anterior brain; protonephridial excretory system (drains directly from body across wall in excretory vessel)

- Motile (predatory) - some parasites secondarily sessile
- Asexual/sexual reproduction - parasitic species use asexual reproduction
- 4 classes:
  - **Turbellaria:** mostly free-living, some commensal, some parasitic; ciliated epidermis for locomotion; traps prey beneath muscular activity
  - **Monogenea:** obligate ectoparasites of fish. Life cycle simple: eggs laid, fall off host, hatch, larva seeks new host
  - **Trematoda (flukes):** flat leaf-like body; obligate parasite. Adults live in intestine of vertebrate host, attach to mucosal wall by suckers; feed on mucus, tissue fluid, blood. Most hermaphrodite. Complex life cycles with 2 or more hosts. Veterinary importance: condemnation of liver, disease and/or death in sheep and cattle, public health concerns. *Fasciola hepatica* life cycle:

Sexually mature fluke in sheep (final host)

Eggs pass in host faeces

Larval stages:
miracidium in water
enters snail (intermediate host)
sporocysts, redia, cercaria by *asexual reproduction*

cercaria *exit snail*

encystment (metacercaria)

Eaten by definitive host eg sheep

Excysts in small intestine, moves to liver

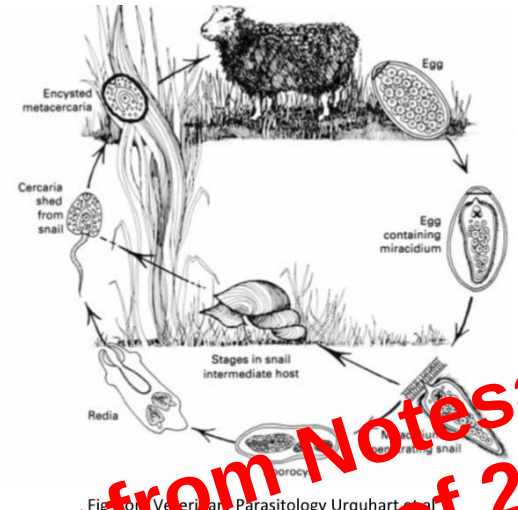
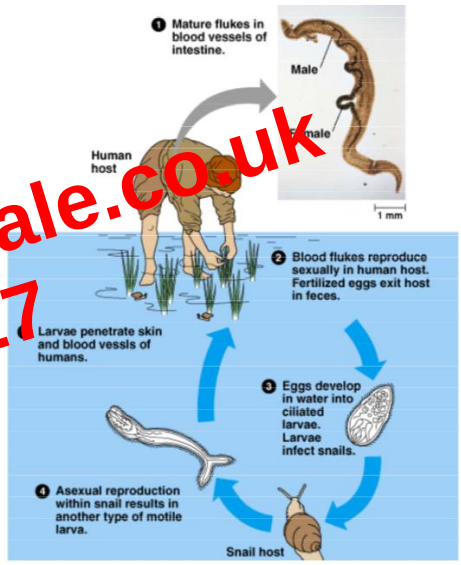
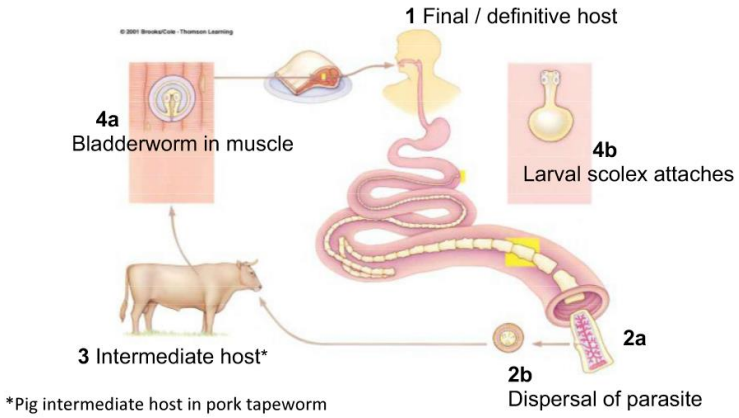


Fig. from Veterinary Parasitology Urquhart et al



    - **Schistosomes:** blood flukes of humans/all domestic animals, 2nd most important parasite after malaria. Unlike *Fasciola hepatica*, have separate sexes and active entry to final host through skin or ingestion.
  - **Cestoda (tapeworms):** parasites of small intestine, tape-like body; no mouth, digestive tract or anus - nutrients absorbed across body surface. Reproductive system replicated as chain
  - **Structure:**
    - **Scolex:** attaches in intestinal crypts
    - **Neck:** generation of new proglottids
    - **Immature proglottids:** with respect to reproductive organs
    - **Mature proglottids:** mature male and female organs
    - **Gravid proglotids:** uterus with fertilised eggs; detach and pass out in faeces
    - **Strobila:** scolex + proglottids

- **Beef Tapeworm in humans:**



  - **Pork Tapeworm:** adults usually in humans, but eggs also infect humans; cysticerci grow in brain (and elsewhere). In pigs, cysticerci stay in muscles
  - **Hydatid tapeworm:** definitive host can be dog, dingo or fox. Intermediate host can be sheep, cow, marsupial and humans. Final hsot infected by ingesting contents of hydatid cyst from raw offal of intermediate host. Only 3 proglottids. Cystic form can undergo asexual reproduction

Phylum: Mollusca

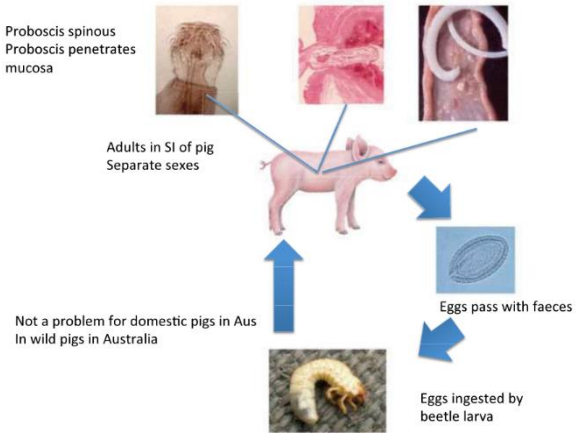
- Includes chitons, gastropods, bivalves and cephalopods.
- Gastropod body plan: ventral nerve cord in snails. Coelom present, but greatly reduced. Spiral shell enables growth. Anus over its head (torsion) as well as gills. Primitive circulatory systems which pumps blood to gills

Phylum: Annelida

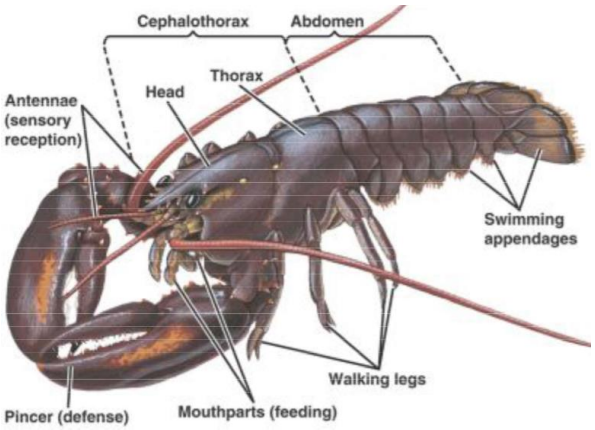
- "Little rings" - segemented worms
- Includes leeches, earthworms, fire worm and Christmas tree worm.
- Segmentation allots better control of body sections, and diversification of functions. Segmentation in earthworm allows expanding of sections to propel worm forward
- Coelom present allows independent movement of body wall and enclosed organs; more space for complex organs and organ systems; storage of eggs and sperm. Coelomic fluid protects internal organs. In some animals, provides circulatory function for oxygen and nutrients to cells; waste removal; hydrostatic skeleton

Phylum: Acanthocephala

- "Spiny-headed worms" - strictly parasitic
- 2 host life cycle - arthropod intermediate host, vertebrate definitive host
- Structure: tiny head (proboscis) and a fluid-filled body and reproductive organs. Use head region to attach to intestinal wall
- Life cycle of *Macracanthorhychus hirudinaceus* (large spiny-headed leach-like worm)



- **Copepods:** important food source, some parasitic on fish, some predatory - has been used to control dengue mosquito in SE Asia



- **Agricultural pests:** moth, 2 species in Sth Queensland - native budworm and cotton bollworm or corn earworm. Damage to crops - eggs on plants, larvae feed on leaves, invade pods/beans/etc. Enter soil and pupate over winter. Tillage of soil can reduce numbers of pupae

Vertebrates

Deuterostome: bilateral symmetry, coelom, radial cleavage during embryonic development (planes parallel to vertical axis); blastopore - anus; two phyla: Echinodermata and Chordata

Echinodermata: includes starfish, sand dollars, sea urchins. DNA indicates Echinoderms and Chordates are related - endoskeleton made of calcareous plates, covered by epithelium.

- **Unique vascular system:** network of water filled canals - branch to form tube feet for locomotion and feeding
- **Sexual reproduction:** release gametes into water - spawning
  - **Asexual reproduction:** autotomy, shed arm ("comet") to make new individual

5 clades:

- **Asteroidea:** starfish, sea daisies
- **Echinoidea:** sea urchins
- **Ophiuroidea:** brittle stars
- **Crinoidea:** sea lilies and feather stars
- **Holothuroidea:** sea cucumbers - important aquaculture species

Chordata: includes 3 subphyla:

- **Vertebrata:** fish, amphibians, reptiles, birds and mammals
- **Cephalochordata:** *Amphioxus sp.*
- **Urochordata:** sea squirts

Four features define chordates: notochord, pharyngeal slits, dorsal hollow nerve cord, and muscular post-anal tail. All chordates exhibit them at one point.

- **Notochord:** slender rod, develops from mesoderm; lies dorsal to coelom - beneath and parallel to central nervous system. Consists of core of cells and fluid, surrounded by fibrous sheath - mechanical properties of elastic rod, which allows locomotion through lateral undulations. In bony fish and terrestrial vertebrates: present during embryonic development, replaced by vertebral column, but persists as nucleus pulposus of intervertebral discs
- **Pharyngeal slits:** longitudinal series of openings in walls of pharynx. In terrestrial vertebrates, present in embryo, but lost during embryogenesis. In aquatic vertebrates, gills develop adjacent to slits, which allow for flow of water across gills
- **Dorsal hollow nerve cord:** derived from ectoderm, lives above got, surrounded fluid-filled neurocoel
- **Muscular post-anal tail:** posterior elongation beyond anus, consists of segmental musculature and notochord

fertilisation; male and female press cloacae together and sperm transferred into female's cloaca. Salamanders - internal fertilisation; male produces spermatophore (cap of sperm on gelatinous stalk), which female picks up with cloaca

- **Brain:** shows little development from fish

Evolution of amniotic egg facilitated the success of vertebrates on land. Amniotes - reptiles, birds and mammals. Amniotic egg characterised by presence of several extraembryonic membranes:

- **Amnion:** encloses embryo - fluid-filled and so protects embryo from mechanical shock
- **Allantois:** contains foetal urine; contributes to placenta in eutherian mammals
- **Chorion:** outer envelope; contributes to placenta in eutherian mammals
- **Yolk sac:** source of nutrition for embryo

In birds and reptiles - embryo enclosed by calcareous or leathery shell - presents desiccation allowing terrestrial reproduction

Eutherian and marsupial (therian) mammals lost shell - eutherians formed placenta, marsupials deliver altricial young (gestation vs lactation)

Monotremes have retained egg shell

Cotylosauria - "stem reptiles", basal group of amniotes

Two major lineages in the evolution of amniotes:

- **Sauropsida:** dinosaurs, modern reptiles, birds
- **Synapsids:** mammals

Evolution of amniotes - characteristics:

- **Skull fenestration:** amniotes can be grouped according to anatomy of temporal region of skull (number of fenestrae, or holes)
  - **Anapsid:** no fenestrae; ancestral amniotes, turtles and tortoises
  - **Synapsid:** one fenestra, mammals
  - **Diapsids:** two fenestrae; dinosaurs, lizards, snakes, crocodiles, tuatara and birds

Evolution of Reptiles

4 extant orders:

- **Testudines:** turtles, tortoises, largest is leatherback turtle (shell up to 2m in length, weighs 900kg). Turtles in habit marine and saltwater, tortoises terrestrial. Herbivorous and carnivorous, but lack teeth - keratinous ridges for slicing and grinding. Two groups:
  - **Cryptodira:** contract neck straight backwards - marine turtles, most freshwater turtles, tortoises
  - **Pleurodira:** flex neck lateral: some species of freshwater turtle
    Unique feature: position of limbs within shell - ribs encapsulate the scapulae
- **Sphenodonta:** tuatara. Native to NZ and surrounding islands. Lifespan about 100 yrs, sexually mature at 20; females only breed every 4 years. Considered most ancestral of amniotes. Teeth fuse to bone early in development - new teeth added caudally. Double row on maxilla (upper jaw) and single row on mandible (lower jaw). Ancestral auditory apparatus - no outer aperture, no tympanic membrane (ear drum). Two species:
  - *Sphenodon punctatus*
  - *Sphenodon guntheri* - very rare
- **Squamata:** lizards, snakes. Lizards evolved 200mya, snakes from lizards 100mya. Venom early in squamate radiation - 60% venomous, predominantly snakes but two lizards (gila monster and Mexican beaded lizard). Moveable quadrate bones (particularly snakes), allow greater range of mandibular motion
- **Crocodilia:** crocodiles, alligators, caimans, gharials; largest species is Australian saltwater crocodile. Semi-sprawled posture, results in belly-walk, and high walk with legs under body. Ancestors were bipedal - sprawled gait is derived trait, and adaptation to semi-aquatic existence