Parasitology & Malacology

Zoo 404

(Theoretical Part)

Second semester

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Parasitology

Chapter 1

Introduction to Parasitology.

Parasitology: is the science dealing with organisms living in or on other organisms.

Parasitism:

Most plants and animals are able to live independently and are largely self-sufficient in obtaining and metabolizing the nutrients they require for their growth and reproduction. A small group of plants and animals however, are not so independent and some of these have evolved a more or less intimate relationship with another organism of a different species so that both partner benefit from the relationship. This relationship in which neither partner is harmed is called commensalisms. If, however, one partner benefits from the relationship and is unable to complete all its development and reproductive processes without the aid of the other partner, the relationship is then one of parasitism.

Parasitic relationship:

In the parasitic relationship, the half of the partnership which benefits from the relationship is the **Parasite**, and that which provides the benefit is the **Host**.

Endoparasite and Exoparasite:

When a parasite lives within its host (malaria), it is referred to as an endoparasite and is said to cause infection. A parasite however which lives on the outer surface or in the superficial tissues of its host (flea) is called exoparasite, and is said to cause infestation.

Life cycles of Parasitism:

All parasites pass through a series of developmental stages before a stage is reached when the organism reproduces and a new cycle of development begins. There may be few or several developmental stages, with at least one stage occurring in a host organism.
Within the developmental cycle (life cycle) they may b several phases or parasite multiplication or only one. According to species the phase of multiplication may be sexual or asexual. In some parasites sexual multiplication is followed almost immediately by asexual multiplication.

Direct and indirect life cycle:

When a parasite requires only one species of host in which to complete its development it is said to have a direct life cycle, e.g. the life cycle of the parasite that cause the amoebiasis in human (Entamoeba histolytica) requires only a human host for its completion.

When two or more hosts are required, the life cycle is referred to as indirect, e.g. the filarial worms that parasitized humans required both human host and insect host in which to complete their development.

Classification of hosts:

Definite host is either:
-The host in which sexual reproduction takes place, for example human is the definite host for Schistosoma haematobium.
Or
- The host in which the mature or the most highly developed form of the parasite occurs. Human is the definite host for trypanosome.

Intermediate host:

This term is used to describe the species of host or hosts, other than the definite host, that are essential to complete the indirect life cycle of the parasite, e.g. tsetse fly is an intermediate host for the trypanosome species that cause African trypanosomiasis.
In the life cycle of the parasitic worms, intermediate hosts harbour the larval forms.
In the indirect parasitic life cycle, the term vector is usually applied only to blood-feeding arthropod intermediate hosts such as mosquitoes, tsetse flies and sandflies.

The term mechanical vector is used, to describe a vector which assist, in the transfer of parasitic form between hosts but is not essential in the life cycle of the parasite, i.e. no parasitic development occur in such a vector. An example of the mechanical vector, is the fly that transfers the amoebic cysts from infected faeces to the food that is eaten by the humans. A non arthropod mechanical vector is called transporter, or paratenic host. In such host the parasite remains viable but does not develop.

Reservoir host (carrier):

A reservoir host is an animal in which a parasite usually resides or one in which a parasite which infects the humans is able to be maintained in the absence of the human host.
A parasitic infection in which the normal host is an animal, but can produce disease in human is called a zoonosis. E.g. leishmaniasis, and African trypanosomiasis.

Transmission and diseases caused by parasites:

Routs of transmission:

1- By ingesting the parasite in the food, water, or from hands that have been contaminated by faeces that contain the infective form of the parasite. Example: Entamoeba histolytica.
2- By ingestion the parasite in the raw or under-cooked meat. Example: Taenia saginata.
3- By ingestion the parasite in the raw or under-cooked fish, crab. Example: Fasciolopsis buski.

4- By contact with the water contaminated with parasite as in Schistosoma species.
5- By parasite entering the blood and tissues through the bite of an insect, as occur in Loa loa.
6- By inoculation of the parasite into the blood by an insect as occur with: plasmodium species.
7- By sexual contact as occur with Trichomonas vaginalis.
8- By infected faeces from an insect being rubbed into the site of the insect bite as occur in Trypanosoma cruzi.

Parasitic disease:

Not all parasitic infections cause disease of clinical significance. Many factors influence whether an infection causes disease including:

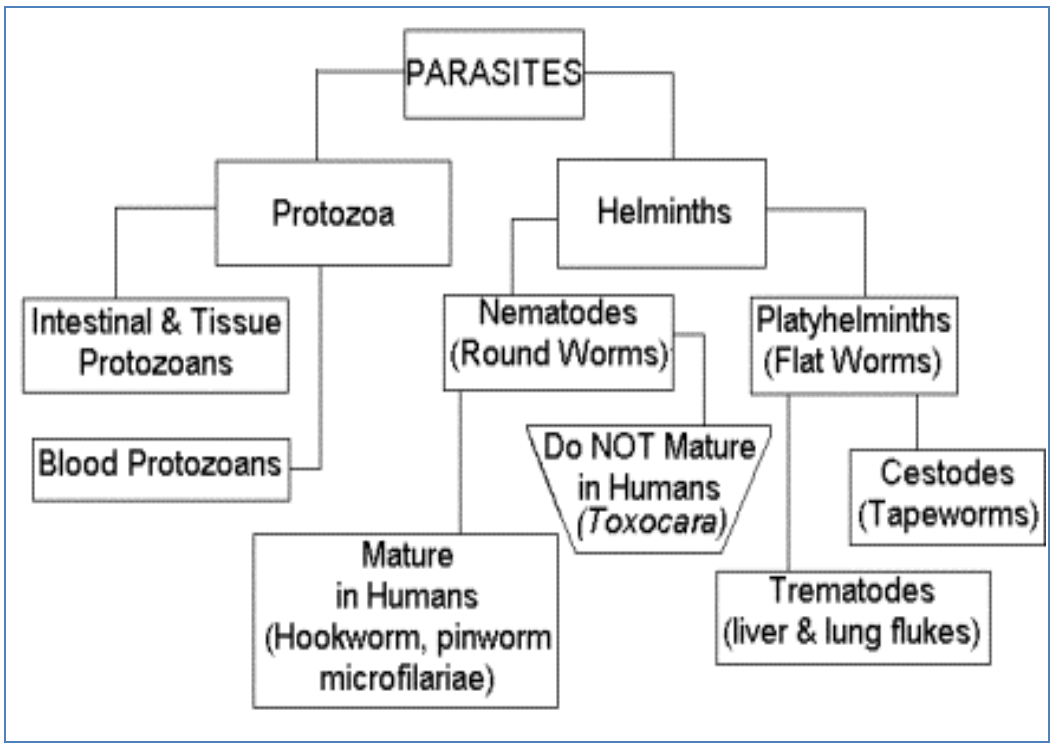
Parasitic factors:

- Number and strain of parasite.
- Strain of the parasite.

Host factors:

- Age and level of natural immunity at the time of infection.
- Immune responses to the infection.
- Presence of co-existing disease or condition which reduces the immune responses, e.g. pregnancy.

General classification:



Genus Entamoeba.

General characteristics:

Intestinal parasites amoeba of man.
Infectious stage to man the cystic stage.
Transmission is by ingestion.
Movement is by pseudopodia called amoeboid movement.

Entamoeba Histolytica.

Geographical Distribution:

Allover the world, tropical and subtropical countries. High numbers found among the countries with high temperature, or communities with bad hygiene.

Habitat :

Trophozoites (adult): found in the large intestine.
Occasionally in liver causes liver abscess.
Occasionally in lungs causes lungs abscess.
Cyst: in intestinal lumen.
No cyst is found in abscess.

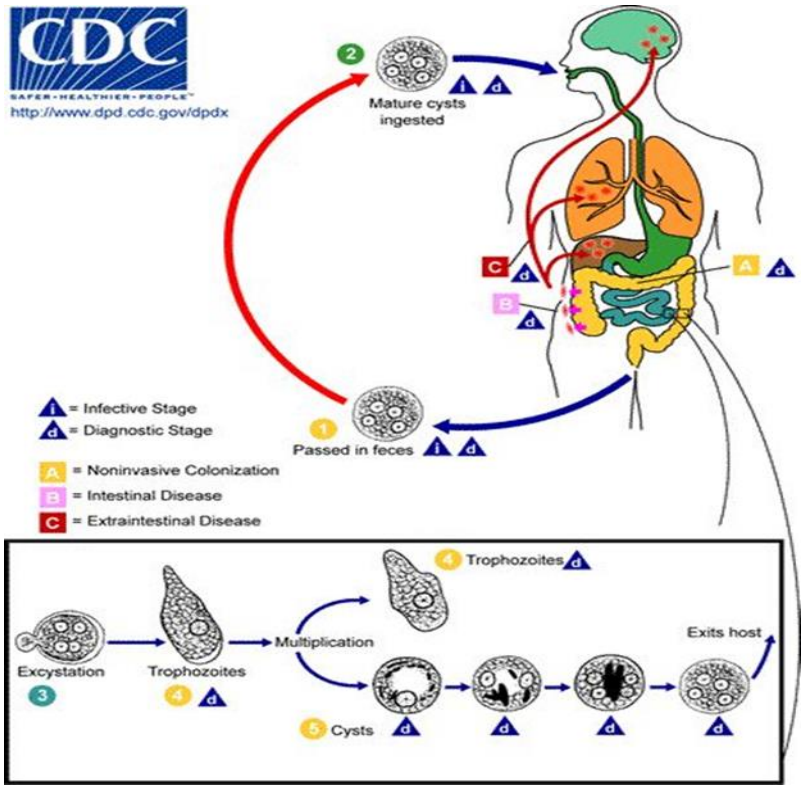
Note : trophozoites and cysts are found in stool liquid fresh from a carrier, especially stool that contains blood and mucus.

Transmission and Life cycle:

Food and drinks, contaminated with feacea containing cysts of E. hystolytica

Life cycle:

1- After ingestion every cyst excysts in the large intestine to produce amoeba which multiply repeatedly.
2- The amoeba form single nucleated cyst which develop into infective cyst which have 4 nuclei. Once cysts are formed, they do not become amoeba again in the same host.
3- The infected cysts are execrated in the faeces. They can survive and remain infective for several weeks in sewage and water.



Pathogenesis:

1. Causes ulceration of the large intestine.
2. Amoebic hepatitis and Lung abscess.
3. Rare cases of brain abscess.

Lab diagnosis:

Specimens: 1- Stool (direct or concentrated method)
2- Serum for serological tests (cellulose acetate precipitin CAP) for liver abscess.
3- Biopsy for liver, lung and intestine.

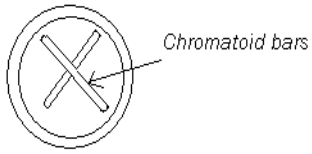
Macroscopic examination:

1- Colour.
2- Smelling (very strong bad smelling).
3- Acidic.
4- Bloody and mucous.

Microscopic examination:

1- Look for cyst.
2- Look for trophozoites

Morphology of the cyst under the microscope:

1- Wet preparation. "saline"	2- Iodine preparation.
	
We can see the chromatoid bodies (small or big, fine or thick). Sometimes we can see the stained nucleus. Glycogen mass can not be seen.	Purpose of Iodine: To see the glycogen mass clearly, and the nucleus (one to 4). We do not see the chromatoid bodies

Important points:

1- E. hystolytica cyst never shows more than 4 nucleus, if more so it will be another species of entamoeba (E. coli with up to 8 nuclues). The cyst measures about 10-15 µm.
2-Amoeba measures 25x 20 µm, and it is moving actively in the fresh worm specimen. It may contain digested RBCs .
.

Commessal Amoebe

EX: Entamoeba Coli.

Entamoeba Coli.

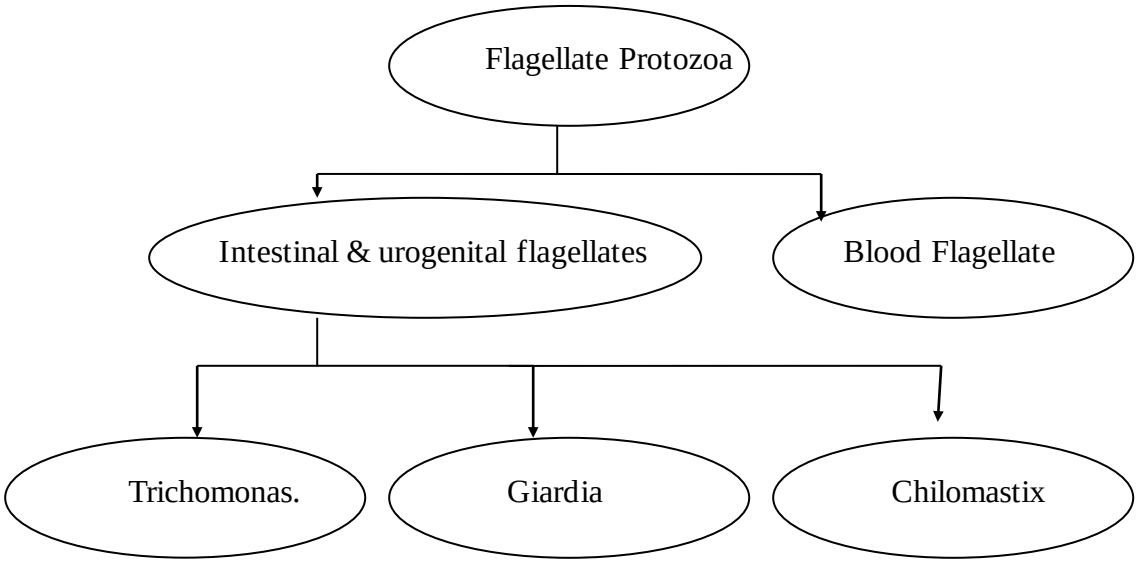
Geographical distribution: all over the world.
Habitat: large intestine of the man.
Morphology: trophozoite measures 15-30 µm, the cytoplasm contains food and bacteria, no red cells.
Cyst : measures 15-30 µm, the cytoplasm contains up to 8 nuclei
In saline: chromatoid body is rare and needle-like.
In Iodine: Glycogen mass faint or diffused.

Life cycle: the same of E. histolytica but not pathogen.

Infection/ pathogenicity:
No pathogenicity.

Flagellate protozoa.

There are called flagellates because they move with flagella.



Some are causative organisms for dysentery.

1) Genus: Trichomonas.
   - T. hominis (intestinal).
   - T. vaginalis (genital organs).
   - T. tenax (human mouth)

General characteristics of trichomonas:

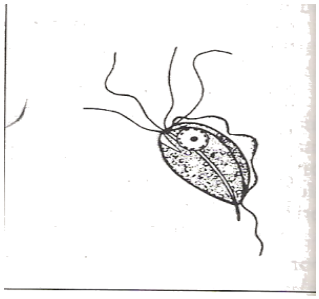
1. Pear shape or ovoid.
2. Have 5 flagella, 4 directed anterior and free posterior enclosing undulating membranes.
3. Have Costa, achromatic basal red.
4. Have exosyle, a structure in the centre.

Transmission:
By ingestion, infective stage trophozoite from flagella form (flagella form).
Note: there is no cystic form.

1-Trichomonas Hominis

Geog. Distribution: all over the world, more in worm areas.
Habitat: in the large intestine especially caecum of human.

Morphology:
Trophozoite: Same as T. vaginalis.



Movement: Jerky.
Cyst: No cyst stage.
Transmission: perhaps by ingestion of the flagella form.
Infection/pathogenesis: not known.
Diagnosis:

1. Wet preparation.
2. Seroimmnunological investigations.
3. Culture.

Specimens: blood or stool.

1- Wet preparation of stool in saline to see the active motile forms (we should examine it quickly).
2- Iodine preparation to differentiate of the morphology characters.
3- Seroimmnunological investigations (agglutination & haemoagglutination).

2-Trichomonas vaginalis

Geog. Distribution: all over the world.
Habitat: In the genital tract of women and man (prostate gland).
Morphology:

1- Average length 13µm
2- 4 flagella anterior.
3- The 5th passing back word to enclose.
4- Undulating membrane.
5- Has exostyle Costa & cleft (mouth).
6- Movement: twist and rotate (likened to a falling leaf).

Plate 14.7 ***Trichomonas vaginalis*** **stained preparation.**
Courtesy of V. Zaman.

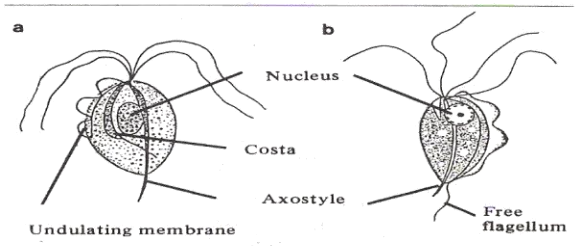
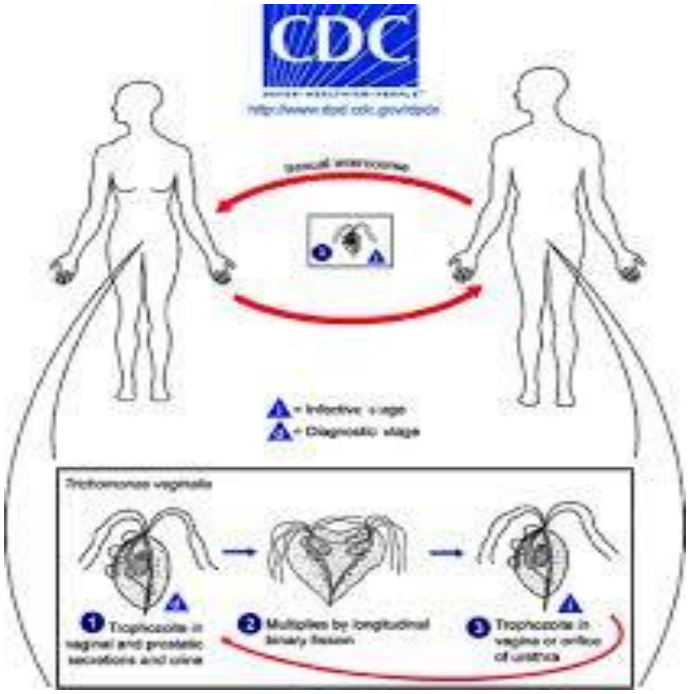


Fig. 14.4 *a* ***Trichomonas vaginalis.***

Life cycle: flagella are found in the genital tract.
Transmission: during dealings with contaminated matters (clothes, cotton..etc.



Trichomonas vaginalis resides in the female lower genital tract and the male urethra and prostate ❶, where it replicates by binary fission ❷. The parasite does not appear to have a cyst form, and does not survive well in the external environment. *Trichomonas vaginalis* is transmitted among humans, its only known host, primarily by sexual intercourse ❸.

Pathogenesis:
In women: Vaginal discharge and vaginal scratching and itching, vaginal creamy discharge and dysuria.
In men: affects prostate gland in man and can cause urethritis and discharge which lasts 4 weeks. The discharge is mainly asymptomatic and the male can serve as carrier.
Diagnosis:
1-Specimens:

- From male: urine, vaginal swap, or urethral discharge.
- From female: urine, or prostate secretions.

2-Lab diagnosis:

1- Examination of vaginal discharge and vaginal scraping (swap).
2- Examination of urine sediment after centrifugation.
3- Stained smear.
4- Culture.

Genus: Giardia

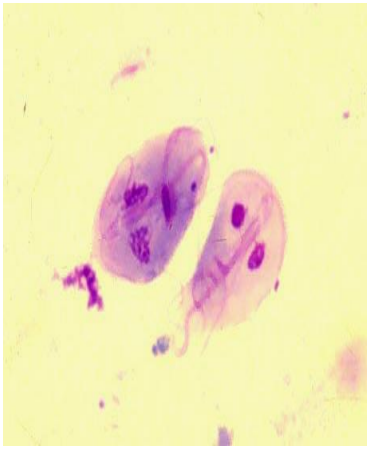
G. lambelia or G. intestinal.
Geographical distribution: all over the world.
Habitat:
Trophozoite: in the upper part of the small intestine, especially in the children.
Also in faesec after laxative and diarrhea.

Morphology:

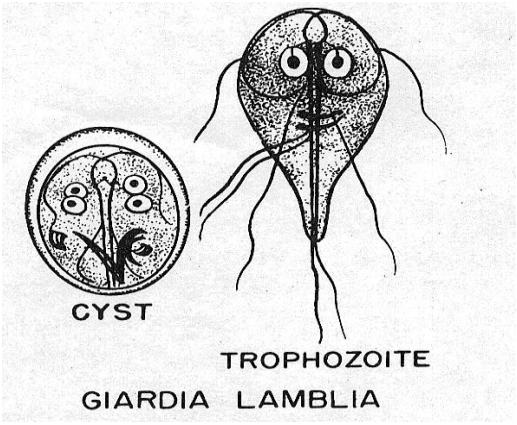
occurs as both a flagellated trophozoite and a non-flagellated cyst form

- trophozoite (9-21 μm long), motile, with 8 long flagella, ventral sucker which attaches to duodenal mucosa; lives only in small intestine; non invasive.

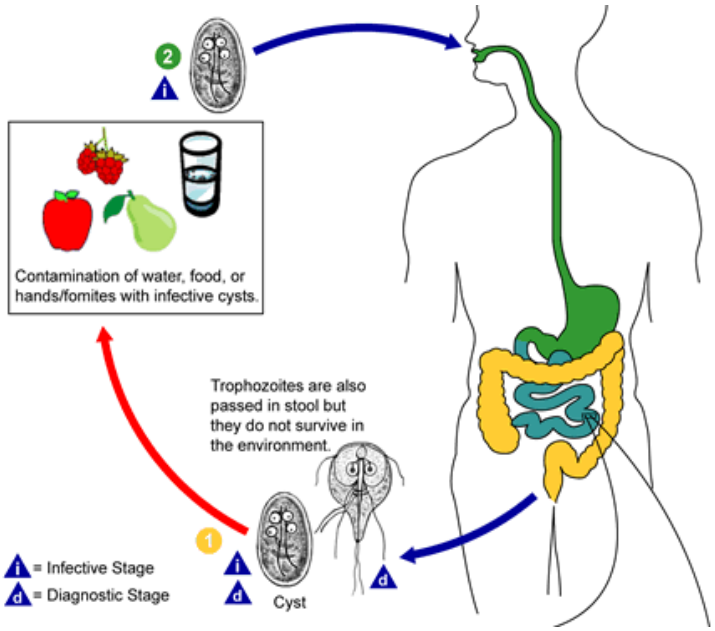
- cyst (8-12 μm); resistant to external environment, to municipal chlorination; intermittently expelled in stool.



Giardia trophozoites



Giardia cyst



Transmission and Life cycle:

It is transmitted by ingestion of the infected form (cyst) in contaminated food or drink. encystment occur in the intestine. Ingestion of contaminated food containing cyst of Giardia. Within 30 minutes cyst hatches out 2 trophozoites. From stomach to the duodenum where cyst divides giving rise to 2 trophozoites. In the duodenum, .multiplication of trophozoites occurs and colonization occurs

Pathogenesis: the disease is called giardiasis, and it affects the wall of the intestine. This can lead to:

1. Nausea, flatulence and some times constipation.
2. It can result in significant morbidity among children.

Lab Diagnosis:
Specimens: stool, serum (immunodiagnosis), duodenal biopsy (histological examination).
Macroscopical examination:
The color of the stool is yellow, fattish, and with foul smelling.
Microscopical examination:
Using the saline or the iodine preparations for stool, we can detect the trophozoite and the cyst forms. The cyst is easy to be found in the stool under the high power (X40).

CILIATE.

Blantidium coli (B. coli).
It is a protozoa moving by the cilia.
It is the only pathogenic ciliate in the digestive tract in man.
Geographical distribution: world wide, more in worm climate areas.

Habitat: Trophozoite in the large intestine of wild and domestic animals. Not common in human.

Infective form: the cyst is the infective form, and can be seen in the stool.

Morphology:

- Trophozoite: largest protozoa in man, measures about 50- 200µm in length and has two nucleolus (macro+micro).

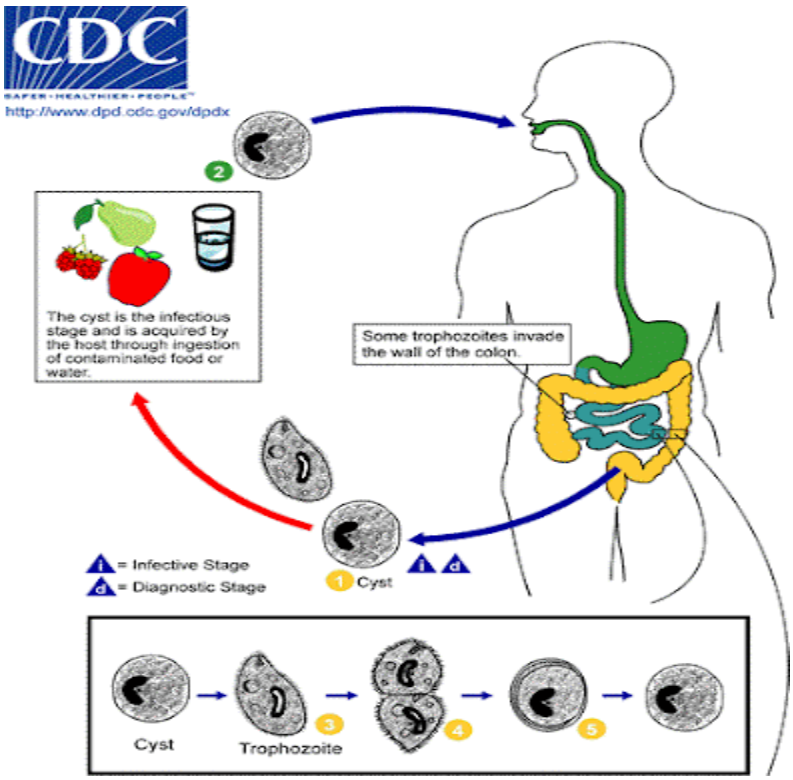
Transmission and Life cycle:

By ingestion of infective form from contaminated food or water or contaminated hands.

- ❖ Following ingestion, the cyst excyst in the intestine, each cyst producing a single ciliated.
- ❖ The ciliates multiply in the colon by binary division often following conjugation during which nuclear particles are exchanged between individuals.
- ❖ Thick walled cyst are formed which are excreted in the faeces. The cysts are infective when passed.

Look for large oval shaped ciliates which have rapid revolving motility. The ciliates are easily seen, measuring 50-200X40-70µm. by focusing the whipping cilia can be seen especially in the cytosome (mouth). In the dysentery specimens the ciliated usually contain ingested red cells.

Note: B. cloi ciliates degenerate rapidly in faeces, therefore sample should be examined while fresh.



Cysts are the parasite stage responsible for transmission of balantidiasis 1. The host most often acquires the cyst through ingestion of contaminated food or water 2. Following ingestion, excystation occurs in the small intestine, and the trophozoites colonize the large intestine 3. The trophozoites reside in the lumen of the large intestine of humans and animals, where they replicate by binary fission, during which conjugation may occur 4. Trophozoites undergo encystation to produce infective cysts 5. Some trophozoites invade the wall of the colon and multiply. Some return to lumen and disintegrate. Mature cysts are passed with feces 1.

Pathogenesis: the disease is called Blantidiasis, Blantidiasis dysentery.
It can cause ulcer in the intestinal mucous membrane, nausea, vomiting.

Diagnosis: specimen is stool.
Macroscopically we see mucous and blood.
Microscopic examination:
We can see both the cyst and\or the trophozoite.

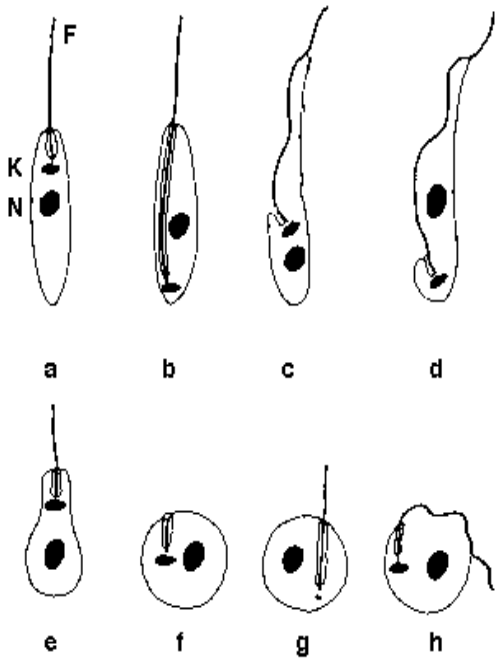
The blood tissue flagellates
Leishmania and Trypanosoma.

Descriptive terms:

Nucleus:
- Kinetoplast: arises from axoneme.
- Undulating membrane: is not present in the non flagellate stage. It is ectoplasm of the body extending to surround the flagellum ranging along the side of the body.

Developmental stage in zoo-mastigophora:

Life-cycle stages of trypanosomatidae a, promastigote; b, ophistomastigote; c,epimastigote; d, trypomastigote; e, choanomastigote; f, amastigote; g, paramastigote; h,....K, kinetoplast; N, nucleus; F, flagellum.



A. Amastigote.
B. Promastigote.
C. Epimastigote.
D. Trypomastigote.

Promastigote form: it is the infective form of the Leishmania.
Transmission to human occurs when the infected sand fly feed from man.

Genus: Lieshmania.

Classification of Leishmania :

It can be classified into:

1. L. Donovani Complex.
2. L. Braziliensis Complex.
3. L Mexicana.
4. L Tropica.
5. L. Major.
6. L. aethiopica

It can be classified als according to the diseases which it causes into:

(1) Cutaneous Leishmaniasis (in the skin).
(2) Mucocutaneous Leishmaniasis (in mucocutaneous tissues and skin).
(3) Visceral Leishmaniasis (in the internal organs- Kalazar).

Lieshmania Donovani.

Geographical distribution:

India and also where, the disease is called Kala-azar.

Pathogencity:

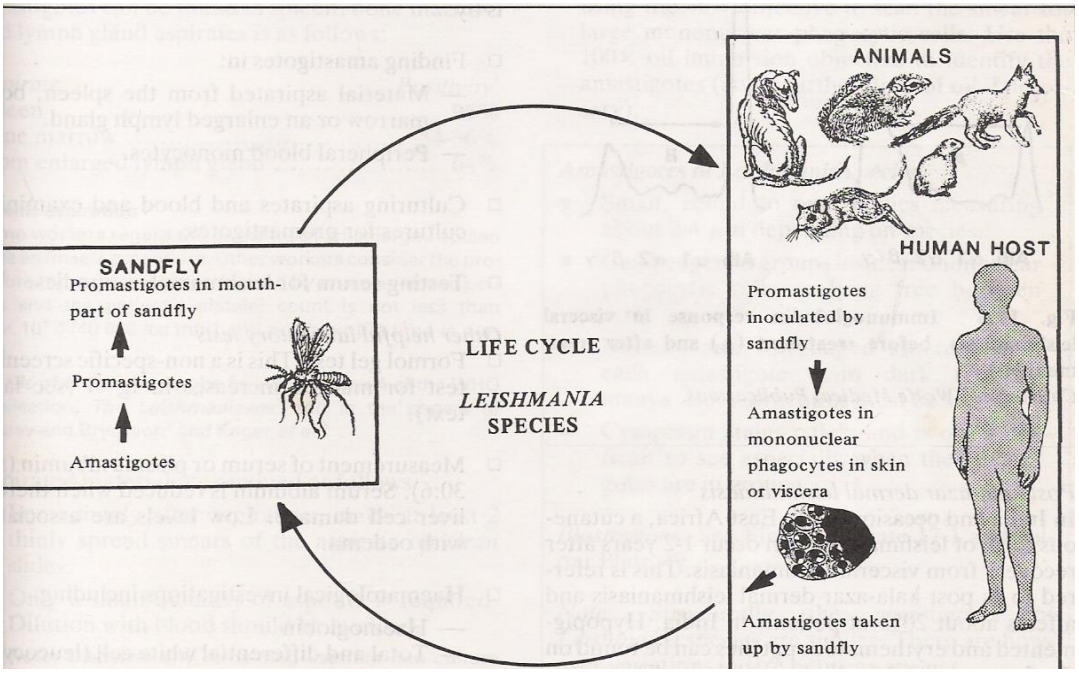
Cause the visceral leishmaniasis or Kala azar, called the death fever, anaemia, dysentery and loosing weight.

Habitat:

Found in RES (Reticuloendothelial System) Visceral organs, specially spleen, liver, bone marrow, intestinal mucosa.
Also in: Kidney, lungs, CSF.

Stages in life cycle:

(1) amastigote in man and reservoirs, e.g. dog and rodents.
(2) Promastigote: in sand fly vector and in lab culture "infective stage".

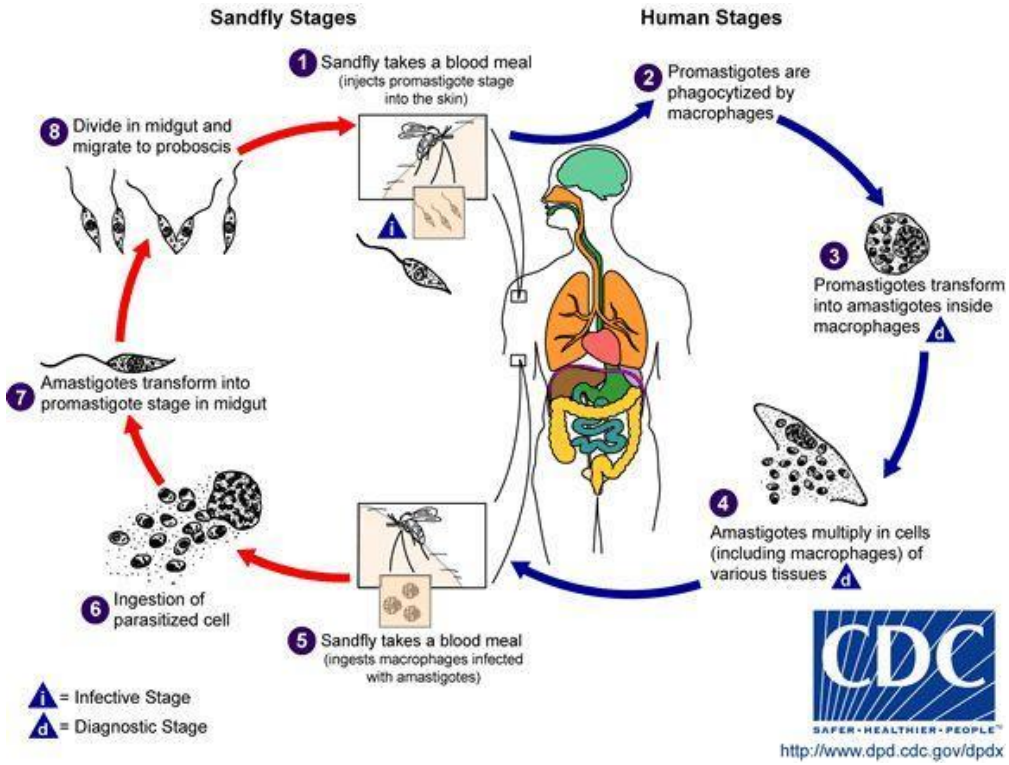


In man:

2. Following inoculation, the promastigotes are taken up by phagocytic cells and develop into amastigotes.
3. Amastigotes are spread in the blood and multiply in the macrophage of the RES, e.g. liver spleen, BM…
4. Intracellular and free amastigotes are ingested by the female of sandfly vector when it sucks blood.

In sand fly vector (Phalebotomus):

5. Amastigotes become flagellated promastigotes in the midgut of the sand fly.
6. Promastigotes multiply and fill the lumen of the sand fly. After several days these move foreword to the head and the mouth of sand fly ready to be inoculated when the vector next takes blood meal.



2- Leishmania causing Cutaneous (skin) Leishmaniasis:

1. L Tropica.
2. L. Major.
3. L. aethiopica

<u>Geographical distribution:</u>
Meddle east, Afghanistan, India, ethiopica and also where.

Life cycle:
The parasites multiply in the skin macrophages.

Pathogenicity:
Causes ulcer in the skin, healing.

Lab diagnosis of Leishmaniasis:

1. By finding amastigotes in:
    a) Material aspirated from spleen, liver, BM and enlarged lymph nodes.
    b) Peripheral blood monocytes.
2. Culturing aspirates for promastigotes
3. Testing serum for leishmanial antibodies.

4. Biopsy.
5. Detection of amastigotes in smear taken from infected ulcer.
6. Animal inoculation.

Genus: Trypanosoma.

Species of medical importance:
T. brucei complex (gambiense and rhodesiense) which cause the African trypanosomiasis.
T. cruzi which causes the American trypanosoiasis.

1. African trypanosomiasis.

Geographical distribution:
African trypanosomiasis occurs in tsetse fly areas of Africa (tropical, east and west).

Habitat:

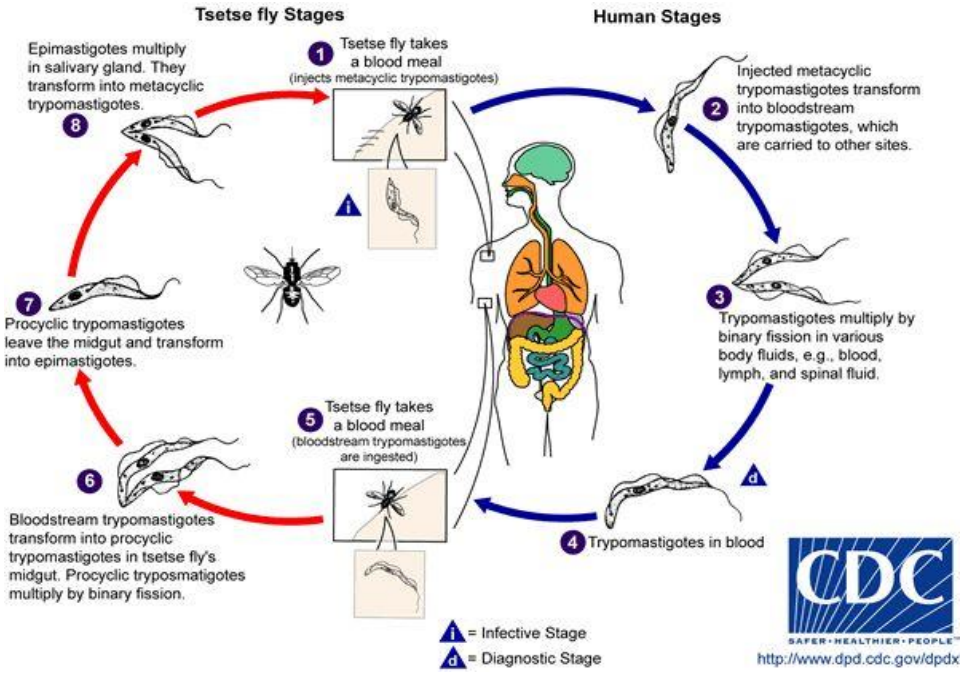
1) trypomastigotes form in man (blood, CSF).
2) epimastigotes and metacyclic forms: in the midgut of the tsetse.

Transmission:

1. By bite of tsetse fly vector (intermediate host).
2. Mechanical inoculation.
3. Blood transfusion.

Life cycle:

During a blood meal on the mammalian host, an infected tsetse fly (genus *Glossina*) injects metacyclic trypomastigotes into skin tissue. The parasites enter the lymphatic system and pass into the bloodstream ❶. Inside the host, they transform into bloodstream trypomastigotes ❷, are carried to other sites throughout the body, reach other blood fluids (e.g., lymph, spinal fluid), and continue the replication by binary fission ❸. The entire life cycle of African Trypanosomes is represented by extracellular stages. The tsetse fly becomes infected with bloodstream trypomastigotes when taking a blood meal on an infected mammalian host (❹, ❺). In the fly's midgut, the parasites transform into procyclic trypomastigotes, multiply by binary fission ❻, leave the midgut, and transform into epimastigotes ❼. The epimastigotes reach the fly's salivary glands and continue multiplication by binary fission ❽. The cycle in the fly takes approximately 3 weeks. Humans are the main reservoir for *Trypanosoma brucei gambiense,* but this species can also be found in animals. Wild game animals are the main reservoir of *T. b. rhodesiense*.



Pathogenecity:

the disease is called Sleeping sickness.

1. Painful Chancre at site of inoculation
2. High Irregular fever, headache.
3. Lymphadenopathy.
4. Loss of weight, sweating.
5. Long time infection can show long time sleeping -central nervous system (CSF) involved and can lead to death.

Life cycle:

1. Metacyclic trypomastigotes are inoculated through the skin (tsetse), they develop into trypomastigotes, which multiply.
2. The trypomastigotes are carried to the heart, and various organs of the body.
3. Trypomastigotes are ingested by tsetse when it sucks blood. In the midget, the parasite develops and multiplies.
4. After 2-3 weeks, the trypomastigotes migrate to the salivary glands where they develop into epimastigote, which in turn develop into metacyclic trypomastigotes.

Morphology: spindle shape body

1- Pleomorphic trypanosomiasis: showing variety of forms measuring from 18-35µm in length.
2- Single flagella arising from kinitoplast, and extend forewords, and undulating membrane.
3- Small dot-like kinetoplast.
4- Dark centrally nucleus, with pale cytoplasm.

Diagnosis:

Specimens: blood, CSF, Lymph gland aspiration.

1- Blood examination: to detect the trypomastigotes.
- ❖ Thick stained blood film.
- ❖ Capillary tube centrifugation concentration technique.
- ❖ Test tube centrifugation concentration technique.

2- CSF and Lymph node aspirate: to detect motile trypomastigote.
3- Serological tests.

4- Inoculation in lab animals.

2- American trypanosomiasis.

Geographical distribution:

South of North America, Central America and South America.

Habitat:

1. Trypomastigotes form in blood of man.
2. Amastigote: in man tissues (liver, spleen, lungs, BM, brain and lymph glands).
3. Epimastigotes and metacyclic forms: in the midgut of the Bug.

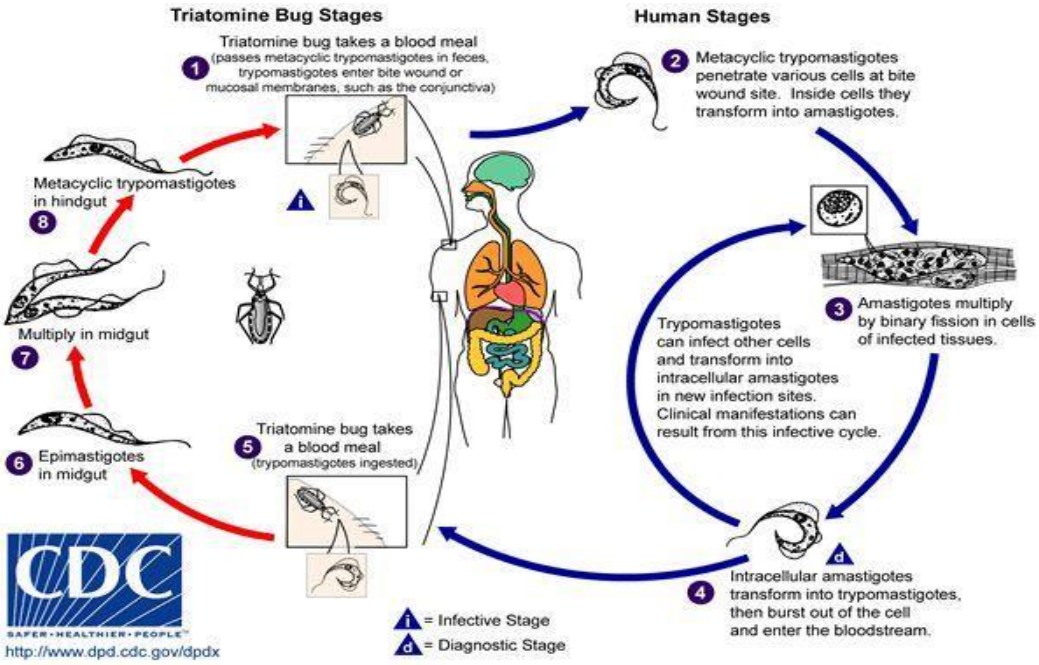
Transmission:

The infective form is the metacyclic trypomastigote, which is contained in the bug faeces, and then rubbed in wound-cut made by insect on the skin.

Life cycle:

- ❖ Metacyclic trypomastigote contained in bug faeces, penetrate the skin after insect bite.
- ❖ Develop into trypomastigotes which infect the RE cells near the site of bite, and multiply intracellularly as amastigotes.
- ❖ Amastigotes develop to form trypomastigote, which released into the blood when the cell is ruptured. NO MULTIPLICATION OCCURS IN THE STAGE OF BLOOD TRYPOMASTIGOTES.
- ❖ By the way of blood, Trypomastigotes reach tissue cell, and become amastigotes and multiply forming masses called pseudocycts.

- ❖ In the pseudocyctes amastigotes develop into epimastigotes, and then trypomastigotes and continue. Some of them taken by the bug through another bite.
- ❖ In the vector, it develops into epimastigotes, which multiply to give metacyclic trypomastigote in the hindgut of the bug.



Pathogenecity:

American trypanosomiasis, or Chaga's disease, Where the patient suffer of inflamed swelling, if it was in near the eyes, this is Romana signs oedema of eyelids. In the acute stage, amastigotes multiply and spread in the tissues, it causes fever, malaise, enlargement of lymph node, liver, and lesser in spleen. Acute attack for the heart can cause death.

Laboratory diagnosis:

1- By finding the trypomastigotes in the blood during early acute infection.
2- Detection of epimastigotes in the blood culture.
3- By finding amastigotes in lymph node aspirate.
4- Serum for serology.
5- Inoculation in lab animals.

Genus: MALARIA PARASITES.

The malaria parasites are protozoan parasites, belong to the family plasmodium, and classified into many species. The plasmodium which infects human are:

Widespread species	Plasmodium falciparum.
	Plasmodium vivax.
Less widespread specie	Plasmodium malariae.
	Plasmodium ovale.

The term Benign malaria is used to describe the P. Vivax and P. Ovale.
The term Malignant malaria is used to describe the P. falciparum. Quart

Transmission and Life cycle:

1- By the bite of the female of the anopheles mosquitoes.
2- By transfusion of infected blood.
3- By injection through the use of needle and syringes contaminated with infected blood.
4- Very occasionally, congenital transmission occurs.

* Two hosts involved: man and mosquito.
* The malaria of man has two stages:

1. In the anopheles a sexual, extracellular cycle of development occurs which called sporogony.
2. In human host, malaria parasite has an asexual intracellular cycle of development called schizogony, the human is the intermediate host.

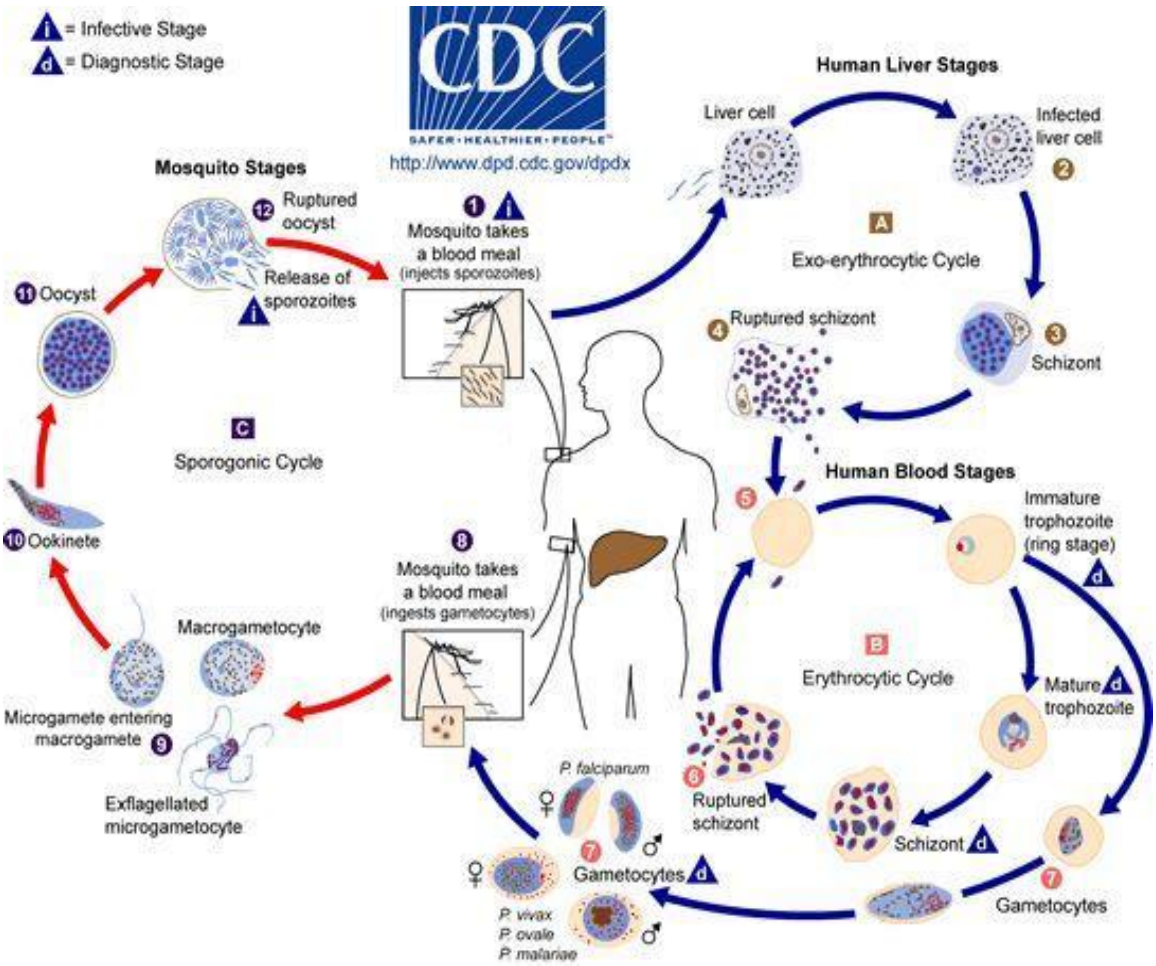
Life cycle:

The infective stage is the sporozoites.

1- Sporozoites contained in saliva of an infected mosquito are injected into the blood of human host.
2- After circulating in the blood stream they enter the liver cells (hepatocytes).
3- They grow, multiply and develop into schizonte (pre erythrocytic schizonte), which when mature contains about 30 000 merozoites.
4- When mature, the schezonte and the liver cell rupture and merozoite enter the blood. To survive it should enter red blood cells within minutes. This stage takes 36-48 h. to complete.
5- Merozoites become trophozoites, and when fully developed will become schizontes (Schizogony) which contains 8-32 merozoites (Erythrocytic schizonte). When mature it will rupture, and release merozoites.

6- After many cycles of invading RBCs, some of the merozoites develop into schizonts which follow a sexual development and become a gametocyte which will be ingested by a female of anopheles.

7- In the mosquito, they develop into male and female gametocytes, which when fertile a zygote is formed.
8- Zygote develop multiple times to form the sporozoites which spread in the saliva of the mosquito and when bite a human start again.



Clinical features:

- The patient Feels cold, rigor and headache.
- Fever, sweating.
- Anaemia with enlarged spleen.
- Diarrhoea and vomiting.

Diagnosis:

Before starting, remember you should ask the patient if he or she has taken any anti-malaria dugs for the last 24 hours.

Specimen:

Blood, serum.

Lab diagnosis:

a- Examining the stained thick blood film to detect the parasites.
b- Examining the stained thin blood film to identify the species of the parasite.
c- Examining the Buffy coat.
d- Serological examination.

Chapter 3

Phylum Platyhelminthes

Flatworms are acoelomate, triploblastic animals. They lack circulatory and respiratory systems, and have a rudimentary excretory system. The digestive system is incomplete in most species. There are four classes of flatworms, the largely free-living turbellarians, the ectoparasitic monogeneans, and the endoparasitic trematodes and cestodes. Trematodes have complex lifecycles involving a molluscan secondary host and a primary host in which sexual reproduction takes place. Cestodes, or tapeworms, infect the digestive systems of primary vertebrate hosts.

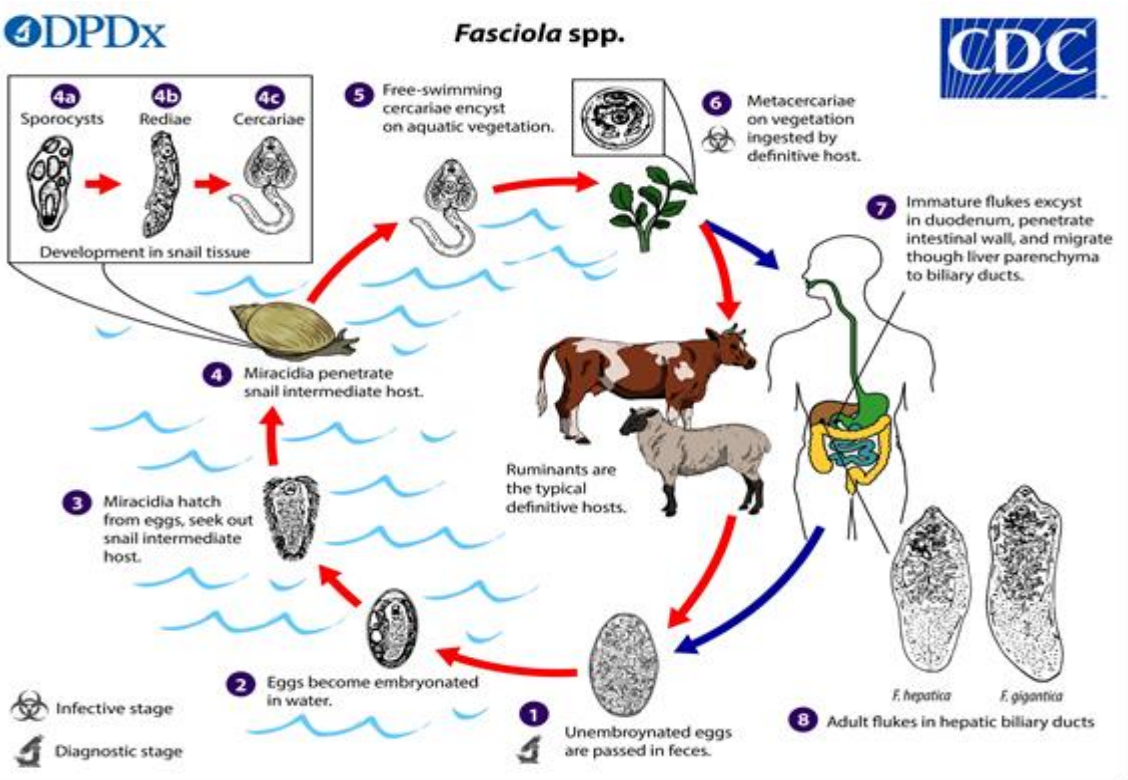
Trematodes

The phylum Platyhelminthes contains the class Trematoda, more commonly known as the trematodes. Most of the common zoonotic trematodes are digenetic, which means these worms require a minimum of two hosts to develop into the adult stage (Nithiuthai et al., 2004). Asexual and sexual reproduction normally occur in an invertebrate and vertebrate host, respectively (Roberts et al., 2013a). Trematodes are primarily hermaphroditic with the family Schistosomidae being a notable exception (Mone and Boissier, 2004). Adult worms live in a variety of locations in the definitive host, including the lungs, liver, and stomach (Bowman, 2009). Regardless of location, operculated eggs are shed in the feces of the definitive host. After a designated time period, which is dependent on temperature, oxygen tension, and pH, the eggs will develop into a miracidium. The miracidium is a ciliated free-living organism, which upon hatching from the egg, enters a mollusk – the intermediate host (Roberts et al., 2013e). The hatching process can occur in water or after ingestion by the requisite intermediate host. In the case of certain species such .(as Fasciola hepatica, light facilitates hatching (Wilson, 1968

Once inside the intermediate host, usually a snail, the miracidium undergoes a complex series of morphological changes to the saclike sporocyst. Inside this sporocyst, other sporocysts, known as daughter sporocysts, may develop. Alternatively, another intermediate stage, the redia or germinal sac, may develop. Rediae normally exit the sporocyst in a dramatic manner, rupturing

the membrane, after which they begin a wandering migration around the host. Rediae can then either develop into daughter rediae or into the next stage, which is the cercaria. The cercariae leave the host and can infect a definitive host in the case of the family Schistosomidae. In other trematodes, the cercariae will either infect a second intermediate host, where they may enter a dormant stage known as the metacercariae (Roberts et al., 2013e). Alternatively, the cercariae of some trematodes, such as the family Fasciolidae, will remain in the environment where they encyst as metacercariae (Olsen, 1947). The life cycle is completed when the definitive host ingests either the second intermediate host containing the metacercariae or the encysted metacercariae in the external environment. As with nematodes, the trematodes undergo complex migrations within the host, after which they arrive at the designated tissue (Nithiuthai et al., 2004; Roberts et al., 2013e). The life cycle and biology described above is what would be considered a classic trematode life cycle. As with all organisms, there are notable exceptions

Liver fluke
Fasciola hepatica
order
Echinostomida
family
Fasciolidae
taxonomy
Fasciola hepatica Linnaeus, 1758, "in aquis dulcibus ad radices lapidum, inque hepate pecorum. Diss. de Ovibus;" Europe.
other common names
English: Sheep liver fluke; French: Grande douve du foie, douve du foie de mouton; German: Großer Leberegel.
physical characteristics
Adult liver flukes may reach 1.7–2.2 in (4–5 cm) in length and 0.6 in (1.5 cm) wide. They are typically about 1.3 in (3 cm) long, 0.4 in (1 cm) wide, and have a spiny tegument. They taper toward the rear. The front end bears an oral sucker and a cone-shaped tip. The sucker on the fluke's ventral (lower) surface is larger than the oral sucker. The ventral sucker is about a third of the body length behind the oral sucker. The branched ovary is situated behind and to the side of the ventral sucker about a third of the way back in the body. The testes are also branched and extend throughout the body behind the ovary.
distribution
Worldwide, but found most often in Europe and Latin America in habitats congenial to their freshwater snail and definitive hosts.



Life Cycle

Immature eggs are discharged in the biliary ducts and passed in the stool 1 . Eggs become embryonated in freshwater over ~2 weeks 2 ; embryonated eggs release miracidia 3 , which invade a suitable snail intermediate host 4 . In the snail, the parasites undergo several developmental stages (sporocysts 4a , rediae 4b , and cercariae 4c). The cercariae are released from the snail 5 and encyst as metacercariae on aquatic vegetation or other substrates. Humans and other mammals become infected by ingesting metacercariae-contaminated vegetation (e.g., watercress) 6 . After ingestion, the metacercariae excyst in the duodenum 7 and penetrate through the intestinal wall into the peritoneal cavity. The immature flukes then migrate through the liver parenchyma into biliary ducts, where they mature into adult flukes and produce eggs 8 . In humans, maturation from metacercariae into adult flukes usually takes about 3–4 months; development of *F. gigantica* may take somewhat longer than *F. hepatica*.

Diagnosis

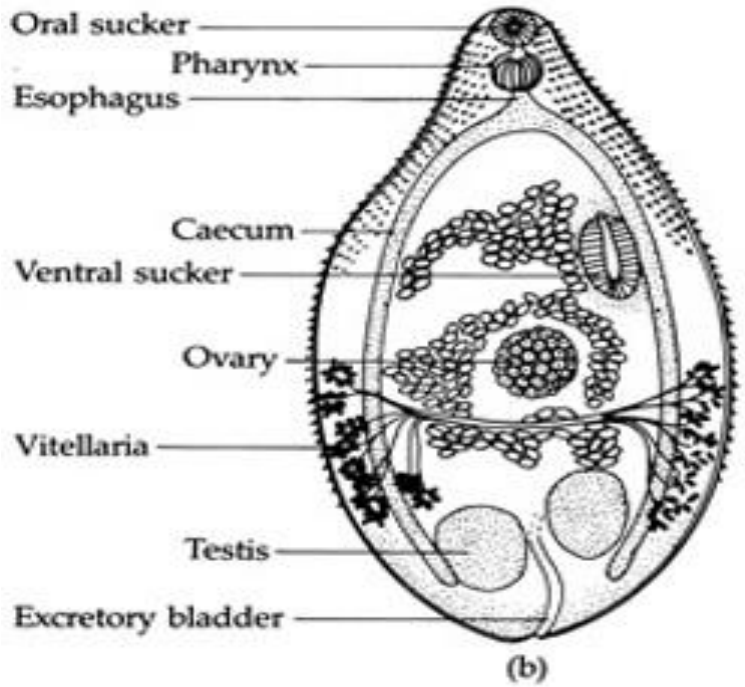
The standard way to be sure a person is infected with *Fasciola* is by seeing the parasite. This is usually done by finding *Fasciola* eggs in stool (fecal) specimens examined under a microscope. More than one specimen may need to be examined to find the parasite. Sometimes eggs are found by examining duodenal contents or bile.

Infected people don't start passing eggs until they have been infected for several months; people don't pass eggs during the acute phase of the infection. Therefore, early on, the infection has to be diagnosed in other ways than by examining stool. Even during the chronic phase of infection, it can be difficult to find eggs in stool specimens from people who have light infections.

Certain types of blood tests can be helpful for diagnosing *Fasciola* infection, including routine blood work and tests that detect antibodies (an immune response) to the parasite.

Intestinal trematodes

The trematode Heterophyes heterophyes, a minute intestinal fluke.



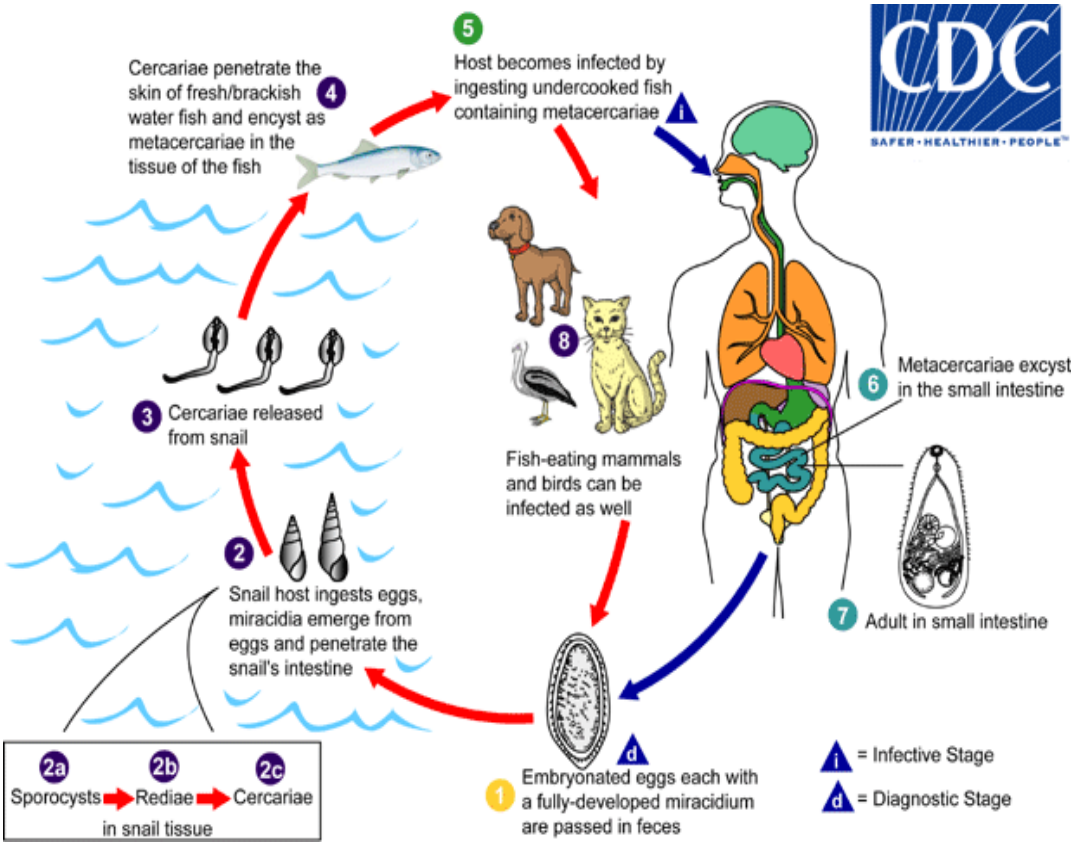
Geographic Distribution

Egypt, the Middle East, and Far East.

Heterophyiasis is acquired by eating infected raw or undercooked fish from freshwater or brackish water containing **metacercariae (encysted stage)**. After ingestion, metacercariae excyst and attach to the mucosa of the small intestine. There, they develop into adults, growing to about 1.0 to 1.7 mm by 0.3 to 0.4 mm.

Life Cycle

Adults release embryonated eggs each with a fully-developed miracidium, and eggs are passed in the host's feces[1] . After ingestion by a suitable snail (first intermediate host), the eggs hatch and release miracidia which penetrate the snail's intestine[2]. Genera *Cerithidia* and *Pironella* are important snail hosts in Asia and the Middle East respectively. The miracidia undergo several developmental stages in the snail, i.e. sporocysts[2a], rediae[2b], and cercariae[2c]. Many cercariae are produced from each redia. The cercariae are released from the snail[3] and encyst as metacercariae in the tissues of a suitable fresh/brackish water fish (second intermediate host)[4]. The definitive host becomes infected by ingesting undercooked or salted fish containing metacercariae[5]. After ingestion, the metacercariae excyst, attach to the mucosa of the small intestine[6] and mature into adults (measuring 1.0 to 1.7 mm by 0.3 to 0.4 mm)[7]. In addition to humans, various fish-eating mammals (e.g., cats and dogs) and birds can be infected by *Heterophyes heterophyes* [8].



symptoms

The main symptoms are diarrhea and colicky abdominal pain. Migration of the eggs to the heart, resulting in potentially fatal myocardial and valvular damage, has been reported from the Philippines. Migration to other organs (e.g., brain) has also been reported.

Laboratory Diagnosis

The diagnosis is based on the microscopic identification of eggs in the stool. However, the eggs are indistinguishable from those of Metagonimus yokogawai and resemble those of Clonorchis and Opisthorchis.

Schistosomes.

Schistosomes are trematodes (flukes) that live in the blood.

Classification of medical importance schistosomes:

1- S. Haematobium (urinary).
2- S. Mansoni (intestinal).
3- S. Japonicum (intestinal).

Features of human schistosomes:

- They develop in the venous system of the intestine and bladder.
- Sexes are separated.
- They are not like the other flukes, which are flattened but they are long and worm-like.
- Human is the definite host of S. Haematobium. S. Mansoni.
- Transmission is by contact with water containing the infective form of the parasite which is the cercariae. These develop in the snail and are able to penetrate the unbroken skin.

Geographical distribution:

S. Haematobium: Africa, M. East and India.
S. Mansoni : Africa, M. East and S. America.
S. Japonicum: Far East.

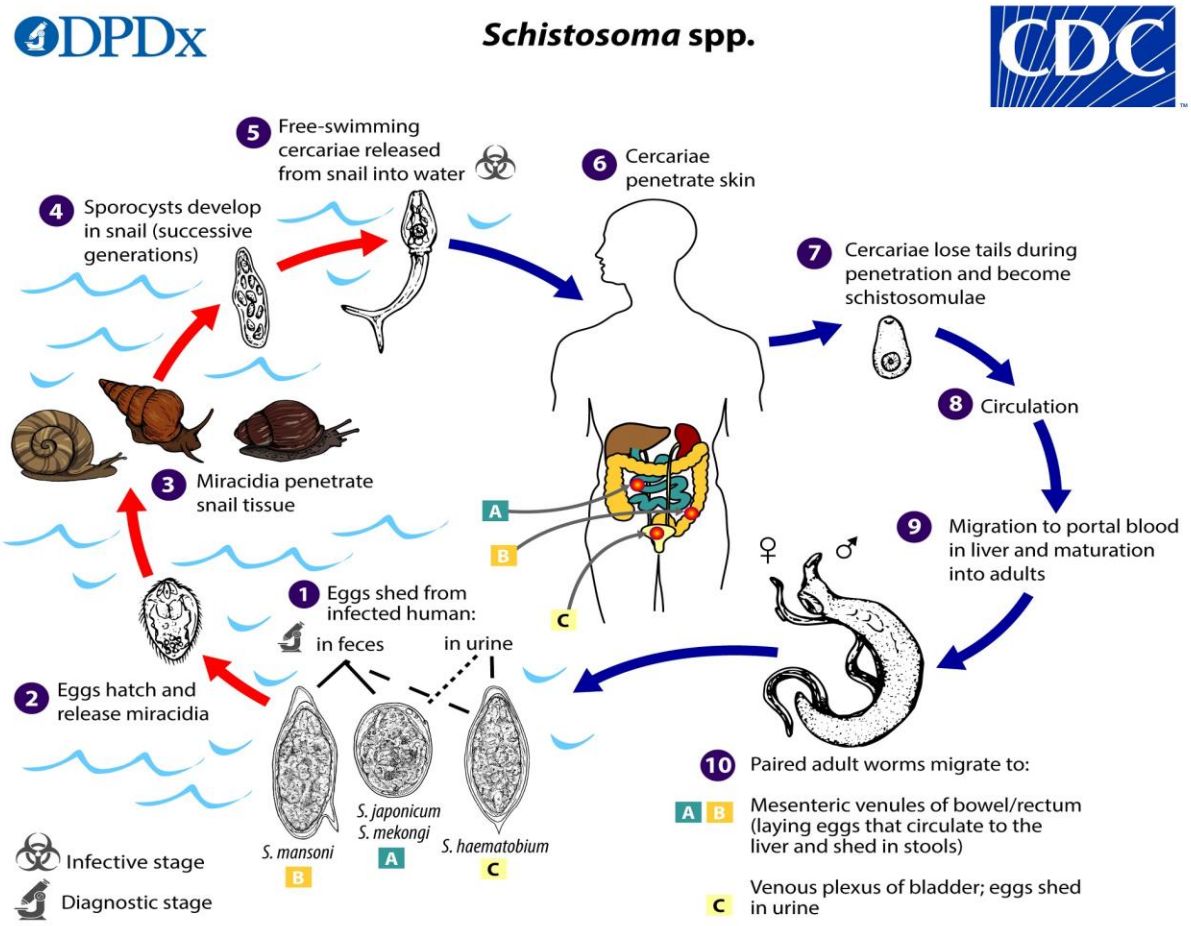
Habitat:

1- S. Haematobium:
- Adult in the venous system of the bladder.
- Egg: in urine and occasionally in stool (contamination).

2- S. Mansoni:
- Adult in the venous system of the large intestine and mesenteric vein.
- Egg: in stool and occasionally in urine.

3- S. Japonicum:
- Adult in the venous system of the large intestine and gastric vein.
Egg: in stool only.

Transmission and Life cycle:



Life Cycle

1- S. Haematobium infection is caused by an infected person passing urine containing the egg of the parasite into water which is used by the others for bathing, washing, agricultural purposes, and fishing.
2- S. Mansoni infection: is caused by an infected person passing stool containing the egg of the parasite into water which is used by the others for bathing, washing, agricultural purposes, and fishing.
3- S. Japonicum infection: is caused by an infected person or animal passing stool containing the egg of the parasite into water which is used by the others for bathing, washing, agricultural purposes, and fishing.

Schistosoma eggs are eliminated with feces or urine, depending on species (1). Under appropriate conditions the eggs hatch and release miracidia (2), which swim and penetrate specific snail intermediate hosts (3). The stages in the snail include two generations of sporocysts (4) and the production of cercariae (5). Upon release from the snail, the infective cercariae swim, penetrate the skin of the human host (6), and shed their forked tails, becoming schistosomulae (7). The schistosomulae migrate via venous circulation to lungs, then to the heart,

and then develop in the liver, exiting the liver via the portal vein system when mature, [8] [9] . Male and female adult worms copulate and reside in the mesenteric venules, the location of which varies by species (with some exceptions) [10] . For instance, *S. japonicum* is more frequently found in the superior mesenteric veins draining the small intestine [A] , and *S. mansoni* occurs more often in the inferior mesenteric veins draining the large intestine [B] . However, both species can occupy either location and are capable of moving between sites. *S. intercalatum* and *S. guineensis* also inhabit the inferior mesenteric plexus but lower in the bowel than *S. mansoni*. *S. haematobium* most often inhabitsin the vesicular and pelvic venous plexus of the bladder [C] , but it can also be found in the rectal venules. The females (size ranges from 7–28 mm, depending on species) deposit eggs in the small venules of the portal and perivesical systems. The eggs are moved progressively toward the lumen of the intestine (*S. mansoni*,*S. japonicum, S. mekongi, S. intercalatum/guineensis*) and of the bladder and ureters (*S. haematobium*), and are eliminated with feces or urine, respectively [1] .

Clinical features:

1- S. Haematobium:

- The disease is called "Bilharzias or Bilharsiasis", eggs classified in the bladder.
- Within 24 h. an intensive irritation may occur at the site of penetration, this is called "swimmer's itch".
- Haematuria: blood in the urine.
- Proteinuria: protein in urine.
- In heavy infections: Liver and spleen enlargement.
- Deposition of eggs in many organs in heavy and old infections.

2- S. Mansoni and S. Japonicum:

- Within 24 h. an intensive irritation may occur at the site of penetration, this is called "swimmer's itch".
- Host reaction to eggs logged in the intestinal mucosa leading to the formation of Granulomata which can cause colonic and rectal polyps.
- Ulceration and thichness of the wall of bowel.
- In heavy infections: Liver and spleen enlargement.
- Deposition of eggs in many organs in heavy and old infections.

Laboratory diagnosis:

1- S. Haematobium:

Sample: urine.

- Finding the eggs or occasionally the hatched miracidia in urine.
- Detecting eggs in the rectal or bladder mucosal biopsy.

2- S. Mansoni:

- Finding the eggs in faeces and may also be found in urine.
- Detecting eggs in the rectal in biopsy if they are not found in faeces.

3- S. Japonicum:

- Finding the eggs in faeces.
- Detecting eggs in the rectal in biopsy if they are not found in faeces.

Other finding:

- Mucous and blood in the stool in the urine.
- Blood eosinophili .
- Bacteriuria.

Chapter 4

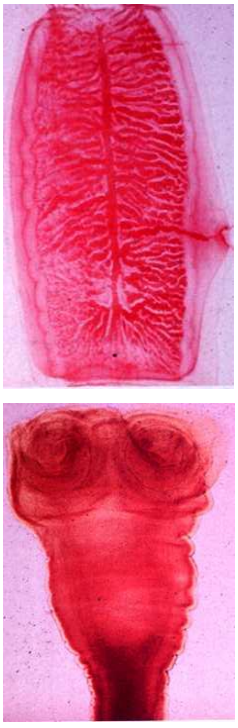
TAPEWORM (CESTODES).

Taenia (cysticercus), Echinococcus (hydatid), Diphyllobothrium, Hymenolepis, Dipylidium

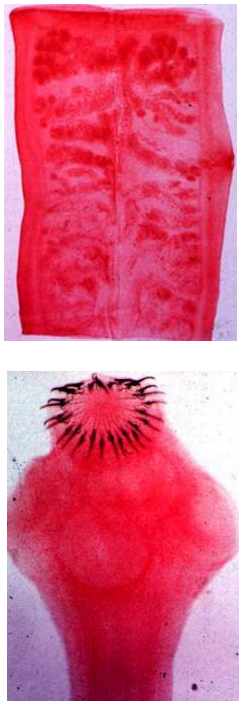
General Structure of Tapeworm

Head region (scolex) : contains suckers (1) and hooks (2) used to attach to a host organism.

Identification of scolex:
It is very small measuring only one mm in diameter.
The scolex has four suckers and crown of hooks.
Taenia saginata and T. solium:
Scolex And Proglottids



(1)



(2)

Zone of Proliferation - Undifferentiated area behind the scolex (neck region)(
Strobilia - Chain of segments (proglottids)
Proglottids : square body segments used for reproduction.
Immature proglottids - developing reproductive
Mature proglottids: mature reproductive organs .
Gravid proglottids: contain eggs in the uterus.

Tapeworms are of considerable medical and economic importance. About 50 million people are infected with Taenia saginata or T. solium, and about 50,000 people die annually of cysticercosis, an infection with larval Taenia. The morphology, life cycles and medical importance of tapeworms (Platyhelminthes, Eucestoda) are discussed. Particular attention is paid to Taenia solium (which causes cysticercosis in humans), Taenia saginata, Echinococcus granulosus and Echinococcus multilocularis (which cause cystic and multilocular=alveolar hydatid disease in humans, respectively), Diphyllobothrium latum, and some other tapeworms of man and domestic animals

Main features of the cestodes:

1. Adults of most live in the small intestine.
2. Human is the definite host of the T. Saginata and T. Solium.
3. Transmission of Taenia species is by ingestion of cysticercus larvae in undercooked beef (T. Saginata) or pork (Solium).
4. Laboratory diagnosis:
5. Is by finding gravid segments and eggs in the faeses. The eggs of T. Saginata can also be found in the perianal area.
6. Body is divided into segments.

1- *Taenia Saginata*.

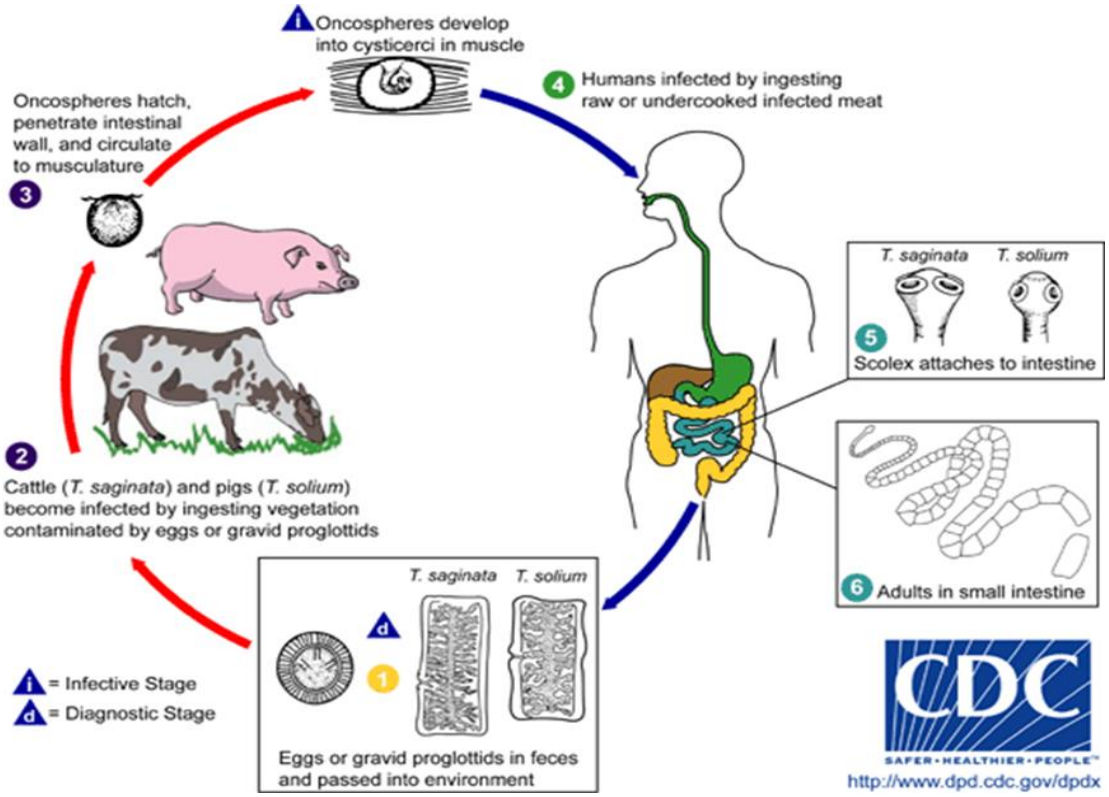
Distribution:

T. saginata has a wide world distribution.

Life cycle:

1. After ingestion of egg, the scolex (head) is freed and become attached to the wall of the small intestine by its suckers. Segments are formed from the neck region and within 2-3 months grow into adult tapeworm with gravid (egg-filled) segments being found at the tail end. Usually one worm present but multiple can occur.
2. When fully developed, the graved become attached and eggs passed in stool.

3. To continue, eggs must reach the place of cattle food, after ingestion by a cow, pass through the intestine wall to the muscles, where the egg grows into infective larvae.



Clinical features:

Usually infection rarely produces serious features. They may be abdominal pain with intestinal disturbances and loss of appetite. Very occasionally appendicitis can occur.

Identification of *T. saginata* scolex:

It is very small measuring only two mm across. The scolex has four suckers and no hooks. The absence of hooks distinguish it from T. Solium.

2 - *Taenia Solium*.

Distribution:

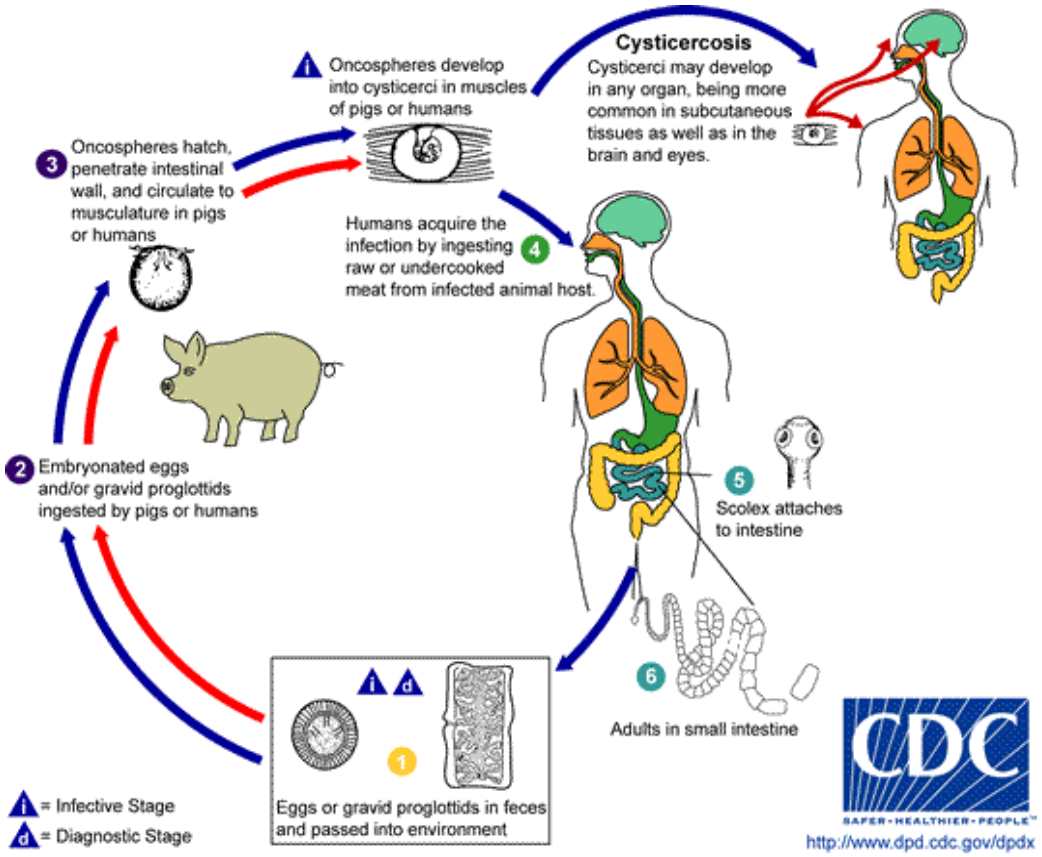
T. solium present mainly in Ethiopia, southern Africa and china .

Life cycle:

4. After ingestion of egg, the scolex (head) is freed and become attached to the wall of the small intestine by its suckers. Segments are formed from the neck region and

within 2-3 months grow into adult tapeworm with gravid (egg-filled) segments being found at the tail end. Usually one worm present but multiple can occur.

5. When fully developed, the graved become attached and eggs passed in stool.
6. To continue, eggs must reach the place of cattle food, after ingestion by a pig, pass through the intestine wall to the muscles, where the egg grows into infective larvae.



Diagnosis

Diagnosis of Taenia tapeworm infections is made by examination of stool samples; individuals should also be asked if they have passed tapeworm segments. Stool specimens should be collected on three different days and examined in the lab for Taenia eggs using a microscope. Tapeworm eggs can be detected in the stool 2 to 3 months after the tapeworm .infection is established

Tapeworm eggs of T. solium can also infect humans, causing cysticercosis. It is important to diagnose and treat all tapeworm infections.

Cysticercosis

Cysticercosis is a parasitic tissue infection caused by larval cysts of the tapeworm Taenia solium. These larval cysts infect brain, muscle, or other tissue, and are a major cause of adult onset seizures in most low-income countries. A person gets cysticercosis by swallowing eggs found in the feces of a person who has an intestinal tapeworm. People living in the same household with someone who has a tapeworm have a much higher risk of getting cysticercosis than people who don't. People do not get cysticercosis by eating undercooked pork. Eating undercooked pork can result in intestinal tapeworm if the pork contains larval cysts. Pigs become infected by eating tapeworm eggs in the feces of a human infected with a tapeworm.

Chapter 4

Helminthes worms.
Nemathelminthes (Round or Cylindrical worm).

Intestinal Nematodes.
Genus: Ascaris.
Species: A. Lumbricoides.

Major features of the intestinal round worms:

- Long cylindrical, non segmented.
- Adult worms live in the intestinal tract.
- Have alimentary canal with mouth and anus.
- Separated sexes (male and female).
- Some have free living while others are saprophytic.
- Female is longer than male, and some have spicules.
- Adult worms are oviparous, egg to larvae then adult worm.
- Some are laviparous: larvae then adult. Example: Strongyloides.
- The term filariform is used to describe the infective larva form that cause infection by penetrating the skin, i.e. S. stercoralis and Hook worm.
- The term rhabditiform is used to describe the non infective larva form that hatch from the egg in the intestine.

Geographical distribution:
World wide distribution, common among children and poor living standard.

Transmission and life cycle:
By ingestion contaminated food, water, or from hands that have become faecally contaminated.

Morphology:
A. Egg:

1. Fertilized egg: yellow-brown and the shell is covered by an albuminous coat. Oval or round measures 60x40 µm. contains a central granular mass which is an unsegmented fertilized ovum.

2. Unfertilized egg: occasionally found. Darker in colour, more elongated.

B. A. lumbricoides worm:

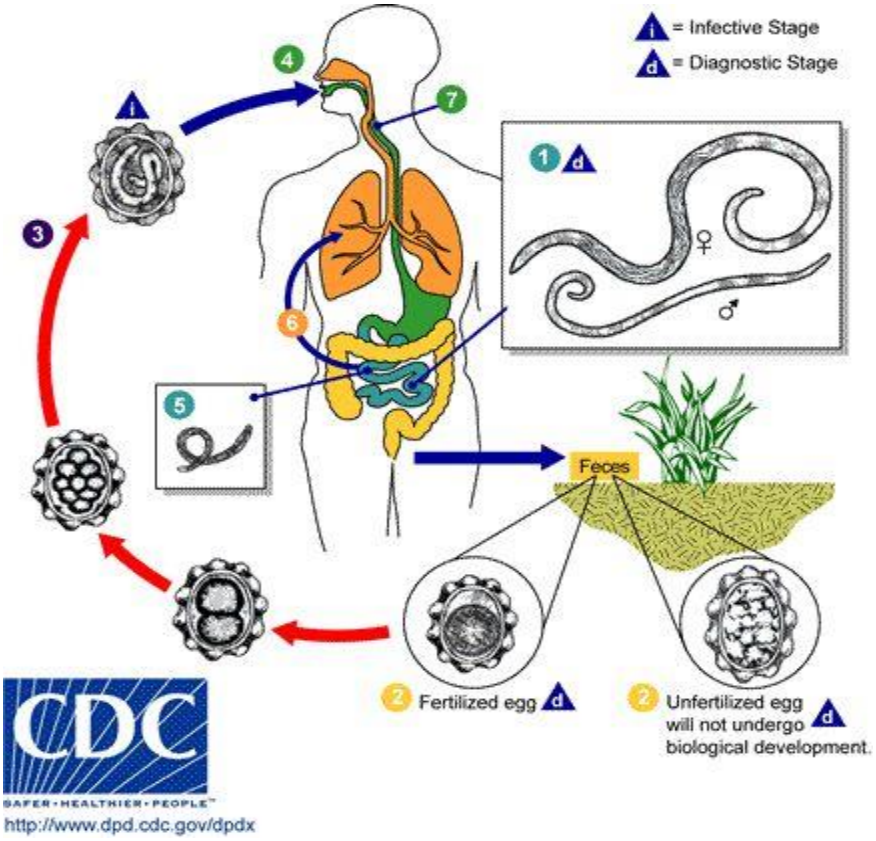
Large, female measures 20-35 cm long.

By 3-6 mm wide and male worms' measure 15-30 cm long by 2-4 mm wide, it is pink-brown or yellow-white in colour. Tale of male has two small spicules (rod-like projections). When examined with magnifying lens, three small lips can be seen around the mouth.

THE INFECTIVE FORM IS THE EGG.

Life cycle:

- Following ingestion of infective egg, the larvae hatch in the small intestine and penetrate the wall toward the blood vessels.
- In the circulation, larvae migrates to the lung-heart circulation during which they develop.
- After migration up to the trachea, they remain in the small intestine and grow into mature worm.
- After mating, the female produces large numbers of eggs which are passed in faeces.
- In soil and under special situations, eggs become infective by containing infective larvae.



(Life cycle of Ascaris Lumbricoides).

Clinical features and pathology:

- During their heart-lung migration, cause inflammatory and hyper sensitivity reactions.

- When they in the intestine, they cause abdominal pain, nausea, diarrhoea and vomiting.
- If heavy infections, cause obstructions in the intestine, bile duct, and pancreatic duct.

Laboratory diagnosis:

1- By finding eggs in faeces by the direct saline preparation.
2- Identifying A. lumbricoides worms expelled through the anus or mouth.

Morphology:

C. Egg:

3. Fertilized egg: yellow-brown and the shell is covered by an albuminous coat. Oval or round measures 60x40 µm. contains a central granular mass which is an unsegmented fertilized ovum.

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2- Enterobius Vermicularis.

Called the thread worm and pinworm, causes enterobiasis.

Distribution:

World wide.

Habitat:

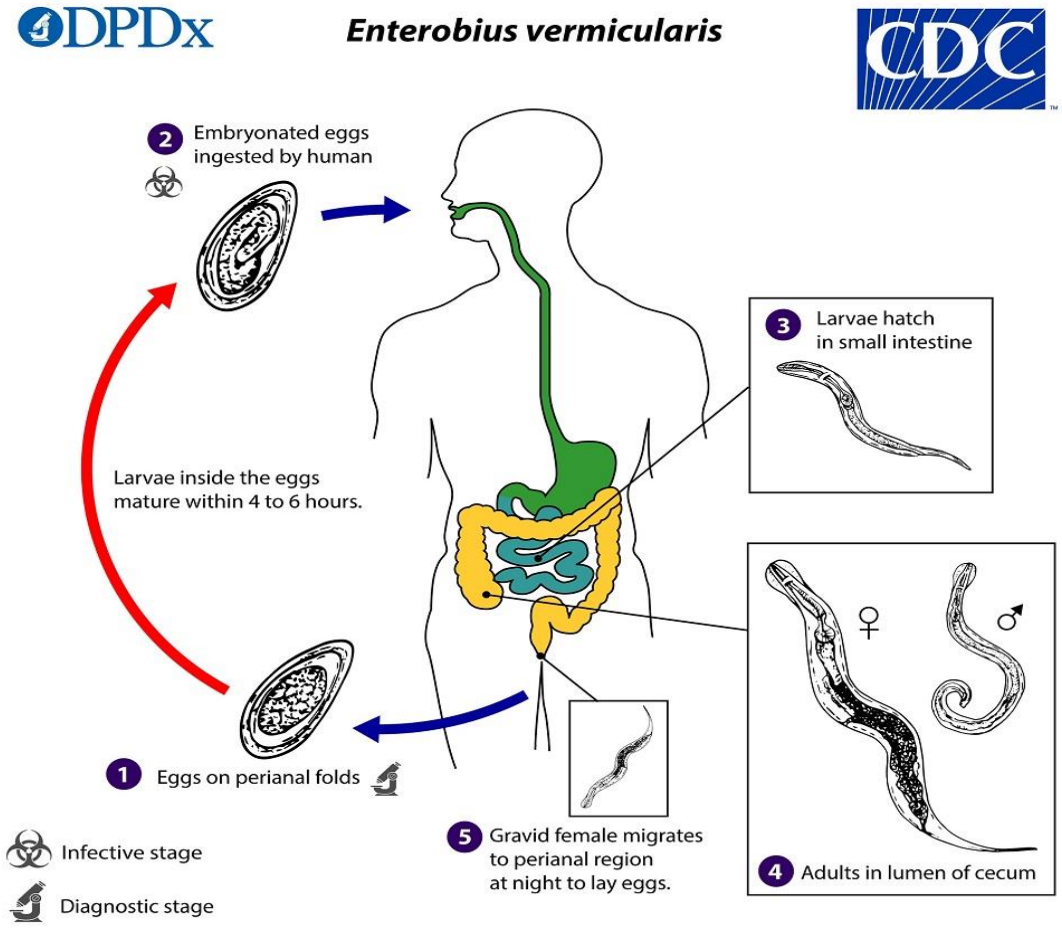
Adult worm in small intestine.
Egg deposited in the peri-anal skin.
Infective larvae: during night when eggs hatch on the buttock.

:Morphology

.Adult: male measures about 4 mm in length with curved tail and spicules
.Female: measures about 10 mm in length, with straight and pointed tail
Egg: asymmetric colorless and flattened from one site, measures about 55-25 µm.

Transmission and life cycle:

1- Ingestion of infective egg.
2- Infection is easily transmitted by contaminated bed or clothes.
3- Autoinfection when egg hatches on the buttocks.
4- Infective larvae migrate back to the intestine.



Gravid adult female *Enterobius vermicularis* deposit eggs on perianal folds (1). Infection occurs via self-inoculation (transferring eggs to the mouth with hands that have scratched the perianal area) or through exposure to eggs in the environment (e.g. contaminated surfaces, clothes, bed linens, etc.) (2). Following ingestion of infective eggs, the larvae hatch in the small intestine (3) and the adults establish themselves in the colon, usually in the cecum (4). The time interval from ingestion of infective eggs to oviposition by the adult females is about one month. At full maturity adult females measure 8 to 13 mm, and adult males 2 to 5 mm; the adult life span is about two months. Gravid females migrate nocturnally outside the anus and oviposit while crawling on the skin of the perianal area (5). The larvae contained inside the eggs develop (the eggs become infective) in 4 to 6 hours under optimal conditions (1).

Rarely, eggs may become airborne and be inhaled and swallowed. Retroinfection, or the migration of newly hatched larvae from the anal skin back into the rectum, may occur but the frequency with which this happens is unknown.

Pathology:

Rarely causes serious disease, usually intense irritation around the anus. In female infection of urinary and genital tract may occur. Worms in appendix may cause appendicitis.

Diagnosis:

1- By finding the egg in samples collected from perianal skin using adhesive tape, or recovered from clothing during the night.
2- Egg can also be found in stool but this is less commonly.
3- By finding the adult (female only) worm in faeces or during clinical examination (occasionally less that 10% of cases).

3-Hook worm.

Ancylostoma duodenale.

Necator americanus.

Distribution:

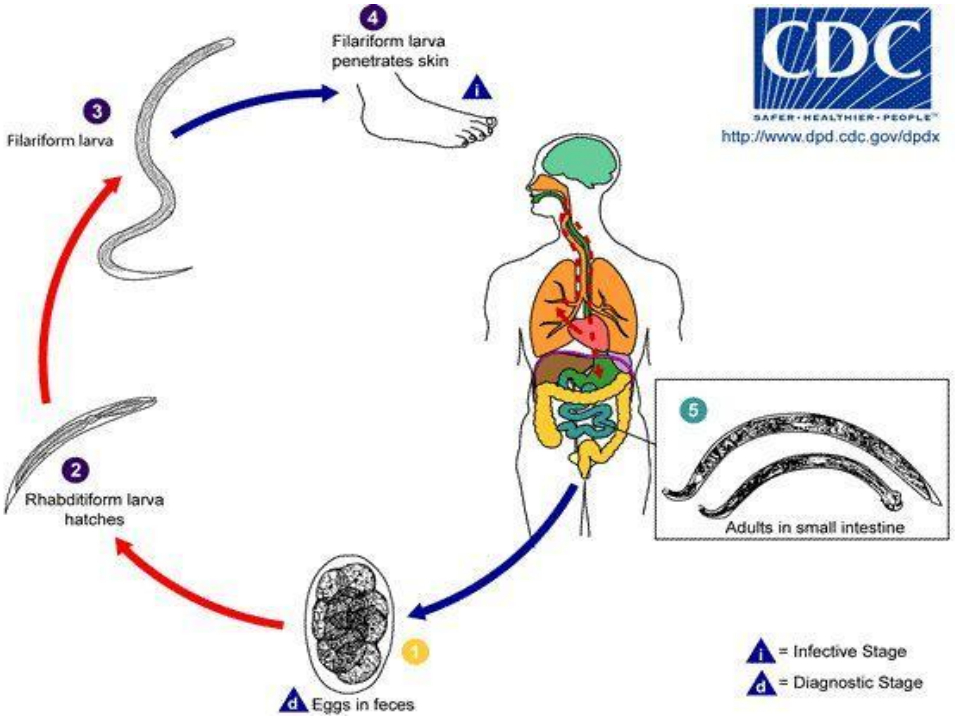
Tropics and sub-tropics, worm areas. Necator americanus is more common than Ancylostoma duodenale.

Habitat:

Adult worm in small intestine.
Egg in faeces but not infective.
Infective larvae: free in soil and water.

Transmission and life cycle:

1- Infection occurs when infective filariform larvae penetrate the skin.
2- Then larvae follow heart-lung migration.
3- Adult in small intestine.
4- Egg passed in faeces.
5- Larvae hatches from egg under favorable condition.
5- Develop into rhabditiform larvae, which develop into infective filariform larvae.



(life cycle of Ancylostoma duodenale.)

Eggs are passed in the stool ❶ , and under favorable conditions (moisture, warmth, shade), larvae hatch in 1 to 2 days and become free-living in contaminated soil. These released rhabditiform larvae grow in the feces and/or the soil ❷ , and after 5 to 10 days (and two molts) they become filariform (third-stage) larvae that are infective ❸ . These infective larvae can survive 3 to 4 weeks in favorable environmental conditions. On contact with the human host, typically bare feet, the larvae penetrate the skin and are carried through the blood vessels to the heart and then to the lungs. They penetrate into the pulmonary alveoli, ascend the bronchial tree to the pharynx, and are swallowed ❹ . The larvae reach the jejunum of the small intestine, where they reside and mature into adults. Adult worms live in the lumen of the small intestine, typically the distal jejunum, where they attach to the intestinal wall with resultant blood loss by the host ❺ . Most adult worms are eliminated in 1 to 2 years, but the longevity may reach several years.

Some *A. duodenale* larvae, following penetration of the host skin, can become dormant (hypobiosis in the intestine or muscle). These larvae are capable of re-activating and establishing patent, intestinal infections. In addition, infection by *A. duodenale* may probably also occur by the oral and the transmammary route. *A. ceylanicum* and *A. caninum* infections may also be acquired by oral ingestion. *A. caninum*-associated eosinophilic enteritis is believed to result following oral ingestion of larvae, not percutaneous infection. *N. americanus* does not appear to be infective via the oral or transmammary route.

Pathology:

1- The first sign is skin reaction at the site of penetration.
2- Mild respiratory symptoms.
3- Adult hookworm causes chronic blood loss leading to developing iron deficiency anaemia in prolonged infection.

Morphology:

Diagnosis:

1- Finding hookworm egg in faeces by direct or concentration technique.

Egg: oval 60X40 µm. colorless with thin shell.
Adult:

2- In old stool sample larvae may hatch.

Books

Doss, Mildred A. *Index Catalogue of Medical and Veterinary Zoology: Trematoda,* Parts 1–8. Washington, DC: U. S. Government Printing Office, 1966.
Olsen, O. Wilford. *Animal Parasites: Their Biology and Life Cycles.* Minneapolis: Burgess Publishing Co., 1967.
Schell, Stewart C. *How to Know the Trematodes.* Dubuque, IA: William C. Brown Co., Publishers, 1970.

Introduction to Medical Parasitology

- **Parasitology : The science which deals with living organismes that living on expense of other organisms getting food and shelter from them, usually causing a certain amount of harm.**
- **There are 3 expiration in parasitology you must know :**
- **Symibosis : Relationship between 2 kinds of organisms both benefit from each other , harmful or even death occur if they were separaeted.**

Example of symibosis :
Green flagelates which lived in small intestine of white ants which feed on cellulose but cant digest it, flagelats converted cellulose into monosacaride and both feeding on this sacaride .

- **Mutualism :Relationship between 2 kinds of organisms ,both benefit from each other but they can lives separeted.**
- **Example : Small bird which feeding on remaining foods between coracoids teeth acting as natural brush .**
- **Commensalism : Relationship between 2 kinds of organisms only one benefit without causing any harm to the other organism.**

Example : *Entamoeba coli* which lived in large intestin of man ,feeding only on bacteria without causing any disease to man.

Classficaion of parasitology

Parasitology divided into 2 groups according to :

1- Position : there are 3 types :

-Ecto-parasite.

-Endo-parasite.

-Tissue parasite.

2- Time : there are 2 types :

- **Temporary parasite.**
- **-Permanent parasite.**

TYPES OF HOST

- **1- Definitive host : The host which harbour the adult stage of parasite and undergoing sexual reproduction.**
- **2- Intermediate host : The host which hrbour the larval stage of parasite and undergo asexual reproduction .**
- **3- Transport host :The host which harbour the larval stage of parasite without any reproduction.**
- **4- Reservoir host: The host which infected with human parasite and able to re-infect man again.**

Types of parasite

- **There are 5 types of parasite :**
- **1- Obligatory parasites .**
- **2- Facultative parasites .**
- **3- Erratic parasites .**
- **4- Incidental parasites .**
- **5- Specific parasites .**

Sources and mode of parasitic infection

1- Food and drink :

Ingestion of raw or undercooked food or drink water containing the infective stage of the parasites .

2- Soil, dust and water(canal and stream):

a- ingestion of food or drink water contaiminated with soil or dust containing the infective stage of the parasites .

b- Inhalation of dust .

c- Direct contact with soil (handling, barefooted) the infected stage penetrates the skin.

d- Water stream (wading, swimming, irrigation, ect.

3- Vector :

a- Bit of vector including the infective stage.

b- Faeces of vector containing the infective stage .

c- Ingestion of vector containing the infective stage

d- Direct penetration of an arthropod into the skin.

4-Direct contact:

a-Skin contact . b- Sexual contact. c- Autoinfection or direct infection.

5- Congestial.

Effect of parasite on the host (pathogenecitiy)

- The effect depend on number, size and shape of the parasite, its activity, site, specific toxin and host reaction.
- The effect may be due to :
- 1- parasite obstracting nourishment from the host.
- 2-Mechanical effect leading to tissue destruction as trauma, pressure, compression or obstruction,feeding on tissue.
- 3-Toxic effect from toxin secreated or wast product excreted by the parasite, leading to poisoning.

4- secondary infection with other organisms as bacteria , the host reaction to the invading parasite may be :

1- Generalized in form of fever, anaemia, leucocytosis and weakness.

2- Localised according to the tissue or organ affected as gastrointestinal distrubances(colic, diarrhoea, dysentery, itching, ulcerationhepatomegaly, splenomegaly, ect

Phylum : Protozoa
Class : Ciliophora
e.g: *Balantidium coli*

Geographical distribution :
Cosomopoltian

Disease : Balantidial dysentery .

Living : In the lumen of large intestine of man .

Morphology :

Moved by cilia, has 2 nuclei, this parasite has 2 stages, trophozoite and cyst.

Trophozite

- **Trophozite is oval in shape pointed anterior and rounded posterior ,covered by cilia. Cilia round the mouth are long and adapted to draw food particles into mouth.**
- **There is a depression at the anterior end(perestome) leads to the cytosome leading to cytopharynx .**
- **In the cytoplasm there are 2 contractile vacuoles, 2 nuclei and food vacuoles containing bactria and also R.B.C.**

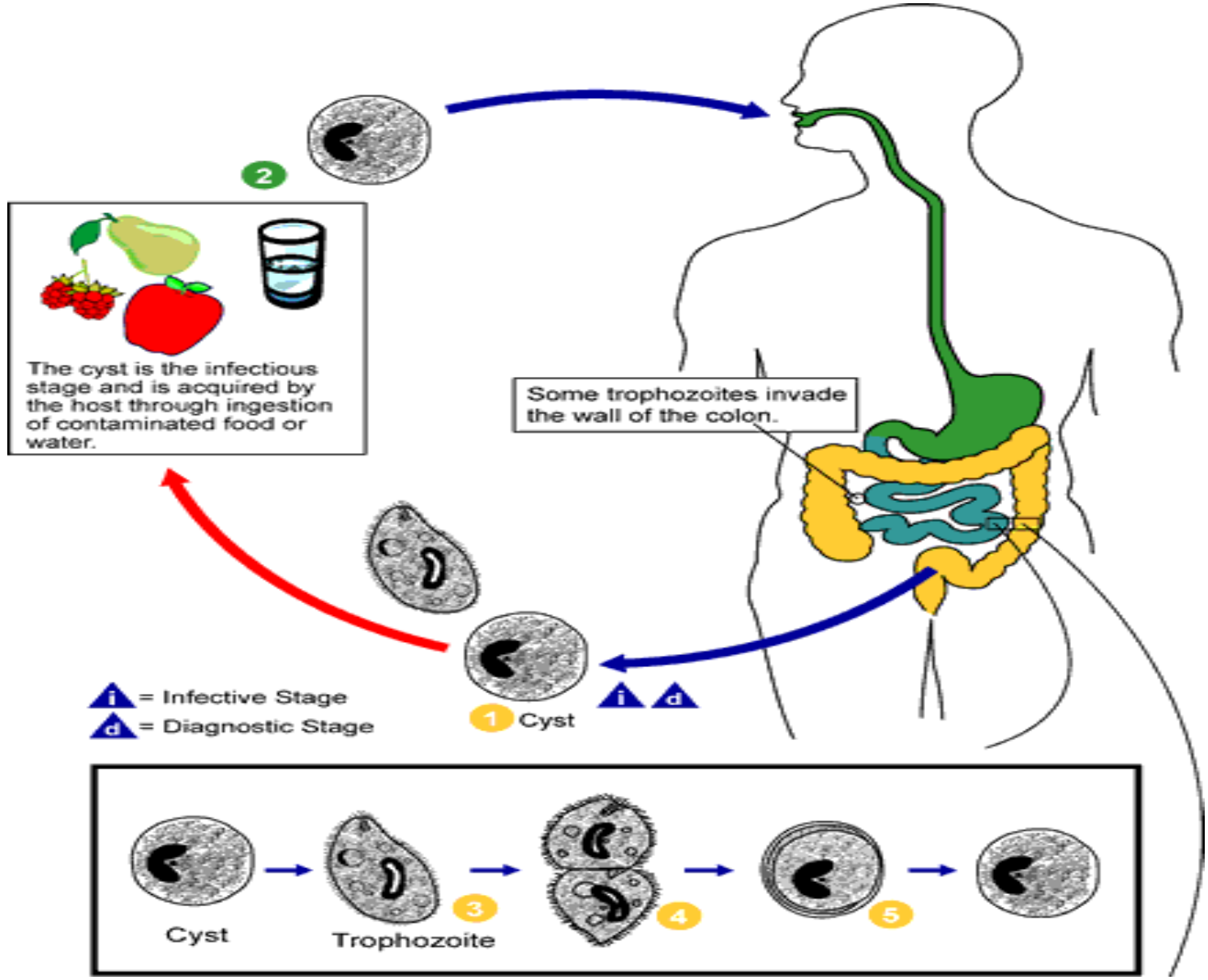
CYST:

- **Cyst is round in shape surrounded by thick membrane and has 2 nuclei.**

Life cycle

- Trophozite lives in the lumen of large intestine of man and may be invade the mucosa .
- . After some time trophozite change into cyst which come out with faeces of patient .
- Cyst is the infective stage ,man is infected by swallowing the infective stage through food or drink,
- Cyst pass through the alimentary canal of man until retching the intestine and change into trophozite and repeat the life cycle .

Balantidium coli Life Cycle



Pathogenicity:

1- Invasion of the muosa and submucosa results in the formation of ulceration.

2-The patient suffer from diarrhea forming balantial dysentery.

.3- Blood vessels are not invaded .Severe infection may be fatal as a result of fulminant ulceration with intestinal perforation and hemorrhage .

Diagnosis:

Stool examination revealed the presence of cyst and trophozite .

Pylum : Protozoa
Class : Sarcodina
e.g.: *Entamoeba histolytica*

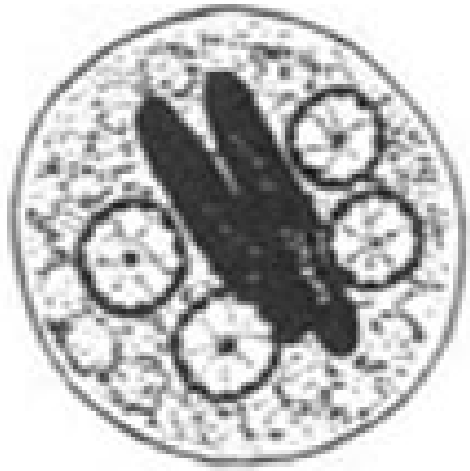
- **Geographical distribution**: Cosmopoltian
- **Diaese :** Amoebiasis, amoebic dysentery.
- **Morphology :**
- *E.histolytica* has 2 stages :
- **1- Trophozite :** Irregular in shape , provided by one pesudopoda, cytoplasm divided into ecto-and endoplasma ,ectoplasma is clear , endoplasma is finaly granular .

- cytoplasm containing nucleus with central endosome and the nucleus surrounding by nuclear membrane having chromatin dots which equal in size and distrubution
- -Cytoplasm containing also food vacuoles containing bactria and R.B.C.

2- The cyst :

- Cyst pass through different stages ,precystic stage with one nucleus , binucleated cyst and finally quadrinucleated stage which is the infective stage (4 –nucleated cyst)

Entamoeba histolytica



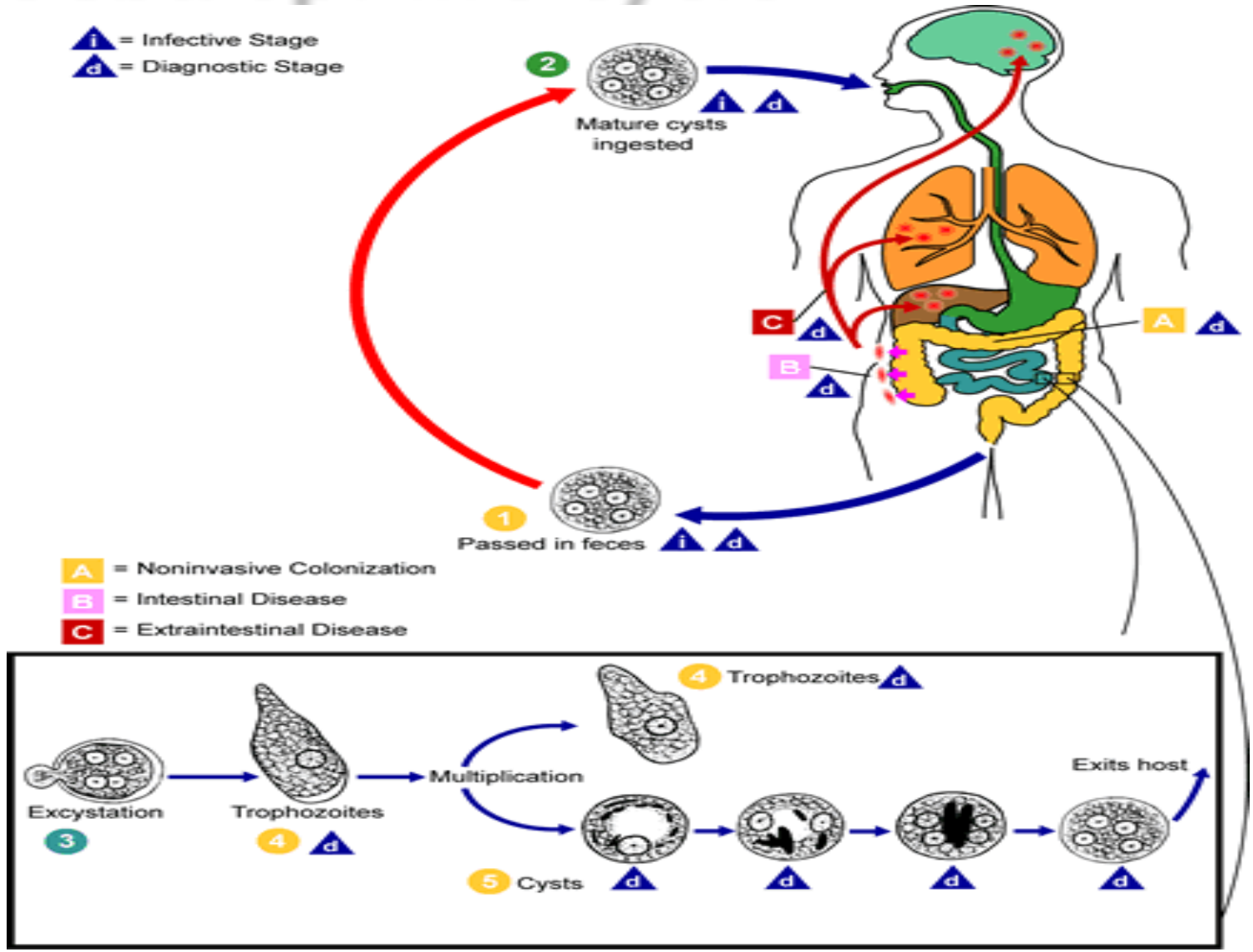
Cyst

Trophozite

Life cycle of *E. histolytica*

- 1- The parasite lives in large intestine of man .
- 2- Man is infected by swallowing the infective stage . 3-At the beginning trophzite feed on bactria .
- , then invade the wall of the intestine and feeding on blood , after some times trophozite change into cyst.
- The cyst come out with faeces to outside.
- When man feed on or drink water containing the infective stage, which pass through the alimentary canal of man until reaching the large intestine and the 4 nuclei divided into 8 small trophozites and repeat the life cycle .

Amoeba sp. life cycle



Pathogenicity

- **1- Intestinal amoebiasis :**
- -Invation of the wall of intestine leads to formation of undermined ulcers, the disease may be :
- In acute cases :there are fever,colic and frequent motion containing blood and mucus.
- In chronic cases : symptoms disappear.
- -Invation of appendex cause appendicitis.

2 Extra- intestinal amoebiasis:

- May occur in the following organs:
- A- Liver abscess .
- B- lung abscess.
- C- Brain abscess.
- D-Skin (cutaneous amoebiasis).

Diagnosis :

- By examination of stool revealed the presence of cyst and trophozite .

Prevention and control

- 1- Personal prophylaxis.
- 2- Examination and treatment of food handlers .
- 3- Human excreta should not be used in fertilizers.
- 4- Treatment of cases .
- 5-Control flies and other insects .

Phylum : Protozoa Class : Zoomastigophora

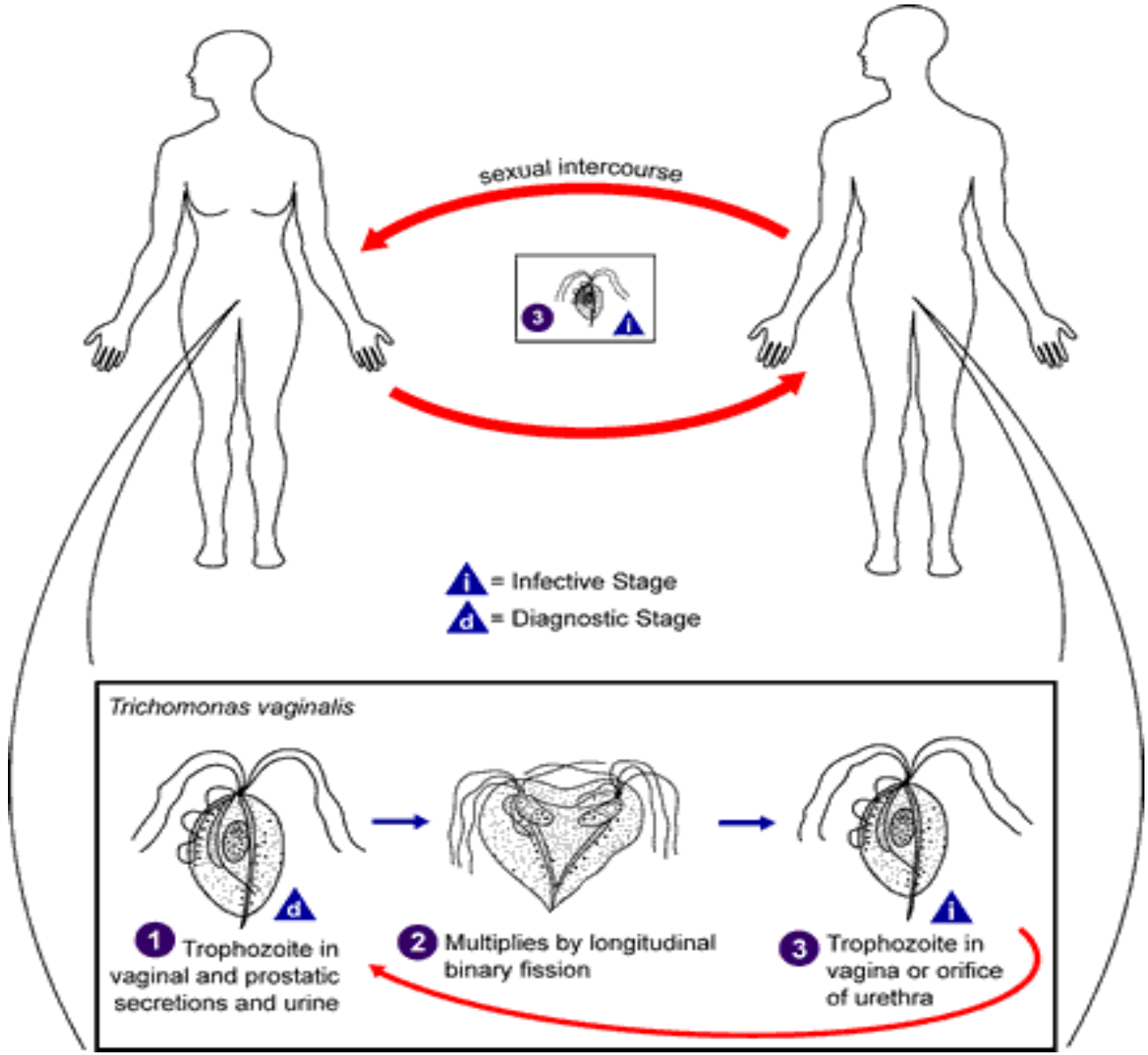
e.g. : *Trichomonas vaginalis*

- **Habitat :**
- **Vagina and urogenital system .**
- **Trophozoite :**
- **Oval to pear shaped, with one nucleus at the anterior end, trophozite provided by 5 fellgella, 4 free anterior and one with ungulating membrane and not ending as free flagellum, there is an exostyle.**
- **Cyst : There is no cyst stage .**

Mode of infection:

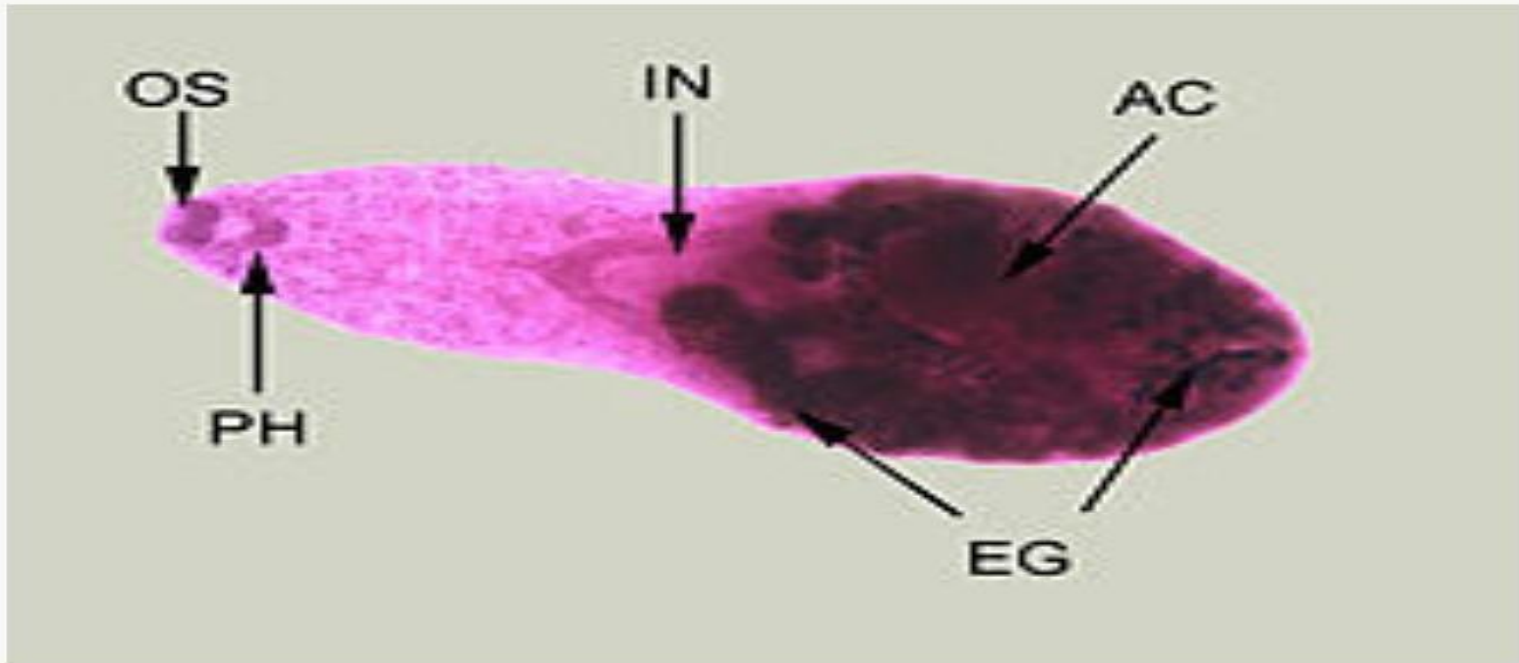
- By sexual intercourse , contamination of toilet seat.
- **Diagnosis:**
- **Examination of vaginal , prostatic or urethral discharge or sedimental urine.**
- **Pathogenicity :**
- **The patient suffers from irritating vaginal discharge, there may be urethritis and prostatitis.**

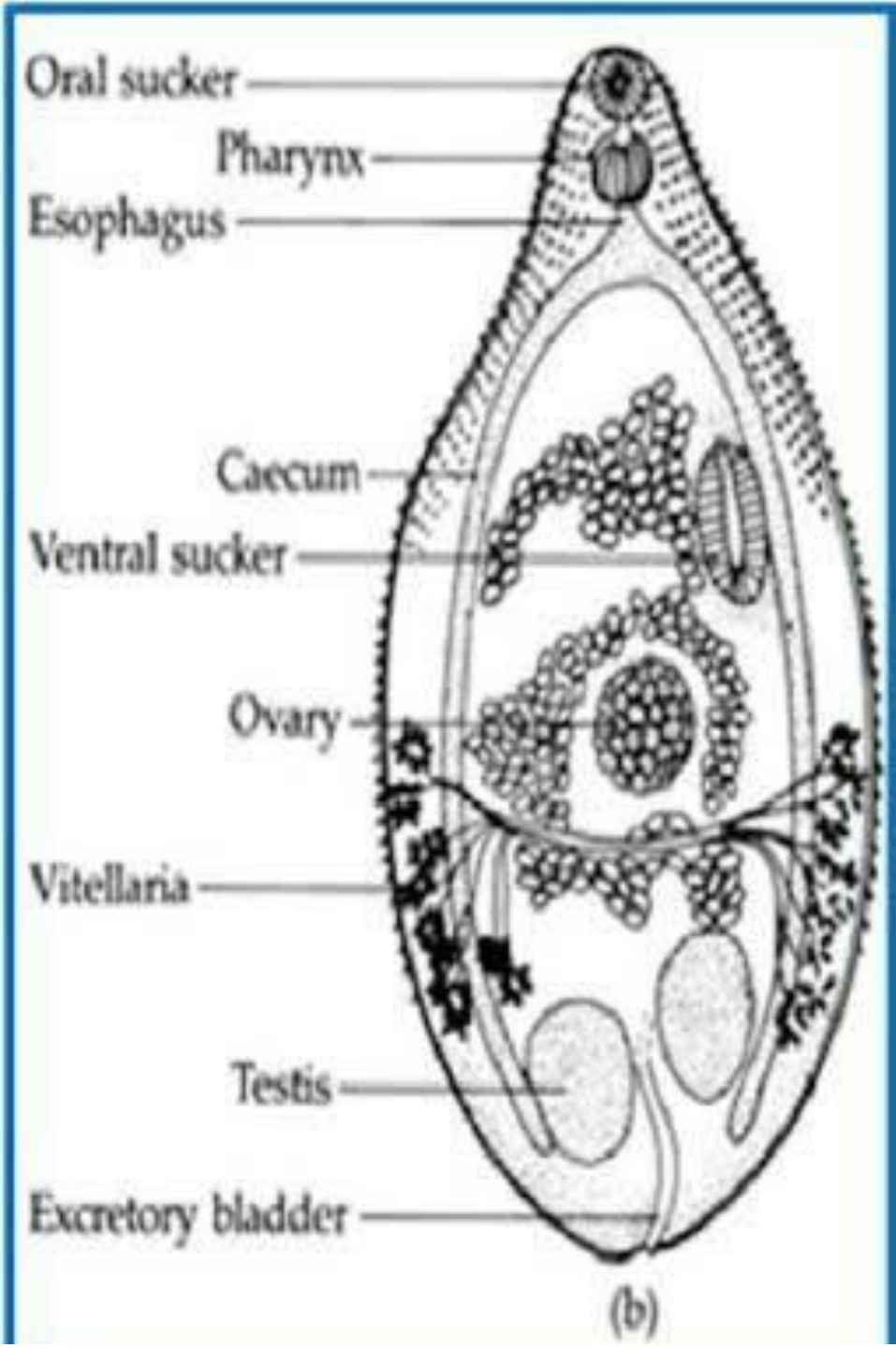
Trichomonas vaginalis Life Cycle

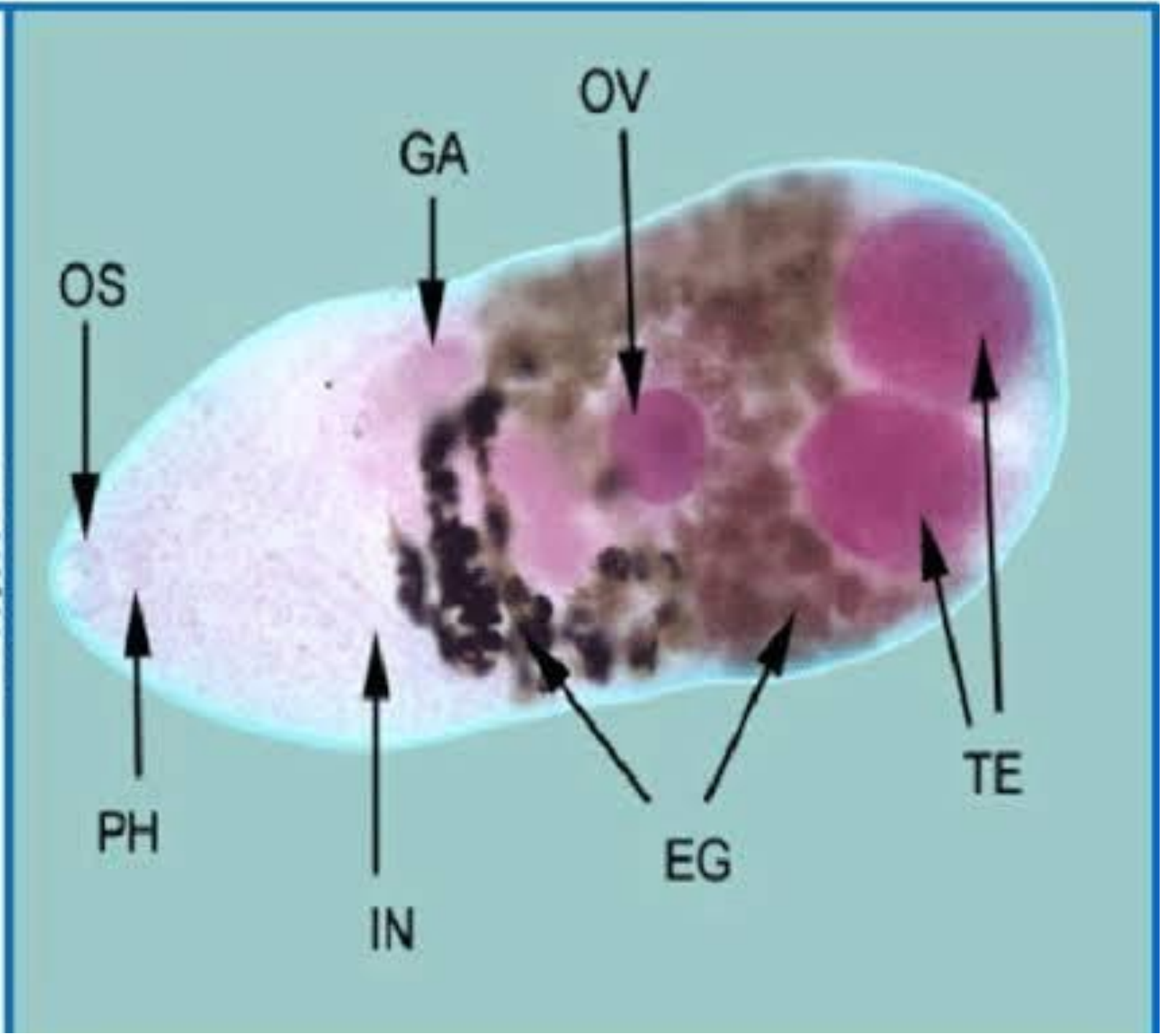


Heterophyes heterophyes is a human parasite.

Heterophyes heterophyes




Oral sucker
Pharynx
Esophagus
Caecum
Ventral sucker
Ovary
Vitellaria
Testis
Excretory bladder
(b)


OV
GA
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PH
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Scientific classification	
Kingdom:	Animalia
Phylum:	Platyhelminthes
Class:	Rhabditophora
Order:	Plagiorchiida
Family:	Heterophyidae
Genus:	*Heterophyes*
Species:	***H. heterophyes***

التصنيف العلمي	
المملكة:	الحيوانات
الشعبة:	الديدان المسطحة
الشعيبة:	حديثات الجلد
الطائفة:	المثقوبات
الطويئفة:	ثنائيات الأجيال
الرتبة:	متأخرات الخصية
الفصيلة:	الخيفانيات
الجنس:	الخيفانة
النوع:	**الخيفانة الخيفاء**

Morphology And Habitat

Minute teardrop-shaped flukes found in the small intestines of birds that eating fish and also present in mammals

The body of flukes ranged from 1.1mm to 1.7mm in length and about 0.35mm at their width

The body of flukes is covered by scales mostly concentrated at the anterior end . Also at the anterior end there is an oral sucker

There is structure called acetabulum located in the medioanterior

At the posterior end of the body there is the male and female gential system.

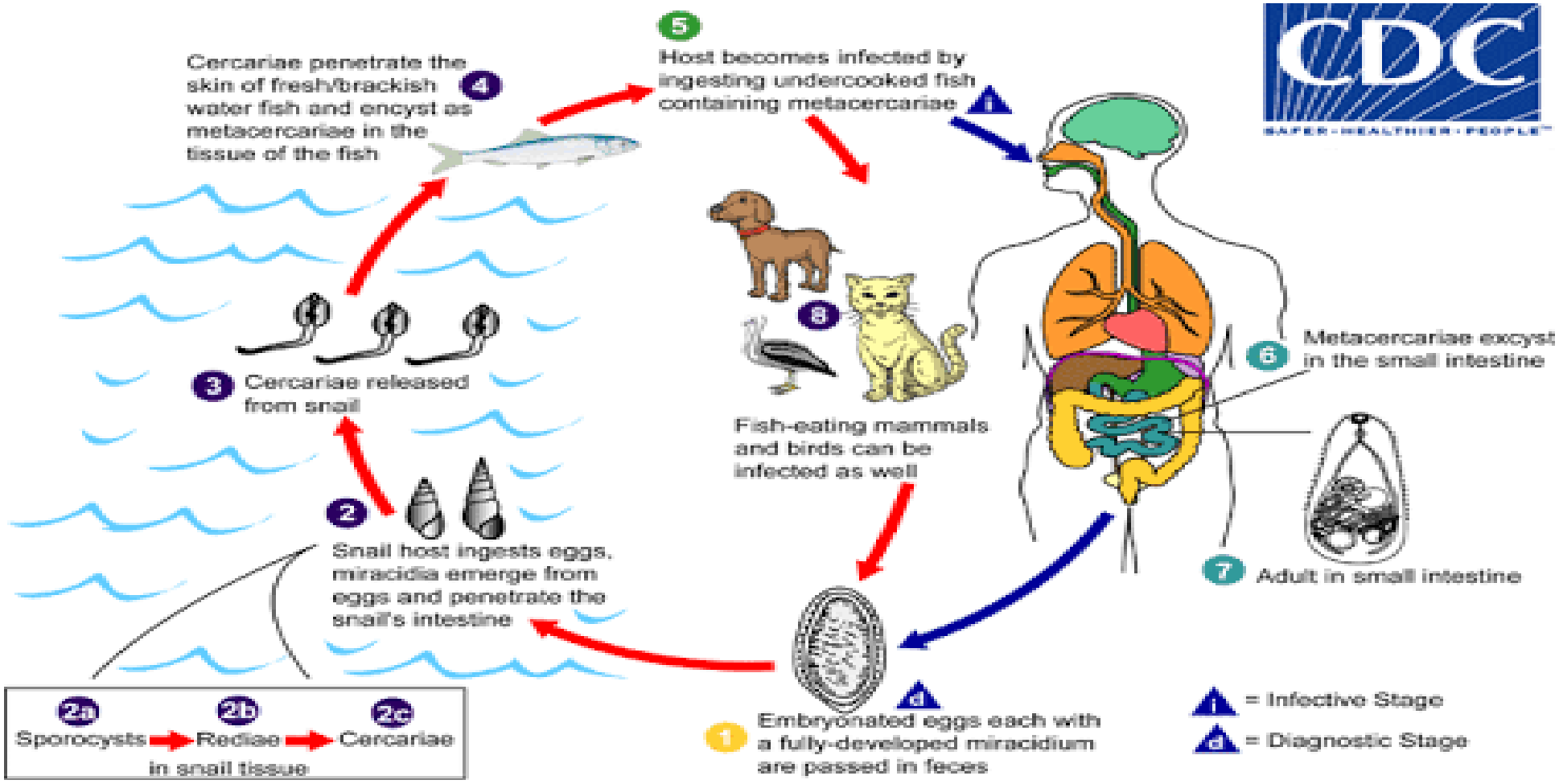
Diagnosis

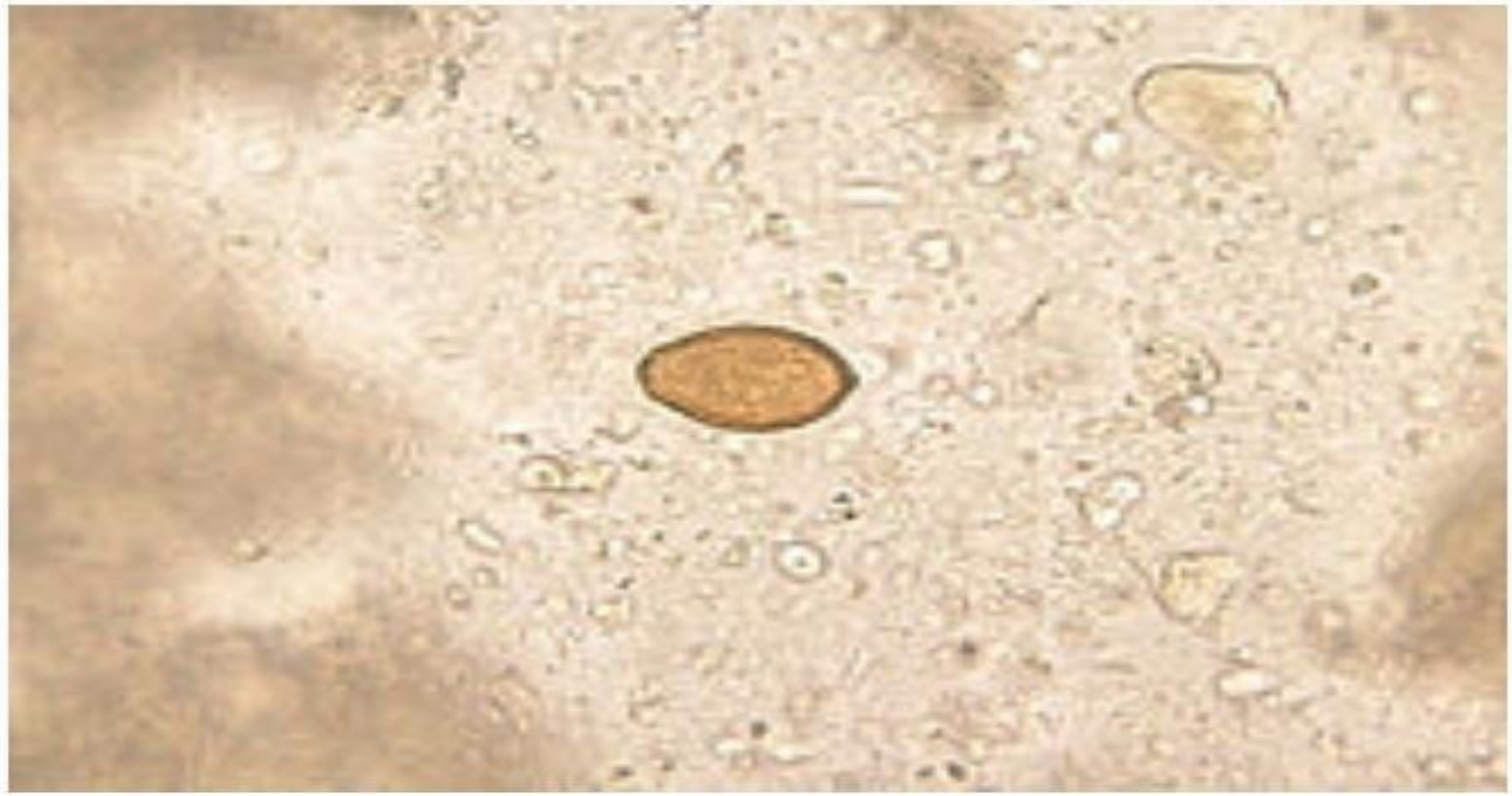
- It is done by examination of stool of patient

- Sometimes the examination become difficult when adult worm is not present because the eggs are hard to distinguish from c.sinensis

Life cycle

- The adult flukes lived burrowed between the villi of small intestine of the host
- Then it possess the egg that contain miracidium but do not hatch until they ingested by snail
- Inside the snail gut .the miracidium become sporocyst which then begin to produce rediae
- The rediae produce cercariae which then go out from the snail and swim toward the surface of the water until contact a fish and penetrate into the epithelium of the fish
- Then the cercariae encyst in the muscles tissue as metacercariae
- Then the human infected by eating and ingesting nudercoocked fish containing metacercariae


Cercariae penetrate the skin of fresh/brackish water fish and encyst as metacercariae in the tissue of the fish
4
5
Host becomes infected by ingesting undercooked fish containing metacercariae
A
3
Cercariae released from snail
8
Fish-eating mammals and birds can be infected as well
6
Metacercariae excyst in the small intestine
7
Adult in small intestine
2
Snail host ingests eggs, miracidia emerge from eggs and penetrate the snail's intestine
2a
Sporocysts
2b
Rediae
2c
Cercariae
in snail tissue
d
1
Embryonated eggs each with a fully-developed miracidium are passed in feces
A = Infective Stage
d = Diagnostic Stage

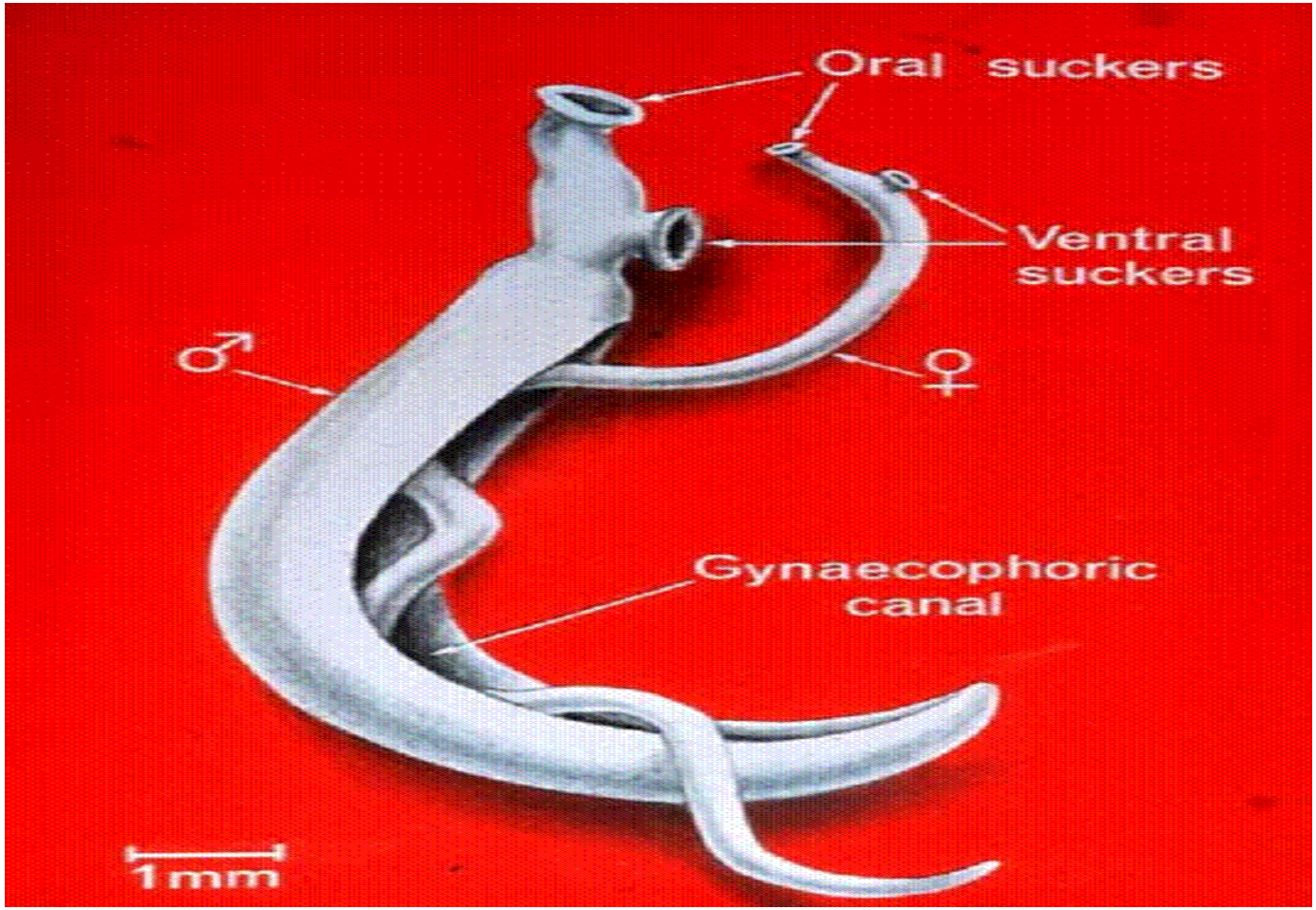


Egg of *Heterophyes heterophyes*

Pathology

- Generally it cause damage to the mucosa and produce intestinal pain and mucosa diarrhea
- Some time eggs can enter the blood and lymph vascular system
- Also the heart can be affected as meracidium cause heart failure
- Eggs can also get into the brain or spinal cord and cause neurological disorder and sometime fatalities

2-Schistosoma haematobium.



Scientific classification

- Kingdom:Animalia
- Phylum :Platyhelminthes
- Class :Trematoda
- Subclass :Digenea
- Order :Prosostomata
- Family :Schistosomatoidea
- Genus :*Schistosoma*
- Species :***Schistosoma haematobium***

Description

- Adult males are 10 to 15 mm long. They have deep grooves called gynecophoral canals in which adult females typically lie.
- Males have many small nodules (tubercles) on their dorsal surfaces and many tiny spines on their suckers and inside their gynecophoral canals.
- Females are longer (16-22 mm), smoother, and more slender. Both sexes have two suckers, one anterior and one ventral, which are used to grip venule walls.

Male

Female

Epidemiology

- *Schistosoma haematobium* is an important digenetic trematode, and is found in Africa and the Middle East. It is a major agent of schistosomiasis; more specifically, it is associated with urinary schistosomiasis.
- Adults are found in the Venous plexuses around the urinary bladder and the released eggs traverse the wall of the urine bladder causing haematuria and fibrosis of the bladder.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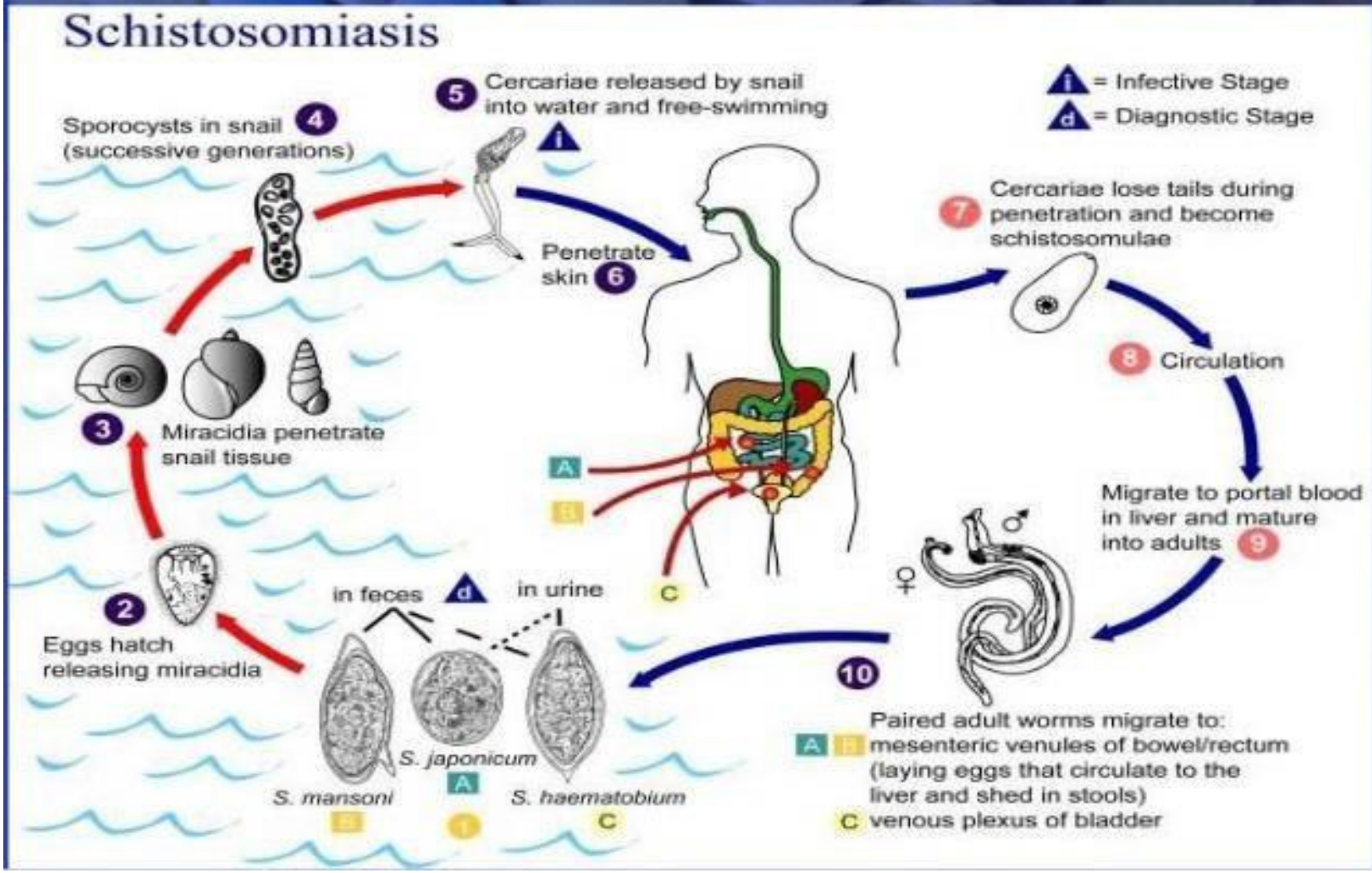
Life cycle

- The free swimming infective larval cercariae burrow into human skin when it comes into contact with contaminated water. The cercariae enter the blood stream of the host where they travel to the liver to mature into adult flukes. In order to avoid detection by the immune system inside the host,
- the adults have the ability to coat themselves with host antigen after a period of about three weeks the young flukes migrate to the urinary bladder veins to copulate.
- The female fluke lays as many as 30 eggs per day which migrate to the lumen of the urinary bladder and ureters. The eggs are eliminated from the host into the

water supply with micturition.

- In fresh water, the eggs hatch forming free swimming miracidia which penetrate into the intermediate snail host *(Bulinus* sp., e.g. *B. globosus*, *B. forskalii*, *B. nyassanus* and *B. truncatus*).
- Inside the snail, the miracidium sheds it epithelium and develops into a mother sporocyst. After two weeks the mother begins forming daughter sporocysts.
- Four weeks after the initial penetration of the miracardium into the snail furcocercous cercariae begin to be released.
- The cercariae cycle from the top of the water to the bottom for three days in the search of a human host. Within half an hour the cercariae enter the host epithelium.

Life Cycle


Schistosomiasis
5 Cercariae released by snail into water and free-swimming
i = Infective Stage
d = Diagnostic Stage
Sporocysts in snail 4
(successive generations)
Penetrate skin 6
7 Cercariae lose tails during penetration and become schistosomulae
8 Circulation
3 Miracidia penetrate snail tissue
A
B
Migrate to portal blood in liver and mature into adults 9
in feces d in urine
C
2 Eggs hatch releasing miracidia
10
Paired adult worms migrate to:
A B mesenteric venules of bowel/rectum
(laying eggs that circulate to the liver and shed in stools)
C venous plexus of bladder
S. japonicum
A
S. mansoni
B
S. haematobium
C

Diagnosis

- The majority of diagnoses are made by examination of the urine for eggs. In chronic infections, or if eggs are difficult to find, an intradermal injection of schistosome antigen to form a wheal is effective in determining infection. Alternate diagnosis can be made by complement fixation tests.


السيركاريا اخترقت الجلد

prevention and control :

- 1- Personal prophylaxis :
- avoidance of wading , bathing, swimming, and drinking poullted water(canals).
- If this could not be avoided, the following metheds should be done:
- 1- Wearing protective clothes.
- 2- Water boiled or stored 3 dayesbefore used.
- 3- Quick and through drying of exposed skin.

2- Health education:

Explaining the life cycle and mode of infection for school children and people in mosques , churches, also by radio, television and press.

3- Mass treatment.

4- Snail control.

- Pathogenicity :
- In case of *Schistosoma hematobium* :
- There are 3 stages :
- 1- Stage of invation : Skin penetration by cercaria leads to irritation and dermatitis .
- 2- Stage of migration :
- Passage of cercaria in lung leads to haemorrhages and may be fever, couph .
- 3- Stage of oviposition and tissue reaction :

In urinary bladder, eggs are distributed in submcosa and mucosa, this result hyperaemia,

Formation of ulceration of mucosa and formation of sand paches.The wall of bladder becomes thickened and loss its elasticity.

In case of *Schistosoma mansoni* :

Eggs trapped in the wall of intestine resulting congestion, ulceration,polyps and sandy patch and finally wall of intestine becomes irregulary thickened,liver fibrosis,hepatomegaly,splenomegaly and oesophageal varices .

Taenia saginata

(Beef tapworm)

Classification :

Kingdom : Animalia
Phylum : Platyhelminthes
Class : Cestodes
Order : Cyclophyllidea
Family : Taeniidae
e.g. : *Taenia saginata*

Introduction :

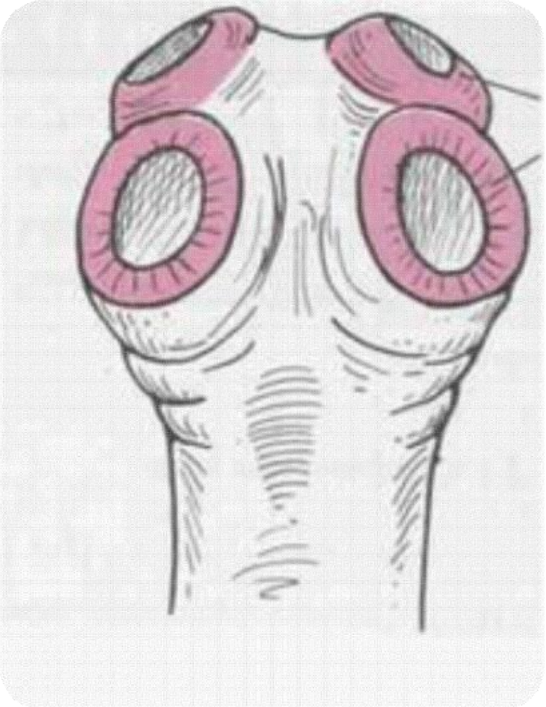
The beef tapeworm, *Taenia saginata*, is a cestode parasite acquired in humans through the ingestion of raw or poorly cooked meat of infected cows. These cows have been infected via the ingestion of human feces containing the eggs of the parasite and these cows contain viable cysticercus larvae in the muscle. Humans act as the host only to the adult tapeworms and can grow up to 25 meters in the lumen of the intestine, but are usually closer to 5 meters in length

Morphology :

Taenia saginata is a cestode worm that characterized by superficially segmented body . *T.saginata* attaches to the surface of the small intestine via four suckers located on the scolex The scolex has a maximum diameter of 1.5 to 2 mm while each sucker is approximately 0.7 to 0.8 mm in diameter .Then thousands of proglottids (segments) “immature ,mature & gravid proglottids”

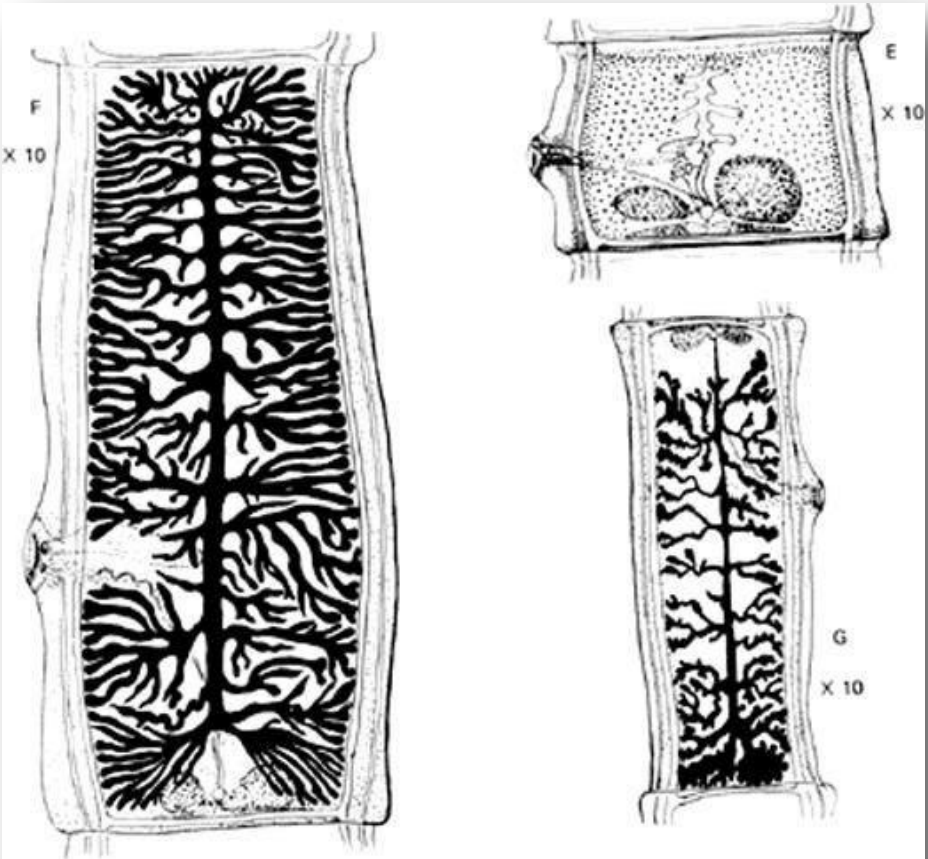
Mature proglottids are close to 12 mm in bredth while immature proglottids are longer (20 mm) and narrower (6 mm)

Mature proglottids each have genital organs consisting of about 300 to 400 testes and a vaginal sphincter. The gravid proglottids are found in the last fifth of the worm and have eggs in them

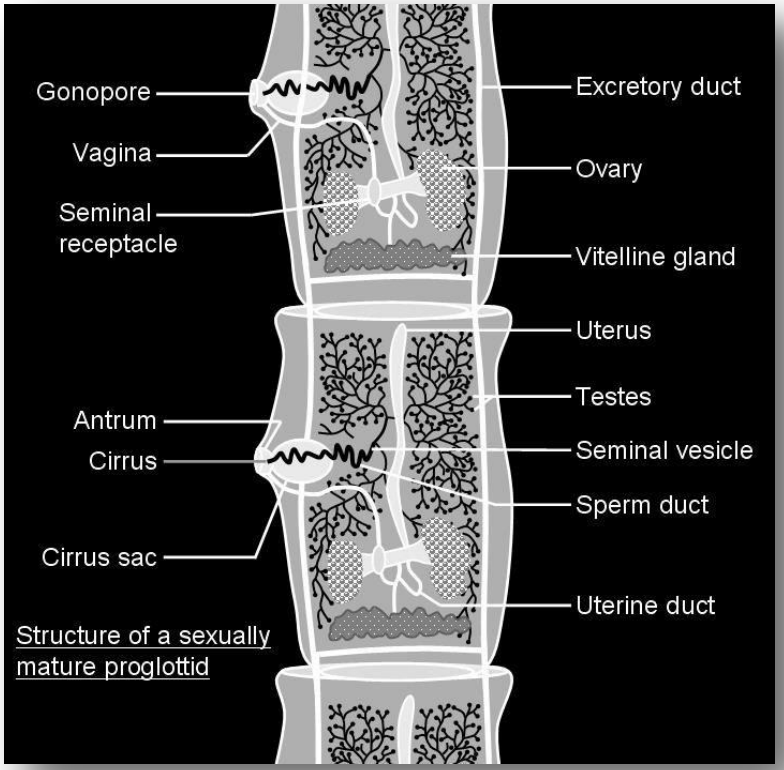


Scolex of *Taenia saginata*
revealing the four suckers

The immature , mature & gravid proglottids



Source: Maxine A. Papadakis, Stephen J. McPhee, Michael W. Rabow
Current Medical Diagnosis & Treatment 2019



Structure of a sexually mature proglottid

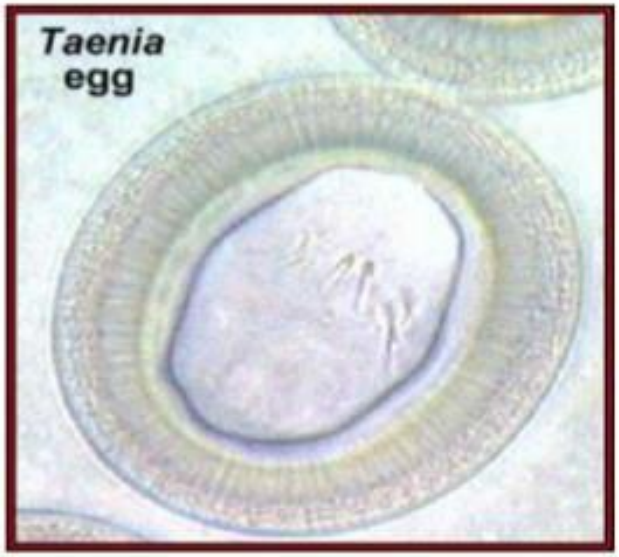
Eggs :

The eggs of both T. solium and T. saginata are indistinguishable. Eggs develop in hyaline capsules and are shed after leaving the proglottid. The eggs contain an outer membrane and are roughly 31-43 um in diameter. These eggs are ingested by cattle or other intermediate hosts and once they reach the duodenum, hatch and penetrate the intestinal wall.

Cysticercus :

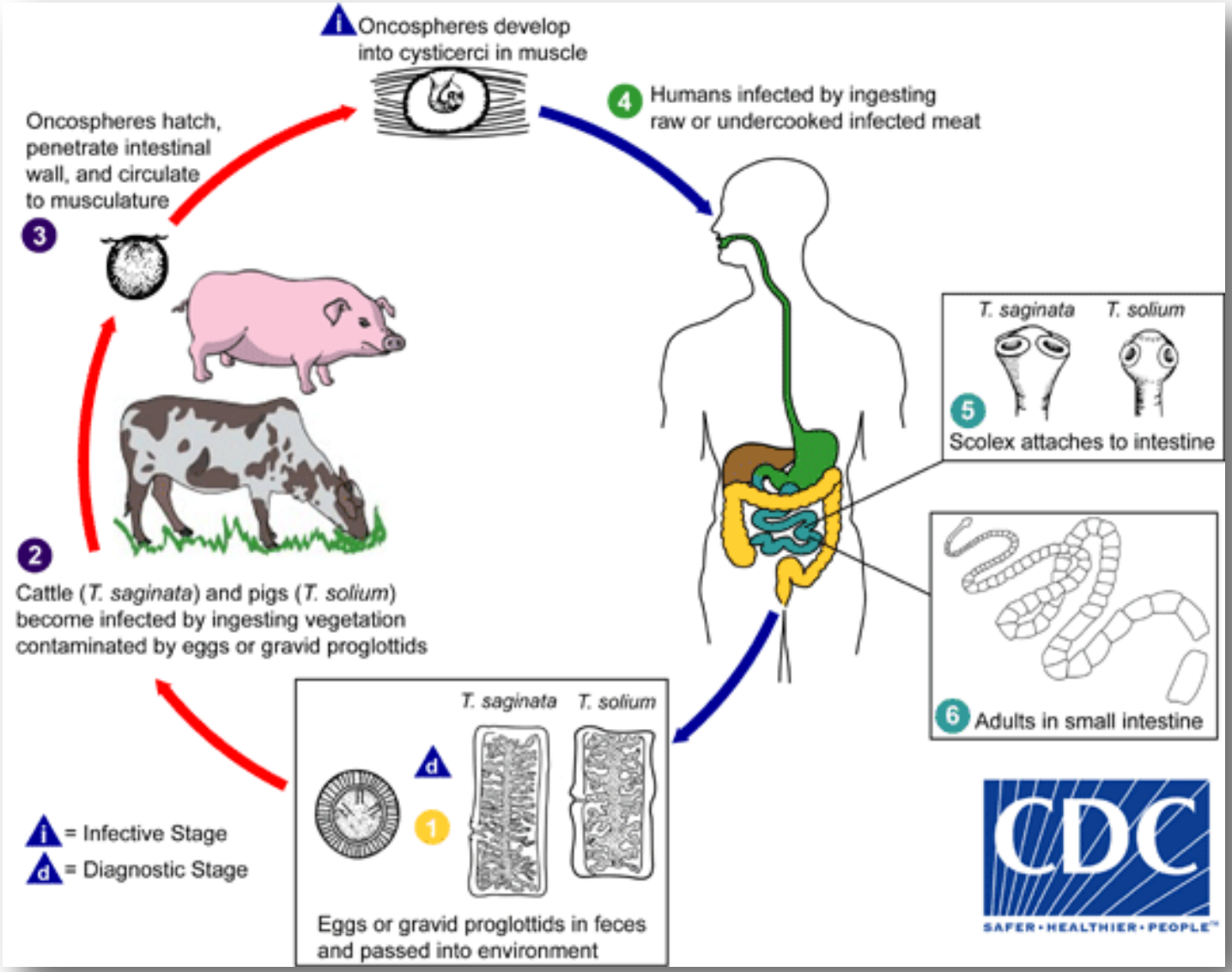
The cysticercus develop and appear in striated muscle and is more concentrated in certain muscle . The mature cysticercus are in the shape of an oval and are milky-white. They are 7.5-10 mm in breadth and 4-6 mm in length.

Egg of T. saginata and T. solium



Life cycle :

1) An infected human passes eggs or gravid proglottids in their feces.
2) Cattle or other intermediate hosts for T. saginata become infected by eating contaminated vegetation that contains human feces with eggs or gravid proglottids.
3) Oncospheres (mature eggs) hatch and penetrate the intestinal wall of the cattle and ciruclate to the musculature. Once in the tissue, the oncospheres develop into cysticerci and the cattle are now infected.
4) Humans become infected by eating uncooked or poorly cooked meat that contain cysticerci.
5) The cysticerci develop into adult worms in the small intestine of humans and the scolex attaches to the intestinal wall.
6) To complete the cycle, gravid proglottids eventually pass through the feces containing eggs.



Life cycle of *Taenia saginata*

Pathogenesis :

Taenia saginata causes Taeniasis that is an infection due to an adult tapworm in the intestine

The infected man usually suffers from few serious symptoms such as diarrhea , hunger pain ,weight loss , flatulence , constipation and abdominal discomfort

Incubation period :

It takes 5 to 12 for worm to mature into adulthood in human intestine

Conclusion

Definitive host	Human
Intermediate host	Cattles (caws)
Infective stage	Cysticercus
Mode of infection	By ingestion of uncooked meat contaminated the inf. Stage (By mouth)
Pathogenesis	Abdominal discomfort, diarrhea , hunger pain ,weight loss , flatulence and constipation
Diagnosis	Examination of stool containing eggs or gravid proglottid
Control	Treatment of patients Cook the food well

Taenia solium

Scientific classification

Kingdom : Animalia

Phylum : Platyhelminthes

Class : Cestoda

Order : Cyclophyllidae

Family : Taeniidae

e.g. : *Taenia solium*

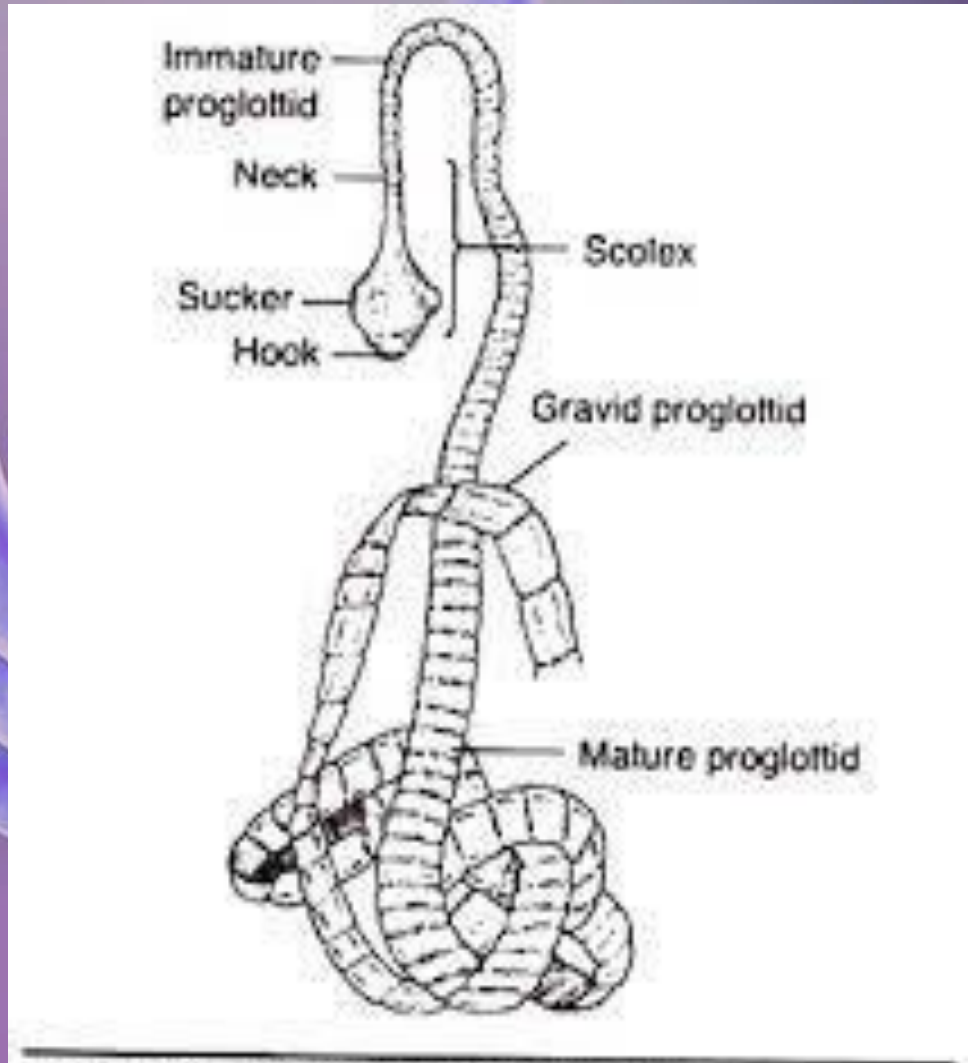


Fig. 7.1: Gross structure of *Taenia solium*

General introduction

. Worldwide distribution

. Large tapeworm

. Larval infection of *Taenia solium* may cause serious clinical
disease : Cysticercosis

Morphology

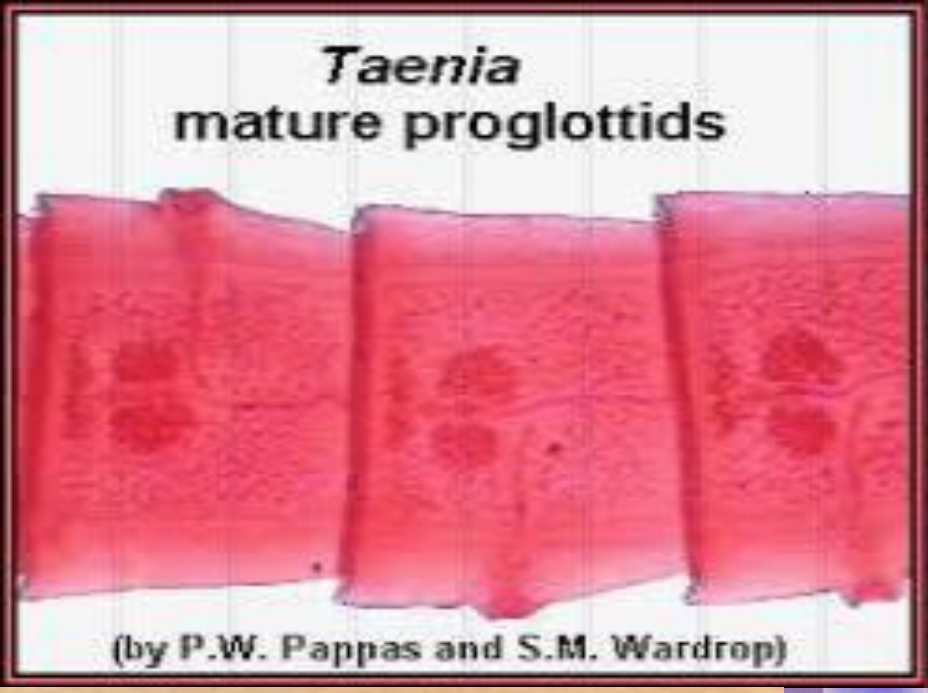
. Can be up to 2 to 4 meters long

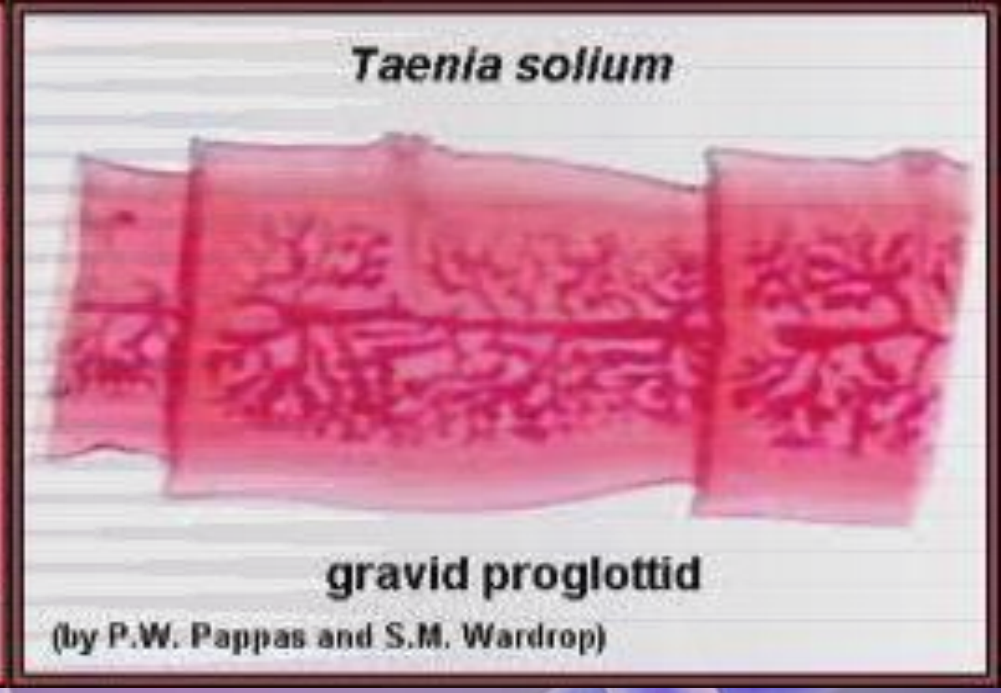
. It has a globular scolex with four suckers and 2 circular rows of hooks (rostellum)

. The gravid proglottids are 5×10 mm with a 7-13 branched uterus

. The eggs of *T. solium* are indistinguishable

Scolex of *T. solium.*


Taenia
mature proglottids
(by P.W. Pappas and S.M. Wardrop)


Taenia solium
gravid proglottid
(by P.W. Pappas and S.M. Wardrop)


Eggs of
Taenia solium

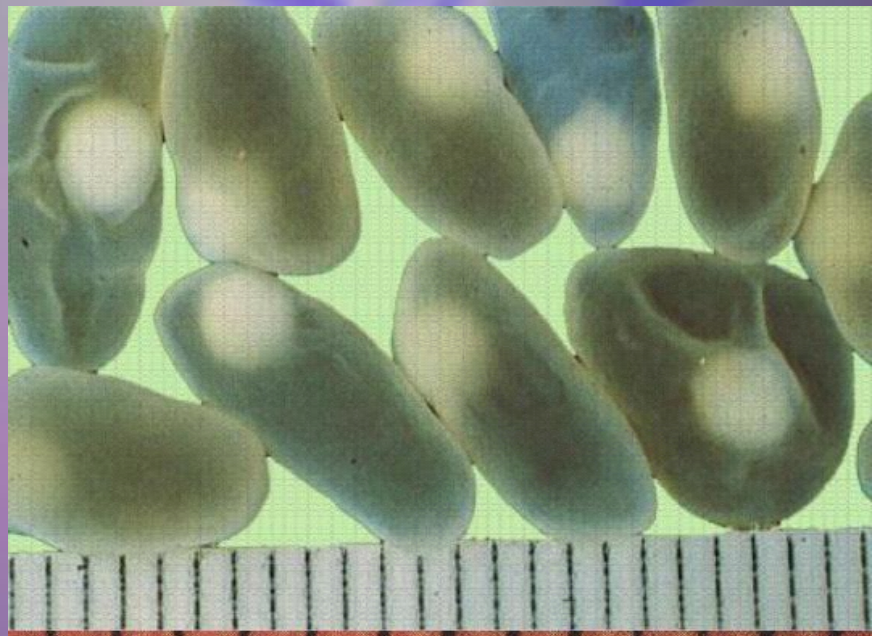
Cysticercus

is a scientific name given to the young tapeworms (larvae).

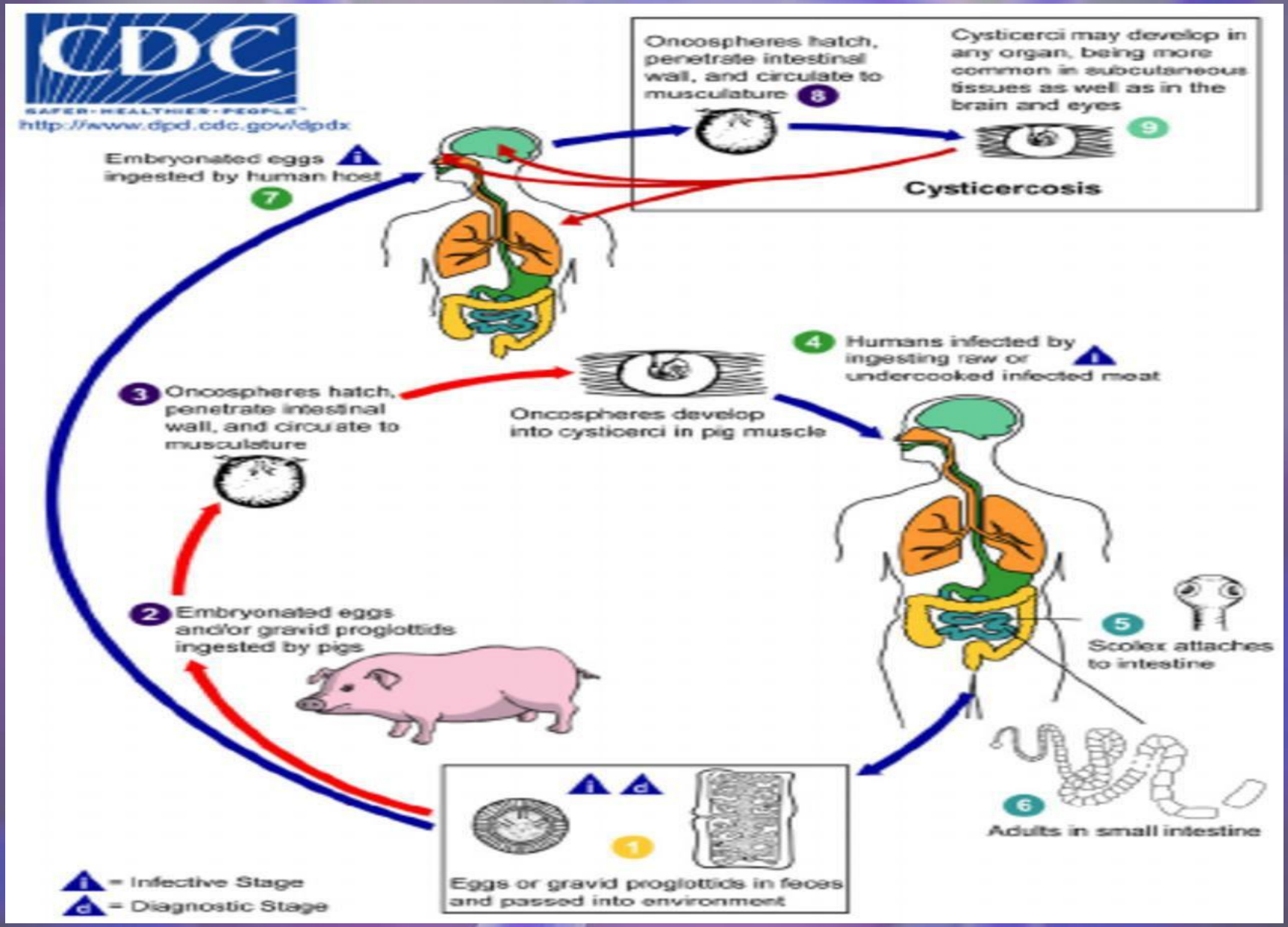
It is a small, sac-like vesicle resembling a bladder; hence, it is also known as bladder worm

It normally develops from the eggs, which are ingested by the intermediate host

The tissue infection is called Cysticercosis.



Life cycle of T.solium



Main points of the life cycle

.Man is the only definitive host, but he can also be the intermediate host for *T.solium*

.Pig is the important intermediate host for *T.solium*

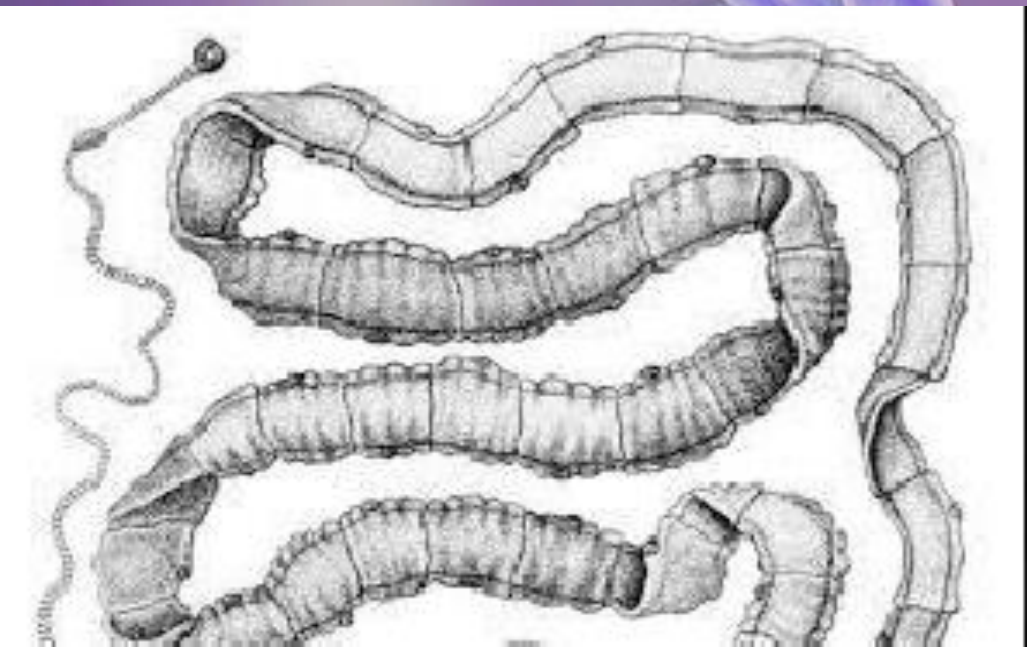
.Adult worm reside in the lumen of the upper part of small intestine

.The infective stage to man are both egg/gravid proglottid and cysticercus for *T.solium*

.A tapeworm larval cyst (cysticercus) is ingested with poorly cooked rice-like meat

.The larva escapes the cyst and passes to the small intestine where it attaches to the mucosa by the scolex suckers

.The proglottids develop as the worm matures in 3 to 4 months



.The adult may live in the small intestine as long as 25 years and pass gravid proglottids with the feces

.When eggs consumed by pigs in which they hatch and form cysticerci

.*T.solium* eggs can also infect humans and cause cysticercosis (larval cysts in lung, liver, eye, maxillofacial region and brain)

Pathogenesis

.Infection with *T.solium* adults is usually asymptomatic.

. The armed scolex may cause some inflammation of the intestinal wall, and rarely may penetrate the intestine, causing peritonitis.

. Heavier infections may produce abdominal discomfort, epigastric pain, vomiting and diarrhea

. The most important health problem is infection by the cysticerci, cysticercosis.

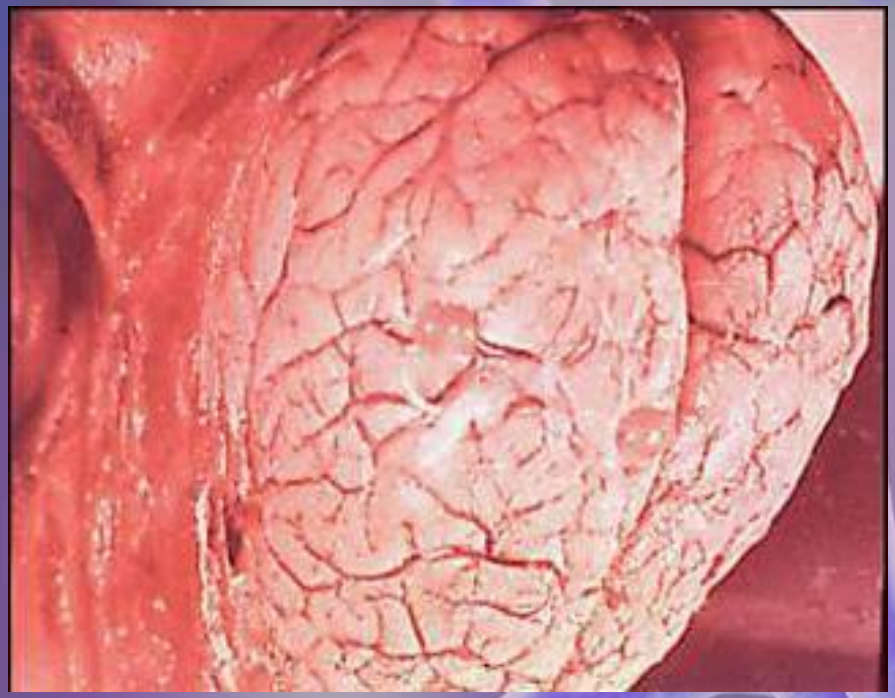
. Eggs that pass through the stomach hatch in the small intestine, penetrate the intestinal wall and are distributed throughout the body in the circulatory system. The most common sites of infection are the skeletal muscle and brain.

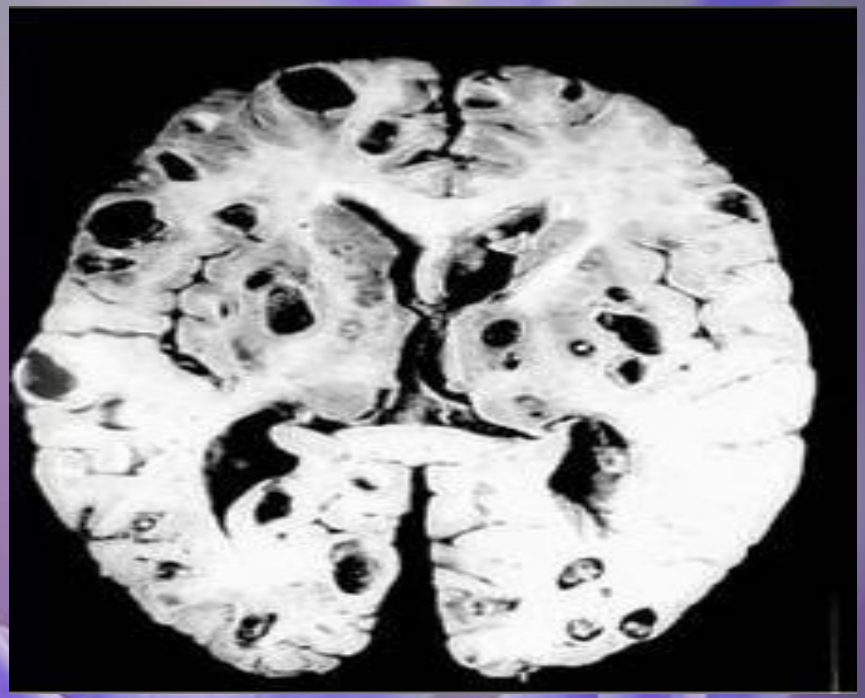
. Cysticerci in the muscle may cause spasms, weakness and pain.

. Calcification of the cysticercus may occur after 1 year and significantly reduces the pathology.

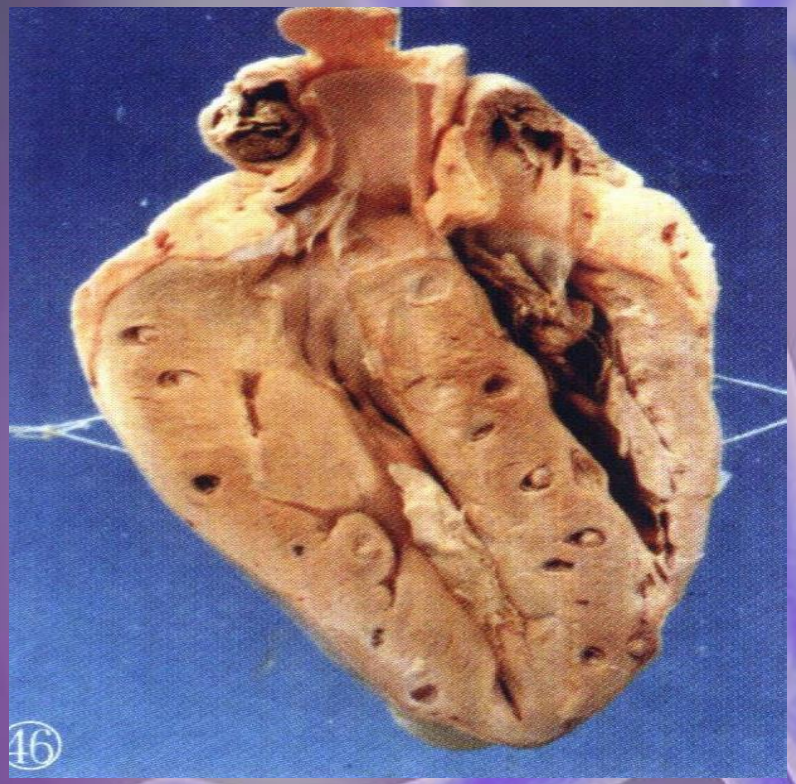
. Cysticerci in the brain cause the most severe pathology, including headaches, local paralysis, optic disturbances, and possibly death.

. Calcification in the brain may not occur and inflammation from dying cysticerci can be extremely damaging.





Cysticerci in brain



Cysticerci in heart

DIAGNOSIS

. Diagnosis of *taenia* tapeworm infections is made by examination of stool samples.

. Stool specimens should be collected on three different days and examined in the lab for *taenia* eggs using a microscope.

. Tapeworm eggs can be detected in the stool 2 to 3 months after the tapeworm infection is established

Prevention and control

. Infection by *Taenia solium* adults can be prevented by fully cooking pork or freezing it before eating it.

. Cysticerci do not survive at temperatures below -10℃ and above 50.

. Proper sanitation and hygiene can prevent the occurrence of eggs in the environment that could lead to cysticercosis.

. Proper disposal of feces and prevention of contamination with food given to pigs is also important.

COMPARISON OF THE TWO TAPEWORMS

	T. solium	*T. saginata*
Size	2-4m	4-8m
Scolex	Rostellum & hooks	No
Mature Proglottid	3 lobes of ovary	2 lobes of ovary
Gravid proglottid	Uterine Branches<13	>15
Intermediate Host	Swine & Human	Cattle
Disease caused	Taeniasis & cysticercosis	Taeniasis only
Infective stage	Egg & Cysticercus	Cysticercus Only
Mode of infection	Cross or autoinfection	Cross only
Diagnosis	Egg may be found in stool	Perianal egg exam
Clinical significance	Much more important	Less than *T. solium*
Chemotherapy	Should be instant	Not so urgent

Ancylostoma duodenale:

- Ancylostoma duodenale is a species of nematode worm of the Ancylostomatidae family.
- This species is known to infect humans predominately in North Africa, the Middle East and India causing Ankylostomiasis, a progressive anaemia.
- This species, more commonly known as hookworm, are approximately 10mm in length with the females being longer than the males.

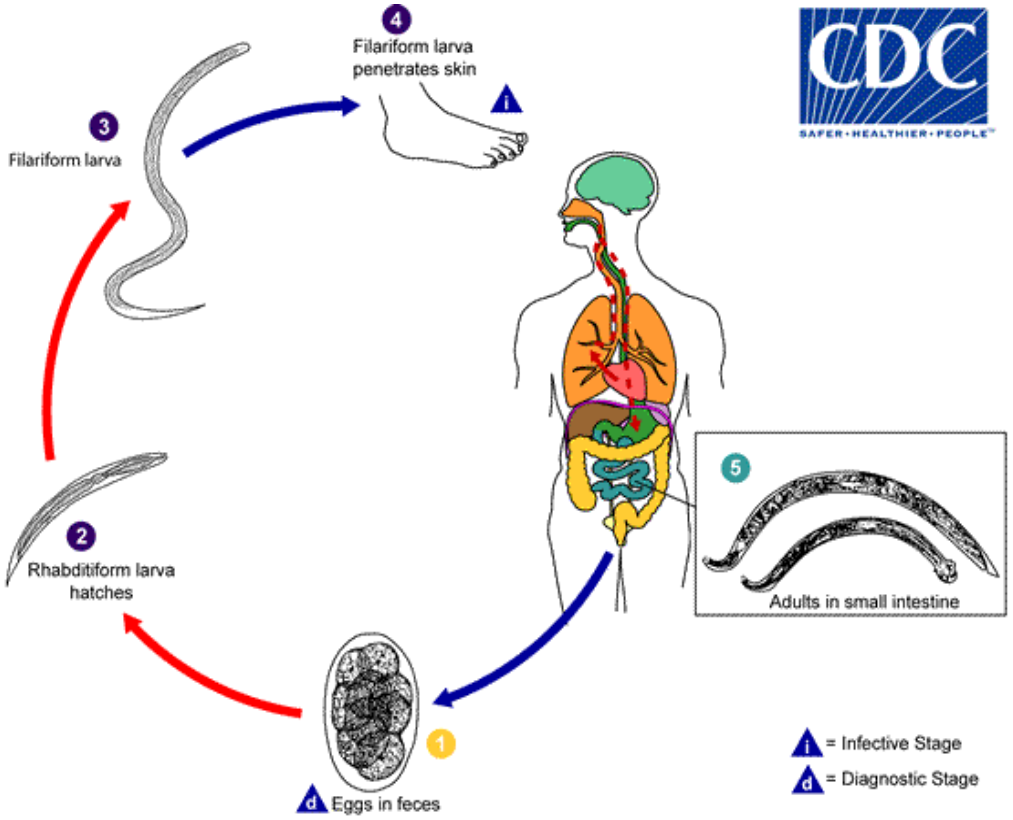
- The anterior end accommodates a buccal capsule with two pairs of teeth used for attaching to the host cells, two plates at the posterior margin and two subventral lancerts in the bottom .
- A club –shaped oesophagus .
- Male : about 1cm in length, has one set of genitalia provided by 2 spicules and a copulatory bursa.
- Female: about 1.2cm length,2 sets of genitalia, vulva open at posterior thirds of body.

- **Life Cycle :**

- 1- Adults live in small intestine of man attached by mouth capsule to mucosa .
- 2- Immature eggs pass in the faeces .
- 3- After 2 days eggs hatching liberating 1st rhabditiform larva, which feeding for 3 days and moult for the first time forming 2nd rhabditiform larva .
- 4- After 7 days the 2nd rhabditiform larva moulting for the second time and changing into filariform larva which the infective stage .

- Man is infected when filariform larva penetrate his skin or mucous membrane of the mouth.
- Larvae reaching the blood and carried to the right side of heart ,then to the lungs , then penetrate the capillaries into alveoli, pass up the tracheal tree , over the epiglottis, pharynx where they moult for the third time and swallowed to small intestine where they moult for the fourth time and become adults and repeat the life cycle .

Life cycle:


4
Filariform larva
penetrates skin
i
3
Filariform larva
2
Rhabditiform larva
hatches
1
d
Eggs in feces
5
Adults in small intestine
i = Infective Stage
d = Diagnostic Stage

Pathogenicity

- **1- Invaion stage :**
- Skin penetration by filariform larvae leads to dermatitis and itching .
- **Migration stage :**
- Passage of the larvae in the lungs leads to minute haemorrhages and pneumontitis, there may be couph, fever and leucocytosis .
- **Intestinal stage :**

- The most serious effects of hookworm infection are the development of anemia and protein deficiency caused by blood loss at the site of the intestinal attachment of the adult worms.
- When children are continuously infected by many worms, the loss of iron and protein can retard growth and mental development.
- Intestinal ulcers formed of sites of attachment,abdominal discomfort .

Diognosis :

- Examination of human faeces revealed the presence of charactristic eggs .

Prevention and control :

- 1-Personal prophylaxis :
- Wearing shoes and other protective clothes as gloves .
- 2-Health education:
- a- Abstinence from walking barefooted . b- Abstinence from defaecation on the ground .
- 3- Sanitary disposal of human faeces .
- 4- Mass treatmen: Periodic mass treatment of the population .

- **Remember very well :**
- Oesophagus of *Ancylostoma duodenale is called club – shaped oesophagus. While oesophagus in Enterobius vermicularis is called double- bulbed oesophagus .*
- *The infective stage of Ancylostoms is filariform larva, while the infectivs stage of Enterobius is the eggs containing the fully development larva .*
- *During the life cycle of Enterobius the larvae moult twice in the small intestine .*
- *During the life cycle of Ancylostoma the larvae moult 4 time .*
- *Vulva in Ancylostoma open at the posterior third of the body, while in Enterobius open at the anterior third of the body,*

Enterobius vermicularis

(Human pinworm)

The pinworm (species *Enterobius vermicularis*), also known as threadworm (in the United Kingdom and Australia) or seatworm, is a parasitic worm. It is a nematode (roundworm) and a common intestinal parasite or helminth, especially in humans.

Classification:

Kingdom	**:**	Animalia
Subkingdom	**:**	Eumetazoa
Phylum	**:**	Aschelminthes
Class	**:**	Nematoda
Order	**:**	Oxyurata
Family	**:**	Oxyuridae
e.g.	**:**	*Enterobius vermicularis*

(formerly *Oxyurias*)

Morphology:

The adult female has a sharply pointed posterior end, is 8 to 13 mm long, and 0.5 mm thick. The adult male is considerably smaller, measuring 2 to 5 mm long and 0.2 mm thick, and has a curved posterior end.

Female adult worm

Male adult worm

Distribution:

The pinworm has a worldwide distribution, and is the most common helminth (i.e., parasitic worm) infection in the United States, western Europe, and Oceania.

Habitat:

The pinworm lives in the lower part of the small intestine, and the upper part of the colon. Unlike many other intestinal parasites, the pinworm does not usually enter the bloodstream or any other organs besides the intestines. Only in rare cases disoriented pinworms can be found in the vagina, and even more rarely in the uterus, fallopian tubes, liver and peritoneum; but the worms cannot survive long in these places.

Hosts:

The definitive host of *Enterobius vermicularis is man.* Pinworms are easily transmitted from human to human and are particularly common in children. Luckily the disease, enterobiasis, causes only anal itching.

Enterobius vermicularis does **not** need intermediate host to complete its life cycle.

Infective stage:

- The infective stage is Embryonated eggs.
- The female Enterobius lays eggs that may not pass out with stool but remain attached to perianal region, representing the diagnostic stage containing larva inside. Once it's mature, it turns into embryonated egg forming the infective stage.

Mode of infection:

Pinworms are transmitted either directly:

- By hand to the mouth of the same person (Autoinfection) or another person (Retroinfection).

Or indirectly:

- Through bedding.
- Clothing.
- Food or other articles.
- Overcrowding.

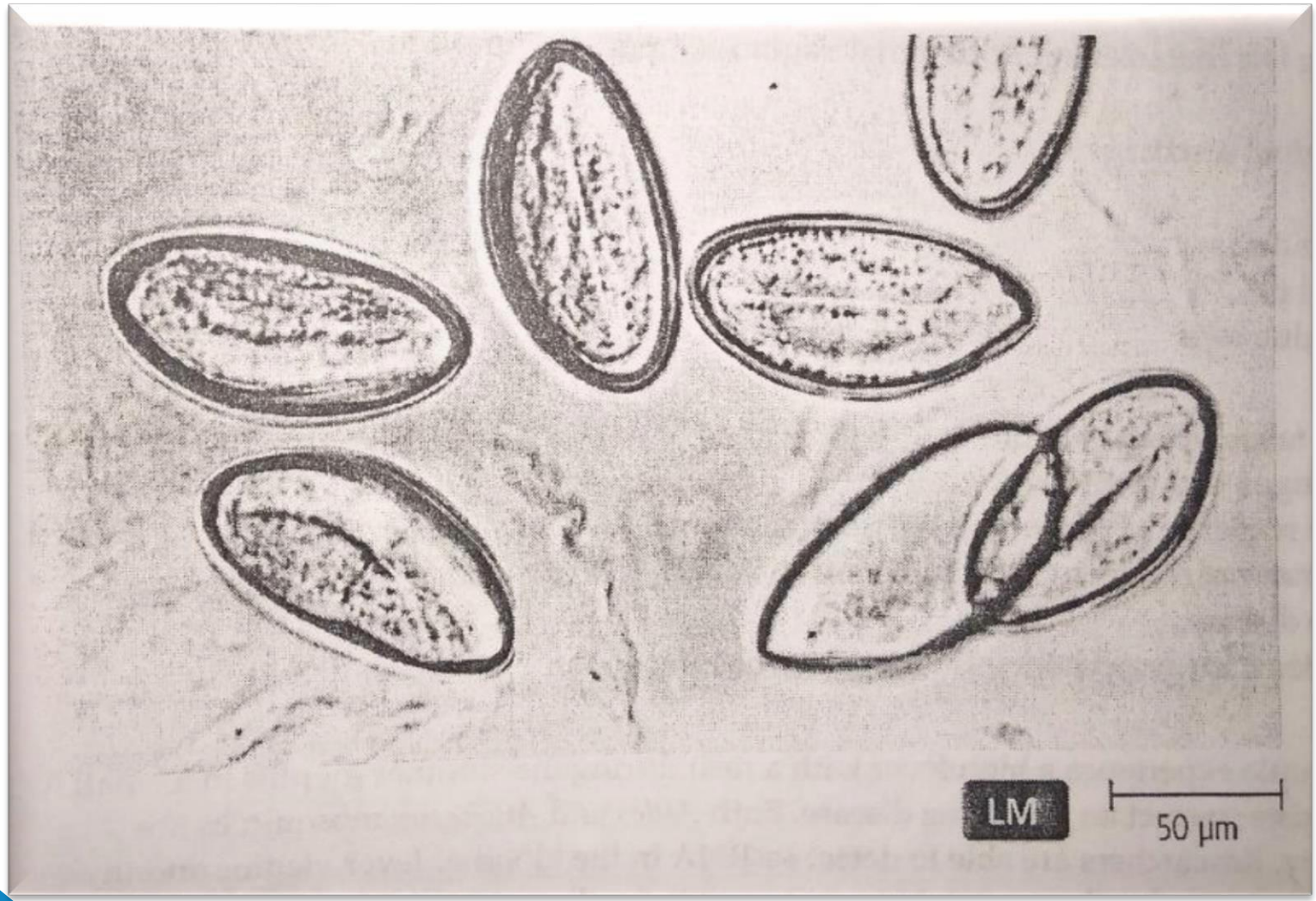
Pathogenicity:

"Enterobiasis"

- Except for itching, Enterobiasis does not cause damage to body organs, but in severe cases it may cause appendicitis.
- It is more common in children, and they may suffer from nervousness irritability and enuresis.
- Also may cause severe fatigue and insomnia.

Diagnosis:

- It's often suspected in children with a perianal itch, and is confirmed by the detection of characteristic pinworms' eggs.
- By observing the female worm in the peri-anal region.
- Examination of stool for the presence of eggs or adult pinworms.

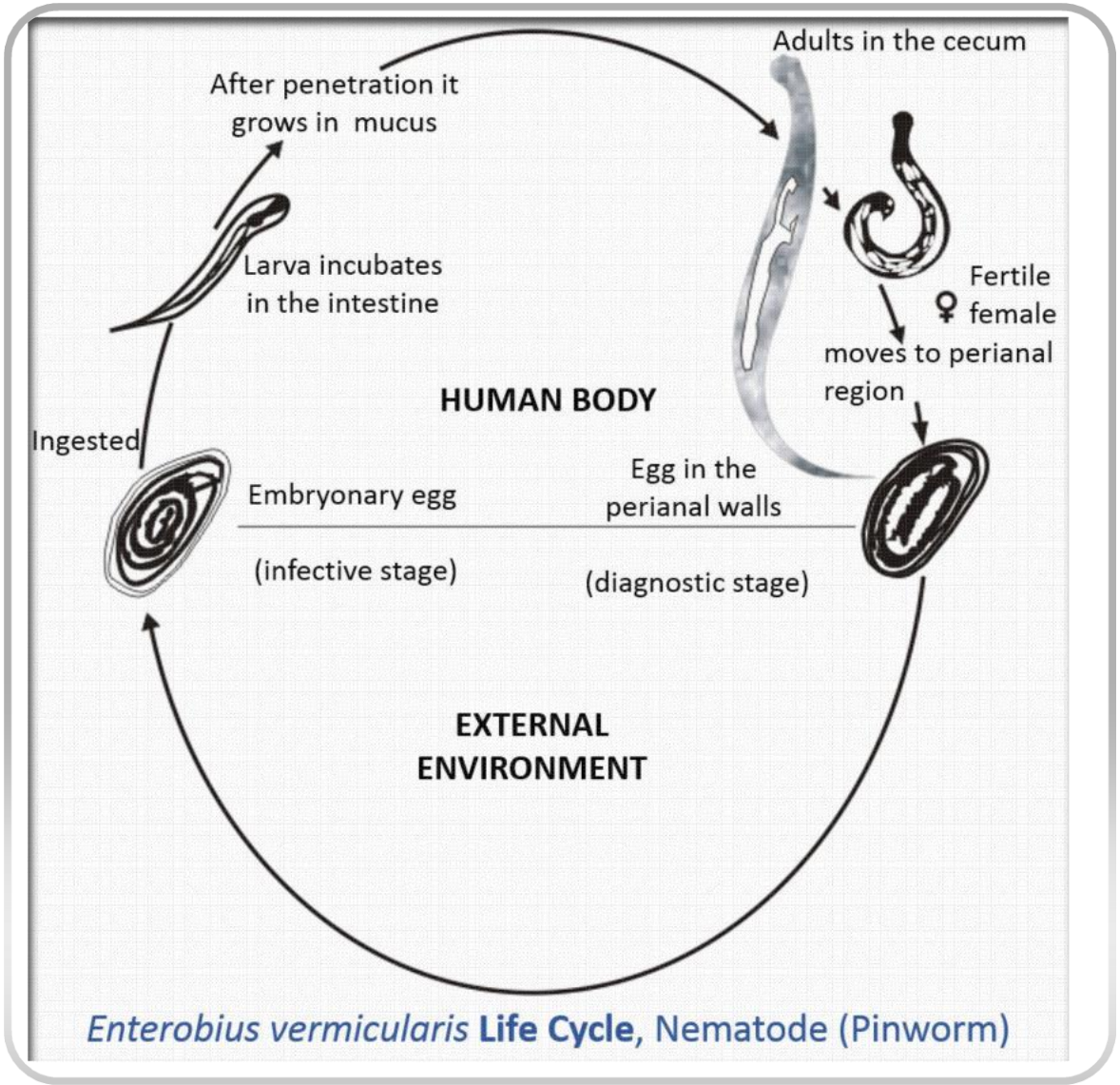

LM
50 µm

Prevention & Control:

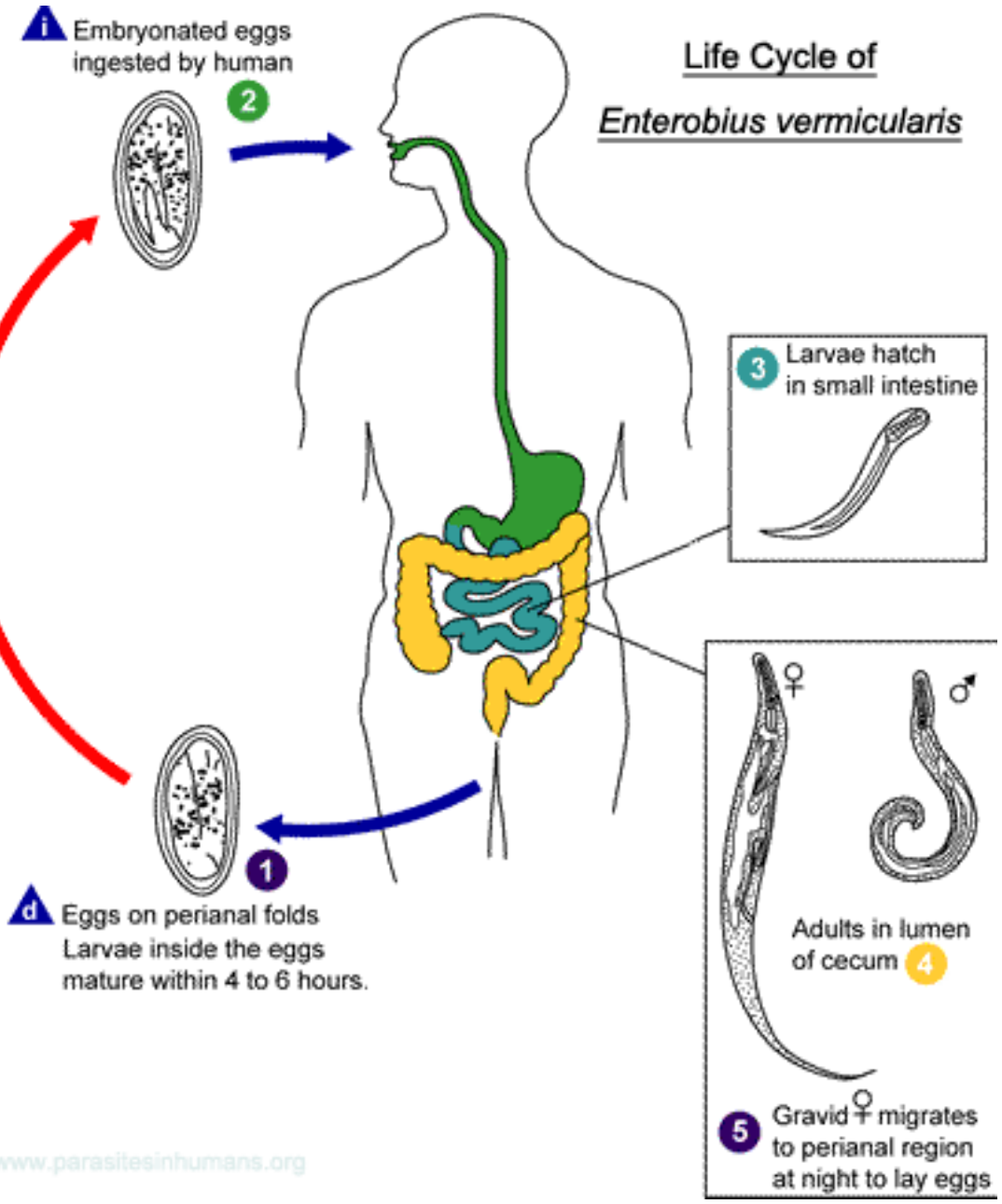
- Mainly it depends on personal prophylaxis to avoid hand-to-mouth infection
- Keeping pets clean, however they can not be infected by Enterobius but they may carry eggs in their fur.
- Examination and treatment of cases.

Life Cycle:

The entire life cycle, from egg to adult, takes place in the human gastrointestinal tract of a single host, from about 2–4 weeks or about 4–8 weeks.

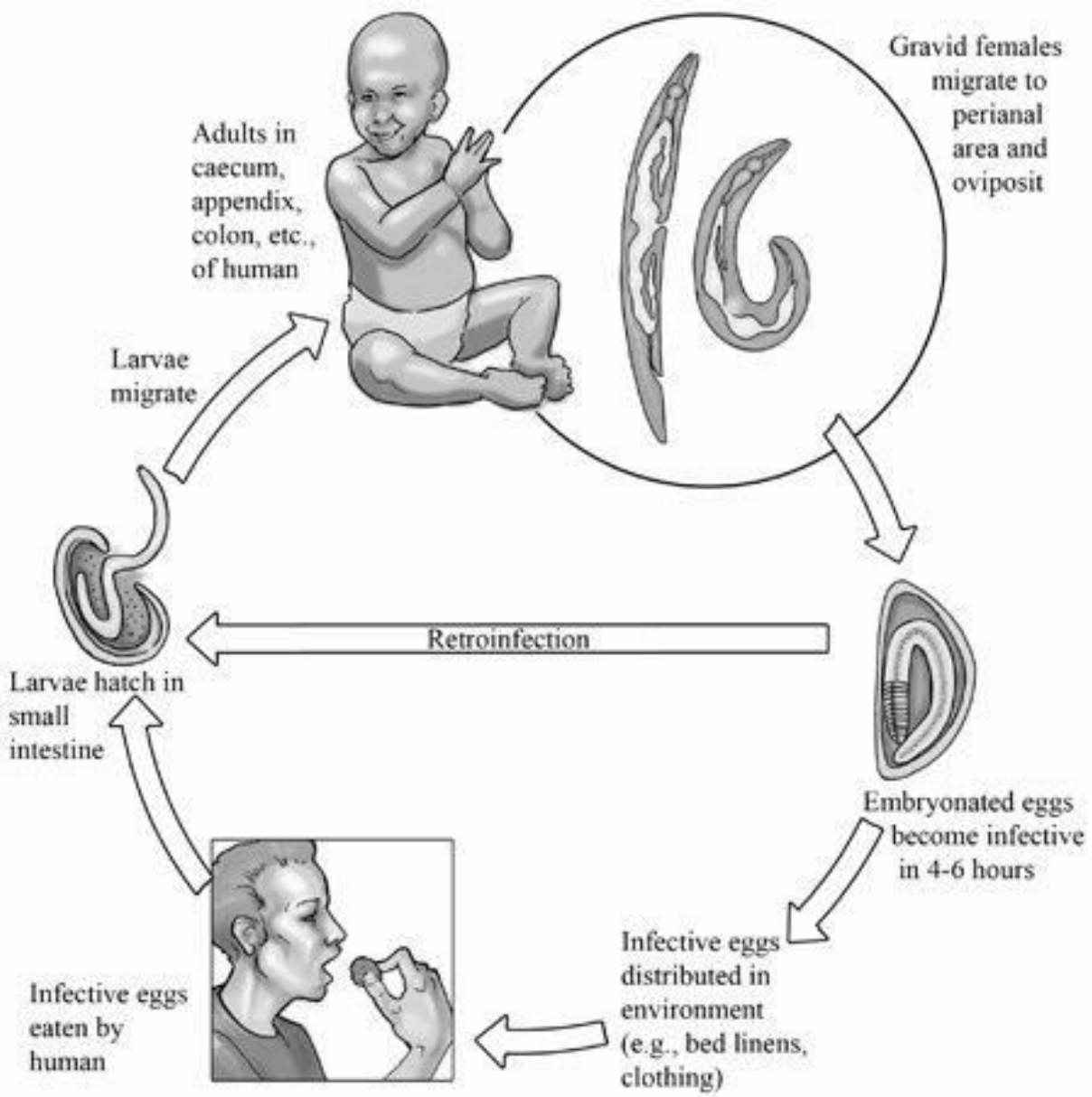


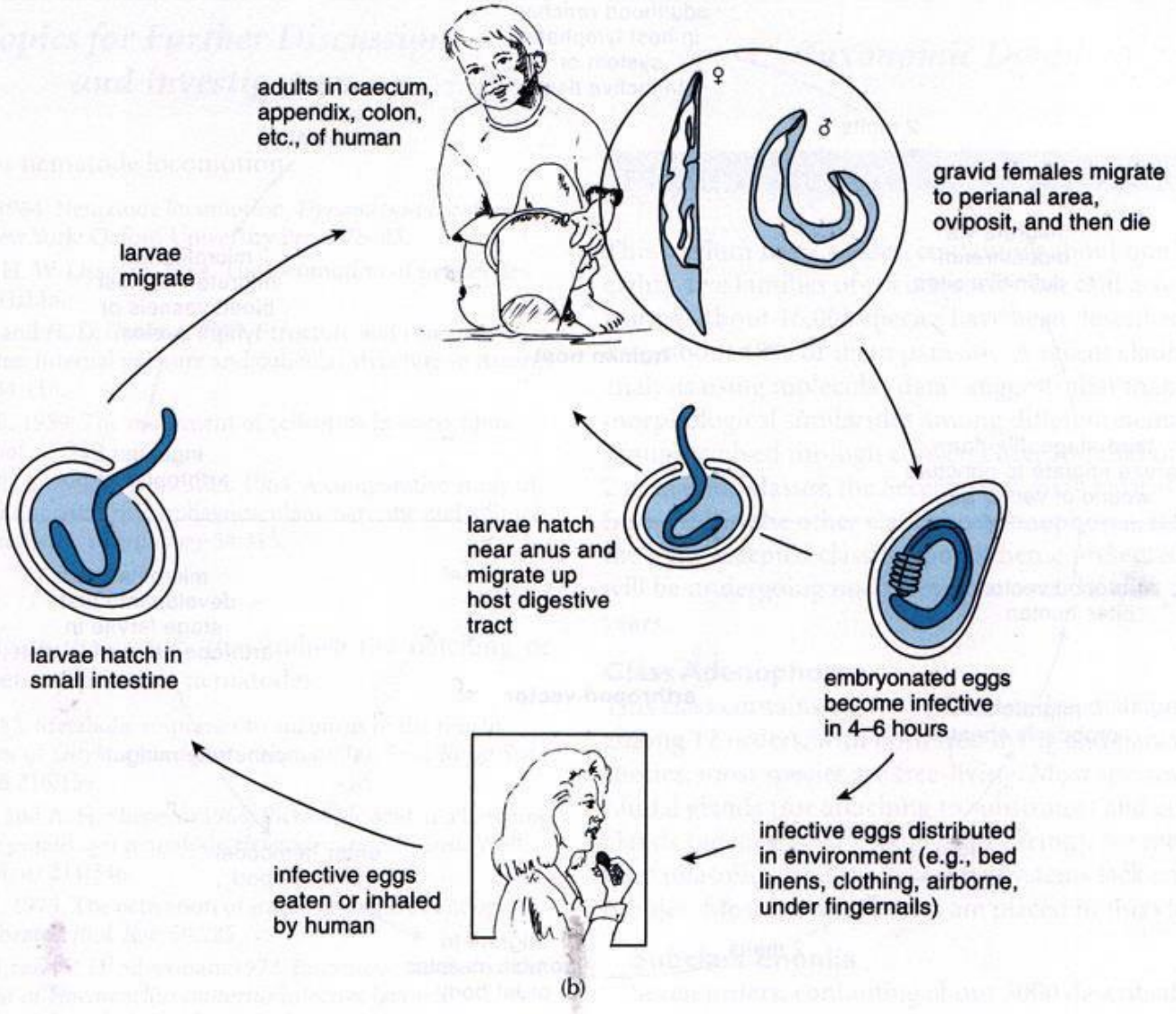
- The life cycle begins with eggs being ingested.
- The eggs hatch in the duodenum (i.e., first part of the small intestine).
- The emerging pinworm larvae grow rapidly and migrate through the small intestine towards the colon.
- During migration they moult twice and become adults, then the male and female pinworms mate in the ileum (i.e., last part of the small intestine).
- The male usually die and the gravid female pinworms settle in the ileum, caecum (i.e., beginning of the large intestine), appendix and ascending colon, where they attach themselves to the mucosa and ingest colonic contents.


Life Cycle of
Enterobius vermicularis
i Embryonated eggs ingested by human
2
3 Larvae hatch in small intestine
Adults in lumen of cecum 4
5 Gravid ♀ migrates to perianal region at night to lay eggs
1
d Eggs on perianal folds
Larvae inside the eggs mature within 4 to 6 hours.
www.parasitesinhumans.org

- Almost the entire body of a gravid female becomes filled with eggs. (range from about 11,000 to 16,000).
- The gravid female pinworms migrate through the colon towards the rectum at a rate of 12 to 14 cm per hour. They emerge from the anus, and while moving on the skin near the anus, the female pinworms deposit eggs either through:

1) contracting and expelling the eggs.
2) dying and then disintegrating.
3) bodily rupture due to the host scratching the worm.


Gravid females migrate to perianal area and oviposit
Adults in caecum, appendix, colon, etc., of human
Larvae migrate
Retroinfection
Larvae hatch in small intestine
Embryonated eggs become infective in 4-6 hours
Infective eggs distributed in environment (e.g., bed linens, clothing)
Infective eggs eaten by human


adults in caecum, appendix, colon, etc., of human
♀
♂
gravid females migrate to perianal area, oviposit, and then die
larvae migrate
larvae hatch near anus and migrate up host digestive tract
larvae hatch in small intestine
embryonated eggs become infective in 4–6 hours
infective eggs distributed in environment (e.g., bed linens, clothing, airborne, under fingernails)
infective eggs eaten or inhaled by human
(b)

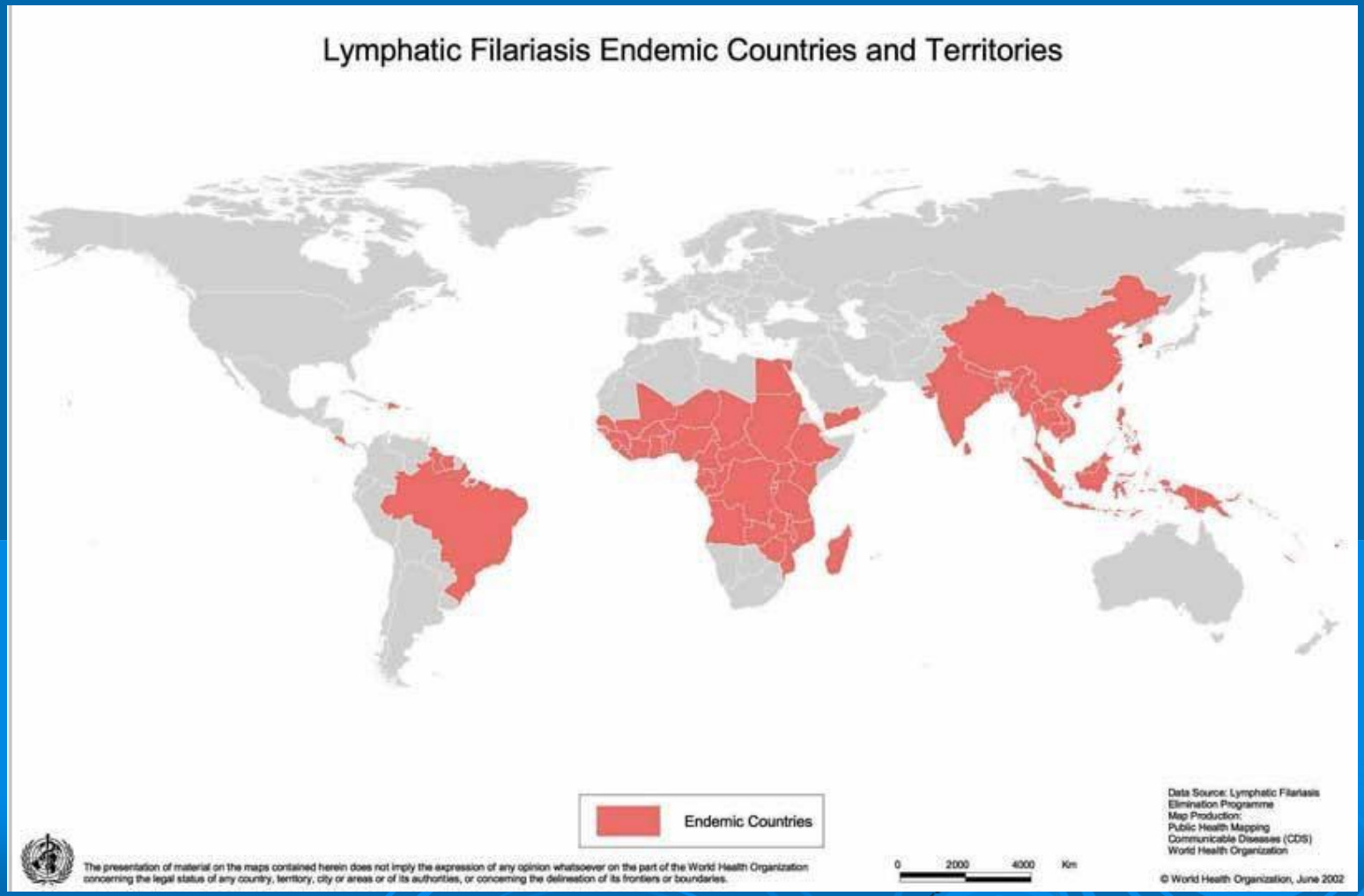
Lymphatic Filariasis

Jack Prior, Ryan M. Murphy, and
Aliya Robbins

What is Lymphatic Filariasis?

- Parasitic disease where worms enter the blood stream through numerous mosquito bites over a number of years.
- Affects 120 million individuals in over 80 countries in the tropical regions due to stagnant water and poor irrigation systems

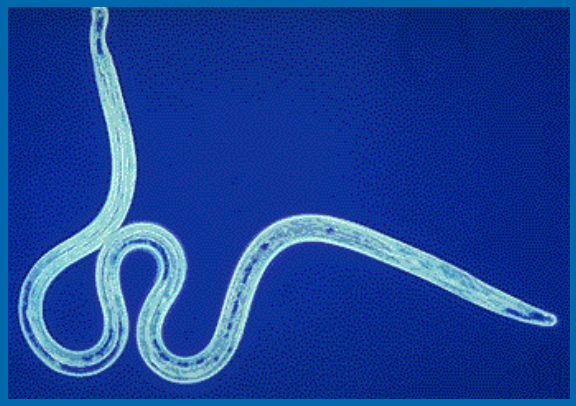
Infected Regions

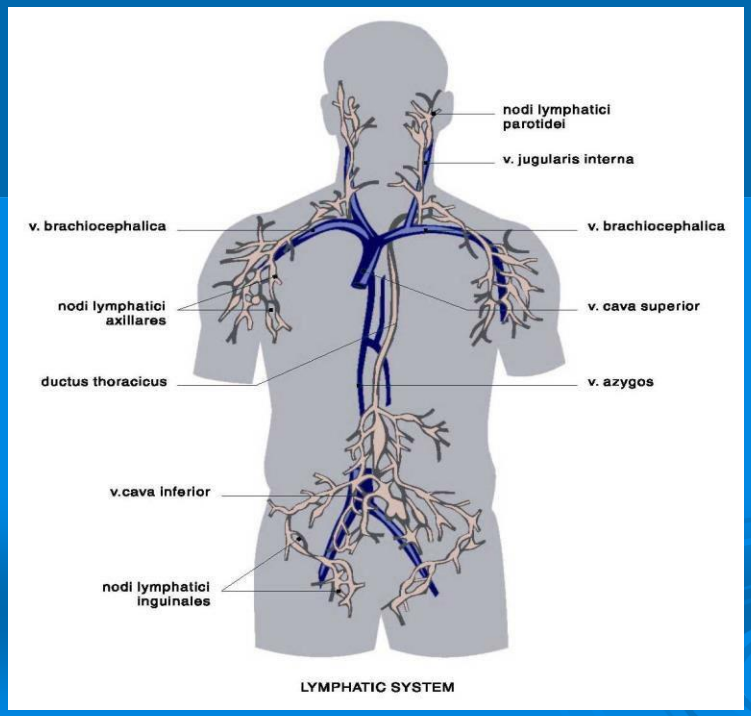


History

- Pre-1876
  - The only known symptom of this disease was elephantiasis because of its outward appearance.
- 600BC
  - Ancient Hindu medical workers referred to elephantiasis in Sanskrit texts.
- 600- 250BC
  - Men affected by elephantiasis were not allowed to become Buddhist priests.
- 10^{th}- 13^{th} Centuries
  - Persian and European physicians have accurate descriptions of elephantiasis.
- 1876
  - Joseph Bancroft discovered the parasite that causes lymphatic filariasis in an abscess on the arm of a butcher.

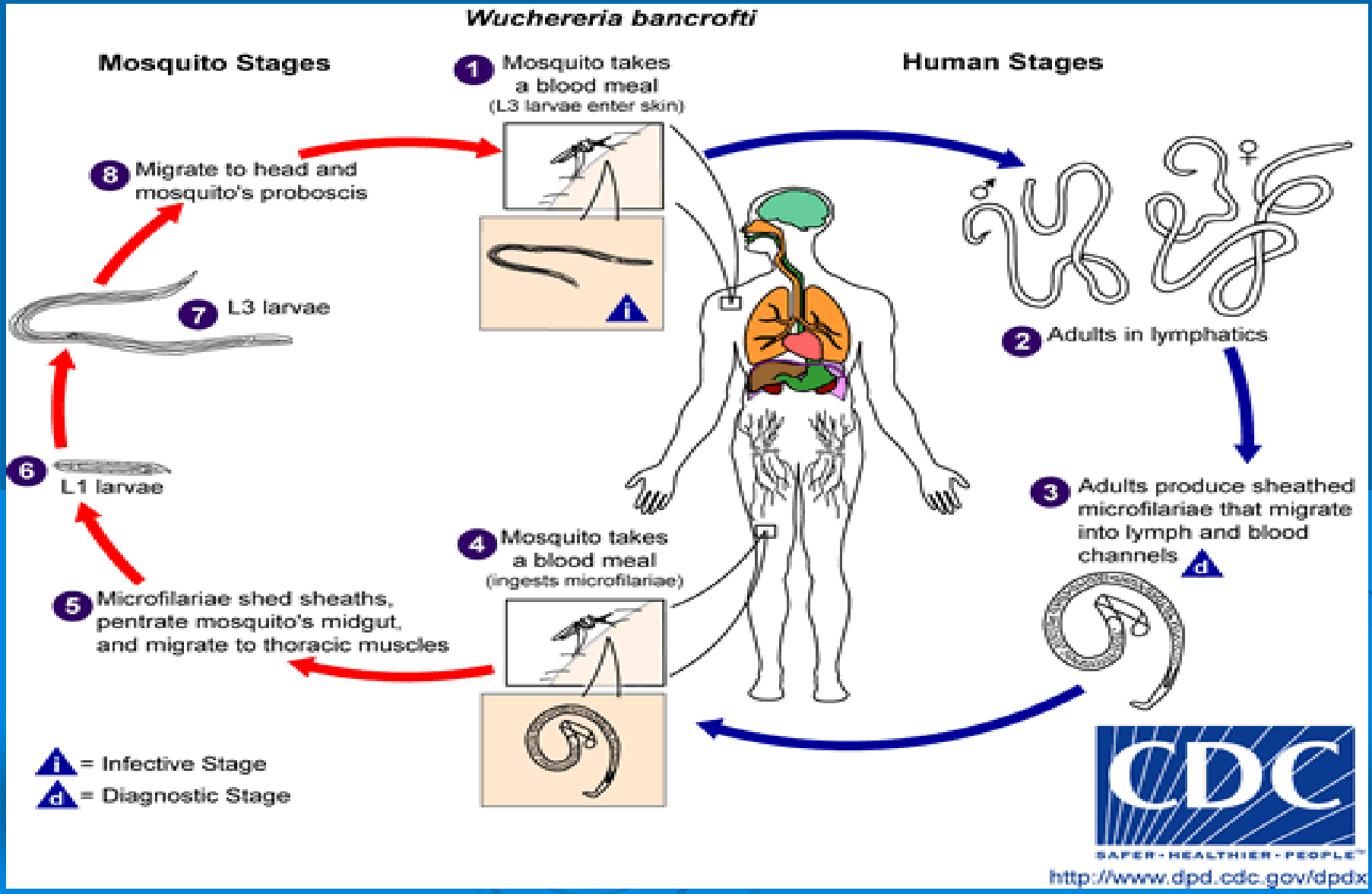
Parasites





- White, slender roundworms
- Three types: Wuchereria bancrofti, Brugia malayi, Brugia timori
- Live for 5-7 years, produce millions of offspring
- Block the lymphatic system
  - Network of channels and lymph nodes that help maintain fluid levels in the body
  - Blockage leads to edema (collection of fluid in tissues)

Process of Infection



Symptoms

- Fever
- Kidney damage
- Skin abnormalities due to bacterial infection.
- Elephantiasis
  - Swelling of limbs and genitalia
  - Male: Enlargement of scrotum, penis retracted under skin, spermatic cords thickened
  - Female: Long tumorous mass covered by thickened ulcerated skin develops on the vulva

Social Impact of Disease

- Sexual Disability
- Communities frequently تنكرshun those disfigured.
- Inability to work
- Women with visible signs may never marry or spouses الازواج and families will reject them.

Malacology

Phylum Mollusca

I. Coelomate Phyla

A. True coelom - body cavity lined by mesoderm

B. More efficient arrangement of internal organs

C. Gastrovascular system surrounded by muscle

II. Phylum Mollusca

A. L. *molluscus*, soft

B. Mol-lus' ka, Mollusca or Molluska

C. At least to Cambrian Period (600 MY)

D. 100,000 living species ;
35,000 extinct species

E. Bilateral symmetry

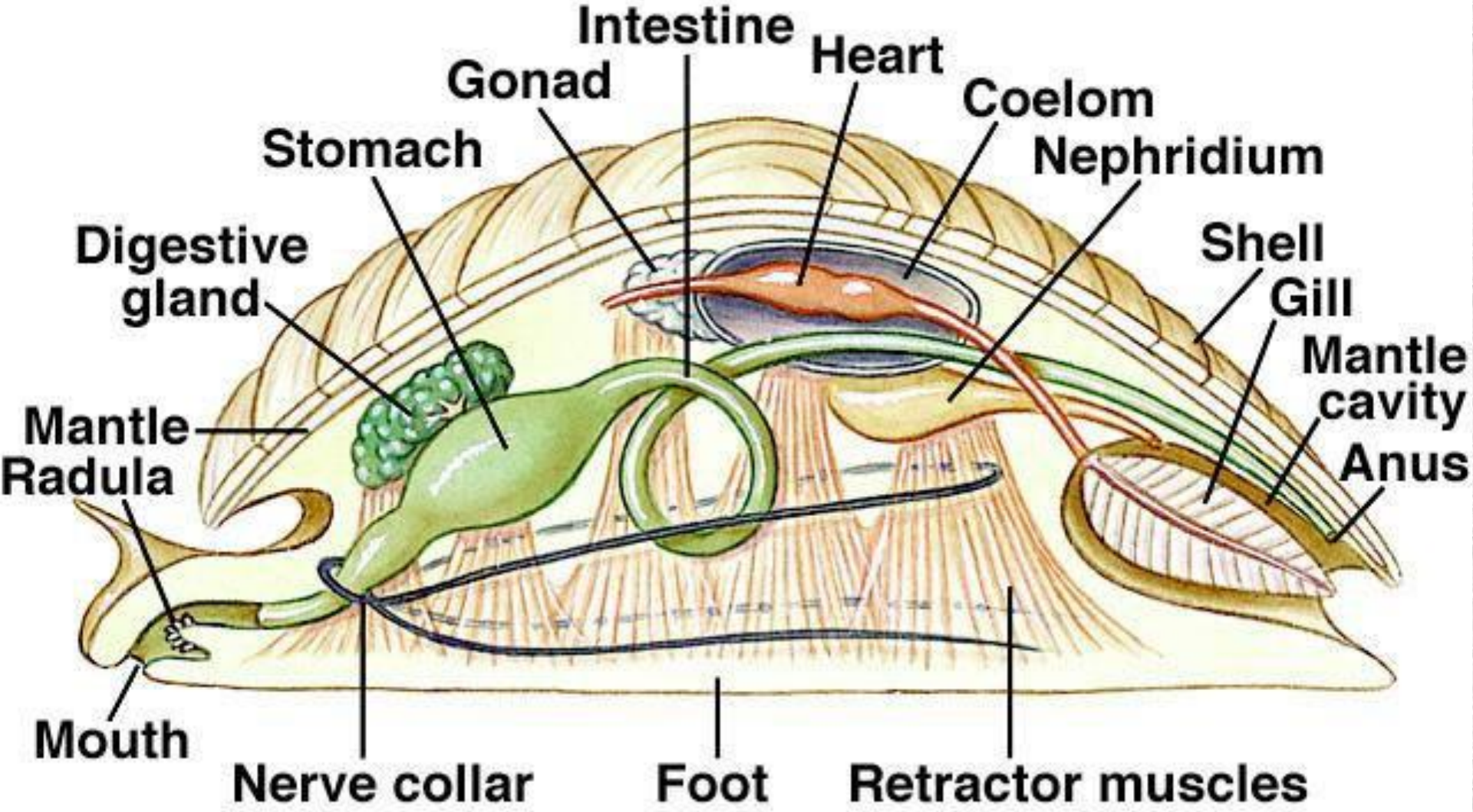
F. To 18m long, most small

- **Malacology; study of living molluscs;**
- **Conchology; study of shells only, shell collector**
- **Often have valves; none to 8**
- **Shell of $CaCo_3$**
- **Most have gills**
- **Usually open circulatory system**
- **Most have kidney (nephridia)**
- **Stomach with crystalline style** نمط بلوری A very long gelatinous **crystalline style** rotates against the gastric shield and releases digestive enzymes into the stomach lumen
- **Feeding; herbivores, carnivores, detrivores, filter feeders, deposit feeders**

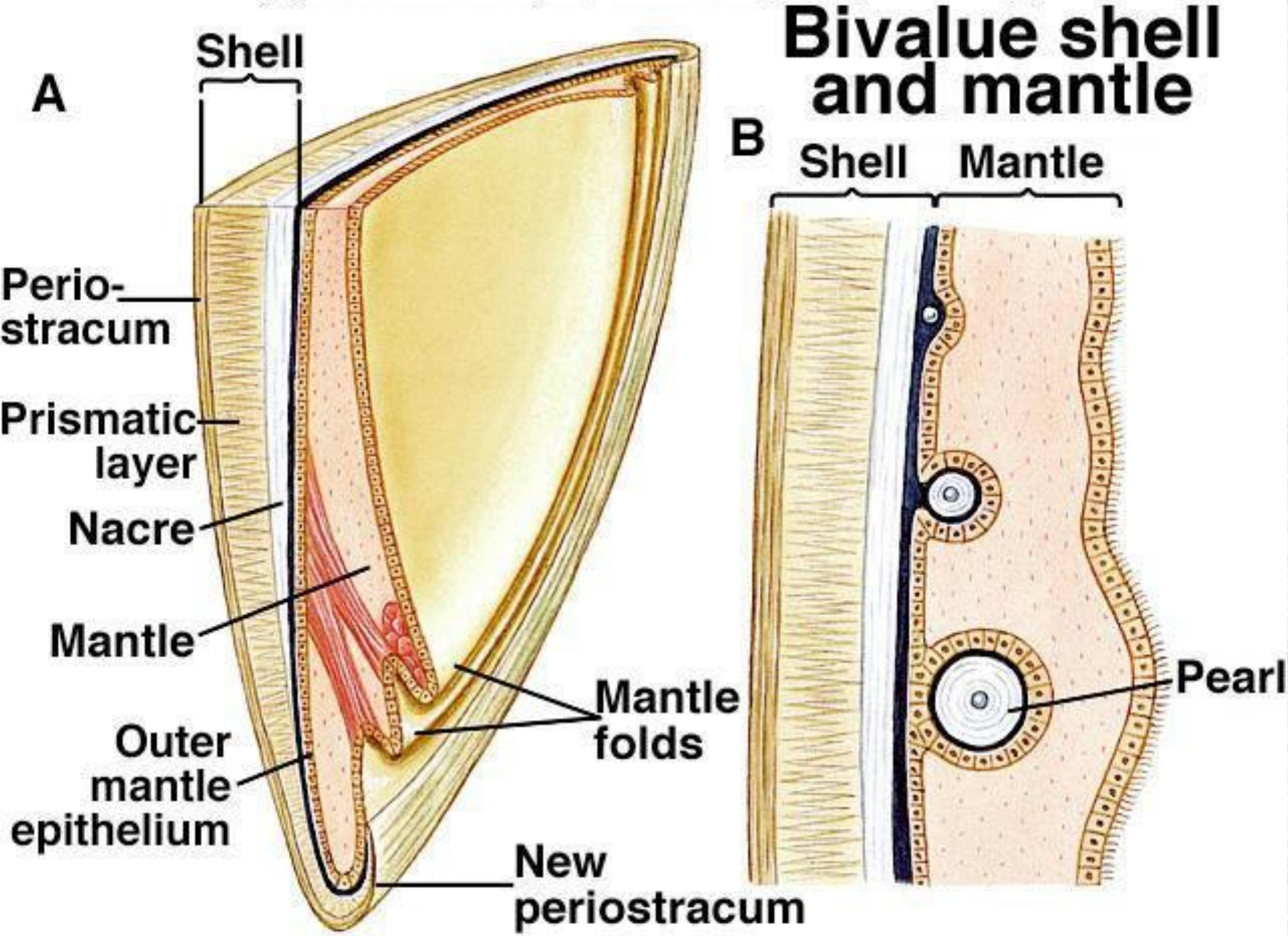
Phylum Mollusca – Body Structure

G. 3 embryonic germ layers:
   endoderm, mesoderm, ectoderm
H. Organ level of organization
I. Extracellular digestion in complete gastrovascular system
J. coelom
K. Excretory system with kidneys (metanephridia)
L. Often with special respiratory structures: gills, lungs, mantle surface

Generalized mollusca body



Bivalue shell and mantle



Phylum Mollusca – Systems

M. Open circulatory system with multi-chambered heart

N. Nervous system varies, based on ganglia at key points
   1. Least sophisticated اقل تطورا in some bivalves
   2. More sophisticated in cephalopods, with nerve ring surrounding pharynx

O. Various sense organs
   1. Eyes of cephalopods most advanced among invertebrates

Phylum Mollusca – Body Surface & Skeleton

P. Cilia on certain body surfaces
   1. Highly advanced on gill surfaces in bivalves

Q. Skeletal systems vary:
   1. Some have none
   2. Some have exoskeleton (shell)
   3. Some have endoskeleton (cuttlebone)

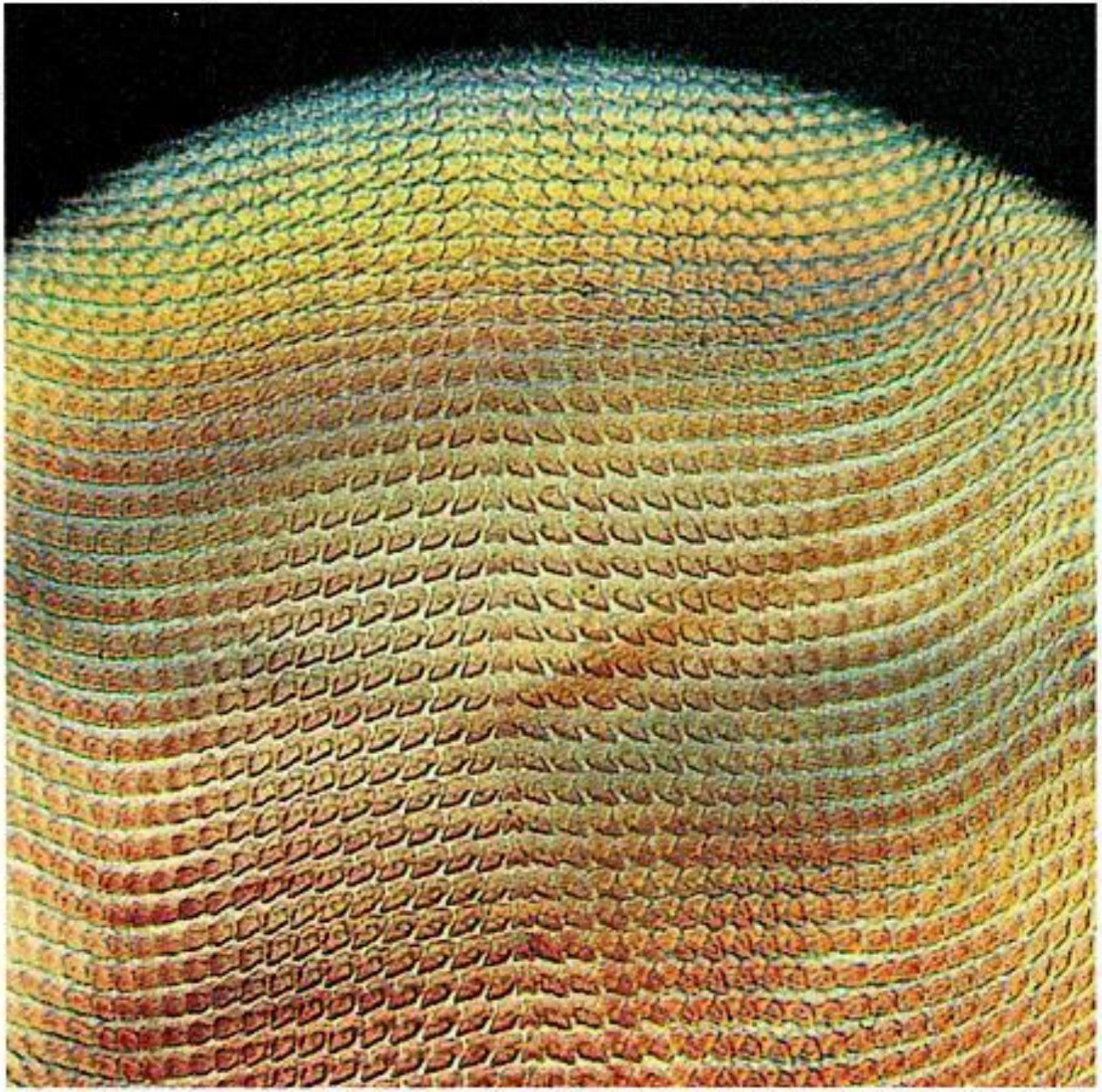
لسان البحر

Phylum Mollusca – Unique Structures

R. Unique mollusc structures:

1. **Mantle: from dorsal body wall**
   a) Often forms gills or lungs
   b) Secretes shell
2. **Foot: from ventral body wall**
   a) Locomotion
3. **Radula**
   a) Scraping structure used for feeding

Radula of a gastropod



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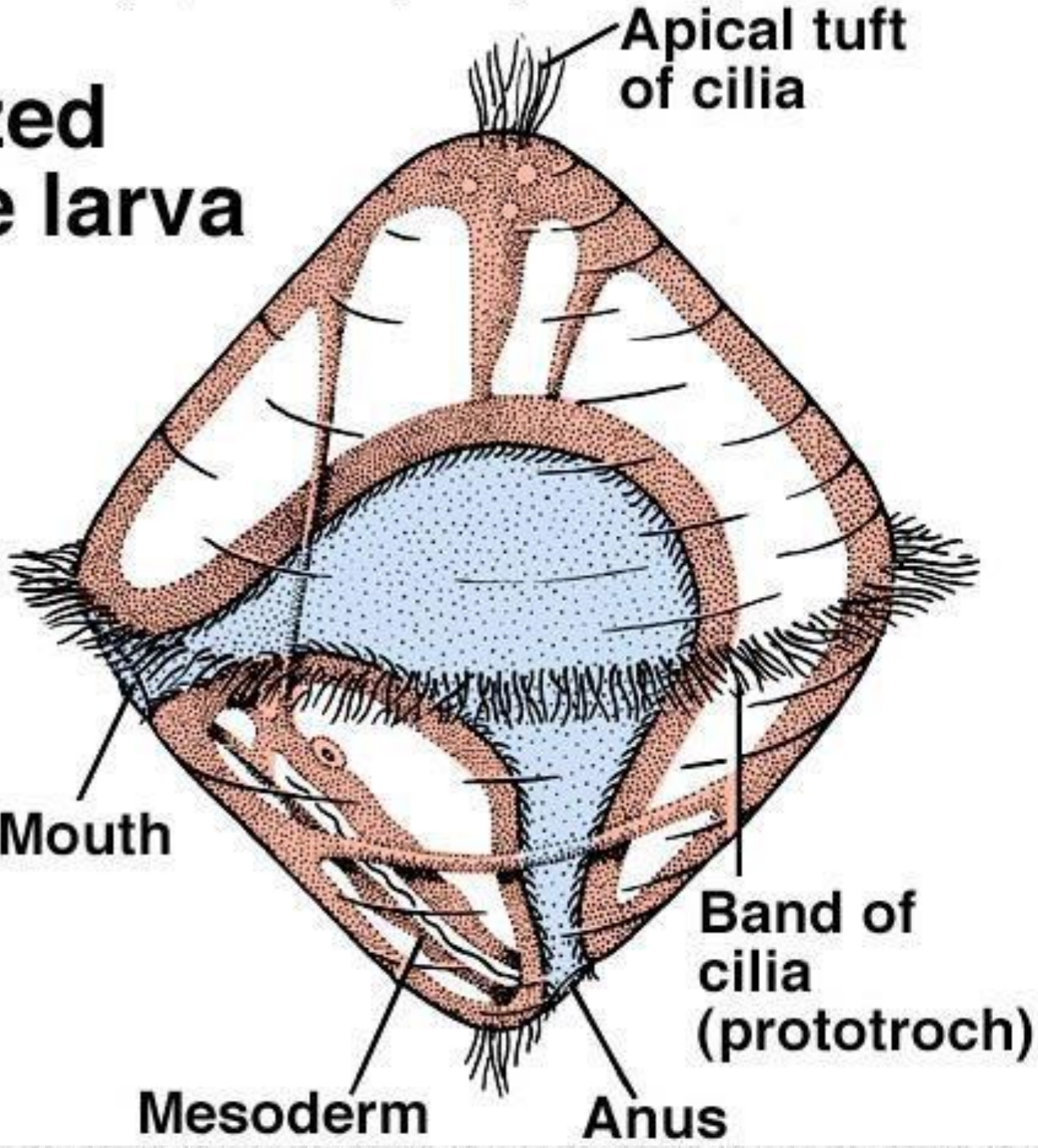
Phylum Mollusca – Reproduction

S. Reproduction usually sexual
   1. Sexual forms dioecious and monecious
   2. Protostome development
   3. Spiral cleavage
   4. Primitive larva - trochophore
   5. Advanced larva - veliger
   6. Some have direct development

T. Marine, freshwater, some terrestrial, some parasitic

Generalized trochophore larva



Phylum Mollusca – Taxonomy

Class Monoplacophora.

Class Polyplacophora .

Class Scaphopoda .

Class Gastropoda .

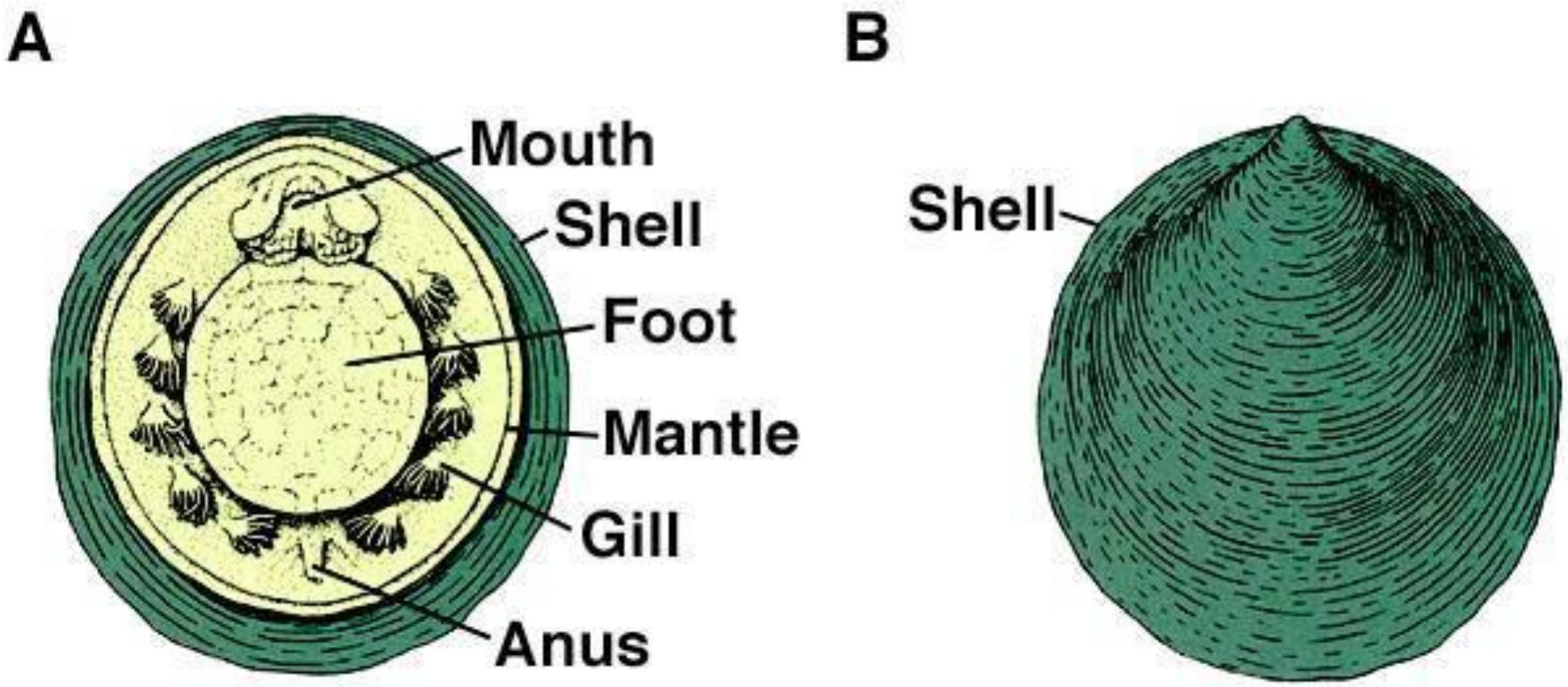
Class Bivalvia .

Class Cephalopoda .

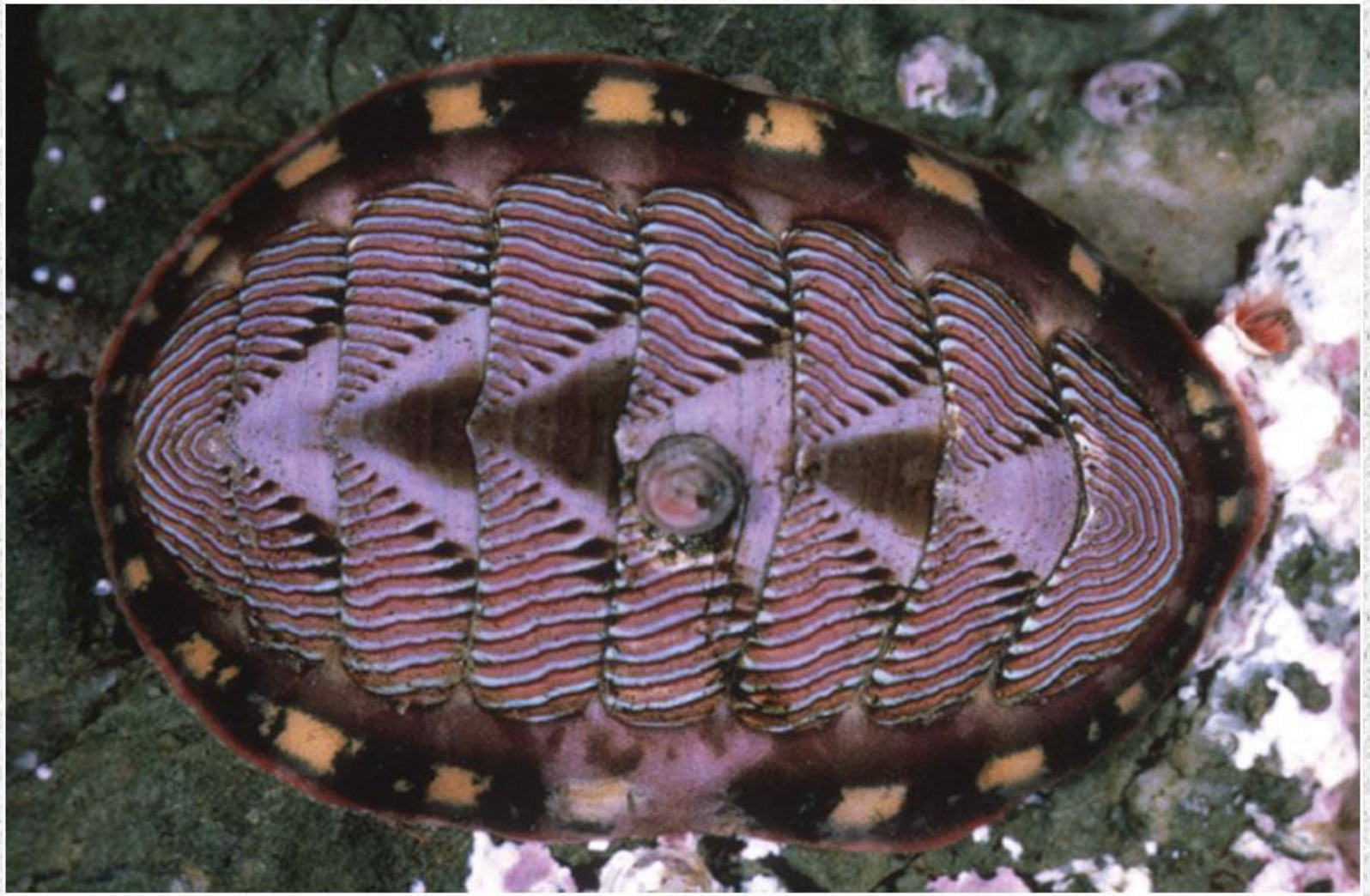
Class Monoplacophora

A. Gr. *monos* - one + *plax*, - plate + *phora*, bearing
B. Mon’ o-pla-kof’ o-ra
C. 12 species
D. serially repeated organs
E. Marine habitat; 2000 to 7000 m depth
F. Unipectinate gill
G. 3 mm to 3 cm size
H. Radula and subradula
I. Separate sexes, external fertilization

The monoplacophoran Neopilina



Class Polyplacophora
Chitons



A

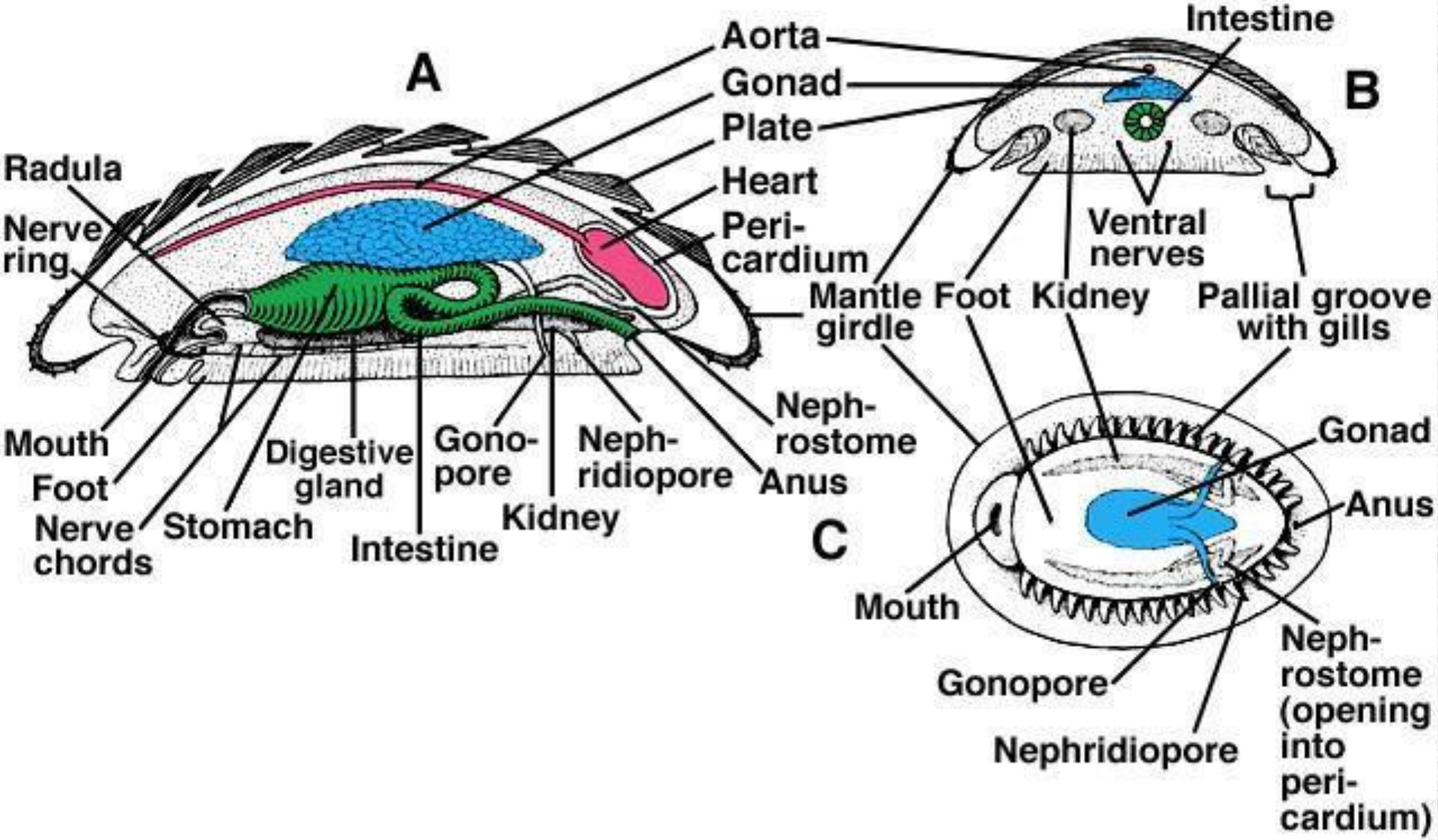
Class Polyplacophora – chitons

A. Gr. *poly* - many + *plax*, - plate + *phora*, bearing
B. Pol´ y-pla-kof´o-ra
C. =Amphineura (old name)
D. 600 species
E. 8 overlapping dorsal plates
F. scrapers using radula; herbivores
G. Marine, benthic
H. No cephalic tentacles or eyes

Polyplacophora continued

I. Buccal cavity has radula sac&subradual organ
J. Simple nervous system; no ganglia
K. Separate Sexes; gonoduct and gonopore presents in pallial groove ميزاب البرنس
L. Trochophore larvae, no veliger larvae
M. Have larval eyes but lose them after settlement الثبات,larval stage last 5 to13 days
N. Long lives, at least to 20 years
O. Hard bottom dwellers

Anatomy of a chiton



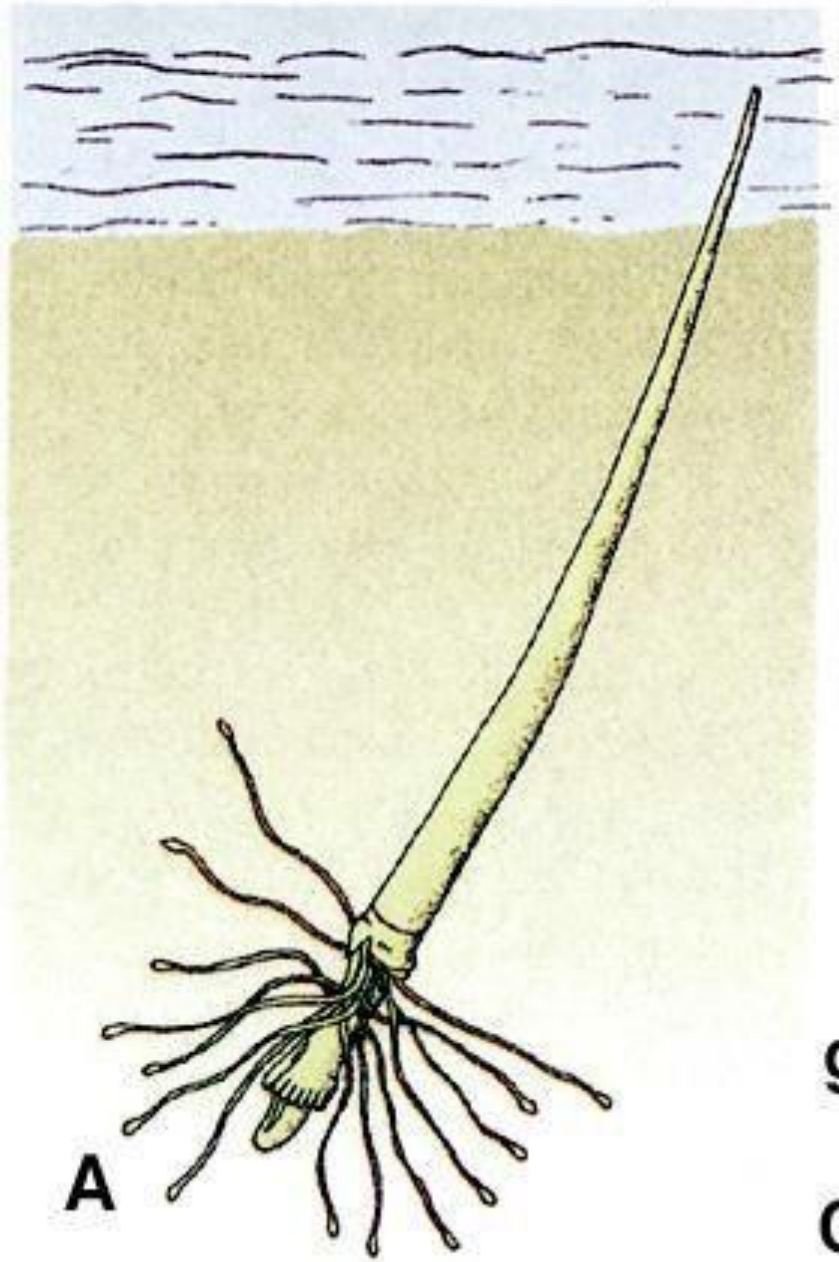
Class Scaphopoda - tooth shells

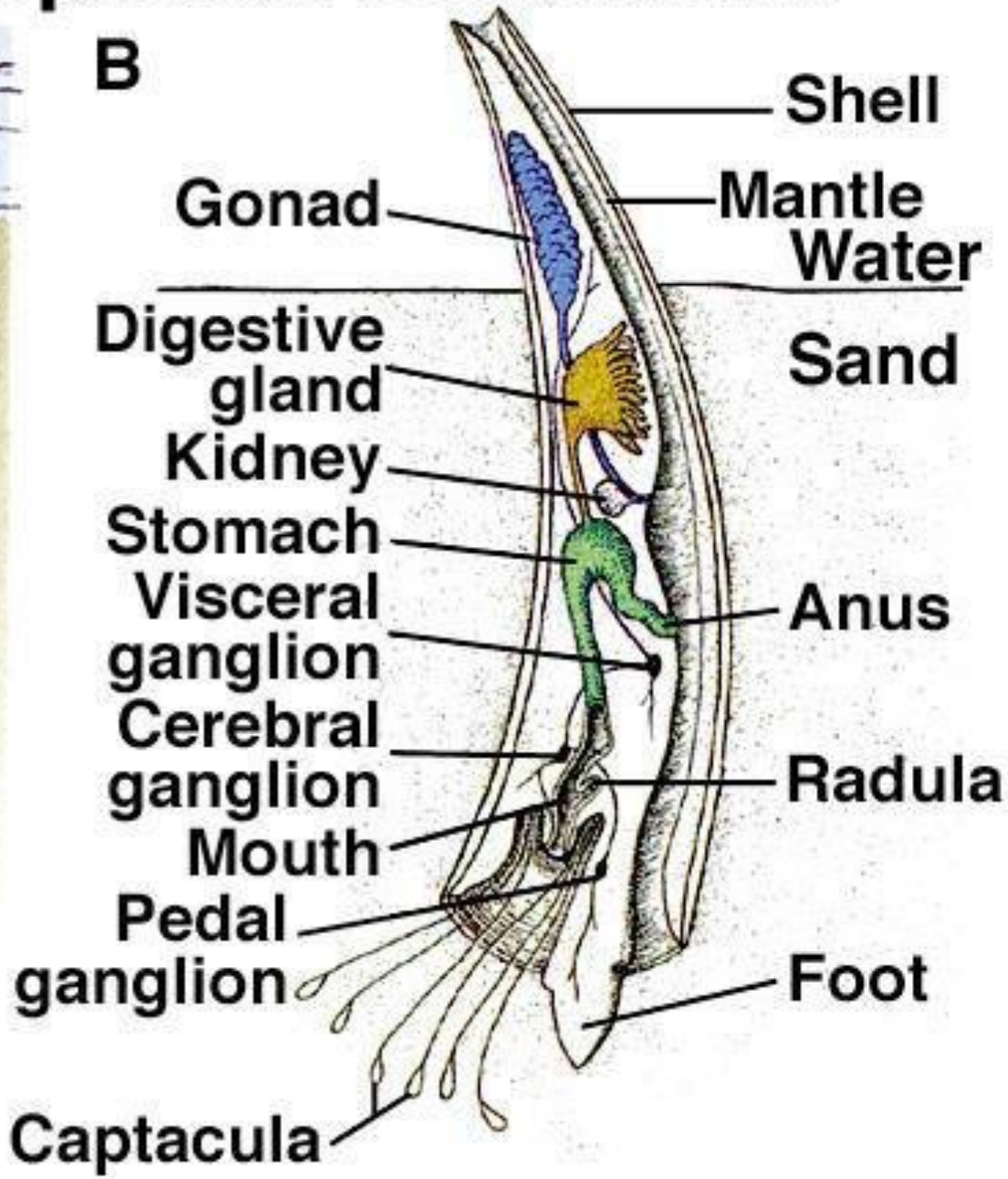
A. Gr. *scaphe* – trough, boat + *podos*, - foot
B. Ska-fop´o-da, shell both ends
C. 350 species
D. burrows in mud, tentacles, cilia capture food, mostly detritus تفتت
E. 4 to 15cm, Marine, benthic
F. No gills, exchange gas through mantle
G. Feed on foramenifera
H. Radula present, for breaking up food particles
I. Separate sexes, external fertilization

Class Scaphopoda – tooth shells

- External fertilization; trochopore and veliger larvae bilobed mantle and shell, like bivalves
- Scaphopods have classic “spiral cleavage”
- Two families; Family Dentalidae-most common ex) Dentalium sp. Family Siphodentaliidae-spiny foot, offshore, ex) Cadulus – cigar shape

The scaphopodan *Dentalium*





Class Gastropoda (복족류)

- One shell (if present)
- Torsion of body

Gastropod Morphology and Movement

- The typical snail consists of a visceral mass, which sits atopاعلى a muscular foot
  - The visceral mass is protected by a univalve shell that is coiled

Characteristics

- The largest and most diverse mollusc class
- >70,000 living species and >15,000 fossil species
- So diverse that there is no single general term in our language that applies to them all as a whole
- Include: snails, limpets, slugs, whelks, conchs, periwinkles, sea slugs, sea hares, and sea butterflies

More Characteristics

- Range from primitive marine organisms to highly evolved terrestrial, air-breathing snails and slugs
- Basically bilaterally symmetrical, except torsion causes visceral mass to be asymmetrical
- Shell (if present) is always one piece (univalve) and may be coiled or uncoiled

*The apex is the oldest and smallest whorl of the shell and successive whorls larger and larger as them spiral around the central axis (columella)
*Shells can be right handed (dextral) or left handed (sinistral) depending on the direction of coiling.
This is genetically controlled. (Dextral) is much more common

Coiling اللتفاف

- Coiling – spiral winding of shell and visceral mass
- Can occur during larval stages at the same time as torsion, but is not the same as torsion
- Coiling evolved before torsion did
- All living gastropods evolved from نشات coiled, torted

من

ancestors اسالف even if they no longer show these traits الصفات.

الالتفاف Coiling

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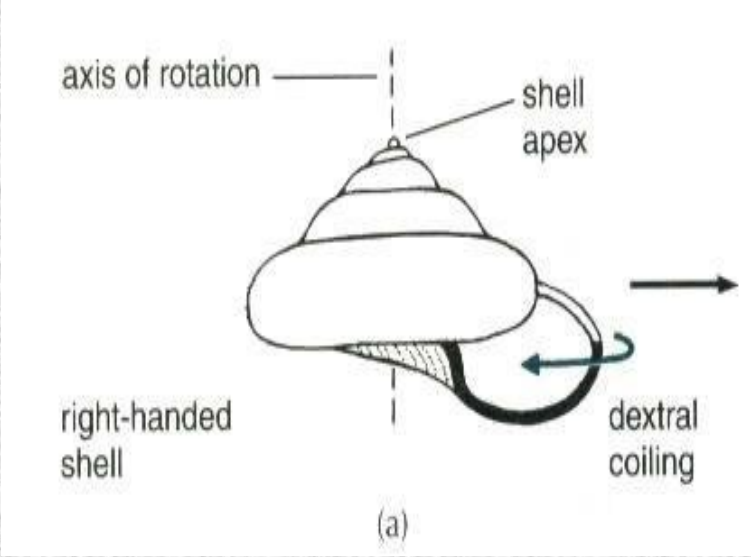
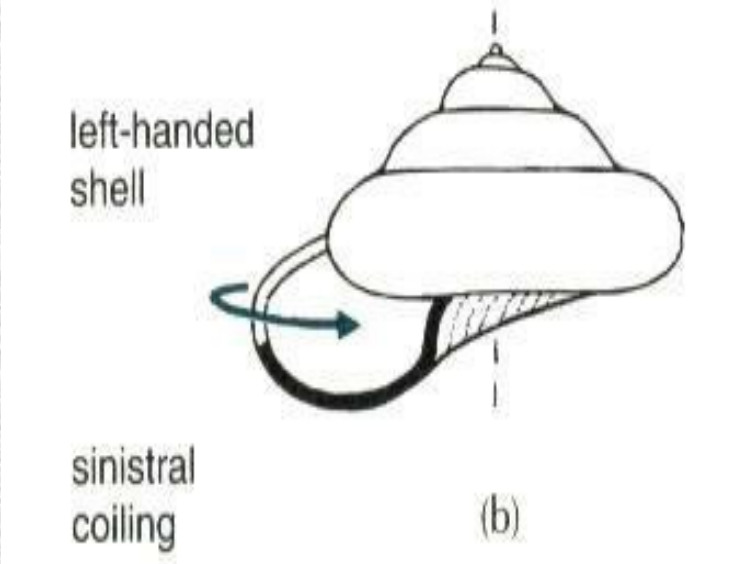
Coiling Continued

- Early gastropods were planospiral (whorls were flat on a single plane)
  - These shells are not very compact (each whorl lay completed outside the previous one
- Conispiral shells evolved (succeeding whorls lies to the side of preceding السابقة whorls)
  - This creates a very unbalanced shape (weight hangs over to one side)
  - Solved this problem by shifting the shell upward and posteriorly with the shell axis oblique to the longitudinal axis of the foot
  - Weight of the shell leaning يميل against one side has caused the gill, auricle, and kidney on the right side to be lost (bilateral asymmetry)

Dextral and Sinistral Coiling





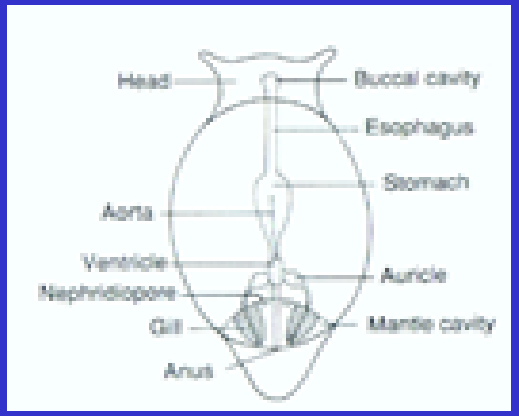
- The shell is usually carried on the left side of the body and coils to the right (dextral)
- Few species are (sinistral)
  - Shell coils to the left

- Early gastropods were planospiral (whorls were flat on a single plane)

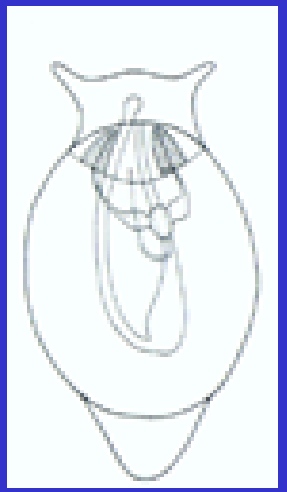
- Conispiral shells evolved (succeeding whorls lie to the side of preceding السابقة whorls)

Gastropod characteristics

- 1. Torsion - primitive bilateral symmetry lost during development
- Twisting of visceral mass, mantle, and mantle cavity



After torsion



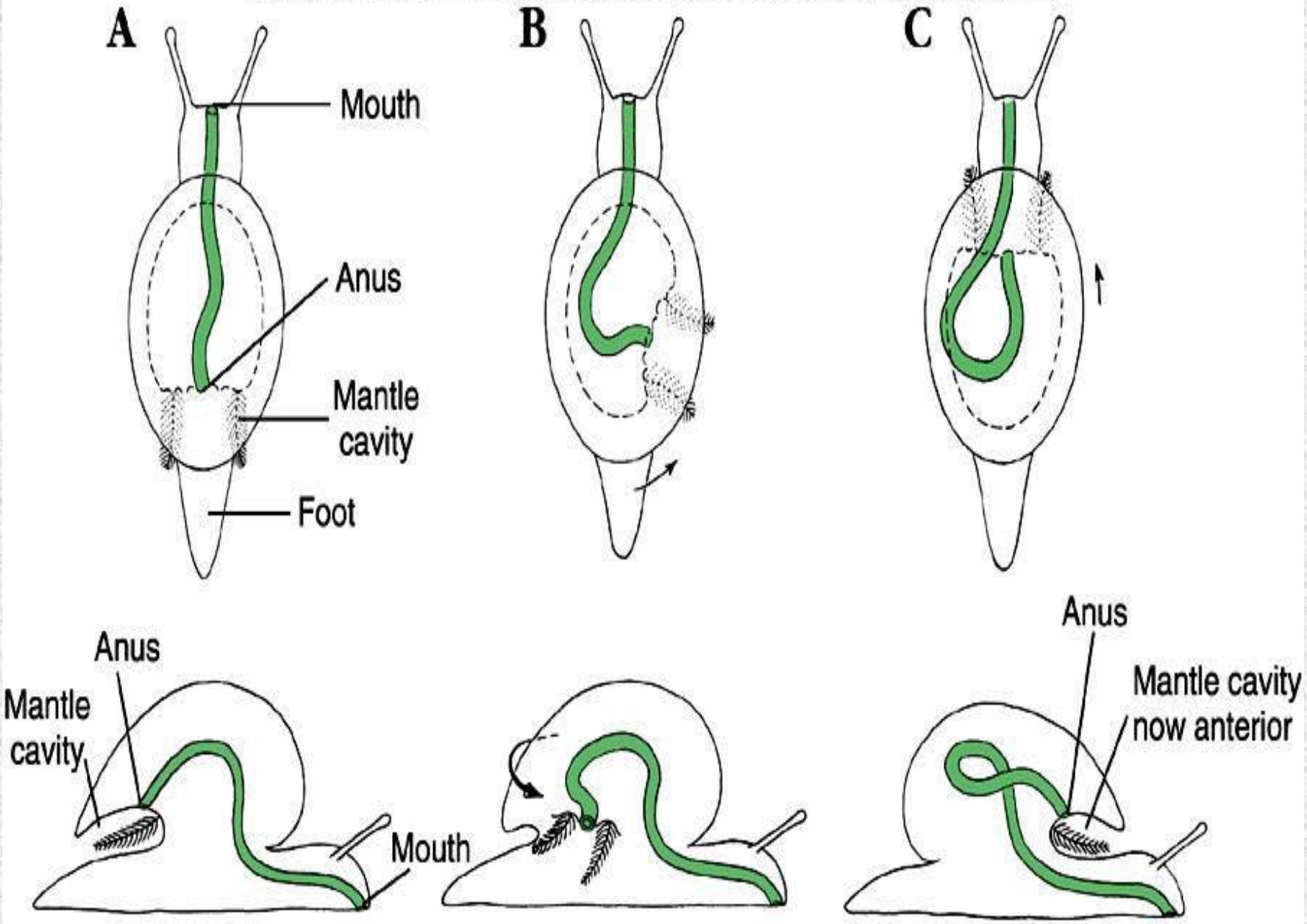
- **Torsion االلتواء**
- **Only gastropods undergo torsion**
- **Torsion is the rotation of the visceral mass, mantle, and shell 180˚ with respect to the head and foot of the gastropod. This brings the mantle cavity and anus to an anterior position above the head.**

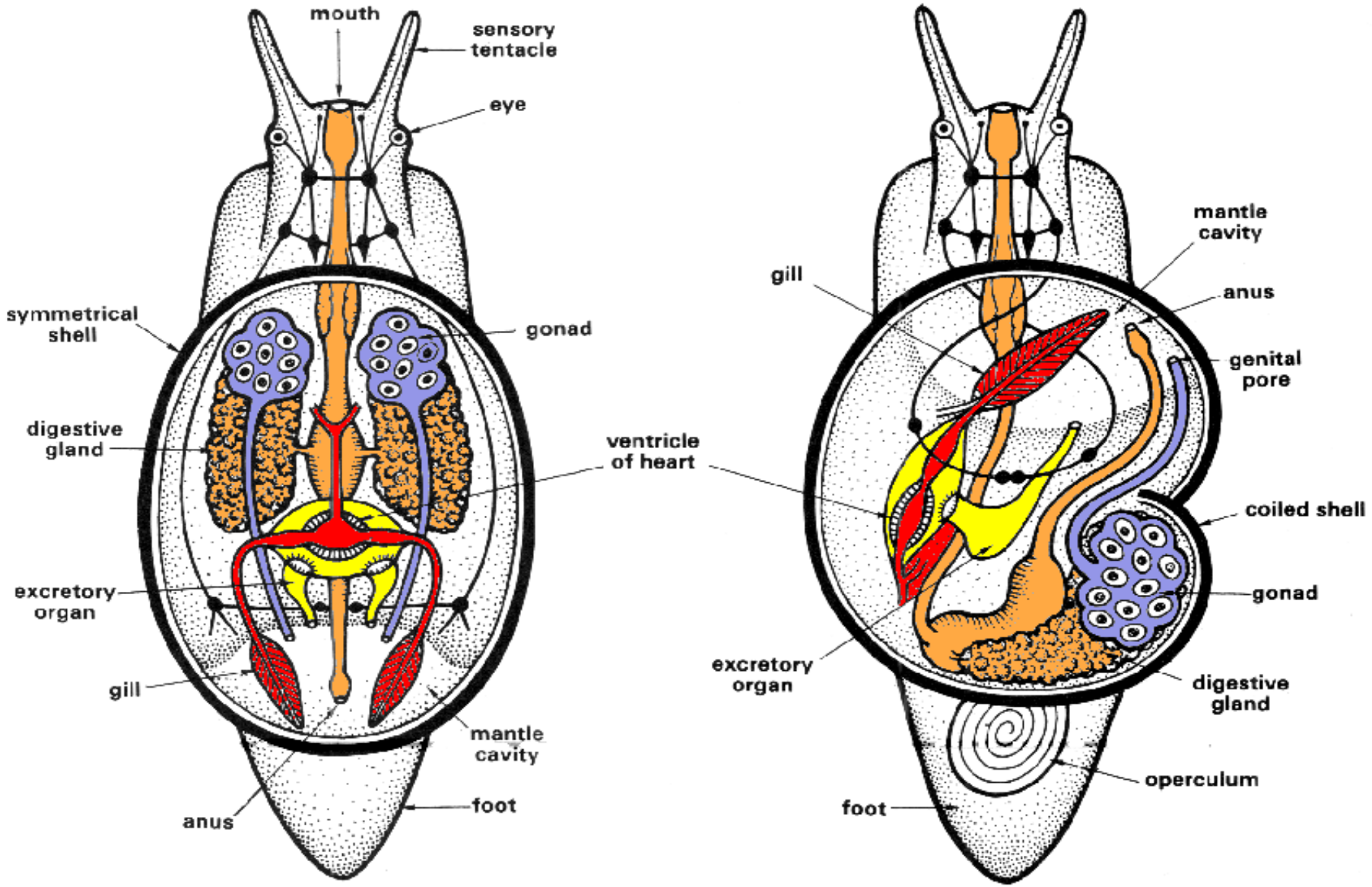
Steps of Torsion

- Two step process that occurs during the veliger stage
- 1st step is quick (as short as a few minutes)
  - Asymmetrical foot retractor muscle contracts and pulls يسحب the shell and enclosed viscera 90 degrees counterclockwise معاكس لحركة عقارب الساعة

2nd - step is slow and takes place over the rest of the development as tissues differentiate

Shell and visceral mass rotate another 90 degrees leaving the anus above the mouth and head





Construct of a gastropod as it would be if torsion and asymmetrical growth did not occur in early development.

Diagram of prosobranch snail in dorsal view, showing torsion and asymmetry of the organ systems.

Results of Torsion

- Anus and mantle cavity become anterior and open just above the head and mouth
- Left gill, kidney, and heart auricle are now on the right side and vice-versa
- The nerve cord is now twisted into a figure eight

Detorsion

- In some groups of gastropods (Opisthobranchia pulmonates الرئويات خلفيات الخياشيم there is a degree of secondary detorsion or rotation towards the original position, this may be only partial detorsion or full detorsion
- Their anus open to the right side or even the posterior

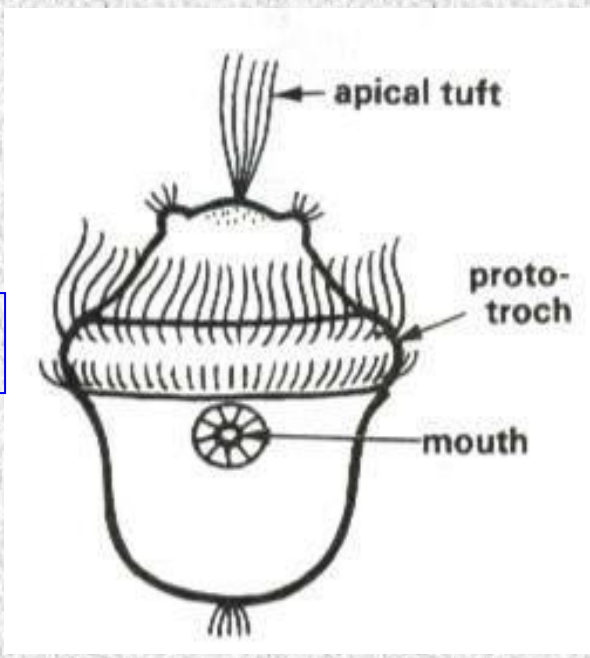
Problem with Torsion

- Fouling – wastes النفايات والقاذورات being drawn into تنجرف the gills – is a problem after torsion
- Many organisms have lost the right gill
- Water is brought in يأتى through the left and travels over ينتقل lungs and then over anus as it leaves through the right side
- Sense organs of the mantle cavity work better when they are facing the direction of travel االنتقال اتجاه يواجهون)The opposite direction(

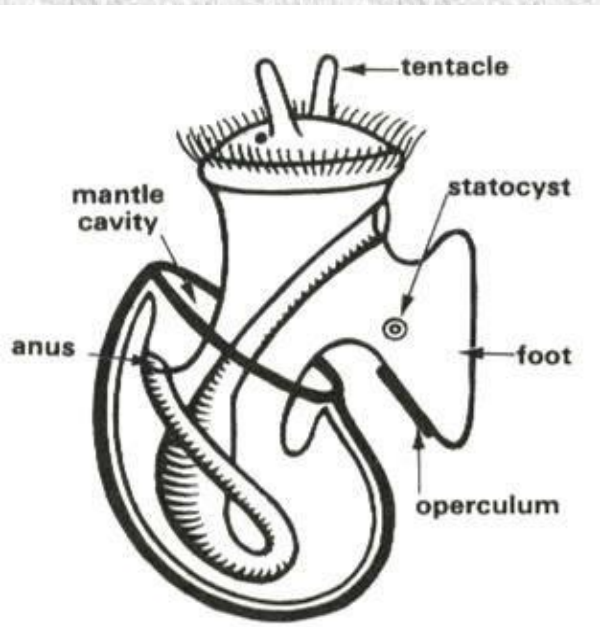
Reproduction

- Life begins as a trochophore larvae which then develops into a veliger larvae
  - The veliger is where most of the organ systems develop
  - During development the process of torsion begins

Trochophore



Veliger



Feeding Habits

- Varied feeding habits, but all involve some use of the radula
- Most are herbivores – rasping off particles of algae from hard surfaces
- Some are scavengers feeding on dead and decaying flesh
- Others are carnivores that use radula teeth to tear flesh

Internal Form and Function

- **Respiration through ctenidium (gills) in the mantle cavity**
  - **Two ctenidia is the primitive condition**
  - **Some forms lack gills all together and respire across the skin**
  - **May have siphon to bring in water**
  - **Pulmonates have lungs that open to the outside through the pneumostome**
    - Aquatic Pulmonates must surface to breathe in and out

More Internal Form and Function

- **Excretion**
  - Most have a single nephridium (kidney)
- **Well developed circulatory system**
  - Open system (during part of its circuit around the body, blood leaves the vessels and directly bathes cells in tissue spaces called sinuses)
  - Heart with a single, muscular ventricle and two auricles
- **Well developed nervous system**
  - Three pairs of ganglia connected by nerves
  - Sense organs: eyes or photoreceptors, statocyts, tactile organs, and chemoreceptors

Reproduction

- Both monoecious and dioecious forms
- Dioecious forms have gonads in spirals of visceral mass and discharge gametes into water for external fertilization
- Monoecious forms usually reproduce by internal, cross-fertilization and deposit fertilized eggs into moist soil
- Larval stage is called the veligar stage

Major Groups of Gastropods

Prosobranchs امامیات الخیاشیم	Opisthobranchs خلفیات الخیاشیم	Pulmonates الرئویات
•Most marine snails and some freshwater and terrestrial gastropods •One pair of tentacles •Sexes are separate •Operculum often present	•Oddغریبة assortment of organisms including sea slugs, sea hares, and sea butterflies •Mostly marine and shallow-water forms •Show partial or complete detorsion •Two pairs of tentacles •Reduced or absent shell •All are monoecious	•Land and most freshwater snails and slugs •Show some detorsion •Have lost ctenidia and have gained lungs •All are monoecious •Aquatic forms have one pair of tentacles with eyes •Land forms have two pairs of tentacles – the posterior bearing eyes

Class: Bivalvia or Pelecypoda

- L. *bi* – two *valva* – folding door
- Bi-val´ve-a
- Or Pelecypoda=axe foot
- 8,000 species
- Marine and freshewater, benthic
- Head reduced, foot compressed, gill and mantle large
- 1 to 2 pairs of adductor muscles with muscle scar
- Commercially important marine bivalves

Class: Bivalvia or Pelecypoda

- If only posterior adductor muscle present, “monomyarian”
- If both present and equal size, “isomyarian”
- If anterior muscle reduced, and posterior large, “anisomyarian”
- Pallial line; where mantle attached to shell
- Pallial sinus; region where muscles that retract siphon are attached
- Periostracum; outside of shell

Class: Bivalvia or Pelecypoda

- No radula in any pelecypod; suspension or deposit feeder
- Stomach usually has style and style sac
- Excretory organ; pairs of nephridia
- Few brood, mostly external fertilization
- 3 types of gills;
- 1) primitive protobranch gill- subclass Paleotaxodonta
- 2) lamellibranch gill-”W-shape” most bivalves
- 3) Septibranch gill- no gill, subclass Anomalodesmata

Class: Bivalvia or Pelecypoda

- Subclass based on shell structure and hinge, gills, feeding types
- Subclass Paleotaxodonta (teeth in a row) – protobranchiated gill, Intertidal to deep sea
- Subclass Cryptodonta (hidden teeth) – protobranchiated gill, valve thin,
- Subclass Pteriomorpha – oysters, mussels, scallops, arc shells, pen shells, pearl oysters, thorny oysters, mostly suspension feeders
- Subclass Paleoheterodonta – freshwater clams, unionid clams, internal fertilization, glochidia larvae
- Subclass Heterodonta – equivalve, eulamellibranchiate gills, usually have siphones (inhalent, exhalent), cockle, clams, jacknife clams, clams, surf clams

A bivalve, *Pecten* sp.

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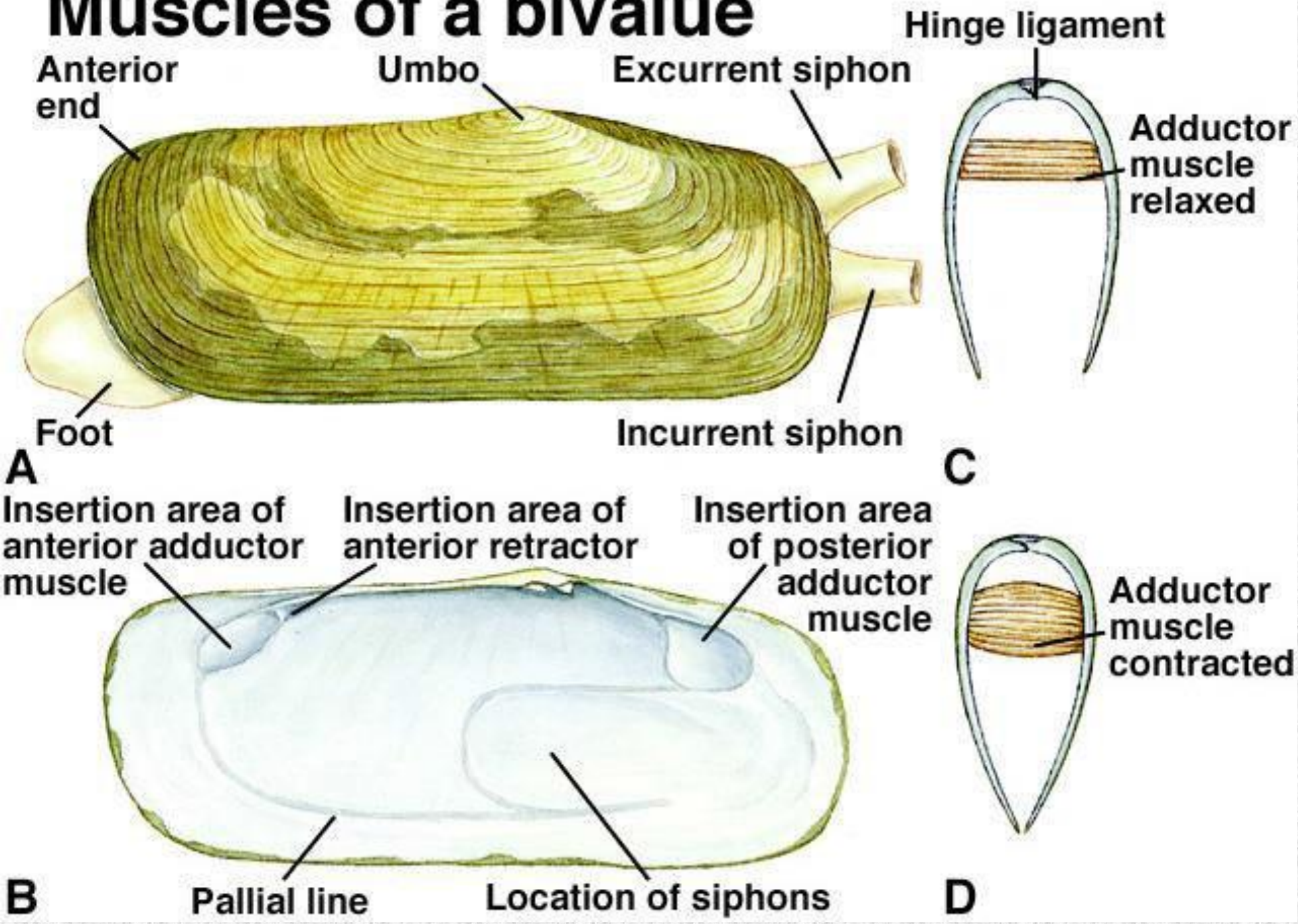
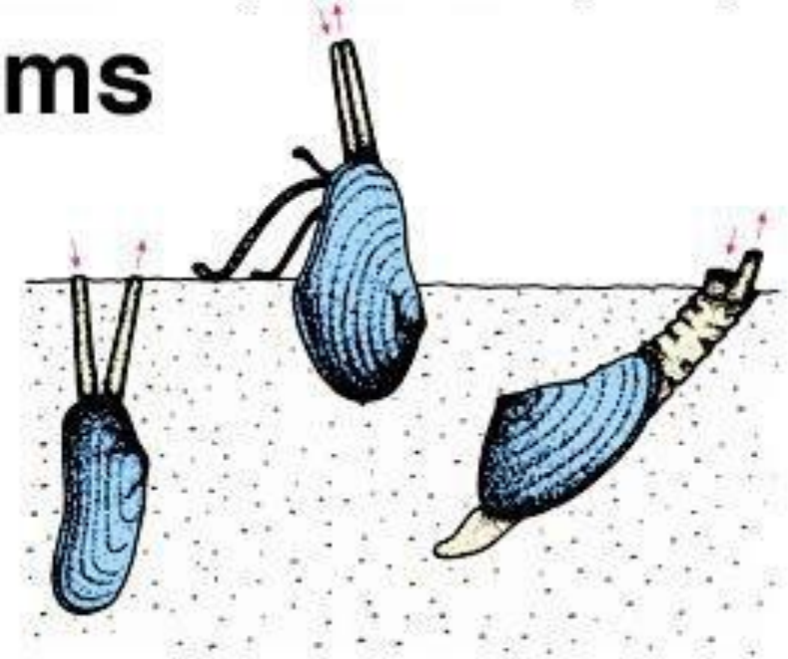
Muscles of a bivalue



Shipworms



A

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B

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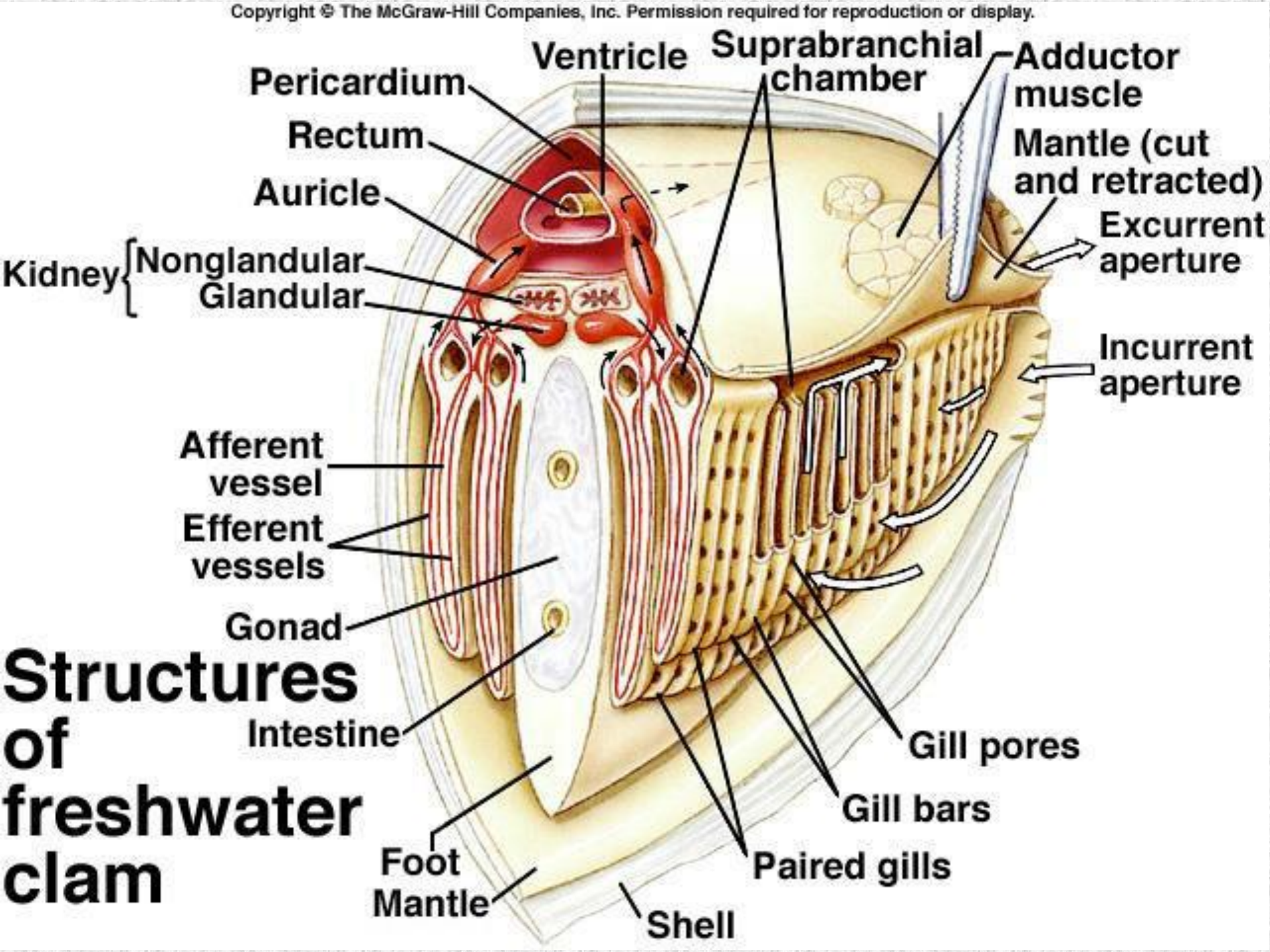
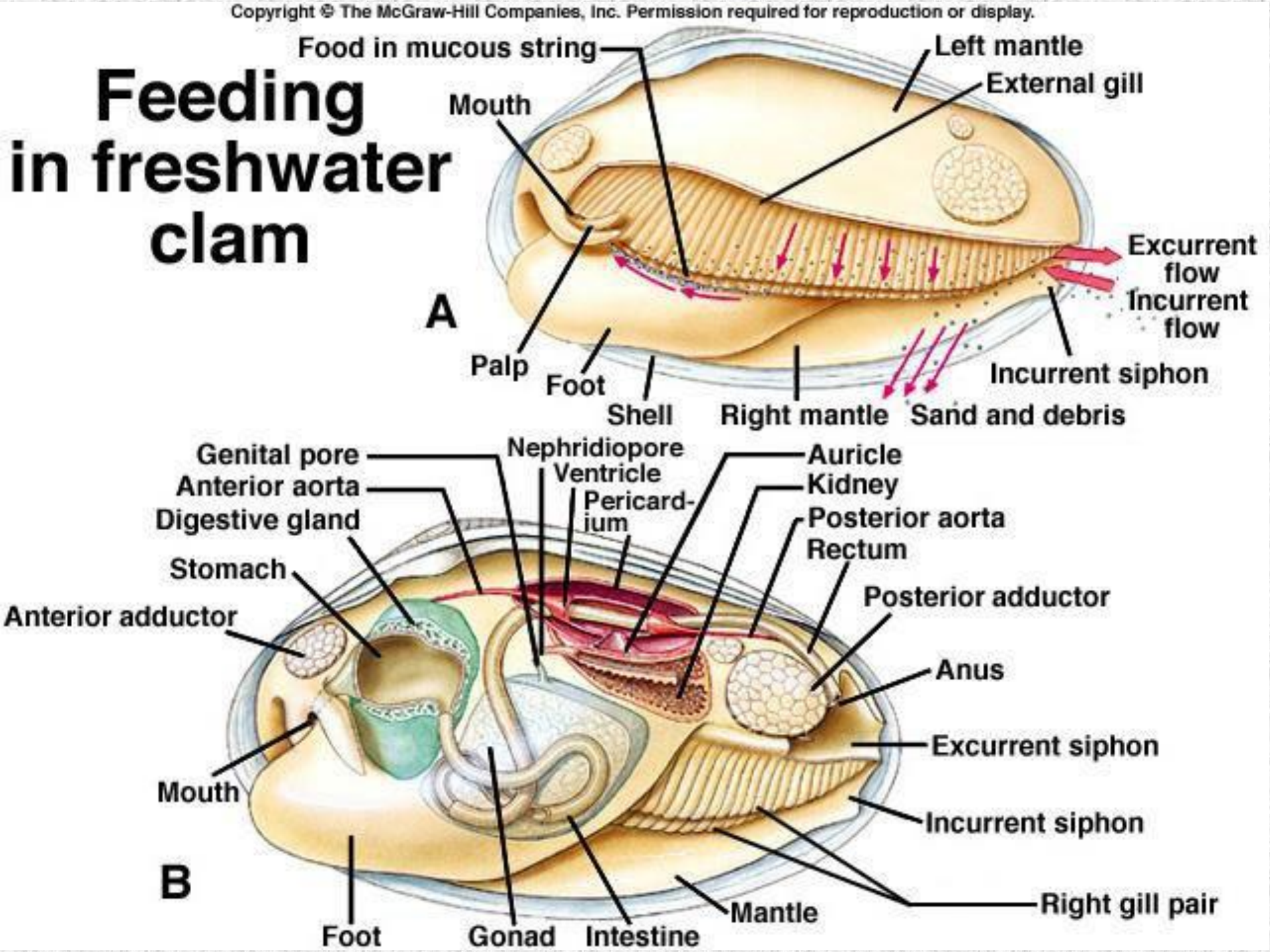
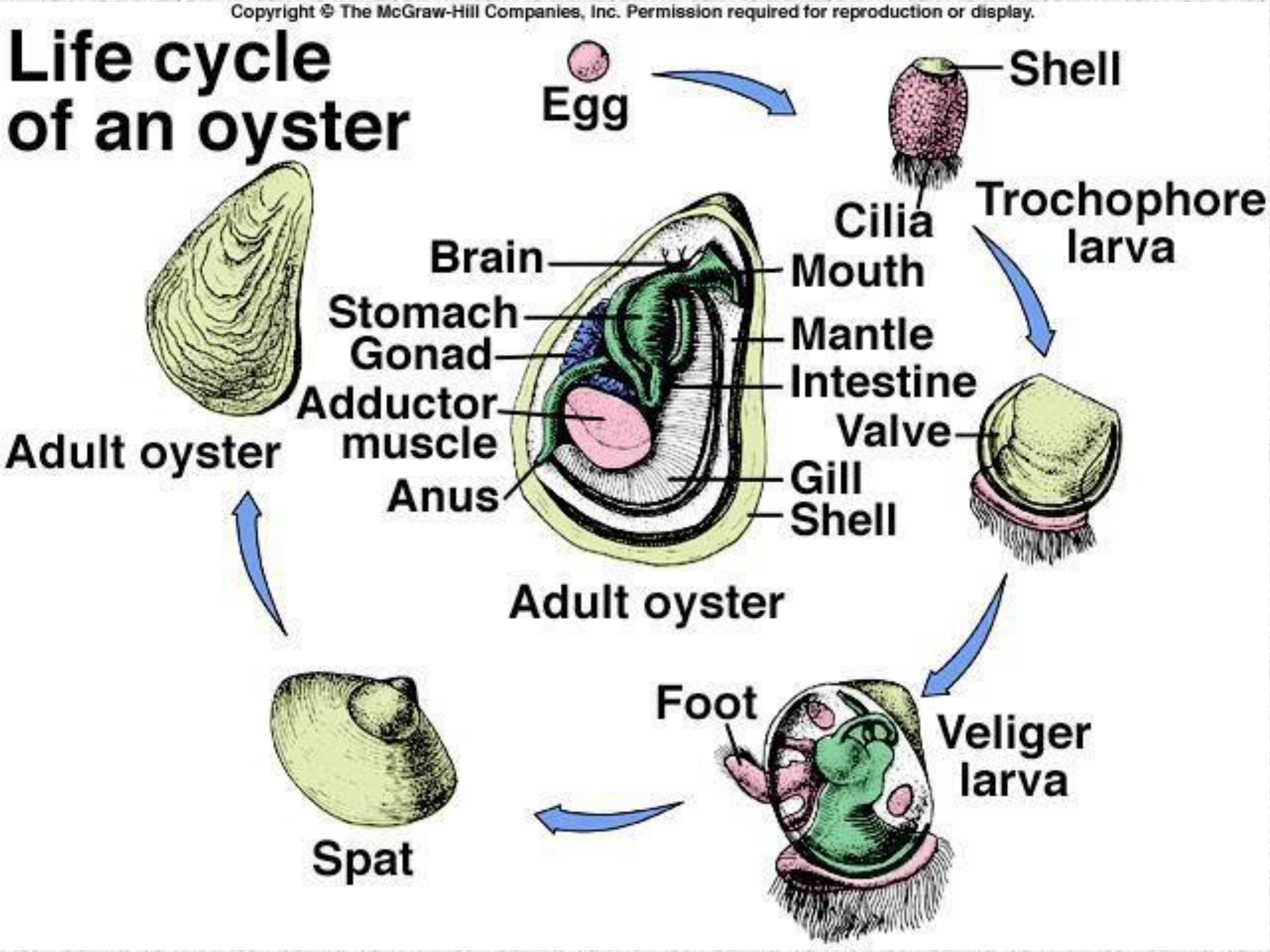


Structures of freshwater clam

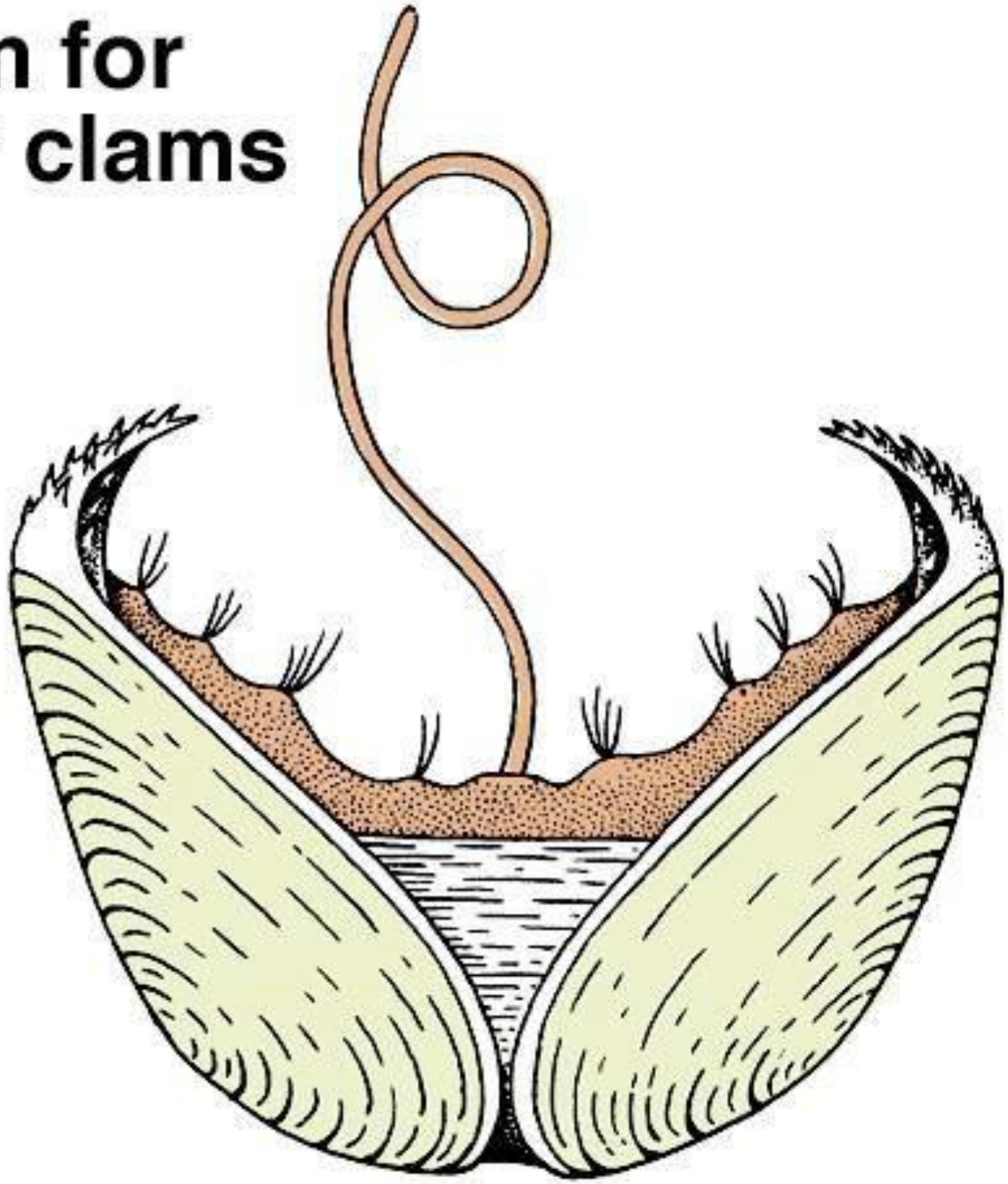
Feeding in freshwater clam



Life cycle of an oyster



Larval form for freshwater clams



Giant clam (*Tridacna gigas*)

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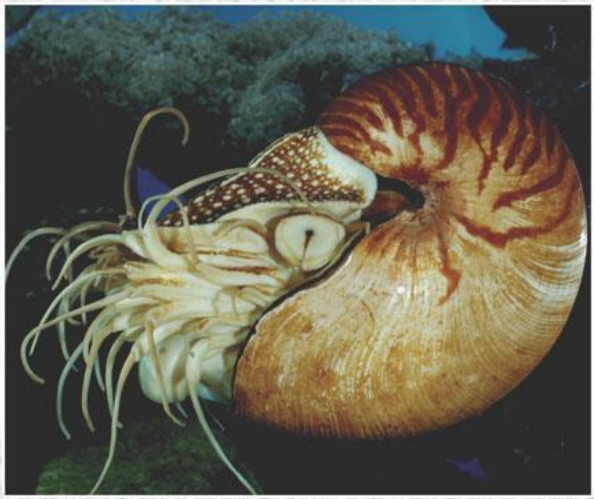
Class Cephalopoda

Class Cephalopoda

- Cephalopods include octopuses, squid, nautiluses and cuttlefish.
- Marine carnivores with beak-like jaws surrounded by tentacles of their modified foot.
  - Modified foot is a funnel for expelling water from the mantle cavity.



All *marine predators*

Foot is in the head region

- Modified for expelling water from mantle cavity

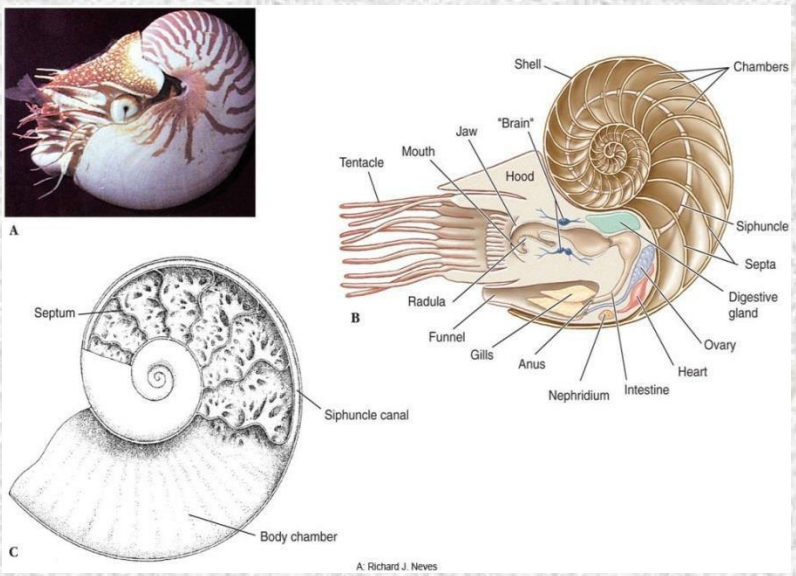
Range from 2 cm to the giant squid

- Largest invertebrate

Cephalopods

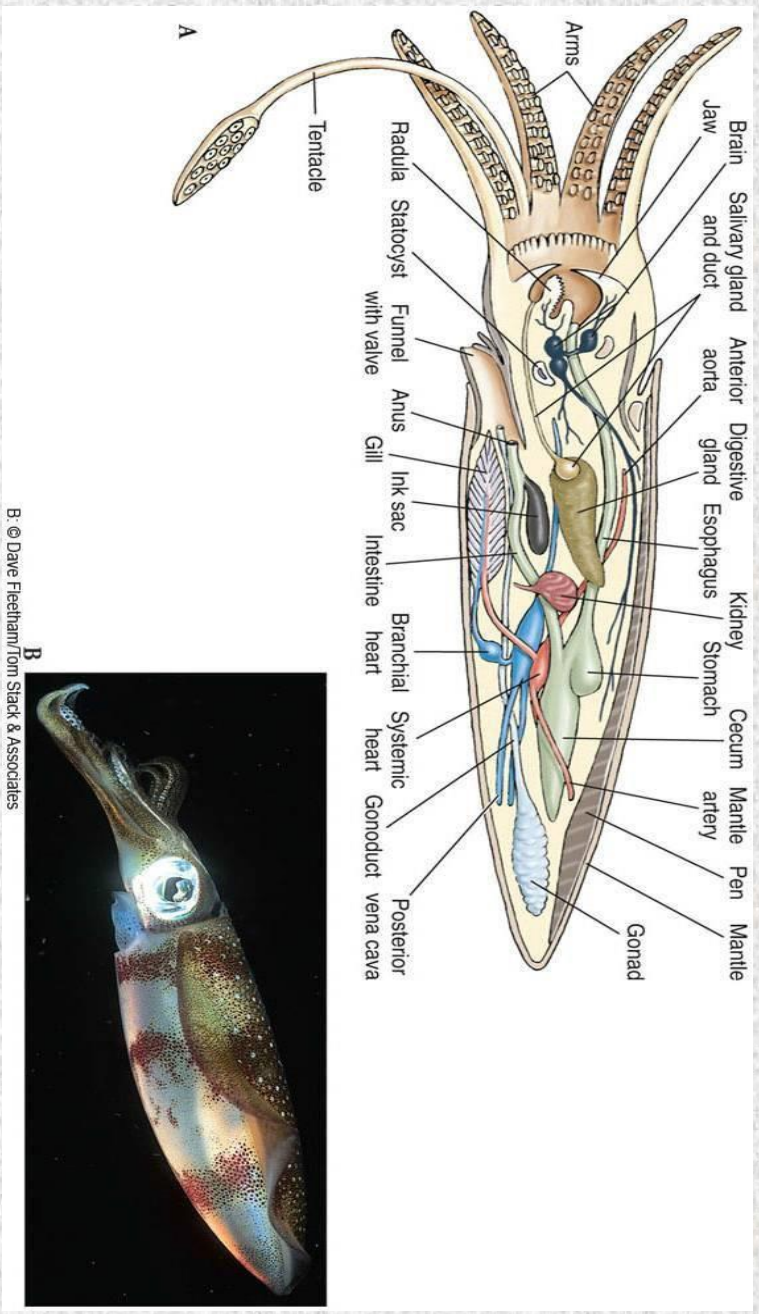
- Mostly marine
- Octopuses mostly intertidal
- Squids are deep-sea animals

- ***Form and Function***
  - ***Shell***
    - *Nautiloid shells* have a gas chamber allowing them to swim
      - **Nautilus shell is divided into chambers**
      - **Living animal only inhabits last chamber**
      - **Cord of living tissue, the *siphuncle,* connects chambers to visceral mass**
    - *Cuttlefish shell* is enclosed in mantle
    - *Squid shell* is a thin strip called the pen, enclosed in mantle
    - *Octopus* has completely lost the shell

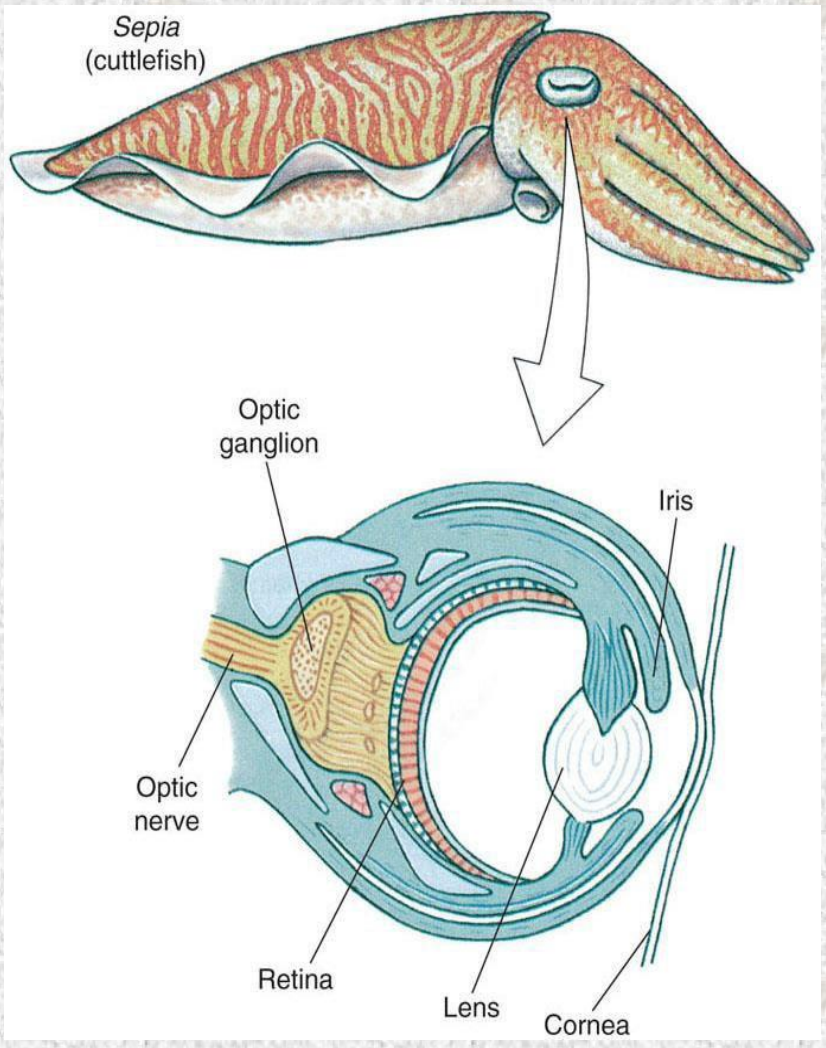


- ***Locomotion***
  - ***Cephalopods* swim by forcefully expelling water through a ventral funnel or siphon**
  - **Control direction and force of the water, thus determining its speed**
  - **Lateral fins of *squids and cuttlefishes* are stabilizers**
  - ***Nautilus* swims mainly at night by changing internal pressure and jet propulsion**
  - ***Octopuses* mainly crawl on the bottom but can swim backward by spurting jets of water**
    - Some with webbing between their arms swim with a medusa-like action

- ***Respiration and Circulation***
  - **Except for nautiloids, cephalopods have one pair of gills**
  - ***With higher oxygen demands*, cephalopods have a muscular pumping system to keep water flowing through the mantle cavity**
  - **Circulatory system has a network of vessels conducting blood through gill filaments**
  - **Accessory or *branchial hearts* at the base of each gill increase pressure to blood going through gill capillaries**



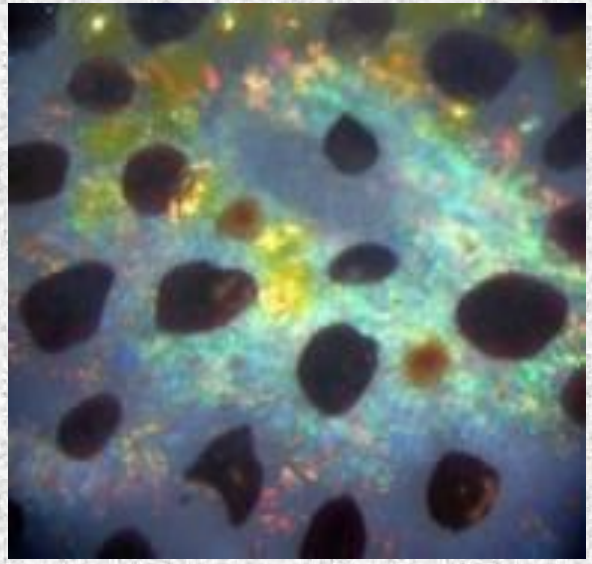
- ***Nervous and Sensory Systems***
  - ***Cephalopod brain* is the largest of any invertebrate**
  - ***Squids* have giant nerve fibers**
  - ***Sense organs are well-developed***
    - Eyes are complex, complete with cornea, lens, and retina
  - **Can learn by reward and punishment, and by observation of others**
  - **Cephalopods lack a sense of hearing but have tactile and chemoreceptor cells in their arms**



Class Cephalopoda – Communication

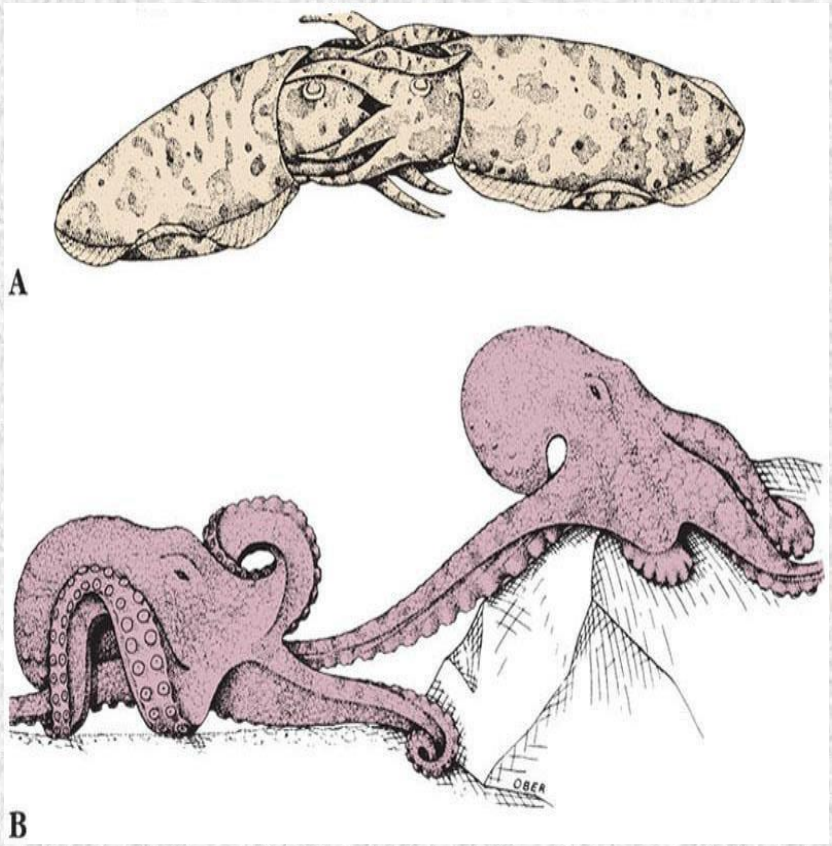
- **Visual signals allow cephalopods to communicate.**
  - **Movement of body and arms**
  - **Color changes effected by chromatophores (cells in the skin containing pigment granules).**
    - Chromatophores can change shape alternately dispersing and concentrating pigment.

- **Communication**
  - Use ***chemical and visual signals*** to communicate
  - ***Chromatophores*** are cells in the skin that contain pigment granules
  - Contractions of the muscle fibers attached to the cell boundary causes the cell to expand and *change the color pattern*
  - Color patterns can be changed rapidly
  - ***Deep-water cephalopods*** have elaborate luminescent organs
  - ***Ink sac*** empties into rectum;
    - Contains ink gland that secretes sepia حبر when animal alarmed قلق



Class Cephalopoda - Reproduction

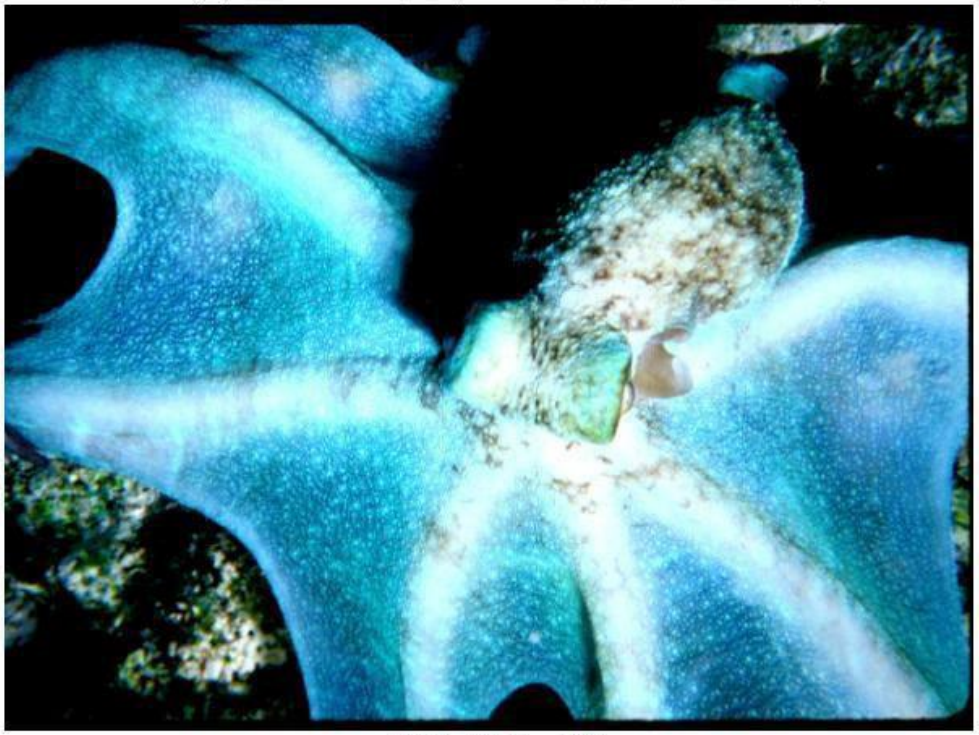
- Sexes are separate in cephalopods.
- Juveniles hatch directly from eggs – no free-swimming larvae.
- One arm of male is modified as an intromittent organ, the hectocotylus.
  - Removes a spermatophore from mantle cavity and inserts it into female.



- ***Reproduction***
  - **Sexes are *separate***
  - **In male *seminal vesicle*, spermatozoa are packaged in spermatophores and stored**
  - **One arm of male is modified as an intromittent organ, the *hectocotylus***
    - Removes a spermatophore from mantle cavity and inserts it into female
  - **Fertilized eggs leave oviduct and are attached to stones, etc.**
  - **Large, yolky eggs undergo *meroblastic cleavage***
    - Hatch into juveniles with *no free-swimming larval stage*

Class Cephalopoda - Locomotion

- Cephalopods swim by expelling water from the mantle cavity through a ventral funnel.
  - They can aim the funnel to control the direction they are swimming.



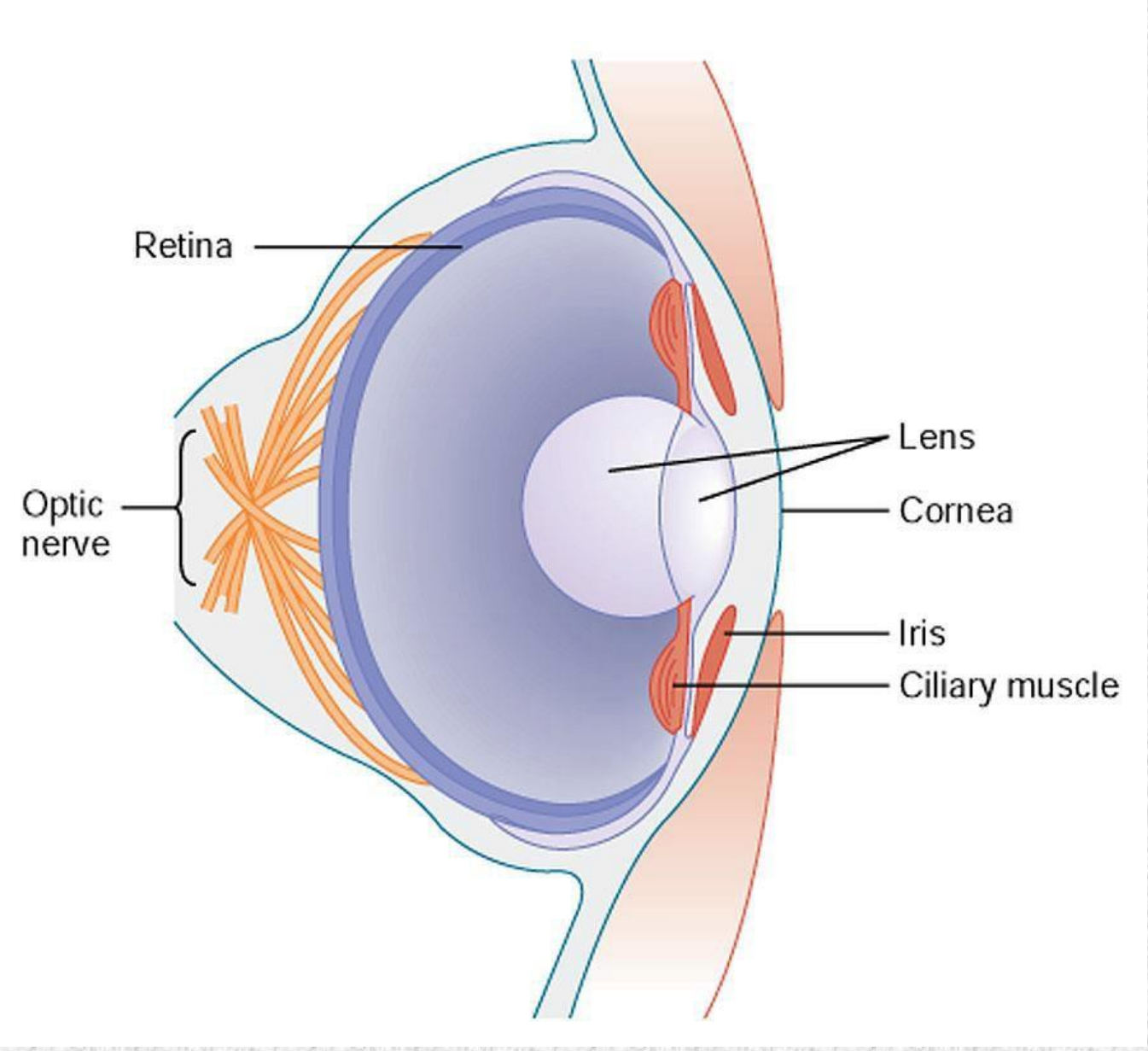
Class Cephalopoda

- Cephalopods have a closed circulatory system.
- Nervous and sensory systems are more elaborate in cephalopods than in other molluscs.
  - The brain is the largest of any invertebrate.

Class Cephalopoda

- Most cephalopods have an ink sac that secretes sepia, a dark fluid containing the pigment melanin.
  - When a predator tries to attack, the animal ejects the ink into the water where it hangs between the animal and the predator screening a quick escape.

Cephalopod Eye



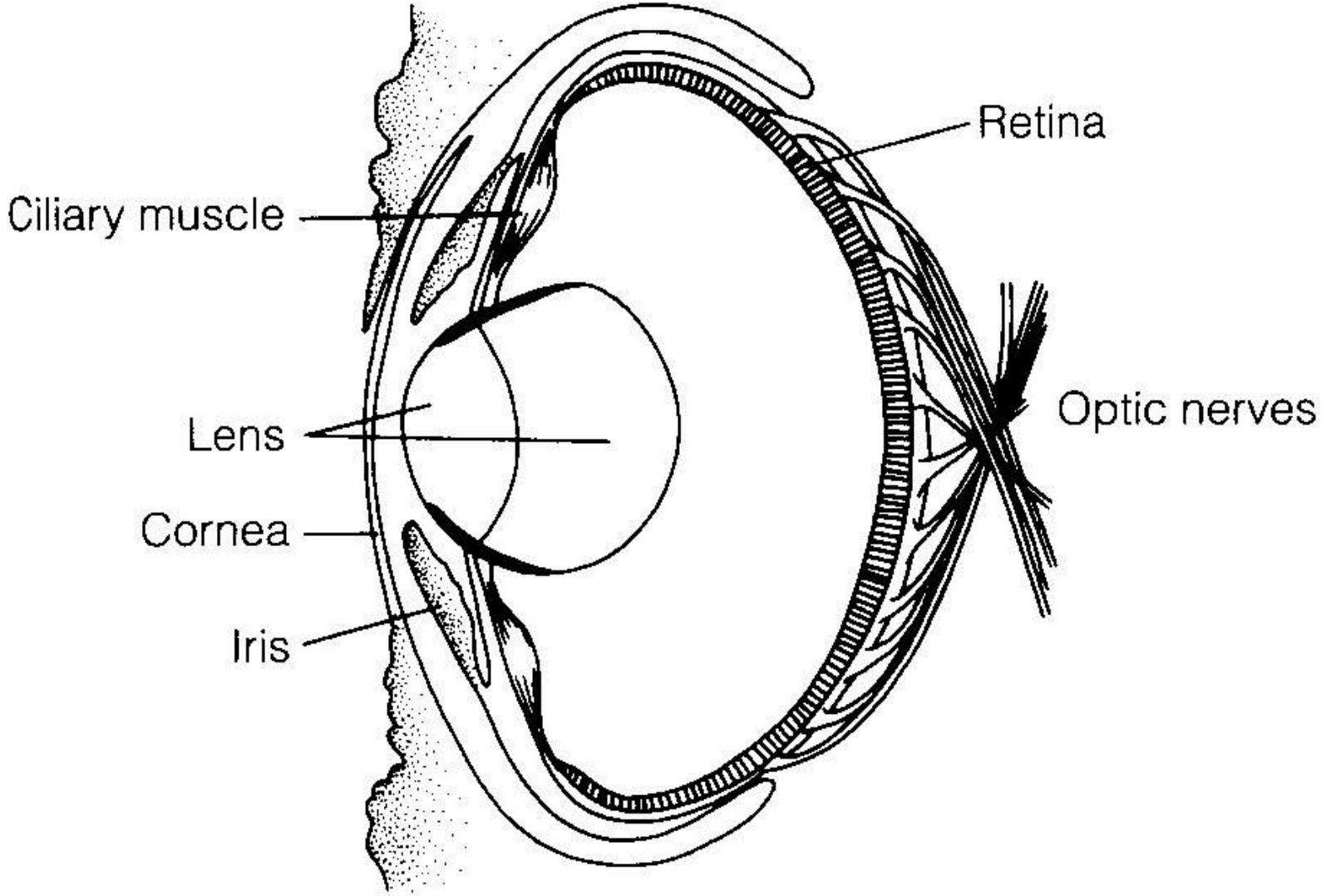


FIGURE 12-82 The eye of *Octopus* in cross section. *(After Wells, M. J. 1961. What the octopus makes of it; our world from another point of view. Adv. Sci. London. 20:461–471.)*