

or Caspian culture? So long as ethnology continues to exist, it will provide a meeting-ground for archaeologists, physical anthropologists, students of linguistics, and social anthropologists. Such a meeting-ground has been provided for a century by the Royal Anthropological Institute and will continue to be provided in the future. Any attempt to impose a more rigid artificial unity will be likely to produce exactly the opposite of the result at which it aims.

GENETICS AND KARYOLOGY OF *DROSOPHILA SUBOBSCURA*

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MODERN genetical theory is largely based on the study of *Drosophila melanogaster*, which has proved a useful guide to the genetics of other organisms. But there has been a tendency to regard this species as a standard, and any deviations from its genetical behaviour as exceptions.

The genetical study of other species of *Drosophila* has not merely opened a promising field of comparative genetics; it has also demonstrated that most species show qualitatively novel features. Thus *D. virilis* has a number of labile genes, *D. miranda* has two X-chromosomes. In *D. ananassae* the males are triploid for at least one gene. *D. pseudo-obscura* A, though apparently monotypic, is polymorphic for a number of intra-chromosomal gene orders, each with its characteristic geographical range; and *D. subobscura* has been found to be a structural heterozygote in both sexes. In general the comparison of species suggests that they differ at least as much in the arrangement and proportions of the gene material as with regard to genes themselves.

C. Gordon¹ began the genetical study of *Drosophila subobscura*, and we owe some of our stocks to him. The study was continued by Gordon, Spurway, and Street² and Christie³, and we hope shortly to publish a series of papers on it. The species belongs to the *obscura* group of the subgenus *Sophophora* (Sturtevant⁴), and its diagnostic characters are given by Gordon (1936) according to Collin (unpublished). It appears to be a native British species, and seems to have a wide distribution in Europe. For in a letter sent just before the outbreak of war with Italy, Buzzati-Traverso and Pomini, of the University of Pavia, informed us that flies of our stocks had given hybrids with flies of a species found in Italy and Germany, on which they had made genetical and cytological studies. Its possible identity with Sokolov and Dubinin's⁵ *D. obscura*-3 from the U.S.S.R., is discussed later. The flies can be caught fairly regularly under 'bleeding' elms and oaks. We know little of the several related British species, and have so far not attempted to study their systematics.

At mitotic metaphase there are five pairs of telomitic rod-shaped chromosomes, and one pair of 'dots'. The X- and Y-chromosomes, which are of equal length, are the longest pair of rods. They can also be distinguished from autosomes in that somatic pairing only occurs at their proximal ends.

The salivary gland nuclei contain one short and five long elements. The Y-chromosome is exceptional in including at least 15 euchromatic bands, which have homologues in the X. One of the autosomes carries a large swelling similar to the 'Balbiani Ring'

of *Chironomus*. The long chromosomes contain a good deal of heterochromatin. In all other *Drosophila* species so far described, except *D. busckii*, the heterochromatin of the proximal ends of the chromosomes forms a large darkly staining chromocentre. In *D. subobscura* this heterochromatin consists of large pale granules, and there is no chromocentre (Emmens⁶).

The most interesting feature of the species is the polymorphism of the chromosomes, each of which presumably represents one element in Muller's⁷ terminology. Almost all larvæ both from wild parents and laboratory cultures show inversion configurations in one to five of the long chromosomes; no translocations have been found. The different chromosomal orders fall into two groups.

(a) Both homozygous forms seem as viable and fertile as the heterozygote. In the four cases of this type so far studied, one order is by far the commoner, and may be taken as the standard, from which the other orders may be said to differ by one or more inversions.

(b) In three cases the heterozygote appears to be more viable and fertile than either homozygote. Most larvæ show salivary configurations proving that in at least two of the paired autosomes the homologues differ in respect of a compound inversion. These inversions are an included inversion covering the middle third of one autosome, two adjacent inversions covering three fifths of another, and a pair of overlapping inversions covering the distal quarter of a third autosome. Thus three of the autosomes have two (if not more) equally common isomeric orders. As they differ in respect of compound inversions, these should reduce crossing-over in heterozygotes very efficiently.

From a cross between two structural heterozygotes, or between a heterozygote and a homozygote, we should expect equal numbers of larvæ homozygous and heterozygous for a particular chromosome. In fact, there are significantly fewer homozygotes, though the nature of the selection against them is so far unknown. Its efficiency may be judged from the fact that a line which, before inbreeding, was heterozygous for the three inversions the heterozygosity of which is favoured by selection, is still heterozygous for all of them after fifteen generations of brother-sister mating. This would only be expected in one of 37,000 such lines in the absence of selection. Another similar stock was still heterozygous for all three after ten generations of brother-sister mating; after nineteen generations it was still heterozygous for one, and died out during the twenty-first. Stocks made cytologically homozygous for any two of the three orders tend to die out; however, we have one cytologically homozygous stock derived from a fertilized wild female; but this is extremely difficult to keep alive, though it can easily be crossed with our other stocks.

Thus the species resembles a permanent structural heterozygote such as many *Oenothera* species, though structural homozygotes are not quite inviable. Sokolov and Dubinin (loc. cit.) reported a similar structural heterozygosity in a species from Ukraine and Caucasia which they referred to as *Drosophila obscura*-3 without giving diagnostic characters. The detailed structure of the inversions seems to be different, and it will be of great interest to determine how close systematically their populations are to ours.

In some vertebrate species, such as mice, pure lines can easily be established. In others, brother-

sister mating leads to low viability or infertility, or else to lines which are not as homogeneous as expected. It is at least possible that in such cases cytological investigations may reveal a condition like that of *D. subobscura*. In any event, a small and rapidly breeding animal species in which inbreeding is harmful is a valuable object of genetical study.

In our present stocks forty-seven loci are marked by visible mutants, several of them by a series of allelomorphs, and forty-four of these loci have been assigned to linkage groups. On the X-chromosome we have fourteen loci, apart from lethals. Some of the sex-linked mutants, such as *yellow*, *cut*, *singed* and *bobbed* with a terminal locus and a normal allelomorph in the Y, are clearly homologous with those of other species. The homologies of the autosomal mutants are more doubtful. The most striking mutants without obvious homologues in other species are an incompletely recessive *white testis*, with no change in eye colour; *bulge*, a sex-linked recessive hypertrophy of the eyes, which may be folded without disarrangement of the facets; *short costal vein*, a sex-linked recessive abolishing one of the diagnostic characters of the genus; and *six-jointed*, an autosomal recessive giving an extra tarsal segment and rough eyes.

Many of the mutants were obtained by inbreeding the progeny of wild flies. Most of these are autosomal, but three are sex-linked. One of these, *withered wing*, found by Street and Gordon (unpublished), is interesting as being sex-limited, only appearing in homozygous females, and not in hemizygous males. It is therefore, like an autosomal recessive, largely shielded from natural selection. Though located near the proximal end of the X, it has no normal allelomorph in the Y-chromosome like *bobbed*. The other two, a lethal and a visible *dried wing*, are ordinary sex-linked recessives.

Since each long autosome will ultimately have three maps, one for each homozygous chromosome order, and one for the heterozygote, mapping is a slow process, but it is certain that the maps of all five long chromosomes will be longer than those of *D. melanogaster*. That of the X is more than 150 units long, compared with 67 in *D. melanogaster*. The minimal estimates of the length of the long autosomes vary from 80 to 140 units, as compared with 47 to 55 units for the arms in *D. melanogaster*.

The total lengths of the genetical maps of different species of *Drosophila* are:

<i>Drosophila virilis</i>	788 (Chino) ⁸
<i>subobscura</i>	570+
<i>pseudoobscura</i> A	420 (Sturtevant and Tan) ⁹
<i>anamassae</i>	326 (Kikkawa) ¹⁰
<i>simulans</i>	311 (Sturtevant) ¹¹
<i>melanogaster</i>	280 (Brehme) ¹²

Thus *melanogaster* is far from typical of the genus. Since the species do not differ markedly in the numbers of bands in the salivary chromosomes, the differences in map-length are probably due to differences in frequency of chiasma formation within homologous regions.

With such large map distances recombination values reach 50 per cent, and at least one, namely, 50.82 ± 0.42 per cent between *scarlet* and *interrupted* venation, the loci of which are more than 86 units apart, is perhaps above 50 per cent. We have also discovered negative interference in connexion with a large inversion in the X-chromosome. The presence of a cross-over in the region immediately proximal to this inversion, so far from diminishing the frequency of cross-overs in the region immediately

distal to it, increases it about twenty-fold. Multiple crossing-over is, of course, much more frequent than in *D. melanogaster*, and we possess considerable data concerning it.

The effect of inversions on crossing-over is also quantitatively different from that in *D. melanogaster*. Thus a single inversion covering about a third of the X-chromosome and reducing the map-length by at least 80 units gave only one internal double cross-over in 8,000 flies. A single inversion covering about 15 per cent of this chromosome, and lying between loci giving 32 per cent of recombination, did not reduce this percentage. This and other facts suggest that chiasmata are localized.

'Non-disjunction' of the sex chromosomes, causing the production of female pronuclei with two or no X-chromosomes, occurs once in about 7,000 oogeneses. But, as in *D. pseudoobscura*, XXY females do not give XX pronuclei with an appreciably higher frequency than XX females.

Meiosis can be observed in male imagines of this and other *Drosophila* species (Philip¹³). The three sex chromosomes in XYY males form a loose trivalent and segregate at random. A male of slightly abnormal phenotype and two normal males were trisomic for one of the long autosomes, a condition which is lethal in *D. melanogaster*.

We have found four flies mosaic for sex-linked genes. One appeared to be wholly female and three gynandromorphs. One of these had two ovaries and two testes, all fairly well developed, but not normal. All the mosaics were 'fore and aft' rather than bilateral, suggesting a pattern of cleavage somewhat different from that of *D. melanogaster*. A sex-linked eye colour which was non-autonomous in two out of three mosaics is probably homologous with *vermillion* in other species.

Unlike all other *Drosophila* species so far tested, *D. subobscura* will not mate in the dark. Since visual stimuli are essential for mating, several mutant forms with abnormal eye colours, including *white*, which, though phototropic, do not respond to moving contours (Kalmus¹⁴) are male-sterile. The mutant *yellow*, as in other species, has a cuticle abnormally permeable to water and other substances (Kalmus¹⁵) and is at a disadvantage in dry environments. In *D. subobscura* it is also at a disadvantage as a male in mating. Normal females generally kick off yellow males which attempt to copulate with them. Yellow females show no preference. But it is possible by selection to obtain a stock in which normal females are comparatively tolerant of yellow males, though the normal body colour is still preferred. Thus we have demonstrated not only sexual selection of a more or less Darwinian type, but also the inheritance of degrees of preference in the female, such as Darwin postulated.

It will be seen that this native European species differs from all animals so far described (if Sokolov and Dubinin's form and our own are conspecific) in being normally a structural heterozygote in both sexes. It is also very favourable material not only for comparative genetics, but for the study of chromosomes with long map distances, of polysomy, of the genetics of behaviour, and many other topics. We hope after the War to compare the British and Continental races. It is also to be hoped that it will be studied in several British centres, in order to investigate whether it possesses geographical races or other adaptations to the different conditions in various parts of Britain.

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¹ *J. Genet.*, **33**, 25 (1936).

² *J. Genet.*, **38**, 37 (1939).

³ *J. Genet.*, **39**, 47 (1939).

⁴ "Genetics".

⁵ *Drosophila Information Service*, **15**, 39 (1941).

⁶ *Z. Zellf. u. mikro. Anat.*, **26** (1937).

⁷ "The New Systematics", 185 (Oxford: Clarendon Press, 1940).

⁸ *Jap. J. Genet.*, **12** (1936).

⁹ *J. Genet.*, **34**, 415 (1937).

¹⁰ *Genetica*, **20**, 458 (1938).

¹¹ Carnegie Institution of Washington Pub., 399 (1929).

¹² Carnegie Institution of Washington Pub., 552 (1944).

¹³ *Nature*, **149**, 527 (1942).

¹⁴ *J. Genet.*, **45**, 206 (1943).

¹⁵ *Proc. Roy. Soc.*, B, **130**, 185 (1941).

HEALTH EDUCATION IN YOUTH SERVICE*

THE Central Council for Health Education, which is recognized by the Government as one of its agencies for health education, has thought it timely to outline the part that it considers health education should play in the youth service of the future.

The general standard of health in the community at present falls so far short of possibilities that there is obviously much room for improvement; and one of the ways in which it can be improved is through health education. Clearly, education alone will not be sufficient—there is needed also an improvement in community conditions (particularly in regard to housing and nutrition). But it is only through education that people can be encouraged to make the best use of conditions as they exist and be made aware of the possibilities of improving them.

Ideally, health education should be a way of living and something that is almost insensibly absorbed in the home, the school, the youth organization and the work place, rather than a formal subject taught in set sessions at set times. It has, however, at least three important aspects—the imparting of knowledge, the inculcation of habits and the encouragement of attitudes. Knowledge will not of itself lead to better health; but it provides the intellectual background to habits already acquired and helps in the development of healthy attitudes. Many of the most important health habits must be inculcated long before the child is capable of assimilating the knowledge which justifies them; but their practice should be reinforced by theoretical understanding as soon as possible. Attitudes are influenced by home environment from the very earliest days, and in particular by the way in which habit-training is carried out, but they also require intellectual understanding for their fullest development. These three aspects of health education are thus closely inter-related.

Knowledge important in health education includes an understanding of the structure and functioning of the body and of the relationship between physical and mental health. Important also is an understanding of how the spread of disease occurs and how it can be prevented or reduced; a grasp of the social factors influencing the health and well-being of the community; and a knowledge of the personal and

social measures necessary to enhance health and build up resistance to disease.

The bodily habits relevant to health education include those consisting essentially of the disciplining of natural functions (for example, eating and voiding) and those others (for example, personal cleanliness) which are essentially habits of civilization. Equally important are the habits of the mind and of behaviour in relation to society.

Among the important attitudes are those of normality towards the body and its functions, deviating neither towards prudish avoidance nor towards prurient curiosity; of regarding health not as a mere absence of disease, but rather as a positive state of joyous well-being; and of feeling a sense of responsibility for the state of personal, family and community health.

Since young people do not enter within the scope of the youth service at the age of fourteen without having been influenced very considerably by their earlier training, any consideration of the type of health education appropriate to the period of adolescence is dependent upon the making of certain assumptions about what will have been achieved before this period is reached. It seems reasonable to assume that by the time children reach the age of fourteen, they will have received in home, school and juvenile organizations, health education along the three lines of imparting of knowledge, inculcation of habits and encouragement of attitudes indicated above, up to levels appropriate to their stage of development. The definition of these levels is in the main a matter for parents and teachers, and those responsible for the youth service will need to continue to build from the levels already reached.

Health Education in Youth Service

The special functions of health education in adolescence would appear to be the reinforcement and widening of earlier education, especially in those directions most affected by the maturing ideals, emotions, experiences and activities of this period. With the statutory raising of the school-leaving age, some of this education will be given in the last year or two at school, and with the establishment of young people's colleges, some will be given during part-time compulsory education. The extra year or two of compulsory education would be most usefully employed in giving systematic instruction in those aspects of health education for which the adolescent is now sufficiently mature—in intellectual and emotional development and in social experience and awareness. For many young people, this will be the last opportunity for systematic instruction, and full advantage should be taken of it.

A great deal, however, will still remain as the special function of voluntary instructional classes and youth organizations.

The whole spirit of health education in youth service should be such as to encourage the development in adolescents of an appreciation of the possibilities of reaching a high standard of personal and community health and the growth of a sense of individual responsibility for reaching this standard. Certainly importance should be attached to the measures which are required from the State, the local authorities, etc.; but it needs emphasizing that increasing social provision should be accompanied by greater individual effort.

Adolescents particularly need help in meeting the peculiar problems of the period through which they

* Memorandum by the Central Council for Health Education.