DEVELOPMENT OF NEW TOOLS FOR SCIENCE,

I. From Hollow Sphere to Super Microscope.

By

Arno Viehoever.

1. Simple Microscope.

The first magnifier, used by man to increase the power of his eyesight, probably was a hollow sphere, filled with water. Simple lenses were indeed known in ancient times both for magnification, and for burning or ignition of combustible matter, placed in the focus of sunlight. But not until the 17th century, or 400 years ago, was the observation made that a combination of lenses resulted in increased magnification. The ingenious studies of the German astronomer J. Kepler (1571-1630) and the Dutch physicist C. Huyghens (1629-1695) contributed greatly to the understanding of optics and the behavior of light rays. This knowledge led to the invention of the simple microscope ("small-seer"), and also the telescope. It became a fad to look through the combined lenses at small creatures, like fleas. Thus the name "Flea Glasses" became a popular designation.

2. Compound Microscopes.

As is well known, the Dutchman van Leeuwenhoek, a "classical microscopist" born 1632 in Delft, spent a life time on his hobby of nature studies; in grinding his own lenses, he obtained finally a magnification of as much as 270 with one of his 400 odd optical apparatus.

The subsequent centuries brought further perfection in the selection of special optical glass and the design and precise grinding, as well as in the combination of new lenses in the compound microscope. Finally, the limit of magnification was reached by the limit of the resolving power (giving clearly defined images of the object). This limit in the ordinary visible light is about 1/2 of its wave length or appr. 100 000th of an inch. The image is directly visible.

3. Ultra-Microscope.

In consequence of this limitation, the visible light was replaced by the monochromatic and especially the ultra-violet light; the latter has about 1/2 the wave length of the visible light and thus about double the resolving power. The optical image is seen with the fluorescent screen or made visible through exposure of the photographic plate. The magnification as high as 5000 diameters resulted in brilliant images, with a degree of detail greatly superior to that of other optical systems. Also optical sectioning through cells became possible. With ultra microscopy the structure of living bacteria, hitherto not clearly resolved with visible light, can now be studied directly, (without staining and thus killing them). Fig. 1 and 2.

The Ultra-Violet Microscope was developed in 1904 by Dr. A. Koehler of the Scientific Staff of Zeiss, Jena, for use in biology. It was further improved by Dr. F. F. Lucas of the Bell Telephone Laboratories, New York, who used it in High Power Metallography and then from 1930 on for the study of the Architecture of Living Cells.

4–5. X-ray and Reflection Microscopes.

X rays, although 10 000 times shorter than visible rays, thus far cannot be focused; a microscope, permitting the use of x rays, has therefore not been constructed, nor one in which reflected light can be utilized as in the telescope.

6. Super Microscope – or Electron Microscope.

In order to overcome the obstacle of limited magnification, caused by the wave nature of light, electrons, already serving radio and television, are also proposed now for use in microscopy. Their wave length is about 1/100 000th that of light. Although they are invisible, these electrons can be focused by a magnetic field, but not by a lens. The electrons are emitted by a hot filament, (as in the radio tube). They pass in succession:

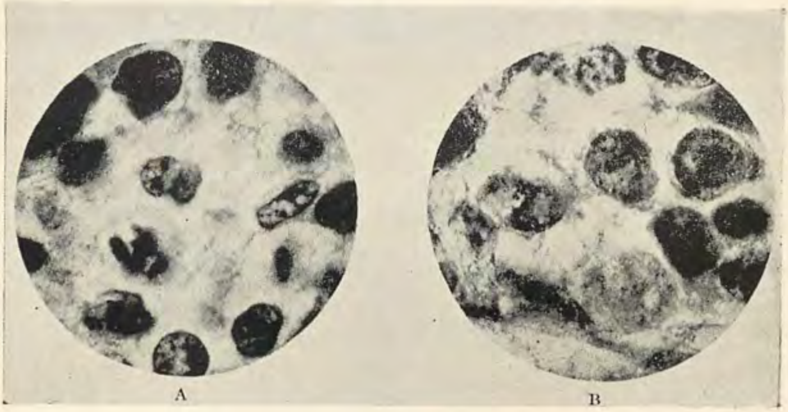
(1) Through the condenser coil (and are thus focused on the object, which is mounted and kept in a high vacuum; a shadow, rather than the true image, is impressed on the beam of the electrons);

(2) through the objective coil (which, like the objective lens in a microscope, focusses the electrons into an enlarged shadow picture);

(3) through the projector coil, (which projects and enlarges again the image on the photographic plate).

The first super microscope, thus constructed, was recently (1938) developed by von Borries and Ruska in the scientific laboratories of Siemens & Halske, Berlin, Germany; another has now been com-

Ultra-Microscopy and Super-Microscopy.



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1. Identical Sections of Carcinoma of the Appendix.
   A. Stained, photographed at 1000 x (indistinct at 1500 x) magnification in compound microscope.
   B. Unstained, photographed at 1500 x magnification in ultra-violet microscope.
2. Optical Section—with ultra-violet microscope—through cell group. (after Lucas).
   A-F: Focal Planes spaced as closely as 1/4 - 1/16 microns apart for progressive photographic recording of cell structure.
3. Super-or Electron Microscope of "Siemens and Halske," (after Chron. Bot.) using beams of electrons (voltage 75000) with much increased resolving power.
4. Bacillus: Corynebact. Diphteriae, photographed at 20.900 magnification in super microscope.

pleted by V. K. Zworgkin and others of the Radio Corporation of America, (which concern offers the instrument at 9,500 dollars for research institutions). An electron microscope of even greater resolving power, namely 60 Angstroms or 6 millionth of a millimeter has been constructed by Drs. E. F. Burton, J. Hillier and A. Prebus of the Toronto University, the theoretical resolving power being 1 millionth of a millimeter—according to Zworgkin's calculations. By microphotographic reproduction a total magnification of 180,000 diameters has been possible.

In a practical application the instrument has permitted the study of finest, otherwise invisible, dust and fume particles of importance in industrial diseases, and of the surface of face powder granules, significant in the development of most effective cosmetics. The virus of small pox has been made visible and structures have been observed in rubber-like synthetics, which are assumed to be actual molecules. The super microscope thus obviously increases the possibilities of exploring those regions of the micro-cosmos which are still obscure—e.g. facilitates the search for ultra-minute carriers e. g. of disease, of inheritance, and permits a closer view of the complex organisation, underlying all matter and life. Figs. 3 and 4.