The Spectroheliograph

The Most Important Instrument in the Study of Solar Physics

By Frank C. Dennett

THE most powerful instrument in the hands of the solar physicist is the spectroheliograph. The following description of the instrument is taken from *Knowledge*. The focal image of the sun, formed by an object-glass of very long focus, is made to fall on the slit plate of a spectroscop, the slit of which is greater in length than the diameter of the image falling upon it. As the object-glass has a long focus, that of the collimating lens must be proportionally long. The diagram (Fig. 1) shows the optical contents of the prism box of the Mount Wilson "Rumford" spectroheliograph. *C* is the tube of the collimator; *D* was formerly a plane mirror, but is now replaced by a diffraction grating ruled with twenty thousand lines to the inch; *P P* two light flint glass prisms 60 degree angle. The spectrum, instead of being examined with a telescope, is caused to fall upon the sensitized plate which replaces the eyepiece of the observing telescope. Before reaching the plate, however, it is intercepted by a second slit, which cuts off all the light save that passing through the tiny portion of the spectrum required—say the K line of Calcium, or the C line of Hydrogen. The image of the sun travels slowly across the first slit, and the photographic plate is caused to travel behind the second slit, by clockwork, at a corresponding rate. Two exposures are made when prominences and disk are to be photographed. A slower exposure for the prominences, the disk being hidden by a screen, and a second rapid exposure, when the screen is removed, for the disk. The total deflection of the ray is 180 degrees, the prisms doing the double work of increasing the dispersion, and getting rid of the small amount of scattered light caused by the diffraction plate. Hydrogen prominences and flocculi are best studied in photographs taken in the red light of *C*. The greater the density of the gas or vapor causing a line, the greater also is the width of the line. The closer a vapor is to the sun, the greater is its density also. Hence it is found that by taking photographs with the light of the middle of a line and comparing it with that of the edges of the line a different image is obtained.

The photograph obtained with the center of the line is largely that of the upper clouds, while that with the edge of the line is a picture of the lower, denser masses.

The spectroheliogram here reproduced from our contemporary *Knowledge* was obtained by Professor George E. Hale, at Mount Wilson, on July 17th,

Fig. 1.—Diagram of the Principal Parts of the Spectroheliograph: *C* collimator tube; *D* mirror or diffraction grating; *P P* glass prisms.

1907, in the light of calcium. The prominences around the southern hemisphere are very fine. The tall tree form on the southwestern limb has an altitude of eighty-seven thousand miles. The beautiful double arch southeast extends over a distance of two hundred and thirty-four thousand miles, the taller arch being fifty-five thousand miles high, while the cloudiness over the southern arch reaches over eighty-two thousand miles in height. The great calcium clouds, or flocculi, over the faculae of the great group near the center cover an area over one hundred and thirty-seven thousand miles east to west.

The Palæontologist's View of Evolution

In his studies of evolution Prof. Henry Fairfield Osborn, president of the American Museum of Natural History, has long held out against the strict

Darwinians or selectionists on the one hand, and against the DeVriesians or mutationists on the other. He has laid special stress on the geological evidence of "definite variations" and of the tendency of animals to evolve in some definite direction. The palæontologist is, he maintains, "practically immortal" as an observer, since his range of observations extends over tremendous stretches of time; whereas the botanist or the zoölogist gets but fleeting glimpses of the fundamental processes of transformation. The former gets the impression of continuity and definite tendency of evolution; the latter get the idea of discontinuity, and of direction determined only by selection.

After taking exception to the use of the term "mutation" by DeVries to designate discontinuous variations or "saltations"—since this term was used by Waagen in 1869 to designate the stages in a continuous process of evolution, Osborn admits that recent experiments and discoveries in Mendelian phenomena have greatly strengthened the doctrine of discontinuous evolution. He harmonizes the two extreme attitudes by claiming that the normal process is a continuous one and admitting that under exceptional conditions new characters may arise suddenly.

These reflections arise from his study of the Titanotheres, which furnish the most complete body of material of any extinct family of mammals. Since both biologists and palæontologists agree that the transformation in the germ is the essential factor in evolution, Osborn leaves out of consideration phenomena resulting from the action of the environment upon the developing organism or from the action of selection upon a succession of organisms. In the animals considered he finds four kinds of changes to have taken place:

1. *Increase of Size*. This is almost universal for this family, although not so for all mammals, nor even for all herbivores.

2. *Loss of Parts*. This principle is more prominent in some other families of mammals.

3. *Changes of Proportions*. This is the most prominent and the most significant principle observed in this group. These changes are designated "Allometric" by Osborn; and new parts originating by this process he calls "Allometrons." Allometrons arise independently of remote ancestral hereditary control. It is not clear from Osborn's description that in this respect the allometrons are anything but discontinuously originating unit characters of the mutationists. But he insists that they are continuous in their origin, as shown by measurements made on long series of specimens.

4. *Rectigradations*. These are adaptive origins of new characters in a definite direction, as exemplified by the cusps on the teeth, or new horns on the skull. In regard to the rectigradations Osborn enunciates four principles:

(a) They appear under the law of ancestral hereditary control, the same character arising independently at different points in the lines of descent from common ancestors.

(b) They are continuous, arising from minute beginnings and developing to the stage of usefulness. This principle had been previously described by Osborn, especially for the horse family, as "definite variation."

(c) They are subject to the influence of surrounding parts, as the shape of the base of the horn may be influenced by the general proportions of the skull.

(d) They are probably subject to fluctuations.

From these studies, as from earlier studies on the fossils of horses and their ancestors and of other lines of mammals, Osborn is confirmed in his view that the law of continuity, "of orderly and in a sense of predetermined transformation can now be established beyond refutation." His general reconciliation of apparently conflicting views he expresses in the following words:

"The normal development of unit characters is a continuous progress; under certain abnormal conditions, as of sudden change of environment, certain new unit characters may appear suddenly; the cross-breeding of pure natural races in which unit characters have been built up by continuous processes breaks up these unit characters into a mosaic and gives rise to the larger part of the apparently saltatory or discontinuous phenomena which are being observed by the modern experimentalists." He believes that if the experimentalists should confine their operations to pure races they would find only continuous series of characters.

Fig. 2.—Spectroheliogram of the Sun. Photograph Prepared by Prof. G. E. Hale of Mount Wilson Observatory.