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A LABORATORY FOR PHOTOGRAPHIC RESEARCH.

BY ROMYN HITCHCOCK.

THE discussion upon the respective merits of ordinary and color-sensitive plates for photographing stars, which has been raised by the French astronomers, is only a single example out of a great number which might be mentioned to show how much experimental work has yet to be done before our photographic processes will fully meet the demands of scientific investigation. Modern photography has experienced very rapid development. It has been such a fascinating subject for experimentation that a great host of workers, many of them skilful and indefatigable, have contributed a countless array of facts, but intermingled with these are so many observations of a different character that the extensive literature of the subject is very confusing. What, for instance, are we to understand concerning the remarkable phenomena observed by several of the early investigators who found that certain rays of the spectrum produced chemical changes which were reversed by certain other rays? It has seemed to me that this subject would well repay investigation with the improved appliances and better knowledge of the present time. The latest application of the phenomenon that has come to my notice has been at the astro-physical observatory at Washington, in an attempt to photograph the invisible infra-red spectrum by means of a phosphorescent plate. The rays of the spectrum destroy the phosphorescence, leaving luminous bands representing the spectrum lines. It is not probable that any such method will prove of much practical value, but none the less is the investigation of the phenomenon to be advocated for the information to which it may lead concerning the nature of radiant energy.

The fact that Professor Langley has resorted to such a device to photograph the invisible part of the spectrum brings clearly before us the supposed limitations of photography in this direction. The limits of the photographed spectrum have within a few years been greatly extended into the red, and even beyond it perhaps, by special sensitizing agents or by peculiar methods of preparing plates. But the theory of the subject has not been worked out, and in this there is a very important field for research. The inducements to carry out such investigations must come from those who most need the results. In other words, here as in other cases the photographic investigator would like to know that his results will be intelligently applied, else he becomes discouraged and enters upon some other field. If the physical observer would encourage research in photography to meet his requirements, and if the astronomer would have plates perfectly adapted to his purpose, let them cease to place their reliance upon color-sensitive plates, or on any other plates prepared for the public demand, and put their photographic work in the hands of an experienced photographic chemist — not a mere operator picked up in a gallery or among amateur experimenters — but one who can apply the latest discoveries to the work in hand. It is because investigators who are not trained photographers, familiar with the processes and discoveries of the time, have undertaken to do the most difficult kind of photographic work themselves, that the results are so frequently inferior to what they might be. It is certainly a fact that the best photographic knowledge we possess is not generally applied to scientific work.

It is upon such grounds as these that I have long advocated the establishment of a photographic laboratory for research in connection with one of our great institutions. Such a laboratory would not only lead to important discoveries and improved methods, but it would give an impetus to the study of photography as a science involving chemistry and physics, in preparation for work in various branches of science. The problems presented in the observatory and in the spectroscopic laboratory could then be systematically studied, as they cannot be by the workers in these different fields. For example, the astronomer desires plates for photographic star-maps, which shall be uniform in character and rapidity, unaffected by temperature or moisture, free from granularity and without the tendency to "halation" by long exposures. More than this, an effort should be made to produce a plate which will reproduce fairly well the relative actinic magnitudes, if I may coin the expression, if not the visible magnitudes of stars. That such plates can be produced scarcely admits of a doubt, but to establish the fact requires some, perhaps a great deal of experimenting. But having once accomplished the result, it would be a boon to astronomy sufficient in itself to justify the existence and liberal endowment of such a laboratory. The mere discovery of a means to produce plates of absolutely uniform sensitiveness, measured in units of time and also spectrographically, would be of incalculable benefit to physical investigation. As regards the granularity of the image, it has been clearly demonstrated that this is greatly influenced by the development, particularly with certain plates more than others.

Now as regards plates for other special purposes, to mention a case in point, I refer once more to Professor Langley's desire to photograph the part of the spectrum which he has so ingeniously mapped with the bolometer. No one has questioned the accuracy of the indications of that instrument, but it would certainly be of interest to see a photographic reproduction of at least a portion of that invisible spectrum, to compare it with the bolometric curves. It would enable us to interpret the latter with much more confidence when it becomes desirable to reduce the curves to spectrum lines.

As already stated, considerable work has been done abroad in extending the photographic action of the red rays of the spectrum. Schumann, for example, has photographed the spectrum, showing line *A* distinctly and for some distance beyond.

But when we consider the enormous extension of the invisible spectrum beyond the blue, recently photographed by Mr. Schumann,[1] on plates especially prepared for the purpose, we have an indication of the possibilities of scientific research in photography. There is really no reason to suppose that we have reached the photographic limit in the less refrangible end of the spectrum.

The interesting phenomenon of the sun's corona has led to many attempts to photograph it on the rare occasions offered by total solar eclipses. But so little have the photographic conditions been considered in this connection, that, as I have elsewhere remarked, the government photographic expedition was sent to Japan without a photographer, and the expedition to Africa went with commercial color-sensitized plates. Now, it would be interesting to learn the reason for the selection of those particular plates for the corona. While I am not prepared to say that they

[1] Hitchcock, R. The latest advances in spectrum photography, *Science*, Feb. 26, 1892.

were not wisely chosen, the facts in the case not being before me, I am free to confess that I have grave doubts whether they were even as well adapted to the purpose as the ordinary dry plates. In any case, the best work on the corona has yet to be done, with plates prepared for that special purpose, and with apparatus specially arranged. Several efforts have been made in this direction abroad, not with entire satisfaction it is true, but they indicate a recognition of progress in photographic work, and a laudable disposition to apply the latest knowledge to special requirements. I am not aware that any photographic experiments are now under way in anticipation of improved methods to be applied to the solar eclipse next year. If not, we have no reason for expecting any better photographs of the corona than those of Professor Holden, which are doubtless as good as can be made without special plates. Let me add as a purely gratuitous opinion, founded, however, upon long consideration of the subject, that I am convinced of the practicability of photographing the corona without waiting for an eclipse. To do this, however, would require no small amount of preliminary work, for which a well-equipped laboratory is necessary.

Not wishing to extend this communication to undue length, I confine my remarks to these few eminently practical subjects for laboratory research, only adding that there are many others which deserve investigation, such as photographic standards of light and color, methods of recording daily solar activity, the comparison of the chemical and visual effect of light of various colors,—a very important subject in stellar photography,— atmospheric absorption, the application of photography to meteorology, the formation of clouds, lightning, and a host of other subjects which will suggest themselves.

The point I wish specially to make is that a photographic research laboratory would be of the greatest value as an aid to research in many branches of physical investigation. It has been my privilege to visit the laboratories of Dr. Eder in Vienna and Dr. Vogel in Berlin, both of which have contributed so much to a practical and scientific knowledge of photographic methods; but above either of these, for purely scientific research, I should say the private laboratory of Mr. Schumann, in Leipzig, although much more restricted in scope, approaches nearer to my ideal of what we most need in this country.

I trust that these few words will receive such favorable consideration and support from the scientific men of the country — especially from those who have experienced the shortcomings of photography in recording the results of their work — as they may seem to deserve, and that a laboratory such as I have indicated may soon be established either in connection with one of our large universities or by private endowment.

The Woodmont, Washington, D. C., Sept. 9.

THE RETICULATED PROTOPLASM OF PELOMYXA.

BY DR. ALFRED C. STOKES.

WITHIN recent years the structure of protoplasm has been much studied by microscopists, and the several theories enunciated have attracted considerable attention and been the subject of considerable discussion. The entire subject is a fascinating one, but among all the doctrines put forth by various observers, either as the result of personal investigations with modern high-power objectives, or as a result of a working of the "scientific imagination," none has received more attention of a certain kind, and none is more pleasing, than Dr. Carl Heitzmann's theory of the reticulation of the protoplasm. Yet simple and beautiful as his doctrine is, it has been ridiculed and summarily dismissed by those that have failed to obtain results similar to his.

Dr. Heitzmann claims that all animal protoplasm is at all times a net-work of delicate threads, in which is the life of the object, the meshes thus formed containing the liquid or semi-liquid and other non-living constituent parts of the protoplasm. His book on the "Microscopical Morphology of the Animal Body in Health and Disease" is somewhat surprising, since he sees all tissues as formed of reticulated protoplasm, an appearance that he seems to have no difficulty in demonstrating, but which the majority of microscopists and histologists claim to be unable to see, and which they say is therefore non-existent. The subject merits further attention. Judging from a limited experience, but from an experience gained through an eye to a certain extent trained in microscopical examination with high powers, I am willing to confess that the Heitzmann doctrine of the structure of protoplasm is more than satisfying; if it should be proved to be illusory or the result of the action of reagents, I should be disposed to abandon it with regret.

In 1873, Dr. Heitzmann, before the Vienna Academy, demonstrated the reticular structure of the protoplasm of the common *Amœba*, a microscopic animal within reach of every microscopist, and one in which the reticulation should be readily seen with the proper optical appliances, if it exist. I do not know that any effort has ever been made in this country to repeat this observation in order to refute or to confirm it. The white corpuscles of human blood are conspicuously reticulated after treatment with certain reagents, and if the common *Amœba* should present a somewhat similar structure without having been subjected to the action of a chemical solution, the fact would be of great importance and interest. It would seem, too, that microscopists are not living up to their privileges if they fail to heed a suggestion that may be of so great importance. Yet so far as any prominent printed record appears, the common *Amœba* has never been examined with modern high-power objectives by competent microscopists having this object in view. If such papers have been published, they have not come to my notice. I am not claiming any merit on my own part, for I am also one of those that have given no attention to this attractive subject. I have never submitted the *Amœba* to the tests needed to demonstrate, for my own personal satisfaction if for no other reason, whether or not the reticulum exists in its protoplasm as Dr. Heitzmann says it exists. But that at certain times in certain places within all animal bodies the structure of protoplasm is reticular there can be no doubt. That the reticulum exists at all times and in all places is another matter.

But recently, while I was making a microscopical examination of a sample of urine, a single scale of epithelium appeared under the objective in a drop of the fluid, and was as perfectly and superbly reticulated as could be desired by the most ardent advocate of the theory. The cell had had no treatment except what may have come from its soaking in the urine, yet the net-work of its protoplasm was perfection, and its prominence must have forced itself upon the attention of any microscopist. But thousands of epithelial scales may be studied in as many samples of urine, and not another found in this beautiful condition.

In reference to the common *Amœba*, although I have never yet studied it with the reticulation of its protoplasm in mind, I have recently had the satisfaction of examining a favorable specimen of the allied *Pelomyxa villosa* Leidy, in whose ectosarc the reticulum of the protoplasm was as perfect and as conspicuously marked as in the single epithelial scale just mentioned. *Pelomyxa* is a common Rhizopod in this locality (Trenton, N. J.), but it is usually so gorged with food, with sand grains or with other opaque particles, that its body is almost black by transmitted light, and therefore unsuited for such a purpose as a search for protoplasmic reticulations. But this particular individual was without these obscuring elements, being almost transparent, and fortunately with the protoplasm of the ectosarc so conspicuously reticulated as to obtrude itself upon the microscopist's notice. If the softer and continuously flowing endosarc had been surrounded or enclosed within a delicate net of cords, the reticulations could not have been more apparent or more distinct, becoming even more conspicuous when this external coating flowed out to cover a newly produced pseudopodium. The meshes of this beautiful net were angular, and the living threads that formed them were rather actively contractile, the meshes becoming narrowed and elongated during the animal's movements of progression. The greatest length of perhaps the largest space was, during quiescence, about one six-thousandth of an inch, the smallest being probably about one-third of that size, although careful measurements were not made of either of these.

There can be no doubt that at least at times the ectosarc of *Pelomyxa villosa* is formed of reticulated protoplasm. That it is