of grouping so that a mean result refers to a mean position. This is now possible by reason of the present state of knowledge of the general distribution of declination, and of the general nature of the movement of the secular-variation curves across the country.

The surveyor need not in general concern himself with questions of diurnal variation, but in careful work it should be considered. A table of the mean departure from the mean of day at different seasons at the five magnetic observatories operated by the Coast and Geodetic Survey for each hour of the day is given in convenient form.

A considerable space has been given to detailed methods of finding the true meridian by observations of the sun and of Polaris, so that a surveyor having quite simple equipment may determine for himself the declination at any desired station. Tables are provided so that any person, with nothing more than a plumb-line and simple carpenter's tools, may easily lay off a true meridian anywhere within the United States by observations on Polaris. The tables are extended to the year 1932. More precise methods are explained for those equipped with a surveyor's transit or its equivalent.

While intended primarily for the use of the land surveyor, the book will be found to contain much interest for students and teachers of physics and surveying, supplementing helpfully the rather inadequate chapters on terrestrial magnetism in most general text-books on these subjects.

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SPECIAL ARTICLES

X-RAYS AND CROSSINGOVER

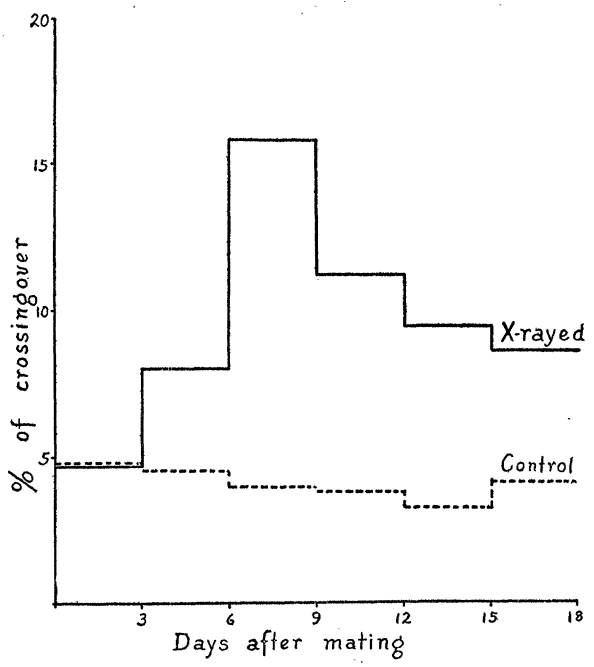
WHEN two or more Mendelian characters which enter a cross from one parent are found to be associated in a greater number of the offspring than could be the case if they segregated independently, the characters are said to be linked. In such a cross the offspring in which the characters are not associated are said to owe their origin to crossingover, the term referring to a process believed to occur in the chromosomes. The percentage of the total offspring in which crossingover occurs is the crossover value for the two characters in question. A small crossover value means a close linkage of the characters and a large crossover value a loose linkage. When a normal, wild-type fruit-fly (Drosophila melanogaster), to take an actual example, is mated with a black-bodied, purple-eyed and curved-winged fly the heterozygous offspring obtain the factors for the three mutant characters from one parent. If now the daughters of such a cross are back-crossed to black purple curved males, a majority of their offspring will be either wild type or black purple curved, showing that these characters are linked (in this case in the second chromosome). There will be also a number of offspring in which the characters are not associated, *e.g.*, normal bodied, purple eyed and curved winged and black bodied, normal eyed and normal winged (crossingover between black and purple), normal bodied, normal eyed and curved winged and black bodied, purple eyed and normal winged (crossingover between purple and curved) and normal bodied, purple eyed and normal winged and black bodied, normal eyed and curved winged (double crossingover). The percentages of crossingover between the characters mentioned have been accurately determined independently by Bridges, Muller and Plough and a summary of their results is given by Bridges and Morgan.[1] They give as the weighted averages of all previous determinations for crossingover between black and purple, 6.2 per cent., the determination having involved somewhat over 50,000 flies, and for crossingover between purple and curved, 19.9 per cent., this determination having involved somewhat over 60,000 flies. It should be added that the determinations by the different investigators are in agreement.

The investigation to be described in the present paper included two experiments. In the first of these twenty sisters from the mating of a wild type female with a black purple curved male were used. Eleven were kept as controls and nine were X-rayed for 3 minutes and 15 seconds at a distance of 23.5 cm from the tungsten target, the Coolidge tube being operated at 50,000 volts and .05 amperes. Previous experiments had shown that the temperature in the X-ray box in which the flies were exposed did not vary from that of the room by more than 1° C. On the day after the X-raying all of the twenty females were mated to black purple curved males and placed in individual culture bottles. The pairs, control and X-rayed, were changed to new bottles every three days until the eighteenth day when they were killed. The offspring coming out in the bottles were counted daily until the seventeenth day after mating. The second experiment was performed in the same way with the following exceptions: the control contained eleven pairs and there were twenty-seven pairs in which the females were X-rayed. The X-ray treatment was the same except that the time was shortened to 3 minutes. The females were mated immediately after being X-rayed and were transferred to new bottles every three days until the twelfth day when they were killed. The flies coming out in the culture bot-

[1] Publ. No. 278 Carnegie Institute of Washington, p. 123.

tles were counted every three or four days until the seventeenth day after mating. The bottles of both experiments were kept in an incubator set at 22° C. and during the whole time the temperature did not go below 20° C. or above 24° C.

Space will not allow the publication here of tables giving the numbers of crossovers and the per cents. and probable errors calculated from them. In figure 1 is a graph of the weighted values of the percentages of



crossingover between black and purple for three-day intervals (each set of bottles) for both of the experiments. The graphs of the separate experiments are similar to the one reproduced with the exception that in the case of the first experiment in which the females were given the larger dose of X-rays, the total number of offspring produced in the first bottles was too small to give a significant crossover value and that in the case of the second experiment the graph does not extend beyond the twelfth day. The control (dotted line) varied from 4.78 per cent. to 3.25 per cent., showing a slight decrease with age until the fifteenth day. This decrease in the crossover value with age has already been reported by Bridges[2] and Plough.[3] The effect of the X-rays on the crossover value (continuous line) becomes apparent in the counts of the offspring of the X-rayed females in the second bottles (the 4th to the 7th day after X-raying in the case of the first experiment and the 3rd to the 6th day in the case of the second experiment). The effect of the X-rays is greatest in the third bottles (6th to 9th day after mating). The fourth, fifth and sixth bottles (9th to 18th day) show a gradual recovery toward the crossover value of the control. The difference between the crossover value in the cultures of the X-rayed and control females divided by the probable error of the difference is for each of the six bottles 0.16, 6.11, 29.14, 20.78, 5.78 and 3.07, respectively.

The data obtained show that X-rays have a similar effect on crossingover between purple and curved although the increase in crossingover is not so great and recovery to the normal crossover value is apparently more rapid. The values of the coincidence of crossingover between black to purple and purple to curved for the cultures of the X-rayed and control females can not be determined with a sufficiently small probable error to admit of an accurate comparison. It may be stated, however, that the values found for coincidence in the cultures of the X-rayed females show no great increase or decrease compared with those of the control cultures.

A careful tabulation and comparison of the percentages of the complementary crossover classes, *e.g.*, normal bodied, purple eyed and curved winged compared to black bodied, normal eyed and normal winged, has shown that the increase in the crossover value found in the cultures of the X-rayed females can not be explained as due to a difference in viability arising from the X-ray treatment of the unfertilized eggs. Such a comparison does not give an absolute proof that the viability of the characters is unaffected by the X-rays since the experiments do not give an opportunity to compare all possible combinations of the characters but it does show that there is not a sufficient difference between any of the classes of offspring of the X-rayed and control females to account for the increase in the crossover value found for the X-rayed females.

It is of great interest to compare the effect which the experiments described show X-rays to have on crossingover in the second chromosome with the effect which Plough[3] has found temperature to have on crossingover. Plough found, using the same characters, that submitting females to temperatures either considerably above or below the normal rearing temperature (22° C.) caused an increase in the crossover value. The X-ray experiments show that X-rays also cause an increase in the crossover value when the flies are kept at a temperature of 22° C. Whereas Plough found that the effect of temperature on crossingover became first apparent on the seventh to eighth day after the beginning of the heat treatment, the X-ray experiments show that the X-ray effect on crossingover becomes apparent on the fourth to seventh day (first experiment) or third to sixth day (second experiment). It is possible that this difference is due to an accelerated development of the eggs due to the

[2] *Journ. Exp. Zool.*, Vol. 19, No. 1.
[3] *Journ. Exp. Zool.*, Vol. 24, No. 2.

X-rays although no other evidence of acceleration is evident in the experiments, *e.g.*, earlier hatching out of offspring of X-rayed flies. A more striking difference is that while the effect of temperature lasts for a time corresponding to the period of time treated and then disappears abruptly the effect of an X-ray treatment which lasted only 3 minutes and 15 seconds starts on the third to sixth day, reaches a maximum on the sixth to ninth day, and then gradually falls off, the effect being still evident after fifteen days.

The effect of X-rays on crossingover in the second chromosomes may be compared with the effect of X-rays on crossingover in the first or sex chromosome already recorded by one of us.[4] Here it was found that X-rays decrease the crossover value for eosin eyed and miniature winged, the effect increasing with the dose. After a dose approximately the same as that given in the first of the experiments on the second chromosome the crossover value for eosin and miniature was decreased from approximately 25 per cent. to less than 10 per cent. and the effect continued from the sixth to the twelfth day after the treatment. We see, then, that X-rays produce opposite effects on crossingover in the first and second chromosomes of Drosophila. This and the duration of the effect suggest that X-rays act on the individual chromosomes affecting them in such a way that crossingover, when it occurs, is modified.

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THE IOWA ACADEMY OF SCIENCE

THE academy met at Cornell College, at Mount Vernon, on April 27 and 28. The opening session was held on Friday afternoon, the 27th, and included, besides the transaction of preliminary business, addresses by three invited speakers. The sections of the academy met at 3 P. M. for reading of papers and at 6 o'clock held their group dinners. President Wylie gave his address on "Experiences in Fiji and New Zealand" at the evening session, after which the faculty of the college held an informal reception for the visitors.

On Saturday morning the sections completed their programs, after which the academy convened for the final business session. The academy took some forward steps in adopting resolutions looking towards an extensive biological survey of the state, in establishing a committee on coordination of scientific research, and in endorsing the plan to establish a national museum and aquarium of fishes in honor of Spencer Fullerton Baird. In adopting the report of the committee on the secretary's report the academy provided for the appointment of a permanent committee on publication which should report to the academy a set of rules and suggestions for preparation and publication of papers. The academy transferred eighteen Associates to the class of Fellows and elected nine new Fellows and sixty Associates. It voted to meet with the State College at Ames in 1924, when Dr. L. H. Pammel, who has been a Fellow of the Academy since 1889, will have completed thirty-five years of service with the State College.

The following were elected officers for the ensuing year: *President,* L. H. Pammel, State College, Ames; *vice-president,* O. H. Smith, Cornell College, Mount Vernon; *secretary,* James H. Lees, Iowa Geological Survey, Des Moines; *treasurer,* A. O. Thomas, State University, Iowa City. *Chairmen of Sections: Botany,* J. N. Martin, State College; *chemistry,* Anson Hayes, State College; *geology,* E. J. Cable, Teachers College, Cedar Falls; *mathematics,* F. M. McGaw, Cornell College; *physics,* J. W. Woodrow, State College; *zoology,* F. M. Baldwin, State College.

After luncheon the academy took a trip to the Palisades of the Cedar, one of the most beautiful localities of central Iowa and a delight to geologists and botanists in particular.

PROGRAM

Teaching and learning a local flora: HENRY S. CONARD. An account of progress in preparing and using keys and manuals to the flora of Grinnell and urging the need of local manuals for several districts of the state.

The field of ornithology: T. C. STEPHENS.

The application of laboratory methods to the study of mental diseases: SAMUEL T. ORTON.

Mathematics

Iowa Section Mathematical Association of America

Abstracts of these papers will be found in the journal of the American Mathematical Association.

On the correction of a common error in the calculation of the mean deviation from a given frequency distribution: H. L. RIETZ.

On the geodesic in four space: CORNELIUS GOUWENS.

A general expression for the schediastic function for the generalized double frequency distribution: E. R. SMITH.

Leibnitz's contribution to the history of complex numbers: R. B. MCCLENON.

Some curves met with in the conformal representation of integral transcendental functions: R. B. MCCLENON.

The definite integral in a first course in calculus: J. V. MCKELVEY.

Certain preliminaries in the calculus: C. W. EMMONS.

The Cochleoïde: ROSCOE WOODS.

On the theory of wave filters with an application to the theory of acoustic wave filters: E. W. CHITTENDEN.

Some functional equations suggested by the mean value theorem: W. H. WILSON.

The differentiation of the trigonometric functions: W. H. WILSON.

What is mathematics? J. S. TURNER.

An application of finite differences: JOHN F. REILLY.

The cycloid and its companion: ELMER E. MOOTS.

[4] *Proc. Soc. Exp. Biol. and Medicine,* Vol. 20, p. 335.