PRESIDENT'S ADDRESS.

By D. W. Dennis.

Photomicrography as it May be Practiced To-Day.

The instrument with which my work in photomicrography is at present being done is in a compartment of the office of Dr. C. S. Bond, of Richmond, Indiana; it rests on a solid stone floor; the source of illumination is an arc light fed by a 52-volt alternating current. The tables, the optical bench, the microscope bench and all the illuminating accessories that it carries and the camera were furnished by the Bausch & Lomb Optical Company; the microscope stand and all its accessories were furnished by Zeiss; the stand is the 1899 model. The instrument is shown in Fig. 1. The objectives are the 70, 35, 16, 8, 4, and 2mm; the eyepieces are the 4, 6, and 8 compensating and the 4 projection eyepiece. The microscope stand is the property of the Earlham biological laboratory; all other parts, including the lenses, are the property of Dr. Bond, who not only by his financial assistance made it possible for me to have such an apparatus with which to work, but he has worked with me in all that I have done, and has carried out without regard to expense every suggestion that we could either of us make, with reference to the betterment of the instrument. The "we" which I use in my paper is not the conventional editor's we; it means the doctor and myself.

INTRODUCTORY.

The photomicrography of to-day at its best has been made possible by the growth of several different lines of work. The perfecting of the arc light is one of these; sunlight will do instead of this, but the uncertainty of being able to use it at any particular time is against it; the arc light is always ready; its brilliancy is always the same; photomicrographs of all diameters from 4,000 down can be made with it in from a very few minutes to a small fraction of one second. After one has fully mastered his apparatus and needs to use the light only for adjustment and exposure it is comparatively inexpensive.

The perfecting of the microscope in all its parts was necessary before the work of making photomicrographs of 1,000 diameters and upwards with such ease and certainty as to make them practicable for ordinary

purposes was possible. Indeed, the proper focusing of the microscope has been made so easy by Zeiss's latest stand that it may be said that only within a few months past has the use of these high powers been available except in the hands of the foremost experts, and even these consumed so much time and made so many failures to every success that a good photomicrograph was as costly as it was rare; an entire revolution of the micrometer adjustment screw in Zeiss's new 1899 model stand for photomicrography lifts or lowers the tube only .04 of a millimeter, i. e., one-fiftieth of the entire focal distance, and since a movement through less than one degree is entirely practicable, the tube of the microscope can be raised or lowered one nine-thousandth of a millimeter, or one two hundred and twenty-five thousandth of an inch. This is one eighteen thousandth of its focal distance.

How correctly to illuminate the object is again a science in itself; unless this is done, the most complete and costly apparatus constructible or imaginable will not give one correct photomicrograph; if the illumination is nearly right the results will be entirely wrong; the object can be drowned in light or it can be surrounded with halos that will remind the operator of a medieval painting without a suggestion of the piety that should accompany the reminder.

The production of a good photomicrograph requires a working knowledge of photography; the use of the right developer, the right plate, the proper use of reduction and intensification of the negative—all affect details. Three or at least two experts have hitherto been necessary for the production of a good photomicrograph of 2,000 or more diameters—a physicist to illuminate it, a microscopist with a knowledge of the object to adjust and focus the microscope, and a photographer to expose, develop and print it. The introductions to all atlases of this sort that I have seen show that the skill of several men has been enlisted in their production.

Photomicrography has grown then with the growth of microscopy, photography, and optics; it has proposed problems to all these sciences which they have separately taken up and solved in its behalf.

To retrace the steps from Daguerre to the end of the century, from Newton to Abbe, from the Dutch spectacle maker to Zeiss, is the work of books, not addresses; the sacrifices and victories along these journeys may have been elsewhere equaled, they have not been surpassed.

THE APPARATUS IN GENERAL.

The apparatus consists of a table 43 inches long and 15½ inches wide on strong and adjustable iron supports. Upon this table rests the optical bench on four adjustable iron legs which permit it to slide back and forth on two iron tracks. This optical bench carries the arc lights and all other accessories for illumination, except those which are a part of the microscope; these are, naming them from the light forward, first the condenser, which consists of two convexo-concave lenses four inches in diameter mounted at the ends of a nickeled tube; the lens farthest away from the light is adjustable in the carrying tube. Then comes the cooling cell, the ray filters, the shutter, the biconcave lens and the field diaphragm (see Fig. 1); all these parts are carried on two nickeled iron rods, and are adjustable in height from right to left and from before backward on the table. A second table placed at the end of this of the same width and height resting also on adjustable iron supports, is 85 inches long and carries the microscope, which has as substage parts the Abbe with its iris diaphragm and an additional iris diaphragm immediately under the object for use when the Abbe is swung out. It carries also an extensible camera which can be drawn out so as to hold the ground glass and the photographic plate at any distance from the object between 20 and 75 inches.

As to the Support of the Microscope.

It has hitherto been regarded as in principle wrong to have the microscope on the same table with the camera; our experience convinces me that this is a good arrangement, if it is accompanied by the other precautions we now have for keeping the microscope steady. As we received our instrument the microscope bench was clasped by iron clamps to two nickeled iron tubes which extend the entire length of the camera table and carry also the camera. By this arrangement any shaking of the camera was communicated to the microscope directly and rendered the preservation of the focus during the replacement of the ground glass by the plate holder nearly impossible; not one in five of our exposures with this arrangement was successful; something had to be done; we could not put the microscope on a separate table without entirely changing the means of controlling the fine adjustment, which is regulated by a rod, with milled head fastened to the table under the camera and connected

by a belt with the micrometer screw; furthermore, this exerted a slight pull on the microscope tube that rendered focusing very difficult; we overcame our difficulties by first placing four adjustable brass pillars under the microscope bench; the bench was now held down to the rods by the binding screws and its distance from the table was made absolutely the same by the brass supports; ordinary sliding of the camera in changing its length or putting in and taking out the plate holder does not in any way damage the focus. To brace the microscope tube against the pull of the focusing belt we supported it two and a half inches behind the milled head of the micrometer screw by an adjustable brass pillar reaching down to the camera table. Since making these additions we have not lost a single plate by change of focus. This result can be brought to pass in other ways, perhaps, but this is one good way and for the following reason is, I believe, the best way: We have fastened also to our camera table a brass rod inside of a brass tube, each provided at the focusing plate end of the camera with milled heads and at the microscope end with separate belts passing around the grooved heads that control the moveable stage, so that the operator six feet away can systematically search a field over, that is three-eighths of an inch in diameter. This is a convenience that comes near to being a necessity; it makes high power work as controllable and as speedy as low; it turns drudgery and annoyance into a pleasure; any one who ever undertook to center an object by giving directions to an assistant at the microscope must know its value. If an object is out of the field, finding it is hopeless in the old way; it is perhaps enough to say for our arrangement that it enables one person to do quickly and exactly what otherwise requires two at a cost of much time, labor and patience. The downward pull on the stage is counterbalanced by an adjustable brass support immediately under the controlling heads of the stage.

MAGNIFICATION.

The linear magnifications possible range from six and a half with the 70mm objective without an eyepiece to 5,500 with the 2mm objective and an 8 eyepiece. The following table shows the magnification at varying lengths of the camera with a few combinations. They were determined in every instance by measuring on the ground glass the projected image of a stage micrometer.

	Objective, 2 mm.			Objective, 4 mm.			Objective, 8 mm.			Objective, 16 mm.			Objective, 35 mm.			16 mm. Objective, Without Eyepiece.	70 mm. Objective, Without Eyepiece.
Camera extension, 25 inches	875	1260	1560	375	500	625	230	325	420	110	153	200	31	42	54	42	9½
Camera extension, 45 inches	1812	2560	3250	750	1062	1375	495	695	875	230	337	430	56	84	112	72	21
Camera extension, 65 inches	2750	3875	5000	1235	1625	2250	730	1062	1375	370	530	675	87	136	166	102	34
Eyepiece	4	6	8	4	6	8	4	6	8	4	6	8	4	6	8		

In will be seen by an inspection of the table that about 35 diameters can be obtained by using the 70mm lens and a camera extension of five and a half feet, or by using a 35mm lens and a 4 projection eyepiece with a camera extension of about 28 inches, or by using the 16mm lens and no eyepiece with a camera extension of 20 inches; each of these methods has of course its advantages, and disadvantages: the first gives a wider field than the last and a deeper focus. Fig. 5 was made in this manner; with the 16mm lens and no eyepiece only so much of the same object could be taken as lies between the points a and b in Fig. 3. The advantage this arrangement has to compensate for its smaller field and less deep focus is its greater resolving power; this principle holds whatever the combinations that produce any given power.

LEVELING.

The tables and the benches must all be exactly leveled; this is easily done by means of a spirit level and the adjustable feet on which they all rest. The cooling cell and condenser must also be level.

THE ILLUMINATION OF THE OBJECT.

(a) Centering.

It is necessary that all parts of this apparatus be most carefully centered. There are several good ways to do this. One is to place in every piece of the optical apparatus a pinhole diaphragm, which may be cut from black cardboard to fit each separate piece, one for the microscope to be substituted for the eyepiece, one for the Abbe and the field diaphragm, unless these parts are already provided with iris diaphragms, in which case they can be shut to a pinhole; one for the biconvex lens and one for the condenser. The instrument is sufficiently centered when a ray of light passes through this series of holes and falls on the center of the ground glass, when the camera is fully extended; these diaphragms should be saved so that proof of the centering can at any time be quickly made.

(b) The Image of the Light.

In order to make a good photomicrograph with an objective of 8mm focal length or less the image of the light should be thrown into the plane of the object. This can, the books say, "with no great difficulty," be effected by slipping the light and the condensing lenses back and forth

on the optical bench; it would be safer to say that it *can* be done; when once a combination has been effected that produces this result the exact position of every optical part should be noted carefully. To facilitate this all makers of photomicrographic apparatus would do well to mark a scale on the tables or on the carrying rods so that all parts can be quickly brought into exactly the same relation to each other and to the object; after many failures and much loss of time in attempting to bring the same state of things to pass that had been previously successful, we had such scales put on our apparatus. Any arrangement of the optical parts will produce an image somewhere; this can be found by carrying a piece of white paper back and forth in the path of the light until the image of the light is found; light and condensers can then be removed until the image rests in the plane of the object to be photographed. In order to have an equally illuminated field it is a good thing to have the size of the equally bright part of the image somewhat larger than the field to be taken; different combinations of the condensers and different positions of these and the light with reference to the object will regulate the size. In work with low powers, 16mm and upwards, this image should fall on the objective instead of the object. If the beginner in his hurry to spoil some plates is satisfied with an approximation to this state of things, or if he lights up and proceeds by the try rule, his time will be lost along with his material.

(c) The Size of the Entering Cone of Light.

Three diaphragms should accompany every complete apparatus: One of these, the field diaphragm, should be placed near the double convex lens, and if possible on its microscope side. This must always be used in every exposure; a second is at the focus of the Abbe nearest the source of light, and need not be used when it is swung out; a third is brought on immediately under the object and is consequently open and not in use when the Abbe is; two of the three are accordingly required in every exposure, namely, the field diaphragm and the one before or the one behind the Abbe.

Only a careful study of the effect on the ground glass will avail in all cases for the regulation of these diaphragms. However, two valuable rules can be given: If the Abbe is not in use the diaphragm immediately under the object must be so closed as to cut off all but the field to be photographed; if the Abbe is being used its diaphragm must in general

be large enough for the cone of light entering through it to fill one-third of the central bright portion of the objective; to ascertain whether this is so or not one looks into the microscope tube when the eyepiece is in with a lens such as is often used for focusing on the ground glass; this must be done with every objective used with the Abbe and the exact point to which the diaphragm is opened should be observed on its graduated scale and recorded; if this is not done, and guesses are relied on, hit and miss (mostly miss) results need only be expected. Too wide a diaphragm will drown the details in light; too small a diaphragm will surround all details with diffraction halos that will gain in ugliness as one learns them better.

(d) Ray Filters.

The various colors of white light have differing values for optical and photo-chemical purposes; they do not focus after being refracted at the same place. When the apparatus is so adjusted that the red, orange and yellow rays which mainly affect the eye are in average focus on the ground glass, the blue and violet rays, which mainly affect the sensitive plate, will be in focus enough nearer the object to spoil the picture. One good way to overcome this difficulty is to use a color screen, which cuts out the red and orange rays and at the same time the blue, indigo and violet rays at the other end of the spectrum, leaving the yellow-green waves of approximately the same wave-length to affect both the eye and the plate; without this precaution a good photomicrograph can not be made with daylight or the electric arc; such a color screen is best produced by placing in the path of the light a glass trough with parallel sides and about three-sixteenths of an inch thick, filled with the following solution:

160 grams of dry, pure copper nitrate.
14 grams of pure chromic acid.
125 cc. of distilled water.

This is Zettnow's filter. We have found great advantage, especially in photographing preparations stained with saffrannin or fuchsine, in adding a second trough filled with a dilute solution of Loeffler's methylene blue.

FOCUSING ON THE GROUND GLASS.

Much has been written about the proper focusing of the object. Our experience leads me to conclude that the real difficulty has always been that the machinery of the microscope was not sufficiently accurate, its parts were not sufficiently firm relatively, the microscope itself was not sufficiently supported against damaging strains and jars, and its fine adjustment screw was not sufficiently fine; we need nothing but a fine ground glass and the unaided eye for correct focusing; a plate glass and a focusing lens are generally recommended; they are scarcely a help; the difficulty vanishes with such stable and delicate machinery as puts control entirely in the hands of the one focusing.

POSITION OF THE SENSITIVE PLATE.

A pure scarecrow of the books is the oft repeated necessity of having the sensitive plate take the exact place of the ground glass; some one must have concluded that a want of coincidence in this respect spoiled his plates, and other essay mongers must have copied the conclusions. Doubtless he and they had spoiled plates, but the cause was not here; a variation of a quarter of an inch makes a perceptible difference in magnification, but not in sharpness, and no instrument probably ever varied so much as this.

EXPOSURE.

The time of exposure depends on so many things it is not possible to give any rules: The source of the light, its intensity, the number and character of the condensers, the number and character of the color screens, the width of the diaphragms, the character of the object, the objective and eyepiece used, the sensitiveness of the plate, and the freshness and strength of the developer, all materially affect the time. Any one can find out the time necessary by a few trials provided he understands development and is a good judge of a negative. If he has not these accomplishments he never can tell. Some kind of shutter with which to accurately measure fractions of a second is so useful as almost to be necessary in getting the right exposure; placing a ground glass in the path of the light near its source will multiply the time of exposure some twenty-five times and would be necessary in the absence of a shutter.

PLATES.

It should go without saying, perhaps, that plates giving correct color values should generally be used. We have used Cramer's isochromatic mediums and Carbutt's orthochromatic mediums and have found them satisfactory.

CHEAP APPARATUS.

I can think of no valid plea for cheap apparatus. Some men with cheap apparatus can, to be sure, do better work than others with the costliest. The difference does not lie in the apparatus; this good work is, however, done at an outlay in time, patience and material that renders it so costly in the end as to be impracticable. This is why photomicrography has not been more used in the past. Makers of apparatus are careful to advertise "any microscope stand can be used." This, except for low power work of the simplest character and second grade in quality, is a delusion. Internal reflections from the microscope tube, the objective and its fastenings injure more or less everything; moreover, the trouble necessary to adjust a microscope every time work is wanted is by far the costliest part of the work; a special stand with a large tube from the walls of which reflection is impossible and into which properly constructed objectives can be screwed without a graduating series of collars, mounted firmly on an unshakable foundation, dedicated to this one use, always ready, quickly capable of adjustment for any practicable powers, with a source of light that does not require long-time exposures, immediately adjacent to a properly equipped dark room, is not only the cheapest arrangement; it is the only arrangement that will for any considerable time be used by a busy man. The complete apparatus as I have described it should be supplemented by a firm, permanent, upright stand for copying all such slides as will not permit the microscope to be brought to the horizontal position. This is one exception to my general proposition that cheap apparatus is too expensive. The exception is, however, only apparent, for this is as good an arrangement for this class of work as it will admit of. This sort of camera should be at hand in every laboratory where there is any one competent to use it, for the things for which it is necessary can neither be sent away nor can they await a more favorable hour often. Such apparatus in convenient form has been exhibited and described before this Academy.

LIMITATIONS.

Photography has its limitations. The time of exposure can not be accommodated to a field unequally illuminated. A man ten feet from the camera and a background of forest and hills from a hundred to a thousand feet away can not all be in correct focus at once. Undesirable and immaterial parts of the field will be taken with the same fidelity as the parts wanted. Photomicrography shares all these limitations. With skill they can be reduced to a minimum. By repeated exposures of the same field all parts wanted can be presented in correct focus and together in their true relationship. Fig. 5 was focused for the centrosome in the larger cell; Fig. 6 for the centrosome in the smaller cell. By the use of a special stage, objects can often be tilted so as to bring related points into the same plane. When one side of a field is lighter than the other something can be done by stopping the development at proper stages, washing the negative off and developing the exposed parts by a local application of the developer. Immaterial parts can be cut out by the application of a reducing agent to the negative or the positive, or by matting out in the process of printing. Much has been said against the use of reduction, intensification, retouching or even spotting out, and many inartistic, not to say ugly, prints have been made that might easily and without damage to fidelity have been made tolerable, if not beautiful. By the adjustment of the light, by the kind of light used, by the character of the developer, by the intensity of development, by the time of exposure and by the quality of the plate, two prints of the same object can be made to tell different tales. Photomicrography is not a means of compelling men to tell the truth; no such means has ever been discovered; the usual bounty for veracity is still to be had at the old stand. Clumsily practiced it tells nothing; it is reliable when the photomicrographer is both truthful and capable. There is no more reason why it should be compelled to tell immaterial stories while it is telling material ones than that any other witness on any other stand should be. I have, notwithstanding all this, always followed the rule never to cut out or reduce anything whatever from the material portion of the field. I have often hunted for hours to find a section free from defects which told exactly the same story that another one told, the defects of which I could have removed harmlessly and easily.

ADVANTAGES OF PHOTOMICROGRAPHY.

One great advantage of photomicrography is that it leads to the preparation of better microscopic slides, because, in part, of the rule that does not permit the negative to be altered in its material parts; in part also because the damaging defect can not always be removed. Another advantage is that when correctly carried out it can tell nothing but the truth with reference to the parts in focus. It is maintained by good authority that it sometimes reveals things not visible to ordinary vision. I have often seen things in photomicrographs that had escaped my attention before, but always when I came to observe carefully again I was able to see them. A skillfully prepared photomicrograph shows details more distinctly, with greater contrast, than they have when one observes them through the microscope; I see no reason why if the proper conditions were at hand it may not reveal details beyond the reach of ordinary microscopic vision. A sensitive plate is not blinded by light or tired with long looking. Photomicrography is not here presented as a remedy for all ills; drawings have certain advantages; but every one can not draw, and careful drawings require much more time than photomicrography. The best of both is had when the details of photomicrography are supplemented by a constructive diagram which uites all in one.

In science teaching photomicrography fills a place that nothing else can. Few people comparatively ever use the microscope to any educational purpose; probably not more than a tenth of the students in our colleges and universities are familiar with anything more than its simplest revelations; popular courses are wanted in and out of the colleges; psychology, pedagogy, child study, and all organic studies call for illustrations of biological laws or histological relationships which concern them; for most of them it is photomicrography or drawings or both or nothing; and no one that has ever tried it will hesitate for a moment to say that the photomicrography must not be left out; it makes things real in a way that a diagram can not; it helps the interest, not indeed to the same extent that the microscope does, but to something like the same extent that the microscope would, if the student did not prepare his own object and if all the students could see the same thing at the same time through it and have the view explained while looking. I am sure that the histological lantern slide is with us to stay, and that the histological half-tone shortly will be.

KNOWLEDGE OF PHOTOGRAPHY.

Any one desiring to learn how to make good photomicrographs must procure a camera and learn how to make a good negative; it will not do for him to press the button and let some one else do the rest; he can not learn what a good negative is until he has made many and tested their printing qualities. When any one is a fair judge of the sort of lantern slide or print a negative will make he can then make a good one, and when he can at morning or at noon, on a clear or a cloudy day make a landscape negative and print it on glass or paper so well that his print compares favorably with the best of its class in the market, he may begin to experiment at photomicrography. He generally begins long before this and always produces and often publishes work that he never would have published could he have known what others were doing. Almost every photomicrographer has thrown away crop after crop of negatives which he formerly cherished as the best producible. At this stage he either quits or goes into a thorough study of the principles of photography on the simplest outdoor work; the production of high-power photomicrographs is the most difficult problem in photography and can only be done by good photographers who have had much experience also in low power work.

THE OBJECT TO BE PHOTOGRAPHED.

The photography of diatoms has flourished as a scientific fad for years. It is a special line of photography, calling for special illumination and specially prepared objectives; it calls for resolution, while general histological work requires penetration. It was for a long time a race with instrument makers to see which could resolve the finest striations; diatoms were used for test objects almost exclusively. It was gravely argued that a microscope that was good for diatoms was good also for other things in like proportion. Oblique illumination and blue light were praised for the same reason. The comfortless purchaser was left to reflect—having resolved a pleurosigma or an amphipleura—how few of them he ever cared to resolve, and that blue light concealed what he wanted to see. Every one easily admits, however, now that a diatom can be photographed; and since the publication of Koch's Bakterienkunde in 1889 and 1890 it has been granted that bacteria can be; they can be made to lies so uniformly in one plane. Doubtless it will always remain true that some things can be photographed better than others, and that

a good preparation is to be preferred for this purpose to a poor one, that only the best obtainable is to be photographed at all; but we are now in a position to photograph any object better than it is possible to see it by any single focusing of the microscope, and by repeated exposures any object can be photographed as well as it can be seen, so that all at least can be seen in the pictures that can be in the object. Fig. 7 is an egg from the ovary of a cat; the section is so thick that tissue cells lying behind it can be seen through it; and yet all is clear. It goes without saying that all the figures of the accompanying plates are of considerable thickness; one of them, Fig. 16, is an unsectioned blastula of Ascaris; the cavity within is seen through a cell which lies above it, and the light that illuminates it has passed through a cell that lies below, and yet the blastocoele is produced with almost diagramatic clearness.

WHAT THE NEXT STEP IN PHOTOMICROGRAPHY OUGHT TO BE.

The apparatus for the best work in photomicrography is very expensive and always will be. It requires and always will require an expert knowledge to make lantern slides and prints from microscopic preparations that an investigator can not afford to acquire and keep, and time that he could ill afford to spare. Education ought not to lack, it must not, will not lack this means of furthering its ends. We must establish here and there laboratories of photomicroscopy, in connection, preferably, with some of our institutions of learning, at which this work can be done for a considerable number of institutions. By this means negatives would accumulate from year to year until thousands of them might be at the command of all; the cost need not be great for all schools to possess slides of their own from this collection, or slides might be rented at a very small cost; all investigation monograms could thus be illustrated and teaching everywhere could be put in almost immediate touch with the latest that is known, and nothing else so vitalizes the work of the class-room, as every one knows who has tried it. I have tried to get slides from the plates used in works that had been published and copyrighted; I have never been able to do so; there was perhaps no means by which they could be easily made; there should be no other reason; they could only be used for teaching purposes; when one has harvested all the honor and money that can come from his publications I can not see why the good, that it does not impoverish him to part with should not be shared.

A scheme of this kind would furnish opportunity for friendly comparison of work which could not be other than a benefit. A half dozen such laboratories could do the work for the whole country: these could be affiliated and along this one line at least we should be spared the wastefulness of the anarchy of independent effort.

COURSE OF STUDY.

It would immediately come to pass in connection with such laboratories that courses of instruction would spring up. Such courses would be elected without doubt by many students in the various departments of botany and zoology, and as a result the ability to do good work would spread with the demand for it. One year's work in optics with special reference to photomicrography, microscopy and projection, one year in the theory and practice of photography, and two in the theory and practice of photomicrography would fill every requisite, whether of quantity or quality, from the beginning; it would be the work of experience to select finally what is just the best for such a course out of very much that is certainly good.

I have seen none of the literature of photomicrography of value except Neuhaus's "Lehrbuch der Microphotographie." Dr. Neuhaus is a practicing physician of Berlin. He has given us a work of such excellence that one does not need to see another; it contains a bibliography that probably leaves out little that has been written that is worth keeping. It should be translated into English. It was first published in 1890 and a second edition was called for in 1898. It is the first German work that has survived into a second edition.

EXPLANATION OF PLATES.

Except where otherwise stated the following figures have been made with a 2mm. apochromatic immersion objective and a 4 projection eyepiece with a camera extention of 37 inches and a magnification of 1,500. The slides, except where otherwise mentioned, were prepared by Mr. Elwood Mendenhall in the Earlham Biological Laboratory. The ascaris slides were stained by the iron-haematoxylin method. The material was fixed in Fleming's chrom-osmium-acetic fixative. The time of exposure was from 2 to 10 seconds. Zettnow's filter was used in each case, and for the Lilium candidum sections which were stained with saffranin, a Methylene blue filter in addition. No ground glass was used in any instance.

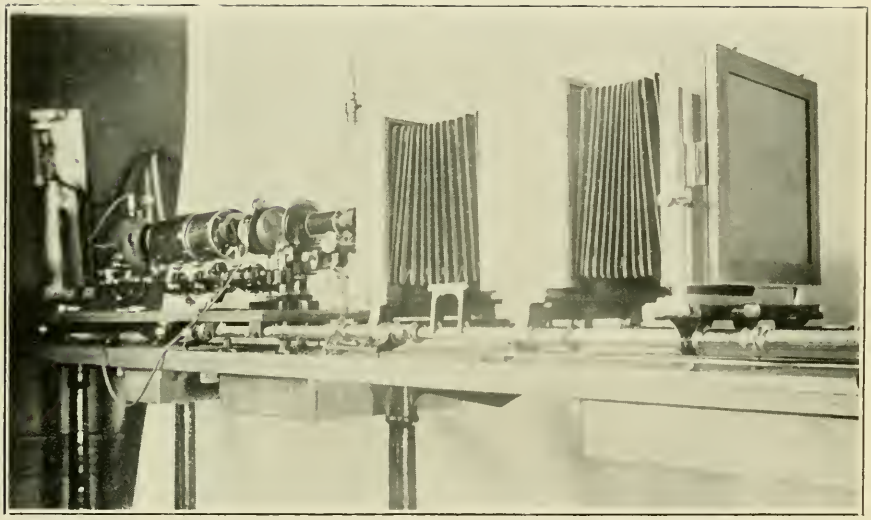
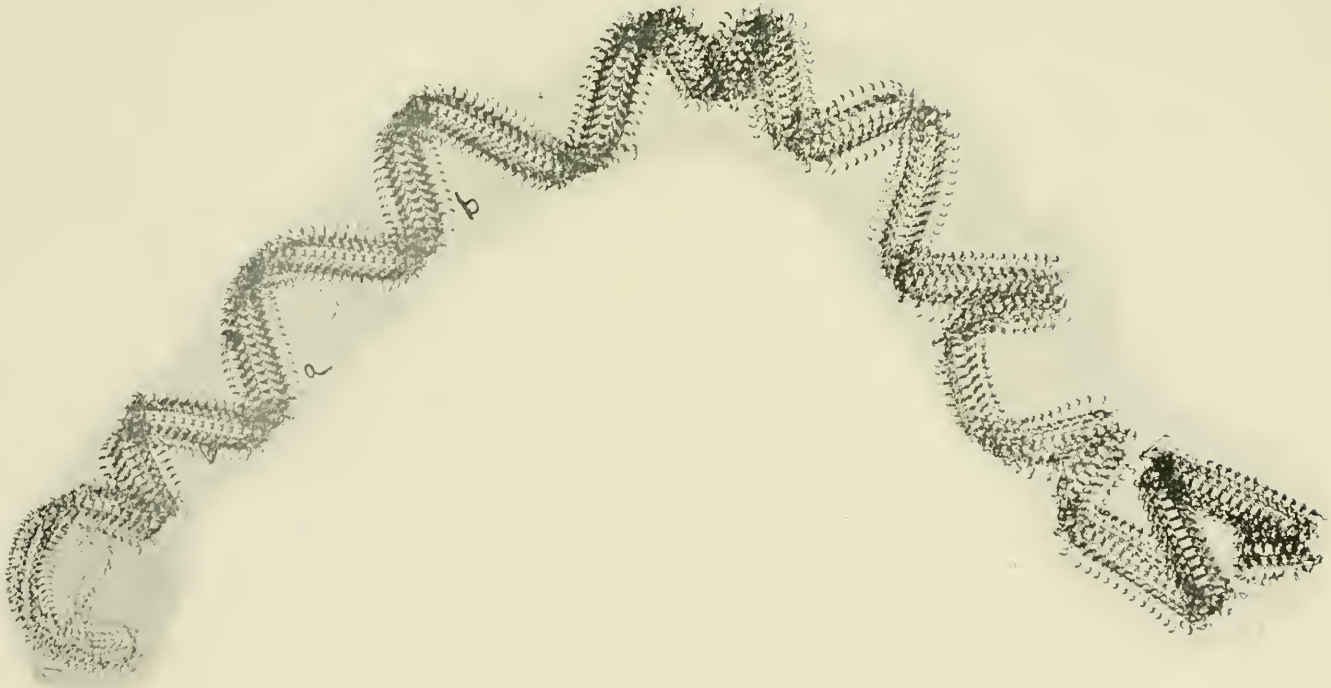


Fig. 1.



TONGUE OF SEA SNAIL.

Fig. 3. 70mm. objective, camera extension of 65 inches. If same magnification had been obtained with 16mm. objective, the field would only have shown portion between *a* and *b*.

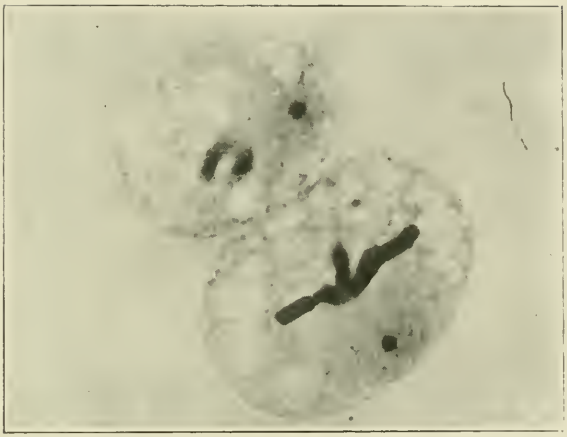


Fig. 5. Ascaris megalocephala, $\frac{1}{12}$ in objective and 4 projection eyepiece; focused for centrosome in larger cell.

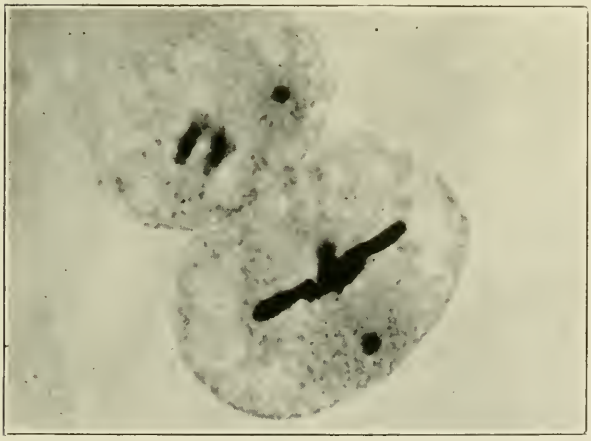


Fig. 6. Same as fig. 5, except it is focused for centrosome in smaller cell.

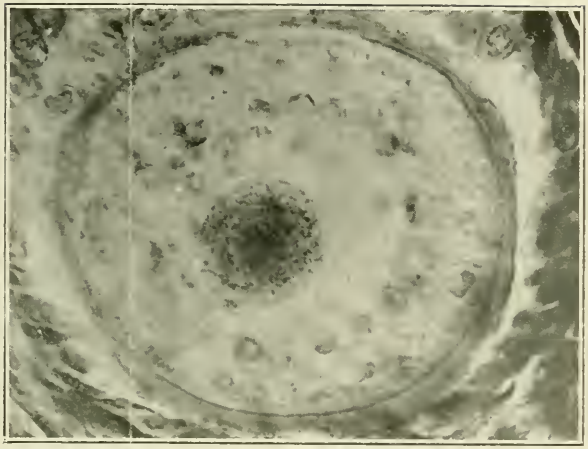


Fig. 7. Egg from the ovary of a cat, multiplied 1,500 times. Slide by Mr. Bertsch.

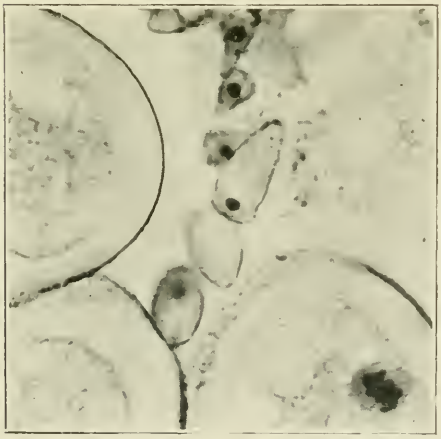


Fig. 8. Sperm cells of ascaris multiplied 825 times. 4mm. objective; 4 eyepiece.

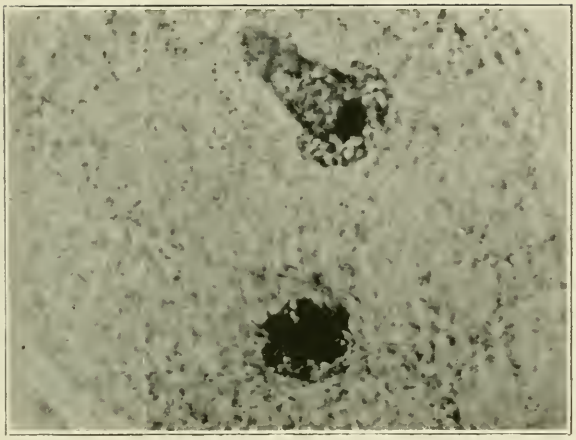


Fig. 9. The sperm cell is entering the egg from above; egg nucleus below multiplied 1,500 times.

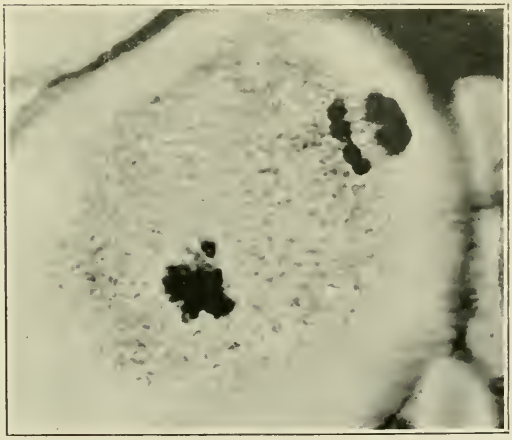


Fig. 10. The formation of the first polar body; sperm nucleus below. Slide by Mr. Irwin

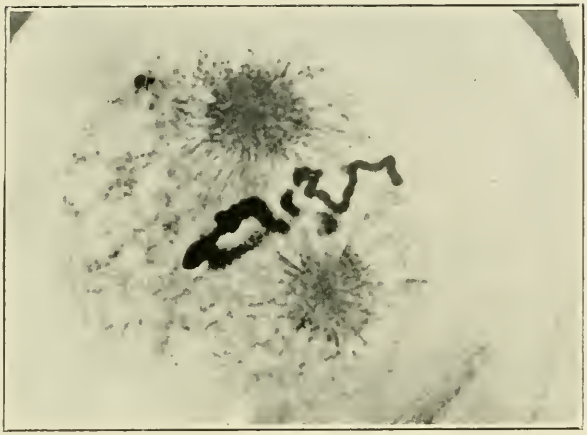


Fig. 11. The mitotic figure is complete.

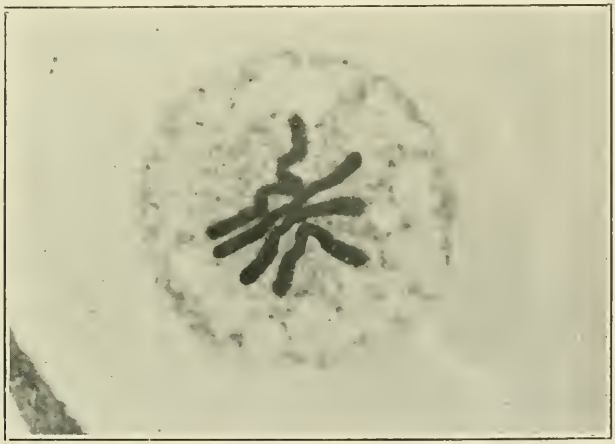


Fig. 12. Chromosomes of the equatorial plate seen from the pole.

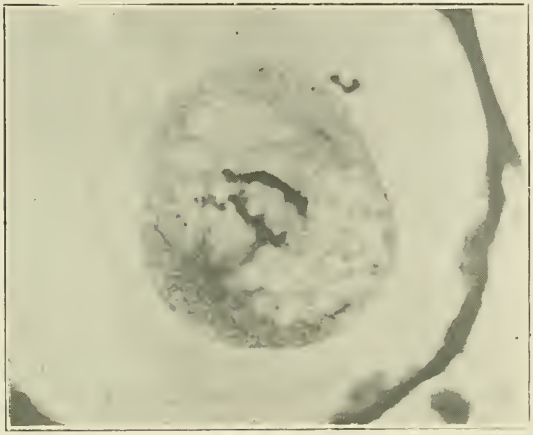


Fig. 13. An early telophase; two centrosomes above; polar bodies outside of egg.

Fig. 14. A somewhat later phase; walls beginning to contract for two-cell stage.

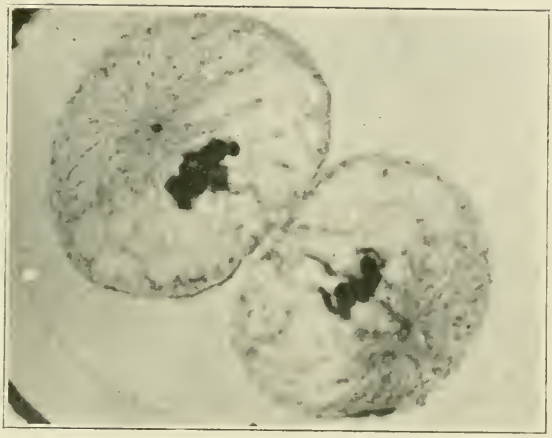


Fig. 15. Two-cell stage.

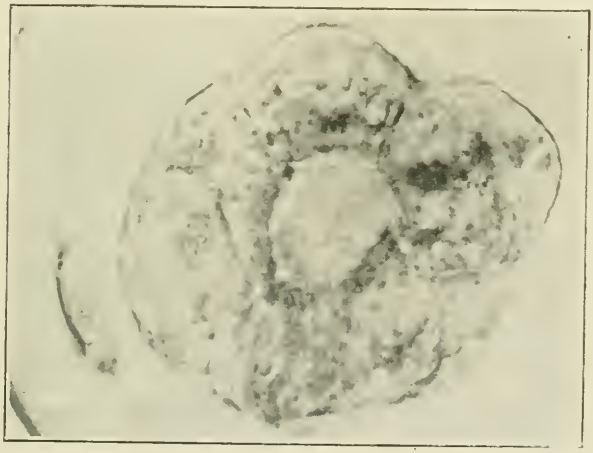


Fig. 16. Blastula of ascaris, multiplied 1,500 times. The specimen is not sectioned; see text.

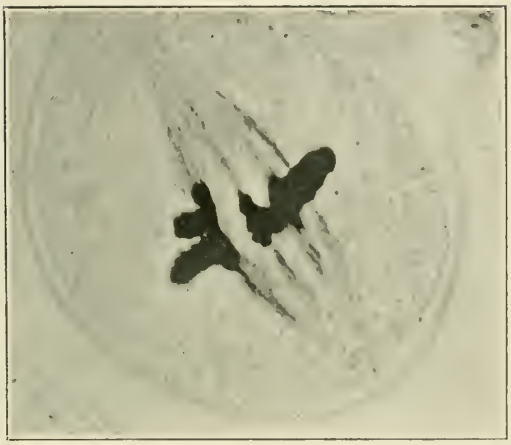


Fig. 17 Pollen mother cell of Lillium candidum; slide by Prof. David M. Mottier, multiplied 1,500 times.

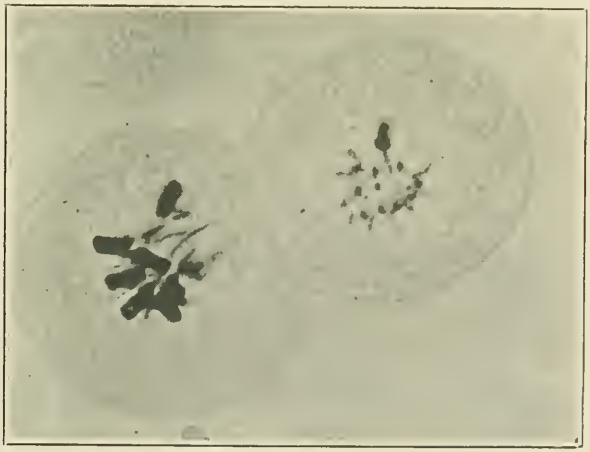


Fig. 18. L. candidum. The right-hand cell is cut at nearly right angles to plane of Fig. 17.

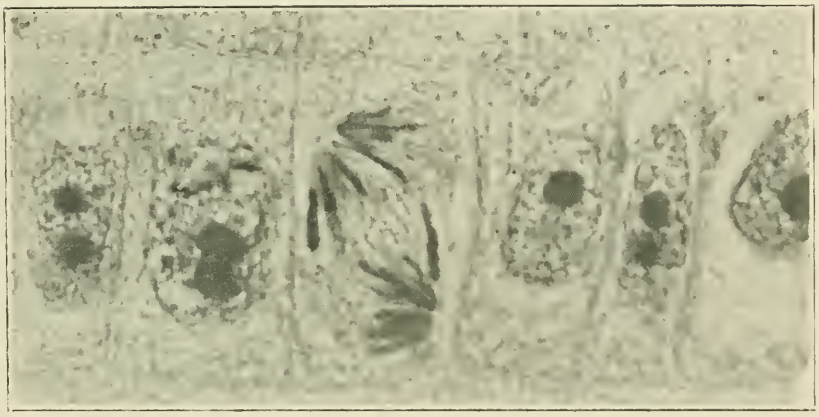


Fig. 19. Onion root; the oblique mitotic figure accommodates itself to the confined cell space.

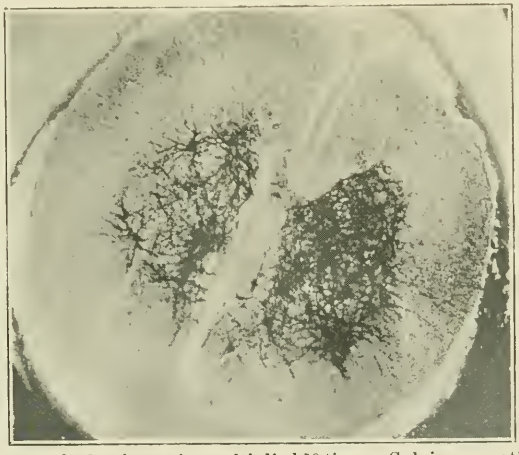


Fig. 20. Spinal cord of embryo pig, multiplied 50 times; Golgi preparation. Slide by Messrs. Warfel and Marshall.

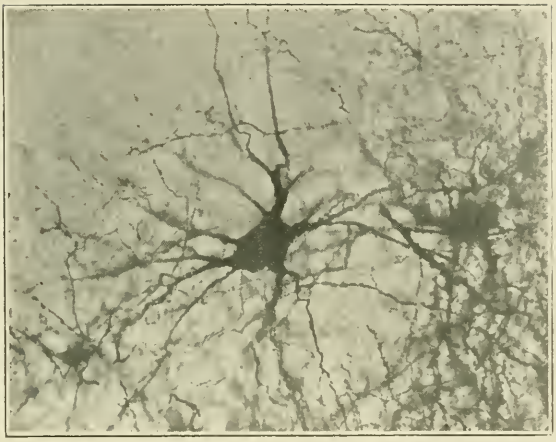


Fig. 21. The upper left-hand cell of fig. 20, multiplied 200 times.

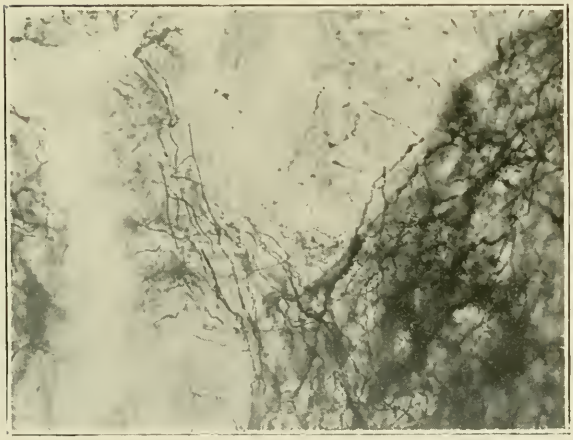


Fig. 22. The Commissure of fig. 20, multiplied 200 times.