groups of phenomena it is impossible for its holder to give a fair share to vulcanology alone. So far the only chair of vulcanology was that of Catania, which was so well occupied by the late Professor O. Silvestri and which after his premature death was abolished.

These are, therefore, the reasons why we shall give a course of lectures on vulcanology in the University of Naples. My lectures will not be simply theoretical ones, for we shall make a number of excursions into the surrounding volcanic districts, where we can examine the phenomena and materials as they occur.

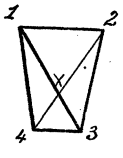
STEREOCHEMICAL THEORY.

BY T. PROCTOR HALL, PH.D., TABOR, IOWA.

In the September number of the Journal of the Chemical Society Mr. S. U. Pickering points out that the fundamental idea of the tetrahedral arrangement of atoms about a carbon atom is that of the most symmetrical arrangement of four spheres about a fifth central sphere, and that the same principle leads to a triangular arrangement about triad nitrogen and a hexagonal arrangement about pentad nitrogen. In the case of the carbon atom this idea has proved so satisfactory that we are naturally anxious to see it tested in regard to all the other atoms. It is not, indeed, to be expected that the actual relations of atoms in three-fold space can be perfectly represented by any theory which takes account only of such relations as can be expressed in a two-fold diagram. Hence, stereochemistry will inevitably become more and more prominent as our knowledge of molecules increases. It may be worth while, therefore, to consider more fully than appears to have yet been done the arrangements which the application of the same fundamental idea require for other atoms having higher atomicities. In the following list the number of possible isomers of each kind is given. I have made no attempt to compare these with the facts; indeed that may not be possible as yet in many cases; but if the fundamental stereochemical idea is to be fairly tested, one of the first necessities is that the logical conclusions from it should be fairly and fully stated, and this I have tried to do.

In the formulæ following M stands for the central atom, whose valance is given; A, B, C, etc., stand for monovalent elements or groups about M whose places in the diagram are indicated by the order of their positions in the formula. For example, MBA_2CB means that about M are grouped two atoms or groups of the kind A, taking the positions marked 2 and 3 in the diagram, two of the kind B in the positions 1 and 5, and one of the kind C in the position 4.

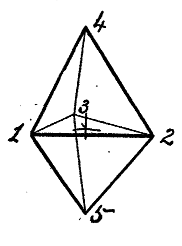
1. A Tetravalent atom may form the basis of two isomeric molecules, namely:



$$\begin{array}{c} M^{iv} \\ (2) \end{array} \left\{ \begin{array}{l} ABCD \\ ABDC. \end{array} \right.$$

2. Pentavalent atoms,—Hexahedron.

$$\begin{array}{c} M^{v} \\ (2) \end{array} \left\{ \begin{array}{l} AB_4 \\ B_4A. \end{array} \right.$$



$$\begin{array}{c} M^{v} \\ (4) \end{array} \left\{ \begin{array}{l} ABC_3 \\ AC_3B \\ C_3AB \\ BC_3A. \end{array} \right.$$

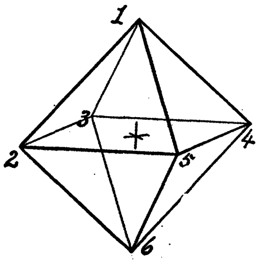
$$\begin{array}{c} M^{v} \\ (3) \end{array} \left\{ \begin{array}{l} A_2B_3 \\ AB_3A \\ B_3A_2. \end{array} \right.$$

$$\begin{array}{c} M^{v} \\ (6) \end{array} \left\{ \begin{array}{l} AB_2C_2 \\ AC_2B_2 \\ ABC_2B \\ ABCBC \\ B_2\,C_2\,A \\ C_2\,B_2\,A \end{array} \right.$$

$$\begin{array}{c} M^{v} \\ (20) \end{array} \left\{ \begin{array}{l} ABCDE \\ ABCED \\ ABDCE \\ ABDEC \\ ABECD \\ ABEDC \\ ACDBE \\ ACDEB \\ ACEBD \\ ACEDB \\ ADEBC \\ ADECB \\ BCDAE \\ BCDEA \\ BCEAD \\ BCEDA \\ BDEAC \\ BDECA \\ CDEAB \\ CDEBA. \end{array} \right.$$

$$\begin{array}{c} M^{v} \\ (10) \end{array} \left\{ \begin{array}{l} ABCD_2 \\ ABDCD \\ ABD_2\,C \\ ACDBD \\ ACD_2\,B \\ AD_2\,BC \\ BCDAD \\ BCD_2\,A \\ BD_2\,AC \\ CD_2\,AB. \end{array} \right.$$

3. Hexavalent atoms,—Oktahedron.



$$\begin{array}{c} M^{vi} \\ (2) \end{array} \left\{ \begin{array}{l} A_2\,B_4 \\ AB_4A. \end{array} \right.$$

$$\begin{array}{c} M^{vi} \\ (2) \end{array} \left\{ \begin{array}{l} A_3\,B_3 \\ A_2\,B_3A. \end{array} \right.$$

$$\begin{array}{c} M^{vi} \\ (2) \end{array} \left\{ \begin{array}{l} ABC_4 \\ AC_4B \end{array} \right.$$

$$\begin{array}{c} M^{vi} \\ (3) \end{array} \left\{ \begin{array}{l} AB_2\,C_3 \\ ABC_3B \\ ABCDC_2\,. \end{array} \right.$$

$$\begin{array}{c} M^{vi} \\ (8) \end{array} \left\{ \begin{array}{l} ABC_2\,D_2 \\ ABCD_2\,C \\ ABCDCD \\ ABD_2\,C_2 \\ ABDC_2\,D \\ ABDCDC \\ AC_2\,D_2\,B \\ ACDCDB \end{array} \right.$$

$$\begin{array}{c} M^{vi} \\ (6) \end{array} \left\{ \begin{array}{l} A_2\,B_2\,C_2 \\ A_2\,BCBC \\ A_2\,BC_2\,B \\ A_2\,CBCB \\ AB_2\,C_2\,A \\ ABCBCA. \end{array} \right.$$

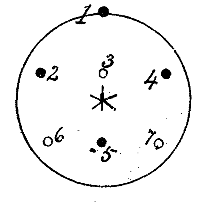
$$\begin{array}{c} M^{vi} \\ (15) \end{array} \left\{ \begin{array}{l} ABCDE_2 \\ ABEDCE \\ ABDCE_2 \\ ABECDE \\ ABCEDE \\ ABDECE \\ ABCE_2\,D \\ ABE_2\,CD \\ ABECED \\ ABDE_2\,C \\ ABE_2\,DC \\ ABEDEC \\ ACDE_2\,B \\ ACE_2\,DB \\ ACEDEB \end{array} \right.$$

$$\begin{array}{c} M^{v} \\ (5) \end{array} \left\{ \begin{array}{l} ABCD_3 \\ ABD_2\,CD \\ ABDCD_2 \\ ABD_3C \\ ACD_3B. \end{array} \right.$$

$$\begin{array}{c} M^{vi} \\ (30) \end{array} \left\{ \begin{array}{l} ABCDEF \\ ABEDCF \\ ABCEDF \\ ABDECF \\ ABDCEF \\ ABECDF \\ \text{and similarly} \\ \text{A———E (six forms)} \\ \text{A———D ``} \\ \text{A———C ``} \\ \text{A———B ``} \end{array} \right.$$

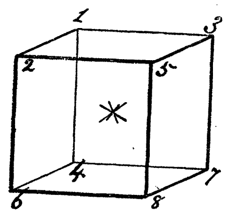
4. Heptavalent atoms,—Irregular.

The nearest possible approach to a regular arrangement of seven atoms around one is perhaps that indicated in Figure 4, in which one atom is above M, three others are at the corners of a horizontal triangle and the remaining three at the corners of a lower triangle alternate with the first. These positions are here assumed only for the sake of the symmetry that then appears with reference to the position 1. A very small change of positions will suffice to make the same symmetrical arrangement with reference to any of the other positions 2, 3, 4, 5, 6, 7; and it is assumed that so much motion may take place that only one form of the molecule MAB_6 is possible. Under such conditions the prediction of isomeric forms is largely guess work; but the following, which include most of the forms actually found, seem probable:



$$\begin{matrix}M^{vii}\\(2)\end{matrix}\left\{\begin{array}{l}A_2\,B_5\\AB_5A.\end{array}\right.\qquad\begin{matrix}M^{vii}\\(3)\end{matrix}\left\{\begin{array}{l}B_4A_3\\BA_3B_3\\AB_4A_2.\end{array}\right.$$

5. Oktavalent atoms,—Cube.



$$\begin{matrix}M^{viii}\\(3)\end{matrix}\left\{\begin{array}{l}A_2\,B_6\\AB_5AB\\AB_6A.\end{array}\right.$$

$$\begin{matrix}M^{viii}\\(3)\end{matrix}\left\{\begin{array}{l}A_3B_5\\A_2\,B_5\,A\\AB_3ABAB.\end{array}\right.$$

$$\begin{matrix}M^{viii}\\(7)\end{matrix}\left\{\begin{array}{l}A_4B_4\\A_3BAB_3\\AB_3A_3B\\A_2\,B_2\,AB_2\,A\\A_2\,B_3ABA\\A_3B_4A\\A_2\,B_4A_2.\end{array}\right.$$

$$\begin{matrix}M^{viii}\\(3)\end{matrix}\left\{\begin{array}{l}ABC_6\\AC_3BC_3\\AB_6B.\end{array}\right.$$

$$\begin{matrix}M^{viii}\\(22)\end{matrix}\left\{\begin{array}{l}A_2\,B_2\,C_4\\A_2\,BCBC_3\\A_2\,BC_2\,BC_2\\A_2\,BC_3\,BC\\A_2\,BC_4B\\A_2\,CB_2\,C_3\\A_2\,C_2\,BCBC\\A_2\,C_2\,BC_2\,B\\A_2\,C_4B_2\\ABC_2\,ABC_2\\AC_3\,ABCBB\\AC_3\,ACB_2\\AB_2\,CAC_3\\AC_3\,AB_2\,C\\AC_2\,BAC_2\,B\\ABCBAC_3\\ACB_2\,AC_3\\ACBCABC_2\\ABC_2\,BC_2\,A\\ABC_3\,BCA\\AB_2\,C_4A\\ABC_4BA.\end{array}\right.$$

$$\begin{matrix}M^{viii}\\(7)\end{matrix}\left\{\begin{array}{l}AB_2\,C_5\\ABC_2\,BC_3\\ABC_3\,BC_2\\ABC_4BC\\ABC_5B\\AC_3\,B_2\,C_2\\AC_5B_2\,.\end{array}\right.$$

$$\begin{matrix}M^{viii}\\(13)\end{matrix}\left\{\begin{array}{l}AB_3\,C_4\\AB_2\,CBC_3\\AB_2\,C_2\,BC\\AB_2\,C_3\,BC\\AB_2\,C_4B\\ABC_2\,B_2\,C_2\\ABC_2\,BCBC\\ABC_3\,B_2\,C\\AC_3\,B_3\,C\\AC_3\,B_2\,CB\\AC_2\,B_2\,C_2\,B\\AC_2\,BCBCB\\AC_2\,BC_2\,B_2\,.\end{array}\right.$$

$$\begin{matrix}M^{viii}\\(24)\end{matrix}\left\{\begin{array}{l}A_2\,B_3\,C_3\\A_2\,B_2\,CBC_2\\A_2\,BC_3\,B_2\\A_2\,CBC_2\,B_2\\A_2\,B_2\,C_2\,BC\\A_2\,C_2\,B_2\,BC\\A_2\,BCBCBC\\A_2\,CBCB_2\,C\\A_2\,BC_2\,B_2\,C\\A_2\,CB_2\,CBC\\AB_3\,AC_3\\ACB_2\,ACBC\\ACB_2\,ABC_2\\ABCBACBC\\ABCBABC_2\\AC_2\,BAB_2\,C\\ACB_2\,AC_2\,B\\AC_2\,BACB_2\\ABC_2\,AB_2\,C\\AB_2\,CACB_2\\AB_3\,C_3\,A\\AB_2\,CBC_2\,A\\AB_2\,C_2\,BCA\\AB_2\,C_3\,BA.\end{array}\right.$$

The possible isomers of more complex molecules of this class are very numerous. But there is no advantage in writing them out since they are not found in practice.

When divalent or trivalent atoms or groups replace two or three monovalent atoms in the preceding formulæ, the possible forms are in all probability restricted to those in which the replaced atoms are adjacent to one another. The molecule $P^{v}NO$, for example, is of the form $M^{v}A_2\,B_3$, but only one of the three isomeric forms given in the table is in this case possible.

If there were examples of still higher valence there would be no regular arrangement possible until twelve atoms were arranged about the central atom, and these twelve would crowd one another or be necessarily so much closer to one another than to the central atom that the form would be unstable. The same cause of instability would of course prevent the formation of molecules in which more than twelve atoms are grouped about one. We have then a plausible reason why valence should not exceed the number eight.

A possible explanation of the fact that elements having odd valence remain odd and those having even valence remain even may be found in the supposition that atoms whose valence is even are symmetrical while those having odd valence are asymmetrical,—that is to say, the latter have their centre of attractive force for other atoms not coincident with their centre of gravity; and on the farther supposition that in order to form a stable compound the atoms must form a more or less symmetrical arrangement about the central atom. An atom having odd valence will then attract one other atom and form with it a symmetrical molecule. A farther addition of one atom destroys the symmetry. The addition of a third restores it. So that if symmetry is a necessary condition of stability the valence must increase by twos. On this hypothesis the stereochemical structure of molecules whose central atom has odd valence will be entirely different from what is represented in the preceding diagrams. The anomaly of chlorine, whose most stable oxygen-acid (per-chloric acid) is the one whose molecule appears most irregular in the above diagrams, disappears, and the arrangement required for the molecule of perchloric acid is perfectly regular. The arrangements for the odd valences, in fact, become the same as for the even valences of the next higher order with the omission of one point whose place is supposed to be (in part) occupied by the asymmetry of the central atom. In some cases the number of isomers possible on this theory differs from the number given in the preceding table. Such cases may decide which (if either) of the views here presented is preferable.

BOOK-REVIEWS.

Investigations on Microscopic Foams and on Protoplasm: Experiments and Observations directed towards a solution of the question of the physical conditions of the phenomena of life. By O. Bütschli, Professor of Zoology in the University of Heidelberg. Authorized Translation, by E. A. Minchin, B.A. (Oxon.), Fellow of Merton College, Oxford. London, Adam and Charles Black, 1894. 1 vol., 8vo, xvi, 379 p., with xii plates.

THIS is an attempt to determine the character of protoplasm, by analogical reasoning from the microscopical appearance and behavior, in water, of drops of oil containing soluble substances, such as salt or sugar, which, by their attraction for the water, cause it to enter into the oil and produce a solution which fills and expands the cavities previously occupied by the salt or other substance, thus converting the oil into a fine froth.