Presenting A Brief History Of the Evolution Of The Microscope

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As we turn back the pages of time in the history of the evolution of the microscope, we trace it's source back to the gray dawn of our historic morning. In the translation from the ancient Chinese, we find that it was used in the Chow-Foo dynasty more than 2,000 years before our Christian era. These leaned men were credited with the making of the first refractive lens in the history of optics.

As near as we can translate from their records, they used a small tube some three feet in length on a suitable base and stand, with a refractive single lens in the lower end of this tube. And with the ingenious method of filling the tube with different levels of water, they attained different peaks of magnification. As near as we can translate, when the tube was completely filled with water they attained a magnification of some 100 moou, which is about 150 times our standard.

There seems to be little or no change in this principal or method over a period of five centuries. And then we loose any data on the microscope whatsoever, until again we pick it up in the time of the ancient Greeks in about 384 B.C., where we find that a type of microscope was used and some of its principles recorded by Aristotle. These devices were more than likely inferior to the ones used by the ancient Chinese. These small spheres of glass were not only used to enlarge small objects, but were also used as burning spheres for the cauterization of the skin lesions of leprosy and allied infections. We derived the word microscope from the compounding of two Greek words, uikpos, small and okottew, view. The first compound microscope was built by Hans Jasson and his son Zacharias, in Middleburg, Holland, about 1590 and was used to some extent on work with insects, but no record of the work attained is on record.

Anthony von Leeuwenhoek, justly called the father of microscopy, was born in Delft, Holland, in 1632. Von Leeuwenhoek built all his own microscopes, preferring the single lens to the compound type, which at that date was very lacking in resolution and detail. He described many small living particles in such minute detail that we know them today as bacteria. Many observers possibly may have seen these live entities, but Von Leeuwenhoek was the first to describe them in detail and record his findings, which were embodied in the form of a contribution which was presented to the Royal Society of London in 1883. From the perusal of the tests and the inspection of the plates there remains little doubt that Von Leeuwenhoek with his primitive lens, had observed the bodies now recognized as the cause of disease.

Many improvements were made in the microscope from that time. The major factor being the mechanics of the instrument in its control and adjustments. But improvements in the optical detail were undoubtedly lacking for over 100 years. Hartnic of Paris is accredited with the construction of the first compound objective lens in 1640, which was a decided step forward.

Dolland of England developed in 1844, the image lens, which was in almost its initial form to the present day. In 1870, Abbe, the immortal optical wizard of the Carl Zeiss works in Jena, developed and brought out the sub-stage condenser, which still bears his name, and was one of the outstanding contributions to the microscope of all time.

From 1880 to 1885 Carl Zeiss introduced many improvements in the microscope. Among them the apocromat objective lens, which was an outstanding optical achievement at that time.

Thus the microscope has slowly risen out of the dim mist of antiquity to the modern instruments of the present day. The writer has over a period of thirty years has designed and built in his own laboratory 5 microscopes of power and resolution far beyond the so-called law of optical physics. These instrument vary in their power from 17 to 50,000 times above and beyond the limits of the standard research instrument. The commercial microscope being manufactured is inadequate for the observation of filterable viruses of disease (as these minute live, living entities are less than 1/20 of one micron in dimension). Thus the need for a device which would carry us farther into this important field of endeavor. We will describe in some detail the most powerful of these microscopes, known as the universal microscope.

The universal microscope, which is the largest and most powerful of the light microscopes developed in 1933, consists of 5,682 parts and is so called because of its adaptability in all fields of microscopical work, being fully equipped with separate substage condenser units for transmitted and monochromatic beam, dark-field, polarized, and slit-ultra illumination, including also a special device for crystallography. The entire optical system of lenses and prisms as well as the illuminating units are made of block-crystal quartz, quartz being especially transparent to ultraviolet radiations.

The illuminating unit used for examining the filtrable forms of disease organisms contains 14 lenses and prisms, 3 of which are in the high-intensity incandescent lamp, 4 in the Risely prism, and 7 in the achromatic condenser which, incidentally has a numeric aperture of 1.40. Between the source of light and the specimen are subtended two circular, wedge-shaped, block-crystal quartz prisms for the purpose of polarizing the light passing through the specimen, polarization being the practical application of the theory that light waves vibrate in all planes perpendicular to the direction in which they are propagated. Therefore, when the light comes into contact with a polarizing prism, it is divided or split into the two beams, one of which is refracted to such an extent that it is reflected to the side of the prism without, of course, passing through the prism while the second ray, bent considerably less, is thus enabled to illuminate the specimen.

When the quartz prism on the universal microscope, which may be rotated with a vernier control through 360 degrees, are rotated in opposite directions, they serve to bend the transmitted beams of light at variable angles of incidence while, at the same time, a spectrum is projected up into the axis of the microscope, or rather a small portion of a spectrum since only a small part of a band of color is visible at any one time. However, it is possible to proceed in this way from one end of the spectrum to the other, going all the way from the infrared to the ultraviolet. Now, when a portion of the spectrum is reached in which both the organism and the color band vibrate in exact accord, one with the other, a definite characteristic spectrum is emitted by the organism.

In the case of the filter-passing form of Bacillus typhosus, for instance, a blue spectrum is emitted and the plane of deviation deviated plus 4.8 degrees. The predominating constituents of the organism are next ascertained after which the quartz prisms are adjusted or set, by means of vernier control to minus 4.8 degrees (again in the case of the filter passing form of the Bacillus typhosus) so that the opposite angle of refraction may be obtained. A monochromatic beam of light, corresponding exactly to the frequency of the organism (for the writer has found that each disease organism responds to and has a definite and distinct wavelength, a fact confirmed by British medical research workers) is then set up through the specimen and the direct transmitted light, thus enabling the observer to view the organism stained in its true chemical color and revealing its own individual structure in a field which is brilliant with light.

The objectives used on the universal microscope are a 1.12 dry lens, a 1.16 water immersion, a 1.18 oil immersion and a 1.25 oil immersion. The rays of light refracted by the specimen enter the objective and are then carried up the tube in parallel rays through 21 light bends to the ocular, a tolerance of less then one wave length of visible light only being permitted in the core beam, or chief ray, of illumination. Now, instead of the light rays starting up the tube in a parallel fashion, tending to converge as they rise higher and finally crossing each other, arriving at the ocular separated by considerable distance as would be the case with an ordinary microscope, in the universal the rays also start their rise parallel to each other but, just as they are about to cross, a specially designed prism is inserted which serves to pull them out parallel again, another prism inserted each time they are about ready to cross.

These prisms, inserted in the tube, which are adjusted and held in alignment by micrometer screws of 100 threads to the inch in separate tracks made of magnelium (magnelium having the closest coefficient of expansion of any metal to quartz), are separated by a distance of only 30 millimeters. Thus, the greatest distance that the image in the universal is project through any one media, either quartz or air, is 30 millimeters instead of the 160, 180, or 190 millimeters as in the employ or air filled tube of an ordinary microscope, the total distance which the light rays travel zigzag fashion through the universal tube being 449 millimeters, although the physical length of the tube itself is 229 millimeters.

It will be recalled that if one pierces a black strip of paper or cardboard with the point of a needle and brings the card up close to the eye so that the hole is in the optic axis, a small brilliantly lighted object will appear larger and clearer, revealing more fine detail, than if it were viewed from the same distance without the assistance of the card. This is explained by the fact that the beam of light passing through the card is very narrow, the rays entering the eye, therefore, being practically parallel, whereas without the card the beam of light is much wider and the diffusion circles much larger. It is this principal of parallel rays in the universal microscope and the resultant shortening of the projection distance between any two blocks or prisms plus the fact that objectives can thus be substituted for oculars, these "oculars" being three matched pairs of 10-millimeter, 7-

millimeter, and 4-millimeter objectives in short mounts, which make possible not only the unusually high magnification and resolution but which serve to eliminate all distortion as well as all chromatic and spherical aberration.

Quartz glasses with especially thin quartz cover glasses are used when a tissue section or culture slant is examined, the tissue section its self also being very thin. An additional observational tube and ocular which reveal a magnification of 1,800 diameters are provided so that that portion of the specimen which is desired should be examined may be located and so that the observer may adjust himself more readily when viewing a section at a high magnification.

The universal stage is a double rotating stage graduated through 360 degrees in quarter-minute arc divisions, the upper segment carrying the mechanical stage having a movement of 40 degrees, the body assembly which can be moved horizontally over the condenser also having and angular tilt of 40 degrees plus or minus. Heavily constructed joints and screw adjustments maintain rigidity of the microscope which weighs 200 pounds and stand 24 inches high, the bases of the scope being nickel cast-steel plates, accurately surfaced, and equipped with three leveling screws and two spirit levels set at angles of 90 degrees. The coarse adjustment, a block thread screw of 40 threads to the inch, slides in a 1 « dovetail which gibs onto the pillar post. The weight of the quadruple nosepiece and the objective system is taken care of by the intermediate adjustment at the top of the body tube. The stage, in conjunction with a hydraulic lift, acts as a lever in operating the fine adjustment. A 6-gauge screw having 100 threads to the inch is worked through a gland in a hollow, glycerine-filled post, the glycerine being displaced and replaced at will as the screw is turned clockwise or anticlockwise, allowing a 5-1 ratio on the lead screw. This accordingly, assures complete absence of drag and inertia. The fine adjustment being 700 times more sensitive than that of ordinary microscope, the length of time required to focus the universal microscope ranges up to 1 « hours which, while on first consideration, may seem a disadvantage, is after all but a slight inconvenience when compared with the many years of research and the hundreds of thousands of dollars spent and being spent in an effort to isolate and to look upon disease-causing organisms in their true form.

We sincerely hope that our efforts in the field of optics, and its allied branches, will stimulate and create a desire in the minds of other workers to carry on in the broad and inviting field before us, one which presents a work so vital and essential for the benefit of all mankind.

ABOUT THE AUTHOR- *Dr. Royal R. Rife is presently retained under contract to Rohr Aircraft Corporation for a special assignment. A fellow of the Royal Microscopic Society, he has designed and built his own laboratory, 5 microscopes of power and resolution far beyond the so-called law of optical physics, several of which are pictured here. Doctor Rife holds a Doctor of Philosophy degree from Heidelburg University, and a Doctor of Science degree from the University of Southern California. He resides in Point Loma.*