ORIGINAL ARTICLES.

THE NEW MICROSCOPY AND EXPERIMENTAL THERAPEUTICS.*

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THOSE who are foremost among the progressive microscopists of the world maintained that the microscope can be improved in its resolving and magnifying power in only two ways, namely, by increasing the angular aperture of the objective or by using light of shorter wave-length. The angular aperture, however, cannot be much increased—it has about reached its limit. The use of the shorter wave-lengths of the invisible ultra-violet rays promises a great improvement in magnification and resolving power, and the farther these improvements are realized the better will be the results achieved by the present form of the microscope.

As is well known, the image—the projected image—of the microscope can be photographed. But if the photograph be subsequently enlarged it reveals no details beyond those found in the photograph from which the enlargement was made. Persons unacquainted with the physics, chemistry and technique of photography and microscopy have imagined that a photograph could be enlarged, and that enlargement again enlarged, and so on, until details wholly invisible to the eye in the first direct picture would make their appearance. But this is not the case. The photograph of the hexagonal openings of a diatom, will, if enlarged, reveal nothing but the same openings of larger size and new details of the structures which compose these openings.

Now in planning an elaborate series of further researches into the psychologic nature of cell-life I was confronted with the fact that not enough could be known about the internal structure of cells to enable me to form safe conclusions regarding the modifying actions of the mental activities of these cells upon their own internal structures. The additional magnification attainable by increased aperture, by using light of shorter wave-length, or by any other known means, did not promise to remove the difficulty. In studying the effects of medicines on cells I needed a far greater magnifying power than that promised by the present form of the microscope. Accordingly I took up the study of improving the microscope, and applied to that study the methods of the art of mentation which have been the guide and the goal of my life's work, and I achieved a much greater thing than the improvement of the present form of the microscope, namely, the extension of the present instrument by the discovery of a double microscope which takes the highest magnification of the present instrument and deals with that result as if it were an unmagnified object to be viewed by a magnifying instrument.

Before we had the microscope we knew nothing of bacteriology, of the germ theory of disease, of ferments, of putrefaction, of the finer structure of the tissues of animals and plants. The microscope taught us that all living things are built up out of little lumps of living substances called cells—it created histology, and was the basis of our knowledge of the brain-cortex.

With the best result of the present microscope we are still in ignorance of the structural constitution of a cell. We know that it is composed of body-plasms, and nucleus and granules, septæ, and filaments and flagella, and that they have different outward forms and movements, but of their real constitution we are more profoundly ignorant than were the earlier anatomists of the structure of the tissues before the invention of the microscope.

Cut a piece of protoplasm into a number of pieces and each piece will still be alive, but it is obvious that there is a limit to this subdivision, and at such a limit we may encounter the lowest and smallest living units or somacules. The secrets of mind are housed within a cell, and there, too, lie those unexplored domains, the study of which promises a better knowledge of health and disease. Surely we may hope that the time is not distant when disease shall be abolished.

The new microscope enters into this domain; it goes where the present instrument cannot go. And how does it do it? I will explain in brief.

In the first place I use the best known form of microscope and prepare the slides and slicings and stainings in the usual way; and focus and illuminate so as to get the clearest and highest magnification of the object, when viewed through the usual ocular. Then I remove the outer lens of the ocular. It can be shown that the "virtual" image produced by the ocular and eye, although it *looks* much larger than the "real" image, *adds no new details* to the real image. This fact is known to many modern microscopists. I therefore use the "real" image as the starting point for my new microscope.

I bring down upon this "real" image or "focal plane" the objective of my *second* microscope, and thus magnify the "real" image so to exhibit in it details which cannot be seen when this real image is viewed through the ocular of the first microscope, or when it is photographed.

This seemingly impossible result is due not only to the special powers of the second microscope, but to an advantage which I have taken of a unique fact in photography, namely, that when two lines, markings or colors in an image are *too close together*, the sensitive plate will not record them as two but as one. Thus, when I ruled two lines upon a metal plate too closely together, the image of these lines thrown by a camera upon a sensitive plate would irradiate in the film and the picture would show only one line. The line of light falling on the photo-salt in the film *spreads by molecular irradiation over more area than the actual width of the line of light*, and there is also *diffused reflection* of this line of light by the semi-transparent substance of the film. To these two causes is due the fact that when the details of two structures are too close together in an image of an

* Written expressly for THE MEDICAL TIMES

object, these structures will photograph as one, and thus the detail will be lost. The line of demarcation between them will, in the film of the sensitive plate, be obliterated by the irradiated and diffused light. This I have discovered to be the reason why all details below a certain size are lost in a photomicrograph. The space between two points that are too close together on a film is acted on by the light irradiated by these points. That is the reason an enlarged photograph shows no new details. If the new details are to appear, the *image must be enlarged before* it is photographed. This is what I have done with my "second" microscope, and thus the "two points" are separated by magnification to such a distance that when the photograph is made the irradiation will not cover the space between the points.

But this is not as easy as it appears. The first microscope takes the light from a very small object and spreads it over an area of sensitive plate one hundred million times as great as the area of the object from which it comes, hence the light has only the 1/100,000,000 as great an intensity as when it started from the object. The light is already too weak to photograph with if best results are desired. But when I select some small area of this faint image and subject it to a still further magnification of six hundred additional diameters, this light becomes only the 1/360,000 as strong as it was, and the natural eye cannot see the second magnification because the light is too weak. But by remaining several hours in a completely darkened room the eye can see very faintly such a magnification. But when I put a sensitive plate in the place of the eye it acts cumulatively, and the faint light rays which the eye cannot clearly see will fall hour after hour upon the plate and gradually accumulate enough effect to make a visible picture. The structural lines which in the image of the first microscope are too near together to be photographed as distinct objects, are in the image of the second microscope 600 times farther apart and hence do not blend by diffusion and irradiation.

It is not very difficult to distinguish on a good photo-micrograph, made by best modern methods, lines which in the original object are not more than the one-ten-thousandth of a millimeter apart, but much beyond this the microscope and photo-micrography refuses to go, because, as I have pointed out, the images of these lines on the sensitive plate affect the photo-salts in the space between the two lines, and this is done by diffusion and irradiation.

This indicates clearly in what direction experimental researches must be made in order to improve the resolving power of the sensitive plate. I should say that the thinner the film on the plate, the less the diffusion, and that the more opaque the film to all kinds of light except to the particular monochromatic light used, the less irradiation.

But I found great practical difficulties in photographing with so weak a light, because of the *dust and aqueous vapor* in the air between lenses and the sensitive plate of the second microscope The light diffuses and radiates from the dust particles, causing these particles to be photographed on the plate with a distinctness greater than the image of the object, so that the image becomes "fogged" or "clouded" even to invisibility. Hence the total failures of my first experiments, in which I got only a fog-like picture. When I removed dust and aqueous vapor I still got "light-struck" plates, with the image almost entirely hidden. So I carried on my further experiments in a dark room, darkened to dark-heat, luminous and ultra-violet rays, and then I got results good enough to prove that I succeeded in magnifying the "real" image of the first microscope. The greatest difficulty arises in the focusing of the projected image of the second microscope upon the sensitive plate, because beyond 30,000 diameters the eye cannot see the image. Hence a great series of empirical approximations must "find" the focus. I hope to repeat these experiments with apparatus specially constructed, and I believe that not only will most of these practical difficulties be removed, but I believe that I can accomplish in a short time the photographing of a magnification of more than 360,000 diameters, say from three to ten million diameters. But I am in no hurry for the last result. Some years of work must first be done with 300 to 1,000 additional diameters, to become acquainted with the rough outlines of the ultra-microscopic world into which we enter.

I am satisfied that life is mind—that vital phenomena are mental. A cell can feel stimuli and can *adapt acts* to *ends*. Now, only mind can do this—only animate bodies have minds, and mind alone it is which constitutes their life. A piece of gelatine is not alive, because it cannot adapt acts to ends, and because it cannot feel. Give it these powers and it will be alive—that is, mind is life, and vitality is mentality. Physiology becomes psychology. I consider it the best work of my life to have demonstrated that cells are the psychologic units of the animal body, and that in them, as in the animal, mental activity creates organic structure. The secrets of life are to be found in the study of Mind, and mind in its most elementary known form exists in the cell.

I therefore hail with delight the advent of the possibility of making a "second" microscope which will take the highest result of the first microscope and apply to it the further magnifying powers of a "second" microscope, because it will enable us to enter into the study of the constitutional units of the cell, as modified by the mental activities of that cell.

The mental state of the cell modifies its metabolism and creates its structural differences. Medicines and forces and foods affect the mentality of the cell, and within that domain are hid the secrets of life and death.

With an instrument which I have just invented I can make slices of tissues very much thinner than has hitherto been possible, even with the most approved microtomes. When the razor of the microtome is not sufficiently depressed at each successive slice it simply slides over the surface of the tissue without cutting it. The limit is somewhere about two thousandths of a millime-

ter in thickness. Now I found it necessary to obtain slices out of the middle of so small an object as a blood-cell or a bacillus. Under the microscope a blood-cell, being partly transparent, diffracts the light and its internal structures can not well be seen. So I devised the following method of obtaining slices of microbes and cells. I cemented upon a glass slide a single layer of cells, and then placed upon this slide another slide whose surface has been freshly covered with cement and allowed them to remain in contact until the upper and lower surfaces of the cells have become cemented to the glass slides. Then I introduced between the two glass plates a very thin blade of copper, the edge of which has been sharpened to the very finest cutting surface possible. A razor when sharpened by the most approved methods exhibits a very rough surface when viewed by a high-power lens and it is very far from being sharp. After a certain degree of sharpness has been obtained the fine edge breaks off abruptly, leaving a blunt instead of a sharpened edge. But copper is a finer grained metal and can be sharpened very much finer than a razor by using adamantine paper upon a glass surface as the whetstone. Then a still finer edge can be obtained by polishing it with a piece of soft wood, care being taken to get the edge exactly in the middle between the two surfaces on the copper plate. This blade is introduced between the two plates and then pushed along between them so as to separate them, and on its way it slices the cells in the middle. One of these plates is then cemented to another glass plate with the cut surfaces of the cells against the other glass plate and the slicing operation is repeated in a similar manner, thus producing a thin section of the cell. I have succeeded in producing a slice of about one-one hundredth, the thickness of the finest slice ever hitherto obtained.

It will be a matter of considerable surprise to biologists to see the amount of detail which the double microscope can get out of such a slice. In several weeks or months I hope to be able to make the apparatus to take a series of photographs of such a slice, and by pasting them together to secure a map of a transverse section of a cell.

The application of this same method to the telescope has been accomplished, and the first tele-photomicrograph was made the 16th of October. It promises to extend the telescope as far as the new method has extended the microscope and to open a new astronomical domain. It not only gives increased magnification, but it resolves details that cannot be seen by the old method. Thus I have placed some finely ruled lines at such a distance from the telescope that the lines could not be seen, and then I applied my lowest power microscope to the occular of the telescope and the lines were not only easily seen, but they were large and far apart. There is no reason to suppose that the same laws will not apply to celestial as well as terrestrial objects. As soon as I secure a siderostat I shall take some pictures of details upon the moon that have never before been seen.

Though the telescope may more powerfully impress the imagination, it will probably not be as useful to humanity as the new microscope, for that deals more directly with the immediate condition of health and disease. The bodily functions are all reducible to cellular activities, and the cellular activities are reducible to mental phenomena. The mind, which has embodied itself in a cell, controls the structure and metabolism of that cell and constitutes its animate character. I have discovered in another series of researches that astonishingly minute doses of medicine can profoundly affect the psychological activities of the cell, and I am profoundly convinced that a series of scientific studies along this line will lead to a new therapeutics and to a more rational etiology and sanitation. Another line of research proved that each emotional state produces in the liquids of the body a definite catastate of a poisonous kind, and that the good emotions augment anabolism. Still another line of research has shown that to rebuild the cellular tissue in any part of the brain simultaneously invigorates that part of the body which is in reciprocal relation to that part of the cortex. And lastly, I have experimentally shown that when the consciousness is limited by the attention to a particular locality of the body, as, for instance a finger or toe, and if this is continued for some time that an increased blood pressure and thermogenic activity takes place in that part. I have called this dirigation, and have found that by it profound changes of a metabolic character can be caused to take place in any organ or locality. I have also shown that every conscious mental activity creates in some part of the organism a new anatomical structure which is the embodiment of the memory of that experience. This is true even in unicellular organism, for when they are subjected to different mental activities new structures arise in the cells and these structures differ in the different cells accordingly as their mental activities are different. This shows that what we call Mind reigns causatively in the units of the animal body, as well as in the aggregate, of all the cells called the body.

The double microscope and the new microtome are instances of a great number of new technical facilities which will make this new line of research one of great interest and importance. There is unquestionably some fundamental truth in most of the pathies and isms which go to make up what is called medicine, but these truths are doubtless small aspects of some greater truth, the discovery of which will rationalize one of the noblest of professions. That a fundamental therapeutic law of a universal character has not yet been discovered I think will be generally admited. It is probable that such a law is closely related to the psychologic activity of cells in functional reaction with the cosmic universe in which they are adaptive organs.

Mr. Isaac Bell, who recently died at an advanced age, was the originator of the present system of managing the charities of New York, in place of that of the old board of governors.