

derstand and appreciate the experimental work of others. The memory is also deficient, and the personal work on a subject may be of great value for that reason as well. But the things which we should endeavor to secure in laboratory instruction are, first, such an acquaintance with experimental methods as shall enable the student to thoroughly grasp the solid experimental basis of the science and give him the mental habit of referring everything back to the rigid experimental test; and second, the ability to do accurate and independent experimental work himself. No student can demonstrate for himself more than an infinitesimal number of experimental facts in comparison with the vast array of such material which has been accumulated.

If the principles which I have suggested are correct, we should endeavor to secure as thorough a knowledge as possible of experimental methods, and neatness and accuracy in laboratory technique rather than the illustration of as large a number of details as possible. These results can be secured more fully by a series of quantitative problems than by a large amount of merely qualitative work. I do not mean by this that qualitative work is not necessary and desirable as well, but for the beginners, especially, quantitative work is of more value. In order to make my meaning more clear I will give a few illustrations. One of the earliest problems that I give is the determination of the weight of a liter of hydrogen essentially by Regnault's method. A bulb containing about one half a liter and bearing a three-way cock is exhausted with a Bunsen pump and the residual pressure determined with a manometer. The bulb is then weighed, using a sealed counterpoise of nearly the same volume, then filled with hydrogen, temperature and pressure noted, and weighed again. The results obtained by careful work are usually one or two per cent. too high. A similar determination of the weight of oxygen gives results with a far smaller percentage error. The determination of the amount of oxygen in potassium chlorate by heating about a gramme of the salt in a small porcelain crucible placed within a second gives a good illustration of the law of constant proportion. The preparation of potassium perchlorate can be made to furnish a considerable amount of valuable instruction. The capacity of a bottle holding about two liters is determined, a calculation of the amount of potassium chlorate required to give oxygen enough to fill it when only the first stage of the reaction is used is made, and the experiment performed. Then the potassium chlorate and potassium perchlorate are separated and the latter is purified by crystallization. A study of the qualitative reactions which distinguish potassium chloride, potassium chlorate and potassium perchlorate is made and the tests to establish the purity of the last are applied. Finally a determination of the amount of oxygen in potassium perchlorate gives, in connection with the last problem, an illustration of the law of multiple proportion. I will give but one further illustration—the determination of the relative atomic weights of hydrogen, chlorine, and silver. A known weight of pure silver is dissolved in nitric acid, precipitated with hydrochloric acid and the silver chloride weighed on a Gooch crucible. In a dilute hydrochloric acid the amount of hydrogen is determined by allowing 10 c. c. of it to act on an excess of zinc in an appropriate apparatus, the hydrogen being measured in a gas burette, accurate corrections being made for temperature, pressure, and aqueous pressure. In another known volume of the same acid the chlorine is determined by precipitation with silver nitrate.

By a careful selection of problems it is possible to give the student, within a reasonable time, practice in the careful use of the more common forms of chemical apparatus. In other words, the student can make a beginning at working as a chemist works instead of doing scarcely more than play with bottles and test tubes. Among other advantages of this method of instruction is the fact that the results which are obtained are usually a fairly good criterion by which to judge of the care with which the student has worked, and the student soon finds that careless work will not give good quantitative results. Also the student dwells long enough on a problem so that many details become thoroughly fixed—a result that is rarely obtained in qualitative work, except by means of many repetitions. I am aware that there are some practical difficulties in the way of carrying out the methods which I propose, especially in the matter of apparatus, but these difficulties are not nearly so great as they appear at first sight, and I am sure that they are not greater than those which have been overcome in many of our physical laboratories.—*Jour. Am. Chem. Soc.*

THE SYNTHETIC POWERS OF MICRO-ORGANISMS.

By O. LOEW, University of Tokio, Japan.

AMONG all living organisms the micro-organisms, micrococci as well as bacteria, bacilli, and spirilli, are especially remarkable for their intensity of chemical activity. Oxidations and decompositions, reductions, and synthetical processes are effected on an extensive scale.

If we consider the destructive and the synthetical operations, we must arrive at the conclusion that the former are necessary for carrying on the latter. The former yield not only the forces necessary for the synthetical work, but also the suitable atomic groups. It is certainly a highly interesting question of physiological chemistry to study the relations of the two different directions and to elucidate which are the groups that serve for the synthetical work. We must first consider the chemical structure of the compounds that can serve as nutrients, we must investigate the causes that bring about the transformation of potential into actual energy, and we must recognize above all that the proteids of the living protoplasm are chemically distinct from those of the dead. We must acknowledge that when the labile character of the former changes by atomic migration into a stable one, the death of the cells has come.

Nutritive and poisonous qualities are relative conceptions. Poisons may become nutrients for bacteria when highly diluted, as phenol or acetic ether, and nutrients may become unfit for nutrition if the concentration reaches certain limits. Small chemical changes

may convert a nutrient substance into a poison and again the poison into an indifferent substance.

As albuminous matter contains carbon, hydrogen, nitrogen, sulphur, and oxygen, we have to consider principally the question, which substances are suitable sources for the carbon, which for the nitrogen, which for the sulphur. Our experiments lead to the following conclusions:

1. As sources of carbon can be used in neutral or feebly alkaline solutions, alcohols, phenols, organic acids, ketones, aldehyds, carbohydrates, ethers and esters, many alkaloids.

2. As sources of nitrogen can serve: ammonium salts, nitriles, amido-acids, amines, ureas, guanidines, alkaloids, nitrates, and nitrites.

3. As sources of sulphur may serve: sulphates, sulphites, hyposulphites, sulpho-acids, mercaptans, sulphones.

It is remarked in a note that the nucleins, which contain phosphoric acid in their molecule, are here left out of consideration.

The following conclusions are drawn for most of the non-pathogenic microbes:

1. Hydroxylated acids are better than the corresponding non-hydroxylated ones, *e. g.*, lactic acid is better than propionic acid.

2. Polyvalent alcohols are more favorable for the development than the corresponding monovalent alcohols, *e. g.*, glycerin is better than propylic alcohol.

3. The nutritive quality of the fatty acids and monovalent alcohols decreases with the increase of the number of carbon atoms in their molecules. Thus acetic acid is better than butyric acid.

4. The entrance of aldehyd or keton groups increases the nutritive properties; glucose is better than mannite.

5. I have observed neither nutritious nor poisonous properties in picro-nitric acid, chloral hydrate, pinakon, ethylenediamine, glyoxal, amido-acetal. Acetoxime, diacetamin, and maleinic acid are very poor nutrients. According to B. Meyer; mesaconic, citraconic, para methyl-succinic, dimethyl-succinic, and benzoyl-succinic acids are not capable of serving as food.

6. The poisonous properties are determined by the energy with which the unstable atoms of the living protoplasm are attacked.—*Central-Blatt f. Bacteriologie; Chemical News.*

INCOMPATIBILITY.*

JAMES KENNEDY, Ph.G., M.D., Professor of Pharmacy, University of Texas.

BY the term incompatibility we mean that property possessed by certain bodies which renders them uncongenial to certain other bodies, and occasions a change in either one or both substances affecting either their physical or chemical constitution when brought into contact with each other. This definition applies to chemical and physical incompatibility.

We may study our subject under four different heads, as follows: 1, chemical; 2, physical; 3, pharmaceutical; 4, physiological.

Chemical Incompatibility.—Substances are said to be chemically incompatible when they react upon each other in such a way as to produce a new compound occasioning changes in the atomic structure of both. Acids and alkalies are incompatible, for the reason that there exists an affinity between them sufficiently strong to cause them to unite chemically. Their atoms enter into a close chemical union, and produce a new substance which possesses properties differing widely from either of its constituents.

If common bread soda (soda bicarbonate) is added to muriatic acid, we will find that the mixture will effervesce, owing to the escape of carbonic acid gas (CO_2). The resulting solution no longer possesses the characteristics of either the acid or the soda, and by evaporation of the solution we obtain the product of their union, which is common salt. The muriatic (hydrochloric) acid being composed of hydrogen and chlorine (HCl), the soda of sodium, and carbonic acid (CO_2) (having the composition of Na_2CO_3), double decomposition ensues, the sodium (Na) uniting with the chlorine (Cl) to form sodium chloride (NaCl), the hydrogen with a part of the oxygen to form water (H_2O), and the carbonic acid gas escapes (CO_2).

Another instance of chemical incompatibility, and one which will serve to illustrate the importance of a knowledge of the subject to both pharmacist and physician, is the changes occurring on the admixture of calomel (mercurous chloride) (HgCl) with muriatic acid. The acid nearly always containing free chlorine, the mercurous chloride takes up another atom of chlorine from the acid, and is converted into mercuric chloride, or corrosive sublimate, a compound differing greatly from calomel, both in its chemical constitution and physiological effect, the former being a relatively harmless cholagogue, while the latter is a powerful alterative in small doses, and a violent corrosive poison when taken in large amounts.

Among the common errors that physicians make as pertains to compatibility in prescriptions are the following: Ammonium carbonate with sirup of squill in cough mixtures. These two substances are incompatible, for the reason that the sirup contains an acid (acetic) which acts chemically upon the ammonium salt, decomposing it, with the formation of ammonia acetate. Tannic acid is sometimes prescribed in combination with tincture chloride of iron, with the view of increasing the astringency of the mixture. The result is that an inky mixture is formed by the union of the tannic acid with the iron, which, in addition to producing an unsightly preparation, possesses less astringent power than was formerly possessed by either one of the constituents of the prescription. The same result will obtain if we combine preparations of iron with fluid extracts or tinctures containing tannin. Most vegetable substances contain tannin in greater or lesser amounts; therefore, if it is desired that iron should be combined with the active principle of the plant, the vegetable preparation should first be detannated; that is, have its tannin removed by the process of precipitation with the white of an egg. The tannin combines with this form of albumen and produces an insoluble compound which may be separated by filtra-

* Lecture delivered before the medical and pharmaceutical students of the University of Texas, and communicated by the author.—*American Druggist.*

tion, leaving the liquid entirely free from its presence. The iron may then be added without producing any discoloration. There are a few drugs, such as gentian, calumba and capsicum, which do not contain any tannin, and may be combined with the salts or iron without producing any discoloration.

Iodide of potassium is frequently prescribed in solutions containing spirit of nitrous ether, and in the majority of instances a discoloration of the mixture results in a short time. This discoloration will not occur if the nitrous ether is perfectly fresh and pure. If, however, a slight decomposition has resulted, and owing to the facility with which decomposition occurs in this compound when exposed to light and air the preparation is seldom found pure on the apothecary's shelf, and may be safely set down as not being a good thing to prescribe in this form of combination. The discoloration which is produced is due to free iodine, resulting from the decomposition of the potassium iodide by acetic acid contained in the nitrous ether as a product of its decomposition under the influence of light and air.

Nitrous ether is often prescribed in combination with antipyrine, but these substances are incompatible in a high degree. The speaker was the first to call attention to the incompatibility of these substances, and in a paper which appeared in the *Pharmaceutical Record*, of New York, he published his researches on this subject. In a later and more exhaustive research conducted by him on antipyrine, the resulting compound was studied both chemically and physiologically (see proceedings of Texas State Pharmaceutical Association, 1889), and the influence of the changes in the substances due to the chemical decomposition, as affecting their medicinal value, was determined. The conclusions were to the effect that the new compound formed is not poisonous, and practically inert; that both the spirits of niter and antipyrine have their medicinal value lessened in proportion to the amount of each suffering decomposition. A mixture of antipyrine and nitrous ether will deposit green crystals if allowed to stand, provided there is not sufficient water present to keep the new substance in solution.

Acetate of lead and sulphate of zinc are frequently ordered in combination for use in the treatment of inflammatory affections of the genital mucous membranes, under the impression that the constringing power of these drugs is enhanced by so doing. This is a mistake. Double decomposition occurs when these two salts are dissolved together; sulphate of lead is precipitated as an inert substance, while the acetic acid is transferred to the zinc to form zinc acetate.

Strychnine is sometimes prescribed in combination with the bromides or iodides. This is a dangerous practice, for the reason that if the mixture has been allowed to stand for some time the bromide or iodide of strychnine will crystallize and be deposited in the bottom of the vial, and as the last dose of the medicine is taken the greater portion of this powerful drug contained may be swallowed, and perhaps with fatal results.

Illustrations of chemical incompatibility might be multiplied *ad infinitum*.

The following rules should be borne in mind:

Acids should never be prescribed with alkalies or their carbonates.

Alkaloids should never be prescribed in combination with alkaline carbonates.

Salts of the alkaline earths, *i. e.*, magnesium, calcium, barium and strontium, should not be prescribed with soluble carbonates, tartrates or oxalates, and in the case of the three latter elements they should never be combined with soluble sulphates, phosphates, arsenates, phosphoric or sulphuric acids.

The heavy metals, such as iron, manganese, lead, mercury, silver and zinc, should never be prescribed in conjunction with the alkalies, their carbonates or oxalates.

Silver should never be prescribed in combination with chlorides, bromides, iodides or hydrochloric acid or organic matter (substances of vegetable or animal origin).

The soluble salts of lead should never be combined with chlorides, hydrochloric, hydrobromic, hydric or sulphuric acid.

It is impossible to tabulate in a lecture of this kind the various incompatible combinations and mixtures, nor would such a tabulation be of any considerable use to either physician or pharmacist. An intimate knowledge of the chemical nature of the substances dealt with is the only infallible guide, the only beacon that can be relied upon to guide us safely past the treacherous shoals of this formidable gulf.

Physical Incompatibility.—By physical incompatibility we mean that property possessed by certain substances which causes them to change their physical properties when brought in contact with each other without affecting their chemical composition, a quality that in many instances may be overcome by the exercise of pharmaceutical skill. For instance, oils are physically incompatible with water (because of a lack of adhesion) and aqueous mixtures, but by the intervention of some viscid substance, *i. e.*, gum acacia, they may be rendered miscible in all proportions. Solutions of resinous drugs are physically incompatible with aqueous solutions, but by the intervention of some saccharine or mucilaginous material many resins may be rendered quite homogeneous.

Pharmaceutical Incompatibility.—By pharmaceutical incompatibility is represented by that class of substance which, by virtue of possessing some property or properties that occasion an undesirable change when brought in contact with each other, and which cannot be overcome or prevented by the exercise of pharmaceutical skill. Of course, in this class of incompatibles we may have the occurrence of either physical or chemical change; for instance, when two or more salts are ordered in powders, and the water of crystallization of one is absorbed by the other, with the effect of liquefying the powder. Strongly alcoholic solutions are incompatible with sirups, for the reason that the sugar is very much less soluble in such media, and in the course of several hours a considerable proportion will be found deposited in the bottom of the bottle, making a very unsightly mixture.

A prescription may be said to be pharmaceutically incompatible when an amount of a given salt which is in excess of its solubility is ordered dissolved in the liquid.

Physiological incompatibility is the property pos-

sessed by one medical substance of neutralizing the therapeutic effect of some other remedy. Medicines possessing this property should never be ordered in combination.

In conclusion, gentlemen, I will state that I have not told you all that you should know concerning this very important subject, but I hope the suggestions which I have given may be fixed upon your memory by the illustrations you have seen this morning, and will incite you to a more exhaustive study of the subject.

When the physician has learned to write compatible prescriptions, and the pharmacist has so mastered his calling that he can dispense the same in a reliable, palatable and sightly form, then will the occasion for mutual criticism have disappeared and given place to mutual respect.

[Continued from SUPPLEMENT, No. 956, page 15280.]

STUDY OF SNOW CRYSTALS.

By Prof. Dr. G. HELLMANN.

(Translated for the SCIENTIFIC AMERICAN.)

Structure of Snow Crystals.—I pass now to observations on the external and internal structure of snow

capillary, hollow spaces. Formerly these hollow spaces were only known to exist in the crystals having the form of six-sided prisms. In 1681 Rossetti observed this, and later Willeke. There can be no doubt now that all forms of snow crystals contain these capillary hollow spaces. I observed it for the first time in a plate-shaped crystal, where they are usually larger and more easily observed, but they may also be distinctly seen in the rays of the star-shaped crystals. Here the hollow spaces are in the form of capillary tubes, which run out to a point at the ends, and lie symmetrically on both sides of the ribs. The inner elongation of these capillaries running parallel to each other usually amounts to from two to five hundredth part of a millimeter, and the tubes at their thickest place are about the same width. The outrunning points of these capillaries are turned toward the middle point of the star. Sometimes there lies before these ends, precisely in the prolongation of both capillaries, two or four diminutive hollow spaces, in form of a blister, which may be considered as the starting point of the formation of the capillary tubes.

It seems to me a fortunate circumstance that I am not alone in ascertaining the existence of these capillary hollow spaces. Herr G. Nordenskiöld also points them out, especially distinct in tabular crystals.

drawings, only those of Waters show hollow spaces—they are not seen in the drawings of Scoresby and Glaisher.

These capillary hollow spaces appear to me to be one of the most important characteristics of snow crystals, distinguishing them from other ice formations. I have never seen these hollow spaces in the frost figures upon the window panes, although cylindrical forms are seen, and fern-like ice formations, similar to a feathered snow star. As is well known, ice arising from frozen water exhibits a great number of air bubbles.

Another characteristic of tabular crystals, which deserves special mention, is the frequent appearance of narrow facets on their edges. I have only twice observed crystals with these facets, but the dark border on the tabular plates in Figs. 6, 8, 9 and 11 proves that they appear frequently. They are well developed in the tabular star, Fig. 11, which furnishes a beautiful model for a reel, also the two plates in Fig. 9 have beautiful facets. Unfortunately it has never been possible to measure the angle which the facets make with each other. Kamtz, who observed these facets, gives a drawing in detail of the vertical incisions of such a faceted snow crystal, from which Galle and Bravais have derived conclusions in regard to the

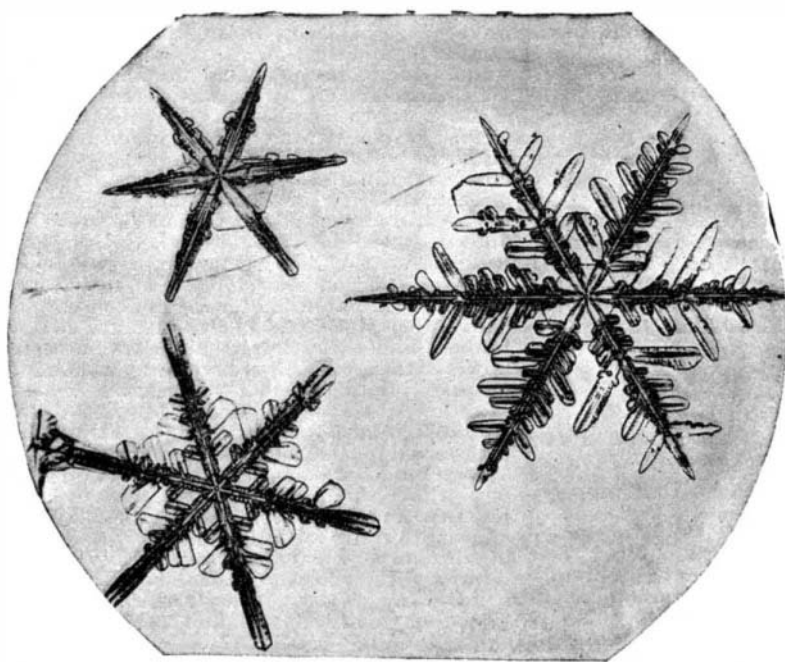


FIG. 5.

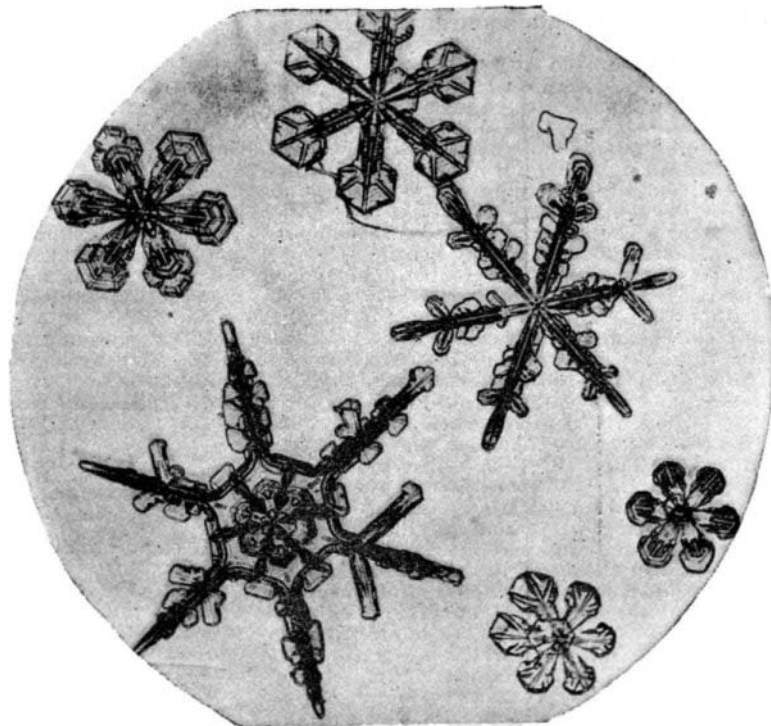


FIG. 6.

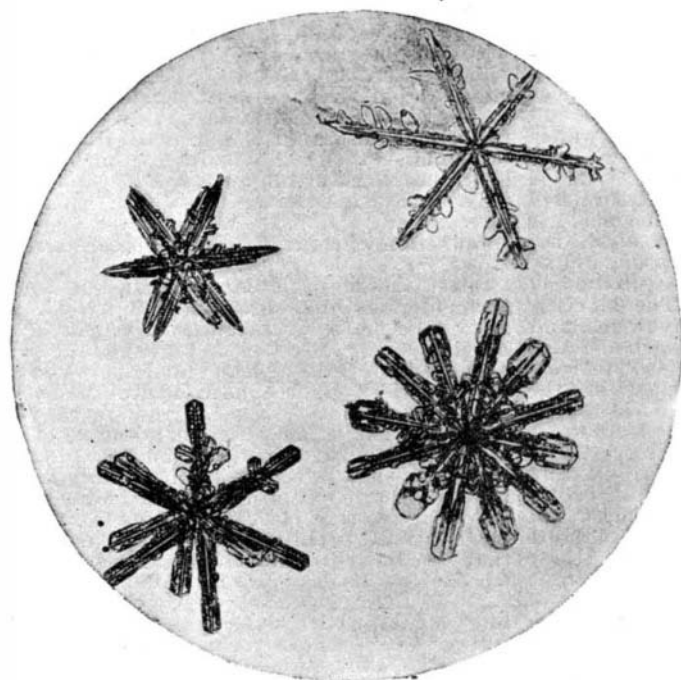


FIG. 7.

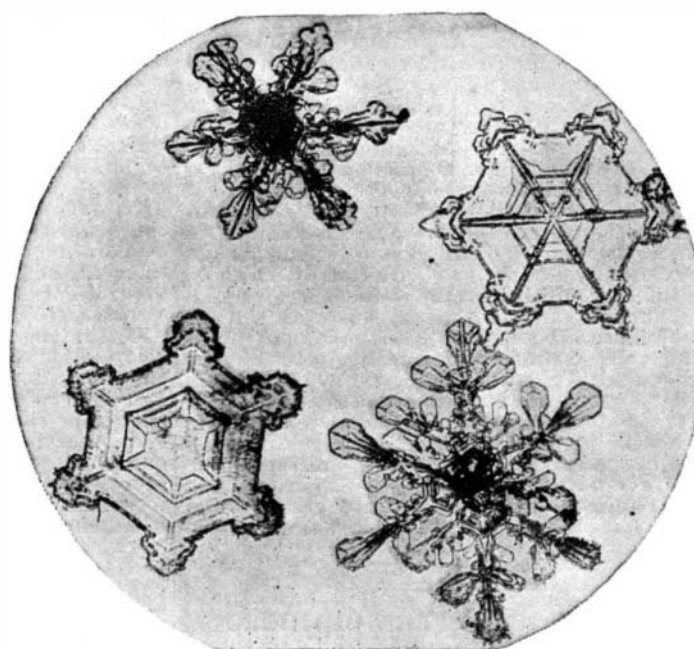


FIG. 8.

PHOTOMICROGRAPHS OF SNOW CRYSTALS.

crystals, which is the most important division of this attempt at their study. Here the photomicrographs have performed an excellent service, as by this process the crystals are firmly held, and accessible to every one. In direct microscopical observation, only a single crystal can be scrutinized, and that only in fragments, as the quickly changing contour and structure of the crystals make a lengthy observation of them very difficult, and often impossible. It is really surprising that such eminent observers as Scoresby and Glaisher discovered nothing in regard to the internal structure of these crystals, or at least published nothing about them. Possibly in their attempt to draw as many as possible they found no time to examine closely the conditions of their formation.

In examining the six-rayed stars and the forms derived from them we find that they have a principal ray and secondary rays, which are not always opposite each other. The strengthening or re-enforcing of the principal rays near their starting point, for a short distance of from 0.2 to 0.3 mm., is sometimes so strongly marked that it appears as if a smaller star were laid concentrically upon the larger one. This may be seen in Fig. 1a.

The most remarkable thing in the structure of the principal and secondary rays is this: they contain

A good example is shown in the large star with tabular center at the left below in Fig. 6. In the inner star two symmetrical systems of hollow spaces may be observed by means of a magnifying glass; one of long drawn out blisters on the inner side of the edges, their long axes running parallel to the edges, looking not unlike six pairs of ants' eggs; then in front of these, in the direction of the center, and standing perpendicular to them, running almost in a radial line, a similar pair of smaller hollow spaces may be observed. It might be objected by some that these are simply points of melting, but their appearance is against this. Melting points look quite differently. Besides, the symmetrical arrangement of these capillary hollow spaces could not depend upon a mere accident.

Is it not a most interesting fact that these capillary, hollow spaces are shown in the beautiful drawings made by Rossetti in Turin, more than two hundred years ago? In the *facsimile* of his drawings, Figs. 5 and 10 show these spaces distinctly. This speaks well for Rossetti's talent for observation. These characteristics were well known to him, in the formation of that class of snow crystals called by him "rosettes;" on account of their great brilliancy he called them "gioie" (jewels), and made various remarks upon them without finding out the correct explanation. Of the later

theory of the rings about the sun and moon. Hollow spaces appear in all the prismatic forms. Their form and position cannot be clearly perceived in our photomicrographs. The original pictures, also observation with the microscope, show that the hollow spaces lie in the direction of the principal axis. Until recently it has been supposed that these hollow spaces contained only air, but Herr G. Nordenskiöld, on the 8th of February, 1893, in Stockholm, made the interesting observation that ice prisms falling on that day contained both air and water, the temperature being -8° .

Beautiful examples of twin crystals may be seen in Fig. 4. The crystals, looking somewhat like a cauliflower, seen in Figs. 10 and 12, may be new. They probably originated by a regular snow crystal, in falling to the ground, passing into a stratum of air, which contained uncongealed water drops; the drops, by coming into contact with the snow crystals, were stiffened into amorphous ice.

Dimensions of Snow Crystals—Dependence of Size and Form upon the Temperature.

We are able now, by means of the photomicrographs, to take all the time necessary for the measurement of the snow crystals. While in direct observation under