoric acid,	0·45	2·55	1·50	trace	2·70	0·50
Carbonic acid,	25·70	15·50	25·38	19·18	24·20	25·40
Water,	3·50	5·00	2·80	4·44	3·20	3·00
Protoxide and Peroxide equal to	101·19	101·31	100·	100·	100·	100·
Metallic iron,	31·85	31·36	28·42	31·36	34·30	33·81

	Phosphoric Acid.	Silica.	Metallic Iron.
Average,	1·28	13·42	31·85
Maximum,	2·70	20·50	34·30
Minimum,	0·45	7·45	28·42

External characters of the stone,—

A,	The roof,	Cinnamon colour, friable, with white oolitic grains.
B,	The floor,	Dark green colour, compact, without oolitic grains.
C,	Intermediate stone,	Compact like B, without grains, faint blue green tinge.
D,	Do.	Light blue green, full of white oolitic grains, very soft stone.
E,	Do.	Composed almost entirely of white grains, held together by a green cement,—soft stone.
F,	Do,	The same as E, but intersected by the green stone, which is without white oolitic grains. Softish stone.

The specimens for the subjoined analyses were selected by taking a large number of stones from the mine, and crushing the whole, by which a very perfect average was obtained, but of course the fluctations in composition cannot be noted in the same way as in the preceding experiments. Mr John Pattinson, of the Clarence Iron-Works, has also analysed these stones, and our results are tabulated side by side. *

Average Analysis of the Normanby Ironstone.

	J. Pattinson. Top, 3 feet.	Crowder. Top, 3 feet.	J. Pattinson. Bottom, 8 feet.	Crowder. Bottom, 8 feet.
Silica,	15·24	23·50	10·36	11·95
Protoxide of iron,	33·86	35·08	38·06	39·05
Peroxide of iron,	0·47	1·43	2·60	3·69
Alumina,	6·92	3·90	5·92	6·41
Protoxide of Manganese,	0·96		0·74	
Lime,	5·82	4·56	7·77	6·35
Magnesia,	3·84	3·23	4·16	3·39
Carbonic acid,	25·00	22·38	22·00	22·29
Sulphuric acid,	trace.		trace.	
Sulphur,	0·40		0·14	
Phosphoric acid,	1·40	1· 4	1·07	1·66
Water,	3·69	4·52	4·45	4·37
Protoxide and Peroxide equal to	97·60	100·04	97·27	99·16
Metallic iron,	26·66	28·28	31·42	32 96

* At the Normanby mines the band of stone is about 11 feet in thickness. The upper and lower portions are separated from each other by a thin band

External characters of the stone.

Top.—Dark sage green, compact, irregular fracture, containing a few shells but very few oolites.

Bottom.—Light bluish-green stone, filled with oolites. I have reason to believe, since making the above analysis, that the determination of the silica in the top seam by Mr Pattinson is more correct than my own, mine being simply the insoluble matter in hydrochloric acid, Mr Pattinson's being the same fused with carbonate of potass and soda, and the silica extracted therefrom. I have therefore adopted his average silica, not having time to repeat my own result.

In concluding the present communication it will perhaps facilitate the reference of such of my readers as are interested in the subject if I give a condensed view of the average value of the various stones examined.

The dark blue magnetic from the quarry.

	Phosphoric acid.	Silica.	Metallic iron.
Rosedale Stone.			
Average, . .		7·66	43·14
The drift 2 miles from quarry. Average, . .		11·84	36·86
Whitby Stone.			
Raithwaite mines, .		12 to 68	16·69 to 45·25
Sleightsbridge. Average, .		9·80	29·83
Tunnel stone. Average, . .		15·10	28·60
Cleveland Stone.			
Eston Nab. Average,	2·39	11·98	31·27
Hutton Low Cross. Average, .	2·21	13·86	30·09
Upleatham. Average, .	1·28	13·42	31·85
Normanby. Average, .	1·55	12·80	30·62

I have again to acknowledge the assistance I have had from my pupil, Mr E. C. Northcott, in the analyses of several Rosedale and other stones. My pupil, Mr G. Steward, has also, in several instances, rendered me valuable service.

of pyrites. The upper portion is about 3 feet, the lower is about 8 feet in thickness.

Notes on the Basalts of the Giant's Causeway, County Antrim. By Edward Hull, A.B., F.G.S. (Plate I.)

The geological structure of the northern coast of County Antrim has already been so fully investigated by a goodly band of observers, amongst whom Dr Griffith and Colonel Portlock may be placed in the front rank, that I should no have presumed to tread upon their steps, did I hold to the principle that what has already been even *well* described should not again be attempted. Upon such a principle, what would become of our histories, books of travel, or treatises on moral or physical science? The indulgence, therefore, which is granted to writers of all classes can scarcely be denied to the geologist, when he endeavours to reproduce the works and investigations, accounts of which are buried amongst the archives of scientific institutions, or in works inaccessible to the general public.

It will scarcely be denied, that there are few districts—not excepting those which may be called the geological "lions" of our isles—which have been so thoroughly explored, that there is absolutely nothing left unnoticed. In general, each observer seizes upon one or more points which bear upon that branch of science to which he specially devotes his attention, and thus, by adding his quota to the general stock, he assists in perfecting the whole.

The feature in the geological structure of the Causeway district which I shall endeavour more particularly to dwell upon, is the stratigraphical position and relationship of the basalt, considered as a *bedded* rock, and therefore presenting many of the phenomena of *strata*, properly so called. But even this view of the subject is by no means new; the bedded structure of the Antrim basalts being admitted by nearly all the writers who have undertaken to treat of them, and who, sooth to say, have left little unobserved to their successors.

The physical features of the north-east coast of Ireland are of no ordinary kind. Whatever may have been the expectations formed, they will probably be found far to surpass them. The magnificent range of basaltic cliffs, extending for several miles in an unbroken coast-line, is almost unique amongst the British Isles, and perhaps is not much exceeded in boldness of aspect, or in variety and regularity in the columnar structure, by any coast-section in the world.

The range of coast-cliffs, stretching for nearly five miles from Ballintrae harbour to Bengore Head, has an average elevation of 500 feet, and in some places of fully 600 feet. The upper portions of these cliffs east of the Causeway Hotel are so precipitous, that they can only be scaled in two or three places; and for one of these, at least, the strong head and firm foot of the native kelp-burner are necessary. In general, the coast forms a succession of semicircular bays, bounded by vertical walls of prismatic basalt. The columns are arranged in tiers of superposition, each tier being distinguished by the size, form, or regularity of its columns; and the effect of these courses of majestic pillars sweeping horizontally round these natural amphitheatres, is indescribably beautiful. From Bengore Head, the coast bends to the south-east, and, in conjunction with the promontory of Fairhead, includes the Bay of Ballycastle. To the north-east, the island of Rathlin, which is composed entirely of basalt resting on chalk,* may be descried, and beyond this, in the distance, the Mull of Cantyre.

The surface of the table-land included by these coast-cliffs is very dreary, and is traversed by low ridges of basalt striking from west to east, the structure of which will presently be explained.

West of Bushmills the coast is less elevated, though often very rugged and bold. As far as the fine old baronial ruin of Dunluce Castle, it is composed of trap of various kinds, though the columnar structure is seldom exhibited; and at a short distance westward from the castle, white smooth cliffs of chalk rise from underneath the dark rugged masses of basalt. From this point to the Bay of Portrush, the superposition of these two diametrically opposite sorts of rock may be traced continuously for a distance of a mile, by the aid of both natural and artificial sections; and here they present many points of interest to which we shall presently revert.

* For an account of the geology of this island, see paper by Professor Haughton. Jour. Geol. Soc. Dublin, 1851.

Perhaps the most prominent feature which at first strikes the eye of the geologist on viewing the basaltic cliffs of this district is their resemblance to stratified rocks. Indeed, of so uniform and regular a character is the bedded structure of these igneous rocks, that we are justified, when treating of them *en masse*, in applying to them the rules which belong to aqueous deposits. We may confidently speak of the "dip," "strike," and calculate the thickness of the Giant's Causeway, as we would do in the case of limestones, or as has been done when treating of the "bedded traps" of North Wales by the Government Geological Surveyors. It is remarkable how persistent are nature's operations, when we find the igneous rocks of ancient Silurian times presenting appearances identical with those of post-cretaceous age. I have seen on the northern flanks of Cader Idris greenstone dykes, bedded conformably with the slates by which they are inclosed, besides being perfectly columnar, with the axes of the columns perpendicular to the planes of bedding. And thus it is with the Causeway basalts. We find superimposed courses of columns, in each of which the columnar structure is developed in a manner and degree which seems to distinguish it from the other courses through horizontal distances of several hundred yards; and these courses, which doubtless represent distinct lava-flows, are amongst the principal causes producing the stratified aspect. Some of these tiers of columns are of remarkable regularity, and may be traced continuously for probably two or three miles along the highest portion of the cliffs. The section (Plate I. fig. 1) taken from the Horseshoe Bay, gives at least five such courses of columns.

	Ft. height.
e, The highest, formed of imperfectly prismatic trap,	50
d, Irregularly formed columns, 2 feet in diameter, .	35
c, Irregular, massive, semiformed columns, . .	50
b, Tier of small, bent columns, 6 inches in diameter, curved and radiating, and the line of junction with tier *a* well marked, ...	40
a, The lowest tier, of perfectly straight, and nearly vertical columns, uniformly 18 inches in diameter,	40

At the base of the lowest tier the rock is covered up with shingle. The lines of separation between *a*, *b*, *c*, are well marked, the others less so; but between Horseshoe Bay and Bengore Head, from five to seven tiers of columnar trap will always be found forming the highest parts of the cliff.

The second cause of the bedded aspect of the trap of this coast is the frequent intercalation of beds of bright red ochre, and variously coloured trappean ashes, which Dr Griffith calls "the lithomarge beds." There are many of these seams through all parts of the series, but there is one bed which is very conspicuous, and extends uninterruptedly from the Causeway Hotel to Bengore Head, and beyond, till it dips into the sea, and is finally lost. Colonel Portlock appears to consider this bed as a volcanic mud, and in all probability it is a strictly stratified deposit. It is affirmed by Dr Griffith to contain pebbles of quartz, and to pass occasionally into sandstone.* Amongst the Causeway cliffs, however, the lithomarge bed occupies a *general* position of 200 feet above the sea; and by its bright red and purple colours contrasts finely with the dark masses of trap which enclose it. It may be observed in all states of decomposition, from that of globular trap to a kind of red and purple marl, speckled with white. A pathway about a foot in width winds along the upper part of this ochreous bed, which there could be little difficulty in following, were it not for the reflection that a false step would often be fatal. This path, however, affords the only entrance to some of the bays, and the native men and women traverse it without hesitation. It is really thrillingly interesting to watch for the first time a human being threading his or her way along the face of these precipitous cliffs.

The thickness of this lithomarge bed varies from 10 to 40 feet, and it divides the whole mass into two portions, which differ very considerably in their general structure. The trap underneath appears generally to be separated into thin regular beds, in which we can find but very rude approximations to the columnar structure; while, on the other hand, the mass above the marly zone exhibits those numerous successive tiers of columns, to which we have already alluded, and which,

* Jour. Geol. Soc. Dub. Vol. I. Part iii. p. 158.

when we regard the regularity of their arrangement and uniformity of size, cannot but fill us with surprise and admiration.

The progress of decomposition in the marly zone may frequently be examined in detail, especially near the Causeway Hotel, where it is most accessible. Where it has attained the bright hæmatitic colour, or where the iron has become entirely a peroxide, the decomposition is most complete; and from this point the various gradations may be traced to the opposite condition of the dark-greenish basalt. In the locality referred to, there are also some instances in which trap, which had assumed the *globular* structure, will be found in various states of decomposition. Each spherical mass, in this case, gives off successive concentric layers, which crumble away and change their colour; but while allowing that this and the other partings of marl and decomposed trap have assumed their present characters to a great extent under subaerial conditions, it appears probable, that this and the other decomposed beds of a similar nature represent periods of rest between succeeding volcanic eruptions, with their accompanying lava-flows. This supposition is borne out by the fact, that there are sometimes associated with them beds of lignite, which must certainly have required tranquil conditions for their deposition. When, therefore, we reflect that the thickness of the tabular trap series is, as I shall endeavour to show, at least 1300 feet, and is divided by from 30 to 40 beds of this decomposing volcanic sediment, we have another instance of the immense length of these geologic cycles which the mind assents to without being able to grasp.

The last cause of the bedded aspect of the Causeway basalt which I shall notice, is the alternation of bands of amygdaloid with others of an opposite character. The coast-cliffs between Bushmills and Dunluce Castle offer numerous examples, one of which is shown in Plate I. fig. 2. In these cases, the bands of amygdaloid, from their containing in their cells numerous crystals of zeolites, glassy felspar, and calcedony, are of a much lighter tint than the intervening spaces, while both follow the lines of bedding. It is difficult to account for this diversity of structure, for the alternate bands do not appear to partake of the nature of lava-flows, the lines of separation not being of that sharp and distinct kind which mark these phenomena amongst the Causeway Cliffs.

The basement beds of the Basalt. At the base of the partly inaccessible rock, crowned by the turrets and battlements of the old baronial ruin of Dunluce Castle, we find the white chalk exposed to view at ebb tide. The irregularity of the line of junction with the trap is here sufficiently apparent; for we may notice an arm of chalk stretched beside another of basalt,—the intervening bay decked with forests of marine vegetation, and bespangled with actiniæ, whose beautiful colours are finely set off by the pure white of the chalk. Upon scrambling over the rocks west of the castle for a few hundred yards, we at length come in sight of the smooth cliffs of chalk, worn into caverns, the roofs of which are supported in natural arches with their piers, while the upper part of the cliff is for the most part capped by dark masses of rudely-columnar basalt. (Fig. 3.) The dip of the chalk, as shown by lines of flint, is towards the south-east, at about 4°. That of the basalt is nearly parallel, but the line of junction is one produced partly by the juxtaposition of the rocks.

The basement beds of the basalt, as seen at Dunluce Castle, are of a very remarkable character. Upon first viewing them, I supposed that they were formed of globular basalt, partly decomposed; but upon hammering many of the blocks, and finding each differing in composition from its neighbour, I came to the conclusion that the mass was in fact a *conglomerate*, composed of waterworn blocks of trap, cemented by an ashy paste.

The blocks are of all sizes, from 5 feet in diameter, and may be advantageously viewed in the seaward cliff. They afford a great variety of trap, and are generally vesicular and amygdaloidal. There is no appearance of bedding, and the mass is at least 100 feet thick, resting immediately upon the chalk. In the court-yard of the Castle, one of these blocks, which is subangular, and composed of dark-blue, compact basalt, is fully 10 feet in diameter, and is imbedded in a trappean ash.

Of a similar character is the base of the trap, as far as it can be traced towards Portrush. It is often very admirably displayed in the picturesque cliffs which bound the coast. The lowest portion being formed of white chalk, worn into caverns, arches, and piers, while the dark basaltic rocks crown the summit. (Fig. 3.) Artificial sections are also opened by the cuttings for the government road; and within a mile of Portrush there is a section, for which we are indebted partly to art and partly to nature, which must not be passed over in silence. It exhibits a great pipe or channel excavated out of the chalk, in depth at least 150 feet, filled in with trappean conglomerate, identical with the rock of Dunluce Castle. This is a highly instructive section, as showing the nature of the floor over which the molten matter was poured. The phenomena presented in this section harmonize with those in the neighbourhood of Dunluce Castle. It is evident that the chalk had undergone considerable aqueous denudation, and that it was scooped into channels and hollows before the overflow of the lava. But the most remarkable fact, and one which, according to Dr Griffith, is universal, is this, that the chalk is no way *altered* at its contact with the igneous rock; on the contrary, it is as entirely granular within an inch of the basalt as at 50 feet further down. At the junction we frequently find nothing remaining but a mass of flint gravel, evincing the marine action just alluded to, and upon this the basaltic conglomerate. It is therefore evident that *in this locality* the first overflow of trap was not in the state of molten matter, but that it had become broken up, waterworn, and drifted, and had therefore assumed rather the nature of an aqueous than of an igneous rock. An example of a similar kind with the above is figured and described by Colonel Portlock,* and the denuded state of the former surface of the chalk appears to be coextensive with the rock itself. The most obvious explanation appears to be, that at the period of the first outburst of lava the depth of the sea was not great; at least the eroded surface of the chalk may be considered as evidence of this. Under this supposition, we may conceive that at some distance from the vent, the lava became

* Rep. Geol. Londonderry, p. 92.

broken up from the sudden generation of steam, and the escape of gases. If this hypothesis be correct, the bed of the sea must have continued sinking during the subsequent period of the eruptions.

The direction of the coast from Dunluce to Bengore Head is nearly parallel to the strike of the beds. At the latter point, however, it bends sharply round to the south-east, nearly at right-angles to its former direction. From Bengore Head to Ballycastle, the height of the cliff gradually diminishes, but it is still very bold and precipitous; and it is along this portion that the bedded structure of the basalt is more clearly illustrated.

This structure also exhibits itself in the configuration of the surface of the country. On crossing the strike from north to south, we meet with a succession of basaltic ridges, presenting their scarped flanks to the north-west, and dipping at small angles in an opposite direction. These are separated by wide valleys, generally of a swampy nature, being scooped out of soft beds of decomposing trap, similar to the lithomarge bed already described. On tracing these ridges to the coast we may see them descend in regular succession into the sea, at angles of from 3° to 5°, and then project out to sea, forming reefs, with intervening bays, representing the ridges and valleys of the table-land.

From this structure of the country, it is evident that the thickness of the basalt accumulates as we approach Ballycastle; when, therefore, we find in this locality coal-measures and chalk (rocks of much older date) arriving at the surface, it becomes evident that their presence must be connected with a fault, probably of very great vertical throw. I regret much that time did not permit of a full investigation of this point; but from what I was able to observe, it appears to me that this line of fault has marked the direction of the northern coast of Fairhead promontory; that it will cross the country a little to the north of Bushmills and Dunluce Castle, and will vanish in the synclinal of Portrush Bay, between the Skerries and the main-land, it being by no means an uncommon occurrence for faults to pass into rolls of the strata.

That there are faults in this district later than the basalt, may be inferred from the fact of their occurrence in the island of Rathlin, as described by Professor Haughton,* and it is not improbable that some of the dislocations which, according to him, range north-west, may be offshoots from the main line which I have here indicated.

The *throw* of this fault will probably be found equal to the whole thickness of the basalt, measured from below the sea-bed at the Causeway coast to near Ballycastle, and this cannot be under 1300 feet, and is probably more. I am aware, however, that Colonel Portlock does not consider the tabular basalts to attain a greater thickness than 700 feet.† This, however, is a question which will depend for its solution on accurate measurements in the Causeway district.

Notice of the Copper Turf of Merioneth. *By* WILLIAM JORY HENWOOD, F.R.S., F.G.S., &c.‡

The copper ores which have been found in some abundance amongst the mountains of Merionethshire have not occurred in such long and regular lodes as characterize many other metalliferous deposits; but are for the most part, obtained from the net-work of irregular strings, which,—chiefly composed of quartz and carbonate of lime in ever-varying proportions, and frequently mixed with *epidote* and other minerals—conform more or less to the natural joints of the hornblende-slate or greenstone.

The district to which my labours were directed a few years ago, is the wild and romantic one, well known to tourists, about three or four miles north-west of Dôlgelly, on the way to Trawsfynnydd; and occupies the irregular triangle included between the rivers Mawddach and Babi. Although the surface is generally steep and rough, there are some gentle declivities, and small vales so slightly inclined as to have permitted the formation of peat, and it is in these that the copper-turf has been wrought.

* Journ. Geol. Soc. Dub. † Report, &c., p. 156.

‡ Read before the Royal Institution of Cornwall, October 31, 1856.

At Bryn-Coch numerous short, thin veins, and isolated spots of copper-pyrites occur in a small rocky eminence; and the water oozing and trickling from it enters a field, long cultivated, but from its infertility called Cae Drwg (the bad field). The soil was examined in my presence, and gave traces of copper.

At Benrhos there are small quantities of antimonial grey-copper ore, of copper pyrites, and of the blue and green carbonates of copper. The earth which receives the drainage of pits sunk in pursuit of these ores, gave slight but unequivocal indications of copper.

Copper-pyrites occur at Tyn-y-myndd, but not abundantly. Immediately below, at Maes-y-Glwysan, the vegetable mould is about three feet in thickness, and reposes on a bed of rotten wood (? hazel) and decayed roots of grass of six inches deep; no sign of copper was detected in either of them; but a bed of peat beneath afforded a moderate produce of copper, and has been occasionally wrought.

By far the best known and most extensive deposit of copper-turf, however is at Dolfrwynog, where some 70 acres of it were worked about 40 years ago; at the base of a hill which forms the southern bank of the Mawddwch and receives the drainage as well of an extensive common, as of a long level driven on a vein of quartz, in which were found several irregular masses of copper-pyrites weighing some tons each. The chief repository of the copper is a bed of peat of about 18 inches or two feet in thickness, which consists for the most part of dead grass mixed with great quantities of rotten wood (oak and hazel). Beneath the peat there is a bed of stones a few inches in thickness, evidently the *débris* of the neighbouring rocks. Many of the stones contain iron-pyrites in abundance, and some of them are thinly encrusted with the green carbonate of copper. A second bed of peat underlies the fragmentary deposit, and also affords copper; but so scantily that it has not been wrought, and its thickness has not been ascertained. Some of the lowest portions of the upper peat-bed were so rich in copper, that they were carried to the Swansea smelting works in the condition in which they were extracted; some of the leaves are said to have been covered with a thin pellicle of bright metallic copper; nuts were coated in like manner, and on being broken afforded also a kernel of the same; and I was informed that the copper was in some cases deposited between the fibres of the wood; so that on being cut it exhibited alternate layers of vegetable matter and of metal.

These were, however, exceptional cases. Ordinarily the turf was cut and dried by exposure to the air, and when sufficiently dry it was set in heaps and burnt. As the mass ignited, recently cut turf was added, which was soon dried by the heat; but especial care was taken that the burning heap should not burst into flame, for it then fuzed into a slag, which would not suit the purposes of the smelter. All the utensils employed, excepting only those for cutting the turf, were of copper, as it was found that iron ones were rapidly destroyed. After the fire had been continued for 8 or 10 days without intermission, the ashes were fit for the furnace; and they were then sold to the Swansea manufacturers.

I was informed that in one year 2000 tons of ashes had been sold, and had realized a profit of about £20,000. At the time of my visit, there still remained an enormous quantity of copper turf, but as its ashes would not yield more than about 2½ per cent. of copper, it was thought too poor to be wrought to advantage.

It is said that a similar formation occurred near the Parys and the Mona copper mines in Anglesea; but it was not wrought when I visited them.

Persons conversant with the copper-turbaries, consider the presence of metal in the soil indicated by the growth of the *Sea Pink* or *Thrift* (*Armeria maritima*), which appears to flourish there with remarkable luxuriance.

3 Clarence Place, Penzance, October 29, 1856.

On the Physical Sciences which form the Basis of Technology; being the introductory prelection for 1856. By George Wilson, M.D., F.R.S.E., Regius Professor of Technology, University of Edinburgh.

In my inaugural lecture of last year I endeavoured to define the objects of Technology. I propose, on this occasion, to consider the physical sciences on which it is based. Yet at the outset, I cannot but ask myself, which of these sciences does not lend support to Technology, and on what plea shall any be omitted from the list of its ministers? In reality none can be. Technology is the sum or complement of all the sciences, which either are, or may be made, applicable to the industrial labours or utilitarian necessities of man. But though this be the case, certain departments of knowledge stand so much more closely related than others to the recurring urgencies of daily labour, that to them a pre-eminent importance must be assigned, in any endeavour to number the scientific pillars on which Technology rests. And, in the first place, to narrow our horizon within limits that can be compassed, let me remind you that our science ministers only to the physical necessities of man. It does not acknowledge his imagination, or directly concern itself with his ascription of beauty to some things, and of ugliness to others. It does not acknowledge his heart, or take heed of his loves and his hates, his exultations and despairs. It does not acknowledge his conscience, or care about right or wrong, or affect any interest in his moral welfare. It does not even pay court to his intellect, or profess sympathy with his cravings after knowledge for its own sake, his impatience of ignorance, and longings for perfection. It knows him only as the paragon of animals, the most helpless, though most gifted of them all; and seeks only to meet his fleshly wants; to enlarge the practical empire of his senses; to make his arms stronger, his fingers nimbler, his feet swifter, and with help from Hygienics, his frame more stalwart, himself a more smoothly moving, well-ordered, living machine.

Putting aside, then, all questions of Beauty, Morality, or

Philosophy, we are to consider where man can acquire the knowledge which will give his body the victory in the daily battle of life. The problem which he has to solve is a vast one; so vast, indeed, that instead of attempting to enumerate the items which make it up, I will say, in one word, that his capital to begin with is one wise head and ten skilful fingers, and that with these he must build such a Crystal Palace as the world saw in 1851, and stock it with all its wondrous contents. To solve this problem, he must fall back upon the sciences which reveal the properties of matter, and the modes of altering it.

The sciences in question are familiarly divided into Natural History, on the one hand, and Experimental Physics, including Chemistry, on the other. Natural History, on this view, is the science of all those objects, phenomena, and laws, which physical nature *spontaneously* presents to our view; whilst Experimental Physics is the science of all the *additional* objects, phenomena, and laws, which our interference with nature enables us to bring under our scrutiny.

Such a twofold division, however, is not sufficient for us. All the sciences observe and register the phenomena and laws which nature presents within the circle allotted to each; and are therefore portions of Natural History, or *Naturalistic*. All the sciences, also, but Astronomy, experiment upon, or subject to trial, the objects presented by nature to each; and are therefore *Experimental*. The difference, accordingly, between the majority of the sciences which are observational, and those which are experimental, is one only of degree. A distinction of a much deeper kind lies in the fact, that the experiments which the one characteristically makes are simply more precise observations of what nature presents; whilst those which the other characteristically makes, imply the transformation or transmutation of natural objects, and the study thereafter of the results of such transformations.

In addition, however, there is a third class of experiments, neither simply observational nor transformational, but *registrative* and *directive*, in modes which I shall presently consider. And, further, Biology, the science of Plant-Life and

Animal-Life, must have a place to itself, from the peculiarity of the subject-matter with which it deals.

I would arrange the physical sciences, accordingly, as related to Technology, in three groups.

I. Naturalistic, Observational, and Registrative sciences, of which the chief are Astronomy and Geology, including Meteorology, Hydrology, Physical Geography, and Mineralogy, as well as descriptive Botany and Zoology.

II. Experimental, Transformational, and Directive sciences, of which the chief are Chemistry and Mechanics, as well as Heat, Optics, Electricity, and Magnetism.

III. Organic sciences: namely, Functional or Physiological Botany, which treats of the plant-life of non-sentient organisms; and Functional or Physiological Zoology, which treats of the animal-life of sentient organisms.

This complex, nominally triple arrangement, is essentially twofold, in its relation to Technology. The industrialist must study one class of the physical sciences, or rather one side of all physical science, to consider what gifts nature offers him with her liberal hand. He must study another class of these sciences, or rather another side of all physical science, to discover how to turn those gifts to account. There is always, on the one hand, something to be had for the taking, a raw material, a physical phenomenon, a physical force. There is always a necessity, on the other hand, for expenditure of skill to effect the *transformation* of the raw material, the *registration* of the phenomenon, the *direction* of the force. To render this clear, I must enter a little more fully into details; and these may be discussed under three heads.

One of the greatest services which observational science is continually rendering to Industrialism, is the discovery of natural substances, mineral, vegetable, and animal, possessed of useful but latent properties. A service not less great, is then rendered by transformational science pointing out how to modify this gift of nature, so as to call into active existence its hidden, precious qualities. Thus, to take a complex but striking example. Through observational science we may discover a soil more or less fertile, all the world over; but transformational science must show us how to fence and till it, how to drain or irrigate, and manure it, before it can be made a fruitful field. Geology, striving ever to reach nearer to the centre of the earth, finds coal for us. Chemistry teaches us how to coke, *i. e.*, literally to cook, this raw material, and how to distil it into naphtha and gas. Mineralogy selects iron-ores for us; Chemistry converts them into steel; and Mechanics forges that into bars. Descriptive Botany plucks a wild currant; Physiological Botany changes it into a sweet grape; Chemistry ferments it into wine, and transforms that into ether. Descriptive Zoology lays its hands on a caterpillar; Physiological Zoology nurses it into a strong silkworm; Chemistry bleaches and dyes the silk which it spins; and Mechanics weaves it into velvet.

A second most important service which observational science renders to Industrialism, is by discovering striking natural phenomena, such, for example, as the eclipses of the heavenly bodies, the alterations in the pressure and temperature of the atmosphere, the motions of a loadstone suspended freely, and the like; which experimental science can so *register* as to make them guides of the greatest value in a multitude of practical labours.

Thus, there is perhaps no more familiar natural phenomenon than that the sun leaves in shadow that side of a body which is turned from him, and that this shadow changes its place in obedience to the apparent motion of the sun. And with no more than this fact of nature made over to him, even the barbaric mechanician constructs his useful sun-dial, and the day measures itself into hours. So also the bar of steel, which the experimenter has rubbed with a natural loadstone, becomes a compass-needle, and deserves its name, by threading the mariner's way through all the labyrinths of the sea. "The wind," said King Solomon, the greatest naturalist of his time, "goeth toward the south, and turneth about unto the north: it whirleth about continually: and the wind returneth according to his circuits." And the sailors of the ships of Tarshish had, like our sailors, their wind-vane and streamers, their anemoscopes and anemometers, though they did not so name them, to tell from what quarter, and with what force the wind blew. The complex and beautiful art of navigation abounds in examples of what I have called Registrative Science. The night-glass, the sextant, the thermometer, the barometer, the sympiesometer, as well as the compass-needle and the simple wind-vane, by the indications of which the sailor makes his ship go straight, as if on a railway, to the desired haven, are industrial instruments of the highest value. No one will doubt this who visits any of our fishing towns during the herring season, when the boats are at sea, and observes how the straining eyes of loving mothers and wives are fixed on the weathercock, and those of faithful fathers and brothers on the doubtful barometer. Here natural phenomena are not merely analysed into greater simplicity, which is the function of observational science; neither are they interfered with, which is the function of tranformational science; but they are made, as it were, to prolong their existence till not merely the speculative philosopher, but also the busy workman, has been roused to their presence, and has had opportunity to profit by their warning. We hold, as we may say, the key down, and let the steam-whistle scream till all have heard the ominous note; we keep the signal flying that all may see that the wind has changed, and the fleet is weighing anchor. This cannot be done without instruments, which, if possible, should be automatic or self-acting; and such instruments are the fruit only of much and varied experimental trial; yet the experiments, as something more than observational, and as in no respect transformational, stand apart, and may, till a more distinctive place is found for them, be ranged under Registrative Science.

A third most important service which observational science renders Industrialism, is by discovering natural powers, forces, or energies, which in their spontaneous action work both good and ill to man; but when disciplined and controlled by what I have proposed to call directive science, become his unreluctant slaves and willing workmen.

Thus, meteorology reveals to us the laws according to which great currents are occasioned in the atmosphere; and then mechanics builds its windmill, and the most impatient breeze that tries to hurry past must stop, and, like a chained slave, take its turn at grinding corn or drawing water. "The wind," said He who spake as never man spake, "bloweth where it listeth, and thou hearest the sound thereof, but canst not tell whence it cometh, and whither it goeth;" but provided only it do not cease to blow, the mariner can turn his sail one way, and set his rudder the other, and make the wind carry him round and round the globe, whithersoever he will. These are achievements of Directive Science, and multitudes more might be named. The clock, for example, moved by the falling weight, the hour-glass, with its noiseless shower of sand, the wheel turned by the stream of water, the mill wrought by the ebb and flow of the tide, the sea salt crystallized by the heat of the sun, the boracic acid of the volcanic lagoon evaporated by the heat of the volcano, the direction and force of the wind noted down on paper by the anemometer, *i.e.*, by a pen put between the fingers of the wind itself, the photographic pictures which we compel the sun to draw with a chemical pencil of his own providing, as often as we choose to spread a tablet before him: those are but a few familiar examples of the office of Directive Science. Between it and Registrative Science it is impossible to draw a sharp line of demarcation. A balance or steel yard, for example, falls as much within the one category as the other; so do all kinds of chronometers. But where we avail ourselves of a Natural agency, like the winds, as a mechanical motive power; or like solar heat, to induce chemical change, we may conveniently refer it to Directive Science; whilst where we employ such agency simply to signal to us a change in events, as when the sun-dial marks the passage of time, the compass-needle altered direction in space, or the thermometer altered temperature of the atmosphere, we may with equal propriety refer it to Registrative Science.

Again, as Registration is but carefully made, fully registered, or prolonged Observation, they must shade into each other. It is important, however, to keep them as distinct as we can in reference to Technology; and the essence of this distinction lies mainly in the different nature of the instruments which they severally employ. The object of the naturalist, using that term in its widest sense, is to separate the complex wholes which on every side nature presents, into their simplest components. His chief implements, accordingly, are analytical, and are represented by such instruments as the telescope of the astronomer, the microscope of the botanist, the mining axe of the geologist, the hammer of the mineralogist, the scalpel of the anatomist, and the voltaic battery of the chemist.

The instruments of Registrative Science, on the other hand are, in the simplest sense of the words, *significant* and *metrical*. They signal the occurrence of a phenomenon; they note the presence of a force, indicate the line of its action, and often also measure its intensity and quantity. Such instruments are the wind-vane, compass-needle, thermometer, barometer, chronometer, voltameter, and many more. These instruments are part of the armament of the Naturalist, who is free to use them all; but the disciple of Registrative Science is not equally free to use the analytical implements of the observer. I may compare the difference between the function of the registrars and the observers in science, to that which subsists between the musicians of an army and its fighting men. The drums and trumpets of the band are at the disposal of any combatant officer who has lawful occasion to give a signal to the troops; but the band-master himself never meddles with those exceedingly analytical instruments, the guns and swords of the active combatants.

Thus, then, in all its departments, and at all times, Technology stretches forth both hands: with the one, receiving from the Observational Registrative Naturalist, an organic or inorganic substance, a physical phenomenon, or a physical force; and with the other, receiving from the Directive, Transforming Experimentalist, the means of changing that rude material into many a precious product; that terrestrial or sidereal, or cosmical phenomenon, into a faithful watcher and measurer, that wild force into a patient, docile servant.

After this explanation, I shall fall back upon the familiar division of all the physical sciences, whether dealing with dead or living matter, into two groups, viz.:—

I. The Observational and Registrative, Natural History Sciences.

II. The Directive and Transformational, Experimental Sciences.

Let us look more particularly at these contrasted groups. The sciences which illustrate the contrast best are astronomy on the one hand and chemistry on the other. I shall commence with them.

Astronomy, the oldest, the grandest, and the ripest of the sciences, is, in relation to the physical objects which it considers, almost purely observational. When we study it, we are like men reading a book under a glass case, the leaves of which are slowly turned over by a self-acting mechanism, so that two pages only can be studied at a time. If we quickly exhaust the meaning of these pages, or tire of their perusal, we cannot hasten the period when the leaf will turn over; and if we miss their meaning, or wish to dwell upon it, we cannot arrest or delay the turning of the leaf, but must wait, it may be for a lifetime, till the cycle is complete, and these pages are opened again.

The magnificent clockwork of the heavens, with all its fiery glories, its stately movements, and faultless machinery, is far beyond and above our slightest interference. We cannot reach it, nor, if we could, dare we approach to touch it. The humiliating contrast which any comparison of the two brings to light, between the immensity and majesty of the heavens and the littleness and impotence of man, presses too heavily on the heart to allow us easily to contemplate with merely intellectual eyes the unapproachableness of the objects of astronomy. The greatest of modern astronomers have often with their lips, and always, I believe, with, their hearts, uttered their amen to the star-loving king of Israel's confession, "when I consider thy heavens, the work of thy fingers, the moon and the stars which thou hast ordained; what is man, that thou art mindful of him? and the son of man, that thou visitest him?"

But upon this moral aspect of the peculiarity of astronomy under consideration I have no desire at present to dwell. I would rather on this occasion forget it; for, in truth, if man has reason to feel proud of any one of his achievements it is of his science of astronomy; and the limitations which restrict its study justify his pride the more.

Those limitations are great. Ages before the existence of scientific astronomy the question was put to the patriarch Job, "Canst thou bind the sweet influences of Pleiades, or loose the bands of Orion; canst thou bring forth Mazzaroth in his season? or canst thou guide Arcturus with his sons?" And when Job in his heart, if not with his lips, answered the Almighty, No, he answered for all his successors as well as for himself. Astronomical problems accumulate unsolved on our hands, because we cannot as mechanicians, chemists, or physiologists, experiment upon the stars. Are they built of the same materials as our planet? Are they inhabited? Are Saturn's rings solid or liquid? Has the moon an atmosphere? Are the atmospheres of the planets like ours? Are the light and heat of the sun begotten of combustion? and what is the fuel which feeds his unquenchable fires? These are but a few of the questions which we ask, and variously answer, but leave in reality unanswered, after all. A war of words regarding the revolution of the moon round her axis may go on to the end of time, because we cannot throw our satellite out of gearing, or bring her to a momentary stand-still; and the problem of the habitability of the stars awaits in vain an *experimentum crucis*. The only exceptions which may be made to the essentially non-experimental character of astronomy are furnished by the opportunity granted us to modify to the extent of our power the sidereal influences, such as heat, light, and actinism, and the sidereal bodies, such as the meteoric stones which reach our globe. The sidereal influences, however, have passed from the domain of Astronomy into that of Physics, before they come under our examination; and the meteoric stones are terrestrial minerals before we can analyse them. Optics and Chemistry claim them from Astronomy.

The astronomer, accordingly, must be content to be the chronicler of a spectacle, in which, except as an onlooker, he takes no part. Like the sailor at the mast-head in his solitary night-watch, he must see, as he sails through space in his small earthly bark, that nothing escapes his view within the vast, visible firmament. But he stands, as it were, with folded arms, occupied solely in wistfully gazing over the illimitable ocean, where the nearest vessel, like his own, is far beyond summons or signal, and the greatest appears but as a speck on the distant horizon. His course lies out of the track of every other vessel; and year after year he repeats the same voyage, without ever practically altering his relation to the innumerable fleets which navigate those seas.

Astronomy is thus pre-eminently the Observational Science; and represents in its greatest purity that function of the physical sciences which consists in the investigation of the works of God, as untouched by man. Such investigation is the basis of all our knowledge and all our industry. And if our human pride ever tempts us to undervalue the astronomer as compared with his brother philosophers, because he is only a spectator, and not an actor, on the field which he cultivates, let us remember that the ever-changing spectacle which he witnesses is one which not only demands for its full appreciation the whole intellect of man, but far surpasses in grandeur the sights which open to the eyes of other students, even though they are free to add to the glories which God has made to shine forth from all his works, every hidden grace which human can bring to view.

This superhuman character of astronomy was recognized from the first. As a bare scientific truth, it was implied in the declaration of the great Greek mechanician Archimedes, that *if* he had a place whereon to stand he could move the world. The ποῦ στῶ, the whereon to stand has not been found. The greatest practical mathematician of antiquity incidentally proclaimed that, though man is free elsewhere to compel nature to teach him the mysteries she seeks to conceal, and to submit to his interference with her, there is one territory of hers, and that her vastest, where she brooks no interference, and he cannot stretch her on the rack, or torture her secrets from her. We have no standing place among the stars, no liberty to lay finger upon them. What we know of them they have told us, spontaneously revealing at all epochs more than we are able or willing to receive. This thought, which was latent in the Greek philosopher's utterance, and in part proclaimed in the question already quoted as addressed to Job, was announced in all its fulness by the inspired Hebrew king—“ The heavens *declare* the glory of God : and the firmament *sheweth* his handiwork. Day unto day uttereth speech, and night unto night sheweth knowledge.”

Unconstrained and spontaneous though the revelations of astronomy thus are, their value to industrial science cannot easily be overrated. Our modes of measuring space and time, and in connection with both the art of navigation, are applications to the most useful purposes, of truths which astronomy offers freely to all who have capacity enough to receive them. The phenomena, in truth, of which Registrative Science takes cognizance, are in great part furnished by this liberal giver; who has also taught us laws regulating many of the forces with which Directive Science deals. It is sufficient on this head to refer to the laws of gravitation.

Astronomy, further, is related to the Experimental Transformational Sciences in a very curious way. If imaginative men, needlessly fearing that the progress of physical science will prove fatal to poetry, rejoice that the sun is as dazzling to us as to our forefathers, and that we no more than they can wreathe our hands in the golden manes of his fiery coursers ; at least we can watch with more exulting delight the sparks which their pawing feet strike out of the starry pavement, and can see other than romantic reasons why they rejoice to run their race.

Daily the conviction deepens among those who have studied the matter, that with a few exceptions all the physical powers which man wields as movers or transformers of matter are modifications of sun-force. It was bestowed upon antediluvian plants, and they locked it up for a season in the woody tissue which it enabled them to weave, and afterwards time changed that into coal ; and the steam-engine, which we complacently call ours, and claim patents for, burns that coal into lever-force and steam hammer power, and is in truth a sun-engine. And the plants of our own day receive as liberally from the sun, and condense his force into the charcoal which we extract from them, and expend in smelting metallic ores. With the smelted metals we make voltaic batteries, and magnets, and telegraph wires; and call the modified sun-force electricity and magnetism, and say it is ours, and ask if we may not do what we like with our own.

And again, the plants we cultivate concentrate sun-force in grass, hay, oats, wheat, and other fibres and grains, which seem only suitable to feed cattle and beasts of burden with. But by and by a Spanish bull-fighter is transfixed by this force, through the horns of a bull, and dies unaware of his classical fate, pierced to the heart by an arrow from Apollo the Sun-God's bow. On English commons prizes are run for, by steeds which are truly coursers of the sun, for his force is swelling in their muscles and throbbing in their veins, and horse-power is but another name for sun-power. Nor is it otherwise with their riders; for they, too, have been fed upon light, and made strong with fruits and flesh which have been nourished by the sun. His heat warms their blood, his light shines in their eyes; they cannot deal a blow which is not a *coup de soleil*, a veritable sun-stroke; nor express a thought without help from him.

In grave earnestness, let me remind you, that as force cannot be annihilated any more than matter, but can only be changed in its mode of manifestation, so it appears beyond doubt that the force generated by the sun, and conveyed by his rays in the guise of heat, light, and chemical power, to the earth, is not extinguished there, but only changes its form. It apparently disappears when it falls upon plants, which never grow without it; but we cannot doubt that it is working in a new shape in their organs and tissues, and reappears in the heat and light which they give out when they are burned. This heat, which is sun-heat *at second hand*, we again seem to lose when we use plants as fuel in our boiler-furnaces; but it has only disguised itself, without loss of power, in the elasticity of the steam, and will again seem lost, when it is translated into the momentum of the heavy piston, and the whirling power of a million of wheels.

The second-hand heat of the sun appears equally lost when vegetable fuel is expended in reducing metals; but oxidize these metals in a galvanic battery, and it will reappear as chemical force, as electricity, as magnetism, as heat the most intense;

and, in the electro-carbon light, will return almost to the condition of sunshine again.

This second-hand plant-heat appears equally lost when vegetables are eaten by animals, but in reality reappears in their so-called animal heat, and in the chemical, electrical, and other forces which act upon and within them. It reappears, also, I do not doubt, in their vegetative life, and changes into what we call vital force. Do not, however, misunderstand me, as going beyond physical force. Life, remember, is not mind. The immaterial spirit, the immortal soul, is far above the Sun. We know him, and we know ourselves, but he knows neither himself nor us.

Astronomy thus stands much nearer industrialism, in all its departments, than perhaps any of us fully realize. I cannot wonder that men, even practical men, were once astrologers. A dim sense of obligation to the heavenly bodies for something more than starlight was obscurely felt perhaps by all, and rested, as the stable foundation-stone of a worthless building, at the bottom of the fantastic erection which formed the astrology of the middle ages. And still more intelligible is sun-worship. Only by a fallen and a rebel angel could such words be uttered as "I add thy name, O! sun, to tell thee how I hate thy beams." The worst of men would recall that God "maketh his sun to rise on the evil and on the good;" and across the chasm of centuries I own to a sympathy with the pagan who worshipped as a god the bountiful Sun.

If now we turn to Chemistry, as pre-eminently the Experimental Science, we shall find everything reversed. Were we to personify ancient chemistry, we should represent her as a speechless priestess of nature, sworn to silence, loving concealment, and the most grudging of givers. She persuaded mankind for centuries that there were but four elements, Air, Earth, Fire, and Water; and so cunning a conjuror was she, that though in open day she was continually taking them to pieces before the eyes of all, they did not detect the trick, but pronounced each fancied element one and indivisible. She still stretches forth her hands, filled with truths the most wonderful; but those hands are clenched, and you must borrow her strength before you can open them. Every substance under her control is a locked casket, with a concealed key-hole, and no key. You must first, if you can, find the key-hole, which a search for ages has often failed to find; and then study as best you may the hidden wards of the lock; and thereafter forge not a pick-lock, but a perfect key, which in a multitude of cases will open only the lock for which it was made.

The characteristic attitude, accordingly, of the chemist, is very different from that of the astronomer. It is true that the former, like the latter, and like all the students of nature, must deal much in simple observation. The colours, the odours, the tastes, the crystalline shapes, the densities, the melting and boiling points, and many analogous properties or phenomena presented by bodies, are carefully noticed and registered by him. In observing these, however, he is not doing his own work, but that of the physicist: his proper work begins where that of the latter ends. Whatever is brought him, whether meteoric stone from the realms of space, or mineral from the bowels of the earth, or essence of plant, or secretion of animal, crystal or liquid, or vapour or gas, he regards as coming in "a *questionable* shape." Is it a compound; and if so, what are its ingredients? Are they compound in a less degree, or in essence simple? Are there any bodies truly simple; and if so, how many? What new compounds is it possible to produce by uniting in ways which nature has not followed the simple and complex substances which she supplies?

To act out in practice those queries and others, the chemist at all times must keep both hands busy. His arms may never be folded. No mighty panorama unrolls itself before his eyes, requiring only that he fix upon it an unwavering gaze. No mysterious strangers longing to unburden their bosoms of truths known only to themselves, seek his cell as a confessional, and whisper revelations into his ear. He must be likened to one of those grim inquisitors of the middle ages, whom no man willingly answered, and who believed in no man's answer unless he wrung it from him by torture. In truth, there is a wonderful similarity between the old drawings of the inquisitors putting their victims to the question, and the old drawings of the alchemists testing the objects of their suspicions. In both cases there is a dark subterranean chamber, with ominous fires lighting up the gloom. In both the presiding genius is a wasted old man, with a haggard look, and the pitiless, unsatisfied eye of a bird of prey which has often missed its quarry. In both, obsequious familiars stand ready to do the bidding of the senior, and strange machines and implements hang upon the walls and burden the floor. In both, to complete the picture, all eyes are fixed upon the doomed object of suspicion in the centre, from which, whatever truths mechanical pressure can crush, or fire and water melt or dissolve, will presently be gathered. The analogy is not a fanciful one, for unless history has wronged the mediæval Inquisition, it reversed the rule of English jurisprudence, and counted every object of its notice guilty, till he proved himself innocent: and such is certainly the law of the chemist, who, like the French terrorist, regards every substance as "suspect" of being something else than it seems, and puts a mark even upon those against whom nothing has been proved before his searching tribunal.

But this comparison illustrates only one-half, and that the less important half, of what distinguishes chemistry from the other sciences. It is not that it experiments, for all the sciences, excepting astronomy, experiment. Nor that it tries to analyze everything, for every science is analytical, none more than astronomy; and all to the extent of their power treat nature inquisitorially. Chemistry differs only in degree from the other sciences in this respect, although the degree of that difference is immense. But it may be said to differ in kind from the other sciences, in its power to modify or transform matter, and to effect the creation of new bodies. That it can separate substances into their simpler ingredients, perhaps into their veritable elements, is a legitimate source of pride; but, in relation, at least, to the arts of life, a greater ground of exultation is, that it can unite those elements or ingredients so as not only to reproduce the compound from which they were taken, but to bring into being, for the first time, compounds new to man. No wonder, then, that Nature is jealous of her chemical secrets. She knows that we shall never try to rival her in lighting up suns and stars, in building granite mountains and digging volcanic craters, or in shaping blades of grass, and manufacturing from it fleeces of wool. For the making of these she has the patent which we cannot infringe. But from the moment that chalk was proved to consist of carbonic acid and lime, the patent for making it expired; and we can not only produce chalk at will, out of its components, carbonic acid and lime, but out of their elements, carbon, oxygen, and calcium, we can make novel compounds, and forestal nature in her own market.

The chemist is thus pre-eminently a transformer, a transmuter, a maker; in one word, a creator, to the full extent a mortal can be. God has given him one world; and, in addition, has permitted him to make as many worlds from it as he can. And every day he is making a new, and still a newer globe, new metals, new earths, new alkalies, new acids, new foods, new drinks, new airs to breathe. Alexander the Great wept because he had not another world to conquer; but no chemist needs weep on that account, for he may be first creator, and then conqueror of world upon world. Since the century began, Davy gave us one new world; Berzelius gave us another; Liebig a third: many more are in store for us.

The ancient chemistry, a mute priestess, has long confessed that her oracles are dumb, and herself listens to the revelations of her unresembling successor. Modern chemistry is an active, full-voiced workman, a daimonic blacksmith, like the Scandinavian Thor or the classical Vulcan; only I do not know that it is essential to our conception of personified chemistry that he should be represented lame. This blacksmith's chief tools are two hammers. The one of them he calls *analysis;* it is a *crushing* hammer. If you bring him anything, no matter how rare and costly, he begs you to lay it on his anvil and let him try it with his tool. There are not many things in the world that can bear uninjured its stroke. The few that can, he sets great store upon, puts aside with a certain reverence, calls elements, and distinguishes by names. Some sixty such elements are all that he has yet encountered; and, with an improved hammer, he hopes to break down many of these. The multitude of bodies that give way before his blows he continues to smite till they will break no smaller, and the grains that remain he separates according to their kinds, and puts into that parcel of the sixty invincibles to which each belongs.

His other hammer he calls *synthesis;* it is a *forging* hammer. Beneath its strokes any two or more of the sixty unbroken residues of his crushing work can be welded together, made to incorporate into new substances, and assume new forms. Two, ten, twenty, the whole sixty simplest bodies may be taken, in equal or unequal quantities, and from each of the endless mixtures a new wonder will take shape under the hammer.

So he stands with a weapon in each hand, for he is ambidextrous; and moreover, he can wield both weapons at once. Neither are these his only tools. Equipped with them and with others, the chemist is pre-eminently a transformer, from the four-fold force which he can bring to bear upon material things.

First; He can analyse or decompose them into their last elements, and avail himself of these, as he does, for example, when he extracts the sulphur and the metal of an ore, and uses both; or when he takes out of salt the chlorine, and bleaches with it; and the sodium, and makes soap with it. Or he can *partially* analyse them, reducing them from their native great complexity to perfect simplicity, step by step; doing this by steps of different length, and obtaining something useful at each stage. Thus, instead of at once decomposing sugar into carbon, hydrogen, and oxygen, he can stop short of this, and decompose it into charcoal and water; or into alcohol and carbonic acid; or into oxalic acid and carbonic acid; or into the acid of milk (lactic acid); or into the acid of butter (butyric acid); or into manna and gum; or into mixtures of various of these, and of other peculiar and highly-prized products.

Secondly; He can unite bodies, so as to obtain artificially compounds which are rare in nature or difficult to procure. Thus, instead of digging in Illyria for cinnabar, he heats together sulphur and quicksilver, and makes vermilion in England; instead of sending to the Italian volcanoes for alum, he makes it at home from clay and oil of vitriol; instead of burning sea-weeds, in Shetland, to get carbonate of soda, or sailing to India for saltpetre, he produces these at his own door, by uniting their constituent acids and bases. Further, out of the sixty elements he manufactures compounds of the greatest value to the industrialist, which are not to be found in nature at all, such as brass, gun-metal, cast-iron, steel, percussion-powder, bleaching powder, chloroform.

Thirdly; He can take certain constituents from a compound whilst he adds in their place others, so that analysis and synthesis proceed side by side. Thus he removes oxygen from iron ore, and replaces it by carbon, converting thereby the iron into steel. He begins with a carbonate, and replaces the carbonic acid in it by sulphuric, nitric, acetic, or other acids, so as to convert it into a sulphate, nitrate, or acetate. He takes carbon, hydrogen, and oxygen from alcohol, and adds chlorine, transmuting the spirit into chloroform. Such processes of substitution are perhaps the most common of all the transformative methods of the chemist, and they often imply complete exchange among all the elements of very complex compounds.

Fourthly and lastly; He can transform bodies, without taking ingredients from them or adding ingredients to them. By a new arrangement of particles, implying neither loss nor gain of weight or substance, one body may be converted into another of properties totally different. Thus starch can be changed into gum, and gum into sugar, and sugar into wood-fibre. A neutral salt may become a powerful base; a volatile odorous liquid an indifferent crystalline solid. Chemistry looks in no direction more hopefully than in this for new triumphs over matter.

There are thus four means of inducing chemical change, resembling familiar arithmetical processes. The first, a process of simple subtraction; the second, a process of simple addition; the third, a process where certain figures are annexed and others removed; the fourth, a process where, without altering the total number of figures, the value of each, and of the sum total is changed, by changing their relative decimal places.

Astronomy and Chemistry thus stand at opposite poles; although no one who studies both can fail to perceive that the stars of the one science are represented by the atoms of the other, and that it is felt to be as natural to speak of the atmosphere of an atom as of the atmosphere of a star. The ancient vague alliance between astrology and alchemy has not been repealed, but only by wise restriction and enlargement made the modern explicit and intelligible bond between astronomy and chemistry. They agree in being observational and analytical, but differ inasmuch as of the two, chemistry alone is synthetical, synthetico-analytical, and transformational. And although as a science chemistry is not more essentially analytical than astronomy; all the sciences, as already urged, being, according to the limits of their domain, equally analytical; as an applied science, *i.e.*, as an art, its powers of analysis give it pre-eminence. In popular language, this word "analysis" is understood to signify chemical analysis, nor need the analysts of the other sciences complain of this. It is the utilitarian value of the material products of such analysis, not the fact or mode of its performance, that chiefly leads to the appropriation by Chemistry of the term. The analysis by the telescope of the milky way into a firmament of stars; of nebulæ into clusters of them; of one evening star into a Jupiter with four moons; of another into a Saturn with rings; of a third into a double star, with each twin differently coloured, are performances as wonderful as the analysis of water into oxygen and hydrogen, or of vermilion into sulphur and mercury. But the moons of Jupiter have no industrial applications, and the rings of Saturn do not alter in market value; the Milky Way has not become more nourishing since the gods vanished from the sky; nor is a double star of more use than a single one. Microscopic analysis, anatomical analysis, crystallographic analysis, yield results as curious and as important as any yielded by chemical analysis, but they have little interest for the Industrialist. It matters not to the manufacturer of phosphorus what the microscopic characters of a bone are, but a great deal what its chemical composition is. It matters nothing to the farmer what the shapes are of the fossil infusoriæ in the soil he tills, but a great deal what the chemical constituents of that soil are. It matters little to the gunpowder maker what the crystalline forms of sulphur and saltpetre are, but he attaches the greatest value to the question of their chemical purity.

There is another reason why the word "analysis," unless qualified, should be so generally understood to signify chemical analysis. Chemistry, alike as a science and an art, does not merely separate the complex material wholes with which it deals, into their simpler and simplest ingredients, but completely detaches each of these from the rest, and handles it apart. We do not merely know that water consists of hydrogen and oxygen, but these themselves are ours, to examine as minutely as we please. The solitary exception presented by the element Fluorine, which chemical science can logically analyse out of its compounds, but which chemical art cannot concretely isolate and exhibit, makes the contrast in all other cases the more remarkable. No doubt our means of mechanical analysis, and isolation are very great, as geology, mineralogy, anatomy, and physics, generally illustrate. Their modes of application, however, and their results, are less numerous and far less striking than those of chemical analysis. The mechanical part, for example, of metallurgy, with its minings and diggings, its crushings and sortings, its siftings and washings, which are all processes of analysis and isolation, makes no such impression on us as the chemical part of metallurgy, where the blast-furnace resolves iron ore into oxygen and iron; and the clay-still resolves cinnabar into quicksilver and sulphur; and the cupel extracts silver from a mixture of metals. The greater impressiveness of chemical as compared with mechanical analysis, largely depends upon the greate rapidity with which the former can be executed, and its results rendered visible. You let fall a drop of oil on the liquid chloride of nitrogen, and on the instant it is resolved into its component gases. You strike a fulminating crystal, or heat a lock of gun-cotton, and in a moment every element in either is set free. You expose a salt of silver for a second to the sun, and silver appears. You add a little green vitriol to a solution of gold, and the gold is at once deposited. You plunge the poles of a galvanic battery into water, and torrents of hydrogen and oxygen instantly rise from the liquid. No science but chemistry can show such things; and if the practical chemist does not analyse quite so swiftly as such feats would imply that he might, he nevertheless always analyses swiftly. But skill to analyse, forms, as we have seen, but one-fourth part of the chemist's power. He can build up as well as pull down; he can do both at once, and he can transmute without doing either, and all as swiftly as he analyses. This four-fold power and this immense energy place chemistry at the head of the experimental transformational sciences; and render it as an art so mighty in effecting useful changes upon matter. It is the type of the one group of industrial sciences, as astronomy is of the other.

Astronomy is severely observational as a science, and passively registrative as an art. At best it lifts up its hand only to warn, and stretches forth its finger only to point. Chemistry is inquisitorially scrutinising as a science, and actively changeful as an art. It lays its hand upon everything within its reach, and is never content till it has made some alteration upon it. The symbol, accordingly, of astronomy, is an Eye; the symbol of chemistry is a Hand: not that astronomy is handless, or chemistry eyeless; but the power of the former is in its eye; the power of the latter is in its hand. The symbol of industrial science is a hand with an eye in the palm, and the fingers free. Let this be the crest of the Industrial Museum.

The other physical sciences rank between those two, standing nearer to the one or the other, as they are predominantly observational or experimental. Nearest to astronomy stands geology. The magnitude of the objects with which it deals, small though they are compared with those which concern astronomy, places them in greater part beyond human interference. And the same influence which illimitable space exerts in astronomy, by lifting the stars to heights inaccessible by us, immeasurable time exerts in geology, by enlarging her almanac, so that less than a line suffices for all the generarations of the most ancient race.

Yet geology is visibly an experimental science, which astronomy is not. Our experiments upon the earth have indeed been more frequently incidental than designed, yet human feet have not trod the globe for thousands of years without leaving foot-prints upon it. And although with all our mines, tunnels, canals, bridges, roads, railways, break-waters, and harbours, we make no greater change on the crust of the globe than the earth-worms do on the soil of our gardens, or the sea-slugs on the sand of our shores; still, like them, we do leave behind us an impression which is not only immense, as tried by human standards, but sufficient, we may believe, permanently to distinguish our planet from all others. Such determinations, also, as those of the heights of mountains, the depths of oceans, and the limits of our atmosphere: such observations as those of the size, and the shape, and the weight of the earth: such bold questions, boldly answered in the affirmative, as—"Is the sea open to the four winds of Heaven? and may we sail upon it whithersoever we will?: "Is there a great continent to the west of Europe, behind the arch of the sea; a land of gold, near the setting sun? Is the ocean a sphere as well as the land, and may we let loose from our sea-rock without anchor on board, and measure the great circle, floating every day on new waters, till we moor beneath the white cliffs of our sea-rock again?" Such achievements, although a strict logic must refer them solely to observational science, inasmuch as they imply no transformative power over the objects with which they deal, yet include in the instruments with which they are effected, so many fruits of transformative experiment, and are wrought out so thoroughly in its spirit, that we cannot easily reconcile ourselves to calling their heroes simply observers. They plainly deserve a middle place. Geology is half of the heavens: half of the earth. She stands an imperial queen, with her head among the stars, and her tresses are white with the snows of ages; but her feet, graceful and quick, are beneath the young grass, and are wet with the dews of to-day. Her hands are often raised to shade her eyes, as she gazes through space to exchange greetings with each sister-presence in the worlds around. But her fingers are as often busy with homely cares, and with bended forehead she traces for the tenant-lord of her estate the best track for his railway and channel for his canal, and shows him where to find coal and iron, and how to dig for gold. The geologist, indeed, is so essentially a miner, a quarryman, a rock-blaster, a stone-breaker, a hill-climber, and leveller, that we do not realize him without such tools in his hands as to the imagination appear more potential than mere instruments of observation. Geology thus forms a link between the contrasted groups of sciences. It is to some extent experimentally transformational, and will slowly, as the ages roll on, become more possessed of this character. *Registrative*, it scarcely is at all. It does not, for example, warn us of earthquakes, but only tells us when they are past; and we can scarcely call it *Directive*. It is of the greatest importance, however, to industrialism, in its purely observational character, as dealing with the globe as a great store-house of mineral matters of the highest value. I need but name building stones, metallic ores, the constituents of glass and porcelain, coal, and lastly water.

Next to Chemistry, as an Experimental Science, wielding immense transformative power, stands Mechanics. I include under this term the science of force, not only as determining the rest and sensible motion of masses or particles of matter; but also as determining all structural or molecular changes in bodies, whether solid, liquid, or gaseous, which are not produced by chemical alterations, or by the vital agencies at work in plants and animals. Were this identity between mechanical force, and all molecular force which is not certainly chemical or vital, made the ground of positive deductions in natural philosophy, it would be liable to the gravest objections. But, regarded simply as an assumption, awaiting refutation, verification, or correction, as knowledge progresses, it will involve us in no speculative error, whilst it greatly simplifies our study of many of the practical applications of science. There are few technical processes, for example, more important than the tempering of steel, the annealing of glass, and the crystallization of salts; yet how far the structural or molecular changes which it is the object of those processes to produce, imply only a mechanical, or, as is most probable, also a chemical change in the relative arrangement of their particles, is unknown. As however no loss or gain of element or ingredient, or any other *sensible* chemical change occurs, whilst a very appreciable mechanical alteration happens, it is convenient to disregard in technological discussions the possibility of the former kind of transformation occurring, and to recognize the occurrence only of the latter. The relation of vital to mechanical force will be considered hereafter.

The transformative power of Mechanics over matter comes before us as industrialists in a threefold way. First; As furnishing a motive power which can be directed on masses both large and small, so as to throw them into motion. Second; As furnishing a means of inducing change by alterations in the external configuration of bodies. Third; As furnishing a means of inducing molecular change in a mass without alteration of its external configuration or production of sensible motion.

So far as the first is concerned, I need scarcely remind you that there is scarcely an industrial art which does not in some of its departments require a motive power. A steam-engine is scarcely wanting from a single utilitarian establishment. Places so unlike each other as a farm, a dye-work, a cotton factory, a stone-cutter's yard, and a wood-carver's shop, have alike this indispensable engine, or some substitute. This necessity is curiously illustrated by the same word *mill* being applied to industrial establishments of the most opposite character. We speak, for example, of a flour-mill, a cotton-mill, a gunpowder-mill, and a saw-mill. As examples of the application of motive power to the production of mechanical transformation, I shall content myself here with referring to the conversion of wool, silk, flax, and cotton, into woven fabrics, and of rags into paper.

So far as the second aspect of mechanical force is concerned, namely, as an inducer of alterations in the external configuration of bodies, it will be sufficient here to refer to the arts of the stone-cutter and wood-carver, and to those of sculptors, carvers, and engravers of all kinds.

As for the third aspect of mechanical force, namely, to induce internal molecular change, such processes as the tempering of metals, the annealing of glass, and the baking of porcelain, in certain of its stages, may serve as illustrations.

In contrasting mechanical with chemical transforming force, it is curious to notice how in one respect the former is the more imposing, in another the latter. Mechanical force, when exerted as a motive power, can be employed by man on a much grander scale than the similar power of chemical force, except in the case of explosives. Artificial chemical processes, again, on however large a plan they are sonducted, are, with few exceptions, such as that of the iron blast-furnace, striking only in their results. But the movements of massive pieces of machinery, even though moving aimlessly, still more when working for a purpose, always awaken in us the idea of power; and often also create emotions of awe and sublimity akin to those which are begotten by the spectacle of great natural phenomena. The sweep of of a railway train across the country, and the dash of a war-steamer against the waves with which it measures its strength, never become paltry pageants, even though we are ignorant of the errands on which these swift coursers are bound. Still more striking are those actions of machinery which involve not only swift irresistible motion, but also transformation of the materials on which the moving force is exerted. Take, for example, a cotton-mill, which some never tire of representing as dreary and prosaic. In the basement story revolves an immense steam-engine, unresting and unhasting as a star, in its stately, orderly movements. It stretches its strong iron arms in every direction throughout the building; and into whatever chamber you enter, as you climb stair after stair, you find its million hands in motion, and its fingers, which are as skilful as they are nimble, busy at work. They pick cotton and cleanse it, card it, rove it, twist it, spin it, dye it, and weave it. They will work any pattern you select, and in as many colours as you choose; and do all with such celerity, dexterity, unexhausted energy, and skill, that you begin to see what was prefigured in the legend of Michael Scott, and his "sabbathless" demons (as Charles Lamb would have called them), to whom the most hateful of all things was rest, and ropemaking, though it were of sand, more welcome than idleness. For my own part, I gaze with untiring wonder and admiration on the steam Agathodæmons of a cotton-mill, the embodiments, all of them, of a few very simple statical and dynamical laws; and yet able, with the speed of race-horses, to transform a raw material, originally as cheap as thistledown, into endless useful and beautiful fabrics. Michael Scott, had he lived to see them, would have dismissed his demons and broken his wand.

Yet magnificent as the scale is on which many mechanical transformations occur, they are to a great extent undervalued because there is nothing mysterious about them. However great the difference between the raw material and the finished product, we can follow each step in the transition from the one to the other. The Portland Vase, for example, is as different, in one respect, from the ball of vitreous jelly out of which it was elaborated, as in another, that jelly is from the sand and alkali and metallic oxides, which were melted together to produce it. Rarely-gifted hands and nice tools were needed to furnish the mere outline of that beautiful vessel; still more to carve the exquisite shapes which are sculptured upon it. Its materials, on the other hand, are of the cheapest; and the most ignorant slave had skill enough to melt them together. Yet we can realise each step in the mechanical workmanship; and some lookers on; if none others, the artists themselves, saw the whole grow into beauty under their eyes, like Aphrodite rising from the glassy sea. But no one saw or can see the sand and alkali change into glass, or can realise what happens during the transmutation. The most critical part of the process is effected *per saltum;* and, as with children trying to watch themselves fall asleep, our eyesight and consciousness fail us at the very moment when the mystery lies bare, and the secret is open to view. It is so with every chemical process: bleaching, dyeing, fermenting, ether-making, reducing of metals, firing of gunpowder. The substances taking part in each reaction are like masqueraders crossing a bridge, the crown of which is hidden by clouds. You trace them, letting no movement escape you, as they climb from one side leisurely towards the elevated centre, and enter the shadowing cloud, but though it seems quite transparent, its entrants grow suddenly invisible, and when you next catch sight of them descending on the other side, they are transfigured and totally changed.

This occult character of chemical force appeals not only to that vulgar wonder which holds *omne ignotum pro magnifico,* but provokes the chastened curiosity of the philosopher, who cannot divine what or how many unexpected figures may emerge from each enigma, and alter the value of all his calculations.

The mechanical powers are like stalwart giants of Northern blood, standing erect and naked to the waist, with their ponderous tools beside them, and their fair, frank faces, ignorant of guile, opening their blue eyes calmly upon us. They possess only strength and skill, and obedience to laws so few and simple that they can be made plain to any intelligent child. We respect and admire them; but we feel that we can measure their height, and take the girth of their arms, and we are not afraid to calculate the horse-power, immense though it is, which lies in the bend of each of their little fingers.

The chemical forces are like supple Eastern jugglers, with swarthy brows, and lustrous, unfathomable eyes, who never look you straight in the face, or measure glances with you. They are robed in gauze, which seems transparent like glass; but when you try you can see nothing through it. The instruments in their girdles are like children's playthings; and the lighted lamp, which they always keep near them, has nothing to distinguish it from ordinary lamps. You may be indifferent when they stretch forth their slender arms, and ask you for the stone beneath your feet; but you are startled when, after some sleight-of-hand, you receive in its stead a steel blade or a sphere of crystal; and you tremble when you see the cunning fingers close for one moment over a little harmless charcoal and water, and open the next to offer you the deadliest poison. These subtle conjurors, secret as the grave, have we know not what of angelic, what of demonic power at their command; and we are continually tempted to put a higher value upon their mysterious legerdemain than upon the open handiwork of the mechanical powers. In so far, however, as the artificial modification of matter is concerned, we almost invariably require the services of both, and they work willingly together. It may be well to have one word, as *transmutation*, to indicate chemical molecular change, and another, as *transformation*, to indicate mechanical molecular change; but, as industrialists, we must hesitate to marvel more at the one than the other. How cheerfully they labour to a common end, like twin brother and sister; the one strong by measurable strength, the other by immeasurable fascinating power, we see in the case of that great world-changer, that emblem of war, and minister of peace, gunpowder. It needs the strong brother to fell the oaks, and with a hint from his twin to burn them into charcoal. It needs his stout arms to quarry the sulphur, and bring the saltpetre from India; to crush them into grains, and grind them together. But it also needs his weird sister, in whose palm he lays the innocent dust, to breathe upon it before the Alps are tunnelled, or Sebastopol lies in ruins.

It is not necessary, after the division I have made, to make special reference to heat, light, electricity, and magnetism as sciences of transmuting and transforming force, since, without deciding on the essential nature of the agencies which they represent, we may, as industrialists, divide them between mechanics and chemistry. Thus heat may be equally partitioned between them, as alike remarkable for mechanical and chemical alterative power. Electricity and light may be given in larger part to chemistry; and magnetism in larger part to mechanics. On the other hand, also, mineralogy, as a lesser geology, may be ranked along with it.

We may suppose all the sciences related to industrialism arranged in the form of a crescent. At the tip of the one horn stands astronomy, next it is geology, and next to that mineralogy. At the tip of the other horn stands chemistry, next it is mechanics, and next to that heat, light, electricity, and magnetism. In the centre of the crescent stands the remarkable science which we have still to consider, namely, biology. It includes botany, the science of plants and plant life. and zoology, the science of animals and animal life. These sciences, in popular estimation, alone constitute natural history, and are often referred to as if they were solely observational and analytical; but they are transformational in a remarkable way, and furnish the industrialist with most important instruments for effecting changes upon matter. After death, plants and animals furnish to the botanist and anatomist endless subjects for the observation and analysis of peculiarities of form, structure, and function. To the practical chemist also and the mechanician they supply the raw or *genetic* materials, such as wood and wool, of a thousand industrial arts. During life they are likewise objects of observational science; and in one respect are as much removed beyond direct human interference as the objects of astronomy. Life builds up a barrier round plants and animals, which we may not overpass, except at a few places. We cannot experiment on them in the way we can on dead objects ; for interference with them, to any considerable extent, either sacrifices life, or so alters its conditions that a dead or diseased thing is left in our hands. Nevertheless every living plant and animal is for the industrialist a machine or apparatus, possessed of remarkable transforming and transmuting powers, which, to a very considerable extent, may be controlled, directed, and even modified by him. And if living organisms cannot be wielded as tools or weapons in the same way as inorganic machines can, there is this great compensation in the fact that, to the extent an organism can be wielded by us, it enables us to add to the transforming and transmuting powers of mechanical and chemical force, which alone are available in the dead machine, the metamorphosing power of vital force. Differences of opinion may exist as to the essential peculiarity of this force, but there can be none as to the practical advantage of regarding it as distinct from mechanical and chemical force. I will go further, and apply the term *metamorphosis* to the kind of change which vitality specially induces in matter, so that, accepting the confessedly arbitrary employment of terms which I have proposed, we shall speak of a mechanical *transformation*, a chemical *transmutation*, and a vital *metamorphosis*.

Looked at from this point of view, biology yields to none of the sciences in industrial importance. Translated into practice, it gives us agriculture, an art so peculiar and extensive, that, like medicine, it demands all the energies of an entire profession. It is not my province to discuss agriculture, but there are certain industrial aspects of the biology on which it reposes, requiring notice here.

Animal force is of immense importance to all the useful arts ; first as a motive, secondly as a transformative power. In these days of railways and steam-engines we are apt to think too lightly of our horses and other beasts of burden, forgetting that without them we could not construct the engines which to some extent are supplanting them, and that they themselves are the best of engines for many purposes. James Watt and George Stephenson, I am sure, respected even a donkey; and were the last of its race to die, we might all join Sterne in weeping over the dead ass. We do not sufficiently remember that all other machines are the offspring of living machines. A steam-engine is the literal as well as the metaphorical embodiment of so much horse-power. A railway viaduct is the petrifaction of so much animal force. A power-loom, after its last improvement, remains still a hand-loom. Archæologists tell us, that in far separate regions of the world, you find stamped on the monuments of forgotten races the impression in red of a human hand. But we need not go to distant lands and the works of extinct races for this mysterious signature. The mark of the red hand, red with the blood which toil has wrung from it, will be found on every industrial instrument and product, and the print of a horse's hoof is generally near it. A horse's shoe, indeed, might be nailed up on many a door besides the blacksmith's, to keep away the evil spirit of idleness, if we are afraid of no other demon.

It is only the sentient organism, the animal, that has motive and transformative powers of the kind we have been considering; and it is only the paragon of animals that is able to direct them at will. But a transmuting and metamorphosing power of another kind, and not less important to industrial art, is common to plants and animals, and in some respects characterizes the former even more than the latter. The plants and animals which as agriculturists we care for, may be regarded as skilled labourers, who in return for food, wages (which must be paid in kind), and a certain liberty of action, agree to collect or manufacture for us a multitude of useful substances. We employ them, and many wild plants and animals also, as collectors or amassers of certain bodies, because although we could collect these ourselves, we could not do it half so well. We employ them as manufacturers, because they keep their processes secret and have a monopoly of the manufacture.

Look first at their skill as collectors. As soon as the seed we sow has germinated, it begins to extract from the soil, or water and air around it, various matters, among others the mineral alkali, potash. Now this alkali is of great industrial value, and it is in our power to procure it from the sources which yield it to plants. To procure this, however, is a tedious, costly, and laborious process, for all the free alkali to be found at any moment in a moderate weight of soil is exceedingly small, and could not profitably be extracted by any artificial method. But a growing plant, day by day appropriates to itself an almost infinitesimal amount of potash through its roots, and like a miser hoards it all, or nearly all, so that if at the close of a season we burn it entire, we find in the ashes all the gathered potash of the year harvested to our hands.

The sea, in like manner, is the great fountain of a rare and prized substance, iodine, but were we compelled to take it directly from the ocean we should require to evaporate tons of water to keep a single photographer supplied with it, and it would be more costly than gold. But the seaweeds employ it as well as the photographers, and have long anticipated the physicians in taking it internally. Day by day they sip a homœopathic dose of iodine and retain it, and by and by we burn them into kelp, and extract iodine and much else that is valuable from the ashes.

To take another example, phosphate of lime, a minute constituent of all fertile soils and of most waters, is of great value to the ivory-turner, the manure-maker, the potter, the silver-assayer, the drug-manufacturer, the dyer, and the lucifer-match maker. It reaches all of them in the shape of the bones of dead animals; dead cattle from our farms, dead horses from the Pampas of South America, dead walrusses from the arctic icebergs, dead whales from the Pacific Ocean, dead men even from fields of battle. Land and sea plants have, as it were, milked this essential constituent of their frames, drop by drop, from the breast of nature. Animals of all classes, from the lowest to the highest, have robbed plants of their hard-gotten gains, and made their bones strong with the precious substance. Finally, the chartered robber man has robbed them all, claiming even the relics of his brethren, and obtaining in a handful of bone-dust the phosphate of tons of rock and water.

The industrial importance, however, of plants and animals, as collectors and harvesters of valuable mineral matters, is insignificant compared with their value as manufacturers of bodies whose worth depends much more on their construction or composition than on their raw material. In their former capacity, living organisms resemble simply filters with apertures of different fineness, and fitted to arrest and detain certain substances in themselves valuable. In the latter, those organisms resemble highly complex machines, able to convert the most familiar things into substances precious almost solely from the workmanship bestowed upon them.

Take for example that important substance, wood. Its chief ingredients, charcoal and water, are uncostly and abundant; but in themselves they are useless to the carpenter, and he cannot change them into timber. So he calls to remembrance that his great grandfather planted an acorn, which has turned its first small capital to so excellent account that now it is a timber merchant on a large scale, and will contract with you to build a ship of war out of oak of its own making. It is with other trees as with this ancestral oak. Each, with its republic of industrious roots and leaves, is a joint-stock company with limited liability, engaging to furnish you with pine-stems for masts, fir-wood for planking, logwood for dyeing, cork bark for bottling, oak bark for tanning, walnut for tables, rosewood for picture-frames, satin wood for looking-glasses, willow for cradles, mahogany for wardrobes, ebony for will-chests, elm-tree for coffins.

Those trees form the Worshipful Company of Woodmakers, an ancient guild. But there are others as old. A peaceful army of flax plants protects the monopoly of linen-weaving. Whole battalions of cotton shrubs watch over calico. No one may infringe the patent of the indigo plants for blue dye; none may borrow the multitudinous crimsons and purples of the madder root; none may rival the elastic fig in manufacturing caoutchouc; or learn from the trees of Siam how to produce gutta percha. The roses of Damascus keep the secret of their otto to themselves; and the acacias of Arabia alone deal in gum.

Each of those plants has a monopoly of its manufacture, and sells, at a price settled by itself, all that it produces. The charge is entirely for work, not for materials. You may bring these, indeed, yourself, and have them made up for you;

and nearly the same materials will suit all the manufacturers. The cane will return them as sugar, and the vine as grape-juice, the olive as oil, and the poppy as opium; keeping only to themselves such a percentage as is needed to maintain their workshops, and multiply their buildings. The day *may* come when the patents of these monopolists will expire, and their secrets be published recipes open to all; but that day is far distant, and chemistry as yet has discovered only so many of their devices as serve to whet to a keener edge her unsatisfied envy of their unapproachable powers. Plants are thus, in virtue of their amazing ability to convert the simplest and commonest ingredients of air, earth, and water into the most complex and precious compounds, of as much value to the industrialist, considered simply as pieces of apparatus, as the most elaborate engines he has constructed. Nor is it otherwise with animals. They do not work with so simple a raw material as plants do: they use plants, indeed, directly or indirectly, as their raw material; but they convert them into products raised in industrial value by the additional workmanship bestowed upon them. We have thus the silkworm, whose calling it is to turn mulberry leaves into silk; the bee, who turns sugar into wax; the coccus, who turns cactus-juice into carmine; the oyster, who turns sea-chalk into pearls; the turtle, who turns seaweeds into tortoiseshell; and the whale, who turns sea-jellies into oil and whalebone. The birds are the only makers of quills and feathers; the hogs of bristles; the elephant, the walrus, and hippopotamus of ivory; the sheep of wool, not to speak of fat and mutton; the ox and his congeners of undressed leather; the beaver and his brethren of hat-felt; and myriads of wild creatures of land and sea of furs and skins. I have barely alluded to one animal, as supplying us with food; although, as I need not remind you, the most important industrial relation of many others is their power, as machines, to convert weeds of various kinds into beef, mutton, venison, milk, butter, eggs, the flesh of birds, and beasts, and fishes.

Two points call for special notice in connection with living plants and animals, as industrial apparatus and machines. Firstly: It is impossible ever to say too much regarding their amazing transforming, transmuting, and metamorphosing powers. Into the question how far their functions, as modifiers of matter, depend upon their vital, as distinguished from their mechanical and chemical endowments, it is unnecessary to enter here. It is sufficient to notice that the power which every blade of grass and green leaf possesses to resolve carbonic acid into charcoal and free oxygen, and thereby to build up the most solid vegetable tissues, chiefly out of air, is beyond the rivalry of all our engines ; and this is but one feat among the thousands which plants unconsciously perform, and in vain bid us repeat. Within the more complex region of animal life, we are equally compelled to be mere spectators of changes of matter which we very imperfectly understand, and cannot effect by our machines. We can scarcely, accordingly, rate too highly the importance of living organisms, as working for us and with us. Secondly : Although we cannot construct machines to rival sugar-canes and silkworms, or any other plants and animals, we have a singular power of modifying these, so as to alter their actions as machines.

At every agricultural show, prizes are given to the exhibitors of vegetables and animals, which differ as much from their protoplasts as Watt's steam-engine does from Savary's or Newcomen's. So much has cultivation changed our most highly-prized cereals, that it is matter of dispute from what forgotten weeds wheat and barley, as we now see them, have been elaborated. Our apples and pears were once sour crabs ; our plums austere sloes ; our turnips acrid radishes. We have as truly created such fruits and vegetables as the chemist has created ether or chloroform. The physiologist, no doubt, is much more limited than the chemist as a creator, but he is as truly one. Both work under that aphorism of the *Novum Organon,* which teaches us to conquer nature by obeying her.

The creating power of the physiologist is still more striking as exerted upon animals. Our dogs, and horses, and cattle, we have *made,* as truly as we have made glass, or bronze, or porcelain. Nature yields no pointers among dogs, or race-horses among steeds, or short-horns among cattle. Food and climate, regimen and temperature, domestication and training ;

above all, pairing in special ways, have given us endless and important varieties of every creature we have cared to subdue; and whenever the whim prompts us to make pets of pigs, or rabbits, or pigeons, we shew through how many phases we can induce our playthings or victims to pass.

We do not generally call this *creation*, because we quickly realise that we are but evolving certain germinal tendencies latent in the plants or animals whose offspring our interference renders so unlike themselves; but we do no more when we call into existence glass or ultramarine; for unless the elements of these compounds had inevitably tended to produce them under the conditions which we secure, the securing of these conditions would no more have produced them than the mating, under certain restrictions, of particular vegetable or animal pairs would have given us the grapes of Portugal or the race-horses of England.

But whether we choose to call it creation or not, it is transformation of a kind as important, industrially, as that which mechanics has effected on many a machine. Ask a baker if he sets the same value on samples of wheat differently derived and grown, and he will offer you twice the sum for one that he will give for another. Ask a brewer the same question regarding barley, and you will receive the same answer. The sugar merchant carefully classifies his beet-roots or sugar-canes, the perfumer his lavender and orange-flowers, the wine maker his grapes, the tea-merchant his teas, the dye broker his indigos and madders, the pharmacologist his poppies and cinchonas. The plants in which those industrialists have an interest may, by variation in stock, in soil, latitude, climate, mode of cultivation, degree of manuring and the like, be made abundant or deficient in starch, sugar, azotised nutritive principles, mineral salts, odorous essences, colouring principles, and medicinal or poisonous alkaloids.

It is the same with animals. A cattle-dealer will give you one calf which shall certainly in course of time prove a bountiful yielder of milk and cream; another which shall as certainly be a fatted ox when three years old; a third which shall by and by be a match for a horse at the plough.

A jockey may at first stun you with what seems his unintelligible slang about blood, and bone, and wind, and bottom; but by and by you discover that these are his technical phrases for certain structural and physiological peculiarities, which he can exalt or diminish in a particular animal by due selection of sire and dam, and fit treatment, and training of foal; so that if you are not very difficult to please, and, moreover, are not in a very great hurry, he will contract *to make* you a horse according to the pattern you select, as an engineer will to make you a steam-engine.

So also: The Yorkshire broad cloth makers choose by preference the long stapled wool of sheep fed plentifully upon artificial grasses, turnips, and the like. The Welsh blanket-makers, on the other hand, prefer the shorter wool of sheep cropping the natural grass of the hills; whilst the Scotch tartan shawl weavers work only with Australian or Saxon wools.

In like manner the comb-makers will tell you that the farmers are injuring them, by multiplying breeds of cattle which quickly fatten, and are, in consequence, killed before their horns are well grown; and those same industrialists will curiously distinguish between the tortoise shell from one region of the sea and that from another.

I should never end, were I to pursue this matter. Let those illustrations suffice to show that living organisms are not only industrialists like ourselves, and in many cases more skilful artists, but are also machines and apparatus which, within certain wide limits, we can wield at will.

Such, then, is the scientific basis of industrialism, a platform broad as the whole earth, and reaching even to the stars. Although to biology we give a special place, because it deals with the inscrutable mystery of life, yet after all we can find room for it in the twofold division of physical sciences which arranges them, as each in part passively observational, in part actively transformational. Our whole work, as industrialists, resolves itself into observing and transforming, and whether we labour as observers or transformers, we have noble work to do. In either case, an edifice rises before us as the fruit and memorial of our labour. In the one case, this edifice is like a Nineveh recovered from oblivion; in the other it is like a Crystal Palace, for the first time given to the world. When we work as naturalists, though we do no more than bring into view objects which, from the moment of their creation, have been within reach of our senses, we are, nevertheless, like those skilful excavators who read a new lesson to the modern world, when they recovered to the light of day the long-buried and forgotten wonders of Herculaneum and Pompeii; or like those unwearied explorers who displaced the sand under which Egyptian temples had been concealing, untarnished and unworn, the paintings and sculptures bestowed upon them centuries before. The same kind of interest which attaches to Belzoni, Denon, and Lepsius, as uncoverers of the sand-hidden pyramids and sphinxes of Egypt; and to Young, Champollion, Rosellini, and others, as decipherers of the hieroglyphics upon them; or to Layard, as a revealer of the disinterred wonders of Babylon and Nineveh; and to Rawlinson, as an interpreter of the Cuneiform inscriptions upon their buildings; attaches to the naturalists of all classes. The most ancient book, it has been finely said, is published to-day for him who reads it for the first time. Herculaneum, Thebes, and Nineveh were as great novelties on the day of their re-discovering as if they had been cities of the Mormons, built yesterday. Hieroglyphics and Cuneatics are, for the novice who encounters them, marvels as astounding as the new language can be, which a tribe of native Africans are asserted (I fear on doubtful authority) to have recently constructed for themselves. And so, although Galileo only discovered the moons of Jupiter, we often and unconsciously think of him as if he had been their creator, and had first set them to play their untiring game of hide-and-seek round the stately planet; and so also in no irreverent spirit we call the laws which Kepler divined to regulate certain movements of the heavenly bodies, "Kepler's Laws," although he disclaimed the title, grandly affirming that God, whose laws they were, had waited some thousand years before one man; even Kepler, had discerned them. And so again, notwithstanding our conviction that the star Neptune has been shining in the sky since what I shall be content to call "the beginning," and that all the tiny planets which have so rapidly been added to our astronomical catalogues are probably as old as the sun, we cannot help feeling as if

Adams, Leverrier, Hinds, and their brethren, had just planted those lights in the sky, and that midnight should be sensibly less dark because of their addition to the heavens. I have taken these illustrations from the most observational science, astronomy; but any other science would have yielded illustrations as striking. The mastodons and megatheria of geology pass with us for creatures more recent than the elephants and camels which were the largest quadrupeds known to our fathers. Coal we think of as a newly invented, not as the oldest fuel; aluminium we deliberately call a new metal, although we know none older; and gutta percha is a new "gum." After all, however, the naturalist is but a disinterrer, his tool is a spade, and his newest things are generally nature's oldest, and have taken longest to find, because they were buried first and deepest.

When we work as transformationalists we are like sculptors, not evolving a pre-existent statue from a concealing mass, but bestowing a statue on a block of marble. The hollow screw is Archimedes' screw; the condensing steam-engine, Watt's engine; the railway locomotive, Stephenson's locomotive; the electric telegraph, Oersted's telegraph; the Crystal Palace, Fox and Paxton's palace. Yet as implied in what has been already said, we treat discoverers as if they were inventors, and to make amends we call inventors discoverers. And although, in strictness of speech, it is inadmissible to speak of Watt, as accomplished men are frequently found doing, as the *discoverer* of the steam-engine, and only Sancho Panza thought of invoking blessings on the man who first *invented* sleep, still the popular confusion between the discoverer and the inventor shows how difficult it is to assign the one higher praise than the other. It is better to decline answering, or to leave each person to answer according to his taste, such questions as, Is the world more indebted to Layard, who recovered Nineveh, or to Paxton, who created the Sydenham Palace? Whether industrialism is more indebted to the naturalist or to the experimentalist, is a problem best disposed of by the logic of the child who, when asked whether he would have an apple *or* an orange, held out each hand and replied he would have *both*.

On the Structure and Habits of the Slow-Worm, (Anguis fragilis, Linn.) By DANIEL R. RANKIN, Esq., Carluke.*

From what is recorded in works of reference, the slow-worm (*Anguis fragilis*), though the most accessible and easily managed of the reptile kind, seems to have engaged the particular attention of few naturalists.

During several years, from daily observation of many individuals of uncertain age, and in every stage of development, from the egg till the seventh year, having accumulated a conderable number of facts regarding the economy of this interesting little animal, I am enabled to give some details which may serve more fully to elucidate its history.

The generic position of the slow-worm is well determined; but as general descriptions seem to have been drawn from limited sources, from young or mutilated specimens, or from individuals in some phase of periodic change, confusion appears to exist; and in other particulars there is uncertainty or error.

To secure clear and distinct delineations of objects in natural history words are seldom adequate; but as the aspects of this animal, within description, may be better given if spoken of under divisions, that method shall be followed.

1. *Form.*—The mature animal, as it is found in Clydesdale, is from 17 to 20 inches in length, and attains to this about the fourth, although its other dimensions are not fully reached till about the seventh or eighth year. It has a small, elongated, somewhat angular and conical head; mouth of almost equal length with the head; eyes lateral, oval, distinct, though not prominent; ruby iris; eyelids, and a moveable membrane within eyelids (*membrana nictitans*); nostrils lateral, directed vertically, and situated in the second scale of the second row of the marginal labial scales of the upper jaw, the scale being reflected into the aperture. The neck is short, and at times is observably smaller than the head, as in the act of inspiring, drinking, &c. The body from the neck gradually swells to the middle, then gradually declines in thickness to the cloaca, and from thence becomes smaller and

* Read at the Royal Physical Society, 26th November 1856.

smaller to the extremity of the tail, which ends a little short of a minute point. A specimen before me, a female fourteen years old, measures 14 lines ($\frac{14}{12}$ of an inch) round the largest part of the head; at the middle of the body, or about 4 inches from the head, it measures 25 lines, and above the extreme point of the tail it measures 5 lines. The head is $\frac{1}{26}$ part of the whole length—the body, including the head, being about 8, and the tail about 9 inches. These proportions produce a form by no means repulsive, if the word elegant is objectionable as regards a crawling thing. The animal is not therefore "alike thick from neck to tail;" nor does the tail end quite bluntly," according to stereotyped descriptions. Young animals of the same, or of greater length, are more slender; those, for example, of the first year are from 13 to 14 inches long, although so slender as to bear the proportions of a large earth-worm, the head and body being of nearly equal diameter, and the tapering tail slightly smaller. A specimen of the fourth year, still of slender proportions, measures 17¾ inches, and one of the seventh year bears nearly the same proportions as the more aged animal before alluded to. After the first year the growth is more to thickness, in proportion, than to length. When observed carefully the body seems somewhat four-sided, and not strictly round—an aspect which the colours of the different quarters tends to favour.

2. *Colour and External Markings.*—The upper part (back) of the head and body, in the mature animal, to the extent of about a fourth of the diameter, is generally of a lustry yellowish-brown marbling; each side to the extent of one-fourth is of a blackish chequered gray, in some instances more intensely dark than in others, excepting on the sides of the head and neck, which is a kind of mottling of lighter colour on a dark ground, the remaining fourth or belly being of a bluish-gray. In passing from the back to the head there is a narrowing of the lustry part, which again swells out anteriorly. Two black spots mark the head—one commonly on each of the larger vertical scales, and in the posterior spot there is an opaque whitish point corresponding with a small opening in the skull. A black zig-zag line passes down the back, dividing equally the bright yellowish-brown part from the

posterior central scale of the head to the point of the tail. In some instances this line is more of a dovetailing character; in others, there are parallel lines or dots, giving the appearance of three, five, and seven lines, in different specimens, and in many the centre line is entirely absent. Among eighteen specimens examined at the time of writing, seven only presented the single central line down the back, which, nevertheless, is the prevailing form. In the young, on leaving the egg, and for some time after, the colour of the back is generally hazy yellow, with, in most instances, a straight black line down the back, while the under three-fourths is glossy black. But from the first there are distinct and numerous varieties of external markings. In an animal, under observation, three years old, the characteristic centre line is wanting; but the yellowish-coloured part of the back is traversed by several faint dark interrupted stripes, and on each side the scales of the fore-part of the body are beautifully marked with spots, each of which consists of a dot of green and a dot of black. In another, sixteen months old, also without the centre line, interrupted dark spots pass down the body, and the scales of the tail are each marked by sometimes two and sometimes three dark streaks, which gives the tail a striped appearance. In another specimen, two years old, there are not only three black lines down the back, but between each two others less dark; and these do not by any means comprise all the varieties of external markings.

But difference of age, or exceptional markings, do not sufficiently compass the aspects of the animal, for the approach of the sloughing periods, which are frequent, very materially alters the appearance alike of the young and old.

3. *Dermal Covering and Sloughing.*—The common notion that a serpent "casts its old skin" once in the year does not hold good as regards the slow-worm, though this is stated by most popular writers. The dermal covering of this animal, unlike that of serpents, but like some other reptiles and fishes, is a beautifully arranged system of plates of bone on which the scales or cuticle repose. These, what I shall call scale-plates, are permanent, and grow with the animal; the scales, on the contrary, are frequently renewed, particularly during the growth of the animal. A specimen, in its eighth year, fed

regularly throughout the whole period while its own dormancy allowed, and while slugs or worms could be procured, sloughed ten times, and in the following year nine times; and this seems, from a large average, to be a common result. In three years one young animal sloughed thirty-four times, and another thirty times. In the first year of rapid growth one sloughed thirteen, and other three twelve times.

The following table gives the exact dates of sloughing of four specimens hatched 3d September 1845, which were easily distinguished, and known by the names heading the table:—

Sloughs.	Spotty.	Spotless.	Spot.	Mag.	Sloughs.
	1845.	1845.	1845.	1845.	
1	October 13	October 13	October 15	October 11	1
2	November 4	November 5	November 13	October 28	2
3	December 9	December 13	December 14	December 7	3
	1846.	1846.	1846.	1846.	
4	January 29	February 1	February 4	January 24	4
5	February 20	February 25	February 24	February 14	5
6	March 14	March 16	March 26	March 6	6
7	April 5	April 11	April 19	March 30	7
8	May 4	May 6	May 9	April 25	8
9	May 28	May 30	June 1	May 11	9
10	June 25	July 1	July 2	June 12	10
11	July 23	July 26	July 28	July 9	11
12	August 13	August 19	August 26	August 1	12
13	September 14	September 27	September 27	September 3	13
14	October 16	November 8	October 30	September 22	14
		1847.			
15	November 4	February 24	November 23	October 14	15
			1847.	1847.	
16	December 21	March 27	January 5	January 14	16
	1847.				
17	January 24	April 23	February 1	February 23	17
18	February 27	May 15	March 1	March 25	18
19	March 23	June 13	March 28		19
20	April 15	July 25	May 15		20
21	May 26	October 3	August 16		21
22	June 21	October 27			22
23	July 26	November 19			23
24	September 13	December 15			24
		1848.			
25	October 28	February 9			25
26	November 24	March 5			26
	1848.				
27	January 9	April 1			27
28	February 2	April 28			28
29	April 10	May 1			29
30	May 22	September 7			30
31	June 22				31
32	July 19				32
33	August 13				33
34	September 14				33

The process of sloughing is very interesting. Eight days usually, but from eight to ten days, before an animal throws off its scaly covering it assumes a peculiar opaqueness, and seems less active. On the fourth or fifth day the original colour is gradually regained, but with less of brightness, and perhaps of a darker shade. On examination about the eighth day, the scales will no longer be found attached to the scale-plates, and the creature is restless. It rubs its head on the grass in the bottom, or on the sides of its box, first on one side, and then on the other, with the evident object of detaching the jaw scales, which it ultimately effects; and so soon as this is the case, the rest of the process may be, and is, performed with apparent ease by muscular action entirely. The scales of the upper jaw being thrown up, and those of the lower jaw down, the head is jerked from side to side till the scales are relieved. A peculiar vermicular action of the body is instituted and kept up, every movement having the effect of gradually sliding the scales back upon each other. But this action does not seem to be entirely local, or directed in such a way as to remove the scales by gradation from the head backwards only, for the action is simultaneous throughout the entire length of the animal. The scales covering the cloacal valve are often carried, by the action alluded to, perhaps an inch backward—by extension—before the head scales are even free, and the scales of the extreme part of the tail are already, it may be, detached from the animal to the extent of from one to two and a half inches when the upwrinkled slough reaches the extremity. An example of sloughing, which, in one well-observed instance, began at the head and cloaca at the same time (from the scales giving way and separating at that point), more clearly illustrates the peculiar action, for each portion moved backward, as if each had been an independent slough.

The time occupied in sloughing, that is from the moment the scales become detached from the head till thrown off, occupies variously from one to two and a half hours; but with assistance, or, perhaps, with such aids as the animal might seek in a state of freedom, the process may be very quickly completed. So soon as the head scales are free, if the animal be taken in the hand and allowed to urge itself through the fingers, placed in such a way as to keep back the scales, detachment is effected in a few minutes—the animal, in apparent ecstacy, working its way out of its skin with elevated head and with lightning-like rapidity, playing, in its characteristic way, its long nimble tongue. But there are states, either of the animal itself, or arising from its treatment, when sloughing seems difficult; the scales seem too dry, are comparatively inflexible, and remain about the body in rings and shreds till bit by bit they are detached.

4. *The Slough.*—The slough, as thrown off from the body, is a mass of scales—not huddled or inverted, but regularly laid one upon another and compacted into a very small space—an inch or two of the tail portion generally remaining free. When newly detached, the slough may be drawn out to fully one and a half the length of the animal. The scales of the head, which are smooth and very varied in size, are so arranged on the upper jaw as to admit of no extension, while those of the under jaw, with the exception of two rows of small scales which cover the bone, are like the other body scales. The largest scales of the animal are the central ones of the head, and those within the angle of the lower jaw, and the smallest are those of the labia, and of the eyelids. The scales of the body, individually, are also smooth, somewhat rhomboid, and collectively are arranged in an imbricated manner, each being encroached upon and encroaching to the extent of one-third, and each having connection with three above and three below. The point of connection one scale with another is the upper border, and each reposes on its scale-plate, the edge of the scale extending beyond the plate; and the whole is united by highly elastic tissue, an arrangement which admits of great expansion and flexibility.

The usual method of enumerating the scales of snakes is scarcely applicable to this species of reptile, for the scales of the entire body, unlike most serpents, are of uniform character. Counting from the margin of the upper jaw along the back, there were, in a specimen carefully examined, 273 rows of scales in the whole length of the animal—7 in the head, 266 in the body and tail, inclusive of the conical scale which terminates the tail. Counting the scales from the under side, there were in all 278, or five more, the excess being in the lower jaw. From the margin of the lower jaw to the verging scales of the cloaca there were 137, and from this to the point of the tail 141.

The valve of the cloaca, situated near the middle of the body, produces no interruption of the symmetry, or of a continuous declination, and, indeed, it would be difficult of detection by those who are unacquainted with the structure of serpents. It is a semilunar flap, so to speak, opening transversely, two scales deep, and fringed by six scales, which are adjusted very perfectly to the scales of the tail. A reflection of the cuticular tissue lines this flap, forming on the upper or body side distinct minute scales, merging in a highly elastic network-like structure, which surrounds the cloacal aperture, and is attached below to the marginal scales of the flap. This reflected portion of the scales is always thrown off as part of the slough, and is seen as a sort of pouch in prepared sloughs.

The colours of the animal are derived essentially more from a sort of pigment which covers the scale-plates than from the scales themselves ; still, most sloughs have faint brown streaks on the back scales, and the side ones are sometimes tinged of a slight dusky hue ; but the scales of the belly, which look dark when in connection with the animal, are always colourless when detached from the body.

The scales and scale-plates are arranged in rows disposed backward from the centre line of the back in an angular manner. There are, however, instances of imperfect rows—a sort of indentation of a partial row, as if to meet some requirement of contour or function.

The rows are, as a rule, of equal numbers, from 28 in the neck to 2 in the tail ; but in every animal there are a few unequal rows, and the tail ends with a single conical scale.

The scales in the upper jaw number	160	
In the under jaw	117	
		—— 277

						277
In body there are	23	rows of	28	scales	644	
...	3	...	27	...	81	
...	33	...	26	...	858	
...	29	...	24	...	696	
...	3	...	23	...	69	
...	27	...	22	...	594	
Ending in cloaca	5	...	16	...	80	
					——	3022
Below cloaca ...	13	...	14	...	182	
...	3	...	13	...	39	
...	60	...	12	...	720	
...	7	...	11	...	77	
...	43	...	10	...	430	
...	8	...	9	...	72	
...	4	...	8	...	32	
...	1	...	7	...	7	
...	2	...	6	...	12	
...	1	...	2	...	2	
...	1	...	1	...	1	1574
					——	——
						4873

This is the result of the examination of only one individual. Of the body scales, those of the neck are smallest and most numerous, admitting consequently of considerable expansion—a condition particularly suited to the requirements of the animal, which swallows its food entire, and often gorges slugs of a size greatly disproportioned to its apparent capacity.

Though not very evident to the eye that the scales of the body differ much in size, the fact is established. In a slough minutely examined, there were in one portion of the body 29 rows of 24 scales each; at the upper part it measured 22, and at the lowest 20½ lines. Above the cloaca there were found 27 rows of 22 scales each; at the upper portion it measured 20½, and at the lower 17 lines. In the tail there were 60 rows of 12 scales each; the upper row measured 14, and the under 12 lines. Still lower in the tail there were 43 rows of 10 scales each, the upper row being 12, and the lower 8½ lines. In sloughing, all the scales of the body are thrown off, including those of the eyelid; but the eyeball does not, though a common belief, cast a film as part of the slough, as occurs in serpents.

5. *Fragility.*—Nature, always bountiful in her provisions for defence or preservation, has given to the *Anguis fragilis* one which, if repulsive to mere observers, is no doubt that best fitted to its peculiar character. It does not bite, at least

in no instance, during years of daily handling, did I ever observe the slightest approach at defence by this mode,—motion is comparatively slow—and it has no adequate defensive armour. The animal must seek its food; but this is generally done without much exposure, for it feeds on slugs, &c., found low in the grass, where, too, from its mode of progression, it is most active and powerful. Sometimes, however, it is found extended as if basking in the sun (probably while incubating, if the phrase can be sanctioned) on sand-beds, or on cultivated ground, helpless, in a great degree, from the want of aids of motion in such situations, and consequently is an open prey to the enemy. But whether in the grass, or thus exposed, it is easily found by the sparrow-hawk (*Accipiter fringillarus*), its most conspicuous foe, which, at the season of the activity of the reptile, may be frequently observed hovering on wing above the sloping banks facing the south, where the animal is most plentiful. When once marked, escape is scarcely possible; but the provision alluded to affords considerable immunity from attack. If the bird seize its prey at any point below the cloaca, the reptile has the power of sundering the part with apparent impunity, and escapes; and if in any way forewarned of danger, the retreat of the animal to the nearest crevice would favour the probability of such a result. Many mutilated specimens are found; and it is scarcely possible to keep numbers that are subjected to daily examination without being a witness to the act which instinct prompts, and which seems to cause little pain or inconvenience. There are sure grounds for affirming that the "breaking in two" of authors is limited to the tail. If violently seized by the body, the tail is, nevertheless, the part thrown off. When a part of the tail is separated from the animal by its own efforts, there seems to be no laceration of the structures, if the vessels and cellular tissue are excepted. Not a scale is torn. Eight conical processes (four pairs), with interspaces between each, projects from each severed part, and each projection consists of one-half of a short muscle which fits or dovetails into each other. The body part has the ball, and the tail part the socket, of the vertebræ. So easy and harmless does this act of the animal appear, that it may almost be classed among the functions.

6. *Reproduction of Parts.*—No sooner is the animal subjected to mutilation than the reparative, and to a certain extent reproductive, process, is instituted. If the loss has been the result of the instinctive efforts of the animal, the parts seem very rugged and irregular, though, on examination, a sort of three-fold dislocation is found to have taken place—scale from scale, muscle from muscle, vertebra from vertebra. As in other animals in similar circumstances, lymph is thrown out, which at first covers the stump, and from day to day is added to till there is a prolongation of a conical form to the extent of about half-an-inch, the reproduced part varying in length and form in almost every case—a result depending, apparently, on the stage of growth at which the animal has arrived. This new structure is at first covered by an imperfect envelope, which comes off with the slough ; but in the course of time—from four to six months—scales are formed, and the reproductive process is at an end. In the case of an aged animal the reproduced part, at 3 inches below the cloaca is 5 lines ; and in a younger specimen, at 2 inches below the cloaca, the reproduced part is 7 lines in length—the first being composed of seven rows of scales, and the other of ten rows, including in both cases the terminal conical scale. The scale-plates and scales of the reproduced part are comparatively strong, small, and numerous. In the first case the part was separated where the scales are ten in number in the circumference of the tail—the new scales, at the point of union with the old, are twenty in number; in the other case the scales at the severed part are twelve—those of the reproduced portion, at the point of union, amount to eighteen. Vertebræ are not reproduced.

7. *Gestation and Hybernation.*—The periods of hybernation and of gestation of the *Anguis fragilis* I have never been able to determine by the closest observation. The artificial method of keeping reptiles necessarily adopted by the naturalist for acquiring a minute knowledge of their habits, is not the best for all purposes. The more equal temperature

of a house, and confinement in boxes, are alike unsuited for successful results. In all instances, in the natural state, hybernation must vary with the setting in of winter and spring respectively. As to gestation, if the reptile, in this country, has only one set of young in the year, which I am disposed to believe, and granting that it follows other cold-blooded animals, to which it has some affinity, in making the reproduction of species its first effort after the slumbers of the winter; and granting, also, that it has been rarely found in activity in Clydesdale earlier than the middle of April, I would be disposed to fix about four months as the period of gestation; because, in every instance within my observation, the impregnated specimens found produced their young or eggs late in August or early in September.

On 3d September 1845 a litter was hatched all but under my own eye, and I had the parent in my possession from the preceding June. On opening the box in which it was confined, I found seven young in great activity, with the fœtal vascular tissues still fresh, attached to the cloacal valve, and four eggs, membranous oblong bodies, little larger than a field bean, three of which ultimately yielded their living contents, and one remained entire with the young one visible within. The young at this stage of existence were from 33 to 36 lines long, not thicker than a small earth-worm, and weighed from 11 to 13 grains. In this way I became possessed of ten objects of special interest. During the first day, one was, no doubt, devoured by its parent, for I found half of the tail unconsumed, which the little creature had in all probability wriggled off in an instinctive struggle. On procuring small slugs, the young reptiles pounced upon them with artful avidity; and so voracious were they, that one of the slugs provided for the old animal was seized upon, although ten times the weight of the creature that made the bold attempt. It was amusing to see the slug moving on in its even course with the slender reptile attached, tugging in vain for the victory. Though all did not grow equally, they on an average gained about an inch in length, with a proportionate growth otherwise, monthly, for the first year. Among my stock I frequently had aborted eggs, apparently all yolk. In spring, these inoffensive reptiles became among themselves pugnacious. Two individuals, in particular, I had frequently occasion to separate from what appeared a death struggle; and as the violence was, in a sense, exceptional, I considered the *causa belli* to be sexual.

8. *Feeding, Motions, &c.*—This reptile shuns the light, and is often found in long grass, or under the new laid swath, where food is likely to be found. In seizing its prey something like a display of strategy is made. The object is marked, the animal hovers over its victim, arches its neck, and ultimately, though the action seems unnecessary, darts upon it. Whatever is seized is gorged, and apparently all but impossible masses are swallowed. I have seen—besides slugs, which it seems to prefer, and worms which it feeds on readily—very small frogs and toads, and also caterpillars, to which it was restricted, taken; and I have good grounds for believing that its own young are not rejected. The manner of seizing its prey would suggest that it has to deal in a state of liberty with animals more active than the snail or worm. The gorging process is slow but certain; the snail being caught, the slow-worm rests for a considerable time, when a sort of convulsive opening and shutting of the jaws take place—a pause and similar efforts occurring at what seems measured intervals, till the object disappears within the jaws. A circumstance which long puzzled my discerning powers, may be worth notice: I remarked that the bulging mouthful, made by a large slug, acquired a singular impulse inwards each time the mouth was *opened*, and that although the mouth was opened comparatively slowly, an instant snap succeeded, as if to make good the advantage. After careful watching, and a thorough examination of the machinery, I came to the conclusion that the peculiar teeth of fishes and of reptiles were contrived not only as seizing and retaining instruments, but that in the opening of the mouth a necessary mechanical power was exercised by the curved teeth, which effected, in animals so constructed, the needful purpose of advancing, at every such effort, the peculiar nutriment. The animal drinks equally slowly. If the water be on a level with its body, it elevates

its head, curves its neck, and projects its long, notched tongue into the fluid, withdrawing and projecting it sluggishly for a considerable time. When satiated it seems delighted, raises its head high, waving it to and fro, performing something like smacking the lips, and accompanying the act with an audible chirp, a sound rarely heard at other times. Many were easily trained to take a drop of water from the tip of the finger.

Upon a flat surface the motions of the animal are awkward and ineffectual; among grass, on the contrary, it urges itself on sweepingly, in a sinuous course, the sides of the body and tail being the motive agents. It has a very perfect reversing action—the retrograde motion without the slightest doubt; and, in addition, it has a sort of prehensile power in its tail, by which it can suspend its body. The respiration is peculiar the animal expires at distant intervals, but no sooner is the expiration made than inspiration follows. In motion, like serpents, the animal is constantly darting out its long, partially-cleft tongue. When in vigour, as in a fine warm day, the act is like one rapid dash; but when less energetic, as in the cold of the morning, the action can be made out very distinctly to consist of three distinct waggles of the tongue up and down. I have long sought to interpret this singular act without success; but I am disposed to think it has something to do either with the search after food, or with discerning obstacles.

Skeleton.—The most notable peculiarity of the bony framework of this animal, and those of the same type, is the well-known existence of vestiges of the agents of locomotion—the rudiments of a quadruped form. In the shoulder there are most distinct scapulæ, clavicles, and a sternum; in the pelvis, besides an expansion of vertebræ, with fixed and enlarged lateral spines, there is a small bone on each side, scarcely connected with the wings of the superior sacral vertebra, which may be viewed either as a sort of completion of the circle of the pelvis, or as representing the bones of the leg.

But there are other peculiarities in the skeleton worth noting, which may not have been recorded.

In determining the co-relation of scale-plates and scales, I had at first concluded that the former were all strictly dermal. On carefully removing this bony investiture, however, plate by plate from the head, it was found that several plates, which in every other part of the body are dermal, had assumed the character of permanent bones of the head at and around the vertex. This is a condition which may probably exist in other animals of the same type. In the alligator, and its allies, something of a similar nature occurs, and in the saurians of the coal age, there is what may be pronounced a strictly identical arrangement.

In studying the skeleton of the serpent, one is constrained to view it as essentially a vertebral column, of very admirable workmanship and adaptation, surmounted by a head which, small as it is comparatively, seems principally to be occupied in giving place and development for the sentient organs, but which, besides, in the venomous tribes, is a startling array of delicate and appropriate machinery for supply and defence; in the innocuous serpents for the former purpose only, so arranged as to encompass what may be viewed as an enlarged or elongated vertebra, the brain-pan proper, forming a small portion of the head, namely, in the slow-worm, one-third in length, or 1-78th of that of the entire animal.

In the *Anguis fragilis* the bones of the head are more compact than those of serpents. It has a single row of teeth in each jaw, widely apart, on a bony setting, and so placed that, viewed from without, half the length of the basement portion is concealed by an over-lapping part of the jawbone, the pointed and curved portion only being seen above the edge of the bone; an arrangement closely analogous to that observed in the bone-clad sauroids of the carboniferous epoch.

The number of vertebræ in the whole length of the animal is 132; but if advantage be taken of a peculiar subdivision of the caudal portion, to be afterwards adverted to, the number will be considerably greater. The whole column may be arranged into 2 vertebræ in the neck, 58 in the trunk, 1 in the lumbar region, 2 in the sacrum or pelvis, and 69 in the tail.

The cervical consist of the atlas and dentata, which are very easily distinguished from each other, the atlas having two sockets, as in serpents, one which receives the ball of the occipital bone, and the other which receives the tooth of the dentata; the dentata having two balls, the tooth anteriorly, and the ball common to all the vertebræ, with the exception noted, posteriorly. The vertebræ of the body are constructed on a more simple plan than in the serpent: each has eight articular surfaces, the socket, the ball, two articular convex processes for the ribs, and four articular facets. The internal aspect is destitute of any process; the animal, accordingly, unlike serpents, has no muscular arrangement on the inner surface of the spinal column; and the processes (apart from the ribs, which are well equipped for motion), for muscular action externally, are small, all indicating a comparatively feeble action in that region. The vertebræ of the body of serpents, on the contrary, have each twelve articular surfaces, and have strong internal and external spines, with a corresponding muscular provision.

The last vertebra of the body may fairly enough be reckoned as the representative of a lumbar division; for although sometimes provided with lateral articular convexities, like the vertebræ of the body, and the short processes which represent the ribs are moveable, or one may be moveable and the other not; still, it most frequently happens that both are fixed, and, in this respect, is more like a caudal vertebra. The two sacral vertebræ have comparatively large lateral spines, and are developed appropriately for the cloacal and generative functions. The vertebræ of the tail, to a greater degree than in any of the long-tailed serpents I have examined, have a construction suited alike for quick, powerful, and varied action. Each member is furnished with six articular surfaces, and with four long spines, a superior, two lateral, and an inferior, which last is divided at its base, giving it the form of a pointed arch, in which the vessels, &c., find a secure passage.

But each caudal vertebra, with the exception of a few near the pelvis, has in itself a sort of spike-and-facet joint, the anterior third, consisting of the socket and anterior articular facets, being moveable upon the posterior and larger portion. When the extreme flexibility and strength of this part is considered, the provision thus exemplified is at once seen to be simple and adequate. So far as my observations have extended, this peculiarity of the caudal vertebræ is unique. though the same, or some modification of it, may be expected to be found in those reptiles which have a similar action of the tail.

Viscera.—The conservative and generative organs of the *Anguis fragilis*, are all but identical with those of serpents.

Diseases.—The morbid states of the animal, which I have marked, resulted probably from faults in management, in a great degree; but as numerous specimens were treated alike, and deaths were unfrequent, the causes were not distinctly traced to this source. Impaction of the rectum by a chalky matter, which appeared in every healthy dejection, to some extent, was, apparently, the cause of death in several instances. In a few instances death seemed to result from retention of numerous unvivified ova. But one specimen, which was long carefully watched, with tumours of the lower jaw, and point of the tail, furnished, on inspection, an example of positive disease. In this instance great enlargement and induration of the kidney on the left side was found to exist. Destruction of some of the vertebræ was also found; a state which might have been ascribed to pressure of the enlarged kidney, had not the external tumours been accompanied with absorption of bone of the adjacent parts. The disease, in this instance, was therefore probably malignant in character.

PROCEEDINGS OF SOCIETIES.

British Association for the Advancement of Science, Cheltenham, August 5–12, 1856.

The following detailed abstracts of the papers submitted by Professor Goodsir to Section D. at the Cheltenham Meeting of the British Association in August last, were prepared by the author for our last number :—

1. On the Morphological relations of the nervous systems in the Annulose and Vertebrate types of organization.
2. On the Morphological constitution of the skeleton of the Vertebrate Head.
3. On the Morphological constitution of Limbs.

1. *On the Morphological relations of the Nervous System in the Annulose and Vertebrate types of Organization.*

The object of this communication is to indicate the morphological character of the apparently different anatomical relations of the central portions of the Annulose and Vertebrate nervous systems.

The term Annulose is employed provisionally, and in a morphological sense, as including all animals possessing a ganglionic nervous collar and axis, and presenting, at the same time, more or less distinct indications of a segmented structure of body.

Physiologists appear generally inclined to consider the central portions of the Annulose and Vertebrate nervous systems as modified forms of the same arrangement. These forms are held to possess a general similarity of structure, and correspondence in function; and the ganglionic collar and axis of the Annulose are assumed to be homologous either with the cerebro-spinal axis, or with the series of ganglions on the posterior roots of the spinal nerves, or with the system of sympathetic ganglions of the Vertebrate animal.

In my own examination of this subject I have been strongly impressed with the necessity of determining the morphological character of the œsophageal collar, and the opposite positions of the so-called brain and abdominal ganglionic cord, before any satisfactory advance could be made in ascertaining the relations of the two forms of nervous system. The apparent morphological difference between them does not appear, in the estimation of physiologists generally, to present that obstacle to a satisfactory comparison which its essentially fundamental character would lead us to expect. The difficulty has, however, been clearly stated by Professor Owen, who, in discussing the relations of the endo- and exoskeletons in his Lectures on Fishes, page 21, says,—" Geoffroy St Hilaire thought it needed but to reverse the position of the Crustacean—to turn what had been wrongly deemed the belly upwards—in order to demonstrate the unity of organization between the Articulate and Vertebrate animal. But the position of the brain is thereby reversed, and the alimentary canal still intervenes in the Invertebrate between the aortic trunk and the neural canal."

I must here premise, that while I hold the general morphological relations of the Annulose and Vertebrate nervous systems to be identical, I do not consider these two types of organization to be mutually reducible. On the contrary, they are fundamentally distinct, presenting differences which demand careful consideration. It is, nevertheless, incumbent on the morphologist to ascertain in what respects they correspond, so as to determine their distinctive limits.

My earlier conception of the morphology of the Annulose nervous system was based on that of Carus. I conceived that each segment of the Annulose animal contains potentially an annular nervous arrangement, set in a plane at right angles to the axis of the segment, or longitudinal axis of the animal; that the only complete nervous ring is that one through which the œsophagus passes; that the ganglions on this ring are arranged in the various forms of superior, lateral, and inferior œsophageal masses; that the nervous rings in the post-cephalic segments are all incomplete above, and have their ganglions united into a single or double mass below; and that all the rings are united by a series of longitudinal abdominal commissures. According to this view, the œsophageal collar, with its superior, lateral, and inferior ganglions, is homologous with each pair of segmental nerves, and the corresponding abdominal ganglionic centre; the œsophageal collar being in a plane parallel to those in which the post-cephalic ganglions and their pairs of nerves are situated, but at right angles to the line of the series of abdominal ganglions.

I first recognised what I believe to be the real morphological relations of the Annulose nervous system during the delivery of a course of lectures on Invertebrate Anatomy in 1849; but more fully and completely during courses on the Anatomy of the Mollusca in 1850, and on the Anatomy of the Crustacea in 1851.

I now perceived that the fundamental difference between the morphological relations of the Annulose and Vertebrate nervous systems, consists in the position of the mouth.

I saw that the entire axis or central portion of the nervous system extends along the neural aspect of the body in both types of organization; but that while, as is well known—although its morphological importance does not appear to have been perceived—the Vertebrate mouth opens into the hæmal, the Annulose mouth passes through the neural aspect of the body.

In the Annulose animal, therefore, the buccal entrance interferes with the nervous axis—passing up between the two lateral halves of one of its longitudinal commissural or inter-ganglionic cords, so as morphologically to divide the continuous axis into a *pre-stomal* and a *post-stomal* portion.

These relations are most satisfactorily seen in the Crustacea, in which the so-called brain, or supra-œsophageal ganglion or nervous mass is actually in front of the mouth, and not above it.

In Insects, Annelids, and Mollusca, the bulk of the buccal mass, and other necessary modifications of the oral apparatus, elevate the so-called brain, curving upwards the morphological axis of the body of the animal.

By comparing the indications of segments in front of the mouth, and their corresponding diverging appendages, with the arrangement and distribution of the nerves given off from the so-called brain, it appears very evident that this brain is the aggregate of the segmental nervous centres in front of the mouth.

In like manner indications afforded by the segments, and their appendages immediately behind the mouth, enable us to determine whether the so-called sub-œsophageal ganglionic mass is a single segmental ganglion, or an aggregate of antero-posteriorly united segmental ganglions.

In this way I was enabled to perceive that the axis of the nervous system of the Annulose animal does not consist of a supra-œsophageal mass, of an œsophageal collar, of a sub-œsophageal mass, and a continuous sub-intestinal ganglionic chain; but of a continuous line of connected and serially homologous ganglions situated in the mesial line of the neural aspect of the body.

The Annulose, like the Vertebrate animal, is developed with its nervous axis turned away from, and its hæmal axis applied against, the vitellary mass.*

But, in the course of development, the mouth of the Vertebrate opens through the surface applied against the vitellary mass, whilst that of the Annulose animal passes through the aspect turned away from it. The Vertebrate mouth is hæmal, the Annulose mouth neural.

Rathke formerly described the pituitary body as originating in a diverticulum passing up from the pharyngeal mucous membrane through the basis of the embryo skull. I at one time conceived it to be probable that the pituitary body, and the mucous tube, in which, according to Rathke, it originates, might be indications in the Vertebrate of a structure which, in the Annulose animal, is converted into the mouth. This presumed neural alimentary passage may be conceived as passing up between the bodies of the anterior and posterior sphenoid bones into the sella turcica, along the course of the infundibulum to the third ventricle of the brain, and through the cavity of that organ to its upper surface behind the cerebellum, thus leaving the origins of the nerves of smell and vision in the pre-stomal portion of the organ, while the origin of the nerve of hearing would remain in the medulla oblongata or post-stomal portion of the cephalic nervous mass. The arterial circle of Willis, and other peculiar arrangements at the base of the skull and brain, appeared to support the view taken. I shall not, however, pursue this hypothesis further, because, from the observations of Reichart, we know that the base of the cranium is not perforated in the embryo, and that the supposed canal or diverticulum was an incorrect interpretation of the peculiar appearances produced by the curvature downwards of the early Mammalian head.†

If I have determined aright the morphological relations of these two forms of nervous system, we shall have advanced a step in our conceptions of the anatomico-physiological relations of the Annulose and Vertebrate animals, and this without losing sight of the fundamental differences,

* From the passage in his Lectures already quoted, Professor Owen would appear to consider the dorsal heart, with its anterior and posterior arterial trunks in the decapod Crustacean, and consequently the dorsal vessel in the Insect, Arachnidan, and Annelid, as corresponding to the thoracic, abdominal, and caudal aortic trunk of the Vertebrate animal. On this supposition only can we understand his assertion, that when the so-called belly of the Crustacean is turned upwards, its alimentary canal is still interposed between the aortic trunk and the neural canal. Embryology, Comparative Anatomy, and Physiology, appear to me, however, to afford ample proof that the cardiac-arterial dorsal trunk of the Annelid, Crustacean, Insect, or Arachnidan, is homologous not with the sub-spinal aorta of the Vertebrate, but with the primordial cardiac-arterial tube in all the forms of the embryo Vertebrate, and, consequently, with the heart and trunk of the branchial artery of the Fish. If this, then, is the real homology of the "aortic trunk" of the Crustacean, and if its "brain" is in fact only a *pre-stomal* portion of its nervous axis, the French anatomist was quite correct in his general morphological statement, although he was not legitimately entitled at the time to employ the illustration.

† I have introduced the hypothesis of a Vertebrate neural mouth (cast aside in the course of my examination of the subject), because I believe it will be found to involve relations of importance in the anatomico-physiological investigation of the pre-stomal and post-stomal portions of the Vertebrate and Annulose cephalic nervous masses.

developmental and structural, between them. The researches of Milne-Edwards, and of Newport and others, on the Annulose nervous axis may thus be physiologically associated with those of Wagner, Schroeder Van der Kolk, Owsjannikow, Jacobowitsch, and Kupffer, on the cerebro-spinal axis; and we may now legitimately employ the Annulose animal in the morphological investigation of the Vertebrate skeleton.

Omitting, for the present, the consideration of the mode in which the nervous systems in the Tunicata, Rotifera, and Entozoa, are reducible to the typical Annulose form, I proceed to make some general morphological statements, based to a certain extent on the principle indicated in this, and introductory to the two following communications:—

1. The morphology of any one organic system in the Annulose or Vertebrate animal, cannot be safely or satisfactorily investigated, without constant reference to the others. That it must be so is evident from the fact, that all the organic systems are dependent on one another, in the constitution of the organism.

2. All sound morphological inquiry demands constant reference to the series of embryo, as well as of adult forms.

3. As morphology deals with forms and relations of position, it demands a careful selection of terms, and a methodized nomenclature. All terms involving more or less than their morphological application demands, must be avoided. Terms derived from other departments of the science, and having therefore an established technical meaning, have invariably produced misconception, when transferred for morphological purposes.

Influenced by these considerations, and satisfied that the Annulose and Vertebrate types of organization, although fundamentally distinct, present parallel forms of structure, and must consequently be closely linked together in morphological inquiry, I have to suggest a more extended and precise system of nomenclature for this department of the science.

In the Annulose and Vertebrate types of organization, the body of the animal consists of a linear series of segments. To the constituent segment, with its diverging appendages, I apply the term *Somatome* (*σωμα. τεμνω*).

For the purpose of avoiding circumlocution, and of supplying a term for a generalized conception, and thereby facilitating morphological description, without encroaching on zoological nomenclature, I denominate a segmented animal, whether Annulose or Vertebrate, an *Entomosome*—an entomosomatous animal (*εντομος. σωμα*).

As the constituent somatomes are invariably arranged in groups, in each of which they are more or less modified in form, or fused together, I find syssomatome (*συν. σωμα. τεμνω*) a convenient designation for such a group. A typical Crustacean presents a cephalic, a thoracic, and a caudal syssomatome, in each of which there are seven somatomes—twenty-one in all.

The constituent somatomes lie in planes at right angles to the *morphological axis* of the body, and are symmetrical in the transverse, but unsymmetrical in the perpendicular direction. They are, however, not only unsymmetrical in their upper and under surfaces, but the surfaces so named in the Annulose are morphologically distinct from those similarly designated in the Vertebrate animal. The Annulose animal moves on the surface which was turned away from the vitellary mass during development; the Vertebrate animal moves on the surface which was applied to it during development. As the axis of the nervous system is formed at the surface turned away from the vitellary mass, and the axis of the vascular system is formed at the surface applied to it in both types of organization, I employ, as morphological designations, the term Neuropod (*νευρον.*

πους) for an Annulose, and Hæmapod (αἱμα. πους) for a Vertebrate animal.

The mouth of the entomosomatous animal is invariably situated between two somatomes, and so that a certain number of somatomes are interposed between it and the anterior termination of the body. As the mouth is only one of a number of openings situated between somatomes, I find such openings conveniently distinguished as *metasomatomic*.

The mouth of the Neuropod is a neural, that of the Hæmapod a hæmal metasomatomic opening.

As the somatome exhibits in its structure corresponding segments of certain or of all the organic systems, I have found the following morphological terms extremely convenient in referring from the segment of one organic system, to the corresponding segments of the others.

For the entire framework of an Entomasome, whether this framework be developed in its integument or in its interior, whether it be fibrous, cartilaginous or osseous, I employ the term *Sclerome* (σκληρος, with the termination of completeness). To a segment of the sclerome I apply the designation *Sclerotome* (σκληρος. τεμνω). An aggregate of more or less modified sclerotomes, I name a *Syssclerotome* (συν). Making use of my former illustration, the sclerome of a typical Crustacean consists of twenty-one sclerotomes grouped in three syssclerotomes. Again, the sclerome of a Mammal consists of a number of sclerotomes, grouped into the cephalic, cervical, thoracic, lumbar, sacral, and caudal syssclerotomes.

For the muscular system I employ the terms *Myome*, *Myotome*, *Synmyotome*; for the nervous system, *Neurome*, *Neurotome*, *Synneurotome*; for the vascular system, *Hæmome*, *Hæmatome*, *Synæmatome*; for the morphologically as well as physiologically important digestive system, with its segments, and groups of segments, *Peptome*, *Peptatome*, and *Synpeptatome*, &c.

Till very lately, I had not met with any indication of the actual morphological character of the so-called supra-œsophageal ganglion in the works of British or Foreign Physiologists. I have now found, in an obscure corner of Von Baer's works, sufficient evidence that he had recognized its pre-stomal character. His statements are contained in a single paragraph, which forms an episode in the middle of the second corollary of the fifth scholium of his work on the Development of the Chick *in ovo*. Von Baer holds, with E. H. Weber and Treviranus, that the nervous axis of the Neuropod is homologous with the series of ganglions on the posterior roots of the spinal nerves of the Hæmapod; and he considers the "supra-œsophageal" ganglion to be the homologue of the Gasserian ganglion; but he adds, "peculiar stress is laid on this, that it (the supra-œsophageal ganglion) lies above the mouth (über). This appears to me to be a false view of the matter; it lies, in fact, in front of (vor) the mouth." He gives a diagram of the arrangement, and proceeds: "The following sketch will make it evident that the so-called brain of the Insect has the same signification as the posterior ganglions; and the œsophageal ring is only a secondary formation, dependent on the breaking through of the mouth, permitted by the symmetry of the structure, and the necessary connection of the ganglions."

It is somewhat remarkable that no one, even of Von Baer's own countrymen, has, so far as I know, made any allusion to this passage. Indeed, he does not appear to have been himself aware of the value of the observation, as he adduces it merely in the form of an argument in illustration of another subject, and does not again recur to it. For my own part, having ascertained, on independent grounds, and publicly taught and illustrated, for some years the principle stated in this communication, I feel gratified in having this opportunity of rescuing from temporary oblivion, and of adducing in support of my own statement of the principle the original announcement of it, made twenty-eight years ago, by one of the most philosophic of modern Anatomists.*

2. *On the Morphological Constitution of the Skeleton of the Vertebrate Head.*

In an abstract which professes to give only the general results of my own investigations, I cannot enter into such critico-historical details as would be necessary were the corresponding or opposite results obtained by other inquirers to be in every instance brought forward. I am therefore obliged at present to state, in a somewhat dogmatic form, the results which I conceive I have obtained, and the views I have been induced to take of a subject in itself extensive and difficult, and one to which so many distinguished anatomists have devoted themselves.

Nature of the subject.—The framework of the Vertebrate head is a syssclerotome—that is, a group of sclerotomes variously modified, and more or less connected, so as to form a distinct whole. The points to be determined are the number and modifications of the sclerotomes in the various forms of Vertebrate head. There are, however, some preliminary questions which must be briefly examined.

The source and mode of origin of the Sclerome in the Vertebrate Embryo.—The knowledge we at present possess of the source and mode of origin of the Vertebrate sclerome is the result of the successive researches more particularly of Pander, Von Baer, Rathke, Reichart, and Remak, on the development of the blastoderma.

Von Baer, while he adopted the doctrine of Pander regarding the so-called " serous " and " mucous layers," took a somewhat modified view of the " vascular layer," and directed attention more particularly to the " dorsal " and " ventral folds " of the blastoderma, in connection with the " corda dorsalis," as fundamental embryological characteristics of the Vertebrate type of organization.

Among the numerous results of the researches made by Rathke in every department of Embryology, there are two which bear particularly on the present subject. These are his early discovery of the so-called branchial clefts ; and his later recognition of the fact that the series of quadrilateral bodies on each side of the " corda dorsalis," instead of being the rudiments of vertebræ, contain potentially the germs not only of these bones, but of the dorsal muscles, and " probably " of spinal nerves.

Reichart supplemented the previous observations of Rathke on the development of the " branchial " or " visceral laminæ," and of the nasal and maxillary portions of the face.

Finally, Remak has ascertained, on independent grounds, that each pair of the dorsal quadrilateral bodies, usually considered as the rudiments of vertebræ, becomes developed superiorly into a right and left muscular plate, and inferiorly into a pair of spinal nerves, with their ganglions, along with the rudiments of a vertebra and pair of ribs, the nerves being in front of the sclerous elements. In the course of development a change takes place in this " primordial vertebral system." The rudiments of the vertebral arch and ribs move backwards, from their original site under the posterior margins of the overlying muscular plates, to the anterior margins of the pair of muscular plates immediately behind, and become united to both pairs. A transverse division takes place at the same time

* I accidentally discovered, a few weeks ago, that Professor Huxley had published translations of portions of Von Baer's works in the Scientific Memoirs for 1853. This judicious selection contains the passage referred to in my paper. (Dec. 4, 1856.)

in the rudimentary central masses of each of the primordial vertebræ. These changes constitute a new order of parts—the order or arrangement of the "permanent vertebral system." Thus, the products of the development of a single primordial vertebra are—1. A pair of spinal nerves, with their ganglions; 2. The vertebral arch and pair of ribs immediately behind this pair of nerves; 3. The anterior part of the body of the vertebra to which this arch and ribs are attached; 4. The intervertebral disk in front of it; 5. The posterior part of the body of the vertebra in front; and, 6. The group of spinal muscles between these two vertebræ. The bones, muscles, and nerves of the abdominal and thoracic wall are formed by an extension downwards, and adhesion of the lower or costal portion of the "primordial vertebral system" to the inner surface of the external of the two layers into which the "primary abdominal wall" divides. This outer or adherent layer of the "primary abdominal wall" becomes the areolar layer of the integument, and enters into the formation of the limbs. The inner layer, separated from the outer by the pleuro-peritoneal space, forms, with its fellow of the opposite side, the Wolffian bodies, reproductive glands, spleen, permanent aorta, mesentery, and the muscular and serous covering of the alimentary tube.

From these remarkable observations of Remak, it would appear that the sclerome of the Hæmapod, from the anterior part of the neck backwards, originates as a series of independent sclerotomes, and that, contemporaneously with each sclerotome, a corresponding myotome and neurotome take their rise in a common primordial segment of blastema.

The cephalic portion of the early Vertebrate embryo is peculiar, more particularly, according to Remak, in the nonappearance of distinct "primordial vertebræ," and of the subsequent changes which result from their development. The great divisions of the brain and of the cerebral nerves indicate, indeed, the segmented character of the entire structure, but I am inclined to believe that, in the present state of the subject, these indications are not to be depended on for the determination of the segments of the embryo or adult head. It appears to me that the segmented structure of the brain is to be looked for, not in its greater masses,—those developments on its upper surface in which it differs from the spinal cord, and by the possession of which it becomes a brain,—but in the series of groups of ganglion cells, the nervous centres of the cerebral nerves, whatever the typical number of these may be, arranged along its base, and strictly homologous with the groups of ganglion cells which undoubtedly constitute the morphological segments of the spinal cord.

The "visceral," or "branchial laminæ" afford, in the present state of the subject, a more secure embryological basis for the determination of the segments of the head. The so-called "first visceral lamina," the one in which the mandibular arch is developed, and the two succeeding "visceral laminæ," those in which the anterior and posterior segments of the hyoid of Mammals and Birds are formed, must be looked upon as embryological indications of three cephalic segments.

On the under surface of the forepart of the embryo head, in front of the so-called "first visceral lamina," there are five processes, in which are developed the palate and pterygoid, the maxillary, malar, and lachrymal, the intermaxillary and nasal bones. The first of these processes on each side extends obliquely forwards from the "first visceral lamina" towards and under the eye. It is the so-called "superior maxillary lobe." The second process on each side—the "lateral frontal process" of Reichart—passes down in front of the eye, the eye being situated in the cleft between it and the former process. The fifth process is situated in front, and in the median line. It is the "anterior frontal process" of Reichart. The clefts or notches between this process and the "lateral frontal process" are considered by Rathke and Reichart to be the external nostrils.

Now, in regard to the so-called "superior maxillary lobes," it is clearly established that the palate and pterygoid Bones are formed in them, but there is no sufficient evidence that they contain the germs of the superior maxillary bones. No traces of the superior maxillary bones appear until these so-called "superior maxillary lobes" have extended forwards, and united with the "lateral frontal processes" and the "nasal process," and until the maxillary margin has become considerably extended. I am, therefore, of opinion that the "lateral frontal processes" of Reichart are, in fact, the real maxillary lobes, and contain not only the germs of the lachrymal, but those also of the maxillary and malar bones. This view of the place of origin of the superior maxillary is in accordance with the adult relations of these bones. The position of the superior maxillary is in front of the eye; the orbit being, in fact, an expanded cleft between it and the palate bone.

Again, the nasal bones of the Mammal are formed in the upper part, and the intermaxillary bones in the lateral angles and palatal lobes of the "anterior frontal process." The notch or cleft on each side of this process cannot therefore become the external nostrils, for these are not situated in the Mammal behind the intermaxillary bones, but in front of them. From these circumstances, I am inclined to consider the external nostrils of the Mammal to be formed by the transverse union of the palatal lobes of the "anterior frontal process;" and by the formation of the cartilages of the external nose in the mesial portion of the free margin of that process.

Embryologists generally consider the so-called superior maxillary lobes to be the upper portions of the "first visceral lamina" bent forward, and the "lateral" and "anterior frontal processes" to be the superadded structures in no way related to the "visceral" or "branchial laminæ." It appears to me, however, that the general aspect, the relations, and the changes undergone by them in development prove these parts to be serially homologous with the "visceral laminæ," and to be, like them, indications of the segmented structure of the head in front of the so-called first visceral arch. The so-called superior maxillary lobes indicate a segment of which the palate and pterygoid bones are elements. The "lateral frontal" indicate a second segment containing the maxillary, malar, and lachrymal bones. The external margins and angles of the "anterior or frontal processes" indicate an intermaxillary segment; and the development of the mesial part of the same process into the cartilages of the nose indicates a segment probably only fully developed in the Mammalian head.

In addition, therefore, to the "visceral laminæ" behind that one in which the mandibular arch is formed, there would appear to be a series of less developed "visceral laminæ" in front of it, all of which, in addition to other structures, give rise to hæmal arches of the sclerome, and indicate a number of corresponding sclerotomes.

Of the Primary or Fibrous Sclerome.—The bones and cartilages to which, from their palpable character, the attention of anatomists has been hitherto chiefly directed, are parts only of the Vertebrate sclerome. They are imbedded in a continuous fibrous matrix which, variously modified, binds them together, and co-operates in their general economy and functions. This matrix forms a more extensive, and, in some respects, a more important element of the sclerome in the lower than in the higher Vertebrata; and if viewed in the former in connection with its early stages of development in the embryo, it will be found to be arranged on the plan of the "primordial vertebral system." It is most satisfactorily studied in the Fish, and particularly in those forms in which the bones and cartilages are feebly developed. The fibrous element of the sclerome forms the sheath of "corda dorsalis" in the Lancelet, and envelopes the column formed by the bodies of the vertebræ in other Fishes. It then bounds the neural and hæmal cavities, and from these cavities passes in the mesial plane above and below to the neural and hæmal margins of the body. Corresponding cartilaginous and osseous parts are imbedded in these fibrous neural and hæmal laminæ. From the right and left sides of this deep or central system of fibrous laminæ, other laminæ extend outwards between the myotomes and are connected to the deep fibrous layer of the integument. The bones usually distinguished as "additional ribs," "upper ribs," "epipleural spines," "diverging appendages," are imbedded in these metamyotomic laminæ; and as the class of radiating bones to which these so-called additional ribs belong may be conveniently distinguished as actinapophyses (ακτισ-ινοσ), I apply the term actinal to the metamyotomic fibrous laminæ of the sclerome. As those dermal bones or plates which, from their histological as well as their teleological characters, certainly constitute elements of the sclerome, are formed in the layer of the integument to which the actinal sclerous laminæ are attached, this integumentary fibrous structure must be considered as constituting a dermal sclerous lamina, and so completing the fibrous portion of the sclerome.

The sclerome thus consists fundamentally of a fibrous structure, which surrounds the "corda dorsalis," bounds the neural and hæmal cavities, forms a mesial septum above and below, separates the myotomes from one another, and, under the integument, envelopes the deeper parts.

The Development of Cartilaginous and Bony Elements in the Fibrous Sclerome.—The immediate development of certain bones from or in a fibrous matrix, and of others in cartilage previously formed in it, has given rise, among other questions, to one, as to whether the former are to be included in the vertebrate system of bones. Now, while I admit the importance of the embryological and histological facts which the discussion of this question has afforded, I am inclined to think that a histological bias has influenced both the views which have been taken of it. Why certain bones originate in a fibrous matrix, why others originate in cartilage which has been previously formed in the same matrix, are questions of undoubted importance, but which at the same time cannot legitimately be put in opposition to the unity of the fully developed sclerome.

Of the Cartilaginous and Bony Elements, and of the general Morphological Constitution of the Sclerotome.—A sclerotome is, fundamentally, a segment of the fibrous sclerome, and the series of fibrous sclerotomes is indicated by the actinal laminæ, each of which, for reasons to be afterwards stated, ought probably to be considered as potentially double, that is, as consisting of two layers, one belonging to the sclerotome behind, the other to the sclerotome in front.

The fully developed Hæmapod sclerotome is therefore a fibrous structure, in which all the cartilaginous and osseous parts are formed and embedded. With regard to these cartilaginous or osseous elements, I shall at present only direct attention to certain points which bear on the constitution of the sclerotomes of the Head. In doing so, I must bear testimony to the general applicability and convenience of the terms employed by Professor Owen to designate the elements of his typical vertebra, venturing to suggest modifications in their application only where I am compelled to differ from him in regard to the relations of the elements themselves.

The term "centrum" is highly useful as a designation for the cartilaginous or osseous mass formed around the "corda dorsalis," whatever the constitution of that mass may be.

The neurapophyses or hard parts developed in the lateral neural laminæ are "typically" two at least on each side. Not only are there two on each side in the trunk sclerotomes of certain cartilaginous and probably osseous Fishes; but there are two on each side in certain cephalic sclerotomes in at least Fishes and Reptiles. Professor Owen admits one neurapophysis only on each side of his typical vertebra. He accounts for the additional pair in the spine of the sturgeon on the principle of "vegetative repetition;" while the additional elements in the neural arches of certain cephalic vertebræ he at one time considered as parapophyseal, and latterly as diapophyseal elements. But it appears to me that a principle of "vegetative repetition" is out of place in a morphological question; and a parapophysis cannot, according to Professor Owen's archetype, be intercalated between a neurapophysis and a neural spine; nor can a diapophysis become an independent element.

The superior or posterior spinous process, "neural spine," or (as a more convenient general designation) metaneurapophysis, is developed in the mesial neural fibrous lamina. As this element is situated in the mesial plane, it is potentially double, and its right and left halves become depressed and more or less flattened out in the cephalic sclerotomes. With the neurapophysis it completes the neural arch.

The cartilaginous or osseous elements developed in the lateral and mesial hæmal laminæ of the fibrous sclerotome constitute the hæmal arch. The fundamental character of the inferior or hæmal arch, as I understand it, consists in this that its constituent elements take their rise at or close to the inner surface of those "ventral laminæ" or "folds" in the embryo, which form the lateral and inferior walls of the visceral chamber. Every hæmal arch, therefore, within the antero-posterior range of the alimentary tube must, according as it is more or less developed, necessarily inclose that tube more or less completely. Accordingly no arch within the range of that tube, if it excludes the tube, can be considered as a hæmal arch, merely because it incloses great bloodvessels. Again, before any arch beyond the range of the alimentary tube can be considered as a proper hæmal arch, its development must have been ascertained; or its relations to those muscular, vascular, but more particularly nervous elements, which constitute in their respective systems the arrangements corresponding to the hæmal arch in the sclerotome, must have been determined.

I must confess therefore my inability to discover the precise view of the hæmal arch taken by Professor Owen. Judging from his diagram of the "ideal typical vertebra," and from his general treatment of the subject, a chevron bone in the Reptile or Mammal, or that portion of the cervical vertebra in certain Birds which completes the canal beneath the centrum, represents the primary typical form of this arch. It would also appear to follow from his doctrine, that the expanded form of hæmal arch, provided for the lodgment of the central organ of circulation, and presented by the thoracic segments, is a secondary formation—the result of the removal of the primary hæmal arch from its "typical" position under the centrum, and its intercalation between the elongated pleurapophyses. But this doctrine appears to me to involve embryological contradictions. The relations of these primary and secondary forms of hæmal arch in the neck and throat respectively are not explained by it. The so-called hæmal arch under the cervical vertebra of the pelican is undoubtedly hæmal in function ; but as it excludes the œsophagus and trachea, it cannot be the real or morphological hæmal arch. In other words, this so-called hæmal arch cannot have been formed in the " visceral laminæ" of the embryo neck.

Again, it is difficult to conceive how the pleurapophyses and hæmal arch of Professor Owen's " ideal typical vertebra" can be developed together in the " ventral folds" of the embryo. For, according to the doctrine of Professor Owen, a pleurapophysis may, in different instances, present two sets of relations. In the thorax it is attached by opposite ends to adjoining sclerous elements, and lies in the wall of the hæmal chamber. In the neck and tail it is connected to its own vertebra at one end only, and does not lie in the wall of the hæmal chamber. The mode in which the continuously arranged elements of the costal arch of a Bird—the " pleurapophyses," " hæmapophyses," and " hæmal spine"—are developed in the embryo is known. But it is difficult to conceive how the detached and peculiarly arranged " pleurapophyses" and " hæmal arch" as represented in the " ideal typical vertebra," or exemplified in a proximal caudal vertebra of a Reptile or perenni-branchiate Amphibian, have assumed the positions they occupy, if they belong to the same group of elements—that is, if they all spring from or originate in the wall of the visceral chamber.

Is the pleurapophysis a fundamental or primary element of the hæmal arch? In other words, is it originally developed in the wall of the visceral cavity, and in certain instances afterwards extruded from it? or is it merely a secondary element in the hæmal arch, that is, formed externally to, or away from it, and only intercalated into it in certain vertebræ?

As a rib, so far as its development has been traced in the series, appears to be formed in the inner layer of the " visceral lamina;" and as it is previously connected or continuous with the diapophyseal portion of the neurapophyses, its head and neck being secondary formations, I am inclined to consider the caudal transverse processes in the Mammal, Lizard, and Amphibian, as lying in the position of the original " ventral folds;" and that, therefore, the feebly developed " pleurapophyses" of this region are the only representatives of its hæmal arches; while the chevron bones have no title to this morphological distinction.*

* In dissecting lately a large crocodile, I found that an aponeurotic membrane extended outwards and curved downwards on each side from the extremities of the caudal transverse processes. These aponeuroses met one another in the mesial line below the tail and were there joined by a mesial aponeurosis which extended down from between the chevron bones. A layer of fat one-third of an inch in thickness lay on the outside of the lateral aponeuroses; and embedded in it the hæmal divisions of the spinal nerves extended outwards, downwards, and backwards, like a series of intercostal nerves. The lateral muscular mass of the tail arranged in myotomes with meta-myotomic fibrous laminæ, nearly as distinct as in the fish, lay on the outside of the layer of fat. Each of the lateral aponeurotic cavities was occupied by the " fémoro-péronéo-coccygien" muscle of Cuvier, which arose from the under surfaces of the transverse processes, the sides of the chevron bones and mesial aponeurosis, and passed out of the cavity through a space left in its outer wall behind the ischium to be inserted into the thigh bone. The mesial membrane divided above; its two laminæ corresponding to the limbs of the chevron bones, and passing in front into the walls of the pelvis.

This arrangement appeared to me to indicate that the transverse processes, the lateral aponeuroses, and the hæmal divisions of the spinal nerves, were in the position of the proper hæmal arches of the tail; that the two aponeurotic chambers constituted in fact, together, the abdominal or visceral cavity, divided by the mesial lamina, and occupied by a pair of muscles, referable to that group of muscles which in the trunk lie on the inner surface of the visceral chamber; and that therefore the chevron bones are not real hæmal arches, but subcentral developments.

The processes which complete the canal under the posterior cranial and anterior trunk centrums in certain Fishes, and of the cervical centrums in certain Birds, are probably of the same nature as the chevron bones, which, according to Joh. Müller, appear to be developments of the inferior pair of constituent pieces of the centrum.

We are entitled, then, to require that every part to which the pleurapophyseal or hæmapophyseal character is attributed, shonld have been proved by direct observation, or otherwise, to have been developed in the "ventral folds."

It appears to me very doubtful whether there are sufficient grounds for limiting the number of morphological elements in the hæmal arch to one pair of "hæmapophyses" and a "hæmal spine;" or to a pair of "pleurapophyses," a pair of "hæmapophyses," and a "hæmal spine;" while an increase in the number of sclerous pieces is accounted for by the principle of "vegetative repetition," or "teleologically." While I admit the grouping of the elements of the more complex hæmal arches into an upper and a lower series, I am compelled on philosophical grounds to deny that the subdivision of a "pleurapophysis" or of a "hæmapophysis," is beyond the range of morphological law; or that morphology and teleology are distinct in the sense that the latter principle provides for what the former is insufficient. Morphology and teleology are merely opposite, because, in the at present phase of science, necessary anthropomorphic aspects of the same Divine principle evinced in the laws of organization.

Until then we know more than we do at present of the laws which regulate the number of "centres of chondrification and ossification;" and, until the constitution of the inferior vertebral arches in the embryo and adult series has been more fully analysed, I cannot give my assent to the expression for a hæmal arch involved in Professor Owen's osteological doctrine.

I must here allude to a point which does not appear to have attracted that attention which it deserves. None of the hæmal arches of the head inclose the hæmal axis. If we are to consider the so-called median and lateral frontal with the superior maxillary lobes as visceral laminæ, then, as such, they have no primordial relation with the hæmal axis, which, under the form of the cardiac-branchial tube, extends forward as far only as the so-called "first visceral lamina." After the hæmal arches have been formed in "the first and other visceral laminæ," usually so called, of the head, the hæmal axis is found to be excluded from them. It is in consequence of this remarkable developmental arrangement, that the heart, branchial artery, and its branches, in the Fish and Amphibia, are situated below and external to the skeleton of the branchial apparatus.

Before pointing out what appear to me to constitute certain of the developmental conditions on which this peculiar relation of the hæmal arches of the head to the hæmal axis is dependent, I must direct attention to another relation, in which the cephalic hæmal arches are peculiar. The hæmal arches of the head are in immediate contact with the alimentary tube; they are lined by the mucous membrane, which is also in contact with their centrums. There is, in fact, no extension of the peritoneo-pleuro-pericardiac space into the head. The cephalic portion of the primary abdominal wall (Kopfseitenplatte of Remak) becomes from the first united to the corresponding portion of the cephalic primordial vertebral system (Kopfurwirbelplatte); and the former, instead of dividing into two layers, one for the wall of the alimentary tube, and another for the wall of the visceral cavity, with a serous space between them as in the trunk, becomes, in conjunction with the latter, perforated by the branchial clefts.

The hæmal portion of the head, therefore, is distinguished from the corresponding portion of the trunk, in presenting meta-somatomic clefts, in having no serous cavity, and in having the hæmal axis external to the hæmal arches of its sclerotomes. We are not yet in possession of sufficient data to explain these various peculiarities of the head in the Hæmapod. I must direct attention, however, to the following facts, which bear upon the cephalic exclusion of the hæmal axis. The anterior portion of the primordial alimentary tube, from the cul-de-sac in which it terminates in front, back to its vitellary margin, consists essentially of two parts; a cephalic portion, terminated by the cul-de-sac, is bounded laterally by the "visceral laminæ," from the so-called first pair of laminæ backwards, and becomes developed into the pharynx; and a cervico-thoraco-abdominal portion, bounded laterally by the anterior portion of the primordial vertebral system of the trunk and the corresponding portions of the primary ventral wall. The primordial hæmal axis (heart and branchial artery) is formed within the pericardiac space, on the inferior aspect of the posterior or trunk portion of the tube from which are afterwards developed the œsophagus, stomach, duodenum, liver, pancreas, and lungs. The heart and pericardium are at first comparatively large, project downwards, and only pass backwards at a comparatively late period into the interior of the hæmal arches of the thoracic sclerotomes in Reptiles, Birds, and Mammals. The cephalic portion, or pharyngeal cul-de-sac, on the other hand, does not present originally any traces of the development of the hæmome. This may be to a certain extent explained by the great comparative development of the cephalic portion of what would have been formerly considered the "serous layer" of the blastoderma. The extremities of the so-called "first visceral laminæ" have in fact approached one another below, before the apex of the cardiac tube has advanced so far forwards as to communicate with them. The precise conditions, however, which determine the formation of the sclerous elements of the mandibular, hyoidean and branchial arches on the inside of the corresponding vascular arches, remain to be ascertained by future inquiry. At present I can only conceive of these conditions as in some way dependent upon the developmental relations to which I have alluded.

These relations of the hæmal arches of the head must be taken into consideration in determining the signification of the branchial arches of the Amphibian and Fish. The division of the sclerous system, into dermo, neuro, and splanchno skeleton was first systematically carried out by Carus. I was early brought, by the study of the works of the philosophical and ingenious Dresden Anatomist, to adopt this three-fold division of the skeleton. I have latterly, however, been induced to reject as untenable the doctrine of a splanchno-skeleton. I believe it may be confidently asserted that no structure referable in any way to the skeleton is developed in or around any portion of the mucous layer of the vertebrate alimentary tube beyond that part of it which belongs to the head; in other words, beyond the pharynx, or part perforated by the branchial clefts. The mandibular, hyoidean, branchial, and pharyngeal arches, the cartilages of the larynx, trachea, bronchial tubes, and lungs, are all primarily developed in immediate relation to the cephalic portion of the alimentary tube.

It is remarkable that those who refer the branchial and pharyngeal arches to a splanchno-skeleton, have not adduced the external position of the hæmal axis to these arches as an argument in support of their opinion. On this ground, however, the hyoidean, and, I believe, the mandibular arch also, as internal to the first, or to the first and second aortic arches, would be also thrown into the system of the splanchno-skeleton. Carus has accordingly done so in the case of the hyoidean arch; but Professor Owen, overlooking the fundamental embryological relations which indissolubly connect all these arches as serially homologous, holds the hyoidean to be a "strong, bony, persistent arch of the true endo-skeleton;" while, on grounds which appear to me altogether secondary, he refers the branchial and pharyngeal to the splanchno-skeleton, and thus relieves himself of the onus of determining their "homologies." From the view I have been led to take of this subject, I am under the necessity of considering these arches as true hæmal arches, and as certainly referable to the endo-skeleton as the mandibular arch itself. I also, for the same reason, conceive that the complete morphology of the skeleton of the head includes the homologies of the cartilages of the larynx, trachea, and lungs.

The cartilages and bones developed in the actinal fibrous laminæ are most important elements in the sclerome. In the head they are variously modified and arranged, not only for the protection of organs, but also as a system of props to afford additional security to the fundamental parts of the skeleton. In the trunk they are chiefly subservient to the myome. They thus exhibit their highest development in the framework of the limbs, for the entire constitution of which they alone, I believe, supply the elements.

The bony rays developed in the meta-myotomic laminæ of Fishes exhibit the most elementary forms of actinapophyses. Here, again, I must differ from Professor Owen, who limits the number of these "diverging appendages" to one—generally attached to the pleurapophysis—on each side of the vertebra. This "epipleural element" he considers to be a part of the endo-skeleton, while the additional radiating bony filaments he refers to the exo-skeleton, and recognises in them a manifestation of the principle of "vegetative repetition." While I admit that the so-called "epipleural spines" are the most constant of these bones, yet as the others are developed in the same fibrous membrane, which has, moreover, no primary relation to the dermal system, I cannot see on what grounds they can be excluded from the endo-skeleton. As, again, I cannot avail myself of the principle of "vegetative repetition" in a morphological inquiry, and as I find all of these "additional ribs" connected with important modifications of the myome, I account for their presence teleologically, and hold, therefore, that they must also be explicable morphologically.

The question as to the typical number of actinapophyses in a sclerotome cannot, it appears to me, be determined in the present state of the science. Their existence and general morphological relations having been ascertained, the conditions which determine their position and number must remain for future inquiry.

On these grounds I cannot, with Professor Owen, regard the branchiostegal rays on each side collectively as a single "diverging appendage." I not only recognise on each side of the hyoidean arch of the osseous fish one series, but a double series of actinapophyses. This double arrangement of the branchiostegal rays has not, so far as I know, been recorded. One series of these rays are attached along the outer, and therefore morphologically anterior surface, and the other along the inner, and therefore posterior surface of the cerato-hyal; but as the two series are attached, the one to the upper, the other to the lower part of the bone, they form together a single range for the support of the branchiostegal fold.

I recognise a similar but more developed form of this double arrangement of actinapophyses in the variously modified cartilaginous or semi-osseous double styles or plates which are attached to the convexities of the branchial arches for the support of the respiratory membrane of osseous Fishes. These branchial actinapophyses also exhibit that jointed or multiarticulate structure so generally presented by the rays of the mesial and bilateral fins.

This leads me to observe, that I have not been able to satisfy myself of the truth of the doctrine at present generally held, that the inter-spinous bones and rays of the mesial fins belong to the dermo-skeleton. I admit that, in certain instances, these fins present more or less dermal bone in their composition; but I cannot see how fin-rays, from which the skin and sub-cutaneous texture may be stripped, can be considered as portions of the dermo-skeleton. These rays can scarcely, I conceive, be referred to the dermo-skeleton in the cartilaginous Fishes; and as the rays of the bilateral fins resemble those of the mesial in their histological as well as in their general relations, they ought to be placed in the same category. The rays of the mesial, as well as of the bilateral fins cannot, therefore, in my opinion, be consistently excluded from that portion of the sclerome usually denominated neuro- or endo-skeleton; but like other elements of the endo-skeleton which approach the dermal sclerous fibrous lamina, they may coalesce with dermal bone.

I have been led to consider the inter-spinous bones and mesial fin-rays as actinapophyseal elements. With reference to the mesial position and characters of these bones, I would remark, that it appears to me to be quite permissible, on morphological grounds, to look upon each inter-spinous bone, with its corresponding fin-ray, as consisting of a right and left actinapophysis mesially united,—that is, to consider the right and left halves of which they consist in the young fish as fundamental elements of opposite sides of the body. This view of the actinapophyseal character of the bones of the mesial fins appears to be supported by the occurrence of double anal and caudal fins in monstrous fishes, and also by the so-called urohyal bone. The relations of this bone appear to me to indicate that it is not referable to the basohyal elements of the arch, but to the actinapophyseal. I recognise it as consisting of two of these elements fused together at the mesial plane.

I am further supported in the view which I take of the actinapophyseal character of the inter-spinous bones and mesial fin-rays, by the well-known and hitherto unexplained antero-posterior duplicity which they exhibit in certain fishes. In the Pleuronectidæ, for instance, the inter-spinous bones are attached in pairs, one bone in front and another behind each spinous process. In these instances I conceive we have examples of mesial anterior and posterior actinapophyses in each sclerotome. The corresponding fin-rays are, it is true, alternate, but this does not affect the general principle, when we keep in view the remarkable antero-posterior movements of certain elements of the sclerome discovered by Remak in the embryo, and the highly important observations of Professor Owen with reference to the alternations of some of the elements of the spine in certain Reptiles and Birds,—alternations undoubtedly referable to movements of the kind discovered by Remak.

In the head actinapophyseal elements are generally bar-like, or more or less flattened from without inwards. From the peculiar forms assumed by these elements in the head, an anterior actinopophysis of one sclerotome may meet a posterior one from the sclerotome in front, so as to form together a bar-like or flattened bridge, or buttress, between the two. These bridge-like connections of neighbouring sclerotomes are not unfrequently completed by the fibrous basis of the sclerome. In Birds, and the typical Lacertians, indeed, in which the actinapophyseal elements exhibit remarkable adaptations, the fibrous matrix in which they are imbedded, and by which they are connected, forms an essential feature of their arrangement.

The actinapophyseal elements of a sclerotome are to be distinguished as hæmal and neural—those attached to the hæmal and those connected with the neural arches. The hæmactinapophyses are the most usual and numerous, and have hitherto been alone recognised as such by anatomists. I shall therefore at present only remark, in reference to the neuractinapophyses, that I consider as such the neural range of "additional ribs," the interspinous bones and rays of the dorsal fins, and of the neural half of the caudal fin in cartilaginous fishes, and also the interneural cartilages, to which attention was first directed by Joh. Müller. In the cephalic sclerotomes, the neuractinapophyses constitute the so-called "sense capsules" and the system of "muco-dermal bones." The so-called "muco-dermal bones" have been latterly referred by the continental anatomists to the dermo-skeleton. I am, nevertheless, inclined to believe, that when the general morphological relations of these bones, and their existence in at least Reptiles and Birds, are taken into consideration, they will be admitted as elements of the endo-skeleton. They are not the only bones in the head of the osseous Fish which are traversed by mucous tubes; but from their superficial position they generally are so, and from the same circumstance are frequently overlaid by dermal bone. Professor Owen has adopted the doctrine of the muco-dermal character of these bones, and includes the lachrymal among them. Believing the lachrymal to be a cephalic neuractinapophysis, I cannot assent to the rejection of this bone from the endo-skeleton, and more particularly to referring the perforation which generally characterises it to the system of dermal mucous canals. The lachrymal canal is a metasomatomic opening. It is the remaining portion of the cleft between the maxillary and palatine visceral laminæ. The lachrymal bone is situated at the upper end of this cleft, at the extremity of that metasomatomic space in which the eyeball is situated—viz., the orbit. The lachrymal bone is therefore grooved or perforated by an integumentary canal which, as a portion of one of the original clefts in the wall of the face, is retained in the adult as a passage for the secretion of the lachrymal gland.

The most important cephalic neuractinapophyses are those fibrous, cartilaginous, or osseous structures which support and protect the nose, eye, and ear. They exhibit their fundamental character most distinctly in the Cyclostomatous and Plagiostomatous Fishes, in which they consist of sessile or pedunculated cartilaginous cups or capsules attached to the outer margins of the cranium. In the other Vertebrata these "sense capsules," variously modified in form and texture, become more or less involved in the wall of the cranium. In their fundamental form they must be considered as parts of the endo-skeleton, homologous in the Hæmapod with those parts of the dermo-skeleton of certain Neuropods, such as the Crustacean, which carry the organs of sense, and are serially homologous with its masticatory and ambulatory limbs.

Professor Owen refers the "sense capsules" to the splanchno-skeleton. But the organs of hearing, vision, and smell, are developed not from or in connection with the mucous layer of the blastoderma, but from the so-called "serous layer"—that is, from that superficial layer which produces the skin, its appendages, the cerebro-spinal axis, and the primordial vertebral system. It appears to me that it would have been more natural to refer the sense capsules, as De Blainville did, to the dermal system; but their histological, embryological, and general relations, indicate, I believe, their real nature as parts of the neuro-skeleton.

The most complex and important development of the actinapophyseal elements of the sclerome are those arrangements which constitute the framework of the limbs. As, however, I find myself compelled to dissent from Professor Owen's determination of the anterior pair of limbs as the hæmal arch and "divergent appendages" of the occipital vertebra; and as I also dissent from his general doctrine of limbs, I shall reserve my observations on the subject for a separate communication.

The osseous formations in connection with the subintegumentary fibrous lamina constitute collectively the dermal portion of the sclerome. As the constitution of the exo-skeleton does not immediately bear on the object I have in view, I shall merely observe, in reference to it, that a more extended and systematic investigation of its structure and morphology is at present very much to be desired.

From the statements already made, it will be observed that I consider that the most general conception we can at present reach of a vertebra or sclerotome, is a somewhat expanded or detailed form of Von Baer's ideal transverse section of the Vertebrate Animal, which is based on the original neural and hæmal foldings of the blastoderma from the sides of the corda dorsalis. With reference to the further development of the idea, I venture to express my decided opinion, that formally to announce the archetypal number of elements in a segment of the skeleton is a premature attempt at generalisation, and that a dogmatic statement on a subject of this kind must have a greater tendency to check legitimate induction the higher the authority from which it emanates.

The modifications which occur in the Sclerotomes towards or at the front of the Head.—It is generally admitted, that in tracing backwards the series of sclerotomes in a vertebrate animal, they become modified in form in proportion to the withdrawal of the other organic systems, until at last the sclerotome may become a mere nodule or filament. Although it is also generally admitted that a certain amount of deterioration takes place in the sclerotome towards the anterior part of the cranium, the nature and extent of the change has not hitherto been precisely determined. I find that it presents, according as the nasal fossæ are or are not present, two forms.

First general form of deterioration.—The deterioration is much less in the first form than in the second. The first form may be best observed in the Mammal, in which alone the nasal cavities are complete. The nasal fossæ of the Mammal are bounded below by a series of at least four hæmal arches, the palatine, maxillary, intermaxillary, and ali-nasal, which, along with the soft parts, form collectively the palatal vault of the mouth, with the upper lip and under surface of the external nose; these three continuous surfaces forming in fact the anterior part of the sternal or hæmal aspect of the head, the palatal portion being inclosed within the mouth in consequence of the elongation of the lower jaw. If now the sclerotome, of which the intermaxillary bones constitute the hæmal arch, be examined, it will be found to present superiorly the two nasal bones, as its neural elements; but which, instead of bounding along with their corresponding centrum, a neural space, assist the intermaxillary bones in forming two spaces, which are completed, and at the same time separated from one another by the centrum, which no longer separating a neural from a hæmal space, separates a pair of lateral neuro-hæmal spaces, or nostrils, from one another. This modification of the sclerotome depends, primarily, on its not being required to enclose a segment of the neural axis; and, secondarily, on its co-operating in the formation of the nostrils. This form of sclerotome, in which the centrum passes from above downwards, I denominate catacentric, to distinguish it from the ordinary form in which the centrum passes across, which, therefore, I also occasionally find it convenient to indicate as the diacentric form of sclerotone. The passage from the diacentric to the catacentric form is exemplified in the ethmoidal sclerotome, the hæmal arch of which, consisting of the pair of maxillary bones. enters into the formation of the nasal passages. The centrum of this sclerotome has assumed the form of a more or less compressed plate, which, while it retains its lateral connections with the neurapophyses, extends at the same time more or less upwards into the neural space, and downwards between the nostrils, which, under this sclerotome and the one behind, consist of a mesially bisected hæmal cavity.

The anterior terminal sclerotome in the non-proboscidian Mammals is cartilaginous and catacentric. Its neuro-hæmal chambers are closed in front by the junction of the anterior margins of its neural and hæmal elements. In consequence, too, of the position of the external nostrils. which, as metasomatomic openings, are situated between the hæmal elements of this sclerotome and those of the sclerotome immediately behind, its hæmal elements are tilted forwards, so that towards their junction with the neural elements, their sternal margins are continuous with the dorsal line of the nose. In the more developed forms of this sclerotome, from one to three hæmactinapophyses on each side enter largely into its arrangements.

In the proboscidian Mammals, instead of being greatly developed, as might naturally be expected, this sclerotome is, on the contrary, much simplified. In the Tapir the hæmapophyses have disappeared, while in the Elephant, the neurapophyses alone exist in a comparatively undeveloped form. I believe, however, that it will ultimately be admitted, that the proboscis is not a mere elongation or development of the external nose, like the pseudo-proboscis of the Bear, Racoon, and Coati, but a syssomatome.

Second general form of deterioration of the Sclerotome at the front of the Head. The character of this form of deterioration may be best observed in the intermaxillary or vomerine sclerotome of the osseous Fish. Instead of being reserved for the purpose of forming portions of nostrils, the neural space no longer required for the lodgment of a segment of the neural axis disappears entirely, the neurapophyses being at the same time generally absent. The centrum may also disappear, or may exist in the form of a cartilaginous nodule; a pair of neurapophyses may therefore form the entire sclerotome. These hæmapophyses generally extend outwards and downwards from one another, or from the centrum if it exists at the mesial plane. They form together, therefore, an arch suspended at its centre, with its piers unsupported. The hæmapophyses of the two sclerotomes immediately behind, form respectively two arches, the maxillary and palatal, suspended by their centres from the base of the skull. The centres of these three arches are, however, morphologically their approximated piers, the actual centres, their sternal or hæmal conjunctions are not completed in the osseous Fish, in consequence of the nonformation of the nasal fossæ. These three incomplete hæmal arches retain their embryonic form of imperfect visceral laminæ. They do not bridge across to form a palate, and therefore the first complete hæmal arch in the osseous Fish is the mandibular. The palate in it is, therefore, like that of the Mammal, morphologically a portion of the external surface of the animal. But they differ from one another in this respect, that the palate of the Fish is a primary, that of the Mammal a secondary surface.

Number of Sclerotomes in the Vertebrate Head.—It has tended not a little to throw discredit on the vertebral theory of the skull, that its advocates have differed much as to the number of its constituent vertebræ. I am inclined to think, that these discordant views are the result of a tendency in later inquirers to be influenced by that *à priori*, or "transcendental" method, characteristic of those German and French anatomists with whom the subject originated. For my own part, so far from coinciding in the received opinion, that the number of segments in the vertebrate head is the same in all its forms, I believe that it varies. I shall state in the sequel the grounds on which I hold the number of sclerotomes to vary slightly in the heads of the ordinary forms of vertebrata. I am, however, inclined to believe, that there are indications afforded by embryology and comparative anatomy, of the existence in certain forms of vertebrate head of a considerably greater number of sclerotomes than has been generally supposed. I base this conjecture, first, on the system of cartilaginous nasal segments in the Cyclostomes; and, secondly, that if the head is to be distinguished embryologically from the trunk, by the presence of "visceral laminæ" separated by clefts, then not only the Cyclostomes, but the still more remarkable Branchiostoma indicate a number of cephalic segments, and a form of vertebrate structure, of which, in the present state of the science, it can only be said, that such a form is deducible from the vertebrate type.

I recognise in the head of the Fish, exclusive of the Cyclostomes, six sclerotomes; in that of the Amphibian and Reptile also six; with the exception of the Crocodiles, in which the seventh is feebly developed; in that of Birds, six; and in that of Mammals, exclusive of the Proboscidians, seven.

I find it more convenient to examine these sclerotomes from before backwards; and I distinguish them provisionally by the following designations—

1. Rhinal.
2. Vomerine.
3. Ethmoidal.
4. Pre-sphenoidal.
5. Post-sphenoidal.
6. Temporal.
7. Occipital.

Keeping out of view, therefore, the Cyclostomatous Fishes and the Proboscidian Mammals, which present indications of a greater number, the Vertebrata generally possess all the sclerotomes enumerated above, except the Rhinal, which exists only in Mammals and Crocodiles.

On a fundamental difference between the cranium of the Mammal, and that of the Bird, Reptile, Amphibian, and osseous Fish.—In my earlier attempts to unravel the intricacies of this subject, I found myself opposed by difficulties in passing from the Mammalian to the lower form of cranium, and *vice versa*. I afterwards discovered, that this mainly depended on the reciprocal development and atrophy of the meta-neurapophyseal elements of four sclerotomes in the two forms. In consequence of this, we had been hitherto confounding the frontal bone, or meta-neurapophysis of the ethmoidal sclerotome of the Mammal, with the so-called "proper frontal bone," which is in fact the meta-neurapophysis of the pre-sphenoidal sclerotome of the Bird, Reptile, Amphibian, and osseous Fish, an element of which there are, and this only in rare instances, faint or doubtful traces in the former; and *pari passu*, we had been confounding the parietal bones, the double meta-neurapophysis of the post-sphenoidal sclerotome of the Mammal, with the so-called parietals, the largely developed meta-neurapophyses of the temporal sclerotome of the Bird, Reptile, Amphibian, and osseous Fish, elements which are much reduced in size, and masked in the former. Among other important organic relations indicated in the existence of these two forms of cranium, I would here more particularly note their bearing on the encephalon. Of the two forms, that of the Fish, Reptile, and Bird, while it adheres to the common type, is modified mainly in relation to the organs of smell, sight, and hearing. That of the Mammal, also adhering to the common type, is modified in relation to the cerebrum proper—to that nervous structure superimposed upon the series of ganglionic masses at the base of the brain which are serially homologous with the spinal cord.

Rhinal Sclerotome—*In Mammals.*—The principal parts of the cranium which remain unossified in the Mammal are the nasal septum and the cartilages of the nose. Of these, the unossified portion of the nasal septum is the anterior prolongation of the basal portion of the so-called "primordial cranium." It is consequently a continuous mass of cartilage, but is nevertheless referable to three sclerotomes; its superior portion completing the centrum of the ethmoidal; its lower portion, the centrum of the vomerine; and its anterior, that of the rhinal sclerotome.

The rhinal sclerotome in the Mammal is fibrous, cartilaginous, and catacentric. Its centrum, formed by the anterior portion of the nasal septum, extends from its neural to its hæmal margin. Its right and left neural elements are the so-called superior or triangular cartilages of the nose. They may be continuous with or merely attached to the neural edge of their centrum. The anterior margins, or angles of these cartilages, and the corresponding point of the septum or centrum is the absolute anterior termination of the animal, or more precisely of its morphological axis. The ridge of the nose downwards and forwards to that point is neural or dorsal; beyond it, although continued in the same line, the ridge is hæmal or sternal.

The two alar cartilages are the hæmapophyses of this sclerotome. Variously modified in form, they are more or less firmly attached to the lower margins of the upper cartilages. In front they are attached to the septum, to which also they are more loosely connected round the tip of the nose, being frequently folded in on the ridges of the septum. In the fibrous membrane occupying the sides of the space between the posterior margins of the alar cartilages which together constitute the hæmal arch of their sclerotome, and the anterior margins of the intermaxillary bones which form the hæmal arch of the succeeding sclerotome, there are generally a number of variously modified cartilaginous pieces. These pieces are teleologically highly important elements of the rhinal sclerotome. Morphologically they are actinapophyses. When fully developed, they are three on each side attached to the alar cartilage. In the Ox and other Ruminants, the superior actinapophyses is an irregular lamina, which, imbedded in the fibrous membrane, assists in supporting the wall of the nostril. The second is a thick, short bar, articulated to the alar cartilage in front, and jointed behind to the corresponding element of the vomerine sclerotome, by which arrangement it is immediately connected with the inferior turbinal bone, which is an actinapophyseal element of the ethmoidal sclerotome. The third or inferior rhinal actinapophysis is a crutch-like cartilage, articulated to the alar element by its stem, which is bent inwards, then downwards, and outwards to the margin of the nostril, which it supports by its curved transverse portion. In the Bear, Racoon, and Coati, the two superior actinapophyses are much developed, and, along with the neurapophyseal, form the cartilaginous wall of the trunk-like nose, or pseudo-proboscis. In the Phacochoer the acuminated nasal bones curve down toward the intermaxillary, so as to separate the neural elements of the rhinal sclerotome from one another. The rhinal centrum is therefore much diminished in extent; but is, at the same time, strengthened for the support of the nasal buckler by a deposit of bone. The hæmapophyseal and actinapophyseal elements are thus pushed outwards, along with the nostril, so as to produce that breadth for which the snout of this Pig is remarkable. In Man the rhinal actinapophyses are reduced to the sesamoid cartilages. In the Solipeds they disappear altogether. The so-called semilunar cartilage of the Horse is, in fact, the alar cartilage itself, the internal inferior angle of which, much elongated, supports the inner margin of the nostril, as the transverse limb of the crutch-like inferior actinapophysis of the Ruminant, supports the outer margin of the orifice.

The rudimentary Rhinal Sclerotome in the Crocodiles.—In the Crocodiles, as in the Mammalia, the vomerine sclerotome is traversed by the nasal fossæ, which open therefore in front, instead of behind it, as in the other Reptiles and in Birds. It is evident, therefore, that if the Crocodiles do not possess, like the Mammalia, a rhinal sclerotome, their external nostrils must present an exceptional arrangement; for, instead of being metasomatomic, they must be terminal. I find, however, that in the Alligator, the hoods which extend from the anterior inner margins and septum of the osseous external nostrils consist of dense fibrous tissue, covered by the muscles which act upon them. This double fibro-muscular hood is so arranged on each side as to have the oblique slit-like nostrils situated between their outer margins and the intermaxillary edges. If a plate of cartilage were developed in the margin of each hood, the whole arrangement would occupy the position, and exhibit the relations of an ali-nasal cartilage—a rhinal hæmapophysis, or neurapophysis, as in the Elephant.

Vomerine Sclerotome—*In Mammals.*—In the Mammal the vomerine is a perfect catacentric sclerotome. The nasal bones are its neural elements, as they occasionally run together, and are evidently, as has been generally admitted, serially homologous with the frontals and parietals; they must be viewed as meta-neurapophyses, the neurapophyses being absent in the absence of a nervous centre. The intermaxillaries meeting below form the hæmal arch, and the centrum consists of the vomer, with a corresponding portion of the cartilaginous nasal septum.

The vomer is a bone peculiarly Mammalian. It may be said to make its appearance as a developed element, along with the completed nasal fossæ. But its development in the Mammalian series is not only dependent on the nasal fossæ, but on the intermaxillaries, with which, as will be shown in the sequel, it is invariably connected. Its passage backwards under the centrum of the ethmoidal sclerotome to abut against that of the pre-sphenoidal, is, as will also appear, a Mammalian peculiarity, and an instance of that antero-posterior elongation and of that overlapping arrangement so frequent in the adaptation of the cephalic centrums to one another.

When the inferior turbinal bone, an actinapophysis of the ethmoidal sclerotome, is highly developed, as in the Ruminants, a strong flattened bar of fibro-cartilage is attached to the inner aspect of the ascending process of the intermaxillary, and widening out into a soft curved cartilaginous plate, completes the fore part of the inferior turbinal connecting it at the same time to the second actinapophysis or turbinal process of the ali-nasal cartilage. I look upon this appendage as a hæmactinapophysis of the vomerine sclerotome; and serially homologous with the second or turbinal hæmactinapophysis of the rhinal, and with the turbinal hæmactinapophysis of the ethmoidal sclerotomes.

These hæmactinapophyses have all of them been enclosed within the nasal chamber during development; having passed in through the meta-sclerotomic clefts, instead of forming parts of the nasal wall, or projecting from its outer aspect.

Vomerine Sclerotome in the Crocodiles.—It is remarkable that the familiar fact of the peculiar position of the external nostrils of the Crocodiles should not hitherto have attracted attention. They open in front of the intermaxillaries as in the Mammals; whereas, in the typical Lacertians, and in the extinct Plesiosaurs, Icthyosaurs, and Pterodactyles, in the Ophidians, Amphibians, and Birds, they open behind these bones. On this peculiarity in the Crocodiles depends the very perfect development of the anterior part of the nasal septum. Along with the complete and pervious intermaxillary arch, we find a complete although cartilaginous vomer. Of that part of the extended nasal septum of the Crocodiles, corresponding to the Mammalian nasal septum, the only ossified portion is an elongated single or double slip along the lower edge of its ethmoidal region, and continuous with the elongated presphenoidal centrum. Professor Owen considers this slip of bone as the vomer. I will only observe at present, that holding the vomer to be invariably in relation to the intermaxillaries, I can only conceive, as the vomer in the Crocodile, that elongated cartilaginous portion of the nasal septum which extends beneath the elongated nasal bones to the intermaxillary suture.

Vomerine Sclerotome in Typical Lacertians.—In the proper Lizards this sclerotome is imperforate. The intermaxillaries not only close in at the palate, but in front also; the more or less elongated and combined ascending processes joining the united or distinct nasal bones. The centrum is represented by the anterior part of the cartilaginous septum. The two bones usually described as the double vomer of the Lizard belong, as I shall endeavour to show in the sequel, to the succeeding sclerotome —the ethmoidal.

Vomerine Sclerotome in Birds.—The vomerine sclerotome of the Bird consists principally of the intermaxillaries, but partly of the persistent anterior portion of the primordial cranium. The intermaxillaries speedily unite below and in front, so as to form the first and principal part of the beak. Their united ascending processes extend up to the so-called "principal frontal bone," and separate completely the so-called nasal bones. In the sequel the evidence will be adduced on which I found my belief that the bone called in Birds the "frontal," or "principal frontal," is not the frontal of the Mammal; but that the two so-called nasal bones in the Bird are the two halves of that bone which in the Mammals is called frontal. If so, where are the nasal bones of the Bird? as the ascending processes of their intermaxillaries, which occupy the proper position of the nasals, have not been observed as separate centres of ossification; and as the greater number of Chelonian Reptiles want these bones, and resemble Birds in the general character and horny covering of their beaks, I am inclined to believe that the nasal bones are deficient as ossified elements in the Bird. In young birds, after boiling or maceration, the osseous elements of the beak may be removed, and the anterior part of the primordial cranium brought into view. In the forepart of its septum we again recognise the vomerine centrum, but more or less deficient in certain Birds from the septal perforation peculiar to them. The upper margin of the cartilaginous septum, where it is in contact with the ascending processes of the intermaxillaries, flattens out into a lamina, which partly roofs over the external nostril on each side. These marginal processes of the cartilaginous vomerine centrum extends down in front, so as to line the fore and under part of the nasal fossæ, projecting somewhat behind the intermaxillary margin of the external nostril.

The broad projecting upper portion of the cartilaginous septum occupies the position of the nasal bones, while the inferior portions project from behind the intermaxillaries, like opercular actinapophyses. In the Chick the part of the primordial cranium just described as belonging to the vomerine sclerotome, presents an opaque aspect and fibro-cartilaginous structure, contrasting with the hyaline cartilage posterior to it—a peculiarity pointed out by Reichart as characteristic of certain portions of the primordial cranium. It will be observed that I do not consider the bone or bones usually called "vomer" in the Bird as correctly designated. In the sequel I shall indicate the grounds on which I hold these bones to be the upper elements of the palatine arch.

The Vomerine Sclerotome in Chelonian Reptiles.—The intermaxillaries in the Chelonian, united below, complete the front of the palate alveolar margin, and floor of the nasal fossæ. The only trace of ascending processes which they present, is a compressed spine which projects upwards at their junction in the median line of the nasal opening of the cranium. The lateral margins of that opening are formed by the maxillaries alone; its upper margin by the so-called pre-frontals, except in Hydromedusa and certain fossil forms. The cartilaginous septum of the nasal fossæ extends up from the intermaxillary suture to that of the pre-frontals.

Is the Chelonian vomerine sclerotome modelled on that of the Crocodile, or of the Bird? The Chelonian presents the first stage in the remarkable development of the nasal passages exhibited by the Crocodiles. But the general deficiency of the nasal bones, the indications of ascending processes of the intermaxillaries in the mesial plane, the formation of the posterior margins of the external nostrils by the maxillaries, appear to me to show that in the construction of its vomerine sclerotome, the Chelonian differs from the Crocodiles, and resembles the typical Lacertians, the Ophidians, Amphibians, and the Birds. The cartilaginous lining of its nasal fossæ, a remnant of its primordial cranium, projects, in general, a little beyond the margins of the osseous nostrils, as in Birds; but in Trionyx and Chelys, the projecting margins run forward together in the form of a double cartilaginous proboscis.

The Vomerine Sclerotome in the osseous Fishes.—I have already described the general constitution of the vomerine sclerotome of the osseous Fish, as one form of deterioration of the forepart of the cranium. Its centrum, the vomer, when it is present, is merely a cartilaginous nodule in the longitudinal axis of the basis of the cranium, in front of the bone usually described as the "vomer," but which I believe to be the centrum of the ethmoidal sclerotome,—the neural elements, and those scale-like bones, which Cuvier recognises, I believe correctly, as the nasals. Professor Owen considers these bones to be the turbinal divisions of the olfactory "sense capsules"; and, according to his doctrine of the sense capsules, elements of the splanchno-skeleton. If Professor Owen understands by the turbinal divisions of the olfactory sense capsules, bones homologous with the inferior turbinated, or even the so-called ethmoidal turbinated bones of the Mammal, it is difficult to understand, on embryological principles, how, as splanchnic bones, and as developed in connection with the maxillaries, they come to be situated under the integument of the upper surface of the head. It is, moreover, questionable, whether the sclerous capsule of this, or of any of the special sense organs, is ever divided, and its parts separated from one another, under such relations as those presented by the so-called "turbinals" and "ethmoidal" of the osseous Fish.

The intermaxillaries form the principal and more peculiar elements of this form of vomerine sclerotome. The nasal fossæ being entirely absent, the merely fibrous olfactory sense capsule is subcutaneous, or partly under cover of the nasal bones (turbinals); the vomer is not developed as a septrum, but merely to supply a fulcrum for the intermaxillaries, which may even constitute the entire sclerotome, but are never united below, so as to form a complete hæmal arch.

The Ethmoidal Sclerotome.—The ethmoidal sclerotome. and the pre-sphenoidal immediately behind it, present, in the different forms of Vertebrata various remarkable modifications of their elements, partly dependent on the position of the olfactory lobes of the brain, partly on the position of the olfactory capsules themselves, partly on peculiar adjustments of the nasal fossæ, and on the arrangements subservient to mastication.

The withdrawal from behind forwards of the neural axis, in the course of development, from the posterior extremity of the neural canal is accompanied by well-known changes in the evacuated, but rapidly increasing posterior trunk sclerotomes. Corresponding, but much more remarkable changes, to which attention has not been hitherto sufficiently directed, accompany the withdrawal from before backwards of the anterior part of the brain from the ethmoidal and pre-sphenoidal sclerotomes. The neural portions of these sclerotomes assume more or less of the catacentric character—they become demicatacentric. The neural chamber of the ethmoidal sclerotome of the Mammal, in addition to a portion of the cerebrum proper, lodges its homologous segment of the neural axis. In the Bird the neural chamber of this sclerotome is completely evacuated by the neural axis, which not only leaves it, but withdraws in part also from the pre-sphenoidal. The absence of the anterior extremity of the neural axis from the neural chamber of the ethmoidal sclerotome, is accompanied by the division of that chamber into a right and left compartment by a mesially laminar centrum, the two compartments being occupied by the olfactory capsules. The olfactory lobes in the Bird are not only withdrawn from the ethmoidal sclerotome, but retreat to a certain distance backwards in the neural chamber of the pre-sphenoidal. To this extent the chamber becomes catacentric; but instead of its two resulting compartments being occupied by new structures, having only to transmit the olfactory nerves, their outer walls collapse upon the mesially laminar centrum, and very generally disappear almost altogether, so as to leave the nerves uncovered on the sides of the laminar centrum as they pass forward to the ethmoidal chambers. The neural chamber of the ethmoidal sclerotome of the Bird, containing only the olfactory capsules, is so connected with the bones of the face, and with the neural arch and centrum of the pre-sphenoidal, as to be more or less moveable along with the lower mandible. The ethmoidal in the Mammal is thus seen to be the anterior cerebral sclerotome, while in the Bird it becomes the posterior facial sclerotome.

In the Reptile both the ethmoidal and pre-sphenoidal sclerotomes are evacuated by the neural axis, the olfactory nerves alone passing along in the compressed tubular, partially-catacentric neural chamber of the latter—the olfactory capsules occupying the right and left chambers of the former. In Reptiles, however, the very varied forms assumed by the bones of the face, and more particularly by those of the palatine arch, in relation to the nostrils, and the arrangements for mastication, produce numerous remarkable modifications of these two sclerotomes.

In passing from the Reptile to the Fish, the ethmoidal sclerotome may be said to gather together its scattered elements, and to present a centrum and neural arch frequently as compact as the Human; but modified by the deficiency of nostrils, and by the withdrawal of the neural axis.

Ethmoidal Centrum and Neural Arch in the Mammal.—The human cranium, as the most perfect in the higher of the two forms of skull, will not unfrequently be found to afford a clue to the signification of bones which, being only applied to their final purposes in it, are more or less masked in the other Mammalia, and apt to be misunderstood altogether in the Fish, Reptile, and Bird. If we examine in connection the two bony masses, which, in the current nomenclature of Human Anatomy, are distinguished as frontal and ethmoid, they will be seen to constitute a ring, the space within which is greatly dilated behind, in consequence of the vast expansion, more particularly of the upper and lateral portions of the frontal; while it is diminished to a tubular chink in front, and is so indistinct towards the nasal fossæ, that the older anatomists named it "foramen cæcum." The development of this bony ring shows it to consist of five pieces. These are, the mesial plate, including the crista-galli of the ethmoid, the lateral masses of the same bone, including the corresponding halves of the crebriform lamina, and the two halves of the frontal. We have here therefore a centrum, a pair of neurapophyses, and a divided meta-neurapophysis. The pair of olfactory nervous centres, which terminate in front the entire series of segments of the neural axis, are the segments of that axis, homologous with this neural arch and centrum. In the Mammalia only, is the upper part of this neural arch expanded and adapted for the protection of the more or less developed forepart of the cerebrum proper. In the central portion and lateral masses of the ethmoid, and in the frontal bones of the Mammal, I recognise the centrum and neural arch of a sclerotome, which I provisionally distinguish as the ethmoidal.

Centrum and Neural Arch of the Ethmoidal Sclerotome in the osseous Fish.—The more or less concurrent statements of Oken, Bojanus, Geoffroy, Cuvier, and Owen, as well as the relations of the bones themselves, leave no doubt as to the homology of the so-called pre-frontals of the Fish. They are neurapophyseal elements, the lateral ethmoidal masses of the Mammal in another form, and *minus* the ossified olfactory capsules. The median bone superimposed upon the "pre-frontals" of the Fish, and which has been very generally held to be the united nasals, and the spine of the olfactory vertebra, must be homologous with the frontal bone of the Mammal, if its relations to the "pre-frontals" and olfactory nerves of the former are compared with those of the ethmoid and frontal bones, and the olfactory nerves of the latter. Professor Owen, while he adopts the determination of the superior median bone, as the united nasals, also holds by the hitherto unanimous opinion of anatomists, that the median bone armed with teeth, situated below the pre-frontals of the Fish, is the vomer. Guided by the ethmoid of the Mammal, I cannot see in this bone aught else than the homologue of the central element of the Mammalian ethmoid. The vomer is a Mammalian bone; if it appears in the Fish at all, it is a cartilaginous or semiossified nodule between the intermaxillaries. That the centrum of the ethmoidal sclerotome in the Fish, considered as the homologue of the central plate or bar of the Mammalian ethmoid, should carry teeth in the Fish, is not more remarkable than that one of the centrums of the cervical vertebræ in that class of animals should be so armed.

Hæmal Arch of the Ethmoidal Sclerotome in the Mammal and osseous Fish.—I have commenced my account of the morphological constitution of this important sclerotome, by pointing out the typical arrangement which its neural arch and centrum present in the Mammal and Fish. As the arrangement of these parts of this sclerotome becomes much and variously modified in Birds, Reptiles, and Amphibia, in relation to the various forms presented by the organs of smell and the nostrils, it will be necessary, before proceeding farther, to examine the constitution of its hæmal arch. Even in its most complex form, this hæmal arch, like those of the rhinal and vomerine sclerotomes, consists of two elements only, the right and left maxillary bones. In the osseous Fish they resemble the "lateral frontal processes" in the embryo; they form only an incipient arch like that formed by the vomerine hæmapophyses in front of them. They do not invariably carry teeth. They are variously connected to the hæmapophyses before and behind them; and superiorly to the lateral and forepart of the centrum, neurapophyses, and meta-neurapophyses of the neural arch of their own sclerotome.

The maxillaries of the Mammal, more or less extended from before backwards, and increased in breadth and depth to adapt them to their functions in mastication; meeting one another below, to form a great part of the vault of the palate, and to assist in the formation of the nasal passages: hollowed out to combine lightness with strength; and buttressed by numerous connections with neighbouring bones, nevertheless retain their connection with the neural portion of their own sclerotome, being attached superiorly to the lateral masses of the ethmoid, and to the frontal. They are not articulated, as in the Fish, to their centrum; but those connections to the neurapophyses and meta-neurapophyses, which in Fish are affected by ligaments, are sutures in the Mammal. In the sequel it will be shown, that of the two connections of the maxillary, that to the frontal, and that to the lateral ethmoid, the former is the most constant; presenting in my opinion the fundamental discriminative character of the remarkably modified frontal of the Bird, Reptile, and Amphibian.

The Ethmoidal Sclerotome in the Bird.—The ethmoidal sclerotome is remarkably modified in the Bird. It forms no part of the cranium proper, but assumes the position and structure of a facial sclerotome. The Bird, like the Mammal, has two proper facial sclerotomes. In the former, there are the vomerine and the ethmoidal; in the latter the rhinal and vomerine. In the majority of Birds, also, the ethmoidal sclerotome, along with the vomerine, moves more or less freely on the presphenoidal. It is, moreover, peculiar in being chiefly devoted to the economy of the organs of smell; in having its meta-neurapophyseal elements separated from one another by the passage backwards of the conjoined ascending processes of the intermaxillaries; in the feeble development of its hæmapophyses; and in its cavities being altogether neural, its neurapophyseal elements forming more or less of its palatal aspect.

The meta-neurapophyses of the ethmoidal sclerotome of the Bird, are the so-called nasal bones. From their invariable connection with the maxillaries, I cannot see in these "nasal bones," aught else than the proper frontal bones—the frontals of the Mammal. They are separated from one another by the ascending processes of the intermaxillaries; a circumstance which does not militate against their being the right and left halves of a meta-neurapophyses. They are more or less elongated in the antero-posterior direction; and they bound the posterior margins of the external nostrils by the descending processes which connect them with the maxillaries. To distinguish them from the meta-neurapophyses of the pre-sphenoidal sclerotome, I designate them ethmoido-frontals.

The arrangement of the centrum and neurapophyses of this sclerotome in the Bird, appear to me to have been in a great measure overlooked, from having been examined in the macerated skull, in which these parts, as consisting principally of cartilage, are to a great extent absent.

The centrum consists of the posterior and greater part of the mesial cartilaginous lamina, the interior portion of which forms the vomerine centrum. The ethmoidal portion of this laminar mesial cartilage flattens out at its upper margin, in the same manner as the vomerine portion in front; and like the flattened upper edge of the so-called "ethmoid bone,"

—the centrum of the pre-sphenoidal sclerotome behind. In the same manner as the flattened upper margin of the vomerine portion extends outwards on each side, so as to form a hood over the upper and forepart of the external nostrils, the flattened upper margin of the ethmoidal portion of the septum passes outwards on each side, under cover of the ascending processes of the intermaxillary, and under the ethmoido-frontal, extending down more or less to the level of the palatal plate of the maxillary, and then turning in towards the mesial plane, approaches or meets the lower margin of the mesial lamina itself. Posteriorly, these curved cartilaginous plates close in upon the posterior margin of the septum; which is not continuous with the anterior margin of the laminar septum of the pre-sphenoid. They are each, however, perforated or notched for the transmission of the olfactory nerve; and they also leave on each side of the septum at their posterior inferior angles, a space for the posterior nasal orifice. The superior and middle turbinated folds of the nasal chamber on each side, are also supported by turbinated cartilaginous projections from the internal surfaces of their plates.

I have already stated that the anterior fibro-cartilaginous portion of the persistent part of the primordial cranium of the Bird enters into the structure of its vomerine sclerotome; it will now be observed that its posterior hyaline portion enters into the formation of the ethmoidal sclerotome. In the majority of Birds, the septal lamina continues cartilaginous, as well as the greater part of the curved lateral plates, with their internal turbinal projections. A more or less extended portion only of each curved plate becomes ossified when it extends inwards across the palate; and the ossified portion becomes anchylosed to the maxillary, or to the descending maxillary process of the ethmoido-frontal ("nasal"), and in many Birds to the anterior extremity of the palate bone.

I recognise, therefore, the posterior part of the nasal septum as the centrum; the so-called "nasals" as the meta-neurapophyses; and the more or less ossified lateral and inferior walls of the olfactory chambers as the neurapophyses of the ethmoidal sclerotome of the Bird. If it be objected to this determination, that the parts which I consider as neuropophyses, are only portions of the olfactory sense capsules, I would merely observe, that these sense capsules are in fact combined with the neurapophyseal portions of the ethmoidal sclerotome in the Bird, as in the primordial cranium of the Mammal, Reptile, and Amphibian, and as in cartilaginous Fishes; but that this circumstance in no way nullifies the existence of the neurapophyseal element itself, either in the sclerotome with which the olfactory capsules, or in those with which the ocular and auditory capsules, are connected. I would also observe, that I base my determination of the neurapophyseal character of these parts, not merely on their relations in the Bird, but on the varied relations exhibited by their corresponding parts in Reptiles.

The maxillaries or hæmapophyses of the ethmoidal sclerotome are feebly developed in the Bird. Connected above, chiefly to the descending processes of the ethmoido-frontals, and more or less prolonged in the antero-posterior direction, the maxillaries do not invariably complete the hæmal arch. Their region, therefore of the palate, is more or less completely occupied by the neurapophyseal plates of their own sclerotome.

The Ethmoidal Sclerotome in the Chelonian.—The connection of the maxillaries of the Tortoises and Turtles, by means of the ascending processes of these bones, with the so-called pre-frontals, appears to me to indicate that the latter are homologous with the ethmoido-frontals of the Bird, or the frontals of Mammalia. I recognise in them the meta-neurapophyses of the ethmoidal sclerotome. Each of these bones sends down from its posterior margin a lamina, concave in front, and forming with the concave under surface of the bone itself, the posterior superior hollow of the nasal fossa. The inner margins of these two descending laminæ give attachment to the anterior margins of the fibro-cartilaginous laminæ, which bound laterally the compressed pre-sphenoidal neural space, and form the so-called interorbital septum. The inner margins of the two descending frontal laminæ are, therefore, separated from one another above by the breadth of the forepart of the groove on the mesial part of the under surface of the combined so-called "frontals." If now the macerated skull of the Turtle be examined, it will be found that a complex bony piece, the so-called "vomer," connects by its pair of short divergent upper processes the inferior extremities of the inner margins of the descending frontal processes, converting the space between them into a triangular orifice. This so-called vomer, after sending a horizontal plate backwards between the palatines to form the mesial portion of the common orbital floor, and to support the cartilaginous bar-like centrum of the pre-sphenoid, passes down as the osseous septum of the posterior nares, and terminates in the form of a pentagonal plate in the palate, between the palatines and maxillaries, and in some species in a hexagonal form, between the palatines, the maxillaries, and inter-maxillaries. The relations of the ethmoidal neurapophyses to their meta-neurapophyses in the Bird, and the presence of the former in the maxillary region of the palate, led me to suspect that the so-called "vomer" of the Turtle is the combined neurapophyses of its ethmoidal sclerotome. But its posterior horizontal laminar process, which supports the cartilaginous pre-sphenoidal centrum, as well as the process which forms the septum of the posterior nares, indicated the probability of the "vomer" being a still more complex bone. I have not met with the palatal plate as a separate bone in the Turtle, although in longitudinal sections I have observed faint indications of its having been so. I find, however, that in certain Tortoises, not only is the palatal plate connected by a distinct suture to the upper portion of the so-called "vomer," but it is divided by a similar suture in the mesial line of the palate into two halves. In these Tortoises, therefore, the separation of the posterior nares, the junction of the descending processes of the ethmoido-frontals, and the support of the cartilaginous bar-like centrum of the pre-sphenoid, are affected by a distinct bone, which, including its connections to the palatines, presents all the characters of the so-called "vomer" of the Bird. But I have already stated my belief, that the bone so-called is not the vomer of the Bird; and in the sequel I shall state the grounds on which I hold it to be the combined entopterygoids—the upper elements of the palatine arch.

Ethmoidal Sclerotome in the Crocodiles.—In the Crocodiles proper, and the Gavials, the lachrymal is interposed between the so-called pre-frontal and the maxillary. In the Alligators the maxillary resumes its connection with the pre-frontal, which it had lost in the two other families on account of the elongation of the snout. The pre-frontals in all the Crocodilians are separated from one another mesially by the passage backwards of narrow contiguous processes of the nasals, and by similar processes which pass forwards from the so-called "proper frontals"—in this respect resembling the so-called "nasals" of the Bird, which are separated from one another by the ascending processes of the inter-maxillaries.

Assuming the relations of the pre frontals of the Crocodilian to the maxillary arch as evidence of their being the meta-neurapophyses of the ethmoidal sclerotome—that is, collectively, the homologue of the Mammalian frontal—the next elements of this sclerotome to be determined are its neurapophyses. At this point the type of ethmoidal sclerotome exhibited by the Bird, and the modification of that type presented by the Chelonian, indicate its character in the Crocodilian. The descending processes of the pre-frontals of the Crocodiles are connected inferiorly to the ascending processes of the so-called "palate bones." Now, a bone connected to the homologue of the Mammalian frontal cannot well be considered as the palate bone, even although it be situated between and united by suture to the maxillary and pterygoid. But a bone with such relations, if viewed in the light of the corresponding relations of the ethmoidal neurapophyses of the Bird, indicates its own real nature. The ethmoidal neurapophyses of the Bird, connected above with the ethmoido-frontals, form below more or less of the palatine vault. The ethmoidal neurapophyses of the Chelonians, pushed away forwards and downwards from the ethmoido-frontal by the ento-pterygoid, still form a part of the vault of the palate. In like manner I recognise, in the so-called "palate bones" of the Crocodilian, the neurapophyses of its ethmoidal sclerotome. The ethmoido-frontals and neurapophyses of the Bird, form, along with their cartilaginous septum or centrum, a complete catacentric neural ring. The interposition of the ento-pterygoid of the Chelonian separates the meta-neurapophyses from the neurapophyses of the ethmoidal sclerotome, and at the same time separates the neural space into an upper portion, mesially divided by the cartilaginous septum or centrum for the passage of the olfactory nerves, and into an inferior, mesially divided by the ento-pterygoid itself for the right and left nasal passages. A similar but somewhat modified change is effected in the ethmoidal sclerotome of the Crocodilian, by the interposition of the anterior extremities of its pterygoids—which anterior processes I believe to be, in fact, the ento-pterygoids. These anterior, generally mesially united, processes of the pterygoids of the Crocodilian, were considered by Cuvier as representing the under portion of the Mammalian vomer. He describes them as two osseous pieces fixed to the inner margins of the "palate bones," in front of the "anterior frontals," and of that part of the pterygoid which covers the nasal canals. Professor Owen describes these pieces as the "vomer," and as being generally anchylosed to the forepart of the basi-sphenoid; but he adds the following very important observation, which I have verified, that they (the "vomer") form a distinct bone in a species of Alligator, which passes so far forward and downwards as to appear in the form of a plate in the vault of the palate, in front of the palate bones.

That this double bony splint is not a vomer, as Cuvier supposed, must be evident, if the vomer is to be considered as an element of the vomerine sclerotome. It cannot be, as Professor Owen states, a vomer united to the "basi-sphenoid;" because, in front of the elevated, laterally-compressed, quadrilateral process which passes forwards and upwards from the centrum of the post-sphenoid, the real axis of the skull is continued forward in the form of a compressed cartilaginous bar, which is the centrum of the pre-sphenoid, and which passes in front into the cartilaginous nasal septum, which constitutes the ethmoidal and vomerine centrums. The Crocodilian and Chelonian skulls are, in fact, entirely destitute of ossified central elements in front of their post-sphenoidal centrums, the superincumbent framework in these forms of cranium being supported along the base, not by ossified centrums, but by greatly expanded and modified pterygoids, ento-pterygoids, ethmoidal neurapophyses, maxillaries, and inter-maxillaries, immediately above which series of bones lies the persistent central axis of the primordial cranium, as far back as the ossified centrum of the post-sphenoidal sclerotome. In a mesial antero-posterior section of the macerated skull of the *Crocodilus vulgaris*, a suture will be found commencing in front of the common orifice of the

Eustachian tubes, and terminating at the lower part of the root of the laterally-compressed post-sphenoidal process already alluded to. In front of this suture, the section presents no traces of central elements, the pterygoids and so-called "palatals" taking their places. In a section of this kind in the Museum of the University of Edinburgh, the extremity of the anterior process of the pterygoid passes forwards and downwards, appearing in the suture between the two "palatines," about an inch from their anterior margins; the right and left portions exposed on the vault of the palate being separated from the "palatines" by surrounding suture, and forming together a narrow double surface, one-eighth of an inch in length. In the section to which I allude, and in similar sections, I observe traces of the line of anchylosis between these anterior processes and the pterygoids themselves. These lines run upwards and forwards, and appear to include the anterior and greater part of the pterygoidal portion of the nasal septum, and the thin plate which, on each side, passes up to be united to the descending process of the "pre-frontal." In disarticulating the skull of the Crocodile the pterygoids generally remain attached to the post-sphenoidal centrum, so that the prolonged anterior processes of the former present the appearance of being elongations of the latter, which they in fact are not.

From the foregoing considerations, and on grounds to be explained in the sequel, when the palatine arch, or hæmal arch of the pre-sphenoidal sclerotome comes to be examined. I recognise in the Crocodilian vomer of Cuvier and Owen the proximal or upper element of the pre-sphenoidal hæmal arch—the same element to which, when existing in certain Fishes, Professor Owen applies the sufficiently expressive term ento-pterygoid.

It will now be observed, that in consequence of the great development of the pterygoids, and of the ento-pterygoids in the Crocodilian, the latter extending forward into the neural space of the ethmoidal sclerotome roof over the greater part, and provide a septum for nearly the whole of that extent of the nasal fossæ, the sides and floors of which are formed by the so-called "palatals" or ethmoidal neurapophyses, and abut against the descending processes of the "pre-frontals" or ethmoido-frontals, without entirely extruding the neurapophyses from these processes, as in the Chelonian. There is another minor difference between these parts in the Crocodilian and Chelonian. In the Chelonian, as has been already stated, the ento-pterygoids having pushed the ethmoidal neurapophyses from their natural connection with the descending processes of the ethmoido-frontals, complete, by means of their ascending divergent processes, the triangular space for the olfactory nerves. In the Crocodilian, again, the descending processes of the ethmoido-frontals complete the space for the olfactory nerves, by means of a short process from each of them, which, passing inwards, meets its fellow of the opposite side a little above the junctions of the descending processes themselves with the ento-pterygoids. The space left between this transverse commissure above, the combined ento-pterygoids below, and the lower ends of the descending ethmoido-frontal processes laterally, is occupied by a prolongation forwards of the cartilaginous bar-like pre-sphenoidal centrum.

If the bones hitherto considered by comparative anatomists as the "palatines" in the Crocodilian, are in reality the neurapophyses of its ethmoidal sclerotome, the question arises—Where are the actual palate bones? This question comes to be examined in the sequel, when the hæmal arch of the pre-sphenoidal sclerotome, of which these bones are elements, is under consideration. At present I may state that the study of the crania of the Bird, Lacertian, and Ophidian, has led me to recognise as the palate bone that bone which Cuvier was induced to consider peculiar to the Lizard and Serpent, and named "os transverse" or "pterygoide externe"; and which Professor Owen also names ecto-pterygoid.

The Ethmoidal Neural Arch and Centrum in the Lacertians.—The maxillaries of the typical Lacertians are invariably connected above to the so-called pre-frontals. These pre-frontals are widely separated from one another by the anterior extremities of the so-called "principal frontals," which pass forward, and bound laterally the divided or undivided nasals. The pre-frontals bound the anterior superior angles of the orbits, sending downwards on each side a plate which separates the orbit from the nasal cavity, is more or less intimately connected with the so-called "double vomer," and with the so-called "palatines." I shall, in the sequel, state the grounds on which I hold the "palatines" of the Lizard, Ophidian, and Amphibian, to be its ento-pterygoids, and to be the homologues of the bone or bones which in the Bird are considered as the "vomer." I believe the "transverse bones" of the Lizard to be actually its palate bones, pushed backwards and outwards by the greatly developed ento-pterygoids, and of its so-called "vomer." The so-called "vomer" of the Lizard consists of two bones, which form the floor of the nostrils, separated from, but at the same time connected to, one another by the lower margin of the cartilaginous nasal septum, abutting against the intermaxillaries in front, and the so-called "palatines" or ento-pterygoids behind, and leaving a space on each side, wider behind than before, between their outer margins and the maxillaries, for the posterior nares. In some Lizards the posterior extremities of the two halves of the "vomer" are separated from the transverse descending plates of the "pre-frontals" by the interposition of the anterior extremities of the ento-pterygoids, but in others they articulate with the pre-fronto-lachrymal. Anatomists appear to have been induced to look upon these two bones in the Lizard as the two halves of the vomer, by the same circumstance which has induced them to consider the ento-pterygoids of the Bird as its vomer, viz.,—their position between the posterior nares. But the general relations of the so-called double "vomer" of the Lizard, indicate that its two halves are homologous with the ethmoidal palate-plates of the Chelonian, with the so-called "palatines" or ethmoidal neurapophyses of the Crocodilian, with the corresponding cartilaginous or osseous pieces in the Bird, and with the lateral masses of the ethmoid in the Mammal. It appears to me that the ethmoidal neural arch and centrum form a catacentric arrangement, the two compartments of which constitute the greater part of the nasal fossæ, the olfactory nerves entering through the mesially divided space between the descending or orbito-nasal processes of the meta-neurapophyses; and the posterior nares passing off on the outer sides, and between the neurapophyses and the maxillaries.

The Ethmoidal Neural Arch and Centrum in Ophidians.—The maxillaries of the Serpent are articulated or connected to the "pre-frontals." The latter are separated from one another mesially by the elongation of the nasals back to the "principal frontals." Each of the "pre-frontals," comparatively large, and anchylosed to the lachrymal, sends down a transverse orbito-nasal plate, notched on its inner margin for the olfactory nerve, but separated from its fellow of the opposite side by the pre-sphenoidal processes of attachment of the "palatines." The space roofed over by the nasals and "pre-frontals" is mesially divided above by the contiguous mesial descending laminæ of the nasals, and below by the cartilaginous nasal septum. It is floored by the double "vomer," the two halves of which, connected by the lower margin of the cartilaginous septum, extend from the intermaxillaries in front to the centrum of the pre-sphenoidal sclerotome behind, being separated from the orbito-nasal processes of the "pre-frontals" by the pre-sphenoidal processes of the "palatines."

From what has already been stated with reference to the corresponding parts in the Bird, the Chelonian, and Saurian Reptile, it will now be seen that I hold the so-called "pre-frontals" of the Serpent to be its actual frontals or ethmoido-frontals; its so-called double "vomer" to consist of the right and left neurapophyses, as the "pre-frontals" are the two halves of the meta-neurapophyses; and the cartilaginous nasal septum the centrum of its ethmoidal sclerotome.

The Ethmoidal Neural Arch and Centrum in the Amphibians.—The view which I take of these parts in the Amphibia will at once appear from the foregoing statements, and may be illustrated by the structure in the Frog. As in the Bird, the basis of the ethmoidal neural arch and centrum consists of that portion of the persistent primordial cranium which is situated behind the intermaxillary region, and immediately in front of the "os a ceinture." The mesial portion of this mass of cartilage forms the centrum of the sclerotome, as the posterior part of the nasal septum. The posterior portions of the nasal fossæ are hollowed out on its sides. Its upper surface is covered by the so-called "pre-frontals," which are, in fact, ethmoidal-frontals, or the two halves of the divided meta-neurapophysis. Its lower surface is supported by the two triangular bones, covered with teeth, and which are the neurapophyseal ethmoidal elements, already examined in the other Vertebrata. The posterior nares are situated behind, between the outer margins of these so-called vomerine bones and the maxillaries. The latter are, as usual, connected to the ethmoido-frontals.

Of the views which have been hitherto taken of the Ethmoidal, or Nasal Vertebra, or Sclerotome.—I am precluded in an abstract from entering upon the important but tangled morphological history of the nasal segment of the cranium. I shall only, therefore, on this department of the subject, make a few observations, in deference to the authority of Professor Owen, and in explanation of those points on which I find myself at variance with his doctrine. I have already so far stated, and in the sequel shall more fully state, the grounds on which I dissent from the doctrine of Oken and Bojanus, adopted by Professor Owen, that the nasals and vomer are respectively the neural spine and body of the nasal vertebra. What I intend more particularly to notice at present is that part of Professor Owen's doctrine which relates to the neurapophyseal elements of the nasal vertebra.

Professor Owen considers the middle plate of the Mammalian ethmoid to be the coalesced pre-frontals, and the two halves of the crebriform plate, the ethmoidal cellules, and turbinated laminæ, to be collectively the greatly developed olfactory capsules. If the latter are kept out of view, as not entering, according to his doctrine, into the formation of the ethmoidal or nasal neural arch, the doctrine necessitates the conversion of the laterally-placed "pre-frontals" of the Fish and Reptile into a single mesial laminar bone. Here I would observe that, overlooking, for the present, the adoption by Professor Owen of the current statements as to the identity of the "pre-frontals" of the Fish with the "pre-frontals" of the Reptile, I cannot conceive how the "pre-frontals," either of the Fish or Reptile, can be homologous with a mesial bone. Embryologically, I cannot understand how the olfactory nerves, which in the Fish and Reptiles are situated mesiad of the "pre-frontals," can become placed in the Mammal on their outer aspects. The pair of "pre-frontals" in the Crocodile or Turtle can be legitimately enough conceived as coalescing mesially into a single bone; but this change presupposes the withdrawal or obliteration of the olfactory nerves; for, otherwise, two conditions must be admitted, both of which are embryologically untenable—first, that the olfactory lobes of the Mammal are at one period in its development mesiad to the right and left halves of its central ethmoidal plate; and secondly, that the nervous and sclerous structures change places, the former passing outwards through the latter, or the latter meeting in front of the former, and passing backwards between them. But the actual facts are these:—The mesial plate, or bar, of the Mammalian ethmoid is mesial from the first; and the olfactory bulbs, or nerves, are situated from the first on its lateral aspects. The mesial plate is the prolongation forward of the central bar of the primordial cranium; it is a true vertebral centrum, and is continued onwards and downwards into the vomerine portion of the cranial axis. The crebriform lamellæ are the only parts, therefore, of the Mammalian ethmoid which present in their embryo and adult conditions all the characters of neurapophyseal elements; connected below with their centrum, and laterally or above with their frontal meta-neurapophyses, they, along with the latter, and the centrum, close in the forepart of the encephalic portion of the cranial cavity, and enclose the olfactory lobes of the brain. That the olfactory, like the fifth nerve of the Mammal, leaves the encephalic cavity by more than one orifice, and that the olfactory "sense capsules" are united to the corresponding neurapophyses, are circumstances which afford no arguments against this determination, but, on the contrary, are in accordance with the union of the auditory capsules with their corresponding neurapophyses, and the exit of the auditory nerve from the encephalic cavity in divisions. It must also be observed, that if we are to look, with Professor Owen, upon the central lamina or bar of the Mammalian ethmoid as the result of the mesial union of a pair of "pre-frontals," we must assign a morphological reason for the co-existence of a mesial cartilaginous septum with divided "pre-frontals" of the Reptile and Fish.

I am also obliged to dissent from Professor Owen's determination of the so-called "ethmoid" of the Bird as the mesially-united neurapophyses of its nasal vertebra. Apparently influenced by its usual designation, and shut up to his own view of its homology by his determination of the "basi-sphenoid" as consisting of the connate centrums of the "mesencephalic" and "prosencephalic" vertebræ, Mr Owen has in the Bird, as in the Mammal, arranged this portion of his morphological system in opposition to embryological facts. The two olfactory nerves of the Bird pass forward on each side of the so called "ethmoid" in shallow grooves; in certain instances only do they pass through notches or complete orifices formed by osseous development from the two surfaces of the bone. The two nerves in no instance pass forwards between the plates of the bone in any part of their extent. At no period during development are the olfactory nerves of the Bird situated mesiad of any part of this bone; for it is originally a mesial cartilaginous plate, a portion of the axis of the primordial cranium, extending forwards and upwards from that part of the primordial axis which, when ossified, constitutes the anterior or acuminated extremity of the centrum of the post-sphenoidal sclerotome. In the sequel, I shall have to point out that this bone in the Bird, which anatomists have hitherto looked upon as the "ethmoid," is, in fact, the body or centrum of the pre-sphenoidal sclerotome converted into a mesial plate extending up to, and flattened out at the upper surface of the cranium, in accordance with the catacentric character of the neural arch of the scleretome, of which it is an element. Its corresponding neurapophyses are the pre-sphenoidal wings, —the "orbito-sphenoids" of Professor Owen,—which not only bound laterally the orifices for the optic, but also those for the olfactory nerves. The so-called "ethmoid" of the Bird is not therefore formed by the coalescence of a pair of "pre-frontals," but is a mesial element belonging to another sclerotome. The Bird already possesses distinct or "divided" "pre-frontals," with all the characters of the "pre-frontals" of the Reptile in its so-called "nasals."

Dugès considered the "os en ceinture" of the Frog to be the ethmoid, from its giving passage to the olfactory nerves by two funnel-shaped orifices at its anterior extremity, and from its intimate connection with the nasal cartilage in front. Professor Owen, on the same grounds, while he holds the posterior part of this bone in the *Rana boans* to consist of the "orbito-sphenoids," looks upon its anterior part as the confluent "pre-frontals." But as the "os en ceinture" of the common Frog originates in a centre of ossification on each side of its fundamental portion of the primordial cranium; and as Professor Owen does not state the grounds on which he holds the "orbito-sphenoids" to be confluent with it in the Bull Frog; as I can find no trace of such confluence, either in the Bull Frog or common Frog: and as the forepart of the bone is divided by a mesial septum,—I look upon it as consisting of a single pair of neurapophyses and a catacentric septum. As this "os en ceinture" is situated upon the upper surface of the anterior acuminated portion of the centrum of the post-sphenoid, as in the Bird; and as it is covered above, and, in the common Frog, is united with the anterior portion of the so-called "parieto-frontal," it appears to me to constitute the neural arch and centrum of the pre-sphenoidal sclerotome, of which the orbito-sphenoids are the neurapophyses. The proper "os en ceinture" of Cuvier is in fact the homologous structure in the aneurous Batrachian with the so-called "ethmoid," and the orbito-sphenoids collectively in the Bird; the centrum being principally developed in the latter, the neurapophyseal elements in the former. On these grounds, and also because I hold, with Cuvier, the "nasals" of the Frog to be its "pre-frontals," I cannot assent to Professor Owen's doctrine, that the "os en ceinture" exhibits a stage in the mesial coalescence of a pair of "pre-frontals," the final effect of which is the formation of a mesial ethmoidal plate, or mesially united nasal neurapophyses.

On the Actinapophyses of the Ethmoidal Sclerotome.—As the radiating elements of the ethmoidal segment of the skull are numerous and important; and as their elucidation requires a more extended reference to corresponding elements in the succeeding sclerotomes than can be made before the examination of these has been entered upon, I shall at present make only a general statement on the subject.

In the Mammal we find a series of sclerous elements arranged from above downwards on each side of the ethmoidal sclerotome. On its upper or neural portion are the olfactory "capsule" and the lachrymal bone. On the lower or hæmal portion the cartilages of the eyelids, with the inferior turbinated and malar bones. If the secondary antero-posterior elongation of the maxillary be kept out of view; and if it be conceived in its fundamental developmentary form as a rib-like bone, the convexity of which is inclined outwards and backwards; and if, at the same time, the possibility of a double arrangement of actinapophyseal elements in each sclerotome be borne in view, it will be seen that the malar extends outwards and backwards from the anterior or outer; the inferior turbinal from the posterior or inner aspect of the bone. I have already stated that the actinopophyseal elements of the cranium are generally flattened or extended so as to abut against one another, and against the other bones of the skull. Thus the malar passes backwards in the fibrous membrane which extends across the orbital opening, and which covers in the temporal fossa. The final purpose of the malar is to afford an abutment against the squamosal so as to strengthen the flank of the Mammalian head. The malar, therefore, in many instances sends secondary processes upwards and inwards, to abut against other bones. While I gladly avail myself of Professor Owen's term "squamosal," and fully agree with him as to the bone itself being a "radiating" element of the cranium; and while I more particularly assent to his very beautiful determination of it as the "quadrate jugal" of the Bird, I must, nevertheless, contend for the much greater probability of its being a radiating element of the mandibular than of the maxillary arch. Its intimate connection with the quadrate bone in the development of the chick, and the disunion of it and the malar in certain Mammalia, appear to me to indicate that they belong to distinct sclerotomes.

The extended attachment from above downwards of the inferior turbinal to the inner aspect of the maxillary of the fœtal Ruminant, a form of attachment which is repeated in the lachrymal process of the bone in the human subject, indicate the primary actinapophyseal form of the bone. Its elongation backwards on the inner aspect of the palate bone, and its prolongation forward to abut against the cartilaginous actinapophysis of the vomerine hæmal arch, are secondary processes in the development of the bone, and steps towards the completion of that antero-posterior system of serially homologous actinapophyses which constitute what may be termed the inferior turbinal system. The inferior concha is peculiar to the nasal fossa of the Mammal. The sclerous elements, which constitute its skeleton in its most fully developed form, are posterior or inner actinapophyses of the rhinal, vomerine, and ethmoidal hæmal arches. These actinapophyses become included in the nasal fossa by the closure of the metasomatomic clefts; and, as they subsequently elongate, they abut against one another in the antero-posterior direction.

I shall, in the sequel, show that the more or less defined space termed orbit, at the side of the Mammalian cranium, is fundamentally the metasomatomic fissure between the ethmoidal and pre-sphenoidal sclerotomes. The upper part of this fissure continues permanently open as the lachrymal canal, and drains away the secretion which bathes the front of the eyeball, while that organ, supported by the sclerotic, which is a presphenoidal neuractinapophysis, and surrounded by its accessory structures, is lodged in its dilated portion. From the upper, anterior, and lower orbital margins, which are formed by elements of the anterior of its two bounding primary sclerotomes, a fibrous membrane extends backwards, covered externally by the orbicular muscle, and closing in the contents of the orbit, with the exception of the front of the eye, exposed through the palpebral fissure. This fibrous membrane is a metasomatomic or actinal lamina, extending very obliquely outwards and backwards, like an operculum over the orbit. The succeeding metasomatomic membrane assumes the form of the tissue which separates the orbit from the temporal fossa, and which, passing backwards external to that fossa, forms the temporal fascia, which constitutes an operculum to that space. The temporal fossa itself is the upper portion of the metasomatomic fissure, between the pre- and post-sphenoidal sclerotomes; occupied by the muscles of mastication and the homologous nerve; the lower part of the fissure on each side remaining permanently open as the mouth, or more correctly as the anterior opening of the isthmus of the fauces. By the extension of ossification from neighbouring bones into the anterior and external portion of this fibrous layer, the orbit may be more or less shut off from the temporal fossa.

The cartilaginous laminæ which support the eyelids of the Mammal are developed in the fibrous layer which constitutes the operculum of the orbit, and lie in the same morphological plane as the malar and lachrymal bones. Their histological as well as morphological relations appear to me to indicate, not only that the palpebral cartilages are actinal elements of the endo-sclerome, but also that they are anterior or external hæm-actinapophyses of the ethmoidal sclerotome. This view of the morphological relations of the malar bone, palpebral cartilages, and opercular membrane of the orbit in the Mammal, is borne out by the corresponding arrangement in the Bird. A fibrous membrane extends backwards over the orbit, from the posterior extremity of the feebly developed maxillary, and from the posterior margin of the descending process of the ethmoido-frontal. In the lower part of this membrane the malar is imbedded; across its centre the palpebral cartilage; and at the antero-superior angle of the orbit, the lachrymal bone. These have all distinct actinapophyseal characters, which, in the case of the lachrymal, enables us to perceive more clearly how the Mammalian lachrymal, having become intercalated between its corresponding hæmapophysis and neurapophysis, retains only so much of its actinapophyseal character as is indicated in the anterior margin of its groove, the remainder of the bone being a secondary expansion.

The lachrymal bone of the Bird may extend into the orbital membrane along the outer margin of the so-called "principal frontal," or sphenoido-frontal, and become attached to that bone without losing its connection with the ethmoido-frontal. It may thus also form a union with the supra-orbital bone, when that bone is present, as in the Hawks. The lachrymal may, moreover, extend backwards under the eye to the post-frontal process, and may have a branch of communication with the antero-inferior projection of the mastoid, as in certain Parrots. It may also extend down to the malar, and may be connected in this direction with the transverse projection of the so-called "ethmoid," or presphenoidal centrum. The infra-ocular bony arch in the Maccaws and certain other Birds is not a zygomatic arch, although consisting like it of actinapophyseal elements. The proper zygomatic arch, as consisting of the malar and squamosal, exists in all Birds; the infra-ocular arch is ossified in comparatively few.

The reference of the lachrymal and the other bony formations round the orbit in Birds to a muco-dermal system by the continental anatomists and by Professor Owen, appears to me to be disproved by their relation to the soft parts. They are all developed in aponeurotic bands, which enter into the formation of the orbital fascia already alluded to. In a band extending along the margin of the sphenoido-frontal, the supra-orbital bone takes its rise, which may thus become connected with the lachrymal, when that bone, which is developed in the anterior extremity of the band, extends backwards in it. A second band extends downwards and backwards from the lachrymal to the malar, forming a ligament between the two bones, and along which ossification may extend. A third band extends from the post-frontal process downwards and forwards to the quadrate-jugal or squamosal, along which ossification may extend from above. In all birds a band connects the lachrymo-malar with the post-fronto-squamosal band, thus forming an arch below the under eyelid. The extension of ossification into this commissural band, probably from both extremities, completes the infra-orbital bony arch, and may approximate or unite it to the squamoso-jugal or proper zygomatic arch. A fibrous band, which extends downwards and forwards in the temporal fascia from the anterior process of the mastoid, becomes ossified in some Birds; and it is an extension of this ossification which appears to form the mastoidal limb, or attachment of the infra-ocular arch of the Maccaw. I shall, in the sequel, state the grounds on which I regard as actinapophyseal all the bones developed in the opercular membrane of the orbital of the Bird. I regard the lachrymal bone and the supra-orbital bone or bones of the Saurians, as referable to the same morphological category; and as due to arrangements in the fibrous operculum of the orbit, similar to those in the Bird; as also the connection between the malar and the post-frontal of the Crocodilian, as well as the change in the direction of the jugal, and the peculiar position of the squamosal in the typical Lizards.

The supra-orbital bone or cartilage, with the infra-ocular bony arch, appear in various forms in the osseous Fish; and the arrangements presented by this form of cranium clearly indicate that these orbital bones are parts of a system of actinapophyseal elements referable respectively to the ethmoidal, pre- and post-sphenoidal, temporal, and occipital sclerotomes, peculiarly modified and connected in front for the protection of the orbit, and behind for the suspension of the pectoral girdle.

The Pre-Sphenoidal Sclerotome.—*Its Centrum and Neural Arch.*—It has been already stated that this sclerotome is peculiar in the Mammal, in the absence of its meta-neurapophyses, while this mesial element is more or less fully and largely developed in the other forms of vertebrata. When the cerebrum proper is developed, the sphenoido-frontal bone is absent; when the cerebrum proper is a mere film, as in Birds and Reptiles, or is absent altogether, the sphenoido-frontal is present. As the evidence on which this statement is based is derived from the consideration of the varied relations of all the primary elements in the different forms of cranium, I am compelled, in this preliminary abstract, to refer those who are desirous of weighing that evidence to what has been already adduced with regard to the ethmoido-frontals, and to the statements to be afterwards made in regard to the meta-neurapophyses of the post-sphenoidal and temporal sclerotomes. In the meantime, I shall confine myself to a general exposition of the arrangement as I regard it.

The anterior part of the body of the human sphenoid, and the corresponding pre-sphenoidal piece in the Mammalia generally, constitutes an undoubted centrum, to which the lesser, anterior, or orbito-sphenoidal wings, are the corresponding neurapophyses.

How far we may be entitled to assume the frequent "triquetral" bones in the coronal suture in the human, and in certain other Mammalian crania, and the separately developed antlers of the giraffe, as indications of the missing bone, remains to be determined. I would only observe at present, that the great extent and permanency of the anterior fontanelle appear to be connected with the deficiency in question.

I have already stated that I regard the so-called "principal frontal" of the Bird as the missing frontal of the Mammal. Distinguishing it as sphenoido-frontal, it is the divided meta-neurapophysis corresponding to the feebly developed "orbito-sphenoids," which, bounding the optic and olfactory orifices, constitute the neurapophyses, and to the so-called "ethmoid" as the centrum of the pre-sphenoidal sclerotome. Assuming for the present the signification I have attached to the "principal frontals," and holding the neurapophyseal character of the orbito-sphenoids as incontestable, I would only add a few remarks regarding the central element. The determination of the "ethmoid" of the Birds as the centrum of the pre-sphenoidal segment of the cranium, while it does not require Professor Owen's hypothesis of connation of this element with the centrum behind, presents the element under a form similar to that exhibited by the ethmoidal and vomerine centrums. It resembles these in being an ossified portion of the primordial axis of the cranium, in being flattened into a horizontal plate at its upper margin, in extending down to the line of the base of the skull, and in thus presenting a catacentric relation to its neural arch. The passage of the anterior acuminated extremity of the centrum behind beneath the lower margin of the pre-sphenoidal centrum, so as to support it, is merely an example of that longitudinal obliquity in the setting of cranial centrums against one another, which may be considered as the rule rather than an exception. The posterior margin of the bone is oblique from below upwards and forwards; gives attachment to the orbito-sphenoids, or to their membranous neurapophyseal substitutes, which bound or give passage to the orbital and olfactory nerves. The obliquity of this margin of the bone corresponds with the similar obliquity of the forepart of the basis of the brain of the Bird, a remarkable feature in its configuration. The flattened upper edge of the bone may be more or less exposed on the upper surface of the cranium; and when the intermaxillaries, ethmoido and sphenoido-frontals are removed, this flattened margin is found to be similar to and continuous with the flattened upper margin of the ethmoidal and vomerine cartilaginous septum. The anterior margin may be nearly perpendicular, but is generally oblique from below upwards and forwards, concave or concavo-convex, sharp, and generally free, being connected to the posterior margin of the ethmoidal cartilaginous septum by membrane, thus permitting more or less movement of the upper mandible, that is of the combined ethmoidal and vomerine sclerotomes on the pre-sphenoidal.

In the majority of Birds a laminar process projects outwards and downwards from the lower and forepart of this bone. This process, variously developed, forms, along with the descending process of the lachrymal, the anterior wall of the orbit, separating it from the nasal space, and permitting the passage of the olfactory nerve through a notch or hole in its upper edge. I regard this process on each side of the pre-sphenoidal centrum as of the same nature as the process which will be found projecting from each side of the lower part of the ethmoidal septum or centrum, and which, abutting against the descending process of the ethmoido frontal, forms a wall or rampart across the floor of the nasal passage, extending nearly half way up to its roof, immediately behind the external nostril, thus converting that part of the nasal chamber in front of it into a vestibule. This process is largely developed in the ossified ethmoido-vomerine septum of the Hawks and Owls.

I would here observe, that the "os en forme de cuiller" of Cuvier, which he considers as the inferior turbinal of the Lizard, and which forms the forepart of the floor of the nostril on each side, and the convex anterior part of which stretches like a buttress across the cavity, between the septum and the maxillary, immediately behind the external nostril, appears to me to be, with its fellow of the opposite side, merely the ossified lower portion of the ethmoidal centrum. These so-called "cornets inferieurs" of the Lizard form the floor, and do not, therefore, project from the outer wall of the nasal passage in the manner of the inferior turbinals; and I believe anatomists will, in reviewing the subject, admit that the inferior turbinal accompanies the fully completed maxillary arch, and only exists, therefore, in the Mammal.

I regard these lateral processes of the ethmoidal and pre-sphenoidal centrums of the Bird as homologous with the pterygoid processes of the post-sphenoidal centrum, and generally with those processes which, under various forms, project downwards from the sides of the lower or hæmal aspects of the occipital and succeeding centrums in certain Fish, or with those processes termed "hypopophyses" by Professor Owen.

Before dismissing the consideration of this important centrum in the Bird, I would direct attention to certain interesting modifications which it may undergo. In the first place, it may, like many other bones in the cranium of the Bird, become greatly dilated and altered in form by the development of air-cells in its interior. The pneumatic openings are two in number, one on each side of the anterior margin below the superior horizontal plate. The pneumatic excavation and dilatation extends backwards more or less in certain species; and in some Owls the bone presents the form of a cubical cellular mass. This peculiarity of form might be adduced in support of Professor Owen's doctrine of the formation of this bone from the coalescence of the pre-frontals; but then it will be observed that the increased breadth of the bone is not due to incomplete mesial fusion of lateral parts, but to expansion from the mesial plane, for the olfactory nerves still run forwards in grooves on its lateral aspects, although these may be deep in front, and, posteriorly, their margins may overlap the nerves. The expansion of the pre-sphenoidal centrum also produces a remarkable separation of the optic foramina. As explanatory of this effect, I would observe, that the development of this bone in the Chick shows that it forms the posterior border of the common optic foramen by means of a pair of processes which project from its posterior inferior angle like the limbs of the letter Y. When, therefore, the bone takes on transverse dimension, the single optic chasm separates into two optic foramina, which, in *Strix flammea*, are three-eighths of an inch asunder.

The separation of the optic foramina from the pneumatic expansion of the pre-sphenoidal centrum leads me, in the second place, to observe, that the characteristic separation of these orifices in the extinct forms Dido, Dinornis, Palapteryx, did not depend entirely on pneumatic expansion of the pre-sphenoidal centrum, nor on such width of that bone as might be attributed to incomplete mesial fusion of a pair of "pre-frontals," but on the remarkable prolongation backwards on each of its sides of the neurapophyseal walls of the ethmoidal olfactory chambers.

Professor Owen, in his series of graphic and valuable memoirs on these three extinct forms, and in his memoirs on Apteryx, assuming the pre-frontal doctrine regarding the bone in question, and directing special attention to the more or less complete passage backwards of the nasal chambers to the anterior or inferior wall of the cranial cavity, and to the passage of the olfactory nerves into these by a number of orifices, apparently recognises in Apteryx for instance (although he does not directly make the statement), a completed Mammalian ethmoid. Now, recalling attention again to the embryological considerations from which the formation of neither the Mammalian ethmoidal septum, nor the so-called ethmoid of the Ostrich, Dinornis, Dodo, nor Apteryx, can be conceived as resulting from coalesced pre-frontals, I would remark, that the arrangement of the nasal fossæ in Apteryx, instead of being Mammalian, presents the peculiar Ornithic character of its parts, fully brought out; all the phases in the development of which may be observed in the series of Birds. In all Birds, the posterior extremities of the cartilaginous pouch-like ethmoido-neural, or olfactory chambers, approach or encroach upon the sides of the pre-sphenoidal centrum; so that the membrane which connects its anterior margin to the cartilaginous nasal septum, and a certain extent of both its surfaces, separate the two pouches from one another. The laminar or hypopophyseal process on each side of the bone, variously modified in form, limits, posteriorly and inferiorly, the olfactory portion of the lateral surface of the bone, and, folded over the pouch, walls it in more or less from below; while the lachrymal from above passes down on its outer side. The gradual environment of the pouch may be traced in the series of Birds; and I find in the Asiatic Cassowary, the stage immediately preceding the completion of the process in Apteryx. In this Bird, the pair of deep fossæ in the interior of the skull, which lodge the olfactory lobes, are separated from one another by the posterior margin of the pre-sphenoidal centrum, which here represents the crista-galli. The plate of bone which forms the floor of each fossa, instead of being crebriform as in Apteryx, is perforated by a single star-like foramen, a form due to the partial shooting across of bony processes from its margin.

In the Chelonian.—The neural arch and centrum of the Chelonian are represented in the dry skull by the pair of bones usually considered as the "proper frontals," but which I regard as sphenoido-frontals. In the recent condition the centrum appears in the form of a compressed cartilaginous bar, continuous posteriorly with the compressed anterior part of the post-sphenoidal centrum, resting below on the conjoined pterygoids and ento-pterygoids, continuous in front with the cartilaginous ethmoidal septum or centrum, and thus presenting all the relations of the pre-sphenoidal centrum of the Bird. It is continued upwards, and represents the orbito-sphenoids, or neurapophyses, in the form of a double fibro-cartilaginous membrane, the two laminæ of which separate to unite with the posterior margins of the orbito-nasal processes of the ethmoido-frontals, with the two parallel descending ridges of the sphenoido-frontals, and with the anterior margins of the peculiar descending processes of the so-called "parietals." The olfactory nerves pass forwards between these neurapophyseal laminæ above; and the optic with the other orbital nerves perforate them.

In the Crocodilian.—In the Crocodiles, the sphenoido-frontals have coalesced; but the cartilaginous centrum, and neurapophyseal interorbital laminæ, present exactly the same relations as in the Chelonian; the only difference being the result of the union of the orbito-nasal processes of the sphenoido-frontals near their lower extremities, and the consequent space left between this bony bridge, and the deep furrow formed by the inclined upper surfaces of the ento-pterygoideal portions of the pterygoids.

In the Lacertians.—In the Lizards, the sphenoido-frontal is again double. In consequence of the mesial separation of the ento-pterygoids ("palatals") and pterygoids, the elongated fibro-cartilaginous centrum and neurapophyseal interorbital laminæ, are left unsupported below; to which circumstance is probably due the formation in the inter-orbital laminæ, of a pair of delicate triradial osseous neurapophyses, which pass off from the upper margins of the optic foramina.

In the Ophidian and Batrachian.—Leaving the further consideration of the special homology of the anterior sphenoidal wing in the Reptiles, and more especially in the Crocodiles, until the posterior sphenoidal wing, and the so-called "petrosal," have been examined, I would observe, that the grounds on which Professor Owen distinguishes the "os en ceinture" of the Frog, from that segment in the Python which includes the so-called "frontals," appear to me somewhat arbitrary. This segment in the Serpent consists of a pair of neurapophyses, or orbito-sphenoids, which are distinct, as cartilages at least, in the embryo; of a double meta-neurapophysis (sphenoido-frontals), which not only occupy on each side the positions of the neurapophyses, but extend the forepart of their inner margins downwards, back to back, in the mesial plane, on the sides of the compressed centrum; which thus, along with them, divides the neural chamber in front, for the transmission of the olfactory nerves. The sides of the "os en ceinture" are formed by neurapophyses; while the so-called "frontals" of the Serpent occupy the greater part at least of the sides of their segment; in other respects, their relations are similar. They are both catacentric; the centrum, in both, resting, as in the Bird, on the upper surface of the anterior acuminated extremity of the post-sphenoidal centrum, and in the plane of the ethmoidal centrum in front. I regard, therefore, the "os en ceinture" in the Batrachian, along with the anterior segments of its "parieto-frontals," as consisting of the centrum, neurapophyses, and meta-neurapophyses of the pre-sphenoidal sclerotome; and, therefore, also as homologous with that segment in the Ophidian which includes its "frontals," but exclusive of the elongated anterior prolongation of the post-sphenoidal centrum.

The Pre-Sphenoidal Centrum and Neural Arch in the Fish.—The bone which predominates over every other in the cranium of the Fish is the so-called "principal frontal"; which, however, as already stated, I do not regard as the frontal or ethmoido-frontal of the Mammal, but as a sphenoido-frontal. It is the pre-sphenoidal meta-neurapophysis of the Fish, presenting all the relations of the corresponding bone or bones in the Bird, Chelonian, and Lizard, except that the ethmoido-frontals anterior to it have coalesced in the middle line; while the ethmoidal neurapophyses have become so much developed, exposed, and connected to it laterally, as to assume the position of the so-called "nasals" and pre-frontals" in the Bird and Reptile. The enormous development of this bone in the Fish and Bird appears to depend on the great bulk of the organs of vision. There is, therefore, in both, an extended inter-orbital space to be filled up. In the Fish, as in the Bird, this is variously effected by means of fibro-cartilage and bone. The extreme forms of the inter-orbital arrangement may be illustrated by the Gadoid and Cyprinoid Fishes. In the Cod the greater part of the so-called inter-orbital septum consists, as in the Chelonian and Lizard, of a double fibrous membrane, which extends upwards from the anterior prolongation of the post-sphenoidal centrum to the margins of the mesial grooves on the under surface of the sphenoido-frontal. The two laminæ of this membrane thus bound the sides of the compressed neural space, along the upper part of which the olfactory nerves pass forward. In the posterior superior part of each of these neurapophyseal fibrous laminæ, a comparatively small plate of bone is developed, while the centrum consists of the bar of persistent cartilage, which extends along the grooved upper surface of the anterior portion of the post-sphenoidal centrum, and terminates above the ethmoidal centrum ("vomer"). The optic nerves pierce the membranes so far back as to notch very deeply the anterior margins of the post-sphenoidal neurapophyses, or post-sphenoidal wings.

In the Carp, again, the inter-orbital space is occupied above by a considerable descent of the margins of the sphenoido-frontal groove; in front, by complete ossification of the fibrous membranes, which thus become pre-sphenoidal neurapophyses; behind, by the passage forwards of the post-sphenoidal wings ("ali-sphenoids"), through which, during development, the optic nerves have passed back, to be lodged in notches in their posterior margins; and below, by the bar of semi-ossified cartilage situated upon the upper surfaces of the posterior sphenoidal and ethmoidal centrums.

Of the Hæmal Arch and Hæmactinapophyses of the Pre-sphenoidal Sclerotome.—The palatine arch, between which and the mandibular the mouth is situated, and which terminates therefore posteriorly the pre-stomal series of hæmal arches, may be presumed to undergo very varied modifications in connection with the olfactory, the respiratory, and the digestive functions. In the present instance, as in many others, the anatomy of the human body, instead of leading astray by complexity and extreme modification of its parts, supplies the key for their morphological solution by affording an example of the employment of the fundamental type of structure for the fulfilment of the most complex functional purposes.

The human pre-sphenoidal centrum, hollowed out by nasal air-cells, as in certain Birds, is bounded below and in front by a pair of separate triangular-curved bony plates, which, limiting the size of the right and left pneumatic orifices, bring these into communication with the posterior ethmoidal air-cells or sinuses. These "sphenoidal turbinated bones," or "bones of Bertin," in contact along their outer margins. and outer part of their inferior aspects, with the sphenoidal processes of the palate bones, constitute the upper elements or suspensory extremities of the inverted arch, completed by the meeting of the palate bones themselves in the posterior part of the mesial line of the palatal vault. The right and left pterygoids are attached, as a pair of actinapophyses, to this arch. They pass off backwards and outwards from the posterior margins of the perpendicular plates of the palate bones, and abut in the embryo against the upper and fore part of the mandibular arch, retaining in the tympanic processes of their adult form, indications of their early connection with that arch. The most important secondary connection of the pterygoids in the human adult is with the pterygoid processes of the post-sphenoid; and it is this sphenoidal connection which is most frequently repeated in the animal series.

I shall not enter at present into the question of the probable existence of "bones of Bertin" in the Mammalia generally; nor enquire whether the separate orbital pieces of the palate bones in the herbivorous Cetacea, according to Cuvier, and the separate anterior portions of the pterygoids of the young Dolphin, as described by Meckel and Rapp, may be indications of the upper elements of the palatal arch; but pass on to the consideration of the palatal arch in the lower Vertebrata, in which the two elements of which it appears to consist on each side, are distinctly developed.

The Palatal Arch and Pterygoids in the Bird.—The bone hitherto considered by all anatomists as the vomer of the Bird, is a more or less elongated narrow plate, the margins of which are bent upwards so as to convert its upper surface into a groove, which is applied against the under surface of the acuminated anterior extremity of the post-sphenoidal centrum, which is therefore interposed between it and the pre-sphenoidal centrum. This bone, more or less compressed or extended laterally, separates the posterior nostrils from one another. Its anterior extremity reaches the anterior limits of these orifices, or, passing forwards into the palate between the ethmoidal neurapophyseal and maxillary palatal laminæ, and concealed more or less by them, may terminate on the surface of the palate between the intermaxillary palatal plates. When this bone is much compressed it is single throughout; when flattened, it is more or less extensively divided in the mesial line.

The palate bones of the Bird, more or less elongated, extend anteriorly under the maxillary palatal laminæ, to which in general they are only slightly connected, forward to the intermaxillary palate plates, with which they are anchylosed or articulated, separated from one another in front, to form the lateral boundaries of the posterior nares, the palate bones become broader posteriorly, approach one another, and are either attached to, or anchylosed with, the posterior extremity of the so-called "vomer." Their posterior extremities are provided with facets for articulation with the bar-like pterygoids, which extend from them, outwards and backwards, to articulate with the quadrate bone on each side. The pterygoids of certain Birds have also secondary connections; they articulate with processes which project from the post-sphenoidal centrum in some part of its extent; and on which their shafts glide, rotate, or vibrate.

The reciprocal relations of the so-called "vomer," the palatines, and pterygoids of the Bird, are extremely interesting and important. At present, I can only direct attention to those relations which bear upon my subject. When the palate bones are greatly developed, the "vomer" diminishes. When, again, the "vomer" is much developed, the palatines are in an atrophied condition. The pterygoids present phases of development dependent on the variations of the palatines and pterygoids. The two extremes may be observed in the Parrots and the Struthious Birds. In the former, the palatines are enormously developed, while the "vomer" has disappeared. In the latter, the "vomer" is greatly elongated and developed, while the palatines present the relation, and exhibit the form of the "transverse" or "adgustal" bones of the Reptile.

The Palatal Arch and the Pterygoids in Reptiles and Amphibians.— The three bones on each side, which form the palatal system of the ordinary Lizard, present the same relations, and almost the same form as the "vomer," palatines, and pterygoids of the Struthious Bird. The pterygoids are in every respect similar. The "transverse bones" of the Lizard are also, in relations and almost in form, like the palatines of these Birds. The so-called "palatals" of the Lizard, while they exhibit all those relations to the "transverse" and pterygoids, which the "vomer" of the bird presents, differ from that double bone in this respect, that although in contact at the mesial line, they are comparatively so much broader, occupying so much of the comparatively narrow palatal space that they touch the maxillaries by their anterior external angles. They bound, therefore, the internal nares posteriorly; but like the so-called vomer in the Bird, separate them from one another, passing forward like that double bone to the ethmoidal neurapophyseal plates, which constitute the so-called "vomer" of the Lizard. In the monitors, these so-called "palatines," like the pterygoids, are evidently separated in the middle line, and forced backwards along the inner margin of the maxillary towards the transverse bones, by the development and elongation of the ethmoidal neurapophyseal elements. In the Crocodiles, again, the full development of maxillary palatal plates, and more especially of the ethmoidal neurapophyses, has forced backwards and towards the middle line, not only the bone called "palatal" in the Lizard, but also the pterygoids; and as the latter also exhibit that remarkable tubular development, various phases of which are perceptible in the Chelonians, Birds, and Mammalia, the former again presents the ornithic vomerine aspect.

In the Ophidia the two halves of the palatal system are widely separated at the middle line. The so-called "palatals," elongated forwards into the ethmoidal region, articulated by ascending processes to the presphenoid, slightly attached externally to the maxillaries, as in the Lizards, bound as in these Reptiles, the nostrils posteriorly, but do not separate them mesially.

In the Frog, the so-called "palatals" extend transversely outwards from the "os en ceinture" to the maxillaries, being also connected at their outer extremities with the pterygoids. The latter are articulated posteriorly to the post-sphenoid and to the quadrate bone. The "os transversum" has disappeared at the junction of the so-called palatal, pterygoid, and maxillary.

The modifications presented by these bones in Reptiles and Amphibia are much too numerous to be followed in detail at present. I have, therefore, selected those which are essential for the elucidation of my subject; and shall sum up the conclusions I draw from them, by a comparison of them with the corresponding elements in Chelonians.

The Chelonians, we are told, have no "transverse bone." They are distinguished in this respect from all the other Reptiles. But if we examine the skull of a Tortoise, we shall find all the elements which enter into the formation of the palatine aspect in that of the Crocodile. In front are the intermaxillaries, immediately behind which, in the median line, is the double bony plate, which is usually described and figured as the forepart of the so-called "vomer," but to which I have already directed attention as the combined ethmoidal neurapophyseal elements. In the Turtles the maxillaries meet across the palatal vault in front of the united ethmoidal neurapophyses, so that the latter are pushed backwards, and are in contact laterally with the palatals in the vault of the palate; while in the Tortoise the latter want entirely the palatal processes, consisting, as Cuvier expressed it, only of their upper portions, and extending outwards on each side from the outer margins of the so-called "vomer," and of the pterygoids, to the inner margins of maxillaries. Now, let the base of the skull of a Tortoise, a Turtle, and a Crocodile, be examined side by side. In all three we shall find the intermaxillaries in front. The maxillaries, although they do not meet across the palate of the Tortoise, do so in that of the Turtle, and thus, as in the Crocodile, bound posteriorly the intermaxillary segment of the palate. The transverse union of the maxillaries in the Turtle and Crocodile, pushes back the ethmoidal neurapophyses (which are in contact with the intermaxillaries in the Tortoise), but to such an extent in the Crocodile that the ethmoidal neurapophyses, also themselves much elongated, carry back the pterygoids, so that the latter almost entirely conceal the post-sphenoidal centrum. The outer margins of the pterygoids, already curved downwards in the Tortoise and Turtle, pass downwards and inwards in the Crocodile, so as to meet again in the mesial line of the palatal vault. The bony septum of the pterygo-ethmoidal portion of the nostrils of the Crocodile is at the same time seen to be the result of the extension downwards in the mesial plane of the middle ridge of the so-called "vomer" of the Tortoise or Turtle, and of the connection of the anterior part of that double bone with the ethmoidal neurapophyses. It will thus be observed, that if the maxillaries of the Tortoise were united across the palate, in front of its ethmoidal neurapophyses, to a considerable extent backwards; if the ethmoidal neurapophyses were also elongated in the same direction; and if the outer margins of the pterygoids, below the palatines, were to meet in the mesial line, the latter would be forced backwards and outwards; so that, still retaining their connections with the pterygoids and maxillaries, but leaving those with the "vomer" in front and internally, to abut against the malar behind and externally—the palatal aspect of the skull of the Tortoise would present the arrangement of the corresponding region in that of the Crocodile, the palate bones assuming the form and relations of "transverse bones."

If to the skulls of the Tortoise, Turtle, and Crocodile, those of a Serpent, a Lizard, a Frog, and an Ostrich be added, it will be observed, that the palate bones have disappeared in the Frog; that they have assumed the form and relations of "transverse bones" in the Lizard, Crocodile, and Serpent; that they are essentially "transverse bones" in the Struthious Bird, while in the Tortoise, but especially in the Turtle, they present the Mammalian character and form. It will also be observed, that the bones in the Turtle, Tortoise, Crocodile, and Bird, hitherto denominated "vomer," are the same bones which in the Frog, Lizard, and Serpent are named "palatals," the term "vomer" being applied in these animals to those two bones collectively, which are situated under the ethmoidal portion of the skull. It will also be noted that the bones called "vomer" in the Turtle, Tortoise, Crocodile, and Bird, and the bones called "palatals" in the Frog, Lizard, and Serpent, are related to the others, along with which they have been examined, exactly as the "bones of Bertin," in the human cranium, are to the palate bones and pterygoids.

The Pre-sphenoidal Hæmal Arch and Hæmactinapophysis of the

Fish.—In the osseous Fish a fibrous membrane extends outwards and downwards on each side from the suborbital bar-like portion of the basis of the cranium. In most Fishes there will be found in this membrane, where it passes off from the pre-sphenoidal portion of the cranium, a more or less elongated scale-like bone on each side. This is the "ptérygoïdien interne" of Cuvier, the "hérisséal" of St Hilaire, the "ento-pterygoid" of Professor Owen. The palate bone, connected by the same fibrous membrane to the outer margin of the ento-pterygoid, extends forwards to the side of the so-called "vomer," or to the ethmoidal centrum and neurapophysis, to which, as also to the maxillary and intermaxillary, it is variously attached directly and indirectly. The corresponding actinapophyseal element or pterygoid in the Fish is firmly connected in front to the palate bone, and less intimately to the ento-pterygoid, and, extending backwards, downwards, and outwards, abuts against the anterior margin of the "hypotympanic" and "pre-tympanic" bones, as the pterygoid of the Bird and Reptile does against the so-called "quadrate," or "tympanic" bone. If, then, the basal aspect of the cranium of the osseous Fish is placed in series with those of the Bird, Lizard, Serpent, Tortoise, and Frog, it will be observed, that while its palatals and pterygoids may be at once associated with the corresponding bones, as already determined, in the Bird and Reptile, the ento-pterygoid of the Fish presents all the relation of the double bone, usually called "vomer" in the Bird; of the posterior or horizontal portion of the bone called "vomer" in the Tortoise; and of the bones called "palatals" in the Lizard, Serpent, and Frog. It will also be observed, that while the toothed bone, called "vomer" in the Fish, has, from a catacentric change, disappeared from the under aspect of the cranium in the Bird, Reptile, and Batrachian, the two bones, called in the Fish "pre-frontals"—its ethmoidal neurapophyses—present the same relations to its ento-pterygoids as the ethmoidal neurapophyses of the Bird to its so-called "vomer," and as those of the Tortoise to the posterior portion of its so-called "vomer," and as those of the Lizard, Serpent, and Frog to the bones hitherto called "palatal" in these three forms. I therefore apply provisionally the term ento-pterygoid to the so-called "vomer" of the Bird, to the posterior part of the so-called "vomer" of the Chelonian, to the corresponding bony piece in the Crocodiles, to the so-called "palatals" of the Ophidian, Lacertian, and Batrachian, to the "bones of Bertin," and their representatives in the Mammal.

The constitution of the Nasal Fossæ, and the relative positions of the External and Internal Nares.—The details necessary for the morphological examination of the rhinal, vomerine, ethmoidal, and pre-sphenoidal sclerotomes, have involved a number of facts connected with the varied constitution of the nasal fossæ in the different vertebrate forms. As, however, the constitution of these fossæ has important bearings on the morphology of the entire cranium, I shall briefly direct attention to the subject.

The only perfect form of nasal fossæ is that presented by the Mammal. They consist of the entire neuro-hæmal cavities of the rhinal and vomerine, combined with the hæmal cavities of the ethmoidal and pre-sphenoidal sclerotomes. That portion of the combined nasal fossæ which consists of the cavities of the rhinal and vomerine sclerotomes, is divided in the mesial plane by the centrums of those sclerotomes; while the dependent portion of the ethmoidal centrum, and the posterior portion of the vomerine centrum, divide in the same manner that part of the combined fossæ which consists of the hæmal cavities of the ethmoidal and pre-sphenoidal sclerotomes. The Mammalian nasal fossæ are therefore bounded in front by the walls of the neuro-hæmal chambers of two catacentric sclerotomes;

and, posteriorly, by the catacentrically divided hæmal chambers of a demi-catacentric and diacentric sclerotome.

As the hæmal portions of the cephalic somatomes are separated from one another in their early embryo condition by meta-somatomic clefts, we may expect to find traces of these clefts in the walls of the adult nasal fossæ.

The first or anterior pair of meta-somatomic clefts of the embryo head, that is the clefts between the rhinal and intermaxillary lobe of the " median frontal process," are retained in the adult as the external nares. These openings in the non-proboscidian Mammal, are situated therefore between the ali-nasal cartilages and the intermaxillary bones. In the proboscidian Mammals, they are probably situated between the ultimate and penultimate, or, at least, between two of the distal somatomes of the proboscis.

The second pair of meta-somatomic clefts, situated between the external angles of the median frontal process and the lateral frontal processes, may disappear entirely in the course of development; but they occasionally remain under the form of Stenson's ducts, which pass obliquely through the so-called " incisive spaces," or " foramina," from the mouth to the nasal fossæ, between the intermaxillaries and maxillaries. The mucous walls of the canals of Stenson are supported by cartilaginous tubular folds, which are continuous superiorly with cartilaginous laminæ, which, passing off laterally from the lower margin of the nasal septum and vomer, cover more or less of the floor of the nasal fossæ, upper part of the incisive fissures, and spaces between the intermaxillaries and maxillaries. The " organs" or " sacs of Jacobson," supplied by the olfactory and fifth nerves, lined by glandular integument, sheathed by a continuation of the cartilaginous laminæ already alluded to, and opening into the canals of Stenson, when these are present, are, whatever their function may be, morphologically connected with the second pair of meta-somatomic clefts.

The next pair of meta-somatomic clefts, situated between the lateral frontal processes and the so-called " superior maxillary" deflection of the " first visceral lamina," continue pervious in all the Mammalia except the Cetacea. The lachrymal canals which connect the anterior pouches of the conjunctivæ with the nasal fossæ, consist of the persistent upper portions of these clefts. Their outer or lower portions are obliterated, but the corresponding inter-scleratomic space, much dilated, constitutes that part of the orbit formed by elements of the ethmoidal and pre-sphenoidal sclerotomes, while the spheno-palatine and posterior palatine foramina and fissures, are also enclosed portions of the space between these two sclerotomes, retained for the passage of vessels and nerves.

The posterior nares are not meta-somatomic openings, they are merely the communications between the catacentric hæmal space of the pre-sphenoidal, and the corresponding but undivided hæmal spaces of the succeeding somatomes.

The mouth is the persistent and developed form of the great cleft between the pre- and post-sphenoidal somatomes. It is situated therefore morphologically in the same transverse plane as the posterior nares. Its fundamental or morphological relations are retained and represented by the posterior isthmus of the fauces. The buccal chamber is a vestibule superadded to the alimentary tube, by the anterior elongation of the lower jaw, and by the development of the floor of the mouth and of the tongue, with the consequent inclusion of the vault of the palate; so that the latter, instead of forming the anterior portion of the hæmal or sternal aspect of the head, becomes apparently a portion of the wall of the visceral tube.

The complete development of the vomer characteristic, as already stated of the Mammalian head, is also a characteristic feature of the nasal fossæ in the Mammal. As the centrum of that sclerotome, of which the intermaxillaries are the hæmapophyses, it extends back from them to abut against the pre-sphenoidal centrum, forming a beam which adds to the antero-posterior strength of the entire arrangement, and which supports the more feebly developed ethmoidal and rhinal portions of the nasal septum. All these relations of the vomer are retained in the remarkably modified nasal passages and snout in the Cetacea.

The seat of the olfactory sense is limited to the upper part of the ethmoidal portion of the nasal fossæ. However complex the arrangement of the ethmoidal turbinal laminæ may be, they invariably present the general character of folded laminar neuractinapophyses, connected to their corresponding neurapophyses, after the type of the cartilaginous sessile olfactory cups in the Plagiostomes.

As already stated, the so-called inferior turbinals consist of an antero-posteriorly arranged series or system of mutually abutting hæmactinapophyses, enclosed during development within the nasal fossæ. The inferior turbinal system is peculiar to the Mammal, and consists of elements which, in developed forms of the system, are derived from, and attached to, the rhinal, vomerine, and ethmoidal hæmapophyses. The palate bone, or distal pre-sphenoidal hæmapophysis, supports the posterior extremity of the turbinal system, but I have not had occasion to observe any turbinal element supplied by it.

As the rhinal sclerotome has disappeared in the Bird, the neuro-hæmal chambers of the vomerine sclerotome become closed in front, and the external nostrils are supplied by those metasomatomic clefts between the vomerine and ethmoidal sclerotomes, which in the Mammal form the "incisive foramina," the "canals of Stenson," and the "organs of Jacobson."

As the anterior nares are removed one somatome back in the Bird, so the posterior nares are removed one somatome forwards. They are situated between the maxillary and incomplete palatine arches, the ento-pterygoids separating them, while the palatines are on their outer sides. The posterior nares, instead of being directed backwards in a plane at right angles to the axis of the alimentary tube, open downwards in the plane of its upper wall. This direction of the posterior nares is due to the following circumstances:—1. that the intermaxillaries, although completing their arch below, are principally developed upwards and backwards; 2. that the maxillaries, even when they meet partially across the middle line, have the space which they enclose occupied by the neurapophyses, centrum, and sense capsules of their own sclerotome—in other words, they are in contact with the central and neurapophyseal aspect of their own sclerotome; 3. that the palatines do not form an arch at all, but lie in the horizontal plane of the under surfaces of the centrums of the cephalic sclerotomes behind them.

The Bird, in fact, does not possess nasal fossæ in the same sense as the Mammal, that is, it does not present nasal chambers, formed by the completed hæmal arches of a certain number of sclerotomes. Its nasal fossæ consist only of the catacentric-hæmal or neuro-hæmal spaces of the vomerine sclerotome, and of the combined neural and "sense capsule" spaces of the ethmoidal sclerotome, which occupy the space enclosed by its hæmal arch. They differ therefore from the Mammalian nasal fossa, not only in wanting rhinal compartments, but also in the deficiency of ethmoidal and pre-sphenoidal hæmal spaces. The palate of the Bird, instead of being like that of the Mammal, situated in a plane inferior and parallel to that in which the vertebral column lies, is in the plane of the latter, like that of the Fish. The palate of the Fish is in the horizontal plane of the vertebral column, because its nasal fossæ are absent, the constituent hæmal arches being all incomplete; and because the cavities of its olfactory capsules open externally. The palate of the Bird is in the horizontal plane of the vertebral column for reasons already stated, and also because the olfactory capsules, instead of being situated external to the cavities of their sclerotome as in the Fish, or in its hæmal cavity as in the Mammal, have become involved in, or have taken the place of its neural chamber, and have therefore their inner orifices or posterior nares directed downwards, on the central aspect.

The mode in which the walls and cavities of the olfactory capsules of the Bird become involved or lost in its ethmoidal neural chamber and walls, may be morphologically conceived, if the structure is compared with the corresponding segment of the cranium of a Ray. The cranium of the Plagiostome is modelled on the form of the "primordial cranium" of the Mammal and Bird. The laterally projecting sessile cartilaginous olfactory cups communicate each by a wide orifice with the cranial cavity. If the orifices be conceived as much enlarged, and the walls of the capsules as withdrawn into, or becoming continuous with, those of the cranium; or if the latter be conceived as disappearing, while the former take their places, the general arrangement of the ethmoidal section of the persistent "primordial cranium" of the Ray will be seen to be similar to that sclerotome in the Bird's skull, which retains most of the primordial character. The development of the imperfect maxillaries in contact with the lower aspect of the slightly ossified inferior wall of the combined capsular and neural mass, and the formation of the ethmoido-frontals in the perichondrium which covers its upper surface, would reduce the entire arrangement to the type of the corresponding parts in the Bird.

By a similar process, the sessile cartilaginous auditory capsules of the Cyclostome may be conceived to become buried in the temporal portions of the cranial wall in the Plagiostome, while in the osseous Fish, after the primordial cranium has become enveloped in the bony plates which are formed in its substance and in its fibrous covering, the auditory capsules pass into the cranial cavity, having been enclosed by the neurapophyseal and metaneurapophyseal bony pieces of their own and neighbouring sclerotomes.

The external nostrils of the Lacertian, Ophidian, and Amphibian, are situated, as in the Bird, between the vomerine and ethmoidal sclerotomes; the intermaxillaries being closed in front and below. The so-called nasal fossæ in their vertebrate forms are also, as in the Bird, merely olfactory chambers, occupying the neural space of the ethmoidal sclerotome. The posterior nares, too, open as in the Bird, between the ethmoidal and presphenoidal sclerotomes, but with the following subordinate differences:— In the Lizard they are separated by the anterior extremities of the ento-pterygoids, and are bounded behind by the maxillary processes of these bones, and externally by the maxillaries themselves. In the Ophidian they are separated by the free margin of the ethmoidal catacentric plates; anteriorly by the posterior margins of the ethmoidal neurapophyses, externally by the anterior projecting portions of the ento-pterygoids, and behind by the pre-sphenoidal attachments of the latter. In the Frog they open between the ethmoidal neurapophyses ("vomer"), the ento-pterygoids ("palatals"), and the maxillaries.

We again approach the Mammalian type of nasal fossæ, through the Tortoises, Turtles, and Crocodiles.

It has been already stated that the anterior nostrils of the Chelonian appear to possess more of the Ornithic than Mammalian conformation. The primordial cartilaginous lining of the olfactory fossæ project in some

Turtles through the anterior nasal opening of the cranium in the form of a double proboscis. The posterior nares in the Tortoises are separated by the combined ento-pterygoids (upper and back part of the "vomer") and are bounded by the maxillaries and the palatines, the latter remaining open or ununited across the vault of the palate. In the Turtles, the vault of the palate and the posterior nares present more of the Mammalian aspect, although still formed essentially on the type of the corresponding parts in the Bird. This is effected by the ethmoidal neurapophyseal plates (palatal plate of the "vomer"), which lie somewhat above the level of the vault of the palate in the Tortoises, passing down into, and forming an area of it in the Turtles, extending from its posterior margin half way, or quite up to the intermaxillary palate plates. In the latter arrangement the ethmoidal area is hexagonal, and separates the palatal plates of the maxillaries from one another. In the former it is pentagonal; and the palatal maxillary plates meet in the mesial line in front of it. The palatal plates of the palatines are more or less developed in the Turtles; and many approach one another at the free margin of the vault, but are always separated by the posterior or free margin of the ethmoidal area.

The arrangement of the vault of the palate in the Turtles, and the peculiar Chelonian configuration of the pterygoids, lead to the very remarkable combination of Ornithic and Mammalian structure presented by the nasal fossæ and palatal vault of the Crocodiles. The Mammalian characteristics are the full development of the inter-maxillary and nasal bones, with the extensive, although cartilaginous, vomer. The vomerine sclerotome of the Crocodile is not closed anteriorly as in all the other Lacertians, in the Ophidians, Amphibians, and Birds; but presents a completely perforated catacentric arrangement. This complete form of the vomerine necessitates a rhinal sclerotome, which, accordingly, feebly represented in the Crocodiles and Alligators, appears to be more fully developed in the Gavials. The extensive and complete Crocodilian palatal vault is only apparently Mammalian, it is partially Ornithic or Chelonian in its constitution. As in the Mammal the anterior extremity of the vault is formed by the pair of fully formed palatal inter-maxillary plates. Except in the Alligators in which there is a slight intrusion of the ento-pterygoids, the palatal plates of the maxillaries meeting along the mesial line, form the second and most extensive area of the palatal vault. The next area of the vault consists, as in the Turtles, of the ethmoidal neurapophyses (the so-called "palatals"), united along the mesial line, and much elongated backwards. The posterior margin of the combined ethmoidal neurapophyses of the Turtle forms the central part of the free margin of the palate; but the completion in the Crocodile of the deflected outer margin and central ridge of the pterygoids into a double tube, or pterygoidean prolongation backwards of the nasal fossæ, produces a corresponding elongation of the palatal vault; which accordingly presents, behind its ethmoidal, an extensive and broad pterygoidean area, which thus completes the vault behind, as in certain Cetacea and Edentata. Among the Mammalia the great elongation backwards of the combined maxillary palatal plates, the corresponding elongation of the combined ethmoidal neurapophyses, and the great breadth of the pterygoidean area, have displaced the palate bones so far backwards and outwards, that, separated from the ento-pterygoids and the ethmoidal neurapophyses by a wide chasm, but retaining their connections with the maxillaries and pterygoids, and coming into contact with the malar, they are, in fact, extended from the walls of the nasal fossæ, and from the palatal vault, and, thus disguised, have been hitherto known only as "transverse bones," "adgustal bones," "pterygoïdes externes," "ecto-pterygoids."

The Nasal Passage of the Cyclostomous Fishes.—The cyclostomes differ from all other Fishes in possessing a tubular passage, which, opening externally above the oral disk, passes backwards to the combined olfactory capsules, and behind which it terminates in a cul-de-sac in the Lamprey, but in the Myxine and Bdellostoma, communicates with the alimentary and respiratory tract.

The form and arrangement of the cartilages, which enter into the formation of the walls of this tubular passage, have been figured and minutely described in the classical memoirs of Joh. Müller, on the Cyclostomous Fishes. It becomes a point of much interest to ascertain the morphological character of this tubular passage, and to determine the morphological relations of its cartilaginous elements.

The olfactory capsules of the Myxine, Bdellostoma, and Lamprey, are completely fused into one another at the mesial plane, so as to form a single chamber, situated immediately in front of, and in a line with, the cranial cavity. The common olfactory chamber communicates with the cranial cavity by two orifices perforated in the fibro-cartilaginous transverse septum, for the passage forwards of the olfactory nerves. The olfactory chamber opens below into the naso-pharyngeal passage. In the Lamprey this passage is membranous throughout, the portion in front of the olfactory chamber lying above the posterior superior oral shield, its posterior portion passing back between the base of the cranium and the central part of the palatal cartilage, terminates in a cul-de-sac at its pharyngeal extremity. In the Myxine and Bdellostoma the posterior portion of the passage is a membranous canal situated between the base of the cranium and the mesial palatal cartilage, and opens posteriorly into the pharynx. That portion of the naso-pharyngeal passage in front of the olfactory chamber is supported above and laterally by a series of ten cartilaginous rings, incomplete below—the entire arrangement closely resembling a Mammalian trachea. The membranous floor of this part of the passage is supported by the anterior portion of the central, and the transverse junction of the lateral palatal cartilages, and in front by the mesial and transverse superior oral cartilages.

The morphological constitution of this remarkable nasal skeleton appears to be similar to that of the nasal fossæ of the higher Vertebrata. The olfactory capsules have passed inwards, as in the Bird and Reptile, so that, instead of projecting from the sides of the cranium, like the auditory capsules, they occupy the space of the corresponding cranial segment. The incomplete cartilaginous rings of the nasal tube, viewed in their relations to the cranium and conjoined olfactory capsules, are in the position of a superadded series of neural arches, similar to the neural portions of the rhinal and vomerine Mammalian scleratomes, destitute, however, of centrums, but supported below by the peculiarly developed palatine and maxillary elements which have passed forward beneath them. The entire arrangement presents the general characters, or is developed on the plan of the nasal fossæ of the Reptile, Bird, and Mammal, with the additional peculiarity of an increase in the number of constituent segments, similar to that which apparently exists in the proboscidian Mammals.

Post-stomal Cephalic Sclerotomes. — *Their Central and Neural Elements.*—As the discrimination of the constituent central and neural elements of the three post-stomal segments of the skull demands a constant reference from the one segment to the other, I shall examine them together. Of these three segments, the post-sphenoidal, the temporal, and the occipital, the second has not hitherto been recognised except by Carus, whose system includes a temporal intervertebra.

My attention was directed to the temporal segment of the cranium by the remarkable indications of it presented by the human skull. The human occipital bone, in addition to that upper angular portion of its squamous plate, which presents the relations of the interparietal, exhibits all the characteristics of a vertebral centrum, in combination with neura- and meta-neurapophyses. The inferior articular processes of this cranial segment are largely developed, in relation to the atlas. But it has not been hitherto noted, that the so-called jugular processes are in fact its upper or anterior pair of articular processes; and that, consequently, the jugular processes on the posterior margins of the petrosal portions of the temporals must be the zygopophyses of the succeeding cranial segment. These occipital and temporal jugular articular processes, like the corresponding processes in the column below, present distinct cartilaginous articular facets, and are contiguous to the "foramina lacera posteriora" or "intervertebral foramina," formed by the conjunction of the temporal and occipital jugular fossæ, and which transmit, as in the spine, vessels and nerves. But the petrous portion of the human temporal bone has, in addition, a pair of distinct pro-zygopophyses. They are situated on the anterior margins of the petrous portions where these margins form the angles with the squamous portions, in which are situated the openings of the Eustachian tubes. The articular surfaces of these processes are perpendicularly striated, and are applied against corresponding surfaces of the so-called styloid processes of the sphenoid at the posterior angles of its great wings. These "styloid processes" are therefore the zygopophyses of the post-sphenoidal sclerotome. The pro-zygopophyses of the post-sphenoidal and the zygopophyses of the pre-sphenoidal may be observed at the forepart of the pterygo-palatine groove in the fœtal bone, but are more remarkably developed in the young Ruminant; in which also may be observed the zygopophyseal connection of the pre-sphenoidal with the ethmoidal neurapophyses.

We have, therefore, in these zygopophyseal connections distinct evidence of five cranial segments—an ethmoidal, pre-sphenoidal, post-sphenoidal, temporal, and occipital, in addition to the vomerine and rhinal.

For the further development of this subject, the cranium of a Cyprinoid Fish should next be selected. If the lateral wall of the cranium be examined, either from the external or mesial aspect, five serially arranged neurapophyseal plates will be recognised, connected to one another by four distinct zygopophyseal articulations. These plates are, from before backwards, the so-called "pre-frontal," the "cranial ethmoid," the "orbito-sphenoid" of Owen, the "ali-sphenoid" of Owen, and the lateral accipital. I have already stated the grounds on which I believe we must look upon the "pre-frontals" of the Fish as the neurapophyses of the ethmoidal, and the "cranial ethmoid," as the combined neurapophyses of the pre-sphenoidal neural arches. If so, then, the succeeding plate must be the "ali-sphenoid," and not the "orbito-sphenoid," as Professor Owen considers it to be; and, therefore, as there has never been a question regarding the lateral occipital, the plate interposed between the latter and the former, as it has all the characters of a neurapophysis, indicates the existence of a cranial segment between the post-sphenoidal and occipital. I shall not at present allude to the various opinions entertained regarding this plate, but shall merely distinguish it as the inferior temporal neurapophysis.

Proceeding now to the consideration of the centrums corresponding to this series of neurapophyses, it must be observed that in no osseous Fish in any stage of development have more than three osseous pieces been observed in the basis of the cranium from the so-called "vomer" to the "basi-occipital" included. The assumed "connation" of the centrums of the pre- and post-sphenoids, as held by Professor Owen, has at present no support from embryology; the missing centrum or centrums must, therefore, be accounted for otherwise than by a hypothetical division of the "basi-sphenoid." Professor Owen appears, indeed, to a certain extent to admit this, for in certain Fishes he considers the symmetrical Y-shaped ossicle marked in his diagrams 9^1, and superimposed on the pre-sphenoidal process of his basi-sphenoid, as the central part; while that process itself he holds to be the capsular portion of the ossified notochord.

That mutual elongation and overlapping of the cranial centrums formerly alluded to, is strongly marked in Fishes, the sphenoidal centrum being dovetailed into and elongated beneath the occipital behind, and above the ethmoidal ("vomer") in front. The manner in which the anterior elongated portion of the post-sphenoidal centrum of the Bird elevates and carries on its upper surface the compressed pre-sphenoidal centrum, has already been stated; and I must again observe, that it appears to me that the pre-sphenoidal centrum exists in certain Fishes only in the form of a bar of cartilage—a portion of the "primordial cranium" situated on the upper surface of the anterior prolongation of the post-sphenoidal centrum, and terminating on the upper surface of the ethmoidal centrum or so-called "vomer;" and that in Fishes with an "ossified orbital septum" or "cranial ethmoid," it is to be recognised in the half-ossified cartilaginous mass which unites the right and left plates of that "septum," and which have been already indicated as its corresponding neurapophyses. The pre-sphenoidal is an undeveloped centrum in the Fish, retaining more or less of its "primordial" texture and form, and elevated, therefore, above, or carried inwards, so as to be covered by the fully developed ethmoidal and post-sphenoidal centrums.

I am acquainted with no example of a fully developed temporal centrum. It is represented in the "primordial cranium" by the quadrilateral cartilaginous plate, bounded laterally by the ear capsules, behind by the portion corresponding to the cartilaginous lateral occipitals, and in front by the part in which the post-sphenoidal centrum first appears. In all vertebrate animals this portion of the basis of the primordial cranium is of great comparative extent, and is encroached upon by the advancing ossification of the occipital and post-sphenoidal centrums in modes which vary in the different vertebrate forms. In Mammals, the occipital advances into it at the expense of the post-sphenoidal centrum. In Birds and Fishes, the post-sphenoidal passes more backwards. In the Reptiles, the two centrums appear to share it equally. In all the forms, I believe that traces of the intermediate or temporal centrum may be detected, either in the cartilaginous or osseous condition. In Fishes, more or less of the primordial cartilage remains above the junction of the occipital centrum, post-sphenoidal centrum, and temporal neurapophyses ("petrosals"), and covered more or less internally, or towards the cranial cavity, by the internal prolongations of the occipital centrum, and of the temporal and post-sphenoidal neurapophyses. The peculiar canal for the muscles of the orbit existing in certain fishes, and which is roofed over principally by the "petrosals," or temporal neurapophyses, appears to be hollowed out principally in the primordial temporal centrum, and to be lined by its constituent cartilage. The peculiar Y-shaped bone met with in the pike, perch, and salmon, marked 9^1 by Professor Owen, and * by Hallman, and considered by the former as that portion of the pre-sphenoidal centrum which results from the ossification of the corresponding central portion of the notochord, appears to me to be a central element; but referable rather to the post-sphenoidal or temporal, than to the pre-sphenoidal segment. For, in the first place, it may be questioned whether the corda dorsalis of the Fish reaches the region of the pre-sphenoid; and, in the second place, if I am correct in my determination of the post-sphenoidal and temporal neurapophyses of the Fish, the two ascending limbs of this bone abut against these latter elements, and are not at all connected with the pre-sphenoidal neurapophyses. As, moreover, these ascending limbs of the bone in question are more intimately connected with the bones which Professor Owen considers to be the ali-sphenoids, but which I must hold to be the inferior temporal neurapophyses, I am inclined to conceive it an ossified portion of the temporal centrum.

With regard to the bone termed by Hallman os innominatum, which is small but well marked in the carp, and larger in the perch, and which Professor Owen considers to be the petrosal, I quite agree with him. But while I do so, I make a distinction between an ossified portion of the auditory capsule and the bone which constitutes the corresponding neurapophysis, in the same manner as I find myself compelled to admit the independent existence of the ethmoidal neurapophysis and the olfactory capsules, whether fibrous, cartilaginous, or osseous, and the corresponding independent existence of the variously modified sclerotics and the orbito-sphenoids.

Proceeding now to the examination of the remaining elements of the post-stomal neural arches in the Fish, I would observe that if we put aside those conceptions of the constitution of the arches in question, derived from previous study of the cranium of the Mammal, the constitution of the corresponding arches in the Fish, which naturally suggests itself, is the following:—

1. Over the occipital centrum, the lateral occipitals and the external occipitals—as two pairs of neurapophyses; and the superior occipital—as a single meta-neurapophyses.

2. Over the position of the temporal centrum, the bones termed petrosals by the continental anatomists, but by Professor Owen petrosals in the cod, and ali-sphenoids in the carp, and over these the mastoids, these "petrosals" or "ali-sphenoids," along with the mastoids—as two pairs of neurapophysis; and the contiguous or separated bones usually termed "parietals," as a divided meta-neurapophysis.

3. Over the great basi-sphenoid, the bones termed by Professor Owen orbito-sphenoids in the carp, and ali-sphenoids in the cod, with the post-frontals—as two pairs of neurapophyses, the meta-neurapophyses being absent.

Before making any statements in support of this view of the constitution of the post-stomal neural arches in the cranium of the osseous Fish, I would direct attention to the corresponding parts in the other Vertebrata, from the same point of view.

In the Bird the occipital neural arch wants the ex-occipitals. The temporal arch possesses no centrum, but the petrosals, mastoids, and parietals, are placed one over the other as two pairs of neurapophyses and a divided meta-neurapophysis. The post-sphenoidal centrum is surmounted by the post-sphenoidal wings and the feebly-developed post-frontals—as two pairs of neurapophyses; while the meta-neurapophysis is deficient.

In the Crocodiles, the occipital arch, as in the Birds, has lost the upper pair of neurapophyses. The temporal centrum is not developed, but the two pairs of neurapophyses, and an undivided meta-neurapophyses—the petrosals (ali-sphenoids of Owen), mastoids, and so-called parietal—form a continuous arch. The post-sphenoidal centrum is again found to carry two pairs of neurapophyses, the great sphenoidal wings (orbito-sphenoids of Owen), and the post-frontals. The meta-neurapophysis is missing.

In the Chelonians, the occipital arch consists of one pair of neurapophyses and a meta-neurapophysis surmounting a centrum. The temporal centrum is not developed. The inferior pair of neurapophyses, the so-called ex-occipitals, abut externally against the mastoids, and are thus connected with the largely developed so-called "parietals." These "parietals" not only form a large part of the cranial and temporal vaults, but send down laminæ to rest on the pterygoids, and thus enter into the formation of the lateral walls of the cranial cavity in front of the post-sphenoidal wings. Above the post-sphenoidal centrum, the post-sphenoidal wings and the post-frontals rise in connection with one another, as two pairs of neurapophyses, but the meta-neurapophysis is again wanting.

In the Ophidians, the occipital centrum is again surmounted by one pair of neurapophyses and a meta-neurapophysis. The temporal centrum has disappeared behind the basi-sphenoid; but the well-developed so-called "petrosals," the ali-sphenoids of Professor Owen, are surmounted by the elongated and nearly extruded mastoids; while the single meta-neurapophysis, the undivided "parietal," is so largely developed, that, passing down as in the Chelonian to the basis of the cranium, it rests upon the post-sphenoidal centrum over a great extent in front of its own neurapophyses, so as altogether to obliterate the post-sphenoidal wing. The post-sphenoidal centrum is there cut off from the post-frontals, which constitute the only remaining elements of its neural arch.

In the Lacertians, the occipital centrum, with its pair of neurapophyses and single neurapophysis, is followed by a temporal arch, without a centrum, but with two pairs of neurapophyses, "petrosals," and mastoids, and an undivided meta-neurapophysis or "parietal," generally single in front, but projecting backwards, with the mastoids on each side behind. The post-sphenoidal centrum is not surmounted by ali-sphenoids, except the parietal columella represent these elements. The post-frontals again appear; but without a corresponding meta-neurapophysis.

In the Frogs, the occipital centrum and the corresponding meta-neurapophyses have disappeared; a single pair of neurapophyses constituting the sole osseous elements of the arch. The temporal centrum appears in the primordial cartilage which extends across on the upper surface of the posterior part of the much-elongated "basi-sphenoid," and between the cartilaginous auditory capsules. The latter are intimately connected to the inferior temporal neurapophyses, the ali-sphenoids of Professor Owen, with which feebly developed mastoids or superior neurapophyses are conjoined; the whole being surmounted by the greatly developed antero-posteriorly elongated so-called "parietals," which dip down slightly at their margins, in front of the temporal region towards the "basi-sphenoid," as in the Chelonians and Ophidians. The portions of the post-sphenoidal wings and the post-frontals are occupied by fibrous texture; the "basi-sphenoid" or post-sphenoidal centrum extending forwards below; and the "parietals" taking the place of the deficient meta-neurapophyses.

The preceding view of the arrangement of the centrums and neural arches of the post-stomal sclerotomes of the lower forms of cranium, is that which would appear naturally to suggest itself to a mind uninfluenced by the arrangement of the corresponding region of the Mammalian skull. It is assumed throughout, that there are more or less complete cartilaginous or osseous auditory capsules in addition to corresponding neurapophyses; and that these neurapophyses are not post-sphenoidal but temporal, as evinced by their zygapophyseal connections in the human cranium. No reference has been made to the relations of the contested "petrosals" and "ali-sphenoids" to the fifth nerve, because, while the fundamental relation of that nerve to the post-sphenoidal sclerotome is admitted, the divisions of the nerve exhibit the same tendency to vary in their points of exit, as is presented by the other cerebral nerves; moving backwards more or less across the corresponding neurapophyses, and notching or perforating the neurapophyses behind. In fact, until a more minute investigation of the development of the cranium in its relations to the cerebral nerves has afforded some explanation of the varied relations of these parts in the series, we cannot, in my opinion, attach much weight to the determination of a "petrosal" or an "ali-sphenoid" by means of their relations to the trigeminal nerve.

Proceeding now to the examination of the post-stomal centrums and neural arches of the Mammalian cranium, let the Human skull be selected for examination. The occipital centrum is surmounted by a pair of neurapophyses and a double meta-neurapophysis. But again, surmounting the meta-neurapophyses there is a double piece, which occasionally remains permanently separate from the "occipital bone." This double piece, or pair of bones, present the relations of the interparietal bones in lower Mammalia. They may extend laterally to join the "mastoids," or they may be connected to the latter by a more or less continuous chain of "triquetral bones" in the line of the lambdoidal suture.

The zygapophyseal attachments of the "petrous portions of the temporal bone" indicate these masses to be neurapophyses enveloping the ossified auditory capsules. Keeping out of view the "squamous," "tympanic," and "styloid" portions of the "temporal bones," the "mastoidal portions" become early and intimately connected with the "petrous portions." Commencing with the "petrous portions," as an inferior pair of temporal neurapophyses, they are surmounted, as in the lower Vertebrata, by the "mastoidal portions" as a second pair of neurapophyses, while the arch is closed by the double element which forms the upper angle of the "occipital bone," as a meta-neurapophysis. There are well-marked indications of a temporal centrum in the human cranium. The irregularly truncated apices of the "petrous portions," directed obliquely forwards and inwards, are continuous, by means of the fibro-cartilaginous remains of the basis of the "primordial cranium," which occupy the "foramina lacera media," with the inclined plate of bone which, in the plane of the "basilar process of the occipital" or occipital centrum, forms the back part of the "body of the sphenoid," including the "posterior clinoid processes." This plate of bone is frequently surrounded by a deep groove, the posterior part of which lodges the "transverse venous sinus," and I have seen it nearly detached.

The feebly developed post-frontals in the Bird have disappeared in the Mammal, so that the post-sphenoidal centrum is surmounted by the "ali-sphenoids," as a single pair of neurapophysis; and by the enormously expanded double meta-neurapophysis in the Human subject, or the less developed form of parietals in the Mammalia generally.

The fundamental facts on which the preceding determination of the comparative constitution of the post-stomal neural arches of the cranium depends, are the zygopophyseal connections of the human "petrosals." If the "petrosals" even in one species can be proved to present the characters of neurapophyses, the sclerotome to which they belong must exist in addition to those to which the "ali-sphenoids" and "orbito-sphenoids" are referable. The existence of temporal neurapophyses explains the existence of interparietal, in addition to parietal bones in the Mammal; both of these meta-neurapophyses taking part in the protection of the developed cerebrum; while the non-appearance of the anterior or spheno-parietal in the Bird, Reptile, and Fish, accords with the complete development of the posterior or temporo-parietal, repressed in the former by the influence of the cerebrum, and by the full development of the ethmoido-frontal. I base my determination of the separate existence and reciprocal development of ethmoido-frontals and spheno-frontals, of spheno-parietals and temporo-parietals, not only on my analysis of the bones themselves in the series, but also on the evident reciprocal influence which the superimposed cerebral mass in the Mammal, and the bulky organs of sense and uncovered sense-ganglions of the lower Vertebrata have on the cranial neural arches. I believe also, that in this as in other departments of inquiry, we are apt to look for greater simplicity and uniformity in details than actually exist. The simplicity of natural law consists in the comprehensiveness of its general principles. In tracing these principles into details, the complexity is found to be infinite.

The Hæmal Arches of the Post-Stomal Cephalic Sclerotomes.—The clue by means of which we can alone be safely guided to the morphological constitution of these arches, in the midst of the varied complexity which they present to the comparative anatomist, is afforded by embryology. The hæmal arches of the post-stomal sclerotomes are developed each in the corresponding pair of "visceral laminæ." By endeavouring to ascertain, therefore, in which of these post-stomal "visceral laminæ" the sclerous elements of the varied forms of the post-stomal hæmal arches are originally formed, the morphological constitution of the individual hæmal arches may reasonably be anticipated. If, again, I am correct in my determination of the constitution of the pre-stomal sclerotomes, the allocation of the individual post-stomal hæmal arches to their proper centrums and neural arches follows as a matter of course.

From the observations more particularly of Rathke and Reichart, the formation of the osseous elements of the post-stomal hæmal arches in the "visceral laminæ," is preceded in each by a more or less distinct and continuous cartilaginous streak or band. Rathke found seven pairs of these cartilaginous streaks loosely connected to the basis of the embryo head of the *Blennius viviparus* and corresponding to the mandibular, hyoidean, first, second, third, and fourth branchial and pharyngeal arches. In the Adder the same indefatigable embryologist and comparative anatomist found a cartilaginous style, with a process directed forward in the position of the maxillary, palate, and pterygoid bones, embedded in the first visceral lamina and its "superior maxillary process," and attached to the side of the basis of the primordial cranium in front of its auditory region; a similar style lay in the second visceral lamina, and was firmly attached to the base of the cartilaginous cranium behind, and external to the auditory capsule; a third style lay in the third visceral lamina, and was also firmly attached like a rib to the occipital region of the primordial cranium. Similar primordial hæmal arches have been found by Reichart in the visceral laminæ of the Mammal and Bird, and by numerous observers in the Amphibia. It is important to observe again at this point, that the relations of all these seven pairs of primordial hæmal arches are similar. Firstly, all the visceral laminæ in which they are developed appear to consist of the serous, vascular, and mucous layers united; secondly, the cartilaginous streaks are formed towards their inner surfaces, under the mucous layer; thirdly, the heart and vascular arches are on their exterior, under the serous layer.

First Post-Stomal Hæmal Arch.—The constitution of this arch must be determined by the examination of the development of the first post-stomal visceral lamina. It has been already stated that the process usually considered as the upper part of the so-called "first visceral lamina" is, if its general relations be taken into account, the posterior pre-stomal visceral lamina in which the pre-sphenoidal hæmal arch is developed.

The cartilaginous streak in the first post-stomal visceral lamina of the Mammal divides into two portions. The superior and smaller of the two becomes the incus. The long inferior portion is the cartilage of Meckel; around the lower part of which the corresponding half of the lower jaw is developed; the upper part forms the slender process and the head of the malleus. As the Eustachian tube, the tympanum, and the external auditory passage, consist of the persistent upper portion of the first visceral cleft, the cartilage of the Eustachian tube, and the tympanic bone, which are continuous with one another, and form the floor of these three spaces, are developed in blastema deposited near the upper extremity of the cleft. This blastema also forms the membrane of the tympanum, into which the handle of the malleus shoots. It is to be observed that this lower jaw and tympanic bone do not originate in the primordial cartilaginous streak, but in blastema deposited around it. The tympanic bone forms at first an inverted arch across the visceral cleft, or a ring incomplete above, which supports the membrane of the tympanum on the outer side of the attenuated portion of Meckel's cartilage, which connects the malleus to the inner side of the jaw. It then extends inwards, so as to form the floor of the tympanum and Eustachian tube, folding up before and behind, and thus inclosing the incus and malleus leaves, the latter connected to the jaw through the tympanic fissure.

The development of the first post-stomal visceral lamina appears, therefore, to indicate at least four elements on each side of the mandibular hæmal arch in the Mammal. The tympanic element is probably complex; the mandibular consists of at least two portions, one on the outer, the other on the inner side of the corresponding portion of Meckel's cartilage.

In the Bird the omoid and palate bones are formed like the pterygoid and palate bones of the Mammal, in the so-called "superior maxillary process." In the proper first post-stomal visceral lamina, the primordial cartilaginous streak divides, as in the Mammal, into two portions. The upper and smaller of the two becomes the quadrate bone; the lower and longer portion—Meckel's cartilage—becomes enveloped in the corresponding half of the lower jaw; but instead of the upper end of this portion forming the slender process of a malleus, it remains as the peculiarly-formed articular piece of the jaw itself. The original intimate connection of the rudiment of the pterygoid bone, in the so-called "superior maxillary process," with the upper or incudal portion of the primordial cartilaginous streak of the first post-stomal visceral lamina of the Mammal, speedily diminishes; but in the Bird, not only does the pterygoid or omoid bone rapidly increase in relative size and configuration; but the quadrate portion of the first visceral streak does so likewise. The latter also exhibits, attached to its outer side, as the omoid is to its internal process, a styliform ossicle, the rudiment of the quadrate-jugal bone, which again is connected anteriorly to the jugal.

Reichart, who has minutely described and figured the development of this visceral lamina in the Bird, makes no allusion to the remarkable indication which it affords of the signification of the quadrate bone, and articular piece of the lower jaw. It affords, as it appears to me, sufficient evidence that the quadrate bone of the Bird is the homologue of the Mammalian incus, and that the articular piece of its lower jaw is the homologue of that ossified portion of the upper end of Meckel's cartilage, which in the Mammal forms the slender process of the malleus.

The quadrate bone has been hitherto considered as the homologue of the tympanic bone in the Mammal, not only from the proximity of the latter to the condyle of the jaw, but chiefly from its presumed absence in the skull of the Bird. But there appears to me to be sufficient evidence of its existence, not only in the fibro-cartilaginous frame which connects the margin of the tympanic membrane to the mastoid, lateral occipital, and basi-sphenoid, but more particularly in the thin well-defined lamina of bone, which, apparently united to its fellow of the opposite side, forms the floor of the tympanic cellular space in the broad posterior portion of the basi-sphenoid. As these apparently united laminæ are continuous with the single cartilaginous Eustachian tube, below the single or double osseous Eustachian orifice, I am induced to believe that they will turn out to be the feebly developed representatives of the tympanic bones of the Mammal.

By a very beautiful analysis Professor Owen has proved that the quadrate-jugal bone of the Bird is the homologue of the squamous portion of the Mammalian temporal. I cannot, however, give my assent to his determination of its special homology, as a portion of the subdivided radiating appendage of the maxillary arch. Its relations in Birds and Crocodiles, in which it presents all its fundamental connections, appear to me to show that it is an anterior actinapophysis of the mandibular arch; passing forwards to abut against the malar, which I have already stated to be a posterior actinapophysis of the ethmoidal hæmal arch, or as in the Lacertians against the post-frontals. The squamous portion of the quadrate-jugal bone is a Mammalian superaddition, to adapt it to the part it takes in the formation of the cranial wall. It is withdrawn therefore from the quadrate or incudal portion of the mandibular arch (which portion diminishes relatively), and passes—as the entire bone does in the Lizards—upwards to be connected with the cranial wall. The development of the first post-stomal visceral lamina in the Bird appears therefore to afford evidence that the mandibular hæmal arch in the Bird and Mammal includes a tympanic element, a quadrate or incudal, a malleal or articular, and the elements of the corresponding side of the lower jaw.

On the same grounds I am inclined to believe that the articular piece of the lower jaw of the Reptile and Amphibian is malleal like the corresponding piece in the Bird, and not the homologue of the condyle of the Mammalian jaw. They are all malleal portions of Meckel's cartilage retained in connection with the jaw. In like manner, I am inclined to believe that the so-called tympanic bone of the Reptile and Amphibian, like the quadrate or so-called tympanic bone of the Bird, is not the homologue of the tympanic bone in the Mammal, but of the incus. The incus of the Mammal has been set free from its fundamental quadrate-jugal and pterygoid connections to co-operate with the similarly released malleus in the economy of the ear. The absence of proper tympanic bones in the Reptile and Amphibian is explained by the absence or feeble development of the tympanic cavity. I am inclined to think, however, that traces of them may be detected under and between the basi-sphenoid and occipital of the Crocodile, in the walls of those canals which connect, as Professor Owen has shown, by a common tubular communication, the sella turcica and the tympanic cavities with the basis of the cranium.

The tympanic systems and lower jaw of the osseous Fish form together a well-marked hæmal arch, developed in the first post-stomal visceral lamina of the embryo. From what has already been stated regarding the sclerous elements which result from the development of this visceral lamina in the other vertebrata, Professor Owen's view of the tympanic system of the osseous Fish, as the teleologically divided homologue of the quadrate bone of the Bird, and tympanic bone of the Reptile, would appear to require additional evidence. We are not yet in possession of materials for a rigorous determination; but it appears extremely probable that the tympanic bones of the osseous Fish are morphological, as well as teleological elements. If the articular piece of the lower jaw be assumed as the malleal portion of the persistent cartilage of Meckel, the hypo-tympanic occupies the position of the incudal element, connected, as usual, with the pterygoid. The epi-tympanic is in the position of the proper tympanic element of the Mammal, while the pre-tympanic, in its relations to the hypo-tympanic and pterygoid, closely resembles the quadrate-jugal or synamosal.

The opercular bones form on each side of the mandibular arch a series of actinapophyseal elements, which, from the view already taken of such elements, would appear to be posterior, as the quadrate-jugal or squamosal is anterior in relation to the sclerotome. With regard to any traces of these opercular or actinapophyseal elements in the mandibular hæmal arch of the higher vertebrata, I must agree with Carus in considering the cartilages of the external ear in the Mammalia as homologous with them. The objection of Rathke to this determination of Carus—that the cartilage of the concha is attached to the tympanic bone so as to be situated at the back of the auditory foramen, that is, at the posterior margins of the first visceral cleft—appears to me to be met by taking into account the peculiar curved form which the tympanic element assumes in passing from before backwards across the cleft.

The allocation of the mandibular hæmal arch to the post-sphenoidal, or first post-stomal sclerotome, follows from the analysis already made of the pre-stomal sclerotomes.

The Second and Third Post-Stomal Hæmal Arches.—As the researches, more especially of Rathke and Reichart, on the development of the first visceral lamina, afford a clue to the constitution of the corresponding hæmal arch; the labours of these observers in like manner indicate the nature of the second and third arches. These arches are developed in the second and third visceral laminæ, and, from the varied forms which they present in the series, could only have been determined by an appeal to embryology.

In the Mammal the primordial cartilaginous streak in the second visceral lamina, and which is attached superiorly to the auditory region, divides into segments, the uppermost of which becomes the stapes; while the succeeding become, in succession with the intermediate soft portions, the "stapedius muscle," the pyramid and its prolongation downwards, the styloid process, the stylo-hyoid ligament, and the series of sclerous elements which terminates below in the anterior horn of the hyoid.

The primordial cartilaginous streak in the third visceral lamina is attached to the occipital region, breaking up into four segments; the two upper disappear; the two lower become respectively the posterior horn and corresponding half of the body of the hyoid.

In the second visceral lamina of the Bird, in like manner, the auditory columella is developed superiorly, and the feeble anterior horn of the hyoid below, while the elements of the suspensory or posterior horn of the hyoid are formed in the third visceral lamina. The fibrous septum of the tongue and the epiglottis of the Mammal make their appearance in the line of junction of the second and third visceral laminæ. The respective share taken by these two laminæ in the formation of the so-called basiglosso- and uro-hyals in the Bird remains to be determined.

The precise observations of Rathke have shown that the lateral halves of the feebly-developed hyoid of the Ophidian are formed by the lower portions of the primordial cartilaginous streaks of the second pair of visceral laminæ, while the auditory columellæ are formed in their upper portions. Rathke also found that the primordial cartilaginous streaks of the third pair of visceral laminæ, and which are attached to the occipital region, disappear altogether.

There are no embryological observations in sufficient detail to indicate the morphological relations of the more or less complex hyoid apparatus in the Chelonian and Lacertian. The so-called hyoid, or suspensory arch of the branchial apparatus in the Amphibia is developed in the second pair of visceral laminæ. The corresponding arch in the Tadpole, and the anterior or suspensory horn of the so-called "hyoid" of the Frog, are also developed in this pair of visceral laminæ. The suspensory arch of the branchial apparatus is attached to the quadrate, or so-called "tympanic" piece of the mandibular arch, and not to the base of the cranium. Rathke had observed a filament extending between the auditory region of the cranium and the quadrate cartilage of the Tadpole. He found that the so-called "malleus and incus" are developed in this filament. According to Reichart, this filament appears to be the upper part of the second primordial cartilaginous streak, which, in consequence of the peculiar manner in which it curves forward superiorly towards the quadrate cartilage (a curvature of the same kind towards the quadrate bone has been observed by Rathke in the Adder), becomes attached to it. In consequence of this attachment, the hyoidean arch becomes suspended to the quadrate portion of the mandibular; and the upper portion, between the quadrate cartilage and the auditory region of the skull, becomes converted into those elements in the Frog, which have their homologues in the stapes of the Mammal, and the columella, with its cartilaginous extremities, in the Bird and Reptile.

As the cartilaginous branchial arches of the Tadpole, and of the other Amphibia, are formed in the succeeding visceral laminæ, it would appear to follow, as a necessary consequence, that the suspensory or hyoidean arch of the Amphibian, with its inferior mesial element, and along with the auditory ossicles, is homologous with the anterior or suspensory part of the hyoid, along with the stirrup-bones in the Mammal, and with the corresponding structures in the Bird and Serpent; and that the first branchial arch of the Amphibian, with its corresponding inferior mesial elements, are homologous with the posterior horns and body of the hyoid in the Mammal, and with the posterior or suspensory horns, with the corresponding inferior mesial elements of the hyoid in the Bird. The so-called posterior horns of the hyoid of the Frog cannot, therefore, be the homologues, as Professor Owen's statements might lead us to infer, of the posterior horns of the hyoid of the Mammal or Bird. The posterior horns of the hyoid of the Frog are the remains of its posterior pair of branchial arches, or enlargements of the posterior angles of its basi-hyals. They are developed therefore in its posterior visceral laminæ; while the posterior hyoidean horns of the Mammal and Bird are developed in the third pair of visceral laminæ.

As the skeleton of the hyoidean and branchial apparatus of the Fish is developed in the form of a series of inverted arches in the corresponding visceral laminæ, from the second inclusive, we are obliged to conclude that its hyoidean arch is the homologue of the stylo-hyoidean arch, with the stirrup-bones,—or second post-stomal arch—in the Mammal; and of the corresponding portion of the hyoidean apparatus in the Bird, with the columellæ; and of the entire hyoid in the Serpent, with the columellæ; and that the first branchial arch in the Fish is the homologue of the corresponding arch in the Amphibian; of the posterior horns of the hyoid, and their associated elements in the Bird; and of the posterior horns and body of the hyoid in the Mammal.

It has not yet been determined upon what developmental change the suspension of the hyoidean arch of the Fish to its mandibular arch depends. It is probably of the same nature as that which occurs in the Tadpole, with this difference, that the upper portion of the hyoidean arch disappears in the Fish, without developing a stapedial ossicle; while its lower portion remains permanently connected to the mandibular arch, instead of regaining an attachment to the cranium.

The hyoidean and branchial arches of the Fish are provided, as has been already stated, with a well-developed double series of actinapophyses, for the support of the branchiostegal membrane, and the branchial laminæ. These actinapophyses in the Fish are foreshadowed in the Tadpole by the tubercular margins of its branchial styles.

The question may now be put—if we are brought by reference to the development of the parts to allocate to the three post-stomal sclerotomes, hæmal arches, consisting respectively of the sclerous parts developed in the three anterior post-stomal visceral laminæ, to what sclerotomes are we to refer the potential or actual hæmal arches in the remaining visceral laminæ? For reasons already stated, they cannot be disposed of by referring them to a splanchno-skeleton, because in that case the hyoidean arch or arches, and apparently the mandibular arch also, must be referred to the same category. Neither can they be referred to any of the cervical, or trunk sclerotomes; because it would appear that the visceral walls of the head are alone perforated by clefts. We are not yet prepared to answer the question. It involves, as it appears to me, the investigation of a residual quantity, the solution of which will require some information in reference to certain points, regarding which we cannot at present be said to possess any. First, the development of the Cyclostomes, but more especially of Branchiostoma; secondly, the mode in which the trunk sclerotomes increase in number and become arranged in groups; thirdly, the mode in which the same changes proceed in the cranium; fourthly, the determination of the series of cephalic nervous centres, with their corresponding nerves (neurotomes), more especially in the medulla oblongata, with the causes which determine the grouping and order in which the cerebral nerves pass through the walls of the cranium.

If there appears to be no sufficient developmental grounds for making a distinction between the branchial arches of the Amphibian and Fish, as belonging to a splanchno-skeleton, and the hyoidean and mandibular as referable to the neuro- or endo-skeleton, it becomes important to determine the signification of the sclerous elements of the larynx, trachea, and bronchial tubes. Without presuming to anticipate the minute observation of the development of the parts themselves necessary for the solution of a question of this kind, I would venture to suggest that the proper cartilages of the larynx are developed from the inferior or mesial extremities of certain of the visceral laminæ; and that the cartilages of the trachea and bronchial tubes are a pair of highly developed actinapophyseal systems, referable to one of the posterior visceral arches.

Post-stomal neuractinopophyses.—In addition to the auditory capsules, I recognise as post-stomal neuractinopophyses more particularly those ossicles attached to the post-frontals, mastoids, and external occipitals of Fishes. Those attached to the post-frontals may enter into the formation of the infra-ocular bony arch. Those, again, which are developed on the temporal and occipital sclerotomes are modified so as to co-operate in the cranial suspension of the scapular girdle.

In conclusion, Goethe was the first to indicate the intermaxillaries, the maxillaries, and palatals, as elements of three distinct cranial segments. In the course of my investigation of the development of the teeth I became early aware of the correctness of Goethe's views on this subject, and have found myself, therefore, unable to coincide with the doctrine of Professer Owen as to the constitution of his palato-maxillary or nasal hæmal arch.

3. *On the Morphological Constitution of Limbs.*

Carus, maintaining generally the doctrine of cephalic limbs, originally propounded by Oken, has at the same time given much greater precision to the conception of the skeleton of a limb, by viewing it as a system of elements radiating from the exterior of a costiform arch. Professor Owen, while he rejects with British and the majority of Foreign anatomists, the fantastic doctrine of Oken and his immediate followers with regard to cephalic limbs, has adopted the general doctrine of the skeleton of the limb as propounded by Carus, and has developed and applied it with much ingenuity to the illustration of actual structure. Professor Owen has, however, at the same time, by his allocation of the scapular girdle to the occipital segment of the cranium, as its hæmal arch. and by the view which he takes of the opercular and brancheostegal elements, actually reproduced the doctrine of cephalic limbs in another form. I do not propose in this communication to examine in detail the grounds on which Professor Owen's general doctrine of limbs is based, but shall merely state categorically those considerations which appear to me to render it untenable.

1. It is highly improbable that the sclerous elements of a limb should be derived from one, or at most two, sclerotomes, while its other elements, and more especially its nerves, are supplied by a greater number of somatomes.

2. It appears to be highly improbable that the bones which enter into the structure of an arm or leg, or that the corresponding sclerous parts in the lower animals should be the result of teleological subdivision of a single "diverging appendage" or "archetypal element." Professor Owen virtually admits that these "teleological" elements have a morphological value when he institutes an inquiry into their "special" and "serial homologies."

3. It appears to me that the scapular girdle cannot be the hæmal arch of the occipital segment of the head—firstly, because that segment is already provided with a hæmal arch in the series of transitory and persistent sclerous elements developed in the third pair of visceral laminæ; secondly, because the scapular girdle is invariably found to be developed at or in the immediate neighbourhood of that part of the trunk of the animal where it is ultimately situated; and, thirdly, because it is improbable that the exceptions to a general law should be more numerous than the instances in which it is adhered to.*

The germs of the limbs make their appearance when the ventral laminæ of the primordial vertebral system are passing down towards the hæmal margin. At first they resemble lappet-like projections of the inferior margins of these laminæ; they extend along at least four or five of their segments, and are situated in those regions of the body to which the future limb is attached, viz., in the pelvic and posterior region of the neck, except in the Fish, in which the pectoral lappets are situated close behind the head. As the ventral laminæ extend downwards, the lappets retain a position more or less elevated on the side of the trunk. At this stage they also begin to exhibit a change in their form and position. They become first sessile, then pedunculated, and the peduncle then indicates by an angle at its centre the formation of the central joint of the shaft of the future limb—the elbow or knee-joint. At the same time, what I term the plane of the limb is changed. The lappet was originally developed in a plane, which is coincident with the axis of the corda dorsalis. This is the primary or fundamental plane of the limb; and when in this plane the lappet presents its radial or tibial margin forwards towards the head, and its ulnar or fibular margin backwards. When the limb leaves its primary position, it lies in its secondary plane, which cuts the corda dorsalis more or less obliquely, so that the radial or tibial margins of the limb are directed more or less forwards and inwards, and the ulnar and fibular backwards and outwards. The permanently sessile pectoral lappets or fins of the osseous Fish exhibit a peculiar modification of the same movement;

* It is somewhat remarkable that the only embryological evidence which Professor Owen adduces in support of that portion of his Doctrine of Limbs, in which the anterior limb is assumed to be developed at or close to the head, is a reference to a passage in Rathke's Entwickelung der Schildkröten, in which the author adduces the *fundamental position* of the bones of the shoulder—viz., the posterior region of the neck—as a circumstance tending to explain their ultimate passage into the thoracic cavity.

they rotate on a transverse axis, so that their anterior or radial margins are directed downwards and their ulnar margins upwards. In the Sharks and Rays the pectoral and abdominal fins continue permanently in the primary plane.

While the lappet is still in its primary plane, the rudiments of the girdle of the future limb may be detected under the integumentary covering, and therefore external to the proper mass of the visceral wall of the body. In the primordial condition of the lappet of the wing of the Chick, Remak has detected four parallel streaks running to its outer margin, and continuous internally with the rudimentary nervous structures of the four primordial vertebræ, with which the attached margin of the lappet is connected.

Guided by embryological facts and conclusions, to the more important of which I have just alluded, I have endeavoured to detect, more particularly in the osseous Fishes, Plagiostomes, Amphibians, and Reptiles, the principle which lies at the basis of the morphology of limbs. The view which this inquiry has induced me to take of the subject I shall, in conclusion, state very briefly.

1. A limb does not necessarily derive its elements from one somatome —about fifty segments of the trunk appear to contribute towards the structure of the great pectoral fin in the Ray.

2. The nervous elements of the limbs appear, as in other parts of the vertebrate animal, to indicate most distinctly the morphological constitution of the sclerous elements. About fifty spinal nerves contribute the greater part of their hæmal divisions to the pectoral fin of the Ray; and there are about one hundred fin-rays—a pair of fin-rays to each nerve, and derived from each sclerotome. This correspondence does not apparently exist between the fin-rays and nerves of the osseous fish; but it may be fairly assumed that when we have detected the developmental circumstances which induce the attachment of the pectoral girdle of the osseous Fish to its cranium, as well as those peculiarities exhibited by its anterior trunk sclerotomes, this discrepancy will be explained. A more careful analysis than we yet possess of the number of spinal nerves which supply branches to the limbs of the higher Vertebrata is still a desideratum in this department of the subject; but it appears to be extremely probable. that in the Mammalia, at least five spinal nerves transmit filaments to the five distal divisions of the limb. It would appear, too, that, notwithstanding their plexiform arrangement at the attached end of the limb. the greater number of the filaments of each nerve reach their own morphological district at the distal part of the limb. The radial and the ulnar nerves are formed principally by the upper and lower roots of the human brachial plexus, that is, from the nerves of the upper and lower primordial segments with which the embryo limb was connected, and from which it derived its various elements.

3. The nerves supplied to a limb are not the inferior or hæmal divisions of the spinal nerves, but radiating on actinal branches of these divisions. The intercostal nerves are not the nerves serially homologous with the roots of the brachial plexus. The thoracic nerves, serially homologous with these roots, are the intercosto-humeral and the succeeding middle intercosto-cutaneous.

4. Each sclerotome supplying elements to the structure of a limb supplies as a sclerous element a single actinapophysis; or, as in the Rays, an anterior and a posterior—that is, a pair of actinapophyses.

5. From the structure of the mesial and lateral fin-rays of the Fish, the actinapophyseal elements of a limb may be assumed as primordially segmented.

6. The fin-rays in the Fish, and the phalangeal, metacarpal, and metatarsal bones of the higher vertebrata, are more or less persistent con-

ditions of the distal segments of the primordial actinapophyseal elements of a limb.

7. By atrophy, or otherwise, one or more of the segments in the successive transverse rows of actinapophyseal elements disappear, so as to leave in Man, *e.g.*, four elements in each carpal row; two in the fore-arm; one in the arm; two in the next row for the coracoid and clavicle; one in the proximal row for the scapula.

8. The nature of the subsequent changes, which the elements of the limb undergo, up as far as the shoulder or hip, may be inferred from an examination of the paddle of the Enaliosaur or Cetacean.

9. A careful application of the hypothesis to the limb girdles of the cartilaginous Fishes, Amphibia, and Reptiles, leaves me strongly inclined to believe that the coracoid is an actinapophyseal segment between the humerus and scapula, prolonged downwards, towards the hæmal margin of the body; that the scapula is a proximal element, elongated towards the neural margin of the body; that the clavicle is the only other retained element in the same transverse row as the coracoid, in front of it, and elongated like it in the hæmal direction; and that the corresponding elements of the posterior limb have a similar morphological signification.

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*American Association for the Advancement of Science.**

Tenth Meeting. Albany, August 20-27, 1856.

As regards the number of persons present, and the interest shown by the citizens generally in the proceedings, this meeting was probably the most successful which the Association has yet had.

The scientific papers and discussions, considered as a whole, give evidence of active and varied research; but while including important contributions to knowledge in numerous special departments, they present no general results of very striking novelty or interest.

The principal rooms of the State Capitol, a spacious building in the centre of the city, were devoted to the purposes of the Association, the Hall of Representatives being used by the general meetings, and at other times by the Section of Geology; the Senate Chamber by the Section of Physics and Mathematics, and the contiguous rooms by the Divisions of Chemistry, Zoology, &c. Nearly all the meetings, sectional as well as general, were attended by numerous spectators of both sexes, and in many cases the rooms were thronged with intent listeners.

The popular interest of the Albany meeting was not a little enhanced by the public inauguration of the *State Geological Museum*, and yet more by that of the *Astronomical Observatory*. The latter, recently endowed by the liberality of several of the citizens, and especially by the munificent gifts of Mrs Dudley, has been called, in honour of its prin-

* In compiling this abstract, free use has been made of the notices which appeared at the time in the *New York Tribune*, *Daily Times*, and *Herald*, and the *Albany Evening Journal*. Where the notices seemed to have been furnished by the authors, they have generally been copied either entire or in part, after correcting typographical or other obvious errors. In most other cases the meagre, and often erroneous, abstracts of reporters have been used as the basis of brief sketches, which, however incomplete, will, it is hoped, be found to involve no positive mis-statements of the facts or opinions of the authors. In this abstract no mention is made of such papers as have thus far appeared only by their titles, and several others have been omitted on account of their purely local interest, or from the difficulty of procuring a satisfactory abstract.

cipal founder, the *Dudley Observatory.* The building, now complete, occupies a commanding position near the north-western edge of the city. It is spacious and well-arranged, and will be provided with instruments of superior excellence ; among them, a heliometer of ten-inch object-glass, to be constructed by Spencer, the celebrated maker of microscopes.

SECTION OF MATHEMATICS, PHYSICS, AND CHEMISTRY.

The Elements of Potential Arithmetic. By Prof. BENJAMIN PEIRCE. —Potential Physic investigates what kind of a world human intellect, having reached its highest point, would construct in respect to the distribution of power ? If it be proved that it would construct one similar to that we inhabit, it indicates that the world was created by an intellect to which ours is in nature similar.

Potential arithmetic pursues this problem so far as regards numbers. By his combination of numbers Pythagoras was able to form his ideal "Man" in physical proportion true to nature, though differing from any actual type of living man. One combination and proportion of his numbers would give the Apollo, another the Venus, another a lower type than either, and another a lower type still. The order and principles which governed his arrangement would seem to indicate that a fixed law of number governed the structure of man. Architecture, by the Pythagoreans, was shown to be also based on a fixed law of number. Hence, number they considered the chief principle of the Universe. One designated the Creator or Unity. Four indicated development. Oriental philosophers also have fanciful theories respecting number. Odd numbers they term masculine, even numbers feminine.

A law of constantly recurring numbers or definite proportions may be traced in the planets, in their motion, in their bulk, density, &c. So also a law of definite proportions, and also of definite arrangement, is traceable in the chemical combinations which make up natural substances. In the organic world, the changes correspond to the change of numbers, by addition, multiplication, square and cube root, and proportion.

Professor Peirce endeavoured to show that by the combination of the simple primary ideas of number, and of the consciousness of power, we should be led to laws similar to or identical with the laws of both organic and inorganic chemistry, and also to those of alternate generation in zoology ; and furthermore, that views of the negative unit and imaginaries could be obtained in this mode precisely similar to those developed in Sir William Rowon Hamilton's purely formal or formalistic discussion of those subjects.

On the Next Appearance of the Periodical Comet of Thirteen Years. By Dr PETERS.—This comet was discovered by Dr Peters at Naples in 1846. He has prepared an ephemeris of the comet from 1857 to 1860, and made an exposition of the methods of observation. It was a comet very difficult to discover. It was necessary to observe it with the eye in perfect darkness, and the time required for an observation is five minutes. In order to facilitate the observations, he has prepared a series of lines, within which it should be found. Its probable orbit gives an ellipse of thirteen years, with a probable error of one year, so that its period might be twelve or fourteen years. In 1853 or 1854 Saturn came into nearly the same position as this comet, and some uncertainty exists as to its distance, it having been difficult to ascertain whether it was nearer the interior or the exterior of that planet. The computation would have been easy but for the startling apprehension that some larger planet, like Saturn, would carry away the comet altogether, so that it would not reappear. Dr Peters, in announcing the result of his observations, remarked that it might seem to be of little use to have discovered a comet so difficult to observe, but he considered the addition of a new periodical comet a matter of the greatest importance, as increasing our knowledge of the space occupied by bodies belonging to the solar system. In his view, the discovery of a new comet was more important than the asteroids which have been discovered. He spoke of certain comets (among others, one described in an elaborate work by Dr Brunnow, of Ann Arbor), which have been diligently sought by astronomers in late years but not found, and alluded to the theory of the dissolution of comets in space—a theory to which one example appears to give support—the division into two parts of one of the comets discovered in 1846. That division still continues. Dr Peters recommended amateurs in science *to search for comets*. The professional astronomer has more earnest duties to perform, and cannot afford time for this search; but every periodical comet that is discovered is of use in determining the space occupied by the planets. The discovery of comets has decreased. Last year, not more than one or two were discovered. Dr Peters thinks this falling-off is owing partly to the fact that the award of a comet medal has been abandoned by the King of Denmark. For many years the discoverer of any telescopic comet received a comet-medal from the King, but in 1848 the custom was abolished, and the zeal for discovery has since declined. Dr Peters thought it would be a wise and useful measure to institute this medal anew. Amateurs in science would then be stimulated to make more researches. Amateurs have not that perfect interest in the subject which astronomers have, but the prospect of a public recompense would perhaps impel them to renewed industry. On the whole, Dr Peters concludes that the interest for science in Europe is decreasing, and in America increasing greatly, especially astronomical science. He hoped the institution of the comet-medal would be renewed here.

On Ammonia in the Atmosphere. By E. N. Horsford.—In this communication Professor Horsford stated, that in a former paper read at the New Haven meeting, he had been led into error by using, as an absorbent, asbestos which had not previously been freed from ammonia, and which therefore gave too large a result. On a re-examination of the problem, with new precautions and modifications, he had found from eight determinations, that a cubic metre contains from four to seven-tenths of a millegramme of ammonia.

On a Possible Modification of the methods of ascertaining the Density of the Earth. By Stephen Alexander.—After adverting to the experiment of the plumb-line near a mountain, as liable to objections arising from the imperfect measurement of the density of the mountain and of the deflexion of the line, Professor Alexander proposed as a substitute to build up by the side of a plumb-bob, furnished with delicate spirit-levels, a mass of lead or iron in the form of a sphere, twenty-five or thirty feet in diameter, and to observe the change of the spirit-levels.

Dr Gould observed that this method was not equal to that of Cavendish, since the torsion balance is a more delicate test of minute forces, such as the attraction of the artificial mountain, than a spirit-level can be. He also repeated the suggestion of Weber, that the Gaussian mirror be used, by which a radius of unlimited length may be obtained.

Professor Bartlett thought there was a more fundamental objection to Professor Alexander's method; that the spirit-level would only show its own level surface, and that would be the resultant of the combined action of the earth and the artificial mountain.

Investigation and Calculation of the results of a General Process of Causation. By John Paterson.—This was an abstruse mathematical discussion, not capable of being made intelligible in a brief abstract.

On the Peculiar Atmospheric Appearance on 23d May last, at St Martin's, Canada East. By Charles Smallwood, M.D., LL.D.—The locality was nine miles from Montreal, latitude 45° 32′ N., longitude 73° 36′ W.; height above the sea-level, 118 feet. A peculiar haze was observed at noon, which had increased at 6.27 so as to obscure the sun completely. The wind died away to a calm; the colour of the haze changed from yellow to reddish, and then to a dark bluish tint. The thermometer marked a high temperature, and the Professor amused himself from six P.M. till dark in catching leaves and collecting ashes which were floating in the atmosphere, while the fowls went to roost and the frogs began to croak, and nature generally gave evidence that something had happened of an extraordinary character. The appearance of things was the more singular, from the fact that while this haze prevailed in the W.S.W., the horizon to the N.N.E. was perfectly cloudless. A similar phenomenon was noticed at Bytown, a long distance away. The cause was an extensive fire in the woods, some hundreds of miles distant. The haze appeared to have absorbed the white rays of the sun, but the calorific rays were not absorbed, the heat remaining oppressive during the whole period of obscuration. On the following morning (Saturday) there was a severe storm of thunder and lightning. Specimens of the leaves and ashes collected were exhibited. The ashes were black and exceedingly fine; the leaves appeared as if scorched; they were all caught before reaching the ground.

Professor Smallwood said the thunder-storm which followed the atmospheric phenomena was of an interesting nature, and proceeded to indicate its features; and as the subject of electricity was before the section, he mentioned his investigations of snow-crystals, the variable form of which he attributed to the electricity of the atmosphere.

On an Improvement in the Anemometer. By Charles Smallwood, M.D., LL.D.—This is a modification of previous instruments, which records, by a steel point on paper, the velocity of wind in miles per hour, and the times at which the velocity changes, at the same moment and by connected simple machinery recording the direction. It registers storms of seventy or eighty miles an hour, and gentle breezes of half a mile, and has been in use for twelve years without the need of repair.

On the Law of Human Mortality. By C. F. M'Coy.—In reading this paper Professor M'Coy illustrates his views by a curve in which the age is the abscissa, and the number living the ordinate. After pointing out the errors of the laws proposed by earlier inquirers he proposed a law of his own, by which the ratio of the number of the living to the dying is represented by one formula from the age of twenty upward. Although founded on an examination of the Northampton and Carlisle tables, it is found to agree very accurately (never varying one year's mortality) with all the tables to which he had had access, embracing the tables used in any of the standard works on life insurance.

Among the inferences that may be drawn from the law are the following:—

1. The rate of mortality invariably increases from youth to old age.

2. This rate is continually accelerated even in a higher ratio than in a geometrical progression.

3. In early manhood the rate does not differ much from a slow arithmetical progression.

4. There are no crises or climacterics at which the chances for life are stationary or improving.

5. There are no periods of slow and rapid increase succeeding each other, but one steady, invariable progress.

6. The law, though not the rate of mortality, is the same for city and country, for healthy and unhealthy places, for every age, and country, and locality; and this law is, that the differences of logarithms of the rates of mortality are in geometrical progression.

Analytical Discussion of the motion of a body under the action of central forces. By BENJAMIN PEIRCE.—This was a purely mathematical paper, taken partly from the author's quarto volume on Analytical Mechanics, now in the press. One point, incidentally brought in, is alone capable of being stated in general language. The discussion involved one of those interesting cases in which a single algebraic formula is suddenly discovered to embrace a great number of geometrical forms which, from all previous modes of investigations, had been supposed to be entirely disconnected with each other—a beautiful instance of science discovering the hidden harmonies of nature.

On Acoustics as applied to Public Buildings. By Professor HENRY.—After some remarks upon the true purposes of architecture, as an art which, in modern times, should regard the useful before the ornamental, although without excluding the latter, Professor Henry gave a sketch of the well-known acoustic laws applicable to the architecture of Public Halls. He then discussed the conditions producing echo and resonance. Under the latter head, he remarked that the material of the wall will affect the duration of a resonance. To test the nature of substances in this respect, a series of experiments was tried with a tuning-fork; first, to show that the motions excited by setting the fork on the back of a solid body are similar to those excited by the impulses of sound coming through the air against that body; and next, to discover what those motions are. A fork suspended by a cambric thread vibrated for 252 seconds, as was determined by holding under it a cavity which would resound in unison with the fork, and listening to it with an ear-trumpet. Placed on a thin pine board, the fork gave a loud sound, which continued less than ten seconds, the motive power of the fork being communicated to so large a mass of wood, and through that rapidly to the air. Placed on a slab of marble, the sound was feeble, but lasted 115 seconds. The fork was now placed upon a cube of India rubber lying on the marble slab. The sound was very feeble, but continued less than 40 seconds. The question, What became of the motive power in this case, as it produced so little sound? was answered by a set of experiments, proving that the sound was (so to speak) converted into heat. The amount of heat evolved in the rubber was so small as to be detected only by a delicate galvanometer. Joule has, however, shown that the mechanical energy generated by a pound weight falling through 750 feet would, when converted into heat, elevate the temperature of a pound of water only one degree. On a brick wall the duration of the vibration was 88 seconds; on lath and plaster there was a louder sound, of only 18 seconds.

A series of different experiments was devised upon the reflection of sound. Parabolic mirrors were tested by lights placed in the focus, and a watch being substituted for the light, the reflected sound and the position of its focus examined by means of an ear-trumpet. Tissue-paper, flannel, and felt were introduced between the watch and the mirror, to try the effect of curtains upon sound.

Notes on the Progress made in the Coast-Survey, in Prediction Tables for the tides of the Coast of the United States. By A. D. Bache.—The following extract includes most of this paper, excepting the formulæ and tabular results:—

As soon as tidal observations had accumulated sufficiently to make the task a profitable one, I caused them to be treated, under my immediate direction, by the methods in most general use. The observations at Old Point Comfort, Virginia, were among the earliest used for this purpose, and the labours of Commander Charles H. Davis, U.S.N., then an assistant in the coast-survey, were directed to their reduction, chiefly by the graphical methods pointed out by Mr Whewell. This work was subsequently continued by Mr Lubbock's method, by Mr Henry Mitchell; and next the tides of Boston harbour were taken up, as affording certain advantages in the observations themselves, which could not be claimed for those of Old Point.

The system of Mr Lubbock is founded on the equilibrium theory; and in it the inequalities are sought by arranging the elements of the moon's and sun's motions, upon which they depend Having obtained the coefficient of the half-monthly inequality of the semi-diurnal tide at Boston, from seven years' observations, through the labours of the tidal division, and approximate corrections for the parallax and declination, I was much disappointed in attempting the verification by applying to individual tides for a year during which we had observations. There was a general agreement on the average, but a discrepancy in the single cases, which was very unsatisfactory. Nor were these discrepancies without law, as representing their residuals by curves did not fail to show. By introducing corrections for declination and parallax of the moon increasing and decreasing, we reduced these discrepancies, but still the results were not sufficient approximations. With the numerical reductions of the observations before referred to was commenced, in 1853, under my immediate direction, by Mr L. W. Meech, a study of the theory of the tides, directed chiefly to the works of Bernouilli, Laplace, Avery, Lubbock, and Whewell. The immediate object which I had in view was the application of the wave theory to the discussion of our observations. I thought that the mind of an expert mathematician, directed entirely to the theoretical portions of this work, with directions by a physicist, and full opportunities of verifying results by extended series of observations, the computations of which should be placed by others in any desired form, would give, probably, the best result in this combined physical and mathematical investigation.

The general form of the different functions expressing the tidal inequalities is the same in the different theories, and may be said, on the average, to be satisfactory as to the laws of change which these inequalities present. Whether we adopt, with Laplace, the idea that periodical forces produce periodical effects; or with Avery, that the tidal wave arrives by two or more canals; or with Bernouilli and Lubbock, the results of an equilibrium spheroid; or with Whewell, make a series of inequalities, semi-menstrual, parallax and declination, with different epochs, we arrive at the same general results, that the heights and times of high-water may be represented by certain functions, with indeterminate co-efficients, in the form of which the theories in a general way agree. By forming equations from the observations, and obtaining the numerical values of the coefficients by the method used so commonly in astronomical computations, the result is accomplished.

A general consideration of the coordinates in space of the moon and sun, without any special theory, would lead to the same result, representing the luni-tidal interval by a series of sines and cosines, with indeterminate coefficients.

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I present to the Association the tables computed by Mr Avery for applying this method to the prediction of the tides at Boston harbour.

In order to test the coefficients, computations were made for different parts of the months of the year 1853, for which we have observations. Transit C was used as the transit of reference. The difference between the predicted and observed results are shown in a table, the first column of which contains the dates of the last, the observed less the computed result.

From this table it appears that in twenty pairs of tides, the morning and the afternoon being grouped to get rid of the diurnal inequality, there are two differences of less than 2^m, thirteen of more than 2^m, and less than 4^m, three of more than 4^m, and less than 10^m, two of more than 10^m. The probable error of the prediction of a single pair of tides is $4^h\ 12^m$.

These laborious researches are still in progress, but I have thought that the results already obtained required a notice of them and a recognition of the labours of Messrs Meech and Avery.

On the History and Theory of the instruments known as Rotascopes, Gyroscopes, &c. By W. B. Rogers.

On a New Method of Measuring celestial Arcs. By Alvan Clark.—Mr Clark described a new instrument invented by him for measuring the intervals of stars too distant to be brought into the field of view of a telescope. Within a year from the first thought of the instrument entering his mind, he had built a telescope of six inches aperture and 103 inches focal length, mounted it equatorially, governing its motion by Bond's spring-governor clock, provided the two eye-pieces, and as a substitute for a bifilar-micrometer, arranged a mode of using pieces of glass ruled with a ruling machine. Experiments had demonstrated the feasibility of using the two eye-pieces in this way, and of obtaining by them very accurate measures of the distances of stars, which are from three to one hundred minutes of space apart. The success of the instrument was, however, greatly due to the spring-governor, which keeps each star upon the wire accurately bisected.

On Various Cyclones or Typhoons of the North Pacific Ocean, with a chart showing their course of progression. By W. C. Redfield.—This memoir comprised notices of about thirty cyclones of violent character in the trade-wind latitudes of the North Pacific. As regards the several months of the year, their concurrence was as follows:—In February, one; April, one; May, two; June, two; July, three; August, four; September, four; October, six; November, four; December, one. At the Marian Islands, about latitude 13° N., they are looked for in December and January, as well as in the summer months. Various other cyclones in the more northern latitudes of the Pacific Ocean were also noticed in the communication. Some of these cyclones were well elucidated by dates afforded by the log-books, and reports of the United States Expedition to Japan, under Commodore Perry, who kindly placed them with Mr Redfield for examination and report. The route of one of these cyclones was brought under the notice of the last meeting at Providence; together with a few other traces on the manuscript chart. This chart, with large additions, is now engraved, and will soon be published. In this memoir Mr Redfield notices the relations of the cyclones to the monsoons, and the trade-winds of the Pacific; and he remarks also on the universality of the laws of cyclonic progression and action in the lower portion of the atmosphere, throughout all oceanic and geographic zones.

On the Modifications of Sesquioxide of Chromium. By E. N. Horsford.—In this paper Professor Horsford gave an account of a series of experiments on the modifications of sesquioxide of chromium, and other substances obtained principally from chrome-alum, illustrating his remarks by numerous specimens of crystals and solutions of brilliant colours. These results present many new instances of the atomic changes which may be produced by heat and other agencies without altering the chemical composition of bodies. A slight change of temperature produces a complete and permanent change of colour in the substance without changing its constituents. The conclusion of the author, from these researches, was, that these modifications were not in the sesquioxide of chromium itself, but in the compounds formed by it with water.

On the Relative Age of the different portions of the Moon's surface, and the catastrophe to which a large portion seems to have been subjected. By Stephen Alexander.—Professor Alexander remarked, that a map of the Eastern hemisphere, taken with the Bay of Bengal in the centre, would bear a striking resemblance to the face of the moon presented to us. The dark portions of the moon he considers to be continental elevations, as shown by measuring the average height of mountains above the dark and the light portions of the moon. He recently had seen the bearing of newly-observed phenomena on the question, the character of the ridges in the neighbourhood of Pico. These ridges are shown by their tints to be of the same geological character as the tops of the mountains. They show themselves to be recent disturbances or upheavals, by the manner in which they cross other formations, as though ejected through cracks in a previous crust. The superior thickness or elevation of crust in the dark portions is shown by the fact that some of these white lines running through everything in the bright portions, cease at the entrance into the darker regions. A close scrutiny of the white portions shows a great subsequent inundation of the white rock flowing over the ocean-beds (if that term be allowed) and raising their level. He thought that these facts threw some light on the inhabitants of the moon. Might not this flow into the ocean-bed have absorbed, by some chemical action (as water of crystallization or otherwise), the ocean and atmosphere. If so, the moon might have been formerly inhabited, and been rendered desolate by this change.

Mr Vaughan alluded to the want of atmosphere in the moon, and thought this showed that gases were not necessary to volcanic action. Nor could he believe that our volcanoes gave out any great amount of gases. If they did, the effect during so many ages would have accumulated, and shown itself in an analysis of the atmosphere.

Professor Mitchell inquired if Professor Alexander had paid special attention to the apparent lakes on the moon's surface; and described a lake about 13 miles long, with a mountainous bank upon one side and a beach upon the other, fed apparently by a river about 150 miles long, with two branches, several islands, and in one place tunneling a hill. He used such terms as though there were water there, because no other language could describe the appearances.

A Report on the New Methods of Observation now in use at the Cincinnati Observatory:—

1. New method of right ascension, as to its limit of accuracy.
2. New method of declination, as to its limit of accuracy.
3. New method of determining personal equation and personal error.
4. New method of determining instrumental errors.
5. New method of determining clock errors.
6. Observations on changes of figures of materials.

By O. M. Mitchell.

—Professor Mitchell commenced by observing, that if our observations in astronomy were only as accurate as the methods of calculation are perfect, we should obtain a marvellous power of astronomical prediction, and a marvellous power in the applications of astronomy. If we could only point a telescope, and tell *exactly* where it points, it would be all that we could require. His attention had therefore been directed to new methods of determining the position or direction of his telescope. The first point to be determined is to know with what accuracy he can determine the right ascension of a star—in other words, the exact moment of its passing the meridian. In order to do this, he attached to the rim of the revolving disc of his chronograph narrow strips of white paper at irregular distances. Close to the rim he placed a narrow bar, to hide or occult the strips as they pass. His assistant and himself then noted the times of their occultation, by means of the chronograph, and thus determined that they were able to estimate the instant of occultation with an accuracy that showed an uncertainty of only eighteen of the thousandths of a second The Professor then went into a very minute, but very clear and intelligible account of his experiments to decide whether they could note the passage of stars over the wires of his telescope with as much accuracy as they could note the passage of these paper strips behind the bar. He and his assistant decided that they could note it with even more accuracy. Taking many observations upon various stars at unequal distances from each other, he had devised means by which he determined the probability of the errors arising from individual peculiarities in the observer's temperament or physical adaptation, and from the effects of variable and unsteady refraction in the atmosphere. Then he passed to the consideration of the errors which may arise from the irregularity of the motion of even the best clocks. There had heretofore been no method by which we could determine the absolute accuracy of the motion of the clock for short intervals of time—no way to determine whether a clock did not hasten for a few seconds, and then move a few seconds too slow, keeping on the average true time. He wished to devise a simple means by which he could determine, on the chronograph, the absolute rate of the clock for each second of time, and had made some partially successful essays toward it. Professor Mitchell then recurred to the subject of personal equation—that is, to the error arising from the imperfect working of human nervous organization. He had devised this plan of determining the personal equation: Under the little strips of paper on the rim of the chronograph he placed a metal point, which should, at the instant of passing the occulting bar, pass through a globule of mercury, completing the circuit, and making thus the strip of paper record, by the magnetic pen, its own occultation with infallible and perfect accuracy. If, then, an observer note the passage with another magnetic pen, he has at once the mode of determining his personal equation or personal accuracy. Passing next to errors of levelling, Professor Mitchell described a mode by which, through the means of cups of mercury placed on each pier of the transit instrument, connected by a tube of mercury, he can at each moment of observation determine the level error of the axis of his transit. This will also give him the means of a perpetual determination of his azimuth error and collimation. Passing next to modes of determining declination or polar distance, Professor Mitchell spoke of the value of the micrometer screw, and gave an account of his experiments, by which he demonstrated the practical liability to error involved in measurements dependent upon a screw, and which had led him to the conclusion that he would henceforth never rely upon micrometric measurement. He must have more perfect instruments. An attempt had been made to make such an instrument; it had been in use in his observatory, and he would now present to the Section some of the results. These results show that his present instrument gave him the means of recording the right ascension and declination of each star of a group, at one single passage of the group over the meridian, with an accuracy unsurpassed, nay unequalled, in the working of any observatory. After mentioning these results, the Professor described the simple machinery of the instrument, by which he gives a mechanical multiplication to the motion of the great telescope, so that the motion of a needle over a graduated arc gives the means of reading, by the naked eye, the motion of the telescope to the tenth of a second of arc. He detailed the careful experiments by which he proved that the needle was absolutely and invariably obedient to the motion of the telescope. He had also the best witness to the accuracy of the machinery in the delicacy of his astronomical results. A double star, for example, of the ninth magnitude, the components being of equal size, about 15″ apart, but differing only nine-tenths of a second in declination. This pair having often been observed on different nights, it occurred to him to make a comparison of the differences on different nights, and he found to his delight that none of the observations differed one-tenth of a second of arc from the mean of nine-tenths. No micrometric work of any observatory is supposed to give such results. Professor Mitchell closed by an account of many delicate experiments to show the changes of figure produced by the changes of temperature, moisture, &c., in the air surrounding the instruments.

Further Investigation relative to the form, the magnitude, the mass, and the orbit of the Asteroid Planets. By Stephen Alexander.—Professor S. Alexander went into a discussion of the form, the magnitude, the mass, and the orbit of the planet by whose rupture he supposed the asteroids were formed. He had attempted to discover the physical characteristics of this planet and its ancient motions by a variety of independent paths, and was led by every path to similar results, namely, that the old planet revolved about the sun in about 1732 days, rotating in three and one-third of our days, and having a diameter about nine times that of the earth, but being excessively flattened at the poles. The orbit of his supposed planet he also shows was very nearly circular. In some of his investigations he had made great use of the remarkable analogy first discovered by Mr Kirkwood and presented to the Association at the Cambridge meeting.

Professor Peirce made a remark on the industry of Professor Alexander, and the remarkable coincidence, to say the least, which he had brought to light. He then observed that the analogy between the ring of Saturn and the belt of the asteroids was worthy of notice. It was to be remembered, that in order to have Saturn's ring remain continuous and flattened into so thin a sheet, the radial or vertical tide in the ring produced by the satellites must be neither too large nor too small. But if the solar system were formed according to the nebular hypothesis, the tides in the remaining mass, after the formation of Jupiter, must have been, from his great size, extraordinarily great, and have produced a different sort of ring at the distance of the asteroids from those produced for the other planets.

Mr Vaughan observed that the orbits of interior planets would render those of exterior ones circular, as grinding a stopper in the neck of a jar rendered it circular.

On the Heat on the Sun's Rays. By Elisha Foote.

On the Heat on the Sun's Rays. By Mrs Elisha Foote. Read by Professor Henry.—These papers described experiments from which it was inferred, that the heating power of the sun's rays varies with the temperature of the place into which the rays fall, that the temperature of air is raised by sunshine passing through it, that in the same condition rarified air is less heated than that which is condensed, moist air more than dry, carbonic acid gas more than atmospheric air, and oxygen more than hydrogen gas.

Approximate cotidal lines of diurnal and semidiurnal tides of the Coast of the United States on the Gulf of Mexico. By A. D. BACHE.—The paper was communicated by authority of the Treasury Department. It is supplementary to those on cotidal lines of the Atlantic and Pacific coasts heretofore communicated to the Association. Preparation was made at the last meeting for these conclusions, by presenting the type curves of the Gulf Coast. The tides from Cape Florida to St George's are of the usual type, with a large daily inequality. From St George's to the mouth of the Mississippi, they are of the single day type. Then the half-day tides reappear to extend beyond Galvestown, the day tides recurring at Aransas in Texas, and southward. When the type curves were presented, the mode of decomposing them into a diurnal and semi-diurnal wave was described.

The tide stations extend along our whole coast, but observations are much wanted beyond it, to complete the investigation, on the south side of the straits of Florida, on the eastern coast of the Gulf of Mexico south of Texas, and especially between Cuba and Yucatan at the entrance of the Gulf from the Carribean Sea. A table of the stations at which the observations were made of the heights of tide (rise and fall) observed, and of the half-day and day tides was given; and another, showing the period of observation and the name of the observer. The first table is represented on a diagram, by which a navigator may find the rise and fall of the tide approximately on any part of our Gulf coast. The least observed rise and fall is at Brazos Santiago, Texas, and is nine-tenths of a foot. The greatest is at Cedar Keys, Florida, and is two and a half feet. The difficulties of the problem presented by these tides are explained,—removable in part by the progress of the survey in the Gulf; inherent in them in part.

A diagram shows the general form of the curve of interval between the moon's transit and high water. Advantage is taken of part of the curve which changes but little in ordinate, to obtain an average luni-tidal interval, corresponding in kind with the number for semi-diurnal tides.

These tides occur about the period of greatest declination of the moon. These intervals at greatest declination vary greatly during the year; and the form of curve showing the annual change, is presented as deduced from observations at Key West, Fort Morgan (Mobile entrance), and Galveston, as well as from San Francisco on the western coast, where the results are remarkably regular.

In comprising the two sets of cotidal lines for the diurnal and semi-diurnal waves, we find a general resemblance in the great bay between the western coast of Florida and the eastern coast of Louisiana.

Supplement to the Paper published in the Providence Proceedings, on the secular variation in magnetic declination in the Atlantic and Gulf Coast of the United States, from observations in the 17th, 18th, and 19th centuries, under permission of the Superintendent. By CHARLES A. SCHOTT.—In a paper communicated to the Association at the Providence meeting, the secular change of the magnetic declination was investigated by Mr Schott. In the course of last summer he made some additional observations by direction of the Superintendent of the Coast Survey, and in the paper now presented the results are combined with those previously obtained. The former deductions have gained considerably in accuracy and have received important additions. The number of stations is increased from ten to thirteen. The recent observations appear to show a slight diminution in the rate of increase of westerly declination, leading to the supposition that the inflection in the curve representing the secular variation corresponds to about 1850. All the observations concur in placing the minimum about 1800. The present rate of increase of westerly declination is about five minutes annually along the Atlantic coast.

Discussion of the Secular variation of magnetic inclination in the North-eastern States, communicated under permission of the Superintendent and authority of the Treasury department. By Charles A. Schott.—The results are confined to the limits of 38° and 41° of north latitude, there being too few observations in the southern part of the United States to permit safe inferences there. The element of magnetic dip, though less important practically than that of declination, is of value in navigation in certain latitudes, and from its connection through Gauss' investigations with the declination and intensity, assumes a high degree of importance. Where the declination observations on this coast go back to the seventeenth century, the dip has only been accurately observed for 23 years; for the earliest observations made in 1782 were, from the imperfection of the instruments, of little value, During this period the dip has decreased, reached a minimum, and began again to increase; so that it has been a highly interesting period for observation. The lines of equal dip have been deduced by Professor Loomis, with his usual ability, from the observations which had accumulated before the date of his paper. The present memoir includes additional results, and discusses 161 observations made at the different stations between Toronto on the north, and Baltimore on the south. The same modes of discussion were adopted as in Mr Schott's former paper, and the results at each station are separately discussed, and the computed result compared in tables with the observed. The average probable error of the results at any one station is about one minute and six-tenths of dip, and the time of minimum dip is ascertained to be about two years and seven-tenths. This time was the year 1843, or rather the close of 1842 (1842-7.) Mr Schott points out why these results do not agree with Professor Hansteen's, who had not observations enough to determine the epoch of minimum depth with accuracy. Observations on the Western coast confirm these results for the Eastern.

Remarks on Ozone.—Observations by Professor William B. Rogers.—Professor Rogers said that the chief object in this communication was to call the attention of American observers to a branch of inquiry which as yet they had greatly neglected, and to indicate a change in the methods of observation, which he thought essential to make the effects on the ozonometer a fair measure of the quantities of ozone in the atmosphere. He had hoped, also, to elicit from Dr Smallwood of Montreal some of the results of his long experience in this class of observations, but was deprived of the advantage by that gentleman's departure.

Professor Rogers presented the results of two short series of observations, the first of which were made in the City of Boston, at a station on the eastern side of the extensive Common, the second on a hill fifty miles westward of the city, at a height of about five hundred feet above tide, in the midst of an undulatory rural district, covered with verdure, and removed from any collection of houses or manufactories. The ozonometer used was the ordinary test paper of Schoenbein, which was exposed freely to the outer air in such a way as to be sheltered from strong light and from rain.

The city observations extended from the 1st of February to the 31st of May. In these it was found that winds coming from any of the eastern points gave little or no indication of ozone, but those from western points, especially from the N.W., produced a strong impression upon the test paper. Thus for the four months of observations in the city, the mean for east winds was 0·6, that for west winds was 3·9, the former showing no trace of ozone unless when the current was very strong.

At the country station, the observations, extending from the 1st of June until late in August, when the report was drawn up, furnished very different results. Here the air, from whatever point it arrived, was more or less ozonized, rarely showing a less amount than that corresponding to 5 on Schoenbein's scale, often attaining 9, and occasionally even reaching the maximum, or 10. In only a single instance throughout the summer was there an entire absence of effect. In this series the mean for east winds was somewhat greater than that for the opposite currents. The former was 7·6, and the latter 6·7 of Schoenbein's scale.

The almost entire absence of ozone in east winds at the Boston station, and its presence in those from W. and N.W, Professor Roger ascribed to the circumstance that the former, in order to reach the place of observation, had to traverse a wide extent of the densely built city, while those coming from westerly points reached the common with but little intermixture of air from streets or buildings.

In all these observations it was remarked, as a general result, that the effect on the test, both as to rapidity and amount, was somewhat *in proportion to the velocity of the moving air*. Numerous instances were noted of a light breeze continuing for several hours with but a small impression on the paper, while the strong wind which followed from the same quarter produced in a single hour the most marked effect. Indeed, in very gusty days the impression was so quickly made and so strong, as to render necessary the renewal of the test paper several times within the twelve hours.

This increase of ozonic effect with the velocity of the wind Professor Roger considered to be mainly due to the larger amount of air brought in contact with the test in a given time. In this view the fact becomes very important, as showing the great imperfection of the common mode of observation, even for purposes of rude comparison, since in observing successfully in a calm and in a high wind, we are in fact *comparing the amount of ozone in vastly different quantities of air*. To avoid this error, some means should be adopted for furnishing to the test equal quantities of air in equal times. Such a result would be secured by an aspirating apparatus having a small chamber in the path of the current to receive the test. Such an arrangement, capable of bringing into action a large volume of air in a short time, would doubtless detect ozone in a multitude of cases where the common observation in calm air would show none. It would also enable us to make hourly, or even half-hourly observations, instead of waiting for the slow development of the action through half a day, a process which, instead of summing up the ozone actions of the twelve hours, allows the effect of one period to be more or less obliterated by that which follows.

Tidal Currents of Saturn's Ring. By BENJAMIN PEIRCE.—Professor Peirce, in commencing his remarks upon the tides of Saturn, observed that this subject was apparently of small importance, even in regard to Saturn's own system. But a knowledge of this subject must lead to a thorough revision of all that has been done upon the subject of the constitution of Saturn's rings. The tides of the ring are therefore important to be considered. Briefly alluding to the main points of the previous discussions, and giving credit to Laplace for a paper on the subject which appeared lately to have been forgotten, he called upon the physicists of the section to listen carefully, and criticise freely the physical assumptions which he should be obliged to take as the basis of his calculations. The Professor then proceeded to discuss his abstruse problem, illustrating the question by means of the brim of a hat, and telling the audience to remember that the ring of Saturn itself was thinner in proportion to its size than the hat brim, the thickness being only one-thousandth of its breadth.

The paper itself was a deeply interesting one to those familiar with mathematical and physical inquiries, but was too technical to admit of a report. The interesting points in the theory of Saturn's ring, to the general reader, are that the ring is fluid, and that it is held up from collision with the planet by the action of the satellites. These points have been announced before, but Professor Peirce, in the present paper, had given a much fuller and more complete investigation of the whole phenomena, as well as of the theory of the subject.

On the Meridian Instruments of the Dudley Observatory. By A. GOULD.—The meridian circle and transit instrument have been ordered from Messrs Pistor and Martin's in Berlin, Prussia, the makers of the beautiful instrument ordered by Chancellor Tappan, recently erected at Ann Arbor, Michigan, and placed under the care of Dr Brunnow. The instruments are to be somewhat of an eclectic construction. There are two types of astronomical instruments—the English and the German. The English are massive, stable, built with the hope of preventing errors in the position of the main parts ; while the German are light, airy, artistic, built for ease of handling, and for accurate measurement of the minuter movements. The one is the instrument of an engineer, the other that of an artist. Dr Gould proceeded to describe the modifications which he had with difficulty induced the German builders to introduce into these instruments. The telescope of the meridian circle was to be of seven and a half inches aperture and ten feet focal. The glasses are from the Messrs Chance of Birmingham, and Dr Gould had wished to have them ground and figured by the excellent artists of our own country, who have so well proved their ability to give unsurpassed accuracy to large object-glasses; but his German friends proved sensitive, and insisted upon either doing the whole work or none, and he therefore had allowed them to figure the glasses, with the proviso that they should be carefully examined and compared with the best American, and the result, whatever it was, should be made public. The eye-pieces are to have both a vertical and horizontal motion, and the diaphragm to be provided with both a vertical and horizontal micrometer. The chronograph was to be used, but in the case of the polar stars the slow motion requires the adoption of a system of micrometric measurement recently introduced into the Imperial Observatory in Paris, by Leverrier. It had been decided to use Challis's arrangement of collimators, instead of the convertibility of the object, and eye-piece, and of the telescope, for the purpose of testing the figure of the tube. Dr Gould would not take up the time of the section in discussing this matter at length, but there was one opinion of his which he would advance, namely, that he did not conceive the flexure of the telescope to be a minimum in zenith observations, nor a maximum at the horizon. The circles are divided to two minutes, and are read by microscopes to the tenths of a second. The illumination of the field of the Ann Arbor instrument was regulated by a set of plates somewhat like those which on a large scale regulated the swell of an organ. A method of observing bright stars has been introduced in the new circle, by which both the threads and the field may be illuminated, but with complementary colours. Dr Gould described the means which had been arranged for determining every instrumental error by two entirely independent methods.

On Some Special Arrangements of the Solar System, which seem to confirm the nebular hypothesis. By Stephen Alexander.—After some remarks to show that this hypothesis cannot justly be charged with an atheistic tendency, Prof. Alexander presented the various proofs of the actual existence of nebulous matter. While many nebulæ, so called, had been resolved, others had not; and the comets, the zodiacal light, and eclipses displayed matter of this kind which, of course, was not thus resolvable. After discussing the densities and distances of the planets, he explained the process of formation of solid planetary bodies by the breaking of gyrating nebulous rings. He showed that the planets, as now situated, mark the centres of gyration respectively of the rings from which they were formed. Neptune was thrown off by itself; there was one ring for Uranus, a double ring for Jupiter and Saturn, and a double one for Mars and the asteroids, and so on.

Professor Peirce remarked that, according to the nebular hypothesis, there should be at first but little eccentricity, and in nature Neptune has scarce any. But Neptune would produce a slight perturbation in the next ring, and Uranus would have, as it has, a slightly more eccentric orbit. When we came to Jupiter, his immense mass would produce tidal currents in the next ring of an extraordinary character, and we have there the group of asteroids with their eccentric orbits. Mars, being smaller, would perturb the earth's ring but little, and the earth has a small eccentricity. But again, Venus, being so large in proportion to Mercury, would give that body the highly eccentric orbit it has.

Discussion of the terrestrial magnetic elements for the United States, from observations in the Coast Survey and others. A. D. Bache and J. E. Hilgard.—The magnetic observations made in connection with the Survey were scattered, at 160 different stations, along the entire sea coast, and the data were reduced to the common period of the year 1850. The line of no variation, or that passing through all the places where the magnetic needle points to the true north, intersects the coast near Ocracoke, between Cape Hatteras and Cape Fear, in a N.N.W. direction, curving gradually to the north, and passing through the middle of Lake Erie.

To the north and east of this line the declination (or variation of the compass) is to the west of north, being 6° near New York, 10° near Boston, and 16° in the eastern part of Maine. To the south and west of the line of no variation it is east of north, being 8° east along a line running directly south a little to the west of St Louis and New Orleans, 13° near San Diego, and 21° near Cape Flattery, on the western coast. A map of this kind is of great practical value to surveyors. The dip of the needle varies from 75° in the north-eastern States to 60° along the northern shore of the Gulf of Mexico, and the horizontal force from 3·5 to 6·0 in the same regions. Mr Hilgard proceeded to institute a comparison with former maps, by Colonel Sabine and Professor Loomis, showing the progress made, and also with the magnetic charts by Gauss. The paper closed with a general table comparing the observations with the map, showing discrepancies and local deviations.

An Account of a large Barometer in the Hall of the Smithsonian Institution. By Joseph Henry.—Attempts have several times been made to form barometers of water instead of mercury. One was by Professor Daniell, in the hall of the Royal Society, in which a glass tube was employed, filled with boiled water while in a boiling state—the lower surface of the water was covered with castor oil, to prevent contact with the air, but this precaution was found not to be sufficient. Air was absorbed by the oil, and the nitrogen of this air absorbed by the water. Another attempt was made to exclude the air by a thin film of gutta percha left after the evaporation of naphtha. But a valid objection to water arises from the vapour which will fill the top of the tube. Professor Henry had decided to use sulphuric acid, which does not give off any appreciable vapour, nor absorb any air. The objections to its use are the liability to accident, and its affinity for water. But care can guard against accident, and the moisture can be absorbed from the air which touches it by a drying-tube apparatus containing chloride of calcium. The construction was intrusted to Mr James Green of New York. The tube is two hundred and forty inches long, and three-fourths of an inch in diameter, inclosed in a brass case, two and a half inches in diameter. The mechanical details of the instrument we need not repeat. The whole of the apparatus is inclosed in a glazed case, one foot square.

On a Method of determining the Latitude of a place, from the observed times when two known stars arrive at the same altitude. By W. H. Chauvenet.—In this method the stars properly situated are supposed to arrive at the same altitude *successively*, and not simultaneously, as in the method of Brown.

Tables of Prussian Mortality, interpolated for annual intervals of age; accompanied with formulæ and process for construction. By E. B. Elliott.

Process for deducing accurate average duration of life, present values of life annuities, and other useful tables involving life contingencies from returns of population and deaths, without the intervention of a general *interpolation.* By E. B. Elliott.—Mr. Elliott's labours upon the Prussian and other tables constitute part of a series of tables that are prepared, or being prepared, at the request of the New England Mutual Life Insurance Company of Boston, from official returns made to the English, Swedish, Prussian, and Belgian Governments, and from such reliable American statistics as can be obtained. In several of the United States, while the returns of the living are sufficiently trustworthy, those of the numbers dying are sadly deficient. The present Secretary of State in Massachusetts has consented to a change in the registration report for 1855, which will afford better material for the satisfactory construction of a life-table for the larger part of the population of that commonwealth. Mr Elliott briefly indicated the nature of the table presented, and the formula and process for construction. He described the more common methods of calculating life tables, and contrasted them with improved methods of his own, illustrating the difference by diagrams, representing the intensity of mortality in various communities by curves. He discussed different methods for deducing from the ratio of the dying, within certain intervals of age, the probability that one living at the earlier age will attain the later, and indicated an accurate method for accomplishing that object, whether the deaths for the period be variable or uniformly distributed throughout the period. He also gave an abridged method for computing the average duration of life, life-annuities, and other useful tables, from population and mortality returns, which reduces the labour of weeks to hours, but giving results almost identical with those obtained by the tedious modes of interpolation in common use ; the average duration of life, for example, calculated by the short method, seldom differing three weeks from that calculated by the usual mode.

Researches on the Ammonia-cobalt bases. By Dr Wolcott Gibbs and Dr F. A. Genth.—This paper presented the results of researches, carried on for several years past, to determine the nature of the bases formed by the union of ammonia with the sesquioxide and sesquichloride of cobalt. Dr Gibbs also referred to a series of compounds discovered by him, which, from their containing sulphurous acids, he had called Thiocobalt. These researches he considered as of high scientific interest, since they involve the combination of organic with inorganic bodies, and have thus an important bearing on medical and other branches of applied chemistry, as well as upon chemical theory in general. He alluded incidentally to the value of Chevreul's scales of colour, and Haidinger's dichroscopic laws.

Redetermination of the atomic weight of Lithium. By J. W. Mallet. This paper, beginning with an enumeration and criticism of the researches on the subject by Arfwedson, Vauquelin, Gmelin, Berzelius, &c., describes a process for preparing pure chloride of lithium from the crystallized spodumene of Goshen, Massachusetts. This compound was then treated with nitrate of silver to determine its chlorine, and then its lithium. The result gave for the equivalent of lithium, 86·89, or on the hydrogen scale, 6·95.

(*To be Continued.*)

SCIENTIFIC INTELLIGENCE.

ZOOLOGY.

*Dr Cleland on the Gubernaculum Testis.**

The following is a summary of the Mechanism of the Gubernaculum Testis, as detailed in the Prize Thesis submitted by Dr Cleland to the Medical Faculty of the University of Edinburgh, and now published.

Viewed from the peritoneal cavity, the earliest gubernacular structures are a peritoneal elevation passing on the surface of the Wolffian body from the lower end of the testicle to the junction of the epididymis and vas deferens, and a more marked continued elevation from the latter point to the groin. The former elevation shortens and disappears by the approach of the testicle to the extremity of the epididymis. The latter one is prolonged into a pit which forms round its inferior attachment, viz., the processus vaginalis. This elevation is the plica gubernatrix.

Similar structures are found in the female embryo, where the cornu uteri corresponds to the vas deferens, the Fallopian tube and its fimbriæ to the epididymis and coni vasculosi, and the corresponding elevation to that first mentioned is the rudiment of the ligament of the ovary, while its continuation is the round ligament at whose extremity is the canal of Nuck.

Viewed outside the peritoneal cavity, the first condition of the gubernaculum is as a cord, formed above from the external surface of the peritoneum, and perhaps some fibres issuing from the plica gubernatrix. This gives and receives fibres from the various layers of the abdominal wall, until it reaches its inferior attachment at the scrotum. As the processus vaginalis is formed, the fibres begin to be developed in two directions, some clinging to the processus vaginalis, and some following the direction of the gubernacular cord to the scrotum. As the process advances, the first set are the principal, and ultimately the only ones which are developed. Thus, is formed, a gradually thickening bulbous extremity, which pushes its way down the centre of the gubernacular cord; whose fibres, separated before it, form a kind of funnel-shaped cavity, and at last, when the processus vaginalis has reached the scrotum, are quite incorporated with the neighbouring tissues.

Fibres of the internal oblique muscle arch downwards in front of the gubernaculum, and from these the cremaster muscle is formed.

Other fibres ascend from the internal oblique muscle on the surface of the gubernaculum, but subsequently undergo atrophy.

The gubernacular cord also receives ascending and descending fibres from the aponeurosis of the external oblique muscle and from the fascia.

The gubernaculum consists altogether of two parts, a peritoneal process descending in advance of the testis, and a fusion of the layers of the abdominal wall.

The plica gubernatrix disappears by contraction, not by eversion.

The purpose of the descent of the Testes.—The descent of the testes to the scrotum is part of a contrivance, to which the peculiar nature of their vascular supply and the dense structure of the tunica albuginea give aid, by means of which an equilibrium of secretion and absorption is maintained, and the testes remain always full of fresh secretion, but not overflowing. The same peculiarities of structure, when the muscular

* Mr Curling has attracted Dr Cleland's attention to the circumstance, that he has referred to Mr Curling's latest paper,—that in the Cyclopædia of Anatomy and Physiology, and not to his original paper on the Gubernaculum, which appeared in 1841, and was therefore several years prior to that of M. Robin.

tunics are contracted, cause the expulsion of secretion from the tubuli seminiferi.

Serresius galeatus, Bonap.—Prince Bonaparte has described a new pigeon from the Marquesas Islands of a very remarkable form. The head, feet, and one wing, are all that have yet been received of this bird. Yet upon these the Prince founds a new genus in honour of his friend Professor Serres, the successor of Blainville and Cuvier. This species, to judge from the portions preserved, is only about one-third less than the Goura, and is allied to that group of fruit-eating pigeons known as the *Carpophagæ*. The bill measures 1½ inches in length, and the toes are longer than those of *Goura coronata*: but the remarkable part of its structure consists in the maxilla, as far as the bend at the tip being covered with a membrane clothed with thick scale-formed feathers. This membrane can, in life, be raised at will, in the form of a feathered caruncle.

Shark Oil.—The shark oil trade is of recent growth in North Greenland. It has lately extended as far north as Proven. At Neorhanek, the seat of the greatest yield, about 300 fish are taken annually. The oil is expressed from the liver of the arctic shark *S. borealis*, the Hvowcalder of the Icelanders; it is extremely pure, resisting cold, and well adapted for lubrication. It brings a higher price in the Copenhagen market than the best seal oils.—(Kane, *Arctic Explorations*.)

ZOOLOGICAL BIBLIOGRAPHY.

The Woolhope Naturalists' Field Club. Established 1851. Hereford, 1856. 8vo.—The first printed record of one of those very useful clubs which devote themselves to the investigation of local natural history. It contains the addresses of the Presidents, and a paper on the Ichthyology of Herefordshire by Hewett Wheatley, Esq.

Die Fossilen Mollusken des Tertiær-Beckens von Wien; unter der Mitwirkuny von Paul Partsch, bearbeitet. Von Dr M. Hörnes. Wien, 1856. 4to.—The third and concluding part of the univalves is completed, forming a volume entire in itself. German, with Latin specific characters, and illustrated by 52 lithographic plates of the greatest artistic excellence.

Finlands Mollusken. Beskrifne af A. E. Nordenskiöld, Licentiat, och A. E. Nylander Kandidat. Med. 7 plancher. Helsingfors, 1856. 8vo.—Appears to be a good guide to the land and fresh water mollusca of Finland. The letterpress is Danish, but the specific characters are given in Latin. The plates are mostly clear outlines.

Monographia Auriculaceorum viventium, sistens descriptiones systematicas et criticas omnium hujus familiæ generum et specierum hodie cognitarum, necnon fossilium enumeratione. Aucture Ludovico Pfeiffer, Dr Cassellano. Cassellis, 1856. 8vo.—Written entirely in Latin. 242 species are described.

Die Tineen und Pterophoren der Schweiz. Von Prof. Heinrich Frey. Zurich, 1856. 8vo.—German, the specific characters written in Latin.

Die Kritischen Gruppen der Europäischen Clausilien. Von Adolf Schmidt. Leipzig, 1857. 4to.—German, with Latin specific characters; with lithographic plates, giving outlines of the shells; and enlarged finished figures, in various positions, of the mouth and other important parts of structure.

BOTANY.

On the Pines of Mammoth-Tree-Vale, Thirty Miles north of Sonora.—Colonel Fremont describes the largest red-wood measured by him to be 15 feet in diameter and 275 feet in height.

Mr Walter Hitchcock gives the following account of forest wonders which fell under his own observation. "One which had been felled was bored down with long augers, and took four men twenty-two days to get it down." The stump remains, 6 feet high; and its surface has been made level. "I measured it," from inside the bark across to inside the bark, "and it measured 25 feet; and is perfectly sound to the heart." Fifty-two feet in height of the bark in sections were taken to New York. At 166 feet from the ground the diameter is 10 feet; at 280 feet it is still 4 feet in diameter. At this point it had been broken across, and the remainder was much injured. But its height before it was felled "was set down at 300 feet."

"There are some larger ones blown down." One, evidently decayed before it fell, had been "in its fall broken off 60 feet from the roots. This part is hollow; and I cannot give you a better idea of its size than by telling you that I rode my horse through it from end to end." "But this is not the largest. There is another one blown down, which measures 110 feet in circumference (35 therefore in diameter) and 410 feet in length. This, too, is hollow."—(*Bartlett's Personal Narrative of Explorations and Incidents in Texas, New Mexico, California, &c., connected with the United States and Mexican Boundary Commission, during the years* 1850–1–2–3, vol. ii. p. 22, foot-note.)

Peruvian Bark-tree.—The trees yielding Peruvian bark, which grow at an elevation of 7000 to 8000 feet on the Andes, have for a long series of years been felled for the sake of their bark, and no pains was taken to replace them. Fears have naturally been entertained that, ere long, the supply of bark, and consequently of Quinine, would fail. Efforts have consequently been made to transplant the tree into countries where it is supposed the climate would be suitable. Dr Royle has taken measures for introducing Cinchona Calisaya or the yellow bark-tree into the higher regions of India; and of late years the Dutch Government have employed Mr Hasskarl to transport plants of various species of Cinchona from North America to Java and other parts of the Dutch East Indies. These attempts have been successful; and the reports, in regard to the growth of the plant, are such as to lead to the expectation that, ere long, the Peruvian bark-trees will be scattered over extensive districts, and will thus be saved from destruction.

Cuba Bast.—The source of this material, which has long been used for various horticultural purposes in this country, has been hitherto unknown. Sir William Hooker has been enabled, through the kindness of Henry Christy, Esq., to ascertain that the plant which yields this valuable fibrous substance is a Malvaceous plant, *Hibiscus elatus*, Sw., *Paritium elatum*, Rich.—a tree scarcely to be distinguished from *Paritium tiliaceum*, St Hil.

Garden at Bangalore, East Indies.—The Indian Government, at the suggestion of Dr Hugh C. Cleghorn, Professor of Botany, have resolved to establish a garden at Bangalore, so as to form a connecting link between the gardens at Madras and Ootacamund. The garden will be placed under the superintendence of Mr Jaffrey, who has been for some years in charge of the Agri-Horticultural Garden at Madras.* Mr Jaffrey was trained under Mr M'Nab, at the Botanic Garden of Edinburgh. The

* Mr Jaffrey is now publishing an account of the Vegetables used in India.

Commissioner of Mysore has entered warmly into the arrangements, and will do all in his power to facilitate the formation of the garden and to ensure its success when established. The locality selected by Dr Cleghorn for the garden is Lall Bagh. It comprises rather more than forty acres, well situated, and sloping gently towards the north. The soil—judging from the crop of sugar-cane now in the ground, and from various other products—is generally good. The supply of water in ordinary seasons is abundant, and the tank at its upper extremity admits of easy enlargement, if this be found necessary. Water has been found near the surface at several places, and there are great facilities for irrigating the ground. The expense proposed is 300 rupees monthly, besides a grant, in the first instance, of 2000 rupees. As regards management, it is suggested that the garden superintendent, and every one connected with it, should be under the immediate and exclusive control of the Commissioner of Mysore. The great objects of the garden, Dr Cleghorn remarks, are the improvement of indigenous products, the introduction of exotics, the supply of them to the hills and plains, and the exhibition to the people of an improved system of cultivation in practical and successful operation. The climate is highly favourable, and the soil capable of producing the best description of many vegetable products. Bangalore is much better suited for agricultural and horticultural experiments than either Ootacamund or Madras, and, from its central position and intermediate elevation, the finer kinds of vegetables and better sorts of graft trees may be disseminated, with great success, to the neighbouring ranges of hills.—*Dr Cleghorn's Report to the Madras Government.*

BOTANICAL BIBLIOGRAPHY.

Loudon's Encyclopædia of Plants, comprising the specific character, description, culture, history, application in the arts, and every other desirable particular respecting all the plants indigenous to, or cultivated in, or introduced into Britain. New edition, corrected to the present time. Edited by Mrs Loudon, assisted by George Don, F.L.S., and David Wooster, late curator of the Ipswich Museum. This is truly a wonderful work, and displays in no ordinary degree the patient research of Mr Loudon. It extends to 1574 pages, and contains nearly 10,000 figures. It is a most valuable work for gardeners and horticulturists, and ought to be in every public botanical institution.

The First Part of the 14th volume of *De Candolle's Prodromus* has just been published. It contains Polygonaceæ by Meisner, with the suborder Eriogoneæ by Bentham, Myristicaceæ by Alphonse Decandolle, Proteaceæ by Meisner, Penæaceæ and Geissolomaceæ by Alphonse Decandolle. We are rejoiced to see that this important work is progressing, although it is still far from being complete. At the present rate of publication it promises to go on for another generation. When finished, the earlier volumes will undoubtedly require to be revised and reprinted, so as to bring them up to the state of science. The labour of such a work is enormous, and the mode in which it has been carried on reflects the highest credit on the Decandolles and their collaborateurs.

Flora Vectensis: being a Systematic Description of the Phænogamous or Flowering Plants and Ferns indigenous to the Isle of Wight, with a Botanico-topographical Map of the Island. By the late William Arnold Bromfield. Edited by Sir William Jackson Hooker and Dr Thomas Bell Salter. This work is the result of the careful observations of Dr Bromfield during many years. The editors give the following statement in the preface:—

"Dr Bromfield became resident at Ryde, in the Isle of Wight, in the year 1836, and shortly afterwards conceived the idea of preparing a Flora of the Island. He was not content to follow the usual practice in the making of local Floras and Faunas, and to be satisfied by presenting merely a tolerably full list; but he determined that the investigation should be very complete, and that every species should reeeive an original description. Nor was he satisfied with a mere cursory research in the framing of these descriptions, or with copying any character from other authors unverified by his own examinations. He was also equally careful to avoid describing general characters from individuals or varieties, and endeavoured, with immense and most persevering care, to select such points as are really the permanent and essential characters of genera and species. To ensure this result he was in the habit of obtaining a very great number of specimens of each species, collected from various localities; and, whenever practicable, he endeavoured to compare Isle of Wight specimens with those collected at a distance. Having thus secured sufficient material for investigation, his next aim was to consult every author within his reach for all the characters which different observers had noticed. For this part of his plans he had collected a very ample botanical library, especially of foreign authors. The characters, however, observed by others were, for his own descriptions, merely suggestive;—none being recorded but such as, after careful examination, he himself found to exist in nature.

"The results of these careful investigations were the most accurate and elaborate descriptions which can well be imagined; but such were the time and labour bestowed on each species—as much as many authors would give to a genus or family—that this circumstance very materially retarded the progress of the work. Unfortunately, also, when the Isle of Wight had been very thoroughly investigated as regards stations, and the work of describing was proceeding, the author enlarged his plan, and determined to comprise the whole county of Hampshire within the scope of his Flora. This certainly would greatly have added to the value of the work, had he been spared to complete it; but, such not having been permitted, it is impossible not to regret the interruption which the search for localities in this new field occasioned to the description of species. Another cause of interruption to the present work must also here be mentioned. Dr Bromfield had an intense love of travel, and this desire ever and anon prevailed, and occasioned a suspension of the Island Flora. Extensive tours through the islands of the West Indies, and through Canada and the States of North America, although they contributed most valuable information to the pages of the *London Journal of Botany*, very much impeded the progress of the present work. Finally, in 1850, Dr Bromfield started on an excursion to Egypt, Nubia, and Abyssinia; after which he was tempted to prolong his tour into Palestine and Syria, where, alas! he was cut off by fever at Damascus. Under these melancholy circumstances the manuscript of the unfinished Flora was committed to the editors by Dr Bromfield's nearest surviving relative."

The editors have bestowed much labour on the work, have done ample justice to the materials left by Dr Bromfield, and have produced a most useful Flora of the Isle of Wight.

Flora Indica.—We regret to learn that this valuable work is likely to be arrested in its progress, owing to the want of encouragement on the part of the East India Company. Drs Thomson and Hooker undertook the work at their own risk. The First Volume gives an earnest of what might have been expected at their hands. The authors are already well known to the scientific world by their botanical works, and every one acquainted with science is aware of their high standing and of their thorough competency for the task they have undertaken. The work is a national one, and promises to be one of the most important which has appeared in the botanical world. It will be the result, in a great measure, of personal observations, aided by the unrivalled resources of the Hookerian Herbarium. That such a boon to science should be stopped for want of funds, and that the authors should suffer pecuniary loss, is by no means creditable to our country. When the Admiralty have most nobly published the results of arctic and antarctic expeditions, it is surely not too much to expect that the East India Company, which is so much indebted to the labours of scientific men, should lend a helping hand in making known the vegetable productions of that vast territory over which they rule.

We think that all interested in science should unite in memorializing the Company on this subject, and we cannot for a moment doubt that the unanimous voice of scientific societies and scientific men will ultimately prevail.

Obituaries.—Christoph Friedrich Otto, late Director of the Royal Botanic Garden at Berlin, died on 7th September 1856. He was born 1st December 1783, and went to Berlin in 1801. He was employed first as a journeyman gardener, and afterwards, at the recommendation of Willdenow, was made Sub-Curator of the Royal Botanic Garden. In 1814 he was appointed Inspector of the Berlin Garden, and Director of the School for Young Gardeners. He received the fourth class of the order of the Red Eagle, in testimony of his services. He retired from his duties in 1843, on a pension of L.120. He published several botanical works, and he edited, in connection with Dr Albert Dietrieb, the "Allgemeine Gartenzeitung." A genus of umbelliferous plants is called *Ottoa*. His son is Sub-Inspector of the Botanic Garden at Hamburg.——Professor Tineo, Director of the Botanic Garden at Palermo, died in October 1856. He is succeeded as Director by M. Todaro, until the return of Professor Gussone from Ischia.

GEOLOGY.

Effects of Arctic Climate on recent Skeletons.—On the first of September, still following the ice-belt, we found that we were entering the recesses of another bay, but little smaller than that in which we had left our brig. The limestone walls ceased to overhang us. We reached a low fiord, and a glacier blocked our way across it. A succession of terraces, rising with symmetrical regularity, lost themselves in long parallel lines in the distance. They were of limestone shingle, and wet with the percolation of the melted ice of the glacier. Where the last of these terraced faces abutted upon the sea, it blended with the ice-foot, so as to make a frozen compound of rock and ice. Here lying, in a pasty silt, I found the skeleton of a musk ox. The head was united to the atlas, but the bones of the spine were separated about two inches apart, and conveyed the idea of a displacement produced rather by the sliding of the bed beneath than by a force from without. The paste, frozen so as to resemble limestone rock, had filled the costal cavity, and the ribs were beautifully polished. It was to the eye an imbedded fossil, ready for the museum of the collector. I am minute in detailing these appearances, for they connect themselves, in my mind, with the fossils of the Eischoltz cliffs and the Siberian alluvions. I was startled at the facility with which the siliceous limestone, under the alternate energies of frost and snow, had been incorporated with the organic remains. It had already begun to alter the structure of the bones, and in several instances the vertebræ were entirely enveloped in Travertin.—(*Kane's Arctic Explorations,* 1856.)

The space occupied by the Papers of Professors Wilson and Goodsir, and by the Report of the American Association, has prevented the Editors from inserting several important Original Communications, Reviews, and the usual Reports of the Edinburgh Societies. They regret that they have been compelled to postpone, till next number, Mr Blodget's Paper on the Distribution of Heat in the North American climate, with Map; Professor Bailey on the Origin of Greensand; Mr Baxter on the Influence of Magnetism over Chemical Action; Mr Murray on Insects transmitted from Quito by Professor Jameson; Mr Brodie on Corals of the Lias; Dr Davy on the Vendace, and several other Communications.

PLATE I.

Edinʳ. New Phil. Journal, New Series Vol. V.

Fig. 1.

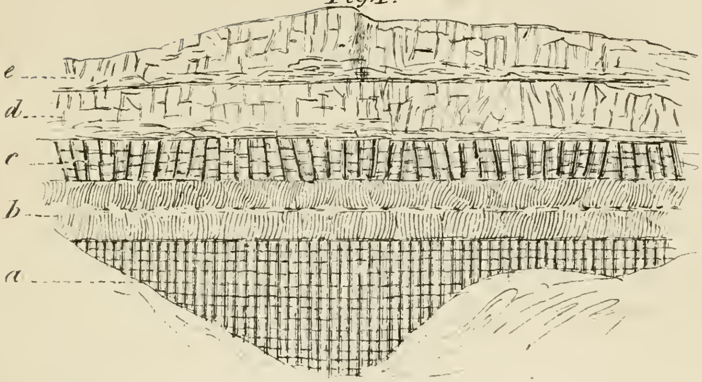


Fig. 2.

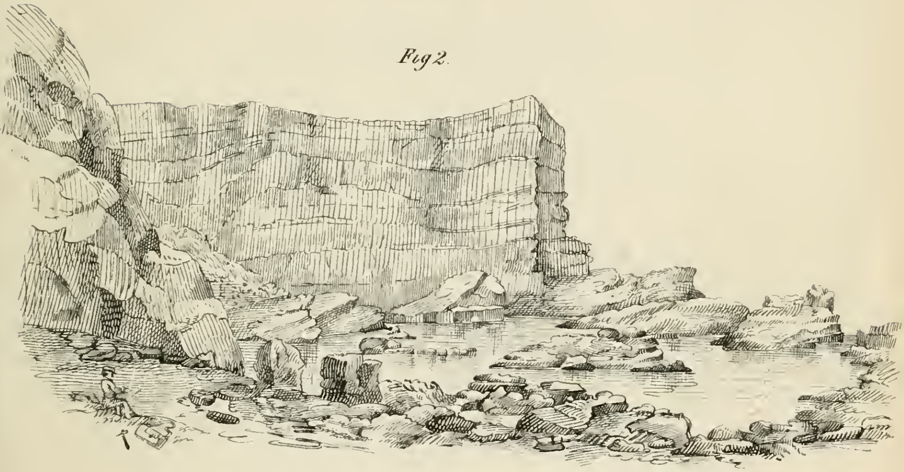
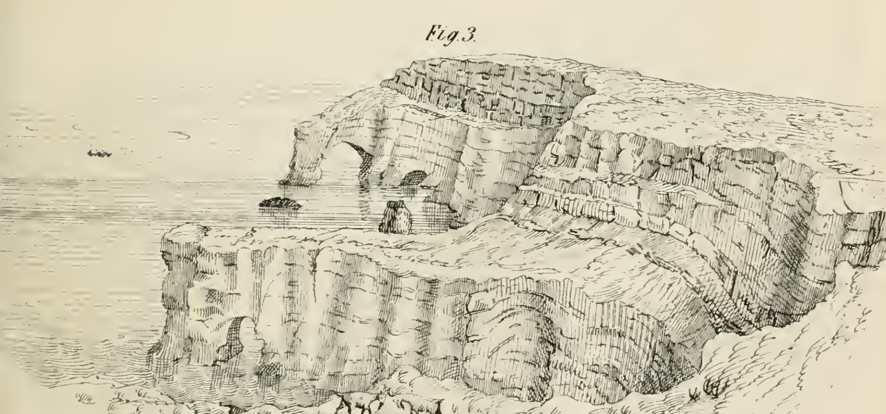


Fig. 3.



NOTES ON THE BASALTS OF THE GIANT'S CAUSEWAY, BY EDWARD HULL A.B., F.G.S.

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THE

EDINBURGH NEW

PHILOSOPHICAL JOURNAL.

Distribution of Heat in the North American Climate. By LORIN BLODGET, Washington. With a Map.

The basis of a discussion, of a more general character than any previously possible, in regard to the distribution of heat in the temperate latitudes of North America, has recently been furnished by the publication of the meteorological observations taken at the military posts of the United States. Though none of these posts have the rank of observatories, with the consequent accuracy of detail desirable for many purposes, the averages and mean results derived from them are still a very near approximation to averages derived from the most elaborate series; while among themselves they are sufficient for all purposes of general comparison. They furnish enough of positive data for conclusions on all the Pacific coast, particularly between the 32d and 50th parallels of north latitude; and this is the critical and important ground previously left quite obscure. It will be seen that this region, in its general expression and its singular anomalies, bears on the distribution of heat elsewhere, and is of unusual interest in itself.

The eastern border of the United States has been known, from various sources of observation, so long, that a reference to its basis of records is scarcely necessary; but those west of the Mississippi, only recently and for the first time collected, are mainly from military stations, and may here be enumerated for the several districts. All the records for the eastern

United States were, however, consolidated in the basis of the discussion referred to in this paper.

First, the eastern border of the great plains has a number of long-established military posts, with series of temperature observations for periods of from twelve to thirty years. From the south, they are in the following order:—Fort Jesup, in Louisiana; Forts Towson, Washita, Smith, and Gibson, in a group near the 35th parallel, longitude 95° west; Forts Scott, Learmonth, and Council Bluffs, on the plains near the 40th parallel; and Fort Snelling, at the 45th parallel. The results at the points first enumerated have been previously discussed on the basis afforded by five to ten years of observation; but for the report prepared by the writer on the army meteorological observations, twelve years' observations were added to each, bringing the results down to the close of 1854. Next to these, westward, are several posts, having three to six years of observation; which, with all the rest on the entire continent west of the 97th meridian, were first discussed in the report alluded to. Two or three of these are near Fort Snelling, extending the area of which that is the centre; next are three forts, for a year or two each; equally dividing the entire length of the Missouri River above Council Bluffs,—the last, Fort Benton, being at the foot of the Rocky Mountains; again, two posts, Forts Kearny and Laramie, dividing the distance to the mountains along the river Platte, and having observations for six years each; and for the last representative of the climate of the plains, Forts Atkinson, Arbuckle, and Union, occupying the same space on the Arkansas and Canadian rivers, in 35° to 37° north latitude.

Below this area of the plains, the posts are more numerous, and they may be grouped in the following order:—Fifteen being placed at the border of the high plains of Texas, about a central point, at 32° north latitude, and 98° west longitude, and having periods of observation from three to six years; eight posts in the vicinity of the Lower Rio Grande, of like periods of observation, and central at a point four degrees of latitude further south. In New Mexico, a group of seven posts in the vicinity of the Rio Grande, from the 32d to the 35th parallel, occurs, having the same periods of observation; and another of six posts, north of the 35th parallel, and at a much greater altitude above the sea than the first. Santa Fe, Fort Massachusetts, and Fort Defiance, are the principal of these.

Still westward, Fort Yuma represents the desert of the Lower Colorado of California, an isolated locality; and at or near the coast, Santiago, with two or three posts less permanent, represents a soft transition climate of vines and tropical fruits in southern California. Proceeding northward, the posts of the entire coast, from Point Conception to Astoria, are identical in climatological character,—Monterey, San Francisco, Bernicia, Fort Ross (Russian), Forts Humboldt, Orford, and Astoria. A group in the interior of California represents an isolated climate,—Forts Tejon, Miller, Reading, &c. Forts Vancouver and Steilacorm represent a partial interior district in Oregon; Forts Dallis, Owen, and Hall, Kooskooskia, and Great Salt Lake, represent positions still farther in the interior, and of considerable diversity of climatological character, but their periods of observation are short.

All the points here enumerated furnish new material of a uniform and comparable character; and all the observations, except those at Fort Ross, are for years since 1848. This comparability constitutes a great advantage; and a second advantage is found in the distribution of the posts in groups, so that the averages of groups and positions may be taken to obtain a perfected general expression. This last is an effective process for correction, when the details of observation may not be implicitly relied upon. All the observations were discussed in this synthetic manner in arranging and reducing the original observations for publication; and all the opportunities for elimination and correction which such a course afforded were seized at the time. In the ultimate preparation of the charts and illustrations this corrective process was continued.

In making up the basis for constructing a climatology including the two leading conditions, the Distribution of Heat, and the Distribution of Rain, the new material alluded to was found most valuable as completing the structure for which summaries had been before accumulated in the eastern United States, making an intelligible framework for that half, but wanting the western half to make up the continental whole.

In the eastern portion the whole mass of material was consulted, though the results at the military posts were alone quite ample. With the very valuable accumulations from scientific sources, it is believed that a better basis could hardly be employed for the illustration of the two leading conditions of the climate. The greatest difficulty arises from the fact of the most extensive scope given to the inquiry by the accumulation of material from so wide a field. It tends to give the discussion a cosmical character,—one too wide and general to permit accurate attention to details; and the details, both of observation and deduction, constantly require a reference to exterior general laws, in order to give the right place to the facts of observation.

The force of this remark is most apparent on reference to the features presented at the immediate coast of the Pacific, and to the measures of heat observed on the highest interior plateaus. In both cases, the facts of observation look incredible, and they must be illustrated and supported by analogies drawn from another continental area, or another coast similarly placed cosmically, to permit us to understand them fairly, and at last to receive them. It is not enough that the simple geographical positions are similar; an identity of atmospheric and maritime influences must exist, and, whatever these are, they must be judged by the aid of their parallels elsewhere, if they have any such parallels. There is no deep sea current refrigerating the western coast of Europe in temperate latitudes, by which the anomalous cold of the Pacific coast of the United States in summer may be illustrated; but we find its type on the Peruvian coast, in the cold waters observed by Humboldt; and the cosmical illustration gives us the parallel, therefore, when geographical position in the same hemisphere fails.

The next general anomaly is the great measure of heat at high altitudes of the interior; and to this there are, doubtless, parallels in the interior of Asia, in positions not geographically dissimilar. The simplest statement of this fact is, that from the 30th to the 45th parallels, on the wide Rocky Mountain plateau, *an altitude of four thousand feet counts nothing in reduction of temperature;* positions up to 4500 feet, in fact, usually giving averages equal to those at sea-level on either coast. The area so affected is nearly 20° of longitude in width, and the condition is thus one of the first magnitude in its relation to the climatology of these latitudes. This feature will again be referred to briefly; and it is cited here to show what problems are started by the simplest illustration of the observed facts of temperature in these new districts.

It must not be forgotten, in entering on the discussion of the distribution of heat here, that at the Atlantic coast we meet at once the converse of laws of position for the isothermals on the west coast of Europe. From the maximum of oceanic influences, the transition is abrupt to a coast in the immediate vicinity of the maximum of the antagonistic continental influences ; and though the coast, softened by proximity to the sea, and by the influence of the gulf stream, gives softened local positions, and northward curvatures of the isothermals of the colder seasons, this influence disappears at a very short distance inland. From Georgia to Labrador the area is continental in its relations to heat, and it is only prevented from being the extreme area of this kind for the continent by the intervention of the great lakes, which throw the extreme district westward of their position at their latitude. Above and below them it is crowded eastward again to the immediate vicinity of the Atlantic coast.

The measure of depression for the isothermals of each season, in passing from the European to the American coast, need not be enlarged upon, as it is already very well known. It is greatest in winter and least in summer; and only in regard to the last season do the present results afford anything new. This new point is the assignment of a higher value to our summer temperature than before, and the development of what may be termed ultra-tropical temperatures in the southern part of the United States—averages as great as those of the arid transition belts of the south of Asia. A curving belt bordering the Gulf of Mexico, and from 3° to 5° of latitude in width, has averages higher than those of the tropical seas of the south ; and there are large areas at some little distance from the coast possessing from 82° to 85° mean temperature for the three months. Above this, and in the Mississippi

Valley, as also on the great plains, the averages of summer heat are very high, and the isothermals, for that reason, exhibit extraordinary curvatures. They are repelled and turned southward at the great lakes, but they advance on the plains in the vicinity of the lakes much beyond the positions heretofore given them. The mean of 75° ascends the valley of the Missouri nearly to the 45th parallel, and this isothermal is bifurcated or expanded over a great area south of that river, where the plain rises above the river valley in its higher latitudes.

On all these plains, and in all the more considerable valleys, it has been the design to illustrate the *actual superficial distribution* in the isothermal charts, without correction or reduction for altitude in any case representing the general surface of the locality or district. The changes of altitude are so moderate, however, that few curvatures depend upon altitude alone, and most of the instances in which a line is thrust northward beyond the average of its position, are evidently due to strictly climatological causes—the expansion of a semitropical heat where surface favours it, and where positive causes do not prevent.

In the whole illustration it has also been found imperatively necessary to adhere to the surface conditions, as presented by the observations alone, and to undertake no reductions by the rules elsewhere found applicable to altitude, to obtain the equivalents at sea-level. On the irregular surface of Europe, with its abrupt elevations, and steep, moderately-elevated mountains, temperatures observed at any considerable altitudes must necessarily be corrected, even to represent the general surface. But here there are few such positions, and generally a high plain or plateau constitutes the general surface of an elevated district. In entering upon these, at whatever elevation, it is at once apparent that the rate of reduction for the altitude cannot be the same as in the case of a sharp single ascent from the sea-level; and that, if a reduction is attempted, new equivalents must be obtained for its scale. It is also unessential to more than one branch of even the most abstract discussion of the laws of distribution of temperature, and, as an indispensable preliminary to all discussion, the surface, or actual distribution, must first be known. This surface distribution must also be illustrated before one derived from it by corrections for altitude can safely be treated, as the results must be generalized, to permit verification of them in the first instance. It has been preferred to open none of the questions of vertical distribution in the present case, and to draw all the isothermals according to the actual conditions of the general surface of the several districts.

The citation of the several differences of vertical distribution actually found to exist is interesting in itself, as well as illustrative of the necessity of a rigid adherence to the rule of taking the facts of observation, without correction, for altitude. At the meridian of Fort Snelling, we find the plain rapidly attaining considerable altitude as we approach it from the east; yet for all seasons except winter, we find the isothermals rising in latitude as they are carried west, particularly above the 40th parallel, and continuing to do so to the foot of the Rocky Mountains. In the mean for the year, Fort Benton, and the vicinity of the Upper Missouri, at 2500 feet above the sea, are warmer than Fort Snelling, at less than half the altitude, and two degrees lower in latitude; and the first point is warmer also than the Atlantic coast at the same latitude. Fort Laramie, on the Upper Platte, and 4500 feet above the sea, presents the same anomaly, being slightly above the mean temperature of the Atlantic coast, and slightly below that of the Pacific coast, on the same parallel. The posts of Upper Texas generally exhibit a slight reduction of temperature when placed at from 900 to 1500 feet elevation, but not such a reduction as would be the equivalent of these altitudes in Europe. In the Rio Grande valley of New Mexico, posts at the average altitude of 4000 feet show temperatures equal to those at sea-level for the latitude; those at 5000 to 6000 feet are much reduced in temperature; and those at 8000 to 9000 feet are so much reduced as to show some decided correspondence to European rules. Thus, El Paso, at nearly 4000 feet above the sea, has nearly the same mean annual temperature as Charleston, which is in the same latitude. Albuquerque, at 5000 feet, most nearly corresponds with Baltimore, 4½° of latitude farther north; Santa Fe, at 7000 feet, with New York, 5° of latitude northward;

and Fort Massachusetts, at 8400 feet, with points on the Atlantic coast at the 45th parallel, a difference of position of $7\frac{1}{2}^\circ$ of latitude. Comparing this point with Norfolk, in the same latitude, a difference of 18° 8′ in the mean annual temperature appears, or a degree for 445 feet of altitude nearly. At El Paso, a short distance southward, at Fort Laramie, not far northward of this position, and at Great Salt Lake, westward—each not far from 4000 feet above the sea—the reduction is not so much as a degree on the annual mean for 4000 feet of elevation. Under circumstances of so much diversity, it is easy to see that no rule can be employed until the entire surface has been observed or represented, and that the fullest comparison of actual observations, with the most careful generalization upon them, is necessary first to settle the facts of actual distribution, before any scale of reductions can be constructed.

The mountain ranges near the Pacific coast are everywhere sharp and high, yet their influence on the thermal condition is deemed less from their altitude simply, than from their obstruction of the atmospheric circulation. The coast itself is so peculiar as to present a greater source of diversity than that of altitude, and, consequently, even the high plains shut away from the sea have a higher temperature for this reason. The interior valleys of Oregon are warmer than the coast, though generally of considerable elevation. California has no high interior valleys, but the valleys it has exhibit excessive measures of heat when shut from the coast by mountain ranges. At great altitudes, this anomalous diversity becomes much modified, and it is doubtless ultimately sunk in the simple relations of vertical distribution alone; but, for the surface which we have to illustrate, and with which we have practically to deal, altitude has little of the significance in reducing temperature on the west slope of the United States which it has in the west of Europe.

It is obvious that the whole theory of vertical distribution of heat requires reconstruction, as applied to the surface of continental areas. There is no rule of uniform value or uniform adaptation, and the corrections required for surface observations, to remove whatever effect may belong to altitude, must be derived from a very thorough and complete collection of these observations themselves. It is probable that then the corrections will be absolute, and not proportional to the altitude; or that one plateau may require 10° of correction for altitude simply, and another 5°, and another no correction at all, though all may be four or five thousand feet high, and nearly alike in this respect. The *Coteaus* near the Upper Mississippi, at 2000 feet above the sea, reduce the temperature between 5° and 10° from elevation simply; the plain at Fort Kearny reduces it slightly at 3000 feet; that at Fort Laramie not at all for 4500 feet; the San Luis valley of New Mexico reduces it 10° or 15° for 8000 feet, &c. Such are instances of the diversity actually existing, where diversity could not have been anticipated. New and most interesting problems are presented by these facts of vertical distribution of heat, and the discussion of them must be reserved for the accumulation of observations from at least all representative positions.

The continental laws of distribution of heat at the surface are opened anew on this basis of American statistics, and the greatest difficulty is experienced in following it in the comprehensive manner which is enforced by the conditions of the subject. Anomalies are presented which may have their solution in facts disclosed in another hemisphere, and for the discussion of which the widest references must ultimately be made. Some of the apparent results may, however, be indicated with sufficient definiteness for the present purpose.

The most prominent point is the *general identity* of the distribution for the same latitudes of the two continents of the northern hemisphere, and the fact that the masses of these continents originate all the curvatures and peculiarities of position in the isothermal lines. In a word, if the continents were removed, all points having the same latitude would exhibit like conditions; and although this appears a plain proposition, needing no new assertion, yet, as here applied, it is intended to signify that the land masses cause uniform and symmetrical departure from the normal uniformity. It has been supposed that America was, to some extent, anomalous, and that it required or possessed a compensation in Europe; but these results give us a higher measure of heat in the south, in the interior, and on the north-west coasts of this continent, than has before been assigned to these districts. These additions bring it nearly up to the standard for the eastern continent, and for the difference that remains the vertical and outline configuration fully accounts.

The next great fact is the dependence,—subordination, it may be termed,—of this distribution on atmospheric and oceanic circulation, and an outline configuration in relation to these. When we find the east and west coasts of the same continent, at the 50th parallel, differing as largely as England and Manchouria and Pekin first, and as Vancouver's Island and Labrador next, it is impossible not to admit the superiority of the only agents which can cause such results—the circulation of the atmosphere and of the sea's waters. The continental influences exerted in the accumulation of heat and in refrigeration, if exerted without modification, would of course be as decided near the western border of the continent as near the eastern;—why, then, are they excessive at the east in both cases, and very slight at the west, if the agents alluded to are not controlling for these latitudes?

The currents of the sea exhibit influences in the Pacific somewhat different from those known in the Atlantic; in the last the warm currents afford the most signal modifications, and in the first the cold currents stand out most conspicuously, as on the coasts of Peru and of California. In California, the facts shown by records at exposed positions on the coast are scarcely credible, without the support afforded by observations of air and water temperatures at sea; and it is obviously indispensable to connect the two in any intelligible notice of the thermal condition of the land areas. Had sea temperature been measured on the British coast, and traced through the belt of warm water which so greatly controls the climate of all the west of Europe, it would have been seen earlier that the west of Europe was largely exceptional in its measure of heat for the latitudes above 40° and 45°. The currents of the Pacific are still quite obscure, and the origin of this refrigerated mass, which has so great an influence in California, can scarcely be settled.

Behring's Straits are too shallow to send it forth, and the Peninsula of Alaska, and the Aleutian Islands, constitute a barrier which must be turned by a current originating in the great northern areas of the Pacific, where the Japan stream mainly wastes itself. Still there seems no source so likely to send this mass forth as the great sea east of Kamtschatka, from which the answering current of the Japan stream must come, if one is returned at all. All the volumes of warm water flowing to higher latitudes elsewhere have equivalents in cold returning masses, and this appears to be a case where such a mass is overlaid by warm waters through nearly its whole course, and appears at the surface only when lifted by the shelving coasts of California.

The two exterior causes, the winds and the sea currents, accord in their action in the higher latitudes of this continent on the west, but conflict below the 45th parallel in the warmer months, producing the greatest changes of thermal distribution through the successive months which are experienced anywhere. These contrasts give the isothermal lines positions which may seem fanciful, and which are difficult sometimes to define. They cannot be placed hypothetically; and if the number of observations is insufficient for a positive definition, they must be regarded as approximations only. They are now so in the interior of Oregon, and for portions of the coast toward Sitka, for portions of the Saskatchewan region, of the Upper Missouri plains, and for the Great Basin southward of Salt Lake. In the warm months the isothermals are compressed into a singularly narrow space, from Monterey, on the coast, to Fort Millar of the interior, and to all parts of the desert basin east of the Sierra Nevada. The higher portions of this basin region, on both sides of the Colorado river, but particularly on the east side, at Fort Defiance, are very much refrigerated in winter also.

In the charts prepared by the writer for his report on the United States military post observations, great care was taken to place the isothermals according to the best analogies afforded by a knowledge of the topography and surface conditions, in districts where observations were wanting, as in those above indicated. This topography is itself a new result, derived mainly from the recent surveys ordered by the United States for military purposes, and for a Pacific railroad. The vertical topography has been made as prominent upon the charts of illustration as could readily be done, because of its inseparable association with the thermal condition everywhere. The representation is still wanting in completeness in that respect, however, and vertical sections can alone answer the whole requirement.

Another point of interest in American distribution of heat, is the frequent institution of thermal areas of too high a temperature to connect even with tropical districts. The whole area, from the 35th parallel to the coast of the Gulf of Mexico, is such for the summer months, being from 5° to 10° above the mean temperature of the seas, and the Central American land areas to the southward, at that season. This excess culminates in the Rio Grande valley, where the mean of 85° for the three months of summer is attained. A mean of 82° to 83° embraces a large area, stretching across to Charleston, and all the excess above 80° belonging to this is, at least, so much above the measure for the tropical districts in these months.

Northward, on the plains, an area, having a mean of 75° for these months, is stretched over a large tract, from the plains near the Arkansas, at 2500 feet above the sea, to the Missouri River valley, at 1800 to 2000 feet, and extending up this last valley above the 45th parallel. The uniformity here is in part due to altitude; the plain declining northward, and the surface favouring accumulation of heat in the warm months, in a somewhat increasing degree, as we advance in that direction. A line is hardly adequate to the representation required here ; an area tinted appropriately, and expanding from a line, to be again contracted to that form, would best illustrate the *actual climatological condition*, which alone can be given now.

In the desert valley of the Colorado of California, the district of greatest excess appears, and for the summer months this excess is far beyond the measure of heat on the west coast of Mexico, southward. The conditions observed at the Persian Gulf, and at the head of the Red Sea, are here reproduced, and the parallelism of the continents is fully shown in this as in other cases. How far this excess extends toward Great Salt Lake, it is impossible now to say, though, in a rigidly accurate illustration, a considerable area would appear to be surrounded by concentric isothermals, or by lines opening southward in a narrow neck along the Gulf of California.

In the San Joaquin and Sacramento valleys of California, the same concentric curve is again required for exhibiting the actual distribution of the climates. Both the coast and the plateaux of the Sierra Nevada differ extremely from the valley; and the segregation is nearly as abrupt at the south and at the north. Cultivable plateaux lie at the south at a great elevation; and as these decline toward San Diego and the coast, they are, on the whole, cool and equable, in contrast with the intense heats of the deep interior valley of San Joaquin. The modifying influences which exist everywhere, in greater or less degree, in configuration and altitude, appear to put on extreme phases in all these districts, and to produce anomalous and opposite results.

There are localities of a similar isolation, only in much less degree, in the valley of Lake Ontario, and in other portions of the north-eastern area of the United States, but they are of small extent. Generally, the high summer temperature, peculiar to the American climate, develops there readily at all points in the whole area under consideration; and in this respect it differs from Europe, though probably it departs less, or not at all, from Asia. It has Asiatic features in surface, character, configuration, and general climate, and decidedly so in this feature of thermal distribution.

The simple continental influences on this distribution of heat are worthy of a more extended notice than can be given them in this place. As said before, they are thrown near the eastern border of the continent, Labrador and the vicinity of Hudson's Bay exhibiting the highest degree of refrigeration known to those latitudes anywhere. But the lower latitudes, falling more particularly within the field of the present discussion, show an interruption of this line of maximum effect at the great lakes, softening the rigour of the winter cold, and thinning the line of minimum temperature at the west of Lake Superior, on the isothermals for the year. Notwithstanding the high summer temperature there, the excessive cold of winter throws the annual average below that for the cooler summer at various points of the same latitude eastward, and the greatest effect of continental refrigeration, as a single agency, is thrown out of the line it has at Hudson's Bay, and placed many degrees of longitude westward. The differences are small, however, and may be defined, in general terms, as the spreading of this line into a wide area, embracing the whole lake district, and affording several areas, signally marked by continental refrigeration.

Southward of the lakes, the maximum continental effect is again thrown eastward, and the line passes through Georgia and Florida for the months of winter, in which season alone it goes so far south in any relation to the atmospheric circulation. There is, indeed, but little difference between the plains of Opelousas, in Western Louisiana, and the central districts of Florida, at the same latitude, in regard to the measure of winter depression, and the high plains of Texas institute an extreme measure of continental refrigeration in winter, which is expended before reaching as far east as New Orleans, and which is felt most decidedly near the Sabine River of Louisiana.

This last general feature of thermal distribution applies to the extremes, or dynamics, of this condition, as they may be called, as decidedly as to the averages, or constants. The sweep of changes, and the range of non-periodic variations of every degree, is greatest along this line of maximum continental refrigeration. The means for successive years show this strikingly, and the range of annual mean temperature, *which reaches* 12° on the high plains of Wisconsin and Minnesota, is highest on a line south-eastward from those points to Augusta, Georgia, Norfolk, and Charleston, At Norfolk and Augusta it has reached 10°; the coldest year being 5° below the average, and the warmest 5° above that average,—a range really of the most extraordinary character, compared with the range in the annual mean in Europe, and on the Pacific coasts generally. In the New England States it is much less, and much less for a large area southward, including Philadelphia.

Each of the general features of thermal distribution, briefly touched upon in this paper, has relations to subordinate features of unusual interest, of which those relating to range and non-periodic variation are the most important. The constants of daily and monthly curvature are scarcely less interesting, and perhaps of greater value ; and all the divisions in regard to annual averages, or to those for the seasons, imply and embrace new divisions of each of these classes. Thus, on the California coast, the horary or daily curve almost disappears for the summer months, and the curve among the months quite disappears from May to October. In the interior valleys, before referred to as having excessive temperatures, both these curves are extremely sharp, passing through a great range.

It is obvious that the problems of thermal distribution require a more extended basis of facts than has heretofore been supposed necessary to their discussion, and *the temperate latitudes of the northern hemisphere* must at least be embraced in any discussion affecting large areas of either continent. It is, in truth, necessary to go still further, and to embrace the same latitudes of the opposite hemisphere.

The necessity of attention to oceanic circulation is enforced by American experience; for these currents, with the atmospheric circulation in the temperate latitudes, produce the most striking phenomena both here and in Europe.

The annexed Map exhibits the Course of the Isotherms for the Year; the following Table contains the results of some of the most interesting Stations:—

Mean Temperature of Stations on the Atlantic Coast, Longitude 67° to 80° W.

Names of Stations.	Altitude in Feet.	Lat. N.	Mean Summer Temp.	Mean Winter.	Mean of Year.
		° ′	° ′	° ′	° ′
Hancock Barracks,	620	46·07	63·33	16·41	40·51
Fort Preble,	20	43·39	65·24	24·70	45·22
West Point, N. York,	167	41·23	71·33	29·69	50·73
Fort Washington,	60	38·43	77·77	37·36	57·87
Fort Monroe,	8	37·0	76.57	40·45	58·89
Fort Johnstone,	20	34·0	80·19	50·60	65·68
Fort Shannon,	25	29·34	80·56	57·18	69·64
Fort Myers,	50	26·38	82·41	65·36	75·04
Rocky Mountains and Plains of their Eastern Slope, Longitude 95° to 110° W.					
Fort Laramie,	4519	42·12	71.94	31·14	50·06
Great Salt Lake,	4351	40·46	75.92	32·08	53·24
Fort Kearny,	2360	40·38	71·47	23·04	47·67
Fort Defiance,	7200?	35·44	67·61	28·74	46·92
Santa Fe,	6846	35·41	70·46	31·64	50·59
Fort Graham,	900?	31·56	82·48	48·75	65·76
Fort Chadbourne,	2120	31·58	76·77	45·87	62·38
Fort M. Scott,	1300	30·10	76·94	47·24	62·46
Fort Brown,	50	25·54	83·58	62·09	73·75
Pacific Coast, Longitude 120° to 125° W.					
Fort Vancouver,	50	45·40	65·65	39·54	52·65
Fort Reading,	674	40·30	80·0	46.13	62 09
San Francisco,	150	37·48	57·33	50.86	54·88
Monterey,	140	36·36	58·64	51·22	55·29

Descriptions of new Coleoptera from the Western Andes and the neighbourhood of Quito. By ANDREW MURRAY. (Plate III.)

PART I.

Most of our readers must be familiar with the name and reputation of Professor Jameson of Quito, from the notices which have appeared, in this and other journals, of the collections he has sent home, and of the new or rare species of plants and animals which he has discovered. The Professor seems to be one of those rarely-gifted individuals whose genius embraces every branch of science. It enables him, while ably discharging his duties as professor of chemistry in Quito, and officially superintending the Mint of the State, also to explore the unknown regions of the country he lives in, and to contribute stores of information, and valuable collections in every department of Natural History, to the scientific world in Europe. In illustration of this, it will be enough to refer to the extensive botanical collections transmitted by him to Professor Balfour and the University of Edinburgh, and to the orchids supplied to Professor Lindley of London; to the numerous new and beautiful plants which have been raised by the well-known successful cultivator and hybridizer, Mr Isaac Anderson of Edinburgh, from seeds sent to him by Professor Jameson; to the mud-gatherings for diatomaceæ which have been communicated to Dr Greville; and to the new or interesting birds sent to Sir William Jardine and Mr Gould. I also have been fortunate enough to participate in the treasures which Professor Jameson periodically lavishes upon his friends and correspondents in this country, and have at various times received collections of insects made by him during his excursions among the upper Andes. The principal portion of the insects which have come into my hands have been Coleoptera; and among them, besides many already known, which are noteworthy, from their geographical distribution and affinities, there are also several new and interesting species, which I purpose to describe in the following pages.

The most striking of these are not from the country immediately around Quito, (which Professor Jameson informs me is not rich in insects), but from the warm and wooded valleys of the Andes, where nature smiles and puts on her gayest attire.

As might be expected from its position (occupying as it does nearly a middle place between the countries on the east and west of the Andes), the district in question furnishes not only species peculiar to itself, but also others properly belonging to the countries lying on each side of it. A considerable proportion of those which I have received are species already familiar to entomologists, as inhabiting the large tract of country formerly known under the name of Columbia, now broken up into several smaller states. Among the most striking of these I may mention ;—*Pseudoxycheila bipustulata, Sterculia fulgens, Philonthus flavipennis,* and *dives*, the rare *Latona spinolæ*, and *Conotelus vicinus, Oxysternon conspicillatum, Hoplites Pan*, the magnificent *Chrysophora chrysochlora, Lasiocala fulvohirta*, &c., &c. Of the species already known as inhabiting the Peruvian side of the mountains, the numbers have been fewer, the most striking being the curious *Golofa Eacus, Cybister laevigatus, Scarites auriculatus*, &c. Besides these, there are a considerable number of species, differing from any known to inhabit the adjacent countries. Some of these, such as *Ancognatha Scarabæoides*, Erichs., *Heterogomphus Bourcieri*, Guer., &c., have been already described, but the most of them still remain unknown. I shall endeavour to reduce the number of these, by publishing from time to time descriptions of some of the species which I have already received, or may in future receive from Professor Jameson. This mode of recording them will necessarily render it impossible to follow out any determinate arrangement. I shall, therefore, not attempt any, but shall merely take them as they come to my hands.

Sphenognathus, Buq.

This genus, which was originally erected by Buquet (after Dejean), *Rev. Zool.* 1838, possesses much interest, as being one of the links which connect the New Holland *Lamprimæ* with the South American *Chiasognathi* and *Pholidoti.*

The only species which have yet been described are *Sphenognathus Prionoides*, Buq. ; *Sph. albofuscus*, Blanch ; and *Sph.*

Feisthamelii, Guer. The former, which was first described, comes from Columbia, and approaches most nearly to the new species which I am going to describe.

This is already known in collections under the MS. name of *Sph. Lindenii;* that name having been bestowed upon it by the Parisian entomologists, to some of whom I supplied it when I first received it from Professor Jameson. This name I have retained.

1. *Sph. Lindenii*, Murr. (Pl. III.; male, fig. 1; female, fig. 2.)

Mas.—Statura *Sph. Prionoides* sed postice parum latior et mandibulis longioribus. Castaneus, supra æneo-virescens, mandibulis elongatis, porrectis, deflexis et apice recurvatis, plusquam duplo longioribus capite; oculis cantho divisis; thorace et capite longa pubescentia fulva vestitis, tibiis mediis et posterioribus fere simplicibus. Long. 15 lin., lat. 7 lin.

Male of the form of *Sph. Prionoides*, but broader behind, and with the mandibles longer. Reddish chesnut brown; thorax and head darker than elytra; in certain lights the upper surface (except the mandibles) has a faint greenish brassy reflection, which is most marked on the elytra; head and thorax, and under side, clothed with a long fulvous pubescence, which disappears on the disk of the thorax. Mandibles porrected, rather more than twice the length of the head, bent downwards about one-third of their length from the base, and slightly reflexed and incurved at the apex (which terminates in a curved tooth), with a ridge running along their upper side, interrupted or bent about one-third from the base; coarsely punctate or granulated on the upper side; smooth and more finely punctate, and with much more pubescence on the under side, particularly towards the base. A row of small teeth on the inner side of each mandible. Palpi dark brown; maxillarypalpi longish. Antennæ 10-jointed —first joint long; second, third, and fourth, short and round (third longest of the three); six last lamellar, gradually increasing to the ninth, which has the longest lamella. They do not differ from the antennæ of *Sph. Prionoides*, unless in that they are comparatively thicker, and the lamella of the ninth joint is perhaps more certainly longer than the tenth, while in *Prio-*

noides they are so nearly alike as to make it difficult to say that the ninth is longest. Eyes divided by a canthus, into a superior and inferior eye; a ridge surrounding the upper half of the eye like a circular eyebrow. *Thorax* coarsely punctate, except on disk, where it is more sparingly punctate, and has one or two prominences, shining and almost free from punctures. A large longitudinal depression occurs on each side in front behind the eyes, and an oblong transverse space is partitioned off, as it were, at each of the posterior angles, by two depressions which join each other nearly at right angles. There is a faint indication of a longitudinal dorsal line. In front the thorax is of the breadth of the head, and gradually becomes wider till about one-third of its length from the base, when it turns and slopes off more abruptly in a sinuated line towards the base, which is slightly emarginate. The pubescence, combined with the slight cutting in on each side of the body, gives the appearance of a tooth projecting there a little backwards. The space between the thorax and elytra, which in all the species of this genus is rather broad, is covered with a pubescence similar to that on the thorax, as is the scutellum, which is large, and nearly semicircular. *Elytra* polished and shining, and free from pubescence, covered with very minute punctures, not perceptible to the naked eye, which in many places run into each other, and give a sort of granular or chagreened appearance under the lens. Besides these, there are larger punctures or depressions irregularly scattered over the elytra, in places showing a slight tendency to run in rows. There are also a few shallow longitudinal depressions, which may be viewed as evanescent striæ. They are slightly depressed around the scutellum. The shoulders, and an elevation or haunch near the outer margin, towards the apex, are prominent. The elytra are expanded a little for the posterior half, and each is rounded in a little towards the suture; a distinct marginal line or thread, reflexed towards the base, goes round the elytra. *Legs* light, reddish chestnut-brown; tarsi long, and dark brown; anterior tibiæ long, flattened, incurved, obtusely denticulated on the outer margin; middle tibiæ with two or three very small teeth; posterior tibiæ with scarcely perceptible indications of denticulation.

The differences between the male of this species and that of *S. Prionoides*, are the following, viz.:—The mandibles in the former are nearly twice as long as in the latter, and are closer set together; the bend or interruption in the ridge on their upper side takes place at one-third from their base, while in *Prionoides* it is at one-third from their apex; and in the latter the ridge runs nearly straight to the head for the posterior half, while in the former it is curved for the short distance it has to go after the bend. The maxillary palpi here are comparatively longer. The thorax is somewhat differently shaped; it tapers towards the front more rapidly in this species. The punctuation is closer and deeper in *Prionoides;* the pubescence in it is cinereous; in this it is russet, or fulvous yellow; it is also in greater abundance here. The æneous lustre on this species is very distinct, while in *Prionoides* it is either wanting or scarcely perceptible. The elytra in this expand distinctly behind; in *Prionoides* the sides are more parallel to each other; in the latter the anterior tibiæ are narrower, and the teeth on the outer margin sharper and more developed; on the middle and posterior tibiæ the small teeth are distinct; whilst in this species they are either awanting or scarcely perceptible.

Femina.—Castanea, thorace transverso parce pubescente, angulis posticis virescentibus, corpore subtus cinereo-fulva pubescentia vestito. Mandibulis curtis, obtuse rotundatis, longitudine capitis; tibiis posterioribus, fere simplicibus. Long. 18 lin., lat. 8 lin.

Female.—Larger and broader than *Sph. Prionoides*, and with differently formed mandibles; dark chestnut; the posterior angles of the thorax virescent, the rest of the body without any brassy or green lustre; under side covered with a dull fulvous pubescence, which occurs also sparingly on the thorax. *Head* coarsely granular, with a transverse ridge having a granular elevation on each side in front, a somewhat triangular granular elevation extending backwards behind this. Mandibles short, like those of the female of *Chiasognathus Grantii*, and obtusely rounded, not longer than the head; inner side straight, denticulated, fitting to opposite mandible; outer margin raised, so that when the mandibles are closed they have the form of a shallow cup ; their upper side is coarsely granular, lower side rounded, punctate, and pubescent ; an oblique sharp ridge extends along the posterior half of the upper side. Eyes as in the male. The antennæ and palpi are comparatively shorter and thicker than in the male. *Thorax* transverse, and of a similar form, but not sloping so rapidly back to the projecting posterior angle, making the whole thorax broader and larger. A large depression on each side in front, between the eyes, and large depressions in each of the posterior angles, leaving a smooth elevated figure, of the shape of a widely expanded V, on the disk, which shows indications of a dorsal longitudinal line ; deeply and densely punctured on the sides ; more sparsely, but still deeply on the disc, which is polished. *Elytra* long and broad, somewhat expanded behind, wholly covered with minute punctures, scarcely visible to the naked eye, but coarser than in the male ; also covered with larger corrugations, mostly running transversely, and some of which exhibit a tendency to longitudinal striation. The *tibiæ* are a good deal shorter than in the other species. The anterior tibiæ are broader, and the two last teeth are larger and more prominent. The middle tibiæ are denticulated, one tooth at least being sharp and prominent. The posterior tibiæ are almost simple, the denticulations doing little more than roughening their edge.

The above two insects are the only species of this genus which I have received, and as the one form is that of a male and the other that of a female, I assume them to be male and female of the same species. Perhaps this is jumping a little too rapidly to a conclusion ; but they do not differ more from each other than the sexes of the other species do ; and the fact that I have received considerable numbers of each, and never any other male or any other female form, induces me to think that I am right in classing them together.

Phanæus, M'Leay.

Ph. velutinus, Murr.

Mas.—Niger, opacus, sericeo-opalino-velutinus, thoracis lateribus, pygidio et femoribus subtus, rubro-cupreis, elytris leviter striatis; subtus minus opacus. Long. 8 lin., lat. 5¼ lin.

Male.—Deep black, opaque, with silky velvety opaline reflexions. *Head* with a nearly straight horn, very slightly bent back, scarcely longer than height of thorax; front and sides of head transversely strigosely granulated. *Thorax* excavated in front, and with two tubercules in the middle, projecting over the hollow, much broader and deeper in front than behind, the anterior angles projecting a little, and slightly reflexed; a narrow irregular space along the margins, of a rich dull red metallic copper colour, which also extends over the reflexed margin at the side of the posterior angles of thorax. There are two shallow depressions at the base of the thorax in front of the scutellar space. No scutellum. *Elytra* contracted at the base, margined with a raised line and reflexed margin, faintly striated; the striæ dull and impunctate, and each ending in a fovea at the base. *Pygidium* very faintly and sparingly punctate, opaque, of the same rich dull red metallic copper colour as the margin of the thorax; as also are the under sides of the thighs. *Under side* less opaque than upper; mesosternum not produced, nearly diamond shaped; anterior point of it a little pinched in, and with a slight depression behind it; anterior tibiæ, with two teeth and a sinuation, besides the terminal tooth.

One of the smallest species of *Phanæus.* A single male specimen is all that I have seen.

Chlorota, Burm.

1. *Ch. lineata*, Murr.

Statura *Euchloræ viridis*, sed magis elongatus et postice latior, nitens, viridis, levissime punctatus; elytris viridibus cum tinctura testacea translucenti disposita in vittis; mesosterno fortiter projiciente; uno ex unguiculis anterioribus bifido, unguiculis ceteris simplicibus; subtus roseo-cupreo-viridi. Long. 12 lin., lat. 6 lin.

Nearly of the same form as *Euchlora viridis*, but a little more elongate, and the elytra a little expanded behind; bright green, polished, shining, exceedingly faintly, irregularly punctate. *Head* with a few scattered, nearly imperceptible, punctures on the forehead, deeply and closely punctate along the clypeus; a black line like a crack starts from the corner in front of the canthus of the eye, and after a short distance breaks into two branches, which soon disappear; as in the rest of the genus, a short canthus half separates the eye into two. Labium emarginate. *Thorax* bright green, with a faint testaceous tint shining through here and there; very smooth on the disk, but a few small scattered punctures may be seen by the aid of a lens, and these are more numerous and visible (although still very faint and sparse) along the sides. The punctures are nearly uniform in size, not large and small mixed together; a marginal stria runs along the sides, not reaching wholly to the basal margin, is continued round in front of the anterior angles, but disappears immediately after; no marginal stria along any part of the base. *Scutellum* elongate, very smooth, nearly impunctate; the apex and margins next to it black. *Elytra* green, with a testaceous tinge shining through, which is disposed in longitudinal stripes,—in my specimen there are three such stripes visible on each elytron,—polished and shining, with scattered minute longitudinal punctures, disposed somewhat in rows, not visible to the naked eye. There are several impressions, like effaced striæ, and a few larger punctures, disposed irregularly along the margin near the base, like a marginal stria. *Pygidium* bright green, with a bronzy hue in some lights; irregularly transversely strigose. *Under side* and *legs* rich rosy copper, with the middle of the breast and basal portion of abdominal segments bronzy green; prosternum, sides of breast, and edges of thighs, thickly clothed with a fulvous pubescence; abdominal segments, except the last, strigosely punctate, with occasional hairs springing from the punctures, which are arranged chiefly in an irregular line, parallel with margins of the segments; last segment smooth and impunctate, except on the margins. Mesosternum produced into a strong decumbent spike, recurved at the apex; sides of breast obliquely strigose; middle, impunctate behind, but punctate in front; the punctures (from most of which a hair proceeds) extending up the mesosternal projection to nearly the point where the punctuation is abruptly terminated by a fine rounded line; a black suture runs down the middle of the mesosternum, with a branch projecting from each side, near the middle, like an arrow-head. One of the anterior claws of the only specimen I have received is bifid, while the middle and posterior tarsi have both claws simple, thus showing that my specimen is a male.

It is possible that the testaceous tinge seen shining through the green in this species, and forming the stripes on the elytra, from which I have given it its name, may appear more or less distinct, according to the maturity of the insect. Having received only one specimen, I cannot say as to this; but my specimen seems in all respects fully matured.

2. *Ch. Euchloroides,* Murr.

Statura fere *Euchloræ grandis,* et colore, et facie supra, et simillima. Politus, nitidus, viridis, punctatus, punctis majoribus et minoribus intermixtis, scutello grandi, mesosterno fortiter projiciente. Long. 13 lin., lat. 8 lin.

Nearly of the form of, and exceedingly resembling, *Euchlora grandis,* in colour and facies. Green, shining, and polished. *Head* finely and densely punctate, particularly in front. *Thorax* densely and finely punctate; the interstices between the punctures filled with a still finer punctuation, and both crowded together into a kind of granulation on the sides of the thorax. There is a marginal line and raised margin along the sides, which disappears after turning the anterior angles, and scarcely turns the posterior. The raised margin is more or less testaceous, sometimes quite yellow, and sometimes green, with a yellow tinge shining through. *Scutellum* large, longer than broad; the apex and adjacent margins black; very faintly punctate. *Elytra* green, with reflexed margin, which is more or less yellow, or green, tinged with yellow shining through; punctate, the punctures as if made from behind, some disposed in striæ, of which depressed traces are seen. *Under side* and *legs* green, with a faint coppery tinge in certain lights, particularly along the margins of the segments of the abdomen; pubescence on posterior sides of breast and edges of thighs not so dense as in preceding species; mesosternal projection and middle of breast with nearly the same markings as last species, but stouter and not punctate. I have only received female specimens with the tarsi perfect. They have the exterior claw in each tarsus bifurcate, as is the character of the claws of the female in this genus.

Leucothyreus.

1. *L. Gigas*, Murr. (Pl. III., fig. 5.)

Supra castaneo-cuprescens, glaber; antennis articulis decem, castaneis, clava rufa; capite magno, grosse denseque punctato-rugoso; prothorace fortiter punctato, lateribusgrosse punctatis-rugosis, marginibus denticulatis; scutello punctato; elytris inequalibus, lineis læviter elevatis signatis, humeris et spatio prope apicem prominentibus, læviter punctatis, punctis minoribus et majoribus interspersis; subtus cuprescens, sparsim fulvo-pubescens; pygidio punctato. Long. 14 lin., lat. 5½-6 lin.

Oblong, and rather depressed; dark, dull, coppery, reddish chocolate-brown, with dull reddish metallic lustre in parts, especially on the head and thorax, and thighs and abdomen; glabrous above. *Head* very large and broad, rounded in front, very deeply, thickly, and coarsely punctate; the clypeus chocolate brown, separated from the forehead by a faint suture; the forehead dull, coppery, reddish brown. Antennæ 10-jointed, chestnut-brown; club, pale and reddish. Eyes large, but not prominent; a short canthus encroaches on the anterior half. Labrum large, declive, projecting in front, foveolate; slightly metallic, and with some scattered fulvous hairs. *Thorax* short and broad, bisinuated behind, deeply emarginate in front; anterior angles prominent and acute, widest a little behind the middle; whole surface covered with large punctures, less deeply impressed on the disk, but very deep, coarse, and rugose on the sides, extending to and upon the raised lateral margin, which appears irregularly denticulate, as if from the large punctures having pierced through the edge and left circular breaks in its continuity. This raised margin is distinct and well marked on the sides, and extends along the base, but is awanting in front. The basal raised margin is virescent; there is the trace of a dorsal smooth ridge most distinct in front. The *scutellum* is dull metallic red, with virescent margins; it is triangular, with the apex rounded, and is distinctly punctate, though not so coarsely or deeply as the head and thorax; a faint irregular impunctate raised line passes down the middle. The *elytra* are smoother, particularly on the disk; but are so closely covered with minute punctures as to have something of an opaque appearance. Besides these minute punctures, there are others of various larger sizes scattered among them; and a third class of still larger punctures is also to be seen, which have a tendency to run in striæ. The whole of these punctures, however, are very shallow, and have no resemblance to the deep punctures on the head and thorax. They are most deeply impressed about the base of the elytra. The disk is flattish, the shoulders are prominent, and a sort of ridge connects them with an apical prominence, the sides falling rapidly down on each side, and expanding somewhat behind; the wings are long and brownish. *Pygidium* finely punctate—most closely and finely at base. The *under side* is of the same colour as the upper; the abdomen and thighs are smoother and more shining. Prosternum, and especially mesosternum, clothed with longish fulvous pubescence; mesosternum coarsely punctate; segments of abdomen more faintly and sparingly punctate; punctures deepest along the margin of the segment; legs coppery, dark reddish brown, with faint metallic lustre; anterior tibiæ with three teeth; tarsi moderate in length, and slightly thickened. In the only specimen I have received, the middle tarsi have the outer claw bifid, and the posterior tarsi the claws simple;—the anterior claws have been broken off.

Ancognatha, Erich.*

1. *A. Jamesoni*, Murr. (Pl. III., fig. 4.)

Testacea, nitida; vertice, pronoti disco, elytrorum disco et margine plus minusve nigris vel piceo-nigris; pronoto elytris

* Notwithstanding the high authority of Professor Lacordaire (Hist. des Ins. iii., 399), who disallows this genus, and retains it as a portion of the Genus *Cyclocephala*, I agree with Erichson in holding that the characters he has given, more especially the recurved mandibles, are sufficient to justify its being retained as a distinct genus, although they may not be of equal value with those of the great genus from which he has separated it.

augustiore; scutello lævissime punctato; elytris geminato-punctato-striatis, postice parum dilatatis; geniculis, tibiis extus et tarsis plus minusve piceis. Long. 12 lin., lat. 6 lin.

Testaceous, more or less clouded, or marked with black, or piceous black. *Head* conically produced, and recurved like a sow's snout; rugosely punctate, the edges and front with a reflexed black margin; two tubercules, united by a curved ridge between the eyes, making a slight separation between the front and back of the head; these tubercules and ridges, the vertex and the reflexed margins of the head, are all more or less distinctly marked with black or dark brown. Mandibles black, protruding, tapering, recurved; but not reaching so far as the end of the snout. Palpi and antennæ blackish brown; antennæ with ten joints. *Thorax*, with two or three depressions or irregularities in the surface on each side of the disk; more or less clouded with black or dark brown, often enclosing two testaceous spaces on the disk; smooth and shining, sparingly punctate, at its widest narrower than the elytra; when seen in profile, not rising in a curve from the base, but proceeding straight forward, and rounding down towards the apex; margin with a raised edging along the sides in front and a short part of the base next the angles, but not on the middle of the base, which is slightly bisinuate; sides rounded, slightly oblique behind, widest a little before the middle, rapidly contracted in front; anterior angles slightly projecting; posterior angles rounded. *Scutellum* triangular; lateral sides very slightly sinuate; sparingly and faintly punctate; testaceous, with a larger or smaller black or dark patch, which is more or less interrupted with testaceous. *Elytra* shining, of rather a coarse texture, more or less clouded with black, the extent of the black varying much. The testaceous portions are usually a space around the scutellum, extending a short distance along the suture and along the base, sending down for a short distance about the middle an arm parallel to the suture, then to the shoulder, after rounding which, at the very base, it turns down and sends an elongated stripe parallel, or nearly so, to the exterior margins, sometimes continuing more or less distinctly round the whole elytron, till it reaches the suture near the apex, where there is almost always a testaceous patch on each side of the suture. The sides of the elytra are not quite parallel, being a little expanded behind the middle. Each elytron is deeply punctate striate, as follows, viz.,—a single regular row of punctures runs next the suture, then follows a space with two or three irregular rows, then two regular rows, then two or three irregular rows, then two regular rows, two or three irregular rows, two regular rows, and the remainder irregular rows. Margin with a reflexed border, which is expanded about the middle of the elytron. *Pygidium* testaceous, rather large, smooth and impunctate; upper side of penultimate segment of abdomen finely punctate. *Under side* of body wholly testaceous; mesosternum clothed with long fulvous hairs; prosternum less hairy, and abdomen with only a few hairs along the margins of the segments, where, as well as on the sides, there are a few punctures. *Legs* testaceous, with a tinge of piceous or brown at the knees, and along the outer margin of the tibiæ; the anterior tibiæ have three teeth. The tarsi wholly piceous, long and slender. The claws simple, and of equal proportions.

This species bears considerable resemblance to *A. ustulata* (Dej.), Burm. Its system of coloration is the same, and its general form is also very near it; but it is larger, of a coarser texture, and has the head and thorax punctate, and the elytra punctate and geminato-punctate striate; whereas in *ustulata*, the head and thorax are smooth and impunctate, and elytra only very faintly punctate.

I have received many specimens of this species from Professor Jameson, in honour of whom I have named it, but I do not find in any of them the thickening of the anterior tarsi, usually seen in the males in this genus. It may be that they are all females, but I have not been able to ascertain this by dissection, in consequence of the interior of the insects having been eaten away by larvæ on their way home.

2. *A. crassimanus*, Murr. (Pl. III., fig, 3.)

Præcedenti valde affinis, sed major et robustior, capite et mandibulis grandioribus; thorace latiore, latitudine elytris equali; scutello fortiter strigoso-punctato; elytris fere parallelis, vix postice dilatatis; pedibus anterioribus valde incrassatis.

Colore testaceo, thorace macula oblonga dorsali, et duabus parvis maculis rotundatis in angulis anterioribus piceis signato; elytris maculis parvis humeralibus et apicalibus piceis signatis. Long. 13½ lin., lat. 6 lin.

Closely allied to the preceding species. Testaceous, with the back part of the head, a dorsal elongate patch and two faint spots in the anterior angles of the thorax, a patch at the base of the scutellum, the sutural line and the exterior margin, as well as a humeral and apical spot in each elytron, piceous or blackish brown. *Head* finely rugosely punctate, projecting very much, and turned up like a sow's snout; the margins with a reflexed black border; the mandibles projecting forward, and recurved like a boar's tusks, extending a third of their length beyond the muzzle; a curved transverse depression between the eyes. The back part of the head marked with a transverse line of black, widest in the middle. *Thorax*, very convex when seen in profile, rising with a curve both from the base and apex, widest a little before the middle, broader at its widest than the elytra; anterior angles acute and produced; posterior angles obtuse and rounded; base bisinuate. It has a reflexed piceous margin all round, most distinct on the sides, which are so much expanded and reflexed as to leave a small gutter between the edge and the body of the thorax; is covered with scattered shallow punctures, and somewhat granular towards the sides. *Scutellum* rounded; triangular, granular, or rugosely punctate at the apex; smooth behind. *Elytra* with the sides nearly parallel, and scarcely dilated behind the middle; with a reflexed margin, most prominent in the middle; punctate striate, the striæ running in pairs, and the interstices irregularly punctured, as in the last species. *Pygidium* with some longitudinal corrugations. *Under side* of body testaceous, with a testaceous pubescence, principally on the mesosternum. The anterior legs are very much thickened, and the tarsi, and more especially the last joint and claws, greatly developed. The anterior tibiæ have three teeth; the middle and posterior thighs and tibiæ are robust, but the tarsi are long and slender. The outer claw of the anterior tarsi is much larger than the inner. The middle and posterior claws are simple, and of equal proportions.

Although this species is very closely allied to the preceding,—so much so as to suggest the idea of its being its male,—I find so many points of difference which I cannot consider sexual, that I am satisfied it belongs to a distinct species. Putting aside the difference in colour, which may be ascribed to the score of variation, the much more developed mandibles, and the immensely thickened legs and anterior tarsi, and the smaller pygidium, which may be viewed as sexual (although in no other species of the group are sexual differences developed to such an extent), we have very marked differences in the proportions and form of the head, thorax, and elytra; the head is proportionally broader and more projecting in front, and the inequalities on the surface are fewer and less marked than in *Jamesoni;* the thorax and elytra are more shining and smooth in the latter, the punctures deeper and better defined. The thorax is of a different form; in *Jamesoni* it is not nearly so convex, the curve proceeding gently and gradually from the base without any rapid or abrupt rise; while in *Crassimanus* it takes a very marked rise, both in front and behind; in the latter also it is broader than the elytra; in the former considerably narrower. The former has the anterior angles only slightly produced; the latter has them much more projecting. The reflexed margins are greatly more marked in *Crassimanus*, which also has the margin all the way round; while in *Jamesoni* it disappears on the base. The scutellum is smooth and nearly impunctate in the one; in the other it is strigosely granular. The elytra in *Crassimanus* are proportionally longer and narrower, and are nearly parallel, very slightly, if at all, dilated behind; while in *Jamesoni* the dilatation is well marked. In it the pygidium is smooth and shining; while in this species it is dull, and has a number of longitudinal grooves or striæ. These differences satisfy me that the two species are distinct.

I have only received a single specimen of this species, and its very curious greatly-developed anterior tarsi leads me to suppose that it is a male.

On the Influence of Magnetism over Chemical Action.
By H. F. Baxter, Esq.

The following inquiry originated in an endeavour to ascertain whether *Magnetism* possessed any influence over *Organic Forces*, and the kind of experiments that were undertaken for the purpose of solving this question, was that of submitting seeds *during* vegetation to the influence of magnetism.* These experiments, however, having failed to give us any definite or decided result, we were ultimately, and perhaps naturally, led to ask ourselves the question, *Does magnetism possess any influence over chemical action?* The solution of this question appeared to be almost a necessary preliminary step to the continuation of our original inquiry.

We shall not in the present inquiry enter into any lengthened detail of the numerous experiments we have undertaken, the results of which were negative, but proceed at once to the main object of our paper, which will be, on the present occasion, the influence of *Magnetism* (in its *static*† or quiescent condition) over *chemical action*; leaving the second part of our inquiry —the influence of *Magnetism* (in its *dynamic* condition, or when in motion) over *chemical action*—to a future occasion.

Part I.—*The Influence of Magnetism (in its static or quiescent condition) over Chemical Action.*

For the convenience of discussion, we shall arrange our present subject under three heads, reversing the order we pur-

* To the Council of the Royal Society, who liberally granted the use of their large magnet, and to Professor Wheatstone, for the loan of his large electro-magnet, we are greatly indebted, and also to the Government Grant Committee of 1855, who granted the sum of £30 for the purpose of carrying on the present inquiry.

† We feel some difficulty in thus expressing ourselves. Can we, for instance, consider the *force* in a steel bar magnet, when quiescent, as being in a *static* condition? We cannot do better than refer to Professor Faraday's papers, and amongst others to that published in the *Phil. Mag.*, June 1852, *par.* 3251, 3269, for the purpose of expressing *our* meaning. We have no wish to depreciate the opinions of other philosophers, but stronger reasons than those that have been already urged against us for adopting the opinions of this eminent individual, must be assigned before we can consider his views as incorrect; whether we are right or not *time* alone must show.

sued in our inquiry. *First*, On the *directive* influence of magnetism (static) over *chemical action; Secondly*, Does magnetism (static) *increase chemical action?* and, *Thirdly*, Does magnetism (static) *excite* or *originate chemical action?*

§ I. *On the Directive Influence of Magnetism over Chemical Action.*

Professor Wartmann,* in the course of his investigations, found that when a bar of iron was magnetized, and placed in a solution of sulphate of copper, a *rotation* of the fluid occurred around the pole. Chemical action of a certain intensity, and that the bar should be in a state of magnetization, were, he considered, requisite and necessary conditions. He refers it to "a new instance of electro-magnetic rotation;" and also states that Professor Grove, by placing an iron bar, suspended to a powerful magnet, in dilute sulphuric acid, had observed the same phenomenon, and that Professor Christie had likewise obtained this rotation.

In the following experiments we made use of a straight bar electro-magnet, in the following manner:—The bar, of soft iron, was fifteen inches in length, and seven-eighths of an inch in diameter. To one end a glass vessel, five inches deep, two inches and three quarters in diameter, open at both ends, was fixed by means of a cork, through which the bar passed to the extent of two inches. This experimental cell, which we shall designate as the upper cell, so arranged, was capable of holding ten ounces of fluid. The other end of the bar could be easily passed through the helix, and placed in another glass cell, containing any solution or not, according to circumstances, and this we shall hereafter designate as the lower experimental cell.

The *helix* consisted of about three hundred yards of covered, rather thin, wire; it was four inches in length, one inch in internal diameter, and one inch and a half in external diameter.

The *battery* consisted of six of Grove's middling-sized cells.

Pouring some saturated solution of sulphate of copper into the upper cell, but not to cover the bar, and looking down

* *Phil. Mag.* 1847, p. 363.

upon the bar, no effect is at first observed: after a short time, as the copper is deposited upon the bar, a slight narrow *rotation* may be observed around the bar, near the surface or sides of the bar; this may, however, soon subside, and some considerable time elapse before the *rotation* recommences. It is best seen when fine particles are floating *in* the solution, and may be observed below the surface before the upper layer of the solution is affected. If pieces of cork, or any other light substance, be placed on the surface of the fluid, they usually floated either to the side of the bar or to that of the vessel. The *rotation* extended to some distance from the bar, and upon looking down upon the fluid, it had the appearance as if the whole mass moved. It generally occupied two minutes in making a complete circuit, it was, however, sometimes less, and at other times longer. Shaking the vessel did not put a stop to the rotation. Adding a few drops of nitric acid to the solution increased the effect, and by rendering the solution darker, made it more distinct; but it was found that if too much acid was employed, and if the hydrogen gas was evolved too rapidly from the surface of the bar, the rotation soon ceased. Stirring the fluid round in the contrary direction to that taken by the fluid during *rotation*, did not destroy the latter, it soon regained its former direction.

The *direction* of the rotation was dependent upon the pole of the magnet. When the wire connected with the zinc end of the battery was uppermost, and consequently the upper end of the bar corresponded to the marked pole of a magnetic needle, the *rotation* went from right to left, round by the east, through south, to the west. Upon *reversing* the poles, the *rotation* was *reversed;* and upon breaking the circuit entirely, it ceased altogether. The *rotation* appears, therefore, to be in the contrary direction to that which is supposed, according to Ampère's theory, to circulate around a bar-magnet.*

* Wartmann states, that "it is directed like the current of Ampère:" but he calls that the north pole, "at which the current enters." Some, we believe, consider the pole of the magnet, which points to the north, to be in reality the south pole of the magnet. We think we are right, however, in considering that the *current* which is supposed to circulate around a magnet, in accordance with Ampère's theory, is similar in direction to that which circulates around the helix forming the magnet.

When the cell was completely filled with the cupreous solution, so as to cover over the pole, the *rotation* did not appear to extend but just above the pole.

The *lower* end of the bar was placed in a glass jar, two inches and a quarter in diameter, and four inches deep, containing some of the cupreous solution, extending about an inch up the bar. The *rotation* was observed as in the upper cell, but in the *reverse* direction, and in the *same* direction as if the lower pole had been *inverted*, looking upwards. Under the supposition that currents circulate around the magnet in a certain determinate direction, according to the theory of Ampère, we expected to find that the *rotation* would have occurred in the same direction as in the upper cell, whilst the bar continued in the same position, being straight, and not of the horse-shoe shape; but the *rotation* was in accordance with the nature of the pole, whether inverted or not.* It occasionally happened, however, and this at first misled us, that an apparent rotation occurred in the opposite direction, which evidently arose from the following circumstance: upon pouring some of the solution into the vessel, from the narrow space that existed between the bar and the sides of the vessel, a circular motion of the fluid was produced; and if a slight evolution of hydrogen gas occurred upon the surface of the bar, this assisted in keeping up this circular motion. Filling the glass carefully with the solution, this motion was prevented from occurring, and the *rotation* was ultimately observed to take place as we have stated; it did not occur, however, high up the bar, but was very distinct near the end of the bar. Occasionally two distinct circles were observed to occur, rotating in the fluid, separated by a narrow band of liquid. Whether this narrow band was quiescent, or whether it was rotating, but not apparent from the particles not being perceptible, we are at present unable to decide.

The appearance of the *rotation* in the two cells was, generally speaking, not simultaneous, although the same solution was employed, the poles equidistant from the helix, and the

* Since this paper was written we have found that De la Rive has made similar observations upon the electro-magnetic rotations of mercury.—(*Mémoires de la Société de Physique de Genève,* t. iii. p. 127.)

two vessels of the same size and diameter. It usually commenced in one cell earlier than in the other.

Instead of the *cupreous* solution we now employed *dilute sulphuric acid* in the same manner. In these experiments we obtained the *rotation* as before, and in the same *direction*, being *reversed* when the poles were reversed, and *ceasing* entirely upon the *breaking* of the circuit. It was necessary, however, in these experiments to take care that the *acid* solution should be very weak, for it was found that a too rapid evolution of hydrogen gas created currents in the fluid, which interfered with the results. The *rotation* did not commence immediately; and under the supposition that the density of the fluid might have some influence, we dissolved some sulphate of iron in the solution with apparent advantage.

It was interesting, in these experiments, to observe the iron, as it separated from the bar, thrown off in jerks, like radii, at right angles to the bar, to some distance in the fluid, where it gradually dissolved ; or forming a thin convex layer, like the upper surface of an open umbrella. At these times, however, the *rotation* was not observed, and it was only during the time when the evolution of gas took place very quietly that it occurred.

When a solution of *sulphate of zinc* was employed in the same manner, we did not obtain any effect, but upon adding some nitric acid to the solution, the *rotation* ultimately occurred as in previous experiments.

As far as we have thus gone, our experimental results confirm those obtained by Wartmann, and perhaps those of Grove and Christie ;* and we shall now make one or two observa-

* The only knowledge we have of the experiments of the two latter philosophers is from the facts, as related by Wartmann (*loc. cit.*). We ought, perhaps to allude to the experiments of Mr Hunt, recorded in the " Philosophical Magazine," June 1846, and in the " Memoirs of the Geological Survey of Great Britain," vol. i. 1846, in which he caused different solutions to react upon each other over the poles of an electro-magnet of the horse-shoe form. When he employed a solution of caustic potash and muriate of tin, " curves of repulsion" were formed, which were reversed upon the reversal of the current. We have employed similar solutions in a similar manner over the pole of a straight bar electro-magnet, as well as over the poles of the electro-magnet of the horse-shoe form ; but we have not been able to obtain any *rotatory* motion, the effects were those of *repulsion*, and appeared to be similar to those observed

tions in a general manner, in reference to the circumstances which appear to us to be influential in producing or interfering with the results. These may for the present be considered under three heads :—*First*, The *strength* of the magnet; *Secondly*, The *density* of the fluid ; and, *Thirdly*, The *chemical action*. If the chemical action be of that nature that a gas is evolved from the surface of the magnet, and powerful in its action, so as to occasion a rapid evolution of gas, vertical currents are created in the fluid, which interfere with the *horizontal* motion ; and no *rotation* is observed. On the other hand, as already remarked by Professor Wartmann, unless the chemical action occur, and is of sufficient intensity, and what is, we may add, of the utmost importance, unless it should *continue*, the *rotation* is not obtained. With the cupreous solution we frequently observed the *rotation* to occur, then stop for some time, and ultimately recommence and continue. If the bar be perfectly smooth and polished, the copper is deposited in a firm compact layer, difficult to remove, even by scraping; this appears to put a stop to the chemical action, and the rotation is checked; should the bar, however, not be polished, the copper is deposited in patches, easily removed, presenting a striated appearance, and does not form a firm, compact covering to the bar. This copper falls off in flakes, and, as the chemical action is thus allowed to go on upon the surface of the bar, the *rotation* continues. That the *density* of the fluid is not without some influence, may be seen in those instances in which sulphate of iron was added to the *acid* solution with manifest advantage. In these instances it could only have acted by increasing the *density* of the fluid, and not by its chemical agency. We shall relate some other experiments presently, in which the same facts were observed.

If the magnet be *powerful*, as appears to have been the case in Professor Grove's experiments, light bodies, such as pieces of cork, may be made to rotate around the pole. It is reasonable also to suppose, that, in those cases in which the

by Plücker in his experiments (Taylor's Scientific Memoirs, vol. v. p. 567), and by Matteucci (Comptes Rendus de l'Académie des Sciences, 23 Mai 1853), and may be considered as *diamagnetic* in their character.

chemical action is either too weak or too powerful (from the evolution of gas) for the *rotation* to occur with weak magnets, it would become manifest with *powerful* magnets.

The question now arose, Is it necessary for the *rotation* to occur, that the *chemical action* should take place *upon* the magnet?

Rings of the following metals—zinc, copper, and tin—were procured, each two inches in height, and one inch in diameter. These rings were placed over the ends of the iron bar, with a layer of caoutchouc in the form of a cap, intervening between the bar and the ring, for the purpose of preventing any chemical action from taking place upon the iron bar. With the *zinc* rings surrounding the ends of the bar, and very dilute sulphuric acid in the experimental cells, the *rotation* was obtained, as if the iron bar alone had been employed, and in the same *direction*, being *reversed* when the poles were *reversed*, and subsiding upon the *breaking* of the circuit. To increase the *density* of the fluid, some sulphate of zinc was added which rendered the *rotatory* motion more evident.

With the *copper* rings and dilute sulphuric acid employed in the same manner, no effect was at first obtained, but upon adding some nitric acid to the solution, it ultimately occurred. In this instance the effects were the same as with the *zinc* rings. Some sulphate of copper was dissolved in the solution with manifest advantage.

With the *tin* rings and dilute muriatic acid no effect; adding some nitric acid, the *rotation* was ultimately obtained, but not so distinct as in the former experiments; the *rotation*, however, was in the same *direction*, and reversed upon the *reversal* of the poles.

The proper strength of the acid in these experiments was best ascertained in the following manner:—The solution being poured into the cells, if no signs of the evolution of gas appeared around the surface of the metal, strong acid was carefully and gradually added and stirred in the fluid, until a small ring of gas bubbles appeared upon the surface of the solution around the metallic ring. Should the evolution of the gas be too violent, the solution was then weakened either by dilution, or, what was better, by adding a salt of the same metal.

We may add, that the *direction* of the *rotation* in the lower cell in all these experiments was the reverse of that observed in the upper cell. The appearance of the rotation in the two cells did not always coincide, evidently indicating that circumstances affecting the chemical action were in operation.

When the *rings* were employed without the magnetized bar no *rotation* was observed.

As it is not necessary for the production of this *rotatory motion* that the chemical action should occur *upon* the magnet, we were next led to the following series of experiments, for the purpose of ascertaining whether, during the reaction of different solutions upon each other, this *rotation* might not also be obtained, and the experiments were conducted as follows:—The lower end of the iron bar was placed in a small porous earthenware cylinder, an inch and a-half in diameter, and three inches in height, this was placed in the glass jar. We now had an opportunity of placing any solution in the porous jar, and another in the glass vessel external to it. Some liq. potassæ was placed in the porous jar, in contact with the iron bar, and dilute sulphuric acid in the external glass vessel. Under this form of the experiment we have never as yet been able to obtain any *rotatory motion* either of the internal or external fluid. In order that the chemical action should occur upon the *surface* of the septum, and not *within* the septum, the different solutions were kept at different heights in the two cells; and although the carbonic acid, in some of the experiments, was given off from the surface, we have never yet been able to obtain any effect indicative of magnetic influence, whether rotatory or otherwise. When acids were employed, and placed in the porous jar, a cap of caoutchouc was placed over the end of the bar to prevent any action upon its surface. The solutions we employed were those of the different salts of potash, soda, ammonia, iron, copper, zinc, alum, and lead, with the mineral and vegetable acids, such as the sulphuric, nitric, muriatic, tartaric, citric, and oxalic. The solutions were of different strengths,—sometimes concentrated, at other times very weak. The salts of the alkalies, or the metallic salts, were placed in substance, either in very fine powder, or moistened, into the porous cell, so as to form, as it were, a column of salt; still we could never obtain any effect.

On the supposition that the earthenware porous septum might have been too thick, other septa were formed, either of animal membrane, or of stout or fine calico, and employed in the same manner, but with the same negative result.

What can be the cause of our failures in these latter experiments? Is it in consequence of the magnet being too *weak* that its influence is not felt? Or is it in consequence of the chemical force being evolved and disposed of in such a manner as not to fulfil the conditions which are essential and necessary for the production and continuation of the rotatory motion, which we have observed in our previous experiments?

We have now arrived at that stage of our inquiry, at which we may be permitted to enter upon a few theoretical speculations, and endeavour to ascertain, if possible, the mode in which the results we have hitherto obtained appear to be brought about; but previous to doing this, it will be necessary to see what the conclusions are which our experiments tend to establish. They are :—

First, When the pole of a magnet is placed in a vessel containing a solution, which is capable of acting chemically upon the iron bar, a *rotation* of the fluid is produced; the *direction* of this *rotation* depending upon the pole of the bar. This conclusion has been already deduced from the experiments of Wartmann, Grove, and Christie.

Secondly, That it is not necessary for the production of this *rotation* that the solution should act (chemically) *upon* the iron bar, for if the bar be surrounded by a metal ring, the *rotation* is produced, and takes the same *direction,* provided the solution is capable of acting chemically upon this metal.

Thirdly, That the *influence of the magnet,* as well as the *existence* of the chemical action and its *continuation,* are essential and necessary for the production of this *rotation.* This conclusion has been already deduced by Wartmann from his experiments.

Professor Wartmann considers these phenomena as " a new instance of electro-magnetic rotation," analogous to those in which mercury is made to revolve round a magnetic pole when traversed by an electric current. He also states, that by placing the platinum electrodes of a rheometer alternately,—one near the margin of the vessel, the other near the bar,—that a *current* may be detected and shown to exist, traversing the solution in this direction, viz., from the margin of the vessel *to* the bar. He considers, also, that the electro-chemical action which occurs when an iron bar is placed in a solution of copper determines an electric current, which proceeds from the peripheric parts to those immediately around the cylinder, in the direction of the prolonged radii of the latter.

In classing these phenomena (as Professor Wartmann has done, and, as we think, rightly) with the ordinary *electro-magnetic rotations*, such as those in which wires, or even cylinders of metal, are made to rotate around the pole of a magnet, as may be seen in the experiments of Ampère, Savary, Barlow, Faraday, De la Rive, and others,*—there is one circumstance which cannot but strike the attention of the most superficial observer as existing in the latter class of facts, and which is absent in the former; we allude to the apparent necessity of a path or conductor for the circulation of the electric current in the latter phenomenon, without which it is supposed the effects would not occur; whilst this path for the circulation of the current is not so evident and apparent in the former phenomena, and appears to be wanting. Now, if the ordinary phenomena of electro-magnetic rotations, which we have referred to, are due to the action of angular currents upon each other, according to the law deduced by Ampère, or to the law of magneto-electric induction, as deduced by Faraday,† it becomes a point not only of some interest, but also of some importance, to ascertain and trace out, if possible, the path of the *current* in those cases in which the *rotation* of the fluid occurs without the intervention of any metallic conductor for the *current*. Wartmann says, that the

* In Becquerel's Traité de l'Electricité, vols. ii. and iii., will be found an account of these phenomena, to which we must refer, and also to De la Rive's Treatise on Electricity.

† "Experimental Researches," vol. i. p. 32, *par.* 114.

galvanometer indicates a *current* to be traversing the liquid *from* the circumference *to* the centre of the solution. In order to account for the *rotation* of the fluid, according to the law of angular currents, this is the path the current would theoretically take. The metal (copper) being deposited *upon* the bar would also indicate that the bar was the *cathode* of the voltaic circuit. Upon placing the platinum electrodes of the galvanometer in the solution in the same manner as pointed out by Wartmann, we have frequently obtained similar results, viz., the electrode in the neighbourhood of the bar being *positive* to the other; occasionally the galvanometer indications were in the *reverse* direction; most frequently, however, no definite result was obtained with the instrument, but merely slight vibrations of the needle occurred. The galvanometer employed was not a very delicate one; nevertheless the indications were not constant. If one electrode was in the solution, and the other on the bar, the latter was, generally speaking, *negative* to the other, and during this period the *rotation* continued. In the other experiments, however, viz., when the sulphuric acid solution was used with the iron bar, or with the metal rings when surrounding the pole, the electrode in contact with the metal was always *negative* to the other in the solution, yet the *direction* of the rotation at this time was that in which the *current* would be supposed to be travelling *to* the metals. If the electrodes were both in the fluid, one near the metal and the other at the circumference of the solution, no definite indication of a current existed. When the metal and the solution were formed into a circuit by means of the platinum electrodes of the galvanometer, we had the well-known elementary circle formed, and the resulting current travelling *from* the metal acted upon through the liquid *to* the other. We placed the electrode in contact with the bar in different parts of its surface, at the extremities of the bar-magnet, and as near the middle as we possibly could through the helix, but on whatever part of the bar the electrode was placed, it was always *negative* to that in the solution.

Although we feel some difficulty in tracing out satisfactorily the exact path of the *current*, or, perhaps, more correctly speaking, the "line of electro-dynamic force;" and although the galvanometer indications are such as to indicate that the metal or the pole is *negative* to the solution, we nevertheless believe that the chemical action which occurs and gives origin to the *current*, and consequently to the rotation, is such as to correspond with the supposition that the current travels *to* the bar or pole of the magnet, in accordance with Wartmann's view; but that the *current* travels from the *circumference* to the centre of the solution is not quite so evident. The *cation* being evolved upon the surface of the bar or metal either as a gas, or deposited as a metal, as is seen with the cupreous solution, would indicate it to be the *cathode*. The currents occurring upon the bar or metal are *molecular*, and, under ordinary circumstances, are free to take up any position; but under the influence of magnetism they are compelled to take up a certain definite direction, the magnet being the fixed point, the fluid alone moveable. This *direction* we are inclined to believe is *horizontal*, not *vertical;* circulating around the bar as several minute *circular* currents, and not travelling *from* the circumference of the solution *to* the centre. From what we have observed during the rise and progress of the *rotation*, it would appear to arise around the surface of the pole in the first instance, and gradually to extend in the fluid; the *action* which gives *origin* to the *rotation* may, and no doubt is, confined to the surface of the pole, but the influence may be felt at some distance, the outer portion of the fluid being inert as far as the *production* of the *rotation*. The *rotation* ceasing when the gas is evolved too rapidly from the surface of the bar, would tend to confirm this view; for in these instances, from the evolution of the gas, these *molecular* currents become vertical, as in ordinary cases; and it is only when the power of the magnet is sufficiently felt, as appears to have been the case in Professor Grove's experiments, that they are compelled to take up the *horizontal* direction; hence the *rotation*. In our endeavours to obtain the *rotation*, by placing the magnet in the *horizontal* position, we for a long time failed, but have at last succeeded in obtaining it with the *cupreous* solution. The greatest care is requisite in preventing the fluid from escaping from the vessel, otherwise the slightest flow of liquid will prevent the *rotation* from occurring. When hydrogen gas was evolved from the surface of the bar, it usually adhered to its under surface, and at present we have not been able to obtain the *rotation* when employing acid solutions. Terrestrial magnetism may have some influence in these experiments.

There are one or two circumstances we may just allude to: the particles that are seen floating in the fluid show no tendency during *rotation* to go either *from* or *to* the centre, they always appear to keep in the same relative position ; and the *direction* of the *rotation* (when once it was firmly established), was almost *immediately* changed on *reversing* the poles. Time, it would appear, was not required to enable the fluid to undergo any peculiar change.

We have not as yet been able to obtain a *rotation* in the reverse *direction,* viz., under the supposition that the *current* travelled *from* the pole *to* the solution. When we employed the different solutions and the porous septum, we had this object in view, but have hitherto failed in obtaining it. In some experiments we have recently undertaken, and in which we employed a metallic ring of some size, so as to contain the solution, and covered the polar end of the bar with caoutchouc, so as to prevent any chemical action from occurring upon its surface, we have obtained some evidence of a *rotatory* motion of the fluid *within* the cell,—being the *reverse* of that which would happen when the chemical action occurred upon the *external* surface, the magnetic pole being within. And in reference to the non-appearance of the *rotation* when the solutions alone were employed, it becomes a question whether the chemical action of mere *combination* without *decomposition*, if such an effect can occur, is incapable of producing a *rotatory* motion ; or whether it requires one of the elements to be in a solid condition, so as to act as a conductor to the "line of electro-dynamic force." This remains to be decided by future experiments.

Before we conclude this part of our inquiry, we must refer to some remarks made by Professor Grove in the last edition of his valuable work,* in which he states, " that when substances are *undergoing* chemical action, and a magnet is brought near them, the direction or lines of action of the chemical

* On the Correlation of Physical Forces, 3d edit., 1855.

force will be changed." We are not aware that Professor Grove has published any experiments in support of this view beyond those we have already related.

§ II. *Does Magnetism (in its static or quiescent condition) increase Chemical Action?*

That magnetism possesses some influence over chemical action has been long believed; and in Professor Wartmann's* valuable paper will be found a long list of authors who have treated of the subject, together with a reference to their respective publications.

Professor Wartmann placed a voltameter, in which some acidulated water was electrolyzed, between the poles of a powerful electro-magnet, but whatever the direction and intensity of the magnetism engendered, and whatever the position of the voltameter, within or without the polar arms, the volume of gas, he states, remained the same. He also adds that Professor Grove has been led to similar results.

By placing cylinders of soft iron in vessels containing sulphate of copper, converting them into temporary magnets, and then passing a *current* so as to decompose the solution, in whatever position in reference to the magnetic meridian these poles were placed, Professor Wartmann could detect no difference as to the quantity of copper deposited upon the cylinders.

Matteucci† has performed experiments in some respects similar to those of Professor Wartmann, viz., submitting an electrolyte, when traversed by a current, to the influence of a magnet; the results were also of a negative character.

Hunt,‡ by magnetizing an iron wire when formed in a circuit, and acted upon by an electrolyte, could not obtain any increase or decrease in the resulting current which could in any way be referred to the influence of magnetism.

In the majority of Professor Wartmann's experiments the chemical action, it will be observed, was excited by the elec-

* *Loc. cit.* † Bib. Univ., t. xxiii., p. 192. 1853.

‡ Phil. Mag., April 1848, p. 252.

tric current; now it is well known that if any circumstance should occur to affect the chemical action in one cell, the same influence would be felt throughout the whole of the circuit; hence arises an objection to this mode of proceeding. These remarks, however, cannot apply to those experiments in which he employed the voltameter.

In the following experiments we refrained from using the electric current as the exciter of chemical action, and employed the osmometer as the measurer of the chemical effect. The *electro-magnet* employed was that belonging to Professor Wheatstone. It is of the horse-shoe shape, consisting of a square bar of iron, each pole presenting a square surface two inches wide, four inches broad, and the space between the two poles is five inches. The coil of wire extends eleven inches up each arm, and within three-quarters of an inch from the top or end of the pole; the thickness of the coil being three-quarters of an inch, and composed of six separate wires.

Two osmometers were employed, and as far as possible identical, each consisting of an expanded bell-shaped glass vessel, an inch and a-half in diameter, an inch in depth at the centre, and capable of holding one ounce of fluid. The tube was one-eighth of an inch in internal diameter, roughly graduated, and twelve inches in length. The septum consisted of animal membrane tied tightly over the mouth. The jar containing the distilled water, or any other solution in which the osmometer was placed, was three inches in diameter and six inches deep, capable of holding twenty-two ounces of fluid.

To concentrate the line of magnetic force upon the osmometer two moveable poles were employed, each of soft iron two inches broad, two inches deep, and four inches and a-half long.

The *battery* usually employed consisted of six of Grove's cells, middling size, and occasionally twelve of Daniell's cells were added.

We must refer to Professor Graham's * valuable paper on

* Phil. Trans., 1854. We soon, however, found that the cleanliness of the tube internally was of the utmost importance. It was always moistened with the same solution as that in the bulb, by passing some of the solution through it previous to every experiment.

Osmotic Force for further particulars in reference to the precautions necessary to be observed in judging of an osmotic result; and as our object on the present occasion was not to study the phenomena of osmose in all its particulars, but merely as a measurer of the chemical effects, we selected, in the first instance, those solutions only for experiment which appeared to present the greatest osmotic activity, such as the dilute solutions. For the purpose of ascertaining whether the *line of magnetic force* would influence the *osmotic action*, we employed the flat osmometer, having only one side, instead of the circular porous earthenware jar, as employed by Professor Graham in some of his experiments, so that the *line of osmotic action* should have a constant and definite relation to the *line of magnetic action.*

The *membrane* used in each osmometer was as far as possible identical, being taken off the same portion of gut, and soaked in the same water (which was changed once or twice), for twelve hours previous to being tied over the osmometer. Care was also taken to have the same surfaces exposed to the same solution.

The solution at first employed consisted of one drachm of liq. potassæ to eight ounces of distilled water. With this solution in the osmometer, and distilled water in the external glass jar, the osmose presented sufficient activity for our present purpose. The osmometer was suspended in the centre of the glass jar by means of strings, and the septum kept within the centre of *the line of magnetic force;* the two moveable poles being in contact with the glass jar, but kept from pressing too tightly upon its sides by means of wedges of wood. The other osmometer was prepared in the same manner, but kept out of the influence of the magnet.

It would be tedious, and moreover useless, to describe the numerous experiments that were undertaken and the results that were obtained, sometimes in favour of, and at other times opposed to, the conclusion that the result was in any way dependent upon the influence of magnetism. It is impossible to obtain two osmometers that would indicate identical results, and the want of a standard osmometer was sadly and early felt. We employed different acid solutions to obtain *negative* osmose. In some experiments an *acid* solution was employed on one side, and an *alkaline* solution on the other; and although the result of the experiment might appear at one time in favour of the osmometer placed in the magnetic field, nevertheless, upon carefully repeating the experiment, it ultimately vanished. We, however, ascertained the following important fact in reference to osmose: Thinking that the *position* of the *septum* in regard to the *line of magnetic force* might have some influence, and especially so since, in the experiments related in the previous section, the *rotation* occurred upon the *surface* of the magnet, we bent the tube of the osmometer so as to place the septum either *vertical* or *horizontal*, looking upwards, and not, as in ordinary osmotic experiments, looking downwards, and placed the septum sometimes just *outside* of the field of force. In our first experiments we were frequently led to believe that we had obtained some decided results, but they were ultimately explained away by considering that as the chemical action upon the membrane might occur, and be confined either to one side or the other, so would the position of the membrane enable the compound thus formed to separate and fall down, and so become more readily diffused in the liquids, allowing fresh particles to come into contact with the membranes to keep up the chemical action, and increase the osmotic action. As the effects occurred in both osmometers, we at first conjectured that terrestrial magnetism might have had some influence over the osmometer, which was not exposed to the influence of the magnet.*

It may, however, be urged, that in these experiments we have been confounding *osmotic* action with *chemical* action, and that although the former is greatly dependent upon the latter, nevertheless other circumstances are influential in producing *osmose* besides *chemical action*, and consequently we have not been dealing with a pure case of chemical action.

* Professor Graham, in his first series of experiments (*loc. cit.*), used a porous circular jar for the osmometer, and in some of his subsequent experiments animal membrane. The earthenware osmometer was *vertical*, the other *horizontal;* and he appears to have obtained some results when using the former, which seem irreconcilable with those that he obtained when employing the latter. We may point out the binoxalate of potash and the sulphuric acid solutions as examples. May not the *position* of the septum have had some influence in producing these apparently contradictory results?

To remove to a certain extent some of these objections, although they may still be urged, we used other septa, formed of coarse thick calico or of sail-cloth, and repeated these experiments. In these instances the osmotic action was not so great as with the animal membrane; in some instances it did not occur as it would have done with the membrane, but the variations were not so great; nevertheless, upon placing different solutions in the osmometer and in the glass jar, we could not obtain any result indicative of magnetic influence.

Similar experiments were undertaken with the large magnet belonging to the Royal Society. The magnet is composed of four hundred and fifty bar-magnets, each fifteen inches long, one inch wide, and half an inch thick, arranged in a box so as to present at one of its extremities two external poles. These poles projected vertically six inches from the box, were twelve inches broad, and three inches wide. They were nine inches apart. We thus had a field of *constant* force.* To concentrate the magnetic force we had two soft iron bars, each two inches and a-half broad, two inches thick, and twelve inches long. These were secured by means of strings or wedges to the extremities of the poles.

In this magnetic field we could place four osmometers, either with their septa all in the same position, or directed in four different positions in reference to the line of magnetic force. Great irregularity appeared in the results, even when the septa were all in the *same* position; the most constant results appeared when the septa were *vertical*. It will be unnecessary to detail the experiments, for in whatever *position* the septa were placed in regard to the *line of magnetic force*, whether in the *centre* of the field or on the *outside*, and whatever solutions were employed, the results were similar to those we had previously obtained with the elec-

* According to Faraday (Exp. Res., vol. i. p. 12) this magnet, when at Woolwich in the charge of Mr Christie, would support a force of nearly one hundred pounds. Upon trying its power when it first came into our possession, it would not support a weight of thirty pounds. This loss of power we attributed to the circumstance that the contacts between the various poles might have been greatly deranged during the conveyance of the magnet from one place to another.

tro-magnet. Tubes with larger bores were employed, and the osmometers allowed to remain for eighteen hours in the magnetic fluid, other similar osmometers being out of the influence of the magnet, yet we could not detect any difference either as to the *rapidity* of osmotic action, or even in its *amount*, indicative of *magnetic* influence. Differences were frequently observed, but these would occur whether the osmometers were in the magnetic field or out of it.

From the results of the experiments that we have related in the previous section, it was reasonable to suppose that if the influence of magnetism was such as to produce motion of a mass of fluid, the power thus called into action might produce some, if not primary, at least secondary effect upon the resulting chemical action, perhaps increasing it by the removal of the compounds formed at the place of action, allowing fresh particles to come into play.

We were now led to the following experiments:

Two osmometers were formed in the following manner:—a cylindrical porous jar, one inch and a quarter in internal diameter, three inches and a half in depth, capable of containing two ounces of fluid, was fitted, by means of a cork, into the mouth of a glass jar, and made water-tight. The size of the glass jar was two inches and a quarter in internal diameter, five inches deep, and capable of holding about eleven ounces of fluid; but when the porous jar was fixed into it, it was then capable of holding about nine ounces of fluid. A narrow graduated glass tube was fitted, by means of a cork, into the bottom of the glass jar, the tube being bent at right angles; it was at this aperture that the osmometers were filled. The osmometer, thus arranged, was placed in a large glass jar, containing water or any other solution, the osmometer being entirely covered with the solution. One extremity of the bar of the electro-magnet was placed in the porous jar, as in former experiments, and, when acids were used, covered over with a cap of caoutchouc. The other osmometer was used in the same manner, having a similar iron bar placed in it, but unmagnetized. Even in this form of the experiment we have not been able to obtain any result indicative of the influence of magnetism (in its *static* condition) over osmose;

there was no increase or decrease in the osmometer containing the magnetized pole compared to that which contained the unmagnetized bar, or even without the bar. Variations in the osmotic result were frequently obtained, but they were similar to those which occurred when no magnet was employed, and such as we had already observed in former experiments.

These experiments having failed to give us any evidence that magnetism (in its *static* or quiescent condition) *increases* chemical action, confirming, therefore, the results of Wartmann, Grove, Matteucci, and perhaps others, it can scarcely be supposed that magnetism, under the same conditions, would *excite* or *originate* chemical action; but as experiments have been undertaken for the purpose of solving this question, we shall, in order to complete the subject of our inquiry, briefly refer to them.

§ III. *Does Magnetism (in its static or quiescent condition) excite or originate Chemical Action.*

"No attempt," says Faraday,* "to separate the perfectly mixed particles of any different substances has ever succeeded, though made with most powerful magnets. Oxygen and nitrogen differ exceedingly, yet no appearance of the least degree of separation occurred in very powerful magnetic fields. In other experiments I have inclosed a dilute solution of sulphate of iron in a tube, and placed the lower end of the tube between the poles of a powerful horse-shoe magnet, for days together, in a place of perfectly uniform temperature, and yet without the least appearance of any concentration of the solution in that end which might indicate a tendency in the particles to separate."

The following general conclusions may be deduced from the foregoing investigations:—

First, That *Magnetism* (in its *static* or quiescent condition), does not *excite* or *originate chemical action*.

Second, That when substances *undergoing* chemical action are submitted to the *influence* of magnetism (in its *static* or

* Faraday's Experimental Researches. *Series* xxv., *par.* 2757. Phil. Trans. 1851.

quiescent condition) *no increase* in the *chemical action* is observed; but that,

Third, Under certain conditions *during* chemical action, the influence of magnetism is such as to indicate a *directive* influence over chemical action; this influence being shown by a *rotatory motion* of the fluid around the pole of the magnet.

Fourth, That it is not necessary for the production of this *rotatory motion*, that the solution should act chemically *upon* the iron bar forming the pole; for, if the pole be surrounded by a metal ring, the *rotation* occurs, provided the solution is capable of *acting chemically* upon this metal ring.

Fifth, That the *influence of the magnet*, as well as the *existence* of the *chemical action*, and its *continuation*, are essential for the production of this *rotation;* and,

Sixth, That the *direction* of the *rotation* is dependent upon the *poles* of the magnet, being *contrary* for each *pole*.

Contributions to Ornithology. By Sir W. Jardine, Bart. No. IV.

Another small ornithological collection from the western slope of the Andes has arrived from Professor William Jameson of Quito. A second specimen of *Saltator arremonops* has been received; and *Tetragonops ramphastinus* has again also been obtained, although not in time to accompany the birds now sent. This last bird "inhabits the deep recesses of the forests on the western flank of the Cordillera. It utters a loud note, the sound of which resembles the baying of a deer-hound; hence '*Venadero*' (a deer hound), the name by which it is known to the natives. From the echoing sound, one would imagine that it proceeded from a bird of much larger size."

Among the birds which we have not previously received from the western side of the Quitan Andes are one or two of some interest.

Thamnophilus immaculatus (Lafresn.)—A specimen of a *Thamnophilus* occurs closely allied to the bird described by Mr Sclater (*Ed. New Phil. Jour.* i. p. 249) under the above name. The carpal joint of the wing has a patch of white, as there described, formed partly by some of the lesser wing-covers being white at the base, and by the feathers which spring from the body immediately at the insertion of the wings having similar markings. The dimensions of our specimen also correspond nearly; and although the length appears greater, it cannot be depended on in a skin, and we could not venture to place the two birds as distinct without a comparison. Length of the skin, 7·5; wing, 3·3; bill to extremity of rectus, 1·2.

Momotus semirufus (Sclater); *Rev. and Mag. de Zool.*, p. 489, 1853.—A rare species of Momot belongs to the group, which have no ornament or bright colouring upon the head; and is at once distinguished from the other brown-headed birds, by the entire head, nape, sides of the neck, chin, throat, breast, and belly, being clear and bright sienna, interrupted only by the deep black of the auricular feathers, the latter colour stretching also in front of the eye to the nostrils (but without forming any frontal band), and at the lower part on the base of the mandible; both eyelids are black. The other upper parts of the plumage are of the usual yellowish-green; the outer webs of the black quills bright blue; the vent and under-tail coverts bluish-green. Length, 17; wings, 5·8; bill, to extremity of gape, 2·2. The edges of the mandibles broken, but not regularly notched.

Mr Gould possesses another skin, marked "Quito," obtained from a collection in that country, and in all probability procured not near Quito, but from the same locality with our own.

There is a specimen of the very beautiful and curious form, *Eurypyga*. It is from the forests on the same western flank of the Andes, where it builds on trees by the sides of the mountain rivers. The young has the nestling plumage of the rails, but appears very soon to assume the painted markings of the adult. From the structure of the plumage in this state we would judge that the young were capable of running and making their own way immediately after hatching; but we hope ere long to have a satisfactory account of their habits and incubation.

The nest of *Trochilus gigas* is a much more solid structure than that of the humming-birds generally, though these birds commonly collect and gather together a mass of materials very large in comparison to their size and strength. The diameter of the nest is a little above three inches, its solid perpendicular height about four. The base is strongly compacted together, and strengthened with clay, so as to be of a weight that will require more than the usual support. The upper or nest portion is composed of fine mosses, bound and felted together with the woolly fibres taken from some of the down-covered plants which are not uncommon in these regions. It is altogether a solid and warm structure.

Correlation of the Triassic Rocks in the Vale of Worcester, and at the Malvern Tunnel. By the Rev. W. S. SYMONDS, F.G.S.

1. Upper Grey Red Marls, 2. Keüper Sandstone, 3. Lower Red Marls, 4. Waterstones,	Keüper.
5. Upper Red Sandstone (Bromesberrow Beds), 6. Lower Red Sandstone (Red Rock of Malvern),	Bunter.

The above represents the order of the triassic rocks in the valley of the Severn, in the Malvern and Worcester districts, now rendered especially interesting by the escarpments laid open in the tunnel of the Worcester and Hereford railroad, near the "Admiral Benbow," at Malvern Wells.

No. 6. *Lower Red Sandstone.*—During the excavations for the foundation of the residence of the Messrs Burrow, near the Bellevue Hotel, at Great Malvern, a dark red sandstone, with black markings of the protoxide of manganese, was exposed, resting against the syenite of the hill, covered up by a thick accumulation of debris, and dipping at an angle of 60° to the south-east. A remarkable erratic block, weighing some hundreds of pounds, angular at the edges, and with no sign of subaqueous action, was found imbedded in the mass of red sandstone. This block consists of the same "Cambrian" rock as the angular Permian breccias of Haffield Camp, and thus favours the Permian glacial theory of Professor Ramsay. The red sandstone, thus curiously exposed at a considerable elevation, and flanking the Plutonic chain of the Malverns, differs considerably in mineral character both from the "Waterstones" and the Bromesberrow beds; I am therefore inclined to place it with the "Lower Red Sandstones" of the geological surveyors, which are developed higher up the Severn valley in the Stourport district. However this may be, the position of this red rock, when compared with the position of the Upper Keüpers in the Malvern tunnel, is very striking, as proving a considerable elevation of the Plutonic and Syenitic range, between the deposition of the Lower Red Sandstone (No. 6) and the deposition of the Upper Keüper Marls (No. 1).

No. 5. *Upper Red Sandstone* (Bromesberrow Beds).—In the Malvern district, the Permian breccias are covered up by a soft red sandstone, well displayed in the parish of Bromesberrow, at the southern extremity of the range. It is necessary to warn the geologist against confounding these beds with the "Newent sandstones," or "Waterstones," of the geological surveyors. They are a LOWER SERIES of strata, as may be seen on working out one or two puzzling sections between the valley of the White-leaved oak and Haffield Camp, at the southern extremity of the Malvern range. The relation of these beds with the "Waterstones" may also be seen at Blakedon Hill, near Leamington, as described by Sir R. Murchison and Mr Strickland; and they are exposed at the base of the Grinshill quarries, eight miles from Shrewsbury.

No. 4. *Waterstones* (Newent Sandstones).—An interesting MORSEL of these deposits flanks the Chase End Hill of the southern Malverns, at the back of the Hawthorns, on the Bromesberrow road. The working out of the relation of these rocks with the Lower Keüper marls and the Bromesberrow sandstone requires some care, and may be best carried out at this point; and again, along the Glynch brook, for the fault from Bromesberrow below Red Marley is extremely puzzling. The lower "Waterstones" are well developed in the neighbourhood of Red Marley D'Abitot, Pauntley, Oxenhall, and Newent. The upper strata are GREY SANDSTONES, passing into yellowish-red beds; the lower beds are exposed in most of the narrow lanes of the Red Marley and Newent Ryeland district, but the upper grey beds are mostly denuded. An outlier, however, is still left near the church of Red Marley D'Abitot, and the church was rebuilt in 1855 with excellent stone from the quarries near. These grey sandstones are, I believe, the equivalents of the celebrated Grinshill sandstones, and the grey beds of Ombersley and Bell Broughton in this county. I visited the Grinshill district last autumn, under the guidance of the well-known naturalist, Mr Eyton of Eyton Hall, who directed my attention to a small trap dyke which alters the Waterstones in contact into a quartzite rock. We saw an interesting specimen of the "Rhynchosaurus" in the possession of a shopkeeper, who refused to part with it. Many of the slabs were ripple-marked, and retained the impression of rain-drops on their surfaces. It was interesting to find my Red Marley friends so persistent in lithological character, yet so wonderfully increased in importance and development.

No 3. Lower Red Marls.—These marls are principally remarkable for their salt springs worked at Droitwich and Stoke Prior, where they have been penetrated to the depth of 600 feet. They are seen to dip under the Keüper sandstone at many localities east of the Malverns. In the railroad tunnel they rest against the Syenite, and dip at an angle of 53° to the south-east. At the point of contact they are much crushed and broken, but without a symptom of metamorphism; in some places they are arched and contorted, and must have been in a plastic state when upheaved. Only a few feet of these lower marls are elevated and exposed. A brine spring was lately tapped at the Asylum near Powick, four miles from Worcester, proving the extension of the salt.

No. 2. Keüper Sandstone.—These grey sandstones have also been cut into, they dip away from the Syenite, resting against the lower marls, at an angle of 50°, and are identical in mineralogical character with the Keüper sandstones of Burghill, Longdon and Pendock; they are succeeded by the upper grey and red marls.

No. 1. Upper Grey and Red Marls.—These beds afford especial interest in the section of the Malvern tunnel. At the mouth of the present opening they exhibit nearly horizontal layers of strata covered by Malvern syenitic debris; allowing for a slight dip, they correspond with the plane of the upper marls of Crowle, the Berrowhill, Sarnhill, and other rounded outliers of the vale, but on proceeding up the tunnel a grand fault is exhibited, for many feet of red and grey strata that graduate towards the Keüper sandstones exhibit the high dip of the lower beds, thus proving to an extreme exactitude one period of an elevation of the syenitic ridge. A little beyond the tunnel mouth the upper marls are cut off by denudation.

It is impossible to study the sections displayed in the works of the tunnel without reflecting on the truthfulness of former geological theories entertained by our most distinguished geologists, as respects the history of the deposition of our Triassic rocks, and the *periodical* and *gradual* upheaval of the Malvern range.

On some Species of Corals in the Lias of Gloucestershire, Worcestershire, Warwickshire, and Scotland. By the Rev. P. B. Brodie, M.A., F.G.S., Vice-President of the Warwickshire Naturalists' Field Club, Hon. Secretary and Hon. Geological Curator of the Warwickshire Natural History and Archæological Society.

My object in the present paper is not to attempt a scientific description of the Liassic corals, which I hope, may be done by some palæontologist better acquainted with them, but rather to note the discovery of some species which appear to be new in the Lias, and to point out the position in which they occur. Very few have been described in this country, and therefore it seemed desirable to draw the attention of geologists interested in the subject to those which have been more recently brought to light. As a general rule, fossils of this kind are not common in the Lias, the sea in which it was deposited being unfavourable to the growth of polyparia, though in some localities they are not so scarce as has been generally supposed. In the upper Lias, the only specimens with which I am acquainted are the *Thecocyathus Moorii* and *T. primus*, belonging to the family Turbilonidæ, found by my friend Mr

Moore near Ilminster, and figured and described by Milne-Edwards and Jules Haime, in the Memoirs of the Palæontographical Society for 1851, and also a small undescribed species of Cyathophyllum, and a Flustra from the same bed. Mrs Hugh Strickland was kind enough to send me a sketch of the upper portion of a large lamellated coral, found by my late lamented friend, Mr Hugh Strickland, in the Lias marlstone at Byfield, in Northamptonshire. It is a simple turbinated coral, probably belonging to the family Fungidæ. In the lower Lias, a few corals have been met with in the clays and shales near Cheltenham (which may evidently be assigned to the genus Montlivaltia), in the same bed as that which contains *Pleurotomaria Anglica* and other fossils. I found three perfect specimens, though of small size, at Down Hatherley, between Cheltenham and Gloucester. A similar genus was obtained by my friend Mr Gavey, at Moreton in the Marsh, and another, and perhaps a different species, beautifully preserved, occurs in the same beds of Lias shale, at Fenny Compton, in Oxfordshire, where the presence of a species of Turbinolia ? (probably a Montlivaltia) is noticed by Conybeare and Phillips in their "Geology of England and Wales." Milne-Edwards, in the monograph on fossil corals above referred to, speaks of the cast of a Montlivaltia in the lower Lias near Bath, in the collection of Mr Walton. All those I have seen of this genus are small, round, turbinated corals, and one or two show the point of attachment. They do not however, appear to be referable to more than two species, and single individuals are not abundant. Through the kindness of Miss Slinger of Cheltenham, I fortunately obtained another small coral, which I take to be a species of Turbinolia. It was found in the shales of the lower Lias, with *Spirifer Walcotii*, and other shells, and it has a minute Flustra attached. On the surface of the blue limestones, containing *Lima gigantea*, *L. rudis*, and *Ostrea*, I detected a small coral, distinct, I think, from the rest, and identical, possibly, with a smaller one in the cabinet of Mrs Hugh Strickland, from the lower Lias of Abbott's Wood, in Worcestershire. There is a stony, shelly band of Lias, seen at Down Hatherley, Bushley, and other places, full of *Cardinia ovalis* and *C.*

Listeri, a few inches thick, which contains a small branching coral in some numbers ; unfortunately the surface of the stone is much water-worn, and the corals are, in consequence, considerably eroded.

This stratum is particularly interesting, from the occurrence of numerous minute Foraminifera, which have every appearance of true "*Nummulites*," described by Mr Rupert Jones, and referred to by myself in a short paper "On the Lias of Fretherne Cliff, below Gloucester," read at a meeting of the Cotswold Naturalists' Club* in 1853, and since published in Taylor's "Annals of Natural History." Many other fossils, especially a variety of little univalves, are associated with them. In the same bed at Purton Passage, on the opposite side of the Severn, a small specimen of Isastrea was obtained, and I lately procured a remarkably fine coral of this genus from the equivalent stratum at Inkberrow in Worcestershire,† where the Lias joins the Keüper, close to the line of fault which traverses that district. Only a few have been met with, but sufficient to show that they formed part of a small reef of Astreidæ, and are not mere isolated individuals, as most of the Liassic corals seem to be. They were found along a narrow ridge in the *Cardinia bed*, in a grass meadow which had not been ploughed up for many years, so that it was impossible to detect the corals *in situ*, though there can be no doubt of their exact position ; they are more numerous than in any other locality, except perhaps in Scotland. The specimen in my possession is a massive, stony, calcareous coral, measuring 1 foot 5 inches long, and 5 inches broad in the widest part, and shows the upper and under surface in tolerable perfection. I was aware of the existence of a species of Isastrea in the Lias several years ago, as a few have been procured from a clay-pit near Evesham, about 10 miles from Inkberrow. They were stated by the workmen to occur at the bottom of the pit in the clay, 40 feet below the surface, and not exactly in the same position as those at the latter place. The specimen in my cabinet, however, belongs to the same

* Proceedings of the Cotswold Naturalists' Club, vol. i., p. 241.

† My attention was first drawn to this locality by my friend Mr Chattock, on whose estate the corals were discovered.

species as the ones found at Purton and Inkberrow, and is a solid, stony mass, but much better preserved ; in some, the cells are soft and crumbly, and not at all solidified, very different from the condition of the majority of Isastrea. In order to compare this species with the one found at Lustra, in the Isle of Skye, I obtained, through the kindness of Mr Archibald Geikie, of the Scotch Geological Survey, a specimen of those fine corals which have been already noticed by Sir R. Murchison and the late Mr Hugh Miller,* and are abundant there in the lower division of the Lias. Mr Geikie informs me that they "vary considerably in size, ranging from about three or four inches to more than a foot in length. They are generally oblong, and a good deal flattened, and sometimes lumpy on the surface, the cells covering, as it were, the inequalities of an inner surface." The one I have displays the coralline structure well, but not better than those from the neighbourhood of Evesham, and belongs, apparently, to a different species. The bed in which they lie, Mr Geikie states, is irregularly two feet thick, and is composed entirely of these Isastrea, cemented together in a hardened mud. They are piled together in masses, one above another, without the admixture of any other fossils. The thickness of the Skye Lias is at least 1200 feet, and, as the *Gryphæa incurva* occurs 100 feet above the Coral bed, it would seem to come very near the horizon of the Isastrea beds in England. In some bands of hard white limestone in the lower Lias, rather low down, I think, near Leamington, in Warwickshire, I have obtained four or five small corals, most nearly resembling the coral from the marlstone in Northamptonshire. There is a similar species in the white Lias, near Southam, and elsewhere in the same county, but higher up in the series. It is worthy of remark, that in places the Lias in Warwickshire assumes a peculiar lithological character, differing in many respects from the equivalent strata in Gloucestershire. This is particularly observable at Newbold, near Rugby, where there is a thin layer of limestone, almost green in colour with Ostrea and spines of Echinoderms, and a soft, white, crumbly stone,

* Edinburgh New Philosophical Journal, New Series, vol. i., p. 366.

unlike any Lias I have seen elsewhere. Much iron pyrites is diffused throughout the mass. I hope hereafter to describe these and other remarkable beds of Lias in Warwickshire.

These are all the Lias corals with which I am acquainted in the British isles, though possibly a few may be buried in private collections. I hope, however, this notice of those which have come under my cognisance may be the means of bringing any others to light, and of inducing some one who has made this branch of Palæontology his study, to describe the whole in detail. A few years since, my friend Professor Buckman sent up some Liassic corals to the late Professor Forbes, but they were unfortunately lost before any description had been given of them; but Professor Buckman thinks that most of them were identical with those above described.

On the Continent, some corals have been met with in the upper Lias at Calvados, in France; and two species of Isastrea and two species of Montlivaltia, are figured and described by M. Chaperis and Dewalque,* from the lower Lias in France and Belgium, in beds which occupy a similar position in the series to those near Cheltenham. The Montlivaltia differs from the species in my collection, but I cannot speak so decisively with respect to the Isastrea.

The Chemistry of the Iron Manufacture of Cleveland District. By William Crowder, F.C.S., Newcastle-on-Tyne.

The present communication is intended to form the commencement of a series of investigations into the various stages of the manufacture of iron, more particularly as pursued in the neighbourhood of Cleveland.

On two previous occasions, I have communicated to the Edinburgh New Philosophical Journal the results of an extensive series of analyses of the ironstones obtained from the different mines in that locality, and in adjoining districts; and I have been naturally led so far to extend the inquiry as to embrace the investigation of the various stages of smelting and refining these ores.

* "Description of Secondary Fossils of Luxembourg," Pl. 38, f. 8.

The subject is one surrounded with great difficulties, partly because we are unable to trace the operations through every stage of their progress, and can only judge of what has occurred by the ultimate result;— partly from the necessity of taking into consideration the numerous complicated conditions required to bring about a given result;—partly on account of the difficulty of collecting some of the products; and last, though by no means least, because of the difficulty and minuteness required in many of the analyses, and the series of tedious repetitions necessary before any safe conclusions can be deduced.

The operations of the iron manufacture are twofold:—

1*st*, The smelting or reduction of the ore, with the production of crude or cast-iron.

2*d*, The conversion of crude into wrought or finished iron.

The present, and one or two future communications, will have reference to the first of these operations, viz., the smelting of iron.

On reflecting for a moment upon the construction of a blast furnace, it will be evident that there are two exits for the products of the changes that have taken place in the interior, viz., at the tunnel-head and at the hearth. At the former will escape all the gases generated inside, together with any solid matters capable of volatilization by intense heat; at the latter, all the solid matters which are non-volatile will escape in a melted state. If, therefore, we collect the solids from the hearth, and the gases and volatilized matters from the tunnel-head, we have an expression of the ultimate effect of the chemical operations that have gone on inside.

It matters little whether we commence our experiments at the hearth or the tunnel-head; but for convenience we have devoted our attention, *firstly*, to the products from the hearth.

The products from the hearth are of two kinds; there is—

1*st*, The slag, produced by the combination of the various impurities contained in the ironstone, and the ashes of the fuel with the limestone used as flux; and,

2*d*, The crude iron, combined with various small quantities of impurities, which latter determine the quality of the preceding in a remarkable degree.

If we desire to obtain the explanation of the composition of the products *obtained* from the furnace, an accurate knowledge of the composition of all the materials *introduced* must be presupposed, else no intelligible equation can be given.

Hence, in the first instance, a complete investig tion into the composition of all these materials becomes necessary.

Having established the composition of all the ingredients with which we start, it next becomes important to detail the various quantities which are mixed together to produce a given result; and if, after subjecting these materials to the process of reduction, we now weigh and then analyse the various products, we ought to get a complete quantitative expression of the mode in which the various matters have been disposed of.

So far as theory goes this is quite correct; in fact, we might regard the operation of a blast furnace in the same manner as an assay on a gigantic scale. Unfortunately, however, the command of uniform conditions is in most cases impossible, principally on account of the variable composition of the calcined stone. It will be evident to persons acquainted with the process of iron-smelting, that it is exceedingly difficult to insure complete or uniform calcination. If this is not accomplished, the proportion of volatile matters remaining behind interferes, more or less, with the accuracy of the result, depending upon the extent to which the operation has been actually carried. All, therefore, that we can accomplish is to ascertain what result is *practically obtained.*

Again, if we collect the solid products at regular intervals *between* one tapping-time and another, upon analysis these products ought, by their composition, physical appearance, and properties, to indicate any changes, however minute, that have gone on inside the furnace since the previous specimen was taken.

It is quite true that these fluctuations cannot be relied on by a few analyses; but when an accumulation of results of this kind, obtained under every variety of condition, and in different furnaces, are compared together, any *constant* change can be easily noted.

In the present investigation I have, as far as circumstances admitted, endeavoured to follow out the course indicated in the preceding remarks, in the hope that the results obtained may prove of some value as a trifling contribution to our present imperfect knowledge of the theory of iron-smelting.

The present paper contains three distinct series of experiments; the first two being the results obtained from the furnaces of Messrs Cochrane & Co., Ormsby Iron-works, Middlesboro'; the third series being from those of Messrs Bell Brothers, Clarence Iron-works, Middlesboro', to both of which firms I am much indebted for the assistance they have so kindly rendered me in my investigations.

The First Series, from Messrs Cochrane & Co., contains the results of analyses of two sets of slags, taken respectively on the 20th and 22d of May, from No. 1 furnace, producing Nos. 1 and 3 iron; the other two sets from No. 2 furnace, taken respectively on the 27th and 29th of May 1856, when the furnace was on mottled iron.

The Second Series, from Messrs Cochrane & Co., contains the results of experiments made on Nos. 1, 2, and 3 furnaces, in August 28, 1856, when on No. 2, and mottled iron, and No. 1, respectively.

The Third Series contains the results of experiments at one of Messrs Bell Brothers' furnaces, when on foundry iron.

In detailing the method adopted in making the analyses, it will be unnecessary to enter more fully into a description of the ironstone analysis than to state that the examinations were conducted in an exactly similar manner to those in my last investigation. The iron was in all cases determined by permanganate of potash.

Method adopted in the Analysis of the Slags.

A quantitative analysis of the slags gives the following ingredients:—Iron, alumina, lime, magnesia, manganese, potash, soda, silica, sulphur, sulphuric acid, phosphorus or phosphoric acid.

The finely powdered material was digested with hydrochloric acid, by which it is decomposed, with the production of a mass of gelatinous silica, it was evaporated to dryness, and redissolved in acid.

The operation was effected much more rapidly by heating on a water-bath, since, by using these means, there is not the tendency to bumping, and consequent loss by projection of portions from the dish, as is experienced when a sand-bath or naked gas flame is used. Sulphuretted hydrogen was invariably evolved in this operation.

After redissolving in acid, the silica was filtered off, and chlorine water was added to the hot solution, and then ammonia, by which iron, alumina, manganese, and phosphoric acid are precipitated; this was well washed with boiling water, dried, and weighed. It was then dissolved in hydrochloric acid; some tartaric acid was added, and then ammonia and sulphide of ammonia. This throws down iron and manganese, leaving alumina in solution; by reprecipitating the iron and manganese with chlorine and ammonia, and filtering, they may now be weighed together as $Mn_3 O_4$ and $Fe_2 O_3$. By determining the quantity of iron present with a very weak solution of permanganate of potash, and deducting it from the weight of the two bodies, the quantity of manganese is obtained. The manganese was also frequently determined by boiling with perchloride of iron and acetate of potash, when the phosphoric acid remains as a precipitate, and the manganese passes through. Since it was found practically that traces of iron and alumina passed through along with the manganese, some tartaric acid was added to the filtrate. Sulphide of ammonia and ammonia precipitated iron and manganese. The manganese was then determined as before.

It was not considered necessary to determine the manganese in every instance, but a sufficient number of cases have been given to show the general proportion of this constituent. Alkalies were determined in the usual manner with baryta. One determination for each set was considered sufficient.

Lime and magnesia were determined in the usual manner. *Sulphur* was determined by digesting the slag in red fuming nitric acid, evaporating to dryness, and redissolving in *hydrochloric acid.*

Great care was taken in these determinations. The nitric acid was purified by distillation with a small quantity of nitrate of baryta, to insure the absence of the last traces of sulphuric acid. A considerable quantity of the distilled acid was evaporated to dryness in a glass beaker, with some nitrate of baryta, and the residue was treated with boiling water. The whole dissolved without leaving even traces of sulphate of baryta, *showing the purity of the nitric acid.*

It having been lately shown by Noad and others that sulphate of baryta is slightly soluble in nitric acid, the precaution of taking up with *hydrochloric acid* was observed; and the close correspondence of the results seems to confirm the accuracy of the plan.

There is invariably present small quantities of sulphuric acid, amounting to from 0·10 to 0·30. As this quantity was so small, the examination for that ingredient was usually omitted, and the whole of the sulphate of baryta obtained calculated into sulphur.

Phosphoric acid was determined by the acetate of potash and perchloride of iron method.

There is great reason to believe that the phosphorus exists as such in the slag, and not as phosphoric acid; for, in looking over the analysis, it will be seen that after adding the quantity for alkalies, the analyses almost invariably come too high. I have therefore calculated it as monophosphuret of calcium = Ca P. It is quite possible that the phosphuret may contain more than one equivalent of calcium, in which case the analyses would come still closer to the 100 parts.

In a few cases the mode of decomposing the slag was by fusion with carbonate of soda; but the results obtained by this method being the same as when hydrochloric acid was used, only a few experiments were conducted by this plan.

Analysis of the Cast-Irons.

The major portion of the iron dissolves in dilute hydrochloric acid, the remainder consists of silica, lime, alumina, magnesia, and graphite. Twenty-five grains were dissolved in dilute hydrochloric acid. The insoluble matter was thrown on to a weighed filter, and after obtaining the weight of the residue, it and the filter were burned in a platinum crucible. A small quantity of nitre and carbonate of soda was mixed with it, and the whole fused. It was then dissolved in acid, evaporated to dryness, and taken up with acid, the silica filtered off, and the iron, alumina, lime, and magnesia determined. The sum of these constituents deducted from the weight of the residue insoluble in acid gives the quantity of graphite or uncombined carbon.

In the determination for graphite, a small correction must be made, since the silica in the insoluble residue, when dried at 212°, is a hydrate, the water of which must be taken into account. This was observed in every case.

The portion *soluble* in dilute acid was evaporated to dryness, and redissolved in acid, to separate any soluble silica, the iron in the liquid was peroxidized with nitric acid; carbonate of soda and acetate of potash were then added, and the manganese, lime, and magnesia passes through the filter. The manganese was thrown down (after concentrating the filtrate) by hypochlorite of soda, and the lime and magnesia in the filtrate, or the manganese was precipitated by sulphide of ammonium, redissolved, and precipitated by carbonate of soda. The manganese was all in the soluble portion.

Sulphur.—Similar precautions were observed in examinations of sulphur as in the analysis of slags, with regard to the solubility of the sulphate of baryta in nitric acid.

Twenty grains of the finely-powdered iron were dissolved in perfectly pure nitric acid, which had previously been distilled with nitrate of baryta. It was then evaporated to dryness, and taken up with pure hydrochloric acid, and the sulphuric acid determined with nitrate of baryta.

Phosphorus was determined in the filtrate by boiling with acetate of potash and chloride of iron.

The precaution of deoxidizing the greater portion of the iron with sulphate of soda was invariably observed, by which means we were enabled to obtain the phosphoric acid combined with only two or three grains of peroxide.

Carbon was determined by combustion with chromate of lead and chlorate of potash, at times assisted with a small quantity of chromate of potash. By deducting the quantity of graphite found in the portion insoluble in acid, the difference was the quantity of combined carbon.

Materials used in the Experiments.

Ironstone.—The stone, as I have already indicated in my previous papers, is a carbonate of protoxide, yielding, by analysis, on an average about 30 or 31 per cent. *metallic iron* in the raw state. As, however, the stone is calcined before introducing it into the furnace, a corresponding increase to the percentage of loss by heat must be made. Six samples were selected and analysed, the results of which were published in my last paper. It will therefore suffice to take the average of these six analyses, and side by side to append its composition in the calcined state. This refers to the first series of experiments, viz., those performed in May.

Calculated average composition of six specimens of Hutton stone from Messrs Cochrane's works, May 1856, raw and calcined.

	Raw.	If Calcined. (Calculated.)
Silica,	14·35	19·77
Peroxide of iron,	44·50	61·32
Alumina,	4·92	6·78
Lime,	4·03	5·55
Magnesia,	2·18	3·00
Phosphoric acid,	2·21	3·00
Sulphur,	0·27	0·37
Sulphuric acid,	0·11	0·15
Loss by heat,	27·43	...
	100·00	99·98
Metallic iron,	31·15	42·90

In the *second* series of experiments, performed at Messrs Cochrane & Co.'s works in August, the calcined stone was *analysed*. In order to procure an average specimen, several hundredweights of the ore from the clamps were crushed to a coarse powder, the whole was then thoroughly mixed together, and a pound sample taken.

The whole of this pound was then ground in the laboratory to a much finer powder, and sifted, and from it the quantity for analysis was drawn.

Analysis of Calcined Hutton Stone.

Silica, ...	16·50
Alumina, . . .	15·03
Peroxide of iron, . .	53·40
Protoxide of manganese, . .	0·25
Lime, ...	8·40
Magnesia, . . .	3·90
Sulphur, . . .	0·31
Phosphoric acid, . .	2·32
Sulphuric acid, . . .	1·33
	101·44
Metallic iron, . . .	37·38

In the *third* series, performed at one of Messrs Bell Brothers' furnaces, the ironstone was from their mine at Normanby. It was calcined, and was taken from a very large quantity, and ground fine, as in the preceding case.

Analysis of Normanby Stone.

	Calcined.	Raw Stone calculated into Calcined.
Silica, . . .	21·00	17·32
Alumina, . .	10·12	8·17
Peroxide of Iron, .	52·68	56·18
Protoxide of Manganese, .	0·30	1·15
Lime, . . .	4·45	9·19
Magnesia, . .	3·23	5·41
Sulphur, . .	0·13	0·36
Sulphuric acid, . .	1.05	trace.
Phosphoric acid, . .	1·70	1·66
Moisture and Carbonic Acid,	5·34	...
	100·00	99·97
Metallic iron, . .	36·88	39·32

Hæmatite.—Along with the previously named ironstone, there was invariably used a certain quantity of Cumberland hæmatite.

As this is used only sparingly, and as the composition of the masses is pretty uniform, it was not deemed necessary to take such great precautions in the grinding of a large quantity. The following were the results obtained by subjecting the different kinds to a chemical analysis :—

Analysis of Cumberland Hæmatites.

	Kidney.	Compact Masses.	The Small.
Silica, .	1·50	10·20	12·30
Peroxide of Iron,	98·00	89·20	86·00
Lime, .	Trace.	Trace.	Trace.
Magnesia, .	...	...	...
Sulphur, .	Trace.	Trace.	Trace.
Phosphoric acid,	0·34	0·32	0·30
Water, .	...	...	1·90
	99·84	99·72	100·50
Metallic iron,	68·60	62·44	60·20

Average of the three specimens, 63·74 per cent. metallic iron.

Limestone.—The limestone used in the experiments at Cochrane & Co.'s was from Frosterly. It is nearly pure carbonate of lime, free from any considerable quantity of silica, sulphur or phosphoric acid. The analysis was as follows ;—

Analysis of Frosterly Limestone.

Silica, ...	0·60
Oxide of iron and alumina, .	0·50
Lime, ...	54·65
Magnesia, . . .	0·55
Carbonic acid, . . .	42·99
Sulphuric acid, . . .	0·50
Water, ...	0·13
	99·92

The limestone used at Messrs Bell Brothers' had the following composition :—

Silica, ...	1·50
Oxide of iron and alumina, .	0·85
Carbonate of magnesia, . .	4·41
Carbonate of lime, . .	93·24
	100·00

Coke.—The fuel used in this district is invariably coke, which is in consequence manufactured in enormous quantities, to supply the furnaces.

That which was used in the present experiments was a fine hard coke, and bears a good name amongst iron-smelters. It is also largely used for locomotive purposes.

Analysis of Coke.

Carbon,	89·70
Silica,	4·43
Alumina,	1·92
Sulphuret of iron,	2·07
Sulphuret of calcium,	1·10
Sulphuret of magnesia,	0·50
Phosphoric acid,	0·28
	100·00

The first specimens of slag for analysis were collected about three or four hours after the last casting, *i.e.*, at 9 o'clock in the morning; at this time the slag *begins* to run over the notch. It was again collected at 12 o'clock, and again at 5 o'clock P.M., just before casting.

It was also collected at times after the iron was run off, since a film of slag of some depth lies immediately on the top of the molten iron, and *below* the notch, consequently this portion runs out *through the tapping-hole*, after the iron is cast, and not by the notch at all. It was thought possible that this "Roughin," as it is technically termed, might differ from the other portion of the slag to some extent, both in its physical and chemical properties. It would be probably denser, and was generally more crystalline, than the slag run at an earlier hour.

The iron taken for analysis was from chips off an average pig, run at 5 P.M.

The pulverization of the iron was effected in a steel mortar, and the resulting powder sifted through a fine sieve.

As the graphitous scales are liable to separate from the iron in flakes, great care must be taken to insure their uniform admixture through the powder.

(*To be continued.*)

On the Physical Geography of the Tertiary Estuary of the Isle of Wight. By H. C. Sorby, F.G.S. (Plate IV.)

In the following communication on the Tertiary deposits of the Isle of Wight, I shall bring to bear facts and general principles that have hitherto attracted very little attention. In my papers on the Physical Geography of the Old Red Sandstone sea of the Central District of Scotland, and on the Terraces in the Valley of the Tay, north of Dunkeld, published in this Journal,* I have described these to some extent; but since, in the subject now before us, the points of importance differ very materially from those then in discussion, it will, I think, be better to reiterate some of them, in order to bring the essential facts more prominently into view.

It appears to me that the physical structure, as well as the organic remains, of the fluvio-marine tertiaries proves that they were formed in an estuary at the mouth of a large tidal river. The chief currents that are present in such a case now are those due to the rise and fall of the tide, the stream of the river itself, and the action of the surface-waves on the coasts and shoals. Those caused by the tide are characterized by moving up and down the estuary as it rises and falls; the direction of this line of oscillation of the current in different parts depending on their configuration. Near the coasts or shoals it is nearly parallel to them; but in intermediate positions it coincides with the resultant axis for the locality. The river-stream follows much the same laws as the out-stream of the tide, and acts as a force to be added to it, and subtracted from the in-current due to the rising tide. These facts necessarily result from the general laws of hydrodynamics, in the same manner as the current down a river must, on an average, be parallel to its banks; and are well known to mariners, being constantly alluded to in "sailing directions" for their use. Some of them are also most completely borne out by the actual observations of Captain Beechey, as published in the Philosophical Transactions for 1848 and 1851; and I would particularly call attention to the

* New Series, vol. iii. Jan. 1856, p. 112, and vol. iv. Oct. 1856, p. 317.

directions of the currents in the Bristol Channel, as given in the maps accompanying the latter paper. In proof of the rest, I refer to the excellent and most instructive chart of England and Holland by Norrie, particularly to the mouth of the Thames; where, however, the arrows indicate only the current of the rising tide. Now, if the organic remains in the fluvio-marine tertiaries of the Isle of Wight indicate that the deposits were formed at the mouth of a great river communicating with the sea, if it was affected with tides, it appears to me to be only strict induction to conclude that the same laws would apply to the currents present in it.

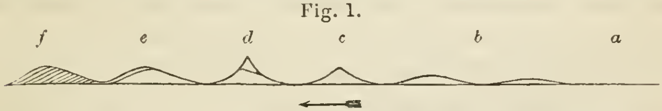
Waves caused by the action of the wind on the surface of water produce, as they pass onward, a current moving in the line of their advance under their crest, and in the opposite, in the intermediate hollow. The extent of this motion, and its velocity, depend on the height and length of the waves, and the depth of the water. If this be considerable, compared with the dimensions of the waves, there is no motion of any importance at the bottom ; but if they advance to where it is shallow, as, for instance, to a coast or a shoal, the movement along the bottom becomes considerable. It is then an oscillating current, moving forwards and backwards in the line of their advance, and perpendicular to their ridges, as extending on the surface of the water. Even if the line of motion of a system of waves be parallel to the shore at some distance from it in deep water, yet, when approaching a shelving coast or shoal, their ridges curve to it in such a manner that, when the depth becomes such that the velocity of the currents they produce at the bottom is sufficient to move the deposits, the direction of the line of oscillation is inclined at a considerable angle to that of the coast. Hence, if the same effective amount of waves comes from all quarters, the mean direction of this line would be perpendicular to the shore, and the range of variation would be about a right angle ; whereas, if that was not the case, this mean line would be inclined from the perpendicular towards the side from which the greatest amount of waves proceeded. As before mentioned, the direction of tidal oscillation, some short way from the coast or shoal, would be parallel to it, and hence, that due to the stranding waves would be nearly perpendicular to that of the rise and fall of the tide. This fact enables us to ascertain the existence and form of the coasts and shoals in the ancient seas, in the same manner as breaking waves serve to point them out to the navigator of those of the present period.

These conclusions are derived from the general and well-known phenomena of wave motion,* and from my own observations at various places on our coasts, which may be so easily made, that any one may readily repeat them, and convince himself of their truth.

When deposits are formed under the influence of a current, the character of the resulting structure depends on its velocity and depth, on the nature of the deposit, and the rate of deposition, which are so connected together that, I feel persuaded, on more extended inquiry, it will be found possible to ascertain their approximate value by examining the rocks. So much, however, remains to be learned by experiments, that I shall not now attempt to do more than indicate in what way the direction and character of the current can be determined, because that is all that is required for the subject in hand.

The direction of ripple-marks clearly shows that of the current which produced them; for they trend perpendicular to its movement, in the same manner as the waves of the surface of water do with respect to the wind. The current often washes forward material, which is deposited in small beds on that slope of the ripple opposite to that from which it flows. This will be better understood from fig. 1, which is an ideal sec-

Fig. 1.

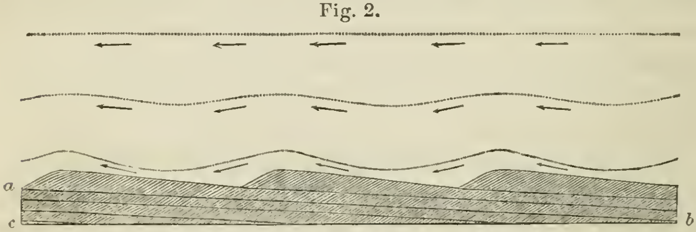


tion perpendicular to the trending of a system of ripples, to show the gradual passage from "level beds" at *a* to gentle curved "ripples" at *b*, becoming crested at *c*, and so sharp at *d*, that the upper part would be washed off to where there is a dotted line, carried forward in the line of the current, and

* See Airy's Treatise on Tides and Waves, in the Encyclopædia Metropolitana, and Scott Russell's Report on Waves, in the Report of the British Association for 1844, p. 311.

thrown down as a small bed at (*e*), on the side towards which the current flows. Fresh material being washed up from the exposed side of the ripple, carried forwards and deposited on the protected side, such a structure as at (*f*) is produced, which I call "ripple-drift." If no permanent deposit was being formed, merely matter drifted onwards, no more material would be added to the protected than would be afterwards washed up from the exposed side; therefore systems of such ripple-drifts would simply advance, and leave nothing behind them. If, however, an actual deposit was being formed, so that more material was added to each ripple than was afterwards washed up again, the lower portion of each would be left behind, and covered up by the next advancing over it. Provided that the accumulation took place at a uniform rate, thin beds, like those shown in fig. 2, would be left behind,

Fig. 2.



having stratula,* as shown in the figure; whereas, if there was a fluctuation in the rate of deposition, the thickness of these bands would vary accordingly. By this means, then, there are produced bands of oblique-bedded stratula, each of which does not coincide with the true horizontal plane of stratification, but is inclined to it at an angle, *abc*. Since the thickness of each of these bands is necessarily the amount of material accumulated during the interval required for each ripple to advance through a space equal to its own length, it is obvious that, when the laws of the rate of this advance have been accurately ascertained, the rate at which the deposit was accumulated will also be known. Of course, if the surface of the ripples can be seen in any rock, the direction of the current can be ascertained at once; but, as is often the

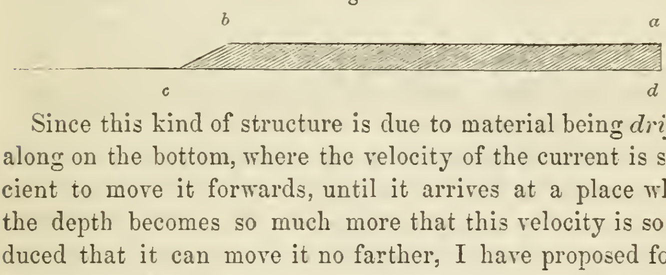
* I most willingly adopt this term, first proposed by De la Condamine in his paper in the Quart. Journ. Geol. Soc., vol. ix. p. 273.

case, if it cannot, this may be learned by taking the mean dip of their stratula, which, owing to the tendency to form small delta-like accumulations, frequently varies considerably. I have now before me in my cabinet specimens showing most perfectly all these peculiarities of structure, as well as most of the others described in this paper.

In some cases, when the current is not of such a character as to produce ripples, and yet is strong enough to drift material along the bottom, there is produced on the surface of the beds a peculiar banding and graining in the line of its movement. This is seen to so great perfection in some thin-bedded flags, as to show the direction of the current in a most satisfactory manner; but it is not easily recognised in such rocks as those in the district under consideration.

The direction of the current can also be most satisfactorily ascertained from that peculiarity of stratification which has usually been called "false-bedding." A single bed of this is shown in fig. 3.

Fig. 3.



Since this kind of structure is due to material being *drifted* along on the bottom, where the velocity of the current is sufficient to move it forwards, until it arrives at a place where the depth becomes so much more that this velocity is so reduced that it can move it no farther, I have proposed for it the term *drift*-bedding, in contradistinction to true horizontal stratification, formed by simple deposition without such drifting, and to ripple-drifting, where the structure has been modified by the formation of ripples. I object to the term *false*-bedding; because it would be quite as applicable to the bands of ripple-drift (and in such cases it is not *false*), and would restrict it to certain cases of unconformable junction of the layers of beds, neither due to true drift-bedding or ripple-drifting, but which may be truly said to have *false stratification*. These various structures are entirely distinct, and should most certainly be known by different names. Though drift-bedding is usually in larger beds—I have seen some upwards of 25 feet thick; yet in many cases their size is no greater than that of bands of ripple-drift; but then they are essentially distinguished by the facts, that each bed of drift-bedding is parallel to the true plane of stratification, is independent of any other, and may exist alone, as fig. 3; whereas, in ripple-drift, each is inclined to it at an angle, as *a b c*, fig. 2, and can only occur grouped with others. The well known ripple-marks are those particular cases of ripple-drift where circumstances have so occurred that the rippled surfaces are preserved. In very many rocks this is an exception; and they have only so influenced the structure as to give rise to what would commonly be called small false-bedding, or oblique lamination. My *ripple-drift*, therefore, includes most cases of *ripple-marks*, and much more besides; in fact, all structures due to their action, whether their perfect *upper surfaces* are preserved or no.

In order to illustrate the production of drift-bedding, I have constructed a working model, which I exhibited and described at the late meeting of the British Association at Cheltenham. In it the action of the current is represented by a kind of coarse screw, which carries forward from a receptacle a mixture of fine, black, specular iron-sand or emery, with about four times its bulk of coarser white quartz sand, as if it was drifted along the bottom of water by a current; for instance, from *a* to *b* of fig. 3. Arriving at the point when it can escape from the action of the screw, like when the current can carry it no farther, as at *b*, it is thrown down on a slope, at the angle of rest, as at *b*, *c*. By turning the screw alternately, quickly and slowly, the heavy fine black and light coarser white sand become sorted, and form distinct stratula, visible through the glass front, just such as are produced by fluctuations in the velocity of the current; whereas, if it is turned round at a uniform rate, no such distinct thin stratula are formed; the only sorting being the accumulation of the fine particles at the top, and the coarser at the bottom, precisely as is invariably found to be the case in natural drift bedding. When due allowance is made for the smaller value of the angle *b c d*, produced by subsequent changes that have sometimes taken place in the material, so as to cause it to occupy less space, or for its original smaller size, that occurs where drift-bedding is tending to pass into the horizontal-grained structure already alluded to, it is found, not only that the general appearances thus artificially generated are precisely like those found in the natural rocks, but all the minute details so entirely correspond, that the manner in which drift-bedding has been produced can admit of no doubt whatever, nor that we may confidently rely on it for determining the direction of the currents, as will, I am sure, be admitted by all who have seen the model in action. Such are now made by, and may be procured of, Messrs Chadburn Brothers, opticians, Sheffield.

As will at once appear from what I have said, the direction from which the current came is opposite to that to which the stratula dip, allowance of course being made for any disturbances that may have subsequently occurred. This, as well as that of the ripple-drift, is often easily determined and measured in ancient deposits, and thus the exact point from which the current came is known. Modern cases would lead us to expect that there would be considerable variation in different parts of a bed in the same locality, though formed under the same general conditions. This is what is found to occur in older rocks ; but then, by ascertaining the directions in various parts, and taking their mean, the average is known, which is the fact required. For these structures, due to the action of currents, I propose the general term, " current-structures ;" and have adopted the following symbols to represent them, which are of very great use in describing the characters of rocks. I have chosen them from such types in common use as do actually somewhat resemble each particular kind, so as to be more easily remembered.

For " level-bedded," (a dash)	—
For " ripple-drifted," (a section) . . .	∽∽
For " drift-bedded," (symbol for angle) . .	∠

By using these symbols the character of a bed of rock is easily expressed, by writing them in the order in which the amount of each kind of structure exists in it.

All these various current structures may often be most conveniently studied in progress in clear rivers; and in wet weather in the streams running by the side of country roads, that are mended with sandy material; and when these are dried up, the most instructive examples of all of them may be observed, and their intimate structure ascertained, by cutting into them. In those actually in progress, the relation between the configuration of the channel, the current, and the structures produced by it, may be readily seen ; and, when dried up, we may see that the current-structures clearly show the direction of the previous current, and that, if the confining banks were to be removed, they would also indicate their general direction in the most satisfactory manner. We may likewise readily observe the fact, that when sand is thus drifted along, in cases where we can see it, one or other of the structures is invariably produced; and that thus, by one or other, according to the circumstances of the case, the direction of the current could be ascertained; and when we cannot inspect it, it is only reasonable to conclude that the same causes produce the like effects. Now, in ancient deposits, we have clear proof that the material of which they are composed must have been transported by some current; and when we examine the rock, we find these structures in all their detail; and hence I think the conclusion necessarily follows, that from them its direction can be satisfactorily determined. I need scarcely remark, that the facts I have so far referred to occur where material is drifted along the bottom, and not where fine mud is first held in suspension in water, and then subsides through it by mere gravitation. The rate at which this takes place would prevent any but very fine grains being transported far by that means by water of no great depth. Many of the strata in the district under consideration appear to have been thus formed, when the currents were not such as could drift forwards the coarser particles of sand; but the coarser grained have the current-structures, as if accumulated by the drifting of material along the bottom, and it is to these, as showing the directions of the currents, that my remarks will be confined in this paper.

If the current be simple, and move only in one direction, though there may be a considerable range of variation, yet the current-structures will show that it was only from one side; whereas, if it be oscillating, as due to the rise and fall of the tide, or to the action of stranding waves, it will be found that they indicate a movement forwards and backwards along a particular mean line. The character of the structure in this case will be seen from fig. 4—

Fig. 4.
From Magnesian Limestone near Tickhill. Scale $\frac{1}{10}$ nat. size.

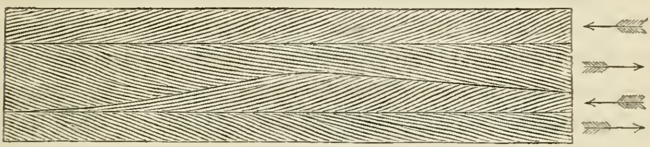
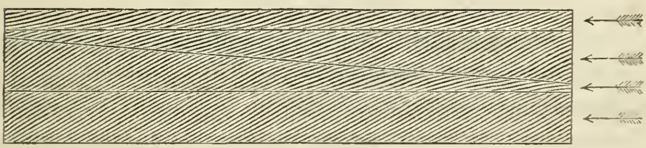


Fig. 5.



where the arrows show from which side the current came for each bed; but if there had not been any such oscillation of the current, the stratula would have dipped to one side in every part, in the manner shown in fig. 5. The same facts are also seen with respect to ripple-drift; there being in one case bands of such a structure as to indicate a simple current from one side, like fig. 2, and in the other alternations of those, showing it to have been first from one side and then from the opposite. By examining what occurs in simple currents, like those of rivers, it is easy to see that the material is deposited only on one side of the ripples; whereas, in oscillating, like those of waves, it is seen to be deposited first on one side and then on the other, and thus gives rise to ripples of a peculiar kind, having portions with stratula dipping in opposite directions, as may be seen by cutting into such on a beach, and as are so often met with in older deposits; and I think there cannot be the slightest doubt that the same must occur when cirumstances are such that drift-bedding, like fig. 4, is produced by oscillating currents. It does not, indeed, necessarily follow, or is it at all likely, that each set of opposite stratula was due to a single wave or tide; but the most probable conclusion is, that each bed was produced during a much longer interval, when the oscillating currents caused a preponderance of action in one or other direction, in accordance with what I describe farther on, when treating on temporary deposition. That drift-bedding or ripple-drifting, with the stratula in different parts dipping alternately in opposite directions, does really prove that the currents were *oscillating*, in my opinion admits of no doubt, and cannot be explained in any other manner, on strict experimental and general mechanical principles. On the contrary, such a structure as that shown in fig. 5 indicates as conclusively that none but simple currents, moving only in one direction, were instrumental in producing it, though, of course, it is possible that occasionally some, too gentle to move the deposits, might flow in an opposite direction. It may be well here to remark, that the delta-like form in which drift-bedding and ripple-drifting are often accumulated, may cause an apparent indication of oscillation where such is not really the case, if the section be cut in particular directions, and care be not used in examining them; in the same manner as we might be led to conclude that a rock dips in a very different direction to what it actually does.

The Magnesian Limestone, in the south of Yorkshire, has furnished me with a most excellent example of oscillating currents. Those due to the tide are extremely regular over a space of twenty-five miles in a direction across the currents which I have explored very thoroughly; and in no place out of several hundred localities are there any simple currents without oscillation. The upper bed of the Millstone Grit in South Yorkshire and North Derbyshire is, on the contrary, a good illustration of a simple current very uniform over a similar space, without any merely simple oscillation, as if it had been such a wind-drift current as is described in my paper on the Physical Geography of the Old Red Sandstone Sea of the Central District of Scotland.* Indeed, the carboniferous and Permian rocks of this district afford most excellent oppor-

* Edinburgh Philosophical Journal, vol. iii., p. 112, Jan. 1856.

tunities for this study; and when, in roaming over my native hills, I see such thousands of most excellent examples of all the structures I have described, both in the act of being formed in the modern streams and rivers, and as existing in the older rocks, I am utterly amazed that scarcely any one but myself should have entered on this field of inquiry, and can only account for it by supposing that geologists have generally been too intent in studying the organic remains to pay attention to the no less important physical structures of the rocks. That these will, however, on careful examination, yield very valuable and instructive facts is my most firm belief.

It is best to ascertain the direction and relative amount from each side in oscillating currents; because the facts of not being equal or opposite are of much importance in deciding several points of great interest. In order to represent the oscillation of currents, I use the mathematical symbol for "varies as," viz., $\propto$, which appears to me extremely well suited for the purpose. If, then, there was oscillation from north to south, and south to north, I express it thus—N. $\propto$ S.; which is to be read, "north oscillating with south." If the number of observations from each side be written, their relative amounts are also seen. For instance, if the oscillation was from N. 20° W. to S. 30° E., with 20 observations from one, and 10 from the other, I represent it thus—N. 20° W., 20 obs. $\propto$ S. 30° E., 10 obs.

I trust that I have now explained these general principles sufficiently for the purpose more immediately before us. My main argument may be summed up as follows:—The examination of modern seas, estuaries, and rivers, shows that there is a distinct relation between their physical geography and the currents present in them; currents so impress themselves on the deposits formed under their influence that their characters can be ascertained from those formed in the ancient periods: therefore their physical geography can be inferred within certain limits.

It is most important that a clear distinction should be made between the *temporary deposition* and the *permanent accumulation* of deposits. If the bottom of the water on a sandy coast on which waves are breaking be examined, where the depth is such that it may be seen through the clear water, and the waves act on the deposits, the sand may be seen to be carried over the ripples towards the shore as the crest of each wave passes, and back from it as each hollow moves over it. In this manner the sand is, for the short time, often deposited with considerable velocity, but is only moved backwards and forwards. If the sea be not rough, the peculiar properties of low long waves advancing to shallow water cause the sand to be drifted more to than from the coast; and hence, for the time, there is a temporary accumulation. If, however, there be a rough sea, with large, high waves, capable of moving the deposits at a greater depth, and more equal in their action to and from the coast, the material thus accumulated is carried farther out from it, to be again brought in during another calm period. In both these cases there cannot, I think, be any doubt that the ultimate structure of the sand would show the action of an oscillating current, and would also indicate, in many cases, a rapid deposition; and yet there might be no permanent addition to the material, and no permanent accumulation during an indefinitely long period. But if a change in depth, by subsidence, or some other alteration in physical geography, should occur, so that material might be deposited quite out of the influence of the subsequent action of the currents, there might be a permanent accumulation of strata; and since such would, in all probability, have been formed during some extraordinary storm, when the waves acted at an unusual depth, their structure might indicate a *rapid deposition*, whilst there might have been a *very slow permanent accumulation*, which would perhaps include an indefinitely long period, where no such permanent accumulation took place. Though we cannot readily examine what goes on in deep water out of the influence of surface waves, yet it appears to me only reasonable to conclude that the same kind of facts occur with respect to tidal currents, whose velocity has been ascertained by observation to be often such as would produce the various current structures. Indeed, it is well known, and is frequently mentioned in "sailing directions," that the chief changes in the form and position of shoals, and the depth of the water, are due to extraordinary high tides, produced during storms by the combined action of the wind and ordinary tide. We may therefore, I think, conclude, that when any permanent accumulation takes place, it will often indicate an unusual rate of deposition of material, which it may have taken ages to accumulate in some situation from which it was removed, and permanently fixed in another locality during some storm. When thus, however, permanently preserved from subsequent changes, I think it is only legitimate induction to suppose that its ultimate structure would indicate the direction and nature of the currents present during its deposition, whether they be simple or oscillating, or of such characters as to give rise to one or other of the current structures already described, according to the circumstances of the case.

In inquiries like the present, it is necessary to take into account the unequal amount of winds from different quarters of the compass. In this part of the world the resultant mean is nearly W.S.W., and the violent gales are far more common from the west side of north and south than from the east.* The size of waves produced by the action of the wind, as is well known, depends on its strength, and on the time and distance that it has acted on the water. If, then, a place in a sea be so situated that the distance to the coast on the east was equal to that to the west, the stronger and more general west winds would cause the largest and most prevalent waves in that locality to be those due to the western winds, which, of course, would move in the same direction. But if the distance to the east coast was very much greater than to the west, the less violent eastern winds, blowing over a greater expanse of water, would give rise to larger and more effective waves than the stronger western, acting over a less space. These facts may easily be observed by any one on the eastern coast of England, and are constantly taken into account by mariners ;

* See Sir W. Snow Harris' Report on the observations of the winds at Devonport and Greenwich in the British Association Report for 1844, p. 241 ; Maury's Physical Geography of the Sea, and his Wind and Tide Charts ; and Johnston's Physical Atlas, first edition, Meteorology, Map No. 2.

and they are of great importance in the subject under consideration.

As before remarked, the organic remains in the upper Tertiaries of the Isle of Wight, clearly indicate that they were deposited in an estuary at the mouth of a great river. In such a case, judging from what occurs now, we should expect to find shoals with deeper tidal channels between them ; for instance, like those shown by a chart of the mouth of the Thames. The action of the tide causes such shoals to be elongated in the line of the axis, and to run more or less closely in the directions of the currents. In studying, then, an ancient estuary, the chief points to be determined are,—what was the line of its axis, which way it opened into the sea, and the position of the shoals. In this communication I shall confine myself almost entirely to the application of the physical principles I have described, and must refer to well-known publications for the general geological structure. On the accompanying map (Plate IV.), the directions of the currents in the various localities are shown by the arrows, and the relative amount from each side by their length. An inspection of it, I think, at once shows that the axis of the estuary in this locality ran from near W. by N. to E. by S., and that there was a considerable shoal in the part included in the dotted line ; as proved by the currents there being perpendicular to the axis, in accordance with the principles already described. This, I think, completely explains why the sections at Alum Bay and Whitecliff Bay differ so much from one another ; for one is through a shoal, and the other through deposits formed in a deeper tidal channel.

It will now, perhaps, be best to describe some of the facts at each part, and to give the actual means, which are represented on the map by arrows. All the bearings are to true north. Commencing in Whitecliff Bay, and referring to the admirable sections of Prestwich (Quarterly Journal of Geological Society, vol. ii., Plate ix)., I was unable to detect any evidence of currents in the lowest part till coming to the upper portion of the "Bognor Beds." Passing upwards, there are alternations of beds showing current structures with others that do not. However, the verticality of the strata renders it impossible to ascertain their direction with great accuracy; but, so far as I could determine, they were, in the marine beds, on an average, N. 37° E., ∝ S. 37° W., in some cases more from N.E., and in others S.W., but on the whole more from N.E. These are shown on the map by the arrows numbered (1); and the others, described below, will be numbered to correspond in the same manner.

(2.) When we come to the horizontal and more fluviatile beds, the directions can be ascertained with sufficient accuracy. They were N. 64° E., 47 obs., ∝ S. 60° W., 13 obs., being the means of the means for the various beds, which do not vary much. These results do not differ materially from those in the lower beds; so that I think we are warranted to conclude that the general line of oscillation was so similar for the whole period as to prove that no coast or shoal was formed.

(3.) In the limestone, on the coast north of St Helen's, we have N. 83° W., 15 obs., ∝ S. 72° E., 11 obs.; whilst in a small bed of sandstone I found indications of a shoal, but not sufficient to determine the directions with accuracy.

(4.) In the quarries at Binsted, S. 50° E., 15 obs., ∝ N. 42° W., 15 obs. The tidal action here was much the most strongly marked in the lower, more quartzose, sandy portion.

(5.) East of Cowes, S. 74° E., 7 obs., ∝ N. 72° W., 4 obs.

(6.) Hampstead Hill, S. 73° E., 3 obs., ∝ N. 60° W., 3 obs.; but the currents here were generally very feeble, and there is seldom evidence of any.

(7.) Near Lymington, S. 70° W., 15 obs., ∝ N. 73° E., 14 obs.

(8.) In the beds above the Barton Clay, near Hordle, N. 63° W., 36 obs., ∝ S. 56° E, 29 obs., being the means of the means of the various beds, which do not differ much from each other.

(9.) I could not make out any current structures in the Barton Clay, but below it, near Muddiford, N. 76° E., 13 obs., ∝ S. 74° W., 5 obs.

These various means, as will be seen from the map, do not differ from one general direction more than would be likely to occur from the interference of shoals and other causes; and, of course, allowance must be made for slight errors of observation; because it is not always possible to see so many good cases of current structures, as to give a perfectly correct mean. I think it cannot be doubted that the whole of those I have given are axial oscillations. The means of the means of those in the fluvio-marine deposits, viz.—Nos. 2, 3, 4, 5, 6, 7 and 8, are S. 77° E., 126 obs., ∝ N. 78° W., 101 obs. These may be relied on as sufficiently exact; but the direction of the currents at the period of the lower, more purely marine, deposits can be determined in so few instances, and then not in a satisfactory manner, so that it cannot be known nearly so well as could be wished. However, so far as I could ascertain, it was N. 68° E., ∝ S. 56° W.; certainly most from the former. This, then, is not exactly parallel to the other, but intersects it at an angle of 40°; being more to the S.W. than the other. Although I cannot rely on it fully, yet, since the same facts are indicated at each locality, and there are several other reasons that tend to confirm it, I think it will be best to conclude, provisionally, that the line of axis of the marines was not exactly the same as that of the fluvio-marines.

In the "mottled clays" in Alum Bay, as was the case at Whitecliff Bay, I could find no current-structures; nor till coming to the centre of the "Bognor Beds." There I saw evidence of a current from near east, which would agree well enough with the general axial direction. Passing upwards to the "lower division of the London Clay" of Prestwich's section, in the beautiful striped sands and clays, it is difficult to tell the directions accurately on account of the verticality of the strata; but I concluded that they were somewhere about S. 18° E., ∝ N. 18° W., in nearly equal proportions. In the more horizontal "Headon Hill Sands" the directions can be ascertained with sufficient accuracy, and I there found them to be S. 28° E., 13 obs., ∝ N. 32° W., 12 obs. (No. 10 of the map), or closely the same as in the beds below. These directions are inclined at 89° to the line of the axis for the marines, as given above, or almost exactly perpendicular. This, then, appears clearly to indicate, in accordance with the principles already described, that the currents were those due to wind-waves stranding on a shoal or coast. I therefore conclude that there was a shoal here, running in the line of the axis, as shown by the broken line on the map.

(11.) The means of the means in the various beds of the fluvio-marines of Headon Hill to Sconce Point, are S. 22° W., 65 obs., ∝ N. 18° E., 41 obs.

(12.) In the limestone near Calbourne, S. 2° W. 25 obs., and N. 2° E., 14 obs.

These, it will be seen, are nearly perpendicular to the axial line. The means of both, (viz., of 11 and 12) are S. 12° W., 90 obs., ∝ N. 10° E., 55 obs., which are inclined at 89° to the axial line of the fluvio-marines, or almost exactly perpendicular. This would agree with the supposition that there was still a shoal, but that its direction was not exactly the same as at the period of the marines, but had changed to that of the fluvio-marine axis, as shown by the dotted line on the map. If such was the case, and when there were no high winds to produce waves of material size, if there was a general axial current due to a river, we might expect to find indications of it, even on part of the shoal. Such, indeed, is the fact; for I found cases where there were beds or stray bands showing such a current, and giving a mean of N. 70° W., from 10 obs., or within 10° of the axis, which is as near as could be expected from the nature of the case. This is shown by the small arrow at (11) of the map.

It appears to me, therefore, that, in the part now constituting the western end of the Isle of Wight there was either a coast or shoal. So far as the directions of oscillation are concerned, either supposition would agree with the facts; but there are reasons for supposing it was a shoal. Unfortunately, there now remain no Tertiary deposits on its south side, so that this could be decided by an examination round it (in the manner I have been able to do in the case of the Magnesian Limestone in South Yorkshire); but it appears to be a decided fact, that on the whole there was very considerably more material carried from the south than from the north, as though the effects of the oscillating currents had been greater from the south side. This would agree perfectly with what would occur if the waves came from the south; because mathematical investigations,* and my own observations,

* See Professor Stokes' paper in Cam. Phil. Trans., vol. viii. p. 446.

show that there is a considerably greater effective force in the line of a wave's movement under its crest, than backwards below the depression. Besides this, if the line of the shoal at the period of the lower marines was as I have given above, the deposits at Whitecliff Bay and Barton would be on opposite sides of it, and hence there could scarcely have been a genuine coast-line. It is these considerations that lead me to infer that it was a shoal, cast up by the action of waves, proceeding chiefly from the south; and, since the currents in the lowest part of the marines are axial, it should appear that the period of its first production was during the "lower division of the London Clay" of Prestwick's section, or just where the difference between the strata here and at Whitecliff Bay becomes so remarkably apparent, and it continues upwards to the upper part of that division. In the "upper division of the London Clay" I could find no indication of a current, and the inference I draw is, that the depth was then too great for the waves to move the deposits at the bottom; but when we come to the "Headon Hill Sands," it was so diminished that the same shoal-action is again met with.

As stated above, the probable line of the axis for the rise and fall of the tide in the lower marines is from E.N.E. to W.S.W. The number of observations, and the extent of the district I have examined, are not sufficient to enable me to pronounce for certain; but the facts, so far as they go, distinctly point to the conclusion, that the sea communicated with the main ocean of the period on the east side; for this would account for the excess of force being from that. Besides this, if it had opened to the west, the great excess of storm surface-waves from that side, produced by the prevailing W.S.W. winds, would have caused the line of shoal oscillation to have inclined considerably towards it; whereas the evidence is that, if anything, the contrary was the fact. These suppositions would agree very well with the great extension of the deposits of this period over central and southern Europe, right into Asia.

Now, I think one cannot fail to be struck with the remarkable parallelism between this line of tidal oscillation and that of the elevation of the older rocks from Bath to Cambridge, which is almost exactly parallel to it; as though the coast to the north-west that determined the line of movement of the tide was related to that direction of elevation. It also distinctly points to the fact of the Wealden elevation not having then occurred, in accordance with what is proved by other phenomena. In the same manner, the line of axis of the fluvio-marines is very similar to that of those repeated movements that have effected the south coast of England, running from a little north of west to south of east, viz.:—

	Trending.
In Devonshire, after the Carboniferous, and before the Permian period, . .	S. 80° E.
In Dorsetshire, after the Oolitic, and before the Cretaceous period, . . .	S. 85° E.
In the Isle of Wight and Wealden district, after the Tertiary period, . .	E. to S. 80° E.
Axis of the fluvio-marine Tertiaries, as deduced above, after the Chalk, but before the conclusion of the lower Tertiary period,	S. 78° E.

It should therefore appear, that after the formation of the lower marine Tertiaries a gradual movement took place, in a direction similar to what has thus repeatedly occurred in this part of England, so as to cut off the sea to the south, give rise to a new line of axis, and determine the existence of the estuary of the fluvio-marines by the crossing of the two lines of elevation named above, in precisely the same manner as that of the Thames of the present period was produced by the intersection of the first named line of elevation with that of the Wealden district. That this elevation and change of line of axis during the lower Tertiary period were gradual, is, I think, indicated by the absence of any decided break in the strata, and by the fact that the beds intermediate between the two portions give an intermediate line of oscillation. I think the evidence leads to the conclusion, that the shore thus produced was considerably south of the Isle of Wight; but perhaps some change occurred also north of it; and indeed, though the facts do not prove it, yet they in many respects render it probable that the line of elevation of the Wealden was partially developed at the same time. (See figs. 6 and 7.)

These conclusions would agree with the supposition that the river came from the west, and of this I think there is good physical proof. In the more purely fluviatile deposits at the western part of the Isle of Wight and in Hampshire, the amount of action from the west side is to that from the east, on an average as 3:2; and the axial currents over the shoal in the Isle of Wight are, so far as I saw, all from the west, as if the river came from that side. Moreover, the fact of the surface-wave oscillations on the shoal being so nearly perpendicular to the axial tidal currents, could not, I think, be accounted for more satisfactorily than by supposing that there was land to the south and west to protect the water, so that the more violent gales from that side should blow over such a smaller surface of sea, that the waves in the district under consideration should not be so great as those produced by the less violent easterly winds blowing over a larger expanse of water. On the whole, then, I think, it may be concluded that the river came from the west; and though I have wished to throw the purely physical data into the front of the battle, does not the distribution of the organic remains agree equally well with this supposition?

It will now, perhaps, be well to consider some of the facts connected with the actions present during the period of the fluvio-marines. Though I have shown that the oscillation of the currents very strongly indicates tidal action, yet it must not be thought that it was present all along in any considerable amount. In fact, the evidence is, that in many cases it was nearly, if not entirely, absent; for very often the strata furnish no indication of any current of importance. It is an extremely common fact to find at the mouth of a large tidal river more or less of a bar, formed by the interfering action of the river and tide. This would, of course, to a certain extent, keep out the sea-water, and impede the tidal action in ordinary cases, so that the water above it might generally be more or less fresh, and not subject to currents of material velocity. However, in unusual storms from seawards, an extraordinary rise of tide might occur, and produce such currents as would wash up deposits formed under more fluviatile conditions, and generate current structures related to the axial line. We might also expect that, in the progress of changes occurring over a long period, the configuration of the estuary would vary in such a manner as to cause the extent of tidal action to differ very materially. The physical structure of the fluvio-marine deposits under consideration agrees very well with these suppositions, and so, I think, do the characters and distribution of the organic remains.

If I am right in inferring that there was a shoal as described above, and not a coast line, in the western part of the Isle of Wight, it is difficult, if not impossible, to ascertain the dimensions of the estuary, because its southern boundary has been removed. Nevertheless, to explain why the shoal was thrown up by waves from the south, I think we must conclude that the south coast-line was as far, or farther, from it than the north, and, if so, the breadth of the estuary must have been at least 15 or 20 miles, or somewhere about the size of that of the Thames east of the Isle of Sheppy. Notwithstanding this, it would appear that the dimensions of the river were such as to keep the water in general more or less fresh; and though there are difficulties in the way of forming an accurate conclusion, yet I think we cannot but infer that to do this a river much larger than any now running in Britain would be required. I have already shown that there is evidence that land existed to the south, west, and north; and if a great river came from the west, I think the inference is, that it was of considerable extent, and that its drainage ran into the sea through the tertiary estuary of the Isle of Wight.

These general conclusions will be better understood from the accompanying figures, which are only intended as diagrams to illustrate the general conditions, and are not professed to be more than first approximations, for reasons already given.

Fig. 6.

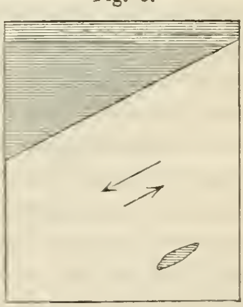


Fig. 6 shows the direction of the rise and fall of the tide at the first period, before the estuary was formed, the line of coast that would give rise to that direction, and the Alum Bay shoal.

Fig. 7.

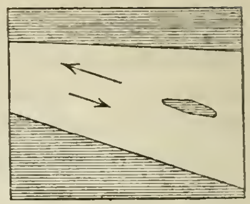


Fig. 7 shows the direction of the estuary at the period of the fluvio-marine strata, with the line of the rise and fall of the tide, and the shoal in its altered position. The change from the first to the latter condition was not sudden, as is proved by the directions of the currents in the intermediate beds being intermediate, as described above; but yet it does not necessarily follow that it was uniformly slow and gradual. These facts, and the verticality of the strata in Alum and Whitecliff Bays, render it difficult to ascertain the exact period of the change. In the vicinity of Barton it appears to have occurred, so that the second line of axis was fully established when the strata just above the Barton Clay were deposited; whereas in Alum Bay this was not the case until the period of the upper portion of the Headon Hill marls and limestones; as though, like the passage from marine to freshwater conditions, the change had progressed from the west towards the east. When completely formed, the general mean line of the axis of the estuary does not appear to have varied much; though its configuration may nevertheless have changed very materially; its depth, and the position of its bounding coasts, may have undergone great alterations. Indeed, the alternation of beds of different physical character, independent of what is learned from the study of the organic remains, in my opinion clearly indicates that such changes did occur; but these might have been very considerable, and yet the mean line of axis might have remained nearly the same. For instance, in the case of the present estuary of the Thames, if, by subsidence or other changes, it was to be extended, so as to comprise the whole of the London Tertiary basin up to the range of the Chalk, so as to cover the whole of the triangle included between Norwich, Hungerford, and Canterbury, we should have a very great change in geography; so much so as to produce a total alteration in the nature of the materials accumulated in many parts of the present estuary: and yet the *mean line of axis* would not be materially different from what it is now. In the case of that in the Isle of Wight, now under consideration, it appears to me to be a question of examination of facts to decide whether this was so or not. The best evidence in this respect that I know is that derived from a comparison of the directions of the currents, as observed in the various strata seen in the section along the coast from Barton to Milford. Dividing the means into three groups, for the lower, middle, and upper beds, we have for the lower, N. 68° W., 16 obs., ∝ S. 69° E., 15 obs.; middle, N. 68° W., 15 obs., ∝ S. 51° E., 10 obs.; upper, N. 69° W., 13 obs., ∝ S. 66° E., 11 obs.; which agree so closely as to show that no material change in the line of the axis had occurred. There is also a similar agreement in the section at Whitecliff, and in the highest beds at Hampstead Hill; though the current was so gentle that its direction cannot be determined well there.

It appears to be very probable, that over the shoal already described the depth could not have been above a very few fathoms, and it might even in part have sometimes constituted dry land; which would account for the greater abundance of land shells in the limestone of the western part of the Isle of Wight. A most careful examination of the distribution of the organic remains, in connection with the physical structure, would indeed be very instructive, but would require much time and attention. I have confined myself as much as possible to purely physical data; but at the same time I think that the facts deduced from them will agree with many of the leading conclusions with respect to the distribution of the various organic remains. For instance, the deeper marine character of the lowest beds; the absence of shells in the "lower division of the London Clay" of Prestwick's section at Alum Bay, and their presence at the same horizon in Whitecliff Bay; and the more marine character of the fossils in beds at Whitecliff, which are equivalent to those that are almost, or entirely fluviatile north of Alum Bay. However, I must leave the detail of this part of the subject to those who are far more capable than myself of doing it justice.

As illustrating some facts of importance in connection with the Tertiary deposits, perhaps it would be well to mention some of the phenomena I have observed in the Drift-Sand and gravel in Hampshire, from Lymington to Christchurch. The line of tidal oscillation was S. 80° W., 49 obs., ∝ N. 86° E., 24 obs. In accordance, then, with the principles already described, this would lead us to infer that the line of coast that directed the currents ran nearly east and west, and that the tide came from the west side. There is no difficulty in seeing that this was really the fact; for the direction of the chalk hills to the south in the Isle of Wight is within 5° or 10° of being parallel to it, the difference agreeing with what would be produced by action of the line of the chalk to the north; and we may consider it almost certain that the tide came from the west side. This close agreement between the general physical geography indicated by the current structures, and that which other facts prove must have been the case, tends, I think, to inspire us with considerable confidence in applying the same general principles to determine that of earlier periods.

On Hydractinia Echinata. By T. STRETHILL WRIGHT, M.D., Fellow of the Royal College of Physicians, Edinburgh. *

Explanation of Plates.

PLATE V.

Fig. 1. Diagram showing the various polypoid forms observed on the (female) polypary—*a*, spiral polyp—*b*, reproductive polyp—*c*, alimentary polyp—*d*, sessile ovary—*e*, tentacular polyp.

2. Solid grooved papilla of corallum.
3. Hollow papilla of corallum.
4. Ideal section of the extremity of one of the propagative stolons—*a*, "colletoderm"—*b*, corallum—*c*, ectoderm—*d*, endoderm.
5. Spermatic capsule of reproductive polyp of male polypary—*a*, ectoderm—*b*, muscular coat—*c*, endoderm—*d*, gelatinous plasma, in which spermatozoa are developed.
6. Ovarian capsule of reproductive polyp of female polypary—*a*, ectoderm—*b*, muscular coat—*c*, endoderm—*d*, ova.
7. Fecundated ovum segmented by yelk cleavage.
8. Larva studded with motionless "palpocils."
9. Young polypary and polyp.
10. Spiral polyps covered with large thread-cells.
11. Large and small thread-cells.

* Communicated to the Royal Physical Society of Edinburgh, Nov. 26, 1856.

PLATE VI.

Fig. 12. Young polypary attached to side of tank, showing tubular net-work of the endoderm.

13. Diagram showing the situation of spiral polyps *a*, and tentacular polyps *b*.

1. In rock pools left exposed by the retiring tide on the shores of the Frith of Forth, numerous Paguri, or hermit crabs are found, inhabiting old turbinate shells, formerly occupied by various species of Buccinum and Fusus. The rough and worn surfaces of these shells also form convenient homes for a great variety of animals, and frequently afford a strange scene of thronged and busy life. In the spring they present the naturalist with a rich field for observation. He will find the fixed and blind Balani, hidden in their mailed armour, winnowing the water with their fan-like cirri, and vomiting forth swarms of bright-eyed and actively swimming larvæ. There the Spio incessantly tosses about her long arms; the Serpula expands its many-coloured branchial plumes; Lepralia and other Polyzoa display their vase-like crowns of ciliated tentacles; and forests of Zoothamnium (an arborescent vorticella resembling a miniature sea-fan) extend their branches and wheel-bearing heads, or quickly coil up their writhing stalks in a compact ball at the approach of danger. All these, and many other forms of life, hurried through the water on the house of the scrambling crab, doubtless profit by the constant renewal of the vital element, and partake of the good fare enjoyed by the eremite within.

2. One of the most frequent co-tenants of the abode of the Pagurus is the *Hydractinia echinata.* Shells infested by this zoophyte appear to be covered by a white shaggy fleece, which consists of a host of hydroid polyps, closely aggregated together as the stalks in a field of corn.

These polyps appear to be careless of the rough motions of the crab, and wave loosely to and fro as it jolts along over the rocks; but when any part of the colony is rudely touched, the whole of the polyps contract *en masse*, and seem to sink down into the substance of the shell. A close examination shows that this consentaneous action on the part of the polyps is caused by their being all developed from a common membranous basis, which spreads itself in a continuous thin layer over the shell, and being intimately connected with their tissues, forms a bond of sympathy between the whole assemblage.

3. The subject of the present communication is by no means new to science. It has been treated of by Fleming, Johnston, Gray, Couch, Hassall, M'Gillivray, Van Beneden, and especially by Quatrefages, whose monograph on this zoophyte is replete with interest. After reading the memoirs of these philosophers, I became convinced that a complete conception of the morphology of Hydractinia had not been attained by any of them. This I had previously been attempting to work out by the examination of some hundreds of specimens, many of which had existed for months confined in glass vessels, and propagating themselves by stolons and sexual reproduction. The conclusions I have come to may be briefly stated as follows:—In Hydractinia, the polypary, or common connecting membrane is to be considered as an individual animal, possessing alimentary and sexual organs polypoid in form. Each polypary is unisexual or diœcious; male and female organs being never situated on the same polypary, or on the same *shell!* The polypary, in addition to its alimentary and sexual polyps, possesses additional organs of prehension and offence, hitherto undescribed, which have a determinate situation. It is also furnished with corallum or skeleton, which, although widely differing in form from the coralla of other hydroid zoophytes, is identical with them in chemical composition and mode of secretion.

Anatomy of Hydractinia.

4. A consideration of the anatomy of Hydractinia may be conveniently divided into three parts:

1st, The Corallum or polypidom, the horny skeleton of the zoophyte.

2d, The Polypary, or common body.

3d, The Polyps.

The Corallum.

5. *The Corallum* is a layer of transparent amber-coloured chitine; a substance having the consistence of horn, but differing from it in chemical composition. It closely invests that part of the shell inhabited by the zoophyte. Its struc-

ture is very dense at the mouth of the shell, where it frequently (as remarked by Johnston) forms a slight extension of the whorl. As it passes backward, it gradually takes the form of a fine indurated membrane beset with spicules of irregular shape. Delicate and transparent casts of entire shells are thus occasionally formed, which may be removed uninjured by the aid of consecutive solutions of nitric acid and caustic potash. I have placed one of these on the table; and it will be seen that the surface, with all its parasitical growths, is copied with the fidelity of the electrotype. Over the more exposed parts of the corallum, the chitine rises up in the form of thickly set papillæ or spines, which have their surfaces furrowed by deep longitudinal grooves (fig. 2). The ridges between these grooves are coarsely lobed or serrated, and after passing from the summit to the bases of the spines, traverse the corallum, and unite with each other, and with the ridges of the neighbouring papillæ, so as to form a raised network, intersecting the surface in every direction. The structure of many of the spines differs somewhat from that above described; some being hollow smooth cones, slightly grooved or reticulated only at their base (fig. 3); while others have their ridges pierced everywhere by foramina, and united by irregular transverse bands, until they become a mere fenestrated structure of interlacing fibres. More rarely, we find the spines here and there fused together in long serrated ridges, running parallel with, or fitting into each other in a variety of intricate patterns. Quatrefages has described the corallum as an endoskeleton deposited in the substance of the polypary, like the solid axis of Gorgonia. But I am satisfied that his views on this point are incorrect, and that its mode of secretion differs in no essential from that of the corallum of other hydroid zoophytes.

The Polypary.

6. The polypary consists of a layer of semi-transparent fleshy matter (either colourless, or tinted with light shades of yellow, buff, or pink), which invests the corallum, and fills up the grooves of its papillæ, the interstices between its reticulations, and the cavities of its hollow spines. It is often absent at the summits of the papillæ, and is so thin over their

ridges, that the serratures appear through it as fine undulating lines.

7. *The Polypary* is the most important part of the zoophyte. It secretes the corallum, renews it when injured, and extends it along the shell. From it the polyps are developed; and it represents the trunk by which the whole assembly are united to form a single plant-like animal.

8. Quatrefages states, that the polypary is underlaid by a network of tubular fibres, which pass between the polyps, and unite their alimentary canals with each other. The existence of this structure has been doubted by Dr Johnston, and altogether denied by Van Beneden; but I have repeatedly detected the tubes *permeating*, rather than underlying, the polypary, and have watched their development day by day, in portions of that body growing over a transparent surface.

9. In the less exposed parts of the shell the polypary frequently passes beyond the papillary corallum as a thin membranous expansion, or breaks into a loose network of delicate anastomosing tubes, which traverse every cranny and furrow of the shell, and can only be detected after their tissues have been coagulated by immersion in alcohol. On these, polyps are developed at long intervals; and in the larger tubes an intermittent circulation of shining globules may be detected by the aid of high microscopic power and direct sunlight. In specimens which have been long kept in captivity I have seen these fibres throw up thick white stolons or suckers, tipped with crimson, some of which have attached themselves to the sides of the tank, expanded themselves into independent polyparies, and afterwards put forth clusters of polyps. The small living specimen on the table, of which fig.12 is a drawing, has been propagated in this way, and shows the tubular structure of the polypary in an admirable manner.

10. The life of the polypary is not dependent on the presence of the polyps. Many specimens of Hydractinia occur in the winter, in which the polypary exists in a high state of development, although its polyps are very few in number, or altogether absent, and which nevertheless become clothed with these organs on the return of spring.

11. The minute anatomical structure of the polypary, the nature of its connection with the corallum, and the mode of

secretion of the latter, cannot readily be investigated in those specimens of Hydractinia which are parasitic on the shell of the Pagurus, as the zoophyte is broken up by an attempt to remove it from its site. A better opportunity for observation is afforded when the animal has extended itself along a transparent surface. The propagative stolon of Hydractinia, after leaving the point of its origin, increases rapidly in diameter, and throws out irregular branches, not unlike a very minute specimen of *Tubularia larynx.* The tips of these branches are covered with a glutinous cement, by which they attach themselves tenaciously to glass or other surface near them. Having attached themselves, they expand laterally, at the same time throwing out finger-like prolongations, which, as they come in contact with each other, coalesce, until a fleshy plate is formed adherent to the glass. Polyps are developed both from the loose branches and the attached polypary; and the latter is clearly seen to be permeated by a beautiful system of anastomosing canals (fig. 12) connected with the hollow bodies of the polyps. Within these canals may be detected an intermittent flow of fluid, containing particles, the dancing motion of which indicates the presence of ciliary action, and which, having passed in one direction for a short time, are arrested, and, after a slight period of oscillation, commence to flow in an opposite direction.

12. A few branches of one of the tubular stolons was submitted to a microscopic power of 600 diameters. They were found to be composed (fig. 4), as is the polypary of every hydroid zoophyte, of an external and internal membrane,—the "ectoderm" (*c*), and "endoderm" (*d*) of Allman,—inclosed in a wide tube or corallum of transparent chitine (*b*). At the growing extremities of the branches the corallum was absent, and its place supplied by an epidermis (*a*), a soft, glutinous layer closely investing the ectoderm.* Further down the branch the corallum appeared, secreted by the ectoderm beneath the epidermis, by which last substance it continued

* This layer which I have called the "colletoderm," (κολλητης glutinator), is constantly found covering the coralla of creeping zoophytes, where it frequently forms a coat of considerable thickness, continued, also, as in Coryne, over the body of the polyp.

coated, and from which it derived its adhesive property. A delicate chitinous investment may also be detected on the creeping tubular fibres from which the stolons of Hydractinia take their rise; but I have not satisfied myself as to its presence on the entire upper surface of adult polyparies. In specimens of Hydractinia, however, growing in the shell, we find that the spines of the corallum, although varying in shape and structure, may be classed in two divisions; the one, solid and deeply grooved, and clothed by the polypary (fig. 2); the other, smooth, conical, and hollow, and inclosing a process of the polypary in their interior (fig. 3).

13. From the above observations, I conclude that the polypary of this zoophyte consists of a single layer of endoderm, inclosed between two layers of ectoderm. That the *lower ectodermic layer*, as it grows over the shell, attaches itself by its "colletoderm," and secretes the horny plate of the corallum. On this plate, by a further process of secretion from the lower ectoderm, the *grooved* spines are erected. That the *upper layer of the ectoderm* is naked over the greater part of its surface, or only covered by a thin epidermis; but occasionally this layer also takes its share in the secretion of the corallum, and in that event produces the smooth, conical spines, the concavity of which it fills.

14. I have been unable to detect the existence of true cells either in the endoderm or ectoderm of the polypary. These membranes appear to consist essentially of structureless modifications of elemental tissue, more or less vacuolated, similar to that we find in the protozoa, and to which the term "sarcode" has been applied by Dujardin. Accordingly, we find that the finger-like processes given off at the borders of the polypary constantly flow into each other when they meet, like the prolongations of sarcode projected from the pores of the Rhizopoda, or the outer layer of Actinophrys.

15. The walls of the tubes which permeate the polypary are frequently loaded with the coarse granular matter of a brown-yellow or crimson colour, which is found in the endodermic tissue of all hydroid polyps. This matter has been considered by some authors as a glandular secretion of the nature of bile. It appears to me to be identical with the brown matter which

exists in the bodies of many of the Protozoa, such as *Vorticella campanulata*, and which in other species of the same genus is replaced by a substance having all the properties of chlorophyll. In the *Hydra viridis*, also, we find green globules possessing the chemical reactions of chlorophyll substituted for brown matter in the endoderm. Whatever purpose this granular matter may serve in the economy of the hydroidæ, it always occurs in excess in situations where the vital functions are most actively carried on; such as the tips of growing stolons, the alimentary tubes of the polyps, and the ovaries and spermatic sacs.

16. *The Ectoderm of the Polypary* contains great numbers of the highly refractive capsular bodies to which the terms "tricho-cysts," "thread-cells," or "stinging organs," have been applied. They are of two kinds (fig. 11), differing very distinctly in size; the larger exceeding the smaller ones by about a diameter and a half. In shape they resemble somewhat a grain of wheat, being respectively flattened and slightly rounded on opposite sides. They are contained within small cells in the ectoderm, and possess dense coats, which, under pressure, burst at one extremity, and protrude a four-barbed dart, from the point of which projects a long stiff thread or hair (fig. 5). These thread-cells, found extensively in all classes of polyps and acalephs, are, I have no doubt, true organs of offence, as I have detected numbers of them plunged beyond the barbs in the soft bodies of worms, rescued from the grasp of *Hydra vulgaris*. But it is to be remarked, that they frequently exist in situations where their mischievous properties are rendered innocuous by the dense coverings under which they lie hid. Thus we find them congregated in masses on the polypary, beneath the thick corallum of *Coryne glandulosa* (Dalyell); and in *Halecium Beanii*, while the naked polyps are armed with unbarbed thread-cells of the most minute and simple kind, these bodies attain a giant size and formidably spinous development of the thread beneath the hard coverings of the reproductive capsules and the corallum.

The Polyps.

17. The polypoid appendages of Hydractinia are of five kinds (fig. 1) :—

1. The Alimentary Polyps, possessing mouth and tentacles (*c*).
2. The Reproductive Polyps, destitute of mouth, and having only rudimentary tentacles (*b*).
3. The Sessile Ovisacs and Spermsacs of the Polypary (*d*).
4. The Ophidian, or Spiral Polyps (*a*).
5. The Tentacular Polyps, or great Tentacles of the Polypary (*d*).

18. *The Alimentary Polyps.*—These organs, which represent the prehensile and digestive systems of the zoophyte, first make their appearance as a thickening of the endoderm in one of the canals of the polypary, attended with a copious deposit of red granular matter. This thickening in a few hours rises from the surface in the form of a fleshy stem, on the summit of which an oral aperture presently appears surrounded by four small pullulating tentacles. When perfectly formed, these polyps are about half an inch in length, club-shaped, and furnished with from eight to thirty tentacles, placed in two alternating rows. Those of the upper row, which are about twice the length of the lower row, are held nearly parallel with each other above the mouth, while the lower row are extended at right angles to the axis of the body,—an exaggerated state of a disposition frequently observed in Sertularian and Campanularian polyps. The mouth opens into a buccal cavity, contained within a more or less elongated papilla, which rises in the centre of the circle of tentacles. This papilla is exceedingly distensible, frequently expanding itself into a wide discoid sucker, as shown in the figures of Quatrefages, and even folding itself backwards, so as to conceal the tentacles, and completely evert the body. A similar habit has been observed by Dr Coldstream in the polyp of *Clava*, and by myself in *Coryne pusilla*.

19. The body of the polyp consists of the same elementary tissues as the polypary, with the addition of a muscular tunic, which is interposed between the endoderm and ectoderm.

20. *The Ectoderm* of the alimentary polyp is a transparent, homogeneous membrane, containing molecular matter, also transparent, but of higher refractive power; so that expansions of this tissue have a finely-dotted appearance under the highest powers of the microscope. The ectodermic layer also contains multitudes of thread-cells of the *smaller kind*. These

are amassed in the greatest numbers at the upper parts and ends of the tentacles. Over the site of each thread-cell a very delicate soft spine or cilium may be observed projecting from the ectoderm, and apparently springing from the thread-cell itself. Similar spines exist over the smaller thread-cells of *Hydra vulgaris*, and those of Sertularian and Campanularian polyps. Now, when the thread-cells of these hydroidæ are displaced by gentle pressure, so as not to burst them, they are found to have a perfectly smooth contour. Moreover, the ectoderm of the planarioid larva of Hydractinia is thickly studded with these spines before any development of thread-cells has taken place. These spines also occur in various tribes of the mollusca; for instance, on the very adhesive tentacles which fringe the inner edge of the mantle of Lima, and on the tips of the branchial papillæ of Eolis. I am led to conclude, therefore, that they are tactile prolongations of the ectoderm, analogous to the prehensile processes of Actinophrys, or the long rays of Podophrya, and that their function is probably to distinguish and seize the prey, and to convey the stimulus necessary to effect the rupture of the death-dealing thread-cells immediately beneath.*

21. *The Muscular Coat* consists of a layer of closely-set, ribbon-shaped fibres, passing upwards from the polypary to the tips of the tentacles, so as to form a continuous tunic between the endoderm and ectoderm more transparent than either. It shows no indications of transverse striæ; but it exercises considerable depolarizing power on polarized light,—a property possessed by both striated and unstriated muscular fibre. There can be little doubt that all the tissues of the polyp have the property of slow contractability; but the muscular tunic appears to be specially adapted for the quick withdrawal of the polyp body between the sheltering spines of the corallum.

22. *The Endoderm* of the polyp is a finely-granular opalescent tissue, darker by transmitted light, and whiter by reflected light, than the ectoderm. Its appearance differs so remarkably in various polyps of the same polypary, that the

* As these processes have not been hitherto noticed, I propose to distinguish them by the appellation of "palpocils."

observer might, with Quatrefages, be induced to represent it as a compound of many different tissues. In its simplest form, as it generally occurs in the reproductive polyps, it is a structureless membrane, similar to the ectoderm, deeply loaded with coloured granular matter, and ciliated on its internal surface. In other polyps the endoderm is extensively vacuolated, or filled with cavities, until it appears to consist of a congeries of cells of every variety in size. In a third class, again, the vacuolation is still more extensive. Here the membrane has the appearance of being split into two layers, one of which forms an intestinal tube, occupying the axis of the body, while the other lines the muscular tunic ; the two being intimately connected by an areolar network of fibres, or septa, or irregular cells. The endoderm of the tentacles possesses a similar variety in structure. I have not been able to satisfy myself of the existence of a canal in their interior.

The internal surface of the endoderm has the function of nutrition ; its external surface that of reproduction.

23. *The Reproductive Polypoid Organs* (fig. 1. *b*), male and female, are always situated on separate unisexual polyparies.

24. The *Male Polyp* is smaller than the alimentary polyp. The buccal cavity and mouth appear to be absent; but I have occasionally seen the place of the latter marked by a whitish spot, through which I have succeeded in forcing the contents of the intestine. The tentacles are merely small protuberances, thickly studded with the *larger* thread-cells, which bodies also occur over the whole surface of the polyp. The parietes of the body consist of the same three elements as that of the alimentary polyp. Their middle third is dilated into a sac, from which numerous diverticulæ protrude, to form spermatic capsules (fig. 5). The endoderm of the sac and capsules is richly ciliated, and loaded with brown granular matter ; and between all the communicating cavities a constant circulation of fluid, charged with globules of sarcode, takes place with a powerful rotatory turmoil. At first, all the coats of the capsules are in close apposition to each other ; but, as they increase in size, the endoderm (*c*) becomes widely separated from the other coats, by the secretion from its outer surface of a dense transparent gelatinous matter. The transparency of this matter, after a time, becomes obscured by the

formation within it of innumerable minute cells, from each of which a single spermatozoon is presently developed. After a time, the endodermic layer of the capsules having been reduced by absorption to a mere linear core of brown matter occupying the axis of the capsule, and the spermatic mass having become liquid and white, the latter is at last evacuated from an opening in the summit of the capsule, and descends through the water as an expanding cloud.

25. *The Female Polyp* resembles the male in its form and the development of its generative capsules. But at an early stage of the development of the capsule, from four to nine ova make their appearance between the endoderm and the other coats, in place of the gelatinous matter secreted in the capsules of the male polyps (fig. 6). These ova, at first consisting of a small transparent vitellus, containing a germinal vesicle and germinal spot, become of an opaque yellow, white, or crimson colour, by the granulation of the yoke, and rapidly enlarge, until the female polyp is almost hidden under the mass of immense ovaries with which it is burthened.

26. *The Sessile Generative Sacs* of the polypary are developed from the tubes of the polypary itself. They resemble exactly those of the reproductive polyp, and contain ova and spermatozoa in the polyparies of different sexes.

27. *Three kinds of reproduction* may be observed to obtain amongst the hydroid zoophytes:—1st, *Polypiparous,* where the young is discharged from the ovarian capsule in the complete form of a polyp, as in Tubularia ; 2d, *Larviparous,* where the young are born as ciliated planarioid larvæ, as in Clava, or simple unciliated germ-masses, as in Coryne, afterwards becoming polypoid ; and 3dly, *Oviparous,* where true ova are discharged from the ovarian sacs, and the subsequent changes into planarioid and polypoid forms take place after their leaving the parent zoophyte, as in the subject of this paper.

28. *In Hydractinia,* the ova, after extrusion from the ovary, and their having undergone fecundation by the spermatic fluid of a male polypary, become segmented (as in fig. 7) by the usual process of yelk-cleavage, and are transformed into transparent fleshy masses, in which may be detected the rudiments of the endodermic and ectodermic tissues.

These masses presently become developed into taper cones (fig. 8), which attach themselves by their bases, travel along the surface of the glass in which they are kept, and congregate on the side next to the light, like a forest of tiny masts. They consist *of an ectoderm*, destitute of thread-cells, but thickly studded with the soft spines I have before mentioned (19), and tenaciously adhering to any body brought in contact with them; *and of an endoderm*,—crimson, granulated, and not vacuolated, inclosing a cavity which occupies the axis of the cone along its whole length. Many of these larvæ have lived for several weeks with me without undergoing any further change; others have in a few days been developed into small four-tentacled polyps (fig. 9), and protruded creeping tubes from their base,—the rudiments of the future polypary.

29. Quatrefages has figured the male or sperm capsule of Hydractinia, and mistaken it for a reproductive "bulbil." Johnston also falls into a similar blunder. Van Beneden, again, has described the male and female polyparies as distinct species, under the name of *Hydractinia lactea* and *rosea*.

30. *The Ophidian, or Spiral Polyps* (fig. 1, *a*, fig. 10, and fig. 13, *a*). I can scarcely express the surprise I felt on discovering these remarkable organs. I was examining a specimen of Hydractinia, from which the crab had been removed, when I found a number of bodies, like small white snakes, closely coiled in one, two, or three spirals, and grouped immediately round the mouth of the shell (fig. 13, *a*). These bodies, when touched, only drew their folds more closely together. But if any part of the polypary, however distant from them, was irritated, the spiral polyps uncoiled, extended, and lashed themselves violently backwards and forwards, and then quickly rolled themselves up again; and that not irregularly or independently of each other, but all together, and in the same direction, as if moved by a single spring. A violent laceration of the polypary caused these polyps to remain extended and stretched like a waving and tremulous fringe across the mouth of the shell for several minutes. The Ophidian Polyps (evidently a barren modification of the re-

productive polyp) are never found in any other situation on the polypary than in that before described, or round the margins of accidental holes in the shell. They have no mouth, and the tentacles are rudimentary. The walls of the body are very transparent, from the extreme vacuolation of the endoderm. The muscular coat, as might be expected from the active movements of the polyps, is highly developed, and forms a beautiful object on the dark polarized field of the microscope, each spiral coil shining out as a bright double ring, divided by four dark sectors. The ectoderm of the whole body and tentacles is crowded with the larger thread-cells. The ophidian polyps are, I doubt not, organs of defence or offence, like the motile spines and bird's-head processes of the Polyzoa, or the pedicellariæ of the Echino-dermata; but I am unable to assign a reason for their peculiar situation. They vary much in number and size in different specimens of Hydractinia, but are rarely altogether absent.

31. *The Tentacular Polyp*—(fig. 1 *e*, and fig. 13 *b*).—Not less surprising than the polyps last described are these, the great tentacles of the polypary. When a specimen of Hydractinia is allowed to rest suspended in a glass jar of water, these organs are extended to a distance of three, four, or even five times the length of the alimentary polyps, and hang down, loosely floating in the water, like the thread-like tentacles of the long-armed hydra. They are found on the outskirts of the polypary, and on each side of the long diameter of the mouth of the shell, so that they must, in their natural condition, reach to the ground, and enable the zoophyte to seize food scattered there by the feeding crab. The tips are covered with a dense pavement of the larger thread-cells; and a few of the same bodies are thinly scattered along their whole length. As far as I know, no organ analogous to them exists in any other hydroid zoophyte. They have not been hitherto described.

32. In our consideration of the subject of this communication, our attention is arrested by the multitude of objects grouped together to constitute a single animal, their variety in form, and the sympathy which subsists between the different parts. The singular spinous skeleton; the expanded membrane of the polypary, with its beautiful internal network of

tubes and delicate peripheric prolongations; the alimentary polyps, some white and filiform, others thick, fleshy, crimson, or yellow sacs, obligingly everted, to expose their interior to our microscopic eye; the reproductive polyps, with their richly-coloured generative sacs; the sessile generative organs of the polypary; the ophidian polyps, coiled in neat spirals when at rest, but starting into furious action, like a row of well-drilled soldiers, when injury is inflicted on the body to which they are attached; and lastly, the tentacular polyps, floating in the water like long and slender threads of gossamer, or dragging up heavy loads of food for the common good; these, together with the intimate relation and sympathy subsisting between the polypary and its associated organs; all combine to form an object of the highest interest, and indicate that in this fixed, yet travelling zoophyte we have a type of structure transitional between the dendritic hydroidæ and the more highly organized acaleph. In the simplest acalephoid form, such as the medusoid of Campanularia (which is nothing more than an extension of the polypary specially organized for independent and motile life), we have (as in Hydractinia) an expanded polypary, represented by the umbrella, and permeated by vascular tubes, from the confluence of which last spring, *at the centre*, the single alimentary polyp; *at the periphery* the tentacular polyps, various in number; and between them the reproductive polyps, represented by the sessile generative sacs. In the higher Rhizostomes we find, as pointed out by Huxley, a multitude of alimentary and reproductive organs, united by ramifying tubes, which permeate a massive swimming polypary. In other acalephæ, such as *Velella*, *Porpita* and *Ratraria*, we probably have a still closer resemblance to Hydractinia, in the development of a corallum, represented by a horny plate, which in the last of these medusæ elevates the crest, serving as a sail by which the floating mass is propelled before the wind along the surface of the waves.

33. In conclusion, I must mention that Hydractinia is infested by a small species of Eolis (*Eolis nana*), which peels off the polypary with its rasp-like tongue, and devours it,—possessed, I suppose, of some potent magic, which renders all the formidable armament of its prey of no avail. Now, each of the

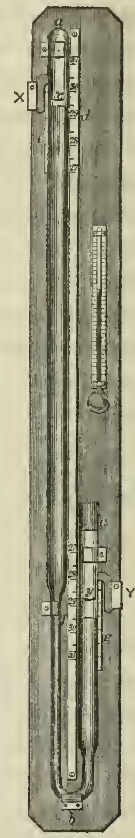
dorsal papillæ of the Eolidæ contains at its extremity a small ovate vesicle, communicating, through the biliary sac, with the digestive system, and opening externally by a minute aperture at the end of the papillæ. This vesicle is found crowded with compact masses of thread-cells; which masses, in *Eolis nana*, consist of aggregations of small and large thread-cells, identical in size and shape with those of Hydractinia,—on which this Eolis preys—not contained in capsules, but cemented together by mucus. When we consider that each of the vesicles is in indirect communication with the stomach, I think we may, without presumption, suggest a probability that the masses of thread-cells found in *Eolis nana* are *quasi* fæcal collections of the thread-cells of Hydractinia, which, protected by their strong coats, have escaped the digestive process. In corroboration of this view, I may mention that the thread-cells of *Eolis papillosa*, as figured in the work of Alder and Hancock, have a perfect resemblance to those found in the Actinias, which last animals furnish an Abyssinian repast to these carnivorous mollusca.

Description of a Self-Registering Maximum and Minimum Arrangement for the Syphon Barometer. By THOMAS STEVENSON, F.R.S.E., Civil Engineer.

At a meeting of the Council of the Meteorological Society of Scotland, held on 11th July last, I exhibited and described a self-registering syphon barometer, of which I now venture to give a more detailed description.

Several forms of self-registering barometers have been published, among which may be mentioned Hooke's in 1685, Dr Traill's in 1830, the late Mr R. Bryson's in 1843, and the photographic register, which has been more recently introduced. Those of Hooke and Bryson are so constructed, I believe, as to preserve a constant register of the oscillations of the mercurial column, and are therefore of a far more complete nature than the instrument I am about to describe. Excepting Dr Traill's, all those barometers require, however, a somewhat complicated system of clock-work, which to a great extent precludes their adoption, unless in regular observatories. Dr Traill's is different from the others, and resembles mine in only registering the maximum and minimum readings, but it requires the employment of two distinct barometers.

I have endeavoured to attain the registration of the maximum and minimum pressures of the atmosphere during any given period, by the use of attached magnets, in the following manner:—Let *a*, *b*, *c*, represent a common syphon barometer. *e* and *g* represent the graduated scale of the ordinary kind. They are so divided that, by adding together the readings of the heights of both the surfaces of the mercury, the total length of the mercurial column, which at any one time balances the terrestrial atmosphere, is at once ascertained. Such is the arrangement for a common syphon barometer. In this instrument, however, there is another scale, *d f*, having a *fixed* zero point, which is ascertained by comparison with a standard barometer. The height of the barometer can therefore be at once got by a single reading on either limb, without any arithmetical process. For example, when the atmospheric pressure balances 30 inches, the surface of the mercury in the long limb should stand opposite to the mark 30 on the scale which is attached to that limb, while the surface of the column in the lower limb should also stand opposite to the mark 30 on the scale adjoining the lower limb. The divisions on this supplementary scale will, however, of course, be only half as large as those on the common scale, where the height of the mercury is ascertained by two readings. *x* and *y* are two small floats of watch-spring, or of soft iron. These floats are made excessively thin, for the sake of being light, and thus they offer but small resistance to the movements of the mercury, on the surface of which they float.* *x* and *y* are two small magnets, having



* I have recently prepared for the lower float a thin vertical piece of iron, stuck into a thin slice of cork, which rests on the surface of the mercury. It might also be an improvement to make the horizontal part of the upper float of glass instead of metal,—a plan which has already been used for metallic indices.

spring clamps which slip stiffly along the side of the wooden framing of the barometer, and are placed so as to be opposite to what may be called the *working parts* of the tube, or those parts in which the variation of the mercury takes place. By moving the magnets up or down a little, the floats can be brought to rest on the surface of the mercury. The instrument is then ready for action. If, during the absence of the observer, the barometer should rise, the mercury will raise the float in the upper limb, while the float in the lower limb being arrested by the attached magnet, will be prevented from following the sinking of the mercury in that limb. If, after having attained its maximum height, it should then begin to fall, it will leave the upper float at its maximum level. In this way the observer will, on his return, be able at once to see how high the barometer has stood during his absence. If, on the other hand, the barometer should have stood lower when he was absent, the minimum reading will be got from the float in the lower limb, which will be higher up than the surface of the mercury. Thus the maximum readings will be registered by the float in the long limb, while the minimum readings will be registered by the float in the short limb.

I may here observe, that, owing to a curious, and, so far as I know, an unexplained electrical action, the upper float, or that which is *in vacuo*, often adheres with sufficient force to the sides of the tube to render the use of the magnet unnecessary for the maximum readings.

In order to insure accuracy in the working parts of the tube, a small piece of tube was selected, which was found to be of uniform bore. This piece was broken into two equal portions, which were then joined to the opposite ends of a longer tube, of a length sufficient to make up the proper length for the barometer. As the working parts of the tube need not together exceed about three inches, there is little or no difficulty in getting a piece of such limited length of uniform bore. In this instrument there is of course no correction for temperature, although this could be attained in some degree by having two fixed zero points for the small scale, the one being suited to a mean of the summer, and the other to a mean of the winter temperature. With the syphon form of barometer there should be no correction either for capillarity or capacity.

I regret being unable to give a register of the indications afforded by this barometer, as the mercury had, shortly after I got the instrument, been unfortunately, as I suppose, brought into contact with some metal, with which it formed an amalgam, thus causing the lower surface to become so viscid as entirely to vitiate the indications. Another barometer was being made for me by our late excellent optician, Mr John Adie, whose lamented death has prevented its completion. I may mention, that a *similar application of magnets may perhaps be found useful in getting maximum and minimum readings with other instruments than the barometer;* and it was very much this consideration which induced me to draw up this brief notice.

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*Notice respecting Father Secchi's Statical Barometer, and on the Origin of the Cathetometer.** By Professor FORBES.

A friend, who returned lately from Rome, has sent me some copies of a pamphlet by Father Secchi of the Collegio Romano, one of which I lay on the table of the Society.

It describes a barometer stated to be on a new construction. The barometric tube is suspended from one arm of a balance, and counterpoised. It is filled with mercury in the usual way; but the cistern into which it opens is fixed apart, and does not move with the beam of the balance. It is evident, therefore, that the varying pressure of the air on the exterior of the tube will require a changing counterpoise, and that the magnitude of the change may be increased by enlarging the section of the tube, so that the alteration of pressure may be indicated with any required delicacy.

It is also obvious that, to use this barometer, the tube does not require to be transparent, but may, for instance, be made of iron; only the internal section must be uniform throughout the range of pressure.

The idea of thus measuring barometric pressures appears so obvious that it is not likely to be really new. But I had

* Read to the Royal Society of Edinburgh, 16th March 1857.

also, when I read the paper, a distinct recollection of having seen it described many years ago.

After a slight search I found it, accordingly, under the name of the *Steelyard Barometer* (the tube being suspended from the shorter arm of a steelyard, while the other points to the angular deviation on a scale), in Rees,' and others of the older Encyclopædias (as in the earlier editions of the *Britannica*), in *Hutton's Mathematical Dictionary*, and in *Gehler's Wörterbuch*. But, what is singular, no inventor is assigned to the contrivance, except in the last-named work, where it is described generally as Morland's, though Hutton, who is there cited as the authority, says nothing of it.

In *Desagulier's Natural Philosophy* (1763), an experiment with a balance, similar to Father Secchi's arrangement, is described and figured, but it is not referred to as a construction available for practical purposes. This might lead one to believe that the contrivance was more recent than Desagulier's time. But, after considerable search, I found, in the nineteenth volume of *Rozier's Observations de Physique* (1782), page 346, a curious historical statement by Magellan, which refers the contrivance to Sir Samuel Morland, who, it is there stated, presented it to Charles II. Magellan does not, however, give his authority for this, stating, on the contrary, that he found no mention of the contrivance in any of the authors who had treated of the subject, but that he had seen two of these instruments. One of them, made by Adams in 1760, belonged to George III; and I think it possible that it may still be found amongst the instruments of the Kew Observatory. The other was made by the celebrated Sisson, and came into M. Magellan's possession; a careful figure of it is given in the work just cited. It is perhaps likely that the ascription of it to Morland, and the story of its presentation to Charles II., was a tradition among the London instrument-makers. It may, however, be recorded in some of Sir Samuel Morland's writings, which I have not found either in the College or the Advocates' Library, and in which it does not appear that Magellan had himself seen it.

I have as yet been unable to trace the steelyard modification of the statical barometer to its origin. I think it likely to be an independent invention.

Of course these remarks are not intended to infer the smallest doubt of Father Secchi being the inventor of the instrument which he describes. Of that there can be no question; and the application of it, which Father Secchi proposes, to the purposes of self-registration, makes it a well-timed resuscitation of an almost forgotten contrivance, which yet appears to date from the same century with the invention of the barometer.

2d March 1857.

Postscript—16th March 1857.—I have not succeeded in throwing any further light on the true origin of the statical barometer. On writing to Mr Welsh of the Kew Observatory, I find that King George III.'s curious collection of apparatus has been long dispersed. I ought perhaps to add, with reference to Father Secchi's contrivance, that he recommends in some cases the *cistern* of the barometer to be made movable, instead of the tube. The balance is then disturbed by the efflux of mercury from the tube of the barometer when the pressure diminishes, and by its influx when the pressure increases. Though less elegant, as an application of a principle, it has the advantage of making the suspended mass lighter. It will be seen, by a reference to Magellan's account of Sisson's instrument, that the weight was such as to require support on friction—rollers instead of knife edges.

Invention of the Cathetometer.—I take this opportunity of adding a historical notice, which has occurred to me whilst making the preceding inquiry. In the twentieth volume of the Philosophical Transactions for 1698, Mr Stephen Gray described a microscope moving on a vertical pillar by means of a micrometer screw, to be used for determining the exact variations of level of a liquid, such as mercury in a barometer or thermometer, and not necessarily connected with the apparatus. This instrument accurately corresponds in most respects with that known to French physicists and instrument-makers under the name of the *Cathetomètre*, which I have never heard ascribed to any inventor in particular, and which, till very lately, has hardly been recognised in this country.

On the Reproductive Economy of Bees; being an Account of the Results of Von Siebold's recent Researches in Parthenogenesis. By Professor GOODSIR.*

The term Parthenogenesis—the production of young by a virgin —*lucina sine concubitu*—was introduced by Professor Owen, to designate "the successive production of procreating individuals from a single ovum;" and, as understood and employed by him, this term is not only distinctive of those peculiar forms of propagation which had previously been generalized by Steenstrup under the phrase, "alternate generation;" but is also expressive of their essential character. It is not proposed in the present communication to examine Professor Owen's doctrine of Parthenogenesis, nor to attempt to determine to what extent it legitimately involves all the remarkable phenomena which it professes to express and elucidate; but to state briefly the remarkable results of observations on the subject made by another Physiologist, whose name is a sufficient guarantee for the care and exactness with which they have been conducted.

Von Siebold of Munich published a few months ago a work entitled "Wahre Parthenogenesis, bei Schmetterlingen und Bienen"—Real Parthenogenesis, as it occurs in Butterflies and Bees. In his introductory chapter, after claiming for himself the previous announcement, in Müller's Archiv, for 1837, of the distinctive peculiarities of the reproductive organs of the oviparous and viviparous aphides, the author gives to the "alternate generation" theory of Steenstrup that place to which the influence it has already had on the science fully entitles it. He cannot, however, admit that alternate generation can be included under parthenogenesis, as has been done by Professor Owen. On the contrary, alternate generation and parthenogenesis are distinct, inasmuch as propagation *sine concubitu* in alternate generation occurs in sexless individuals; whereas propagation *sine concubitu* in parthenogenesis occurs in actual females.

* The importance of the results contained in Von Siebold's work induced the author of this abstract to communicate it to the Royal Society of Edinburgh. He only became aware of the approaching publication of Mr Dallas' able translation of the work itself on the evening on which his own abstract was read.

While I admit the propriety, as I believe will be generally done, if such a form of propagation be confirmed, of limiting Professor Owen's expressive term parthenogenesis to propagation by a female *sine concubitu,* or more precisely to development of an individual from an ovum into which no spermatozoon had previously entered, I must observe that Von Siebold has somewhat misunderstood Professor Owen in reference to the so-called aphides nurses. Although Professor Owen terms these intermediate forms virgins, and considers them to be females, he states that they do not possess spermathecæ and colleteria; and in support of this quotes Von Siebold himself, as reported in Froriep's Notizen. The difference in the views of Owen and Siebold regarding the aphides nurses is this—that the former believes them to be undeveloped females, which propagate "*in utero,*" under the transmitted influence of "*an ancestral coitus;*" while the latter holds them to be sexless individuals, which propagate by internal gemmation.

Von Siebold next examines at considerable length the statements of the various entomologists who have asserted the capability of reproduction by unimpregnated females in certain species of Lepidoptera. He comes to the following conclusions: That due precautions had in no instance been taken to prevent the access of the male, remarkable, in this order of insects, for the instinctive sagacity and ingenuity of his approaches; and that all the observations had been accidental or indirect, and therefore destitute of the precision essential to such inquiries.

Notwithstanding these conclusions, Von Siebold could not avoid being influenced by the repeated assertions of the existence of parthenogenesis in the genus *Psyche.* Although the established facts, that the footless and wingless females of this genus are impregnated within the sac, and again enter the chrysalis case in order to deposit their eggs in it, and that the footed but wingless females of the genus *Fumea* are impregnated on the upper surface of the sac, but deposit their eggs in the chrysalis case left within it, might appear to cast much doubt upon any assertion of parthenogenesis based on the fact of the eggs being deposited in such a locality; nevertheless there appeared to be such indications of its actual occurrence, more particularly in the restricted genus *Solenobia,* as warranted special inquiry.

Siebold was indebted to Reutti, an able lepidopterologist in Freiburg, for numerous sacs of *Solenobia lichenella*, Lin., and of *Solenobia triquetrella*, F. v. R., gathered in that neighbourhood; and he himself collected around Berlin, in 1850, 1851, and 1852, many hundred sacs of both genera. To his great astonishment all these sacs produced females, with the exception of two from a single locality, which produced males. These sacs were kept and observed in small vessels closed with glass plates, so that no males could have access to them. The females, after leaving the sacs, and dragging their pupa-cases out along with them, clasped firmly the exterior of their sacs, and, to Von Siebold's great surprise, speedily began to deposit their eggs in the latter.

In this respect these *Solenobiæ* females differed from those of the genus *Fumea*, which, if excluded from the male, would remain attached to the exterior of their sacs until they died, without depositing a single egg. So powerful was the impulse of these *Solenobiæ* females to lay their eggs, that, if slightly removed from the sac, they would stretch their ovipositors towards its aperture, and drop the eggs on its exterior. But if Siebold was struck with the egg-laying propensity of these virgin females, he was still more astonished to find that the eggs produced larvæ, which, with the greatest eagerness, endeavoured in every direction to procure materials for the manufacture of their sacs.

At this stage of the inquiry Siebold, although satisfied that these Lepidoptera are capable of reproduction *sine concubitu*, was inclined to believe that these apparent females were only sexless individuals, as in the case of the aphides nurses. He found, however, on dissection, that they possessed the characterisic reproductive organs of the female moth. The anterior orifice opened into a fully developed but perfectly empty bursa copulatrix and receptaculum seminis, while the posterior communicated with well-stocked ovaries. These *Solenobiæ* were, therefore, fully developed virgin females.

The *Solenobiæ* are not the only ascertained representatives of parthenogenesis among the Lepidoptera. *Psyche helix*, a species which has been carefully investigated by Von Siebold, and of which the female only has been with certainty recognised, affords an equally surprising example of virgin procreation. The larva of *Psyche helix* is a leaf-burrowing, sac-bearing caterpillar, feeding on *Artemisia Vulgaris*, *Anthyllis Vulneraria*, &c. Siebold named the species from the form of the sac, which, about the size of a pea, and consisting of aglutinated particles of earth, is wound spirally two whorls and a half to the left, and, like some other insect structures of the same kind, had been mistaken for the shell of a mollusc. When the caterpillar is feeding, the mouth of its spiral sac covers the orifice made in the epidermis of the leaf, while its margin is applied against the surrounding uninjured epidermal surface. Its body is spirally curved, and, when full grown, occupies only two complete whorls. It evacuates its fæces through a lateral orifice, situated at the junction of the incomplete with the second whorl of the sac. When about to pass into the pupa form, it leaves the plant on which it has been feeding, and spins the mouth of its sac firmly to the surface of a stone or rock. The butterfly itself is destitute of wings and antennæ, its feet are feebly developed, its body spirally bent, its movements inert, but its reproductive organs fully matured. She deposits her eggs in her pupa husk, within the spiral sac, and having then shrunk to a comparatively small size, comes out of the sac by the lateral orifice left near its apex, for this and other purposes, by the instinct of the larva; after leaving it she speedily dies. Siebold does not admit that the male of *Psyche helix* has been discovered; but as it must be admitted that the females of this, as of the other species of *Psyche*, are impregnated within the sac, and that the act must be effected through the lateral orifice, the abdomen of the male is probably spirally curved in a corresponding manner.

By keeping the spiral sacs of *Psyche helix* under glass covers until the larvæ had passed through their pupa stage, and until the eggs deposited by the imagos had produced larvæ, Von Siebold satisfied himself that, in this species of insect, the ova may be developed without the influence of spermatozoa.

With reference to the sex of the Lepidoptera producing *sine concubitu*, it appears extremely probable, from the rarity or apparent deficiency of males, that it will turn out to be female.

While engaged with the parthenogenesis of the Lepidoptera, Von Siebold entered on the investigation of the numerous conflicting questions and statements regarding the reproductive economy of the bee. With this view, he put himself in communication with various bee-masters, but more particularly with Herr Dzierzon, a clergyman at Carlsmarkt, in Silesia; and, with the

Baron von Berlepsch, of Seebach, in Thüringia. The most important result of these personal inquiries was a new theory of the reproductive economy of the hive, propounded by Dzierzon, which involved and explained, in the most satisfactory manner, all the hitherto inexplicable genetic mysteries of the bee colony. The anatomico-physiological verification of this theory constituted the greater part of Von Siebold's labours in this department of his subject.

Herr Dzierzon had recorded his hypothesis as early as 1845, in Barth and Schmid's "Bienen Zeitung;" and also in 1849, in his work on the "Theory and Practice of Bee Farming."

Dzierzon's hypothesis is to this effect—that although the queen, or perfect female bee, in order to be fully fitted for her position in the hive, must be impregnated by a drone or male bee during her marriage flight; yet nevertheless, those eggs from which drones are developed are not impregnated. It is admitted that an unimpregnated queen bee may produce drones; and that even working bees, which are incapable of sexual conjunction, may occasionally deposit drone eggs. The spermatheca alone is impregnated during the flight of the queen bee; the ovaries are not affected. The queen, after impregnation, retains the power she previously possessed of depositing drone or unimpregnated eggs; but she can also thereafter deposit impregnated eggs, from which alone working bees and queens can be developed.

In proceeding to the verification of Dzierzon's theory, there are certain fundamental physiological facts in the economy of the hive to be kept steadily in view.

The young unimpregnated queen is never impregnated within the hive, but always on the wing, high in the air. As Dzierzon's hive permits, for the first time, every part of the hive, and every side of each comb to be minutely examined, and as every effort has been made, without success, by experienced observers, to detect the impregnation of the queen bee within the hive, it may now be safely assumed that it takes place only during flight. This mode of impregnation occurs in many other insects; but in the Hymenoptera it is peculiar in the rapidity with which it is effected. Von Siebold examined and dissected a queen bee sent to him by Baron Berlepsch, taken immediately after her return from her marriage flight. He found the male organs detached and retained in connection with her bursa copulatrix, and her spermatheca fnll of spermatic fluid. Leuckart has also proved that the intromittent organs of the drone can only be protruded during flight; and that they are so protruded, not by muscular or erectile arrangements, but by the pressure applied to them from within, by the distension of the abdominal tracheal pouches during flight.

Von Siebold had already proved that the spermatic fluid deposited in the spermatheca *in coitu*, retains during, or nearly to the close of the life of the queen bee, its characteristic or essential spermatozoa. He had also shown that the spermatheca is provided with voluntary muscular fibres, so as to enable the animal to retain or evacuate its spermatic contents. These facts are in accordance with, and therefore tend to support, the second position assumed in Dzierzon's theory—*viz.*, *all the eggs which come to maturity in both ovaries of the queen bee, are of one kind, which, if deposited without having come in contact with spermatic fluid, are developed into drone or male bees; but if impregnated by spermatic contact, are developed into female bees, that is, into working or queen bees, according to their subsequent treatment.*

It will be at once perceived that this position, while it completely resolves all the difficulties which have hitherto obstructed every attempt to explain the reproductive economy of the hive, is in direct opposition to what has hitherto been considered a fundamental physiological law, *that an egg, whether it be developed into a male or a female, must have been previously impregnated.* Von Siebold has nevertheless satisfied himself of the truth of Dzierzon's assumption by extended indirect as well as direct evidence.

Experienced bee-masters know the evil consequences which follow from a queen born with defective wings. She cannot take her marriage flight; but her impulse to deposit her eggs is unrestrained. She lays them in the working cells and drone cells in apparently the usual manner; the working bees feed the resulting larvæ, which, however, being all drone larvæ, those which are in working cells become too large for them, these cells require to be altered, and the economy of the hive becomes disarranged.

Berlepsch instituted a very interesting experiment on this point. At the end of September, when the drones were all dead, he got a virgin queen to deposit eggs, which produced drones in the succeeding year. This queen was dissected by Leuckart, and found by him to be unimpregnated. The acknowledged fact, that working bees occasionally produce drone eggs, is explained by, and powerfully supports Dzierzon's hypothesis. Madame Jurine proved anatomically that the working bee is not a neuter, but an undeveloped female. And Baron Berlepsch has lately afforded Leuckart an opportunity of dissecting two drone-producing working bees, and of verifying the results of the Baron's own dissections. Five or six tubes were found in each ovary full of perfect eggs; but the colleteria and spermathecæ were so feebly developed that they were at first overlooked by Leuckart, and supposed to be absent.

It occasionally happens that towards the close of the career of a queen bee, spent in depositing in the normal manner drone and working bee eggs, she deposits drone eggs alone. This circumstance is explained by, and supports Dzierzon's theory. For the queen bee undertakes the marriage flight only once in her lifetime; and it may be fairly assumed that when she closes her career by producing drones only, her spermatheca has become empty.

Dzierzon's doctrine involves also the position that *the queen bee has the power to deposit at will male* or *female eggs*,—that is, *unimpregnated* or *impregnated eggs.*

The discovery, by Siebold, of voluntary muscles in the structure of the spermatheca in the queen bee, is explained by and supports this position. When she inserts the extremity of her abdomen into a cell, she ascertains, by the sense of touch, whether it has been prepared for a drone or for a worker. If it is a drone cell, she contracts the orifice of the spermatheca, and the egg passes out unimpregnated. If it is a working cell, she contracts the spermatheca itself, and the egg is smeared in its passage. That the queen bee possesses the voluntary power of depositing male or female eggs, appears also to be proved by the fact, that by means of a Dzierzon's hive, she may be induced to deposit either kind of eggs, by supplying her with the corresponding combs.

With reference to this part of the subject, two observations made by Baron Berlepsch are of importance.

While endeavouring to confine a queen bee in a small box, he accidentally bruised the extremity of her abdomen. She laid afterwards, as before, many thousand eggs, but they were all male. He unfortunately lost her, and could not ascertain by dissection the nature of the injury by which the spermatheca had been affected. It had probably, as Siebold suggests, been torn off or detached.

Von Berlepsch's second observation is still more important. Müller having shown that spermatozoa, after having been subjected to a freezing temperature, do not again regain their locomotive powers, but are in fact destroyed, Herr Berlepsch placed three impregnated queen bees for thirty-six hours in an ice-house. One of them recovered, was restored to her people, and deposited afterwards, as before, many thousand eggs in working cells; but *they all produced drones.*

Two varieties of bees are cultivated in Southern Germany; the German bee, with a dark brown abdomen, and the Italian bee, with a yellow abdomen. These two varieties produce, by mixture, what are termed bastard forms. Baron Berlepsch has investigated these bastard bees, with the view of ascertaining how far they afford support to the reproductive theory of Dzierzon. The results obtained by him are briefly these:—An Italian queen impregnated by a German drone bee, or *vice versa*, produced invariably—1. Females, purely Italian in colour; 2. Females, purely German in colour; and, 3. Females, of mixed colour; but the drones produced were all invariably of the colour of the mother. An Italian mother only produced Italian males; a German mother only German males.

In the present phase of physiological science, nothing short of direct proof can be admitted for the establishment of a doctrine so startling as that by means of which Dzierzon explains the genetic economy of the hive. It must be shown that spermatozoa invariably enter the female eggs through their micropyles; and that spermatozoa do not pass into the drone eggs.

Leuckart made the first attempt to verify the doctrine, by means of the microscope. He proceeded, in May 1855, to the residence of the Baron Berlepsch, at Seebach, and after having examined many females, and a greater number of drone eggs, his results were unsatisfactory and doubtful. He could find no spermatozoa on the male eggs; but, on the other hand, he only detected them in four or five instances on the micropyles of female eggs.

Von Siebold visited the Baron for the same purpose at a less favourable season—at the end of August of the same year. He began by accustoming his eye to the microscopic examination of the bee's egg, and by ascertaining the best mode of bringing its contents into view. This he found to be, as is generally the case, a very simple and ordinary procedure, to compress the egg set on end, by means of the thin glass cover, so as partially to evacuate its contents. On the 22d August, at 10 A.M., he commenced the examination of a comb with female eggs, which had been deposited one hour previously. On the same day he examined female eggs deposited twelve hours previously, and on the two succeeding days eggs which had been deposited fifteen hours previously. The result was, that in the empty space left in the egg by the evacuation of its contents under the micropyle, from one to three or four motionless or lively spermatozoa were found in almost every specimen which had been successfully compressed.

He experienced some difficulty in procuring a satisfactory number of drone eggs. But he examined with great care twenty-seven male eggs deposited twelve hours previously, and failed in finding, either on their exterior or interior, the slightest trace of seminal animalcules.

Von Siebold, therefore, considers himself fully entitled to conclude, that the females of certain Lepidoptera, and the males of the bee, are developed from unimpregnated ova.

REVIEWS AND NOTICES OF BOOKS.

Results of a series of Meteorological Observations made in obedience to instructions from the Regents of the University, at sundry Academies in the State of New York, from 1826 *to* 1850 *inclusive. Compiled from the original returns and the annual reports of the Regents of the University.* By FRANKLIN B. HOUGH, A.M., M.D. Published by Legislative Authority. 4to. Albany, 1855.

It is generally known to those interested in Meteorology that methodical observations, principally of the thermometer and rain-gauge, have for many years been in progress at numerous academies of the State of New York, and that the results of these have from year to year been published, and pretty extensively circulated by the Regents of the University in that State. These observations, though far from complete, according to our present notions of completeness, contained a vast body of interesting matter ; for unquestionably the meteorological element of Temperature is by far the most important of all, while it is the easiest obtained, the instrument being of simple construction, and capable of being observed with small chance of mistake. The rain-gauge is also a simple instrument, and its results are of great practical consequence.

Amongst sixty-two Observatories, many of them comparatively remote, it is not to be supposed that indifferent, and even careless, observations may not occur. But the number is so considerable, compared to the area of the earth's surface on which they are situated, that by combining the results in groups, or by selecting the most obviously trustworthy, a very correct idea can be obtained of the mean temperature of this part of the globe, of the distribution of heat and cold over the different seasons, and of the humidity of the climate.

Such data are the more important, because, not long before these observations were commenced, scientific as well as practical men were only beginning to understand the fact of the widely different laws of temperature which prevail in the Old and New World, to which, perhaps, Baron Humboldt first distinctly called attention. The following little table will illustrate the difference of climates of America and Europe in nearly the same parallel of latitude.

	Latitude.	Temp. Year.	Hottest Month.	Coldest Month.	Diff.
New York,	40°·43	51°·6	73°·1	34°·3	38°·8
Naples,	40·52	60·3	76·3	46·2	30·1

Thus we see that the mean temperature of Naples exceeds that of New York by nearly *nine degrees*, and that the difference of monthly temperature at New York exceeds that of Naples by almost the same quantity. If we took the extreme range of the thermometer, we should find the excess vastly greater in the New World. To put it in another light, the temperature of New York is nearly the same as that of the south coast of Cornwall, which is *ten degrees* of latitude more northerly. After all, the city of New York, being near the sea, is one of the most *temperate* climates of the State. The value of these thermometrical observations has been sufficiently recognised. Professor Dove, in his researches on climate, has used them extensively.

In the volume before us we find the results collected in a commodious form, superseding the necessity of referring to the reports for individual years. This good service has been performed at the expense of the legislature, who voted no less than 3000 dollars for this purpose, an example worthy of imitation by our own government, who have as yet shown much apathy with regard to any attempts to explain the meteorology of Great Britain, although willing to second the efforts of merely nautical men in this direction.

The introduction to the work before us explains that when an improvement was contemplated in the form of registers to be adopted in future, the opportunity was thought a good one to collect the more important results of twenty-five years' observations on the old plan.

We have here, therefore, in the first place, the monthly averages of temperature, rain, and the direction of the wind, for every successive year, and for each of the sixty-two academies or institutions. These occupy 460 pages. A condensed summary of the whole then follows, and gives the most important results within the space of a very few pages, and in immediate juxtaposition.

From these tables, we learn that the mean temperature of the whole State is 46°·74, not very different from that of Edinburgh. The mean monthly range (which is the average of the extreme ranges during a given month for the whole period of years) amounts to 67°, and the mean annual range, or the average of the differences of the extremes of each year, 103°, which must be under the mark, as self-registering instruments were not generally used. At every station, except one (Oyster Bay), the thermometer has fallen below zero of Fahrenheit during the period embraced by the observations; and at sixteen of the stations it has exceeded 100°. The highest temperature recorded is 105°; the lowest—40° (at three stations); which is the lowest that could be correctly measured, if the thermometers were mercurial (as is probable). The extreme range of temperature in the State for twenty-five years was therefore *at least* 145°; and what is remarkable, several of the stations show a range nearly of this amount (Gouverneur, Lowville, and Washington [Salem] all 140°), the greatest cold and heat occurring usually in the same places. These facts give a lively impression of the *excessive* character of one even of the maritime States of America.

The average direction of wind throughout the State is S. 80° W. The mean aspect of the sky (showing a remarkable variety in different localities) gives an almost exactly equal number of clear and cloudy days in the course of the year. The average amount of rain in the States is 34·9 inches. June and October are the two wettest months. But at the maritime stations the largest quantity falls in spring. An account of auroras observed both in America and Europe concludes the work.

Advanced Text-Book of Geology. By DAVID PAGE, F.G.S. Blackwood. 12mo. 1856.

In our remarks on Mr Page's Introductory Text-Book of Geology, we felt called upon to notice certain errors in the author's arrangement of stratified deposits and grouping of fossils. Mr Page received those remonstrances in an excellent spirit, and, in a second edition, corrected the mistakes of the first. It is, therefore, with unfeigned pleasure that we record our appreciation of his "Advanced Text-Book of Geology." We have carefully read this truly satisfactory book, and do not hesitate to say that it is an excellent compendium of the great facts of geology, and written in a truthful and philosophic spirit. There is, however, one serious objection to the commencement of his tenth chapter. He almost entirely ignores the Cambrian system of Professor Sedgwick. Now, the highest authorities on geology, Sir C. Lyell, Professor John Phillips, and Professor Rogers of America, &c., consider that the Cambrian system requires a *distinct and independent grouping* from the Silurians, and that the Lower Silurians terminate with the base of the Llandeilo rocks. Mr Page must be aware that the "*hard lines*" drawn by many geologists are rapidly vanishing, as brighter light illuminates the still indistinct records of Palæozoic ages, or he would not have warned his readers so frequently "against the error of attaching to groups, and systems, and periods, a value that does not properly belong to them." The acknowledgment of the Cambrian system by the distinguished authors already mentioned should have induced him to admit a nomenclature long since established, and which to cashier altogether is absolutely UNJUST.

"It is true," we read (p. 274) "that the general facies of the plants and animals that lived during the Silurian epoch, differs considerably from the facies of the Devonian flora and fauna; but it is not true that the strata we call Silurian imbed a system of life altogether DISTINCT and DIFFERENT from that imbedded in the strata we term Devonian."

Let this reasoning be applied to the CAMBRIAN ROCKS. The division of Silurian and Devonian strata is convenient, although some of the organic forms *are identical*, and pass into both systems; and we are not aware that *Trenicola didyma*, *Palæopyge Ramsayi*, or either of the species of *Oldhamia*, are found in the Silurian rocks at all. If Mr Page classes the Cambrian deposits as lower Silurian strata, simply because trilobites occur in them, he should extend the term upwards, and include the carboniferous; for trilobitic crustaceans range in those rocks also!

Modern geologists and writers on geology would do well to remember what they owe to the "Principles," and that the "Silurian System" was for years, at least throughout Europe, the sole guide on Silurian geology. Again, no geologist has done so much to unravel those rugged strata termed Cambrian as Professor Sedgwick, or deserves higher acknowledgment at the hands of the rising disciples of the science. The hard-working and active-minded Professor is not so vigorous as formerly, and those who have profited so much by his assiduity and experience should be especially careful to render honour to whom honour is due.

Report on the United States and Mexican Boundary Survey. By Major W. H. EMORY, 1st Cavalry U. S. Army. (U. S. Boundary Commissioner.)

The first volume of this interesting Report has been printed, but owing to delays in the engraving of the valuable maps designed to illustrate it, it is not yet published. Having recently perused the printed portions of the work, and been permitted to inspect the maps and illustrations in the office of the Boundary Survey in Washington, we propose to give our readers a brief sketch of its scope and character. Perhaps there is no survey executed under the direction of the government of the United States,—if we except the admirably organized and conducted Coast Survey,—which, for accuracy and breadth of research, promises to contribute so much to our knowledge of the geography of the Continent, as this important exploration along the extended Mexican frontier of the country. Nor are its contributions to the Natural History of the interior of the continent of less relative value than its Geographical and Astronomical results.

We propose, after sketching concisely the history of this survey, to state the nature of some of its contributions to science, under the general heads of Astronomy, Geography and Climatology, Geology, Botany, and Zoology.

The war between the United States and Mexico resulted in 1848 in a treaty of peace, which aimed at defining a new boundary between the two countries; but in tracing that boundary, a difference of opinion arose among the officers of the United States Government employed to run the line, and the work was virtually suspended. It appeared that no interpretation of the treaty was compatible with a boundary line which would permit a ready communication between the United States military posts and settlements on the River Gila, and those on the Rio del Norté; or, in other words, a practicable road between the Pacific and Atlantic slopes of the United States,—only wide desert plains, and rugged barren mountains, scarcely passable, lying along the projected frontier. The two governments therefore concluded a new treaty in 1853, which adjusted all disputed points, and defined such a line of boundary as was supposed, at the time, to include a practicable route for a common road, or even a railway, across the continent.

The boundary line now successfully traced coinciding only in part with the line agreed upon in 1848, may be defined as follows: It commences at the mouth of the Rio Bravo del Norté (usually called in the United States, Rio Grande), runs thence up that river to its intersection with the parallel of 31° 47′ north latitude; thence, along that parallel 100 miles; thence, due south to the parallel of 31° 20′; thence west to the 111th meridian of longitude measured from Greenwich; thence, in a straight line, to a point on the Rio Colorado, 20 miles below the Gila; thence, up the middle of the Colorado, to a point near its junction with the river Gila; and thence, in a straight line, to a point one marine league south of the Port of San Diego.

To Major Emory was assigned duty on the first boundary line, as chief astronomer and surveyor, and under the last treaty he was appointed the commissioner in addition to his other duties, the government combining the whole into a military organization. The entire survey has therefore been conducted under his direction, and to him and his assistants we are indebted for the ample mass of information embodied in the Report and maps, now soon to be published.

This Report consists of four parts, in two large quarto volumes, and is divided as follows:—Part I. embracing the personal narrative with description of the country, and the Astronomical results; Part II. the Geology; Part III. the Botany; and Part IV. the Zoology.

The maps are of three classes; 1st, a General Map on a scale of $\frac{1}{6.000,000}$; 2d, four maps for military purposes, on a scale of $\frac{1}{600,000}$; 3d, a series of 53 maps, on a scale of $\frac{1}{60.000}$; and, 4th, a series of maps on a scale of $\frac{1}{6000}$, representing the islands and special localities, and the features according to which they have been assigned to the respective countries. The maps of the 3d and 4th classes are not to be published, but are to go into the archives of the government.

There are about 300 illustrations, including those of objects of natural history. Among them are views along the parallels of latitude, enabling the line to be hereafter identified, should Indians or others remove the monuments erected along it. Besides these, there are several profiles, exhibiting the undulations and altitudes of the surface, and others constructed as geological sections, to represent the stratification of the country.

Astronomical Results.—The entire length of the boundary-line following the sinuosities of the rivers, is upwards of 2000 miles. When it is considered that a very large portion of this vast space is travelled by bands of hostile Indians, it must be obvious that a trigonometrical survey was not practicable. The next most accurate method for adoption was that of linear surveys, checked by astronomical observations. Nine or ten principal points were selected as primary stations, and their exact places determined by elaborate observations, for longitude on the moon and moon-culminating stars, and for latitude on stars near the zenith; the instrument used being a 46-inch telescope made by Troughton and Simms. Intermediate points were then determined by transmission of chronometers, by occultations and eclipses of the satellites, and by all the means resorted to which give results of a secondary degree of accuracy. In tracing the parallels, the latitude was determined every 15 or 20 miles, and the ordinates to the parallel measured from the prime vertical, which was determined by measurements of the elongation of Polaris, made with the best Gambey theodolites. The reductions for longitude were made, in all practicable cases, from corresponding observations, most of which were furnished by Professor Airey of the Greenwich Observatory, and for which Major Emory gratefully acknowledged his obligations at a meeting of the American Association for the Advancement of Science, held in Washington in 1854, the Association voting thanks to Professor Airey.

Among the more valuable of the astronomical results may be stated,—the determination of 208 points in latitude and longitude, extending entirely across the continent, most of them not previously ascertained, even within approximate limits. That the astronomical work has been conducted with extreme care and attention to accuracy, is shown in the fact, that the table of the latitudes obtained by using the zenith telescope developes very distinctly errors in the declination of many stars, as given in the Catalogue of the British Association.

The catalogue, known as the "Twelve year Catalogue," of more recent date and greater accuracy, could not be advantageously used, because of the limited number of stars recorded in it; and therefore the much more comprehensive British Association Catalogue was employed.

Two Geoditic lines, of very considerable extent, were determined in connection with this boundary. The first connects the initial point on the Pacific with the junction of the Gila and Colorado, and has a length of 148 miles. The second, ranging from the point on the Colorado, 20 miles below the junction to the intersection of the 111th meridian of longitude with the parallel of 31° 20′, has a length of 237 miles. As the nature of the country, especially its want of water, and of the means of subsistence, precluded all hope of uniting the extremities of each line by triangulation, it was resolved to establish the latitude and longitude of each point by direct observation on the heavenly bodies, and compute the azimuth of the line connecting them. So nicely were the observations made, that when the parties charged with tracing the first line upon the ground met in the Desert, north of the Colorado, they were within 100 feet of each other.

A portion of the country adjacent to the United States and Mexican boundary was examined by Major Emory in 1846, and some of the results of this reconnaissance have, through an error of the venerable Humboldt, been accredited to Abert and Fremont, neither of whom had explored the region till after this eminent author had published the edition of his (Aspects of Nature) in which the allusion is made. It is but justice to mention, that the astronomical determinations made during that reconnaissance with the sextant have not been changed by the more elaborate observations since undertaken with instruments of a higher class.

Physical Features.—We cannot, in this brief sketch, offer a connected description of the remarkable topographical features of the country intersected by the boundary line, nor more than allude to the great table-lands, and chains of mountains arising from these. Their influence is all-controlling, whether we view it in its physical or social relations. No student of the physical geography and climatology of the continent can find his way to an interpretation of their phenomena without acquainting himself with the structure of this region; nor can the statist measure at all the probable future progress of population without gaining first a close understanding of its topography.

This exploration has called for important changes in the map of this part of the continent. Following the line of the boundary inward from the Gulf of Mexico, we pass a belt of lagoons separated from the sea by a chain of low, sandy islands and marshy flats. The firmer land bordering the lagoons is, for the first ten or twenty miles, a flat, verdant prairie, formed of alternating river and marine deposits. West of this low plain are salt lakes and tracts encrusted with white saline efflorescences, and devoid of vegetation. More generally there is a clothing of high luxuriant, coarse grass, interspersed with clumps of the live or evergreen oak. Passing the belt of prairie, there is seen a ridge of low sand-hills, apparently an ancient coast-line or sea-margin. This steppe, extending many miles into the interior, has a sandy, calcareous soil, the washings of the wide cretaceous formation, which spreads hence to the centre of the continent. The soil itself is unsurpassed in productiveness, wherever the vegetation finds a sufficiency of moisture; but between the Nueces and the Rio Bravo del Norté, a great deficiency of rain renders agriculture extremely precarious. Indeed, when we approach the Rio Bravo, the aridness becomes excessive, and the natural vegetation, in adjustment with it, is that of a semi-desert country, consisting largely of the Cactaceæ and other spinous plants. Large tracts to the west and south of the Nueces, are, however, richly covered with grass, and here are to be seen countless multitudes of wild horses and cattle. Towards the Rio Bravo the surface is extensively cut by deep precipitous gullies, called Arroyos, which for many months contain not a drop of water, and again in the brief season of rains are the channels of wild, impetuous torrents.

In the more prosperous days of Mexico extensive reservoirs for water were kept up at certain stations throughout this deficiently-irrigated country, but these have gone to ruin. Throughout the entire valley of the Rio Bravo and its tributaries Indian corn can scarcely be cultivated, except in the low lands, susceptible of natural overflow or artificial irrigation. On the table-lands or Mesas, unsuited to cultivation, grow many semi-tropical plants, as Yuccas, Dasylirions, and Agaves, useful for their fibres; also leguminous shrubs and trees, furnishing gums, tanning, and nutritious pods. While the upper Rio Bravo is fed by the melting of the snows of the Rocky Mountains, the lower portion of the river receives only tributaries supplied by the tropical rains.

Ascending the gulf-slope of the continent westward, there succeeds an elevated plateau known as the Llano Estacado or Staked Plains, through the eastern terraces of which issue, by deep and narrow defiles, called Ca~ons, the attenuated sources of the Red River and other streams. Throughout a great portion of the year this table-land, which varies in elevation from 3500 to 4000 feet, is almost absolutely rainless. Perhaps the total rain-fall for the year amounts to 8 or 9 inches. Between the 102d and 106th meridians of longitude, a broad belt of mountain table-and crosses the Rio Bravo W. of the Pecos, ranging N.W. and S.E. It is this broad barrier which deflects the Rio Bravo at its great bend, the river flowing through a stupendous narrow ravine or Cañon between gigantic vertical walls for more than one hundred miles. These mountains rise to a great height near Monterey and Saltillo, and form, it is thought, the Sierra Madre of Nuevo Leon in Mexico. Still further west we meet other spurs of the Rocky Mountains, one main range of which subsiding in height near the 36th parallel of latitude and east of the Rio Bravo, crosses the boundary under the name of the Organ Mountains, near El-Paso, sinking to rise again and merge itself in the high table-lands of Mexico. This ridge, or chain of ridges, is by some geographers regarded as the Sierra-Madrè, or Mother Mountain, that is to say, the true water-shed of New Mexico; but Major Emory states that the Sierra-Madrè and the Rocky Mountains, about the parallel of 32°, lose their continuous character, and assume the forms graphically described in the western country as *lost mountains*, or mountains without apparent connexion. The ridges rise abruptly from the high plateau which supports them, and as abruptly terminate; so that, by winding around their bases, it is possible to cross the whole mountain system in the region near the boundary-line, or near the 32d parallel, almost on the plane of the table-land, and at a height not exceeding 4000 feet. This table-land, forming the backbone of the continent, attains its greatest elevation in Mexico, where it is nearly 10,000 feet above the sea, and it is an interesting circumstance, that its lowest depression is very nearly coincident with the parallel of 32°. Ascending thence from a height of 4000 feet, it undulates between 7000 and 8000 feet to near the 49th parallel, or the northern boundary of the United States, where it once more begins to sink. It was upon a hint supplied by the reconnaissance of 1846, of the existence of this remarkable transverse depression near latitude 32°, that the government of the United States instructed its minister, when negotiating the treaty of Guadalupe Hidalgo, not to take a line north of the 32d parallel as the boundary with Mexico.

Between the Rio Bravo and the head of the Gulf of California the general trend of the more distinctly marked mountain ranges rising above the great table-land of New Mexico, is N.W. and S.E. From the eastern edge of the plateau westward, to longitude 110, the principal ridges adjacent to or crossed by the boundary line, are the San Luis, the Guadalupe, and San Padro, in the order named. The San Luis Mountains, rising abruptly a little north of the line, and running south, appear to be by far the most massive chain in this latitude west of the Rio Grande. They are the Sierra Madrè Mountains of Sonora and Chihuahua, though it would appear that they are not on the very water-shed of this part of the continent, some of the Pacific rivers originating to the east of them, and flowing through them by gigantic chasms.

Geological Results.—The geological examinations made in connexion with the United States and Mexican Boundary Survey embrace a general reconnaissance of the formations illustrated by collections along the entire line from the Gulf of Mexico to the Pacific Ocean. Among the main facts elicited are the following:

The existence of a marine tertiary belt on both sides of the Rio Bravo, skirting the west coast of the Gulf of Mexico, but less developed in horizontal breadth and in thickness, than where it forms the low Plain of Louisiana, Mississippi, and Alabama. The interior limit is near San Antonio, or more strictly at Reynosa, where the tertiary strata are succeeded by the cretaceous. This latter great system of deposits, abounding in well characterized fossils, spreads continuously from near San Antonio, to the watershed between the Rio Pacos and the Rio Grande, which river passes through it by a series of gigantic cañons or profound ravines. The continuity of the formation is interrupted below the Presidio del Norté by prodigious masses of intrusive igneous rocks, which have variously inclined its elsewhere nearly horizontal strata. In some localities the nearly level beds are extensively covered with overflows of comparatively modern lavas. The Limpia Mountains contain various igneous rocks, such as recent lavas, trachyte, amygdaloid, and porphyry. On the western slope of this range we encounter the Carboniferous Limestone rising out from beneath the cretaceous, and dipping strongly towards the west. This limestone gives indications of metamorphism from heat, and is traversed by many outbursts of igneous matter. Hence to the eastern base of the Sierra Madrè the traveller meets a succession of mountain-ridges and plateaux composed largely of the carboniferous and other palæozoic rocks, supporting in the valleys and plains between them narrower isolated basins or shallow patches of the cretaceous deposits. The Sierra Madrè itself is characterized by igneous products not differing materially from those which occur in the Limpia range. As a mountain system it includes a great number of broken ridges, running, for the most part, N.W. and S.E., but tied together by transverse ridges, inclosing extensive basin-like plains,—the parched and formidable Jornadas (journeys or forced marches) of this district.

Advancing westward, the first extensive exhibition of the ancient plutonic rocks, granite, &c., and of the older metamorphic strata, gneiss, mica-slate, &c., is low down along the valley of the River Gila, where they occur first in isolated exposures, but further on constitute the main crests of the Cordilleras of California. North-east and east of the San Barnardino range, and west of the Colorado, occur wide beds of comparatively modern tertiary deposits, and other apparently still more recent tertiaries around the head of the Gulf of California. West of the Peninsular chain, or immediately bordering the Pacific, is a very narrow interrupted strip of tertiary strata, probably of several dates, but mainly Miocene.

Botanical Results.—The botanical collections of the Mexican Boundary Survey include a large mass of material, illustrating well the geographical distribution of plants throughout the long zone explored. The final revision of these is not yet completed, but enough is known to authorize us to state, that the new species, including those already published in the Plantæ Wrightianæ, pertaining properly to the boundary survey, amount to at least 500, embraced in some fifty new genera. The Cacti alone include fifty new species, presenting numerous examples of all the extra-tropical genera, Mammillaria, Echinocactus, Cereus, and Opuntia. The final Report will be richly illustrated with good drawings of the new species, and will contain much interesting information on their geographical distribution, treating also of the medicinal and economical uses of the plants of the district surveyed.

Zoological Results.—Though it is premature to attempt at present any detailed notice of the zoological discoveries connected with this boundary survey, the final determinations and special reports being not yet completed, we are justified in stating that important additions have been made to the recorded fauna of North America. Many species, either entirely new, or for the first time discovered within the limits of the United States, have been collected by the commission. The list includes about twenty-five species of mammals, fifteen of birds, sixty-five of reptiles, and eighty of fishes contributed to the fauna of the United States; of these at least, four-fifths are entirely new. Of serpents alone there are twenty-five species. Among the mammals may be mentioned *Felis Yagouarundi*, and *F. unicolor*, *Cerous mexicanus*, *Lacidea berlandieri*, also species of *Geomys*, *Neotoma*, and *Sigmodon;* among the birds, *Vireo*, *Dendrocygna*, &c.; the reptiles, *Heloderma*, *Dipsas*, *Crotalus*, *Ranhyla;* and among the fishes, families of *Characini*, and fresh-water *Labroidi.*

H. D. R.

CORRESPONDENCE.

To the Editors of the Philosophical Journal.

Gentlemen,—Of the celebrated men of science of the last century, there is one who holds a high rank as a discoverer, as a philosopher, in the best sense of the word, and as an historian of science, viz., Bergman. Amongst some letters which have lately come into my possession, there are several from this distinguished man. They had been preserved by my brother, the late Sir Humphry Davy. The mere circumstance of being kept by him, who was little in the habit of keeping letters, would seem to indicate the value he attached to them. They are all in the Latin language, and are all addressed to the same individual, a Dr Schwediauer, who, from the terms employed, was evidently an esteemed friend of their author. The short period they comprise is that of four years, from 1780 to 1784,—these, his last years, his death having taken place on the 8th July 1784, at the little advanced age of 53. In one of these letters, that of the 12th October 1781, it is worthy of remark, that he makes mention of a severe attack of hæmoptysis following the suppression of an habitual hæmorrhoidal discharge to which he had been subject—an attack from which he recovered with difficulty, and which probably shortened his life. Notwithstanding, I can find no notice taken of it by any of his biographers.

As examples of the manner in which men of science then corresponded, as well as on account of the reputation of the writer, and the topics which they treat of, I have selected five out of the sixteen in my possession as most likely to be interesting: these I inclose, venturing to indulge in the hope that you may consider them deserving of insertion in the *Edinburgh Philosophical Journal.*

Those of your readers who may not be well acquainted with the varied labours and discoveries of Bergman, will find, should their curiosity be excited, a pretty ample account of them, and of the particulars of his career of life devoted to science, either in Rose's Biographical Dictionary, or in the eleventh volume of the Philosophical Transactions, abridged, or more in detail in the second volume of Dr Thomas Thomson's History of Chemistry.—I am, gentlemen, your obedient servant,

John Davy.

Lesketh How, Ambleside, Nov. 14, 1856.

Celeberrime Domine Doctor.

Tuam 3 Julii scriptam epistolam nuper accepi, eamq. non sine singulari voluptate perlegi, quippe quæ novissima Chemiæ incrementa generatimq. hujus scientiæ in Anglia statum enarrat. Quod mea opuscula approbatione recipiantur, me non potest non delectare. Veritatem, ubi decet, candidus quæsivi, et ea, quam illis per totam Europam adquisivi benevolentiam, meos labores non prorsus caruisse successu, mihimet persuadet. Defectum exemplarium in Anglia eo magis ægre fero, quo certius naves hoc anno vestram insulam petituræ dudum abierunt, adeo ut, nisi inopinata occasione, plura apportari nequeunt citius, quam proximo vere. Tunc autem ut habeas operam dabo. Interea titulos Dissertationum in secundo volumine occurrentium memorasse non forte displicebit. Primum undecim continet, secundum quatuordecim. xiima agit de formis crystallorum; xiiima de Terra silicea; xivma de Lapide hydrophano; xvma de Terra gemmarum; xvita de Terra Turmalini; xviima de Calce auri fulminante; xviiima de Platina; xixma de mineris ferri albis; xxma de Niccolo; xxima de Arsenico; xxiida; de mineris zinci; xxiiitia de Præcipitatis metallicis: xxivta de Docimasia minerarum humida; et xxvta de Tubo ferruminatorio, ejusdemq. in explorandis corporibus usu.

Dissertationes de Terris geoponicis et de pigmento indigo, in Gallia sunt impressæ, adeo ut non nisi unicum utriusq. exemplar possideam, sed in volumine tertio prodibunt revisæ una cum aliis de Productis vulcaneis, de Attractionibus electivis, de calculis animalium, et quæ sunt reliquæ. Immo huic volumini Sciagraphiam regni mineralis, secundum principia constitutiva digesti, inserendam cogito.

Laminam metallicam mihi missam examinavi, eamque præter cuprum et zincum vix quidquam continere reperi. Ferro caret et nihil aliud esse videtur, quam orichalci species, quæ ignita aquæ immergitur, ut fiat durior et magis elastica, has enim qualitates fusione fugavi et dicta operatione revocavi pro lubitu.

Observationes et experimenta Domini Crawford de igne lubenter legerem, nec non Domini Higgins de glutine murario, aliaq. novissima Chemiam quodammodo tangentia. Si cujusvis operis exemplar Domino von Asp, Legationis suecicæ Secretario tradere. Tibi placeret, hic sine dubio prima occasione mittet. Quo Tibi lubet modo debitum solvam. Sveciam sero ingrediuntur libri anglici.

Quod a Domino Fontana mihi missum scribis, non accepi.

Experimentum cum Phosphoro vitrum corredente notatu est dignissimum et cito repetendum meditor. Sed forte vitri anglicani, quod multum plumbi continet, in hoc momento longe alia est ratio, quam nostri.

In dissertatione anno 1740 edita Dr Haupt salem vocat perlatum, qui in urina inspissata una cum sale microcosmico deponitur. Hic, uti jam notum est, constat alkali minerali, acido phosphori satiato.

In Medical Review, pag. 139, determinationem desideras canthari, at sequenti explicatione memet sine dubio sufficienter excussatum reperies. In experiundo Sveciæ pondera et mensuras adhibui, praterea q. supervacaneam cum exoticis comparationem duxi, quum hæc satis adcurata in Actis Academia Stockholmensis, ante plures retro annos translatis in linguam Germanicam, et postea quoq. in Latinam et Gallicam, occurrat. In volumine nemper septimo, pro anno 1746 pondera et in volumine sequente, pro anno 1747, mensuræ nostræ examinantur. Pes suecanus in volumine primo determinatur. Itaq. non potui non hæc præterire, quum eadem cognita crediderim.

Hac occasione plura scribere non vacat. Dum proxima vice mihimet scribis, epistolam extus ita signes.

To the Royale Society, at Upsal, in Sweden.

Intus vero ad initium adscribis: To Mr T. Bergman. Ceterum, anglica, vel qua Tibi libuerit lingua, scribas. Valeas, vir Celeberrime, optat.

Tui Nominis.

Dabam Upsaliæ, die 19th Sept. anno 1780. Cultor observantissimus,

T. Bergman.

Celeberrimo Experientissimoq. D. Doctori Schwediauer, S.P.D.
T. Bergman.

Epistolam tuam die 24 Octobris scriptam die 10 Dec. obtinui. Si nondum sarcinulam ablegaveris, quæ opuscula anglica mihimet destinata continet, eximas Scheelii tractatum de igne, quippe quem mihi misit D. Forster una cum itinere islandico translato, itemq., Dissertationem Domini Magellan, quam dono auctoris jam possideo, et Mülleri de Turmalinis Tyrolensibus, A. D. Born, missam. Addas vero, si placet, quæ Priestleyus nuper edidit, cujus hactenus non nisi tria volumina de aëre adquirere potui. Sarcinula sine dubio adhuc restat apud D. Asp, adeo ut hæc permutatio facile peragi possit, et etiam quæ hac hieme imprimuntur addi, quum vix nisi primo vere eam mittendi occasio occurret. In proximis litteris memet instruas, quomodo inscribenda sit sarcinula, cum prima nave imminentis anni Tibi mittenda, ut illam Londini cito et tuto obtineas? Quædam ne desideras exemplaria Dissertationum, Opusculis licet dudum insertarum, si quæ forte supersunt primæ editionis specimina, seorsim edita? Opusculorum, vol. secundum, nondum Lipsiam attigit. Bibliopola Iversen, Lubecæ habitans, exemplaria per Germaniam divendendi curam in se suscepit, quæ dudum in ejus manus pervenisse spero. Est ne quidquam commercii Lubecam inter et Londinum? Facilius saltim, quam e Lipsia, exemplaria adquiri posse videntur si quædam desideras antequam proximo vere mihimet mittendi, occasio subministrari potest. Jam ad quæstiones propositas seorsim resolvendas memet confero.

Lacca sigillatoria cærulea e cæruleo Berolinensi, quod immisceatur gummi laccæ leniter fuso. N.B. instar ceræ dealbato, nam si flavet, viredo oritur. Hanc laccam sigillatoriam non ad candelæ flammam accendere licet, sed mediante idoneo æstu caute est fundenda, dum litteris claudendis inserviet. Vitrum cobalti similiter adhiberi potest.

Animalisatio telæ linteæ primo peragitur illam cum stercore vaccino recente probe fricando et in äere exsiccando. Dein tela lota pluries immergatur lixivio saponaceo e sale sodæ et pinguidine animali, præsertim cetaceorum, facto, et inter quamlibet immersionem solis exposita radiis exsiccetur. Hæc sunt momenta operationis cardinalia.

Sal ammoniacus acido constat muriatico per alkali volatile satiato, ubi notum est. Ut hic cum lucro confici queas principia habeantur oportet vili pretio. Sed aqua marina, separata per crystallisationem muria, multum continet magnesiæ acido salis satiatæ, adeo tamen laxe adherentis, ut solo calore destillatorio acidum sejungi possit. Hinc intelligitur ratio ob quam in confiniis maris arte facilius paretur sal ammoniacus. Alkali volatile ab ungulis et cornubus animalium obtinetur, nec non ab omnibus aliis animalium partibus.

Molybdæna vix novum continet metallum. Constat namq. acido quodam particulari sulphuri adunato. Quum arsenicum regulinum experimentis congruenter nihil sit aliud, quam peculiare acidum phlogisto satiatum, adeoq. sulphuris species, arsenicum autem album idem acidem tanto foetum inflammabili, quanto coagulationi (non saturationi) opus est, non sine magna probabilitatis specie credo, quodlibet metallum constare quodam acido radicali, quamvis hactenus a nullo acido metallico, præter arsenicale, phlogiston penitus evelli potuerit. In molybdæna præsens acidum, ni fallor, metallicum est, forte stanni. Plumbago longe alius est indolis, continens vix aliud quam acidum æreum et phlogiston.

Magnesia nigra minime eodem modo reduci potest, quo alia metalla. Methodum idoneam, in Opusc., vol. ii., descriptam invenies, vel, si desideras, alia vice in litteris communicabo. Descriptio Telluris physica secunda vice prelo subjecta est anno 1773. Annis 7 sequentibus multa didici, multa huc pertinentia ab aliis sunt detecta, quæ ideo desiderantur. Versionem secundæ editionis Germanicam nondum vidi : ut compares suecanum mittam exemplar.

Nonne in Officina Bentleyana imagines quorundum chemicorum et illustrium physicorum fingantur ? Si ita, illas lubenter emerem, simulq. quæ in anglia æri incisæ reperiuntur. Contemplatio imaginum virorum, qui in physica et chemica palæstra desudarunt memet magnopere delectat.

Quanti constat series imperatorum et illustrium Romanorum, more Bentleyano fictorum ? Quanti notabiliorum Deorum et Dearum ? Nonne catalogus haberi queat cum addito pretio ?

Eximia est observatio Domini Fontanæ de Sulphure majore æstu rigescenti sed idem accidit antimonis crudo, argento salito multisq. aliis corporibus.

Huic epistolæ Dissertationem adnecto nuper editam de diversa in metallis phlogisti quantitate. Si plura desideras exemplaria indices numerum.

D. Rinman nuper pigmentum viride invenit, quod tam aqua quam cum oleo non tantum egregium est, sed etiam nulli obnoxium mutationi. En præparationem: Solutio cobalti commiscetur cum Solutione zinci et dein alkali fixo præcipitatio instituitur. Sedementum roseum collectum, lotum, exsiccatum et tandem calcinatum virescit plus minus saturato colore, pro vario ingredientis zinci quantitate.

Actorum Stockholmensium in linguam Germanicam translatorum nuper volumen 35 in lucem prodiit. Vale, vir celeberrime, iterumq. vale. Dabam Upsaliæ, die 22 Dec. 1780.

Amplissimo Clarissimoq. Viro, D.D. F. Schwediauer, S.P.D. T. Bergman.

Epistolam tuam scriptam, d. 27 Jun., æque ac alium d. 24 Aug. Londini datam accepi. Epistolas tuas in posterum sicut antea inscribas. "To the Royale Society at Upsal," et in meas mox pervenient manus, modo, ut antea, ab initio meum memores nomen. Nec opus est, ut peculiari charta involvantur. Gaudeo, quod mea ultima sarcinula ad te rite parvenerit. A Te ad me missum nondum accepi, nec hactenus de illa Stockholmiæ ullam notitiam adquirere potui. Utinam nomen naucleri vel navis in memoriam Tibi revocare posses, et tempus quo abierit, tum forte, hisce cognitis, melius succedet nova inquisitio. Ut de hisce momentis cito me instruas oro.

Ad finem Augusti gravi afflictus sum morbo. Sanguis, qui per hæmorrhoides per plures annos consuetum habuit exitum, subito corporis superiores partes et præsertim pulmones adgressus est, unde violenta oriebatur hæmoptysis. Parum abfuit, quum hæc in tumulum memet transtulerit. Jam quodammodo restitutus adhuc tamen magna laboro debilitate, adeo ut hac vice plura scribere nequeam. Vale, vir experimentissime, iterumq. vale.

In enumeratione librorum, quos mihi missos scribis, Kirwan de acidorum fortitudine, quam antea promisisti, desidero, sed forte in sarcinula nihilo minus adest, modo illam reperire potem.

Dabam Upsaliæ, d. 12 Oct. 1781.

Celeberrimo D^{no} F. Schwediauer, S.P.D. T. Bergman.

Tandem heri arcam a te misam laetus accepi, simulq. e tua epistola moræ causam, mihi proficuæ, perspexi. Quum autem in litteris, ad finem Junii datis, illam dudum in navi depositam narraveris, inimico fato perditam non potui non credere mense Octobri.

Libri omnes gratissimi fuerunt. Kirvani Schediasma adfuit, quamvis in catalogo missorum ejus fueris oblitus, sed nova methodus Henryana desideratur, hic tamen defectus memet non angit, namq. in opere Cavalliano explicatam spero. Quod imagines ejusdem magnitudinis haberi non potuerint, certo quidem respectu collectionis meæ imperfectionem prodit, sed hoc ipso plerosq. majores ideoq. pulchriores obtinui, sine dubio tamen longe cariores, quod in Te minime redundare debet. Ut igitur quod debeo indices rogo et, præter gratiarum actiones, pecuniam lubenter solvam. In epistola 16 numeras, sed non nisi 15 accepi. Forte Cartesii, qua haberi non potuit, connumerasti. Crystalli arenaceæ gallicæ mihi fuerunt perquam gratæ, æque ac lapidis cyaneo et viridi resplendescentis, nam, quod antea possideo specimen, solum cyaneum colorem monstrat. Alia variatio flavo splendet, sed hanc nondum vidi, forte rariorem.

Crystalli salinæ, quas misisti, nihil aliud sunt, quam Sal Seignetti. Primo intuitu cognoscebam. Auctoris ideo arcanum nihil valet. Pulvis pro poliendo auro est subtilis ochra. Residuum post destillationem nitri cum vitriolo martis solvatur aqua, quantum nimirum fieri potest, hæc solutio filtro coletur, addatur solutio alkali fixi et subtilis decidet ochra, aurifabris sine dubio æque apta, ac missa, forte eadem methodo parata, forte etiam e dicto residuo, motu tantum aquæ, quæ pulverem subtilissimum diutissime suspensum tenet, separata. Color panni lutei missi, ni fallor, modo in § 377 Prælect. Scheffer. descripto, efficitur, potius ochraceus, quam flavus vocandus. In Suecia flores Chærophylli sylvestris (Fl. suec. 257) linteis materiis colorem longe lætiorem impertiunt, qui pluries lotionem cum sapone perfert et lente quoq. solari debilitatur luce. Conferatur specimen heic inclusum.

In quadam epistola dephlogisticationem acidi salis per calcem memoras. Eamdem dein frustra tentavi, nec video qua ratione effici queat. Ut proportiones igitur indices oro, qualitatemq. calcis salitæ : num calx aërata, an vero usta sit solvenda, an residuum post destillationem salis ammoniaci cum calce adhibendum? Dnus. Keir mihi notus est, sed nominas quoq. Keer : num duo diversi chemici ? an vero posterius nomen festinante calamo procreatum ?

Dnus. Ferber, Prof. Mitaviensis, per aliquot annos a me petiit Regni mineralis Sciagraphiam secundum principia proxima digesti. Talem illi nuper misi manuscriptam, et hac lecta, ut typis divulgare sibi permitterem desideravit et voto ejusdem non potui resistere, quamvis hoc tentamen etiamnum valde sit imperfectum.

Nundinis proximis paschalibus hoc opusculum destinatum credo, quod vix 100 paginas, in octavo impressum, efficiet. In analysi ferri pag. 68, seq. calcem albam a metallo separatum memoravi. Hanc dein ulterius examinavi et, ni fallor, novum indagavi semimetallum, ferro maxime amicum et in illo frigido fragilitatem procreans, cujus causam hactenus multi frustra quæsiverunt. Ceterum hoc metallum a ferro est diversissimum et magnetis imperium omnino recusans. Experimentorum descriptionem Societati Upsaliensi tradidi, ut tomo quarto inserantur. Stannum sulphuratum nuper detexi, cujus in gremio terræ existentiam hucusque omnes ignorarunt mineralogi, sed inter Siberica mineralia, mihi missa examinataq., talem rarissimam inveni mineralisationem. Diu miratus sum, quod hæc desideraretur, nam stannum per artem sulphur facillime suscipit et sulphur in naturæ officina uberrimum occurrit.

Quum Tu omnes cognoscas, qui Londini in Chemiam vel adfinem Philosophiam nat. incumbunt, ut singulorum historiolam pedetentim mihi narres oro. Woulfe, Kirvan, Priestley, Keir, Higgins, Saunders, Crawford, Cavallo, Henry, Bewly, Warltire, Winch, &c. qua nomina et nonnulla opera novi, sed ætatem, munera genium, merita et notabiles vitæ circumstantias ignoro, quæ tamen Historiam litterariam scientiæ, cui me addixi, multum illustrant. Num quidem Pemberton in chemicis scripsit? Citatum vidi. Num ejus imago, quæ in Catal. Bentl. Gallico pag. 67, n. 32, occurrit?

Hanc epistolam scripsi d. 20 Nov., sed per octiduum retinui, tuam responsionem expectans ultimæ meæ præcedenti, jam vero diutius morari nolo. Vale, Vir celeberrime, tuaq. amicitia memet in posterum, sicut huc usq., amplectere.

Quod D. Achard äerem, qui phlogisticatus vocari solet, per nitrum fusum duxerit, illumq. eo ipso connexerit, narras. Methodum certe ignoro, qua hic äer nitri massam transire possit sine admixtione aëris ex ipso nitro orti, qui, uti notum est eximia gaudet puritate, et in hoc casu correctionem efficit. Cerussa sine dubio in Anglia quoq. præparatur, ast peregrinatores, ni fallor, tales fabricas minime memorant.

Dominis Priestley, Kirvan et Hopson meo nomine gratias agas pro missis libris. Qua in posterum Tibi mittuntur multipla ita distribuas oro, ut hi Domini singuli exemplar obtineant. Tractatus Crawfordiani nova editio diu forte morabitur. Quum igitur parvi sit voluminis, ut credo, nonne nitide et accurate describi posset? Impensas lubenter solvam.

Quale est pondus a Priestleyo aliisq. Physicis usurpatum? Quomodo dividitur? Quid significat dwt.? Quando *gallon* simpliciter nominatur, nonne Londinensis pro vino intelligatur? *Winchester gallon* quantum differt?

Dabam Upsaliæ, d. 30 Nov. 1781.

Celeberrimo Dno Schwediauer, S.P.D. T. Bergman.

Sarcinula a Te Edinburgo missa d. 23 Sept. in meas pervenit manus d. 11 Januarii sequentis, adeoq. prius respondere non potui. Frustum terræ ponderosæ aëratæ gratissimum mihi fuit, ut facile Tibi persuadere potes. Donanti ideo Domino Black meo nomine multas persolvas gratias. Quod libri a me missi Londinum appulerint salvi ad finem Septembris, proxime præteriti, per D. Kirvan cognovi: de effigie idem spero, sed ad Te scribere non potui, penitus ignorans ubinam esses, usq. dum adveniret epistola Edinburgi scripta. Marmor metallicum Cronstedtii nihil aliud est, quam Terra ponderosa vitriolata, toto cœlo differens a Lapide ponderosa qui in Mineralogia Cronstedtii inter mineras ferriferas memoratur, § 209, i., edit. suec. Lapis ponderosus est calx acido novo metallico satiata. Est autem adeo rarus hic lapis, ut defectu materiæ non dum metallum, ad quod pertinet acidum, determinare licuerit. Conferas in vol. iii. dissertationem de acidis metallicis.

Ut muria liberetur magnesia calceq. salitis meliorem vilioremq. ignoro methodum, quam quæ in Galliæ quibusdam regionibus adhibetur et in Mem. de l'Ac. 1763 describitur. Scilicet muria collecta in cumulis conicis sub dio accumulatur et culmo tegitur, ne pluvia dissolvat. Interea atmosphæræ humiditas sales deliquescentes devehit.

Calx flava, quam Dr Withering e ferro extraxit, forte nihil est aliud, quam calx Sideri, martiali contaminata, de qua in vol. iii. agitur.

Methodus salis ammoniaci conficiendi a D. Hutton adhibita valde est notabilis.

Pro missis libris, et iis, quos polliceris, gratias ago.

D. a Linné febri biliosa, ter redeunte, lacessitus tandem apoplexia occubuit. Sed hoc sine dubio Tibi dudum innotuit. Quod ad meam attinet valetudinem, hæc certe valde est debilitata. Æstate sub itinere gravem hæmoptyseos accessum passus sum, sed postea vires quodammodo reparata fuerunt, et hæc hiemq. huc usque, ni fallor, minus mihi fuit molesta, quam binæ præcedentes.

In nova elaboranda Oryctologia jam occupatus sum, duobus in 8° comprehenda voluminibus. Num prior hoc anno in lucem prodire queat dubito, ob magnum analysium faciendarum numerum. Regni Senator et Collegii metallici Præses, illustrissimus Comes Bjelke, ut lingua conscribatur suecana petiit, uberiorem inde in nostros monticolas redundaturum fructum exspectans. Methodum ex commentatione de systemate fossilium naturali, quam misi, cognoscere potes. In novellis litteratiis alicubi legi Priestleyum in Americam abituram, ni fallor, vel in Siberiam. Num verum?

Experimenta aërostatica in Anglia incepta novi. Describas mihi adcurate methodum, qua globos aëre inflammabilo implent? Quo medio hunc aërem procreant? Quomodo sub itinere hujus aëris volumen augent, si altius surgere volunt? Cetera. Vale, Amice æstimatissime, et memet inter tuos numera amicos.

Dabam, die 13 Jan. 1784.

Notice of the Vendace of Derwentwater, Cumberland. In a Letter addressed to Sir William Jardine, Bart., F.R.S.E. By John Davy, M.D., F.R.S., Lond. and Edin.

My dear Sir,—I have carefully compared the vendace from Lochmaben, which you have been so good as to send me, with the one I have which was taken in Derwentwater, and the result is, that they are in every respect so alike, that no doubt can be entertained, I think, of their being of the same species. I have shown them to my friend Sir John Richardson, and he is equally convinced of their identity.

You remark that this fish, the vendace, is quoted as an instance of "local distribution;" adding, "it is right that its range should be corrected," and you express the opinion that it is "more extended." As the distribution of species has now become a subject of more than ordinary interest to the philosophical zoologist, it may not be amiss, perhaps, to enter into some particulars relative to the vendace, as showing, in accordance with the opinion you have expressed, that its habitat is not so limited and isolated as was long the current belief.

By my friend Dr Lietch of Derwent Bank, Keswick, to whom I am indebted for the specimen of the fish from Derwentwater, I have been informed that its existence in that lake has been for many years past known to the boatmen; and an old fisherman, one of those boatmen, has assured me that it is not only well known, but known to be pretty common there. He stated, that about eight years ago, many were taken, towards the upper parts of the lake, at Lodore, at one draught of a net; that he himself once took one with the artificial fly, and that he knew of another having been taken in angling with a worm. The specimen in my possession, I was told, was one of two killed accidentally by a stroke of an oar.

From the same informants I learnt that this fish occurs in Bassenthwaite Lake—a lake which is separated from Derwentwater only by about three miles of river (the Derwent), of gentle flow,—in its whole course of about three miles, without any obstructing fall or rapid; and, in short, the fish is about as common in the one lake as in the other. In confirmation, it was mentioned that, not long ago, no less than sixteen or eighteen were captured there at one cast of a net. A specimen from Bassenthwaite is preserved in the Museum at Keswick, and, from such an inspection as I have made of it, I believe it to differ nowise from the vendace of the adjoining lake.

Whether the vendace exists or not in any other lakes of the lake district I am not prepared to say. Such inquiries as I have made after it on visiting the larger lakes, have hitherto been unsuccessful. The most likely places to discover it are the secluded mountain tarns, in which a net is seldom if ever cast.

You are aware that in two of the lakes of the district, and in one of its tarns, viz., Ullswater and Hawes Water, and Red Tarn, a fish certainly of the same family occurs, and is plentiful. The Coregonus of Hawes Water I have examined: I was present at the capture of a specimen taken with the artificial fly—an uncommon incident. It appears to be the same as the schelly, figured and described by the late Mr Yarrell in his "History of British Fishes," and supposed by him to be identical as to species with Gwyniad of Bla Lake in Wales. The Coregoni of Ullswater and of Red Tarn, are commonly spoken of by the country people as fish of the like kind, under the name of the fresh-water herring, or schelly; but that they are truly identical species, I cannot even offer an opinion, never having examined a specimen of either, and not being aware that they have hitherto been examined with sufficient care by any competent observer.

Recurring to the speculative subject—the distribution of species—one naturally casts about for a way to account, not for the isolation of the fish under consideration, but for their diffusion, moderate as that is, according to what is known of their localities at present. Of the many conjectures that may be offered, one, and the most obvious, is, that they were intentionally conveyed by man from their original locality; another, that they were accidentally carried from place to place by an aquatic animal, such as a water-ousel or an otter; a third, that they might have been transferred by means of a moving body of ice, a glacier, or by a water spout; a fourth, that they might have found their way by the sea.

The first mode of conveyance—that by man—seems plausible enough in this instance of the vendace, especially since the attempt made with the impregnated ova of the fish, the distance between the lakes of Lochmaben and those of Cumberland being so inconsiderable; but this same method hardly comes within the bounds of probability in the instance of the schelly of Red Tarn, that tarn being one of the least accessible of our mountain tarns, and the fish itself one of the most difficult to capture. Of the other suggested ways, the third and fourth seem the least probable, and the last hardly even possible. First, in the instance of the fish of Red Tarn, considering the situation of that tarn on the flank of Helvellyn, and only three or four hundred feet below its summit; next, in that of the vendace of Derwentwater and Bassenthwaite, keeping in mind that there are falls and rapids in the river in its course from the latter lake to the sea, such as it is difficult to suppose surmountable by so feeble a fish as the one in question. It is worthy of remark, however, that the vendace has been taken alive in the tideway of the Solway—an emigrant no doubt from one of the lakes of Lochmaben. The fish, I believe, is known to you; I have been assured of it by Sir John Richardson, by whom the specimen then taken was deposited in the Haslar Museum, and afterwards transferred to the British Museum. The second mode, —that of accidental conveyance by an aquatic animal,—seems to be least open to objection. In a paper published in the Philosophical Transactions for last year, and in another to be found in the Proceedings of the Royal Society for the present, I have related experiments proving that the impregnated ova of the salmon may be kept many days exposed to the atmosphere, when the air is saturated with moisture, without their losing their vitality; that under the same circumstances, when packed in moist moss or moistened wool, they may be conveyed many hundred miles with a like result, and be afterwards hatched; and also, that their vitality is not destroyed by their coming in contact with and adhering to ice, their temperature at the same time being reduced to the freezing point of water. Are not these facts applicable by analogy to the ova of the schelly and vendace? And if so, are they not capable of affording some explanation of these fish in common with so many others, especially the trout, being found in waters so situated as to render it extremely improbable that they could have been introduced where found, excepting in this accidental way?—I am, &c.

John Davy.

Lesketh How, Ambleside,
November 8, 1856.

Note to Dr Davy's Paper on the Vendace of Derwentwater. By Sir W. Jardine, Bart.

From the foregoing observations, it will be seen that the vendace is no longer to be considered as confined to the Lochmaben lochs. These have long been taken as the only locality for it, and, like that of the supposed restricted locality of the British red grouse, has formed the basis for argument and theory on the distribution of species. Some years since, by the attention of Mr Davies, now assistant to Professor Allman in the University of Edinburgh, I received a drawing from the English lake district of a fish which appeared very similar to that from Lochmaben, but on which alone it was unsafe to decide without the examination of specimens. Dr Davy has, however, now removed that doubt, and the locality remains no longer restricted. The specimen taken in Derwentwater has been obligingly sent for comparison; when placed beside a Lochmaben fish of equal size, the general form appears stronger or stouter, the proportions of the parts larger; but I cannot mark anything that would entitle it to specific distinction. Since the MS. of Dr Davy's observations came into my possession, I have also received from T. C. Eyton, Esq., specimens of a fish from Bala Lake in Wales. These Mr Eyton compared with specimens of vendace from Lochmaben, and I have now done the same. There are slight differences in the opercular outline; not more, however, than would occur in specimens from the same lake. Mr Eyton thinks the Welsh fish identical, and I cannot perceive any differences of sufficient value to place them as distinct. Thus it is that the distribution in this country appears to have a considerable range; and it remains yet to be seen whether the British fish are not also the same with one of the continental species. When Professor Agassiz visited this country in 1834, specimens of the Lochmaben vendace were shown to him. He thought it distinct from the species known on the continent as the *Coregonus marænula.* At that time he expressed no doubt, and on this account the Lochmaben fish was named in honour of the great British ichthyologist Willoughby. I have never been able to make the comparison between British and continental specimens, but, except from the statements of Agassiz while in this country, there is no authority from direct comparison for stating that it is distinct. My impression is, that it will prove not to be so, and that the range will therefore extend to the lakes of the continent.

Dr Davy mentions one instance of the vendace being taken in the English lakes with the artificial fly. I do not doubt this, as the habits of the fish may differ from the abundance or scarcity of entomostracan food in the waters it inhabits; but the form of the whole mouth,—the small weak teeth,—the elongation and structure of the gill appendages, all show an apparatus for taking that peculiar food with which we have always found the stomach of the Lochmaben fish crammed. Dr Baird, of the British Museum, so well known for his researches among the entomostraca, examined the Lochmaben fish last summer by the water side, with the view of determining the species of entomostraca taken as food, and found nothing but these small animals in the stomach. The stomach of the Bala fish was also sent to him, but this presented very different contents,—the debris of water insects and their larvæ, and the remains of some dipterous insects; but only one specimen of entomostraca (Daphnia) could be found. The stomach of the Derwent-water fish was entirely empty of all food.

Thus it appears that the different localities afford different food, and in those where entomostraca are scarce, other support must be collected, and an artificial bait will occasionally be taken.

Entomology of the Vicinity of Melbourne, Australia. Communicated in a Letter to Mr Jones, Worcester. By Mr P. Edwards.

I now come to our favourite order Coleoptera; and were I to say all that I ought to say about the many beautiful species to be found in this country, I should tire your patience, and fill more sheets than I have time to write. I shall, therefore, briefly glance at the principal families, noticing more particularly any remarkable species, and leave you to form your own judgment from some specimens which I will shortly send to you. We appear to have several families which have no representatives at home, but with most of them I am familiar, and I will endeavour to give you some idea of what my collection of Coleoptera is composed.

First, then, the Adephaga are by no means so numerous as at home, and are chiefly confined to the Lebiidæ and Harpalidæ. Of the Cicindelidæ I have seen no example; and in a collection belonging to Mr Robert Bakewell, containing upwards of a thousand species of Coleoptera, this family was wanting. The Lebiidæ are perhaps more numerous than any of their tribe, and are found chiefly under the bark of the gum trees. Many of the species are very prettily marked with the colours of tortoise-shell; they are mostly small insects, rarely larger than from 2½ to 3½ lines. One species, which I met with under burnt logs on the Plenty Ranges, has remarkably flabellate antennæ; elytra rich chestnut brown, faintly striate; thorax cylindrical. This insect has been described, I believe, by Mr Hope, but I am ignorant of its name. The Scaritidæ give me three species, one of which is about 8 lines in length; the other two appear to be of the genus Clivina. My Carabidæ are very few also, and principally small species, like those of Helobia and Leistus at home, though some most beautiful examples of Calosoma have been taken here. The Harpalidæ are by far the most numerous of the Geodephaga, though, as I have said, by no means so common as at home. I possess a few very fine species; the largest is a species of *Catadromus* about 1 in. 3 lines in length, deep black, with punctate striate elytra—the striæ very distinctly marked; and with a broad margin of brilliant golden-green, which fades slightly after death. This insect is found under stones in the winter, and, upon being taken in the hand, exudes a yellow acrid fluid, which, once coming in contact with one of my eyes, caused me very considerable pain. Other Harpalidæ are mostly black or brassy green, like the genera Harpalus and Agonum. Of the Bembidiidæ, the genus Lopha, or one very similar to it, appears to be far from rare, and I have found many small insects like Bembidium; but this tribe requires more studious investigation than I have been able to give to it. In the Elaphridæ we are poor. Two small species, about 1½ lines in length, which are both found on flowers of Composite, are all I am acquainted with. The flowers on which I have met with these beetles were covered with myriads of very minute Aphides, and probably they formed the objects of which the Elaphri were in search. Among the Hydradephaga, two species of Colymbetes are most abundant in all our waters, and in the evenings of summer are found on the wing in almost incalculable numbers. Hydroporus, too, has its examples; but Dyticus I have not seen. Gyrinidæ are most plentiful in the Creek, one species being extremely like the Gyrinus natator of England. We have one, however, with the posterior half of the elytra light chestnut-red, the remainder black. This is not common. The Helophoridæ are not frequent, only about four small species being known to me. The aquatic insects of the colony would well repay investigation, as I am sure many more than those we are acquainted with must remain unknown. The Sphæridiidæ present us with some small species, principally found on flowers, and under the bark of the Eucalypti. The Necrophaga are by no means numerous; and, indeed, the offices which they perform in the economy of nature appear to belong to the lot of the ants and flies. I have seen and taken, however, one species of Necrodes, with high broken ridges on the elytra (*N. lacrymosa*); a genus of small insects of the Nitidulidæ, with the elytra only covering half the abdomen; three Silphæ under bark of gum-tree; a few small Mycetophagidæ; two Engidæ in the bole of a tree; and three Dermestidæ, besides a small species which I took a few days ago, and which may turn out to be an Anthrenus. Most of these have been found in situations entirely different from their habitats in England, having been principally met with underneath bark, and among decayed wood; but with one exception, none have been seen by me in carcasses, though I make a rule to turn over every dead opossum or native cat I meet with. The Byrrhidæ I do not know here. Of Histeridæ I have one species, bright golden or purplish-green (*Saprinus laetus*, Erichs); very common in carcasses and decayed vegetable matter. It is about 2½ lines in length. Of the Pectinicorns, one of the most beautiful is the well-known *Lamprima œnea*, which is found in immense numbers in the dry months of our summer. It is of the most brilliant golden green, sometimes bluish or purple, with very large mandibles (smaller in the female); it feeds upon the wattle trees (Acacia), whole groves of which it sometimes destroys in the course of a season. We are far from deficient in the Lamellicorns. Onthophagus presents us with four species, mostly ash-coloured, with dark markings, very similar to those well known to you at home; and I think five or six Geotrupidæ may be named. Six of the Aphodiidæ are all I have seen. The Melolonthidæ are very numerous,—two large and brilliant species positively swarming upon gum trees in the early part of the spring. The small genera, like Phyllopertha and Hoplia, are abundant on young shoots; and a few species are also found on the flowers of different shrubs. Of the Cetoniadæ we have some: one genus (Schizorhina) is extremely abundant on the flowers of the native box (*Bursaria spinosa*). The *S. punctata* is about six lines in length, with gold-yellow elytra, irregularly marked with black spots; the pale testaceous appearance it bears in collections in Britain gives no idea of its beauty; and the *S. australasiæ* is still more remarkable for its colours. The elytra are rich brown, with waved bands of black and bright canary-yellow. Both these insects I have positively seen this season in thousands. The *Diaphonia Hookeri* is a handsome species, about ten or twelve lines in length; elytra pale chestnut-brown, inclining to testaceous, with a broad black band extending down the thorax and along the sides of the suture. This is found upon the acacia, though it does not appear very common.

To give you some idea of the numbers in which some species are found, I must tell you that upon a single tree, in one morning, I took upwards of 200 specimens. After our hot winds, which, unfortunately for the health of the colony, are too prevalent in the summer, the Longicornes are seen in great quantities, and frequently fly into our houses at night by the open windows. The different species of Eucalypti are their special home, and sad havoc they make among some of the trees. They are principally Cerambycidæ; though of the Lepturidæ I have taken six or eight examples. In many of the former family the antennæ are twice the length of the body, The Crioceridæ have two beautiful species found on the acacias in spring, one of which is vermilion-red with black spots, and the other orange with black spots and a black thorax. These are far from frequent. I have seen no Donaciæ, though I have searched well for them upon the aquatic plants in our locality. The Cyclica are very numerous, particularly the Galerucidæ and Chrysomelidæ, both of which families exist in profusion upon the gum trees, and present an almost endless number of forms, many of which are very striking in the disparities of their colours. We have several Halticæ—one species very similar to the *H. nemorum*; but none, as far as I have been able to learn, so destructive in habits as that well-known insect. The genus Cryptocephalus is very abundant in species, several of which have very brilliant colours. I know two species of Cassidæ, both found on Eucalypti. Of the Coccinellidæ, I know one Chilocorus and five Coccinellæ, all of which are found on acaciæ. Our Tenebrionidæ are principally found under bark; one species is very large, being about ten to eleven lines. Of the Blapsidæ we have two species, Cistelidæ five, and Lagria, so like *L. hirta*, that I cannot distinguish any difference. Several large and beautiful Mordellæ occur on flowers—one Rhipiphorus on gum trees; and a large and beautiful beetle, with pectinated antennæ, which I have taken on the Plenty Ranges, belongs apparently to the genus Trigonodera. The genus Anthicus is abundant; and one species of Noxoxus occurs. The Brachelytra are comparatively few, and not very different in general appearance from our common species at home. I only possess about twelve species.

This ends my list of Coleoptera, and I therefore pass on briefly to mention the remaining orders. The Orthoptera are very numerous, and number among them some very singular insects. Among the more remarkable are the Phasmidæ, or walking-stick insects, as they are familiarly called. These curious creatures are found upon gum trees in abundance in some parts of the bush. They are often four or five inches in length, though the body of most of them is seldom thicker than a straw. We have several of the genus Mantis, which are also very curious insects. I have taken one Gryllus, with much the same habits as the *Gryllotalpa vulgaris* of Britain. The Locustidæ and Achetidæ are very numerous indeed, particularly during the driest part of our summer, furnishing an abundant supply of food to the bush turkey (*Alectura Lathami*, Gray) and somei of our plovers. I have collected nearly 100 species of the Hemiptera, many of which are large and handsome. The Eucalypti furnish them in abundance, as well as the next order, Homoptera, of which the most remarkable insect is a very large Cicada, which exists in such numbers in this locality, and creates such a tremendous noise, as to be a complete pest. Its clear membranaceous wings, when expanded, are almost four inches in width; the head is very broad, eyes red, disk prominent. On a hot summer day these insects are so abundant, and so incessant is their chirping, if it may be so called, that you are almost bewildered with the sound. Several curious insects, allied, I think, to Centrotus, are found upon the wattle trees. They are remarkable for having singular protuberances from the thorax. The Neuroptera are plentiful in the neighbourhood of streams; and many of our dragonflies are large and brilliant in colour. I have seen two or three of the ant-lions (Myrmeleonidæ) on the Plenty Ranges, and I have also taken specimens of the genus Ascalaphus belonging to the same group, which are very peculiar, in having long filiform antennæ, terminated by a knob like that of the diurnal Lepidoptera. One genus, with black and yellow wings, allied to Panorpa, is found on the trunks of gum trees in the autumn. I know two species of Termes, and a species of Hemerobius, very like *Chrysopa perla*, is occasionally found in gardens, &c. The caddis-flies are numerous in the Merin Creek; and one species I have remarked to have antennæ nearly three times its own length. Hymenoptera are most abundant on flowers, &c. My collection numbers 180 species. Ichneumons are very numerous, and some of them with ovipositors of an immense length. As to the ants, they are one of the greatest nuisances of the colony, not a single place being free from them. If you walk in the bush, they crawl up your legs, and soon remind you of their presence; in the house they devour sugar, meat, flour, butter, and in fact anything which is consumable. But what annoyed me much more than this, was the fact of their attacking my Lepidoptera, and devouring many beautiful species, just leaving me the pins. In the bush there are incredible numbers; and a few of the species raise enormous mounds, from which a path, perfectly free from all impediments, and cleared of all the grass, generally conducts to the nearest gum tree. Some of the nests formed by the wasps are very beautiful, and are often found attached to branches of shrubs. The honey-bee (*Apis mellifica*) has been introduced here, and thrives admirably. I now come to the Lepidoptera, which are not nearly so abundant as I expected to find them. The butterflies are particularly few, only nineteen species being known to me. One of them, and the most common, is closely allied to the *Cynthia cardui*. We have two or three Polyomati, and a beautiful Thecla, with pale metallic-blue wings, edged with a broad black band. The underside of this insect is buff, with irregular markings of orange and black. A small copper butterfly is common on the grass plains, and we have two or three species of Hipparchia. Of the Sphingidæ, I know but three species, and two or three resemble the genus Ino, and are found in the same situations. A large and beautiful Smerinthus is the remaining species. I should have mentioned that four skippers are found in one neighbourhood. We are richer in the moths, and possess many which are remarkable for form and beauty of colouring; but the smaller species, such as the Tortricidæ and the Yponomeutidæ are the gems of our Australian Lepidoptera. I have paid a good deal of attention to them, and number nearly 200 species of these two families. Of the Diptera we are furnished with a superabundant supply, and particularly of the *Musca domestica*, which exists here in such numbers as to be a complete plague. Even while I write, they are all over my face, and making most persevering efforts to get into the corners of my eyes. It is useless to try to avoid them, for go where you will, there are the flies also; and, after slapping your face and rubbing your eyes until you are a fright, you feel like Keeley in one of his farces, "almost tempted to say—damn;" but you dare not do so, for if you but open your mouth, down pop half-a-dozen resolute flies, and you are bound to cough for an hour to get rid of them. The only way to avoid this terrible annoyance is to wear a veil; thank goodness, the fires and frost kill them. Among the rest of our Diptera, we have some large and bright-coloured species; and one singular black and white fellow is distinctly marked with a skull and cross-bones. I have seen two or three of the Bombylii, but they are by no means numerous. Tabanidæ are common in exposed situations; and I have taken two or three singular species parasitic upon birds. These latter are, I think, of the genus Oxypterum.

An Account of an unusual Thunder-Storm, and of a Destructive Local Flood. Contained in extracts of Letters addressed to Dr John Davy, F.R.S. By Mr WILLIAM PEARSON of Windermere.

On Tuesday, 9th Sept., we had here almost continuous thunder all the afternoon. But about 6 P.M. there occurred a sudden tremendous burst; it seemed right over the house—the flash and report simultaneous. If a heavy cannon, a thirty-two pounder—had been fired on the roof, it could not have been louder, nor I think so loud. We had, however, no damage done except a square of glass cracked in the dining-room.

But the farmer, on fetching up the cows from the meadow below the house, noticed tufts of grass and sods scattered on the ground not far from the hedge. They had come from the dyke on which it grows, at the foot of a large ash tree, some of the roots of which were laid bare and the bark peeled off; the hazels in the hedge stript of their leaves, and a kind of opening made. The sods, with fern roots attached, had been driven on each side of the hedge, in nearly a straight line, to the distance of 15 or 20 feet. I think there can be no doubt that the electric force came from the ground, for if it had descended from the clouds, would not the tree have shown some signs of it? but there was not a leaf or branch disturbed, though hanging right over the dyke from whence the sods, &c., had been ejected. These appearances were not observed before the thunder-storm, and, no doubt, were caused by it—probably by that tremendous crack.

Several years ago I witnessed here effects somewhat similar from a thunder-storm. A holly tree, on a rough pasture, had been struck—the root bared from soil, and some of it thrown up among the leaves. But what was curious, the electric matter had diverged from the tree to almost every point of the compass, like the spokes of a wheel, ripping up and slightly guttering the earth, as if caused by the plough. A few yards from the tree on one side was a stone wall—one of those spokes or divergent forces had encountered it—had passed beneath it, under the foundation-stone, and come out at the other side, where was growing a crop of potatoes; it had cut through five or six of the rows or stitches as cleverly as if it had been a plough!

The question the meteorologist has to solve is, How a fall of rain—that is, small globules of water—could so suddenly produce a volume of that element, of such weight and force as to cause the effects described.

You would doubtless read in the newspapers at the time a note of a very heavy fall of water, attended by thunder, that occurred at Borough Bridge, on the Lune, on the 8th of August 1855, if I remember correctly. About a week after, I visited the place, accompanied by a friend, on a journey we made to some of the eastern parts of the county. There was something so tremendous in the havoc this storm had occasioned, that I am sure you will excuse me if I endeavour to describe some of the most prominent effects we witnessed. At Cragrigg Hawse we first came in sight of the Lune valley. Carnigill, east of the Lune, a mountain with a smooth green surface, is right opposite; but it was now (contrary to what I remembered) furrowed with several red streaks or gutters, caused by the sudden and heavy rush of water down its smooth declivity. In the stone wall at its foot there was a large gap, 20 or 30 yards in width at least, which had been made by the impetuous flood, and in the field below an immense mass of earth and stones, covering about an acre of it. The road from the Hawse to the inn is a long descent. There is a new stone wall on the right of the road, on the other side of which the mountain rises pretty steeply. This wall, in one or two places, was washed down, and the road covered in parts with soil, stones, and gravel; in one place a complete landslip had occurred—a part of the mountain side, with the green sod at the top, had slid across the turnpike, so as to prevent the passage of carriages till a part of it was removed. On reaching the inn, we were told the flood had entered the house. We saw that, in running down the lane below, it had worked itself a channel of about two feet deep. But the greatest havoc was east of the Lune. After crossing the bridge, we went up the lane that leads to a farm-house just under Carnigill. It was rendered quite impassable for carts—a channel of from two to three feet deep being cut in the middle of the road. But what shows more convincingly than anything I have mentioned the immense mass of water thus suddenly precipitated, was, that the branches of the hedge on our left, through which the water had passed into the lane, were covered with pieces of grass and wreck to the height of at least three feet! And, recollect, that this body of water had flowed down the smooth slope of a mountain, and not been absorbed by the ghylls, as would have been the case in a common heavy thunder-shower. It seems to me that if the contents of one of our small lakes (Esthwaite Water for instance), could have been carried to the summit of Carnigill, and then suddenly let fall, it would not have produced a heavier or more overwhelming flood. Mr Day, the landlord at Borough Bridge, told us that this shower (it was a shower in the valley below, with loud thunder) did not cover an area of much more than a mile in diameter. Is it not extraordinarily odd that this huge mass of aqueous vapour should reach the top of Carnigill before it met with a body of cold air to change it into water?

PROCEEDINGS OF SOCIETIES.

American Association for the Advancement of Science.

Tenth Meeting. Albany, August, 20–27, 1856.

(Continued from p. 198.)

Whirlwind and Tornado Vortices. By W. C. Redfield.—A special rotation constitutes the essential portion of these remarkable movements in the atmosphere. As regards the interior and the more exterior portions of the whirling body, the course of the spiral rotation, whether to the left or the right, continues one and the same. But the oblique inclination which the spiral movement also has to the plane of the horizon, in these two portions of the vortex, is found to be in opposite directions. Thus, in the outward portion of the whirlwind the tendency is downward, when the axis is vertical; but in its interior portion the spiral inclination or tendency is *upward*. This fact explains the ascensional effects in tornadoes, and in more diminutive whirlwinds. Owing to the greater density of the air at the earth's surface, the normal course of the gradually descending movement, in a symmetric whirlwind, is that of a closing spiral; while the course of the ascending movement in the interior portion of the body is that of an opening spiral.

In the aerial vortex, the area of the ascending movement, or spirality, is by far the smallest portion of the body; for the reason that its rotation is proportionally more active and intense, being produced by the great weight and momentum of the surrounding body, converging by an increasingly rapid motion into a smaller area.

In aqueous vortices, the spiral inclination of the interior and exterior portions is reversed, the descending spiral being nearest the axis of the vortex. Hence, lighter bodies, and even bubbles of air, are often forced downward in the water in the manner in which heavier bodies are forced upward in the aerial vortex.

So-called Human Petrifactions. By Trail Green.—Descriptions of petrifactions of human bodies which occur in the newspapers appear to refer to the conversion of bodies into adipocere, and not into stone. All the supposed cases of petrifaction are probably of this nature. The change occurs only when the coffin becomes filled with water. The body, converted into adipocere, floats on the water. The supposed cases of changes of position in the grave, bursting open the coffin lids, turning.

over, crossing of limbs, &c., formerly attributed to the coming to life of persons buried who were not dead, is now ascertained to be due to the same cause. The chemical change into adipocere, and the evolution of gases, produce these movements of dead bodies.

II. SECTION OF GEOLOGY, NATURAL HISTORY, AND ETHNOLOGY.

On the Volcanic Phenomena of Kilanea and Mauna Loa; and on the Dynamical Theories of Earthquakes, &c. By C. F. Winslow.—Referring to the phenomena of the eruption of Manua Loa in August 1855, and to numerous facts observed by him in Hawaii, and by other observers there and in other parts of the globe, the author maintained the general theory that volcanic and earthquake actions are due to powerful movements in the molten matter beneath the thin crust of the earth. He attempted to show that they were more frequent in winter than in summer, and thence concluded that they were due to the force created by the sun on the molten interior of the globe, which being greatest in winter when the sun is nearest the earth, would at that time occasion an increased pressure of the liquid against the superincumbent crust.

Exhibition of Living Gar-pikes. By J. E. Gavit.—Professor Agassiz said that the apparition of the oldest-fashioned fish alive was hardly less striking than if one of the old Egyptians were suddenly to present himself in the hall. There were very few types of this kind to be found among living fishes, but there were many among fossils. They had what other fishes had not, a ball-and-socket joint in the neck, so that they could bow; this was common to them with reptiles. Their pectoral fins were small, and continually in a vibratory motion like the cilia of animalcules. The same motion was also observed in the upper lobe of the caudal fin, which was the actual prolongation of the back-bone, and analogous to the tails of reptiles. In the Old Red Sandstone he had found a fish which he called Glypticus, with the same sort of tail. This went, with so many other things, to show that the order of succession in past times was exemplified now in the development of individuals. Here were also two features observed in genuine reptiles, the power of moving the head on the back-bone, and the *quasi* tail. He had noticed, also, that these fishes would rise to the surface of the water, draw in air at the nostrils, and then emit bubbles from his gills. This was singular, and was a character only known to exist among reptiles.

Notes on the Geology of Middle and Southern Alabama. By A. Winchell.—This was a somewhat detailed account of the geology of those parts of the State examined by the author, and was illustrated by a map comprising the country, from the Tertiary near the junction of the Tombigbee and Alabama rivers, north along their courses, half way up the State, exhibiting a complete range of strata to the Silurian. The map was also accompanied by some valuable sections, by specimens of the rocks, and by a very large collection of Tertiary fossils, principally Eocene.

Parallelism of Rock Formations in Nova Scotia, with those of other parts of America. By J. W. Dawson, A.M.—In this communication Professor Dawson sketched the chief features of the geology of Nova Scotia, from the submerged forests, and Boulder Clay and Drift, to the

Silurian rocks, dwelling more particularly on the Carboniferous system so largely developed in that region. He spoke of the gypsiferous Limestone formation, or lower Carboniferous group, as gradually running out in a certain direction, and giving place to Conglomerate. Just as the Carboniferous Limestone tract of the Appalachian was known to disappear, and give place to coarse sedimentary rocks in approaching that chain ; and he referred to the gypsum deposits, and the Coal-measures below the Limestone, as features peculiar to this north-eastern region, which were not recognised in the Appalachian belt. He exhibited specimens of rain-marks and foot prints, as well as of stigmaria and other characteristics of the coal measures.

Professor W. B. Rogers remarked that the parallelism of formations in Nova Scotia and the United States was much closer in some respects than had been represented. The Limestone beneath the great Coal series (Carboniferous Limestone), instead of being wanting in the Appalachian belt, as stated by Professor Dawson, was present, throughout a great part of it, in much greater force even than in the far west. Along the south-eastern margin of the chain in Pennsylvania, it is represented by a vast thickness of red and variegated shales and sandstones, which, in approaching the Potomac River, is parted into an upper and lower mass by the intercalation of a wedge of Limestone, which, expanding towards the south-west, attains, in the vicinity of New River, in Virginia, a thickness of more than a thousand feet. Here it is found to include a very thick deposit of gypsum associated with rock-salt. Below this group of shales and limestone, there may be traced, for many hundreds of miles, a thick mass of grayish sandstones, shales, and pebbly rock, containing coal-plants, and, towards the south and west, including one or more seams of coal. This group of beds, designated as the Vesperteni series, is of sufficient thickness to form in general a distinct ridge or crest. Thus, in the Appalachians, we are presented with the Carboniferous Limestone and gypsiferous rocks, and the subjacent oldest Coal-measures not less distinct, and on even a larger scale than in Nova Scotia.

On Carboniferous Reptiles. By Jeffries Wyman. — Professor Wyman remarked, that as we descend in the series of deposits the remains of such fossils become fewer downward to the Coal formation. In America the remains of reptiles in the coal series are found by their footprints. Some have been discovered by Lea, and others are to be described by Rogers—but these are of the Batrachian order. Now, it is necessary that great caution be used in deciding upon the character of animals thus made known to us, since they sometimes exhibit both reptilian and ichthyic characteristics. The Gar-pike, for instance, described by Professor Agassiz, might be taken for a reptile if only a part of its skeleton was found, and *vice versa*. One part of a vertebra would lead the anatomist to judge it a fish, another part would give equal reason to suppose it a reptile. We must therefore have many parts of a skeleton. The fossil which was now under discussion was forwarded by Dr Newberry, from the coal of Ohio, and was undoubtedly a reptile. The cranium is so much like that of a frog as to give the impression, upon first inspection, that it is that animal ; but on counting the vertebræ, we find the number to be too great. The skull is that of a tailless batrachian ; the posterior parts, those of one with a tail. He was sure it was not a fish ; it looks like a serpent. There are in these remains two characters not found in existing reptiles : First, broad processes in the vertebræ, comparable to the *Menapoma* of the western rivers, and thus far the animal was batrachian; Secondly, ribs like those of a serpent, unlike any known batrachian. Of existing batrachians, some are without limbs, and some with limbs. Some of these latter have two toes ; some three, and others four and five. The footprints found in Pennsylvania exhibit five toes before and four behind. In this specimen appearances indicate the existence of a fifth toe on the forefoot, which may yet lead to the discovery of the connection of these footprints with batrachian reptiles.

Professor Agassiz said that this was very welcome evidence of reptile life, and the difficulty of identifying animals from mere portions of them. He said that in the dissection of turtles he had discovered the bones in the turtle's neck which were supposed to be peculiar to birds, so that had a skeleton been found, the upper portion of it would have been referred to a bird, and the lower to a reptile. These discoveries forced upon science the necessity of reconsidering many cases which were now relied upon as furnishing good evidence of the existence of peculiar animals in past ages. He believed that the batrachians did not belong to the class of reptiles, but that they formed a class of amphibians intermediate between reptiles and fishes, and comprising a large portion of what were called the large reptiles of the old ages.

Proof of the Protozoic Age of some of the altered rocks of Eastern Massachusetts, from fossils recently discovered. By W. B. Rogers.—The substance of this paper has already appeared in the September No. of this Journal.

On the Geological Position of the Fossil Elephant of North America. By J. W. Foster. This was an elaborate paper comprising a variety of local details. The following is the author's summary.

From all the facts, I am disposed to believe that the fossil elephant commenced his existence before the drift agencies had entirely ceased—when the water stood at a higher level—when the contour of the continent was different—when a different climate prevailed, and when a subarctic vegetation stretched far towards the tropics—at a time when the valleys were excavated by the returning waters, and the streams assumed nearly their present direction. It was a period of erosion, which ought to be marked by distinct geological monuments. I would designate it as the Fluviatile Period. Although, in rare instances, the remains of the elephant and the mastodon are found side by side, there are deposits apparently newer, which contain the mastodon, and in which those of the elephant have never been found. The inference, therefore, might be drawn that, although at one time contemporary, the one was introduced earlier, while the other survived later. Contemporary with these fossil pachyderms was the fossil beaver (*Castor oides*). In bulk he was twice the size of the existing species, and was adapted to a wide geographical range. Contemporary too with these pachyderms was the mastodon (*M. giganteus,*) of a more ponderous frame, but of an inferior weight. The fossil beaver tenanted the streams and lakes. Herds of cattle (*Bos* *bombifrons* and *Bison latifrons*) roamed over the plains, while the tapir wallowed in the swamps. In the milder regions of the south, visited by the elephant and the mastodon in their migrations, lived the great leaf-eating megatherium, the mylodon, megalonyx, the hippopotamus, the horse, the elk, and the deer, all belonging to extinct species, while at the head of the carnivora stood the colossal lion (*Felis atrox*), which then, as now, was the monarch of the forest.

On Some Points in the Geology of the Upper Mississippi Valley. By Professor James Hall.—Professor Hall exhibited a map of the Middle and Western States, which was the first attempt made by him in 1841 to represent the geological formations of the east, and their prolongation in the west. At that time he was led into some errors, which subsequent investigators have set right. The Cliff Limestone of Owen and the western geologists embraces strata belonging to the Lower Silurian, the Upper Silurian, and the Upper Helderberg groups, as is now known. One of the difficulties in the way of identifying the western formations in the eastern was the supposed absence of the Hudson River group at the west. In 1850, in company with Mr Whitney, he traced this group around the north sides of Lake Huron and Lake Michigan to Pointe aux Baies, and thence along the eastern shore of Green Bay to Lake Winnebago. The washing away of the softer shales of the Hudson River group has given Green Bay its present configuration. This group should make its appearance on the Mississippi if continuous in a western direction, but up to the last year it had not been recognised in that region. In the autumn of 1855, however, he had, in company with Mr Whitney, while engaged in the Iowa survey, examined several localities where shales may be observed lying between the Galena or lead-bearing limestone, the upper member of the Trenton group, and the Niagara limestone. These shales are filled with organic remains of the age of the Hudson River group of New York, and thus furnish evidence that the sequence of the rocks. as observed in this State is the same, or nearly the same, in this part of the Mississippi Valley. The " mounds " of Iowa and Wisconsin are made up in part of these shales, overlaid by the harder beds of the Niagara limestone, and a fine section of nearly the whole series may be obtained at Scale's Mound, near Galena. Owing to the soft and easily decomposing nature of these beds, they are usually covered by soil and vegetation, but the peculiar shape of the mounds, as well as other circumstances, would lead to the conclusion that such beds as these would be found in them. He had also ascertained that the Onondago Salt Group existed with a thickness of 100 feet on the Mississippi, distinguished by the same lithological character as in New York. A thick bed of limestone, above the Niagara, might probably be referred to the age of the limestone of Galt, Canada, since its fossils and other characters were similar ; and perhaps a portion of the rocks of the north shore of Lake Michigan, hitherto supposed to be of the Niagara age, might be referred to the same age as the Galt limestone.

On the Plan of Development in the Geological History of North America. By James D. Dana.—This paper was an application to the geological development of North America of views previously published by the author. Adopting the idea, that the shrinking of the earth's crust has been the direct agent in all the great geological changes of the surface, he regards the subsidence of the ocean basins as the immediate instrument in uplifting and corrugating the adjacent continents. He maintains that the typical form of a continent is a trough or basin, whose sides, raised into mountains, are so turned as to face the widest range of ocean, and that the height of those mountains, and the extent of igneous action along them, is directly proportioned to the size of the oceans.

Referring to the development of North America, we see the small Atlantic on one side, and the great Pacific on the other, making the relative amounts of force from the two directions, the south-east and south-west, during the progressive ages of the history, the former gently folding up the Appalachians, and the latter, with far mightier energy, raising the rocks and mountains, and opening the volcanoes of Oregon. Remarking that the area of Azoic rocks has something of a V shape, and opening towards the north, with Hudson Bay between its arms, Professor Dana considers this area as a stand-point against which the uplifting agency operated from the Atlantic and Pacific sides, the evolution of the continent taking place through the consequent vibrations of the crust, and the additions to this area, along its south-east and south-west sides. These two systems of forces—the south-east and south-west—continued to act until the close of the Tertiary period, when, having brought the continent nearly to its present form, they died out, or gave place to a northern force, which made itself felt in long and slow oscillations of the arctic regions during the Post-Tertiary period.

Notice of a remarkable instance of Inclined Stratification in Warren County, New York. By J. D. Whitney.—In the locality referred to, near Lake George, a fine white sand, containing small quartz pebbles, has been deposited over a considerable extent, and with a thickness of 25 feet vertical, having a dip of thirty degrees. The fact, thus established, that strata may be deposited at a high angle, led to the development of a theory of the formation and dip of the sandstones of the Connecticut Valley, and other similar deposits on the Atlantic slope of the Appalachian chain. The main point of the theory was this: that these beds of sandstone were originally deposited in an inclined position in a basin of subsidence, by currents of water carrying detritus, which currents were produced by the subsidence itself. If a fault originated in a valley, at one side or the other, and there should be a subsidence on that side, a current of water would be produced, of greater or less violence, which current would set across the valley, and carry with it the material abraded from the adjacent region, which would be deposited in strata dipping at a considerable angle, at right angles to the line of direction of the fault, as in the Connecticut Valley. According as the subsidence was to the east or the west, the dip of the strata would be in the opposite direction. Thus, the origin of limited basins of sandstone, having a dip transverse to the direction of the basin, would be fully explained by a cause lying within the basin itself—a phenomenon which had not as yet been satisfactorily explained by geologists.

On the Geology of the Broadtop Coal Region in Central Pennsylvania. By J. P. Lesley.—The author stated, that he had made a nearly complete survey of the seventy or eighty square miles which it covers. The levels of more than nine thousand points upon the mountain had been obtained, and the structure made out with a fair approximation to accuracy. In another season the economical operations upon the mountain will be so multiplied that the minutest features of structure will become known, and a complete discussion of the fossils be possible. The present paper was intended to present only the fact and method of his survey, with its principal results. It has determined that the succession of the measure was not different from the system made out in Western Pennsylvania and Eastern Ohio.

On the Deposits of the Fossil Fishes and Reptiles of Linton, Ohio. By J. S Newberry.—Professor Newberry exhibited to the Section a series of fossil fishes of great beauty, and well preserved, derived from the Carboniferous strata of Ohio, from a locality which he had discovered nearly two years ago, and which rivalled, in the variety and beauty of its fossils, the famous fish-beds of Solenhofen or Monte Bolca. These fishes were, however, truly carboniferous (occurring near the centre of the Ohio portion of the Alleghany coal-field), both geogra- phically and stratigraphically. The deposit was therefore to be compared with that of the fossil fishes at Burdiehouse in Scotland, so fully illustrated by Dr Hibbert. In the Ohio deposit was represented every genus found in the limestones of Burdiehouse, with a single exception ; while in addition there were several genera not yet found in Scotland. The number of species was greater in the American than the Scotch deposits, and all were different. Nearly all the species had, however, a character common to those of Burdiehouse, in the elaborate ornamentation of their scales and plates, in which they differed from most of the fossil fishes of the coal series. He said the similarity of all, and the identity of many, of the fossil plants from the coal strata of Europe and America had been noticed, and now the general similarity of the fossil fishes still further indicated the synchronism of the Coal period on the two continents. These fish remains were found in a thin stratum of cannel coal lying at the base of a thick bed of bituminous coal. There was every reason to conclude that these fishes had inhabited a lagoon or space of open water in the coal-producing marsh, as within a mile or two in any direction the cannel coal and the fish remains ceased to be found ; that in this lagoon the smaller fishes lived in great numbers, and, as their teeth proved, lived on vegetables. On these fishes, which were of the genera *Palæoniscus, Amblypterus, Mekolepis*, &c., the *Cœlacanths*, which were carnivorous, subsisted ; while these, in turn, became the prey of the great sauroid *Megalichthys*, and of the sharks. These facts he inferred from the coprolites of the larger fishes being composed almost entirely of the scales and bones of the smaller species which had served them for food. Probably this lagoon communicated with the open ocean, where the sharks and rays, &c., lived. It had been evidently a favourite feeding ground with them, but by some means the entrance had been stopped, the lagoon dried up, partially at least, and the fish dying in great numbers about the same time, furnished us with so many beautiful, unmutilated specimens of old and young. Subsequently the surface was occupied by a growth of marsh vegetation, and the bituminous coal was formed without a trace of fishes.

In connection with this paper, Professor Newberry made some remarks on the mode of formation of cannel coals. He stated that an examination of the coal beds of Ohio, their changes from one outcrop to another, both in physical and chemical characters, had convinced him that the distinctive peculiarities of seams of this kind of coal are due to their deposition in water, and to the commingling of a considerable portion of animal matter with the macerated and dissolved vegetable tissue of which they are chiefly made up. That a resinous vegetation could have given its inflammable character to cannel, he thought improbable. He had found unchanged resin in bituminous coal, but never in cannel. The greater relative proportion of earthy matter in cannels would be an almost necessary result of covering the vegetable matter with a fluid heavier than air, and having greater power of transporting sediment. The appearance of the fossils previously noticed also seems to prove the aqueous nature of the origin of cannel. Pieces of cannel from England correspond with those in which these fossils are found. Shells, too, are not unfrequently found in the middle of a stratum of cannel. Among the vegetable remains found in this coal by Mr Newberry are *Stigmariæ* roots and rootlets of trees which grow in coal-producing marshes,—roots characteristic of the under class of the coal-seams, and others. Strata of ordinary bituminous coal usually consist of layers of greater or less thickness of brilliant bitumen, having a conchoidal fracture, alternating with thin layers of what is generally cannel, sometimes containing so much earthy matter as to become bituminous shale ; at times these layers of cannel are of considerable thickness, and form an important part of the stratum. This arrangement is attributed to the variable quantity of water covering the coal-marshes—the cannel-like layers being deposited during the prevalence of higher water, when the fishy remains could naturally have become a portion of the stratum.

On the Organization of Acanthocephala. By Dr Weinland.—The anatomy of a worm would seem a matter of not very great importance. But those who have followed the development of science have seen that many little facts in the animal kingdom, and particularly observations made on the so-called lower animals, are just those upon which rests a great part of all physiology, including that of man. In those lower animals, in a worm, for instance, we have all the so-called physiological systems, the reproductory as well as the digestive and respiratory organs, in the most simple form. There we must study first all those processes which go on in what we call a living being. Two years since a very strange discovery was made in an intestinal worm in relation to its reproduction : and now this strange fact has become a law throughout the animal kingdom, including mankind. This, I think, is the true view of these so-called lower animals. I intend to speak to-day on the digestive apparatus of the acanthocephala, a sub-order of the helmintha, which apparatus I discovered last winter. There have, in zoology, remained still a large number of animals, which are said to have no distinct digestive apparatus. And this is certainly true of the rhizopodes, a family of infusoria—the lowest animals which we know. Let us look at such a rhizopod, of perhaps 1·400th of a line indiameter—a mucous matter, which may now have the shape of a round ball, now that of a star, without any skin around it, but with some globules in its body, which are swallowed as food balls. We remark near its margin a reddish dot ;—this reddish dot is a heart, for it contracts once every minute. Now, how does this animal feed? There is no mouth, no intestinal canal. A friend of mine, Mr Capaside, has seen it eating. When another infusorium (for these are the food of the rhizopodes) comes into its neighbourhood, we see the rhizopod at once throwing all its body over it and in the next second we see the prey in the centre of the rhizopod. A motion begins in the body, and a minute after, the eaten infusorium is a shapeless food ball. I have seen this myself once—a rare chance, for it eats only once in about ten hours. But there are said to be many other animals which rank much higher than the infusoria, who feed without mouth and digestive apparatus, by a mere imibition through the skin. Among others, till lately, all the sub-order of the acanthocephalous worms have been considered as having no mouth, no intestine. But last winter I found a mouth and two intestinal ears, starting from it and hanging down into the body, in four different species of this sub-order; and we can state, from analogy, that all this sub-order has a digestive apparatus like that other sub-order, trematoda. Its generally being found empty may account for its being overlooked for so long a time by naturalists.

On some Euphotides, and other felspathic rocks. By T. Sterry Hunt.—The name of *Euphotide* was applied to certain rock masses of the Alps and of Corsica, which were composed of an aggregate of a felspathic mineral, more or less compact, to which the name of *Saussurite* was given, and some variety of augite or hornblende, whose different nature has caused the rock to be designated as *hypersthenite*, *gabbro*, *granitone*, and *euphotide*, by different authors. The results of the author's studies of the so-called Labradorite rocks of the Laurentian system, show that these altered sedimentary deposits consist essentially of lime-felspars of the triclinic system, holding small and variable amounts of hypersthene or of pyroxene. The felspars vary in composition, yielding sometimes the formula of andesine, at others that of Labradorite or anorthite. Sometimes they are coarsely crystalline: in other cases fine-grained and almost impalpable, resembling Saussurite, and constituting, with their intermingled pyroxene, veritable euphotides, which pass by insensible degrees into the coarse-grained Labradorite rocks, with which they are chemically and mineralogically identical. In support of these conclusions, the author presented a series of specimens and a great number of analyses.

The altered lower Silurian strata of the Green Mountains present, in close association with serpentines, a series of fine-grained felspathic rocks, sometimes crystalline, and at others almost impalpable, which are found, on careful examination, to consist essentially of a triclinic felspar, having, in the case of the specimens exhibited, the composition of albite associated with an anhydrous silicate of lime, magnesia, and oxide of iron, having all the characters of hornblende. These rocks have a density of above 2·75, and form large interstratified masses in the vicinity of the serpentines. They are, according to the author, veritable euphotides.

Other felspathic rocks in the same series have the characters of petrosilex, and appear to be referable to the eurite of D'Halloy. The specimens exhibited were of a tough, dusty, sub-translucent greenish-white rock, having a density of about 2·64. The result of its analysis showed that it is to be regarded as probably an intimate mixture of quartz with felspar, having the formula of albite. The sedimentary origin of these deposits is undoubted, and the consideration of their metamorphosis presents many points of great interest.

On the Serpentines of the Green Mountains and some of their associates. By T. Sterry Hunt —In this paper was considered the nature of the serpentines of the Green Mountains in Canada. The researches of Sir William Logan have fully established the stratigraphical position of the serpentine as belonging to that portion of the Hudson River group which contain the sparry limestones of Eaton. The serpentines are sometimes homogeneous, and are hydrated silicates of magnesia and protoxide of iron, without any admixture of carbonates, but frequently they assume the form of conglomerates, in which rounded or angular masses of serpentine are imbedded in a paste, which is a carbonate of lime, magnesia, and iron, constituting a ferruginous dolomite, at other times a nearly pure carbonate of lime. Diallage is often intermingled with the serpentine, or constitutes a rock by itself. The same series of rocks presents great beds of siliceous dolomite containing much carbonate of iron, at other times the lime is wanting; and we have magnesite rock, which is sometimes mingled with a large amount of nearly pure siliceous matter to which the carbonate series is a cement. At other times the siliceous mixture is a mixture of talc with a silicate resembling a felspar in composition. Small portions of oxide of chrome and of nickel are always found in the magnesites, and these two metals are also frequently found associated with the serpentines not only of Canada but of other regions. Associated with the serpentines, and sometimes intermingled, is a white massive rock, having a density of about 3·50, and being a silicate of alumina and lime, having the composition of a lime garnet; other specimens, having a density of 3·30 to 3·40, appear to be ultimate mixtures of garnet with a white pyroxene. The aluminous silicate in some of these rocks may possibly be related to idocrase or epidote. This remarkable variety of rock is evidently derived from the alteration of an argillaceous limestone, which has lost its carbonic acid, by a process precisely similar to that by which serpentines, talcs, and chlorites may be formed from siliceous and argillaceous magnesites, while the similar dolomites give rise to diallages, and asbestus, and hornblende rocks. As a general fact, it may be said that the original sediments contain all the ingredients necessary to yield the different species which are brought out by subsequent metamorphism—a proposition of the highest importance for the correct understanding of the theory of the metamorphic rocks.

Exhibition of Fossil Fish Remains from the Carboniferous Limestones and Coal-measures of Illinois. By A. H. Worthen.—The occurrence of these remains has up to the present time been considered extremely rare in the Mountain Limestones of the Western States; and except in the thin bands of limestone about to be described, they are among the rarest of the several beds that compose the sub-carboniferous series of the region under consideration. Several years since, while engaged in collecting the fossils of this formation near Warsaw, Ill., Mr W. observed a thin band of gray crinoidal limestone, which contained the palate bones of fish in considerable numbers; and subsequent research has revealed two more of these "platforms of death" lower down in the series, densely filled with these remains. The upper fish-bed is situated in the upper part of what Mr Worthen calls, for the want of a better name, the *Lower Archimedes Limestone*, since it is the lowest bed at present known to contain fossil corals of the genus Archimedipora. The remains from this bed, with one or two exceptions, consist entirely of palate-teeth, associated with cyathophylla-formed corals, *Spirifer oralis* and *Spirifer cuspidatus*. The middle fish-bed is situated at the base of this Archimedes Limestone and near its junction with the Cherty beds below. This bed has proved by far the most prolific in these remains, and from it Mr Worthen obtained more than five hundred well-preserved teeth at a single locality, and on a surface not exceeding ten feet square. The fossils from this bed are mostly jaw-teeth, with comparatively few palate-teeth and spines. The matrix in which they are embedded is a coarsely granular crinoidal limestone, not above four inches thick, and sometimes so friable as to be easily crumbled between the fingers. This character of the matrix enables the collector to obtain these delicate and beautiful fossils in a rare state of preservation. Beside the cyathophylla-formed corals in the upper bed, we have an interesting coralline form occurring in equal abundance, and belonging to a genus which he did not know. He also obtained the head of one species of Actinocrinus from this stratum. This bed is separated from the one above by the limestones and marlites of the Keokuk quarries, from 25 to 30 feet in thickness. The lower fish-bed is situated near the top of the Burlington crinoidal limestone, and the stratum in which the fish-remains occur does not differ materially either in its lithological or palæontological character, from the associated strata. This crinoidal limestone forms the base of the mountain limestone series in this region, and rests directly upon rocks equivalent to the Portage and Chemung groups of New York. This lower bed has yielded a great number of teeth, though they are usually of smaller size than in the upper beds. This stratum was first observed at Quincy, Illinois, and has since been recognised in Henderson County, in the same state, and at Augusta, in Iowa, points nearly one hundred miles distant from the one first named, showing that these fish-beds are not local. This bed has also afforded one well-marked bone nearly four inches long. From these specimens it seems that the fishes of the sub-carboniferous era increased in size from the beginning to the end of that period, and that by far the greater portion of them were cartilaginous, only two well-marked bones having been obtained from at least one thousand well-preserved teeth. The *Pentremitæ* and *Archimedes* limestones of southern Illinois have afforded several very fine specimens of fish-remains, but a very careful examination has not yet revealed any strata in which they occur in such profusion as in the lower beds. Going south through Tennessee and Northern Alabama, though this formation attains a thickness of more than one thousand feet in the valley of the Tennessee River, these remains are exceedingly rare, and a careful research of several days yielded only three or four specimens of this class of fossils. An interesting inquiry arises as to the causes which destroyed such great numbers of the vertebrated inhabitants of the ocean during the deposit of the thin bands of limestone in which their remains are entombed in such numbers. Unlike the *Ichthyolites* of the Old Red Sandstone below, and the Lias and Chalk above, these of the mountain limestone, now before us, only occur in the fragmentary condition of isolated teeth and spines, affording in themselves no clue to the causes which may have operated in their destruction, and leaving us to conjecture whether they fell victims to disease, or to an injection of heated water or noxious gases into the ocean in which they lived. From the want of authorities and foreign specimens, Mr Worthen has not attempted to identify these fossils with similar ones in Europe. Still we may reasonably expect that, when all these collections have been fully collated, many new species will be added to those already known to occur in the upper Palæozoic. The fossils presented were only a small part of those which had been collected in that region.

Professor Agassiz alluded to the fact that two varieties of fish-remains are found belonging to the same geological period. The differences found in these proved to him the fact that they must have lived in waters of a different nature—in other words, that one variety belonged to fresh or brackish water and the other to salt. These specimens brought by Mr Worthen are precisely like those of Ireland; those brought by Mr Newberry are like those found near Glasgow in Scotland. Mr Worthen's he holds to be truly marine; it is now to be found alive only as a marine fish, and in certain parts of the Pacific. These fishes have no skeleton, and of course, after death, unless preserved by some extraordinary conjuncture of circumstances, will entirely decay, excepting the teeth, and possibly a bone or two, and the two hard spines of the dorsal fin. Of these spines he found two specimens among these remains. Though he had studied the best collection of fossil fishes in Europe, yet this one affords the means of beginning the study anew, and gaining new information upon the subject. These fragments will enable the Naturalist to go further in reconstructing the animal than all the others. In one of these specimens he finds two teeth, connected in such a manner as to show him that marks which he has formerly published as proving the existence of two species, are in fact those of a single one. He thought this collection so fine and valuable as to be worth having every specimen carefully depicted. The *Lepidosteus* of this collection is now found alive only in the rivers of Senegal; and as it there never descends into the salt water, he infers that these must also have been fresh-water fish.

On the Relation of the Post-Permian Fishes of Connecticut and other Atlantic States to the Triassic and Jurassic periods. By J. H. Redfield and W. C. Redfield.—This paper refers in some detail to the previous publications of Mr J. H. Redfield and Mr W. C. Redfield, on the fossil fishes of the sandstone belt of some of the Atlantic States. The nearly homocercal character of some of these fishes was, in 1837, remarked upon by the former as "implying for the formation even a higher place in the series than that assigned it by geologists," (New Red). And in a report to the American Association in 1845, which has remained unpublished, he infers, from like evidence, that the including rock cannot be older than the triassic, while it must be placed at least as low in the series as the lias or oolite.

Mr W. C. Redfield, on the ground of the homology of caudal structure, reclaims the *Dictyopyge* of Egerton, founded on his *Catopterus macrurus* as still belonging to the genus Catopterus. In a postscript, he adds, that he finds the remains of Catopterus brought from the North Carolina belt by Professor Emmons to be scarcely distinguishable from most of those of the Connecticut and New Jersey rocks.*

Permian and Triassic Systems of North Carolina. By Prof. EBENEZER EMMONS.—After describing the chief lithological features of the rocks composing the two sedimentary belts here referred to, the author stated his reasons for regarding them as made up of portions belonging respectively to the Permian and the Triassic systems. In what he described as the lowest of these groups, he had found remains of Thecodont Saurians. The teeth of the Saurians are in sockets, the vertebræ are concave at both ends, and constricted at the sides, the ribs are double-headed. Several of the teeth agree with those of *Clepsysaurus pennsylvanicus.* One tooth he regarded as belonging to Palæosaurus. Another specimen presented what he thought to be the plates of the head of Archagosaurus. These specimens are found, some embedded in coal and some in hard rock. Along with them is a minute Cypris, and among the coal-measures a variety of plants. This division Professor Emmons regards as *Permian.* The group of rocks above this containing Cycadeæ, Voltzia, and Walchia, he refers to the *Keuper.*

MR WM P. BLAKE *read a paper on the Orography of the Western portion of the United States, illustrating it with a map.*—It was but a few years, he said, since the vast territory lying between the Mississippi and the Pacific was an almost unknown region. The recently completed surveys made to determine the most practicable railroad route to the Pacific have added largely to our previous knowledge. Eight expeditions have been sent out, each with an independent outfit, instructions, and line to survey. They crossed the country at different parallels of latitude, and their routes were selected with reference to the unexplored spaces. The result of these surveys filled up nearly all the previously blank spaces on the map of the territories. The position, direction, and altitude of ranges of mountains not before described had been made known. The direction and position of a part of the Great Colorado and other rivers have been changed, and the boundaries of the Great Basin restored to the limits originally assigned by Fremont. As the attention of the surveys had been specially directed to the determination of altitudes and grades, and a large number of accurate instruments had been provided for this purpose, the results were unusually interesting in an orographic point of view. The materials which had been collected at the date of publication of the preliminary report were sufficient to admit of the construction of five profiles of the country from the Mississippi to the Pacific. These were reduced to one scale, and published on one sheet, under the direction of the Secretary of

* It will be seen that these inferences harmonize with the conclusions drawn by Professor W. B. Rogers, from an examination of the vegetable remains of the eastern belt in Virginia, and from his subsequent discovery in this and the other belts of certain common fossils, especially Cypridæ and Posidonomyæ. The former inquiry led him, in 1842, to assign to the eastern belt of Virginia a position low in the Jurassic series, and the latter has more recently led him to place the western or great prolonged belt, on a horizon but little lower than the former, near, but still above, the upper limit of the Trias. The discovery, lately, by Mr E. Hitchcock, of a Clathropteris in the Connecticut sandstone, lends further support to this view.

War. It is from these new materials, combined with the results of previous explorations, that Mr Blake had prepared the map which was before the Association. The great number and wide distribution of the mountains, and the variety of names under which the same chain is known at different places, make it necessary to consider them in groups, in order to facilitate descriptions and comparisons. They are separated by nature into three great divisions, which may be described as follows :—The first group consists of the great line of water-shed between the Pacific and the Atlantic Oceans, commonly known in part as the Rocky Mountains, extending from the table-land of Mexico to and beyond our northern boundary. The second may include the Sierra Nevada of California. and its prolongations, south into Lower California, and north into Oregon and Washington territories ; also all the ranges between this chain and the coast—the coast-mountains of California The third is composed of the numerous and broken ranges lying between the first and second groups. The first group is sufficiently characterized by being the dividing ridge or crest of the continent, from which the waters flow each way into the Pacific and Atlantic. The second is characterized by its lofty and unbroken line of snowy peaks, forming a great wall along the Pacific : and the third is well separated from the first by the valleys of the Colorado and Green River in the south, and Snake River in the north, while on the west it is separated from the second group by the well defined line of snowy heights of the Sierra Nevada, and further south by the low valley of the Colorado Desert and the Gulf of California. Two other groups may be formed, of the long line of azoic rocks extending northwest from the Great Lakes, and of the Appalachian chain, and its extensions through New England and Canada, and thus the principal chains of the Continent will be included in five groups. We find the northern portion of the first group to be composed of three principal and nearly parallel ranges:—the Rocky Mountains proper, the Bitter Root Mountains, and the Cœur d'Alene Mountains. The last two ranges are intersected by the head waters of the Columbia River, but they are very properly referred to this group. The Bitter Root range extends from about lat. 46 deg. to Clark's fork of the Columbia, and is prolonged beyond it to the eastern side of Flatbow Lake, where it is known by another name. A parallel chain, or possibly a portion of the same, is called the Kootanie Mountains. The Bitter Root range is considered more lofty and rugged than the Rocky Mountains, with which it is joined by the dividing ridges between the Bitter Root River and the Jefferson fork of the Missouri. The Salmon River Mountains, further south, may be regarded as connected with these ranges. The Rocky Mountains proper extend in our territories from the boundary in a direction S. 20 deg. E., 260 miles to lat. 46 deg., where they curve to the south-west and unite with the Bitter Root range. From this point south there is but one range, of which, however, very little is known, until it unites with the Wind River Mountains, which extend S. 40 deg. E. for about 170 miles to the depression known as the South Pass. In this range we have the highest point in the group (Fremont's Peak) 13,570 feet in altitude. From the end of this range to the next there is a wide interval without any mountains. The country is a table-land or gently rolling prairie, 7500 feet above the ocean. About 140 miles S.E. we find the ranges again in parallel ridges, trending southerly, and inclosing wide rectangular valleys known as the Parks. The first, Medicine Bow range, is nearly coincident in direction with the Wind River Mountains, and is separated from a parallel range by the head waters of the Platte. These mountains, south of the Medicine Bow range, display on the maps a singular rectangular intersection of the ridges, arising partly from errors of drawing. These mountains are known as the Park Mountains, and extend south to the sources of the Arkansas River. Some of the highest points of the group are here, such as Pike's and Long's Peaks. The long ridge usually represented between Fort Laramie and Fort Union, called Black Hills, does not exist, as recently determined by Lieutenant G. K. Warren. The great central chain in the territory of the United States is about 1400 miles in length, consisting principally of ranges running about N.N.W. and S.S.E.

Mr Blake remarked that the great range of the Sierra Nevada was not one continuous ridge or snowy crest, as is generally supposed. It is formed of many nearly parallel ranges, which inclose elevated valleys, precisely as in the Great Basin. The northern part of the Sierra is flattened down into a broad table-land. This plateau, in the vicinity of the Madelin Pass, has an elevation of about 5000 feet, and a width of some twenty miles; it is walled in by ridges on each side, rising from 500 to 3000 feet higher. This plateau is broken by short ranges; but it extends northward into Oregon, to the numerous small lakes about Lake Albert. A chain of lakes, in fact, occupies the lower portions of the plateaux for the whole length of the chain, and shows the great amount of precipitation on the summits. The passes through these mountains generally turn the points of the isolated ridges, or cross them at their lowest point. In passing southward along the crest, the elevation of these mountains increases, as shown by the observations of those who have searched for a location for a waggon-road. Thus Fremont's or Carson's Pass, traversed by Fremont in 1844, is nearly 8000 feet high, and one from Sonora, across to the basin, is 10,033 feet in height. Further south the chain trends to the west, and its altitude decreases, preserving, however, its broken character. Here were high valleys wooded with oaks and covered with grass. This plateau is about 3500 feet high, and the passes from 4000 to 5300.

In the Great Basin mountains, the principal range is known as the Wahsatch Mountains, which form the eastern rim. Between this and the Sierra Nevada there is a constant succession of ridges, which are short and much broken, arranged in parallel lines, and generally trending north and south. The general surface of the Basin has an average elevation of 4500 feet, and these ranges rise from 1500 to 3000 feet higher. Midway between the Lake and the Sierra, swells up the Humboldt Mountains, reaching an altitude of 9000 or 10,000 feet, the summit of the principal pass being 6579 feet high. He proposed to call the grand central chain, extending from the Andes to the Arctic Ocean, the Anahuacian chain, since it might be said to commence in the south, where it formed nearly the whole of the table-land of Mexico, or Anahuac. The second chain, traversing the two Californias, and including its northern prolongations, the Cascade ranges, he thought a more appropriate name could not be found for than the Californian chain. For the third group he suggested the general appellation of the

Aztecian chains, or Great Basin chains. These names harmonized with the elegant general title of Appalachian, proposed for the Alleghanies and their extensions by the Messrs Rogers. a name which had now passed into general use. The two great chains were each about 1500 miles long in the United States territory. The Californian chain extended along the peninsula 800 miles further south, and the Anahuacian became the table-land of Mexico. The greatest breadth of surface covered by these chains was along the parallel of 40 deg. from the meridian of 105 deg. 30 min. to 124 deg., or about 1200 miles. This, however, includes the elevated table-land at the sources of the Colorado. The breadth diminished both toward the north and the south. Comparing these two chains, we were struck by their general and close parallelism throughout, even the irregularities of one chain finding their counterparts in the other. The parallelism of the coast-line with the mountains was also interesting, the coast-line being formed principally by erosion, and not, as our Atlantic sea-board is, by deposition. One of the most important characteristics of these chains was the great number of ridges of which they consisted. These ridges were not ranged exactly side by side; they generally overlapped each other. This distribution *en échélon* was not a new feature; it was found in the Appalachians, and was one of the results of the earth's contraction, which, according to the theory so ably sustained in this country by Professor Dana, was the cause of the great plications of the crust. This overlapping was very well shown in the Coast Mountains of California, where the ranges reached the coast successively from the south northward. The Bay of Monterey is included between the end of the projection of one ridge into the ocean at Point Pinos, and the side of another which ends much further north. This parallelism and overlapping of the ridges, as in the Appalachians, show that forces similar to those which formed the Appalachian chain have been here exerted on a much grander scale. Instead of one chain we have several, each rivalling the Alleghanies in extent and altitude. The folding of the rocks is not only inferred from the topography of the ranges, it has been found in the Sierra Nevada and Coast Mountains of the Californian chain, as well as in the chains of the Great Basin. We cannot contemplate the peculiar relations of the principal chains, as exhibited in the map, without recognising the result of the action of two opposing forces. If we conceive the principal lines of flexure to be meridional, north and south, the folding may be referred to a force of contraction, acting in east and west lines, and this may be termed the equatorial contraction. The trends of the ranges show also the action of force in another direction, or from north to south; a polar contraction, to which the sudden bends in the long chains of mountain may be referred. These bends are found in the Sierra Nevada, east of the Bay of San Francisco, in its southern portion, where it curves gradually round to the south-west; and in the Bernardino Sierra trending at nearly right angles to the Sierra Nevada. Parallel deflections are found in the Anahuacian chain in the Wind River range, and again they are seen in the Wahsatch range of the Aztecian chains. Thus all the long chains are bent, as if by compression, upon the ends; and the action of a force exerted at right angles to the force which has produced the prevailing meridional folding is clearly shown. It is most probable that this force has acted in north and south lines, and we may term it the *polar force* or contraction. The overlapping of the ridges and ranges is another evidence of this polar contraction; for we see that it is nothing more, to speak in general terms, than the sliding of portions of the range upon themselves—at least the appearance presented is the same, although there is perhaps no actual break. We may also refer the great north-west and north-east trends to the interference of this polar force or resistance,—either producing the same result with the equatorial contraction,—the diagonal trends being the resultants of the two forces.

The Proceedings of the Royal, Royal Physical, and Botanical Societies are unavoidably postponed for want of space.

SCIENTIFIC INTELLIGENCE.

ZOOLOGY.

Die Schmetterlinge des Südwestlichen Deutschlands. Von G. Koch. 8vo. Cassel. 1856.—One volume, written entirely in German, and apparently a useful work for the local entomologist.

Die Mikroskopische Zouna des Septarienthones. Von Hermsdorf bei Berlin. Von Dr J. G. Bornemann. 8vo. Berlin. 1856.—The text entirely in German, illustrated by ten beautifully-executed plates.

Mr Yarrell's Collections.—Mr Yarrell's ichthyological collections have been purchased in one lot, by Dr Gray, for the British Museum, for L.126, the New Museum at Oxford being the other bidder for it. This collection contains the type species of the History of British Fishes and those described in Mr Yarrell's papers; and it is of importance that they have been placed in the national collection, and will thus become accessible to those who may wish to compare and consult them.

American Oology.—"We have in the press the first part of Dr Brewer's great work on *American Oology*. It will include the rapacious birds, and perhaps the swallows. There will be five quarto plates to this part; all the figures taken in photograph, from the original eggs, and printed in colours. The result is extremely beautiful and accurate."—(*Letter from Dr Baird, Smithsonian Institute, Washington.*)

Viviparity and Oviparity.—At the American Association (Albany) meeting, Professor Agassiz made a communication on viviparity and oviparity, " on which his researches in embryology have thrown great light. At one time it was believed that those animals which brought forth their young alive had peculiarities which indicated exclusive relationship. The progress of embryology had proved that there was no such relationship, and no radical difference between viviparous and oviparous animals. In the family of snakes there were viviparous and oviparous genera. The vipers brought forth their young alive, but they were not on that account like quadrupeds. Among quadrupeds, too, the marsupials, when first born, were carried about by the mother, attached to the nipple, until they were capable of being again born, and, as it were, standing on their own legs. Placental connection between mother and young was of not much consequence. Sharks showed that; some being oviparous, others viviparous, with or without placental connection. Yet the mode of development in all was precisely the same, and was a shark development. There was a nothing in it which was allied to that of birds. This had a decided influence on classification. There was no reason for separating the marsupials from other mammals. In each group and different class the relation between the modes of development indicated the real relations of the animals. Animals which were developed in the same manner were sure to be found in the end to belong to the same general division. He maintained that the distinctions founded on complications of structure must be given up for general classification, and confined to the minor distinctions.

BOTANY.

On the Law of Phyllotaxis.—The following is an abstract of a paper on the above subject, read at the last meeting of the American Association, by Dr T. C. Hilgard :—The author endeavours to construct a theory of the cause of Phyllotaxis or arrangement of leaves. Hitherto, Phyllotaxis has only been studied in its mathematical relations, and in its analogy to cosmical or to zoological order. It had been shown that leaves not opposite are arranged about a stem always in either two, three, five, eight, or thirteen rows, and that if the bases of the leaves taken in their order of height on the stem be connected by a thread winding round the stem, then between any two successive leaves in a row, the thread winds round the stem once if the leaves are in two or three rows ; twice, if in five rows ; three times, if in eight ; five, if in thirteen, &c. In other words, two successive leaves on the thread will be at such a distance, that if there are two rows, the second leaf will be half way round the stem ; if three rows, the second leaf will be one-third of the way round ; if five, the second will be two-fifths of the way round ; if eight, three-eighths ; if thirteen, five-thirteenths, &c. But the question of Dr Hilgard is, why is this so ? What is the organic law of development that produces this result? If we cannot anwer this question, can we not, at all events, throw some light upon it, or give some hint towards its solution ? If we take a flower-stalk of the common plantain (*Plantago major*) between the thumb and fingers, we can, by twisting the stalk in one direction or the other, arrange its buds in any number of rows that the law of Phllyotaxis permits, two, three, five, eight, &c. As we can thus pass from a higher to a lower number, or from a lower to a higher, at pleasure, by simply twisting the stalk, that is, by introducing a constant disturbance at every point of the stalk, it is plain that the mathematicians will allow the organic law to be founded either upon a very high number of rows, which, by a constant interference, is reduced to smaller numbers, or upon a low number, which is modified into higher ones. The former had been the view of Professor Pierce, in his paper presented to the Cambridge meeting in the United States, viz., that the organic law of vegetable growth contained, as a fundamental constant, the surd towards which the series $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, &c., approximates ; and that interferences with it, constant, or nearly so, in each botanical species, produced the approximations. Dr Hilgard, on the contrary, seeks for the germ of the law of Phyllotaxis in the numerical genesis of cells. Starting with a primal cell generating a second, and assuming that the second requires a time to come to maturity, during which the primal cell recovers its powers and produces a third, we have a law which gives the Phyllotaxian numbers. *One* cell generates a *second*, and then a *third*. The first and second then simultaneously generate each one, which makes the whole number *five*. The first, second, and third are then mature enough to generate each one, which make the whole number *eight*. Five are then sufficiently mature to generate each one cell, which raises the whole number to *thirteen*. Here, then, is a simple mode of conceiving of the genesis of cells, which gives us at once the numbers that occur in Phyllotaxis, and no others. But, we need also the geometrical element, the position as well as the number of the leaves; and if we can obtain it from this same conception of numerical genesis it will be a strong confirmation of the theory, that this lies at the foundation of this organic law. Now, if we take a rosette of the houseleek, for example, and number the leaves of the whorl in Phyllotaxian order, we shall find the successive numbers actually placed in juxtaposition to those which in our law of cell genesis would be their parents; that is, 4 and 5 will be placed at the base of 1 and 2; 6, 7, and 8 at the base of 1, 2, and 3, &c. This conception of numerical genesis fulfils, therefore, the geometrical conditions required, and thus asserts its claim to a fundamental position in any theory of the organic law of vegetable growth.—(*Wells' Annual of Scientific Discovery.*)

Reproduction of Spheroplea Annuline.—Cohn says, that the grains of chlorophyll in this plant unite together and form groups nearly equidistant; around them a mass of endochrome collects, then the cell of the plant divides by partitions into distinct compartments, each containing one of these groups, which assumes a star-like appearance. The compartments then become filled with utricles of different sizes and forms, the chlorophyll disappearing more or less completely. Finally, openings take place in the membrane of the common cell containing the utricles. The utricles or cellules become filled with chlorophyll, but in their early state they have no proper membranous envelope. In this state they are primordial spores fit for fecundation. Spermatozoids enter by the openings in the mother cell, and move rapidly about. Fecundation is effected, and after this the spores become covered with a proper integument. The chlorophyll in the fecundated spores becomes first orange, and then red. The green filaments of the male cells assume a reddish tint, and this substance is resolved into spermatozoids. These are detached from the mucilage which envelopes them, and move rapidly round the large vacuoles in the mother cell. The spermatozoids finally issue by openings from the large mother cell.

On the Reproduction of Œdogonium.—Pringsheim has examined the reproductive process in two genera of minute algæ, Œdogonium and Bulbochæte. The greater part of the cells of Œdogonium contain each a zoospore, provided anteriorly with a complete crown of cilia. This body (the zoospore) is produced without sexual intercourse. It germinates, and gives rise to a new plant in the same way as the bud does. Between the common cells of the plant occur other utricles, usually more swollen, either isolated or in groups. In these are formed motionless spores, which are the female sexual organs. In the individuals which produce these female cells, as well as in others which have no such cells, there occur a third kind of cell, shorter than the common cell of the plant, and forming irregular groups. This third kind gives birth to spermatozoids, either at once or after the appearance of an intermediate production of a special nature, which becomes detached from the primordial filament, and contains the male sexual apparatus.

In *Œdogonium ciliatum*, a small species found attached to the leaves of aquatic mosses, the cells containing the male organs are found towards the anterior extremity of the filament, between the setiform terminal cells and the upper female organ. In each of these cellules there is formed at the expence of the contained plastic material a single small zoospore-like body called *microgonidium*. This, according to Pringsheim, is the antecedent or generator of the male organs, and he calls it an *androspore*. These androspores, furnished with a circle of cilia at their anterior and transparent parts after quitting their mother cells, move about at first, and then become fixed, in a determinate manner in each species, either to the female organ itself or in its neighbourhood. Pringsheim has seen in *Œdogonium ciliatum* several androspores fix themselves on the surface of the female organ. The female organ continues to be developed, while each androspore becomes a sort of compound cellular plant. In one part of it, the spermatozoids are formed; this part may be called the proper antheridium.

The fixed androspore acts like a mother cell. The antheridium, properly so called, represents the secondary utricle produced at the upper part of the androspore, and the stalk of the antheridium is formed by the secondary inferior utricle. The antheridium bears at its summit a small lid, formed from the upper part of the membrane of the androspore. The antheridium, at first unicellular divides into two cells, which become the mother-cells of the spermatozoids. The whole plastic contents of each mother-cell are employed in the formation of a single spermatozoid of considerable size. When the spermatozoids are mature, then the upper spermatozoid raises slightly the lid of the antheridium. In the meantime, the female organ is going through a process of development. When its contents are mature, the membrane of the female organ is ruptured all at once a little below its summit, the upper part (forming a sort of lid) and the filament which surmounts it, are turned to the side by the swelling of the plastic contents. There is thus a space in one side between the lid and the lower part of the female organ; then the mucous and colourless portion of the endochrome protrudes from the aperture, and its colourless cellular membrane presents a distinct lateral opening, turned towards the antheridium. When the female organ has undergone these and further changes in its contents, the lid of the antheridium is completely detached, and allows the upper cuneiform ciliated spermatozoon to escape. This spermatozoon, after moving around the female organ for some time, enters the opening, reaches the female globule which is to be fertilized, and seems to be absorbed in its substance; after this the female globular body becomes more and more definite, and finally becomes surrounded by a double membrane.

Biography.—Jules Thurmann was born at Neuf-Brisack (Haut-Rhin) on 5th November 1804. His father died 15 months after his birth, and his mother returned to her native city. Porrentrui, with her son, who passed his early period of study there. He afterwards went to Strasburg and remained there four years, prosecuting chiefly the study of mathematics and of law, and receiving the degree of Bachelor of Letters. He subsequently studied in the Ecole des Mines at Pau. He afterwards returned to Switzerland, and studied for 18 months at Constance. Here he devoted his leisure hours to botany and geology.

In 1830 he returned to Porrentrui, and continued to prosecute his geological researches. In 1831 he took an active part in the organization of the geological portion of the Museum at Strasburg, and in 1832 published in the Memoirs of the Nat. Hist. Soc. of that city, his first paper, *Sur les soulèvement Jurassiques.* In 1832, he became a member of the administration of the College of Porrentrui. He made many improvements in the College, instituted a mineralogical collection, and became Professor of Mathematics and of Natural Science. He was one of the founders of the Statistical Society of the Jura district. He prosecuted his geological researches in the Jura Mountains, and brought his theory as to their elevation under the notice of the Scientific Association, which met at Stuttgart and Soleure in 1834 and 1836. He was now nominated director of the Normal School of Jura, was elected a member of the Geological Society of France, and presided at the meeting of that Society held at Porrentrui in 1838. In 1843 he resigned the direction of the Jura School and retired into private life, with the view of prosecuting his scientific researches.

He published several scientific papers in the Memoirs of Societies; such as an account of the Vascular Plants of Porrentrui,—Observations on periodical Phenomena in the Bernese Jura, &c. His great work, however, was his "Essai de Phytostatique Appliqué à la Chaine de Jura," or the Influence of the subjacent rocks on the dispersion of Vascular Plants. In 1853 he brought this subject under the notice of the Helvetic Society of Sciences which met at Porrentrui, under his presidency. He continued his geologico-botanical researches to the close of his life. He was preparing to take an active part in the meeting of the Helvetic Society at Chau-de-fonde, when he was attacked by cholera, which cut him off, 24th July 1855,*

Botanical News.—It is expected that the French government will purchase the Herbarium and M.SS. of Jussieu. The Herbarium is extensive and contains interesting notes by Jussieu, as well as by Lamarck, Poiret, and others. The M.SS. are valuable. They embrace among other things the journal of Gundelkheime, the companion of Tournefort; the MS. of Tournefort on the Flora of Paris, many papers by the elder Jussieu, and his correspondence with Linnæus, &c.

M. Alphonse de Candolle is now printing the Memoir of M. Meisner on the Thymelæaceæ for his Prodromus.

M. Cosson is continuing to publish his Flora of Algeria, and is about to take a fourth botanical trip into that country. He proposes to examine the numerous oases of the so-called Desert of Sahara. On the mountains of Atlas at each journey species have been discovered which were supposed to be peculiar to Egypt or Arabia.

The expedition of Mr Richard to Higher Egypt has not as yet afforded good results.

Preservation of Timber.—The Permanent Way Company, 26 Great George Street, Westminster, are employing with success Dr Boucherie's method of preserving timber. Solutions of preservative substances are introduced by the patent process into various kinds of timber, in such a way as to expel the fermentescible sap, and substitute matter less liable to undergo destructive changes. It has been found that sulphate of copper, dissolved in the proportion of at least $2\frac{1}{4}$ lbs. to 22 gallons of water, is the best preservative. It is said that white pine thus impregnated with sulphate of copper, placed in the ground as railway sleepers, or exposed to the action of the air, lasts longer than oak unprepared placed in the same situations. The Directors of the Chemin de Fer du Nord state, that Dr Boucherie's process has produced most satisfactory results as regards sleepers when completely prepared. Those in use since 1846 were as good in 1855 as when laid down. The sleepers are Beech, Hornbeam, Birch, and Pine. The posts for the telegraphic wires prepared by this process, have also shown great durability. The process thus appears to impart durability to woods which are cheap and abundant.—(*Reports on Boucherie's Patent; Permanent Way Company.*)

CHEMISTRY.

On the Composition of the Phosphate of Lime found in Waters naturally.—The following is a brief abstract of the results obtained by Dr A. A. Hayes in his experiments on the subject.

Where bones immersed in water, either pure or saline, are exposed to the temperature of 80° F., a fermentative decomposition of the tissues of the bones commences and continues for some time. The gases evolved are mixed with the acids and ethers usually produced in the decomposition of muscle, and the sulphur compounds are also present, air being freely

* Actes de la Société Helvetique des Sciences Naturelles, 1855.

admitted. The fat-cells of the tissues become broken, fats and oils are separated, while a superficial breaking-up of the structure of the bone occurs; translucent bones, like fish bones, become more opaque, and an evident chemical change of composition advances.

The water becomes grayish in colour from suspended matter, and contains the whole series of acids known to attend organic decomposition in presence of azotized compounds, but most remarkably, it is *alkaline* in its action on test papers. At a certain stage of the action, *no ammonia is present as a base.* The fluid either frompure water, or saline, or sea-water, will bear heating to 200° F., and a coagulation of albuminous compounds ensues, *the fluid remaining alkaline.*

Tested for bone phosphate of lime, this salt is found to be present in the same proportion as we find dissolved from recent bone by warm water digestion, and without further examination the case might be passed as one of simple solution of bone phosphate in a gelatinous solvent.

If an excess of ammonia be used to separate the bone phosphate dissolved, and a moderate heat, or even boiling, be resorted to, the whole of the bone phosphate can be separated, leaving a clear fluid, which, thus deprived of most of its organic matter, readily passes the filter.

On adding to this filtered solution an ammoniacal solution of lime, an instant abundant precipitation of a hydrated salt takes place to such an extent that the whole fluid becomes a jelly in consistency. This salt is principally bone phosphate of lime, crenate of lime being present, besides other organic salts of lime.

The *phosphoric acid* thus separated from the bone in putrefaction, leaves the lime base in the presence of arsenic and other organic acids, for the carbonic acid to unite with and form carbonate of lime, at the same moment *phosphoric acid dissolves in the fluid without preventing an alkaline re-action.*

Recently prepared bone phosphate of lime can be decomposed by a current of carbonic acid in pure water; the bicarbonate of lime separates partly as carbonate and partly remains in solution. Ammonia causes bone phosphate to fall, but the filtrate contains much phosphoric acid, which is uncombined with an earthy base.

The fluid which dissolves phosphoric acid from the bone, also holds a small quantity of bicarbonate of lime in solution, but the alkaline action is not wholly due to the presence of this compound. It appears that a portion of protein or other animal organic base holds the phosphoric acid engaged at the moment of its separation.

In two cases of poisoning by phosphorus, which were chemically examined by Dr Hayes, the contents of the stomach, and even the parts of the tissues, altered by the phosphorus were strongly alkaline. Both cases afforded a compound in which the phosphorus as phosphoric acid was in union with organic matter.

This elimination of phosphoric acid in the progress of putrefactive fermentation, explains, as had been done, the formation of rock guano. It shows us how readily bones give to sea water and other waters their phosphoric acid. In connection with physiology, the experiments show that phosphoric acid may exist in the tissues, although the compound be alkaline or neutral, and that a phosphate may pass away or be so placed without the disturbance which might have been expected.

Wohler has more recently shown the solubility of bones in water, but it is possible the beautiful decomposition here described may have escaped his attention.—(*Wells' Annual of Scientific Discovery.*)

Tests of Strychnine and Brucine.—Extract Letter from Dr Traill to Professor Balfour.—Among your articles of intelligence you may add, as a sequel to my remarks on *strychnine*, what was unfortunately omitted in that communication, that *brucine*, the alkaloid most nearly allied to strychnine, is easily distinguished, by the test of chloride of gold added to the acetates of both. With that test strychnine gives a copious, rich, gamboge-yellow precipitate; but with brucine there is no precipitate whatever, and the mixture assumes a deep reddish-violet colour.

The most delicate test, however, of strychnine is Dr Marshall Hall's, the limbs of a frog, which are thrown into violent convulsions by the smallest atom of strychnine.

A New Gun Cotton.—A correspondent of the American Journal of Pharmacy (Mr Caldwell) describes a new kind of gun cotton, which is made as follows:—Newly prepared gun cotton is placed in a saturated solution of chlorate of potash, and allowed to remain for fifteen minutes. It is then gently pressed between folds of clean linen rag, and dried over a heat of 150 degrees. The cotton thus prepared explodes much quicker, and more like fulminating silver, than the ordinary gun cotton. From some experimental shots the result was as follows:—A pistol loaded with nine grains by weight, of the ordinary cotton, sent a ball about half through a yellow pine door one inch thick, at the distance of twenty feet. It was then fired with two grains of the cotton, treated with chlorate of potash, when the pistol was shattered to pieces. Another pistol was loaded with one grain of the cotton, when the ball passed entirely through the door, making a perfectly smooth perforation.

GEOLOGY.

Kidderminster Deposits.—We have received information from the President of the Malvern Natural History Field Club (Rev. W. S. Symonds), that the equivalents of the Caithness, Lesmahagow, Kington, and Ludlow tile stones, or transition beds between the Ludlow and Old Red Sandstone deposits, have been lately discovered by Mr G. E. Roberts, of Kidderminster, three miles north of that town. The organic remains are most abundant. The Pterygotus and Eurypterus are found in the same bed with *Cephalaspis Lyellii*, and are associated with beautiful specimens of molluscan or crustacean spawn, probably the latter. Terrestrial plants, apparently allied to Equisetum, are imbedded with the fossil seed-vessels of Lycopodiaceæ, determined by Dr Hooker from the bone bed of Ludlow, with many other fossils yet to be described. The persistence of this bed throughout so large an area is very extraordinary.

Generalities of the Geology of Northern California and Oregon.—At the Albany meeting of the American Association, Dr Newberry gave a general view of the geology of Oregon and that part of California lying north of San Francisco, and of the age and structure of the three ranges of mountains which, he said, gave character to the topography of the Far West, and of the valleys which lie between them. These "valleys," he said, were rather plains or plateaux than valleys. The Sacramento Valley was a plain lying between the Coast Range and Sierra Nevada—for the most part destitute of trees—through which the river ran with tortuous course, like a brook in a meadow. In the lower part of the Sacramento Valley there were no rocks older than tertiary: but at the head of the valley he had found the carboniferous limestone, clearly marked by its characteristic basalts, on which were lying the cretaceous and tertiary strata, precisely as on the Upper Missouri.

Crossing the volcanic spur of the Sierra Nevada connecting Mount Shasta with that great chain of mountains, he had descended into the Klamath Basin, which he said formed an appendage to the great basin of the Salt Lake, and was a plain somewhat cut by subordinate ranges of mountains, lying at a considerable elevation, and containing a large number of lakes, of which the Klamath were the most important. This basin was drained through the canons of Pit river, the largest tributary of the Sacramento, which, like the Klamath river, had forced its way through the mountain ranges which lay between the basin and the sea; Pit River flowing through an impassable canon nearly an hundred miles in length. The Klamath basin was once to a much greater extent covered by water than now; and, before it was so perfectly drained as now, its waters deposited a variety of strata, some of which were as white and fine as chalk, though having a very different composition.

He said further, that the basin or plateau of the Des Chutes was not separated by any barrier from that of the Klamath lakes, and exhibited all its peculiar features still more strongly marked. The Des Chutes basin was a plateau lying between the Cascades and the Blue Mountains, and, with the Klamath basin, belonged, from its topography, geology, fauna, flora, and climate, to the great central basin. Like the Klamath basin it was once covered with water—was a lake drained by the Columbia, as now, but not so perfectly drained. The Columbia had been gradually deepening its bed. The Des Chutes lake, as it then was, had deposited sediments to the depth of 2000 feet or more, for the streams which now traverse it have cut canons in this plateau to that depth. These sediments were covered by a floor of trap, which had been poured evenly over the whole surface—which had not been subsequently disturbed, and when broken open, exhibited a columnar structure—the columns being quite perpendicular, and sometimes one hundred feet in height. Below the trap was a series of strata exhibiting all possible varieties of volcanic tufa, some very fine and chalky, others coarser; and the different layers, which were from two to ten feet in thickness, and perfectly parallel, were coloured with all the hues of the rainbow—red, green, yellow, blue, orange, pink, white, &c., and as highly coloured as a geological chart for a lecture-room. It had often happened to him, travelling over this plateau, to come suddenly and without any warning to the brink of one of these canons two thousand feet deep, at the bottom of which a stream was flowing.

The Cascade Mountains, he said, were not a simple chain, but a broad belt of mountain peaks, sometimes fifty miles or more in width, many of the summits being covered with perpetual snow, the passes being generally about 7000 feet in height. He had found extensive proofs of the existence, at a former period, of glaciers capping the Cascade range, and extending far below the present limit of perpetual snow. The Cascade range was eminently volcanic, abounding in craters, lava fields, and congealed lava streams, all as fresh and ragged as though just poured out from some volcano; indeed, Mount Hood and Mount St Helens may still be considered as active volcanoes, giving off gases and steam continually, and within a a few years have emitted showers of ashes.

Professor Newberry's theory of the excavation and filling of the valleys of California and Oregon was, that at one time, probably at a period corresponding with that of the drift in the Eastern States, all that portion of the continent was raised to such an altitude as to produce a degree of cold which covered the mountains and filled the valleys with ice. By this ice the surfaces of rocks were worn down, and the marks of glacial action which now abound produced. The valleys were excavated in part by this process. As the continent was depressed the valleys were occupied by water, in which the ashes from ranges of active volcanoes were discharged, and arranged in strata of sediment.—(*Wells' Annual.*)

On the Discovery of Volcanic Cinders at the bottom of the Atlantic.—The specimens from the bottom of the Atlantic obtained by the U. S. steamer Arctic, in her recent deep-sea sounding expedition, between the coasts of Newfoundland and Ireland, having been submitted to microscopical examination by Professor Bailey of West Point, show evidence of the existence of a volcanic deposit on certain portions of the ocean-bed. In reference to these Professor Bailey says :—The occurrence of what appear to be volcanic products in the bed of the ocean for a distance of about twenty-two degrees of longitude, or about 1000 miles, is an extraordinary fact, and one which deserves careful scrutiny. That any one familiar with the microscopic appearance of volcanic ashes, &c., would pronounce these matters to be of volcanic origin I have no doubt. These volcanic products consists of pumice, obsidian, crystals of horneblende—single and in groups—and other igneous products penetrated by crystals. As, however, the ingenious suggestion was made to me that these igneous products might be derived from the fires of the ocean steamers, along or near whose pathway these soundings were made, it became important that these furnace products should also be studied. An examination was accordingly made of specimens of such matters as are thrown overboard from the ashpits of the steamers Asia and Baltic. Careful examination of the specimens showed that they contained a group of products which could not possibly be confounded with the supposed volcanic matters. In fact, there was no relation between the two classes of bodies, except that both were evidently the results of intense heat upon different mineral matters. Among the furnace products of the steamer Baltic were numerous single and aggregated glass spheres of minute, or even microscopic size, which, if they should ever be found in the ocean soundings, would be very puzzling without this clue to their origin. The question of the original source of these volcanic products is one of great interest. How far these plutonic tallies may have travelled, and in what direction—whether from the Azores, the Mediterranean, or from Iceland—involves a study of currents and an examination of soundings which have yet to be made.—(*Wells' Annual.*)

Deep-Sea Soundings in the Arctic Ocean.—From a recent report of Lieutenant Maury to the Secretary of the Navy, we derive the following extract relative to some observations made last year by Commodore Rodgers, in the U. S. ship Vincennes, on the temperature and specific gravity of the water at the surface, midway, and at the bottom of the Arctic Ocean. These observations are highly interesting. He passed up through Behring's Straits into that sea during the summer of 1855, and, though he remained in it but a few days, he availed himself of the opportunity to try the temperature and specific gravity of the water at various depths and places; and his observations show uniformly this arrangement or stratification in the fluid mass of that ocean—warm and light water on top, cold water in the middle, and warm and heavy water at the bottom. These observations, if extended, would go far towards the final settlement of the question of an open sea in the Arctic Ocean. It is likely that this warm water went in as an under current; that though warmer it was salter, and for that reason it was heavier. It was made salter, we conjecture, by evaporation ; and while it was subjected to this process it was in some latitude where it received heat while it was giving off fresh water vapour. This substratum of heavy water was therefore probably within the tropics and at the surface when it received its warmth. Water. we know, is transported to great distances by the under currents, of the sea without changing its temperature, but a few degrees by the way. Beneath the Gulf Stream, near the tropic of Cancer, and in the month of August, with the surface of the ocean above 80 degrees, the deep-sea thermometer of the Coast Survey reports a current of cold water only 3 degrees above the freezing point. That cold current, or the water that it bore, must certainly have come from the Polar regions.

We know of numerous currents flowing out of the Polar basin, and discharging immense volumes of water into the Atlantic ; we know of but oue surface current, and that a feeble one, around the North Cape, that goes into this basin. All these out-coming currents are salt-water currents; therefore we cannot look for their genesis to the rivers of hyperborean America, Europe, and Asia, and the precipitation of the Polar basin—for all the water from these sources is fresh water. The salt that these upper currents bring out is sea-salt; hence we should be forced to conclude, were there no other evidence to warrant the conclusion, that there must be one or more under-currents of salt and heavy water flowing iuto the Arctic basin. A considerable body of water at the temperature of 40 degrees rising to the surface there—as come to the surface it must, in order to supply the out-going upper currents—would tend mightily to mitigate the severe cold of those hyperborean regions.

This discovery of Rodgers furnishes the only link that seems to have been wanting in the chain of reasoning to complete from known facts the theory of an open water in the Arctic ocean; and this discovery, taken in connection with what northern voyagers tell us concerning the migration of animals in those regions; with what Dr Kane saw and De Haven says; with the fact that harpoons fastened in whales on the shores of Greenland have been taken out of whales along the shores of Kamtschatka and Japan—these facts, taken in connection with the discovery which my own researches have fully developed, that the right whale of Greenland and the right whale of the North Pacific are the same fish, and that to it the torrid zone is as a sea of flame which it cannot pass; I say these facts, linked together, and taken in connection with other facts and circumstances, seem to form a chain of faultless circumstantial evidence, showing the existence of an open water in the Polar basin.—(*Wells' Annual.*)

On the Gulf Stream and its Deposits.—When the stream, in sweeping round the point of Florida, had parted with so much of its sediment as to bring the bottom within 60 or 70 feet of the surface, it became possible for the coral to exist, provided it could find water of sufficient purity. This would be the case at any point so far from the shore as to be beyond the influence of the surf's disturbance of the mud deposited along the coast. As the bottom formed by a deposit is necessarily situated on a slope, the coral would find a line parallel to the shore, along which none of the conditions of its existence would be wanting. This line would be that of a reef. Did not the island of Cuba interpose, this extension of Florida might go on indefinitely; but as the passage narrows, the force of the current necessarily increases, and there is therefore no hope that in this manner Cuba will be annexed. The laws regulating the deposition of sediment also afford an explanation of the long parallel ridges on the sea-bottom of the coast of South Carolina, in the bed of the Gulf Stream. Suppose that two or three submerged peaks, in the line of the Bahama Islands, stand within the stream. Behind these peaks there must be still waters, or at least an eddy. Here matter will be deposited by the waters, and this will in turn offer an obstacle which will continue to cause the effect further and further away from the original point. Again, while the Gulf Stream is moving in a curve around the point of Florida, nearly all its deposits will be made on the river side of the curve, that is upon this point; but after passing into the open sea, it takes a straight course and begins to deposit on both sides alike. Hence, by this theory, the origin of the Bahama Banks. Another very curious result of all this reasoning remains to be mentioned. As the limits of a channel narrow, the current necessarily increases its velocity. The heat of a warm current is therefore retained to a far greater distance from the point of departure. It is well known that the Gulf Stream affects favourably the climate of the north-western portions of Europe. There is nothing then absurd in the idea that during the decrease of the breadth of the Gulf Stream between Cuba and the main land opposite, a decrease of hundreds of miles, the temperature of the water carried across the ocean to the coasts of Ireland, Scotland, and Norway, has been constantly rising, and that from this cause an increasing amelioration of the climate of that part of the eastern continent has resulted.

MISCELLANEOUS.

Present Annual Production of Iron.—Mr Hewitt of New York, in a paper recently presented to the Geographical and Statistical Society, furnished the following memoranda respecting the production and manufacture of iron. Cast iron can only be traced back to the 13th century. Previously, the ore and charcoal were placed in alternate layers in a rude oven, and there smelted by a blast injected by a bellows worked by hand. Even so late as 1740 the total annual product of England was but 17,350 tons, made by 59 furnaces, at the rate of 294 tons per annum to each furnace—say one ton per furnace for each working day. Mr Hewitt estimates the entire annual product of Europe at that time at 100,000 tons, 60.000 of which were made in Sweden and Russia, and one-half of this quantity exported to England. The total consumption of iron in England at that day (only 116 years ago, or since the birth of some persons yet living) was not 15 pounds per head per annum, and that of all Europe but *two* pounds per head. The whole human race did not then annually require or produce so much as *one* pound of iron per head. Now Mr Hewitt produces data showing an annual production of *seventeen* pounds per head for the whole human family, or seven millions of tons in the aggregate, of which Great Britain produces rather more than one-half, and consumes at least one-fourth. The total product of 1856 is estimated by Mr Hewitt, from imperfect data, as follows:—

	Tons.		Tons.
Great Britain	3,585,000	United States	1,000,000
France	650,000	Prussia	600,000
Belgium	255,000	Germany (bal. of)	200,000
Russia	300,000	Austria	200,000
Sweden and Norway	179,500	Spain	27,000
Italy and Elba	72,000	Denmark, &c.	20,000
Total	6,889,000 tons.		

Asia, Africa, and America outside of the United States, may possibly raise this aggregate to 7,000,000 tons.

The annual production and consumption of the several countries is estimated as follows:

	Produce per head, lbs.	Consume per head, lbs.
Great Britain	287	144
United States	84	117
Belgium	136	70
France	40	60
Sweden and Norway	92	30
Germany, including Prussia	50	50
Austria	12½	15
Russia	10	10
Switzerland	—	22
Spain	4½	5

The rest of the world too little to be computed.

The intimate relations of iron to industrial progress and efficiency, as exhibited by this table, need here only be suggested.

Height of the Himalayas.—It appears from a late survey made of the Himalaya range, by Colonel Waugh, that the Khanchinjinga, which has been hitherto supposed to be the highest summit, is in fact not so—a higher mountain having been discovered, situated between Katamandoo and Khanchinjinga. This last named is 28,156 feet above the level of the sea; but the new summit reaches the enormous height of 29,002 feet. It has been proposed to call this Mount Everest, after a former surveyor-general of India.

New Form of Telescope.—At the American Association for the Promotion of Science, Mr Alvan Clarke, of Cambridge, gave a description of a new instrument of his own invention, for measuring the distance apart of stars too distant to be brought into the field of view of a telescope. Within a year from the first thought of the instrument entering his mind, he had built a telescope of six inches aperture, and 103 inches focal length, mounted it equatorially, governing its motion by Bond's spring-governor clock, provided the two eye-pieces, and as a substitute for a filar-micrometer, arranged a mode of using pieces of glass ruled with a ruling machine. Experiments have demonstrated the feasibility of using the two eye-pieces in this way, and of obtaining by them very accurate measures of the distances of stars, which are from three to one hundred minutes of space apart. The success of the instrument was, however, greatly due to the spring-governor which keeps each star upon the wire accurately bisected.

Mr Yarrell's Library.—In our last number we had occasion to notice the decease of an old and esteemed friend, William Yarrell. Leaving this world without having any one who would carry out and reciprocate his own pursuits, his comparatively small but peculiar library was disposed of at Stevens' sale-rooms on 13th, 14th, and 15th of November. The number of the whole lots for the three days only amounted to 772, but the sale did not conclude until past 5 on Saturday evening. Many of the books brought high prices. The following are those of a few, which in after days may be a curious record of the value and estimation of some works. Doubtless some were purchased as memorials of an old friend and companion.

Macgillivray's Natural History of Dee-Side and Braemar, privately printed for H.R.H. Prince Albert, £7; Bewick's British Birds, 1st edition, £5, 10s.; Walton and Cotton's Complete Angler, £9, 10s.; Forbes and Henley's British Mollusca, £12; Yarrell's British Birds, 3 vols., copies sold from £4, 4s. to £10, 10s., one copy with "Bewick's cuts" introduced, £21; Alder and Hancock's Monog. Brit. Nud. Moll. (Royal Society), £6; Owen's Odontography, £9, 15; Gould's Birds of Europe £91; Gould's Birds of Australia £79, (bought up by Author, work being out of print).

METEOROLOGY.

To the Editors of the Edinburgh Philosophical Journal.

Gentlemen,—As one of the first fruits of the Meteorological inquiries in which I have been engaged during the past year, I send you the Rainfall at 37 stations over Scotland, arranged so as to exhibit the amount at each station during every month of the year 1856. It is right to mention, that no selection of stations has been made, but that every station is included from which perfect returns were received for the twelve months.

It will be seen from this table that the average fall of rain over Scotland during the year 1856 amounted to a mean depth of 36·96 inches—say 37 inches. This, according to our present knowledge, derived from imperfect and partial data, would seem to be a very large amount; but as we have no returns equally extensive to compare with, we must suspend our judgment on this point.

The fall of rain during September was excessive, particularly on the eastern half of the island, and sufficiently accounts for the greater amount of damage sustained by the crops on that, than on the western side of Scotland.

It is instructive to note, that if we select from this table the most western stations, and compare them with some of the eastern stations, we shall find that the difference between the fall of rain on the eastern and western side of the island was quite immaterial. Thus five selected stations, on or near the west coast, gave a mean depth of 37·78 inches of rain;

while seven stations on or near the east coast gave a mean depth of 37·11 inches of rain. The position of the station in reference to the hills and mountains seems to have much more important bearings on the quantity of rain deposited, than the mere circumstance of the station being on the eastern or western side of the island. Thus at twelve stations, which may be called midland, the mean fall of rain greatly exceeded that of either east or west coast stations, amounting to a mean depth of 44·23 inches.

From directing attention to these facts, it is not intended to be stated that anything like satisfactory conclusions as to the general distribution of rain over the country could be deduced from one year's observations: But as much misconception at present seems to exist relative to the comparative depth of rain which falls on the eastern and western side of the island, and the influence of the hills on the fall at such stations seems to have been somewhat overlooked, it was deemed right to direct attention to the subject, and at the same time publish the table in full, that every one may have it in his power to study the facts, and deduce his own conclusions.—I am, Gentlemen, your most obedient servant,

JAMES STARK, M.D.

FALL OF RAIN AT THIRTY-SEVEN STATIONS IN SCOTLAND, DURING EACH MONTH OF THE YEAR 1856.

1856.	Jan.	Feb.	Mar	Apr.	May	Jun.	July	Aug	Sept	Oct.	Nov.	Dec.	Year.
Sandwick,.........	2·33	2·42	0·34	0·34	0·89	2·36	3·36	1·40	3·18	1·01	4·61	5·17	27·41
Galston	1·20	1·60	0·60	0·20	0·80	4·80	5·70	2·20	2·70	0·40	4·20	6·30	30·70
Stornoway, ...	2·06	3·62	0·17	1·59	0·97	6·13	5·85	2·26	2·40	1·43	3·71	5·50	35·69
Culloden, ...	1·97	2·48	0·12	2·74	2·58	3·13	2·37	1·63	5·14	0·49	1·74	1·66	26·05
Elgin, ...	1·77	1·35	0·27	3·40	1·81	2·89	2·89	1·57	4·31	1·40	3·17	2·14	26·97
Castle Newe......	1·87	2·21	0·22	5·11	3·19	1·92	4·10	2·35	8·91	1·13	6·24	2·56	39·82
Fettercairn	2·80	2·55	0·11	3·70	1·35	1·40	1·40	2·20	3·80	1·00	1·10	1·90	23·31
Strachan	2·89	3·55	0·12	5·40	1·96	2·84	2·74	2·53	6·90	1·33	2·67	2·13	35·06
Barry	4·17	4·03	0·01	3·22	3·84	4·01	2·48	4·21	7·00	1·27	1·34	2·58	38·16
Kettins	3·21	4·28	0·29	3·40	2·62	3·72	2·48	4·60	6·98	1·38	1·91	3·30	38·17
Arbroath	3·03	2·78	0·12	3·09	2·91	3·20	2·12	3·78	5·43	1·53	2·02	2·25	32·26
Perth, ...	1·86	4·08	0·19	2·18	2·63	3·68	1·98	5·08	5·62	1·40	1·04	3·79	33·49
Anstruther	2·22	2·59	0·08	2·20	2·46	3·95	1·86	5·10	3·78	1·53	0·95	3·25	29·97
Alloa...............	2·40	4.85	0·20	1·30	3·07	2·97	2·10	4·20	3·12	1·12	0·70	4·10	30·13
Callton Mor	2·18	4·00	0·10	2·17	2·92	6·50	4·16	3·68	2·57	3·23	2·64	6·68	40·83
Greenock	3·90	6·20	0·80	4·10	4·20	7·30	2·55	4·80	3·15	3·22	2·70	7·65	50·57
Edinburgh	2·29	2·01	0·11	1·56	2·61	3·12	1·81	3·12	4·66	0·55	0·47	2·63	24·94
Glencorse	3·05	2·85	0·10	3·55	3·65	5·15	2·40	4·65	7·45	1·35	1·40	5·20	40·80
Swanston	2·87	2·70	0·09	2·90	4·65	4·30	2·20	4·25	7·10	1·80	1·40	4·50	38·76
Harlaw	2·68	3·10	0·11	3·20	4·12	4·20	2·38	4·41	8·20	1·30	0·90	4·40	39·00
Colzium	3·24	3·94	0·11	2·73	4·21	4·84	3·20	4·76	8·56	1·59	1·21	7·50	45·89
East Linton......	3·00	2·60	0·10	2·50	3·00	4·40	2·10	3·85	6·90	1·00	1·50	4·00	34·95
Thurston	3·80	5·85	0·01	1·20	2·80	5·90	0·80	5·40	7·70	1·20	0·90	1·60	37·16
Yester	2·65	3·70	0·40	2·00	4·65	6·80	1·40	3·35	8·05	2·80	1·90	4·65	42·35
Thirlstane	1·00	1·35	0·50	1·59	3·00	2·68	1·93	4·18	7·20	1·30	0·80	2·65	28·18
Milne Graden ...	0·70	1·30	0·10	2·20	3·60	3·00	2·60	3·00	4·70	0·30	1·10	3·20	25·80
Kirkpatrick	3·20	5·00	0·05	2·75	2·50	4·72	2·40	4·30	3·40	2·55	0·80	8·30	39·97
Dumfries	2·80	2·86	0·94	2·35	2·51	3·51	1·51	4·65	2·43	2·48	1·03	4·04	31·11
Thornhill	3·40	3·70	1·50	2·60	2·90	4 00	2·20	4·40	3·10	3·10	0·90	5·70	37·50
Wallacehall	2·50	3·50	1·10	2·10	2·00	3·40	2·00	3·50	2·20	2·30	0·70	5·90	31·20
Penpont	3·20	3·90	0·70	2·10	3·10	5·10	1·70	4·50	2·10	2·70	1·50	6·10	36·70
Keir	4·30	5·20	1·30	3·00	3·10	5·30	2·00	4·70	2·70	3·20	1·75	6·50	43·05
Auchenbrack ...	5·55	4·65	0·45	3·00	4·40	6·30	3·00	5·65	1·55	3·20	2·30	8·10	48·15
Hastings-hall ...	5·00	6·00	1·40	3·90	5·50	6·40	3·30	5·30	2·50	4·30	2·30	10·10	56·00
Kirkconnell	2·50	3·70	0·40	3·50	3·30	5·30	2·40	5·60	3·00	3·40	4·20	5·60	42·90
Sanquhar	3·00	4·30	0·30	2·80	3·30	4·20	2·50	4·70	3·60	2·20	2·50	6·40	39·80
Wanlockhead ...	5·10	6·55	0·10	4·10	2·65	8·00	5·70	8·15	4·90	5·15	2·90	11·50	64·80
MEAN,	2·86	3·55	3·37	2·69	2·96	4·36	2·64	4·00	4·79	1·91	1·98	4·85	36·96

ABSTRACT OF THE METEOROLOGICAL REGISTER FOR 1856,

Kept at Arbroath, by ALEXANDER BROWN, Honorary Member of the Literary and Philosophical Society, St Andrews; and Observer for the British and Scottish Meteorological Societies.

Latitude 56° 34′ N. Longitude 2° 35′ W. Distance from the Sea, ⅜ths of a Mile.
Height of the Barometer above the Sea, 80 feet; height of the Thermometer from the ground, 11 feet, and of the Rain-Gauge, 2 feet.
The number of "Rainy Days" includes those days on which snow or hail fell.

1856.	BAROMETER. Corrected to 32°, and reduced to sea-level.		THERMOMETER.							Days Ther. below 32°.	Rain in Inches.	HYGROMETER.		Fair Days.	Rainy Days.
	8½h. A.M.	10h. P.M.	8½ A.M.	7¾ P.M.	Mean.	Mean Max.	Mean Min.	Mean.	Spring Water.			Mean Dew Point.*	Degree of Humidity (complete Sat. 1·000).		
January	29·45	29·47	33·3°	33·6°	33·4°	38·0°	30·0°	34·0°	46·0°	21	3·030	29·8°	0·885	18	13
February	29·87	29·88	37·0	38·7	37·8	44·3	33·7	39·0	46·0	12	2·780	32·0	·839	16	13
March	30·21	30·19	37·7	38·0	37·9	46·3	32·1	39·2	45·7	18	0·121	30·9	·785	26	5
April	29·71	29·70	43·2	41·6	42·4	50·3	35·9	43·1	46·0	6	3·094	37·5	·827	15	15
May	29·85	29·84	46·5	45·3	45·9	53·7	38·4	46·1	46·5	2	2·910	39·2	·775	18	13
June	29·86	29·86	55·2	53·8	54·5	61·5	44·6	53·1	48·0	—	3·199	47·8	·773	13	17
July	29·86	29·86	58·2	57·0	57·6	66·6	46·2	56·4	48·5	—	2·119	51·1	·788	15	16
August	29·93	29·92	56·4	54·8	55·6	64·6	47·6	56·1	49·0	—	3·783	49·6	·770	19	12
September	29·82	29·81	51·5	50·0	50·7	57·3	43·7	50·5	49·5	—	5·431	44·5	·788	17	13
October	30·04	30·04	47·7	47·7	47·7	54·9	42·1	48·5	49·5	—	1·535	44·1	·916	20	11
November	29·95	29·84	36·8	37·4	37·1	42·7	33·1	37·9	48·7	18	2·021	32·4	·885	18	12
December	29·54	29·52	36·0	36·4	36·2	41·0	31·3	36·1	47·5	17	2·251	33·0	·900	19	12
Mean	29·84	29·83	44·9	44·5	44·7	51·8	38·2	45·0	47·5	94	32·274	39·3	0·825	214	152
Do. 1855	29·81	29·81	44·2	43·9	44·1	51·8	36·8	44·3	47·2	142	21·026	37·1	0·793	231	134

1856.	WINDS, AT 8½ A.M. N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	Total.
January	6	—	4	6	3	1	3	6	2	31
February	2	—	5	3	1	4	5	6	3	29
March	6	2	6	1	—	1	5	9	1	31
April	4	1	7	4	3	2	2	4	3	30
May	8	6	11	2	2	—	—	2	—	31
June	2	2	2	2	1	2	17	2	—	30
July	1	—	2	3	2	6	7	6	4	31
August	6	3	5	3	4	—	1	6	3	31
September	3	3	1	4	2	2	6	6	3	30
October	6	—	—	4	3	3	3	4	8	31
November	6	—	1	1	1	—	8	10	3	30
December	3	1	—	2	1	1	15	8	—	31
Mean	53	18	44	35	23	22	72	69	30	366
Do. 1855	62	19	25	41	42	35	41	69	31	365

Barometer at 8½ A.M. was highest on 3d March, 30·67. Wind N.W.
Do. do. was lowest on 24th January, 28·53. Wind S.E.
Do. at 10 P.M. was highest on 2d March, 30·63. Wind N.W.
Do. do. was lowest on 24th January, 28·49. Wind S.E.
Thermometer at 8½ A.M. was highest on 1st August, 69°. Wind S.
Do. do. was lowest on 3d December, 16°. Wind N.W.
Do. at 7¾ P.M. was highest on 25th June and 1st Aug., 69°. Wind W. & S.
Do do. was lowest on 3d December, 19°. Wind N.W.
Thermometer in night, highest, 30th July, 56°; lowest, 2d and 3d December, 16°.
Thermometer in day, highest, 26th June, 77°; lowest, 3d December, 25°.
Coldest day, 3d December, when average of Thermometer was 20½° for day and night.
Hottest day, 1st August, when average of Thermometer was 65½° for day and night.
Coldest month of the year, January; hottest, August.
Wettest month of the year, August; driest, March.
Mean temperature of the year, 44·85 degrees.
Mean temperature of thirteen years, 45·532 degrees.

For ten years the average daily temperature at 8½ A.M., at 7¾ P.M., and the mean of the daily extremes, are as follows, viz.:—

	8½ A.M.	7¾ P.M.	Mean of Extremes.
1847	45·°6	44·°7	45·°9
1848	45· 1	44· 4	45· 0
1849	45· 1	44· 4	44· 7
1850	45· 5	44· 9	45· 5
1851	45· 7	45· 4	46· 3
1852	46· 0	45· 9	46· 2
1853	45· 4	44· 9	45· 6
1854	46· 3	46· 4	46· 3
1855	44· 2	43· 9	44· 3
1856	44· 9	44· 5	45· 0

The average temperature of the six months of chief vegetation, viz., those from April to September inclusive—for nine years, is as follows:—

1848 ...	51·°7	1851 ...	52·°0	1854 ...	53·°5
1849 ...	52· 2	1852 ...	53· 0	1855 ...	52· 1
1850 ...	51· 7	1853 ...	53· 4	1856 ...	50· 9

* The dew-point thus found is obtained from observations of the Wet and Dry Bulb Thermometers, and deduced by Mr Glaisher's Hygrometrical Tables. The observations of the Wet and Dry Bulb Thermometers are made daily at 8½ A.M. The times of observation of the instruments stated in the Table are Greenwich mean time.

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INDEX.

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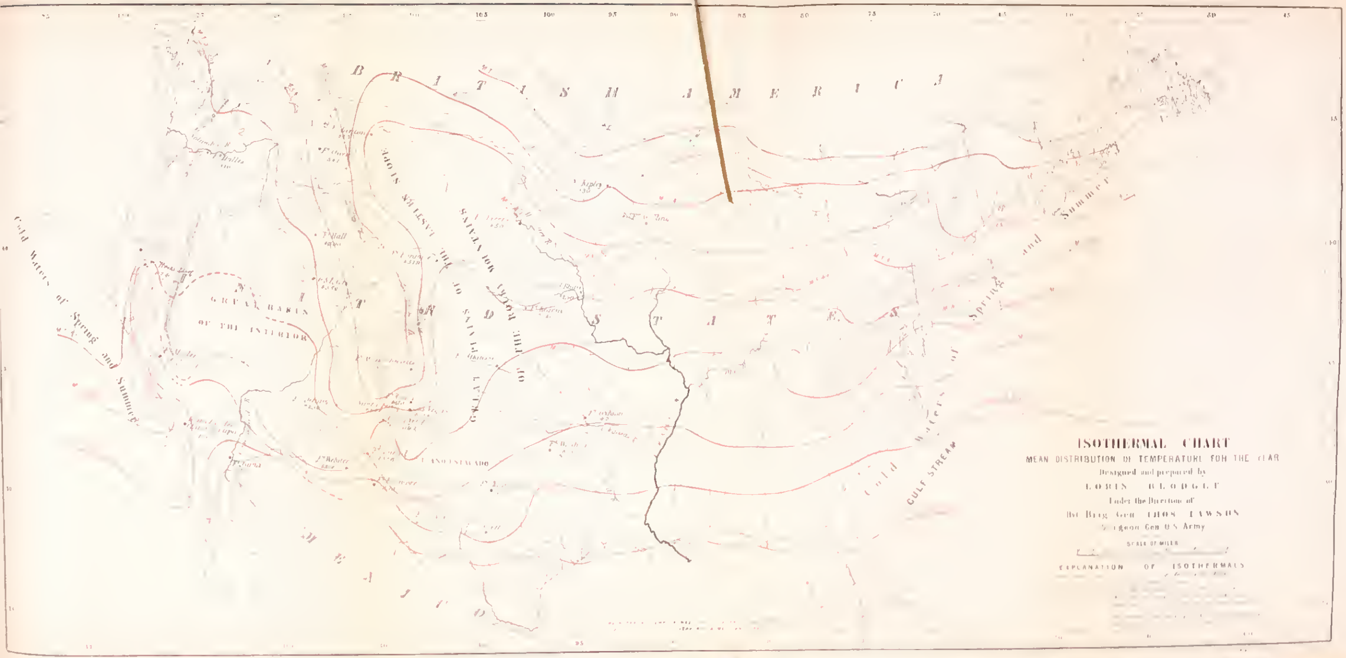
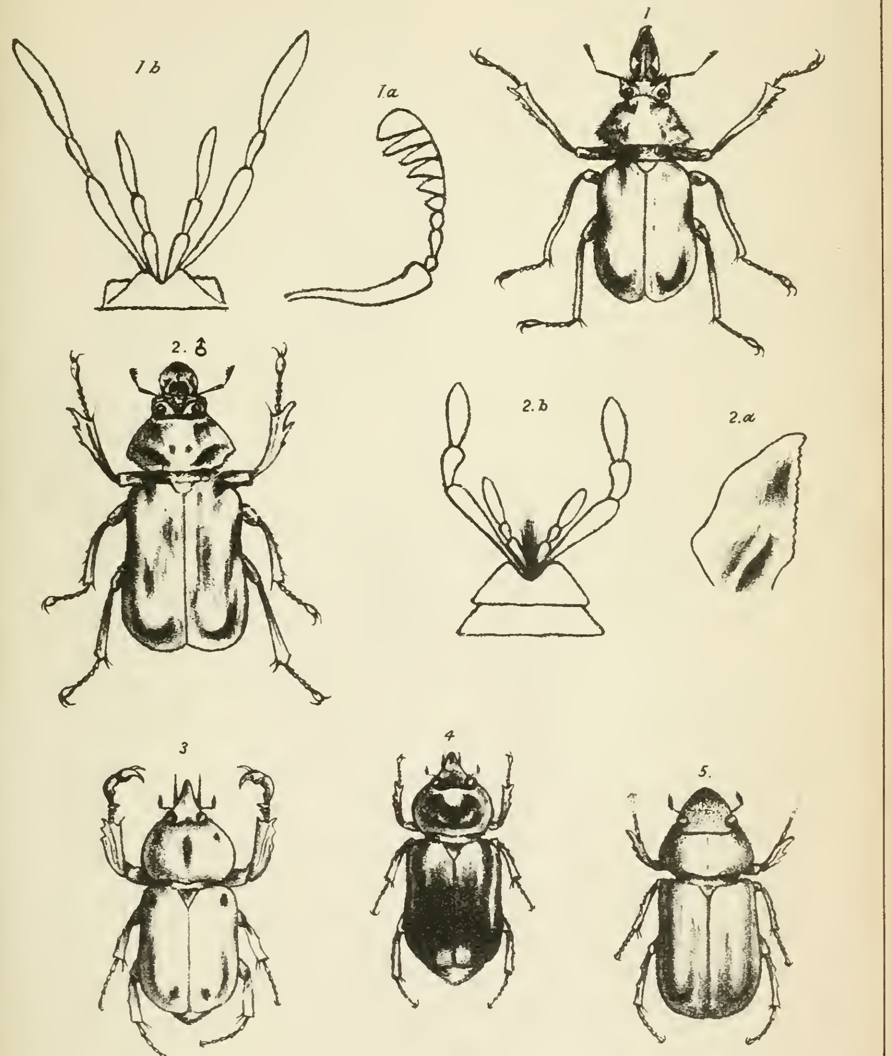

ISOTHERMAL CHART
SCALE OF MILES
EXPLANATION OF ISOTHERMALS
BRITISH AMERICA
GREAT BASIN OF THE INTERIOR
GULF STREAM
Cold Waters of Spring and Summer

PLATE III.

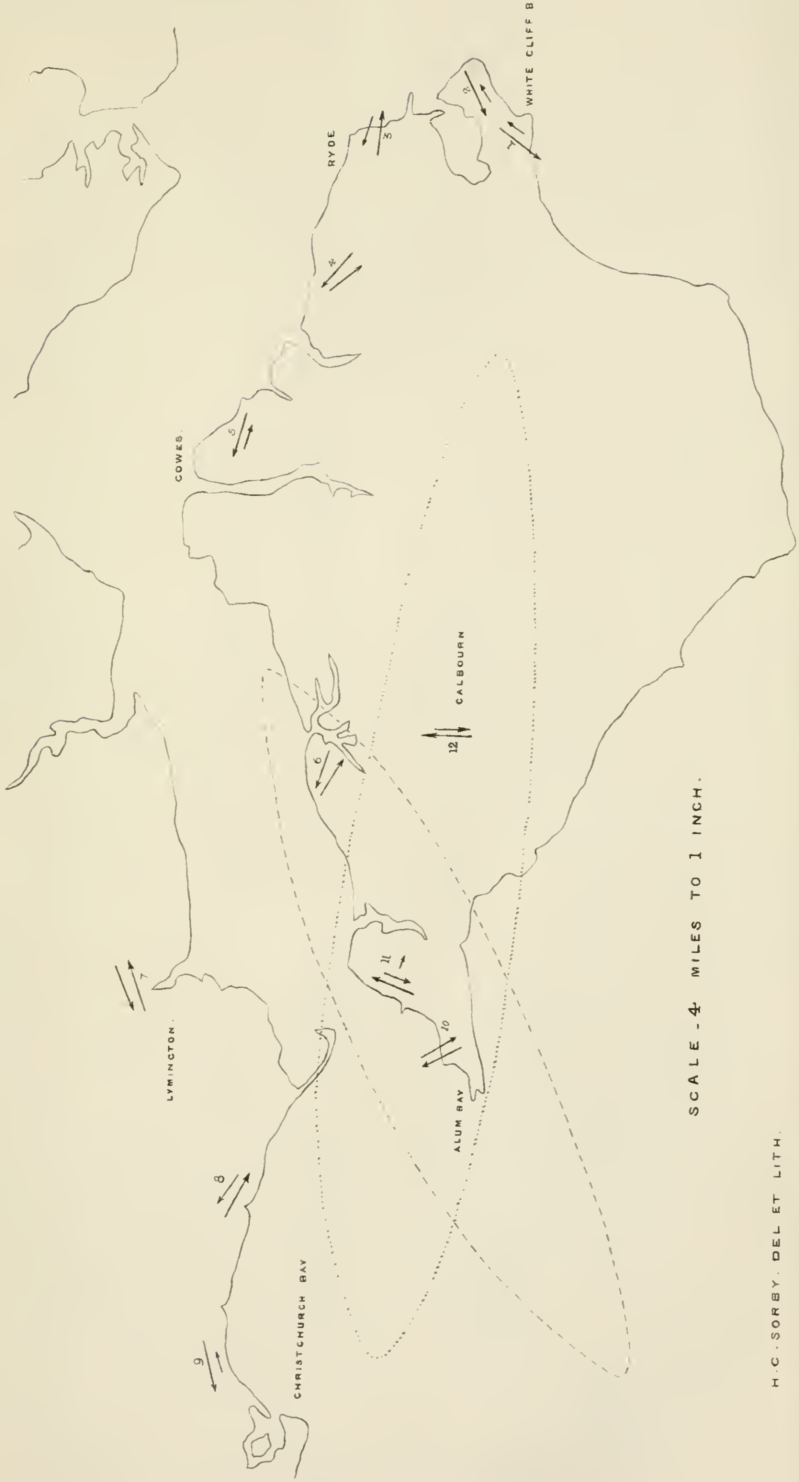
Edinr. New Phil. Journal, New Series Vol. IV.



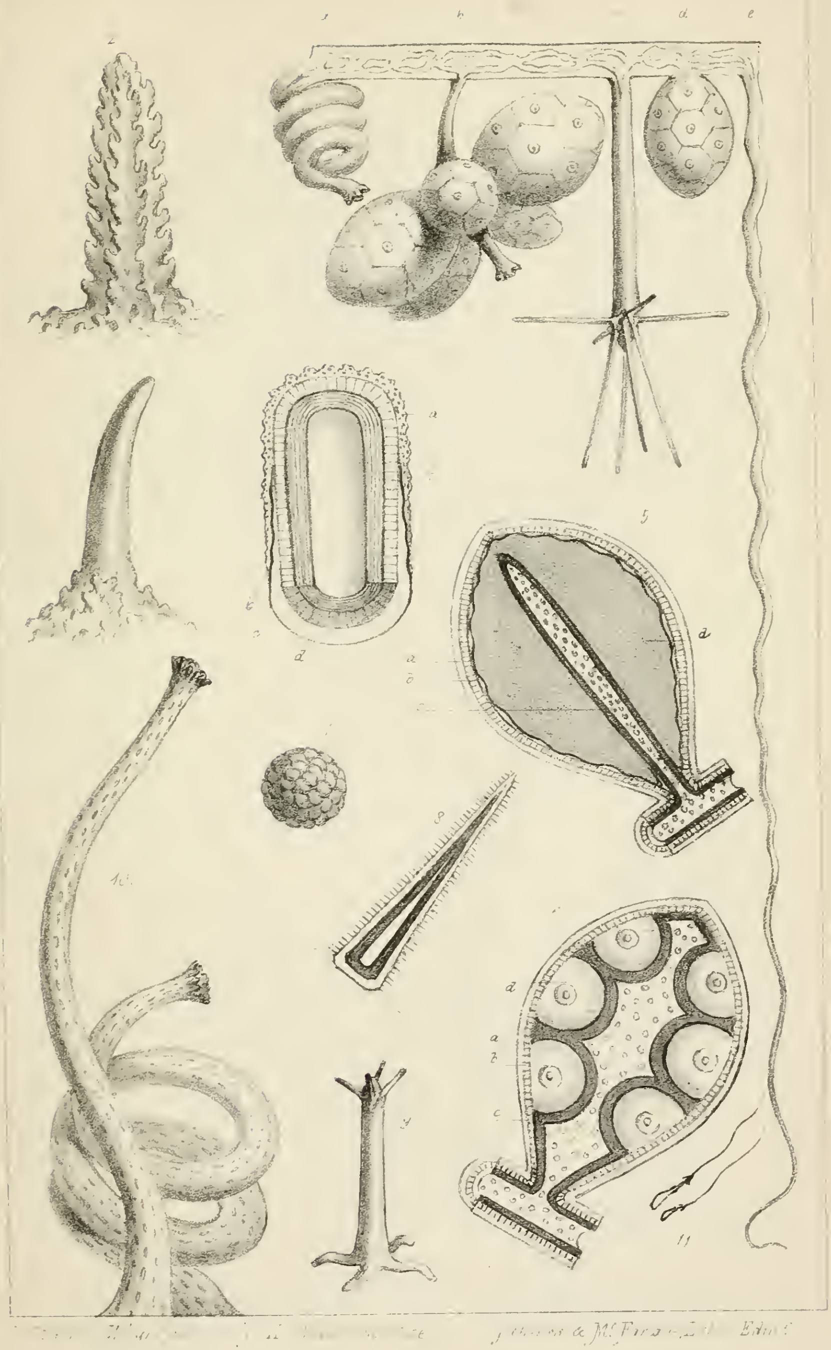
1. Sphænognathus Lindenii ♂ 3. Ancognatha Crassimanus,
2. Do. Do. ♀ 4. Do. Jamesoni.
5. Leucothyreus gigas.

A. Murray Del. et Lith W. H. Lizars Imp.

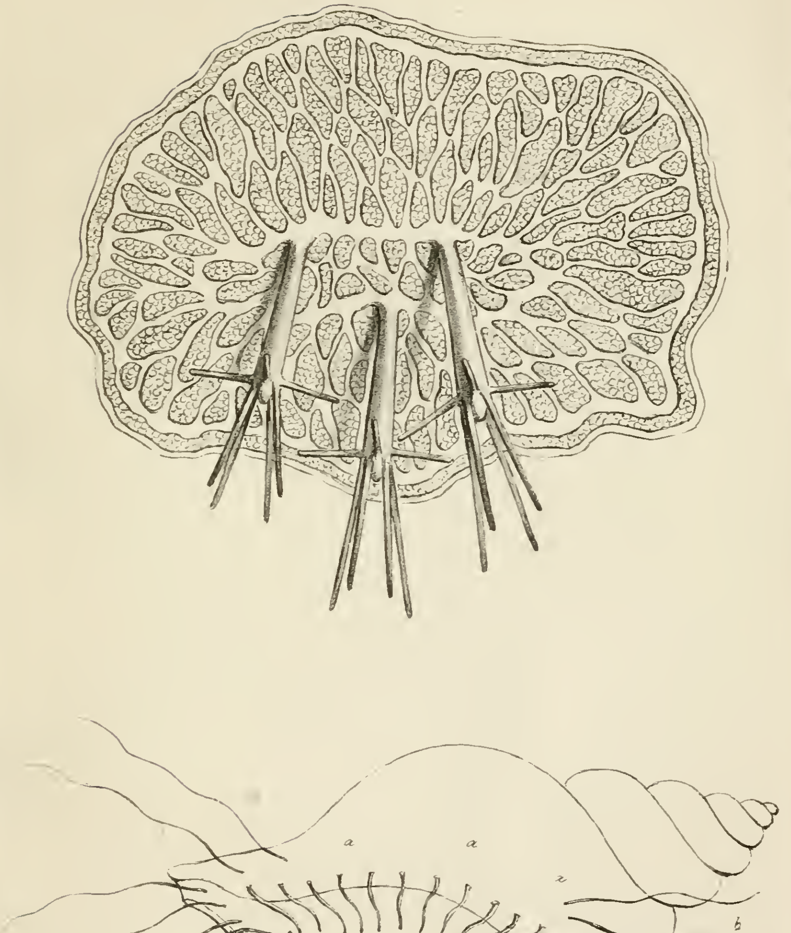
PLATE IV



H. C. SORBY. DEL ET LITH.



Hydractinia



M. Farlane Lith. Edin.

Hydra– nia