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Fruit Fly (*Drosophila melanogaster*) - A model organism for Genetic Research

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SUMMARY

Fruit flies have a very simple genetic structure, which makes them ideal for genetic research. It is useful to study mutant fruit flies, as their quick reproduction rate allows scientists to observe the advantages and disadvantages of certain mutations. *D. melanogaster* remains one of the most studied organisms in biological research, particularly in genetics and developmental biology. It is also employed in studies of environmental mutagenesis. *D. melanogaster* was among the first organisms used for genetic analysis, and today it is one of the most widely used and genetically best-known of all eukaryotic organisms. Hence *Drosophila melanogaster* (Fruit fly) is called the “queen of genetics”..

INTRODUCTION

Drosophila derived from the Greek word drosos means dew loving. They belong to the Droso–philidae family; and are most frequently known as fruit flies or often called vinegar, wine or pomace flies. Their main distinguishing character is to stay on fruits, which are ripped or rotten. There is another related family Tephritidae, their members are also called as true fruit flies or fruit flies. *Drosophila melanogaster* is a small, common fly found near unripe and rotted fruit. It has been in use for over a century to study genetics and behavior. Thomas Hunt Morgan was the preeminent biologist studying Drosophila early in the 1900’s. He was the first to discover sex-linkage and genetic recombination, which placed the small fly in the forefront of genetic research. Due to its small size, ease of culture and short generation time, geneticists have been using Drosophila ever since.

Classification

Domain: Eukarya
Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Diptera
Family: Drosophilidae
Genus: *Drosophila* (“dew lover”)
Species: *melanogaster* (“dark gut”)

Morphology

Most *Drosophila* spp. are small, about 2–4 mm long, but some are larger than a house fly. They are typically pale yellow to reddish brown or black and transverse black rings across the abdomen with brick red eyes. Many species have distinct black patterns on the wings with plumose (feathery) and arista antennae, bristling on the head and thorax (Vilela and Gupta 1999). The characteristics of wing venations are used to diagnose the family. *Drosophila* flight path of straight sequencing with rapid and jerky turns of the wings with intersperse between positions of rest is known as saccades movement. However, when it turns in saccades movement, it can be revolved at the angle of 90° in about 50 milliseconds. Moreover, *Drosophila*'s wings can beat 220 times per second (Fry and Dickinson 2003).

Life cycle of *Drosophila melanogaster* :

Drosophila melanogaster exhibits complete metamorphism, meaning the life cycle includes an egg, larval (worm-like) form, pupa and finally emergence (eclosure) as a flying adult. This is the same as the well-known metamorphosis of butterflies. The larval stage has three instars or molts.

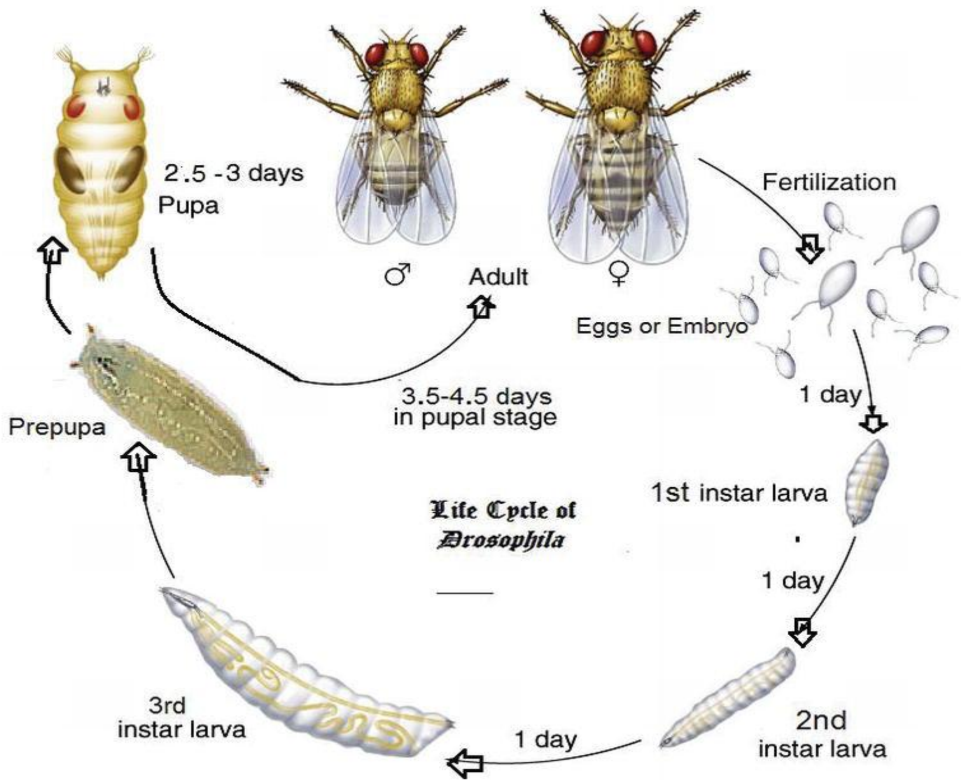

Figure 1. Life-cycle of Drosophila (♂: male; ♀: female) with three larval instar and a pupal stages; bar on photograph: 25 cm (Weigmann *et al.*, 2003).

Day 0	:	Female lays eggs
Day 1	:	Eggs hatch
Day 2	:	First instar (one day in length)
Day 3	:	Second instar (one day in length)
Day 5	:	Third and final instar (two days in length)
Day 7	:	Larvae begin roaming stage
Pupariation (pupal formation) occurs 120 hours after egg laying		
Day 11-12	:	Eclosion (adults emerge from the pupa case)
Females become sexually mature 8-10 hours after eclosion		

Habitat

- The generation time of *Drosophila melanogaster* varies with temperature. The above cycle is for a temperature of about 22°C (72°F). Flies raised at lower temperature (to 18°C, or 64°F) will take about twice as long to develop.
- Females can lay up to 100 eggs /day.
- Virgin females are able to lay eggs; however they will be sterile and few in number.

Key facts

- The fruit fly (*Drosophila melanogaster*,) is the most extensively used and one of the most well understood of all the model organism.
- *Drosophila* fruit flies measure approximately 3 mm in length.
- *Drosophila* larvae are small, white and glossy with a similar appearance to worms. Within 5-6 days they increase around 1000-fold in weight.

- Adults in the wild are tan with black stripes on the back of the abdomen and vivid red eyes. However, there are many visible genetic mutations, including many different eye colours, which are valuable for geneticists studying *Drosophila*.
- Females live for about one month at room temperature but this can increase to over two months at lower temperatures.
- A female may lay 30-50 eggs per day throughout her lifetime at room temperature. Daily egg production is reduced at lower temperatures.
- The *Drosophila* feeds and breeds on fermenting fruit or on other sources of fermenting sugar such as waste in drains or rubbish bins.

Genome Size

- The story of *Drosophila* in biological research began in the early years of the 20th century.
- *Drosophila* is ideal for the study of genetics and development.
- The complete genome sequence of the *Drosophila* was published in 2000.
- Its genome is 168,736,537 base pairs in length and contains 13,937 protein-coding genes.

History of use in genetic analysis

Alfred Sturtevant's *Drosophila melanogaster* genetic linkage map. This was the first successful gene mapping work and provides important evidence for the chromosome theory of inheritance. The map shows the relative positions of allelic characteristics on the second *Drosophila* chromosome. The distances between the genes (map units) are equal to the percentage of crossing-over events that occurs between different alleles.

Thomas Hunt Morgan began using fruit flies in experimental studies of heredity at Columbia University in 1910 in a laboratory known as the Fly Room. The Fly Room was cramped with eight desks, each occupied by students and their experiments. They started off experiments using milk bottles to rear the fruit flies and handheld lenses for observing their traits. The lenses were later replaced by microscopes, which enhanced their observations. Morgan and his students eventually elucidated many basic principles of heredity, including sex-linked inheritance, epistasis, multiple alleles, and gene mapping. (*Pierce 2004). D. melanogaster* had historically been used in laboratories to study genetics and patterns of inheritance. However, *D. melanogaster* also has importance in environmental mutagenesis research, allowing researchers to study the effects of specific environmental mutagens. (Kilbey *et al.*, 1981)

Genetic markers

In the list of a few common markers below, the allele symbol is followed by the name of the gene affected and a description of its phenotype.

- Cy^1: Curly; the wings curve away from the body, flight may be somewhat impaired
- e^1: Ebony; black body and wings (heterozygote's are also visibly darker than wild type)
- Sb^1: Stubble; bristles are shorter and thicker than wild type
- w^1: White; eyes lack pigmentation and appear white
- bw: Brown; eye color determined by various pigments combined.

- y^1: Yellow; body pigmentation and wings appear yellow, the fly analog of albinism

Basic Drosophila Genetics Nomenclature

Drosophila melanogaster flies have 4 chromosomes.	
The genotype is written as	Chromosome Chromosome or Chromosome / Chromosome
When writing the genotype, in general, chromosomes are separated with a semicolon.	X chromosome; chromosome II; chromosome III; chromosome IV
Wild-type is denoted as	"+" or WT
Dominant mutations are written with a capital letter	Bar or B
Recessive mutations are written with a lower case letter	white or w

Technical advantages of using Drosophila – Genetic Model

- They are easy and inexpensive to culture in laboratory conditions.
- They have a much shorter life cycle.
- They produce large numbers of externally laid embryos.
- They can be genetically modified in numerous ways.

Reasons for T. H. Morgan used fruit flies for his genetical experiments

- Fruit flies have a short life cycle so genetic traits can be studied in many generations in a short span.
- They reproduce rapidly and produce many off-springs.
- They have four pairs of polytene chromosomes which are large and can be easily seen under a light microscope.

CONCLUSION

D. melanogaster was among the first organisms used for genetic analysis, and today it is one of the most widely used and genetically best-known of all eukaryotic organisms. All organisms use common genetic systems; therefore, comprehending processes such as transcription and replication in fruit flies helps in understanding these processes in other eukaryotes, including humans.

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