ROCHESTER
ACADEMY OF SCIENCE.

BULLETIN
OF THE
SECTION OF MICROSCOPY.

MEETS IN THE SECTION ROOM, REYNOLDS' ARCADE,

THE 4TH THURSDAY OF EACH MONTH,

JULY AND AUGUST EXCEPTED.

ANNUAL MEETING IN JANUARY.

OFFICERS :

PRESIDENT.	VICE-PRESIDENT.	SECRETARY.
J. EDW. LINE.	WM. STREETER.	CHAS. E. ALLING.

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SECTION OF MICROSCOPY.

Rochester, N. Y., Oct. 22, 1885.

The President, J. Edw. Line, in the chair.

The minutes of March 26th and April 9th were approved as read.

After a general discussion, Jas. E. Whitney, J. Edw. Line, and Chas. E. Alling were appointed a committee to arrange for a series of papers for the meetings of the ensuing year, with instructions to report at a special meeting to be held Nov. 5th. Adjourned.

Nov. 5th, 1885.

The President in the chair.

The committee appointed at the October meeting to prepare and present for the consideration of the Section a programme for the ensuing year, reported the following list of essayists, the subjects to be announced from time to time in the daily papers:

Friday,	Nov. 27th	Mr. Ernst Gundlach.
Thursday,	December 24th	Mr. Wm. Streeter.
"	Jan. 28th	Mr. Edw. Bausch.
"	Feb. 25th	Mr. H. F. Atwood.
"	March 25th	Dr. M. L. Mallory.
"	April 22d	Mr. Jos. N. Levi.
"	May 27th	Mr. A. M. Dumond.
"	June 24th	Mr. W. C. Walker, Utica.

The committee also recommended the appointing at each meeting of one or more members to give practical demonstrations of methods of work, or exhibit instructive objects and new apparatus, at the meeting next following their appointment.

The report, also the recommendation, were adopted. Adjourned.

Nov. 27th, 1885.

The President in the chair.

The minutes of Nov. 5th were approved as read.

The following paper, prepared by Mr. Ernst Gundlach, was read by Mr. H. H. Turner, Mr. Gundlach being prevented by illness from being present:

ASTIGMATISM AND ITS RELATION TO THE USE OF OPTICAL INSTRUMENTS.

Astigmatism is a defect of the human eye which disturbes the true or normal vision in such a way that, for instance, a point appears elongated in one direction, or rather it appears in a line. It is caused by a certain irregularity in curvature of one or both surfaces of the crystalline lens of the eye, that is, the surfaces are stronger curved in one direction than in another, thus giving the crystalline lens different focal lengths in different directions, so that, for instance, a line may appear sharp and distinct in one direction but become quite blurred if the direction is changed. Astigmatism can be corrected by glasses one or both surfaces of which are of a convex or concave cylindrical curvature, and if, beside this defect, the eye is either short or far sighted, a certain combination of such cylindrical curvatures and their axial directions, concave or convex as the case may require, will at the same time correct both defects and make objects appear as they do to the normal eye. Indeed such glasses are made as spectacle glasses with complete success, but, however, the determination of the correct formula for the proper construction of such glasses requires a rather complicated and systematic examination of the defective eye, which can only be accomplished by a specialist thoroughly familiar with this branch of science. Astigmatism is very common, and even the healthy eye is not free from it. The curvature of the crystalline lens is a little shorter in vertical than in horizontal direction, thus making a line of a certain length appear shorter when seen in horizontal and longer in vertical position provided the distances in both cases are equal. Although the disturbance of clear and distinct vision may not be directly perceptible to the healthy eye under ordinary circumstances, it will become quite apparent if the pupil is unusually enlarged, as is the case in the dark, and the eye is directed to an isolated object the light power of which is not sufficient to cause much reduction in the size of the pupil by contraction. In cases of a high degree of astigmatism the prismatic colors will appear at the edges of objects in certain directions, according to the direction of the astigmatic axis, and add to the indistinctness.

Having thus given a brief account of the nature of astigmatism and its interfering influence to the perfect and natural use of the eye, and the remedy of the defect of the same by the use of spectacle glasses of peculiar construction, it remains to consider the relation of the astigmatic eye to the use of optical instruments.

The telescope and the microscope serve to increase the power of the eye, not only by simply showing us an object on an enlarged scale and with a wider angle of view, but also at the same time—by means of increased quantity of light—enabling us to distinguish shades of color or close lines at a smaller angle of view than the unaided eye is capable of doing. This latter property of the optical instrument we call resolving power. It is dependent on the angular aperture of the instrument and is directly proportionate to it. It gauges the distinguishing capacity of our eye to an extent which it has no opportunity to develop under ordinary conditions. In other words, the telescope and microscope not only increase the angle of view, that is, magnifying the object, but also the angular aperture, and consequently the resolving or separating power of the eye. To those unacquainted with the use of optical instruments the amount of magnifying power may seem to be the most important. if not the only, condition of the capacity of the instrument, but the experienced manipulator knows too well that high magnifying power is of no value without a corresponding amount of resolving power. A telescope of six inches aperture will separate a double star that a two-inch glass is incapable of showing any trace of separation in, even though both instruments are of the same magnifying power. The difference is due alone to the fact that the six-inch glass increases the angular aperture of the eye three times more than the two-inch. The principal endeavor of the optician in constructing optical instruments is not the highest possible magnifying power—indeed there is no special difficulty in this direction—but to combine with a given magnifying power such high angular aperture with a minimum of optical errors so as to increase the resolving power to the highest possible degree, so that the closest lines or dots can be seen distinctly separated from each other. But any optical instrument, however perfect it may be in its construction, will fail to perform to the satisfaction of even the most experienced operator if his eye is optically defective in such a way as to interfere directly with the normal performance of the instrument, and astigmatism must be regarded as such a defect. Near and long sight is corrected by simply focusing the instrument. But on our present instruments there is no means provided to correct astigmatism. The astigmatic microscopist may fail to separate some close and fine lines, which the day before under more favorable conditions to his astigmatism he saw quite distinctly; and, on another occasion, he perhaps experienced a similar change within a few minutes without any change in conditions except that he accidently changed his own position to his microscope by a turn of ninety degrees around the table, thus placing his astigmatic axis in a more favorable or unfavorable direction, as the case may be, to the direction of the fine lines.

The telescope as well as the microscope shows the errors produced by astigmatism. Close double stars appear different in the angle of separation at different times, or, at times become too indistinct to be separated at all, owing to the change of their line of position to the astigmatic axis of the observer's eye. Circular objects, such as faint clusters, nebulæ and comets, appear elongated, winged, or in other way of irregular shape. In fact there is not a case possible where astigmatism could not be to some degree injurious to the perfect definition of the fine details of an object, and this is increased the higher the perfection of the instrument.

Having thus explained the general injurious effects of astigmatism on telescopic and microscopic observations, it remains to find a suitable remedy, and, as such, I propose a most simple and effective one in the use of an eye-piece of an asymmetric form so as to just neutralize the asymmetry of the crystalline lens of the eye. This can best be done by making the outer surface cylindrical instead of spherical or plano. It may be made either concave or convex as the requirements of the case may demand. The eye-piece must be constructed with special regard to the purpose so as to place the asymmetric surface in such close proximity to the eye that no perceptible secondary distortion is produced by the oblique direction of the eye toward the edge of the field, and, at the same time, the prismatic colors dispersed in the direction of the astigmatic distortion must be neutralized.

I intend to construct such eye-pieces, and expect to start with a one-inch. To enable the applicant, for this special purpose at least, to be his own examiner for astigmatism, I intend to furnish with the eye-piece three eye glasses, alike in mounting but different in the degree of asymmetry, for selection. The difference being such as to practically approach both limits of common astigmatism, and the one of the three lenses nearest in asymmetry to that of his eye will correct his astigmatism to an undisturbing minimum. The observer will then have to test all the lenses, beginning with the weakest, on a suitable object, slowly revolving the eye-piece until its best position is found. Mark this position, and do the same thing with the other lenses. After this, compare the action of the lenses, each in its best position, to find the one best fitted for the eye. Of course the eye piece, or rather its asymmetric eye lens, must then always be used in the same position to the astigmatic axis. To do this there will be no difficulty when using the microscope, but for the equatorially mounted telescope a special contrivance may be required, so that the position of the eye-piece may be easily controlled in the dark by the fingers and corrected after each change of the position of the body.

After a general discussion of the paper, Mr. C. E. Alling gave a practical demonstration of double staining of plant sections with carmine and aniline green. Adjourned.

Dec. 24th, 1885.

The President in the chair.

The minutes of Nov. 27th were approved as read.

The stated paper of the evening was read by Mr. Wm. Streeter:

ON TESTING OBJECTIVES AND RESOLUTION OF TEST OBJECTS.

My position here this evening in discussing the merits of objectives and the resolution of test objects is fairly expressed in the language of Marc Antony when he says: "I have neither wit, nor words, nor worth, action, nor utterance, nor the power of speech to stir men's blood. I only speak right on. I tell you that which you yourselves do know, show you sweet Cæsar's wounds, poor dumb mouths, and bid them speak for me."

The matter of selecting a microscope and objectives is one of no little anxiety; and while this can well be considered of most vital importance, I am of the opinion that we are almost too much inclined to distrust the opticians. I believe all reputable makers intend to bring their work to a certain standard of perfection before permitting it to leave their hands; but the beginner is apt to expect too much of an objective, and attempt with it work for which it was never intended, failing in which he is at once greatly disappointed. For in the selection of a microscope the first idea is (not knowing the exact line of work to be pursued) that he, like "Titbottom" with his magic spectacles, will want to examine everything, from the potato bug to the *Amphipleura pellucida*, and he naturally requires an objective that will do this; but he gradually learns that the range of work for which any one objective is well adapted is quite limited, and this first disappointment overcome he will provide himself from time to time with such lenses as are best suited to the kind of work he wishes to pursue. For the microscope, it must be confessed, has very grave defects, which utterly defy all skill of the optician; for instance, as you increase the magnifying power you lessen the range of vision, which is a most serious fault, and brings this prime quality of amplification within certain limits, beyond which the loss of light, the smaller field, and impaired definition, more than overbalance the increased amplification,—consequently, as a rule, never employ more magnifying power than is just necessary to give the details of an object sufficient size to be readily seen. The question should not be, How much will your instrument magnify? but rather, How much can be seen with it? The power and the angular aperture must always be taken into the account when we ask what an objective ought to do. Lastly, the price of the objective. We should not expect as good an objective for six as for eighteen dollars. Though this statement must be modified, for a cheap objective will in a certain class of work, sometimes give as good results as a costly one. I had an illustration of this not very long ago. Three objectives of the same power, 1 inch, were sent me for inspection, varying in price as follows: 13, 22 and 40 dollars, with the request that I take particular notice of the highest grade which claimed 40° angle of aperture, and would resolve 40,000 lines to the inch. I examined these objectives very carefully, and for all purposes for which I should use a 1-inch I would prefer the 13 dollar objective to the 40 dollar at the same price. Now, right here, I am aware that I am coming in collision with the expressed opinion of some opticians of high repute, thereby probably exposing my ignorance, but a wide angle objective, though it will resolve lines which a narrower angle will fail to show, may have other defects which the narrower angled objective is free from, so as to give the preference in favor of the less pretentious lens. A wide-angle resolving objective may show lines on a test object, and still have so much spherical aberration as to be almost worthless for general work. I would not for a moment be understood as speaking against wide-angle objectives; for I believe that every degree of aperture that can be brought in, and properly corrected, adds to the fine definition of the objective, whether for central or oblique light. On the other hand every degree that is taken in and not properly corrected detracts in like proportion from the fine definition. And I consider flatness of field of almost primary importance. Take two objectives of same angular aperture, one with much spherical aberration, the other free from it, the former will seem to have much less penetration and much smaller available field, from the fact that only one point can be in focus at the same time, and a point has no field, consequently no definition and no penetration; while with flat field we have good definition and can see a little above and a little below the exact plane of focus. This gives whatever can be of penetration, and as I should never take a 1-inch objective if I were going to show the lines on *Amphipleura pellucida*, I should not deem it a defect that it would not do this work, while it is so much better done with a higher power. This also applies to the 40,000 lines to which I referred. Again, the working distance of medium powers from $\frac{1}{2}$ to $\frac{1}{4}$ in. dry objectives should never be sacrificed for the sake of wide-angle, but should be always sufficient to permit their use upon opaque objects with reflected light from the mirror above the stage, or a bull's-eye condenser.

For the method of examination of an objective to determine its corrections, I am indebted for valuable suggestions to my good friend Gundlach.

Pleurosigma angulatum is perhaps the best known, and is a very useful test for the aberrations of medium and wide-angle objectives. If the objective is spherically over-corrected, the plane in which the fine lines appear will be above the plane of the outlines of the shell, or *vice versa*. A small black spot upon light ground may also serve for the test of both aberrations. If the objective is spherically over-corrected the black spot will appear surrounded with a bright, though not sharply defined, ring. When the objective is moved slightly out of focus upward, that is, away from the object, the spot will quickly become indistinct and shaded at the edges, and diminish in size when the objective is thrown out of focus in the opposite direction, that is, toward the object. The reverse in both cases will take place if the objective is spherically *under*-corrected. If the objective is chromatically over-corrected, then the black spot will show a bright yellow color around the edge when brought out of focus in the direction away from the object, and a blue color when too near the object. If the objective is under corrected for color, then the reverse in both cases will appear. But if *just right* in correction for color, then a yellowish green will appear if out of focus away from the object, and a violet if too near to the object. These latter colors, which indicate the unavoidable "secondary spectrum," will appear on oblique illumination when the object is just in focus, the violet being on the side where the mirror is placed, the green on the side opposite. By the greatest obliquity of light these colors will change to blue and yellow, as a result of the peripheric part of the objective being slightly over-corrected for color, while the central part is slightly under-corrected. This defect is called "aberration of higher order." It is often mistaken for the secondary spectrum, which latter is the result of the disproportion between flint and crown glass, of the relative width of the spectral colors. The more oblique light the objective can stand without changing the neutral colors to blue and yellow the better the objective, for the lesser the aberration of higher order.

THE SCREW COLLAR.—This adjustment, it must be admitted, is at present a deplorable necessity for dry or water immersion objectives of wide angle, and we are obliged to use it as the last means of improving our seeing of an object. But I must confess that I never examine an unfamiliar object with one of these lenses that I am quite sure of what I am seeing, and if that is really the way it ought to look—the adjustment has so much to do with the correct definition. On a diatom with which I am familiar it is quite easy to adjust till I get the familiar appearance; but with a strange object the case is entirely different, and I never feel quite sure until I resort to my non-adjustable homogeneous objective (this never lies), which requires no correction, but is always ready, and yields such a brilliant and perfect picture as to dispel all doubt in regard to its truthfulness. While some have argued for an adjustable mount in this class of objectives, my own judgment is to the contrary, for with the proper tube length and a homogeneous medium, once right you are always right, and your objective at once yields the best possible result with the smallest chance of error.

In the use of these dry or water immersion objectives of wide angle, a correction for the varying thicknesses of covers is always necessary.

And while a diatom such as *Pleurosigma angulatum* may be the best object on which to determine this correction, still, in the process of investigation, it is plain we can have no such object, as the correction has to be applied to each object individually. And I think Mr. Wenham gives the only rule I have ever seen of much practical value, which is as follows: Select any dark speck or opaque portion of the object, and bring the outline in perfect focus, then move the fine adjustment briskly up and down from the first position. Observe the expansion of the dark outline of the object, both when within and when without the focus; if the greater expansion or coma is when the object is without the focus or furthest from the objective, the lenses must be separated; but if the greater coma is when the object is within the focus, or nearest the objective, the lenses must be brought closer together. When the objective is in proper adjustment, the expansion of the outline is the same, both within and without the focus.

But I would recommend as the simplest plan for general work the selection of cover glasses of uniform thickness, which is easily and quickly done by the use of the micrometer caliper, reading to the one hundredth of a m. m.; once find the position of the collar adjustment for the thickness of these selected covers, and you have the proper correction for all, without further change, and it will be found a great saving of time, and will yield, I think, results quite as satisfactory.

I ought to say a word in regard to eye-pieces, as too little attention is paid to this part of the instrument. Good eye-pieces are almost as essential as good objectives. They determine the size of the field, and often materially affect the spherical aberration. I have often seen the performance of a good objective rendered absolutely bad by a faulty eye-piece. The periscopic eye-piece, if properly constructed, is unquestionably the most perfect ever invented, and will yield the finest results. It is especially adapted for use with the eye-piece micrometer.

But I am afraid I am occupying too much time in this talk about objectives. I was very much at a loss to know where to begin, and now I am even more at a loss to know where to leave off. But one place may be as good as another, since I shall not be able to do any kind of justice to a subject so vast in this very limited discussion.

And furthermore I proposed to speak of test objects. Perhaps to show them so that they may speak for themselves will be sufficient. The late Dr. Carpenter recommended as tests for flatness of field for low and medium powers, sections of spine of Echinus, or thin wood sections, or histological sections. But perhaps the best test for flatness of field for all powers is ruled lines, like Nobert's or Fassoldt's test rulings. Then for definition, proboscis of blow fly, scales of butterflies, and *Lepisma Saccharina*. And for higher powers the *Podura* scale was and with some is still, a great favorite. But the diatoms furnish a range so vast that he must be a very critical person who shall fail to find a satisfactory test among them for almost any power. Möller's Test-plate of twenty diatoms furnishes a wide range of lines, and will be found a suitable test for the definition and resolving power of almost any objective, ranging as they do from about 4,000 to 100,000 to the inch. But here again, as in the test for flatness of field, the ruled lines of Nobert may be, and undoubtedly are, the best test for the resolving power of an objective.

In choosing a place for work with the microscope, a north window is preferable, as the light is more uniform throughout the day. Always take care that there are no shadows reflected from the mirror, such as the branches of trees or the window sash, which are very disturbing, and greatly impair the seeing. At night a German student lamp is an excellent steady light, and will be sure to give satisfaction. I prefer to have the light directly in front, as in the manipulation and adjustment of the slide the hands never obstruct it; and central light is so much easier got in this position, which, of course, is chiefly employed in ordinary investigations; and even for difficult resolution with the use of the small hemispherical lens sufficient obliquity can always be had with the lamp in this position. But for the mirror alone, to obtain the greatest obliquity, I place the lamp directly to the right of the microscope. With low powers do not flood the field with too much light; always get an even illumination over the entire field, but not a glare directly into the objective.

Always use the concave mirror, except perhaps with a *very* low power, or when in use with some accessory like the paraboloid, requiring parallel rays. But with all use your best judgment, and never abandon anything attempted so long as there is a chance for success But I will stop here, and give the objects a chance to speak.

A number of test objects were shown, and the numerous points made in the paper practically demonstrated under the microscope by the essayist. *Amphipleura pellucida* was resolved perfectly and with ease by Mr. W. M. Rebasz with a Gundlach one-eighth homogeneous immersion objective. Adjourned.