

On the stronger fulcrum for support afforded by the leaf-partitions of *Myriophyllum*, the illoricate species *Codosiga pulcherrima* (Plate 1, Fig. 9) is often present in great profusion, its sociable pedicellate colonies being so thickly placed as to present the appearance of a perfect little forest of crystal-fruited trees. More rarely, under similar conditions, the extremely elegant and symmetrically tripartite branching pedicellate form *Codosiga umbellata* (Plate 1, Fig. 4) may be likewise met with.

At the outset, considerable difficulty will doubtless be experienced in the satisfactory definition of the hyaline collar characteristic of all the members of this group, a most careful manipulation of the light being often requisite to show this structure to advantage. It frequently happens again that when the entire contour of the wineglass-shaped collar is not to be distinguished, its presence is indicated by the clearer outline of its two lateral margins, which, standing out at an acute angle from the perpendicular line formed by the central flagellum, present the aspect of two additional hair-like processes. The appearance of this organ, when seen as described in the last sentence, is indicated at Plate 2, Fig. 41, illustrative of the so-called "animalcule with ear-like processes," figured many years since by Mr. Carter, but which undoubtedly represents a species of *Salpingoeca* with the characteristic collar indistinctly seen. In a similar manner other species now shown to belong to this newly discovered collar-bearing group have from time to time been imperfectly figured by various authorities, who, when encountering them, have not employed sufficient magnifying power or that mode of illumination requisite for the interpretation of their true character.

Having, with the assistance of these few hints, made himself familiar with but two or three only of the interesting types here introduced to his notice, the investigator will experience but little difficulty in extending the circle of his acquaintanceship with the same, and can scarcely fail before long to become so absorbed in admiration of the infinite variety of form and vital phenomena they present, as to regard as lost any further time bestowed on the markings of either Diatoms or Podura scales—*et hoc genus omne*.

THE SYNTHESIS OF THE LICHENS.

The greenish or yellowish membranes which are found attached to trunks of trees, the gray spots which cover rocks, the curious vegetable substance which adheres to the boughs of oaks and firs, or sometimes appears on the ground like the mosses, constitute the large family of cryptogams known as Lichens. The study of these growths offers many difficulties, and it is comparatively recently that their organization and strange mode of life have been revealed. Their man-

mushroom spores which under analogous conditions will germinate. Now, by studying comparatively the green gonidia of a large number of lichens and the inferior unicellular or filamentous algae which grow on rocks and trees, M. Schwendener has discovered that each gonidia of the lichens corresponds to an absolutely identical free alga. The alga it will be remembered are a large family of cryptogams, including the sea weeds and a number of species which grow on rocks and trees, deriving their moisture from the air. Thus, for example, M. Schwendener has shown that the nostocs (Fig. 1, B), which are small fresh water algae which form blackish green masses at the bases of trees,

and thus definitely establishing the constitution of the lichens.

These curious organisms, therefore, offer one of the rare natural examples of a community of two absolutely different species maintained to the benefit of both. Nor does the utility of the association stop with the interchange of nourishment. The alga, when set at liberty, requires great atmospheric humidity. A single ray of sunlight falling on the green covered trunk of a tree of the small *Pamella* algae is often sufficient to dry them up and kill them; while if these same *Pamella* are associated with a fungus, to make a lichen of which they constitute the gonidia, the coherent

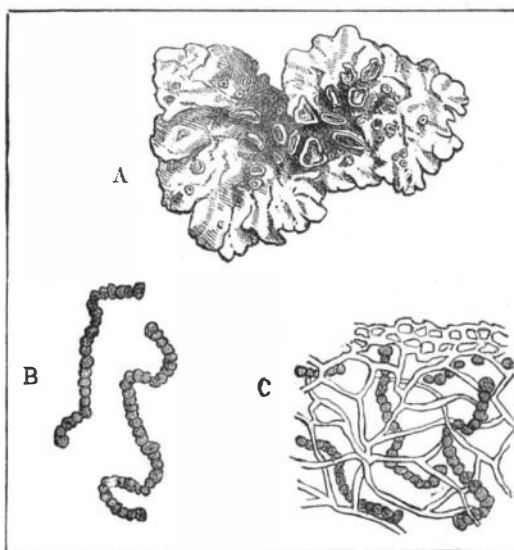


FIG. 1.

rocks, and walls, are in all respects similar to the gonidia of the *Collema*, Fig. 1, C. Another alga much more common, which covers with green the moist trunks of all trees, has the same form as the gonidia of the *Endocarpon*.

From his investigations M. Schwendener has determined a theory of the constitution of the lichen, which he considers not to be a vegetable species but the association of two different species—the alga and the fungi. Lichen gonidia, he says, are algae, and the fungus is a parasite of the latter, which it surrounds with its filaments. It takes from the alga carbon which it assimilates for the entire colony, by means of the green chlorophyll which it contains. The *Collema* (Fig. 1, C) would thus be the association of an ascomycetes fungus and the alga *Nostoc*; the *Endocarpon* that of another fungus and the alga *Cystococcus*. The alga can live alone; the fungus cannot. Without the alga the spores of the latter become abortive, whence it would seem that the fungus is a parasite of the alga, although in reality if this is true the reverse also exists, as we shall presently see. If the alga is useful to the fungus, so is the fungus to the alga. It may assimilate nitrogen directly, for example, and furnish it to the alga, while the latter returns in exchange the starch which it abundantly forms. There therefore exists between the two associates an amicable interchange of nitrogenous and hydrocarbon matters.

In order to verify M. Schwendener's theory, the result of analysis, synthesis is the best means. That is to say it is necessary to determine whether with a fungus spore and an alga a lichen can be produced showing all the characteristics of those of natural growth. Experiments in this direction have been made by Messrs. Rees, in Germany, and Bornet, in France. Rees has formed a gelatinous mass analogous to a true *Collema* by causing the spores of the *Collema glaucescens* to germinate on the *Nostoc lichenoides*, but he obtained no fructifications, and hence his synthesis was not complete.

Bornet has made a number of incomplete recompositions, and among them one very interesting experiment. The *Endocarpon minutum* has gonidia which resembles the alga *Cystococcus*. In order to determine whether the identity exists M. Bornet has extracted these gonidia from the tissue of the lichen and has succeeded in keeping them living and self-multiplying for more than a year. To all these experiments, however, the objection may be urged that the artificial lichens have never fructified and that the cycle has never been completed from spore to spore. More recent investigations have however removed this difficulty, and the hypothesis of Schwendener has been reduced to practical certainty by the late work of M. E. Stahl.

An account of his labors has recently been published in *Leipziger*, and an abstract of them appears in *La Nature*, to which journal we are indebted for the illustrations given herewith.

Returning to the section of the lichen *Endocarpon* represented in Fig. 2, A, it will be observed that in the cavity in which the spore bearers exist there are numerous little points surrounding the latter. These are gonidia of the same form as those of the vegetable tissue, but smaller. Not being in contact with the fungus filaments they do not exchange nourishment with them, and hence are less developed. They accumulate however around the spore cellules as the latter become ripe, and as fast as the spores leave the membranes which envelope them, these little gonidia accompany them. A mixture is thus formed of fungus spores and partially developed gonidia which escape at the maturity of the fructification of the lichen, Fig. 3, A. Placed in exterior favorable conditions this mixture goes on to develop. The small unicellular algae attach themselves to the spores and take nourishment while giving back support through the action of their green parts under the influence of light, Fig. 3, B. Each spore emits on all sides cylindrical filaments which develop themselves around it, and these elongate more and more, unite, and envelop the small algae which they meet until a definite association is established.

It is not at all necessary that the small algae should come from the same lichen as the spores. M. Stahl has succeeded in producing the same development with other gonidia and other algae.

Meanwhile the white fungus tubes continue to increase more and more, while the algae multiply and each separates into three or four others. Then a sort of regularization takes place in the entire colony, all the algae uniting themselves into a false median tissue. On one side this green mass is covered with a colorless membrane; on the other all the elongated filaments of the fungus take the largest proportions, Fig. 4. Here culture on glass is arrested, but if the initial sowing is done on moist earth development continues, and M. Stahl has reconstituted the *Endocarpon* analogous to that in Fig. 2, completing the entire cycle of transformations

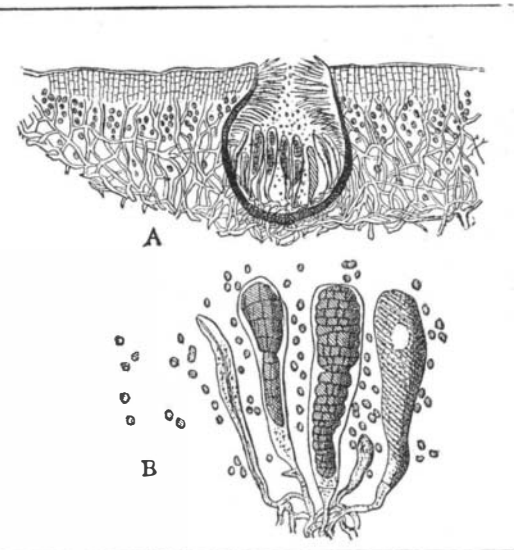


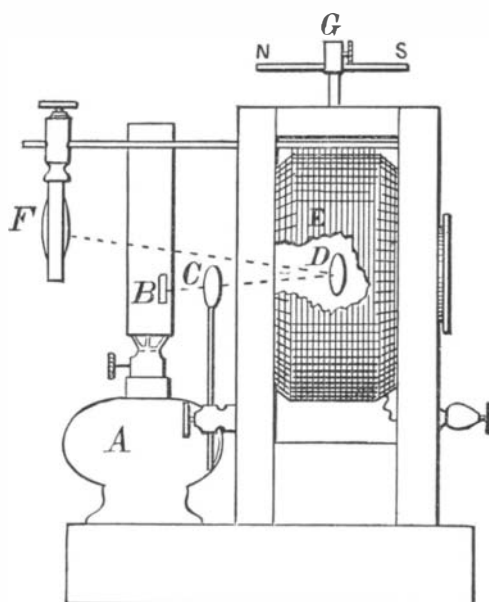
FIG. 2.

mass of tissue retains its humidity for a long time, and thus sustained and protected the alga is able to keep its vitality despite surrounding dryness. With regard to the fungus, we have seen that the alga not only furnishes it with carbon, but it is often indispensable to the germination and always to the fructification of the former.

CONVENIENT ARRANGEMENT OF THE MIRROR GALVANOMETER.

By A. FLOYD DELAFIELD.

THE mirror galvanometer is universally recognized as the most delicate instrument of the kind. It is used for electrical measurement, and also on account of its showing the presence and direction of very feeble currents as a receiving instrument on the Atlantic cable. In its ordinary form it consists of a coil of fine insulated copper wire wound round a brass or copper tube, in which a thin mirror is suspended by a fiber of silk. To the back of this mirror are fastened two or three little magnets. A convex lens can be moved back and forth in the tube. In order to use this form of galvanometer it is necessary to have a screen of peculiar construction. It is a board about two feet long and ten inches high, which is placed in front of the instrument at a distance of two or three feet, standing at right angles to the axis of the coil. A scale of equal parts is fastened to the board, and below the center of the scale is a slit behind which stands a lamp. The light from the slit is reflected from the mirror, and an image of the slit is formed on the scale. For many purposes, and especially for lectures, the screen with a lamp behind it is inconvenient. The object of the ar-



NEW MIRROR GALVANOMETER.

angement here described is to dispense with this screen and use a blackboard or other surface usually found in lecture rooms. For this purpose the lamp is placed on the base of the instrument. An ordinary little kerosene night-lamp, A, is taken, and the chimney removed and replaced by a brass tube two or three inches long, in which is cut a small slit, B. A mirror, C, is placed so as to reflect the light from this slit upon the magnet mirror, D, within the coil. This mirror is of microscope glass, silvered on the back, and to the back of it are fastened with shellac four pieces of No. 11 sewing needle, which are all magnetized in the same direction. A convex lens, F, of 6" or 7" focus, can be moved along a rod projecting from the frame of the instrument. At the top of the frame a small magnet, G, is placed, which is used to bring the suspended mirror at right angles to the axis of the coil. The instrument is placed on a lecture table facing the blackboard, which should be chalked or covered with white paper where the image is to fall. On darkening the room and adjusting properly the lens and directing magnet, a magnified image of the slit will be seen on the board. An instrument of this pattern with a coil of one pound of No. 28 wire was placed seven feet from a blackboard. The

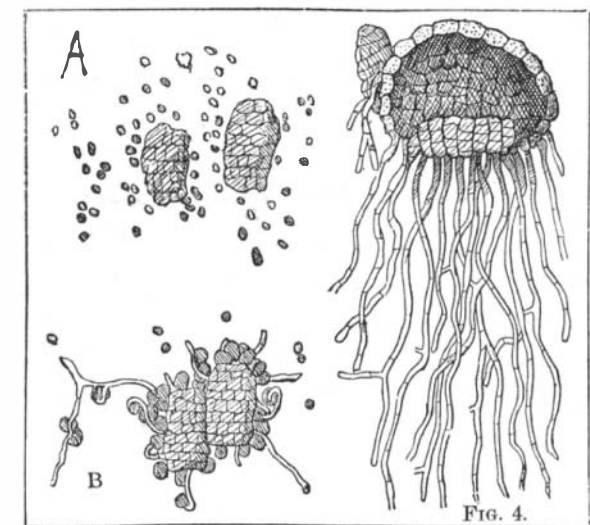


FIG. 3.

ner of fructification prevents their being separated from the fungi, and yet the large number of green chlorophyll cellules which they contain places an obstacle in the way of this classification, for fungi are never green.

The organization of the lichen may be seen by examining microscopically two species, the *Collema* and *Endocarpon*, a thin section being cut through the tissues of each perpendicularly to their flattened surface. These sections are represented in Figs. 1, C, and 2, A. In both of these lichens there is seen in the middle portion whitish filaments which interlace, forming a closer network as the edges are neared. In the midst of these filaments, which resemble those of the mushroom, can be seen scattered cellules round in shape and green in color. In the *Endocarpon*, Fig. 2, A, these cellules are isolated, while in the *Collema*, Fig. 1, C, they form small garlands which wind in and out of the meshes of the filaments. To these cellules the name *gonidia* has been given, and through the action of their chlorophyll they fix the carbon of the carbonic acid of the air, under the influence of light, and so enable the vegetable to live independently and not as a parasite after the manner of the fungi. As the structure of the filamentous network may be very different in different species of lichens, so also may the forms of the gonidia vary. They may be simple small unicellular grains as in the *Endocarpon*, sometimes cubical, oval, or in parallelopiped form, or they may be cylindrical or arranged in chaplets, as already noted.

The fructification of the lichen as shown in the *Endocarpon* section resembles that of some of the fungus family, notably the moielles and truffles. Here and there are found salient portions (Fig. 1, A) brilliantly colored in yellow or red. In other parts these become simply dark spots indicating the place where the reproductive apparatus exists. Generally there is a cavity hollowed in the mass of the lichen (Fig. 2, A) containing in the midst of its cylindrical filaments a certain number of long cellules larger at the summit than at the base—within these elongated pear-shaped parts the spores are formed. If the successive development of the fructifying material be studied, the contents of the special cellules will be seen to separate into a certain number of small masses which detach themselves from the sides and eventually are set at liberty by the destruction of a part of the membrane which contains them.

Here, however, a curious anomaly is encountered. If the naked spores be placed on the bark upon which the parent lichen normally grows, no matter what the conditions of heat and humidity may be they will not reproduce a new lichen—and in this respect they differ altogether from the

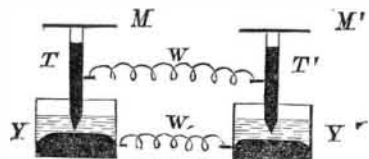
battery used was a copper cup the size of a percussion cap, containing a drop or two of diluted sulphuric acid into which dipped a little zinc spiral. With this battery and an interpolated resistance of 9,000 ohms, a resistance one-eighth greater than that of the Atlantic Cable, a large deflection was obtained.

THE TELEPHONE.

A MODIFICATION of the telephone is described in the *Moniteur Industriel Belge*. The receiving instrument is in all respects identical with that known as Professor Bell's. The transmitting instrument is thus constructed: The bobbin of wire in the ordinary instrument is dispensed with, and the magnetized core replaced by a bar or screw of copper. This is brought as closely as possible to the vibrating iron disk. The copper is connected with one pole of a battery, the other pole being to earth. The vibrating disk is connected with the line wire, which is attached at the other end to the receiving instrument, the circuit of course being completed through the earth.

BREGUET'S TELEPHONE.

M. BREGUET has invented an entirely novel telephone, based on the principle of Lippmann's electro-capillary electrometer. The transmitter and receiver are exactly alike, and each consists simply of a glass vessel containing a layer of mercury over which floats a layer of acidulated water. Into this water dip the point of a glass tube containing mer-



cury. The upper part of the glass tube contains air, and may be open to the atmosphere or closed by a plate or diaphragm capable of vibrating. The circuit is formed by connecting up the mercury in the tube of the transmitting telephone with that in the receiver, and also the mercury in the vessel of the transmitter with that in the receiver. When one speaks over the top of the tube of the transmitter the vibrations of the air are transmitted through the mercury to the point of the tube where the mercury makes contact with the acidulated water of the vessel by the fine capillary bore of the tube. Here the electro-capillary action takes place, the vibratory motions of the mercury generating electro-capillary currents which traverse the circuit to the receiver, and by a reverse process reproduce the air vibrations at the top of the tube of the receiver. M. Breguet says that this telephone, unlike Professor Bell's, is capable of reproducing not only oscillatory motions of the air, but of reproducing the exact range of the most general movements of the vibratory plate. A portable form of this instrument, constructed by M. Lippmann, consists of a fine glass tube several centimeters long, containing alternate drops of mercury and acidulated water, so as to form an electro-capillary series. It is sealed at the ends, by which two platinum wires make contact with the terminal mercury drops. A *rondelle* of firwood is fixed normally to the tube by its center, and gives a larger surface for the voice to act against, so as to furnish more motion to the tube when it acts as a transmitter, and be easily applied to the ear when it is a receiver.

M. Breguet claims for this telephone that it will act through submarine cables with instantaneous effect, because it will only establish *variations of potential* at the sending end of the line, and, unlike other telephones, will not generate *currents* to flow through the line. But this claim does not appear to us to be justifiable, since currents must result in the line from the variations of potential set up, and if there is to be any communication at all, they must travel throughout the length of the cable from end to end.

THE ZODIACAL LIGHT.

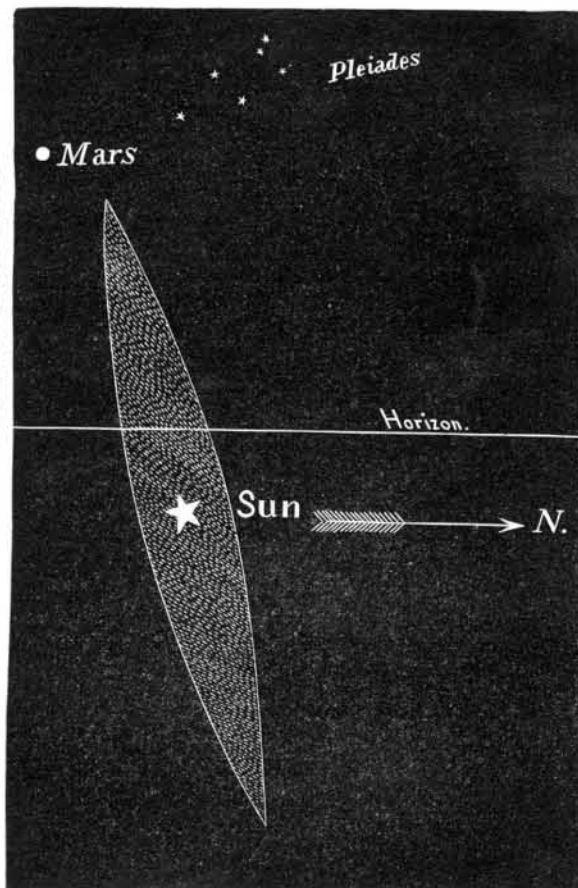
By PROF. C. W. PRITCHETT.

SOME of our recent clear nights have afforded fine opportunities to see this phenomenon at its best. It is, however, really surprising that so few persons ever see it during their whole lifetime. As I write for students and general readers rather than for astronomers, this note is made in the hope of inciting attention to something very easily seen and still very curious.

The Zodiacal Light, first so called by J. D. Cassini, in 1683, is apparently a faint luminous cone, whose axis extends from the sun, along the plane of the sun's equator, to a distance of from 30° to 105° from the center of the sun. The variable length of the axis is *apparent*, not *real*, and is due to the varying inclination of the sun's equator to our horizon at different seasons of the year. The light is brightest and is recognized as extending further from the sun the more nearly its axis is perpendicular to our horizon. For hundreds of years to come this season will be March and April for the western sky and September and October for the eastern sky. Any one may illustrate for himself, in two minutes, the *varying* position of this conical axis of light, by revolving a celestial globe, previously adjusted to the latitude of his position. In a minute he can see that the ecliptic makes the largest angle with the horizon when the *equinoxes* are in the horizon; and since the sun's equator is only inclined 7½° to the ecliptic, the projected equator of the sun will make its *largest* angle with the horizon nearly at the equinoxes; and, therefore, we *then* see the luminous cone most nearly perpendicular to our horizon. The apparent breadth of the conical base varies from 8° or 10° to 20° or 25°, as we see it more or less obliquely. It is brightest near the horizon, and fades away by insensible gradations toward the vertex. The light resembles that of the Milky Way or that of the tail of a faint comet. During last week the vertex was near the planet Mars, and a little west of the Pleiades. The accompanying figure will show its form and relation to the sun, our horizon, Mars and the Pleiades, at 7½ hours mean time, February 28. Its *form* is that of an excessively oblate spheroid or lens-shaped body. The *figure* will be recognized as a plane section of the spheroid, made through the center of the sun and at a right angle to our axis of vision.

Many speculations have been hazarded concerning its nature. Kepler thought it might be the solar atmosphere, but La Place showed this hypothesis to be untenable for these two reasons: 1. The solar atmosphere cannot extend beyond the

distance at which the centrifugal force, due to rotation, would be balanced by the sun's attraction. This point lies within the orbit of Mercury, or within less than 28° from the sun. 2. The ratio of the axes of the spheroid of atmosphere must be within these limits, Major: Minor:: 3: 2, while the *actual* ratio is incomparably greater. Cassini thought it might be the blended light of an innumerable number of very minute bodies revolving round the sun. Euler thought it proceeded from the repulsive energy of the sun, after the



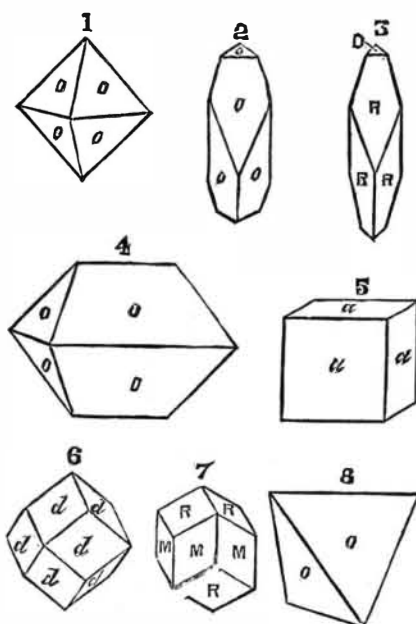
manner of comets' tails. Sir John Herschel says: "It may be conjectured to be no other than the *denser parts* of that medium which we have some reason to believe resists the motion of comets, loaded, perhaps, with the actual materials of the tails of millions of these bodies, of which they have been stripped in their successive perihelion passages." In conclusion, it is but right to state that *trustworthy* observers have testified to the *simultaneous* presence of the luminous cone in both western and eastern sky. See *Gould's Ast. Journal*, No. 84, for May, 1855; also *Monthly Notices R. A. S.*, vol. xvii., and Fourth Ed. U. S. Exploring Narrative, Washington, 1856. Of the same tenor is a communication of Humboldt to the Berlin Academy, July, 1855. Mr. Jones, Chaplain of the U. S. steam frigate Mississippi, during a cruise round the world, had *very rare* opportunities for observing the zodiacal light in all latitudes, and seems to have improved them very diligently. He remarks: "It seems to me that these data can be explained only by the supposition of a nebulous ring, with the *earth for its center*, and lying within the orbit of the moon."—*Western Review*.

STUDY OF CRYSTALS.

By J. H. COLLINS, F.G.S.

(A.) COMPARISON OF FORMS.

THE bounding planes of crystal forms are usually referred to six distinct "systems" of axes, in which the axes vary in length, relative position, and number. The essential characters of these systems are defined in all mineralogical text-books, and will not be referred to here. The object of the present arti-



cle is to call attention to certain resemblances which exist between forms and combinations belonging to distinct systems, and to suggest certain observations on such "deceptive forms" which may be made by students who find themselves involved in difficulties.

1. *The Regular Octahedron* (Fig. 1).—The following forms closely resemble the regular octahedron, and may even be absolutely indistinguishable from it when the several axes happen to be nearly equal, or when the cubical form happens to be somewhat unequally developed or distorted:

- The tetragonal pyramid, 111.
- The tetragonal pyramid, 101.
- The hemihedral form of the ditetragonal pyramid π k l.
- The rhombic pyramid, 111.
- The rhombic combination, 101,011.
- A peculiar combination of a rhombohedron with the basal plane sometimes observed in *chalybite*.

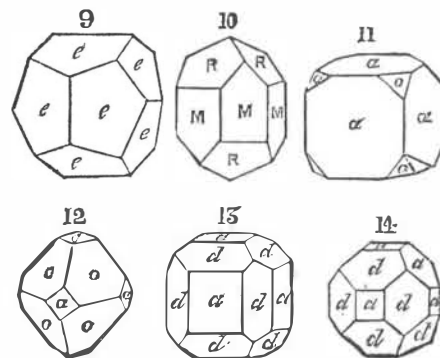
2. Irregularly Developed Octahedrons.

- The acute rhombohedron, which may be cleared from fluor by omitting one pair of faces of the octahedron, exactly resembles the acute rhombohedron sometimes seen in *calcite* and *chalybite*.
- The combination (Fig. 2) sometimes seen in spinel much resembles the acute rhombohedron, with basal plane (Fig. 3) observed in *calcite*.
- The irregularly developed octahedron (Fig. 4) often seen in *alum* exactly resembles the rhombic combination 102,011 (macrodomes with brachydomes), which is sometimes called the rhombic pyramid on square base.

3. *The Cube* (Fig. 5).—The following forms may closely resemble it:

a. TETRAGONAL FORMS.

- The square tetragonal prism of 1st order, 110,001.
- The square tetragonal prism of 2d order, 101,001.
- The hemihedral form of the ditetragonal prism, 1m0,001.



β. RHOMBIC FORMS.

- The rectangular prism, 101,010,001.
- The prism, 110,001.
- The "macrodomes," 0kl,100.
- The "brachydome," h0l,010.
- The "brachy prism," 1k0,001.

γ. HEXAGONAL FORM.

- The rhombohedron, when the angles differ but little from right angles.

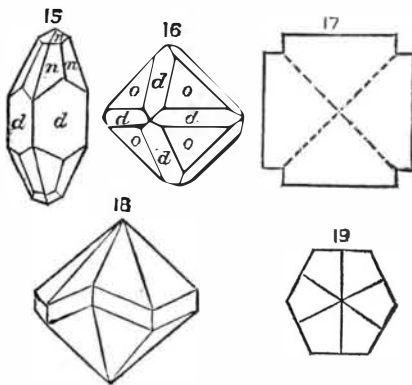
4. *The rhombic dodecahedron* (Fig. 6) closely resembles the hexagonal combination of prism and rhombohedron (Fig. 7) sometimes seen in *calcite*.

5. *The tetrahedron* (Fig. 8) often closely resembles the tetragonal sphenoids which are the hemihedral developments of the tetragonal pyramids, 1a and 1b. Such sphenoids are often seen in the chalcoprite from the mines near Redruth.

6. The pentagonal dodecahedron (Fig. 9) very closely resembles the hexagonal combination of prism and rhombohedron (Fig. 10).

7. Combinations of the cube with the octahedron (Figs. 11 and 12) very closely resemble combinations of a tetragonal prism with a pyramid of a different order—either 110,001,101 or 100,001,111. Here, of course, the resemblance will be more close in proportion as the slope of the pyramid approaches that of the regular octahedron; and this, of course, depends upon the relative lengths of the principal and lateral axes.

8. Combinations of the cube with the rhombic dodecahedron (Figs. 13 and 14) may closely resemble the tetragonal combinations of two prisms and a pyramid—either 110,100,001,001 or 110,100,111,001.



9. The peculiarly and partially-developed combination of rhombic dodecahedron and deltohedron (Fig. 15), figured by Dana as occurring in *garnet*, might be easily mistaken for the tetragonal combination of prism, ditetragonal prism, and pyramid, 110,1nm,111.

10. The combination of octahedron and rhombic dodecahedron (Fig. 16) closely resembles the tetragonal combination—110,111,101—sometimes found in *cassiterite*.

11. The rhombic macle of *Harmotome* (shown in cross section in Fig. 17) resembles very closely a tetragonal prism.

12. The tetragonal macle of *Rutile* (Fig. 18) closely resembles a hexagonal combination of scalenohedron and prism.

13. The rhombic macle of *Aragonite*, *Chalcocite*, and *Niter* (Fig. 19) closely resembles the hexagonal prism, 110,001, or 120,001.

14. A great many cubical, tetragonal, rhombic forms and combinations are apt to resemble certain oblique and anorthic combinations when their axes are not highly inclined.

15. Cleaved fragments of tetragonal, rhombic, and oblique minerals may be mistaken for cubical forms.