

Classroom



In this section of Resonance, we invite readers to pose questions likely to be raised in a classroom situation. We may suggest strategies for dealing with them, or invite responses, or both. "Classroom" is equally a forum for raising broader issues and sharing personal experiences and viewpoints on matters related to teaching and learning science.

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Teaching and Learning Genetics with *Drosophila*

1. *Drosophila* as a model system

The birth of a child is always an event for rejoicing in every family. On such occasions, relatives and visitors invariably try to match a few features of the child with those of the mother, the father, the grandparents and other relatives. This is a common experience witnessed in all families, and reflects the general awareness in people about the pattern of biological inheritance of characters in human beings.

What is Biological Inheritance?

Both parents contribute genetic material to their children through the gametes (eggs and sperm). This material carries the information needed for the development of the various structural and functional characteristics of the child (*Box 1*). The genetic material from the two parents assembles in the child and is expressed appropriately to determine the characters, features etc. of the child. Even though the child has received genetic material in equal quantity from both the parents, its resemblance or lack of it, to them varies to different degrees in different children and in different aspects. The study which helps us to

understand how characters are inherited by offspring from their parents is called *genetics*. The inheritance of characters is not a haphazard event. Rather, it is governed by a set of norms and the science of genetics tells us about these norms.

How Can We Learn About the Norms of Inheritance?

One can study the pattern of inheritance of characters from parents to their offspring in any animal or plant system. However, it is desirable to have a system with which one can get the information in less complicated ways, in a relatively short period of time. For such experiments, one of the most suitable systems is an insect, popularly called the 'fruit fly', 'vinegar fly' or 'honey dew lover', which has the zoological name *Drosophila*. This fly is being used the world over to learn and teach various aspects of genetics at different levels. It is, in fact, also one of the most popular model systems for research in many diverse areas of genetics at all levels of biological complexity, from the molecular level to the population level.

What is *Drosophila* ?

Drosophila is an insect with two wings (Diptera) and it undergoes complete metamorphosis from egg to larva to pupa to adult (holometabolous). Like any other arthropod, it has a chitinous exoskeleton and paired jointed appendages. It is a typical hexapod, with a pair of antennae on the head, and a pair of legs for each of the three thoracic segments. Of the two pairs of wings, the front pair is attached to the second thoracic segment and is completely developed, while the hind wings on the third thoracic segment are reduced and transformed into balancers or halteres which help in maintaining proper balance during flight.

In *D. melanogaster*, the most commonly used species for genetic work, the females are bigger than the males (*Figure 1*). The abdomen of females is large and pointed at the end while that of males is rounded at the end, rather like a cigar. The posterior end of the dorsal (top) side of the abdomen of the male is heavily pigmented compared to that of the female. At the tip of the

Box 1. Genetic Material

The sperm and eggs carry one set of chromosomes from the respective parents. The fusion of these gametes results in the formation of a zygote carrying two sets of chromosomes, from which the new individual develops. Each chromosome contains information for certain features of the individual in the form of genes. Chemically, genes are made up of deoxyribose nucleic acid (DNA). The informational content of a gene depends on the sequence of four nitrogenous bases (adenine, cytosine, thymine and guanine) of the nucleic acid. The length of the gene or the genome of the individual is measured in terms of number of bases (1000 bases = 1kb).



Figure 1. Male (left) and female (right) of *Drosophila melanogaster*. Note the size and pigmentation differences in the abdominal regions.

abdomen, the female has a vaginal plate while males have a genital plate. Moreover, the males are characterized by the presence of chitinized black teeth (sex comb) on the first tarsal segment of the first pair of legs. Thus, there is strong sexual dimorphism in *D. melanogaster* (Figure 1).

Drosophila is commonly found in residential areas, vegetable markets and also in cooler parts of natural habitats where fresh or fermenting fruit material is available. There are over 2500 species of *Drosophila* and, of these, *D. melanogaster* is the one that has been extensively exploited for research and hence the scientific literature is flooded with information on *D. melanogaster*.

Why is *Drosophila* a Good Model System for Genetics?

Drosophila has been used as model organism right from the beginning of the 20th century, in the very early years of the development of the field of genetics. T H Morgan, at Columbia University, USA, pioneered the use of *Drosophila* for the study of genetics. There are very important reasons for considering *Drosophila* as one of the most suitable model systems for genetic work. With a short life cycle of about 10 to 11 days at 22° C, and with high reproductive potential, it produces a large number of progeny, which is a prerequisite for statistical analysis of the

Box 2. *Drosophila* Media.

A commonly used artificial medium to breed and maintain *Drosophila* in the laboratory is the 'wheat cream agar' medium. The ingredients for 30 half-pint bottles are:

Wheat cream	100 gms
White jaggery	100 gms
Agar-agar	10 gms and
Propionic acid	7.5ml (acts as anti-fungal/bacterial agent)

These constituents are boiled in one litre of distilled water till a creamy consistency is reached. Immediately, it is poured into sterilized bottles and plugged with sterile cotton. After it cools down, a few granules of baker's yeast is added to the medium.

results. On wheat cream agar media (*Box 2*) seeded with yeast (or a variety of media using commonly available ingredients such as jaggery, bananas, corn flour etc.), *Drosophila* can be easily and cheaply bred and maintained in colleges/research laboratories. Within a span of less than two months, students can have the opportunity to review how the characters of the parents have been passed on to the first generation (F_1) and to the second generation (F_2) of offspring. This is ideal for the studies on inheritance of characters from one generation to the next.

Different characters follow different patterns of inheritance. For instance, there are a few features which are influenced by one gene alone. There are often a few genes which determine more than one character (pleiotropic effects of a gene). Sometimes, many genes contribute to a phenotype and the nature of involvement and interaction of different genes in such cases may differ from one character to another. Therefore, the dynamics of inheritance of characters is a complex phenomenon.

To study the inheritance of a character, the most important requirement is individuals with differences for particular characters. For instance, *D. melanogaster* normally has red eyes. If this was the only variety that was available it would be difficult to understand the pattern of inheritance of eye colour. Therefore, what one needs is a variation (mutant form) of this character. For example, one variety of *D. melanogaster* has white eyes. By making use of red and white eyed flies, one can study the inheritance of the eye colour by examining the eye colour of offspring derived from crossing (mating) white eyed with red eyed flies. Over the years, geneticists have found mutations for a very large number of characters in *D. melanogaster*. They have also established pure breeding mutant lines for different mutant forms of these characters. Yet another salient advantage inherent in working with *Drosophila*, is that one can mate flies with different contrasting characters at will in the laboratory, and then study the inheritance of that particular feature. Such mutant stocks, pure breeding for various characters, are available

Box 3. *Drosophila* Stock Centre, Department of Studies in Zoology at the University of Mysore

Activities of this Centre are:

1. To procure and to maintain different genetic strains of *Drosophila melanogaster* required for both routine teaching and research purposes.
 2. To maintain stocks of different important species of *Drosophila*.
 3. New genetic strains of *D. melanogaster* generated by investigators, as well as new species of *Drosophila* collected will be received and added to the collection.
 4. Periodically, the Centre will bring out a catalogue of strains available in the Centre which will be widely circulated.
 5. These genetic stocks are available free of cost to those who need them for teaching/research.
 6. The Centre organises short duration workshops for college teachers to impart basic techniques required for *Drosophila* work, and the Centre also convenes periodical meetings of *Drosophila* biologists of our country to provide a forum for interaction.
- Interested researchers and teachers are invited to interact with the Centre and to utilise the facilities available at the Centre to achieve the purpose for which it was established.

Suggested Reading

- [1] M W Strickberger . *Experiments in Genetics with Drosophila*. Wiley and Sons, New York, USA, 1962.
- [2] M Demerec and B P Kaufman. *Drosophila - A Guide* Carnegie Institute Washington Publication, Washington DC, USA, 1973.
- [3] M Ashburner. *Drosophila: a laboratory handbook*. Cold Spring Harbour Laboratory Press, USA, 1989.
- [4] D L Lindsley and G G Zimm. *The Genome of Drosophila Melanogaster*. Academic Press. San Diego. USA, 1992.

at *Drosophila* stock centres, both in India and abroad. Thus *D. melanogaster* provides innumerable mutant forms to study various patterns of inheritance.

Genes are located on chromosomes found in the nucleus of the cells in organisms. *D. melanogaster* has just 4 pairs of chromosomes. That means that all genes are packed into these 4 chromosomes, which together amounts to a genome size of about 0.17 million base pairs. In humans, on the other hand, there are 23 pairs of chromosomes, with more complexity, harbouring about 300 million base pairs. Yet another unique attribute of *Drosophila* is that the cells of the salivary glands and several other tissues in the larvae have giant polytene chromosomes, which are 1000 times bigger than normal chromosomes. Therefore, cytological and molecular resolution of the chromosomes is very much easier with *Drosophila*.

The *Drosophila* genome also has a large number of mobile elements, commonly called *jumping genes*. Transposons are one type of mobile DNA sequence. During the last decade, transposable elements have been extensively used to induce mutations and to understand the structure and function of genes. Over 3000 different lines of *D. melanogaster* are available with different transposon induced mutations. These lines are of immense help to assess almost every gene in the fly.

During the past 90 years, countless numbers of geneticists have worked and are working on *D. melanogaster*. They have generated a lot of information about genes, characters and the fly. *Drosophila* is also known as the 'Cinderella of Genetics' and the 'Queen of Genetics'. Whatever genetic principles we learn from *Drosophila* are extendable, in principle, to many other plant and animal systems, including human beings.

In the next article of this series we will see how the variant characters of this tiny insect can help us to learn more about genetics.