EVOLUTION AND CHARACTERISTICS OF IMPORTANT INVERTEBRATES TAXA

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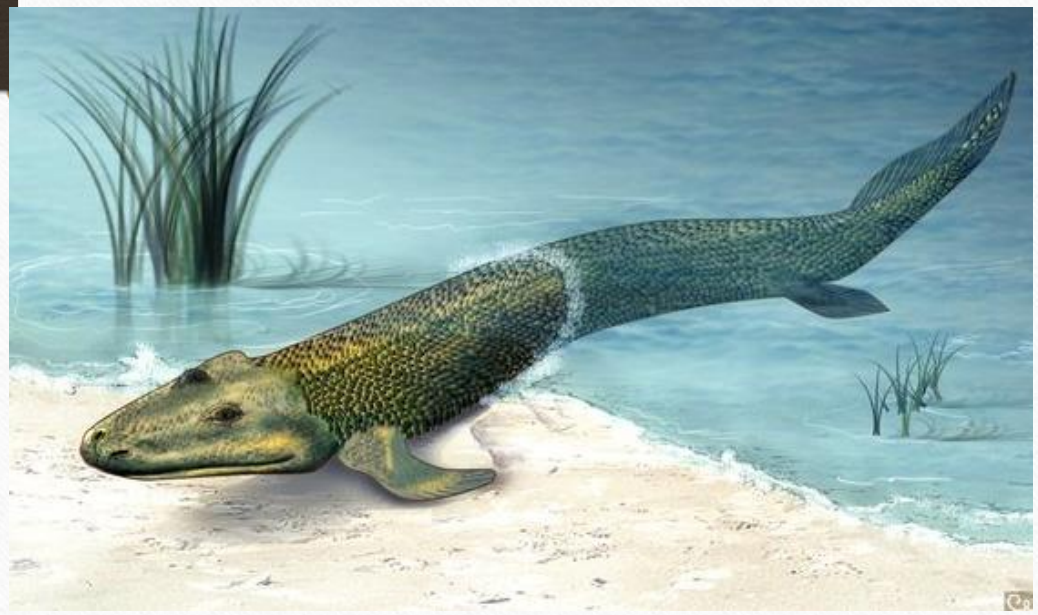
UNIT: IV



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UNIT-IV

EVOLUTION AND CHARACTERISTICS OF IMPORTANT INVERTEBRATES TAXA

Organization and affinities in fossils. Affinities of living fossils. Polymorphism and colony formation. Parasitic adaptation and life cycle patterns in parasites belonging to different taxa. The parasites listed by World Health Organization under preventive programmes. Invertebrate model organisms and their importance

ORGANIZATION AND AFFINITIES IN FOSSILS

- Fossils are generally of rock that had replaced the preserved organism or its traces
- It usually occurs when the organism is covered quickly so it is preserved
- Sediment, forming sedimentary rock, is then laid down
- Fossils are preserved remains or traces of living things.
- Fossils normally form in sedimentary rock.
- Hard parts are the only parts of an organism that leaves a fossil.
- Petrifaction follows
- Not all fossils are petrified
- Some are preserved by dehydration (mummified), in ice, in peat bogs, in tar beds or trapped in amber
- Examples: Bones, shells, teeth, seeds, and woody stems.

- The discovery of fossils is greatly assisted where there has been natural erosion, which exposes the deeper, older layers containing the fossils
- Useful sites include gorges, quarries, caves and desert areas.
- Therefore, fossils are only formed under certain conditions and then have to be uncovered
- The chance that a body will be fossilized is rare and the chance that it will be discovered is even rarer
- The fossil record is far from complete
- This may account for the ‘missing links’ and for apparently restricted distribution of many species
- But palaeontologists can improve their chances by searching systematically in places where fossils are likely to be found
- Sedimentary rock is laid down in layers or strata the deepest usually being the oldest
- This sequence forms the stratigraphy of the rock and together with the fossils and artefacts which are present, give a relative dating
- However, due to earth movements in the past and to the great time spans and migrations of some organisms, this method is not very accurate.

Relative dating

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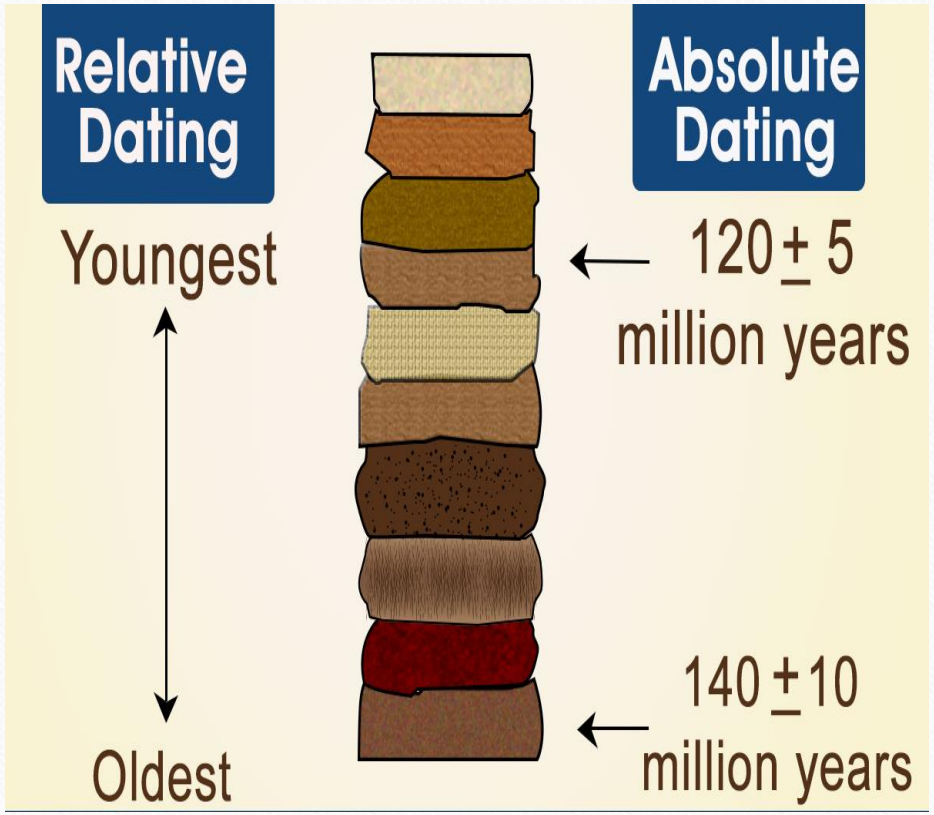
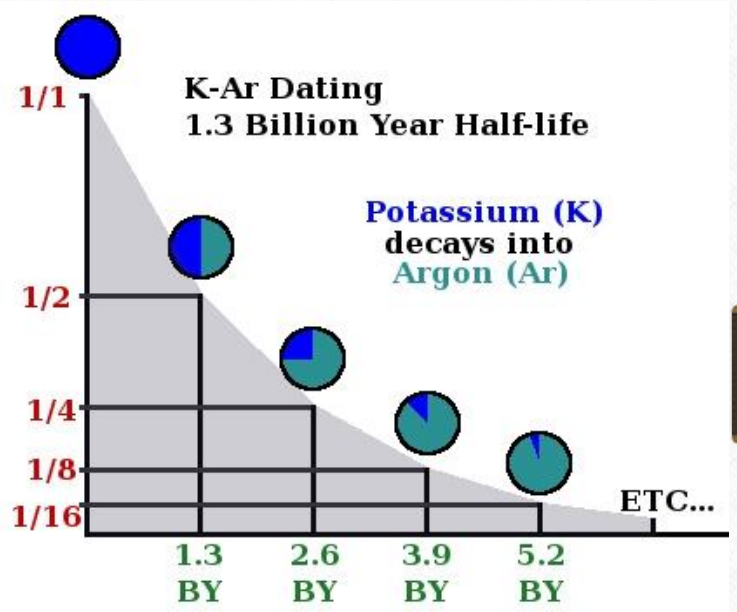
Absolute dating

- Accurate dating can be obtained using radiometric dating
- This uses the phenomenon of radioactive decay of isotopes
- When sedimentation occurs radioactive isotopes are incorporated
- These decay to form other atoms at a known rate
- This rate is measured as the half-life of the isotope, defined as the time taken for half the parent atoms to decay to the daughter atoms

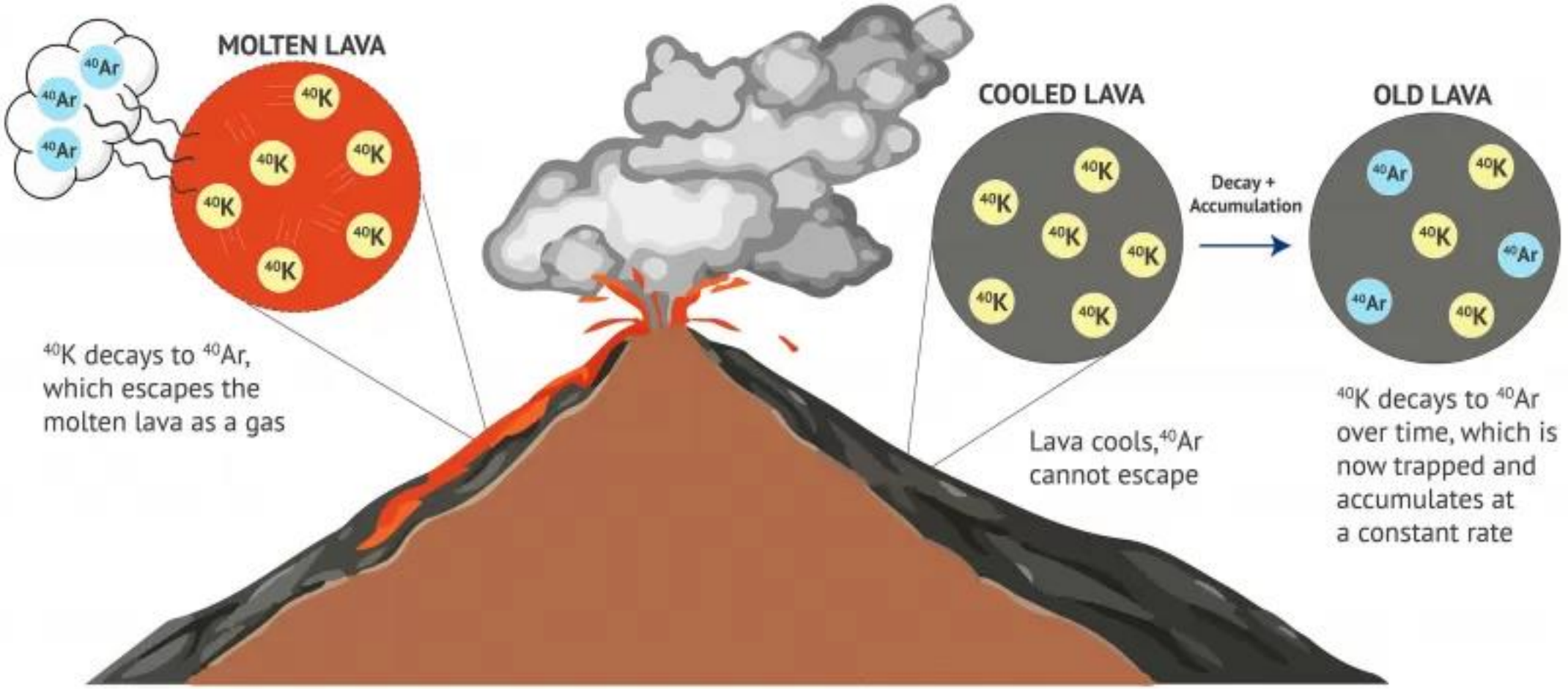


Potassium-Argon Method

- Potassium-40 (40-K) decays to form Argon-40 (40-Ar), which is trapped in the rocks
- The amount of argon is measured, so that this is known as an accumulation method
- The half-life of 40-K is 1.3 x106 years, so it is useful for dating very old rock (as old as the Earth), the minimum age being 100 000 years.
- The limitation is the degree of precision of the measuring devices
- As these improve more recent events may be dated
- Volcanic rock is particularly useful for this technique
- When it melts the rock releases any 40-Ar it has in it, setting the clock to zero
- Then when the molten rock crystallises it becomes impermeable which traps 40-Ar gas so it cannot escape
- With time the 40-Ar builds up and the 40-K diminishes
- Volcanic rock, however, does not contain fossils
- So when fossils are dated using this method their association with the lava flow or ash fall needs to be established.

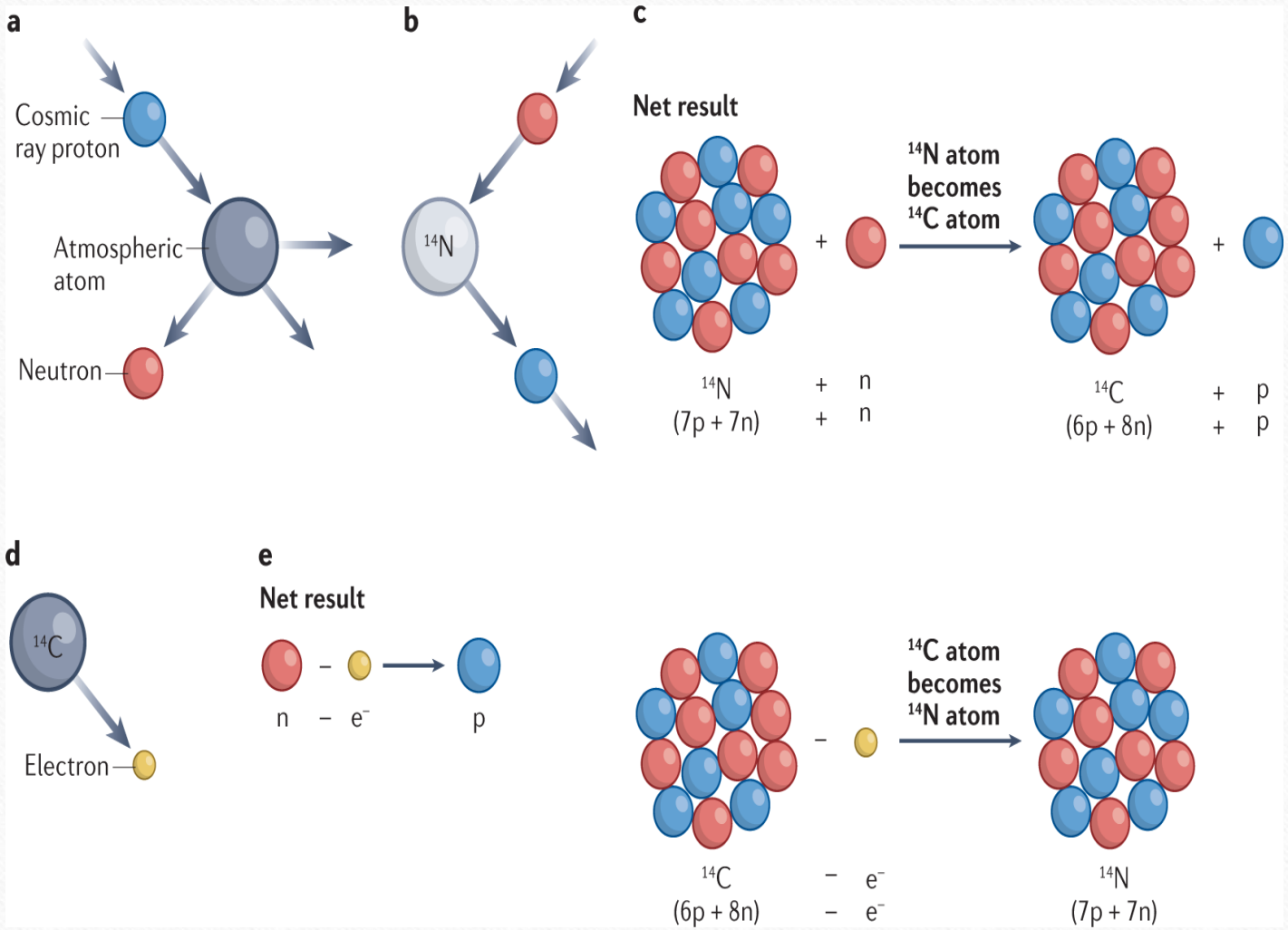


Principles of Potassium-Argon Dating



Carbon-14 Method

- The ratio of 14-C to 12-C is measured. 12-C is a stable isotope, which does not decay. So as time goes by the ratio of 14-C/12-C gets smaller.
- The half-life of 14-C is 5 730 years, so it is used to date very recent remains, the maximum age being 50 000 years (there is not much 14-C left after 9 half-lives).
- The amount of 14-C in the atmosphere varies with the amount of bombardment of the atmosphere by cosmic rays. Therefore, correction factors are used which have been calculated using other methods (e.g. dendrochronology –tree ring dating).

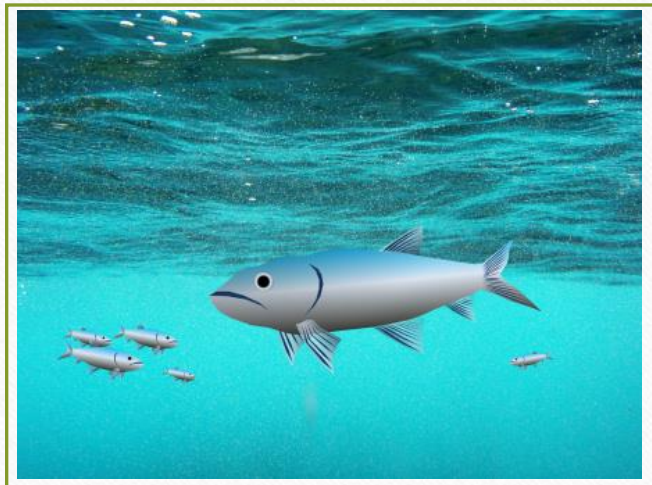


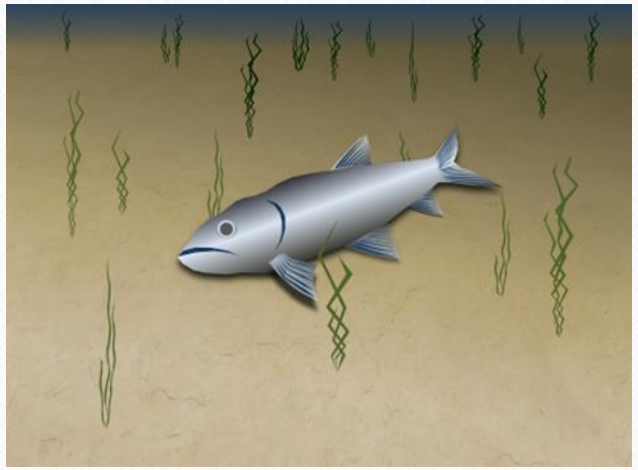
How Fossils Form

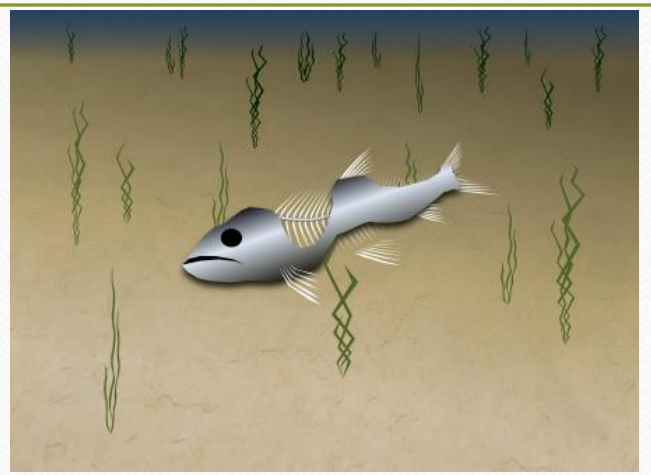
- For an organism to be preserved, it must be in an environment free of oxidation and bacterial decay.
- The organism must be quickly buried by sediment and must be shielded from oxygen
- Environments that are covered by water are more likely to preserve organisms
- Ex: Swamps, deep lakes, tar pits, oceans
- When an organism dies, its soft parts often decay or are eaten by animals
- This is why only hard parts leave fossils.
- Ex: bones, shells, seeds, stems
- Sediments cover over the organism remains

Fossil Formation

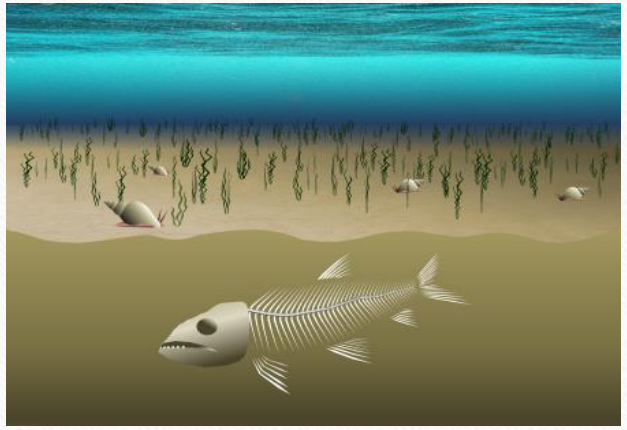
- The sediment becomes rock, preserving parts of the organism.
- As the sediment hardens, minerals take place of any holes left by the skeleton as it dissolves. The result is a mineralized copy of the original organism
- Weathering and erosion eventually expose the fossil at the surface.

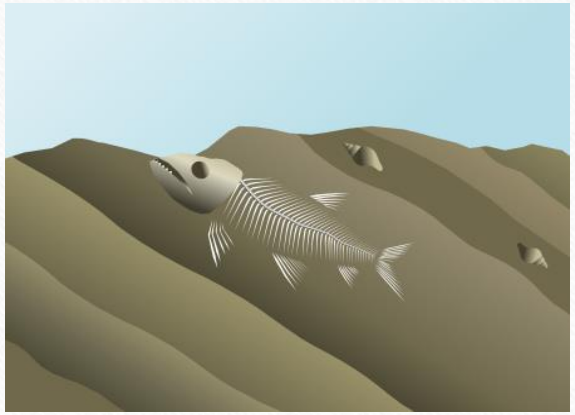






Fossil Formation





Types of Fossils

Molds

- A hollow area in sediment in the shape of an organism is a mold
- A mold forms when the hard part of the organism is buried in sediment.
- When water comes in and dissolves away the organism the hollow area left that is in the shape of the original organism is the mold.

Casts

- Water carrying dissolved minerals and sediments may seep into the mold.
- This sediment may harden and take the shape of the mold making a copy of the fossil.
- A cast is a solid copy of the shape of a fossil or organism.
- A cast is the opposite of its mold.
- Both the mold and casts preserve details of the organism's structure.

Petrified Fossils

- Petrified fossils are fossils in which minerals replace all or part of an organism
- Water rich in dissolved minerals seep into spaces of the organism.
- Over time, the minerals come out of the solution and harden filling in all the spaces. This causes the organism to be preserved.

Molds

Casts

Petrified Fossils

Carbon Films

Carbon Films

- Carbon films are a extremely thin coating of carbon on rock.
- When sediment buries an organism, some of the materials that make up the organism evaporate or become gases.
- These gases escape from the sediment, leaving carbon behind.
- Eventually only a thin layer of carbon is left behind. This helps in preserving the organism.

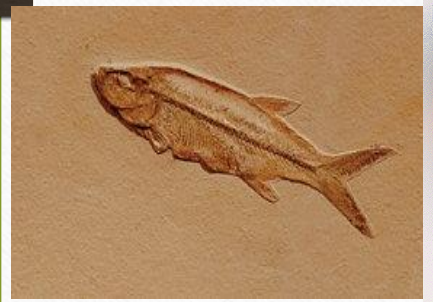
Trace Fossils

- Trace fossils provide evidence of the activities of ancient organisms.
- A fossilized footprint is a trace fossil.
- From trace fossils, scientists can learn about a prehistoric organism's size, diet, environment, and behavior.

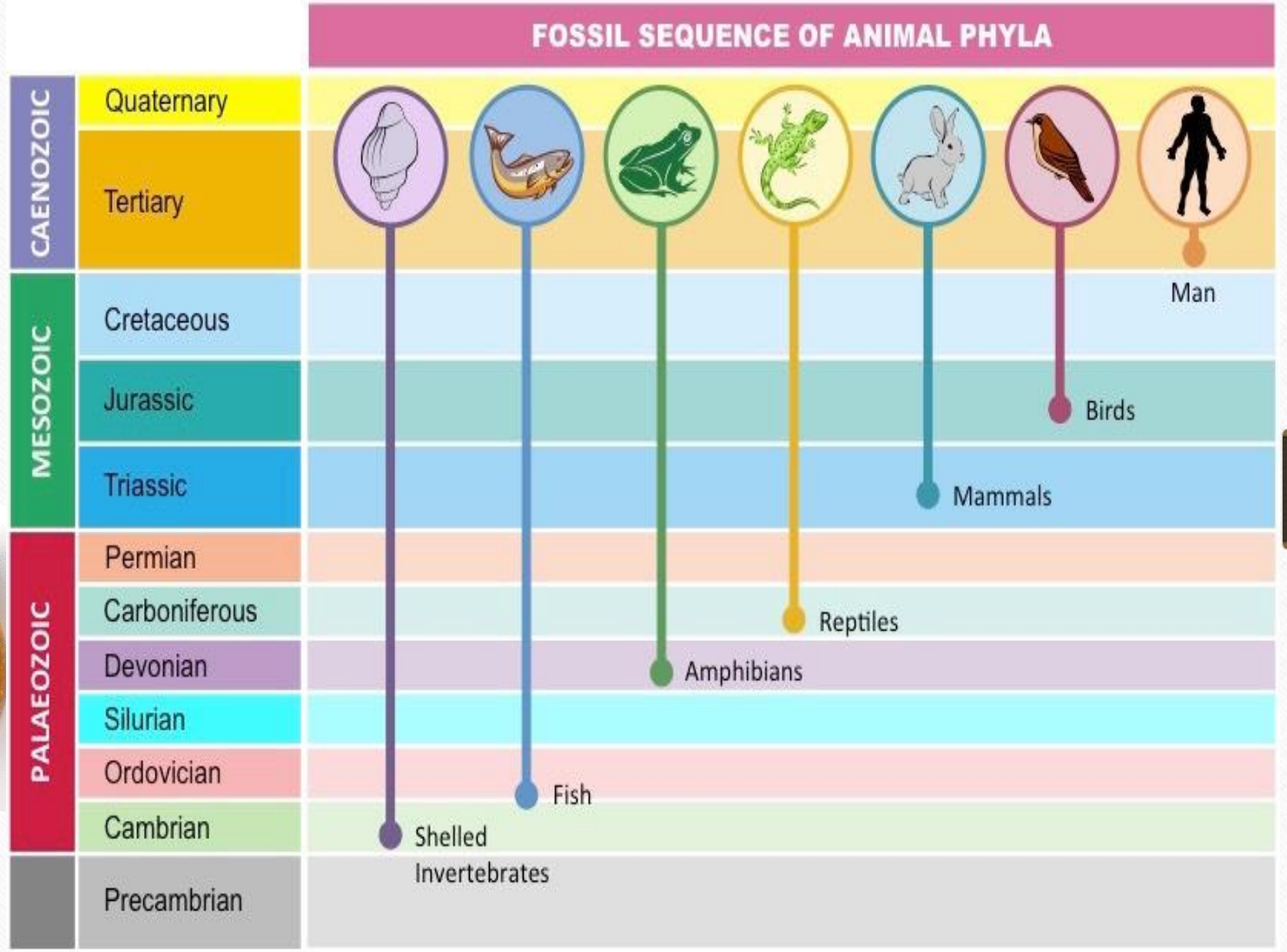
Preserved Remains

- Some processes preserve the remains of organism with little or no change.
- Processes that preserve the remains of organisms with little or not change include: Tar, Amber, and Ice

Trace Fossils



Preserved Remains



Using the Fossil Record

- A paleontologist is a scientists who studies fossils.
- All the information that paleontologists have gathered about past life is called the fossil record.
- The fossil record provides evidence about the history of life and past environments on Earth.
- It also shows how different groups of organisms have changed over time.

Fossil Record

- The presence of coal in Antarctica shows that the climate there was once warmer.
- Scientists use the fossil record to support theories of how living things have changed over time
- The relative age of a rock is its age compared to other rocks
- The absolute age of rock is the number of years since that rock was formed.
- A fossil that is widely distributed and represents a type of organism that existed only briefly is called an index fossil.
- They are useful because they can be used to identify the relative age of rocks.

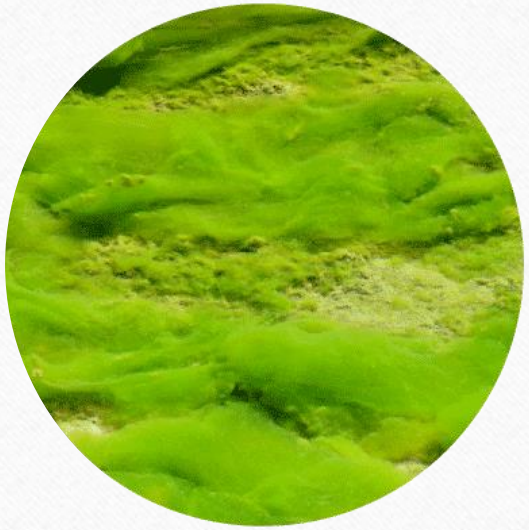
AFFINITIES OF LIVING FOSSILS

Living fossils:

Fossils which range from ancient time upto the present day without any change in their primitive characters are known as living fossils.

The term "living fossil" is mainly used for describing the similarities and differences between the living organisms and fossils of extinct specimens which virtually had unchanged structure and function. The term living fossil was developed by an English naturalist Charles Darwin. In one of his famous books, "The Origin of Species, he has described extensively about those living creatures that have remained largely unchanged for billions of years. He also included those creatures which have not changed since their ancestors were fossilized. In his chapter on natural selection, he explained about the species and its group which is termed as aberrant.

Living fossils are one of the best pieces of evidence from which various living species can be proved to have common descent. If both present living and fossil creatures are similar and identical, then the older fossils are found to be similar to the present day creatures. Darwin believed that all living fossils were exceptional and strange. We can easily identify many fossils as they represent an animal that no longer exists on Earth. Each and every living species has continually modified to changing environments, rising and dropping temperatures and other changes in atmospheric composition and conditions. These species have settled to their environmental controls in which they have achieved a competence peak in environments that constantly strengthen certain physicality. Some fossils show no identical features, therefore it is evident that the creature once existed. These extinct creatures are a reminder to the world which is losing other living species.



Examples: Unicellular Organisms- Bacteria, Algae, and Protozoa.
Multicellular Organisms- Animals and Plants.

POLYMORPHISM AND COLONY FORMATION

Polymorphism, in biology, a discontinuous genetic variation resulting in the occurrence of several different forms or types of individuals among the members of a single species. A discontinuous genetic variation divides the individuals of a population into two or more sharply distinct forms. The most obvious example of this is the separation of most higher organisms into male and female sexes. Another example is the different blood types in humans. In continuous variation, by contrast, the individuals do not fall into sharp classes but instead are almost imperceptibly graded between wide extremes. Examples include the smooth graduation of height among individuals of human populations and the graduations possible between the different geographic races. A polymorphism that persists over many generations is usually maintained because no one form possesses an overall advantage or disadvantage over the others in terms of natural selection. Some polymorphisms have no visible manifestations and require biochemical techniques to identify the differences that occur between the chromosomes, proteins, or DNA of different forms. The castes that occur in social insects are a special form of polymorphism that is attributable to differences in nutrition rather than to genetic variations.

(GR: POLYS = MANY, MORPHE = FORM)

- **Occurence in the same species of more than one type** of individual, which differ in form and function is known as Polymorphism. Polymorphism denotes division of labor among the zooids of the individual.
- Polymorphism is one of the characteristics feature of Coelenterate animals.
- In coelenterata or in **hydrozoa** which may be single or colonial, here occur two main types of individuals or zooids-**Polyp** and **medusae**.

Trimorphic: Besides **gastrozooids** and **gonozooids** they also possess a third type individuals the **dactylozooids.**

Polymorphic: Animals having more than three types of individuals are called polymorphic. some what greater degree of polymorphism is found in the encrusting colony of Hydractinia with five types of polyps each performing a specialized function.

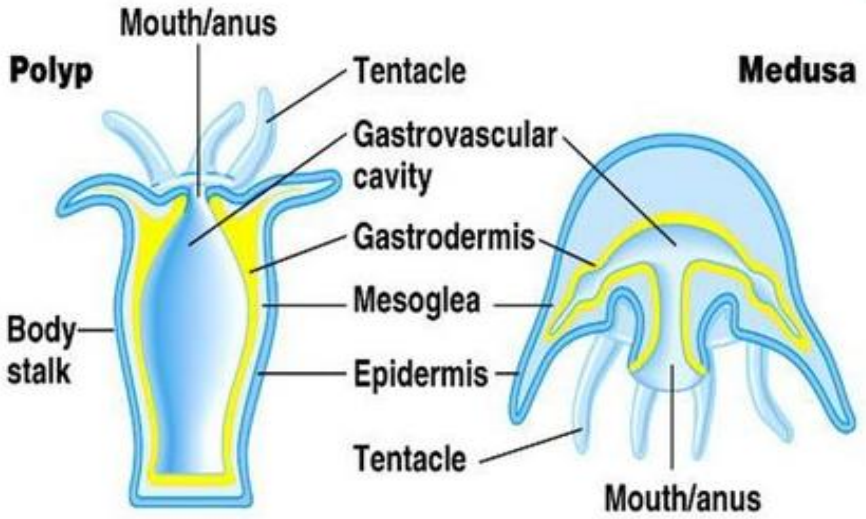
Gastrozooids	-	**feeding**
Dactylozooids	-	**protection.**
Tentaculozooids	-	**Sensory cells**
Skeletozooids	-	**Spiny projections of chitin**
Gonozooids	-	**Reproductive individuals.**

Polymorphism (Gr., poly = many; morphe = form) is the occurrence of several different types of individuals or zooids in a single species during its life cycle or as members of the colony, the members perform different functions so that there is a division of labour amongst the members.

Coelenterata are noted for their polymorphism, but the various types are reducible to either a polypoid or medusoid type. The polyp and medusa occur in a number of morphological variations. However, polymorphism may be defined as the representation of a single organism by more than one kind of individuals or zooids which differ in their form and function.

- **Polyp:** A polyp has a **tubular body** with a mouth surrounded by tentacles at one end. Other end is blind and usually attached by a pedal disc to the substratum.

- **Medusa:** A medusae has a **bowl or umbrella shaped** body with marginal tentacles and centrally located mouth or manubrium.



(a) Sea anemone: a polyp

(b) Jelly: a medusa

PATTERNS OF POLYMORPHISM:

Degree of polymorphism varies greatly in different groups of hydrozoa.

1. **Dimorphic:** Simplest and commonest pattern of polymorphsm is exhibited by many hydrozoan colonies like **Obelia, Tubularia** etc.,

   They have two types of individuals or zooid namely:

Gastrozooids or hydranths are connected for feeding

Gonazooids or blastostyles with asexual budding forming sexual **medusae or gonophores.**

This phenomenon is termed as **dimorphism.**

POLYPOID ZOOIDS ARE :

1. Gastro zooids
2. Dactylo zooids
3. Gono zooids

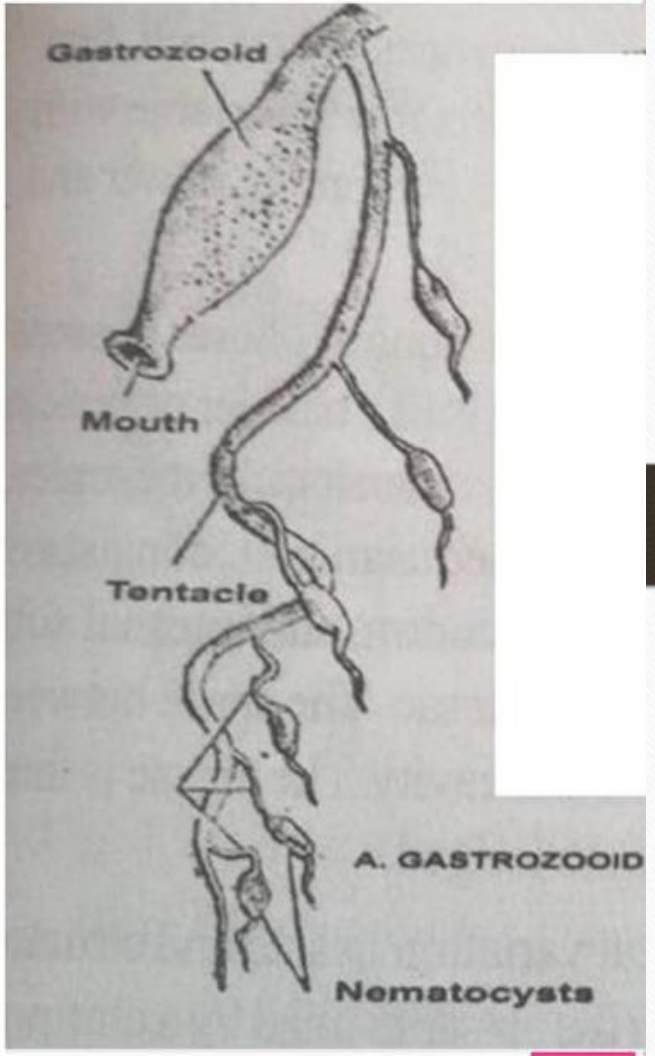
1. Gastrozooids :

The **nutritive polyps** are called gastro- zooids.

They alone take up nutrition in the colony.

A mouth is present at the tip of the hypostome. Near the base of a gastrozooid usually a single, long and contractile tentacle arises. It shows batteries of nematocysts. Lateral branches are present called tentilla.

Gastrozooids **catch the prey** and digest it. The digested food is thrown into the coenosarcal canal.



In **Pennatula** the gstrozooids modified in to nectocalyx which are like buds on the body and helps in driving the water.

In **Renella** nectocalyx are in bunches some times called as pseudonecocalyx.

In **Millipora** many gastropores protrude out from the polyp. Each polyp with 4-6 tentacles and cnidoblast buds .

2. Dactylo zooids :

They are called **Palpons, feelers or tasters.**

They resemble the gastrozooids.

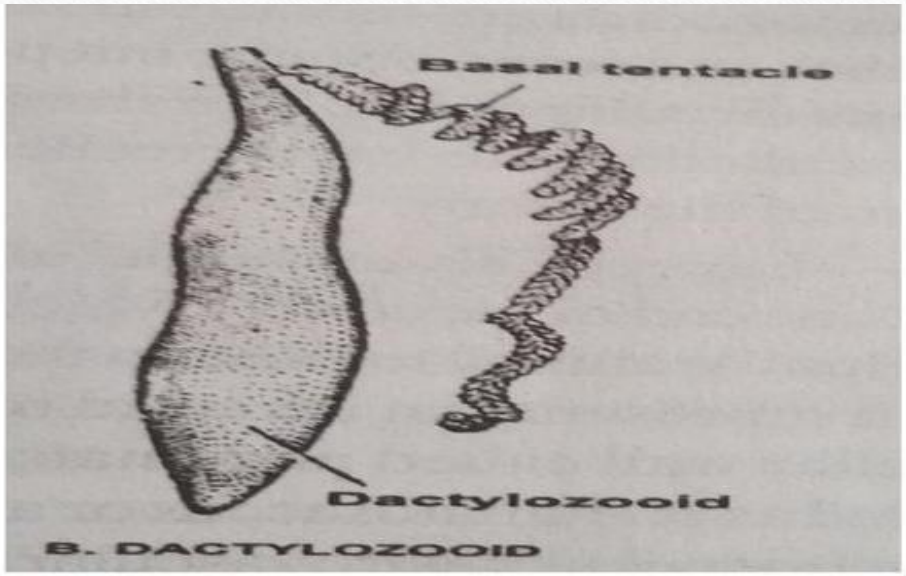
They do not show mouth. Their basal tentacle is un branched.

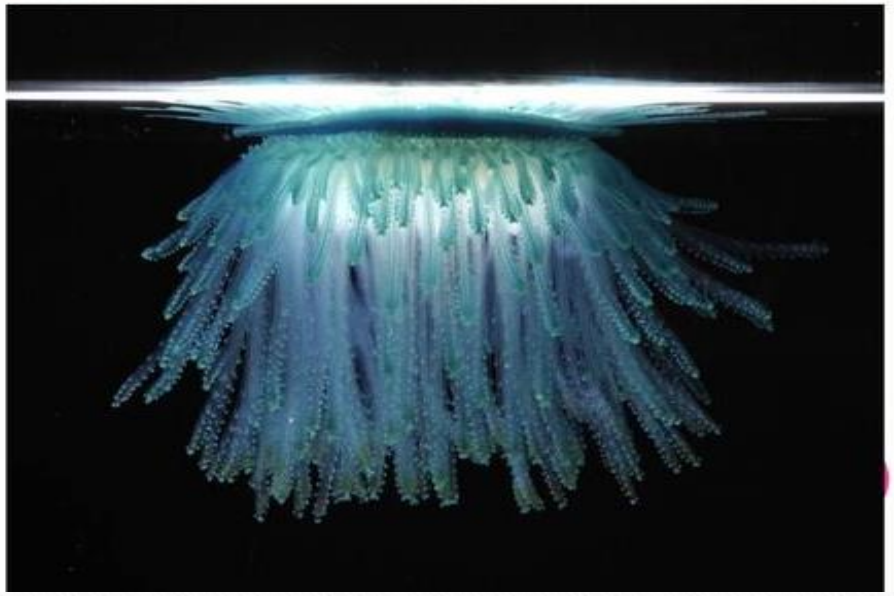
In Physalia, the tentacle is very long.

In velella and Porpita the margin of the colony bears long and hollow tentacles.

These zooids are **protective in function.**

They bear batteries of nematocysts.





3. Gonozooids :

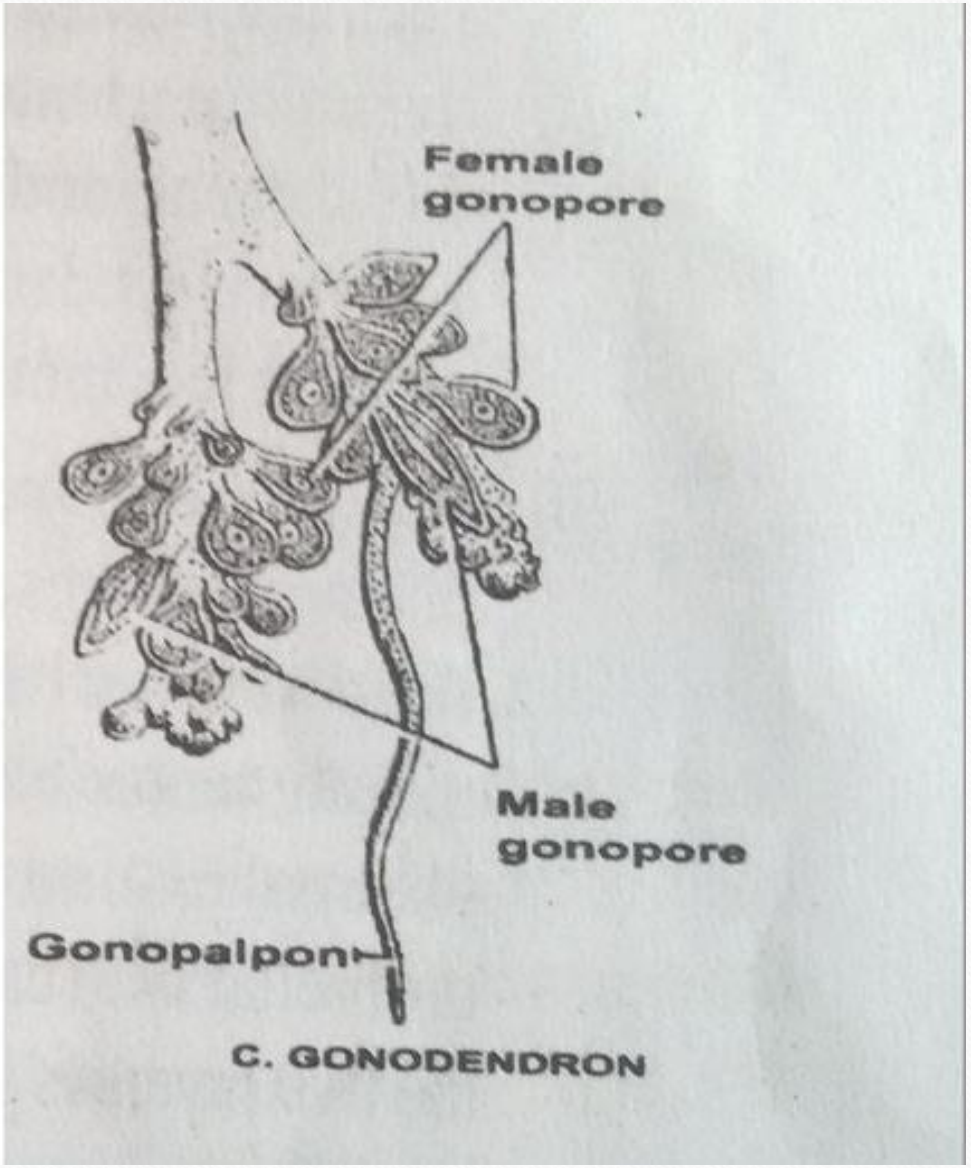
The reproductive zooids

They have no mouth.

In Physalia the gonozooid shows branched stalk, bearing clusters of gonophores (gonopalpon).

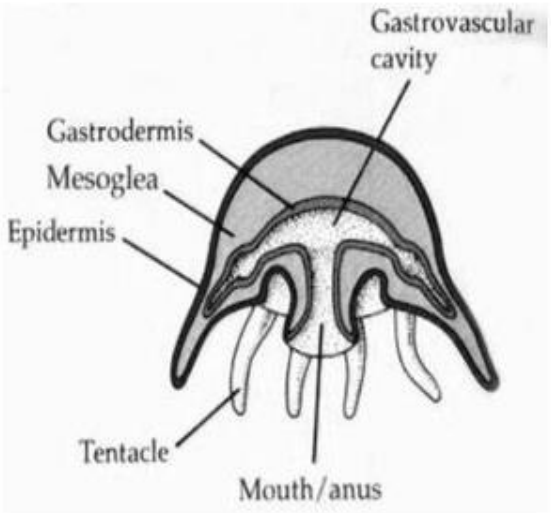
Gonozooids produce medusae called gonophores.

In Porpita and Velella dactylozooids are treated as gonodactylozooids.



MEDUSOID FORMS :

- **Pneumatophores :**
- **Nectopore or Nectocalyx or swimming zooid:**
- **Bracts :**
- **Gonophores :**



1. Pneumatophores : It functions as a **float**. It is an inverted medusan bell. The walls are two layered and highly muscular. The epidermal lining becomes glandular to form a gas gland. The gas gland secretes gas into the air-sac

1)The pneumatophore is small in Halistemma.

2)The pneumatophore is very large in Physalia.

3)It is disc-shaped in porpita.

2. Nectopore or Nectocalyx or swimming zooid:

Nectocalyces or nectophores are bell-shaped medusoids with a velum, radial canals and circular canal, they have no mouth, manubrium, tentacles or sense organs, A nectocalyx is muscular and brings about locomotion of the colony by swimming. It is also referred to as nectophore or nectozooid.

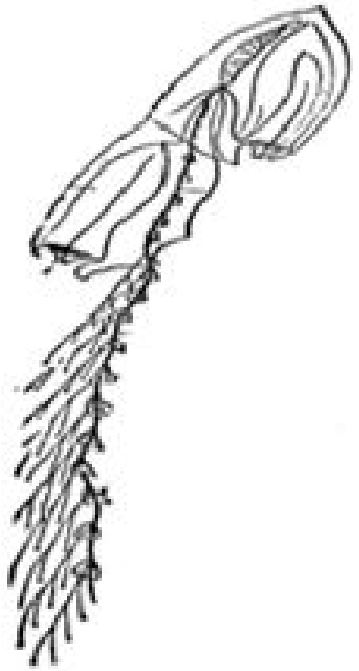


Fig: Nectocalyx

3.Bracts : They are also known as **hydrophyllia**. They are **leaf like, helmet shaped**.

- They serve to cover and **protect other zooids of the colony.**

Fig. Bract(Hydrophyllia)

4. Gonophores : Bearing **gonads**, male gonads produce sperm and female gonad produce ova

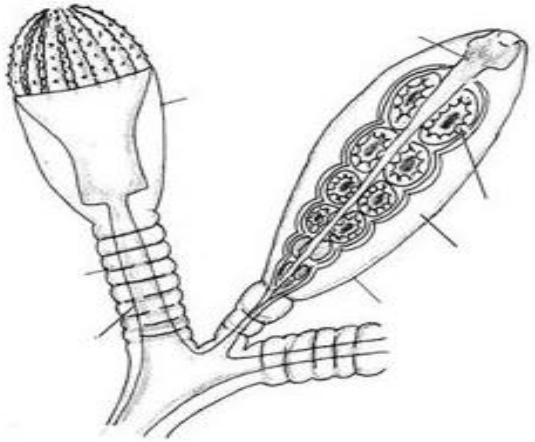


Fig: Gonophores

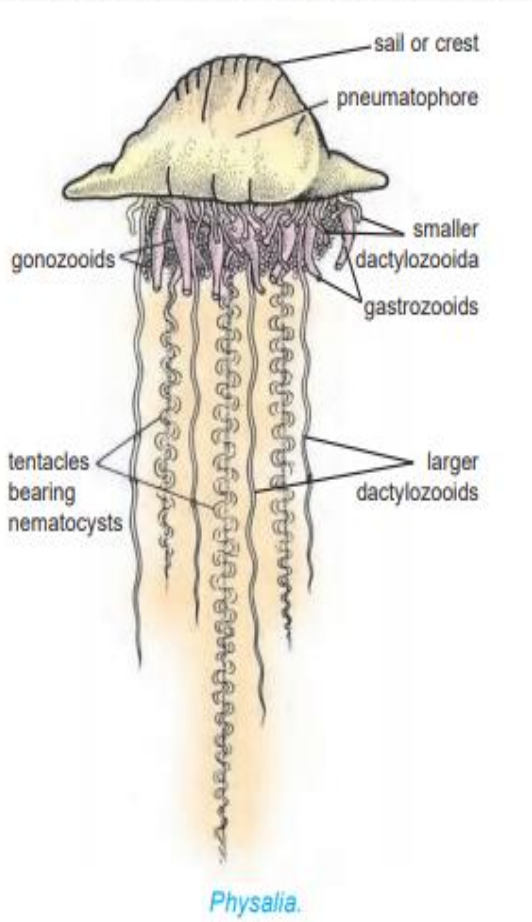
NOTABLE POLYMORPHIC COLONIES

Hydrozoans exhibit remarked development of Polymorphism. Some of them are Physalia, Halistemma, Porpita

Physalia: Is commonly called as **Portuguese man of war**. This is a free floating pelagic colonial form.

The medusa is modified in to a big pneumatophore or float which floats above the water. The underside of the float has cormidia. Each cormidium consists of a small dactyl zooids with a long slender tentacle, a large dactylozooid with an enormous nematocyst bearing fishing tentacles.

A branched gonozooid with male and female gonophores is present.

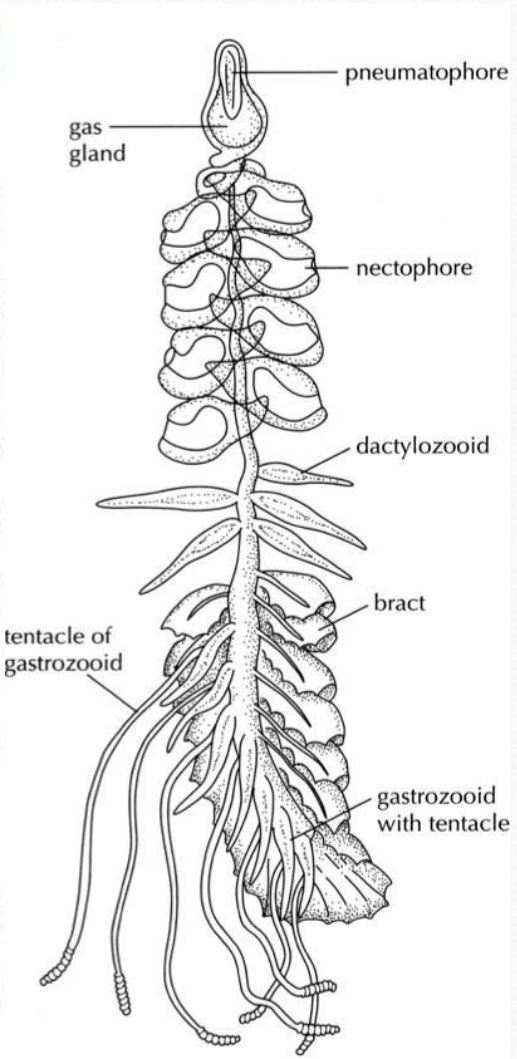


Physalia.

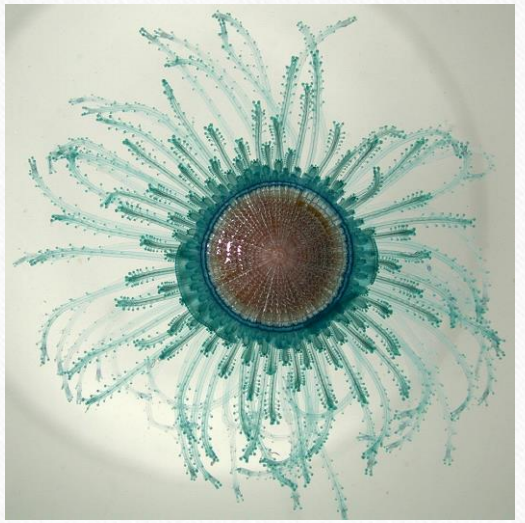
Halistemma: This is a **floating form** with long, thin peduncle

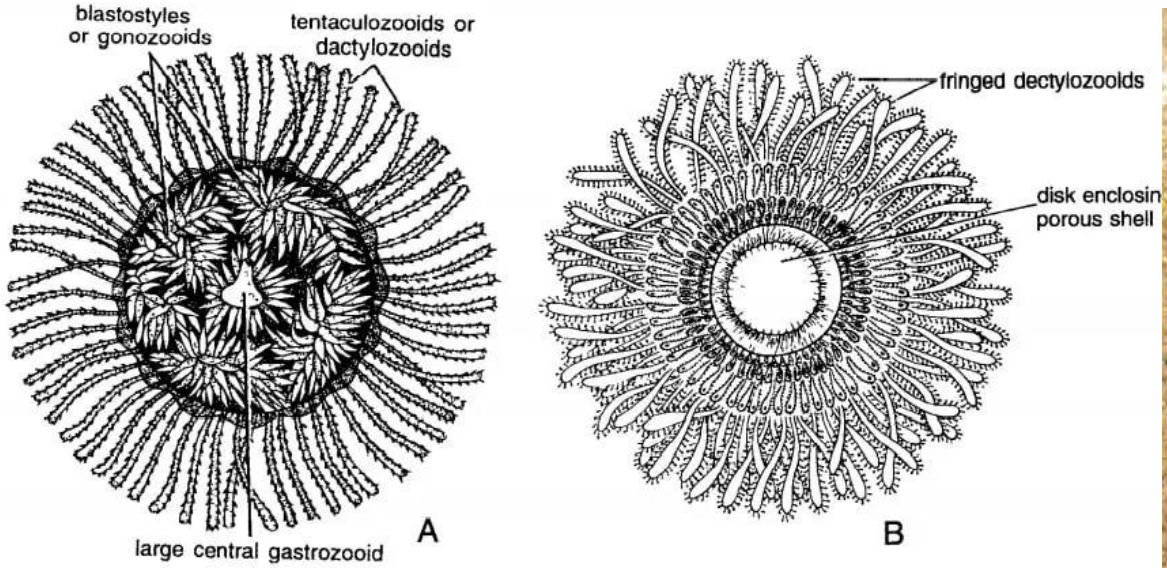
(with nodes) having different zooid. Pneumatophore is at first anterior end of peduncle and helps the animal float on the surface of the water. The bottom of the float has asmmetric medusa, which are called nectocalyces which help in locomotion.

Each nectocalyces is with nodes and bell shaped. Manubrium is absent.



Porpita: It has medusoid disc like large pnematohore and chitinous shell with many concentric gas chambers. On the ventro-central region is a single large gastrozooid which is surrounded by clusters of small gonozooids which bear sexual medusae. On the edge of it tantacle like dactylozooids armed with nematocysts.





Porpita. **A.** Oral ventral side, **B.** Dorsal side.

SIGNIFICANCE OF POLYMORPHISM

The phenomenon of polymorphism is essentially one of **division of labour** in which specific functions are assigned to different individuals. Thus, **polyps are modified for feeding, protection and asexual reproduction,** while **medusae are concerned with sexual reproduction.** This distribution of functions among diversified individuals and their subsequent modifications in coelenterates may have resulted from their initial simple organization and lack of organ specialization. Polymorphism gave the colonies competitive edge in protection and food gathering and eventual survival. polymorphism: colonies of some species have morphologically differing individuals each specialized for certain roles e.g. feeding, reproduction & defense etc.

PARASITIC ADAPTATIONS AND LIFE CYCLE PATTERNS IN PARASITES BELONGING TO DIFFERENT TAXA

The parasitic adaptation can be defined as the profound changes and modifications occurring in per-suit of successful living so that the parasite is fully adapted inside the body of the host. Cameron (1965) has stated that "the parasites continue to lead their life successfully by adopting various modifications and compromises—compromises in some respects parallel to those found among free-living sessile animals and those which have adopted monophagy."

Morphological Adaptations:

Transformation from external to internal:

Parasitism undoubtedly began as a chance of contact of one organism with another. Sooner or later the guest began to partake the food procured by the host, becoming more and more dependent on such food and in many instances was gradually changed from an ecto-to endo-parasite. The structural and functional modifications in parasites depend on the degree of parasitism. In a successful parasitic group of animals the modifications run in two distinct directions—one leads to loss or degeneration while the other leads to gain or new attainment.

Degeneration

The degeneration particularly involves the locomotor, digestive and sensory organs. As the parasites live on the digested or semi digested food of the host, their organs of locomotion and alimentation have become simplified. They are mostly useless.

Organ of locomotion:

Total reduction of locomotor organs is observed in adult except in the free-living larval phase when the ectoderm becomes ciliated, e.g., Miracidium and Hexacanth of flatworm.

Organ of alimentation:

(a) Total disappearance in the adult tapeworm;

(b) In the hermaphroditic adult trematode it consists of a blind gut;

(c) In Redia stage it is further simplified and completely eliminated in the Sporocyst stage.

Sensory organs:

The sensory organs are reduced or absent (e.g., Fasciola) in some endoparasitic platyhelminthes, and in some nematodes (adenophoreans) the sensory organs are poorly developed and represented by amphids. This condition can be correlated with the sedentary life of endoparasites in which they live, in a more or less uniform host's environment.

New Attainment:

Integument:

The integument covering the body of helminthes has become greatly modified to serve following three important functions:

Absorption:

The phenomenon of absorption is striking in larval stages which develop in the lymph spaces of mollusca or in blood stream, muscle fibre or musculature of vertebrates (Cysticercus, Trichinella) and in the adult blood flukes in the hepatic portal system and in various species of liver flukes (e.g., Fasciola) in the bile tract. In these cases, the body is leaf-shaped and dorsoventrally flattened, and the entire integument becomes thin and undoubtedly serves partly or fully as a means for food absorption.

Protection against the digestive juice of the host:

In the case of the larval flukes which have to pass through stomach in order to reach the bile passage for further development—a cyst capsule is provided as a protection against the digestive juice. Certain Amphistomes (in Ruminants) and Gnathostomes (in cats, dogs and horses) remain attached to the stomach wall. They are provided with thick resistant integument impregnated with chitin-like substances of impermeable nature.

Protection against abrasion:

Many trematodes living in the intestinal tracts are provided with spinous integument to guard against the abrasive action of the food and roughage passing through the gut. These spines may be of accicular, dentate or placoid types and are rooted into the sub-integumental layer. The oriental liver fluke Clonorchis sinensis, which was probably an intestinal parasite before it became a bile duct inhabitant, possesses a spinous integument during its larval phase— in fact, until it becomes safely located in the bile passage..

Modification for attachment:

Essential prerequisite for parasitic life is the possession of suitable mechanism to attach strongly with host body. Following modifications for attachment are often encountered:

Acetabulum or sucking organ:

In the liver flukes (e.g., Fasciola) it consists of two suckers on the ventral side of the body—one anterior and the other posterior to it. In the case of human tapewarm, it consists of either sucking tongue or groove, or four cups at the cephalic end of the worm. In the tapeworms, the scolex bears four large suckers (*Taenia solium*) or accessory suckers (e.g., Myzophyllobothrium) or leaf-like outgrowth on the scolex, called bothridium. Phyllobothrium -has four bothridia, each bothridium with a sucker. Echinobothrium bears two bothria (It is a shallow groove on the scolex) and a spiny head stalk. Tetrarhynchus bears four bothria and four eversible proboscis bearing spines.

In some monogeneans, a highly specialized attachment organ at the posterior part of body called haptor (Opisthaptor) with suckers and hooks (e.g., Polystoma, Choricotyle, Polystomoidella) and an anterior adhesive organ (sometimes called prohaptor) consisting of suckers and adhesive glands (e.g., Gyrodactylus) are present.

Hooks

In Taenia, hooks are arranged in double circlet at the base of rostellum. In the dog tapeworm (*Diphylidium caninum*), it occurs in several rows around the proboscis which may be everted. Hooks are often provided with series of teeth and are placed in the buccal capsule. In Macracanthorhyncus sp. a buccal armature of tooth-like structure is present, which serves for tissue aberration and anchorage.

Glands

Anchorage in favourable habitat, and Aid in food supply. In trematodes these unicellular glands, known as cystogenous gland, are more common in the Cercarial stage and serve the purpose of penetration to host tissue by elaborating histolytic substances. In hookworms (Ancylostoma)— there are glands in buccal region which are supposed to have anti-coagulative and histolytic properties.

Modification for reproduction

The most conspicuous elaboration in organs and tissues in the helminthes is that of the reproductive system.

Both Platy—and Nematodes have large part of their body mass occupied by these organs and their products. The adult flatworms, with few exceptions, are hermaphrodite. The roundworms are dioecious. Adult flukes and tapeworms have particularly complex reproductive organs. In both the groups, cross-fertilization, which was formerly the rule and is still a possibility, has been superseded by self-fertilization. In tapeworm, instead of a single body unit, there are multiple segments— proglottids, each one is sexually complete in itself. To ensure the perpetuation of the parasite species, endoparasites produce a large number of eggs. The adult *Ascaris lumbricoides* produces 200,000 eggs daily. The human hook-worm Ancylostoma duodenale produces 25,000- 30,000 eggs per day. Each gravid segment of tapeworm contains 30,000- 50,000 eggs and the gravid segments may produce up to 1000. *Hymenolepis diminuta* may produce up to 250,000 eggs per day throughout the life. Such an enormous amount of eggs which are produced by the endoparasites help to continue the race where the chances of survival are very remote.

The unaltered systems

Two systems of organs—the nervous and excretory, have remained almost unchanged. However, the excretory system in the case of flatworms has undergone some insignificant changes. Greatest modifications among the helminthes have been encountered in such forms that reside in the blood or lymph systems (blood flukes and filarial worms) or in the muscular tissue (Trichinella) or forms that attach to the peritoneum (Hydatid cyst).

Physiological Adaptations:

Intracellular digestion

Adult liver flukes, Fasciola hepatica feed on bile, blood, lymph and other nutrients of the host and digestion probably extracellular and takes place in the intestinal caeca. Reserve food is mostly in the form of glycogen and fat. They can take up glucose and other molecules through their body surfaces. The species in which nutrients are absorbed through the body surfaces, is regarded as the intracellular digestion. Cestodes lack any form of digestive canal, so they feed on tissue elements and inflammatory exudates of the hosts. All nutrients are absorbed across the tegument. So digestion is intracellular. In *A. lumbricoides* both extracellular and intracellular digestions have been reported. When the cells of the intestinal wall engulf solid particles for digestion, it is called intracellular digestion. Digestion is started extra- cellularly when takes place within the intestinal lumen but is completed intracellular.

Osmoregulation

By the process of osmoregulation the endoparasitic helminthes maintain a relative constancy of balance of salts, ions and water in their tissues. Parasitic platyhelminthes such as cestodes and trematodes maintain the same osmotic pressure as that of their hosi, so there is no difficulty in maintaing life.

Anaerobic respiration

The endoparasites live in an environment where there is more or less lack of O_2. So they have become adapted in a low metabolic rate which requires a minimum amount of oxygen. In this case the respiration is anaerobic type consisting of extracting oxygen from food which are absorbed in the tegument. In the absence of O_2, energy releases by the fermentation of glycogen which is broken by glycolysis and form pyruvate or pyruvic acid ($C_3H_4O_3$) as a hydrogen acceptor from NAD and forms lactic acid ($C_3H_6O_3$) and CO_2.

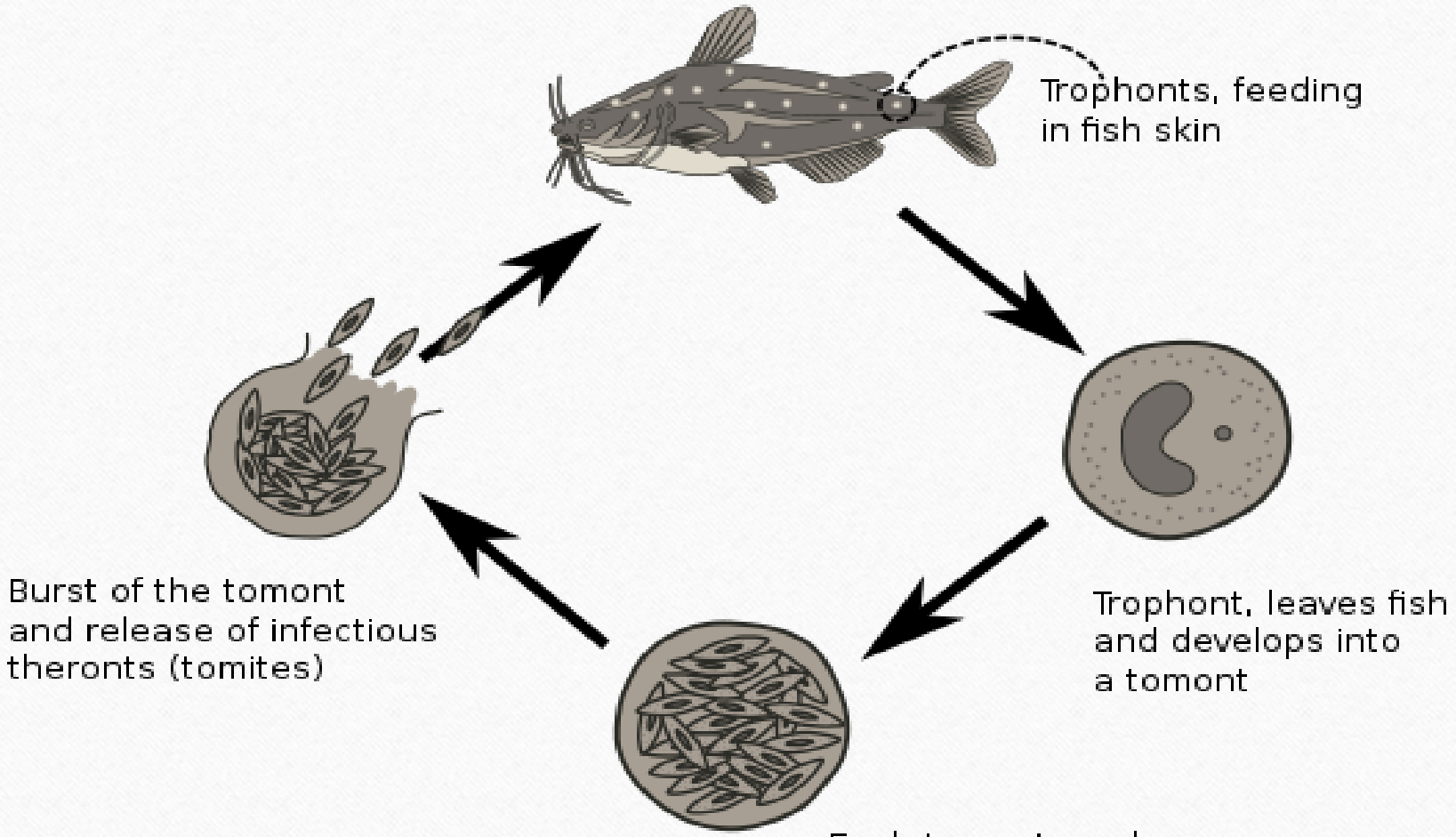
Conclusion

Viewing the groups of parasitic helminthes as a whole with respect to successive stages of adaptation which they have undergone and are undergoing, one is able to appreciate the vastness and profoundness of the principles of adaptations and at the same time how marvellously the parasitism has become successful in helminthes.

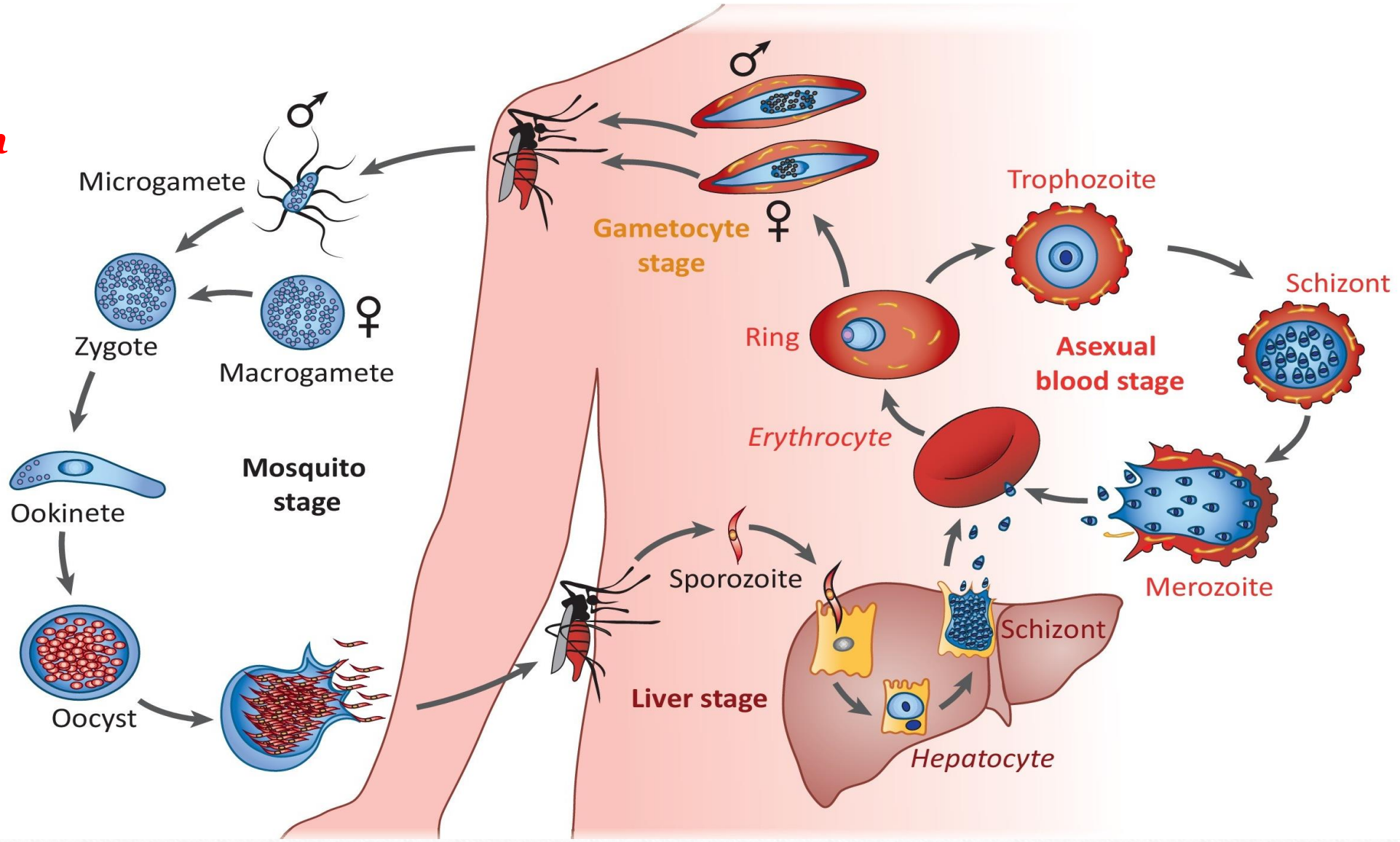
Parasite Life Cycle:

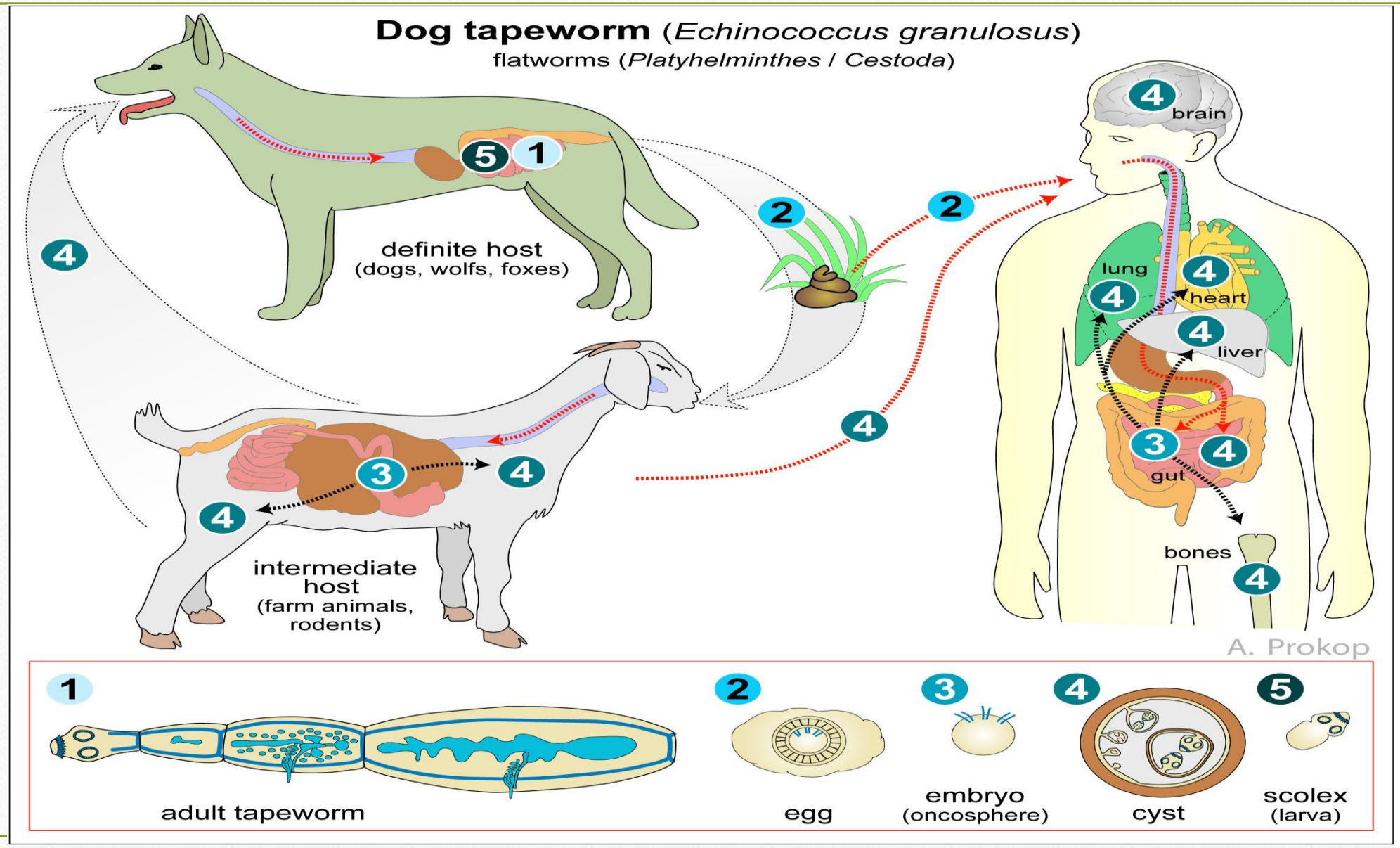
- The life cycle is a never-ending chain of events that lead to the parasite constantly reproducing and re-infesting another animal.
- There are two types of lifecycles:
  - Indirect - require different types of hosts or a vector (intermediate host) for various stages of their life cycle.
  - Direct - a life cycle in which a parasite is transmitted directly from one host to the next without an intermediate host or vector of another species.
  - Required by some parasites to complete their life cycle,
  - Advantages of an intermediate hosts include: increasing the spread of the parasite & protecting the parasite from spending too much time in the environment.

Life Cycle of Ichtyophthirius multifiliis

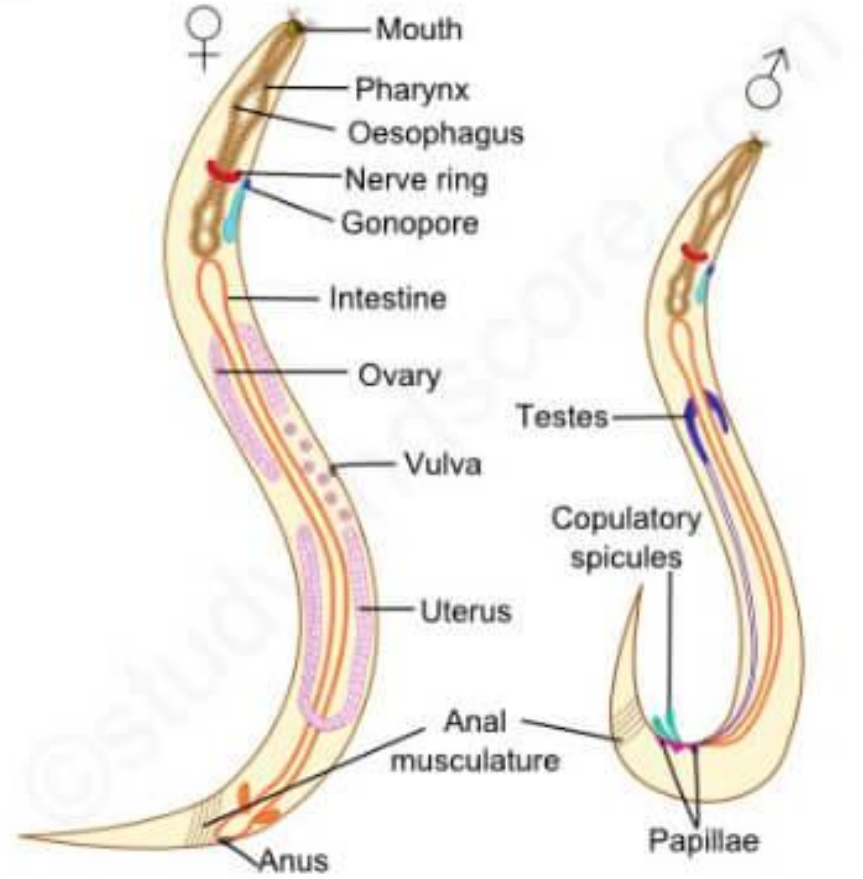


Plasmodium falciparum

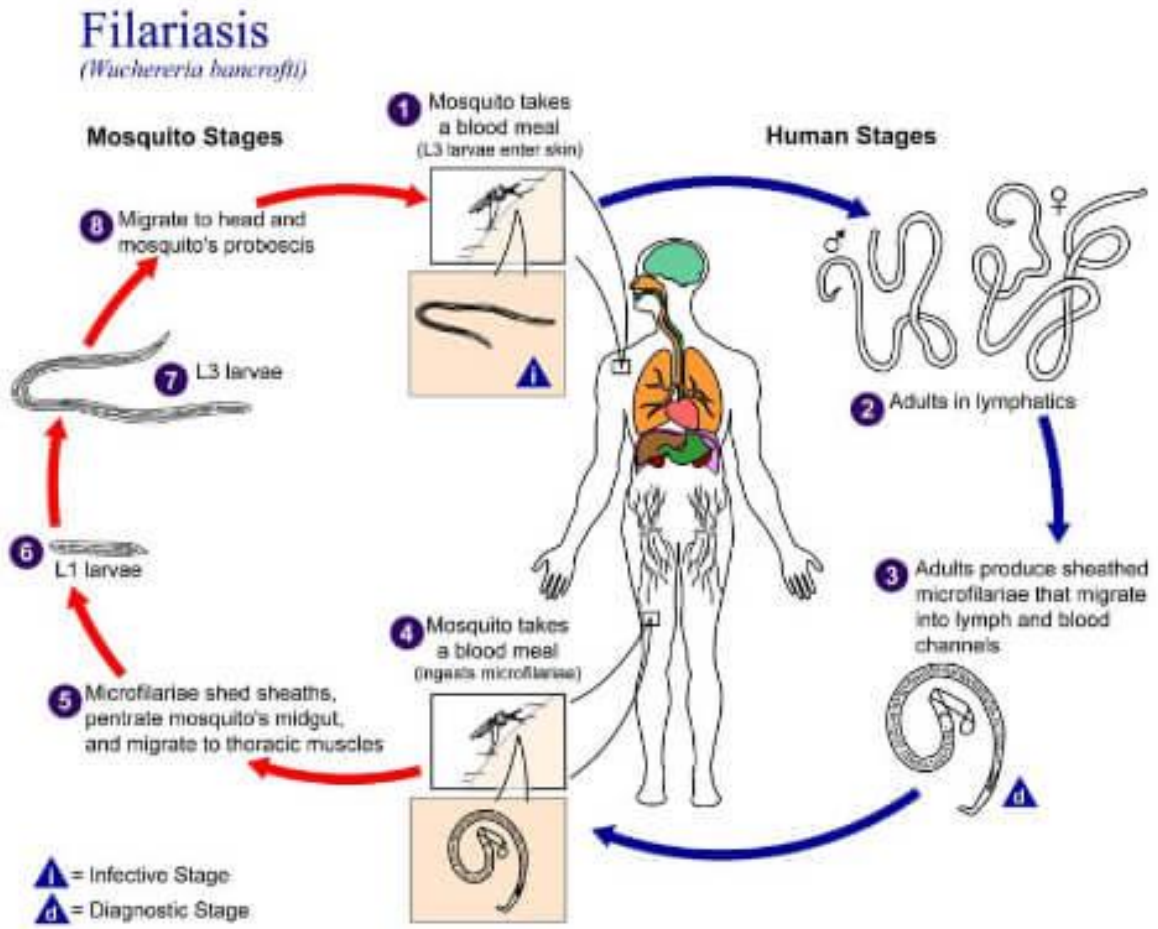


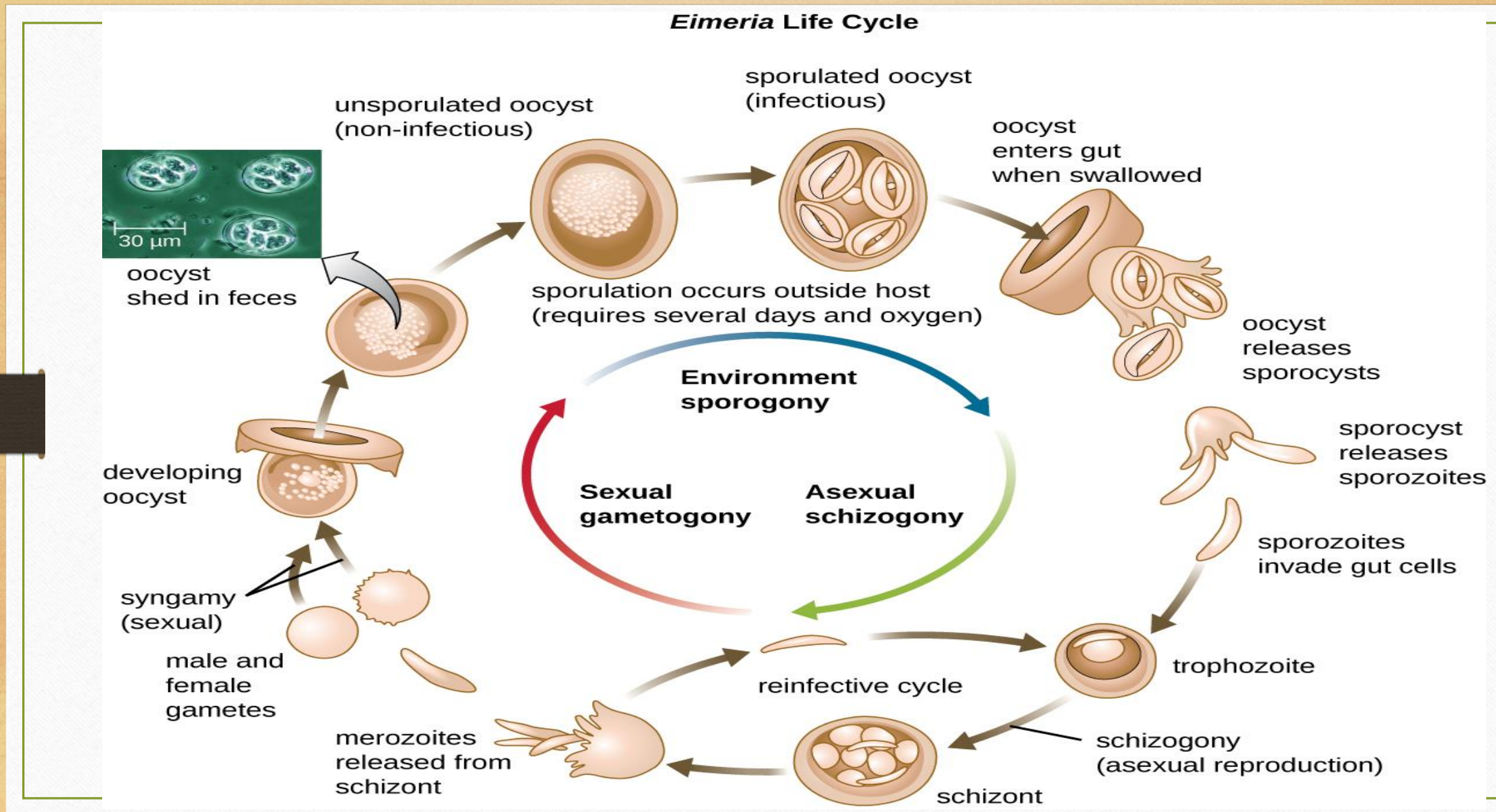

Dog tapeworm (Echinococcus granulosus)
flatworms (Platyhelminthes / Cestoda)
definite host
(dogs, wolfs, foxes)
intermediate host
(farm animals, rodents)
brain
lung
heart
liver
gut
bones
A. Prokop
adult tapeworm
egg
embryo
(oncosphere)
cyst
scolex
(larva)

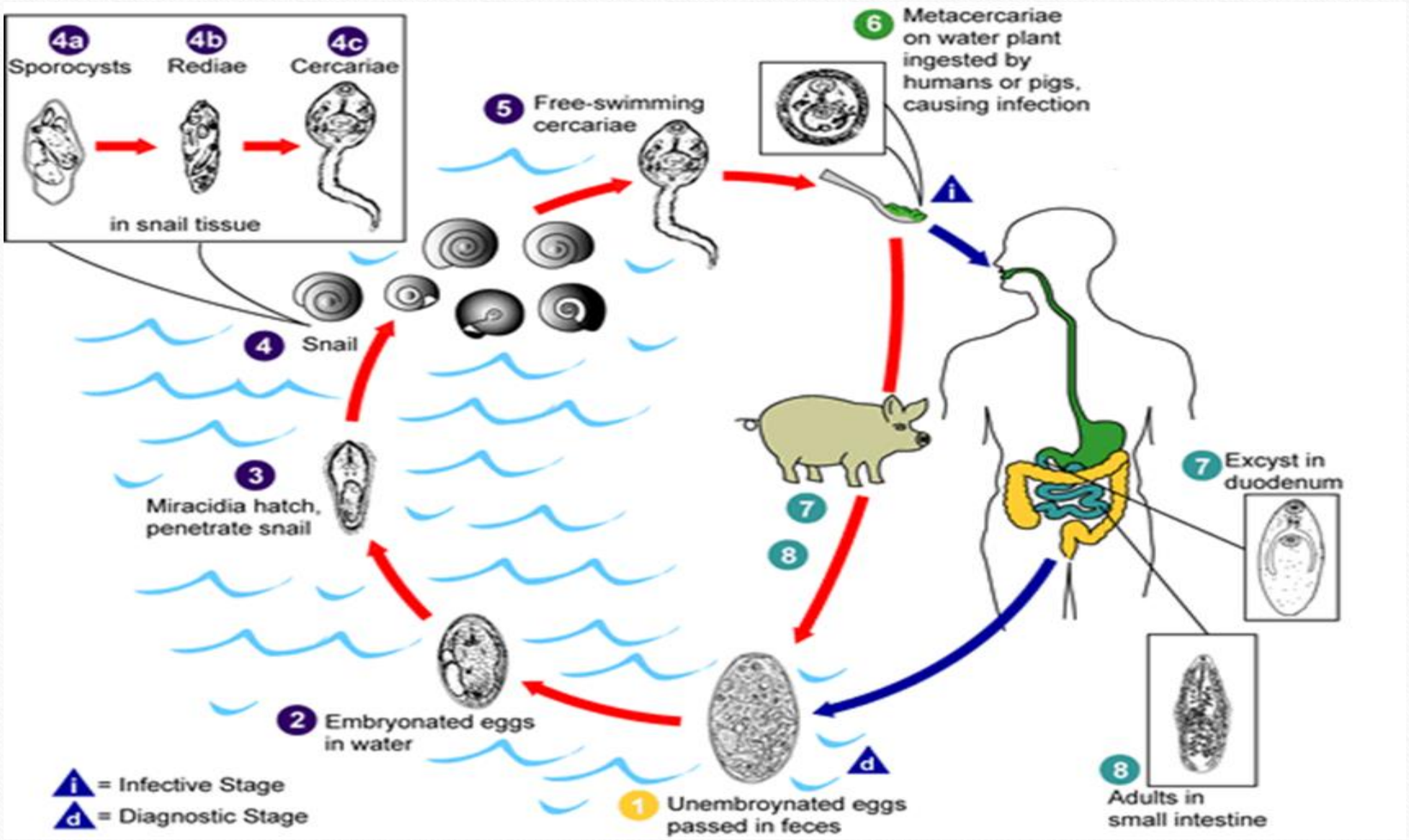
Wuchereria bancrofti- Habitat, Morphology and Life Cycle



WUCHERERIA - ADULT FEMALE AND MALE




Eimeria Life Cycle
unsporulated oocyst
(non-infectious)
sporulated oocyst
(infectious)
oocyst
enters gut
when swallowed
30 µm
oocyst
shed in feces
sporulation occurs outside host
(requires several days and oxygen)
oocyst
releases
sporocysts
Environment
sporogony
sporocyst
releases
sporozoites
developing
oocyst
Sexual
gametogony
Asexual
schizogony
sporozoites
invade gut cells
syngamy
(sexual)
male and
female
gametes
reinfective cycle
trophozoite
merozoites
released from
schizont
schizogony
(asexual reproduction)
schizont

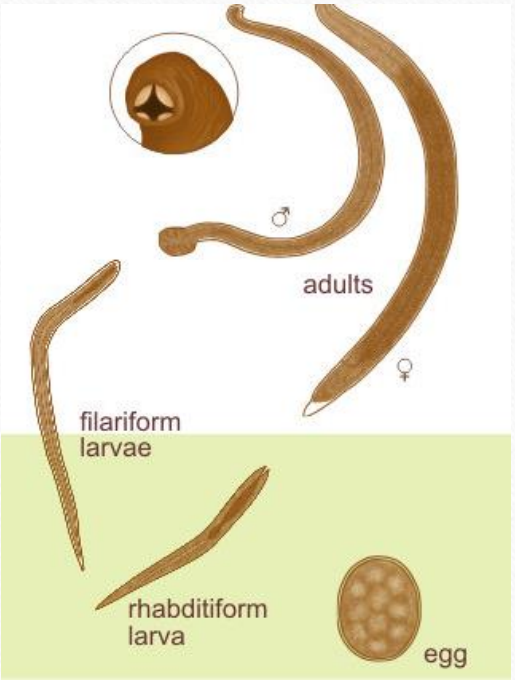

4a Sporocysts
4b Rediae
4c Cercariae
in snail tissue
5 Free-swimming cercariae
6 Metacercariae on water plant ingested by humans or pigs, causing infection
i
4 Snail
3 Miracidia hatch, penetrate snail
7
8
7 Excyst in duodenum
2 Embryonated eggs in water
d
1 Unembroynated eggs passed in feces
8 Adults in small intestine
i = Infective Stage
d = Diagnostic Stage

PARASITES LISTED BY WHO

- Hookworm
- *Scabies mite*
- Roundworm
- Flatworm blood fluke
- Tapeworm
- Pinworm
- *Wuchereria bancrofti*
- *Toxoplasma gondii*

Hookworm (*Necator americanus*)

- This parasitic nematode worm begins life outside the body and is transmitted through contaminated water, or fruits and vegetables.
- The hookworm larvae grow inside the human intestines where they attach to the wall of the intestine and drink the blood of the host, sometimes causing a form of anaemia called anchylostomiasis.
- Symptoms: weakness, abdominal pain, nausea, diarrhoea, anaemia

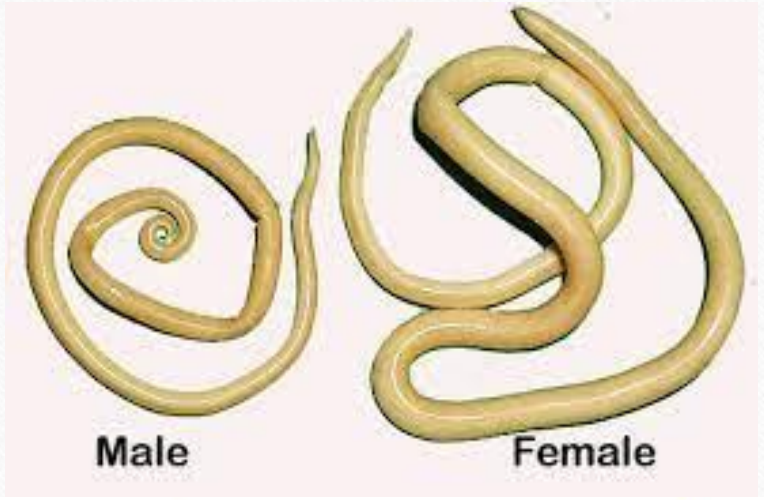


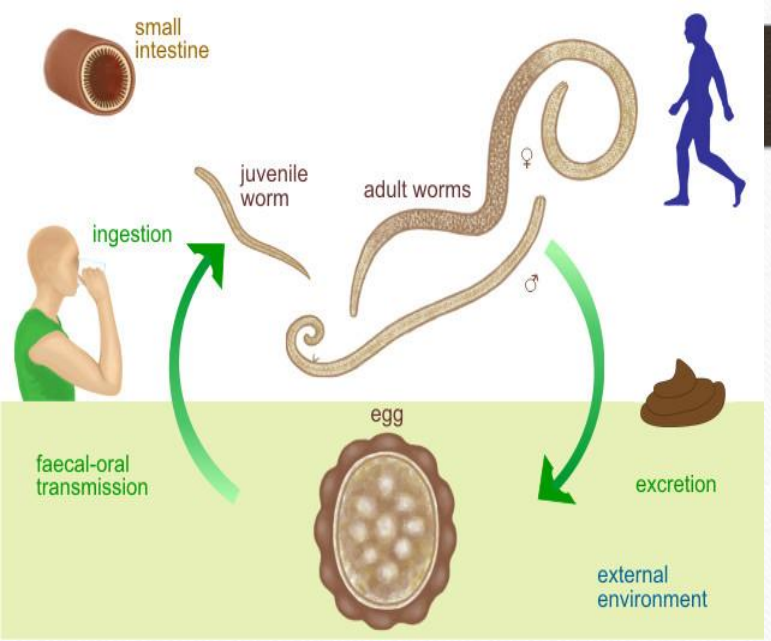
Scabies mite (*Sarcoptes scabiei var. hominis*)

- Commonly known as the human itch mite, the parasite is transferred by physical contact.
- The female mite lays her eggs on the skin of a human, causing a reaction and inflammation.
- This is exacerbated when the mother begins burying the eggs under the skin causing intense itching, a condition commonly known as scabies.
- Symptoms: itching, soreness, pus-filled nodules, skin irritation

Roundworm (*Ascaris lumbricoides*)

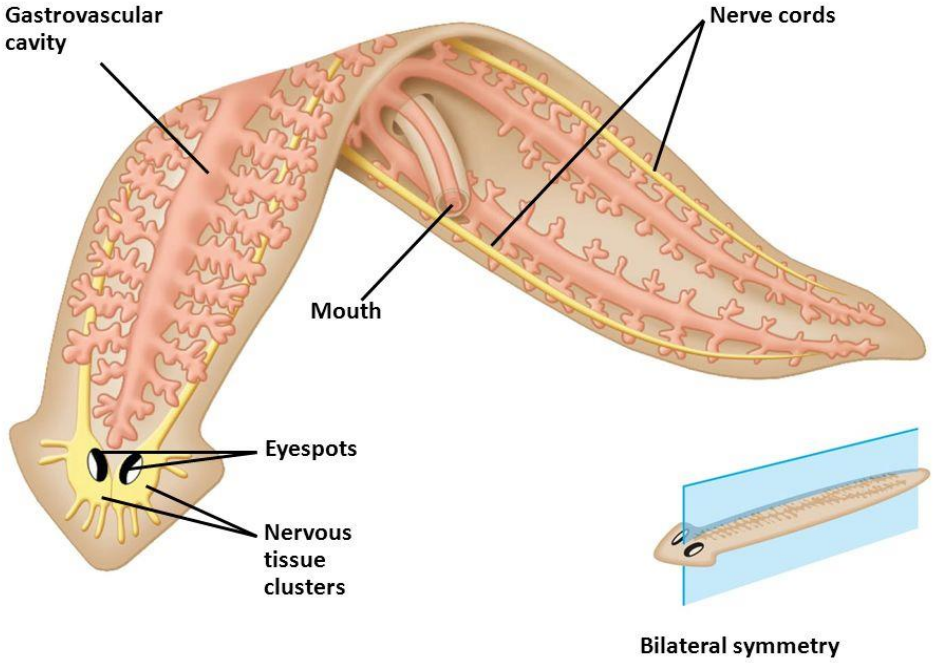
- These are the largest of the intestinal nematodes affecting humans, growing to 15-35 centimetres in length.
- They are transferred by ingestion. The eggs hatch and quickly penetrate the intestinal wall, where they enter the bloodstream.
- From there, the roundworm makes its way to the lungs, from where it is coughed up and swallowed, returning it to the gut.
- Symptoms: fever, tiredness, allergic rash, vomiting, diarrhoea, nerve problems, wheezing / coughing





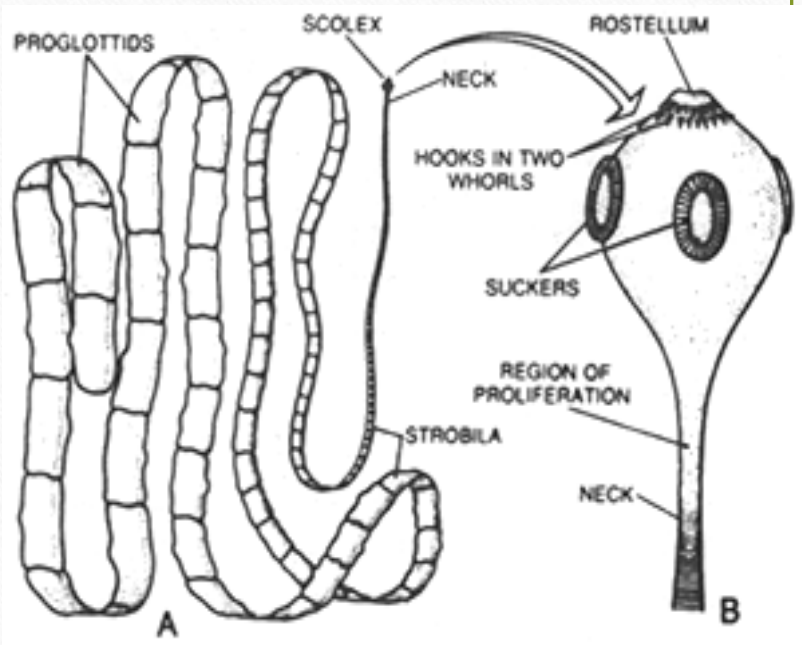
Flatworm blood fluke (*Schistosoma mansoni, S. haematobium, S. japonicum*)

- These small flukes live in the bloodstream of infected hosts and cause schistosomiasis, also called bilharzia.
- They live in water, and penetrate the skin of victims who come into contact with contaminated water.
- The parasite causes inflammation (swelling) and damage to organs, particularly the liver.
- The adult worms can persist in their human host for decades, and may not cause any symptoms for years.
- They leave the host in faeces and spend part of their lifecycle in a snail host.
- Symptoms: fever, aching, cough, diarrhoea, swollen glands, lethargy



Tapeworm (*Taenia solium*)

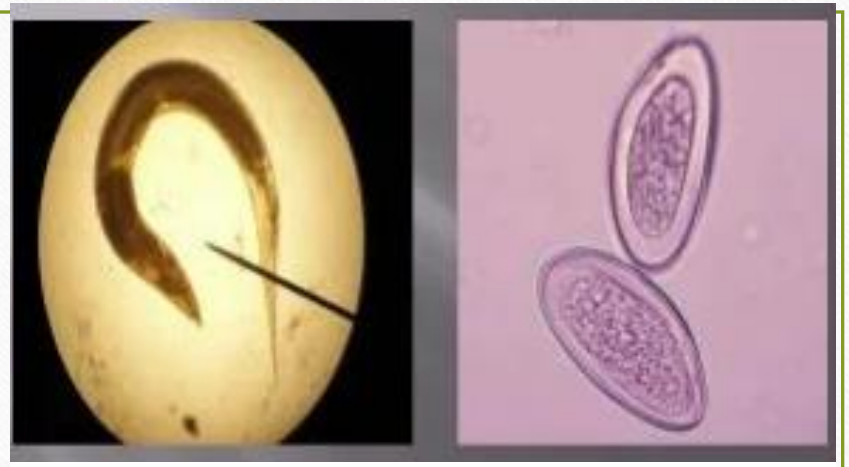
- Transmitted through infected food, a tapeworm attaches itself to its victim's intestine with hooks on its "head", or scolex.
- They mature over three to four months, during which time the reproductive organs develop.
- Tapeworms can survive for up to 25 years in humans.
- Their eggs are excreted in faeces and can survive on vegetation, where they are then consumed by cattle or pigs, or passed on to humans.
- Symptoms: nausea, vomiting, inflammation of the intestine, diarrhoea, weight loss, dizziness, fits, malnutrition

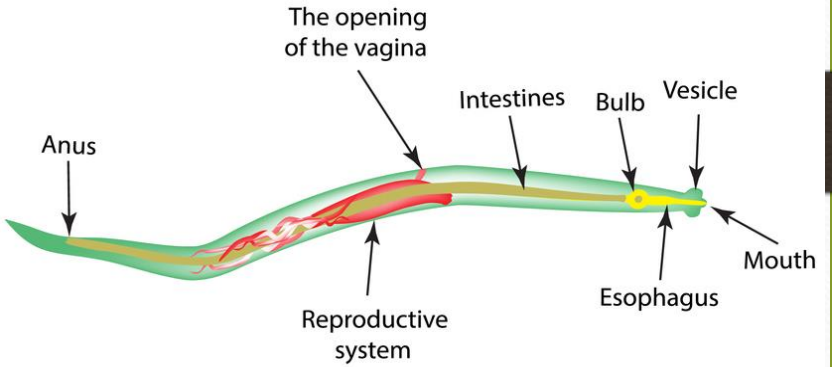


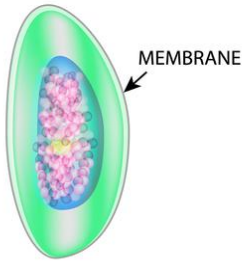
Taenia solium : A. whole; B. its scolex

Pinworm (*Enterobius vermicularis*)

- Pinworms are a common human parasite, causing enterobiasis.
- Adult females range from 8 to 13 millimetres in length and have a long, pin-shaped posterior, for which the worm is named.
- Pinworms mate by traumatic insemination - the male stabs the female with his penis - after which the male dies.
- They make their home in the host's intestines, but unlike many parasites they do not pass into the blood and cannot survive in other parts of the body for any length of time.
- They lay their eggs outside the body, usually around the anus, causing itching: this assists the larvae's spread via hand contact.
- Symptoms: Irritation and scratching



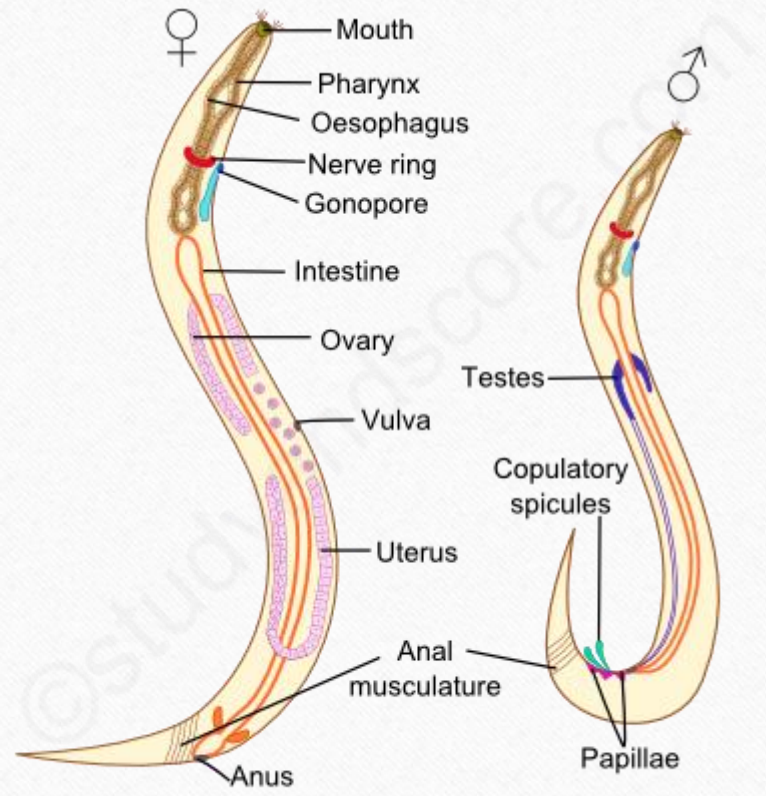




EGG OF PINWORM

Wuchereria bancrofti

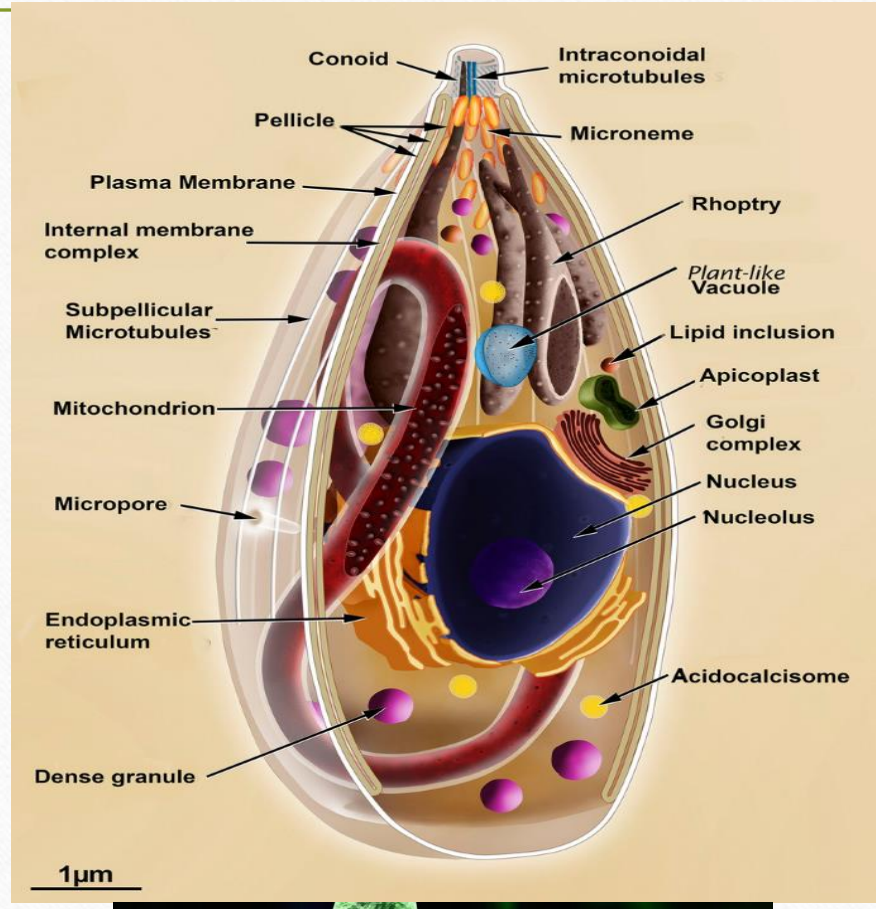
- Mosquitoes carry this parasite, which they release into the bloodstream of a human host as they feed.
- The larvae move to the lymph nodes, which are predominantly in the legs and genital area, and develop into an adult worm over the course of a year.
- They are commonly responsible for the tropical disease filariasis, but in extreme cases can cause elephantiasis.
- Symptoms: fever, chills, skin infections, painful lymph nodes, thickened skin, swelling



WUCHERERIA - ADULT FEMALE AND MALE

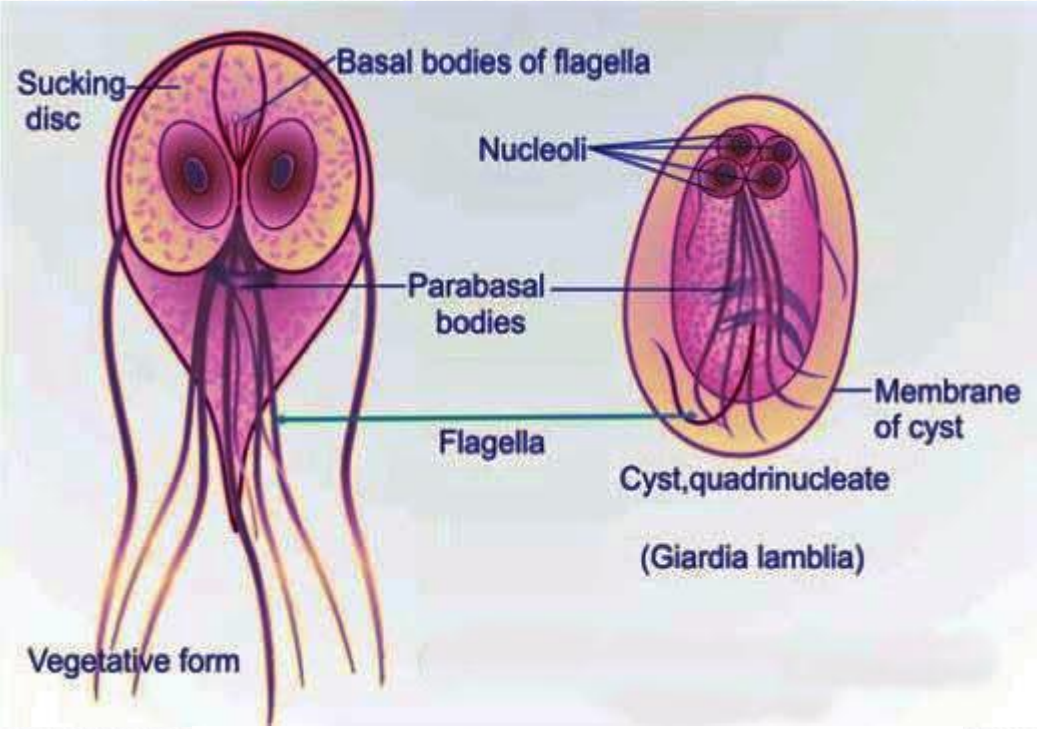
Toxoplasma gondii

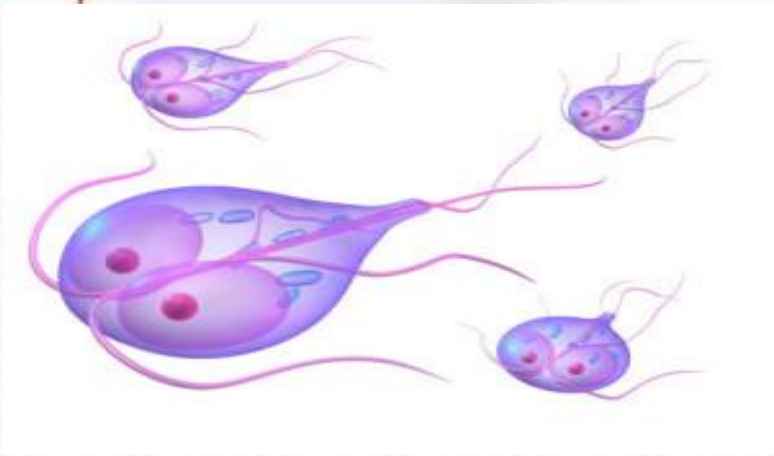
- A common, crescent-shaped parasite that invades the central nervous system.
- Humans become infected with this organism by eating undercooked meat or by handling infected cat litter.
- Most people have been exposed to this parasite and show antibodies for it, but few individuals show symptoms.
- Those with a compromised immune system are more susceptible, and fetuses can suffer serious or fatal effects from infection.
- Symptoms: flu symptoms, fever, chills, fatigue, headache



Giardia lamblia

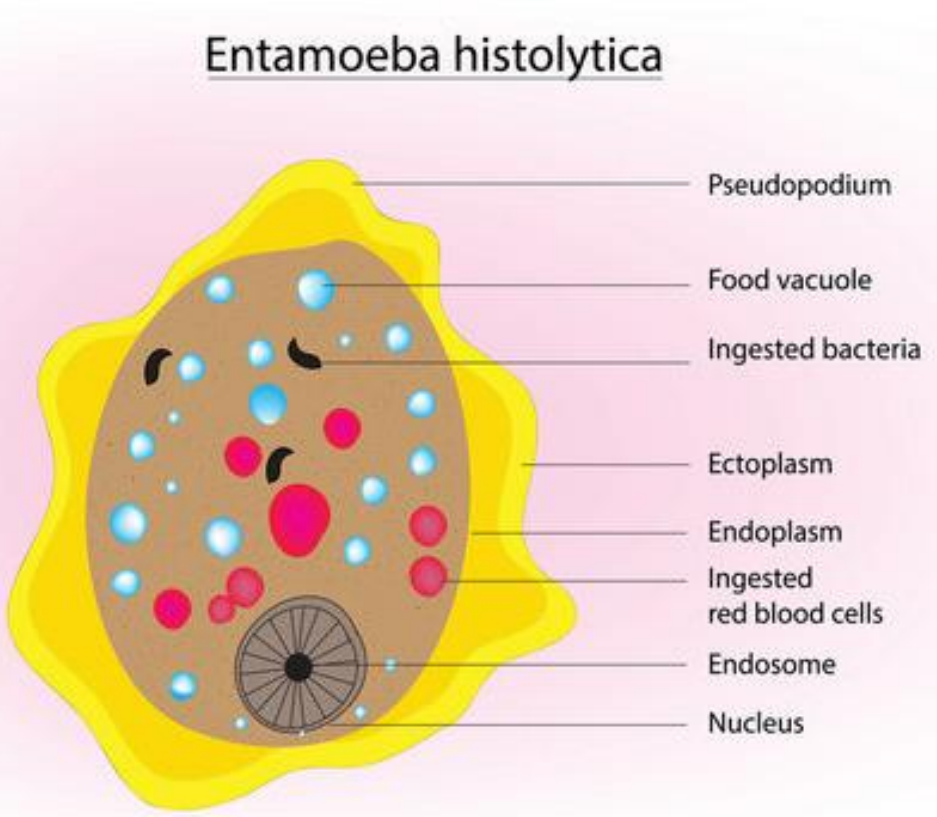
- Giardia lamblia is a flagellated protozoan parasite.
- It lives and reproduces in the intestine, causing an infection of the small intestine known as giardiasis.
- When it takes up residence in a human's gut, it results in inflammation and and other damage, reducing the gut's ability to absorb nutrition and causing diarrhoea.
- The parasite is highly resistant to water treatment and is known to exist in drinking water.
- Symptoms: diarrhoea, nausea, abdominal pain, weight loss, characteristic "rotten-egg"-tasting burps

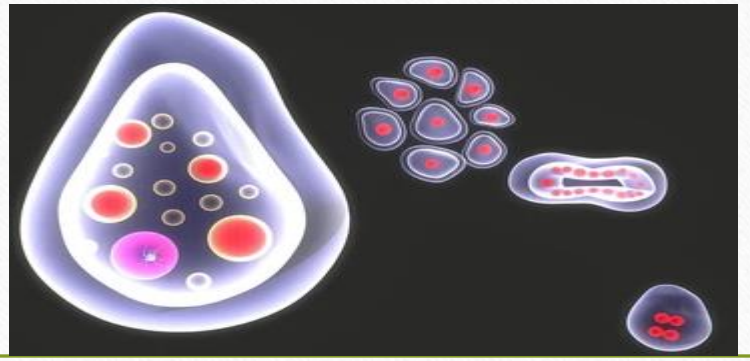




Entamoeba histolytica

- This single-celled organism causes a disease called amoebiasis.
- It predominantly infects humans and other primates.
- It can be found in water, damp environments and in soil, and can contaminate fruits and vegetables.
- It spreads through faecal contamination.
- Other than the malarial parasite, it causes more deaths than any other protozoan.
- Symptoms: abdominal pain, weight loss, weakness, diarrhoea, liver abscess





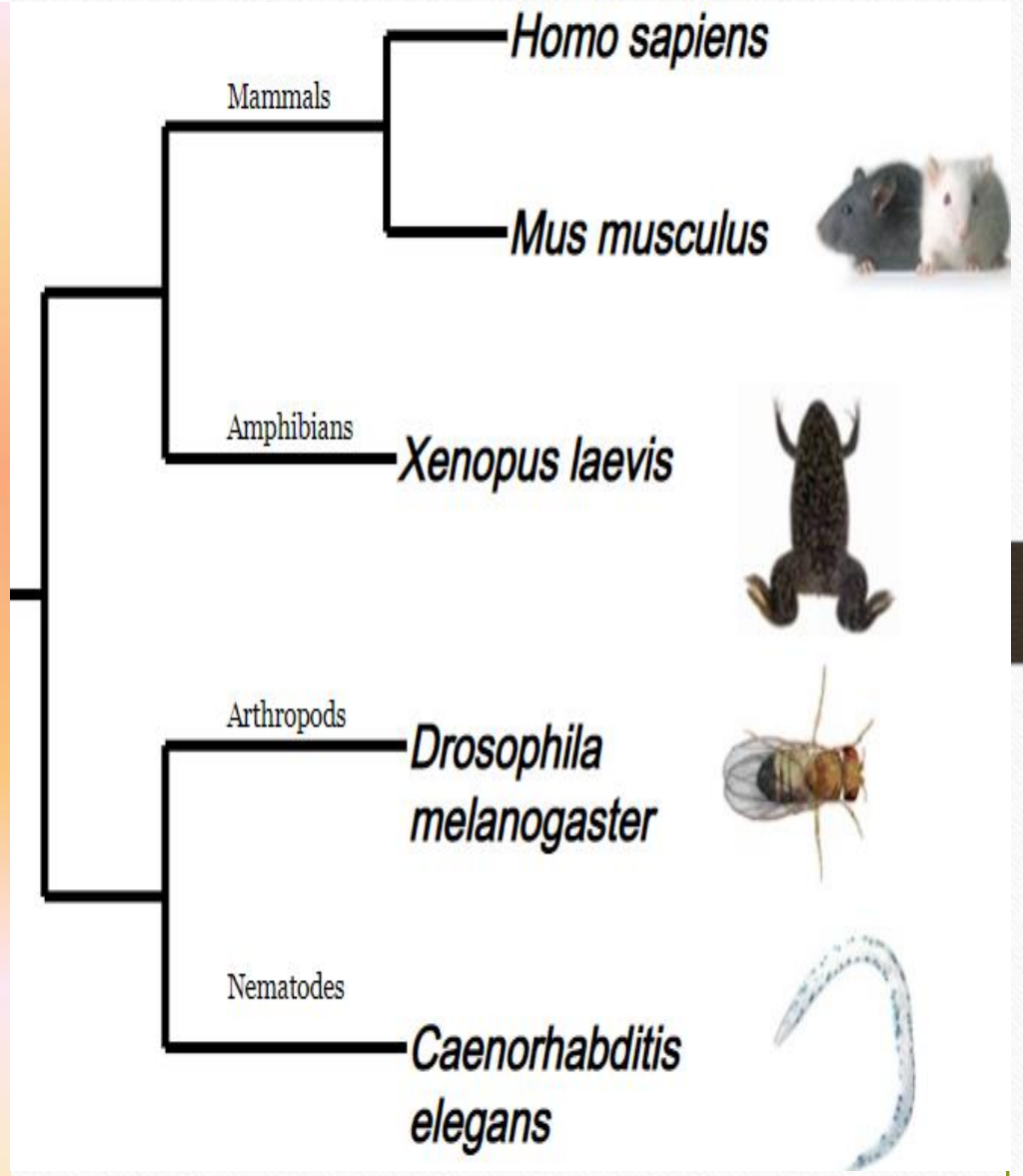
INVERTEBRATE MODEL ORGANISM AND THEIR IMPORTANCE

Definition of Model Organism

- Specific species or organism
- Extensively studied in research laboratories
- Advance our understanding of
  - Cellular function
  - Development
  - Disease
- Ability to apply new knowledge to other organisms

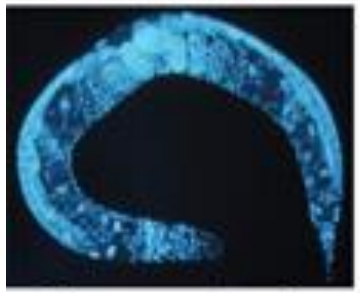
Current Models

- Drosophila
- Xenopus
- Zebrafish
- Mouse
- C. elegans
- Yeast
- E. coli
- Arabidopsis



Common Characteristics of Model Organisms

- Short generation time
- Production of numerous progeny
- The ability to carry out controlled genetic crosses
- The ability to be reared in a laboratory environment
- The availability of numerous genetic variants
- An accumulated body of knowledge about their genetic systems



Nematode
(*Caenorhabditis elegans*)

Sea Urchin
(*Strongylocentrotus purpuratus*)

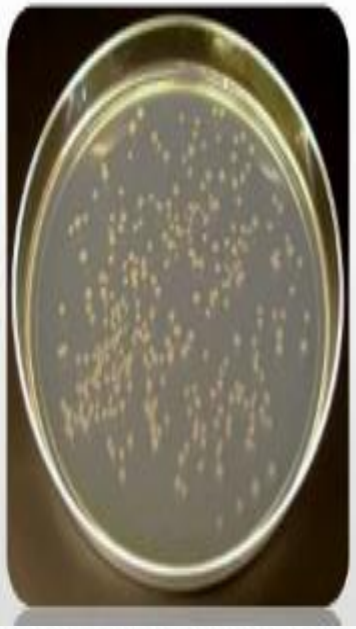
Fruitfly
(*Drosophila melanogaster*)

Escherichia coli

- Escherichia coli or E. coli is a Gram-negative, rod-shaped bacteria that is a normal inhabitant of the lower **gastrointestinal tract of warm blooded animals**.
- *E. coli* is **expelled** into the environment within **fecal matter**. The bacterium grows massively in fresh fecal matter under aerobic conditions for 3 days, but its numbers decline slowly afterwards.
- The E. coli **genome is relatively small, 4.5 to 5.5 Mbp** and simple when compared to our own.

- It is an unicellular organism. There are no ethical concerns about growing, manipulating, and killing bacterial cells, unlike multicellular model organisms like mice or chimps.
- They are able to reproduce and grow very rapidly, **doubling its population about every 20 minutes**. This is helpful in research to get subsequent generations within a short time.
- They can survive and adaptive to variable growth conditions.

- Culture media containing simple and inexpensive ingredients and nutrients can successfully spur E. coli to grow and divide.
- It is easy to culture in laboratory in liquid medium or solid medium within petriplates.
- In liquid culture, E.coli cells will grow to a concentration of a billion cells per milliliter, and trillion of bacterial cells can be easily grown on a single test tube.
- When E. coli cells are diluted and spread onto the solid medium of a petridish, individual bacteria reproduce asexually, giving rise to a concentrated clump of 10 million -100million genetically identical cells , called a colony.



- This colony formation makes it easy to isolate genetically pure strains of the bacteria.
- Most strains are harmless.
- They can be manipulated and engineered easily.
- Mutants are easily obtained using well established methods and screening techniques, which has enabled many biochemical processes to be linked to the molecular genetic level.
- E Coli Genome is found to be a **circular DNA molecule** 4.6 million base pairs in length, containing **4288 annotated protein-coding genes** (organized into 2584 operons), seven ribosomal RNA (rRNA) operons, and 86 transfer RNA (tRNA) genes.
- Current research areas for E. coli include acting as a vector, a host for genetic elements and synthesis of proteins of interest

yeast

- Yeasts are eukaryotic, single-celled microorganisms classified as members of the **fungus kingdom**.
- Most yeasts reproduce asexually by mitosis, and many do so by the asymmetric division process known as budding.
- With their **single-celled growth habit**, yeasts can be contrasted with molds, which grow hyphae.
- Yeast sizes vary greatly, depending on species and environment, typically measuring **3–4 µm in diameter**, although some yeasts can grow to **40 µm in size**.

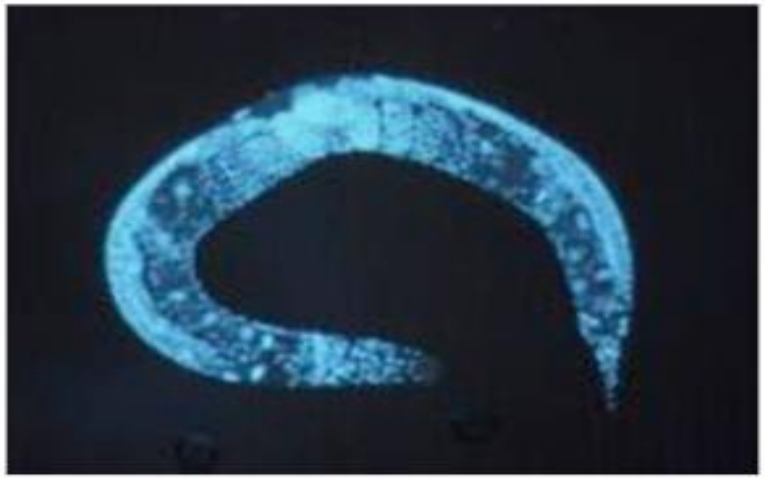
- **Yeast is one of the simplest eukaryotic organisms but many essential cellular processes are the same in yeast and humans.**
- **It is therefore an important organism to study to understand basic molecular processes in humans.**

- Yeast was the **first eukaryotic organism to have its genome sequenced**.
- Yeast chromosomes share a number of important features with human chromosomes.
- **Fission yeast** (*Schizosaccharomyces pombe*) has become a popular system for **studying cell growth and division**.
- It is useful partly because it is easy and inexpensive to grow in the lab, but also because its cells have a regular size and grow only in length, making it **very simple to record cell growth**.

Yeast has many High-throughput genomics data

- **Gene expression** (by microarray or RNA-seq)
  - Cell cycle, deletion strain, chemical perturbations
- **Transcription regulation** (binding by transcriptio factors)
  - ChIP-chip, ChIP-seq
- **Protein-protein interactions and complex data**
  - Yeast Two-Hybrid (Y2H), TAP-tagging, literatur curation
- **Genetic interactions and pathways**
  - Synthetic Genetic Array (SGA)
- **Chemical genomics**
  - Small molecule – gene interactions
- **High content morphological screening**

- Yeast is a powerful model organism that has enabled a **better understanding of human biology and disease**.
- Between 2001 and 2013, four Nobel Prizes were awarded for discoveries involving yeast research, an impressive number for a single organism.
- The genome of ***S. cerevisiae* yeast** was published in 1996 and the ***S. pombe*** sequence in 2002.
- As a result, projects have been initiated to determine the **functions of all the genes in these genomes**. One such project, the **Saccharomyces Genome Deletion Project**, aimed to **produce mutant strains of yeast** in which each one of the **6,000 genes in yeast is mutated**.



Caenorhabditis elegans

Nematode Worm

Nematodes account for an estimated four of every five animals in the world !

Smooth-skinned, unsegmented worms first used as a model organism by Sydney Brenner in 1965

C. elegans is diploid and has five pairs of autosomal chromosomes (named I, II, III, IV and V) and a pair of sex chromosomes (X).

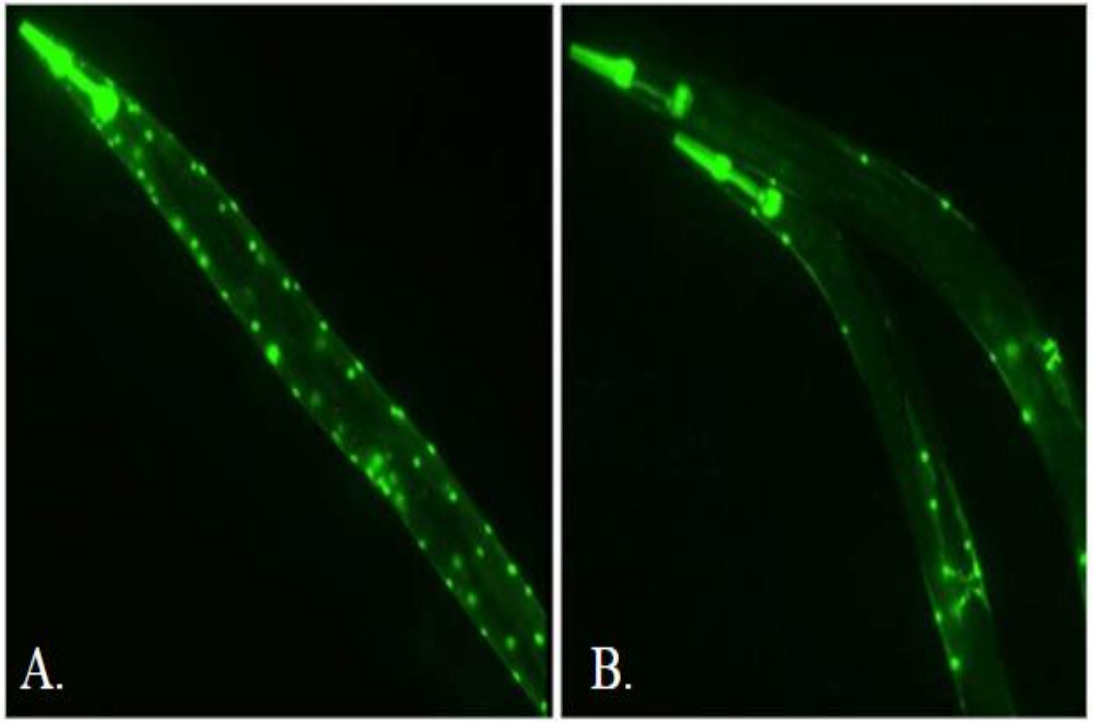
Most adults are hermaphrodite (XX) but .05% of lab populations are male (XO)

Lifespan is 2 to 3 weeks

Worms are usually kept on petri plates and fed E.coli

About 10,000 worms fit on a single plate

Using RNA interference for local and systemic gene silencing in C. elegans



A. *C. elegans* hermaphrodite expressing GFP transgenes in the pharynx and the nuclei of body-wall muscle cells

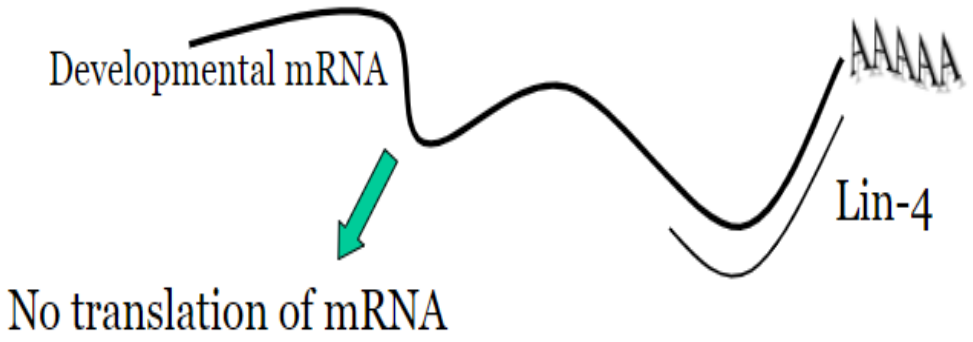
B. *C. elegans* hermaphrodite expressing GFP transgenes + GFP double stranded RNA in the pharynx

Small RNAs as regulate gene expression during development

- Look for heterochronic defects in mutagenesis screen

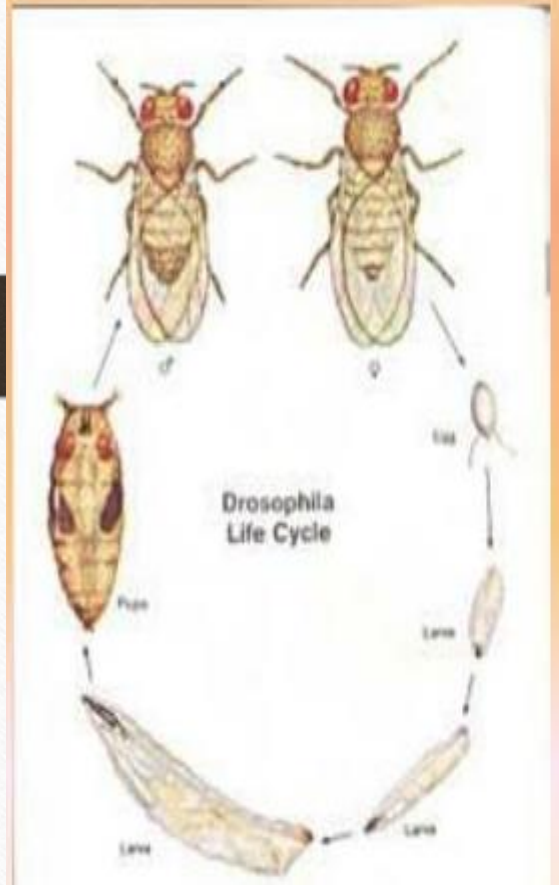
  -- cells behave as if in an earlier or later developmental stage

- Regulatory cascades unveiled which involve small RNAs (21-22 nts)
- Lin-4 and Let-7 encode short untranslated RNAs and function by binding to complementary sequences in mRNAs of specific genes controlling development
- Lin-4 expression allows cells to progress from larval stage 1 to 3
- Let-7 expression allows cells to progress from late larval to adult stages



Drosophila melanogaster as a model organism

Characteristics of Drosophila that make it a good model organism



- Small, easy and cheap to maintain and manipulate
- Short lifespan
- Produce large numbers of offspring
- Development is external
- Availability of mutants
- Lots of history/previous experiments and discoveries
- Genome is sequenced
- Homologues for at least 75 % of human disease genes
- Exhibit complex behaviours
- Fewer ethical concerns

Drosophila in Research

- Early research aided in the understanding of development
  - Made first link between chromosome and phenotype
  - Identified various genes and mechanisms of development
- Current research focuses on the study of human disease
  - Developmental disorders
  - Neurological disorders
  - Cancer

Technique: Second site modifier screen

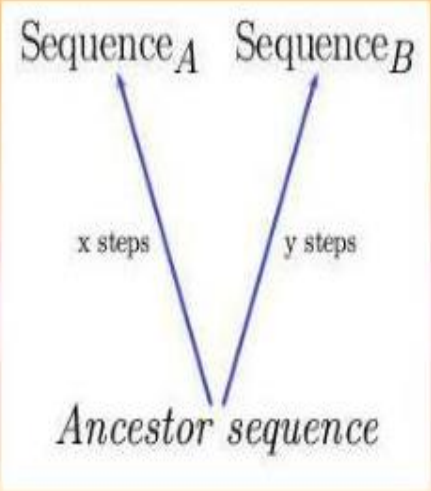
- Begin with a fly posessing a mutant phenotype
- Create random mutations that might effect this phenotype in this genetic background
  - Via radiation or feeding of a mutagen
  - Observe offspring or "grandoffspring" for either less or much more severe phenotype
- Some might be revertants of the original gene
- Others might be mutants for upstream or downstream components of the pathway(s) that lead to the original phenotype
- Rarely, there might be mutants of a ge with a compensational function.

Human Disease : Developmental Disorders

- Dysmorphologies
  - Diseases resulting in morphological defects
  - Largest, most prevalent human genetic disorders
- Result from mutations in genes that control important steps in development, such as:
  - Transcription factors
  - Proteins involved in signal transduction
- Two broad categories:
  - Conserved genes with orthologous function
  - Conserved genes having different functions

Conserved genes, Similar functions

- Genes have:
  - Homologous functions
  - Involved in the development of conserved structures in both humans and flies
- Mutations in both human and fly homologues affect same tissue/cell type

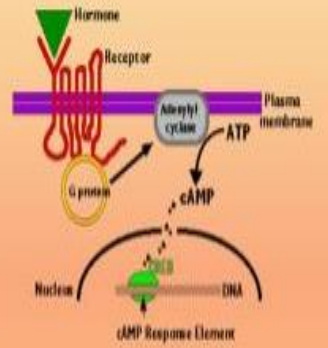


Human gene	Drosophila gene	Affect when mutated
Hox genes	Hox genes	Alteration of anterior-posterior identities
PAX6	*eyeless*	Defects of the eyes
SALL1	*salm or salr*	Defects of the auditory system
TWIST1	*twist*	Malformations of mesodermal derivatives
NKX2-5	*tinman*	Defects in heart specification and function

Conserved genes, Similar functions

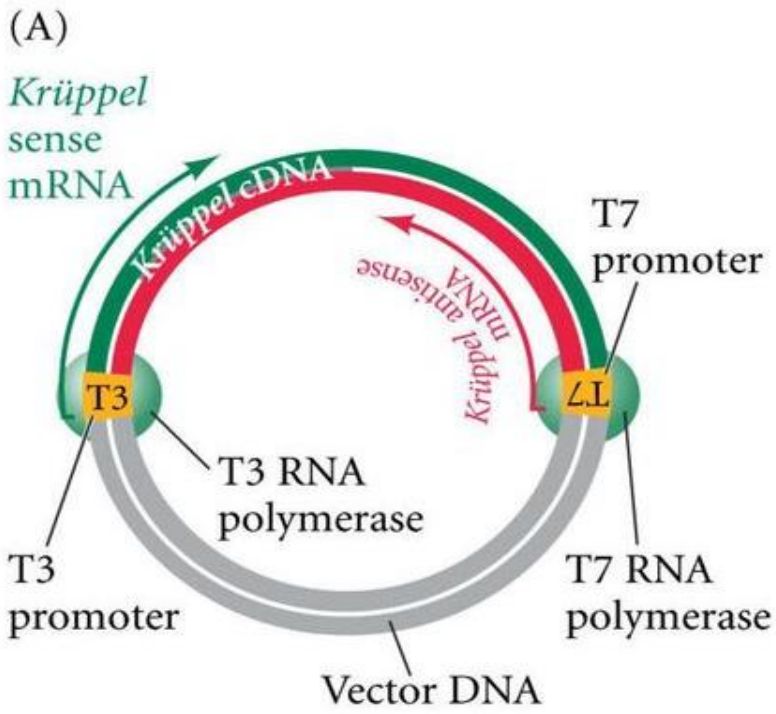
- Regulators of expression of effector genes
- Sometimes effects on the transcription of target genes differ between fly and vertebrate
  - Flies: *twist* activates *FGFR* (Fibroblast Growth Factor Receptor)
  - Mammals: *TWIST1* negatively regulates *Fgfr2*
- Hox genes differ in their detailed nature of target recognition
  - Overall proteins function in a homologous manner to determine cell fate
- Recognition of DNA binding sites on target genes remains evolutionarily conserved
- Enhancer sequence containing DNA binding site may have changed slightly due to natural selection

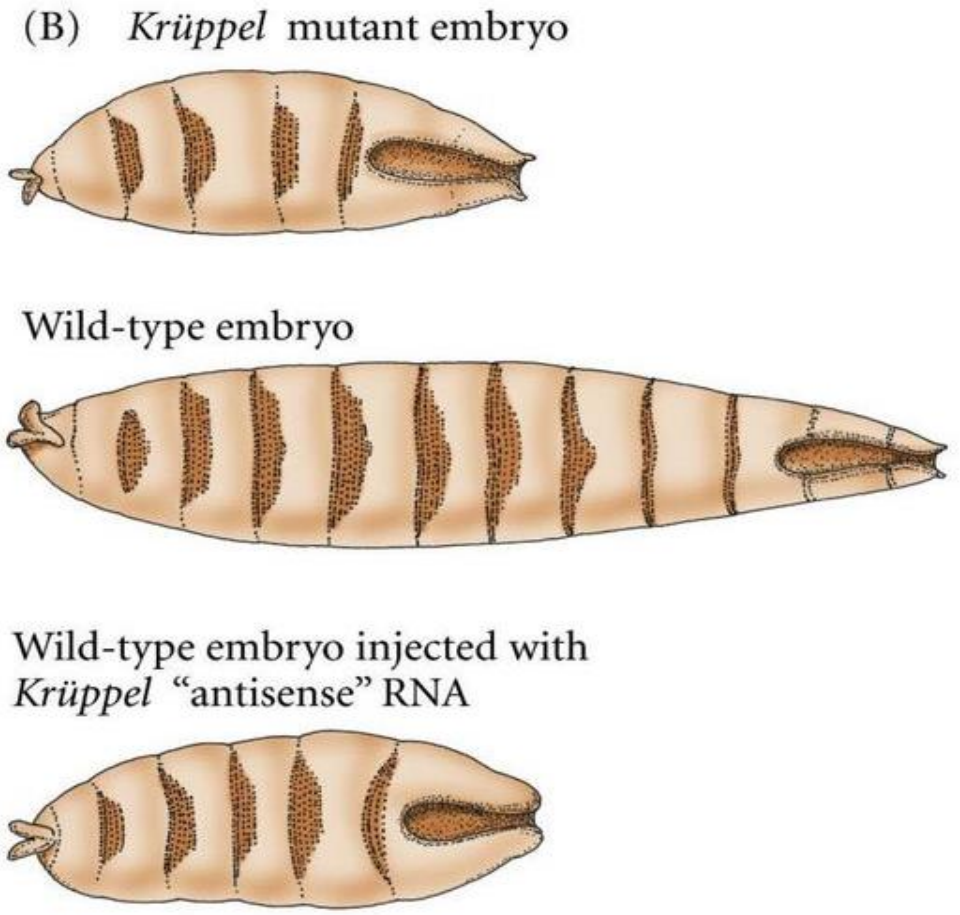
Conserved genes, Different functions



- Common signaling pathways
  - Used several times in development
  - Also in species specific processes
- Notch pathway
  - Homologous development function:
    - Defines dorsal-ventral boundary of appendages in Drosophila
    - Establishes apical ectoderm ridge in vertebrate limbs
    - In both cases, regulated by glycosyl transferases in the Fringe family
  - Species specific processes
    - In vertebrates, essential for segmentation of somitic mesoderm and skeletal elements
    - In flies, limits the width of wing veins
    - Species specific structures
    - Relevant inferences can be drawn from one system to the other

Use of antisense RNA to examine the roles of genes in development





Wild type

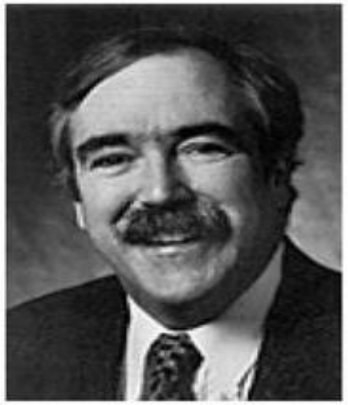
Ubx mutation

1995 Nobel Prize in Physiology and Medicine

"for their discoveries concerning the genetic control of early embryonic development"

Edward B. Lewis

Christiane Nüsslein-Volhard



Eric F. Wieschaus

Feature	Yeast	*C. elegans*	*D. melanogaster*
			
Advantage of experiments	Simple growth requirements, Rapid cell growth, Ease of genetic manipulation, Genome-wide screening	Short lifespan, Rapid life cycle, Small body size, Transparent body, Ease of genetic manipulation, Knockout mutant libraries, Behavior pattern	Excellent fertility (identical offsprings), Distinct developmental stages, Transgenic flies
Clinical meanings	Determination of candidate genes and proteins in response to radiation Cell-based drug screening for radiotherapy (basic tool)	Cellular response to radiation, IR-induced aging mechanisms, IR-mediated neuronal pathway	Analysis of IR-induced phenotype changes, IR-affected innate immunity Examination of heritable effects

Zebrafish (*D. rerio*) 	• Considerable genetic conservation with the human genome (~70%)[5] • Large availability of genetically modified models[6] • High fecundity, eggs released every one-to-two weeks[6] • Transparent during early development[6] • **Axenic animals can be derived using simple and well-established protocols[8]** • **Simple mono or conventional colonization by immersion[8]** • Diversity of automated behavioral assays to assess microbiota-gut-brain axis[6] • Medium-throughput model for toxicity testing[6]	• GI track lacks distinguishable lymph nodes, splenic germinal centers and Peyer's patches[7] • Diet and environment significantly differ from humans[2] • Microbiota composition markedly different from human (dominated by Proteobacteria and Fusobacteria)[4] • No established protocols for generating axenic
Fruit fly (*D. melanogaster*) 	• Highly fecund, eggs released every day[9] • Rapid development and generation time[9] • Axenic animals can be derived using simple and well-established protocols[9] • Mono or conventional colonization via diet[10] • High-throughput potential for toxicity testing[9]	• Low conserved homology with human genome (~50%)[9] • GI tract consists of a simple epithelium, surrounded by visceral muscles, nerves, and tracheae[9]
Nematode worm (*C. elegans*) 	• Highly fecund, eggs released every day[11] • Rapid development and generation time[12] • Transparent until adulthood allowing real-time visualization[12] • Axenic animals can be derived using simple and well-established protocols[12] • Mono or conventional colonization via bacterial diet[12] • High-throughput screening potential[12]	• Low conserved homology with human genome (~35%)[12] • Basic GI tract consisting of a tube of enterocyte cells[12] • Microbiota composition typically consists of a