Model Organisms and the Rise of *Drosophila*

1. What is a model organism?
2. What are the primary model organisms and their characteristics?
3. How did *Drosophila* become a model organism?
4. What have been the primary contributions of *Drosophila* as a model organism?
5. Who have been the major figures in *Drosophila* research?
6. What is the current status of *Drosophila* as a model organism?

A **model organism** is a species that is extensively studied to understand particular biological phenomena, with the expectation that discoveries made in the model organism will provide insight into the workings of other organisms.

This is possible because fundamental biological principles such as metabolic, regulatory, and developmental pathways, and the genes that code for them, are conserved through evolution.

What are the characteristics of a model organism?

1. Short life cycle
2. Small adult size
3. Readily available
4. Tractable
5. Cost effective

The major model organisms:

1. *Escherichia coli*
2. *Saccharomyces*
3. *Caenorhabditis elegans*
4. *Drosophila melanogaster*
5. *Mus musculus*
6. *Brachydanio rerio*
7. Human cell lines
8. *Arabidopsis thaliana*
9. *Brassica rapa*
10. *Zea mays*
**Escherichia coli (E. coli)** is one of the main species of bacteria that live in the lower intestine of warm-blooded animals and are necessary for the proper digestion of food.

**THE WORM**

*Caenorhabditis elegans* is a small (about 1 mm long) soil nematode found in temperate regions.

**THE MOUSE**

*Caenorhabditis elegans* is a small (about 1 mm long) soil nematode found in temperate regions.

**Types of biological problems?**
Gene regulation, transcription, translation

**Resources?**
- Genome sequenced
- E. coli stock center-Yale

**Advantages?**
- Single, simple chromosome
- Cheap, fast generation time, easy to manipulate

**THE MOUSE**

**When?**
- William Castle 1902
- Inbred strains of mice

**Advantages?**
- Mammal, short generation time

**Types of biological problems?**
- Cancer, diabetes, aging, development, immune disorders, neurological disorders

**Important dates in the history of genetics**
- 1859: Darwin
- 1865: Mendel
- 1900: Rediscovery of Mendel
- 1902-3: Sutton: Chromosome Theory of Inheritance

**Major resources for mouse research?**
- Jackson Laboratories-Maine
- 3000 strains of mice
- 2 million mice shipped/year

**What was the important scientific question at the time?**
DROSOPHILA AS A MODEL SYSTEM

- D. melanogaster and early studies in genetics
- Other Drosophila species
- Drosophila Stock centers
- Sequencing projects
- Other resources

C.W. Woodworth - Harvard University
Bred Drosophila, in his laboratory, suggested it would be a good organism for heredity studies 1902

Thomas Hunt Morgan (1866 - 1945)
1890 Ph.D. Johns Hopkins University experimental embryology marine organisms
1904 Faculty position at Columbia University in New York City.
1909 Started working with Drosophila, looking for a cheap and easy system

What did Morgan do?

1. Looked for mutants by inbreeding and by using X-rays
2. Finally in 1910, white eyed mutant was found.
3. Bred white eyed males to females and crossed the progeny he noticed that only males displayed the white-eyed trait.
4. Morgan also discovered a pink-eyed mutant that showed a different pattern of inheritance.
5. 1911 Science: concluded that
   (1) some traits were sex-linked
   (2) the trait was probably carried on one of the sex chromosomes,
   (3) other genes were probably carried on specific chromosomes
The Thomas Hunt Morgan group at Columbia University
1910 - 1928 "FLY ROOM"

1. Chromosomes as the hereditary material
2. Discovery of crossing over, or genetic recombination
3. Creation of genetic maps
The basic Drosophila karyotype is five rods and a “dot” all referred to as “Muller Elements”, six of them in all. D. melanogaster has an acrocentric X (one arm), metacentric second (two arms) metacentric third (two arms) and a small fourth, the dot.

**Other Drosophila species (about 2000 of them):**
- Sturtevant: Drosophilidae of North America
- Patterson and Stone: Evolution in the genus Drosophila (The Texas group) 1940s-1970
- Hawaiian Drosophila Project
- Russian and Japanese Drosophila projects pre-WW2
  - *D. virilis*
  - *D. ananassae*

**Examples of traits with significant interspecific variation in Drosophila**
- Body size, morphology
- Coloration
- Growth rate
- Longevity
- Reproduction
  - egg production
  - sperm production
  - copulation duration
  - seminal “feeding” or ejaculatory donation to eggs
  - female remating
- Stress tolerance
  - heat
  - cold
  - desiccation
  - starvation
  - toxic chemicals
- Immunity
- Locomotor activity
- Ecology

**Genome related traits showing interspecific variation in Drosophila:**
- Karyotype
- Chromosome number (centric fusions)
- Inversion polymorphism
- Levels of variation
- Codon Bias
- Transposable elements
- Genome size
- Heterochromatin
Other *Drosophila*
Tucson Stock Center
250 species, 1600 stocks

D. *melanogaster*
Bloomington Stock Center
15,000 stocks

Flybase
What are the important questions that Drosophila can be used to address?

How do new species form?

What are the genetic bases of:

- Insecticide and drug resistance?
- Cancer and the control of cell division?
- Aging?
- Developmental defects?
- Stress resistance?