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.

speeches with a distinction between a speaker and an audience and the sessions were not open to the biological public. Instead the 36 specialists who attended[2] sat around a large table and took part in a free back-and-forth discussion of topics in which they could exchange experiences and make suggestions toward the solution of problems involved in the artificial cultivation of tissues apart from the parent plant.

The program was varied by trips to the Smith College Genetics Experiment Station, to the Massachusetts State College and Agricultural Experiment Station and by a tea given by President and Mrs. Herbert Davis, of Smith College, to those who attended the conference and to members of the biology departments of the four neighboring colleges—Amherst, Mount Holyoke, Massachusetts State and Smith. Smith College provided lodging for the conferees in guest rooms of the college dormitories. Other expenses of the conference were cared for by a grant from an outside source.

One of the features of the conference which met with general approval was its informality and lack of restraint that might have ensued if the members had felt their remarks were to be published. A suggestion that a detailed report of the proceedings should be assembled and sent around to those who attended was voted down. It was felt, however, that publication of a brief note on the organization of the conference and the topics discussed would be desirable.

An agenda was prepared and sent to the conferees before their arrival, which served, with slight modifications, as a basis for consideration of the problems which were brought up during the sessions. For each main topic a chairman was suggested who led in the discussion of the subject in which he was especially familiar. Speeches, however, were barred, and there was no transgression against the definition that a monologue continued for five minutes would be classified as a speech.

[2] The investigators from other institutions were: James Bonner, A. J. Haagen-Smit and R. Siu, California Institute of Technology; Lewis Knudson, L. F. Randolph and L. G. Cox, Cornell; Ernest Ball, A. O. Dahl, P. R. Gast, H. J. Sax, Karl Sax and R. H. Wetmore, Harvard; R. E. Cleland, Indiana University; J. van Overbeek, Institute of Tropical Agriculture, Puerto Rico; F. K. Skoog, Johns Hopkins; H. B. Tukey, New York State Agricultural Experiment Station at Geneva, N. Y.; R. F. Dawson, Princeton University; P. R. White, Rockefeller Institute at Princeton; W. G. Whaley, U. S. Department of Agriculture; Carl La Rue, University of Michigan; J. W. Marvin, University of Vermont; R. A. Brink, D. C. Cooper and A. J. Riker, University of Wisconsin; Hempstead Castle and E. W. Sinnott, Yale. Those from the Smith College Genetics Experiment Station were: A. F. Blakeslee, Sophie Satina, A. G. Avery, Sara Bache-Wiig, Lenette Atkinson and the following student assistants: Jean Cummings, Susanne McLean, Peggy Lieb, Mary Sanders and Carmen Sanz.

While naturally the discussions touched largely on matters of technique, it was early emphasized that the broad objective of fundamental importance toward which the conference might contribute was an understanding of factors in growth and differentiation from development of the egg through the embryo to the seedling and adult organs of the plant. Emphasis in the discussions was placed upon embryo culture, but similar problems are involved in the cultivation of other plant tissues in the study of which there were several specialists who took part in the conference.

The following main headings, which were further subdivided in the agenda, served as a basis for the detailed discussions: What each is doing and why; Objectives; Applications in genetics engineering; Instruments and methods of dissection; Seed dormancy relieved by embryo culture; Possible barriers to crossability; Morphological changes in growth and differentiation of embryos *in vivo* and *vitro;* Abnormalities in hybrid embryos; Micrografts; Infection by bacteria and molds; Why embryos fail to develop after starting; Physical requirements of media; Inorganic requirements; Organic requirements; Chemical nature of "Embryo Factor"; Effect of stage of development on nutrient requirements; Speeding up growth at different stages; Possibility of cultures in injected capsules; Special problems.

Those of us in the Smith College Genetics Experiment Station profited greatly from the many suggestions and new points of view that came out of the conference. This feeling of the value of the opportunity for exchange of ideas in a field in which all the conferees were actively carrying on research appeared to be shared by all who attended. The discussions at the conference gave evidence that increased research in embryo culture may be expected.

One has characterized the conference as "the most productive of any similar session which I have ever attended and I believe it is not too much to say that it has laid the foundation for the science of plant embryology in the modern sense." Whatever influence the conference may have on the future trend of botanical research it showed clearly to us who took part in its sessions that the problems of plant growth and development may be profitably attacked by experimental procedures, that development is controlled through a progressively changing internal environment, that an understanding of the environmental factors involved may be aided by study of tissues in cultures apart from the parent plant, and that further knowledge of these factors may lead to conscious control of a wide range of life processes.

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