the emetic. He knows many of our standard remedies, while of others equally accessible to him he is ignorant. Thus he uses indigenous species of Nephrodium for the relief of tape-worm, and croton as a purgative, but it is apparently from the white man that he has learned that the *Ipomoea purpurea* has qualities analogous to jalap, and though castor-oil is used for dressing hides he is not aware of its medicinal value. But he undoubtedly is acquainted with a great number of simples, mostly vegetable; and Father Bryant believes that the further investigation, and in particular the chemical examination, of many of the drugs which he names will in all probability add valuable remedies to our pharmacopœia. Dr. E. Warren, curator of the museum, promises that his department will provide all possible assistance in material and information to any competent chemist who is prepared to undertake such an inquiry.

AMERICAN INVERTEBRATES.

BULLETIN No. 63 of the United States National Museum is devoted to a monographic revision, by Mr. F. E. Blaisdell, of the beetles of the Eleodine section of the family Tenebrionidæ inhabiting the United States, Lower California, and the adjacent islands. The memoir includes 534 pages of text and thirteen plates.

In No. 2 of the Leland Stanford Junior Publications of the University of California Prof. F. M. Macfarland describes in considerable detail the anatomy of the opisthobranchiate molluscs obtained during the Brauner-Agassiz expedition to Brazil in 1899. The collection, although small, adds seven to the list of Brazilian species of the group; and since little was previously known with regard to the structure of the opisthobranchs of the district, the opportunity was taken of studying this as minutely as the amount of material permitted. A number of diagrammatic figures of the radula in different genera is given.

The feather-stars, or ophiurids, of the San Diego region form the subject of vol. vi., No. 3, of the University of California Publications in Zoology. The author, Mr. J. F. McClendon, began his investigation in the hope that a taxonomic and biological study of the local members of the group might facilitate work in which it was important to know the breeding-seasons and habitats of different species, but, unfortunately, he could not remain long enough to obtain all the data desired. It is believed, however, that the height of the breeding-season for most of the species is in the spring, although individuals full of apparently unripe eggs were taken in spring.

A number of new fossil echinoderms from the Cretaceous and Tertiary Ripley beds of Mississippi are described and figured by Mr. A. W. Slocum in vol. iv., No. 1, of the Geological Publications of the Field Museum, Chicago.

The re-arrangement of the large collection of graptolites which for many years has been in course of formation in the U.S. National Museum has afforded to Mr. R. S. Bassler the opportunity of revising the species of the dendroid group from the Niagaran Dolomite of Hamilton, Ontario, and the results of his studies are published, with a large number of illustrations, in Bulletin No. 65 of the museum.

THE SEVEN STYLES OF CRYSTAL ARCHITECTURE.[1]

THE proverbial importance of the number seven is once more illustrated in regard to the systems of symmetry exhibited by solid matter in its most perfectly organised form, the crystalline. For there are seven such systems or styles of architecture of crystals, just as there are seven distinct notes in the musical octave, and seven chemical elements in the octave or period of Newlands and Mendeléeff, the eighth or octaval note or element being but a repetition on a higher scale of the first.

A crystal appeals to us in two distinct ways, first compelling our admiration for its beautifully regular exterior shape, and next impressing us with the fact of its internal homogeneity, expressed in the cases of transparent crystals by its perfect limpidity, and the obvious similarity throughout its internal structure. As it is with human nature at its best, the external appearance is but the expression of the internal character.

The purpose of this discourse is not so much to dilate upon the seven geometrical systems of crystals as to show how they are occasioned by differences in the internal structure, and to demonstrate this internal structure in an ocular manner, unfolding at the same time some interesting phases of recent investigation.

To the Greeks, whose wonderfully perfect knowledge of geometry we are ever admiring, the cube was the emblem of perfection, for like the Holy City, lying "foursquare," described in the inimitable language of the book of Revelation, "The length and the breadth and the height of it are equal." Moreover, even when we have added that all the angles are right angles, these are not the only perfections of the cube, for they carry with them, when the internal structure is developed to its highest possibility, no fewer than twenty-two elements (thirteen axes and nine planes) of symmetry.

At the other extreme is the seventh, the triclinic, system, in which the symmetry is at its minimum, neither planes nor axes of symmetry being developed, but merely parallelism of faces, sometimes described as symmetry about a centre, and in which there are no right angles and there is no equality among adjacent edges. Between these two extremes of maximum and minimum symmetry we have the five systems known as the hexagonal, tetragonal, trigonal, rhombic, and monoclinic, possessing, respectively, 14, 10, 8, 6, and 2 elements of symmetry. All crystals do not possess the full symmetry of their system, each system being subdivisible into classes possessing a definite number of the possible elements. Altogether there are thirty-two such classes, and their definite recognition we owe to the genius of von Lang and Story Maskelyne.

The characteristic property possessed in common by all crystals is that the exterior form consists of and is defined by truly plane faces, inclined, in accordance with one of the thirty-two classes of symmetry, at specific angles which are characteristic of the substance. This has only been proved to be an absolute fact within the last few years, although asserted by Haüy so long ago as the year 1783; for the numerous cases of so-called "isomorphous" salts, the first of which were discovered by Mitscherlich in the year 1820, were for long believed to be exceptions, and until the year 1890 no actual evidence one way or the other was forthcoming. But it was eventually shown that the crystals of the members of an isomorphous series did differ, both in their angles and in all their other crystallographic and physical properties, although in the cases of the angles the differences were very small. Moreover, the differences were shown to obey a simple but very interesting law, namely, that they were functions of the atomic weight of the chemical elements of the same family group the interchange of which gives rise to the series.

All crystals possess one other obvious property, that of homogeneity, and we now know that it is the character of the homogeneous substance which determines the external form. There are no fewer than 230 different kinds of homogeneous structures, neither more nor less, the elucidation of which we owe to the independent recent labours of Schönflies, von Fedorow, and Barlow; and it is a significant fact that the whole of them fall naturally into the thirty-two classes of crystals, leaving no class unaccounted for. Of these 230 modes of regular repetition in space fourteen are the space-lattices long ago revealed to us by Bravais, and all recent investigation concurs in indicating two facts, first, that it is the space-lattice which determines the crystal system, and second that it is the arrangement of the chemical molecules which is represented by the space-lattice. Each cell of the space-lattice corresponds to a molecule. The structure is certainly not solid throughout, however, part only being matter, and the rest æther-filled space, the relative proportions and the shape of the material portion being as yet unknown. We limit ourselves, therefore, to considering each molecule as a point, and we draw the lattice as a network of three systems of parallel lines, parallel to the directions of the three principal crystal edges, analogous, according to the system of symmetry, to

[1] Summary of evening discourse delivered before the British Association at Winnipeg on August 26 by Dr. A. E. H. Tutton, F.R.S.

those of the cube. The points of intersection we consider as those representing the molecules, inasmuch as any point within the limits of the cell may equally well be taken to represent the cell and the molecule, provided the choice is analogously made throughout the structure.

It has recently been found possible to determine the relative dimensions of these molecular cells, the distances of separation of the points of the space-lattice, in those cases where we know that the structure is similar, as in isomorphous salts; and the interesting discovery has been made that the "molecular distance ratios," as these space-dimensions are called, are functions of the atomic weights of the interchangeable members of the family of chemical elements constituting the series, just as the crystal angles have been shown to be.

We are now able, moreover, to take yet one further step, for the chemical molecules are composed of atoms, and it has been indubitably shown that the atoms occupy definite positions in the crystal. For when we replace, say, the alkali metal in a sulphate or selenate by another, we observe a marked alteration in the crystal angles and the molecular distance ratio along a particular direction, this direction being the same whichever metals of the group are interchanged; whereas if we replace the sulphur by selenium, a similar kind of alteration occurs, but along a totally different direction. Now we know that the atoms are arranged in the chemical molecule in what is known to chemists as their stereometric arrangement, depending on the maximum satisfaction of their chemical affinities. Hence this important experimental fact of the occupation by the atoms of definite positions in the crystal proves, first, the homogeneous similarity of arrangement of the molecules, and, secondly, explains why we have classes or subdivisions within the systems. For it is the arrangement of the atoms within the molecule which causes the variations of the degree of symmetry, within the limits prescribed by the system and space-lattice; in other words, which determines the class.

Now obviously any one of the atoms in the molecule may be chosen to represent the latter, and the points thus chosen analogously throughout the structure will constitute the molecular space-lattice. Hence the whole structure may be considered as made up of as many interpenetrating similar space-lattices as there are atoms in the molecule. The crystal structure will thus be dependent on two factors, the space-lattice and the scheme of interpenetration of the space-lattices, the former dominating the style of architecture, the crystal system, and the latter the vagaries of the style, the crystal class. Sohncke has shown that there are sixty-five such vagaries possible, which he terms regular point systems, and these coincide with sixty-five of the 230 possible modes of partitioning space.

These are the broad, simple facts, now proved up to the hilt, which explain the majority of crystal structures, all, in fact, but a very few, of the more complicated classes of the thirty-two. For the remaining 165 ways of appropriating space all fall into a very small number of crystal classes. They are of very great interest, however, and involve an entirely new principle, that of "reflective" or "mirror-image" symmetry, enantiomorphism as it is technically termed, and include those crystals which possess the remarkable property of rotating the plane of polarised light. These are the cases the geometrical possibility of which has been accounted for by the simultaneously independent work of Schönflies, von Fedorow, and Barlow, and to which we were experimentally introduced by the discovery of the right- and left-handed varieties of tartaric acid by Pasteur. The latter has since been followed by the revelation of many similar cases of two forms of the same chemical substance, related crystallographically and structurally like a right hand to a left-hand glove, and optically differing by the direction in which they rotate a beam of plane polarised light.

With their discovery and explanation the elucidation of the seven styles of crystal architecture and their thirty-two subdivisions becomes *un fait accompli*, and although many difficult problems still confront the crystallographer, problems of vast importance to chemistry, the groundwork is now securely laid, the memorable achievement of the last twenty years. The results, moreover, are in entire accordance with the now well-proved fact that the chemical atom is composed of electronic-corpuscles. For the definite orientation of the atom and its sphere of influence within the molecule and the crystal is thereby accounted for, the motion in the solid state so frequently hitherto attributed to the atom being a myth, such motion relating, in fact, to the corpuscles within the atom.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, August 23.—M. Bouquet de la Grye in the chair.—The calculation of the roots of numerical equations: M. **Lémeray**. Referring to a recent paper by M. de Montessus on this subject, the author points out that he published a method on the same principle in December, 1898.—Movements from the vertical due to the attraction of the moon and sun, the earth being supposed absolutely rigid: Ch. **Lallemand**.—A poison elaborated by yeast: A. **Fernbach**. It has been recently shown by F. Hayduck that there exists in the yeast cell a substance which is toxic to yeast. The present paper contains some new observations on the same subject. A solution of the toxic substance is shown, not only to be antiseptic to yeast cells, but also to bacteria such as *B. coli* and Staphylococcus, although it has no effect on moulds. The most remarkable property of this substance is that it is volatile under reduced pressure at a temperature not above 40° C. The distillate contains no formaldehyde; further researches on the nature of this substance are in progress.—The development of the eggs of *Philine aperta* exposed to the action of radium: Jan **Tur**.

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