On the structure of the raphides of Cactus enneagonus / by John Quekett.

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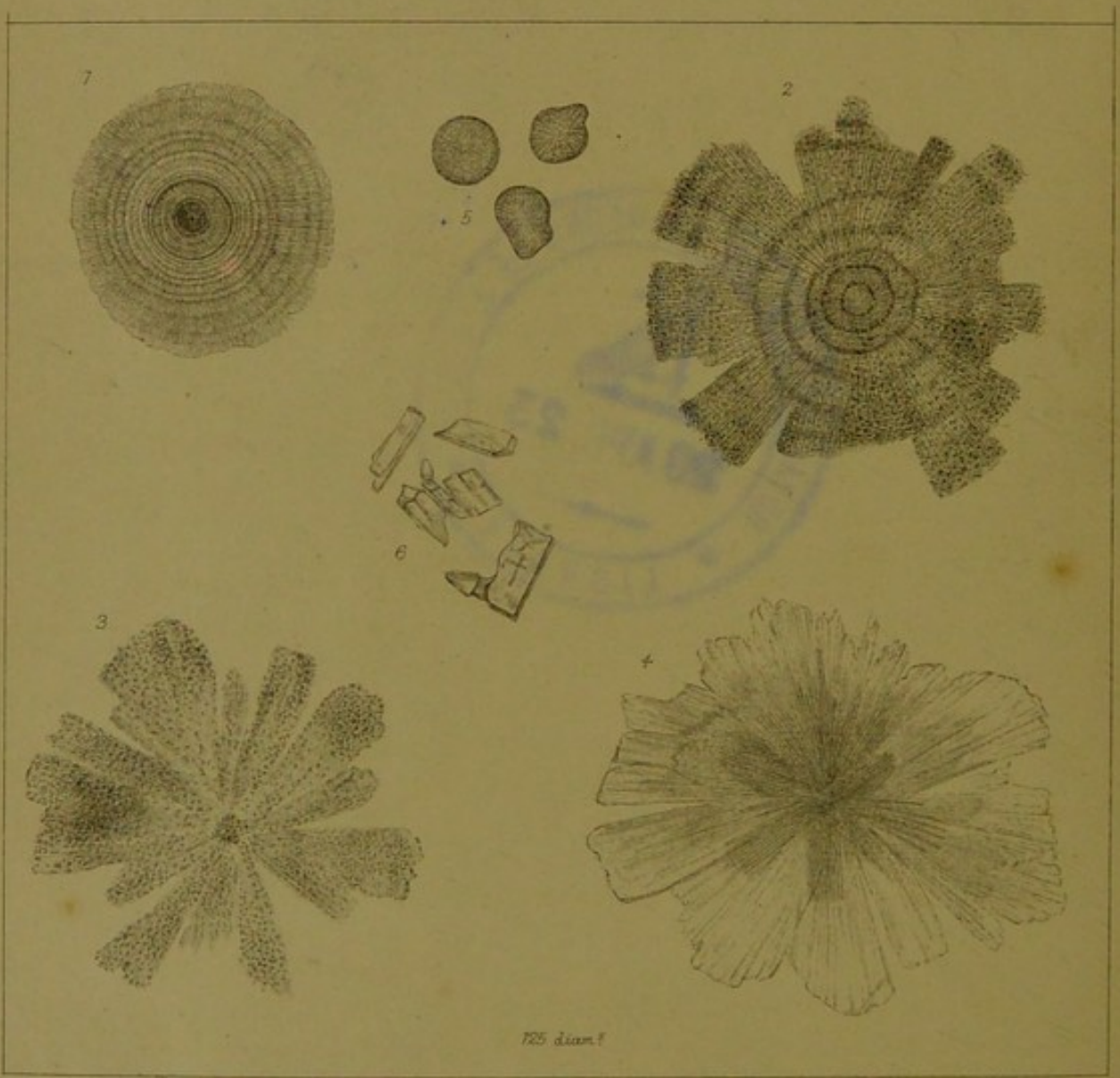
1
2
3
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125 diam.

ON THE STRUCTURE

OF THE

RAPHIDES OF CACTUS ENNEAGONUS.

By JOHN QUEKETT, Esq.,

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(*Read Jan.* 28, 1852.)

Every living being that is made up of parts or organs, each having a definite structure, and performing a certain office, is termed an organized being; and the materials, however complicated, of which it is composed, are termed organic matter.

The components of the Mineral Kingdom, on the contrary, possessing little or no structure, but generally being homogeneous throughout, and having no adaptation of parts to perform separate functions, are called inorganic or inorganized.

If organic matter be subjected to chemical analysis, it will be found that in the first stage certain compounds, termed by some chemists proximate principles, or organic compounds or organizable substances by others, will be obtained; each of which principles, by further or ultimate analysis, will yield simple elements. Thus, for instance, from the organized substance termed muscle we obtain by analysis, first, fibrine, a proximate principle, which is its chief constituent; and, subsequently, by the analysis of fibrine, we get the principal elements—oxygen, hydrogen, carbon, nitrogen, and sulphur in certain proportions. If, however, a mineral, or inorganic matter of any kind be subjected to analysis, we get no proximate principles, but only simple elements. Organic matter may be found in two states, viz., in that of life or in that of death. Living matter possesses the powers of growth and integrity, may select from surrounding materials, and appropriate to its uses the inorganic elements; but in the state of death these powers are destroyed, and decay is the natural consequence.

It is to the nature of this organic basis or matter of plants that I would now direct your attention, leaving that of animals for future consideration.

In commencing our examination with the vegetable kingdom we shall find that inorganic or earthy matter exists in plants in two states, viz., 1st, as crystals, termed raphides, occurring in the interior of cells, and 2nd, in intimate connexion with the organic basis of the plant—in this last state the inorganic element chiefly consists of silica.

If we examine a portion of the layers of an onion or of a squill, or by taking a thin section of the stem or root of the garden rhubarb, we shall observe many cells in which either bundles of needle-shaped crystals or masses of a stellate form occur; these are termed raphides, from the Greek Ραφις, a needle, the first crystals discovered being of this shape.

Raphides were first noticed by Malpighi in *Opuntia*, and were subsequently described by Jurine and Raspail.

According to the latter observer the needle-shaped or acicular are composed of phosphate, and the stellate of oxalate of lime. There are others having lime as a basis, combined with tartaric, malic, or citric acid. These are easily destroyed by acetic acid; they are also very soluble in many of the fluids employed in the conservation of objects: some of them are as large as the 1-40th of an inch; others are as small as the 1-1000th. They occur in all parts of the plant—in the stem, bark, leaves, stipules, sepals, petals, fruit, root, and even in the pollen, with few exceptions. They are always situated in the interior of cells, and not, as has been stated by Raspail and others, in the intercellular passages.*

Some of the containing cells become much elongated, but still the cell-wall can be readily traced. In some species of Aloe, as for instance *Aloe verrucosa*, with the naked eye you will be able to discern small silky filaments. When these are magnified they are found to be bundles of the acicular form of raphides. In portions of the cuticle of the medicinal squill—*Scilla maritima*—several large cells may be observed, full of bundles of needle-shaped crystals. These cells, however, do not lie in the same plane as the smaller ones belonging to the cuticle. In the cuticle of an onion every cell is occupied either by an octohedral or a prismatic crystal of oxalate of lime—in some specimens the octohedral form predominates, but in others from the same plant, the crystals may be principally prismatic, and are arranged as if they were beginning to assume a stellate form.

Those persons who are in the habit of examining urinary

* As an exception I may state that, many years ago, I discovered them in the interior of the spiral vessels in the stem of the grape-vine; but with some botanists this would not be considered as an exceptional case, the vessels being regarded as elongated cells.

deposits must be familiar with the appearance of the crystals of oxalate of lime, and would readily recognise their close resemblance to those in the cells of the onion.

Raphides of oxalate of lime are found in very great abundance in the medicinal rhubarb—the best specimens from Turkey containing as much as 35 per cent.; those from the East Indies 25; and the English, or that sold in the streets by men dressed up as Turks, 10 per cent.

Buyers of this drug generally judge of its quality by its grittiness, that is by the quantity of raphides it contains; and this is a curious fact, as the crystalline matter cannot be of any beneficial importance in the action of the medicine, for the tincture in which no raphides are contained is as efficacious as the powder.

Some plants, as many of the cactus tribe, are made up almost entirely of raphides. In some instances every cell of the cuticle contains a stellate mass of crystals, in others the whole interior is full of them, rendering the plant so exceedingly brittle that the least touch will occasion a fracture, so much so that some specimens of *Cactus senilis*, said to be 1000 years old, which were sent a few years since to Kew from South America, were obliged to be packed in cotton, with all the care of the most delicate jewellery to preserve them during the transport,

Raphides of peculiar figure are common in the bark of many trees. In the hiccory (*Carya alba*) may be observed masses of flattened prisms having both extremities pointed. Similar crystals are present in the bark of the lime-tree; they occur in rows, their pointed extremities nearly touching each other, their principal situation being in the cellular tissue close to the medullary rays. Other forms of crystals, as the rhombohedron and a small stellate form, are also found in the bark of the lime.

In vertical sections of the stem of *Elæagnus angustifolia* numerous raphides of large size may be seen in the pith.

Raphides are also found in the bark of the apple-tree, and in the testa of the seeds of the elm; each cell contains two or more very minute crystals.

It is at present not known what office raphides perform in the economy of the plant: some have gone so far as to state that they are deposits to be applied towards the mineral part or skeleton of the plant; but the fact of their being insoluble in vegetable acids would prove this view of their use to be erroneous. The more rational supposition is, that they are generally accidental deposits formed by the union of vegetable acids with lime or other base existing in the plant or

taken up from the soil. They may, however, be formed artificially, and my late brother succeeded in doing so in the following manner:—If oxalic or phosphoric acid be added to lime-water, the precipitate will be pulverulent and opaque. If, however, a vessel containing oxalate of ammonia in solution be connected by means of a few filaments of cotton with another vessel containing lime-water, crystals will be formed at the end of the fibres in contact with the lime-water.

This led him to attempt to form them in the interior of cells: he selected for the purpose a portion of rice paper; this substance was placed in lime-water under an air-pump in order in fill the cells with the fluid; the paper was then dried, and the process again and again repeated, until many of the cells were charged with lime-water; portions of the paper were then placed in weak solutions both of oxalic and phosphoric acid, and at the end of three days crystals were found in the cells in both instances, those of the oxalic acid being of the stellate and those in the phosphoric acid being of the rhombohedral form. None of the acicular, however, were ever present, although the process was continued for ten days. One of these pieces of rice paper I now show you, and a stellate mass of crystals is very plainly to be seen in the centre of the field—each precisely resembles the raphides found in rhubarb.

The above description, which is a modification of that given in my lectures, well applies to the raphides in most plants, but the case will appear to be a little different in those plants, such as the cacti, which live to a great age, and in which the crystalline matter is in the greatest abundance. Whilst working at this subject about twelve months since I was induced to examine the raphides of a species of *Cactus* termed *enneagonus*, a specimen of which had been given me by a friend as abounding in crystals. This specimen I have with me, just as I received it, the part containing the crystals being about thirty-nine years old; that they are very numerous, and at the same time very large, may be known by their being visible to the naked eye. If any of these raphides be examined in fluid with a power of at least 100 diameters, they will appear to be made up of crystals (as far as their external surface is concerned), which project outwards in the form both of sharp pointed and truncated prisms; and if the centre be brought into focus this part will be found more opaque than the rest, and to be of a circular figure like a nucleus. If the masses be mounted in Canada balsam before they are examined they will then present one or other of the appearances given in Plate III. figs. 1, 2, 3, 4; some, as in fig. 1, will show a nucleus

surrounded by concentric laminæ of a brown colour; others, as in fig. 2, will exhibit a spot like a nucleus, first surrounded by concentric laminæ, but towards the margin the laminæ become irregular, and the margin itself is composed of prismatic flattened crystals, not clear and transparent, but more or less granular, whilst some other specimens, as shown in figs. 3 and 4, are made up almost entirely of the prismatic crystals, with little or no trace of concentric lamination. Having found this to be the case I was anxious to ascertain the chemical composition of these so-called raphides, and for the purpose I tried the action of various re-agents upon them, and noticed that the crystals were slowly dissolved in dilute hydro-chloric acid, but I was much astonished to find that in many cases a basis or cast of the entire mass was left behind after the action of the acid had ceased; and in most instances I could tell precisely not only the spot where the crystals had been, but also form some general idea of the shape of the mass, and instead of their being, as I first imagined, a mass of crystals only, I found that there was some organic matter or basis connected with them.

When one of these raphides is crushed between two plates of glass, the outer crystals are readily detached; some of these are represented by fig. 6: the part composing the nucleus is much the hardest, and exhibits a radiated and concentric laminated deposit, like the masses of carbonate of lime found in the urine of the horse. If portions of the cellular tissue of the cactus be examined, some cells will occasionally be found in which a more or less spherical mass, as shown in fig. 5, occurs in the centre of each: these masses correspond in every respect with the nuclei of the larger raphides: it would therefore appear that in the early stages of development of these raphides the nucleus consisted of one of these spherical bodies, and the crystals on the exterior were formed subsequently. It may also happen that the bases of some of the crystals in process of time coalesce to form laminæ, a condition not unlike that occurring in shell, as has been so well described by Dr. Carpenter, or rather like that which takes place in the formation of most of the laminated kinds of urinary calculi.

My object in bringing the subject before the Society at this time is to ask those of our members who are chemists, and would be willing to look into the matter, if they could determine the nature of the residuum or basis left after the destruction of the earthy ingredient by means of the acid. They will find, as I shall presently have the opportunity of showing you, that there is something peculiar in the dissolution of the crystals—they are all, more or less, granular, as if the organic

matter were not confined to the investing membrane, but intimately mixed up or incorporated with every atom of the lime. I have this day examined some sections of the Soap wood of China, in which stellate masses of crystals are very abundant. If these be acted on by dilute hydrochloric acid, the earthy constituent will disappear, but a cast of the original mass will be preserved in what may be termed organic matter. This point, however, is the one which requires to be carefully examined by persons more skilled than myself in the science of organic chemistry.

As far as my observations have hitherto gone, it would appear to be a rule that we rarely, if ever, find inorganic material in the vegetable or animal kingdom, except in the crystalline state, without the existence of an organic basis.

Since the above was written, my friend Dr. Lionel Beale has been kind enough to examine the raphides in question, and the following is his report on the subject.

"A few of the white globular crystalline masses were treated with boiling distilled water, and the aqueous solution, after being filtered, was evaporated to a small bulk. Upon examining the residue by the microscope, numerous small colourless crystals, in the form of obtuse rhomboids, were observed. The residual solution was found to give precipitates insoluble in strong nitric acid, with solutions of nitrate of barytes and nitrate of silver, proving the presence of chlorine and sulphuric acid. Oxalate of ammonia gave a precipitate insoluble in acetic acid, but soluble in strong nitric acid, showing the presence of lime.

"Hence boiling distilled water extracted a small quantity of soluble matter, which contained lime, chlorine, and sulphuric acid, probably in the form of sulphate of lime and chloride of sodium.

"*Acetic Acid.*—The crystalline masses were not affected by boiling acetic acid.

"*Potash.*—No observable action was produced by boiling a few of the masses in solution of caustic potash.

"*Nitric Acid.*—Upon the addition of strong nitric acid, effervescence occurred with some few of the bodies as they dissolved, but upon the majority this re-agent exerted little action in the cold. When the mixture was boiled, complete solution immediately took place.

"The acid solution was evaporated to dryness; the dry residue was boiled in distilled water, and the filtered solution, after concentration, was allowed to remain in a still place for some time. Upon examining the residue with the microscope

numerous well-formed octohedra of oxalate of lime were observed.

"Another portion of the original matter was incinerated:—the masses still retained their globular form, but became black, and the products of combustion burnt with a blue lambent flame. After exposure to a dull red heat for three or four hours, the crystals were perfectly decarbonized, and by the unaided eye could scarcely be distinguished from those which had not been incinerated. Upon microscopical examination, however, the crystalline fragments of which the crystalline masses were composed, were found to have acquired a dark granular uneven surface, and the sharpness of outline had been destroyed. The decarbonized residue was entirely dissolved in acetic acid with brisk effervescence; and upon the addition of a solution of oxalate of ammonia to the acid solution, an abundant white precipitate was immediately produced; this was soluble in strong nitric acid, but insoluble in excess of acetic acid—*oxalate of lime.* In all probability, therefore, the crystalline masses consisted of—

"1. A little organic matter;

"2. Sulphate of lime;

"3. A little of carbonate of lime;

"4. Traces of chloride of sodium;

"5. A vegetable salt of lime, containing a considerable proportion, or consisting entirely of *oxalate of lime.*"

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