Book Reviews

Symposium on Chromosome Breakage. (Suppl. to *Heredity,* 6 [1953]). Held at the John Innes Horticultural Institution, June 9–11, 1952. London–Edinburgh: Oliver & Boyd, 1953. 315 pp. Illus. + plates. $7.50.

Chromosome breakage is a fundamental factor in biology. It is related to gene mutation, structural changes in the chromosomes, and crossing over, all of which are basic factors in the evolution of plants and animals. The killing of cells with ionizing radiation is associated with chromosome breakage and is an important factor in cancer therapy. The artificial production of chromosome breaks with ionizing radiation and chemicals has provided a tool for the chemical and physical analysis of chromosome structure and behavior.

The symposium on chromosome breakage held at the John Innes Horticultural Institution in 1952 included material on radiation breakage, chemical breakage, secondary and spontaneous breakage, and a general section dealing largely with biochemical problems. With the exception of Professor Oehlkers of Freiburg, all the contributors were from England, and the discussion was based largely on the work of English cytogeneticists, cytologists and biochemists.

Most of the radiation work on chromosome breakage was based upon the analysis of *Tradescantia* chromosomes. Koller described the various cytological effects of ionizing radiation. The physiological effects result in chromosome stickiness, suppression of mitosis, aberrations in spindle formation and centromere misdivision. At low intensities there is evidence of a stimulating effect which increases the rate of mitosis. This observation is of particular interest in view of the many reports of a stimulating effect of low doses on plant growth.

The genetic effects involve chromosomes and chromatid breakage, resulting in chromosome and chromatid deletions and the exchanges, dicentrics, and rings produced by fusion of broken ends of chromosomes and chromatids. The frequencies of breakage and reunion are reduced when irradiation is reduced from high to low intensities. Koller attributes this decrease in part to the physiological effect of radiation.

Lane's experiments show that fractionation of the dosage with rest periods up to 4 hours results in a decrease of chromosome aberrations. With longer rest periods up to 12 hours, the aberration frequency increases until it approaches that induced by the same total dosage given in a single exposure. The decline in aberration frequency with fractionation of the dosage is attributed to a physiological suppression of breakage by the first exposure. With longer rest periods, the cells recover their sensitivity and the aberration frequency increases. No satisfactory explanation is given to explain the drop in aberration frequency when the rest period is increased to 18 hours. Similar experiments by Haque support Lane's results. Both authors conclude that the decrease in aberration frequency following fractional dosage or low intensity irradiation cannot be attributed to healing of broken ends of chromosomes, as various investigators in the United States and England have assumed.

Radiation of meiotic cells results in a series of physiological effects which disturb both spindle and chromosome behavior. Darlington and La Cour found that breaks induced at first metaphase are not evident until the second division, due to the close association of chromatids until interphase. They no longer maintain that the metaphase chromosomes are protected against radiation breakage by their accumulation of nucleic acid. Haque finds the meiotic divisions about 20 times as sensitive to irradiation as are the mitotic divisions in the microspore of *Tradescantia.* Many of the breaks induced at meiosis remain "open" to give rise to chromatid aberrations in microspore divisions occurring 4 to 6 days after irradiation.

The various types of aberrations found by Darlington and his students are referred to by code letters. The code system is not explained and the reader is referred to an earlier paper by Darlington and La Cour. It is possible to decipher the code by referring to the description of figures, but the complex system is confusing.

The first section of the symposium also includes a report on chromosome division in *Luzula* by La Cour. The effects of radiation treatment indicate that the chromosomes are polycentric rather than having a diffuse centromere system. Morrison finds that x-rays induce polyploidy as well as chromosome aberrations in *Triticum.*

The contributions of Thoday and Gray deal largely with x-ray-induced chromosome aberrations, although they are included in the general section. Thoday's work with *Vicia* supports the target theory and shows that chromosome breakage can occur both before and after the splitting of the chromosome into chromatids, as has been observed in *Tradescantia.* Gray's analysis of chromosome breakage by different ionizing agents and modifying factors also supports the target theory, as elaborated by Lea.

Chromosome breakage by chemicals differs in many respects from that induced by ionizing radiations. Oehlkers finds that in *Oenothera* chromosomes there are regions of differential breakability and differential sensitivity. According to Revell, chemically (diepoxide) induced aberrations in *Vicia* chromosomes occur at limited times in the cell cycle, and the frequency of aberrations does not vary with dosage intensity. The chemical action is indirect and chromosome association is necessary for the production of the aberrations. Maleic hydrazide, a growth suppressor, also induces localized chromosome breakage. It suppresses growth in all plant tissue, but breaks only chromosomes which are heterochromatic. McLeish therefore concludes that the two processes are not directly connected.

In an analysis of *Drosophila* chromosomes, Fahmy and Bird found that diepoxide and triazine produced a higher proportion of small deficiencies than did x-rays or mustard gas. Lethals with rearrangements increase more than linearly in relation to dose, while lethals without chromosome rearrangements show less than a linear relation to dosage.

The section on secondary and spontaneous breakage involves a heterogeneous collection of articles. La Cour's analysis of *Hyacinthus* chromosomes shows that chromatid reunions at the second division must be attributed to deferred union or deferred breakage. Koller finds that chemically induced tumors in rats occasionally show recurrent chromosome breakage. This spontaneous breakage was suppressed when the tumor was grown in tissue culture. A somewhat similar dicentric chromosome cycle was found in *Narcissus* by Darlington and Wylie. The cycle is permanent, but union of broken chromosomes ends may be limited by spatial or physiological limitations. In *Agropyron* also, the breakage-fusion-bridge cycle of dicentrics may fail if the breakage is not proximate, because of healing of broken ends. Hair found that some of the new chromosomes produced by breakage of dicentric bridges improved the efficiency of pairing and the genetic balance. Rees describes abnormal chromosome separation at anaphase in *Scilla* following irradiation, and due to the physiological effects of x-rays. Auerbach's analysis of the sensitive stage of *Drosophila* gonads shows that x-rays and mustard gas are most mutagenic at the stages of active nuclear synthesis, but that formaldehyde is most effective on the mature spermatozoa. This variation in sensitivity to mutagenic agents may provide data of value in the analysis of the causal factors in mutation.

The general section of the symposium deals largely with chemical factors in chromosome breakage. Irradiation not only decreases mitotic activity and results in chromosome breakage, but it also depresses the synthesis of deoxyribonucleic acid (DNA). Howard and Pelc used P^{32} intake in *Vicia* roots to measure DNA synthesis, and found that neither repression of division nor chromosome breakage caused by irradiation seems to be associated with DNA synthesis; but, as Walker points out, the determination of the amount and nature of DNA is subject to error.

The molecular orientation of the chromosome in relation to breakage is considered by Ambrose and Gopal-Ayengar. A comparison of fresh salivary gland chromosomes and oriented nucleoprotein fibers indicates that the longitudinal cohesive forces are due largely to hydrogen bonds. Certain chemicals could act directly on the hydrogen bonds, but others such as the diepoxides and nitrogen mustards probably result in a defect of synthesis. Ionizing radiation could disperse the bonds by localization of energy or by producing radicals which break primary bonds. A mechanism for uniting broken ends of chromosomes, one which would not disturb the reproductive system, is described. Loveless proposes the rather unorthodox suggestion that the chromosomes do not have a structural continuity, so that the problem of chromosome breakage is based upon failures in chromosome synthesis.

The variation in the time frequency and nature of induced chromosome breaks in different tissues and organisms, the differential effects of various mutagenic agents, and the effects of modifying factors, all indicate the complexity of the problems of chromosome breakage. The great variation does, however, provide a method of analysis of the various factors involved in chromosome breakage and reunion. The complexity of the problems of chromosome breakage are even greater than the symposium would indicate, because the conclusions on the action of ionizing radiation are based largely upon the work of the John Innes cytologists. The symposium has raised far more questions than it has answered.

KARL SAX

Arnold Arboretum, Harvard University
Jamaica Plain, Massachusetts

Stochastic Processes. J. L. Doob. New York: Wiley; London: Chapman & Hall, 1953. 654 pp. $10.00.

This book, one of the volumes in the series of Wiley Publications in Mathematical Statistics, is written for mathematicians. It seems to me that the author's hope that it may be accessible to readers familiar with the manipulation of random variables conditional probability distributions and conditional expectances is rather optimistic.

The first chapter describes the probability background of stochastic processes and in the second chapter the author describes the various classes of stochastic processes which are discussed in detail in chapters III to XI. These classes are processes with mutually independent random variables (ch. III), processes with mutually uncorrelated or orthogonal random variables (ch. IV), Markov processes (with discrete parameter, ch. V; with continuous parameter, ch. VI), martingales—the fortune of a gambler taking part in a fair game is a typical example of a martingale—(ch. VII), processes with independent and orthogonal increments (chs. VIII and IX), and stationary processes (chs. X and XI). The last chapter discusses prediction theory and the book concludes with a supplement giving the necessary elements of measure theory, an appendix with historical notes, a bibliography to this appendix, and a subject index.

Stochastic Processes seems to give a comprehensive and authoritative account of the mathematical background of the subject. The references to applications, which to my mind are far too few, are excellent and lucid. It is to be regretted that probability theory has now developed into a branch of measure theory and that modern developments in this subject are often couched in a language that is almost incomprehensible to ordinary experimental scientists and to most theoretical physicists. Since the language used in this