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An Introduction to *Drosophila melanogaster*

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Abstract

Drosophila melanogaster, also known as the fruit fly, is a powerful model organism widely used in biological research that has made significant contributions to the greater scientific community over the last century. First, this video introduces the fruit fly as an organism, including its physical characteristics, life cycle, environment, and diet. Next, the reasons why fruit flies make an excellent model organism are discussed. For example, fruit flies are inexpensive to maintain in the laboratory, have simplified genetics, and short generation times allow for quick experiments with high sample numbers. Then, key discoveries and important *Drosophila* researchers, such as Thomas Hunt Morgan are profiled. Finally, applications of *Drosophila* research, ranging from genetics to cardiac and neurological development and disease, are provided. This video serves as an overview of the highly-important and influential model organism that is *Drosophila melanogaster*.

Transcript

Drosophila melanogaster, also known as the "fruit fly," is a small insect that is commonly found near ripening fruit. *Drosophila* is a widely used model organism for scientific research and the study of this organism has provided insight into eukaryotic genetics and human disease.

To begin, let's get to know *Drosophila* as an organism. *Drosophila* have three main body segments--the head, thorax, and abdomen--as well as a single pair of wings, and three pairs of legs. They are between 2-4 mm long and weigh about 1 mg. Females are typically larger than males. Wild-type fruit flies have large red eyes, and pale yellow or light brown bodies with black stripes on the abdomen.

The *Drosophila* life cycle is about 2 weeks long, and is comprised of 4 major stages: the embryo, larva, pupa, and adult. The average lifespan of *Drosophila* is between 60-80 days, however lifespan can be affected by factors such as temperature or overcrowding.

Fruit flies are present on every continent except Antarctica. More often they are found in tropical climates, but they can adapt to colder climates by moving indoors.

Drosophila can survive in a range of 12-35 °C. In the lab, we store flies in incubators set to 25 °C and 60% humidity for ideal survival and fertility.

The typical diet for *Drosophila* are the microorganisms, such as yeast, that inhabit very ripe and rotting fruits and vegetables. However in the lab, we use food composed of cornmeal, molasses, agar, sugar, yeast, and water.

Now that we've learned a bit about *Drosophila* the organism, let's discuss why researchers have decided to study it. First, the small size of the fly makes them easy to both handle and anesthetize.

Flies are also appealing to work with because they require inexpensive equipment to maintain and house in the laboratory.

Thanks to their short life cycle, it takes approximately 2 weeks from when mating is set up to generate new adult progeny. Females are extremely fertile and can lay hundreds of eggs per day. Therefore, experiments with flies can be conducted quickly and with very high sample numbers.

Drosophila are easy to study, because their genetics are simple in comparison to mammals. The *Drosophila* genome is comprised of only four chromosomes with approximately 14,000 genes. Flies also have limited genetic redundancy. Genetic redundancy means that more than one gene is responsible for a certain biological function. For example, mice may have three copies of a gene causing a particular phenotype. When one gene is mutated, the others can compensate leading to no observable developmental or physiological change. Thus, the mutagenesis experiment in mice is less informative. In contrast, flies may only have one version of a gene, so when that gene is mutated it causes a change in phenotype, giving insight into that particular gene's function.

Furthermore, several methods have been developed to induce genetic mutations, including X-rays, or UV irradiation, and homologous recombination. Lastly, many years of research yielded a friendly community of *Drosophila* scientists, which makes it easy to access the vast number of mutant lines and genetic tools.

Finally, flies are an excellent model organism because of their striking genetic similarities to humans and other mammals. Approximately 50% of fly genes are homologous to mammalian genes, meaning the gene originates from a common ancestor. Furthermore, 75% of human disease-related genes have orthologs, or genes with similar functions, in the fly.

So now that we've heard a bit about what makes *Drosophila* so great for experimental study, let's check out some of the great research that has been done on flies. In the early 20th century, flies first emerged as a model organism in the lab of Thomas Hunt Morgan. In 1910, Morgan discovered a white-eyed fly among a collection of red-eyed flies. Using microscopy, he observed the banding patterns of chromosomes, and saw that the same pattern was always observed in white-eyed flies. With these experiments he established the chromosomal theory of inheritance for which he won the Nobel Prize in 1933.

In 1927, one of Thomas Hunt Morgan's students, Hermann Muller, discovered x-rays can induce genetic mutations. Muller won the Nobel Prize in 1946 for his discovery.

During the ’70s and ’80s, Ed Lewis, Christiane Nusslein-Volhard, and Eric Wieschaus performed screens to identify a number of genes that are essential during development. They identified some of the genes that establish the dorsal-ventral and anterior-posterior axes of the embryo, as well as the genes involved in segmentation, which specify the body plan. They won the Nobel Prize in 1995.

In the 1990’s, Jules Hoffmann used *Drosophila* for research on innate immunity, the first line of defense against pathogens, like bacteria. He discovered Toll receptors and demonstrated their importance for sensing and defending against pathogens. Here are embryonic hemocytes, cells that can recognize and respond to pathogens in the *Drosophila* embryo. Hoffman won the Nobel Prize in 2011 for his work on the *Drosophila* innate immune system, and shared the prize with Bruce Beutler and Ralph Steinman for their work on innate immunity in mammals.

Work in *Drosophila* has many important applications, ranging from genetics to human disease. For example, the genetics of development are often homologous, so the identification and characterization of genes that regulate development in flies has been important for understanding human development. The *Drosophila* "eyeless" gene is essential for development in the fly. The mammalian homologs of eyeless have many functional similarities, thus understanding *Drosophila* eye development could have implications in understanding human eye development and disease.

Drosophila research can also have implications in understanding human neurological diseases. For example, expression of a human gene involved in Parkinson’s disease in the fly, leads to a loss of neurons over time and an accumulation of protein aggregates culminating in decreased locomotor ability.

Research in the fly has lead to important knowledge of human heart development and function. Many genes associated with cardiac function are conserved between flies and humans, and, similar to humans, exercise training can greatly improve performance with physical tasks.

You’ve just watched JoVE’s introduction to *Drosophila* melanogaster. In this video we reviewed the characteristics of Drosophila, the reasons why it makes such a powerful model organism, as well as important discoveries and applications. Although they may seem very different from humans, *Drosophila* research has been an important source of understanding human development and disease. Only time will tell what the future of *Drosophila* research holds.