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Studies on the Chrysomonads. I.

By

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(With 1 figures the text and Plates 8—11.)

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1. *Physomonas vestita* Stokes.

(Plate 8 Figs. 1—8.)

This interesting organism, though colourless, exhibits some important features peculiar to the Chrysomonads, so that it is admissible to describe it here as an apochlorotic and very specialised representative of this group. The only account of it we find in old works of Stokes (16, 18), out of which only that of 1888 was accessible to me. Since that time the organism has been met with no more (9, p. 93), which fact appears to show that *Physomonas vestita* is of the rarest occurrence not only in Europe, but also in North-America, where it was found by Stokes. According to my observations, however, *Physomonas vestita* is one of the most common inhabitants of pools and ponds, prevailingly it colder seasons, like the majority of the Chrysomonads, though I have found it also in hot summer months. In natural conditions the organism never attains large development, which probably accounts for its not having been recorded by any other observer. On the other hand, Stokes' description of *Physomonas* is not quite complete, which also is possibly the cause of its being overlooked.

The present description is based on the study of the material obtained in the winter of 1926 from a basin in the Kharkov Botanical

Garden, together with *Synochromonas pallida* (see farther) and *Chromatium Okenii*. The latter proved an excellent food for *Physomonas*, which after several days of vigorous multiplication in laboratory conditions became the predominating form in the culture vessel. Unfortunately, its development was only ephemeral, and as soon as all the food had been exhausted, the organism disappeared restless. My observations on *Physomonas* are therefore incomplete in some points, especially with respect to its cytology. Since then I have made many attempts to obtain once more a sufficiently abundant material, but without success. I hope however that my present account of this little known organism will be of interest for the protistologists. The characters of the organism found by me are exactly identical with those referred to by Stokes, except for some details of secondary significance. For the sake of a more convenient comparison, I quote here Stokes' original description of *Physomonas*, only several less important sentences being omitted.

"Body subglobose, the anterior truncation obsolete; the entire surface clothed with a delicate, mucilagineous, finely granular investment, through which penetrate numerous fine, flexible, raylike bodies apparently originating from all points of the cuticular surface; long flagellum twice the diameter of the body in length, the distal extremity arcuately curved, the secondary appendage one-fourth that length, vibratile; endoplasm granular; pedicle filiform, flexible, four times the diameter of the body in length; contractile vesicles two, situated close to and slightly in advance of the median line; a linear, somewhat curved band or groove near the frontal body-margin. Diameter of the body 1/1666 inch..... With the present species the food, thrown down by the action of the short flagellum, enters at any part of the surface, usually, however, near the base of the flagella, where the surface opens, the mucilagineous investment and the radiating filaments moving outwardly on what appears to be a delicate cuticle; a wave-like outflow of the endoplasm surrounds the particle and draws it into the body, enclosed in a large drop of water. In length these ray-like cuticular appendages are little shorter than the short flagellum. The nucleus is indistinct. It is presumably located centrally, although it has not been positively identified" (16, p. 82).

As is seen from this description, only the attached stage of *Physomonas vestita* was known to Stokes. The organism may be attached to various filamentous algae, or to the sand-particles on the bottom of the vessel, but in especial abundance it may be found

on a thin film on the surface of the water in culture vessels, consisting of various bacteria, algae, and small crystals of calcium-carbonate. The cells are fixed either by means of thin and very resistent filamentous stalks of a variable length, or directly by the end opposite to that bearing the flagella. All these cases are but various stages of the development of the stalks.

In the material mentioned above, the stalks were coloured somewhat brownish and sometimes had at their base short deep brown appendages, applied to the substratum and apparently strengthening the connection of the stalk with the latter (Pl. 8 Fig. 1). These appendages arise probably from short ramifications of a protoplasmic protrusion of the body, by means of which the attachement of still sessile cells takes place. Commonly the stalks are colourless and indistinct.

The echinulate investment of the body is a very interesting structure, but its description by Stokes is incorrect. Under high magnification, the body of *Physomonas* appears to by surrounded with a very thin wall, somewhat retreating from its surface and bearing radiating bristles, which, according to Stokes, are attached to the surface of the body and penetrate a delicate, mucilagineous finely granular investment round the cell. The bristles were in my case exceedingly fine, so that only their somewhat thicker basal parts were discernible. To see them in their full length two methods may be used. The simplest consists in drying up the organisms on a cover-glass and examining the preparation resulted as Diatoms, without mounting it in any medium. The second, more troublesome method is that of the dark-field illumination, by means of which very fine pictures can be obtained.

In my searches for the method of demonstrating bristles in *Physomonas*, I was much surprised by the fact that they cannot be stained with any stain whatever. Even in preparations made after Löffler's method of staining cilia, the bristles remained almost colourless, although the flagella and stalks were stained very deeply. Some stains, as methylen-blue and acid fuchsin, proved appropriate, but only because they stained minute particles adhering to the bristles. The presence of these particles suggested that the body of *Physomonas* is surrounded with aqueous mucilage, coagulating under the action of stains. But the examination of the cells of *Physomonas* in a solution of Indian-ink showed that there is no mucus round them, the above mentioned particles having obviously no relation to the organism. In living cells I have never seen

anything like that finely granular mucilagineous coat on the surface, described by Stokes.

My further investigations of the chemical nature of the bristles led me to the surprising result that these consist of an inorganic substance, namely of silica. Indeed, they do not disappear on calcination, and after the subsequent treatment with concentrated sulfur-, or nitric-acid. On the other hand, they are dissoluble in strong KOH-solution. It is thus quite natural that they cannot be stained.

Stokes' indication that the bristles are attached to the surface of the body proved also incorrect. They are not connected with the body, but only with its envelope, which becomes evident when the latter retreats from the body on the dying off of the organism. The method of calcination permits to make out the structure of this envelepe. It consists of minute, no more than 2 μ in diameter, and exceedingly thin, round plates, each bearing a bristle, up to 10 μ in length, attached normally in the centre (Pl. 8 Fig. 4). Siliceous elements of the envelope of *Physomonas* resemble thus nails with relatively large flat heads. They can also be observed in a dark-field illumination, if the cell is dead and its envelope somewhat disorganised, and in this case one can see that the plates are somewhat thickened on the margin. It is very probable that all the basal plates of the bristles are joined together by some organic substance, or at least imbedded in a thin mucilagineous coat round the cell. We see that there is a striking resemblance between *Physomonas* and *Mallomonas*, with respect to the structure of their envelopes.

As to the structure of the protoplast, it is very surprising that Stokes could not discern the nucleus, which is much more prominent than the bristles. It is disposed at the distal end of the cell, and is ovoid or pyriform in shape (Pl. 8 Figs. 2, 5), the narrowed end being approached close to the point of insertion of the flagella. After the death of the cell, as well as in stained preparations, the nuclear membrane becomes clearly seen. The caryosome is also very distinct, even in living cells, which is due to the absence of any granules round it, appearing only on the death of the cell.

Applied closely to the nucleus, there is a "linear, somewhat curved band or groove near the frontal body-margin", which is much more prominent than the nucleus, and observable even with middle-power objectives. In German literature it is called the "Mundleiste", and in the following statement I shall designate it the

"mouth-band", though no mouth is present in *Physomonas*, as well as in all other organisms provided with the same structure.

The nature and function of this mouth-band is quite obscure. It appears as a straight or slightly curved, strongly refracting plate, closely applied side-wise to the nucleus, its anterior end getting at the place where the basale-granule of the flagellar apparatus is presumably situated (Pl. 8 Figs. 2, 5). Both ends of the band are somewhat curved outward, and imperceptibly merge into the surrounding protoplasm. If viewed from its broad side, the mouth-band has no definite outlines. On fixation with osmic-acid the mouth-band looses a little of its former distinctness, becoming almost indiscernible in stained preparations. This probably accounts for the fact that this structure has been neglected by the protistologists, in spite of its often occurrence in the Protomastiginae and Chrysomonads. The narrow space between the mouth-band and the margin of the body is more transparent than the neighbouring protoplasm, and with sufficiently high magnification of the microscope, and especially in compressed cells, one can see here several minute vacuoles, the whole region having therefore a spumous structure. Sometimes I observed these vacuoles to coalesce into larger vacuoles, and even the contraction of one of them, quite similar to that of ordinary contractile vacuoles. But this is by no means a general rule, and the significance of these vacuoles remains quite mysterious.

On the same side of the body, at some distance from the above described spumy region, two contractile vacuoles are disposed. They pulsate alternatively, being formed by the coalescence of several small vacuoles arising on the place of disappearance of the former vacuole.

There are two flagella in *Physomonas*, attached close to each other at the rounded distal end of the body. One of them is 40—45 μ long, the other only about 6 μ, i. e. somewhat shorter than it was indicated by Stokes. Their movements are similar to those in all Chrysomonads with unequal flagella (*Synura*, *Synochromonas*, etc.). The longer flagellum is kept rigidly forwards, arcuately curved from above the middle, performing extremely quick oscillations throughout its length. The shorter flagellum is bent aside and somewhat backwards, and moves more slowly.

According to Petersen (12), in some of the Chrysomonads with unequal flagella the longer flagellum is pinnate, and it was of interest to see, whether, or not, the same structure is to be found in *Physomonas*. Löffler's method as well as that of dry cover-glass

preparations gave negative results in this case. But in my attempts to stain the envelope-bristles with acid fuchsin, I remarked that in some instances the longer flagellum appeared to be covered with short hairs scarcely visible due to their thinness, the presence of which was obviously responsible for the adhesion of numerous particles to this flagellum. Though the pictures obtained by this method were not quite convincing, the structural resemblance between the flagella of the Chrysomonads and *Physomonas* is hardly to be doubted.

In conditions of poor nourishment the protoplasm of *Physomonas* appeas rather homogeneous, with only very small granules scattared throughout (chondriosomes and volutin?). But in the material with *Chromatium*, where the quantity of food was at the beginning unlimited, the cells of *Physomonas* were especially large, and contained an irregularly shaped drop of some strongly refractive substance, which I am inclined to consider as storage-product. These drops often attain considerable size, being usually disposed laterally (Pl. 8 Fig. 5) in the free space between the nucleus and digestive vacuoles. They can be pressed out of the cell, and then a very thin membrane can be seen round the drop. Under the stronger pressure the membrane bursts, and the contents flow out and disappear in water. It the intact cells the drops disappear on the treatment with various fixatives, leaving behind vacuoles with aqueous fluid and numerous minute particles in quick Brown-movement. The latter are to be considered as a result of coagulation of the former strongly refracting substance, the loss of refraction preceding the appearance of the particles.

The above described inclusions in the body of *Physomonas* show a striking resemblance with leucosin masses in the Chrysomonads, both being to be considered as vacuoles with very resistent walls, filled with a certain strongly refracting substance. Chemical nature of the latter is quite unknown, but it is likely that, contrary to Klebs' supposition, leucosin is not a carbohydrate, but a strong solution of proteins. It must be mentioned that the contents of the vacuoles in *Physomonas* exhibit a somewhat less refraction than that of leucosin of Chrysomonads, which moreover in different individuals may be different, obviously in dependence on the concentration of the contents. I have not observed such a variability of the refraction of leucosin in the Chrysomonads, but I think that this does not hinder us form analogising the inclusions of *Physomonas* with leucosin.

The method of capturing prey in *Physomonas* was correctly des-

cribed by STOKES, and resembles that observed in various Chrysomonads. When nutrition is abundant, the cells of *Physomonas* become filled with large digestive vacuoles and attain enormous dimensions. Undigested particles are extruded nearer to the posterior end of the body (Pl. 8 Fig. 6).

STOKES has described only attached stage of *Physomonas vestita.* My observations however show that this is not the only possible here, and that motile condition is no less common than the attached one. It is not improbable that environmental conditions are the only controlling factor in this case. So far as I could observe, in laboratory cultures, when the water is quiet, the attached state becomes prevailing, while in fresh samples all the individuals may be motile. On the other hand, in microscopical preparations one can observe the fixed cells to detach themselves from the substratum, and after some period of time the majority of them may become free. This shows that detachement may be conditioned by the quantity of oxygen decreasing in not fresh preparations.

The swimming cells of *Physomonas* are much more variable in shape than the attached ones. They may be spherical, ovoid, conversely ovoid, elongated, etc. (Pl. 8 Fig. 2), and it is not wonder if this stage has escaped STOKES' attention. The movements of motile cells of *Physomonas* are usually slow, probably due to the presence of bristles on their surface.

Multiplication in *Physomonas* occurs independently of the condition of the organism, both attached and swimming cells being capable of dividing. Division is preceded by the formation of two additional flagella disposed first close to the place of insertion of the former two (Pl. 8 Fig. 3). Concurrently with this a second mouth-band is formed *de novo* on the side of the nucleus opposite to the preexisting mouth-band. Further on the division of the nucleus begins. My preparations, fixed with SCHAUDINN'S fluid and stained with iron-hematoxylin, were not very successful, so that I confine myself to the description of what was observed on the living objects.

After the formation of the new mouth-band the outlines of the nucleus become indistinct, and the caryosome swells and flows out, the space between the mouth-bands being now occupied for a short time by a finely granular substance. This is evidenly the prophase of the nuclear division, the granula mentioned representing the particles of chromatin. Whether they derive from the caryosome, or whether they appear independently of it, was not to be decided from my rather superficial observations.

Just after the disappearance of the caryosome the mouth-bands begin to diverge, and together with them the flagella, separated into two pairs. Disposed formerly at an obtuse angle to each other above the nucleus, the mouth-bands move a little apart until they are arranged parallelly (Pl. 8 Fig. 7), and now one can see further course of the nuclear division. Minute chromatin-granules are agglomerated, and form chromosomes, densely crowded into an equatorial plate running across the homogenous field between the mouth-bands. Soon this plate divides longitudinally into two plates of the daughter chromosomes, each of which joines the corresponding mouth-band, disposes itself close to it (Pl. 8 Fig. 8), and ultimately transformes into the caryosome of the daughter-nucleus.

Now the constiction of the body begins, starting from the anterior end, between the places of insertion of the flagella. The division of the body proceeds rather slowly, especially if there is a large vacuole with leucosin, which must undergo passive division. A part of the digestive vacuoles are by this time extruded, the others sometimes remaining only in one of the halves of the body.

It is clear that the division of a free swimming individual produces two ones of the same kind. As to the final result of the division of an attached cell, I cannot say anything based on direct observation, but probably only one of the daughter-cells becomes free after the completion of division, while the other remains attached to the old stalk. Formation of colonies has never been observed.

I had no opportunity to observe the transition of *Physomonas* into a resting condition. But once there was found an already finished cyst of a Chrysomonadine type, with a firm, strongly refracting wall provided with a pore and stopper. It was spherical in shape, and with a slightly developed collar round the pore. The cyst was enclosed in the investment with bristles, which shows that it was really the cyst of *Physomonas*. Unfortunately, I made neither a drawing, nor a measurement of this cyst.

The encystement requires apparently some special conditions, because the cyst described was the only I have seen, in spite of the abundance of my material.

In conclusion, several words must be said about the taxonomical position of *Physomonas*. The presence of leucosin, as well as the structure of cysts, makes it evident that there is a close relationship between this organism and Chrysomonads. *Physomonas vestita* is to be considered as an apochlorotic Chrysomonad, as are some species of *Monas*, and *Anthophysa vegetans*. But the presence of a so highly

differentiated envelope composed of siliceous disks with bristles renders *Physomonas* a very specialised type, analogous in this respect to Mallomonas, out of the true Chrysomonads. There is no doubt that the Protomastiginae are an artificial group, comprising several lines of a quite different origin, and it is more than probable that a good deal of them have derived from the Chrysomonads. But much work is to be done, to render possible any sound improvement of their present system.

2. *Amphichrysis compressa* n. gen. et sp.

Plate 9 Figs. 13—20 and Plate 10 Figs. 21—23.

This curious Chrysomonad belongs evidently to the rarest forms of the group. It has been found only once in early spring 1928 in a small swampy pool on a meadow in the nearest environs of Kharkov. Brought to the laboratory it developed very rapidly in a small glass cup filled with water from the swamp, and placed at the north-side window, so that in a short time I was in possession of a rather abundant material. Likewise it felt fairly well in the hanging-drop preparations, living there during several days, which enabled me to study with sufficient completeness its structure and life history.

Usually, in laboratory conditions at least, the individuals of *Amphichrysis* showed little tendency to swimming about, and most of them were lying at the bottom of the cup amidst the detritus, or keeping to the surface of the water in association of a variety of other floating organisms. The material to be investigated could thus be conveniently taken either by a pipette from the bottom, or simply by means of a cover-glass from the surface of the water. In the preparations thus obtained the cells of *Amphichrysis* were usually very lazy, many of them quite motionless, but after some time most of them began moving and ultimately swimming about rather lively. After several hours they became quiescent again.

In connection with these changes in the behaviour are those in the shape of the body. When quiet, the cell is strongly compressed from both sides, appearing roughly elliptic or ovoid from the broader side (Pl. 9 Fig. 13). Often there are excavations of a varied size at the fore, and especially at the posterior ends (Pl. 9 Fig. 15). In this condition the body is up to 27 μ long, and 18 μ broad, the thickness being about 5 μ. In motile condition the organism becomes elongated and less flattened, up to quite round in a cross section,

tapering towards the posterior end, or more or less obtusely rounded at both ends (Figs. 14, 18). If the microscope with the hanging-drop preparation on its stage is inclined, the cells lying in the upper part of the drop, where only a thin film of the water remains, are squashed and desintegrated. All this shows that there is no differentiated periplast in *Amphichrysis*, which is also evident from an immediate observation.

The most prominent feature in *Amphichrysis* are its strongly developed and deep brown chromatophores. They are so large that the immotile flattened cells appear coloured throughout, except on the very edge and in narrow slits between the chromatophores. Unlike most of the Chrysomonads, where chromatophores are ordinarily one or two in number, and very simple in outlines, in *Amphichrysis* there are constantly four chromatophores of a very characteristic shape. It is to be noted that only in rather rare cases I succeeded in obtaining sufficiently precise notion of the form of the chromatophores. Usually, due to various deformations of the body: contraction, torsion, elongation, etc., the outlines of the chromatophores become quite indiscriminate. It was especially difficult to made accurate drawings from the living cells which can remain quiet only for some 2—3 minutes. Therefore in my drawings from living objects only the cells with simples chromatophores are shown, while in other cases I used preparations fixed with Schaudinn's fluid and stained with iron-hematoxylin. Many of the cells were there deformed, but many proved admirably well conserved.

One of the simplest cases, as to the shape of the chromatophores, is represented in Pl. 9 Fig. 15, showing a quiet and flattened cell. Out of the four chromatophores only two are visible, the other two lying underneath almost coinciding in outlines with the upper ones. As is seen, each of the chromatophores is an irregular elongated plate extending throughout the cell and placed so close to one-another that there remains only a very narrow slit between them along the mediane of the cell. In the given case this slit is somewhat curved, but often it is almost straight (Pl. 9 Fig. 13). The outer edges of the chromatophores are rather symmetrically sinuous, the slight excavations in the middle being especially prominent and constant in occurrence. In most cases these excavations are much deeper, in form of a gulf directed forward, the mouth of which is often narrowed or even closed due to the overlapping of the lobes of the chromatophore. Very often to this excavation an other one is added, situated somewhat behind (Pl. 9 Fig. 18, Pl. 10 Figs. 25, 26, 28).

The outer edges of the chromatophores may thus be more or less deeply lobed, and owing to the overlapping of the lobes belonging to the same chromatophore, or often to the neighbouring ones, the picture of the whole cell may become very indistinct.

At the fore end there are two contractile vacuoles, situated also symmetrically on the edge of the body, to the right and left of the mediane in a broad side view. They lie between the upper and the lower chromatophores, which are somewhat excavated in these places. This is especially well seen by viewing the cell from the pole, or from the narrow side, in which latter case the cell also appears built up quite symmetrically. There are thus two planes of symmetry in *Amphichrysis*, lying at right angles to each other. One of them, in which the contractile vacuoles are situated and the compression of the body takes place, may be taken for the main plane of symmetry, the term to be used in the further description of the cell division.

The outlines and arrangement of the chromatophores are usually obscured by large masses of leucosin lying on the outer sides of them; and it is only by viewing the cell from the anterior pole, that a clear idea of its general structure can be obtained. Figs. 16, 17, 19 show the cells of *Amphichrysis* in such a position. In Fig. 19 the chromatophores are disposed in pairs on both sides of the main plane of symmetry, forming in optical section an elongated rhomb. Two contractile vacuoles are well seen between them. One of the chromatophores bears a fairly conspicuous stigma at its anterior end, to bee seen also in the side-view. Since the chromatophores come together at the fore end of the organism rather closely, the stigma occupies an almost central position in our figures.

Commonly another stigma, of much lesser dimensions, is to be seen at the fore end of the chromatophore diametrically opposite to the one with the large stigma (Pl. 9 Fig. 17). The presence of two stigmata is very common in the Chrysomonads, and is connected with the cell division, the daughter-stigma being formed de novo beforehand. Sometimes a third small stigma was found in a close vicinity to the large one (Pl. 9 Fig. 19), representing the second daughter-stigma, and depending in its appearance on some peculiarities of the cell-division.

Once a cell with four contractile vacuoles was met with (Pl. 9 Fig. 20). Such a condition might be considered as one immediately preceding the cell division, because just in this period the formation of additional vacuoles usually takes place. It will be shown

however that the behaviour of the contractile vacuoles during the division in *Amphichrysis* is not a mere parting of the previously formed vacuoles between the daughter cells, and the significance of the above mentioned condition is thus obscure.

The chromatophores may occupy still another position, which is shown in Figs. 16, 20. Namely, they form in a cross section a more or less regular square, which arrangement is connected with that described before through all possible intergradations. It must be remembered that all these data were obtained by observing freely swimming cells, after the above described deformations of the body had been completed.

In observing the cell from the pole, one can make out the distribution of leucosin in the body of *Amphichrysis*. In most cases this substance is laid down in form of four irregularly outlined bands along the chromatophores, on the outer sides of them (Pl. 9 Fig. 20). It is largely due to such peripheral arrangement of the leucosin masses and their strong refraction, that the picture of the interior of the cell appears so indistinct; which circumstance made me select for my drowings the cells with little, if any, leucosin.

Sometimes the leucosin bands on either side of the main plane of symmetry may flow together, which is apparently associated with the rhombic arrangement of the chromatophores (Pl. 9 Fig. 19).

The distribution of leucosin is not restricted to the periphery of the protoplast. Often a large ovoid drop of it is to be seen inside the cell, filling all the space between the chromatophores in the posterior half of the cell (Pl. 9 Fig. 17).

Just in front of the eentral leucosin drop lies the nucleus whose outlines are to be seen even in living cells. It is in this structure that the strange double nature of the cell of *Amphichrysis* stands out with an especial clearness. In fixed and stained preparations the nucleus offers nothing peculiar in comparison with the nuclei of other Chrysomonads. It is ovoid in shape, its pointed anterior end terminating with a strongly stained rhizoplast in form of a narrow conical appendage on the nucleus (Pl. 10 Figs. 26, 27, 29). The rhizoplast is followed by a single flagellum, very feeble and thin, and not exceeding the length of the body. I could not ascertain, whether it is pinnate, as the flagella of many other Chrysomonads, according to Petersen's and my own observations. I think this not improbable, however.

There is a caryosome in the nucleus, placed centrally or somewhat aside, and surrounded by numerous minute particles, which

are much less chromatophilous than the caryosome. Sometimes two caryosomes are present. The nucleus-membrane was not to be discerned.

Such is the nucleus in stained preparations. In living cells however one can see some other details, disappearing under the action of a fixative. As it was indicated before, in the majority, and possibly in all, of the freely swimming Chrysomonads there is an interesting structure with an unknown function, which I call the mouth-band. Throughout the group there is a single mouth-band in a cell, according to which only a single plane of symmetry may be drawn through the body. The symmetry of all these forms is thus bilateral. In contrast to this, in *Amphichrysis* two mouth-bands are present. They lie in the main plane of symmetry, embracing from both sides the nucleus and converging at the base of the flagellum (Pl. 9 Figs. 13, 15). They are very distinct in a broad side view of the cell, but not from the narrow side. One can see them also from the pole, in form of two brackets with the nucleus between them (Pl. 9 Fig. 16). According to the presence of two mouth-bands and their disposition in the cell of *Amphichrysis*, two planes of symmetry can be drawn through the cell of the organism, coinciding with those about which the chromatophores and contractile vacuoles are disposed. The body of *Amphichrysis* may thus be imagined as composed of two cells of a typical for the Chrysomonads structure, with fused nuclear and neuro-motor apparatus, but with the other structural elements maintaining their individuality.

After this general outline of the structure of *Amphichrysis*, it remains to describe the method of multiplication in this original organism.

Multiplication in *Amphichrysis*, as it was observed in hanging drop preparations, takes place in the evening. The individual going to divide stops swimming, but does not lose its flagellum. The body becomes rounded, and soon a second flagellum begins to grow out near the former one. Further a longitudinal constriction appears round the body, in the plane perpendicular to the main plane of symmetry (Pl. 10 Fig. 21), and each of the daughter halves receives thus a flagellum, a pair of chromatophores, and one of the former contractile vacuoles. After the constriction has attained considerable dimensions, a second contractile vacuole appears anew in each of the daughter halves, near the place of insertion of the flagellum (Pl. 10 Fig. 22). In the meantime the preexisting vacuole travels by 90^0 from its former place, its new position being in the mediane

of one of the chromatophores. The vacuole formed anew in its turn moves to the opposite side. It must be supposed that further on both chromatophores are divided longitudinally, and the contractile vacuoles move into the slits between their halves. The direction of the new main plane of symmetry is thus perpendicular to that of the former one.

As to the stigmata, one of the gaughter cells receives the large mother stigma. The other one receives a smaller stigma, which has been formed beforehand on one of the chromatophores of the mother cell.

It is not unlikely that in the same evening a second division can occur. This is suggested by the fact that many of the dividing cells were of a less size than the ordinary mature cells. On the other hand not seldom pairs of dividing cells were observed (Pl. 10 Fig. 21), arranged very regularly relative to each other, which arrangement might have arisen in the course of successive divisions in two perpendicular directions. Attention must be turned to the fact, however, that in the group of the cells in Fig. 21 the number of the chromatophores is eight. This suggests that, if we have here really the beginning of a second division, the latter has been preceded by the splitting of the chromatophores just after the first division, otherwise their total number ought to be four, each cell of the second generation containing only one chromatophor. Yet my observations give no evidence in this respect, though they may be somewhat incomplete in this point.

The development of *Amphichrysis* in my culture has been concluded by the formation of cysts. The cells going to transform into cysts became balled, and cover themselves with a thick layer of aqueous mucilage (Pl. 10 Fig. 23). Later on a thin membrane appears on the surface of the body, to give a temporary protection for the cell. The process of encystement takes place endogenously inside this membrane, and offers nothing peculiar as compared with that in other Chrysomonads. The finished cyst is perfectly globose, smooth, with an ordinary stopper in a small pore of the cyst-wall. The chromatophores are disposed along the wall of the cyst, leucosin is gathered on the side opposite to the pore, and in an excavation on the anterior side of the leucosin mass is placed the nucleus with both mouth-bands, which become concave. In the just formed cyst a stigma is seen in form of a small red point on one of the chromatophores.

Several days after the formation of the cyst, the primary mem-

brane disappears and the cyst becomes free. The formation of this membrane is in interesting peculiarity of *Amphichrysis*, as so far it has not been observed in any of the Chrysomonads.

In conclusion I give the diagnoses of the genus an species.

Amphichrysis, gen. n.: Cells solitary, motile, without any differentiated periplast, metabolic. Four chromatophores, and two contractile vacuoles, disposed symmetrically relative to the two longitudinal planes perpendicular to each other. Flagellum single, apical. Leucosin masses an the outward sides of the chromatophores, and also between them, in the posterior part of the cell. Division longitudinal. Endogenous cysts of an ordinary type, their formation being preceded by the secretion of a temporary envelope and mucilage round the body. Nutrition holophytic.

Amphichrysis compressa, mihi: Cells varying in shape from conversely ovoid and flattened, to almost regularl elongated elliptical and round in cross-section, with all intergradations between these extremes, the regularity of the form being sometimes broken by excavations at the anterior, and especially at the posterior ends. Flattened cells up to 27 μ long, and to 18 μ broad; the rounded ones about 30 μ long, and 15—16 μ thick. Chromatophores extending through the whole length of the cell, often somewhat twisted about the axis of the latter, usually lobed on the outer margin, and overlapping one another. One of them, but often two or three, are provided with stigmata. Contractile vacuoles two, near the anterior end, on the opposite side of the cell, between the excavated edges of the chromatophores. Flagellum of a variable length, about as long as the cell when fully developed, very thin and weak. Cysts spherical, smooth, to 22 μ in diameter, formed inside the temporary protective envelope surrounded with a thick mucilagineous coat.

Found in a pool on a meadow in the environs of Kharkov. Very rare.

3. *Synochromonas pallida*, n. gen. et sp.

(Pl. 9 Figs. 9—12 and Pl. 10 Fig. 24.)

The organism to be described was first found in winter of 1926 in a basin with swamp plants in Kharkov Botanical Garden, together with *Phyllocardium complanatum* recently described by me (6). In the next year it was absent there, but in 1928 appeared again, though in less abundance. In November and December of 1928 I found it also in several pools in the environs of Kharkov, so that this organism cannot be taken for a rare form. But its development

is confined only to cold season, when the basins begin to cover themselves with ice. It is not impossible that not only temperature, but also some changes in the chemical composition of the medium, are responsible for the apparition of this Chrysomonad. As I could thus far observe, the development of *Synochromonas* is usually associated with that of various sulfur- and purple-bacteria, which must change the gaseous balance of the water in a frozen basin. It is of course impossible to obtain any sure data without exact chemical analysis.

In the laboratory the organism kept fairly well at the temperature of about 8^0 C., but ordinary room temperature made it disappear from the culture reservoirs, largely due to the development of other forms. *Synochromonas pallida* proved very unresistent in the hanging-drop preparations, perishing there after several hours, or at least stopping in its development and nutrition. This accounts for its life history not having been studied in all details.

The new Chrysomonad represents a round colony of many cells, resembling in its general appearance *Synura uvella* (Pl. 9 Fig. 9). There are however some peculiarities which permit to separate it into a particular genus and even family. The cells of *Synochromonas pallida* are imbedded in the aqueous mucilage, that not only occupies the spaces between the cells, but covers the whole colony all around, to form a peripheral layer, up to 5 μ thick, through which the cilia penetrate. This envelope is not to be seen either by usual observation, or in dark-field illumination, and it is only in Indian-ink solution that its presence here can be demonstrated. The mucilage stains with certain dyes, for instance with gentian-violet, but in this case it undergoes so strong contraction, that no instructive picture is to be obtained in this way.

It proved a very difficult task to make a sufficiently correct drawing from the colony. All attempts to draw living colonies remained unsuccessful due to their being in incessant movement. At the same time, they are exceedingly unresistent, and the slightest pressure in order to stop them leads to their disorganisation, or at least to the loss of their characteristic shape. A tolerably true drawing (Pl. 9 Fig. 9) was made from the colony "fixed" in the hanging drop with xylol vapours.

The number of cells in full grown colonies attains 40, but often smaller colonies are met with consisting of several cells only. The cells are asymmetrical in shape, being almost straight on one side, to be termed ventral, and strongly convex on the other one that

will be named dorsal. At the distal end, where the dorsal side passes over into the ventral one, the cell is obliquely truncated, which is better to be seen on Pl. 9 Fig. 10, where the cell is shown at a greater scale. Just from this place two cilia of an unequal length project, the longer one measuring about 35 μ the shorter one only 5 μ. The shorter flagellum appears to be dorsal in the sense that it is attached nearer to the dorsal side of the body. The flagella are very thin throughout their whole length, and apparently smooth, not covered with secondary cilia as are the flagella of *Synura* and some other Chrysomonads (12). It must however be mentioned that I used only LÖFFLER's method of demonstrating cilia, which is not the best one in such cases. The pinnate flagella having been found in many Chrysomonads, there will be nothing unexpected, if such proved to occur in *Synochromonas* too.

The cells are tapered towards the centre of the colony, where they are probably joined together by their ends. This connection, if generally present, must be exceedingly loose, because in no case I could see it directly. There is no possibility to obtain any sure evidence of this by observing untouched and freely swimming colonies. By the slightest pressure or fixation the cells more or less contract, especially at their basal ends, and disjoin from one another. If the pression has became greater, the cells slide out of their mucilaginous investment, and soon burst.

Each cell of *Synochromonas* has usually two chromatophores. They are biscuit-shaped due to a slight constriction in the middle, but often may be protracted and pointed behind (Pl. 9 Figs. 10, 11). The chromatophores are not closely applied to the surface of the body, but lie freely within the latter, one a little behind the other. The anterior chromatophor reaches the fore end of the body, and here, at the place of its contact with the periplast, a very small stigma is situated, in the form of a short thick rod. The stigma is very variable in size, being often punctiform, and even wholly absent.

The relation of the stigma to the flagellar apparatus is worth attention. The stigma is always closely applied to the base of the shorter flagellum, and it is likely that there is an actual connection between them, since by various deformations of the body the stigma does not separate from the flagellum. The same was clearly shown by TROITZKAJA for *Uroglenopsis americana* (18).

The longer flagellum is attached just near the short one, but has no relation to the stigma. When the cell is dying off, the stigma

may be detached from the chromatophor, but its connection with the flagellum is preserved.

The chromatophores of *Synochromonas* are relatively small and very pale, which is evidently conditioned by a low intensity of light and peculiarities of nutrition of the organism. In the material obtained first, the chromatophores were so pale that it was somewhat difficult to follow up their outlines when working with the camera-lucida. In my collections of the last year, however, the chromatophores were coloured more intensively, approaching it this respect to those of *Synura*-species, found together with *Synochromonas*.

The nucleus lies at the fore end of the cell, between the chromatophores. In favourable conditions, it appears as an indistinctly outlined, finely granular body with a very small caryosome in the centre (Pl. 9 Fig. 12), and applied to it there is a mouth-band, invisible from its broad side and appearing as a short, refringent line when viewed from the narrow side.

There is one contractile vacuole in *Synochromonas*, disposed on the ventral side of the body at some distance from the place of insertion of the flagella. It functions like contractile vacuoles in the Ochromonads, and in this respect *Synochromonas* has nothing in common with *Synura*, *Mallomonas*, etc. with their complex vacuolar apparatus.

The basal end of the cell is occupied by a large mass of leucosin, which is very unresistent here. While in many other Chrysomonads leucosin can be pressed out of the cell, in *Synochromonas* this is impossible to do, because under the slightest pressure the leucosin drop transforms into a vacuole filled with a fine suspension of minute particles in Brownian movement, which is accompanied by the loss of the former refraction power.

On the periphery of the cell are scattered small globules of oil, staining red with Sudan III, and droplets of volutin.

Besides these ergastic bodies, in the cells of *Synochromonas* one can see various smaller organisms, in my case more often *Chromatium Okenii*, lying in digestive vacuoles. *Synochromonas pallida* is thus capable of holozoic nutrition, like *Ochromonas* and many other Chrysomonads, and it is likely that this method of nutrition predominates, because in room cultures the development of *Synochromonas* was clearly dependent upon that of the food-organisms. The method of capturing prey by *Synochromonas* could not be followed, because in hanging-drop preparations the organism not only does not catch its food, but throws out that already swallowed. But once I saw the last stage of swallowing a cell of *Chromatium*, which enabled me

to obtain a general idea of the process. The food-particles, driven up to the base of the flagella, are catched by means of a food-vacuole, arising on the dorsal surface of the body at some distance from the flagella. The food-vacuole must evidently penetrate the layer of mucus surrounding the whole colony, and the question rises in which way the cell of *Synochromonas* is influenced by the food-organisms. It seems very likely that the corresponding stimulation is received and transferred by the shorter flagellum, which is almost wholly enclosed in mucilage and is practically inactive.

Indigested remains of the food-organisms are extruded also near the fore end of the cell.

The details of cell division in *Synochromonas* were not followed up, but it seems that there are no particuliarities in comparison with what is observed in other Chrysomonads. The cells going to divide increase considerably is size, and the number of the chromatophores doubles. Just before division two new flagella grow out, the cell becomes more rounded, and then longitudinal constriction of the body follows. I have not observed the autonomous division of the colonies, but it can be brought forth artificially, by means of a light pressure on the cover glass.

My observations on the process of encystement are very incomplete, but worth mentioning. The formation of resting cells was observed in a jar with water from the basin with *Synochromonas*, after about two weeks staying in the laboratory. During this time a rather good development of the organism took place, but after all the solid food had been exhausted further development stopped, and colonies began to fall to pieces. Soon solitary cells appeared in the jar, which were balled, as if inflated, so that their relation to *Synochromonas* was not to be readily established.

Knowing that the cyst formation in other colonial Chrysomonads (*Skadowskiella*, *Uroglena*, *Dinobryon*) is not preceded by the desintegration of colonies, I turned no attention to the process described, considering it as that preceding the dying off of the organism, and interrupted further observations on the latter. On the third day however I found that the surface of the water was densely covered with innumerable spherical cells with several brown chromatophores, evidently originating from the colonies of *Synochromonas* which were quite absent now. The cells were immotile, but judging from their fresh appearance, by no means about to die off, and the closer examination showed them to be cysts of *Synochromonas*. Their formation evidently took place during the interruption in my observation, and remained thus unfollowed in detail.

The cysts were perfectly globose and covered with a smooth thin colorless membrane without any pore, in contrast to the cysts of other Chrysomonads. The membrane was soft and little refringent, which showed that it was not silicified. There was no evidence that it was formed endogenously, as in other Chrysomonads, and I think it to be a mere external secretion of the balled and inflated cells I saw before. Inside the cyst, excentrally, was placed a large drop of leucosin occupying the greater part of its interior, the protoplasm forming only a wall-sided layer round it. Almost discoid chromatophores were disposed peripherally close to the cell wall, somewhat crowded in the thicker part of the cytoplasm layer, and put asunder or even absent on the opposed side where the leucosin mass was pressed against the wall. Contractile vacuoles were not seen. As to the nucleus, the examination of living cells showed that there were two nuclei in each cyst, and this remarkable fact was confirmed by examination of the cells fixed with Schaudinn's fluid and stained with iron-hematoxylin, which all proved binucleate (Pl. 10 Fig. 24). The structure of the nuclei showed nothing peculiar. There was seen a small and deeply stained caryosome, lying nearer to the inner concave side of the nucleus and surrounded with particles of chromatin of a considerably paler tint. The nuclei were disposed at some distance from one another on the side of the cyst opposite to the leucosin mass, the protoplasm layer being here the thickest.

There hardly may be any doubt that the cells described were not ripe cysts, because in all known cases the cysts of the Chrysomonads have siliceous wall provided with a pore and stopper, this structure being preserved even in the most deviating forms of the group. In any case, the soft membran of these cells cannot be of any service in protecting the cell from drying up. I suppose therefore that the formation of this membrane is only a preliminary stage of encystement, the true cysts to be formed endogenously inside this temporary envelope, as this was observed in *Amphichrysis*. Unfortunetely, I could not verify my supposition by a direct observation, because in the jar with *Synochromonas* the development of *Physomonas vestita* began, which in some two days annihilated all the cells of *Synochromonas*.

The most remarkable point in the morphology of the cysts of *Synochromonas* is undoubtedly their binuclearity. It is evident that the nuclei of the cyst arise by division of the formerly single nucleus of the cell, but the significance of this phenomonon is quite

obscure. Observations on the germination of the cysts could possibly throw some light on this fact. It must be mentioned that, according to my recent observations, the cysts of *Uroglena volvox* are also binucleate, and in this case I could convince myself that this is due to the division of the nucleus of ordinary cells, which preceds the formation of cysts.

As to the taxonomical position of *Synochromonas*, the new genus belongs evidently to the group called by PASCHER (11) *Ochromonadae aggregatae* (CONRAD'S *Ochromonadaceae*), where it, along with *Chrysobotrys* CONRAD (2) must occupy the lowest place due to the simplicity of the structure of the cells and colonies.

Diagnoses of the new genus and species are as follows:

Synchromonas, gen. n.: Freely swimming spherical colonies composed of a variable number of cells which are united by their protracted basal ends and surrounded with a general mucilaginous investement. Cells of the type of *Ochromonas*, dorsiventral, without any differentiated periplast or envelope, with two unequal flagella, two chromatophores, one contractile vacuoles, and a nucleus; leucosin, oil, and volutin are present.

S. pallida mihi: Colonies to 60 μ in diameter, consisting of up to 30 and more cells. Cells elongated, tapered behind, obliquely obtuse in front, convex on one (dorsal) side, and almost straight on the other, up to 27 μ long. The flagella about 35 μ and 5 μ long, the shorter one almost inactive. Chromatophores two in number, biscuit-shaped, or protracted behind, lying freely in the protoplasm, one of them usually with stigma at the anterior end, to which the shorter flagellum is attached. Nucleus and mouth-band at the fore end. A simple contractile vacuole on the ventral side of the cell, nearer to the fore end. Leucosin mass single, at the basal end of the cell. Nutrition mainly holozoic, the solid food being captured by a food-vacuole on the dorsal side of the cell. Cysts solitary, binucleate, with many chromatophores, covered (in unripe condition?) with a thin exogenous unsilicified wall, 11—14,5 μ in diameter.

Found in Kharkov Botanical Garden, in an artificial basin, and in the environs of the town, in pools, under ice.

4. The genus *Synura* and its taxonomy.

(Pl. 11 Figs. 31—65 and Fig. A in text.)

The genus *Synura*, though it has been the object of investigations of many prominent protistologists since EHRENBERG'S times, has proved to be one of the most obscure among the Chrysomonads. Referring

for details to the original works of Klebs (4), Pascher (10) and Conrad (1, 2), I confine myself to a general outline of the morphology of *Synura* based on the data of these authors. *Synura* represents a spherical colony consisting of a variable number of elongated cells joined together with their posterior tapered ends, and not surrounded with a general mucilagineous envelope, as for instance *Synochromonas* is. Each cell is covered with a dense envelope ("Hülle" of some German authors) ornamented outwardly with a more or less prominent net-like ridges, and in most cases still with short bristles or warts on the knots of the net. The posterior end of the body is occupied by a mass of leucosin, and in the same region many contractile vacuoles are scattered, whose method of functioning is not wholly elucidated (Pascher 10, p. 44, Conrad 1, p. 5). There are two elongated chromatophores disposed on the opposite sides of the body, and between them and in front of the leucosin mass lies the nucleus pointed anteriorly towards the basal-granule of the neuro-motor apparatus (Petersen 12). There are two flagella, of an equal length (Stein, Klebs, Pascher, Conrad and others, save Petersen).

According to these characters, *Synura* has been referred by Pascher to the Hymenomonadaceae eggregatae in his system of the Chrysomonads.

The question of the structure of the cell of *Synura* became very intricate after Petersen had shown that the data of the former authors concerning the periplast and the flagella in *Synura* are incorrect. Acording to the author, the flagella are unequal, as to their length, structure, and function. One of them is considerably longer, and bears two rows of short hair-like appendages. It is to these flagella that the progressive movement of the colony is due. The shorter flagellum is smooth, and causes the rotating movement of the colony.

As regards the envelope of the cell of *Synura*, it was shown to consist of many elliptic scales disposed regularly on the surface of the cell, as in *Mallomonas*. This fact is the more surprising that the difference between the envelopes in *Synura* and *Mallomonas* was emphasised by Klebs, who writes on this subject as follows: „die Hülle von *Synura* ist nicht derjenigen von *Mallomonas* gleich gebaut, sondern höchstens nur dann anscheinend gleich ist, wenn in älteren Kolonien Bakterien sich ihr anhängen" (4, p. 417).

It is clear that Petersen's detection throws quite a new light on the taxonomical position of *Synura*.

As to the species of the genus existing in nature, the question has been obscure from the very beginning. Besides *Synura uvella* EHRB., there were described *S. reticulata* LEMMERMANN (7), *S. verrucosa* PASCHER (11), *S. Adamsii* S. M. SMITH (14) and *S. australiensis* PLAYFAIR (13). *Synura Klebsiana* LEMMERMANN (7) has as yet been considered as a doubtful species (CONRAD 1, p. 7).

Synura Adamsii and *S. australiensis* are well characterised by the form of their cells, and not to be confused with other species, though there may be some doubts as to their being not the same species. The other three forms are distinguished by so subtile characters, that only their authors have possibly been capable to determine them with certainty. As to me, I never felt myself on a firm ground in identifying *Synura*-species.

That this is not only my personal impression is evident from the remarks of so prominent investigators as PASCHER and S. G. WEST. So, PASCHER writes about *Synura* as follows: „Eine ungemein variable Gattung, die nach jeder Richtung hin, auch morphologisch und entwicklungsgeschichtlich noch genauen Studiums bedarf" (11, p. 49). According to WEST, "it is doubtful whether more than one species of *Synura* has so far come to light, the diverse ornamentation of the periplast, upon which other species have been based, appearing to be a variable feature" (19, p. 325).

One of the recent investigators of the genus *Synura*, CONRAD, came tho the same conclusion, as is seen from the following quotation:

"L'étude attentive et poursuivie de la structure cellulaire nous dévoilera un jour s'il s'agit là reellement de trois espèces distinctes. Entretemps nous sommes convaincu qu'une seule forme, *S. uvella* EHRB., a été observée, mais qu'elle est fort sujette à varier au pont de vue du contour général et, surtout, des enveloppes" (I, p. 8).

It is evident that PETERSEN's detection of the scaly envelope in *Synura* put forth quite new principles of the taxonomy of the genus, analogous to those used with respect to Mallomonas. At the same time the leading characters established by former authors ought to be considered as imaginary and thus inapplicable.

While studying *Skadovskiella* and later on *Synochromonas*, I could not avoid, for the sake of comparison, the investigation of *Synura*. But my first results were erroneous and contradictory, as well as some data concerning *Skadovskiella* itself. It seemed to me (5, p. 453) that the form of *Synura*, found together with *Skadovskiella* and determined by me as *S. uvella* had the cells covered only with a smooth periplast without any net-like ornamentations. Later on in the same

basin I have found a *Synura*-like organism with scaly envelopes round its cells, just as it was described by Petersen, and this organism proved to be widely distributed not only in the environs of the Hydro-physiological Station in Zvenigorod, where I was working then, but also in the Kharkov District.

In connection with this the following question was to be solved: whether there exists in nature the "true" *Synura*, as it has been described by Klebs, Pascher and Conrad, Petersen's *Synura uvella* representing a new and independent genus; or whether it is only by Petersen, that *Synura uvella* has been described correctly. To answer this question the re-investigation of the genus was necessary.

Very favourable weather in the autumn and first winter-months of 1928 enabled me to collect a large material, the study of which showed that in the environs of Kharkov there exist no less than five forms of *Synura*, which I am inclined to consider as independent species. They all are quite identical in size and structure of the colonies, and not to be distingushed by superficial observation. Also the form, size, and general structure of their cells, are so similar, and at the same time so variable in dependence on the environmental conditions, as not to be of any service as distinctive characters. It is only on the form of scales constituting the cell-envelopes, that the taxonomy of the genus can be based. The future will show how sure such a base is, but at present I think that only in this way any good results may be gained. As to the *Synura* with naked cells provided only with a periplast, such a one has not been found by me since the time I began to pay sufficient attention to this point, so that the current characteristic of the genus must be changed in this respect.

There is no need to enter into the description of the protoplast, the structure of which, the same in all the species, was correctly described by Klebs, Pascher, Conrad and Petersen. But some of my observations are worth of mentioning, in view of some uncertainties with respect to the contractile vacuoles in *Synura*, and its multiplication.

So, Klebs (4, p. 417) describes in *S. uvella* „mehrere kontraktile Blasen im Hinterende, eine Zellblase im Vorderende". According to Pascher's (10, p. 44) diagnosis, „Vakuolen zwei bis drei, seltener mehr Vakuolen, deren System noch nicht völlig geklärt ist"; and further (l. c. p. 46): „Vollständig ungeklärt ist das Vakuolensystem von *Synura*. Es werden 3—5 angegeben. Soviel ich sehen konnte, ich richtete mein Augenmerk zu spät darauf, stimmt das Vakuolen-

system in vieler Hinsicht mit dem von *Microglena*, *Mallomonas*, *Taumatomastix* überein. Es scheinen die Vakuolen miteinander zu kommunizieren — wobei es aber zur Differenzierung einer besonders auffälligen Hauptvakuole gekommen wäre; jene Vakuole, die gewöhnlich groß und auffällig gezeichnet wird. Ob aber diese Hauptvakuole so weit wie bei den genannten Gattungen differenziert ist, vermag ich nicht zu sagen".

The description of the vacuolar system of *Synura* given by Conrad (1, p. 5) is not clearer: "A la base de la cellule se trouvent deux ou trois vacuoles pulsatiles contigues, dont le fonctionnement est difficile à observer. Dans quelques cas, pourtant, il nous a été possible de voir que'elles battaient alternativement à peu de secondes d'intervalle. Sont-elles réunies, comme chez *Mallomonas*, en un véritable système pulsatile? C'est probable, mais ce système est des plus simples: une sorte de vacuole collectrice faisant, croyons-nous, défaut. A l'avant du corps s'observe parfois une vacuole supplémentaire."

According to my observations, the vacuolar system of *Synura* is very similar to that of *Mallomonas*. Contractile vacuoles are disposed in a thin protoplasmic layer in the posterior part of the cell round the mass of leucosin. Their number is quite indefinite, even in the same individual, because in *Synura* contractile vacuoles are not so constant in position, as for instance in *Physomonas*. Their functioning can be described as follows. In the close neighbourhood of each of the large vacuoles going to contract, a system of small vacuoles is to be seen, which have appeared, partly simultaneously, partly successively, in the place of the already contracted vacuole. They increase gradually in size and fuse together, so that their number is ultimately reduced to one or two. In the meantime the former large vacuole disappears, and its place is also occupied by a system of small vacuoles, some of which have been formed round the large vacuole when still in the state of diastola. Due to their fusion the former vacuole may be restored, but often a part of them fuse with a part of the neighbouring system of vacuoles, which leads to the formation of two vacuoles, instead of the one expected. Which place will become the centre of formation of a new vacuole, is a matter of chance, therefore the contractile vacuoles in *Synura* are inconstant, either in position, or in number. As is seen, collecting vacuoles, like those in *Euglena* (*Microglena* and *Taumatomastix*, referred to by Pascher, have not been studied by me), are absent.

The functioning of the vacuolar apparatus in *Mallomonas* is essentially the same, with the only difference that here contractile vacuoles are grouped between the chromatophores.

As to the anterior vacuole (Klebs' „Zellblase", and Conrad's "vacuole supplémentaire"), I have seen nothing of this kind. Just before the leucosin-mass there is disposed the nucleus which with insufficient powers of the microscope can appear like a vacuole narrowed towards the base of the cilia. Close to the nucleus lies the mouth-band, which in *Synura* is not very distinct, and not to be taken for a vacuole. The indications of Klebs and Conrad concerning the anterior vacuole in *Synura* are probably based on some mistake in observation.

Neither stigma, nor hematochrom-droplets at the anterior end, were found in the forms of *Synura* from my material.

As regards the flagella, my recent observations have fully confirmed Petersen's data on the subject. All the Synurae of my collections were found to have unequal flagella, the longer of which was pinnate. It seem rather strange, that so many prominent observers have overlooked this fact, but I myself became a victim of the same error with respect to *Skadovskiella*. I described it to have two equal flagella, as in *Synura* according to Stein, Klebs, Pascher and Conrad, whose works alone were then known to me. It was only after my paper on *Skadovskiella* had been printed, that I could see my error, and I avail myself of this opportunity to correct it. In *Skadovskiella* only one of the flagella is as long, as it is shown in my drawing (5, Pl. 7 Fig. 1). The other is somewhat shorter, about a half of that length, but there were no possibility to make exact measurement, because I could not obtain the cells with stretched flagella in fixed preparations: the flagella were either thrown off, or so much curved and entangled, that their length could be estimated only approximately.

The same proved to be the case with *Synura*-species.

It is to be mentioned, that hairy appendages on the longer flagellum can be demonstrated by a far simpler method, than that of Löffler. Indeed, they may be recognised merely in the dry, but unstained, cover-glass preparations. The cells must be dried alive, not fixed afore, and examination must be made with the highest magnifications of the microscope, and under the best possible illumination. Of course, a certain experience is also necessary. In some cases the pictures obtained by this method are no less clear and convincing, than with Löffler's staining.

In the same way the scales of the cell-envelope of *Synura* can be investigated, but in this case the organic substances in the preparation must be removed by calcination, as in the case of the Diatoms. After this treatment there remain only the scales of the envelopes, which shows that these consist of silica, as in *Mallomonas*. It is best to examine them directly, without mounting in the mediums used for the Diatoms-preparations, because their outlines become then very indistinct.

By means of this simple method I could convince myself that in the small region involved in my investigation there exist at least five forms of *Synura* distinguished by the shape of their scales. So far I have met with no intermediary forms between them, whose existance ought to be expected from the stand-poind of the former taxonomy of the genus. Since in the series of the outwardly very similar forms described here, undoubtedly comprising the species already known, there are no other features to be taken for a sure taxonomical base, I consider the forms distinguished by the shape of their scales as independent species. This is the more convenient, that it permits to determine species on preserved material which was formerly impossible.

After this general outline of the genus *Synura* we pass over to the description of the species so far registered in the environs of Kharkov.

Synura uvella Ehrb.

(Pl. 11 Figs. 31—37.)

It is hardly possible to make out which of the species found by me has been described by Ehrenberg under the name of *Synura uvella;* and at present it appears that the organism figured by Stein (15, Pl. 13 Figs. 24) is not identical with those described and figured under the same name by Klebs (4, Pl 18 Fig. 8, in supposing these figures being quite correct as to the shape of the envelope), Conrad (2), and especially by Petersen (12), whose drawings alone give an exact idea of what he has seen. Pascher's drawings (10, Pl. 11, Figs. 26—29) relate probably to more than one species, Fig. 29 showing especially great resenblance to Stein's drawings. G. S. West (19, p. 325 Fig. 135) judging from his drawing of *Synura uvella*, has also been dealing with Stein's species.

The question is thus very intricate. In order to solve it in any way, I propose to call *Synura uvella* St. only the form described first by Stein, i. e. that with prominent spines on the envelope,

distinguishable even by means of not quite perfect optic. It is to be mentioned, however, that this form is of a rather rare occurrence in our basins, the most widely distributed one being identical with that described by Petersen, and probably by Conrad, judging by his rough drawings.

This species of *Synura* has been found by me in some of the bogs in the environs of the Zvenigorod Hydro-physiological Station (dir. prof. Skadovsky), and Kharkov. Its colonies and cells show nothing peculiar in comparison with those of other forms, and are described in literature with a sufficient correctness. It may only be mentioned that I have never met with colonies with so many cells as in other species; but this fact may have been dependent on the environmental conditions. Therefore I confine myself only to the description of siliceous scales, which are of the greatest taxonomical significance in this case.

These scales are very interesting structures, to be easily recognised among those of other species. Each cell has two kinds of scales. Those covering the posterior narrowed part of the body bear no spines, and represent irregularly elliptical plates of a comparatively small size (Figs. 35—37). On the analogy with other species of *Synura*, one must expect that there are more strongly elongated lanceolate scales, disposed at the very end of the cell; but I could not find such ones in my preparations containing only a few of colonies of *Synura uvella*.

The posterior heel-like part of the scale is bordered with a strong broad thickening milled on its upper surface, as this is rather imperfectly shown in my figures. Among all the species of *Synura* known to me, *S. uvella* alone has the scales with such thickenings.

The anterior not bordered part of the scale overlapped by the posterior ends of the scales in front is less developed, being in general very variable in dependence of the position of the scale: the nearer to the fore end of the cell, the greater and broader become the scales, and the smaller becomes their anterior lobe in comparison with the posterior one. The smallest scale observed were 3,5 μ long and 2 μ broad, the largest up to 5,5 μ lang aud 5 μ broad.

In the space between the anterior ends of the marginal thickening the scale is also ornamented with slight thickenings in form of a very fine and regular net visible only under the highest magnifications. Fig. 35 is a very imperfect attempt of illustrating this interesting detail, in other figures the areolated area being only indicated by a mere shading. The net is especially clearly

seen in the largest not spined scales, where the anterior margin is smooth. In the smaller posterior scales the net extends over the whole anterior lobe, but is very indistinct (Fig. 37). On a not quite correct focussing this part of the scale appears merely shadowed in contrast to the transparent middle part, which makes an impression of an opening.

Nearer to the fore end of the cell the spined scales are disposed. The anterior not-thickened lobe is here reduced so that the scales are obtuse in front, usually resembling the heel of a boot (Figs. 31, 32), but in some cases being almost round (Fig. 34). To the middle of the reticulated part of the scale a strong hollow thorn is attached, bent aside at an angle of about 45°—60° to the surface of the scale, dependent opon the place of the latter on the body: the nearer to the fore end, the greater is this angle. Due to such a position, the thorns on the body are somewhat spreading and easy to be seen. Often the scales are met with of a type intermediary between the two described above, *viz.* provided with only a very short thorn (Fig. 34), so that a full series of intergradations between the anterior and posterior scales may be traced.

The scales in *Synura uvella* are disposed straightly forward, not obliquely, as in other species with not-spined scales.

Synura spinosa mihi.

(Pl. 11 Figs. 38—41.)

Showing no peculiarities in the shape and structure of its colonies and cells, this species differs from *Synura uvella* by the form of its scales. These are much finer, and consist also of a posterior heel-shaped part with a thickened border, and an anterior lobe, both being here almost equally developed (Figs. 38—39). In smaller scales, which are obviously disposed at some distance from the anterior end, the frontal lobe is shorter than the posterior one (Figs. 40—41). The posterior half of the scale is not so broadly rounded as in *Synura uvella* (Figs. 38, 39), but in this respect variations occur, some of which are represented in my figures. The marginal thickening is very slight, and the scales are in general much finer than those in *Synura uvella.*

The anterior lobe in some cases is almost symmetrical with the posterior one (Fig. 38), being yet more variable than the latter, as is to be seen from the figures. It is either rounded, or provided with slight lateral excavations (Figs. 38, 39). In the vast majority of scales in the posterior halves an approximately semicircular spot

was to be seen, lighter or darker than the area in front, according to the adjustment of the tube of the microscope, and appearing as an opening (Fig 39). The anterior part of the scale is obviously somewhat thikened, and in some cases an exceedingly fine and indistinct net was to be discerned. Judging from my not quite perfect preparations, the anterior lobe is not thickened on the very margin, which at a certain adjustment of the microscope-tube appears either darker, or lighter than the middle.

The spines in *Synura spinosa* differ clearly from those in *Synura uvella*. They are solid and very thin, slightly tapered and blunted at the tip. They are a little shorter than the scales, but if the latter are short the spines may even surpass them in length (Fig. 44).

The spines are attached to the fore end of the scale, and directed almost in the same plane, so that in the living cells of *Synura spinosa* they do not spread so much as in *Synura uvella*, being therefore less observable than in the latter. The scales are disposed in longitudinal direction, as in *Synura uvella*.

I could not learn, whether all the scales of a cell are provided with spines. In my preparations the envelopes of *Synura spinosa* had not been disorganised before drying up, and almost all the scales, save the peripheral ones, lay as a dense almost untransparent mass, in the middle of which the basal scales were hidden. But it is likely that in the species concerned there is the differentiation of the scales similar to that in *Synura uvella*.

The size of the anterior scales ranges from 3 μ to 5 in length, and 2,5—3 μ in width; thorns are 2—3 μ long.

As is seen, the difference between the envelopes of the two forms of *Synura* is quite distinct and permits of recognising both species even in living condition; of course, with good optic and sufficient attention.

It is not improbable that the form of *Synura* figured by Klebs (4, Pl. 8, Fig. 8 b) is identical not with *Synura uvella*, buth with *Synura spinosa*. This is suggested by its spines being very thin and not so spreading, as in *S. uvella*. But it is impossible to establish in what degree Klebs' drawing is correct in this respect.

Synura echinulata mihi.

(Pl. 11 Figs. 42—53.)

This species has been found in a pool near Kharkov, and seems to be of a rare occurrence here. It differs from the other species by its scales only. These are also provided with thorn-like appen-

dages, which in the anterior scales are almost as long as the scale itself. At the posterior end of the cell the scales are without spines, all intergradations being to be found between these extreme types.

Anterior scales are heel-shaped (Figs. 42—45), with a little developed anterior lobe. As in *Synura uvella*, the latter varies in size according to the position of the scale, attaining a minimum at the fore end of the cell. The sides of the anterior lobe are almost straight, converging at a more or less obtuse angle towards the mediane. The much larger posterior half of the scale is either evenly rounded, or somewhat narrowed behind (Figs. 44, 46, 47). Its margin it thickened, and the thickening extends also on the anterior lobe, being here less marked however. The difference is in general rather little, so that under a superficial observation the scales appear to be thickened evenly all around, making an impression of irregular rings. The spine is uniformly thick through its length, and in most cases is bent aside, as in *Synura uvella* (Fig. 42). The length of the scales together with spine averages 3 μ; width is about 2 μ.

Nearer to the posterior end of the cell, the scales become more narrow, the spines shorter, the anterior lobe increases in size, and its marginal thickening disappears (Figs. 48, 49). Often on such scales one can find the rudiments of spines. At the very base of the cell the scales become quite small, as few as 1,5 μ long, which is largely due to the reduction of the anterior lobe (Figs. 50—53). Their form is very variable, as is seen from the figures.

Synura Petersenii **mihi** (*S. uvella* auct.).

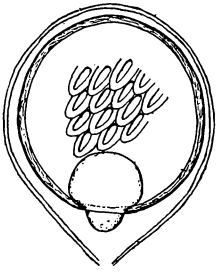
(Pl. 11 Figs. 54—58.)

This is the most frequent species of *Synura*. The structure of its envelope has been described by Petersen (12), but the chemical nature of the scales constituting them has then remained unknown to the author. Later on both he and Conrad (2, p. 206) have found that the scales resist calcination, being consequently composed of silica.

The scales of *Synura Petersenii* represent somewhat irregular, especially at the anterior end, elliptic plates, twice as long as broad, averaging 4 μ in length and 2 μ in width. Sometimes they are narrowed behind and more obtuse in front (Fig. 56). Marginal thickening is not very great, but distinct, and surrounds the greater part of the scale, being absent only at the anterior end of it. In the mediane there is disposed a clearly outlined elongated ridge,

narrowed behind and obtusely rounded in front. It extends through the anterior three-fourths of the scale, somewhat protruding beyond its anterior end. This ridge is not a mere thickening of the scale, but only a sharply outstanding fold on its outward side, which is especially well seen in the scales on the margin of the cell while observing them in optical section.

The scales are disposed obliquely relative to the long axis of the cell, at an angle of about 40^0—45^0 to it (Fig. A in text), adhering to the protoplast and overlapping one another by their edges. Due to the ridges on the scales the periphery of the cell appears denticulated. When seen from the surface, the envelope seems to be ornamented with warts, or short denticles, while the overlapping edges of the scales look as a net-like work on the cell surface. It is only under the highest magnifications that the true picture of the structure of the envelope stands out, as is shown in Fig. A in text. After the deadth of the cell the envelope retreats a little from the protoplast, the scales become somewhat spreading, and the envelope takes the appearance schematically but rather expressively represented in Conrad's drawings, relating just to this species.



Text-Figure A.

Posterior scales of *Synura Petersenii* are in general similar to those of the above described species. They are very small, narrow, often lanceolate (Figs. 57, 58), and have no mediane ridge, whose absence is compensated by a strong development af the anterior lobe.

I confine myself only to the description of the scales of this species, since in other respects it was with sufficient correctness described by other authors. As regards its identity with any of the already known species, I can say nothing definite. It must be mentioned, however, that Petersen's identification of the form, he has found, with *Synura uvella* Ehrb. is objectionable. In Pascher's „Süßwasserflora" Vol. 2 p. 49, *Synura uvella* is characterised as having the envelope with shorter or longer bristles, and not reticulated on the surface. Petersen's form of *Synura* hardly could have such an appearance, because according to his own description there were no bristle-like appendages on the scales of his *Synura*.

The question as to the relation of *Synura Petersenii* to other two *Synura*-species referred to by Pascher (*S. reticulata* Lemm. and *S. verrucosa* Pasch.) can hardly be decided. Pascher himself indi-

cates (10, p. 44—45) that the difference between them is essentially a quantitative one, the species in question being only the extremes of a continuous variation-series. At present, after we have learned that the envelope in *Synura* is not a mere periplast with various superficial ornamentations, but has quite another structure, the difference between *Synura reticulata* and *verrucosa* becomes obscured. The question can be solved only by the re-investigation of these species with respect to the structure of their envelopes, because the differences in form of the cells, referred to by PASCHER, have no taxonomical value: they are very subtile, and can easily be explained by the difference in nutrition contitions.

Synura glabra mihi.

(Pl. 11 Figs. 59—65.)

This apparently rather rare species is peculiar for its cells showing no traces of ornamentation on their surfaces. Even under the highest magnification the cells appear quite smooth and deprived of any dense envelope. Just this species has undoubtedly been found by me in the environs of the Hydrophysiological Station in Zvenigorod, and has suggested the existance of a form of *Synura* with naked cells, without any siliceous envelope. Recently I have found this species near Kharkov, and its investigation showed to me the incorrectness of my former observations mentioned in my paper on *Skadovskiella* (5, p. 453).

That the cells of *Synura glabra* are covered with a differentiated envelope becomes sometimes clear after their deadth, when the anterior part of the anvelope is detached from the protoplast. But even in this moment it is impossible to discern the structural elements of the envelope, which appears as a continuous membrane, because the scales constituting it are so thin and transparent, as not to be seen in water when isolated. The method of calcination however permits to investigate them no less precisely than in other species.

In general, the scales of *Synura glabra* resemble those of *Synura Petersenii*. They represent very small plates of an elliptic form, but less elongated than in *Synura Petersenii*, measuring up to 3,5 μ in length, and to 2,5 μ in width. Often the scales are met with the length of which is almost equal to the width (Fig. 62). Anterior scales never are narrowed behind, as are sometimes the scales of *Synura Petersenii*, and their frontal edge is usually obliquely obtused.

The marginal thickening is much less distinct than in *Synura Petersenii*, and the median ridge is also less prominent, often being somewhat curved behind (Figs. 61, 62). Such a slight development of the thickenings on the scales accounts for the envelopes in *Synura glabra* appearing smooth.

Nearer to the base of the cell the scales decrease in size, and become more elongated (Figs. 63—65). The smallest of them I have seen were provided with rudimentary ridges, in which respect they differed from those of *Synura Petersenii*. But I am not quite certain that the scales without median ridges are quite absent in *Synura glabra*.

It is not impossible that there are slight specific differences also in the form of the cells of *Synura glabra*. So, in my material the cells in colonies were grouped very densely, as compared with those of *Synura Petersenii*, and were more rounded, even somewhat flattened at the anterior end. But so far it is uncertain in what degree these characters are independent of the environment. I can only mention that during the period of about five weeks the cells of *Synura glabra* from the material kept in cold retained their former shape, while those of *Synura Petersenii* in the same conditions became more slender due to the decrease in the amount of leucosin.

As is seen from the preceding description, two types of scales may be distinguished in the species of *Synura*: one with a thorn-like appendage at the anterior end of the scale, and one without them, but with a mediane ridge on the outer surface of the scale. The difference is essential, and it is not easy to imagine any transition from one type to the other. I think however that it would be inconvinient to attach to these peculiarities any more than specific significance, therefore I consider all the forms described as species of a single genus *Synura*.

In connection with the establishment of a new base for the taxonomy of this genus, the question must be discussed of the relationship between it and *Skadovskiella sphagnicola* recently described by me (5). This new genus has been created in the supposition, which has now proved inconsistent, that the genus *Synura* is characterised by having equal flagella and no silicified scaly envelope, as this has been described by all the investigators of the genus, Petersen's data referring to some another genus. Moreover, according to my former observations *Skadovskiella* seemed to be provided not with true scales, but with siliceous rings with terminal rod-like appendages, which was considered as a good distinguishing feature of the genus. However, the re-investigation of *Skadovskiella* confirmed

PASCHER's supposition, expressed in one of his letters to me, that the rings of *Skadovskiella sphagnicola* are in fact only marginally thickened plates. Indeed, the examination of them in a dark-field illumination showed that the central parts of the rings produce reflection of light, which indicates the presence there of an extremely thin lamina, not to be detected by ordinary methods.

In this connection the question arises, whether there is now any reason to maintain the generic name of *Skadovskiella*, and whether it would not be better to include the organism concerned into the genus *Synura* as a particular species of it.

My present opinion is that this may be done, because there is no essential difference in the structure of the envelope between the two genera. The fact that the scales in *Skadovskiella* are spreading, not adhering to the cell-surface, as in other species of *Synura*, hardly can be considered as that of generic significance, as well as some particuliarities in the distribution of leucosin in the cell. The name of *Skadovskiella sphagnicola* must consequently be replaced by that of *Synura sphagnicola*, comb. n. mihi. The generic diagnosis given in my paper on *Skadovskiella* may be taken for that of the species, with necessary corrections as to the length of the flagella, and the structure of the scales.

Another way to solve this question is to unite under the generic name of *Skadovskiella* the species of *Synura* with spined scales (*S. uvella*, *S. spinosa* and *S. echinulata*). But this hardly could be considered to be appropriate from the practical view-point, because the extreme minuteness of the scales would render it rather difficult to distinguish the genera in question in ordinary floristic works.

In conclusion I give a key for the species of *Synura*, I have found, based of the structure of the envelopes.

1. Scales with an anterior thorn, without median ridge, disposed longitudinally — 2.
   Scales without thorn, with median ridge, disposed obliquely to the long axis of the cell — 5.
2. Scales regular elliptic, with a uniform ring-like marginal thickening, attached only by the basal end to the surface of the cell. *S.* (*Skadovskiella*) *sphagnicola*.
   Scales of another kind - 3.
3. Anterior scales very robust, heel-like, strongly thickened and milled marginally, with hollow acute subterminal thorn bent aside. *S. uvella* EHRB.
   Scales of another shape, with solid terminal thorns — 4.

4. Anterior scales with large frontal lobe not thickened marginally, with long spine not bent aside. *S. spinosa.*
   Anterior scales very small, with a little developed obtuse-angled frontal lobe slightly thickened marginally, with short rod-shaped thorn bent aside. *S. echinulata.*
5. Scales elliptic, twice as long as broad, distinctly thickened on the margin, with a prominent median ridge. *S. Petersenii* (*S. uvella* auct.).
6. Scales less regular, broadly elliptic, obliquely obtused in front; marginal thickening and median ridge inconspicuous. *S. glabra* mihi.

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Description of Plates.

Plates 8—11.

All the figures have been sketched with the aid of ABBÉ camera-lucida from living, or (Figs. 4 and 24—30) fixed objects.

Plate 8.

Physomonas vestita STOKES.

Fig. 1. Basal portion of the stalk. 1000 : 1.

Fig. 2. Freely swimming individual. 1000 : 1.

Fig. 3. Stalked individual. 1500 : 1.

Fig. 4. Siliceous disks with bristles constituting the cell envelope. 2000 : 1.

Fig. 5. Beginning of division; the second mouth-band and two new flagella are formed. Bristles are not drawn, as well as in Figs. 6—8. 1000 : 1.

Fig. 6. Further stage of division: mouth-bands and contractile vacuoles diverge; between and below them four digestive vacuoles. 1000 : 1.

Fig. 7. Somewhat later stage of division: formation of new contractile vacuoles. At the right a clump of extruded food. 1000 : 1.

Fig. 8. The same cell at the stage of constriction. Daughter nuclei finished. 1000 : 1.

Plate 9.

Figs. 9—12. *Synochromonas pallida* mihi.

Fig. 9. General view of the colony. 900 : 1.

Fig. 10. Separate cell with biscuit-shaped chromatophores. 1000 : 1.

Fig. 11. Cell with elongated chromatophores. 1000 : 1.

Fig. 12. Cell with four chromatophores, flown out in hanging drop. Between chromatophores lies nucleus with mouth-band (*b*) at the right; *c. v.* contr. vac., l. leucosin. 1000 : 1.

Figs. 13—20. *Amphichrysis compressa* mihi.

Fig. 13. Flattened cell from the broad side; leucosin is not shown.

Fig. 14. Rounded cell in another projection (note the position of contractile vacuole!), with leucosin masses between chromatophores and along their outsides. 1000 : 1.

Fig. 15. Flattened cell in a broad-side view. 1000 : 1.

Fig. 16. Rounded cell in optical cross-section. Note two mouth-bands on opposite sides of the nucleus lying between the chromatophores. 1000 : 1.

Fig. 17. The same cell, viewed from the pole. 1000 : 1.

Fig. 18. Elongated and rounded freely swimming cell with lobed chromatophores. 1600 : 1.

Fig. 19. Polar view of the cell as in Fig. 18 with rhombic arrangement of chromatophores, and two leucosin masses. 1000 : 1.

Fig. 20. Polar view of a cell with four contractile vacuoles (abnormal case!) and four masses of leucosin. 1000 : 1.

Plate 10.

Figs. 21—23. *Amphichrysis compressa.*

Fig. 21. Two cells in division. 1000 : 1.

Fig. 22. One of them in a later stage of division. Former contractile vacuoles

(*c. v'.*) have travelled to the mediane of the chromatophores on the right side, and new vacuoles, near the flagella, have formed. 1000 : 1.

Fig. 23. Formation of cyst. 1000 : 1.

Fig. 24. Binucleate cyst of *Synochromonas pallida.* Iron-hematoxylin. 1500 : 1.

Figs. 25—30. *Amphichrysis compressa.* Iron-hematoxylin. 1000 : 1.

Fig. 25. Cell with twisted chromatophores, of which the whole set is drawn.

Figs. 26—27. Cells with longitudinal chromatophores, of which only the upper pairs are drawn.

Figs. 28—29. Upper and lower pairs of chromatophores of the same cell.

Fig. 30. Small elongated cell with simple chromatophores and flagellum preserved.

Plate 11.

Figs. 31—37. Scales of *Synura uvella* Ehrb. (emend.). 2000 : 1.

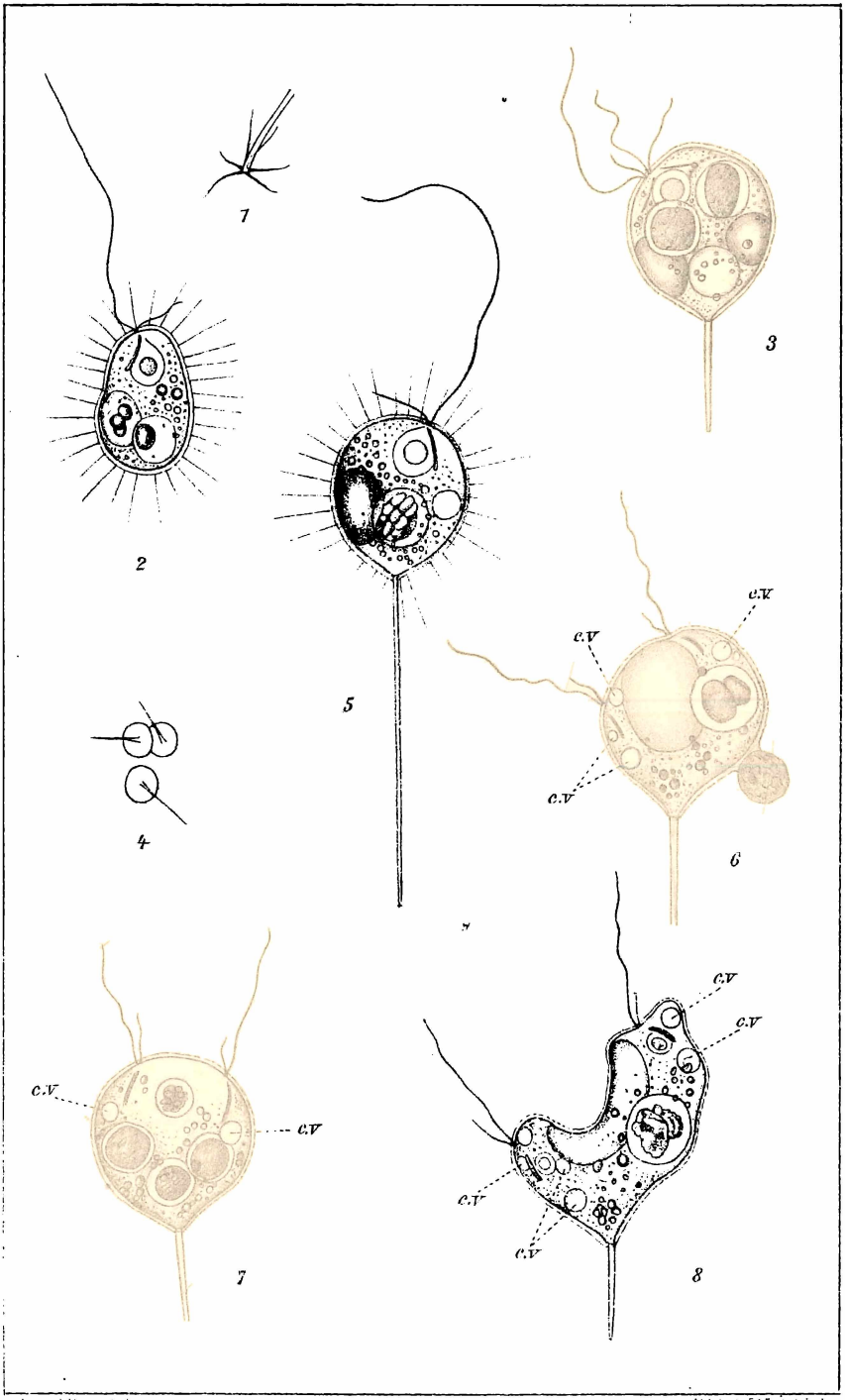
Figs. 38—41. Scales of *Synura spinosa* mihi. 2000 : 1.

Figs. 42—53. Scales of *Synura echinulata* mihi. 2000 : 1.

Figs. 54—58. Scales of *Synura Petersenii* mihi (*S. uvella* auct.). 2000 : 1.

Figs. 59—65. Scales of *Synura glabra* mihi. 2000 : 1.

Unfortunately, Textfig. 1 in text had to be omitted, because it was lost while being travelled abroad.



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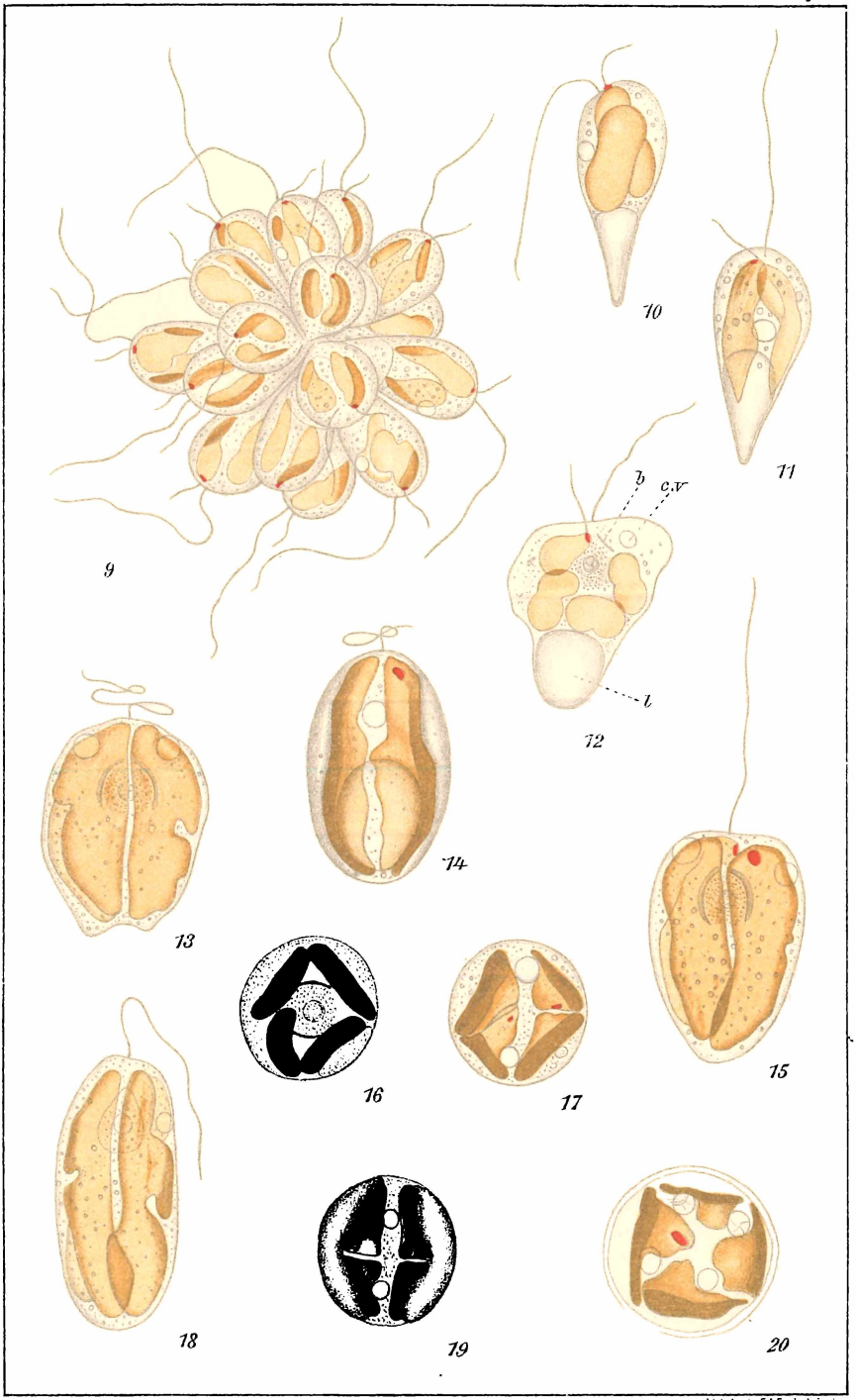

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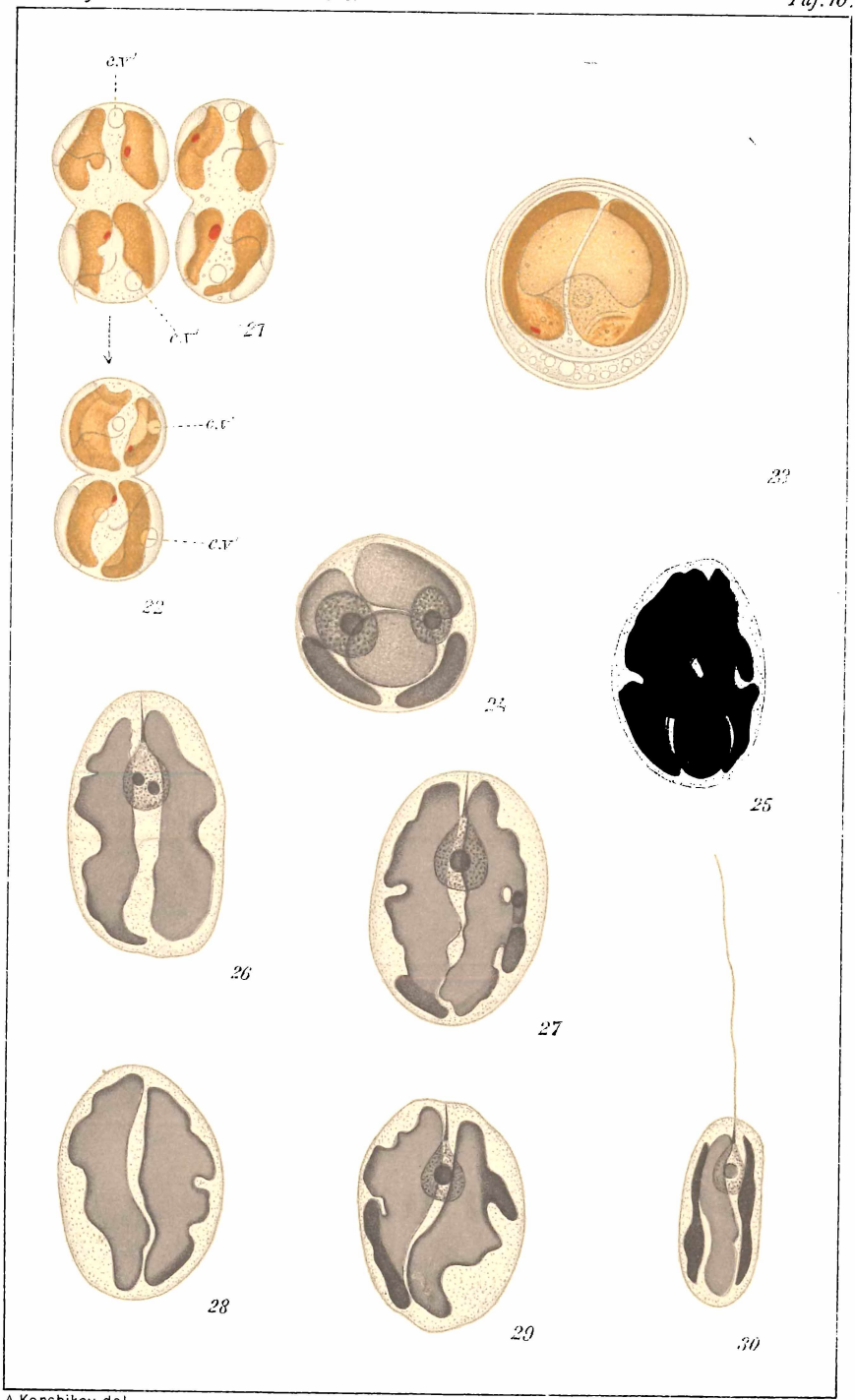

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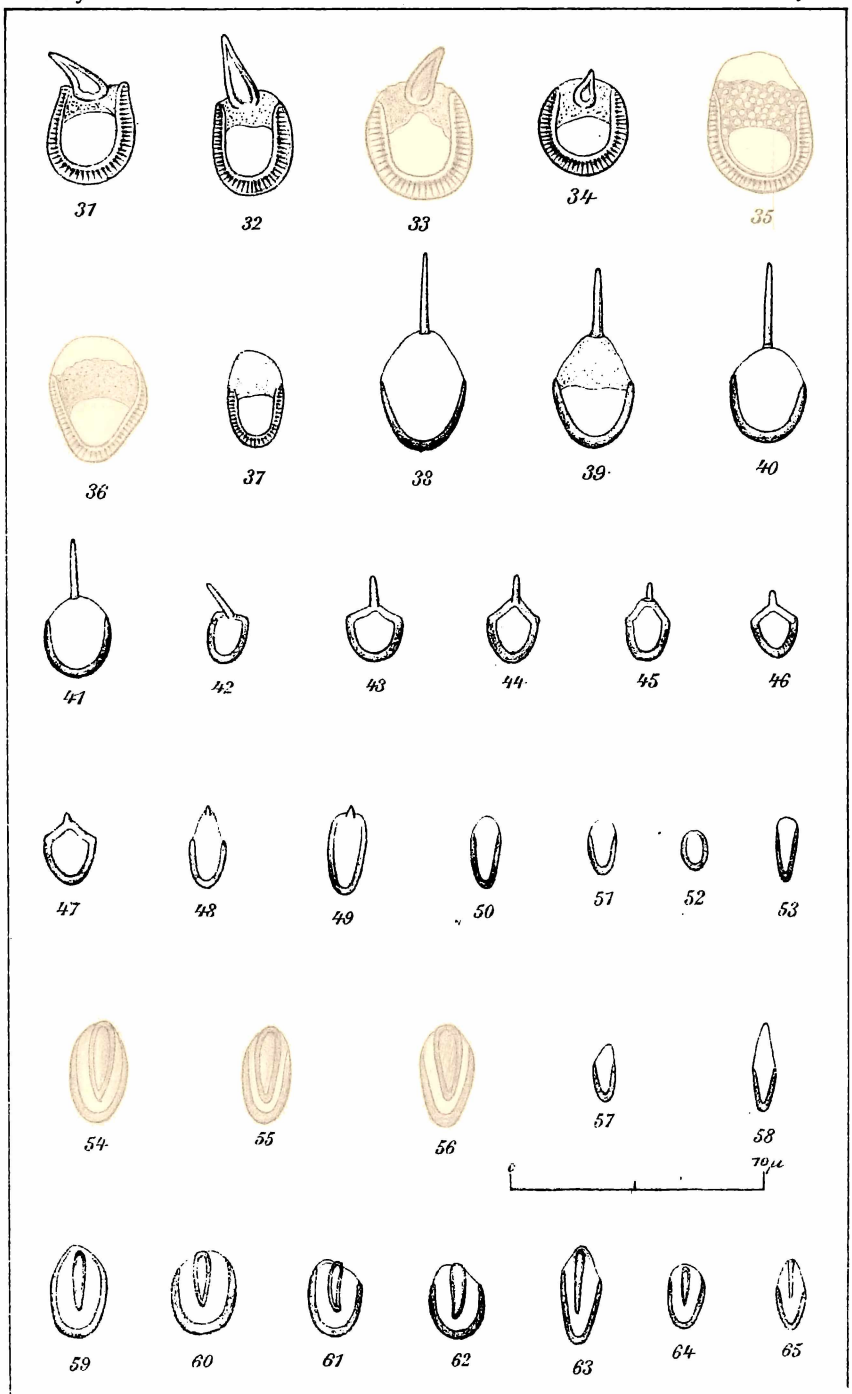

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