The Use of Drosophila for High School Projects in Biology

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While the use of *Drosophila* is well known in laboratory exercises, the author here notes that this should be more widespread. Dr. Druger is Assistant Professor of Zoology and Science Teaching.

The practical training of talented high school students in methods of research has become an important problem in science education. Too often, able high school students are obliged to be content with a largely verbal indoctrination in scientific methodology, and must wait until college to venture into experimental work. One approach towards remedying this situation in many high schools has been special project work on an after-school basis. The success of such programs depends to a large extent upon the nature of the projects undertaken and the choice of experimental organisms. Unless careful guidance is given in these respects, a potentially good scientist may have a frustrating and discouraging experience, which may cause him to cultivate a distaste for experimental work. The present article intends to emphasize the value of *Drosophila* projects as a means of introducing students of varying abilities to the challenges and intricacies of experimental research

I. *The Organism. Drosophila* comprises a group of small, common flies which are very easy to handle in large numbers. They breed rapidly (about 10 days per generation at 25°C) and produce many progeny. A great variety of mutant stocks are available which differ in easily distinguished characters, and the heredity of a given character can be followed quite readily. The giant chromosomes of the salivary glands in *Drosophila* provide useful material for cytological study.

II. *Equipment and Facilities*. The simplicity of equipment and the small amount of space required are two of the virtues of *Drosophila* projects for high school students. Basic equipment includes a binocular dissecting microscope or a hand lens, a light-source, a porcelain counting plate, half-pint milk bottles and caps, a small brush, a disposal jar containing oil, a cork with a cotton wad fixed to it for anaesthetizing flies in an empty bottle, and a watchglass for re-anaesthetizing flies. Ether or CO_2 may be effectively used as fly anaesthesia. A variety of simple media are known. Basic *Drosophila* techniques, materials and media have been discussed in several publications, and it is not the purpose of the present article to give a detailed account of these. *Drosophila Guide* by M. Demerec and B. P. Kaufmann (which may be obtained in quantity from Carnegie Institute, Washington, D. C.) is an inexpensive and widely used source for this information. Many different mutant stocks may be easily obtained from biological supply houses or laboratories where *Drosophila* work is being conducted.

III. *Projects*. There are numerous ways in which *Drosophila* can be utilized as a basic tool for exploring biological problems. Projects can be devised to fit all levels of ability. The following survey of projects is intended to illustrate the varied potentialities of *Drosophila* for experimental research by high school biology students.

A. *Basic Crosses to Illustrate the Principles of Heredity*. The beginning student might make crosses between normal and mutant flies, raise an F2 generation, make backcrosses and analyze the results. Complex crosses may involve sex linkage, balanced lethal systems, multiple characters, etc. Analysis of an "unknown" mutant is a challenging activity for a bright student. Interactions between different mutant genes affecting the same character may be studied.

B. *Cytology*. Salivary gland chromosomes in *Drosophila* provide useful material for several types of projects. Perfecting the technique of making the preparation constitutes a simple project in itself. (A technique is given in *Drosophila Guide.*) Some students may be interested in attempting to devise improved stains for chromosomes. Students can learn to identify chromosomal inversions by studying the banding patterns in the chromosomes; discovering and comparing the frequencies of such inversions in different natural populations of *Drosophila* can be an interesting field study. The effects of radiation treatment on chromosomal integrity may also be investigated.

C. *Selection and Evolution. Drosophila* can be used to investigate basic principles of evolution in the laboratory. The experimenter can choose and breed from particular genotypes and thus direct the evolution of the laboratory population with respect to the chosen character. For example, in order to evolve a population of flies that have higher or lower than normal numbers of abdominal or sternopleural bristles, the experimenter scores a sample of virgin flies and mates the females with the highest bristle scores to corresponding males in subsequent generations; selection for low bristle number is carried out by mating lowest score females to lowest score males, continuing this line separately. Another line is established as a control, wherein parents are chosen at random each generation. A few generations of selection are likely to result in populations with mean bristle numbers higher and lower than the control.

A great variety of problems may be investigated that utilize selection techniques. Selection studies may involve resistance to radiation, insecticides, heat, various chemicals, etc. The student may be interested in the effectiveness of selection under different environmental conditions. He may wish to attempt to devise methods for exceeding the usual selection limits for a character, or investigate the reasons for selection being more effective in one direction, or study the relation of selection for change in a given character to the fitness of the population. He may wish to study the effects of different mating procedures or different degrees of inbreeding on the outcome of selection. These are some of the real problems currently being attacked by geneticists.

D. *Population Cage Studies.* Population cages have been used to observe short-term evolutionary changes in the laboratory. A competitive situation between different genotypes or different species may be set up in a population cage, and changes in relative frequency of the different types are recorded in successive generations. Jars with fresh food are added to the cage at regular intervals, and those with worked-out food removed, thus allowing the population to maintain itself.

Since population cages are likely to be unfamiliar to the reader, two such devices will be described in some detail. One type of cage (designed by Dr. Stuart Barker, Department of Animal Husbandry, University of Sydney, Australia) consists basically of a wooden box, 15 in. x 15 in. x 8 in., without a top. A glass top is fitted into place with adhesive tape. A square ventilation opening is made at one end At the opposite end, a round hole 5 inches in diameter is made and a 15-inch nylon gauze sleeve nailed and taped around the hole. Thus the experimenter can put his hand into the cage to change food jars without letting flies enter or leave the cage. The entire cage, of course, is fly-tight. A piece of plywood with 16 holes the size of the food cups is fitted onto the floor of the cage. Jars of food sit in the depressions thus made.

A polyethylene refrigerator box, 12 in. x 8 in. x 4 in., with a cover, has been used as a population cage by genetics students at Columbia University. A ventilation opening may be cut in the cover and a fine mesh screen fitted into place. Twelve holes are made in the bottom of the cage such that food bottles fit tightly into these. One-ounce bottles with screw-type tops can be used for food bottles. A hole about one inch in diameter is made in the side of the cage for inserting or removing adult flies. When not in use, all holes are plugged with corks of the appropriate size. These are only two of the many possible types of cages that can be designed and constructed by the student.

The techniques for maintaining cages are quite simple. To start a cage experiment, about 400 flies (half male and half female) of the desired types may be introduced into the cage through one of the openings. Several food bottles are placed in the cage. Once the population cage is under way, one bottle of food is added every three days, without removing any, until all food spaces have been supplied. Then the first bottle of food, which by now has been thoroughly consumed, should be replaced by a fresh bottle. Three days later the next food bottle should be replaced; this procedure should be followed regularly, changing each food bottle in turn. The food-changing intervals should be scheduled so that each bottle remains in place long enough for most of the hatching to occur. The three-day food-changing interval is appropriate for the polyethylene cages. The student will have to experimentally determine the best schedule for his type of cage.

Cage experiments may involve competition between different species, different mutant genotypes, or carriers of different chromosomal inversions. Cages may be sampled at regular intervals either by taking adults directly from the cage, or collecting eggs from the food cups and rearing the flies in bottles. In studies involving single gene differences, and chromosomal inversions, fairly stable equilibria may develop instead of one genotype being completely eliminated by the other. Such experimental results lead to further studies.

Population cages also offer a simple way to select populations for increased resistance to insecticides, high salt concentration or other substances. Many other experimental uses can be made of such a device.

E. *Behavioral Studies.* Geotaxis and phototaxis are two behavioral patterns in *Drosophila* that can provide the basis for some interesting experimental work for high school students. Dr. Jerry Hirsch, of the Psychology Department at the University of Illinois, has demonstrated the heritable nature of geotaxis in *Drosophila* using a maze made from a series of small T-tubes fitted together on a large board. Small funnels are fixed into the ends of each T-unit to prevent flies from reversing their direction in the maze. In a ten-trial maze, there will be 11 collecting stations. A tube of food is placed at each end-point. The maze is stood upright and a fluorescent light is fixed vertically near the end-tubes. Virgin females are placed in the first T-unit. At the end of 24 hours, most flies will have found their way to the end-tubes, each one having made a series of up or down choices. Any fly that gets to the topmost tube has made all "up" choices. A fly in the lowest tube has made a sequence of "down" choices only. Flies that end up in intermediate tubes will have made some "up" and some "down" choices. Thusly, the flies distribute themselves and scores can be assigned for each level, or a fly may be assigned a score for each up or down choice it has made. Males are run separately. Males and females that reach the topmost tubes are mated to start the "up" line. The flies in the lowest tubes are mated to begin the "down" line. Thereafter, the two lines are maintained separately and run through the maze each generation, with the appropriate matings being made each time. After several generations, it may be seen that the selected populations differ with respect to geotactic response in the maze.

The same maze may be used for similar studies on phototaxis by laying the device down flat and setting up a light gradient. This sort of device can be utilized in many original projects with *Drosophila* that probe into problems of behavior. Other *Drosophila* behavioral studies may deal with food and habitat preferences of different mutants or different species, the role of larval competition in determining survival, the relation of population density to survival or migration, the reaction of larvae and adults to various stimuli, and studies on sexual isolation and courtship behavior.

The types of projects briefly described above by no means comprise an exhaustive list but hint at some of the many different problems that can be investigated using *Drosophila*. It is hoped that this article has aroused interest in the potentialities of *Drosophila* for high school student experimentation, and that teachers will make students aware of the versatility and practicality of this organism for projects, especially where facilities are limited. An abundance of *Drosophila* literature is available, and it is likely that an interested student can formulate a worthwhile project that will help him to develop desirable skills and attitudes.

Some References for Prospective Drosophila Workers

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Who?

"Grouse, if not destroyed at some period of their lives, would increase in countless numbers; they are known to suffer largely from birds of prey; and hawks are quided by eyesight to their prey-so much so, that on parts of the Continent persons are warned not to keep white pigeons, as being the most liable to destruction. Hence I can see no reason to doubt that natural selection might be most effective in giving the proper colour to each kind of grouse, and in keeping that colour, when once acquired, true and constant. Nor ought we to think that the occasional destruction of an animal of any particular colour would produce little effect: we should remember how essential it is in a flock of white sheep to destroy every lamb with the faintest trace of black. In plants the down of the fruit and the colour of the flesh are considered by botanists as characters of the most trifling importance: yet we hear from an excellent horticulturalist, Downing, that in the United States smooth-skinned fruits suffer far more from a beetle, a Curculio, than those with down; that purple plums suffer far more from a certain disease than yellow plums, whereas another disease attacks yellow-fleshed peaches far more than those with other coloured flesh. If, with all the aids of art, these slight differences make a great difference in cultivating the several varieties, assuredly, in a state of nature where the trees would have to struggle with other trees and with a host of enemies, such differences would effectually settle which variety, whether a smooth or downy, a yellow or a purple fleshed fruit, should succeed."

Dampier, W. C., and M. Dampier, *Readings in the Literature of Science*, Harper and Row, Publishers, New York. p. 237.

Answer: Charles Darwin.

Fish Story

Workers at Humboldt County's Prairie Creek fish hatchery in Eureka, California had a finny visitor recently and are now telling a fish story that tops all fish stories. The visitor, named "Indomitable," is a two-year old, 14-inch silver salmon that overcame all obstacles and returned to the tank in which it was spawned. To do so, the fish had to swim some five miles from the Pacific Ocean up Redwood Creek, into Prairie Creek, up a drainage ditch, through several other drains, straight up a four-inch drain pipe that had a 90-degree sharp turn in it, then knock off a wire screen cover over a 2½ inch stand pipe before finally clearing a nearly impassable wire net into the tank. "Indomitable" was none the worse for his journey except for a slightly bashed-in nose, apparently received when he knocked off the wire screen cover. Hatchery manager Kenneth Johnson terms the trip "the most amazing spawning journey known to world fish history."