the pole of the field-magnets. In such machines the motion of the poles of the armature is also more in a line, coincident with the line of attraction as exercised between the two systems of poles; while in machines with field-magnets of two poles only the motion of the poles of the armature is at times at angles of 45 degrees to one degree from the direct pull.

I may, perhaps, be allowed to call attention to another matter of importance, awaiting further research. We find that in the three types of dynamo-machines, as constructed by Siemens, Gramme and Wilde, the relative positions of the axes of the field-magnets and those of the armatures are altogether different. Yet the three systems work well. We are unable, however, to state with certainty which positions of the axes are the best, or why any one of these positions should be better than the others, and in the face of experience, the theory of tubes or lines of force is little more than a hypothesis, with all its diffusion, vagueness and uncertainty.

Having so far considered general principles chiefly, I now beg to describe this motor (Fig. 5). A B C D is a wooden baseboard, E F G H a frame, consisting of the two parallel round rods F E and G H, and the two flat bars F G and E H, made of the best wrought iron, and carefully softened. The four bars are screwed together at the corners, and supported by four brass brackets over the baseboard. These inner rods form the compound core of the field magnets, a combination, as it were, of two horseshoe magnets, whose similar poles (S S and N N) form the junctions. Thus we have practically two poles only, a S and a N pole. Six coils of insulated copper wire are wound over the different portions of this core, shown in the drawing; the active pole-pieces are left exposed for a long distance, bearing no coils, The spindle P L, which carries a Siemens armature of the old form, or an armature with a compound tubular core; the commutator and pulley traverses the flat crossbar F H. The core of the armature is made of sheets of charcoal-iron, and it bears a coil of stout insulated copper wire. The commutator is of the ordinary kind, consisting of two half-tubes of brass, insulated from each other and from the spindle, and each forming one of the terminals of the coil. Fig. 2 represents a sectional view of a compound machine, acting on the same principles; Fig. 1 is a view of the two-end castings which hold the field-magnet. This machine contains a system of six field-magnets and six poles, and a compound armature with six poles. The current is to be reversed six times for each revolution, and to accomplish this I have devised the following commutator (see Fig. 8): —In these machines, also, the poles of the field-magnets or those of the armature may be of such a shape as to be nearly always approaching to, or receding from, each other, while in active motion,

The development of most important machines is destined to reach a certain stage of perfection, when further improvements cannot be accomplished by the inventor unaided; the second and important factor needed then is the co-operation of inventive and investigative talent with capital. This stage of perfection has been reached in the steam-engines, gas-engines, printing-machinery, etc., and it may be said to be rapidly approached by the progress made in dynamo-machines and electro-motors.

The development of the latter machines is followed by the scientific world with greater interest, and it evokes more eager expectations than that of other machinery, chiefly because it is not, and cannot be, identified with the solution of a problem limited within the confines of mechanical difficulties and commercial interests, but necessitates a further and deeper investigation into that great and subtle power, electricity, whose manifestations are so striking in their effects, so mysterious in their nature, so promising of great results in an immediate future, so fertile a field of research to the pioneer of science.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. 1880.

THE British Association for the Advancement of Science met at Swansea on the 4th of September last, under the presidency of Dr. Ramsey, who took as the subject of his address, "The Recurrence of Certain Geological Phenomena in Geological Time." His object appeared to be to show that all known geological formations have been produced under physical circumstances closely resembling, if not identical, with those with which we are more or less familiar. Through the various geological epochs he traced this identity of operations in respect to the metamorphism of rocks, the products of volcanoes, the upheaving and denudations of mountain chains, the deposit of great *inland areas* of salt, a recurrence of fresh-water conditions in lakes and estuaries, and glacial influences. His conclusion was that from the Laurentian epochs down to the present day all physical events in the history of the earth have varied neither in kind nor in intensity from those of which we now have experience.

The conclusions drawn from this address are summed up in the closing words of Professor Ramsey's discourse, as follows:

"In opening this address, I began with the subject of the oldest metamorphic rocks that I have seen—the Laurentian strata. It is evident to every person who thinks on the subject that their deposition took place far from the beginning of recognized geological time. For there must have been older rocks by the degradation of which they were formed. And if, as some American geologists affirm, there are on that continent metamorphic rocks of more ancient dates than the Laurentian strata, there must have been rocks more ancient still to afford materials for the deposition of these pre-Laurentian strata. Starting with the Laurentian rocks, I have shown that the phenomena of metamorphism of strata have been continued from that date all through the later formations, or groups of formations, down to and including part of the Eocene strata in some parts of the world. In like manner I have shown that ordinary volcanic rocks have been ejected in Silurian, Devonian, Carboniferous, Jurassic, Cretaceo-oolitic, Cretaceous, Eocene, Miocene, and Pliocene times, and from all that I have seen or read of these ancient volcanoes, I have no reason to believe that volcanic forces played a more important part in any period of geological time than they do in this our modern epoch. So, also, mountain chains existed before the deposition of the Silurian rocks, others of later date before the Old Red Sandstone strata were formed, and the chain of the Ural before the deposition of the Permain beds. The last great upheaval of the Alleghany Mountains took place between the close of the formation of the Carboniferous strata of that region and the deposition of the New Red Sandstone. According to Darwin, after various oscillations of level, the Cordillera underwent its chief upheaval after the Cretaceous epoch, and all geologists know that the Alps, the Pyrenees, the Carpathians, the Himalayas, and other mountain chains (which I have named) underwent what seems to have been their chief great upheaval after the deposition of the Eocene strata, while some of them were again lifted up several thousands of feet after the close of the Miocene epoch. The deposition of salts from aqueous solutions in inland lakes and lagoons appears to have taken place through all time—through Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous. Eocene, Miocene, and Pliocene epochs—and it is going on now. In like manner fresh-water and estuarine conditions are found now in one region, now in another, throughout all the formations or groups of formations possibly from Silurian times onward; and glacial phenomena, so far from being confined to what was and is generally still termed *the* Glacial Epoch, are now boldly declared by independent witnesses of known high reputation, to begin with the Cambrian epoch, and to have occurred somewhere, at intervals, in various formations, from almost the earliest Palæozoic times down to our last post-Pliocene "Glacial Epoch."

If the nebular hypothesis of astronomers be true (and I know of no reason why it should be doubted), the earth was at one time in a purely gaseous state, and afterwards in a fluid condition, attended by intense heat. By and by consolidation, due to partial cooling, took place on the surfate, and as radiation of heat went on the outer shell thickened. Radiation still going on, the interior fluid matter decreased in bulk, and, by force of gravitation, the outer shell being drawn towards the interior, gave way, and, in parts, got crinkled up, and this, according to cosmogonists, was the origin of the earliest mountain chains. I make no objection to the hypothesis, which, to say the least, seems to be the best that can be offered, and looks highly probable. But, assuming that it is true, these hypothetical events took place so long before authentic geological history began, as written in the rocks, that the earliest of the physical events to which I have drawn your attention in this address was, to all human apprehension of time, so enormously removed from these early assumed cosmical phenomena, that they appear to me to have been of comparatively quite modern occurrence, and to indicate that from the Laurentian epoch down to the present day, all the physical events in the history of the earth have varied neither in kind nor in intensity from those of which we now have experience. Perhaps many of our British geologists hold similar opinions, but if it be so, it may not be altogether useless to have considered the various subjects separately on which I depend to prove the point I had in view."

MATHEMATICS AND PHYSICS.

The address was delivered by the president, Prof. W. Grylls Adams. In it he dealt with the subject of magnetic disturbances, and pointed out that in many instances the disturbances at the various stations of observations were not precisely alike, showing probably the change of the direction or intensity of the earth's magnetism arising from the solar action upon it. He believed there was a sufficient cause for all our terrestrial magnetic changes, for these masses of metal were ever boiling up from the lower and hotter levels of the sun's atmosphere to the cooler upper regions, where they must again form clouds to throw out their light and heat, and to absorb the light and heat coming from the hotter lower regions; then they became condensed and were drawn again back towards the body of the sun, so forming those remarkable dark spaces or sunspots by their down-rush towards the lower levels. In these vast changes, which we know from the science of energy must be taking place, but of the vastness of which we can have no conception, we have abundant cause for the magnetic changes which we observe at the same instant at distant points on the surface of the earth, and the same cause acting by induction on the magnetic matter within and on the earth may well produce changes in the direction of its total magnetic force, and alter the direction of its magnetic axis. These magnetic changes on the earth will influence the declination needles at different places, and will cause them to be deflected. The direction of the deflection must depend on the situation of the earth's magnetic axis, or the direction of its motion with regard to the stations where the observations are made. Thus, both directly and indirectly, we find in the sun not only the cause of diurnal magnetic variations, but also the cause of these remarkable magnetic changes and disturbances over the surface of the earth.

CHEMISTRY.

The address was delivered by the president, Dr. J. H. Gilbert, F.R.S., who referred mainly to the subject of agricultural chemistry, and in the course of his remarks said, referring to the assimilation of carbon, that the whole tendency of observations was to conform to the opinion put forward by De Saussure about the commencement of the century, and so forcibly insisted upon by Liebig, forty years later, that the greater part, if not the whole, of the carbon, was derived from the carbonic acid of the atmosphere. Judging from more recent researches, it would seem probable that the estimate of one part of carbon or carbonic acid in 10,000 of air was more probably too high than too low as an estimate of the average quantity in the atmosphere of our globe. Large as was the annual accumulation of carbon from the atmosphere over a given area, it was obvious that the quantity must vary exceedingly with the variation of climatical conditions. It was, in fact, several times as great in the case of the tropical vegetation—that of the sugar-cane, for instance. And not only was the greater part of the assimilation accomplished within a comparatively small portion of the year, but the action was limited to the hours of daylight, whilst during darkness there was rather loss than gain. In a general sense it might be said that the success of the cultivator might be measured by the amount of carbon he succeeded in accumulating in his crops. And as the amount of carbon accumulated depended on the supply of nitrogen in an available form within the reach of plants, it was obvious that the question of the sources of the nitrogen of vegetation was one of first importance. The result of experiments that had been conducted went to prove—first, that without nitrogenous manure, the gramineous crops annually yielded, for many years in succession, much more nitrogen over a given area than was accounted for by the amount of combined nitrogen annually coming down in the measured aqueous deposits from the atmosphere; second, the roots yielded more nitrogen than the cereal crops, and the leguminous crops much more still; and third, that in all cases—whether of cereal crops, root crops, leguminous crops, or a rotation of crops—the decline in the annual yield of nitrogen, when one was supplied, was very great. The next point referred to was the condition of the nitrogen in our various crops. They could not say that the whole of the nitrogen in the seeds with which they had to deal existed as albuminoids. But they might safely assume that the nearer they approached to perfect ripeness, the less of non-albuminoid nitrogenous matters would they contain; and in the case of the cereal grains, at any rate, it was possible that if really perfectly ripe, they would contain very nearly the whole of their nitrogen as albuminoids.

GEOLOGY.

The address was delivered by the President, H. C. Sorly, LL.D., F.R.S., who took for his subject the comparative structure of artificial slags and eruptive rocks. His conclusions may be thus summed up:

The objects I have described may be conveniently separated into three well-marked groups, viz.: artificial slags, volcanic rocks and granite rocks. My own specimens all show perfectly well-marked and characteristic structures though they are connected, in some cases, by intermediate varieties. Possibly, such connecting links might be more pronounced in other specimens that have not come under my notice. In any case, the facts seem abundantly sufficient to prove that there must be some active cause for such a common, if not general, difference in the structural character of these three different types. The supposition is so simple and attractive, that I feel very much tempted to suggest that this difference is due to the presence or absence of water as a gas or as a liquid. In the case of slags it is not present in any form. Considering how large an amount of steam is given off from erupted lavas, and that, as a rule, no fluid cavities occur in the constituent minerals, it appears to me very plausible to suppose that those structures which are specially characteristic of volcanic rocks are, in great measure, if not entirely, due to the presence of associated or dissolved vapor. The fluid cavities prove that water was sometimes, if not always, present as a liquid during the consolidation of granitic rocks, and we can scarcely hesitate to conclude that it must have had very considerable influence on the rock during consolidation. Still, though these three extreme types appear to be thus characterized by the absence of water, or by its presence in a state of vapor or liquid, I think we are scarcely in a position to say that this difference in the conditions is more than a plausible explanation of the differences in their structure. Confining our attention to the more important crystalline constituents which are common to the different types, we may say that that the chief structural characters of the crystals are as follows: (*a*) Skeleton crystals, (*b*) Fan-shaped groups, (*c*) Glass cavities, (*d*) Simple crystals, (*e*) Fluid cavities. These different structural characters are found combined in different ways in the different natural and artificial products, and for simplicity I will refer to them by means of the affixed letters. The type of the artificial products of fusion may generally be expressed by $a + b$ or $b + c$; that is to say, it is characterized by skeleton crystals and fan-shaped groups, or by fan-shaped groups and glass cavities. In like manner the volcanic group may be expressed occasionally by $b + c$, but generally by $c + d$, and the granitic by $d + e$. These relations will be more apparent if given in the form of a table as follows:

Slag type........	$a + b$	$b + c$		
Volcanic type.. ..		$b + c$	$c + d$	
Granitic type				$d + e$

Hence it will be seen that there is a gradual passage from one type to the other by the disappearance of one character and the appearance of another, certain characters in the meanwhile remaining common, so that there is no sudden break, but an overlapping of structural characteristics. It is, I think, satisfactory to find that, when erupted rocks are examined from such a new and independent point of view, the general conclusions to which I have been led are so completely in accord with those arrived at by other methods of study.

ANATOMY AND PHYSIOLOGY.

The address was delivered by Mr. F. M. Balfour, F.R.S., one of the vice-presidents of the section, who observed that in the spring of the present year Prof. Huxley delivered an address at the Royal Institution, to which he gave the felicitous title of "The Coming of Age of the Origin of Species." It was, as Prof. Huxley pointed out, twenty-one years since Mr. Darwin's great work was published, and the present occasion, Mr. Balfour remarked, was an appropriate one to review the effect which it had had on the progress of biological knowledge. There was, he might venture to say, no department of Biology the growth of which has not been profoundly influenced by the Darwinian theory. When Messrs. Darwin and Wallace first enunciated their views to the scientific world, the facts they brought forward seemed to many naturalists insufficient to substantiate their far-reaching conclusions. Since that time an overwhelming mass of evidence has, however, been rapidly accumulating in their favor. Facts which at first appeared to be opposed to their theories have one by one been shown to afford striking proofs of their truth. There are at the present time but few naturalists who do not accept in the main the Darwinian theory, and even some of those who reject many of Darwin's explanations still accept the fundamental position, that all animals are descended from the common stock. To attempt in the time at his disposal to trace the influence of the Darwinian theory on all the branches of anatomy and physiology would be wholly impossible, and he would confine himself to an attempt to do so for a small section only. There was perhaps no department of Biology which had been so revolutionized by the theory of animal evolution as that of development or Embryology. The reason of this is not far to seek. According to the Darwinian theory, the present order of the organic world has been caused by the action of two laws, known as the laws of heredity and of variation. The law of heredity is familiarly exemplified by the well-known fact that offspring resemble their parents. Not only, however, do the offspring belong to the same species as their parents, but they inherit the individual peculiarities of their parents. It is on this that the breeders of cattle depend, and it is a fact of every-day experience amongst ourselves. A further point with reference to heredity to which he must call their attention was the fact that the characteristics which display themselves at some special period in the life of the parent are acquired by the offspring at a corresponding period. Thus, in many birds the males have a special plumage in the adult state. The male offspring is not, however, born with the adult plumage, but only acquires it when it becomes adult. The law of variation is, in a certain sense, opposed to the law of heredity. It asserts that the resemblance which offspring bear to their parents is never exact. The contradiction between the two laws is only apparent. All variations and modifications in an organism are directly or indirectly due to its environments; that is to say, they are rather produced by some direct influence acting upon the organism itself, or by some more subtle and mysterious action on its parents; and the law of heredity really asserts that the offspring and parent would resemble each other if their environments were the same. Since, however, this is never the case, the offspring always differ to some extent from the parents. Now, according to the law of heredity, every acquired variation tends to be inherited, so that, by a summation of small changes, the animals may come to differ from their parent stock to an indefinite extent. Mr. Balfour then referred to what he spoke of as a concrete example of the application of these two laws, his object being to demonstrate how completely modern embryological naming is dependent on inheritance and variation, which constitute the keystones of the Darwinian theory. He maintained that "The Origin of Species" afforded explanations of important embryological facts, and added that no explanation, for instance, could be offered of the fact that a frog in the course of its growth has a stage in which it breathes like a fish, and then why it is like a newt with a long tail, which gradually becomes absorbed, and finally disappears. To the Darwinian the explanation of such facts is obvious. The stage when the tadpole breathes by gills is a repetition of the stage when the ancestors of the frog had not advanced in the scale of development beyond a fish, while the newt-like stage implies that the ancestors of the frog were at one time organized very much like the newts of to-day. The explanation of such facts has opened out to the embryologist quite a new series of problems. Having examined these in regard to phylogeny and organogeny, and entering into elaborate scientific details and arguments, Mr. Balfour concluded by remarking that although the present state of our knowledge on the genesis of the nervous system is a great advance on that of a few years ago, there is still much remaining to be done to make it complete. The subject, he urged, was well worth the attention of the morphologist, the physiologist, or even the psychologist, and we must not remain satisfied by filling up the gaps in our knowledge by such hypotheses as he had been compelled to frame. New methods of research will probably be required to grapple with the problems that are still unsolved; but when we look back and survey what has been done in the past, there can be no reason for mistrusting our advance in the future.

RELATION OF VERMONT ARCHÆOLOGY TO THAT OF THE ADJACENT STATES.*

By Dr. George H. Perkins.

Vermont is a very barren region archæologically as compared with many parts of the West, yet thorough investigation has shown that even there interesting results may be obtained. We not only have found a not inconsiderable number of stone relics, but we have also found, as we think, an interesting relation between these specimens and those from surrounding States. West of the Green Mountains we find our greatest variety of objects, and we find at least two classes, and perhaps more, which should be referred to different people. Here and there, but especially near Lake Champlain, we find objects of copper, and polished stone much more skillfully made than most of the specimens found in New England. In certain graves found near Swanton, and described fully at the Portland meeting of this Association, we find this class of objects. A peculiar form of slate knife (or lance?), polished and with notched haft, is found in Western Vermont, but occurs in greater abundance across the lake in New York and in Central New York. At Palatine Bridge Mr. S. L. Frey has discovered graves of the same kind as those found at Swanton. Taking these finer specimens of ancient workmanship as a basis of comparison, leaving out of account the ruder stone objects and the pottery, we can duplicate most of our Vermont specimens in Central New York, and also we find from Western New York and the mounds of Ohio many which are identical in all essential characters. This is true of shell and copper beads, of copper spear-heads, of stone tubes, axes, gorgets, banner stones and other objects. As we go westward we find these specimens increasing in number and of greater variety, and we also find a few forms absent. These specimens seem to me sufficiently characteristic and numerous to warrant the inference that in them we have a record of a people who emigrated from Ohio through New York, crossed Lake Champlain and reached as far east as the Green Mountains, where they stopped. They also appear not to have reached further north than Northern Vermont, nor further south than the southern end of Lake Champlain.

The other class of relics is composed of ruder objects associated with pottery. So far as I know no pottery has been found with the first class of relics. This pottery is quite unlike that from the mounds or most of that found

* Read before the A. A. A. S., Boston, 1880.