In a paper on "The Principle of the Unobservable," the present writer[3] formulated criteria by means of which one can determine whether or not a definition or a concept or a proposition is significant. On the basis of these criteria, the concept of the color of an unexposed film is, in the terminology of that paper, logically unobservable; because it contains a logical contradiction. Du Noüy's question asks for the specification of the color of a film, but it rules out exposure to light at any stage of the operation by means of which it may be determined. In other words it, in effect, eliminates the concept of light as an element in the concept of color. But since light is a necessary element of color, the concept of color implied by the question is self-contradictory; consequently, it is logically unobservable; and the question is meaningless.

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IN No. 2598 of SCIENCE Lecomte du Noüy in an effort to illustrate the Heisenberg's principle of indeterminancy tries to present "an observation which would be at the same time practically and theoretically impossible."

He asks a question: "What is the color of the emulsion of an unexposed photographic plate?" and asserts "that we can not know it, and that it will never be experimentally checked."

I do not think that the proposed experiment would serve the purpose, and, therefore, the argument based on this "impossibility" appears to me not convincing.

Every photographic emulsion has its threshold of sensitivity with respect to the duration of an exposure. In many emulsions the exposure of a plate to the light of 1 candle-power for 0.0001 second would produce no chemical change in the emulsion, and, therefore, no change in color of the emulsion layer.

On the other hand, the response of a photo-electric cell to the flux of light of the same intensity is faster than 0.000001 of a second, and, possibly, instantaneous. Therefore, it is possible to devise a photoelectronic colorimeter which, being placed in a camera with the experimented photographic plate, will register and read the color of the light reflected from the plate during 0.0001 of a second.

Furthermore, the belief that "the old determinism received its death blow" is not universal yet. It may be agreed that speed and position of an electron can not be observed simultaneously if a single or few sources of illumination are used. The situation is changed, however, when an infinite number of sources is used which illumine a moving electron from an infinite distance. In such case the impacts of photons (whatsoever their values of $h\nu$ may be) upon the electron produce a continuous pressure, especially when it is considered that each single photon must embrace an electron completely.[1]

Considering an electron of finite dimensions acted upon by photons of finite velocity, we have to ascribe a finite time to the action of a single photon upon the observed electron. Therefore, there is, at least, a statistical possibility to determine the speed and the position of the electron under observation. The time of a single observation must be less than

$$\frac{\text{diameter of electron}}{\text{velocity of photons}} = \frac{2.10^{-13}}{3 \times 10^{10}} = \frac{2}{3} 10^{-26} \text{ sec.}$$

This time may be considerably longer if photons have a length.

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SCIENTIFIC BOOKS

MITOSIS

Mitosis. By FRANZ SCHRADER. 110 pp. New York: Columbia University Press, 1944.

MITOSIS, like photosynthesis and certain other familiar processes, has long presented one of biology's standing riddles. And it still does. Why this is so is ably brought out in Professor Schrader's thoughtful monograph. The author has performed a valuable service in bringing together the ramifying literature in this field and subjecting it to critical analysis. As the sub-title indicates, the treatise is restricted to chromosomal phenomena and deals with cytoplasmic constituents only in so far as they are directly involved in the mitotic process. Viewing the monograph as a whole the reader will perhaps find the following four characteristics especially prominent: (1) Brevity. The size of the volume (only 86 pages in the text, and large print) precludes full treatment of the subject and whets the appetite for the type of survey which the author's 18-page bibliography shows he is prepared to give. (2) Emphasis on recent work and on the modern viewpoint of the biochemist and biophysicist. (3) Skilful treatment of the numerous aberrant types of mitotic behavior which must be considered along with the standard ones before any adequate conception of intracellular kinetic activities can be obtained. This treatment the author is, of course, uniquely fitted to give. (4) Recognition and revelation of the extraordinary complexity of the mitotic

[3] Dadourian, *Scientific Monthly*, 293, 1944.

[1] H. A. Lorenz, *Phys. Ztschr.*, 1910, s. 355.

process and the difficulty of explaining chromosome movements on the basis of any one simple principle.

Aside from a three-page introduction and a conclusion of similar length, the text consists of three chapters. Two of these, one on the structure of the mitotic apparatus and one on hypotheses of mitosis, make up the body of the work. The third, of 9 pages, deals with "related problems" which serve to emphasize the fact that mitosis is itself a part of a larger cycle representing a "highly involved complex of processes" extending through the entire cell generation.

In considering the origin and structure of the components of the mitotic apparatus evidence is reviewed from living as well as fixed material and from experiments as well as direct observation. Although not all present in all cells, the main components such as centrioles, astral rays and spindle fibers are real and exist in the living cell. The incompleteness of our knowledge of such structures, however, is "in a sense a measure of our ignorance of the forces of mitosis."

Two main types of mitotic spindles are recognized, with accompanying differences in the mechanics of chromosome movement. In the "direct" type the chromosomes are connected directly with the poles by means of "chromosomal" spindle fibers and are guided, if not actually pulled, to the poles thereby. In the "indirect" type the chromosomes are connected with "continuous" fibers (which have arisen independently between the poles) and slide along these fibers to the poles. "An element of fundamental importance in the movements of chromosomes" but one which has only recently "received the attention which it merits" is "the kinetochore or centromere" (point of spindle fiber attachment on the chromosome). Observations and interpretations as to its structure differ so much, however, that any broad consideration "must at present stand largely on hypothetical grounds." The probable homology between the kinetochore and the astral centriole is brought out and numerous illuminating departures from "orthodox" conditions are reviewed, including those involving multiple or diffuse kinetochores. Astral rays and the "continuous fibers" of the spindle are regarded as similar in structure and origin and as probably representing lines of flow in which "the long molecules of the ground substance are oriented in parallel rows so as to form fibrous configurations."

In considering hypotheses of mitosis, events leading up to metaphase are treated separately from those that follow because different types of movements are involved. "It is indicative of our ignorance that we can not see the bearing that the problems of prophase and interphase have on the points that puzzle us in metaphase and anaphase." Comparison of the evidence on spindle fibers with that on myofibrils suggests that both may contract by means of "fundamentally the same mechanism—namely, a change in the shape of a protein chain. . . ." Hypotheses involving both a contraction and expansion of spindle constituents are becoming increasingly plausible because of the newer concepts of the changes in form of protein chains. The complexities and difficulties inherent in the problem of mitosis are well brought out by the author's discussion of views attributing chromosome movement to changes in viscosity or hydration of protoplasmic materials or to electrostatic forces. The latter forces furnish the best theoretical explanation of the events of mitosis but at the same time make "a glaring exposure of our ignorance concerning the physical chemistry of the cell. . . ." Diffusion currents and regional currents in the spindle, hydrodynamic forces, and recent evidence on tactoids are all considered, but again the handicap is lack of evidence to support the hypotheses.

Special attention is given to the possibility "that the mitotic movements of chromosomes are largely autonomous" and "that the forces involved reside or originate in the chromosomes themselves," a view which has acquired some prominence "through the study of special cases which rule out any explanation based on contraction, expansion, streaming or electrical forces" and also receives support from earlier experimental evidence.

The work closes with a three-page conclusion in which the inadequacy of all current hypotheses is balanced against the fact that probably the majority of hypotheses "have a portion of truth in them." The inherent difficulties in the experimental method of attack are cited and promising lines of future investigation are depicted. The latter section not only lends a final cheerful and encouraging tone to the survey but will be of practical value to future investigators.

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REPORTS

SMITH COLLEGE CONFERENCE ON PLANT EMBRYO CULTURE[1]

A CONFERENCE on the culture of embryos and other excised plant tissues was held at Smith College, Northampton, Mass., for two and a half days, from July 14 to 16. The meeting was organized by the Smith College Genetics Experiment Station on a somewhat different plan from that of most scientific gatherings. There were no prepared papers and no

[1] Contributions from the Department of Botany, Smith College, New Series, No. 14.