Artificial Cells*

Remarkable Imitation of Natural Cells

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It is a well-known fact that numerous attempts have been made to reproduce the structure of the natural cell, especially by Bütschli, Traude, Lebuc, and Herrera. Professor Herrera gives here the results of his latest researches, which have been remarkably successful, along these lines.

It must be borne in mind, of course, that the structures of natural cells obtained by treatment according to the classic histological methods, can hardly be said to correspond closely with the aspect of the same cells while living. When the endeavor has been made to indicate the structure of natural cells by means of precipitates from various solutions, the investigator has too often taken as his model the histological aspect, and not the living appearance of the cell in question. Because of this, considerable caution must be maintained in drawing definite conclusions from such experiments.—Preliminary note by the Editor of *La Nature*.

THE admirable researches made by Gautier and Clausmann with respect to the biological importance and the general occurrence of fluorine in organic creatures are now well known, as are also the studies made by Schultz and Boudard concerning the presence of silica in organic tissues together with the physiological rôle and therapeutic application thereof. These two elements have been unjustly neglected for a great many years, but modern research has shed light upon their importance in the phenomena of life. One fact of especial significance is prominent through the researches with regard to plasmodeny, which I have been conducting since 1897, and which have led me to devote special attention to the fluoro-silicate. This fact is that the imitations of cells and tissues obtained by means of the silico-carbonate of calcium although possessing a great morphological resemblance to natural elements are attacked and dissolved by the histological fixators, all of which are acid—a circumstance which sets them greatly apart from living models. Nevertheless, I have sought to discover artificial structures capable of presenting a like degree of resistance to acid. An earlier observation incited me to study the remarkable imitation produced upon glass by the vapors of hydro-fluoric acid—structures which reproduce those of micro-organisms found in stagnant water, but which are much harder than the latter and which exhibit much difficulty in acquiring histological coloration.

In my first experiment I repeated the technique employed by Harting (vide C.R. *de l'Acad. d. Sc.*, May 19, 1919). In an 18 cm. crystallizing dish I placed some colloidal silica having a density of 1,030 together with two soluble salts, calcium chloride and potassium fluoride. Through slow diffusion and incomplete crystallization I secured the formation of really remarkable imitations of amoeba and of organic cells. Finally, by means of a gradual improvement in the conditions of diffusion I succeeded in producing truly wonderful facsimiles of histological elements. The specific technique employed consisted in compressing between sheets of glass two solutions, one of potassium silicate having a density of 1,100 and containing traces of potassium bifluoride and the other of calcium fluoride with a density of 1,320. The solution of the silicate should contain as small a quantity of potash as possible; it is prepared by dissolving freshly prepared gelatinous silica in 750 cubic centimeters of water to which have been added 10 drachms of caustic potash. As high a temperature as possible is then applied in a vulcanizer.

In the last experiment a drop of silicate was compressed beneath a sheet of glass by means of a weight of 22 kg., while the drop of calcium chloride was compressed by a weight of 5 kg. beneath the contiguous sheets. The sheets of glass are then covered with a bell glass under which are introduced moistened cloths; the edge of the bell-glass is smeared with plaster of paris in order to prevent the drying of the solution. The object of the compression is to retard the diffusion of the liquid, thus imitating those infiltrations which produce agates. Twenty-four hours later they are washed and examined under the microscope then fixed, colored, and mounted in balsam as is done in the case of ordinary sections of tissues. Care must be taken to employ Kuhne's blue and mordants, since the structures are still too hard and too slightly permeable.

The waves of diffusion produce periodical precipitates and the exhaustion of the calcium chloride solution occasions the gradual transformation of the waves into smaller and smaller segments, which reproduce the form and structures of cells with surprising fidelity, as can be seen by the accompanying sketches and microphotographs.

In preparation 3,804, of May 17, 1920, there was observed a complete colony of cells having a membrane, a spongy cytoplasm, or spongioplasm, a nucleary membrane, a nucleus, a nucleole and chromatic filaments. The pseudo-cells earlier observed by Traube, Leduc, myself, and others, are far inferior to these truly magnificent elements in which the enormous nucleus, when highly magnified, shows the finely granulated aspect of the nucleus found in true cells as well as other well-known details.

And an even more striking feature is the tendency to division exhibited by all these cells, as can readily be seen at certain points in the reproduction of this same preparation, as well as in others prepared for the Academy of Sciences.

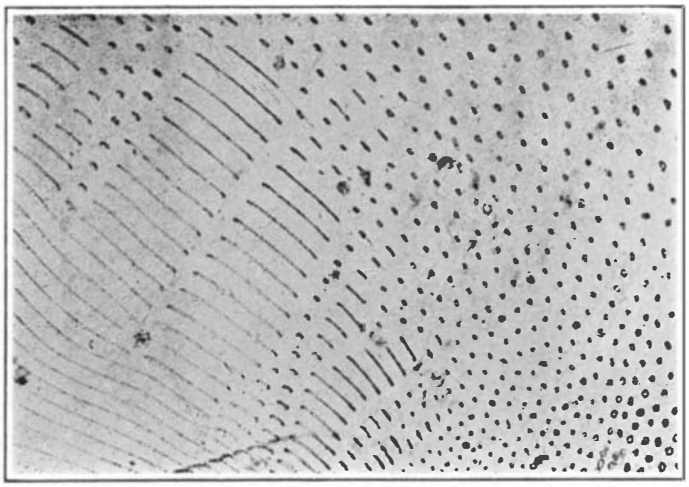

FIG. 1. MICROPHOTOGRAPH OF A PREPARATION MADE BY PROFESSOR HERRERA

The mitosic figures are still vague and incomplete, but two stars (asters adossi) backed up against each other in the poles of the ovoids and the filaments between them can readily be distinguished. Asters are often found in the points of an elongated granular tube. By compressing the

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), July 31, 1920.

sheets of glass under a pressure of 60 kg. I succeeded in obtaining colonies of cells undergoing the process of division, taking the blue stain and revealing all the passages between the cells with the nucleus and the protoplasm in a state of repose, as well as those showing the division of the nucleus without the division of the protoplasm, with an ulterior division of the latter and the complete separation of the daughter-cells. One of these preparations was sent to the French Academy of Sciences, and the other to Dr. MacDougal of the Desert Laboratory at Tucson, Arizona.

But what explanation can be offered for the occurrence of these results and how shall we interpret them? This question is not very easy to answer and is much less interesting than the facts themselves.

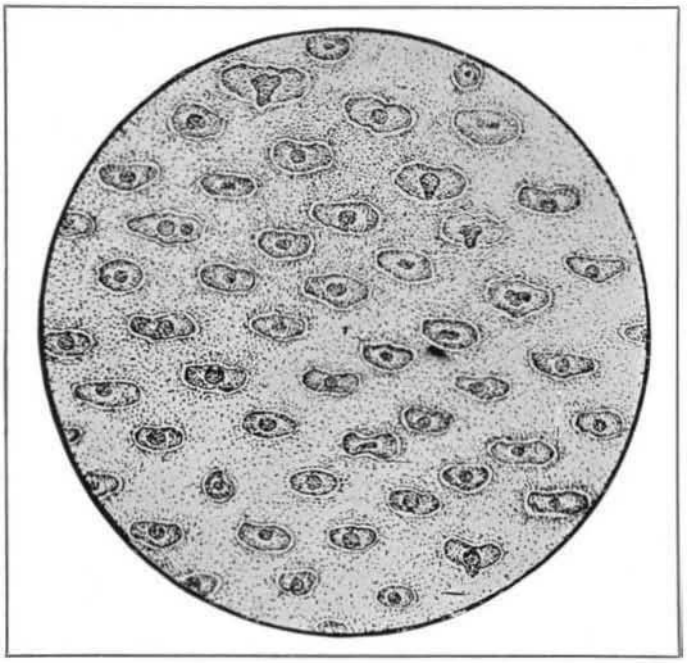

FIG. 2. CELLULAR APPEARANCE OF PREPARATION NO. 3804 OBTAINED BY SUBJECTING POTASSIUM SILICATE AND CALCIUM CHLORIDE TO PRESSURE

FIG. 3. MAGNIFIED VIEW OF A PORTION OF THE PREPARATION SHOWN ABOVE

At 2 is shown the reticulated structure of a natural cell, after Schäfer, showing, from periphery to center the membrane, protoplasm, nucleus and nucleole

When macroscopic crystals of the double chloride of calcium and potassium are placed in a bath of potassium silicate, it is observed that each crystal encloses a residue of the calcium chloride solution; this produces very fine precipitation, membranes forming a sort of protoplasmic emulsion. It is probable that the same effect is likewise produced in this instance, but upon a microscopic scale and that we obtain a perfect reproduction of the structure of the protoplasm and the nucleus of which Bütschli speaks. The cause of the segmentation, it is to be presumed lies in the osmotic swelling of invisible alveolæ whose saline enchylema must be supposed to have a great affinity for the water of the external milieu. The hardening of the structure is due to a sort of intensive plasmolysis or dehydration which prevents the later development of the cells and which I have sought, by the condition of my experiments, to retard as much as possible.

A hypothesis at once suggests itself as the result of our researches and reflections. I refrain from calling it a certainty to the effect that life itself may have had a similar origin in the form of slow infiltrations of salts in the silica containing fluorides. A large number of organic compounds of fluorine, of silica, and even of fluoro-silicates, are known to us, and it is possible that upon a mineral skeleton natural forces—heat, sunlight, etc.—have produced protobias capable of living by means of antotrophic processes. Whatever may be thought of this theory, however, the fact reported above, of the production of cells, not only complete in all their parts, but actually undergoing division is both entirely new and profoundly interesting.

NEW FACTS ABOUT VITAMINES

MUCH as we have learned in recent years about those all important though minute constituents of our food, the vitamines, the field of research is by no means exhausted and still attracts many investigations. Some recent results of their studies have appeared lately in various places. Among these are those of M. Auguste Lumiére, who has been trying to find out whether these bodies are as essential to the lives of plants as to those of men and animals. He comes to the conclusion that this is not the case. He bases his views upon the fact that microbes can be readily cultivated in mediums of strictly mineral composition which exhibit no traces of organic matter. According to another investigator, maize is capable of attaining complete development in a liquid containing 15 simple substances without any organic matter whatever. Lumiére made certain experiments of a similar nature with beer yeast, which is particularly rich in vitamines, for which reason it rapidly effects a cure in pigeons suffering from malnutrition. He found that when the yeast was heated to a temperature of 135° C. for one hour, it had lost all its curative virtues, its vitamines seeming to be entirely destroyed. Yet fungi were found to grow readily in a broth made of this dead yeast. Furthermore, he found that it was possible to isolate the vitaminic principles of the yeast and add them to various culture mediums, without apparently improving the species grown in these. He, therefore, finds that plants do not require the presence of vitamines for their development.

Another experimenter whose work is reported in the *Presse Médicale* believes that he has obtained proofs that the disease of rickets which so often afflicts under-nourished children, is really due to a lack of vitamines, particularly of the lipo-soluble vitamine A. By experiments upon dogs he demonstrated that a diet which produces rickets in the animals ceases to do so if foods rich in vitamines be added, among which he mentions especially butter, unskimmed milk, cotton-seed oil and cod liver oil. He finds fresh support for his views in the fact that rickets is a very rare disease in the Hebrides, in spite of the many hardships and privations to which the inhabitants of these islands are exposed. The population lives almost entirely upon fish, oatmeal and eggs, being particularly fond of fish livers, which are known to be especially rich in lipo-soluble vitamines.

It is interesting to find that the popular estimation of cod liver oil as a waste repairing food is thus justified and explained by modern research. Apropos of various facts it is worth noting that while butter and cream and cod liver oil are extremely rich in vitamines, ordinary fat is much less so, especially when it is white in color. Lard, for example, contains practically no vitamine, whereas the yellow fat of grass-fed cattle contains a considerable percentage.