Model Organisms and the Rise of *Drosophila*

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 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**

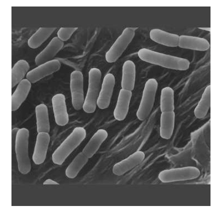
The major model organisms:

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.**

When?
1950's after DNA confirmed as genetic material, structure, etc

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



Types of biological problems?
Gene regulation, transcription, translation

Resources?
Genome sequenced
E. coli stock center-Yale

THE WORM

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

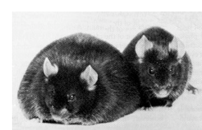
WHEN ?
1960's

Advantages?
959 cells in the adult hermaphrodite;
1031 cells in the adult male

Types of biological problems
Development, neurogenetics, aging

Resources?
Sequenced genome, Wormbase,
Stock centers (1000 strains)

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

Important dates in the history of genetics

1859 Darwin

1865 Mendel

1900 Rediscovery of Mendel

1902-3 Sutton: Chromosome Theory of Inheritance

What was the important scientific question at the time?

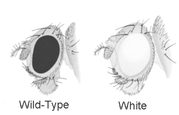
C.W. Woodworth - Harvard University

Bred *Drosophila*, in his laboratory, suggested it would be a good organism for heredity studies 1902

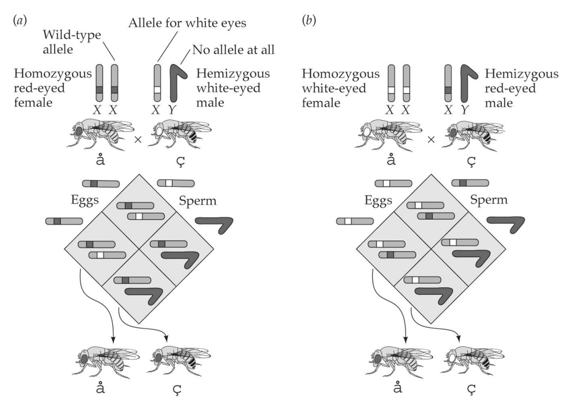
Thomas Hunt Morgan (1866 - 1945)

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

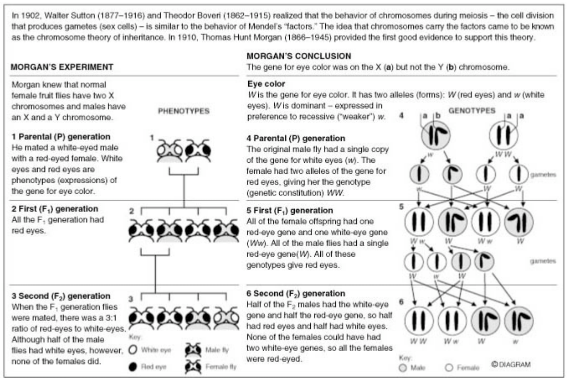
What did Morgan do?



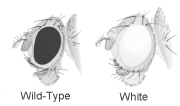
1. **Looked for mutants by inbreeding and by using X-rays**
2. **Finally in 1910, white eyed mutant was found.**
3. **Bred white eyed males to females and crossed the progeny he noticed that only males displayed the white-eyed trait.**



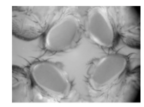
LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 10.23 Eye Color Is a Sex-Linked Trait in *Drosophila*



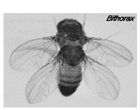
What did Morgan do?

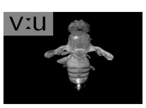


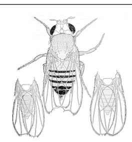
1. Looked for mutants by inbreeding and by using X-rays
2. Finally in 1910, white eyed mutant was found.
3. Bred white eyed males to females and crossed the progeny he noticed that only males displayed the white-eyed trait.
4. Morgan also discovered a pink-eyed mutant that showed a different pattern of inheritance.

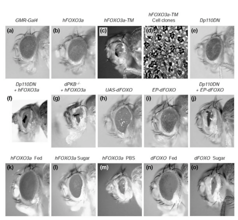


5. 1911 Science: concluded that
   (1) some traits were sex-linked
   (2) the trait was probably carried on one of the sex chromosomes,
   (3) other genes were probably carried on specific chromosomes









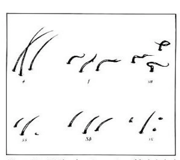


Figure 25 Bristle phenotypes: +, wild; f, forked (1-56.7); sn, singed (1-21.0); ss, spineless (3-58.5); Sb, Stubble (3-58.2); sv, shaven (4-3.0). Bristle phenotypes can be readily distinguished with the magnification of a stereomicroscope.

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 Thomas Hunt Morgan group
Moved to the California Institute of Technology 1928

Calvin Bridges
(Chromosome maps, sex determination)

Alfred Sturtevant
(additional *Drosophila* species)

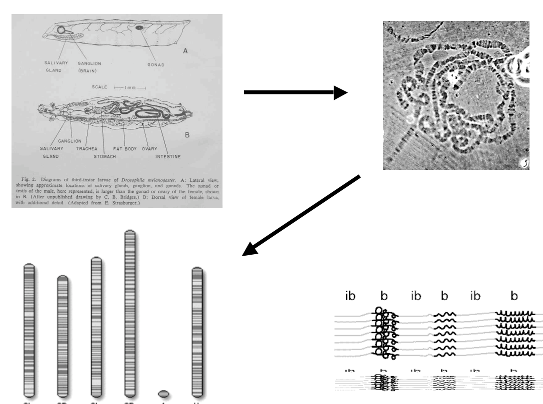
Herman J. Muller
(Indiana University radiation genetics)

The Thomas Hunt Morgan group
Moved to the California Institute of Technology 1928

THEODOSIUS DOBZHANSKY

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 acrocenteric X (one arm), metacentric second (two arms) metacentric third (two arms) and a small fourth, the dot.**

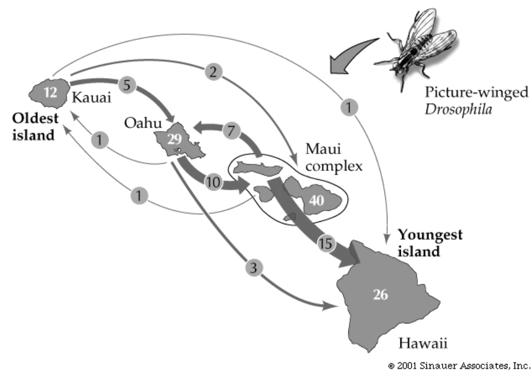


Other *Drosophila* species (about 2000 of them):

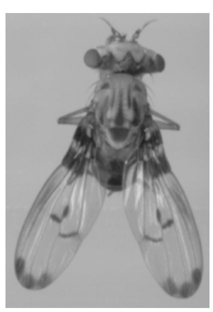
- Sturtevant: Drosophilidae of North America
- Patterson and Stone: Evolution in the genus *Drosophila* *(The Texas group) 1940s- 1970*
- Hawaiian *Drosophila* Project
- Russian and Japanese *Drosophila* projects pre - WW2

D. virilis

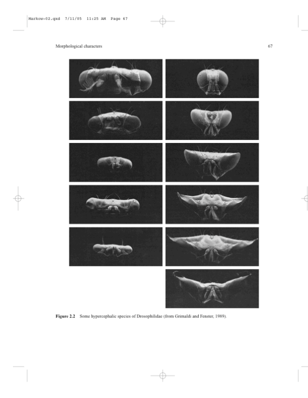
D. ananassae



D. silvestris



D. heteroneura

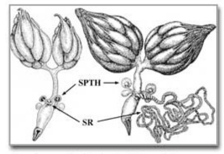


Examples of traits with significant interspecific variation in *Drosophila*

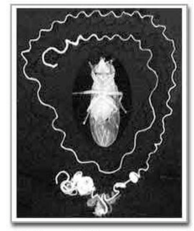
Body size, morphology
Coloration
Growth rate
Longevity
Reproduction
- ***egg production***
- ***sperm production***
- ***copulation duration***
- ***seminal "feeding" or ejaculatory donation to eggs***
- ***female remating***

Stress tolerance
- ***heat***
- ***cold***
- ***desiccation***
- ***starvation***
- ***toxic chemicals***

Immunity
Locomotor activity
Ecology

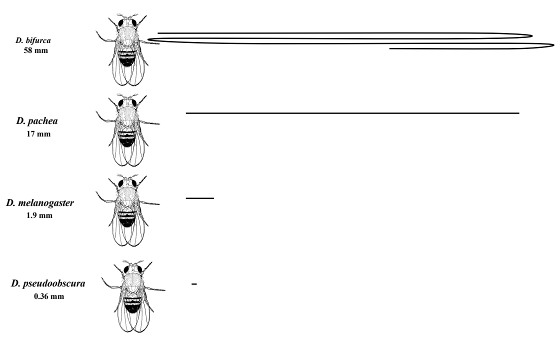


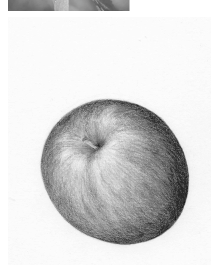
Female reproductive tract of *Drosophila pseudoobscura* (left), which has 0.36 mm long sperm, and of *D. bifurca* (right), which has 58.3 mm long sperm. SR = seminal receptacle, SPTH = spermathecae. Drawings by J. T. Patterson. See Pitnick et al. 1999 for details.



Male *Drosophila bifurca* surrounded by one of his testes (reproductive tract dissected after imaging male then photographed at same magnification). The energetic demand of such massive testes underlies many life history costs. See Pitnick 1996 for details.

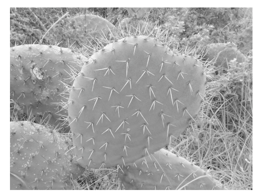
Tamaño del espermatozoide en varias especies de *Drosophila*





Fruits

Slime flux



Genome related traits showing interspecific variation in *Drosophila:*

Karyotype

- ***Chromosome number (centric fusions)***
- ***Inversion polymorphism***

Levels of variation

Codon Bias

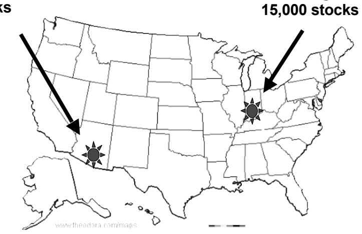
Transposable elements

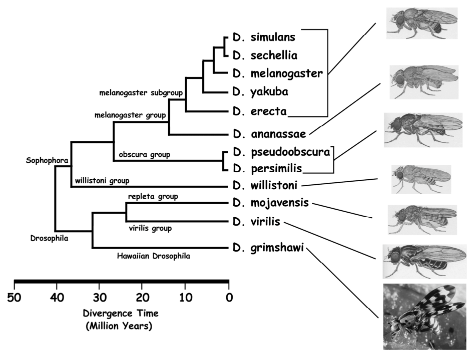
Genome size

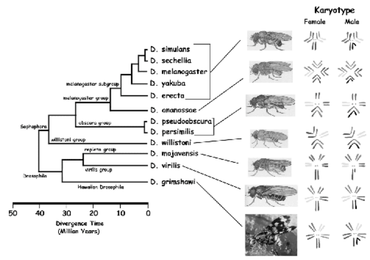
Heterochromatin

Other *Drosophila*
Tucson Stock Center
250 species,
1600 stocks

D. melanogaster
Bloomington Stock Center
15,000 stocks



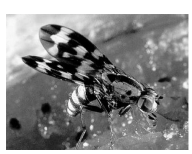




A	B	C	D	E	F
X	2L	2R	3L	3R	4
XLXR	3R	3L	2R	2L	4L4R
XL	4	3	XR	2	5
XL	2R	2L	XR	3	
X	3	5	4	2	6
X	4	5	3	2	6
X	3	2	5	4	6

DROSOPHILA AS A MODEL SYSTEM

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



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?**