MODULE 18

MODEL ORGANISMS

A model organism is any non-human species which is studied extensively in order to gain insight into any biological phenomenon.

Scientists use model organisms to study human diseases because performing experiments on humans is unfeasible and unethical. To that, researchers use traditional and powerful tools of molecular genetics.

Some of the most commonly used model organisms are Zebrafish, *Drosophila* and Mice.

Why is experimenting with model organisms feasible?

1. The model organisms are the common descent of all living organisms.
2. The metabolic and developmental pathways are conserved in all organisms.
3. The genetic material is also conserved over the course of evolution.

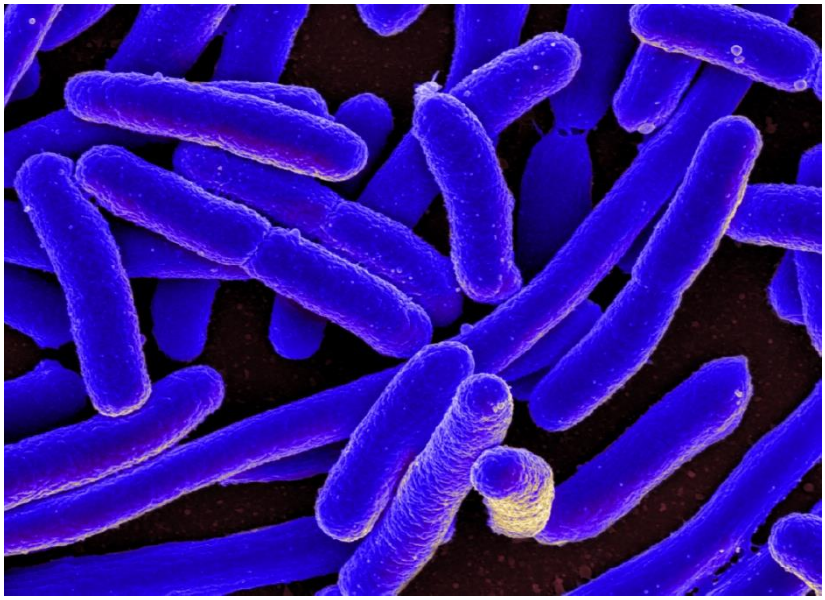
How to select a model organism?

1. Small size
2. Short generation time
3. Simple life cycle
4. Amenable to observation and experimentation
5. Should have many known and mapped mutations.
6. Completely sequenced genome.
7. Cheap to maintain
8. Can be easily transformed
9. A comprehensive online database should be available.

Important Model Organisms

1. *Escherichia coli*

- *E.coli* is a gram negative, facultative anaerobic bacterium which normally inhabits the small intestine of warm-blooded organisms.
- They do not normally cause harm to their hosts, but in some cases they can cause food poisoning.



Advantages-

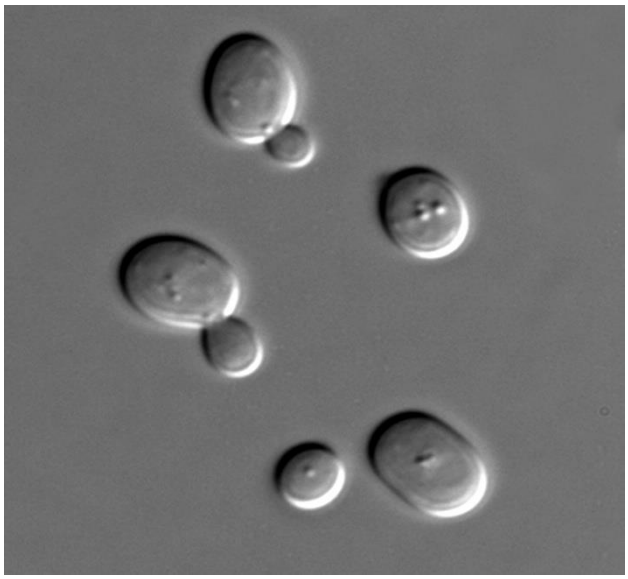
- Easy to manipulate.
- They can be grown in a simple nutrient broth in a lab.
- Cheap and easy to maintain.
- Reproduce at a rapid rate.
- Can develop mutations at a fast rate.

Limitations-

E.coli is a prokaryotic organism and humans are Eukaryotes. Eukaryotes are normally larger and more complex than prokaryotes. These structural and functional differences pose limitations on the usage of *E.coli* to study human diseases.

2. *Saccharomyces cerevisiae* (Yeast)

- Yeast (also known as Baker's yeast and budding yeast) is the simplest Eukaryotic organism used as a model organism.
- It is extensively used to understand the basic molecular processes in humans.
- It was the first eukaryotic organism to have its genome sequenced.
- Yeast is single-celled Eukaryotic microorganism belonging to the kingdom fungi.



Advantages-

1. Being single-celled, they are easy to manipulate.
2. Can cope with a wide range of environmental conditions.
3. Yeasts are able to control cell division in a similar way to human cells.
4. Their genes can be easily cloned.
5. Possess all the basic eukaryotic cell organelles.

Limitations-

Despite the similarities of yeast with human cells, there is one limitation of using them as model organism. Yeast lacks distinct tissues which limits their use for certain studies.

3. *Drosophila melanogaster*

- Also known as fruitfly.
- A Drosophila undergoes a 4-stage life cycle- Egg, Larva, Pupa and adult fly.
- Drosophila has been used as a versatile model organism for biomedical research in order to study various biological phenomena.

Advantages-

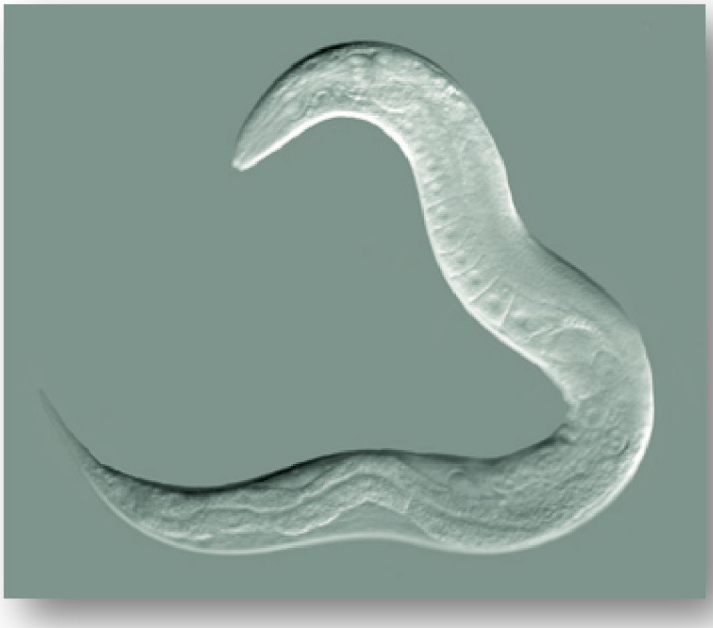
- Their care is inexpensive. Their culturing does not require much space and equipment.
- No ethical or safety issues.
- *Drosophila* is easy to anesthetize them with ether. Once anesthetized, their morphology can be studied readily.
- They have a short generation time. Therefore, it is easy to study multiple generations within a few weeks.
- Females have a high fecundity. Each female can lay up to 100 eggs per day.
- Their genome consists of 4 chromosome pairs.

Limitations-

- Embryological manipulation is difficult.
- It is difficult to perform targeted gene disruption in *Drosophila.*

4. *C. elegans*

- *C. elegans* is a non-parasitic (free living) nematode with a transparent body.
- These nematodes are mostly hermaphrodites.
- Because of its various advantages, *C. elegans* has been extensively used a research model in labs.



Advantage-

- *C. elegans* are hermaphrodites. They reproduce through self-fertilization.
- Fast generation time.
- Their genes can be easily cloned.
- The total no. Of cells in their body is 959.
- Their morphology is not fully characterized.

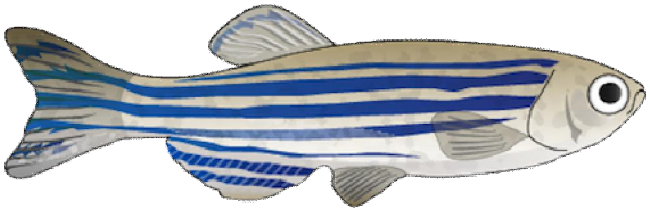
- All cell lineages of *C. elegans* are known.

Limitation-

- Limited external morphology.
- Some embryological manipulation is difficult.

5. *Danio rerio*

- Zebrafish has been used as a model organism since 1960s.
- It's a tropical fish which is found in Southeast Asia.
- In its larval stages it appears transparent, while an adult Zebrafish has stripes (like a Zebra) that run along the length of its body.
- The first genome sequencing of Zebrafish was done in 2013.
- Its genome size is 1,505,581,940 bp having around 26,000 protein coding genes.



Advantages-

- Small in size and cheaper to maintain.
- A female Zebrafish produces as much as a 100 offspring on a weekly basis, thus making the supply of embryos to the scientists easier.
- They have a faster growth rate.
- Embryos of a Zebrafish are naturally transparent. This feature makes it easier for researchers to examine the results of experiments as well as its development easier.

- Almost 70% of Zebrafish's genes are similar to humans and out of those, about 84% of the genes are associated with a number of human diseases.

Disadvantages

- Several mammalian organs are not present in the Zebrafish.
- Unlike humans, Zebrafish are ectothermic or cold blooded.

6. *Mus musculus* (Mouse)

- Mouse is used as a preferred mammalian model organism to study human genetic aspects for many reasons.
- Scientists have been able to stimulate human genetic disorders to study their early development and test the new therapies.
- The genome sequence of mouse which was published in 2002 has been of great use to accelerate the progress of research in human genetics.

Advantages

- Because mice are very closely related to humans, hence they are considered the best model for mammalian genetic disorders and development.
- Their genome has been fully sequenced.

- Genetic manipulation can be done easily.
- Mice are small in size, have a short generation time and are able to produce approximately 10-15 offspring per litter and about one litter every month.
- Around 450 inbred strains are available.

Disdvantages

- Drugs that have been tested positively in mice have also been found performing poorly in humans.
- Inbred mice are unable to capture genetic variations existing in human population.