presented in the form usual in the several branches of trade statistics. The result is that the values stated for the different products are necessarily taken at different stages of production or transportation, &c. Theoretically perfect statistics of mineral products would include first of all the actual net spot value of each substance in its crudest form, as taken from the earth; and yet for practical purposes such statistics would have little interest other than the fact that the items could be combined in a grand total in which each substance should be rated on a fairly even basis. The following groupings, therefore, are presented with a full realisation of the incongruity of many of the items. The grand total might be considerably reduced by substituting the value of the iron ore mined for that of the pig iron made, by deducting the discount on silver, and by considering lime, salt, cement, borax, &c., as manufactures. It will also be remarked that the spot values of copper, lead, zinc, and chrome iron ore are much less than their respective values after transportation to market. Still the form adopted seems to be the only one which admits of a comparison of the total values of the mineral products from year to year.

Résumé of the Values of the Metallic and Non-metallic Mineral Substances produced in the United States in 1884.

Metals	$186,097,599
Mineral Substances named in the foregoing Table	220,007,021
	406,104,620
Fire-clay, kaolin, potter's clay, common brick clay, terra cotta, building sand, glass sand, limestone used as flux in lead smelting, limestone in glass making, iron ore used as flux in lead smelting, marls (other than New Jersey), gypsum, tin ore, antimony, iridosmine, mill-buhrstone, and stone for making grindstones, novaculite, corundum, lithographic stone, talc and soapstone, quartz, fluorspar, nitrate of soda, carbonate of soda, sulphate of soda, native alum, ozokerite, mineral soap, strontia, infusorial earth and tripoli, pumice-stone, sienna, umber, &c., certainly not less than	7,000,000
Grand Total	$413,104,620

The total value of the metals and minerals produced in 1884 was $39,100,008 less than in 1883, and the decline in 1883 from 1882 was $3,012,061; that is, the falling off in value began on a small scale in 1883, but was accentuated in 1884. The net decline has been due rather to a depression in price than a decrease in quantity; indeed, several important substances show a decided increase in production, notwithstanding the general dullness of trade. The over-production, taking the whole field into consideration, has been less than was generally feared.

PROF. L. SOHNCKE ON THE ORIGIN OF THUNDERSTORM ELECTRICITY[1]

IN order to express more than mere surmises as to the origin of thunderstorm electricity we must, above all, be familiar with the atmospherical conditions under which thunderstorms usually occur. For this purpose we must first take into consideration two general facts in meteorology: first, the average decrease of temperature with increase of height in free air; and secondly, the nature of the upper clouds.

With regard to the first point, a considerable amount of data is available in the observations of several scientific balloonists, especially those of Mr. J. Glaisher. Glaisher has constructed a table, based upon his numerous ascents, showing the average decrease of temperature for the altitudes of 1000, 2000, 3000 feet, &c. This table shows that even in the warm summer months the temperature of the freezing-point is met with generally at the level of between 3000 and 4000 metres (say 10,000 to 13,000 feet).

Generally speaking, the aggregate of those points of space in which the temperature of 0° C. prevails at any given moment must lie on a certain surface, which may be denoted as the "isothermal surface of zero C." It is of especial interest to ascertain whether the result yielded by Glaisher's ascents as to the height of this surface in midsummer is confirmed by other ascents. In order to obtain an opinion upon this point I have grouped together those ascents which afford a sufficient number of data, in order to deduce therefrom the height of the isothermal surface of zero. This table includes twenty-three ascents by eight different balloonists at different seasons of the year; about half the ascents were made during the summer months. The following are the conclusions drawn from this table:—

In the warmest summer months the isothermal surface of zero was found to be at an height of about 3000 to 4000 metres, but occasionally sinks even at this season to about 2000 metres (say 6500 feet) above the level of the sea. It generally rises in the course of the forenoon, and, apparently, more rapidly the nearer noon is approached. It sinks in the course of the afternoon, and, apparently, more rapidly with the greater distance from noon. Its level may vary about 2000 metres in from one to two hours. The change from rising to sinking does not occur exactly at noon, but perhaps one hour or even more after noon, according to season.

A knowledge of the decrease of temperature on days of thunderstorms, especially just before the storm, presents therefore especial interest. Only few data exist on this point.

Glaisher made an ascent at 6 p.m. on the 31st August, 1863, after a thunderstorm had taken place at 8 a.m. He did not reach the isothermal surface of zero, but found a temperature of 1° C. at a height of 2300 metres (say 7500 feet). I have never found such a low temperature at a similar height in any of the six ascents in August and the beginning of September.

Flammarion made an ascent during the night of the thunderstorm of the 14–15 July, 1868, and met with 0° C. at a height of 2400 metres (say 6500 feet), but this was at 4h. 26m. a.m. Among all the midsummer ascents there is only one in which the isothermal surface of zero was met with at a lower level.

Welsh made an ascent in the afternoon of the 17th August, 1852, two hours before the occurrence of a thunderstorm; at 5 p.m. the isothermal surface of zero lay at a height of 3500 metres (say 11,500 feet), but it was rapidly sinking. Welsh did not find such a rapid decrease of temperature upwards in any of his other three ascents as in this one.

Kämtz has drawn the conclusion, based upon the great refraction which has often been observed with sultry thunderstorm air, that the rapid change of temperature with height is an important condition for the formation of thunderstorms, especially in summer. In order to obtain more precise data upon this point I have undertaken a small meteorological investigation as to the difference of temperature existing just before thunderstorms between Freiburg in the Breisgau and the Höchenschwand in the Black Forest, 2326 feet above it. I found that in seventeen cases which were suitable for comparison, in the years 1880 and 1881, the difference of temperature just before the thunderstorm was less than the average for the day and season in three cases only; in other cases it was greater.

From this it appears that, in most cases, the abnormally rapid decrease of temperature with height, and, in connection with this, the abnormally low position of the isothermal surface of zero may be taken as characteristic of the condition of weather before thunderstorms.

Secondly, attention must be paid to the nature of the upper clouds not only generally, but also more especially before thunderstorms. The clouds which lie above the isothermal surface of zero must of course mainly consist of ice particles, although, of course, the formation of clouds of superfused water particles is not excluded. The appearance of the ice clouds is, moreover, somewhat different from that of the water clouds. The former are known as "cirrus" and the latter as "cumulus" clouds. Observations on the height of clouds, made either in balloon ascents or on the ground, agree in showing that the limit of both kinds of clouds in midsummer lies about 4000 metres (say 13,000 feet) high, which agrees pretty well with the above calculation of the level of the isothermal surface of zero. It is not surprising, therefore, that balloonists frequently reach snow-clouds even in midsummer—for instance, Glaisher on June 26, 1863, between 3300 and 4200 metres (say 11,000 and 14,000 feet); Fonvielle on July 4, 1875, at 3450 metres (say 11,300 feet); Barral and Bixio on July 27, 1850, between 4500 and 6300 metres (say 15,000 to 20,500 feet); Welsh on August 17, 1850, at 5990 metres (say 19,500 feet).

While the distinction between ice and water-clouds, from their mere appearance as seen from the earth, is always somewhat difficult to be made out, we have in many cases an infallible

[1] Extract from "Sitzungsberichte der Jenaischen Gesellschaft für Medecin und Naturwissenschaft." Jahrg. 1885. Sitzung vom 1 Mai.

means of distinguishing between them—namely, by the character of the solar and lunar halos which are very often seen in thin veils of clouds. It has been established beyond doubt that the rings of light of larger size, or halos of about 22° diameter, are caused by refraction in ice crystals. (This angle is that of the least deviation for rays of mean refrangibility in passing through ice-prisms of 60°). On the other hand the smaller rings (coronæ) of from 1° to 6° diameter owe their origin to the refraction of light through spheres of uniform size. Halos are not nearly so rare as is commonly supposed. M. Galle observed seventy-eight halos and about as many parhelia in a year and a half, and often even in the heat of summer. Kämtz laid great stress on the importance and infallibility of this optical means of distinguishing between the two classes of clouds.

After these preliminary considerations let us turn to thunderstorms. The local or heat thunderstorms (identical with most summer thunderstorms) are best known, while the large cyclonic thunderstorms have been less investigated. In the first case, the appearance of the clouds which rise high in the sky as gigantic columns of cumulus, show that they owe their origin to a strong ascending current of great humidity. According to Dr. Reye, the principal condition for the formation of a continuous ascending moist air current is the abnormally rapid decrease of temperature in its vicinity, while in the current itself the decrease of temperature with height is essentially retarded, owing to the latent heat set free by the condensation of vapour. Under these conditions, the distribution of temperature in the atmosphere is therefore such that the isothermal surface of zero in the ascending current is raised especially high, while outside this current the surface has an abnormally low position. In this way, therefore, water still in a liquid state reaches the ice-region; ice-clouds and water-clouds must exist side by side. If the moist current rises sufficiently high its temperature sinks below 0° C. and this gives rise to cirrus clouds of snow and hail, which latter frequently accompanies thunderstorms. Kämtz has shown from his observations in high mountains that the height of the locus of thunderstorms must not be placed too low; the usual estimations of the height of thunderstorms based upon observations of lightning and thunder cannot be taken into account here, for they only show (and that very inaccurately) the position of the lowest structure of the thunderstorm clouds.

Both Hann and Kämtz agree that water and ice clouds always exist simultaneously in the sky, and not only during local thunderstorms but also during those of the other kind. Hann describes the layers of "cirrostratus" cloud as always existing with thunderstorms. Kämtz has always been able to recognise halos *i.e.* the characteristic indication of the presence of ice particles before thunderstorms, as soon as he could trace the change from clear sky to thick clouds. And in all three of the previously mentioned balloon ascents on days of thunderstorms ice particles have been observed in the air.

We may take it that it has been established that in every thunderstorm clouds composed of water particles and others of ice particles exist simultaneously side by side, and that, of course, they are mutually changing places it is very easy to suppose that the friction of water particles and ice particles may serve as a source of electricity. But this is in no way a mere supposition, for it is a fact already established by Faraday. In his experiments on the cause of the production of electricity in Armstrong's steam electrical machine, which was considerably modified by him, he frequently caused compressed air to strike against solid objects. The cooling arising from the expansion of the air caused a copious formation of fog, and the friction of these particles against the objects always excited the particles with + electricity and the solid objects with − electricity. It was only by the friction of the particles against ice that the latter became + on every occasion, while wood and metal were excited with − electricity by the friction of the particles.

I have frequently repeated these experiments of Faraday's, and, as was to be expected, entirely confirmed them. Of course several precautions must be taken if we do not wish to be checked by evidently contradictory results. The principal causes of disturbance may arise by the carrying away of particles of grease from the greasing of the taps, and on the other hand by the friction of the particles on the walls of the tube, if the turning on is not quick enough. In the latter case the particles become + and communicate this electricity to the objects they meet, and thus, therefore, the character of the electricity by friction with these bodies is partially or wholly masked. The colder the ice the more powerfully it becomes electrified—a fact which appears to be in connection with the increase of its insulating power with decreasing temperature.

If, therefore, air-currents flow against each other, one being of ice particles and the other of water particles, the ice particles become positively and the water particles negatively electrified, and as by no means a rapid mixing of both kinds of air-currents is requisite, which may be seen *inter alia* from various observations on smoke-laden air-currents in laboratories, the oppositely electrified bodies are quickly repelled from each other.

The real cause of thunderstorm electricity appears to me to lie in the sequence of phenomena above described. It is not my intention to discuss the behaviour of the further phenomena connected with thunderstorms.

A more detailed exposition of the theory very briefly sketched here, as well as the observations used for its proof, will be found in my Treatise on the Origin of Thunderstorm Electricity and of the Ordinary Electricity of the Atmosphere, just published by G. Fischer, Jena. ("Der Ursprung der Gewitter-Elektricität, und der gewöhnlichen Elektricität der Atmosphäre.")

CYSTOLITHS

M. J. CHAREYRE[1] has made a detailed examination of these structures in plants belonging to the Urticaceæ, and to many other families. The following are some of the chief results:—

In the Urticaceæ the prolonged action of darkness causes complete disappearance of the calcium carbonate in the cystolith, though without their mass sustaining any diminution; they retain completely their original form. This takes place before the etiolation which is the result of placing the plants in question in the dark. It is due probably to the cessation of the action of chlorophyll. Calcium oxalate disappears in the same way from the cystoliths. The lime set free by the decomposition of these salts collects in the stem, where it exists in combination with some other acid.

In the Acanthaceæ, on the other hand, none of these phenomena are exhibited, and the cystoliths undergo no change from the action of darkness; and this difference in the behaviour of the cystoliths in these two natural orders appears to correspond to no less important differences in their constitution. The calcium carbonate appears in one family in the crystalline, in the other family in the amorphous, form.

All the seeds of Urticaceæ examined before germination presented reservoirs of food-material consisting exclusively of aleurone, in each of which was a rounded globoid. The same was the case with the Acanthaceæ, except *Acanthus* and *Hexacentris coccinea*, plants containing no cystoliths, and in which the reserve-material of the seeds consists chiefly of starch. The calcareous reserve-material contained in the seeds in the form of globoids disappears more rapidly when they germinate in a soil formed of pure silica than in ordinary soil, or in one composed of calcium carbonate. But no part of this reserve-material contributes to the formation of deposits of calcium carbonate, whether as cystoliths or in any other form, nor to the production of crystals of calcium oxalate. In seeds which germinate in pure silica the cystoliths do not arrive at full development; the pedicel is formed, but no deposition of either cellulose or lime takes place at its extremity. In soil composed of calcium carbonate the cystoliths appear at the same time as in ordinary soil, *i.e.* at the moment when the green cotyledons are disengaging themselves from the seminal envelopes, but their development is somewhat more rapid. Seeds sown in ordinary soil or in calcium carbonate, but kept in darkness, give rise to rudimentary cystoliths without any calcium carbonate.

Yellow dying leaves of many Urticaceæ present, as contrasted with green leaves, cystoliths containing a smaller quantity of calcium carbonate, but this is not the case with Acanthaceæ or with *Pilea*.

Both the calcium carbonate in the cystoliths and calcium oxalate are believed by the author not to be merely products of excretion, but to play an important part in the life of the plant.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

THE following list has been issued by the Science and Art Department of successful candidates for Royal Exhibitions,

[1] See *Revue des Sciences Naturelles* for 1884 and 1885.