i) Digestive tract (evolution of the stomach)

(1) Large capacity: food reserve and efficient digestion = more time allocated to other tasks

(2) Preservation (no rotting): creating an acidic environment in the stomach to prevent rotting

(3) Aid digestion: more muscle layers and evolution of the enzyme (evolved to work in acidic environment)

caused by diet and selective pressure/evolution

ii) Development of gonads

(1) greater storage capacity and massive production of gametes (ex. salmon)

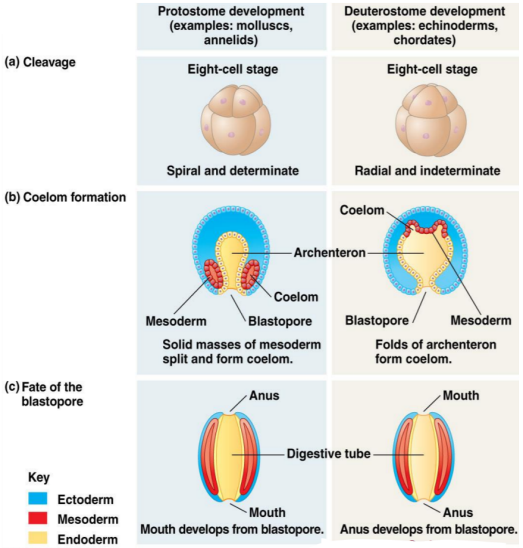
b) Coelomate

i) Organs suspended in the mesoderm (organisation of the mesoderm)

ii) Mesoderm-endoderm contact allows for the development of complex organs (ex.stomac)

iii) Development of the vascular network for the organs (circulatory system)

E) Evolution of embryogenesis - Deuterostome



A. Radial cleavage: parallel to the axis of the body (vs. spiral cleavage: oblique to the axis of the body)

B. Indeterminate cleavage: each cell has the potential to produce a complete embryo; has all the genetic information to do so (vs. determinate cleavage: each cell defines a part of the embryo

C. Origin/Mode of apparition of the coelom/where the mesoderm forms

a. Alpocketting of the archenteron creates space; this space is the coelom formed in the back portion of the archenteron and is surrounded by mesodermal cells/tissue (vs. mesodermal cell will differentiate between the ectoderm and the endoderm and the coelom will form with in the mass of cells that will developpe)

D. Blastopore is the anus; the mouth will develop later as the second opening (vs. mouth = blastopore and the anus will develop later in the embryo)

To conclude:

- Animal = heterotrophic eukaryotes (main characteristic: organised tissue)

Chapter 17: Evolution of Animals: Echinoderms and Chordates

Chordates and echinoderms(form a monophyletic group): **deuterostomes**

- Radial/indeterminate cleavage
- Folds of the archenteron form coelom
- Formation of the mouth at the opposite end of the blastopore (blastopore=anus)

Echinoderms (sister group of chordates):

- Marine animals that move slowly or are sessile
- Radial adult form (secondarily derived), bilateral symmetry seen in larvae

Ex. sea lily/urchins

Chordates:

Derived characteristics:

1. Notochord (shape/form: central axis)
2. Dorsal, hollow nerve cord (relative to notochord) = reversal in body plan
3. Post-anal tail
4. Pharyngeal slits/clefts (often associated with respiratory organs) **[**tendency to disappear as lungs are used for respiration**]**

Cephalochordates: most primitive taxon of chordates

= small animals (sessile)

= usually live in streams (use cirri for feeding)

= morphology resembles a chordate in adulthood

Ex. lancetes

Urochordates: sister group of vertebrates

- **Chordate feature only visible in the larva**

****paedomorphic hypothesis of the evolution of vertebrates form the larvae of urochordates (active=great capacity of locomotion)****(acquisition of reproductive organs (accelerated development of sexual organs))

- Sea animal (sessile) **[**large filter, water circulates**]**
- Larvae are mobile (evidence: muscles for transportation; allowed for ongelations of the body)
- Metamorphosis; adult = sessile

Vertebrates:

Vertebrates: **active** predatory animals having a **vertebral column** and more complex nervous system

Derived characteristics

1. portion of the notochord solidifying into a vertebral column (dorsal placement of neural tube relative to notochord)
2. Solidification of the central axis of the body (notochord surrounds itself with cartilage or bone, the centrum)
    a. Good place for muscles to attract to bones (ribs) - aid location of these active animals - vertebrates
3. Neural tube surrounded by a neural arch (dorsal wings)
4. Flexible and strong vertebral column on which muscles of locomotion will attach.

Primitive vertebrates: jawless vertebrates (hagfish and lamprey)

Initially: fauna of jawless vertebrates was much more diverse with varying shapes/formes

a) Haikouella: brain, no skull
b) Myllokunmingia: brain and skull, no vertebrae (first fossilized vertebrate)

Monophyletic group = cyclostomes

- Living jawless vertebrates with rudimentary vertebrates

Embryonic development of a vertebrate:

- Notochord surrounds itself w cartilage/bone
  - Centrum
- Neural tube surrounded by neutral arc (dorsal)
- Flexible and strong vertebral column on which muscles of locomotion will attach

Hagfish:	**Lamprey:**
- Mobile (flexible = cartilaginous vertebral column) - Good decomposers of dead animals - Slime glands (mechanism of protection against predation)\ - Microfilaments produce massive quantities of muscle when in contact with water	- Passive lamprey: (sessile until sponing = death) - Active parasitic (through metamorphosis): lamprey (larger with facial disk composed of tooth-like structure) - Sensitive to pollution

Jawless vertebrates = **+initial diversity**

- Various shapes and forms of boney plates
  - Ostracoderms (non-monophyletic group): jawless vertebrates with bony plates (does not include hagfish/lamprey)
- Abundant from the Cambrian - Devonian ONLY (extinction)

Gnathostomes

= jawed vertebrates
= mineralization of endoskeleton (cartilaginous with deposition of calcium carbonate)
= lateral line (especially in aquatic gnathostomes)

- Detection of movement (by changes of pressure) in water ("ear")

Evolution of jaws:

**** 2 pharyngeal slits (gill arches) were modified to create jaws and it support structure (skeletal rods)****

Exaptation: structure with initial purpose of respiration now aimed at catching food (mandibular arch) and supporting the jaw (hyoid arch)

Hyoid arch: link upper and lower jaws to the cranium (suspensorium)

∴exception from respiration to feeding [branchial arches→mandibular/hyoid arches]

First fish fossils:

Placoderms: marnie fish with armour (large) = boney plate around the head/mobile heads (fierce predators)

Ex. Dunkleosteus

Acanthodians: fresh/salt water fish with spines on body (ancestor of bony fish)

Cartilaginous fishes (chondrichthyans)

3 large groups; sharks (400myr) and rays/chimaeras (200myr)

Derived characteristics:

- Calcium carbonate reinforced skeleton (+rigidity)
- Short intestine with spiraled valve (food travels in a spiral, though short, food has sufficient time for nutrient absorption by intestinal wall)

Sharks:

Derived characteristics:

- Modified scales (minute scales on body and upper/low jaws
- Upper and lower jaws not attached to the cranium (forward projection: retracts due to hyoid arch/suspensorium)
- Over 20 rows of teeth with continuous replacement (modified scales)
- Hydrodynamic profile: body structure
    - Ideal shape to move around water without creating turbulence
    - Muscular pectoral fin for "hovering" to water column
    - Caudal **heterocercal tail** (orientation and propulsion)
        - Upper lobe of tail is longer than lower lobe (swim with head towards the surface): allows the shark to remain relatively close to the surface without sinking (ability in maintain themselves in the water column/body denser than water)
- Large sharks: planktivores (no constraint on size as plankton is very abundant in oceans)
- Reproduction: diversified
    - **Internal fertilization** (clasper duct in males = spermatic)
        1) Oviparous: eggs released into the environment (apprednages on eggs allows for hooking onto vegetation)
        2) Ovoviviparous: eggs hatch within the female, though do not require nutrients from the female
        3) Viviparous: secretion by female, absorbed by developing embryo

Bony fishes/ray-finned fish (osteichthyes)

= most diversified group of vertebrates (32 000 species)

Derived characteristics:

- Radial fins (actinopterygians)
- Fully mineralized, ossified (bone) endoskeleton (calcium phosphate)

Sarcopterygii (lobed-fin fish)

[intermediate between ray-finned fish (actinopterygii) and tetrapodes**]**

3 major groups: coelacanth (fossil reconstruction, not abundant presently)/lungfish/tetrapods

- Fin is not attracted to the side of the body, there is a structure (small) between the body and the fin

Coelacanth

- Fish with functioning lungs
- Homology of fin element with the bones of tetrapodes
    - Bones of limbs: basal piece homologous to humerus/ulna, radius (bones of wrist) and fin rays (fingers) **[fish with fins with all the internal structure of limbs: homology of fin elements]**
- Ovoviviparous (hatched with in the female, born fully formed with no exchange of nutrients from the mother)

- Deep environments (lungs - not functioning: vestigial structure)

Lungfish (dipnol)

- Freshwater fish
- Gills and lungs (equivalente to those of tetrapodes)
- Capable of estivation (dig into dirt and form a cocoon-like structure during warm/dry seasons for survival with minimal dependance on H2O = torpor)
- Lobes are more relieving = “amphibious animal” (limbs with fins)

Evolution of Tetrapods

[limbs with digits]

First tetrapod:

= mixture of aquatic/terrestrial life during the Devonian period

Ex. tiktaalik (375 myr) = transition for water to land

(scales, lungs, gills, limbs+fins, flat skull with eyes on top(similar to crocodilian), ribs, fin skeleton)

= first neck: pectoral girdle is not attached to the cranium, found on the side of the body ∴ freed the head with the link with the limbs

Advantage of invading terrestrial environments?

\+ Competition in aquatic environment for access to resources (+evolution of advantageous trait)

\- Resources in the aquatic environment (feeding/reproduction)

\+ Food resources available on land:opened an ecological niche for species (plants and insects) [+biodiversity]

Implied: changes in body structure to support the body in a terrestrial environment

Amphibians

= the step of the emergence of limbs with digits

\+ Internal structure of limbs becomes more pronounced

Order urodela (salamanders)

➔ Presence of a tail

Order anura (frogs)

➔ Absence of a tail

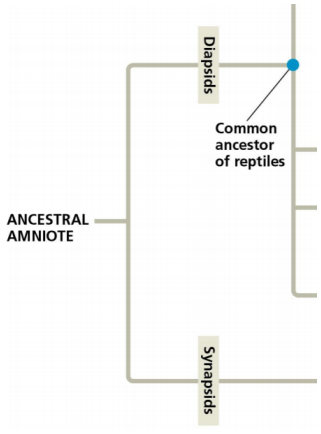
Order apodes

➔ Absence of limbs

Evolution of amniotes

[retiples, birds, mammals**]**

= presence of an amniotic egg

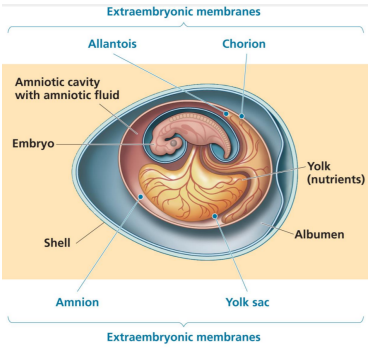


Diapsids: (turtles/crocodiles/birds/dinosaurs)

Synapsids: mammalian reptiles

Animotes:

- **Amniotic egg** (mini ecosystem)
    - Contains the membranes that protect the embryo (extraembryonic membrane)
    - Amnion: membrane that surrounds the embryo~contains the amniotic fluid
    - Other membranes:
        - Yolk sac: reserve of nutrients for the embryo (reduced as embryo grows)
        - Allantois: accumulates metabolic waste produced by embryo (increase in size as embryo grows) + role in respiration
        - Chorion: main respiratory role
    - Presence of a shell
        - Rigid in birds
        - More flexible in reptiles and monotremes
        - Absent in other mammals



Evolution of Reptiles

(9000 species, excluding birds)

- Dry skin (scales containing keratin: preservation of humidity to prevent evapotranspiration)
- Internal fertilization
- Improved locomotion/mobility

During 250 myr (Mesozoic), the **reptiles were the dominant class** of medium/large sized vertebrates.

After the mass extinction of the Cretaceous (65 Myr ago) which led to the disappearance of dinosaurs, the **mammals experienced a great adaptive radiation** (adaptive radiance) and now they dominate the fauna of medium sized to large terrestrial animals.

Dipsides:

Cranium: 2 temporal fenestra (allow articulation of muscles and help action of muscles~jaw muscles)

Anapsides (turtles)

- Among the first reptiles that appeared in the Carboniferous (disappeared at the end of the Triassic)
- Stalky and big herbivores
- Turtles are the sole survivors (with protective shell)

Cranium: anapsid cranium has no orbital fenestra cranium (derived from the diopside cranium)

Lepidosauria (lizards/squamates/tuatara)

- +locomotion
- +muscles and jaw strength

Cranium: diapised cranium has 2 temporal fenestra

Archosaurs (crocodilian/dinosaurs/birds)

- **Predatoristic characteristics**
    - -weight (of cranium)=
        - \+ Mobility
        - \+ Agility
        - \+ Movement of head

Cranium: 2 temporal fenestra fused together to form a single temporal fenestra + large antorbital fenestra

Success of dinosaurs (archosaurs):

1. **Posture**
    a. Primitive, sprawling posture (horizontal femur, limbs away from trunk: movement by tortions of the body and movement of limbs)
    b. Advanced archosaurs = birds and dinosaurs
        i. Parasagittal limbs: limbs in a vertical plane under the body
        ii. Vertical femur with head: 90 degree angle with the body
        iii. Upright posture: rotation of the knee towards the front (full weight on hind legs)
            1. Removed constraint associated with size

    **mammals: added backwards rotation of the elbow to the upright posture of the hind limbs
2. **Bipedalism** (may be lost in some species; it is a secondary loss)
    a. Forearms have other function (not necessarily associated with with locomotion
        i. For birds: front limbs are used for flight (locomotion)
3. **Most recent = largest**
    a. predator/prey relationship
        i. Upright posture ∴ no restraint on size

Evolution of birds

(10 000 species with **+diversity**)

Ancestor: Maniraptora(dinosaur) = sister group of birds

appeared during the Jurassic period

Derived characteristics:

- Adaptations for flight: **reduction of mass**
    - Small gonads/females only have 1 ovary
    - Pneumatic bones (less compact bones)
    - No bladder (uric acid waste; less water thus less mass in waste)
    - No teeth

- Light feathers (made of keratin) are modified from reptilian scales
- Endotherms
- Internal fertilization produced eggs with shells
- Parental behavior

Ex. from emu (non-flying) to swallows (agile)

Evolution of Mammals

*evolved from mammalian reptiles: **synapsids***

Oldest reptile fossil (340 myr): separated into diapsids and synapsids

(65 myr): end of the dinosaur era, ++mammal abundance/multiplication

A) Pelycosaurs (good predators)
   a) Masticatory muscles were anchored in the temporal fossa
   b) Primitive morphology (sprawling posture)
   c) First land vertebrates to kill prey of their own size (diversified)

   Ex. Dimetrodon: dorsal sail (may have been a solar sensor)

   d) Dominant type of reptile that were domination until the end of the great Permian Extinction
      i) Replaced by **theraspides**

B) Theraspides (mammalian reptiles)
   a) Small reptiles
   b) Very active predators
   c) Nocturnal (endothermic?)

   Ex. first mammal; basal mammal (small, nocturnal predators...dinosaurs occupied the daylight niche)

   d) Diversified after mass extinction of dinosaurs

C) Mammals (6000 species)
   a) Derived characteristics:
      i) Hair
      ii) Endothermy
      iii) Mammary glands
      iv) Diaphragm (respiratory system)
      v) Differentiation of teeth

Appearance of 3 large groups of mammals:

Monotremes (echidna/platypus)	**Marsupials**	**Eutherians**

[only mammals that lay eggs(small)]
• Presence of mammary glands
  ○ No nipples (secretion of milk-young cannot attach)
• Presence of an incubating pouch (where the young developpe)
(Australia and New Guinea)
	• Gives birth to offspring
	  ○ No egg
	  ○ Offspring are not well developed
	• Pocessess nipples (differentiated milk reserve)
	• The embryo develops in the uterus
	  ○ Presence of a short placenta
	• Premature birth and growth
	(Australia, North America and South America)
		• Placental mammals
		• Longer gestation period, well-developed embryos
		= group that became abundant after the end of the Cretaceous period
		
		** the phylogenetic relationship of mammals remain controversial** (difficult to establish a phylogeny based on morphology/molecular data)

Primates (our group (humans) in the mammals)

Derived characteristics:

- Opposable thumbs from the other fingers
    - Ability to move with in trees
- Fingers and toes have flat nails
- Orbits(eyes) migrate towards the front and offer excellent binocular vision (important for animals living in trees)

Homo sapiens:

Derived characteristics:

- Larger/more complex brains
- Languages and symbolic thought (abstract)
    - Capable of making complex tools
- Reduced jaw bones/muscles (food was processed therefore less jaw volume/muscles required)
- Shorter digestive tract (meat diet: allowed for faster digestion of food)
    - Evolutionary compromise??
        - \- Length of digestive tract
        - \- Energy required to maintain/developpe
        - \+ Complexity of the brain??