terrestrial magnetism and its relations to the earth-currents, Polar lights, and solar energy. Prof. Bergmann, of Berlin, followed with some remarks on the relations of modern surgery to the treatment of internal ailments. After some formal proceedings, the third general sitting, and with it the fifty-ninth gathering of the German Naturalists and Physicians, were brought to a close.

In a brief report of this nature it would be impossible to do more than refer in the most summary way to the work done in the several Sections, of which twelve were devoted to scientific and eighteen to medical subjects. Altogether 522 topics were discussed, and 155 demonstrations carried out. Most of the proceedings will be published in special scientific journals, and here it will suffice to mention more especially the remarkable synthesis of coniine, the poisonous alkaloid of hemlock, effected with surprising success by Prof. Ladenburg. Thanks to this achievement, the artificial production of a vegetable alkaloid may now for the first time be regarded as successfully accomplished. In the physiological department the question of the localisation of the cerebral functions gave rise to an animated discussion, in which Profs. Hitzig, Munth, and Soltz took part. In the section devoted to the subject of scientific instruction, Prof. Haeckel pleaded strongly for a severer training in this branch of knowledge amongst young students. It may be mentioned in conclusion that, in connection with this meeting, an exhibition of scientific instruments, apparatus, and educational appliances was held in the apartments of the Academy of Arts and Sciences. There was a good show of instruments of precision, microscopes, electric, medical, and other appliances, which attracted a large number of visitors during the few days the exhibition lasted, from September 16 to 26.

THE HARVEIAN ORATION

DR. PAVY, F.R S., delivered the Harveian Oration at the Royal College of Physicians on Monday afternoon. After giving the directions marked out by the founder of the Oration—viz., to commemorate the benefactions that have fallen into the possession of the College and to search and study out the secrets of Nature by way of experiment—the orator alluded to the augmentation which the income from the endowment of the Croomian Lectureship has recently undergone, by which the amount available is raised from 10*l.* to 200*l.* per annum; and to the sum (2000*l.*) bequeathed by the late Dr. Gavin Milroy. He next spoke of the course pursued by Harvey as set forth by Lord Bacon, in his "Novum Organum," or "true directions concerning the interpretation of Nature." Instead of giving himself up, as others had done before him, to arguing out conclusions from accepted axioms, Harvey struck out, Dr. Pavy continued, into the hitherto untrodden path of inquiry—that of induction—and sought knowledge by a direct appeal to Nature through the medium of observation and experiment. "It were disgraceful," he says, "with this most spacious and admirable realm of Nature before us, did we take the reports of others upon trust, and go on coining crude problems out of these, and on them hanging knotty and captious and petty disputations. Nature is herself to be addressed, the paths she shows us are to be boldly trodden." In the discovery of the circulation Harvey applied the principles of induction and argued upon them in a strictly logical way. He showed himself to be a good and careful observer, judged even by the standard set forth by John Stuart Mill on the process of observing. The experiments which Harvey conducted on the arteries and veins, to assist him in his inquiry, were founded upon a well-devised plan. Dr. Pavy next spoke of the new departure in physiology which Harvey's discovery established, of the opposition with which his views were received, and remarked that the high position in his profession he had attained did not suffice to secure his escape from the effect of the prejudice against innovation entertained by the multitude. Aubrey tells us he had "heard him say that after his book on the circulation of the blood came out he fell mightily in his practice; 'twas believed by the vulgar that he was crack-brained, and all the physitians were against him." Harvey lived, however, to see his doctrine generally accepted. The orator next referred to one issue of research derived, he said, from the labours of the present day, which has already yielded much good and useful fruit and gives promise of yielding much more. "Belonging to the realm of living Nature there are," he continued, "small organisms, the existence of which we must have remained unconscious of in the absence of the aid of the microscope. These bodies are known by the name of bacteria or bacilli, and, while some difference of opinion has existed, it is generally thought that they are organisms belonging to the vegetable kingdom. There is nothing in their appearance to strike the observer that they possess any significance, and yet by recent research it has been found that they play a most important part as constituents of the living world." The experiments of Spallanzani, Schulze, and Swann, were next described by Dr. Pavy, the natural conclusion to be drawn from which, he said, "goes far towards absolutely establishing that the air contains the germs of living organisms, and that it is these that constitute the source of the microscopic organisms found to become developed in the presence of organic matter, which some have contended take rise spontaneously. This view is supported by the researches of the present day, and nothing that would bear the scrutiny of strict investigation has ever been adduced against it. It stands at the foundation of our modern notions regarding the *rôle* played by bacilli, and thus occupies a position of weighty importance with reference to the matter. The step from the action exerted by bacteria as agents exciting the decomposition of organic products to that which brings them before us as a source of disease is not a large one. In the one case they lead to change which would not otherwise occur, and in the other they disturb the order of changes naturally taking place and thus induce an abnormal state; and although there is nothing in their morphological characters to show the reason, different trains of phenomena—in other words, different diseases—are occasioned by different kinds of bacilli. . . . Through the indefatigable researches of Pasteur and others the distinguishing form and life-history of certain of these organisms have been clearly made out. Placed under suitab'e conditions, it has been found that they can be reared or cultivated artificially, and one of the most marked and important characters belonging to them is the enormous extent of self-propagating power they possess. This accounts for the rapid spread that is observed to take place of an infectious disease, if allowed to progress without controlling measures being brought to bear upon it. We have to deal, then, with something that lives and grows by virtue of a power pertaining to itself. Permit this living growth—this parasite, in fact—to become dispersed and to enter the system of a living person, and presuming it has lodged upon a soil supplying suitable conditions for its development, it will thrive and multiply and give rise to a series of phenomena which the physician has no power to arrest. Once the bacillus is implanted and the disease established, all that the physician can do is to see that the patient has fair play—that he is kept under the most favourable conditions for battling successfully against his enemy. What is to be philosophically aimed at, however, is to check the spread—to bar the transmission of the parasite from one person to another, by attacking it outside the body; and this, with the application of the proper measures of disinfection, can with facility be done, but naturally the facility of preventing extension stands in proportion to the degree of limitation at the time existing. The spark of fire is with the greatest ease extinguished, but let it kindle into flame, and in proportion as the flame spreads the difficulty becomes greater to get the conflagration under. This is one way in which the attack upon the bacillus may be made, and the ravages of disease restrained. Another way, by quite a different line of tactics, presents itself; and the knowledge of this is due to the researches that have been recently conducted. The vulnerable point to which I am alluding lies not in connection with the bacillus itself, but with the condition of the medium upon which it may chance to fall. It has been found that the parasite requires virgin soil for its growth. This observation stands in harmony with the result of common experience as regards disposition to contract infectious disease. It has been from remote times generally known that a person who has passed through one attack of an infectious disorder is not liable to the same extent as before to become affected on exposure to contagion. An influence has been exerted giving rise to more or less protection being afforded against a recurrence of the disease. Now it happens that by certain means the bacillus may be brought into such a weakened state as only to occasion, when introduced into the system of an animal, an effect of a mild nature, not dangerous to life, instead of the ordinary form of disease; but the effect produced, and this is the great point of practical importance, is as protective against a subsequent attack as the fully-developed disease. There are two methods by which attenuation in virulence of the disease-producing organism may be brought about—

by conducting their artificial cultivation in a particular way, and by transmission through the system of an animal differing in nature from that in which the disease naturally occurs. When the chain of discoveries reached the point of showing that bacilli could be reared outside the body in an artificial soil or cultivating medium, a great advance was made towards obtaining a full knowledge about them, as it placed the observer in a more favourable position for the successful prosecution of research by enabling him to vary and control his conditions in a manner that could not otherwise have been effected. Although much has been accomplished, it must be said much still remains to be done. In the case of a few bacilli the life-history has been pretty clearly made out. Cultivated in a certain way they retain their virulence, no matter through how many successions they pass. The last product in a series of successive cultivations is as virulent as the parent stock. By modifying the conditions under which the cultivation is carried on, the successive products of descent may be gradually weakened until they become harmless. Such being the case, any desired degree of attenuation may be obtained, and by inoculation with a virus brought down to the proper strength the non-fatal affection may be occasioned which gives immunity from subsequent liability to take the disease under exposure to contagion. The knowledge thus acquired has been already practically turned to account upon a large scale for checking the ravages of that exceedingly fatal disease among cattle known as anthrax, or splenic fever, and through the success attained much sacrifice of life has been averted. If this can be accomplished for one disease, and more than one can be mentioned, is there not ground for believing that means will be found for placing others of the class in the same position? Attempts are being made in this direction. All eyes throughout the civilised world are, indeed, at the present moment fixed upon the work of Pasteur in Paris with reference to hydrophobia. It would be a great achievement for this frightful disease to be brought under subjection, and certainly the results that have been obtained appear to give hopes that an approach to something of this kind has been arrived at. Looking at the nature of the disease, there is nothing inconsistent with its being dependent upon a bacillus, or microbe, as Pasteur calls it. On the contrary, owing its origin as it does, when occurring naturally, to inoculation with the poisoned secretion of an affected animal, and taking into view the facts that have been learnt in connection with its transmission by artificial inoculation, evidence points to such in reality being the case. If due to a bacillus, why may not this bacillus be open to attenuation in the same manner as that of anthrax? If thus open to attenuation, why not susceptible of producing a non-fatal form of affection? And if this condition has been produced and passed through, why should not protection be thereby given against the subsequent development of the disease as a result of the primary inoculation from the bite of the rabid animal? Such a train of reasoning is quite legitimate, and for the application of the principle of action to which it leads, there is this advantage on the side of hydrophobia, that from the prolonged period usually taken for incubation after the introduction of the poison in the ordinary way, time is given for the artificial inoculations by subcutaneous injection to produce their effect and to render the system refractory to the further development of disease. I have been an eye-witness of Pasteur's work. It is from the nerve centre, the seat from which the symptoms of the disease start, that he obtains his virus. Employed for inoculation in a fresh state it produces a fatal disease, and the disease has been transmitted successively on through a number of animals, with the result that the last affected animal yields as strong a virus as the first. Kept in a pure, dry air, attenuation advances, and after a certain time the nerve centre loses its disease-producing power. Used for inoculation at a given period of preservation it produces an effect which renders an animal resistant to the influence of inoculation with the virus in a fresh state, and Pasteur contends that it acts similarly when the virus has been introduced in the ordinary way. The treatment of persons bitten by rabid animals by inoculation with attenuated virus has now been on its trial a considerable time, and a large experience gained. Judgment, it must be stated, still stands in suspense; but it must also be said that the results obtained tell decidedly in favour of the view advanced. The other method by which it has been recently experimentally found that the virulence of bacilli can be weakened is by transmission through an animal of a different nature from that in which the disease naturally occurs. This, in reality, represents the principle at the foundation of the system of vaccination, discovered by Jenner at the close of the last century. It may now be regarded as an accepted conclusion that vaccine-lymph is the virus of small-pox modified by transmission through the cow. Jenner's discovery consisted in showing that the result of vaccination with the lymph of cow-pox affords as much protection against small-pox as an attack of small-pox itself. This was the fact he educed, but the knowledge possessed in his time did not permit of its being looked at in any further way than as a simple fact or truth of Nature. Viewed, however, with the light that has been thrown upon it by the researches of the present day, we see not only the fact, but also its explanation: we see that the principle of action of the procedure proposed by Jenner, which has conferred such incalculable benefit upon mankind, is based upon the attenuating effect upon the small-pox virus of the human species by transmission through another animal; and knowing this, the prospect is presented of its being rendered susceptible of application for the control of other diseases. Whether this should prove so or not, at all events advantage is gained by the knowledge acquired. Need I say anything more to exhort you, in accordance with the duty that has devolved upon me? Surely the acquirement of knowledge, giving us as it does greater power in the exercise of our calling, and thereby promoting the high and noble object of rendering our lives more useful to our fellow-creatures—surely this is a sufficient incentive, following the words of Harvey, 'to search and study out the secrets of Nature by way of experiment.'"

NOTE ON THE ASTRONOMICAL THEORY OF THE GREAT ICE AGE[1]

THE following calculation has convinced me that Mr. Croll's theory affords an adequate explanation of the Ice age. I compute the total quantity of heat received by each hemisphere of the earth during summer and winter respectively as follows:—

Let $2H/a^2$ be the quantity of sun-heat falling perpendicularly on an area equal to the section of the earth at the mean distance a from the sun in the unit of time.

Let δ be the sun's north declination. Then the share received by the northern hemisphere will be

$$\frac{H}{a^2}(1 + \sin\delta),$$

and by the southern

$$\frac{H}{a^2}(1 - \sin\delta).$$

At the distance r, and in the time dt, the heat received in the northern hemisphere will be

$$\frac{H}{r^2}(1 + \sin\delta) \cdot dt;$$

but we have

$$r^2 d\theta = h dt,$$

whence the expression becomes

$$\frac{H}{h}(1 + \sin\delta) \cdot d\theta;$$

but we have

$$\sin\delta = \sin\theta \cdot \sin\epsilon,$$

where ϵ is the obliquity.

The total heat received by the northern hemisphere from the vernal to the autumnal equinox is

$$\int_0^{\pi} \frac{H}{h}(1 + \sin\epsilon\sin\theta) \cdot d\theta = \frac{H}{h}(\pi + 2\sin\epsilon).$$

We have thus the following theorem:—

Let $2E$ be the total sun-heat received in a year over the whole earth; then this is divided into shares as follows:—

$$\text{Northern hemisphere, summer, } E\frac{\pi + 2\sin\epsilon}{2\pi},$$

$$\text{,, winter, } E\frac{\pi - 2\sin\epsilon}{2\pi};$$

with identical expressions for the summer and winter in the southern hemisphere.

[1] Paper read at the Royal Irish Academy on May 24, 1886, by Sir Robert Stawell Ball, LL.D., F.R.S. Communicated by the Author.