

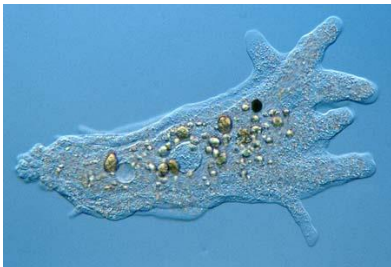
Excretory system

The function of the excretory system to remove wastes from the body. These wastes include water, CO₂, **nitrogen**, and salts

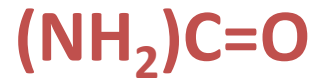
Ammonotelic animals NH_3

Most of the aquatic animals including protozoans, crustaceans, platyhelminths, cnidarians, poriferans, echinoderms, fishes, larvae/tadpoles of amphibians are ammonotelic – extract ammonia.

- ammonia easily pass through the body surface
- it often does not require special excretion organs to remove it (it diffuses through e.g. gills)

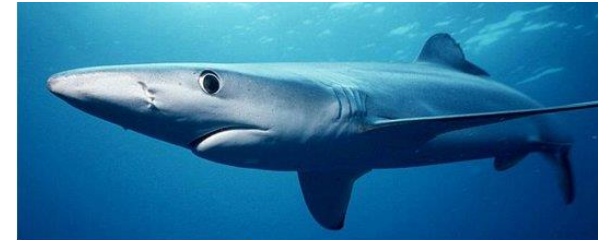


Ureotelic animals

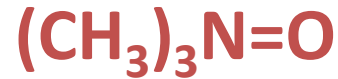


A ureotelic organism excretes excess nitrogen as **urea**. Urea is less toxic and needs less water in comparison to ammonia.

- Cartilage fish, terrestrial amphipods, mammals



URICOTELI animals



The uricotelic organism excretes **uric acid** or its salts. In contrast to ammonia and urea, uric acid is the least toxic and the least soluble in water.

- reptiles, birds, terrestrial snails, insects,...

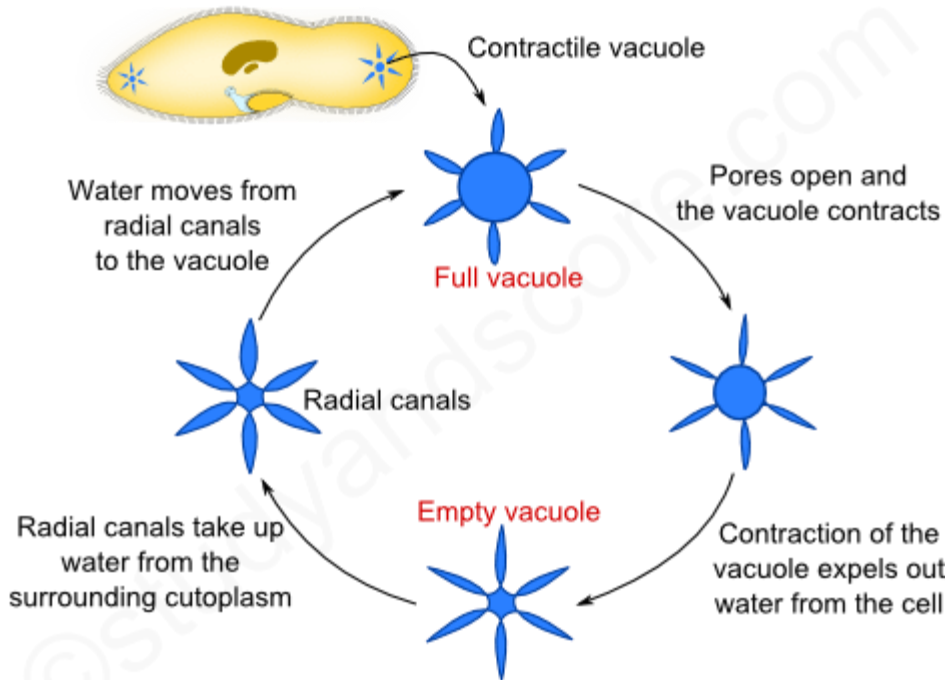
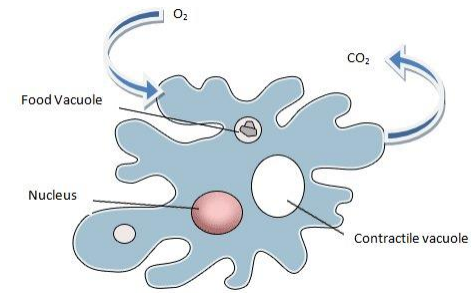


OVERVIEW

▪ Protists

- Body surface

- **Contractile vacuole** - (1 or more)
- osmoregulation + ammonia



STEPS IN THE PROCESS OF OSMOREGULATION IN PARAMECIUM

„real” excretion organs in multicellular animals

3 „ways”:

- invagination of the surface into animals - **PROTONEFRIDIUM**
- unfolding of the mesodermal walls of the body towards the outside - **METANEFRIIDIUM**
- unfolding of the intestine - **Malpighian tubules**

exceptions:

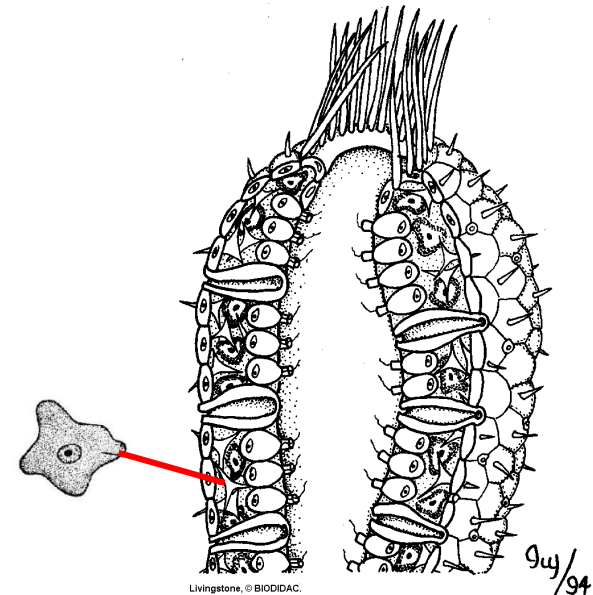


Phylum - PORIFERA (SPONGIA)

- No specila organs



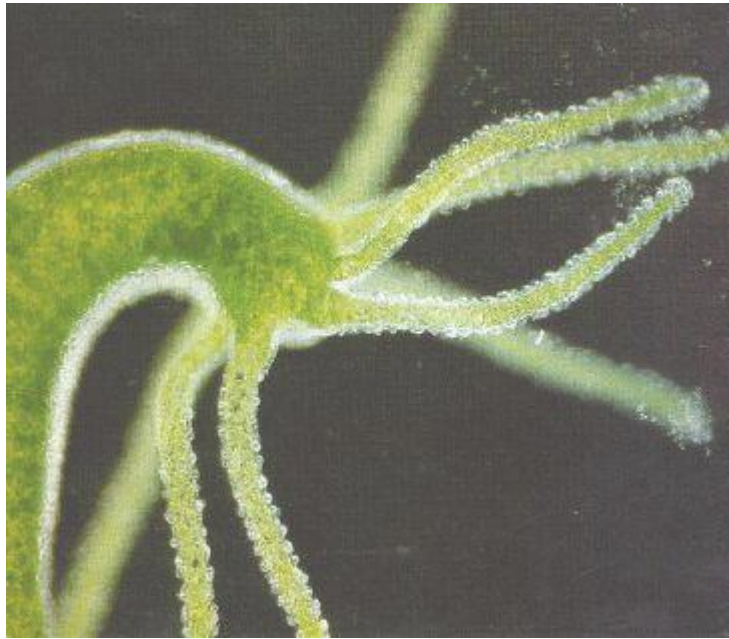
Amoebocytes – when they are full – to the surface and fall apart



Phylum Cnidaria

-No special organs

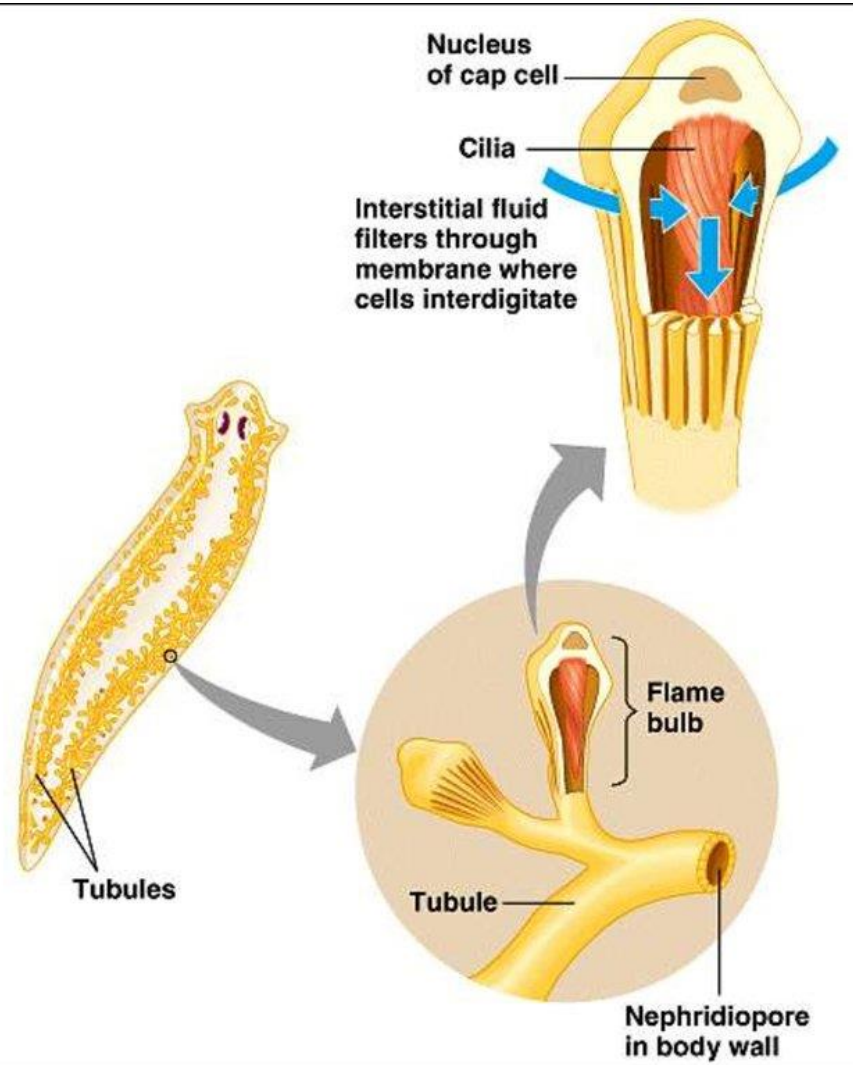
- excretes in the gastrodermal cells and out of the body



➤ protonephridia (invagination)

➤ flame cells or solenocytes are the excretory structures in **Platyhelminthes/flatworms, Rotifers,** some annelids and Cephalochordate(**Branchiostoma**).

Excretory organs
are **Flame cells**
(protonephridia)



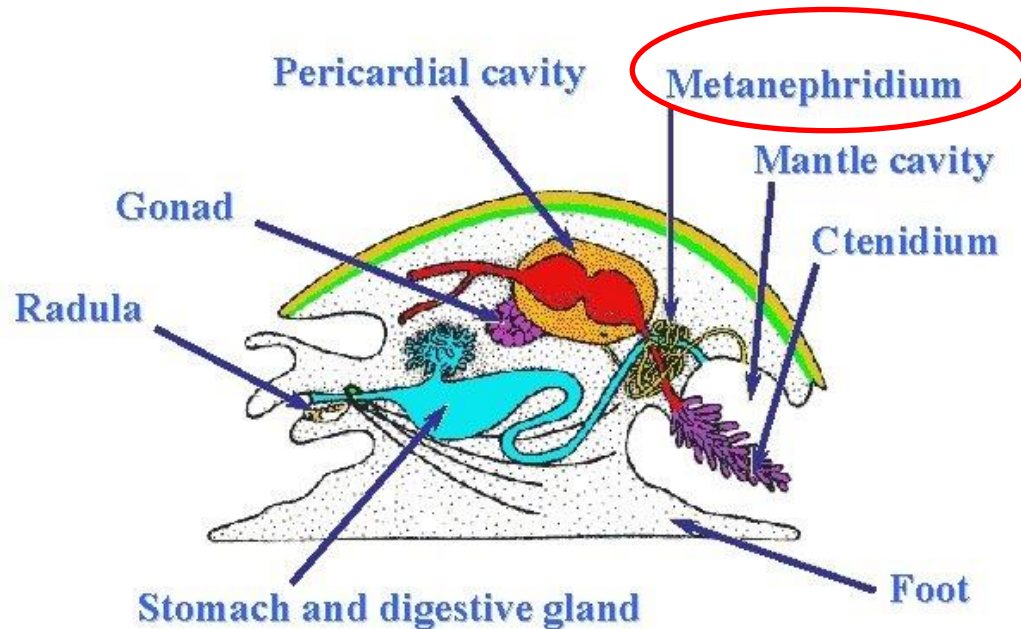
METANEFRIDIUM

(unfolding of the mesodermal walls of the body towards the outside)

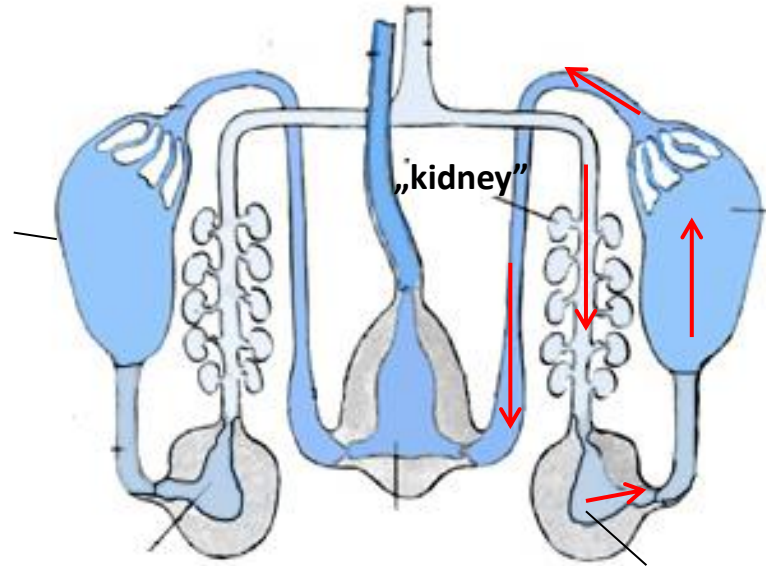
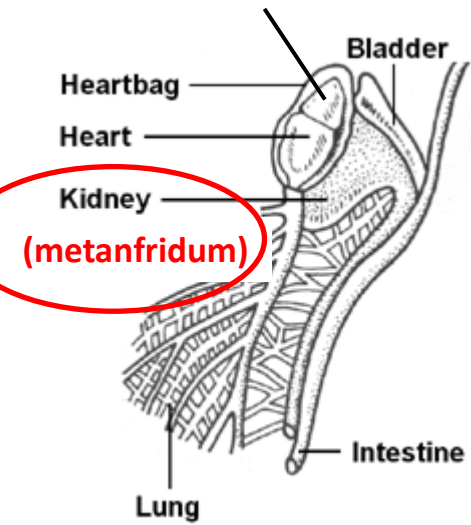
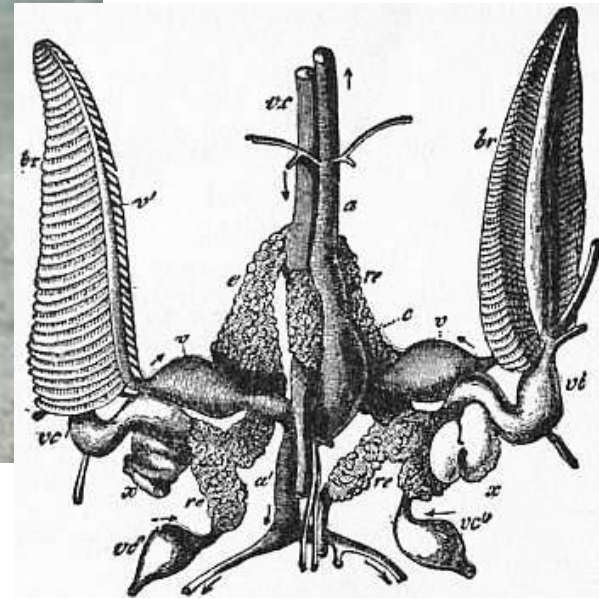
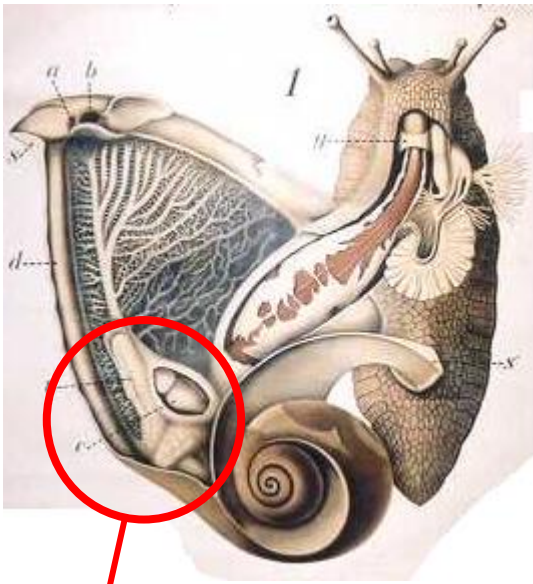
- Animals with bigger bodies (molluscs, annelids....)

Phylum MOLLUSCA

- a pair of metanefridia – filter fluid from pericardial cavity



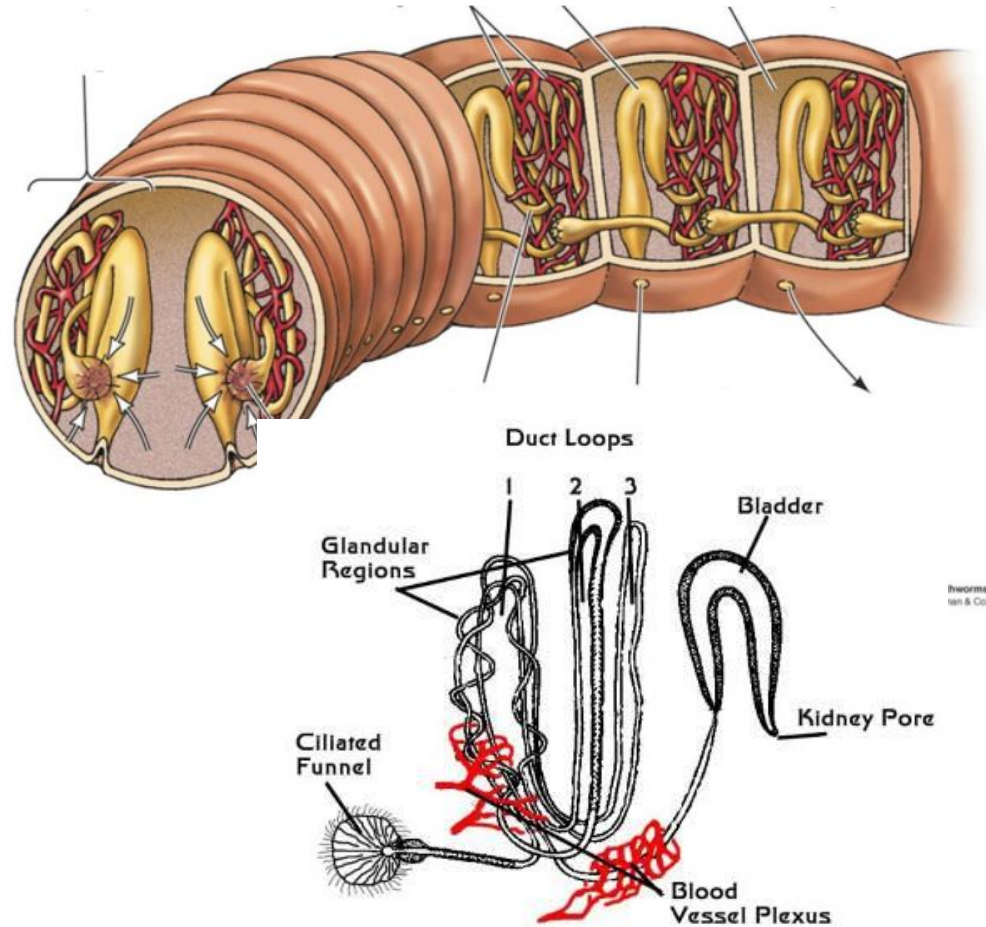
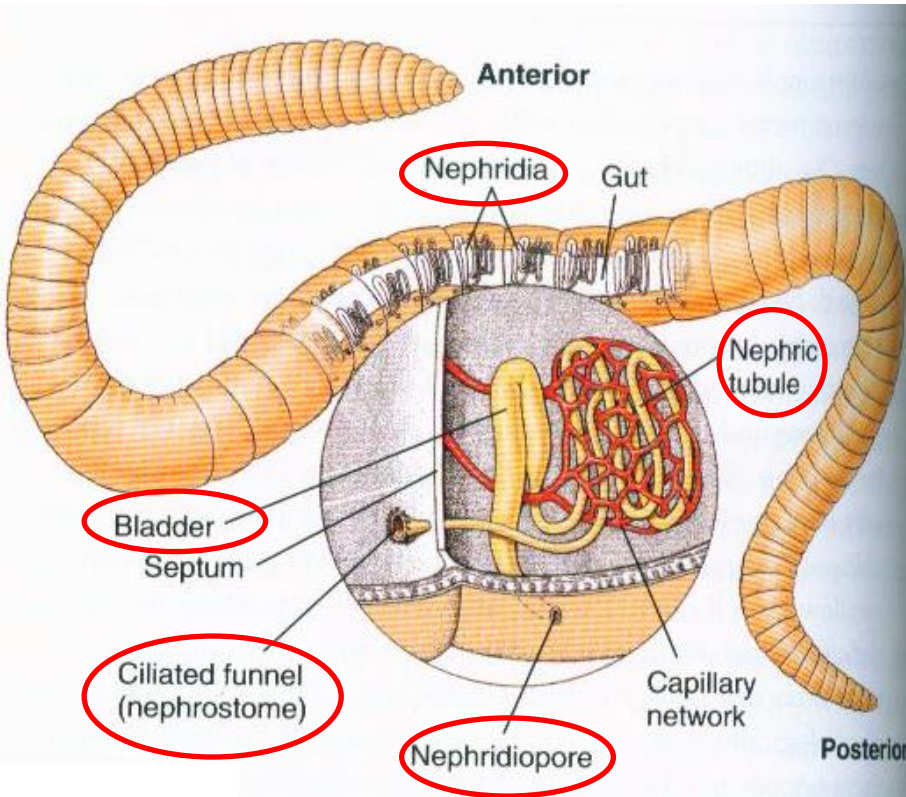
METANEFRIDIUM



Annelida

METANEFRIDIUM

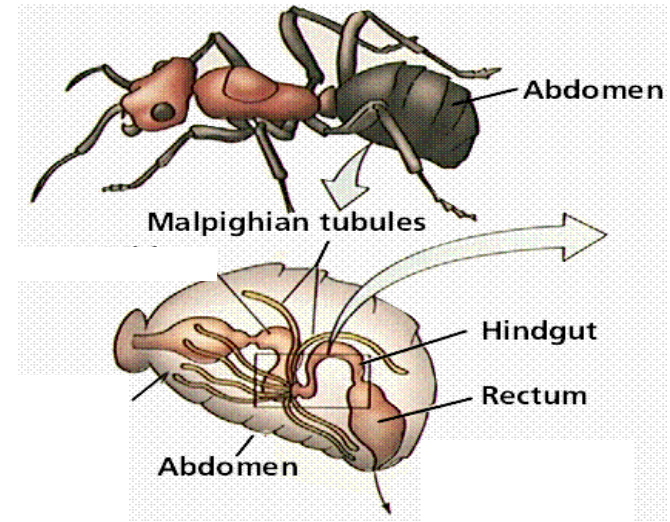
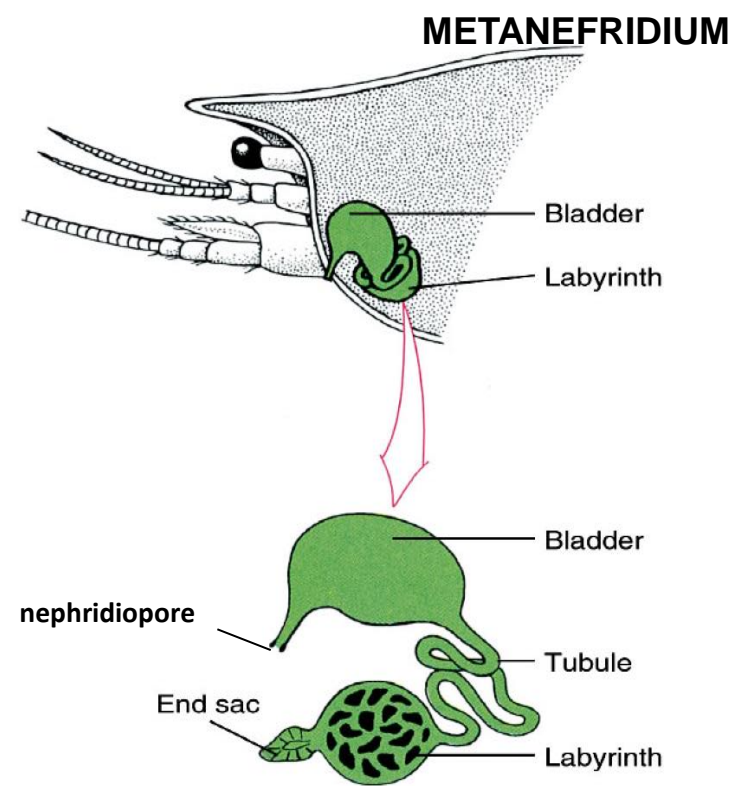
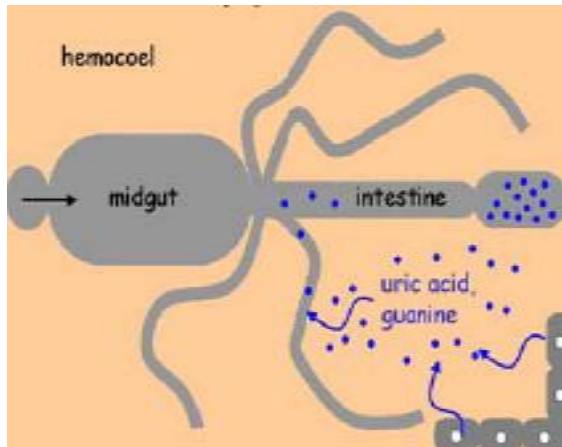
- metanephridia, repetition from segment to segment



- On the surface of blood vessels **PODOCYTES** - specialized epithelial cells that cover the outer surfaces of capillaries – filter the blood – into coelom fluid – into nephrostome

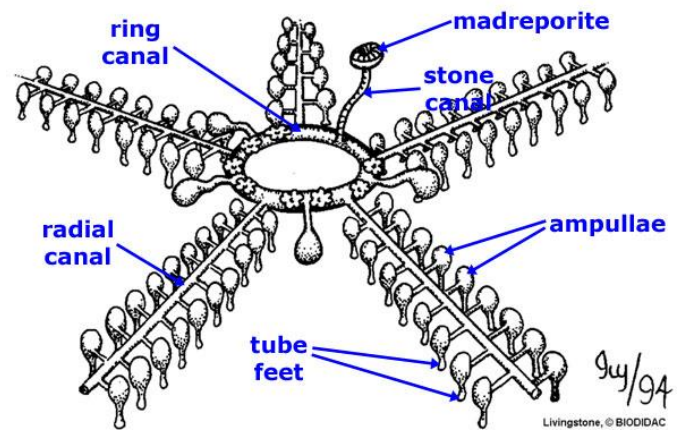
phylum ARHTROPODA

- partially through gills or body surface
- partially through organs similar to excretory organs in annelids
- **antennal glands (green glands) – open at basis of antennae (CRUSTACEANS)**
- **Malpighian tubules**
- Midgut-intestine (INSECTS; SPIDERS)



Phylum Echinodermata

- No special organs – ambulacral system

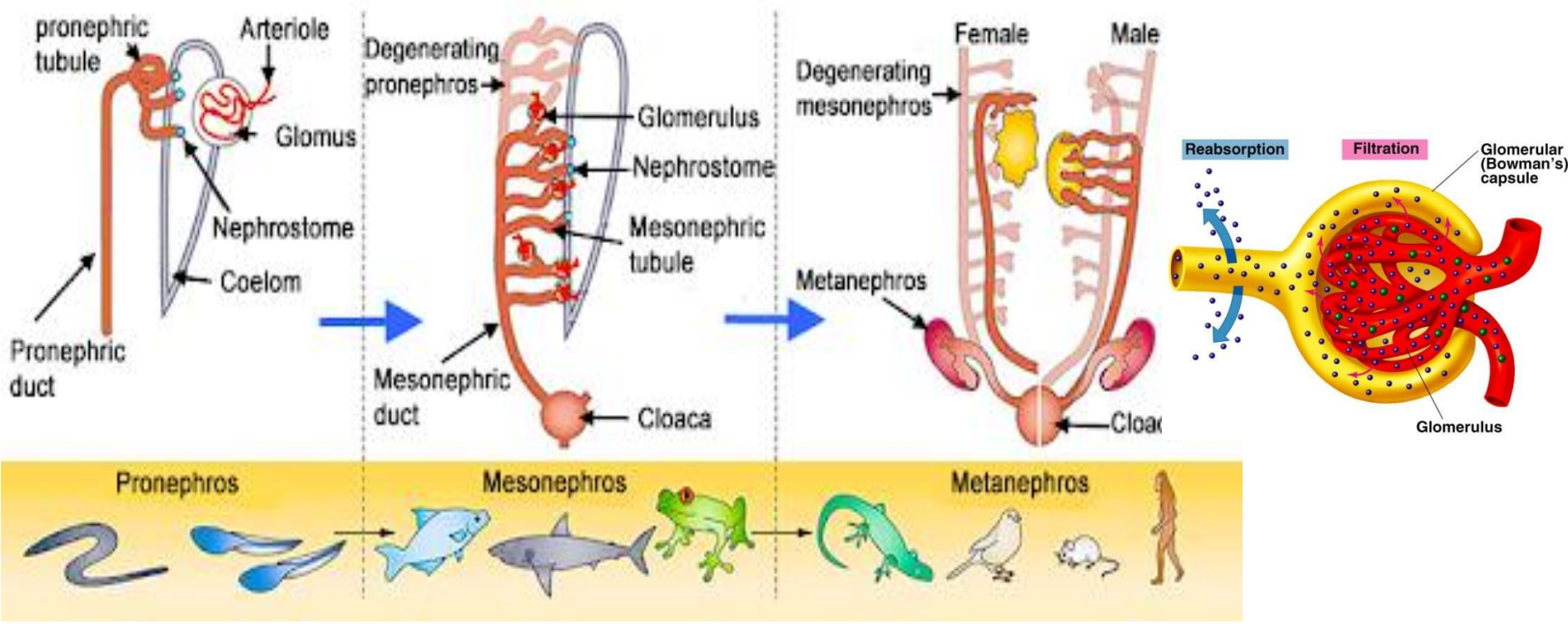


phylum CHORDATA – subphylum Vertebrata

1. Blood vessels (**glomus**) close to **nephrostomes** – collection tubes = pronephric tubules – pronephric duct = **PRONEPHROS**

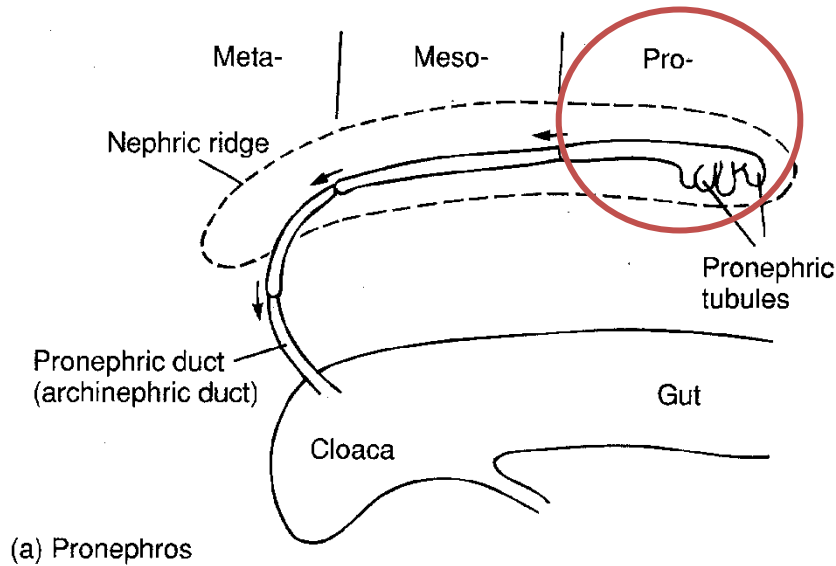
2. Blood vessels (**glomerulus**) „enter” nephrostome (= **Bowman’s capsule**) – mesonephric duct = **MESONEPHROS**

3. System gets more and more complex and organised = **METANEPHROS**

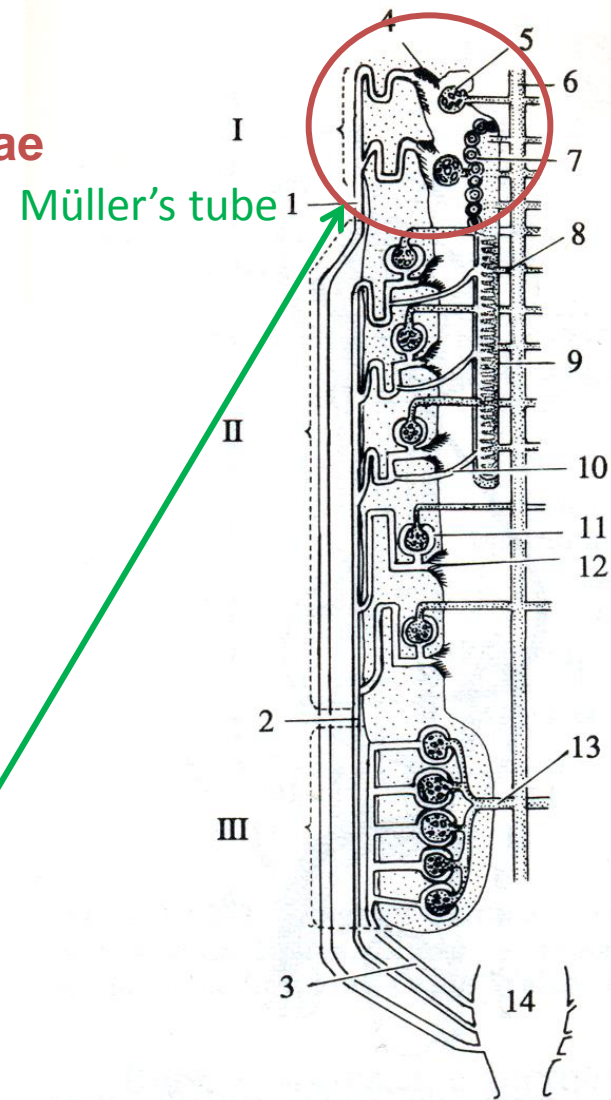


1. PRONEPHROS

cyclostomata, fish and amphibian larvae



- Next to pronephric duct Müller's tube – in females it serves as **oviduct**

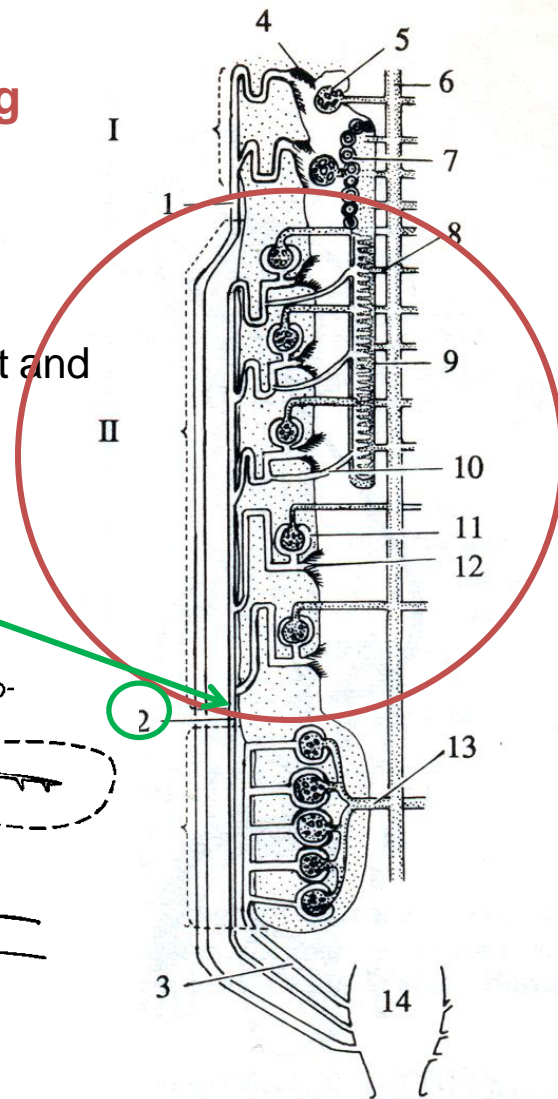
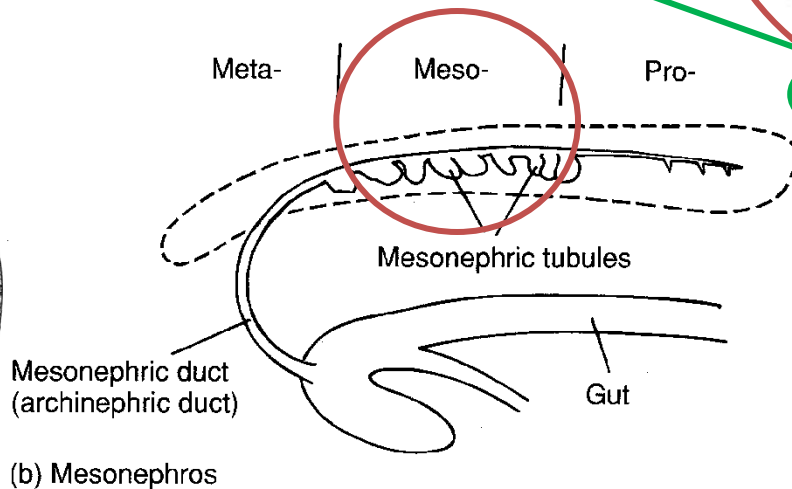
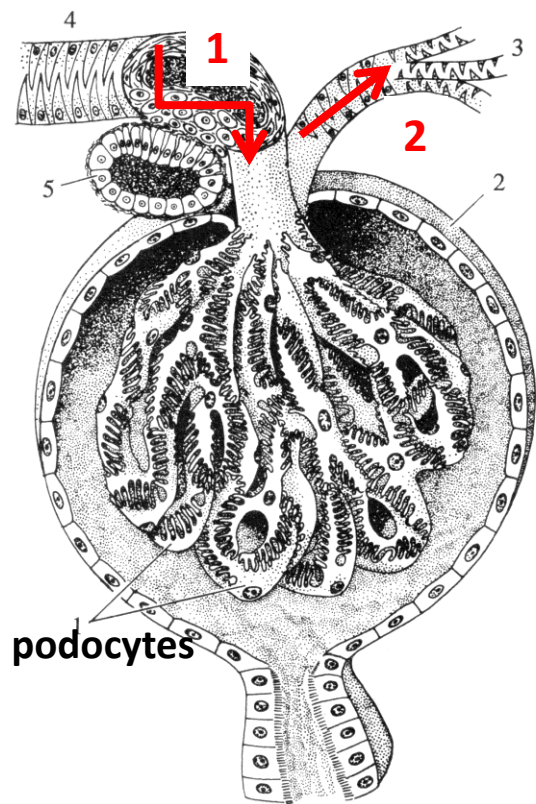


Slika 10.258. Shema pronefrosa, mezonefrosa i metanefrosa kod kralješnjaka i njihova povezanost sa spolnim organima: I — pronefros, II — mezonefros, III — metanefros; 1 — Müllerova cijev, 2 — Wolfova cijev, 3 — mokraćovod, 4 — lijevak pronefrosa, 5 — glomerulus, 6 — leđna aorta, 7 — jajnik, 8 — arterija spermatica, 9 — sjemenici, 10 — sjemenovod, 11 — Malpigijevo tjelešće, 12 — lijevak mezonefrosa, 13 — bubrežna arterija, 14 — kloaka (Wurmbach)

2. MEZONEPHROS OR WOLFF'S CORPUSCLE

fish & amphibians; reptiles, birds & mammals during
embryonal develop.

- glomeruli get into tube (= **Bowman's capsule**) and form **Malpighian body**
- Mesonephric duct = **Wolff's tube**, in amphibians both spermiduct and uretra



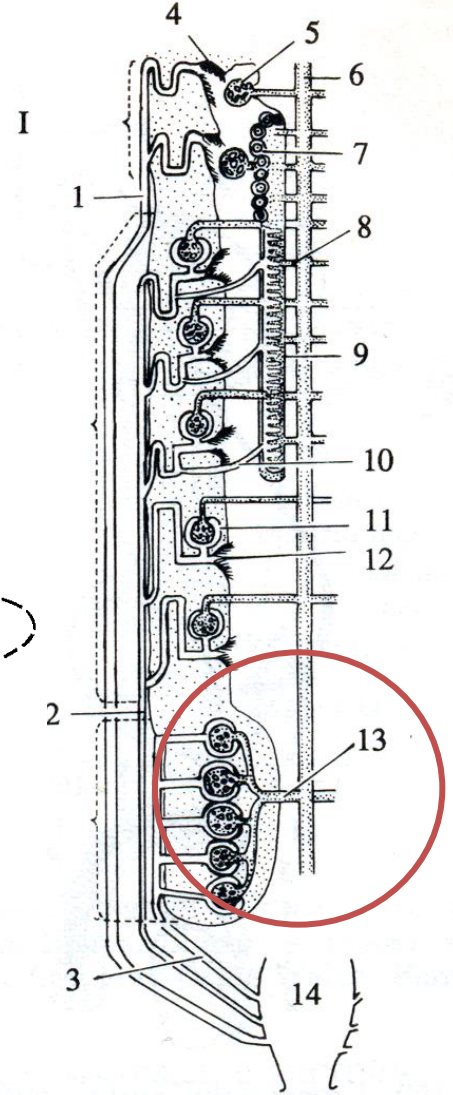
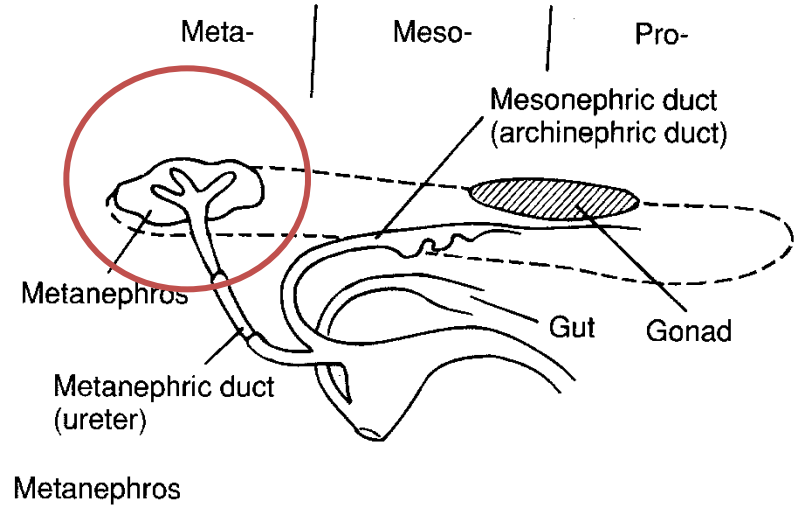
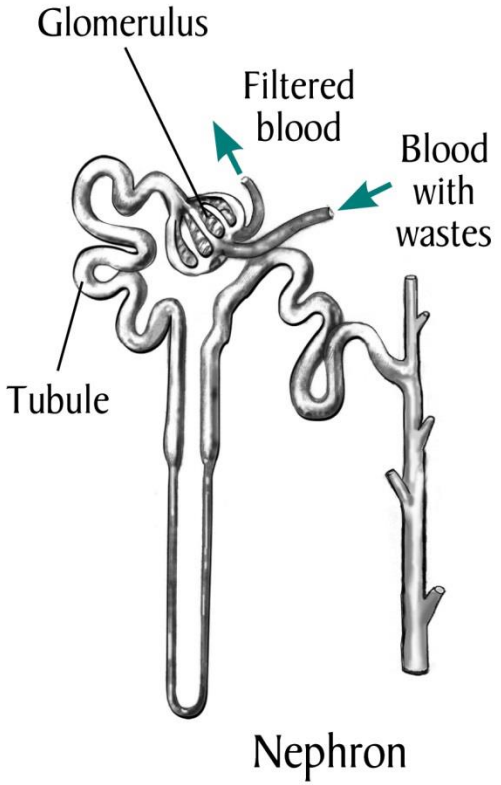
Slika 10.258. Shema pronefrosa, mezonefrosa i metanefrosa kod kralješnjaka i njihova povezanost sa spolnim organima: I — pronefros, II — mezonefros, III — metanefros; 1 — Müllerova cijev, 2 — Wolfova cijev, 3 — mokraćovod, 4 — lijevak pronefrosa, 5 — glomerulus, 6 — leđna aorta, 7 — jajnik, 8 — arterija spermatica, 9 — sjemenici, 10 — sjemenovod, 11 — Malpigijevo tjelešće, 12 — lijevak mezonefrosa, 13 — bubrežna arterija, 14 — kloaka (Wurmbach)

Slika 10.257. Malpigijevo tjelešće. Krv ulazi u Bowmannovu čahuricu kroz prilično široku dovodnu arteriolu (arteriola afferens) prema kapilarnoj mrežici, odakle izlazi kroz dosta usku odvodnu arteriolu (arteriola efferens). Podocyte su stanice s brojnim

3. METANEFROS

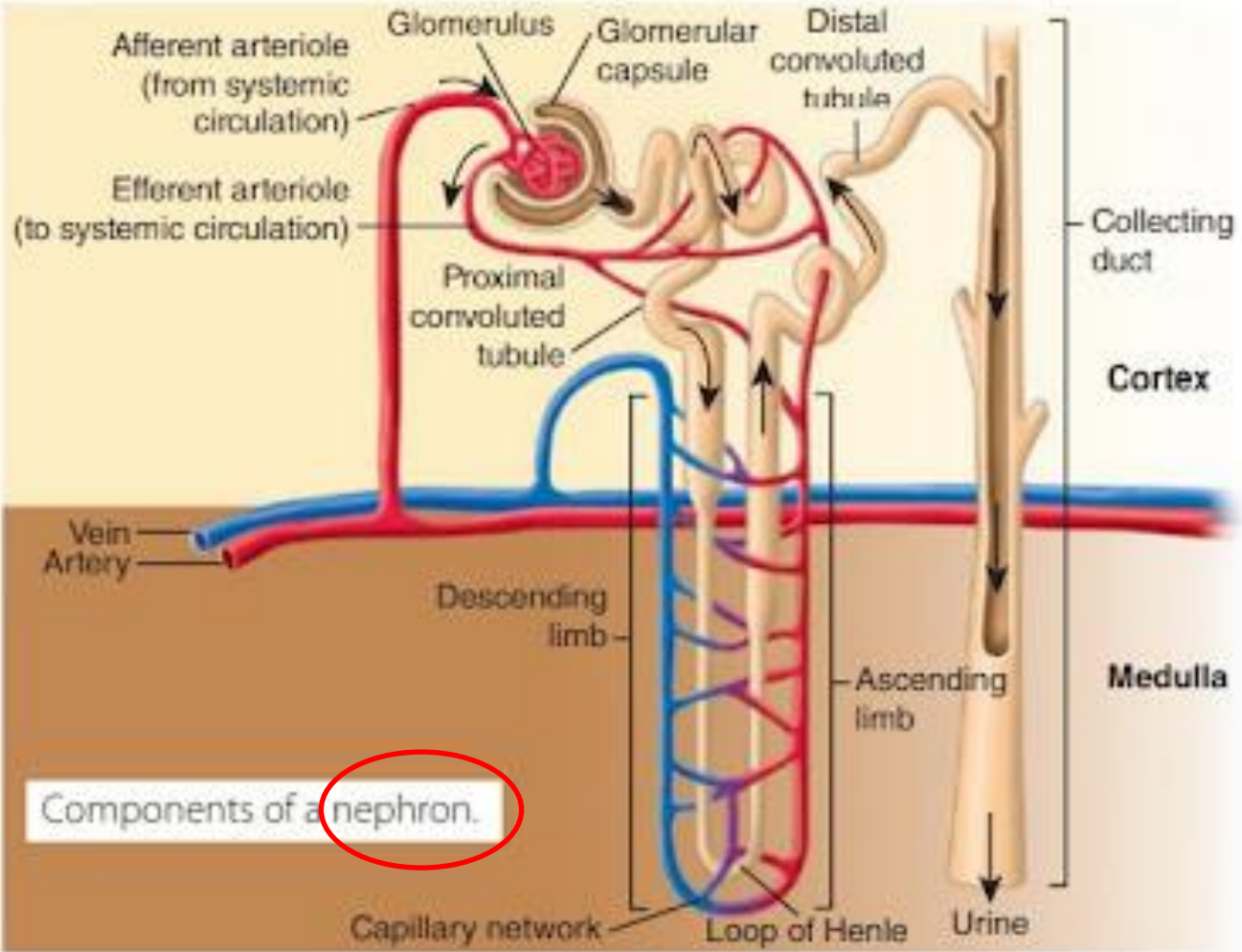
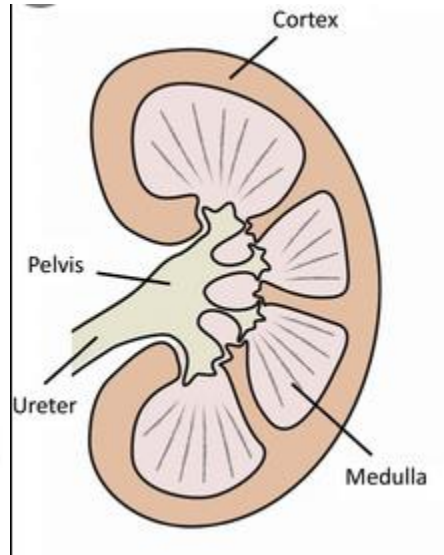
- reptiles, birds & mammals

- Numerous Malpighian bodies (=glomeruli + Bowman's capsule)
- Together with metanephric tube - **nephrons**



Slika 10.258. Shema pronefrosa, mezonefrosa i metanefrosa kod kralješnjaka i njihova povezanost sa spolnim organima: I — pronefros, II — mezonefros, III — metanefros; 1 — Müllerova cijev, 2 — Wolfova cijev, 3 — mokraćovod, 4 — lijevak pronefrosa, 5 — glomerulus, 6 — leđna aorta, 7 — jajnik, 8 — arterija spermatica, 9 — sjemenici, 10 — sjemenovod, 11 — Malpigijevo tjelešće, 12 — lijevak mezonefrosa, 13 — bubrežna arterija, 14 — kloaka (Wurmbach)

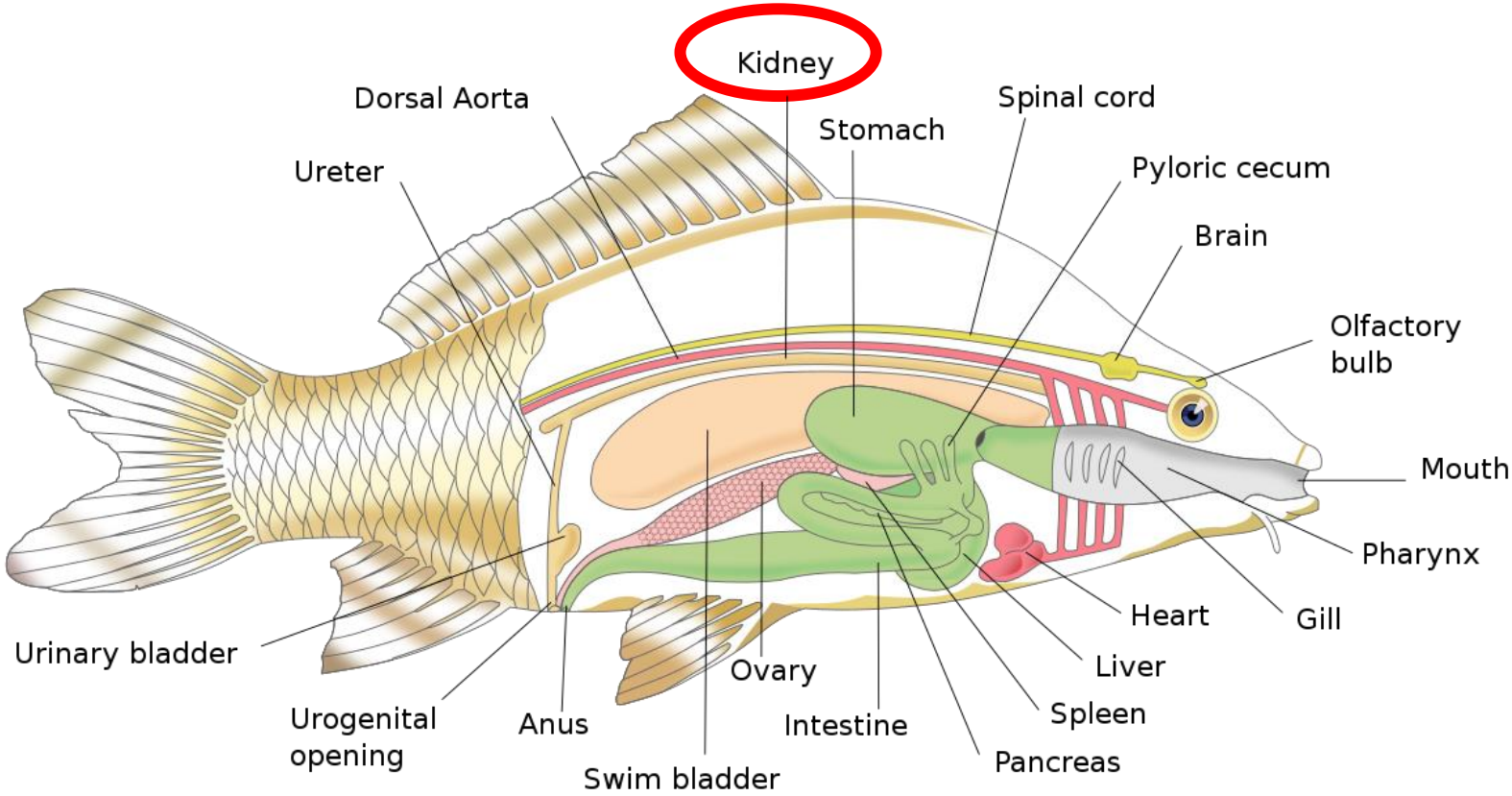
3. METANEFROS



Components of a nephron.

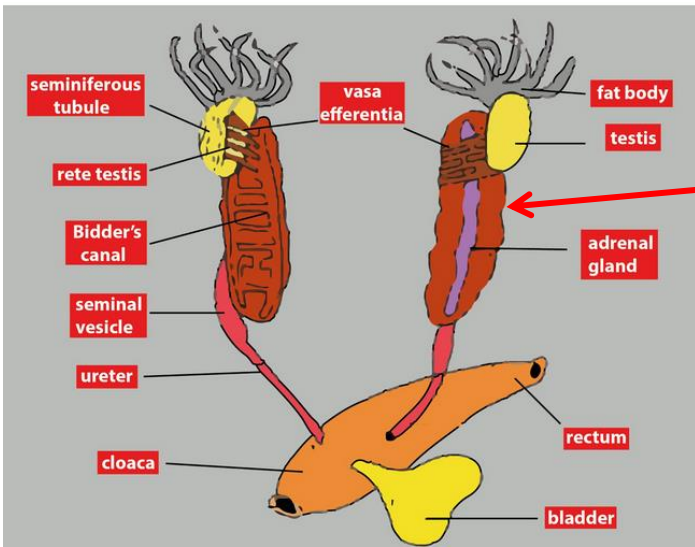
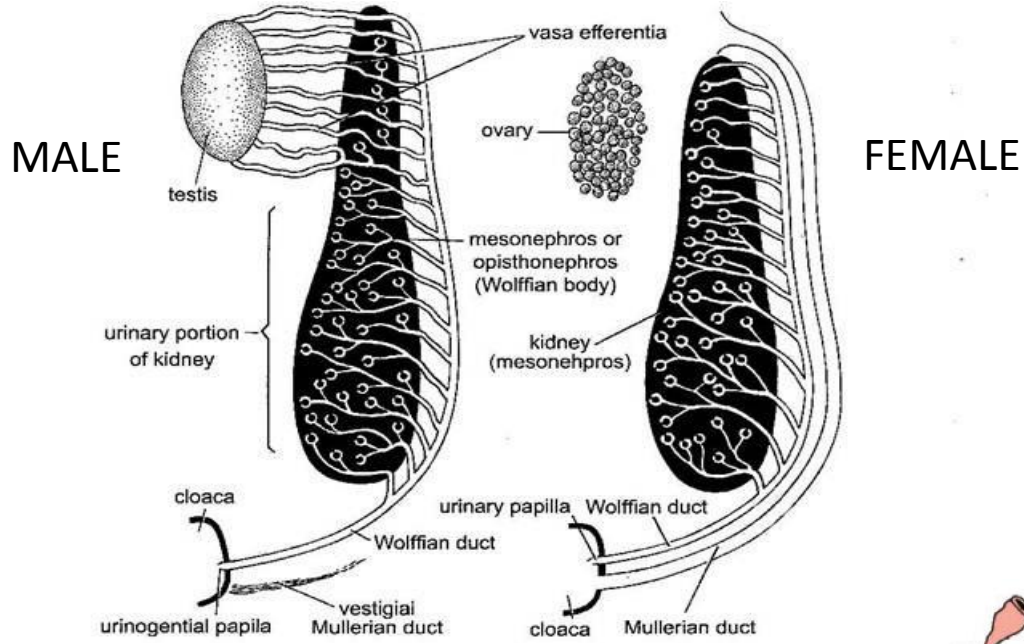
• FISH

- mesonephros (larvae have pronephros)
- dorsally

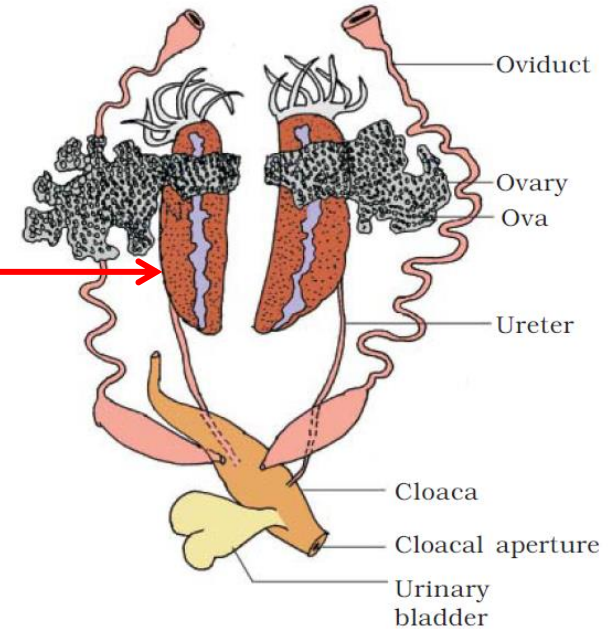


•Amphibians

- Mesonefros (larvae have pronephros)



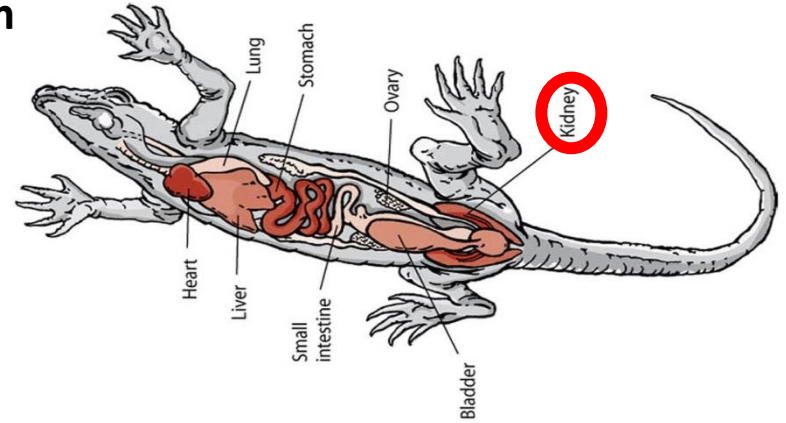
kidney



- **Reptiles**

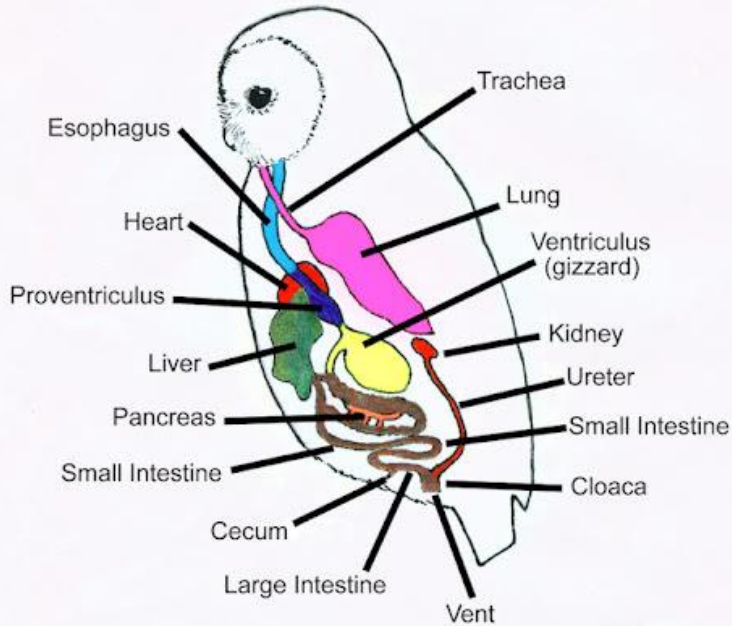
- Metanephros (all amniota have it)
- Completely separated from reproductive system
- Uricotelic

Basic Anatomy of a Lizard



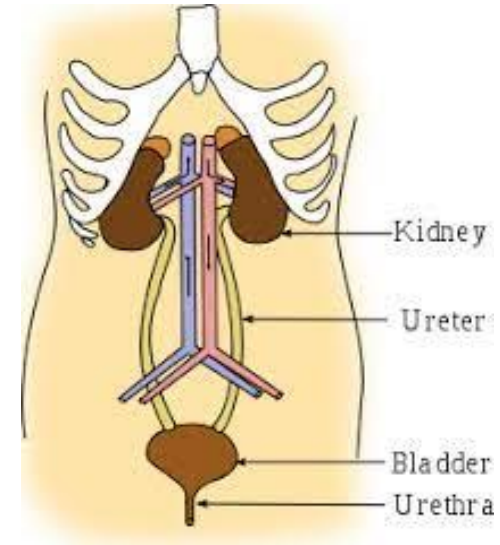
- **Birds**

- Metanephros
- Uricotelic
- No urinary bladder



- **Mammals**

- Metanephros
- Ureotelic



REPRODUCTIVE SYSTEM

The tissues, glands, and organs involved in producing offspring

Omne vivum ex vivo



Louis Pasteur

I. ASEXUAL REPRODUCTION

MITOTIC DIVISIONS NEW INDIVIDUALS (protists, numerous invertebrates)

1 parent → two or more descendants – identical as parent (clones)

(first type of reproduction)

II. SEXUAL REPRODUCTION

MEYOTIC DIVISION (GAMETOGENESIS) – germ cells (eggs and sperms)

2 parents – when nuclei are merged - **zygote** or fertilised egg

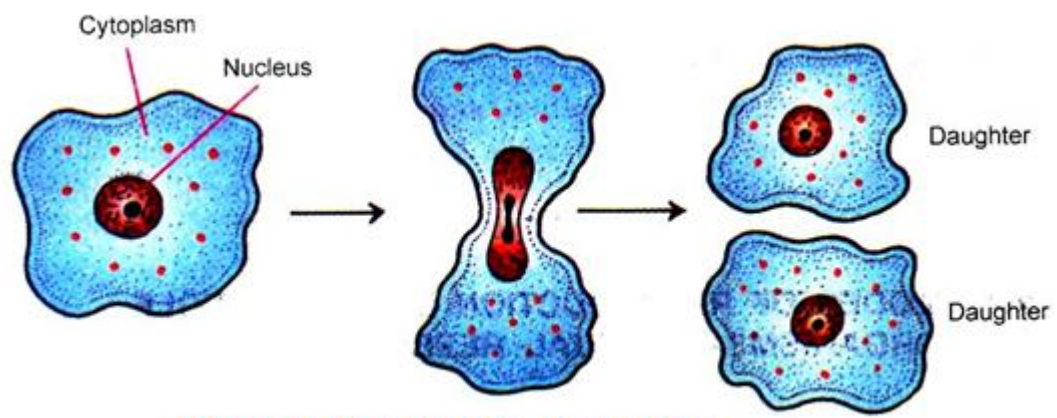
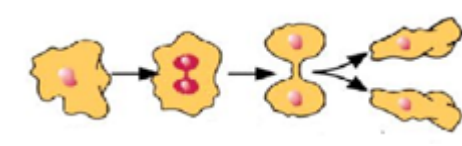
***1 parent** – **parthenogenesis**

(wide spread, exist in all animal groups)

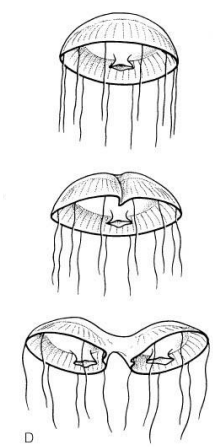
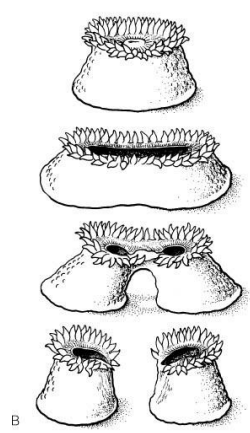
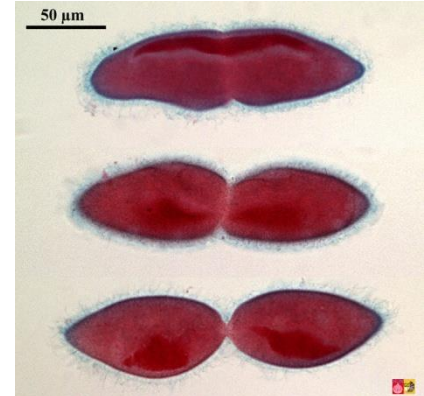
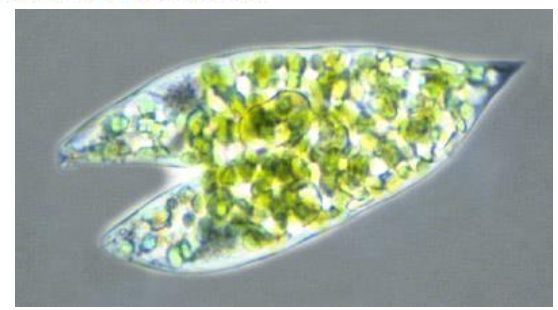
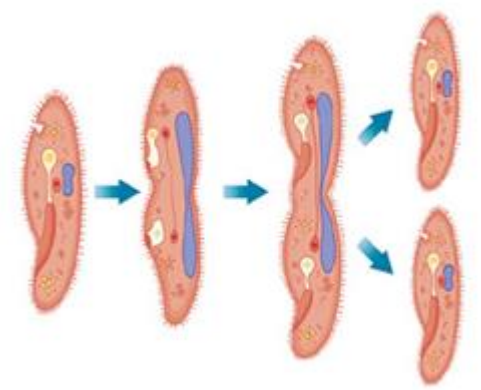
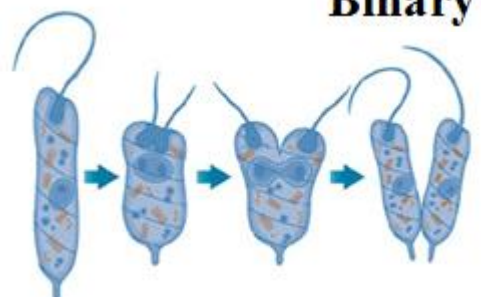
I. ASEXUAL REPRODUCTION

Binary fission

-Parent disappears

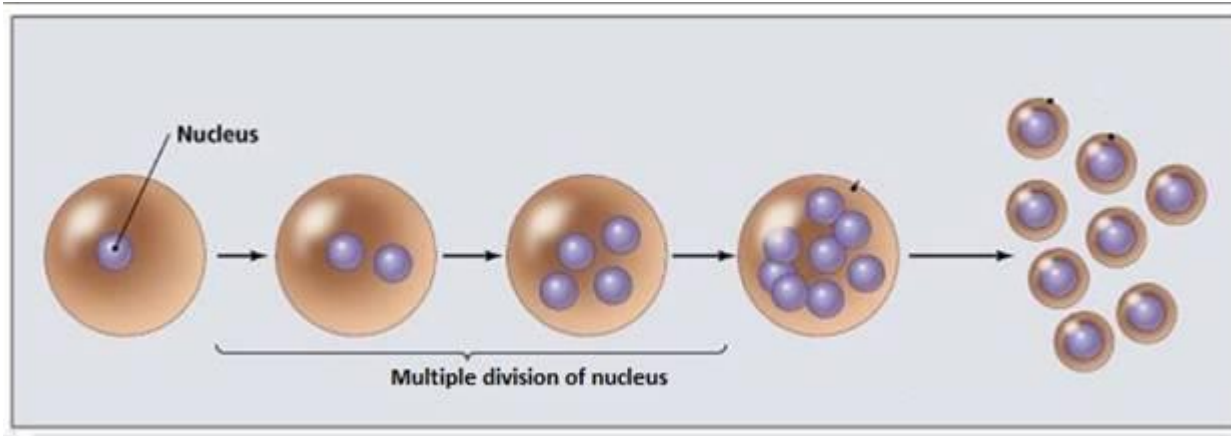


Binary fission in Amoeba



Multiple fission

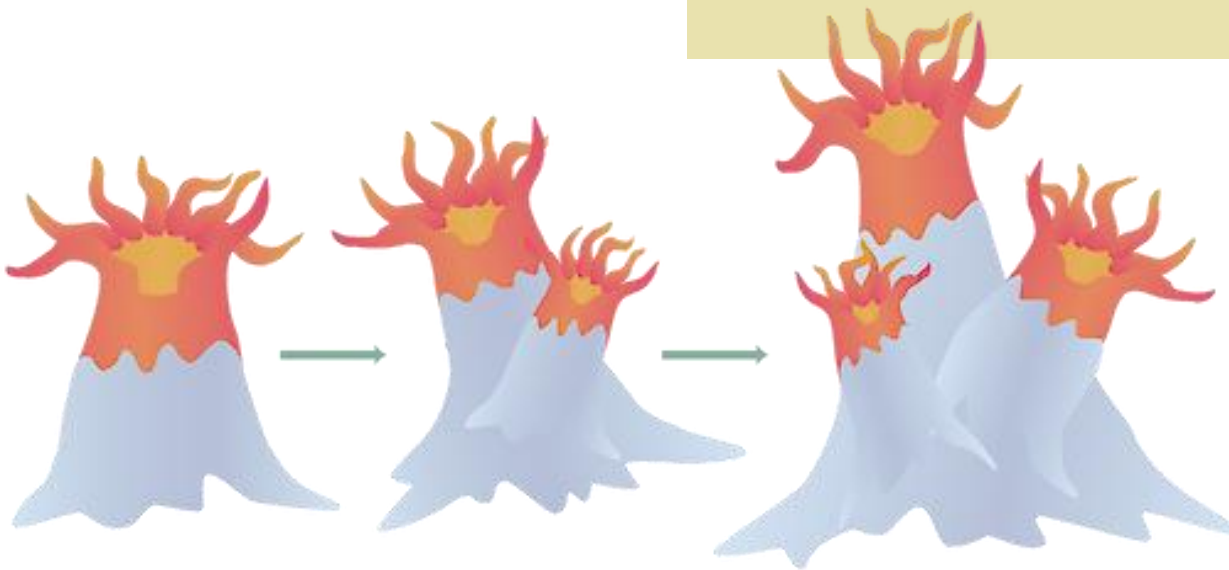
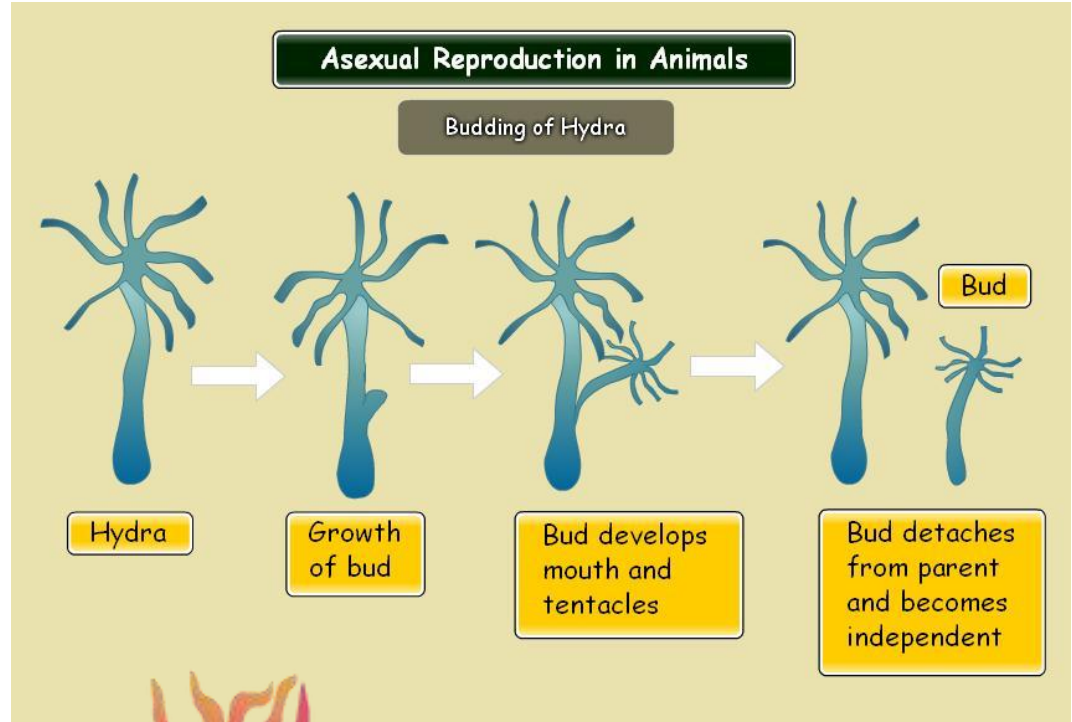
- Many descendants, parent disappears



- protists – amoeba, Haemosporida (e.g. *Plasmodium malarie*)....

Budding

- Parent survive



Formation of coral colony via asexual budding

II. SEXUAL REPRODUCTION

1. **GONADS** - organ that produces gametes; a testis or ovary.
(*ovotestis* both gamet types, e.g., some snails)
2. **GONODUCTS** - tubes leading from a gonad to the exterior, through which gametes pass
(*oviduct* – Müller's tube; *spermiduct* – Wolf's tube)
3. **ADDITIONAL ORGANS FOR COOPULATION, GLANDS....**

GONOHORISTIS

= separate sexes

▶ sexual dimorphism

- primary sexual features

(difference in the reproductive organs)

- secondary sexual features

The rest that differs females and males



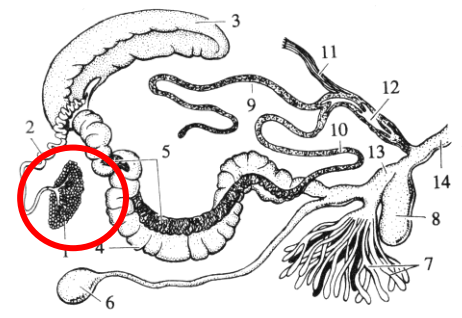
HERMAPHRODITES

= both female's and male's gonads

to avoid self insemination, gametes don't „ripe” at the same time

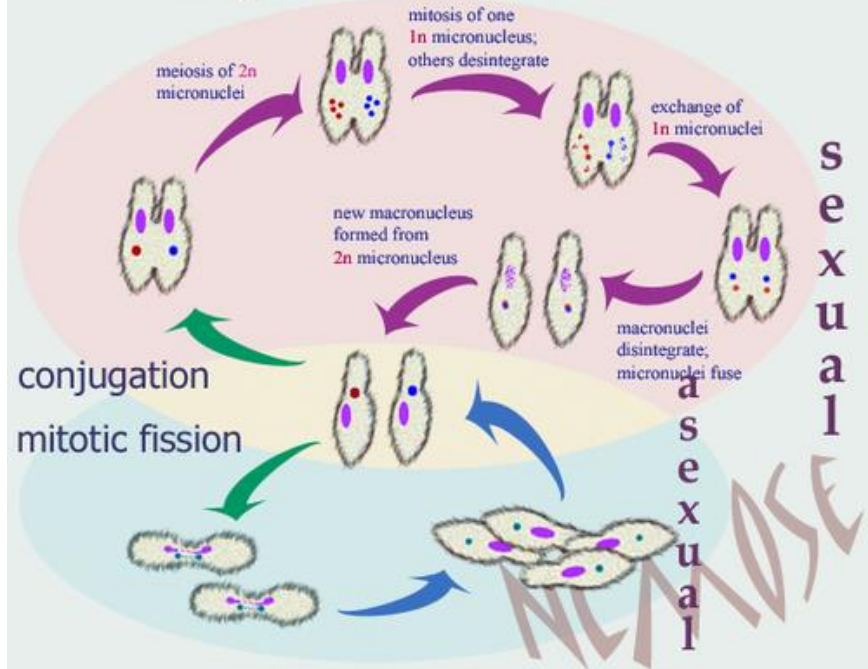
proterandry – first male's gametes

protogyny – first female's gametes

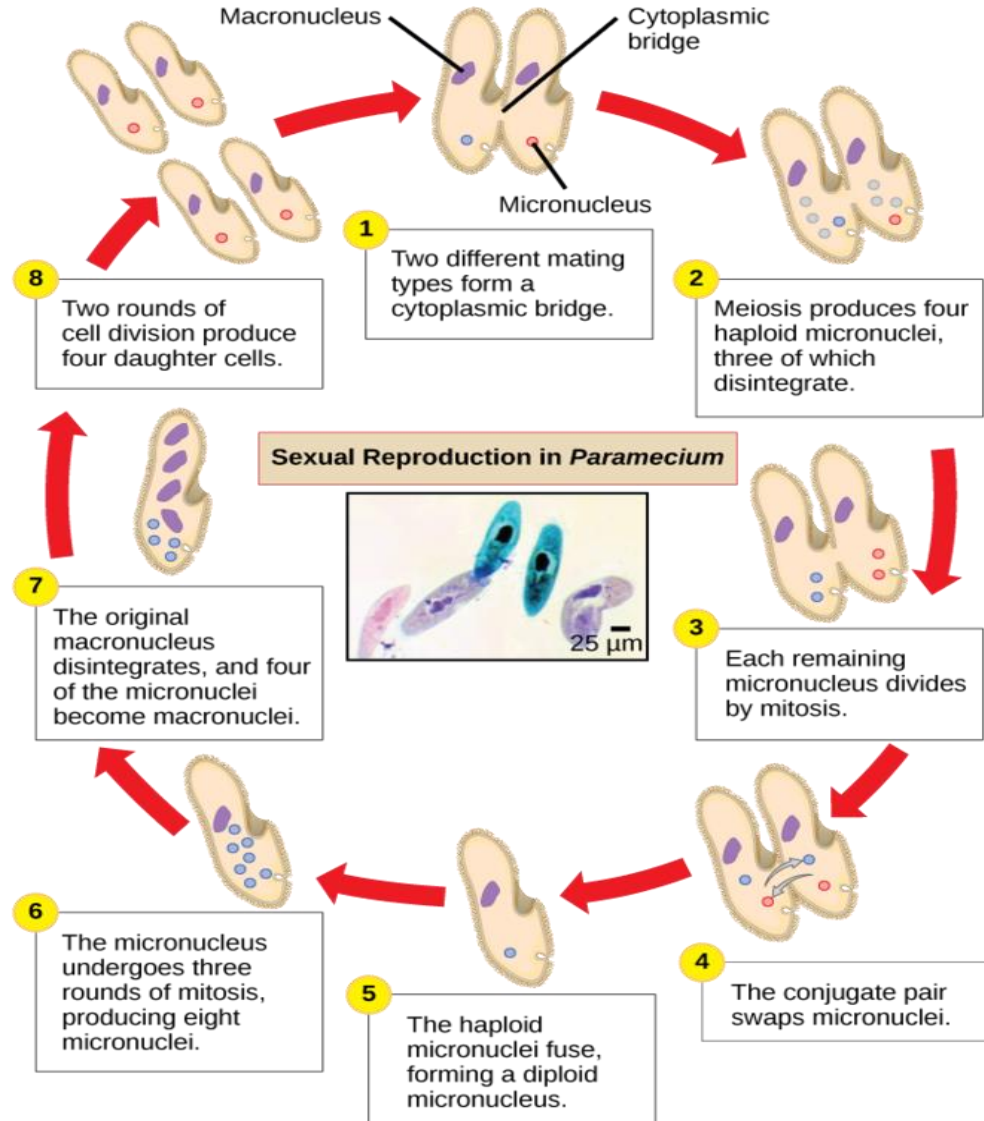


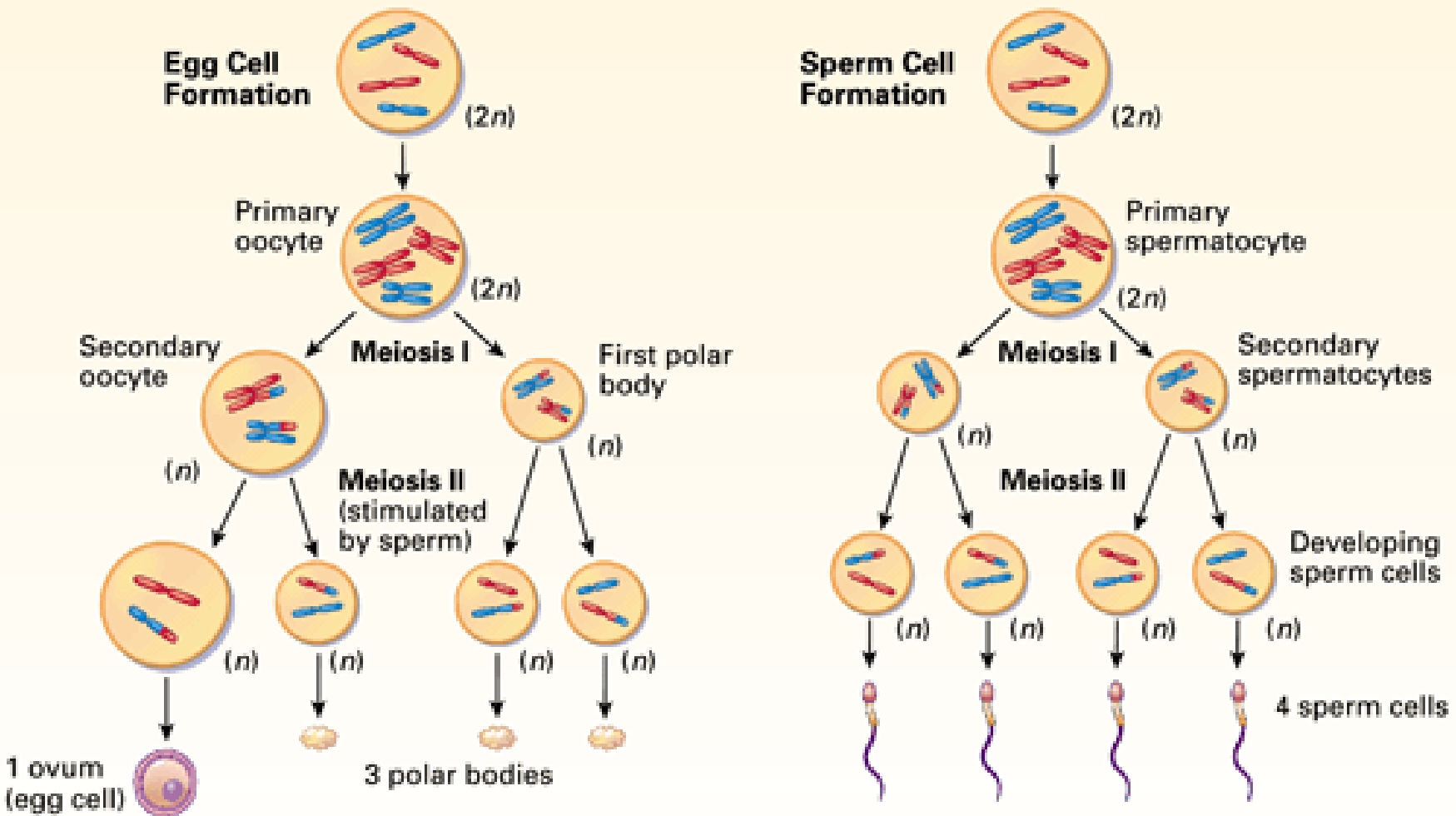
Slika 10.314. Dvospolni rasplodni sustav puža vinogradnjaka, *Helix pomatia*: 1 — dvospolna žlijezda, 2 — dvospolna cijev, 3 — bjelančevinasta žlijezda, 4 — jajovod, 5 — sjemenovod, 6 — sjemeno spremište (receptaculum seminis), 7 — prstasti privjesci, 8 — vrećica s ljubavnom strelicom, 9 — bič, 10 — vas deferens, 11 — mišić retraktor penisa, 12 — penis, 13 — vagina, 14 — spolno predvorje

Life cycle of *Paramecium*



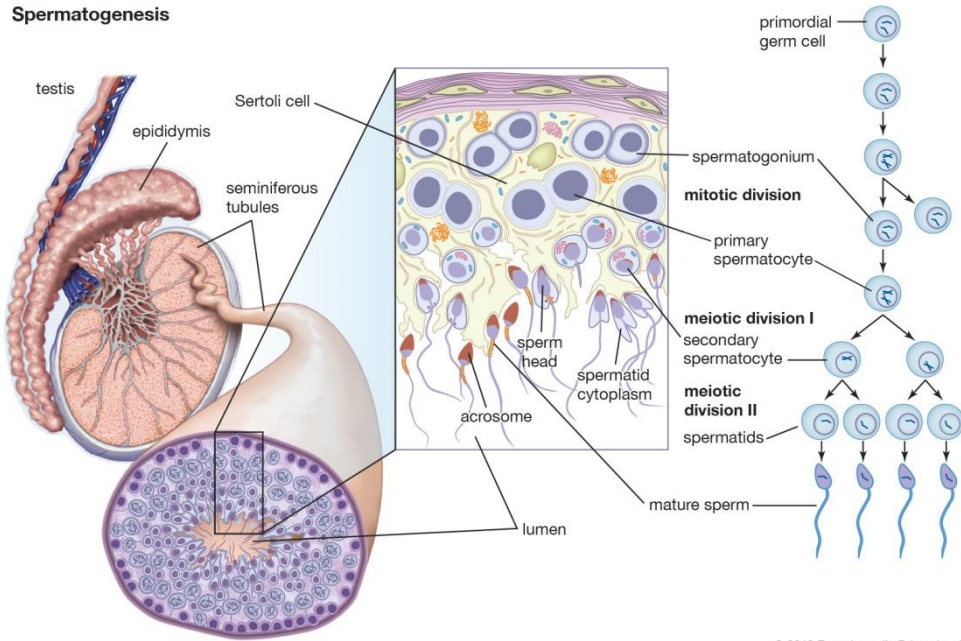
SEXUAL REPRODUCTION PROTISTS



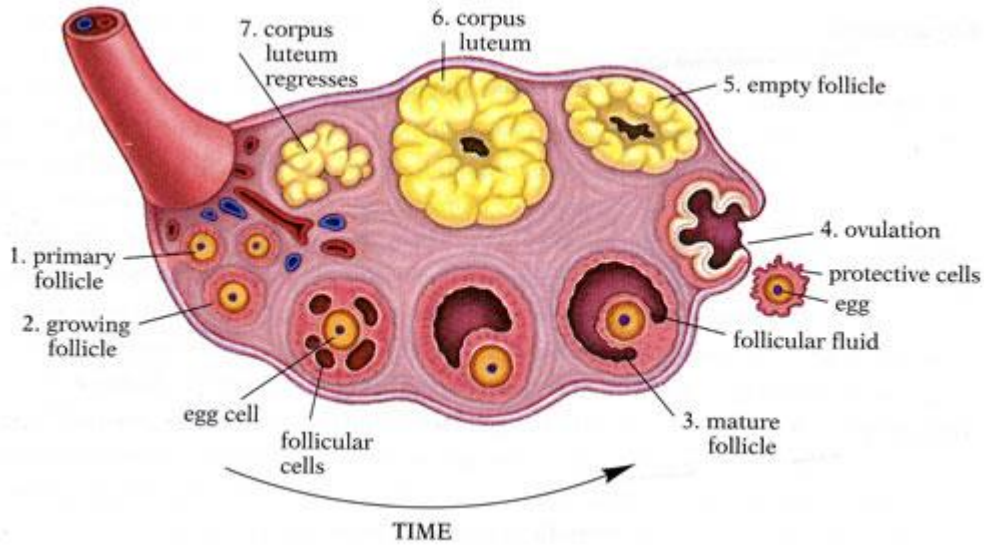


SEXUAL REPRODUCTION MULTICELLULAR ANIMALS

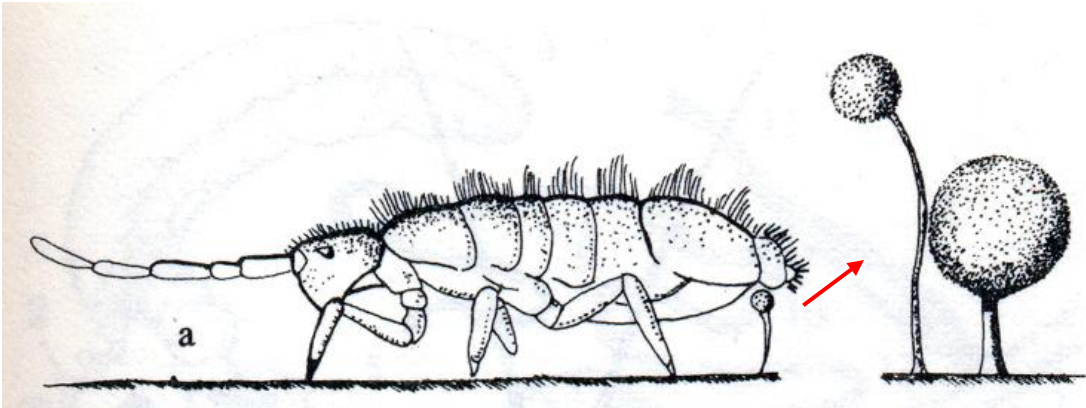
Spermatogenesis



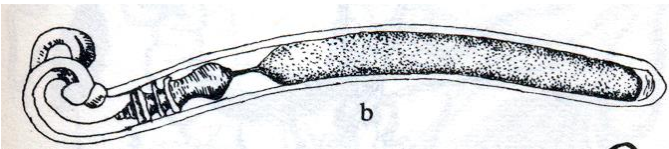
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- Many males pack sperms into packages **spermatophores** (cephalopods, insects, crustaceans, terrestrial snails, leaches...)



Spermatophores from *Orchesella vilosa*

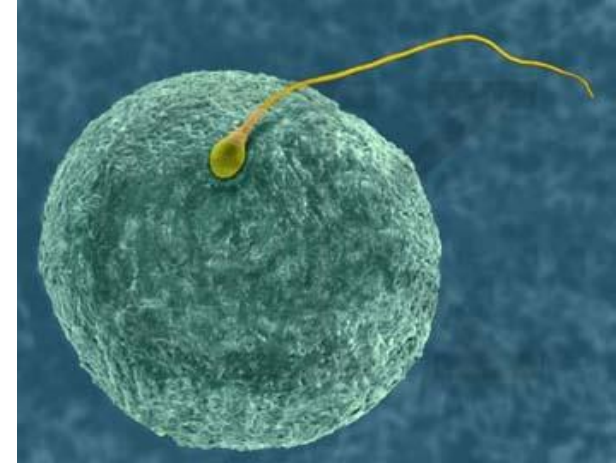


Spermatophores from *Sepia officinalis*



Spermatophores on female crayfish

Egg cells (ova)



- Bigger than sperms (food storage for embryo)

- **Cytoplasm with nucleus + egg yolk**
(= lipids, proteins....)

• Egg types (depend on the quantity and position of the egg yolk)

1. **Telolecithal** - refers to the uneven distribution of yolk in the cytoplasm of ova found in **birds, reptiles, fish, and monotremes**. The yolk is concentrated at one pole of the egg separate from the developing embryo.
2. **Centrolecithal** - describes the placement of the yolk in the centre of the cytoplasm of ova. Many **arthropod** eggs are centrolecithal.
3. **Isolecithal** - refers to the even distribution of yolk in the cytoplasm of ova of **mammals and other vertebrates**
4. **Alecithal** – no yolk (**mammals with placenta**)

FERTILISATION:

1. **EXTERNAL** - mainly in water, many germ cells, no organs for copulation
2. **INTERNAL** - terrestrial taxa
 - smaller number of germ cells
 - organs for copulation exist



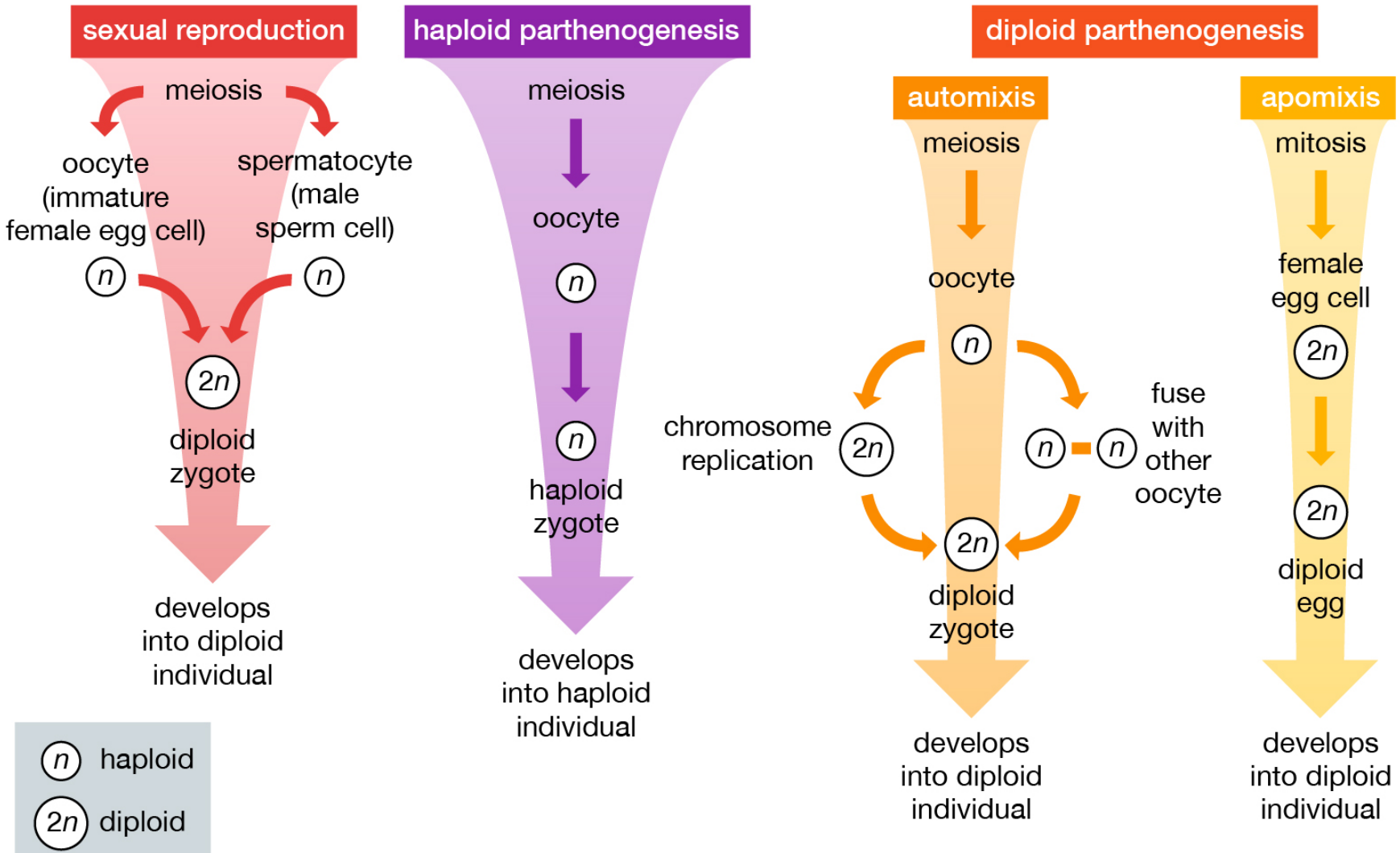
* parthenogenesis

▶ includes egg and not sperm

haploid parthenogenesis - haploid organisms (some wasps, ants...)

diploid parthenogenesis – diploid organisms (some insects, crustaceans...)

The process of sexual reproduction versus several forms of parthenogenesis



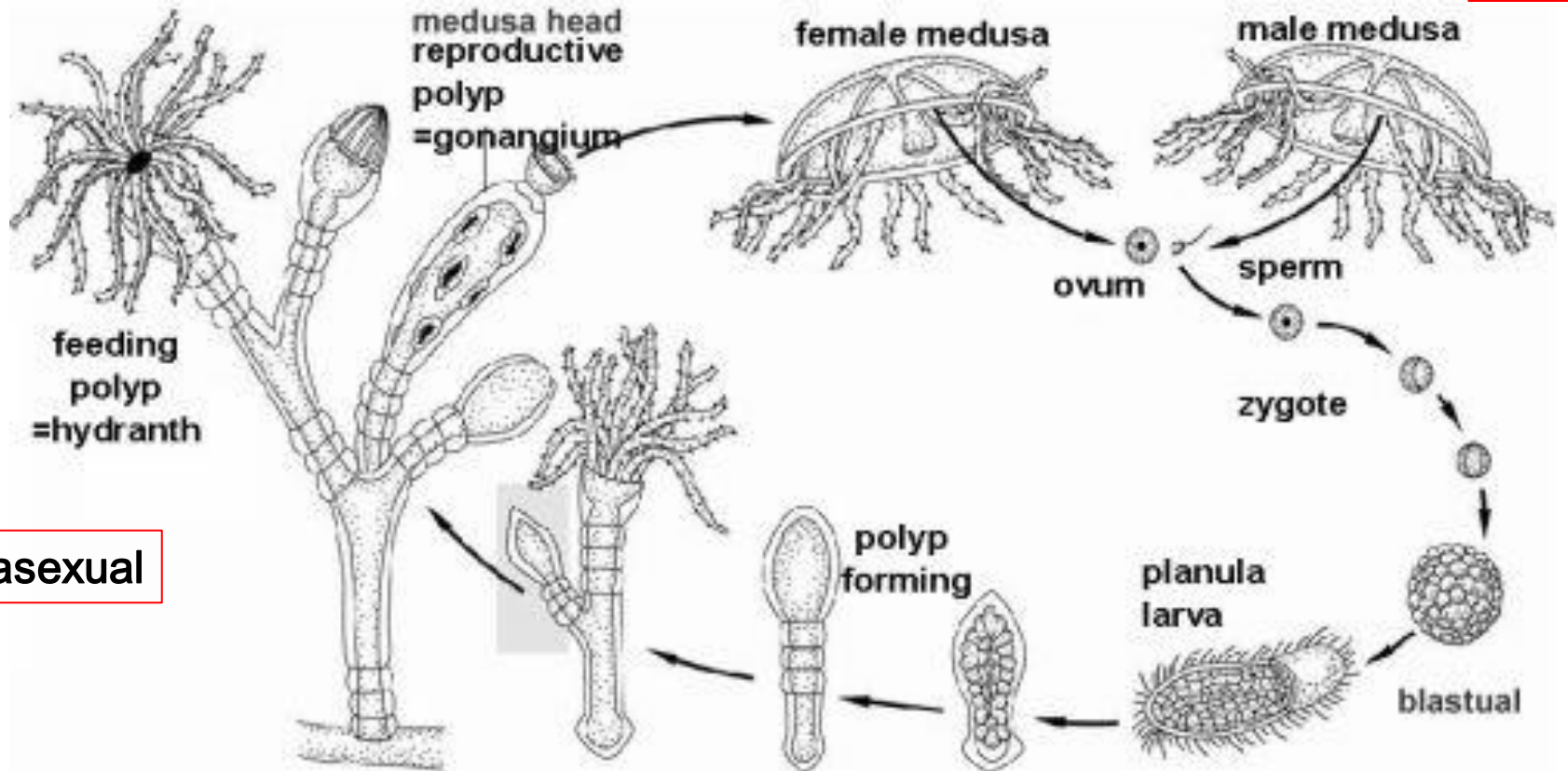
Life cycle cnidarians

overview

Both sexual and asexual reproduction – **metagenesis**

sexual

asexual



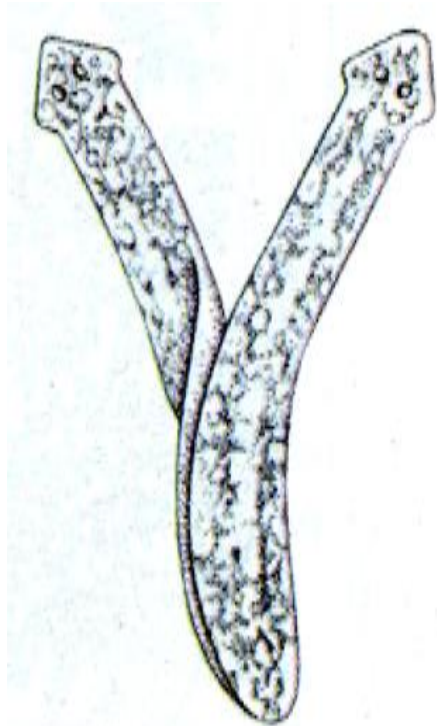
Phylum Platyhelminthes (Turbellaria, Trematoda, Cestoda)

metagenesis

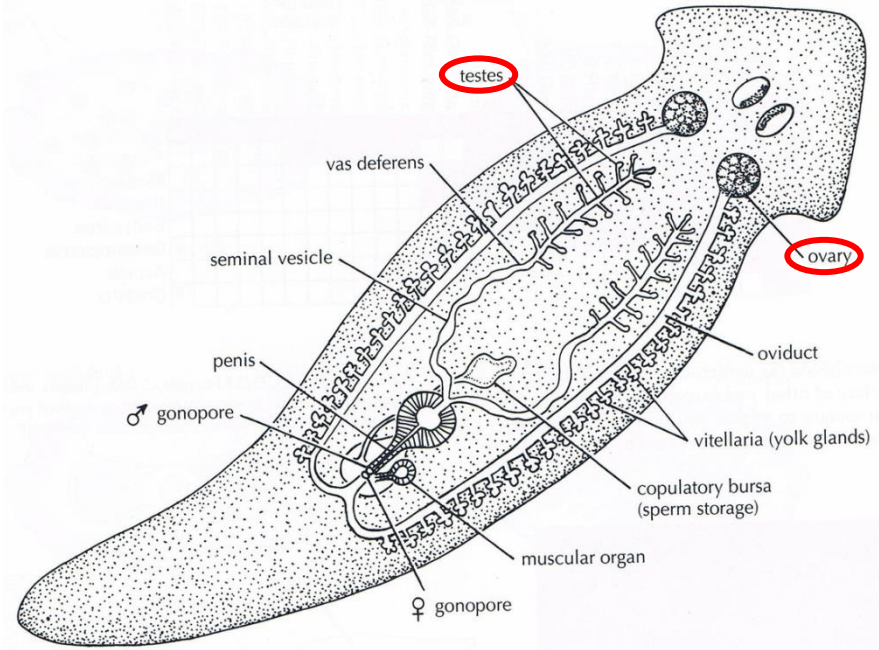
• ASEXUALLY (BINARY FISSION)

• SEXUALLY

- Mainly hermaphrodites
- Internal fertilisation
- Fertilised eggs with hard shell (protection)

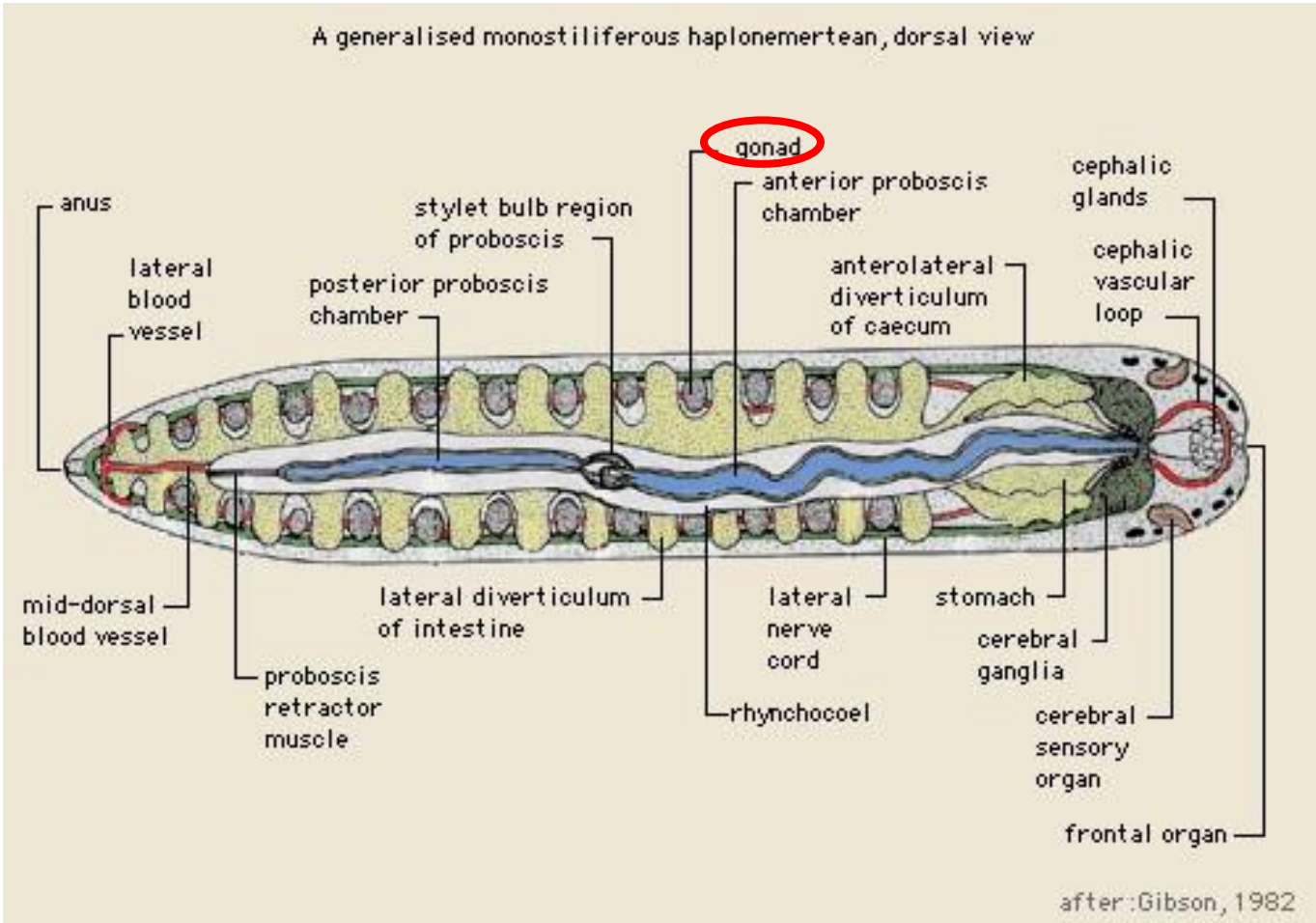


Turbellaria



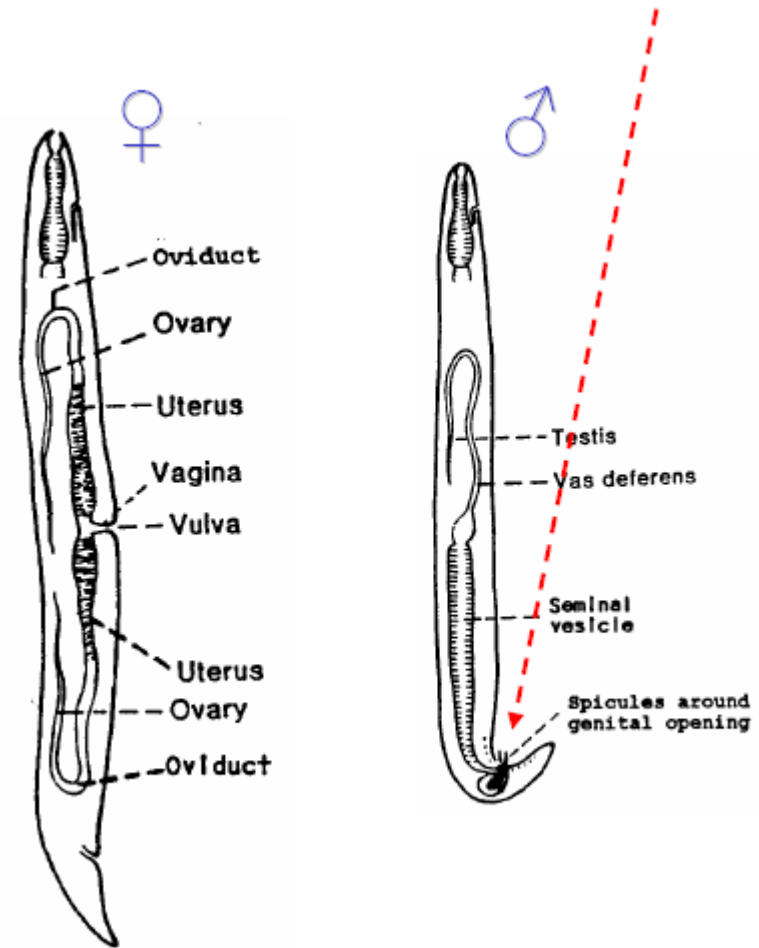
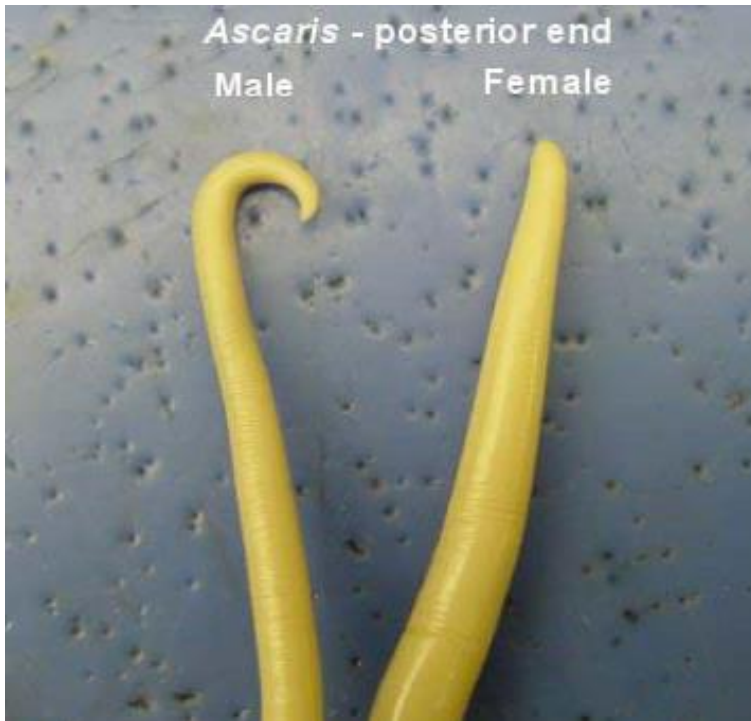
phylum NEMERTINA (NEMERTEA) (ribbon worms)

Along body, open on the surface, external fertilisation

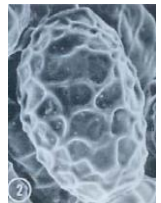


Phylum Nematoda

- sexual dimorphism
- body filled with reproductive system
- internal fertilisation



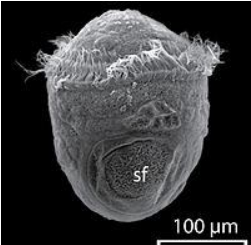
Female lays up to 200 000 eggs/day
- Eggs are well protected (up to 7 year in the soil)



Phylum MOLLUSCA



- some hermaphrodites (terrestrial, in freshwaters)
- fertilisation either in the mantle cavity or in the water
- from fertilised egg – larvae (*trochophore*, *veliger*, *glochidia*) - adult



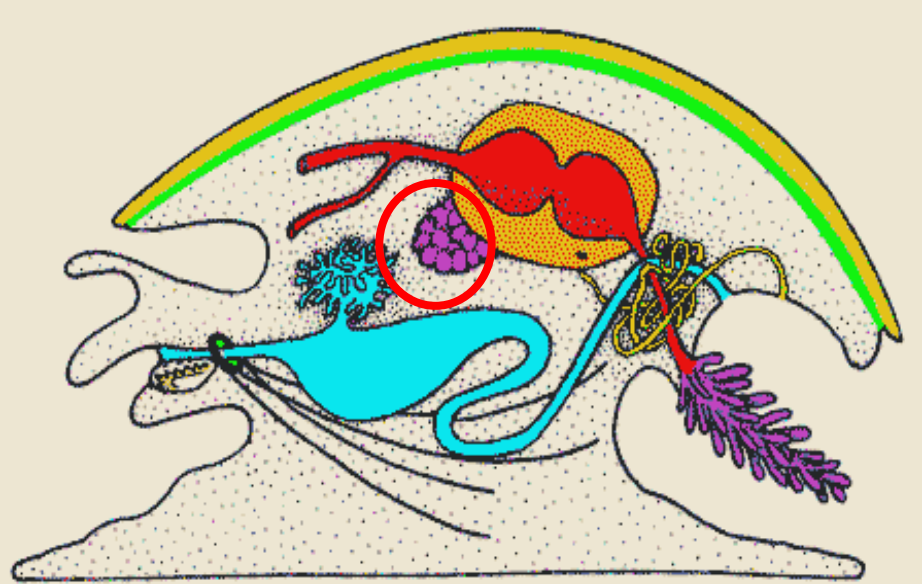
trochophore



veliger

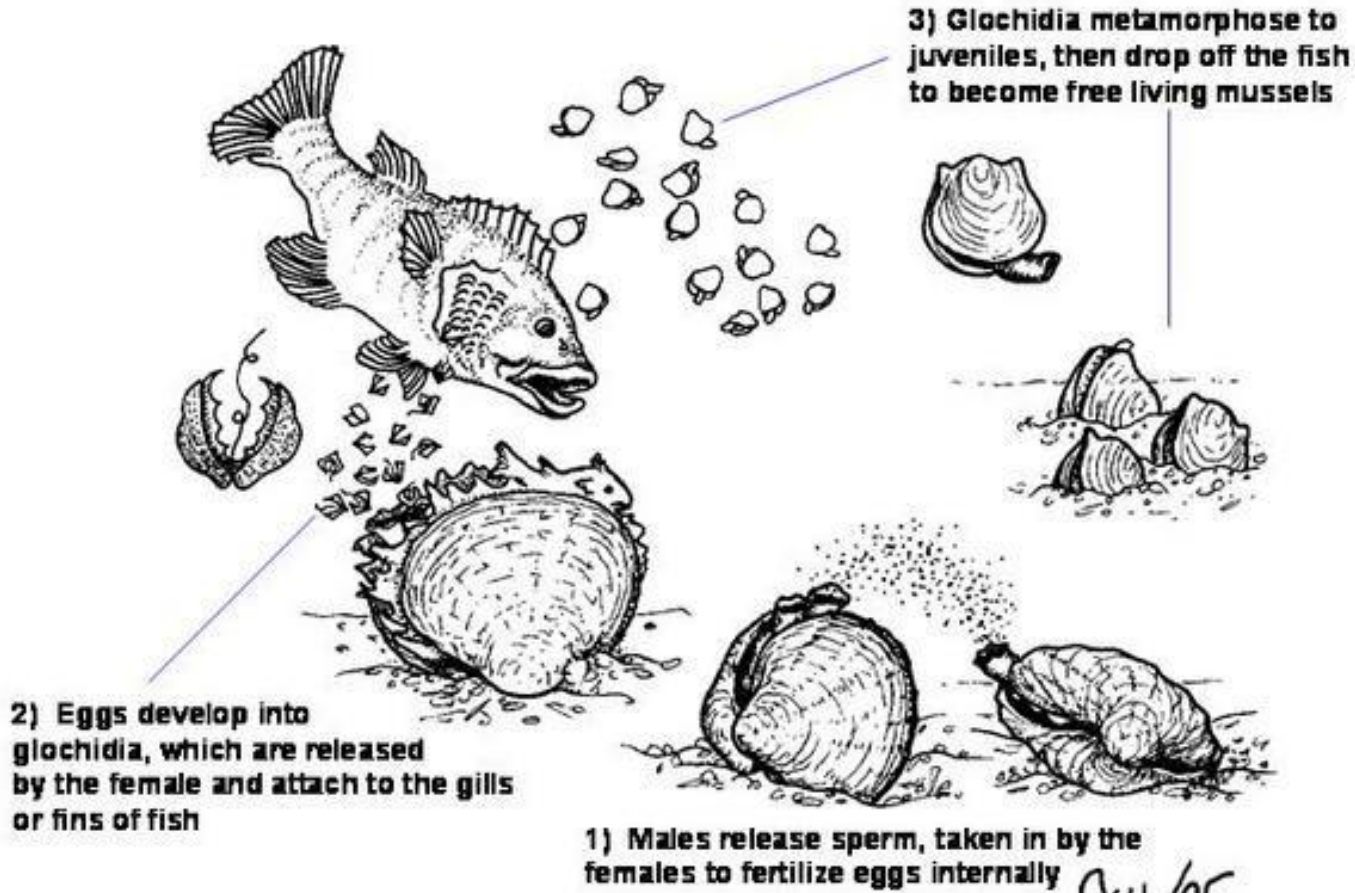
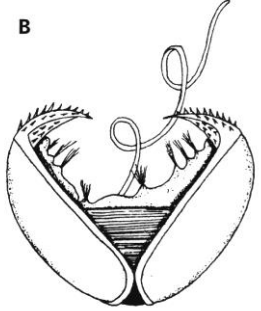
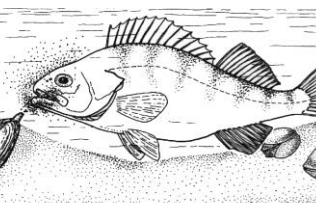
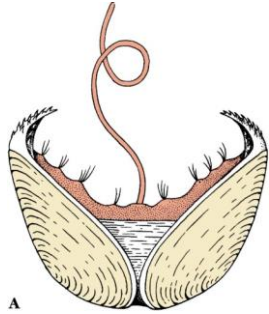
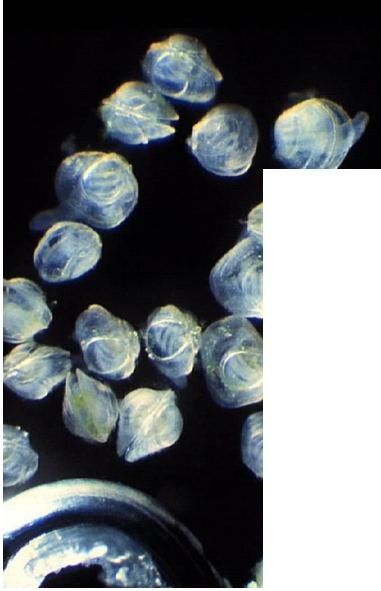


glochidia



glochidia – freshwater larva

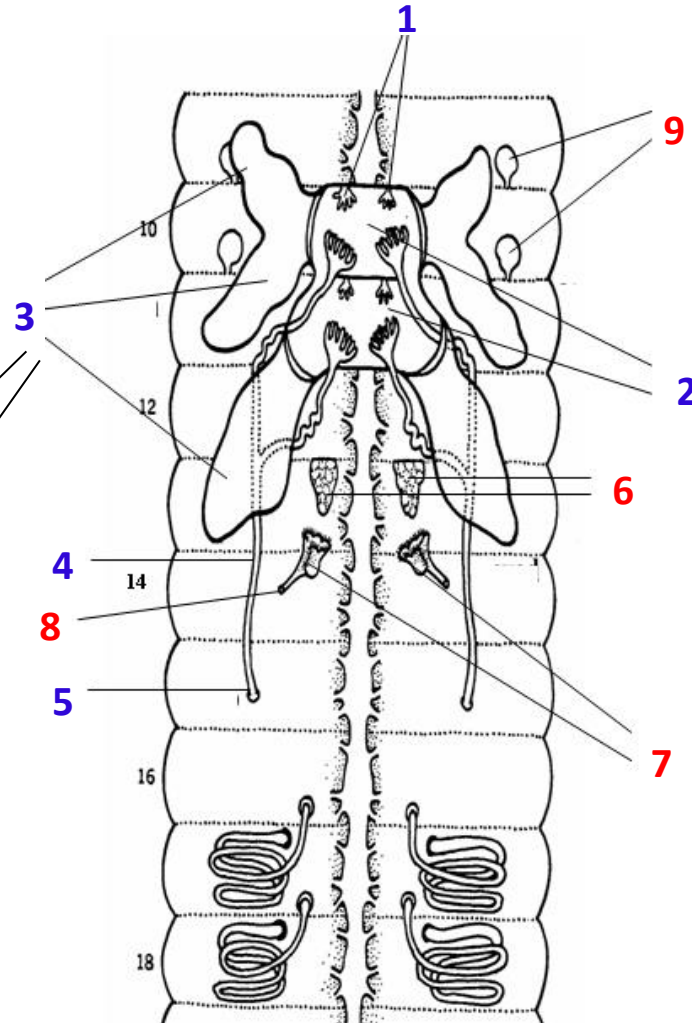
- internal fertilisation



Guy/95

Phylum ANNELIDA

- hermaphrodites
- external fertilisation



Male's: 2 pairs of testes (1)
1 pair of spermiducts (4)
male gonopores (5)

Female's: 1 pair of ovaries (6)
1 pair of oviducts (7)
female gonopores (8)
2 pairs of sperm storages (9)

Phylum ARHTROPODA

- gonohorist (mainly)

Scorpiones



Crustacea



e.g.: [Habronattus tarsalis](http://www.youtube.com/watch?v=BMjniVovzI8)

[http://www.youtube.com/watch?v=](http://www.youtube.com/watch?v=BMjniVovzI8)

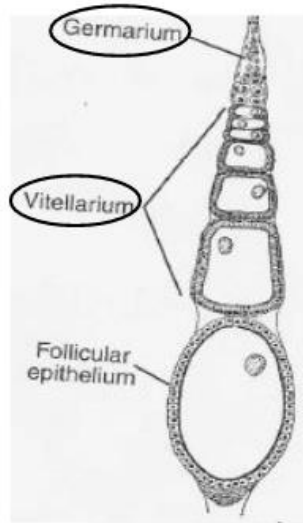
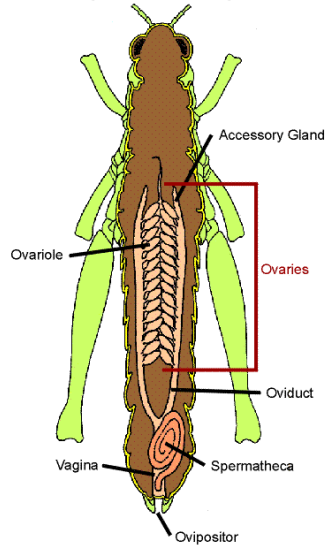
BMjniVovzI8

Arachnida



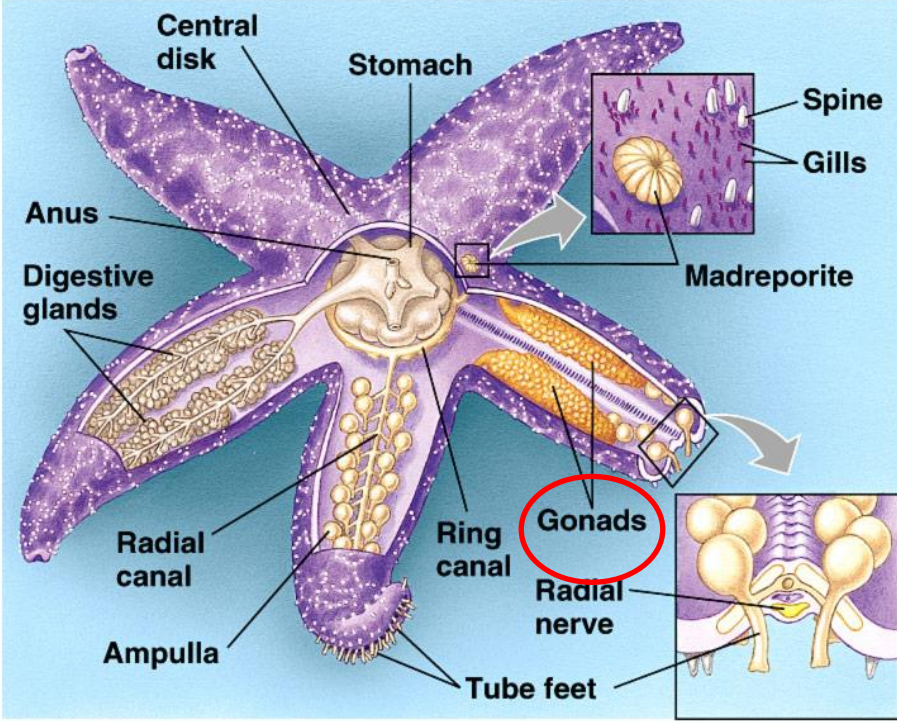
Insecta

GRASSHOPPER
Reproductive System
(Adult Female)

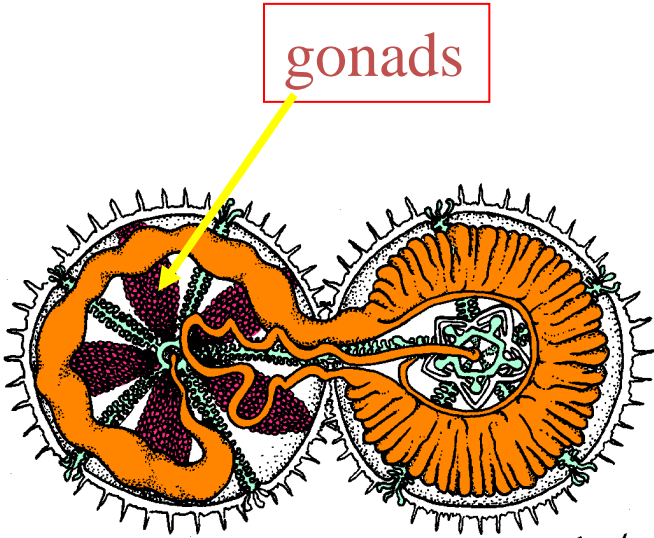


Phylum Echinodermata

- gonochorist
- external fertilisation



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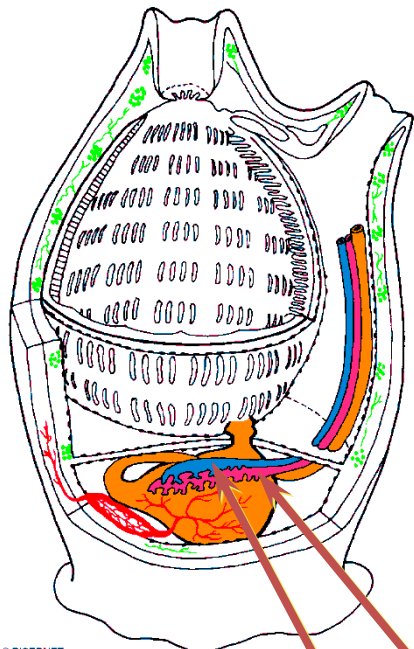
Livingstone, © BIODIDAC

9/4/94

subphylum: Tunicata (phylum Chordata)

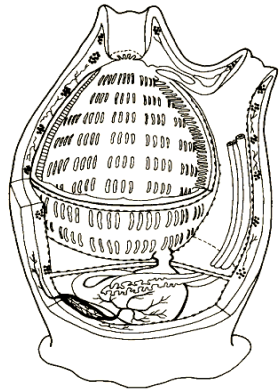
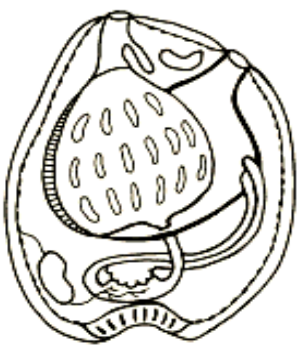
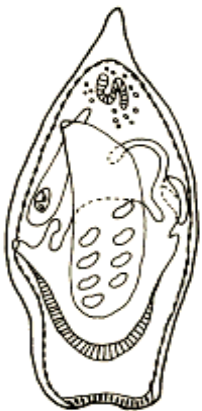
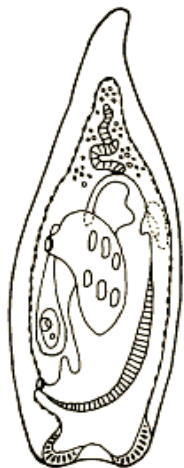
sea squirts - Ascidiacea

- hermaphrodites
- External fertilisation
- Possible also budding



© BIOEDNET

testis
ovarium

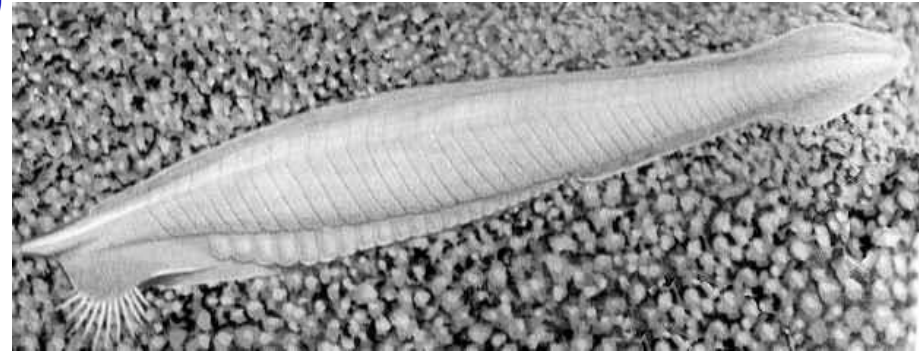


larvae

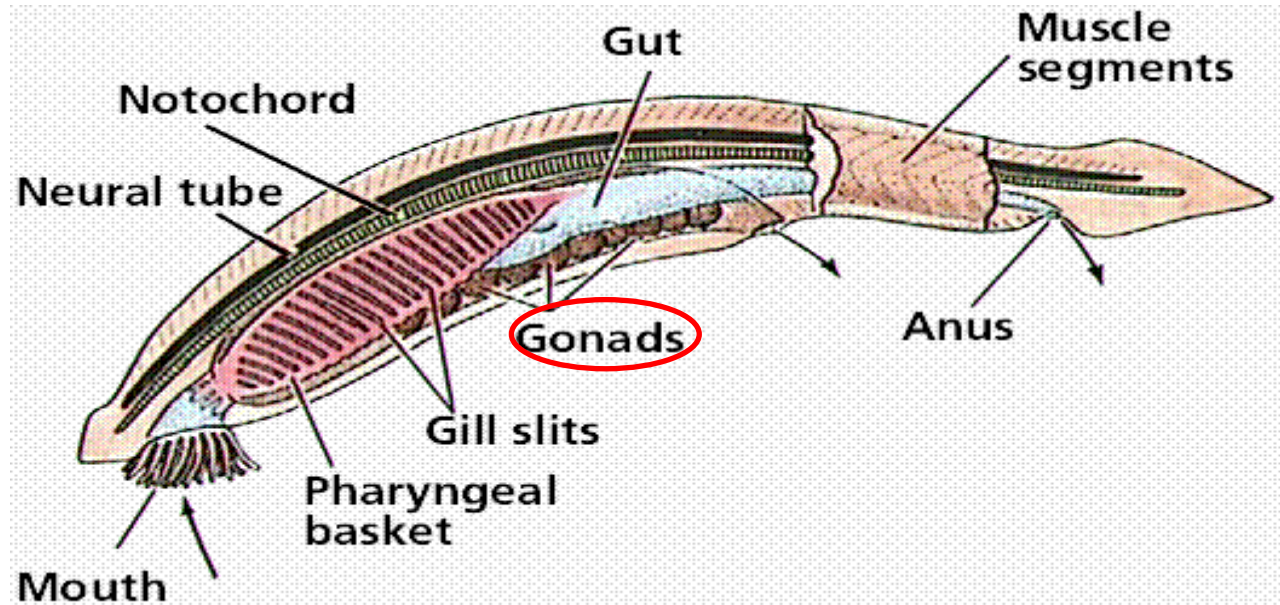


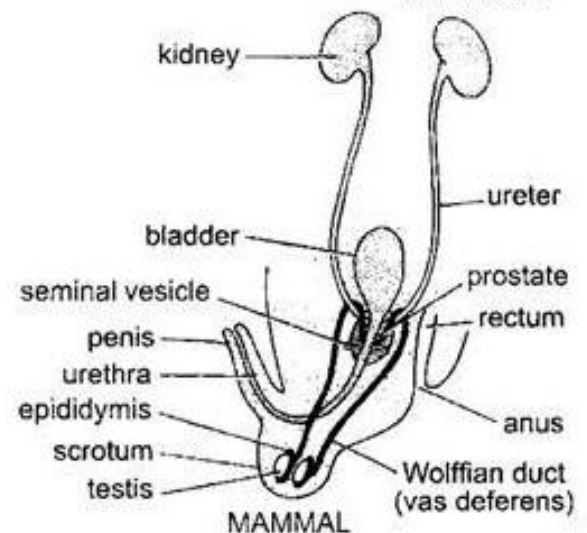
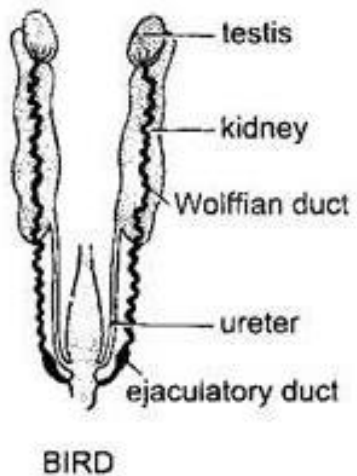
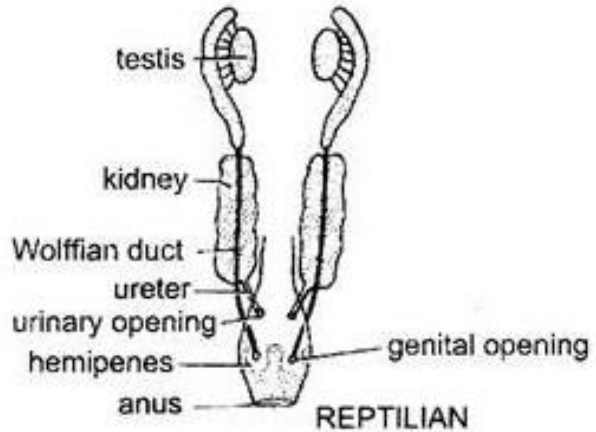
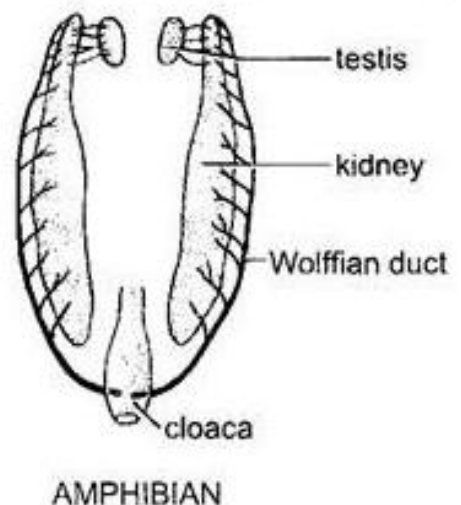
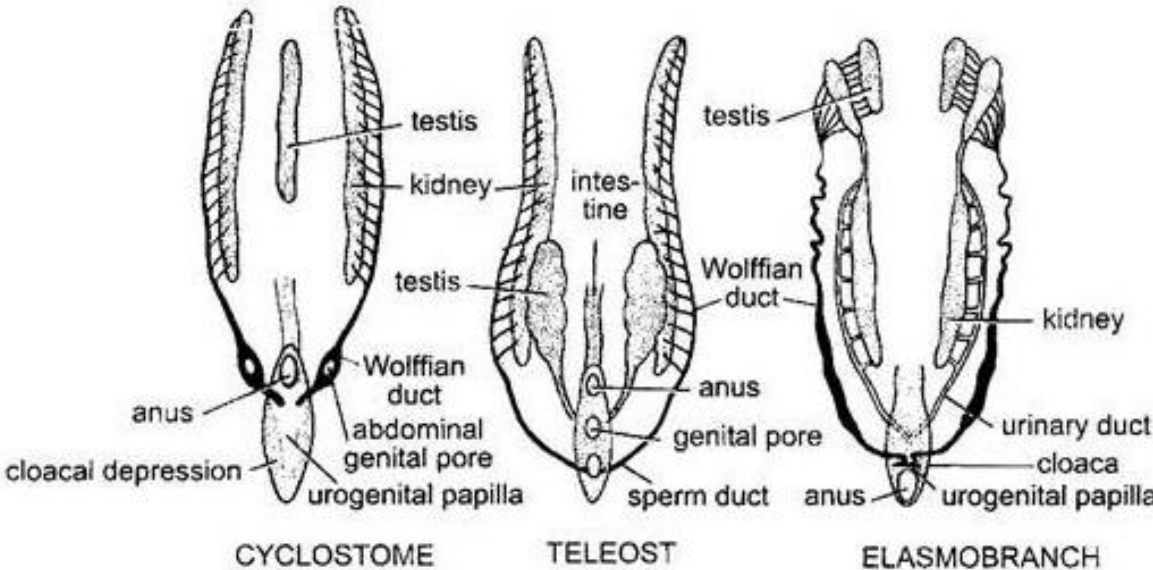
adult

subphylum: Cephalochordata (phylum Chordata)

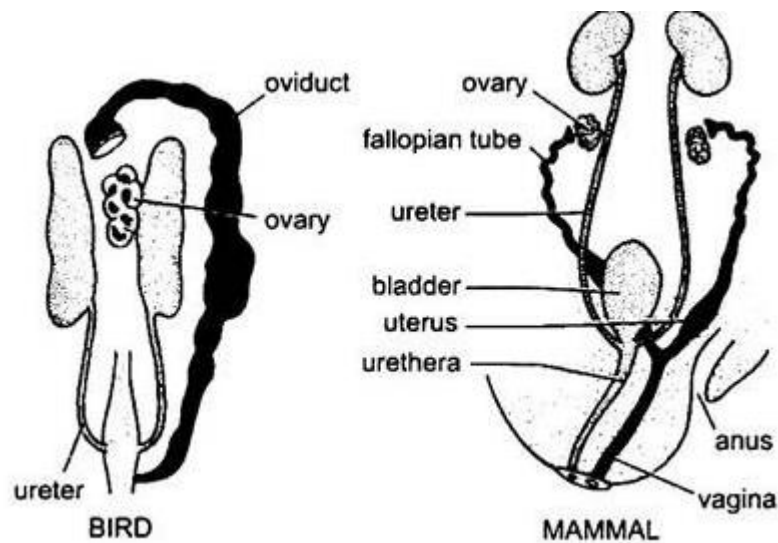
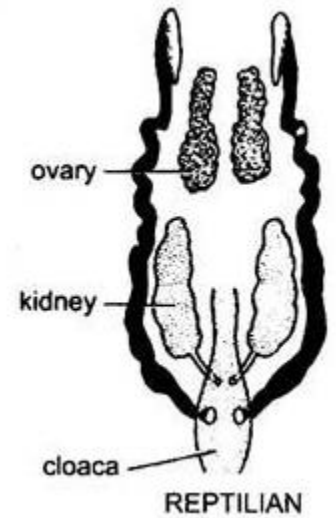
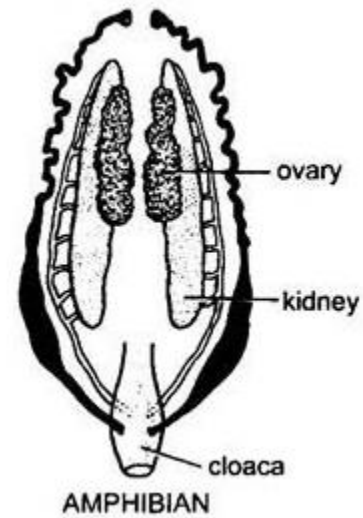
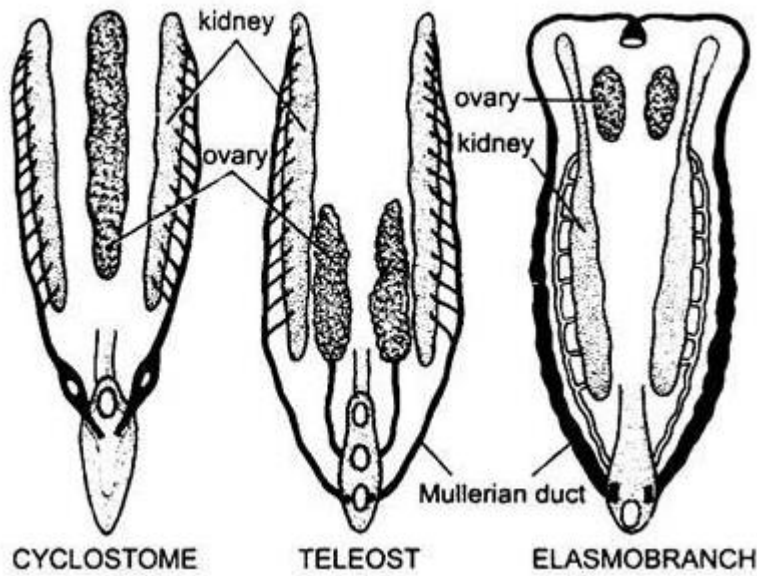


- gonochorists
- gonads along body
- external fertilisation





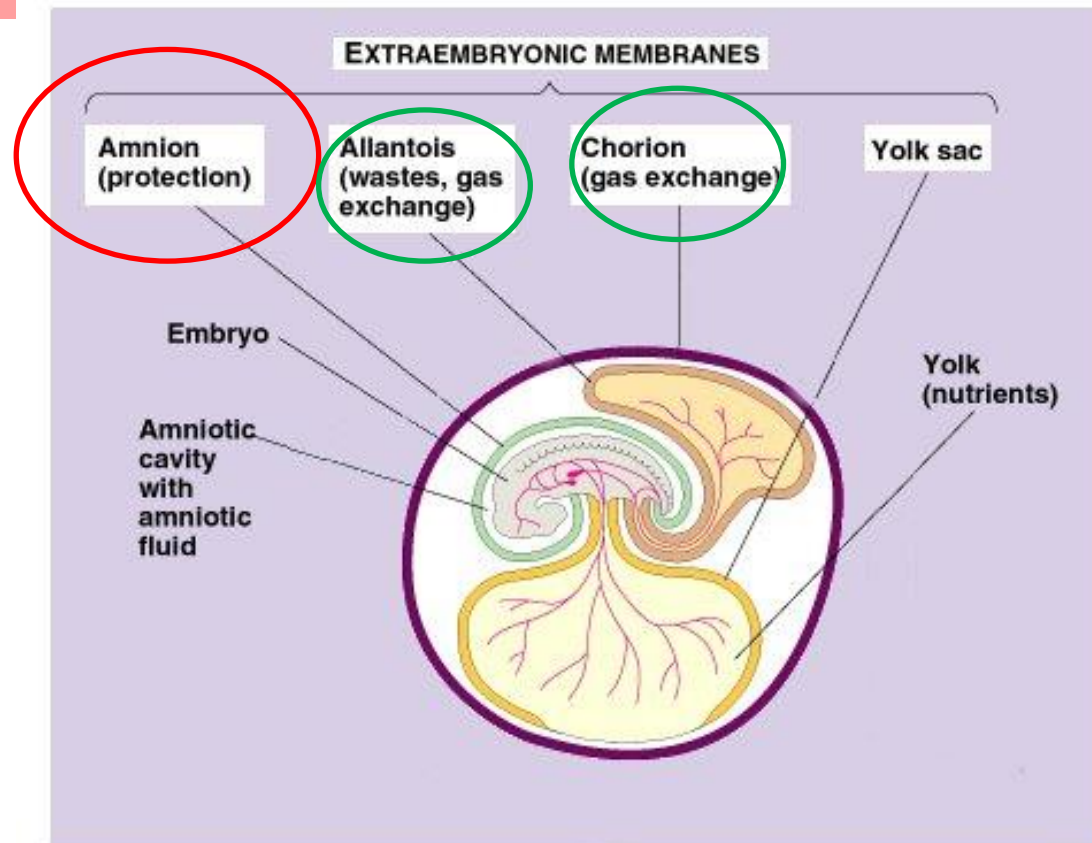
females



- Their reproduction is not connected to water!

► eggs are deposited on the soil – embryo develops within egg that protects it well (shell + membranes + fluid)

Only reptiles, birds and mammals - AMNIOTA

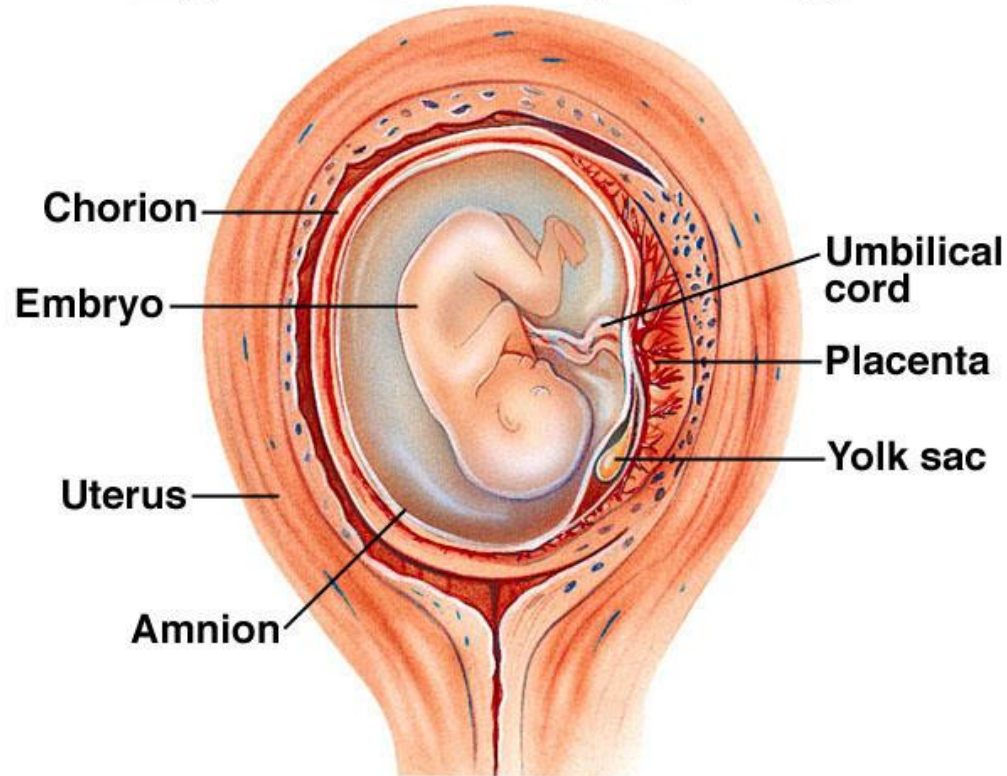


placenta

This structure provides oxygen and nutrients to embryo and removes waste products from embryo's blood. The placenta attaches to the wall of uterus, and your embryo's umbilical cord arises from it.

- it develops when chorion and allantois merge with uterus wall

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▶ PLACENTALS – mammals with placenta

▶ APLACENTALS – no placenta (monotremes and marsupials)



monotremes

marsupials

placentals

