

Semejanza general (escuela fenética: no utiliza una perspectiva evolutiva)



Pero es un sentido evolutivo, sabemos que las aves descienden de reptiles

Noción de parentesco (no necesitan ser “generalmente parecidos”)

Pueden evolucionar novedades evolutivas (apomorfías).

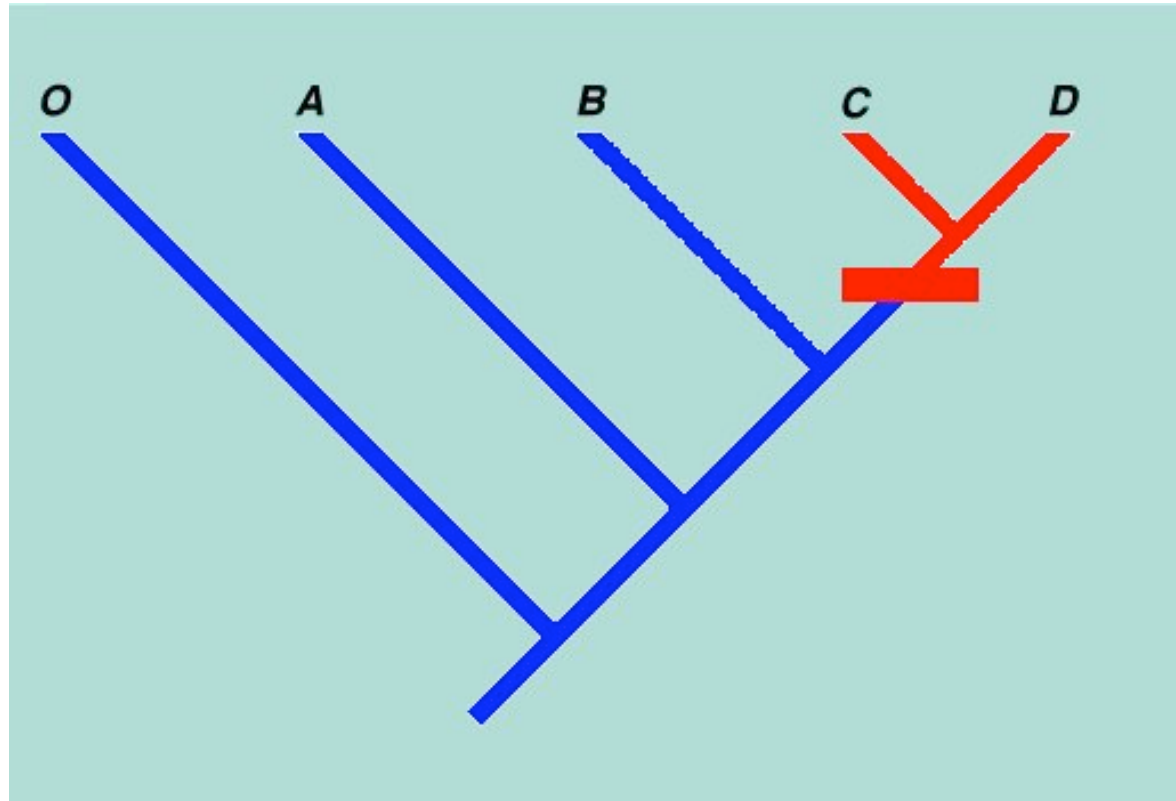
Novedades evolutivas compartidas: Synapomorfía

No compartidas: autapomorfía.

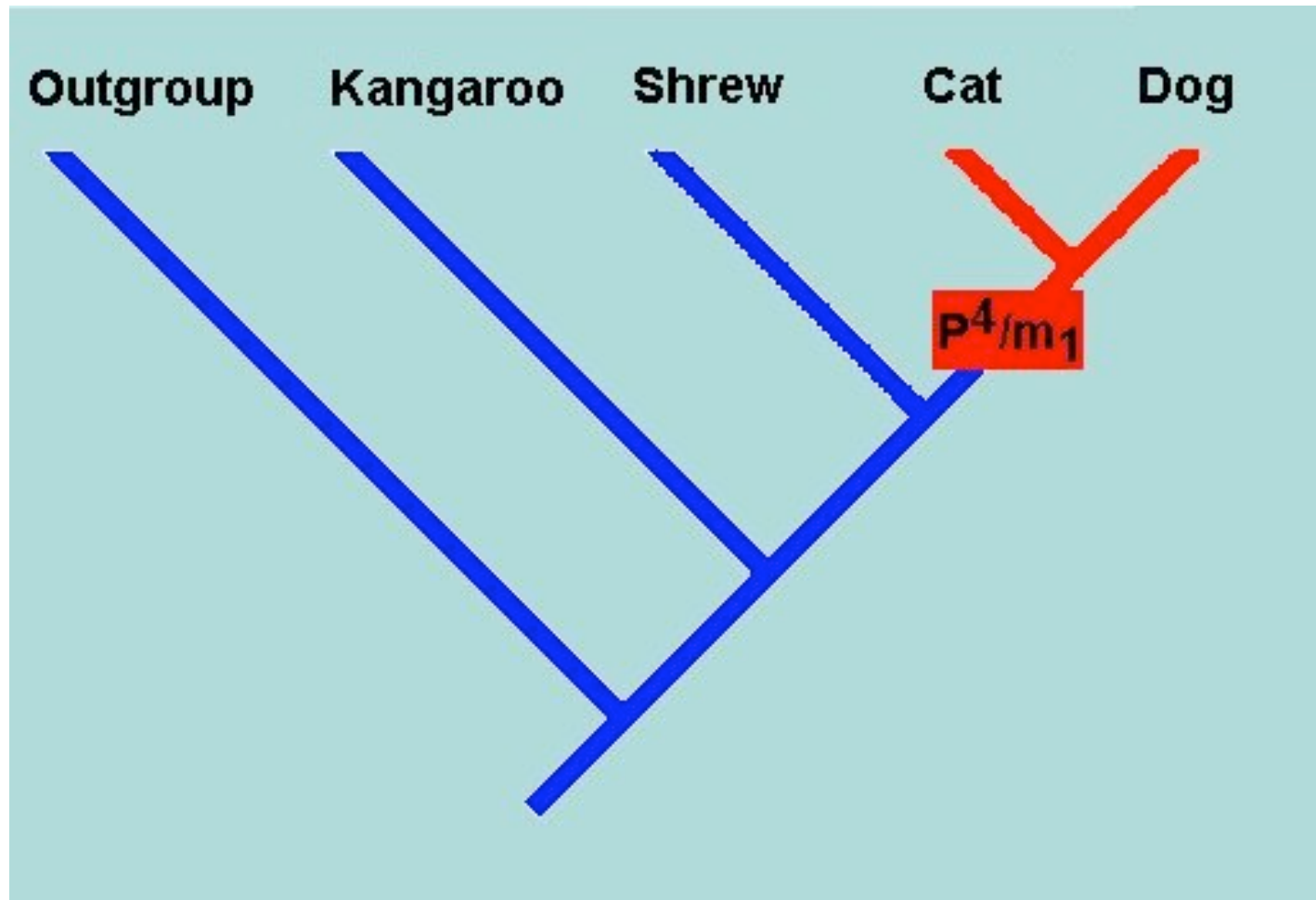


Apomorfía: Carácter derivado de un estado ancestral. Por ejemplo, la presencia de alas en los insectos es apomorfo ya que deriva de un estado anterior sin alas.

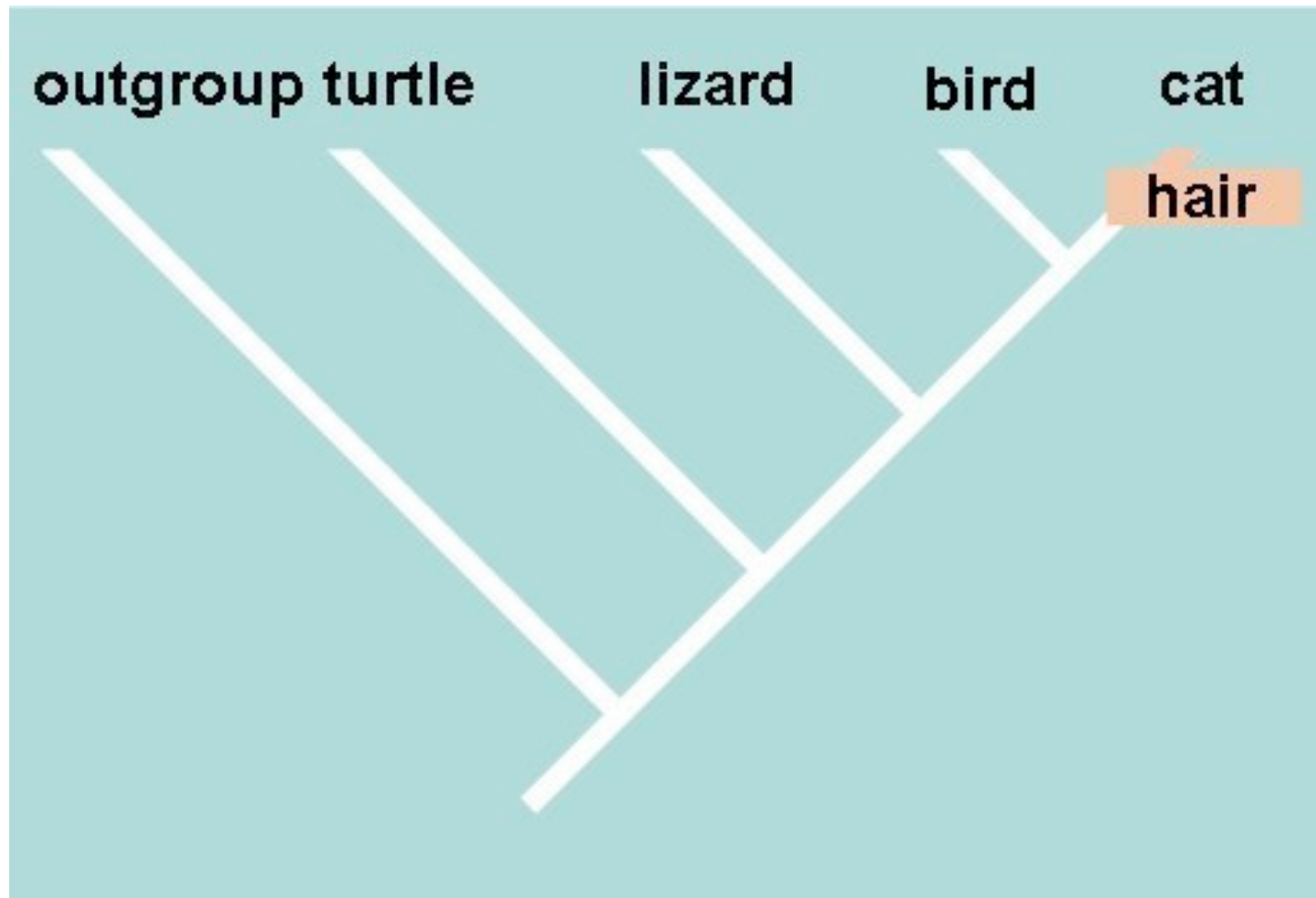
Plesiomorfía: Estado primitivo (ancestral) de un carácter. Ej. Escamas en las manos



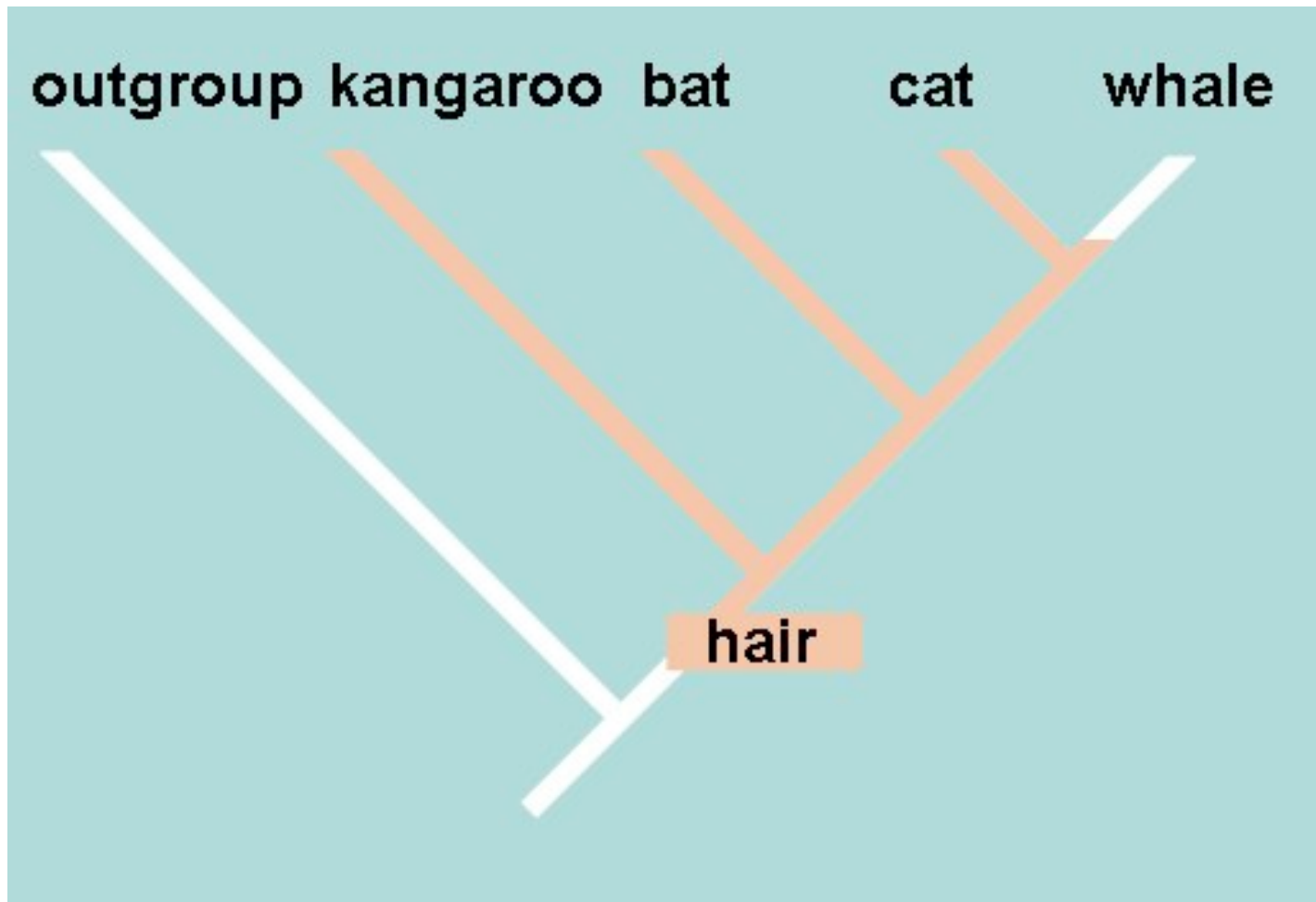
The ancestral (plesiomorphic) character state is "blue", the derived (apomorphic) character state is "red"



Sinapomorfía: Carácter apomorfo compartido por dos o más taxa. En este caso, dientes “carnasiales” cortantes son una synapomorfía de el perro con el gato. Se usan para definir grupos naturales (monofiléticos).



Autapomorfía: apomorfía exclusiva de un taxon. Por extensión apomorfía compartida únicamente por un grupo supraespecífico. Ej la presencia de mentón es una autapomorfía de los humanos



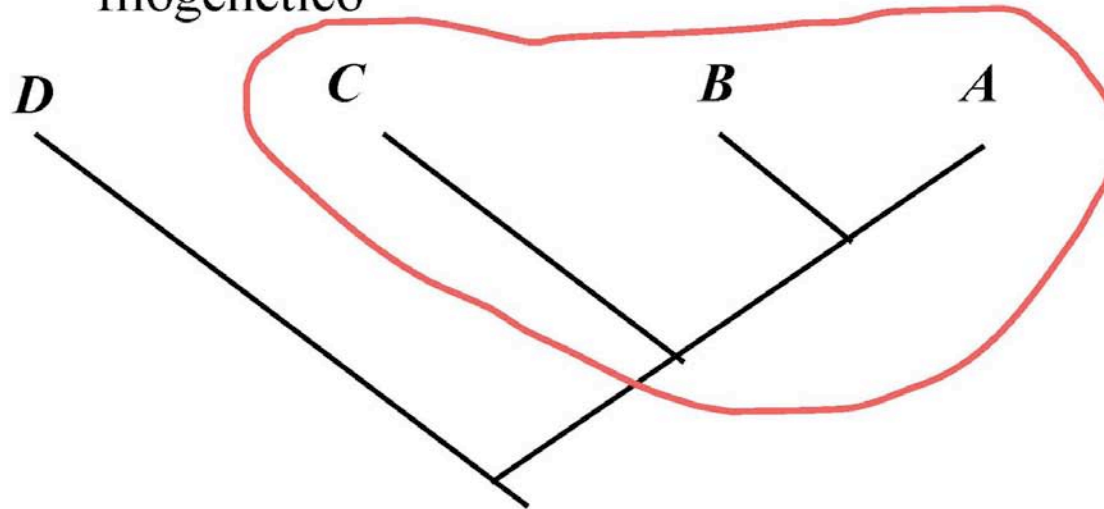
Simplesiomorfo: Carácter plesiomorfo compartido

Within this taxon set, hair is a **shared ancestral character (symplesiomorphy)** of **non-cetaceans**.

It would *not indicate a close relationship of marsupial and placental mammals.*

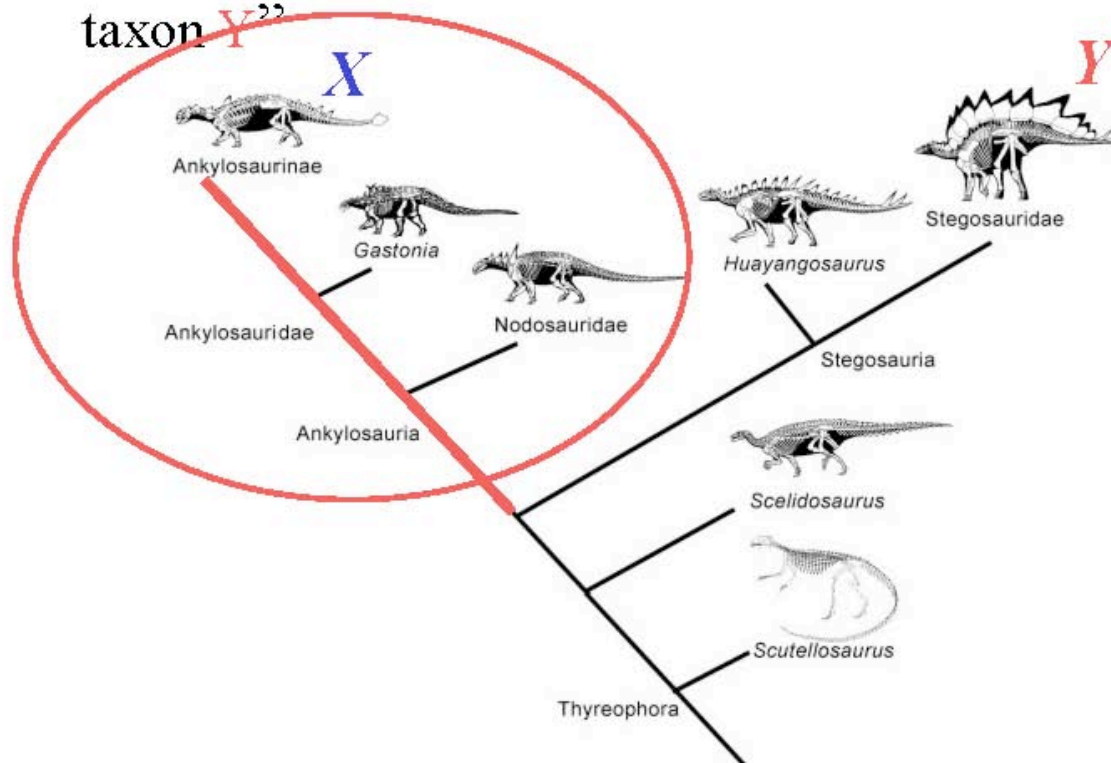
Las plesiomorfias compartidas no definen grupos naturales, sino parafiléticos

- **Grupo Monofilético** (“rama única”): todos los descendientes de un ancestro común.
 - o El ancestro común más reciente de los miembros de un grupo monofilético es también un miembro de aquel grupo
 - o Representa una rama completa del árbol filogenético



Los grupos monofiléticos son “grupos naturales”

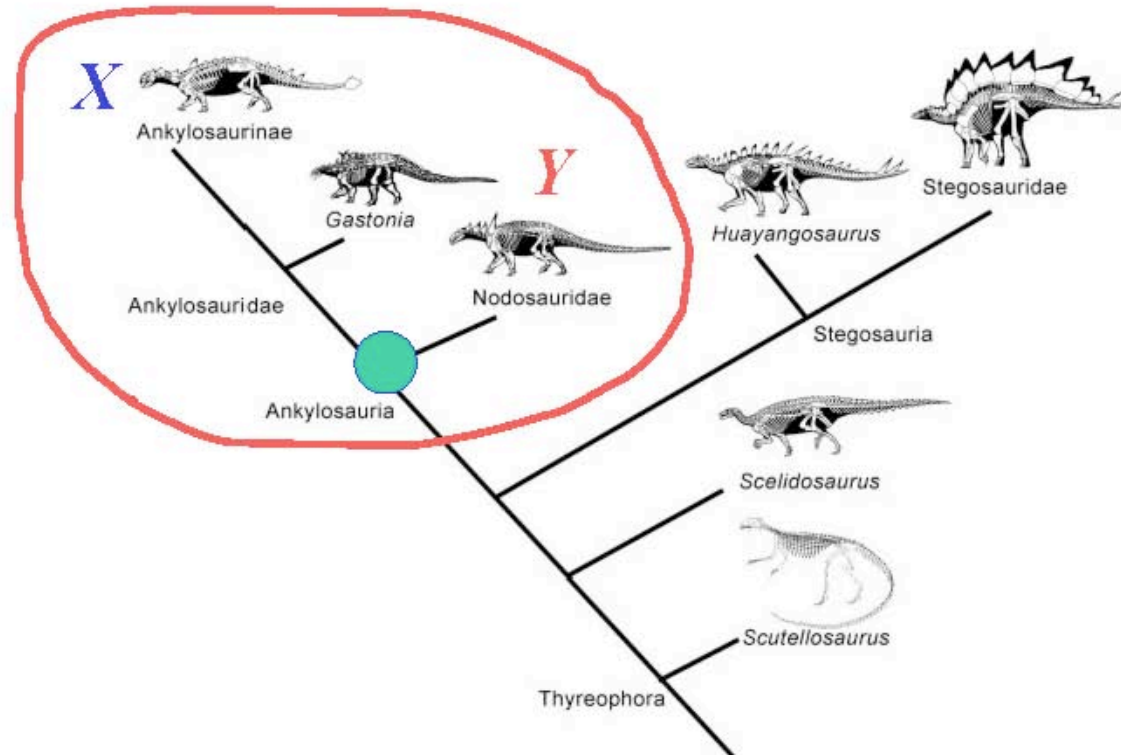
- Taxón basado en rama (stem-based taxon) -
 “Taxon X y todos los organismos que comparten una ancestro en común más reciente que con el taxon Y”



Ej. Los protostomos son todos los bilaterales que comparten un ancestro en común más reciente con una mosca que con ser humano

(nota para profesor: detenerse un poco en las ventajas para la designación de formas fósiles...el “primer” vertebrado, por ejemplo)

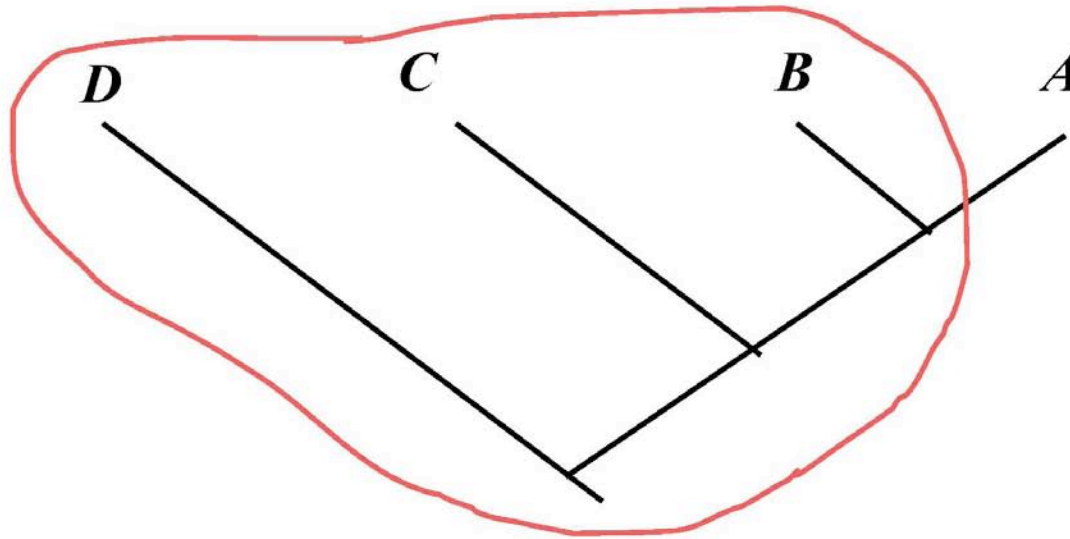
- Taxón basado en nodo (Node-based taxon)- “El ancestro en común más reciente de los taxones X e Y, y todos los descendientes de aquel ancestro”



Ej. Bilaterales: El ancestro en común más reciente de una mosca y un ser humano, y todos los descendientes de aquel ancestro

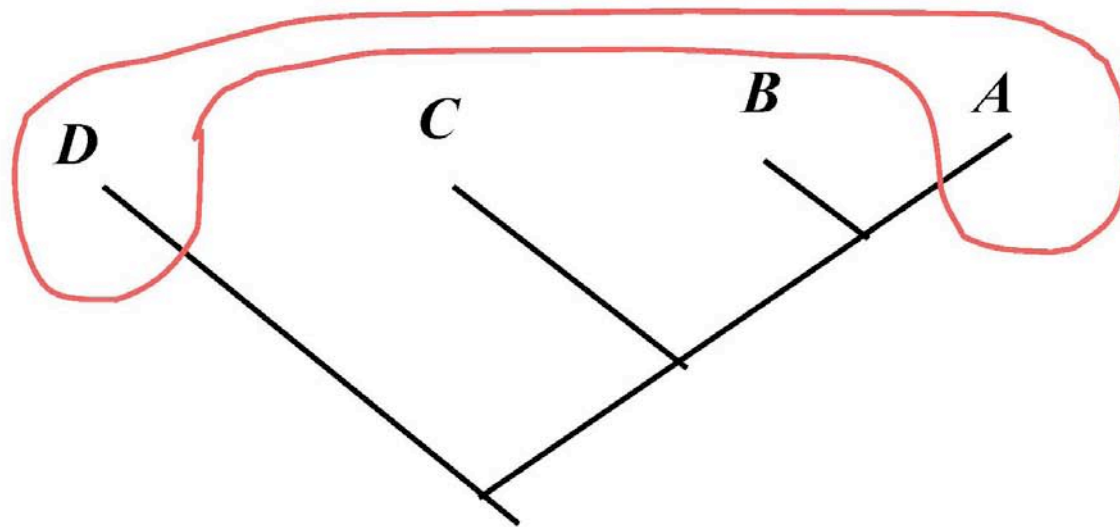
(nota para el profesor: detenerse en la utilidad para designar grupos corona o “verdaderos” ej eutetrapodos, neornithes)

- **Grupo Parafilético** (“casi una rama”): Algunos, pero no todos, los descendientes de un ancestro en común
 - o El ancestro en común más reciente de un grupo parafilético es también un miembro de aquel grupo
 - o Representa una rama del árbol filogenético con algunos brotes y ramitas podados



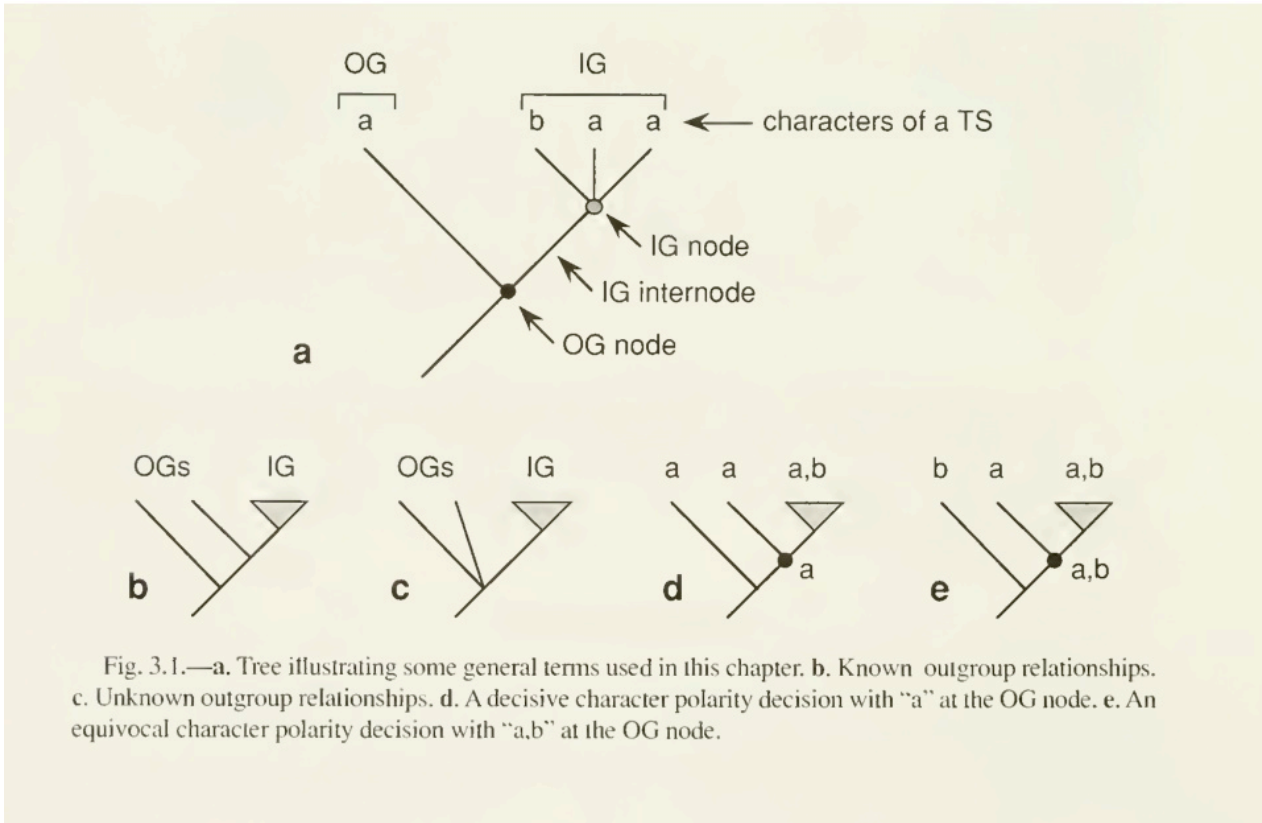
Ej. “Peces” incluye a los peces pulmonados pero excluye a sus descendientes tetrápodos

- **Grupo Polifilético** ("muchas ramas"): grupo compuesto por taxones que no comparten un ancestro en común más reciente que también pertenezca al grupo
 - o El ancestro en común más reciente de un grupo polifilético **no** es un miembro de aquel grupo
 - o Representa dos o más ramas separadas del árbol de la vida



Ej. Paquidermos incluye a rinocerontes e hipopotamos pero excluye cerdos y camellos (A es hipopotamo, B es cerdo, C es camello y D es rinoceronte).

El arte de polarizar caracteres



Desde las ramas más distantes, haga lo siguiente: Marque el nodo “a” si el nodo inferior y el nodo adyacente son ambos “a” o bien “a” y “a,b”. Marque “b” si son ambos “b” o “a,b”. Si el nodo inferior y el adyacente son diferentes (“a” y “b”) marque una asignación equívoca “a,b”

Table 3.1.—Data matrix for the analysis of Sidae (Example 3.1).

TS	Taxon							Sidae
	M	N	O	P	Q	R		
1	b	a	a	b	b	a	a,b	
2	b	b	a	b	b	a	a,b	
3	a	b	b	b	b	a	a,b	
4	a	a,b	a	b	b	a	a,b	

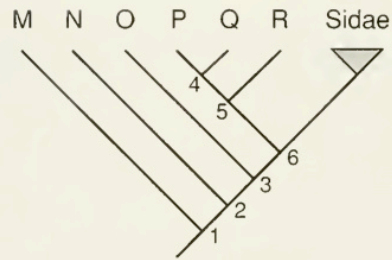


Fig. 3.2.—The relationships of the Sidae and its closest relatives. Outgroups are letters, nodes are numbers (Example 3.1).

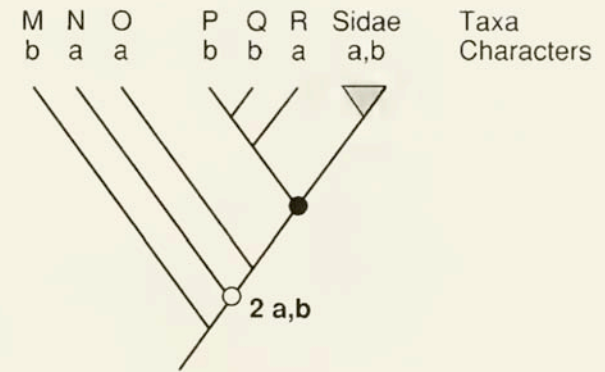


Fig. 3.4.—First polarity decision for TS 1, analysis of the Sidae (Example 3.1).

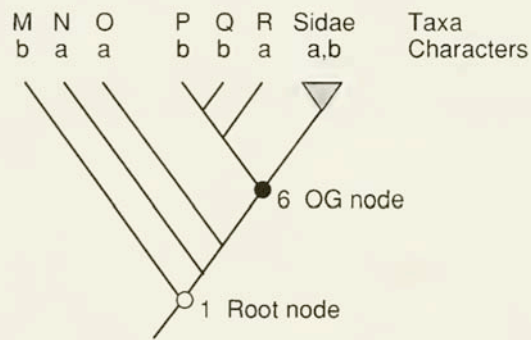


Fig. 3.3.—The relationships of the Sidae and its relatives, with characters from TS 1 (Table 3.1) and relevant nodes labeled (Example 3.1).

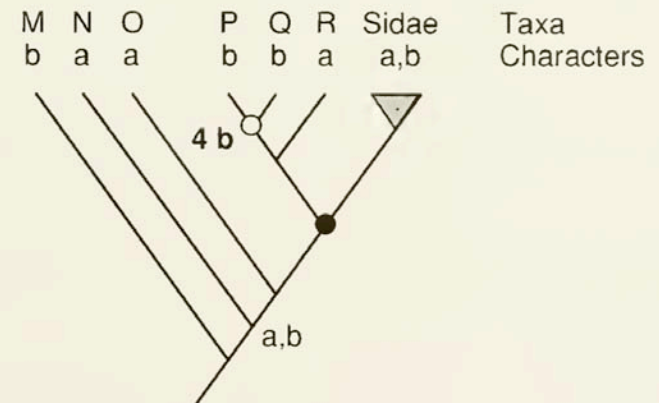


Fig. 3.5.—Second polarity decision for TS 1, analysis of the Sidae (Example 3.1).

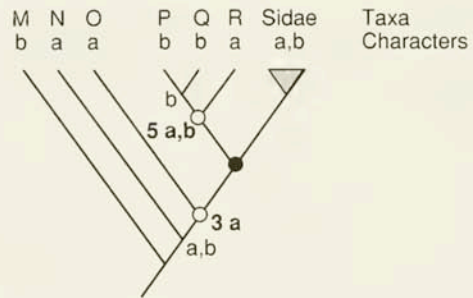


Fig. 3.6.—Third and fourth polarity decisions for TS 1, analysis of the Sidae (Example 3.1).

6. The analysis is over when we reach an assignment concerning the OG node. In this example, the assignment to node 6 is a decisive "a" (Fig. 3.7).

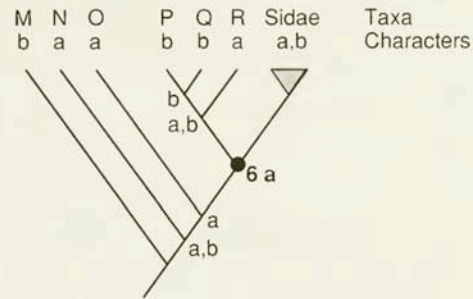


Fig. 3.7.—Assignment of polarity to the OG node for TS 1, analysis of the Sidae (Example 3.1).

Figure 3.8 shows characters of TS 2 of the matrix worked out for each node. Note that in this case the decision is equivocal for the OG node.

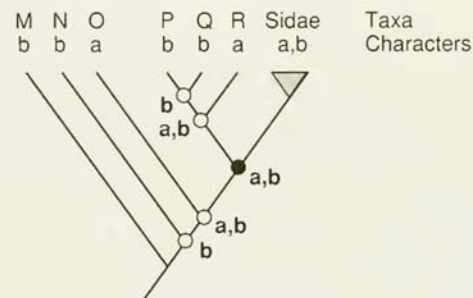


Fig. 3.8.—Polarity decisions for TS 2, analysis of the Sidae (Example 3.1).

Table 3.1.—Data matrix for the analysis of Sidae (Example 3.1).

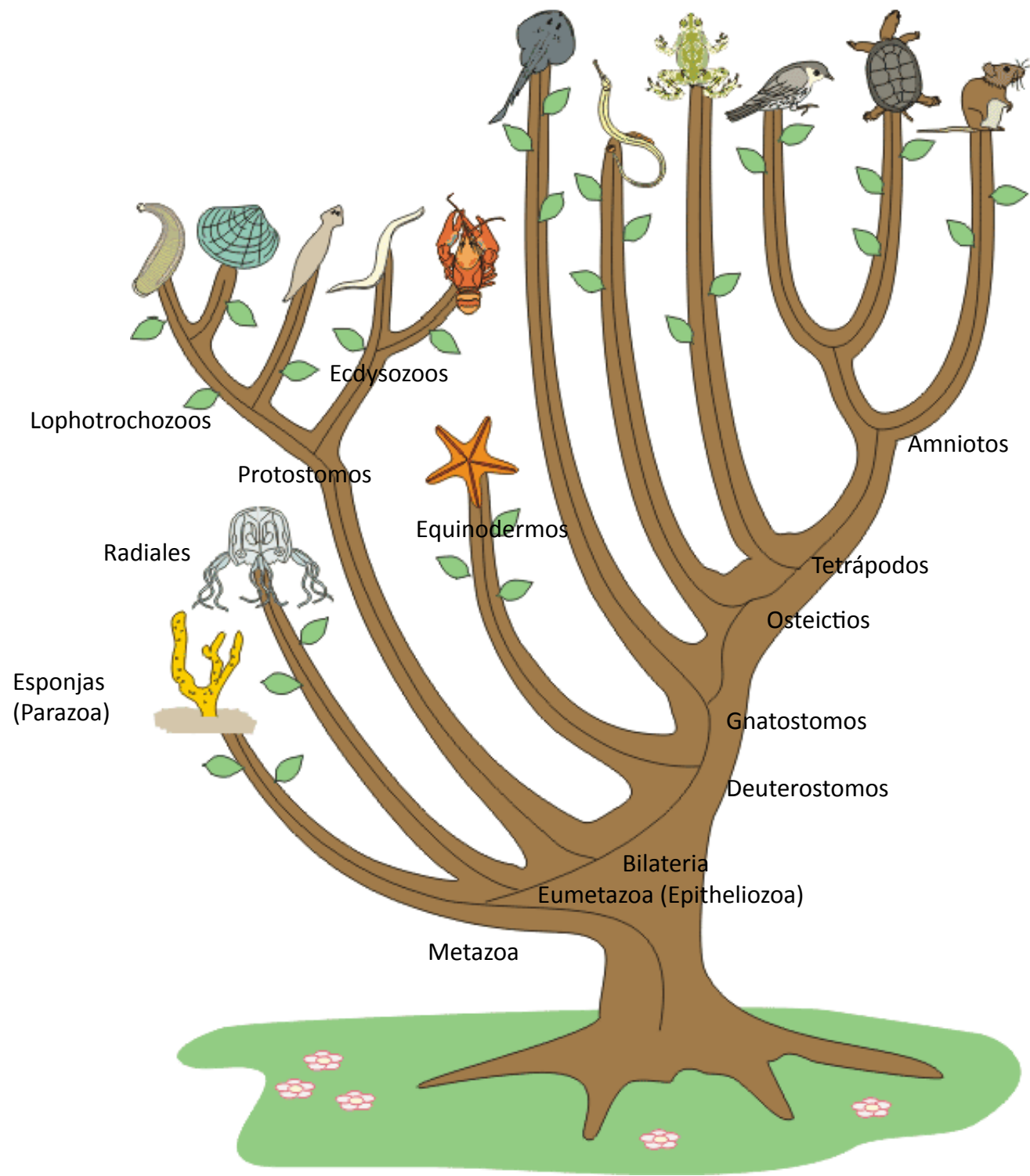
TS	Taxon						
	M	N	O	P	Q	R	Sidae
1	b	a	a	b	b	a	a,b
2	b	b	a	b	b	a	a,b
3	a	b	b	b	b	a	a,b
4	a	a,b	a	b	b	a	a,b

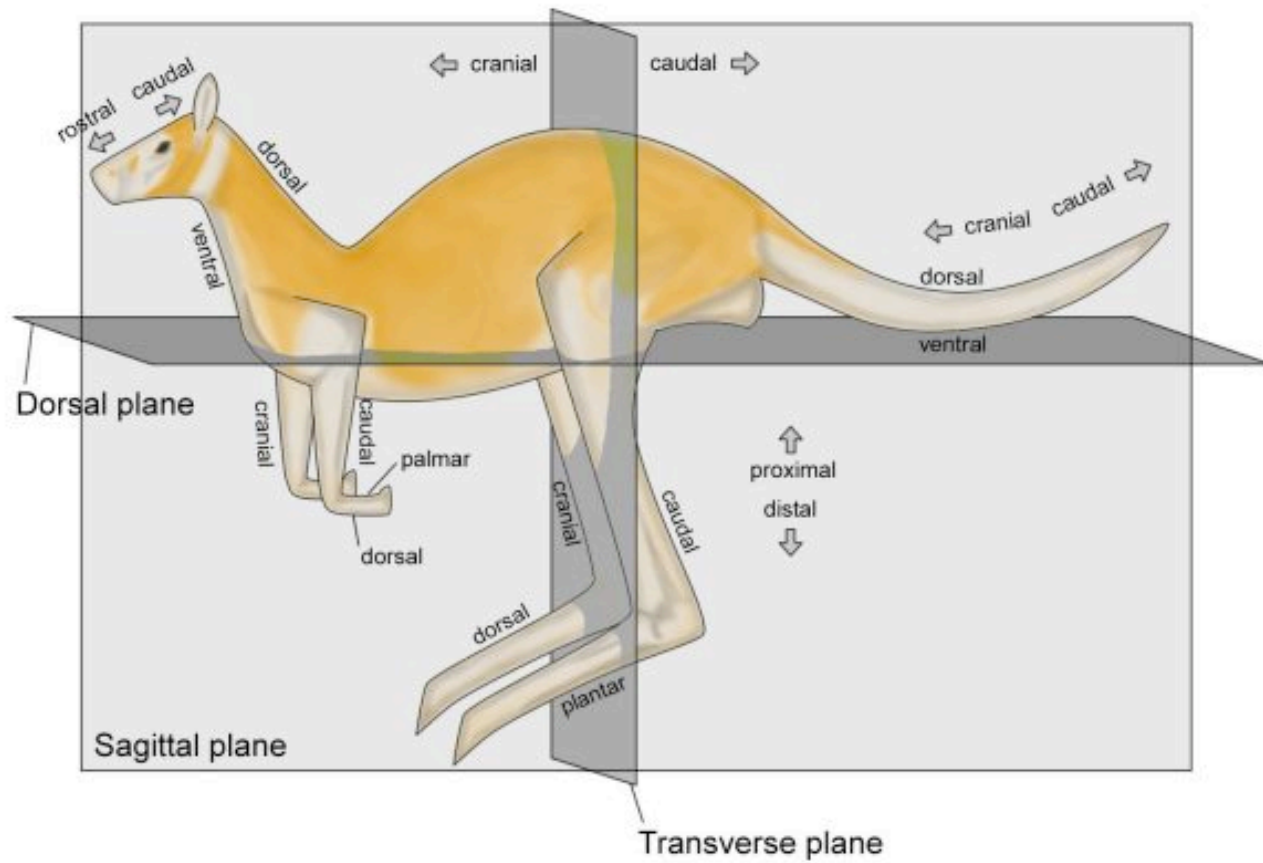
RULES OF THUMB

Maddison et al. (1984) present two rules of analysis that can be used when sister group relationships are known. These rules will help you bypass some of the argumentation for each node of the tree.

Rule 1: The Doublet Rule.—If the sister group and the first two *consecutive* outgroups have the same character, then that character is decisive for the OG node. Any two consecutive outgroups with the same character are called a **doublet**.

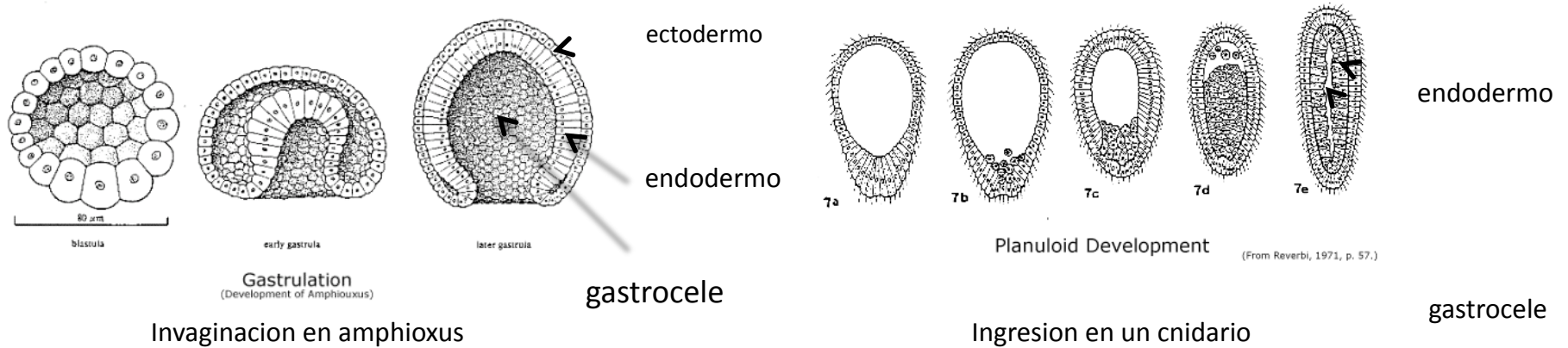
Rule 2: The Alternating Sister Group Rule.—If characters are alternating down the tree, and if the last outgroup has the same character as the sister group, then the character will be decisive for the OG node. If the last outgroup has a different character, then the character decision will be equivocal.





Mediante el proceso de gastrulación, las células que ingresan conforman un intestino primitivo (**arquenteron**) en forma de tubo interno.

El espacio al interior del arquenteron se denomina **gastrocele**. Durante la gastrulación, el blastocele que existía entre epiblasto e hipoblasto es obliterado y desaparece. La capa de células que queda hacia el exterior se llama **ectodermo**; la capa de células del tubo interno (que da al gastrocele) se le llama **endodermo**, que da lugar a todas las vísceras (excepto urogenitalia)



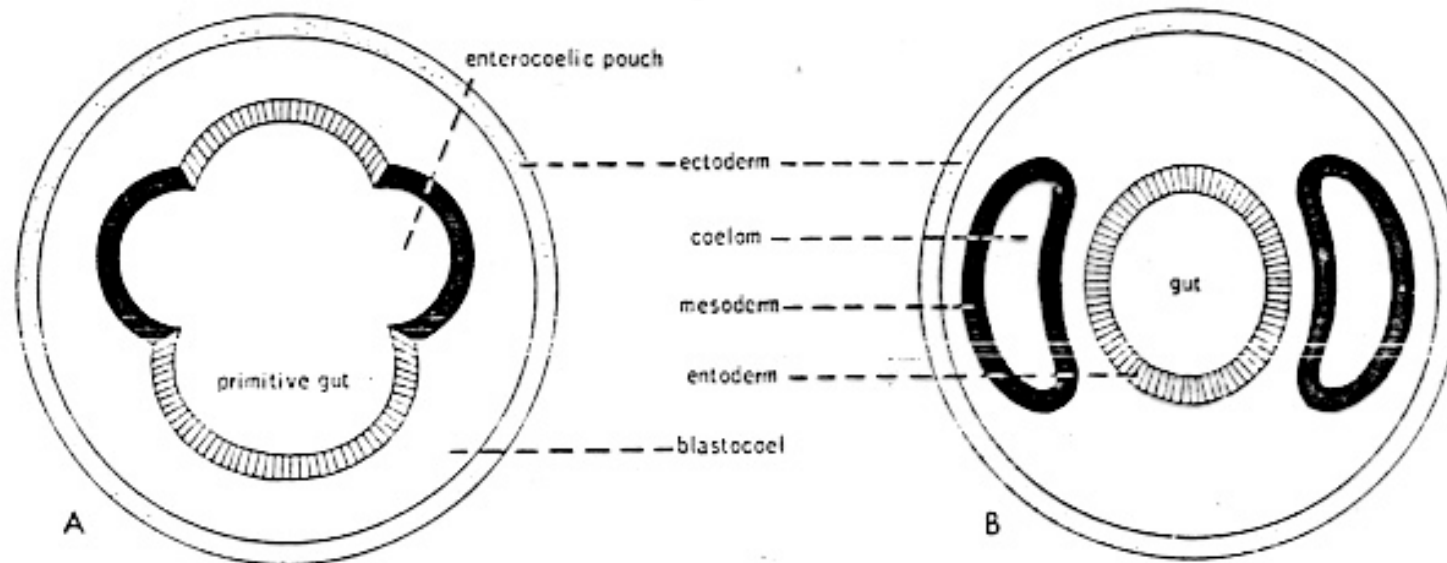
El epiblasto da origen al ectodermo, la capa externa de células que dan lugar a la piel y el sistema nervioso

El hipoblasto da origen a estructuras asociadas a la alimentación, el arquenteron en animales basales, y **saco vitelino** en vertebrados amniotas. Ambos se consideran derivados endodérmicos

Las células que ingresan al embrión, además de dar lugar al endodermo dan lugar a una tercera capa de células que se ubica entre el endodermo y el ectodermo: El **mesodermo**, que da lugar a tejidos conectivos y musculatura

El mesodermo genera cavidades corporales internas, “**celomas**” conformando una suerte de endoesqueleto hidrostático. Este es un rasgo propio de los animales bilaterales (protostomos + deuterostomos) o **celomados**, ausente en cnidarios y poríferos.

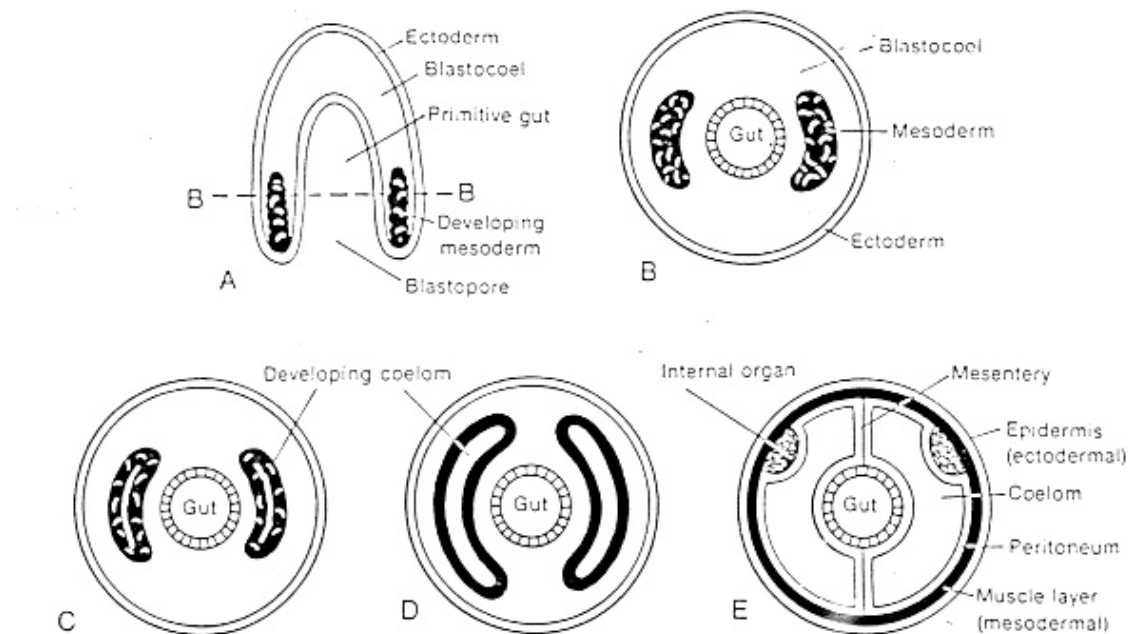
En los bilaterales basales, el mesodermo de las cavidades celómicas se origina a partir de evaginaciones del endodermo, hacia la región dorsal del arquenteron. Esto se denomina como formación **enterocélica** del celoma. La cavidad del celoma es originalmente continua con la del blastocele.



Mesoderm and coelom formation by enterocoelic pouching. A. Lateral evaginations of wall of primitive gut. B. Separation of pouches to form coelom, mesoderm, and definitive gut endoderm.

Formacion enterocelica del celoma en un erizo

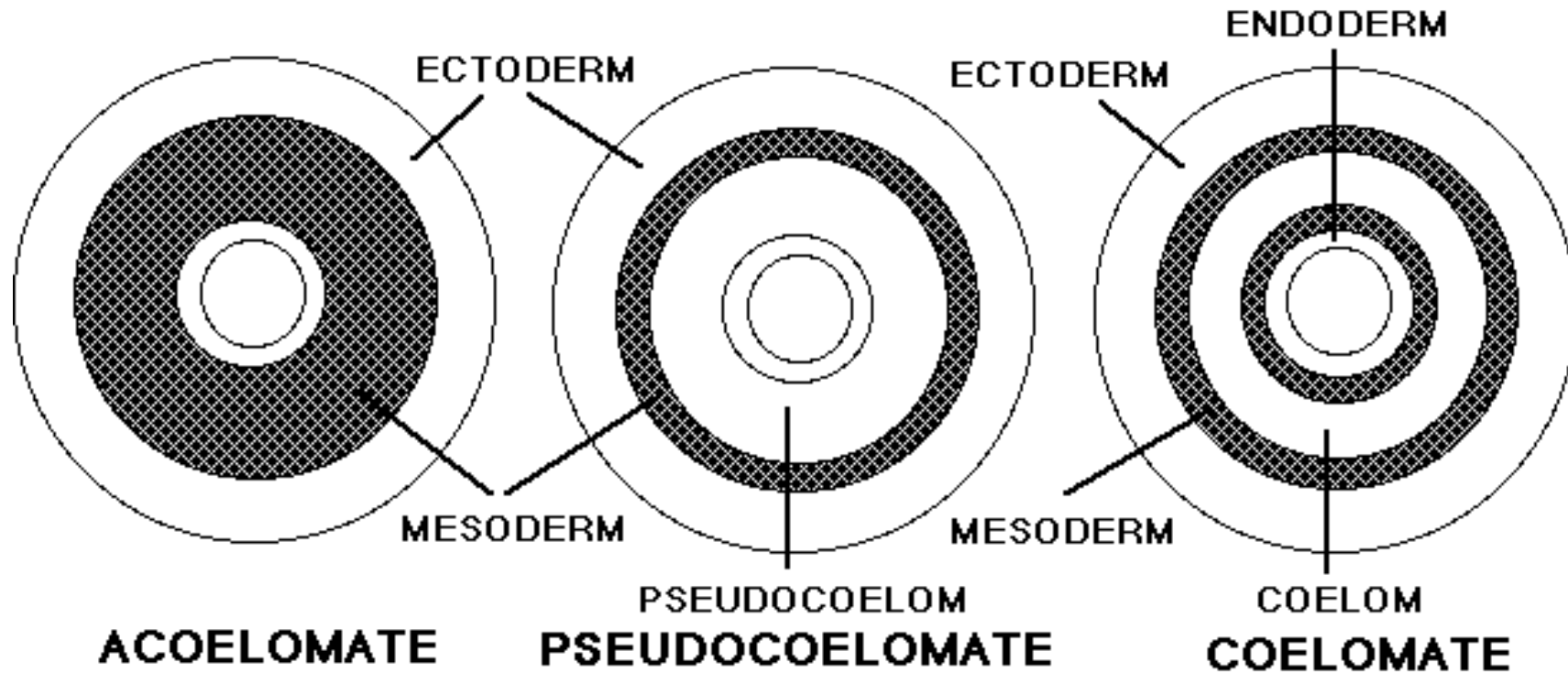
En la gastrulación, las células del mesodermo pueden ingresar como un mesénquima laxo de células ameboides altamente móviles. Estas pueden luego condensarse en bloques inicialmente macizos pero que luego desarrollan una cavidad interna, en lo que se conoce como desarrollo **esquizocélico** de la cavidad del celoma



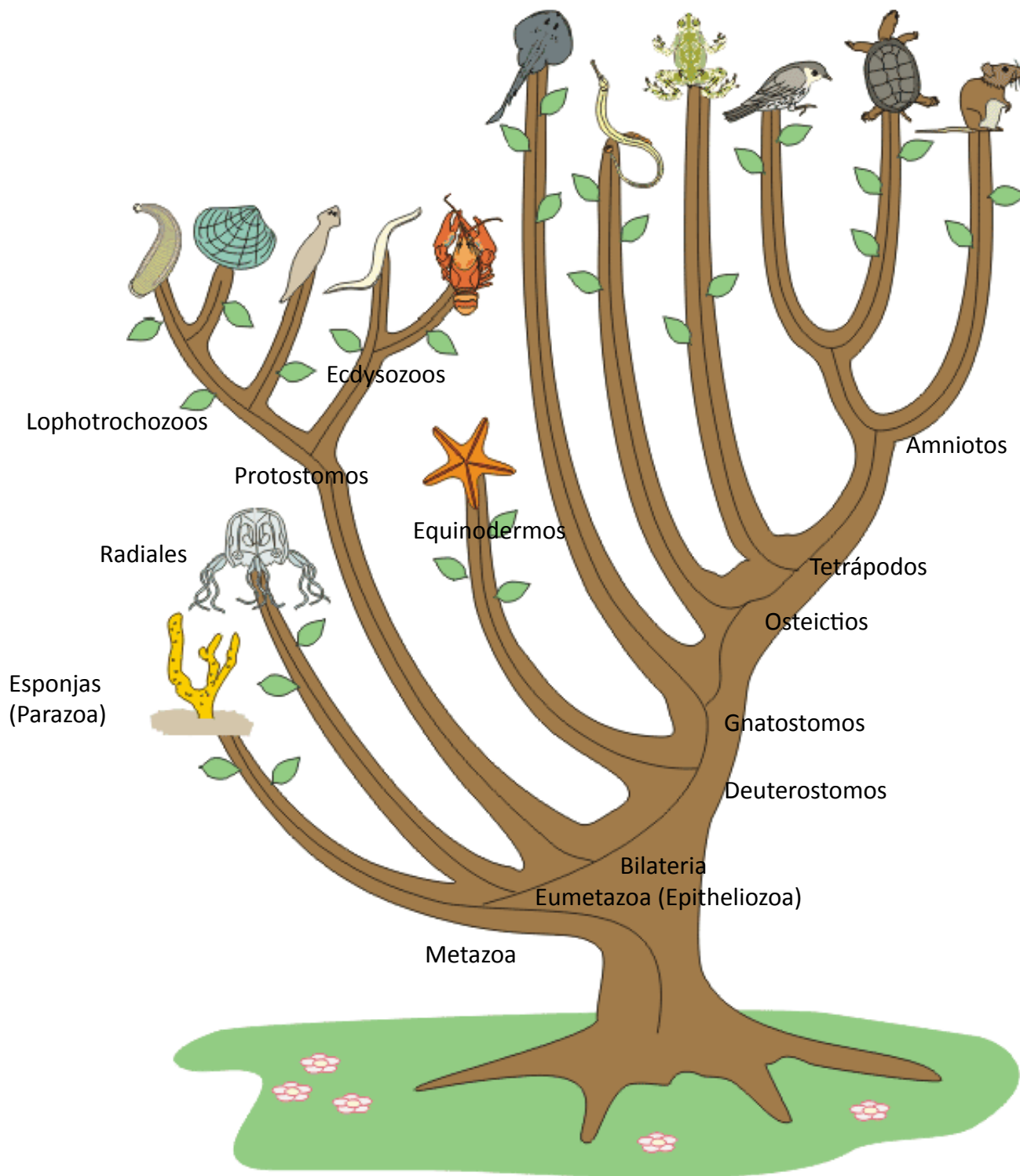
Origin of the coelom by schizocoely. A. Frontal section of a late gastrula. B. Cross section of gastrula at level indicated in A. C. Coelom developing as a split (schizocoel) in the mesodermal mass. D. Further development of the mesoderm and coelom. Note that the old blastocoel is gradually obliterated. E. Cross section through an adult coelomate protostome. Muscle layer develops from mesoderm. Internal organs lie behind peritoneum (retroperitoneal), which lines coelom.

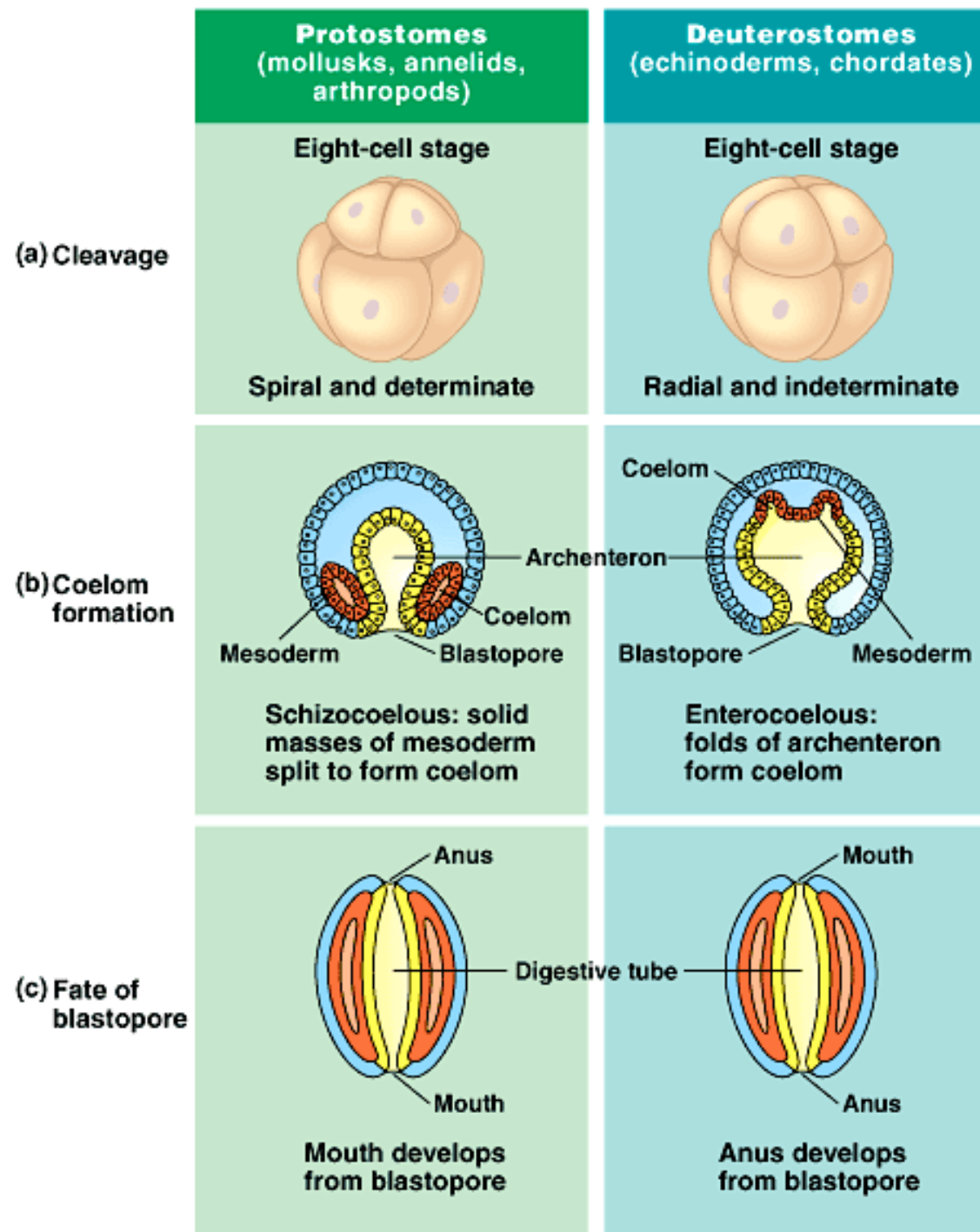
El celoma da origen a la pared muscular del cuerpo y a los revestimientos musculares de las vísceras

En algunos bilaterales la organización de cavidades internas se simplifica o pierde parcialmente: Acelomados, Pseudocelomados. Alguna vez se pensó que algunas formas como estas eran basales, hoy sabemos que descienden de verdaderos celomados.

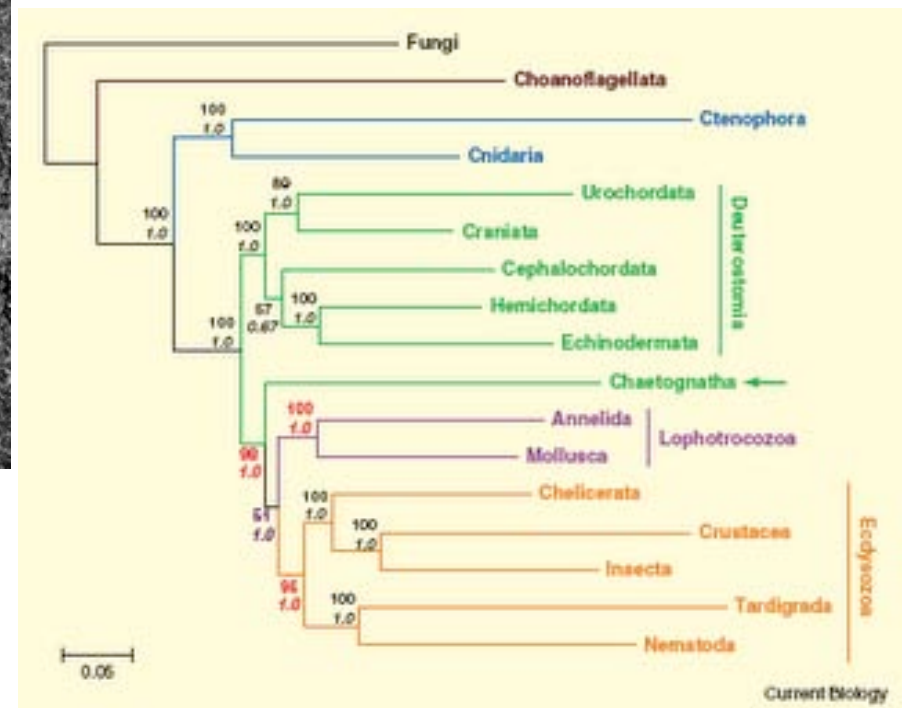
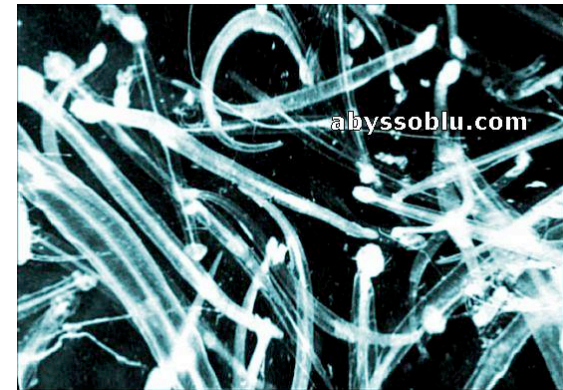


REDRAWN FROM: WHARTON, 1986 (PAGE 9)

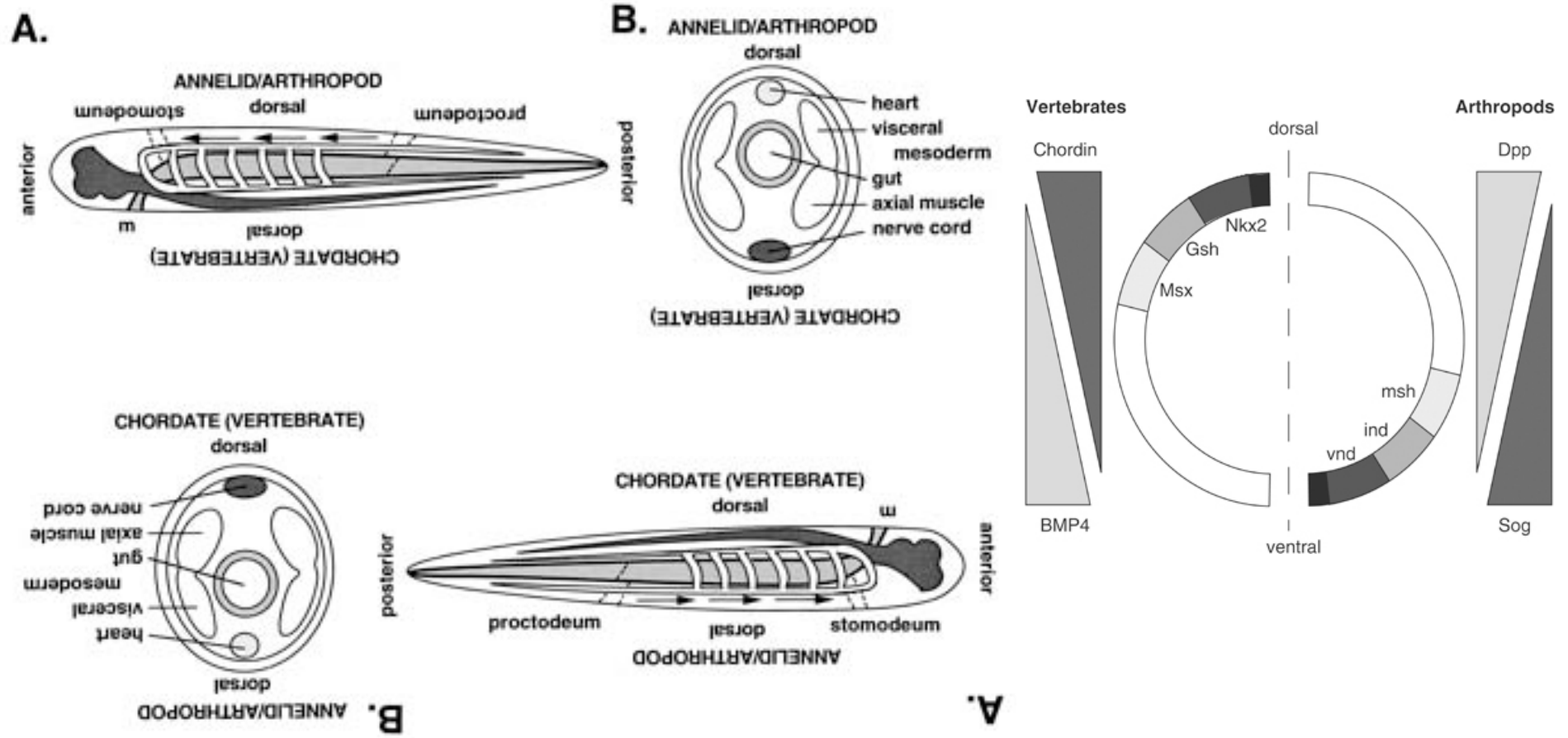


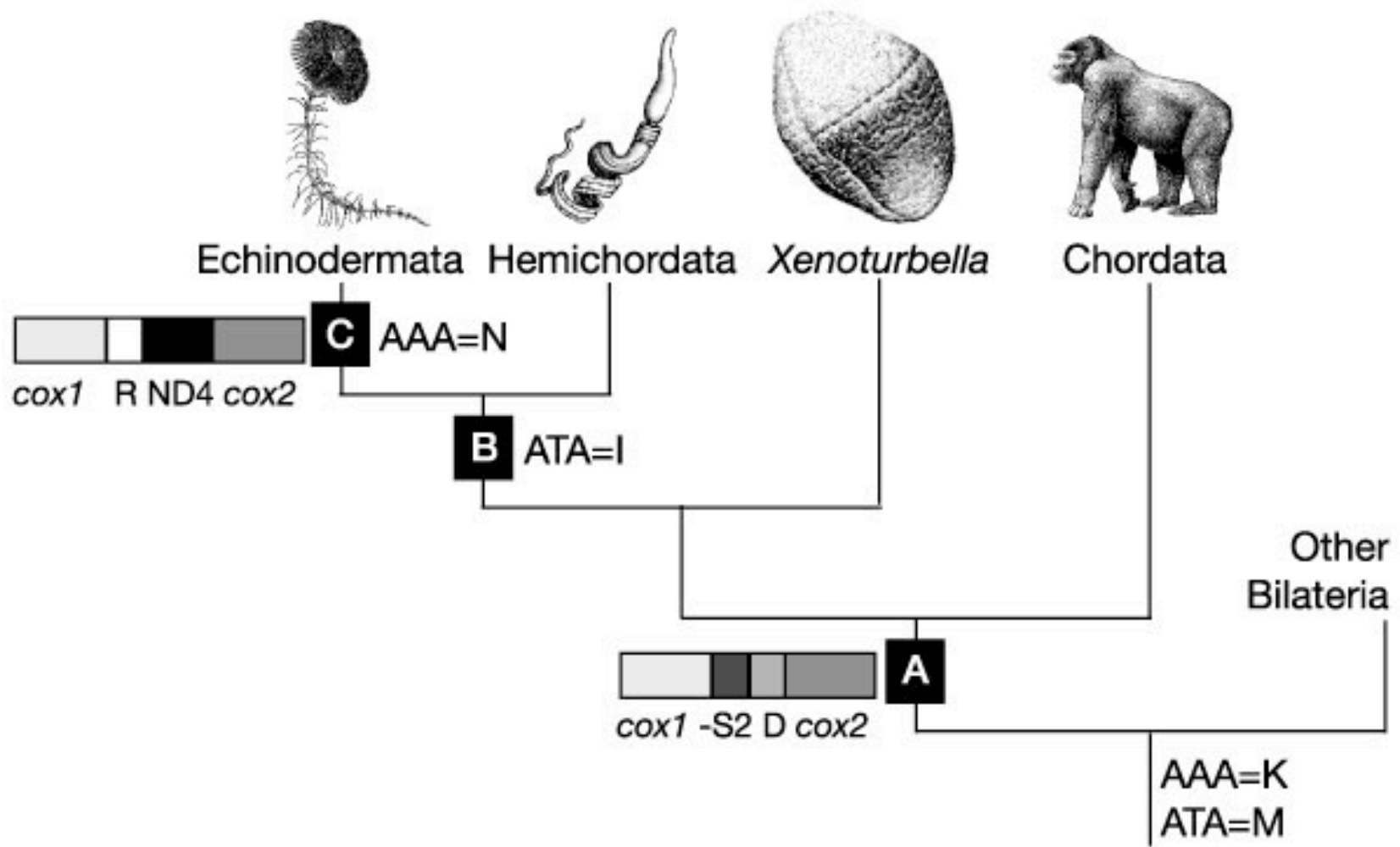


Los primeros bilateria eran semejantes a deuterostomos. Los Chaetognatha o gusanos flecha son protostomos basales. Desarrollan cavidades celomicas pareadas y enterocelicas en la region cefalica y un blastoporo que forma el ano. Estos rasgos estaban presentes en el ancestro comun de protostomos y deuterostomos. Los Chaetognathos presentan una cola post-anal nadadora que tambien es posible que haya estado en los primeros bilateria



Los Protostomos están orientados al revés (“de espaldas”) que un Deuterostomo





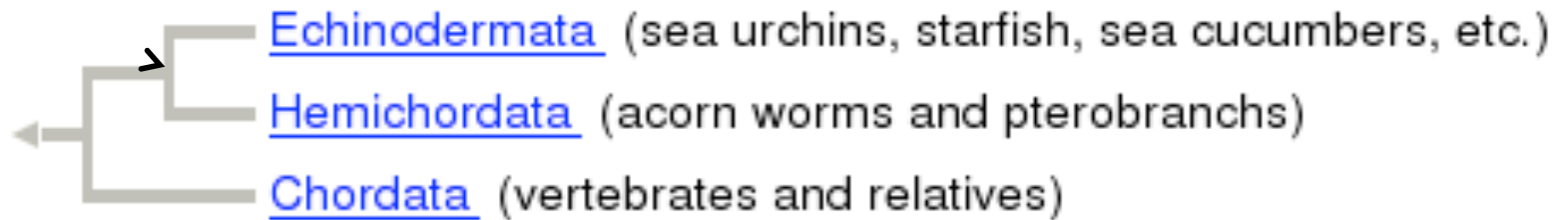
Deuterostoma

Sin embargo, existe consenso de que los ancestros de los vertebrados tendrían varios rasgos más semejantes a los cephalochordata que a los urochordata (ej, somitos y arcos faríngeos pareados). Los primeros vertebrados del registro fósil son semejantes a cefalocordados.

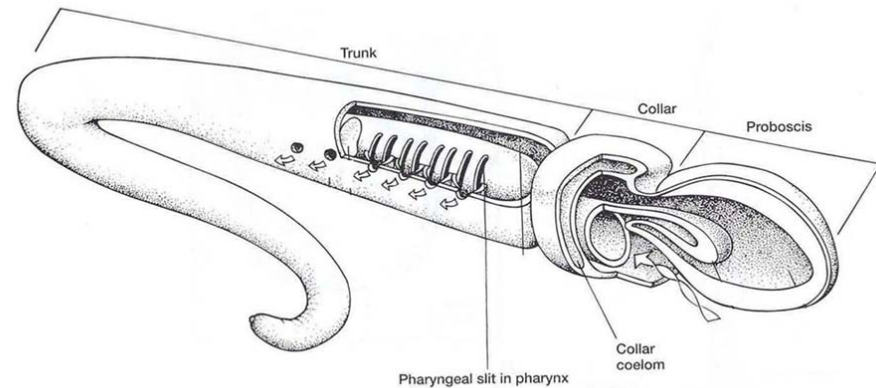
Los primeros deuterostomos eran semejantes a cordados

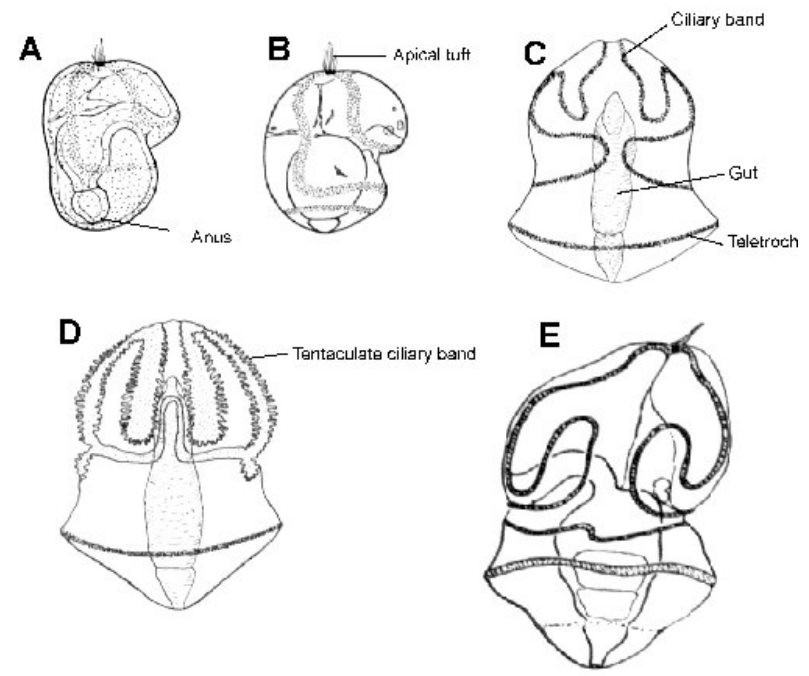
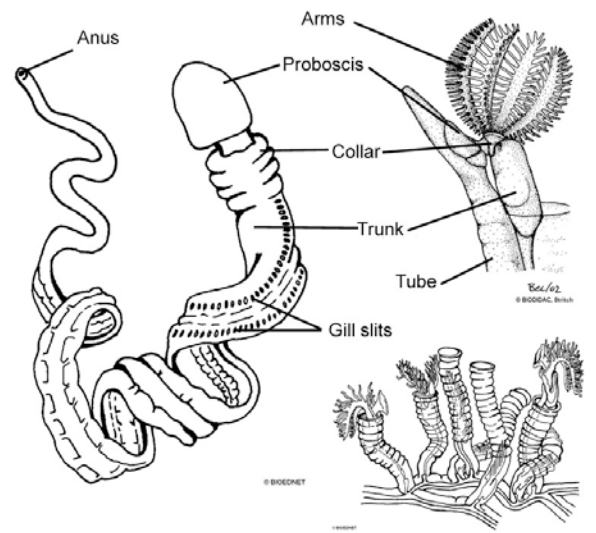
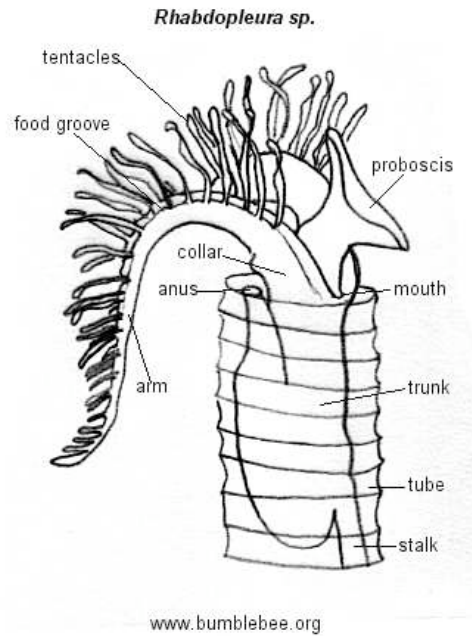
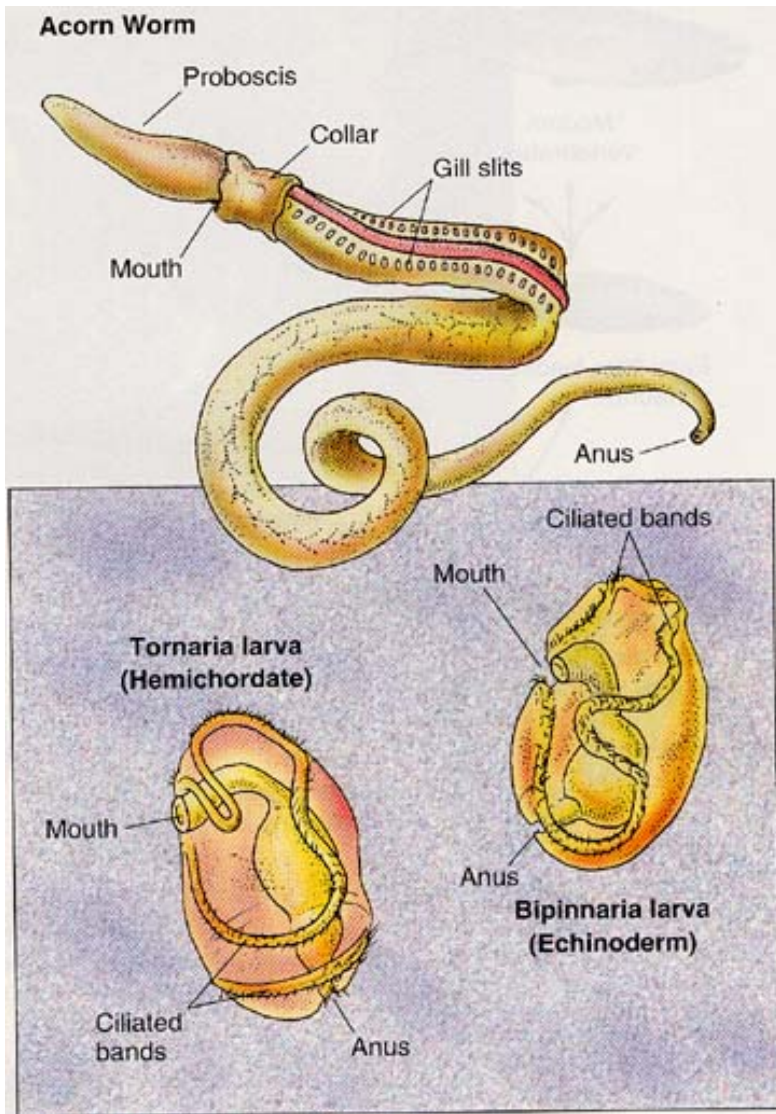
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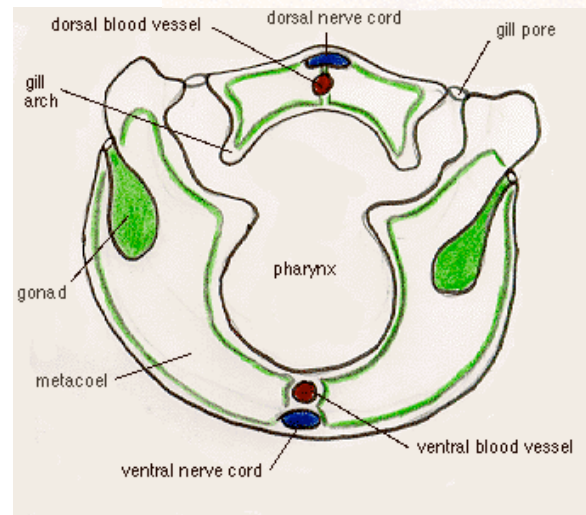
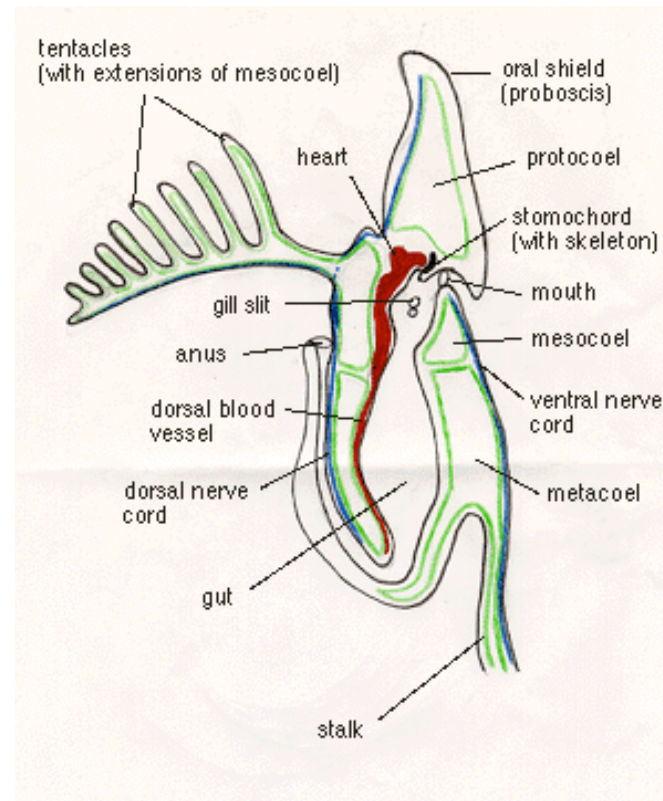
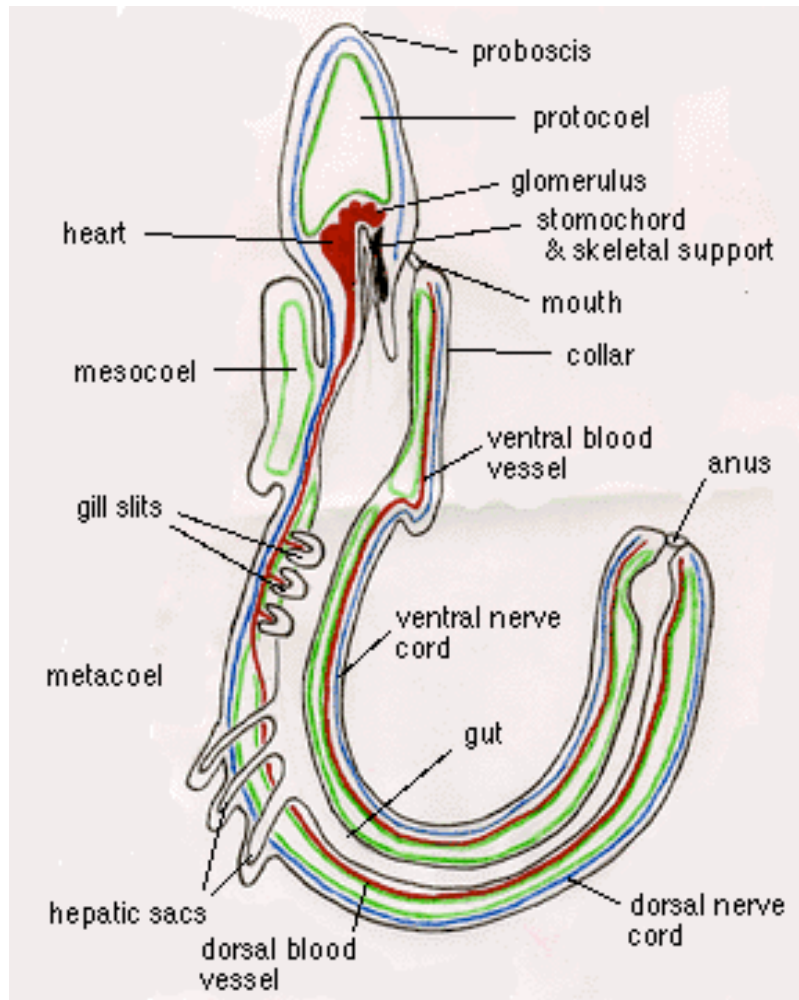
Ambulacraria

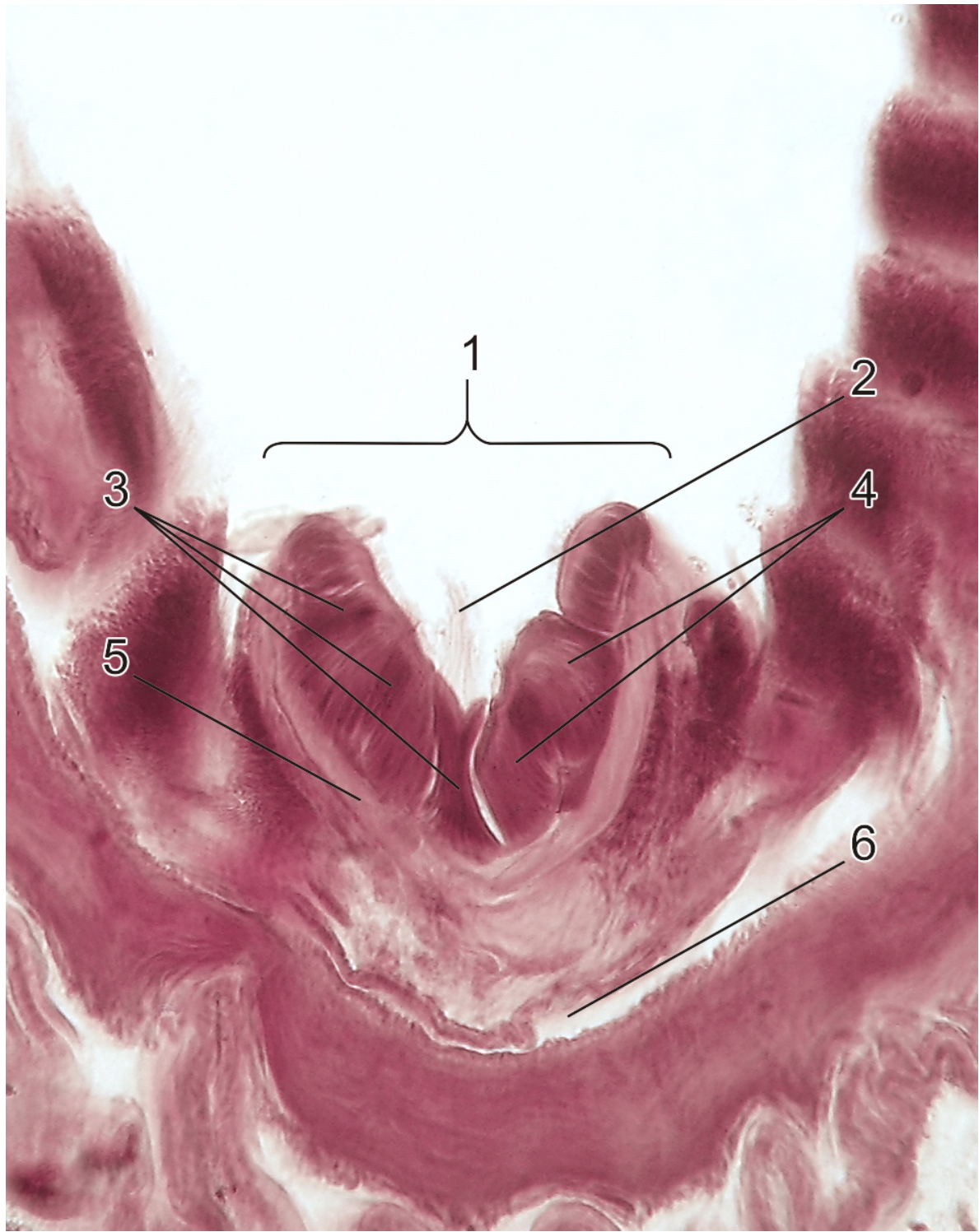


Los hemichordados enteropneustos, al igual que en cordados, posee una faringe que comunica a la boca con *arcos branquiales cartilagosos*. Posee dos plexos nerviosos longitudinales, uno ventral y uno dorsal, y dos estructuras semejante a la notocorda (el estomocordo y el pygocordo).

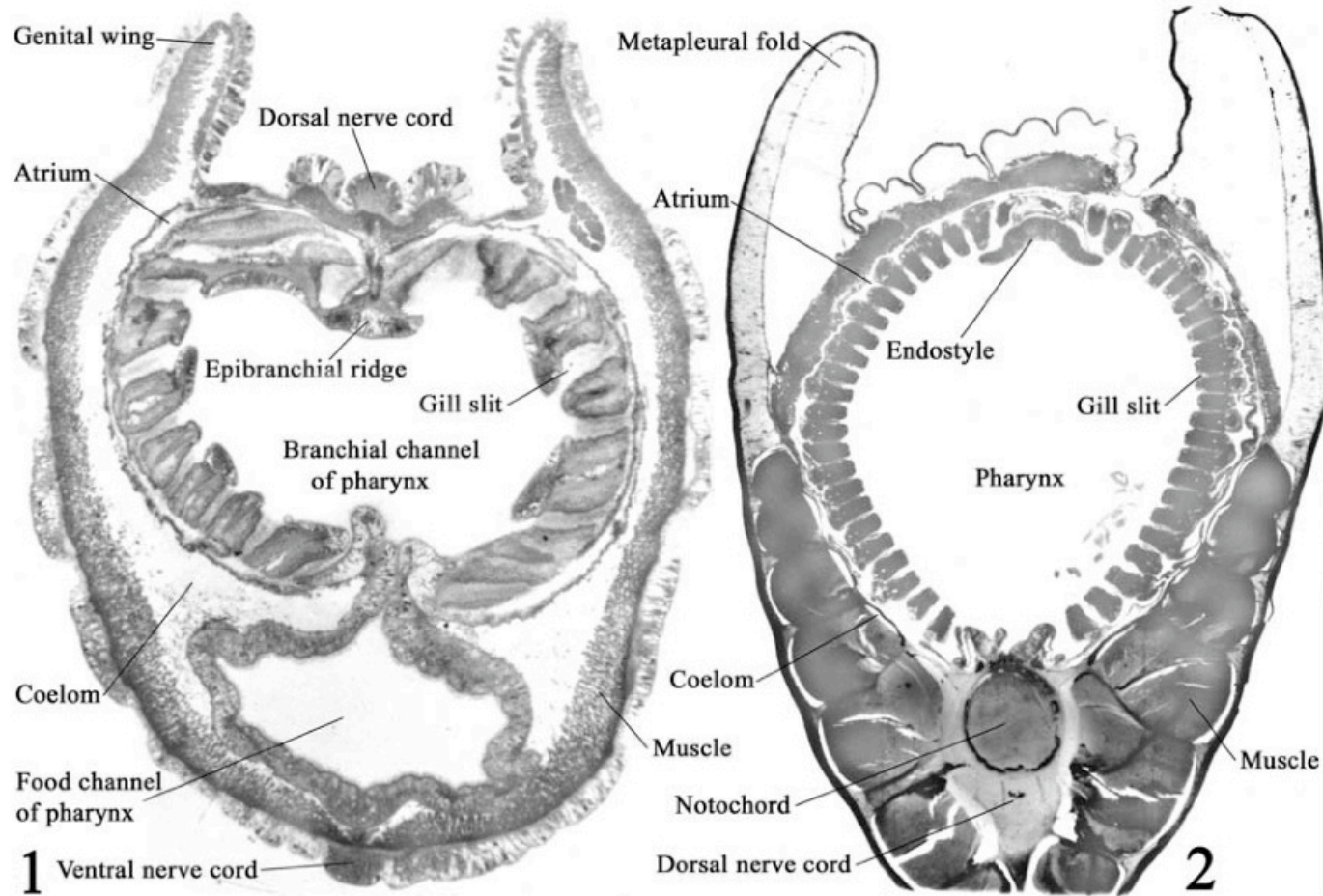


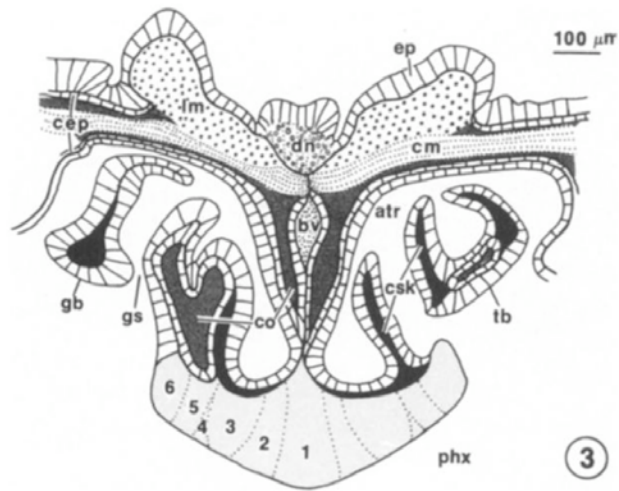




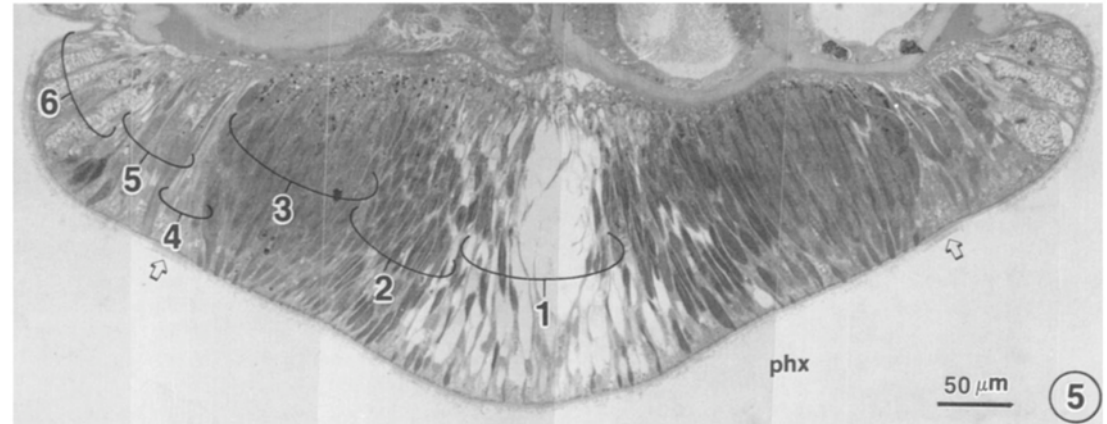


Figs. 1 and 2. Anatomy of the branchial body region of Enteropneusta and Cephalochordata in transverse section at the same scale. Fig. 1. The enteropneust *Balanoglossus aurantiacus* in conventional dorsoventral orientation. Fig. 2. The cephalochordate *Branchiostoma virginiae* Hubbs, 1922 in inverted (ventral side up) orientation. Scale bar = 1 mm.

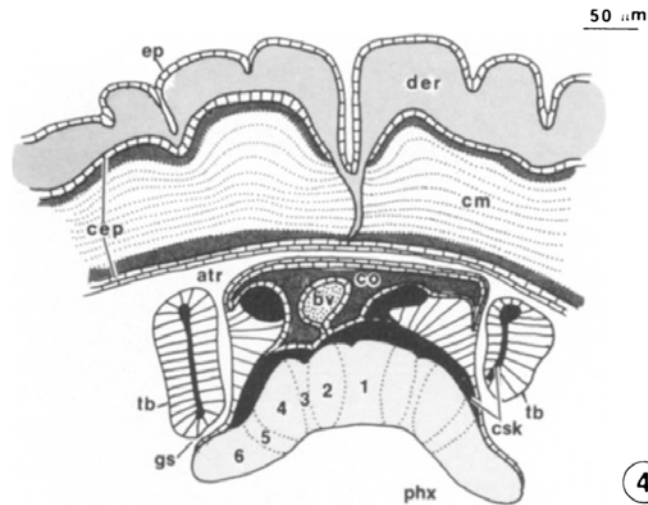




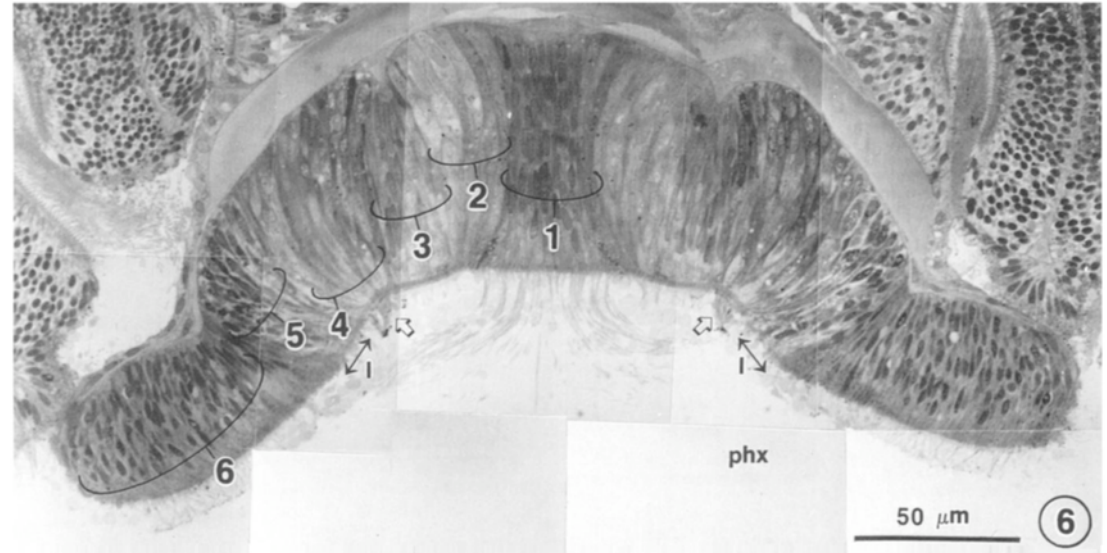
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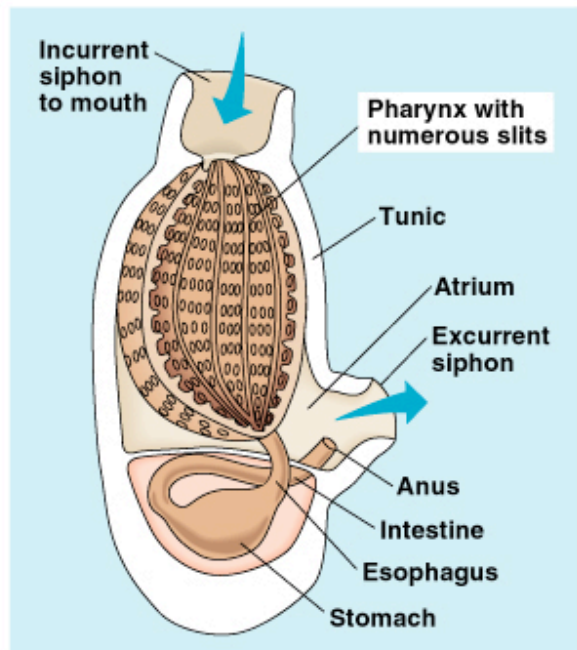
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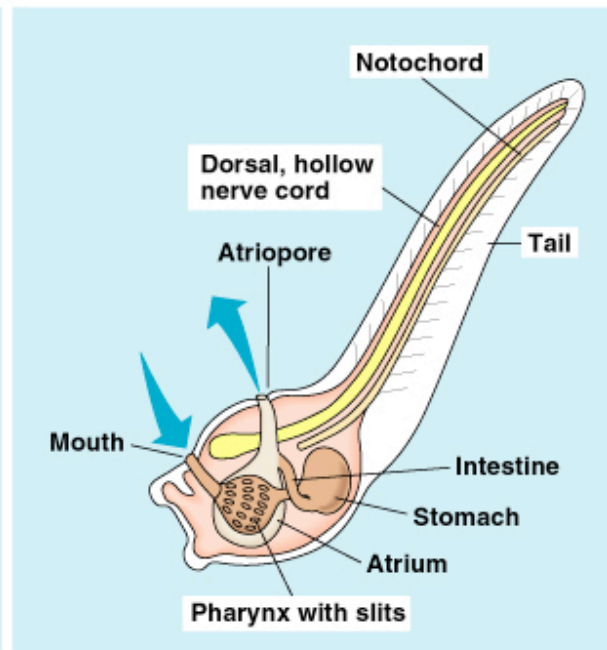
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Figs. 3, 4. Diagrammatic cross-sectional organization of the epibranchial ridge and body wall of the enteropneust *Schizocardium brasiliense* (Fig. 3) and the endostyle and body wall (inverted) of the cephalochordate *Branchiostoma virginiae* (Fig. 4). 1–6, cellular zones of secretory epithelium. Atrium or branchial sac (atr); blood vessel (bv); coelomic epithelium (cep); circular muscle (cm); coelom (co); collagenous skeletal material (csk); dermis (der); dorsal nerve cord (dn); epidermis (ep); primary or gill bar (gb); gill slit (gs); longitudinal muscle (lm); pharynx lumen (phx); secondary or tongue bar (tb).

Chordata

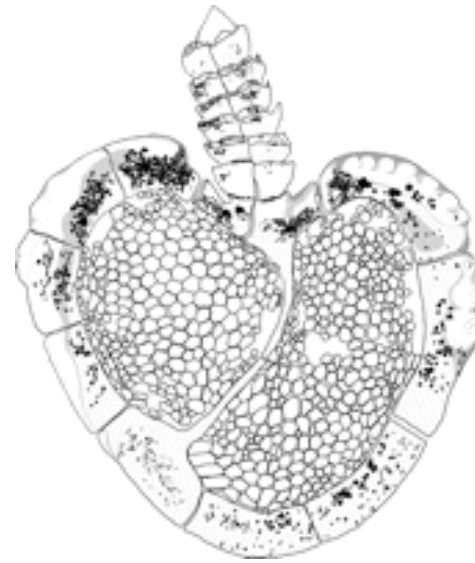


(b)



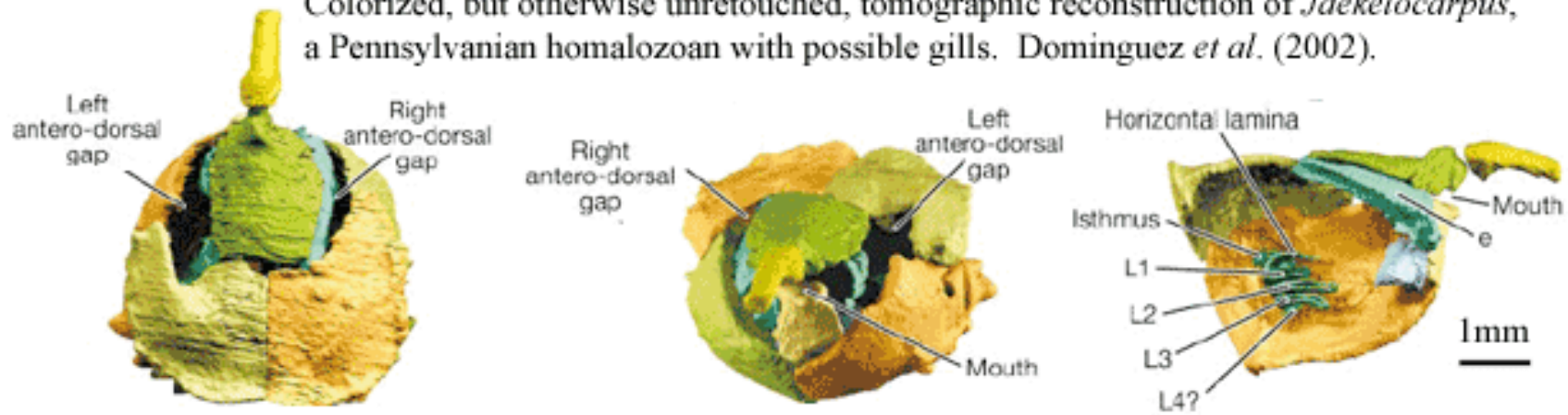
(c)

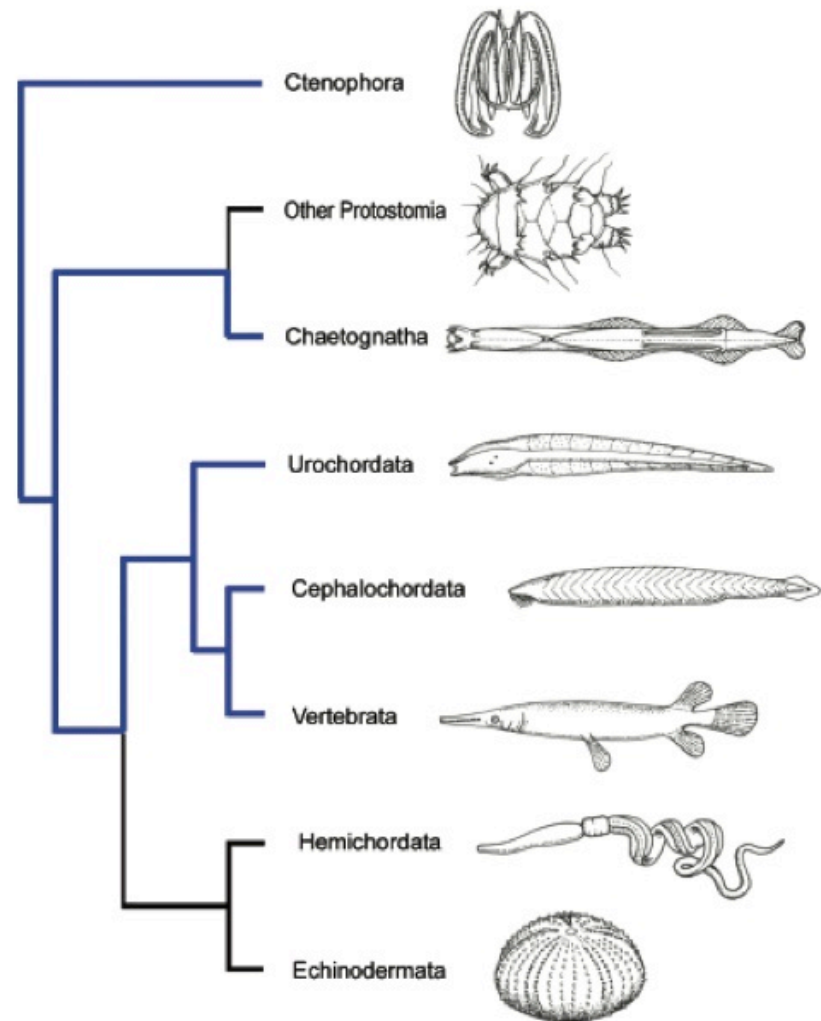
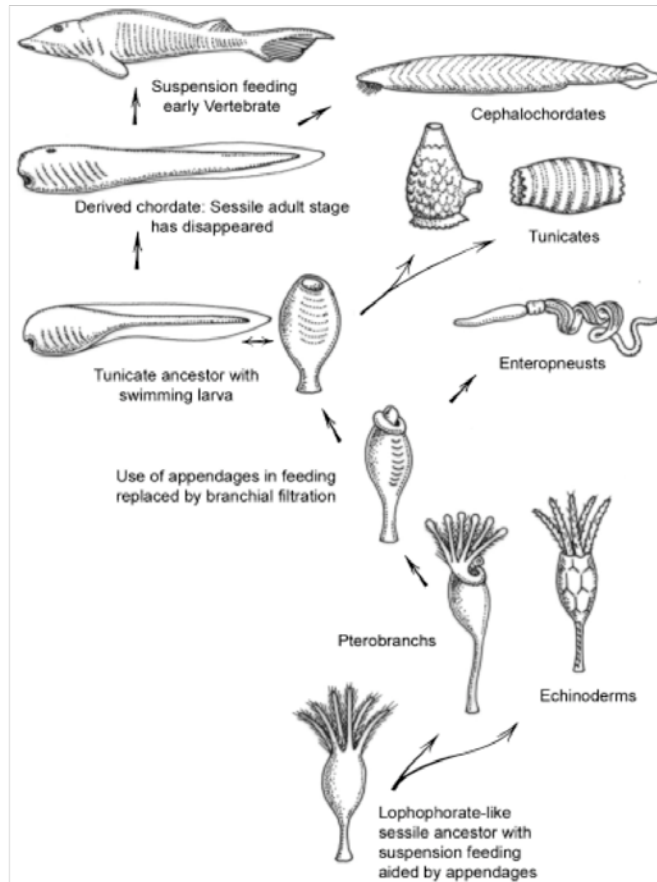
Los chordata poseen un notocordo: El notocordo es un elemento endoesquelético longitudinal, de células vacuoladas. El notocordo está presente en el embrión de todos los vertebrados y participa en la inducción del desarrollo del sistema nervioso.



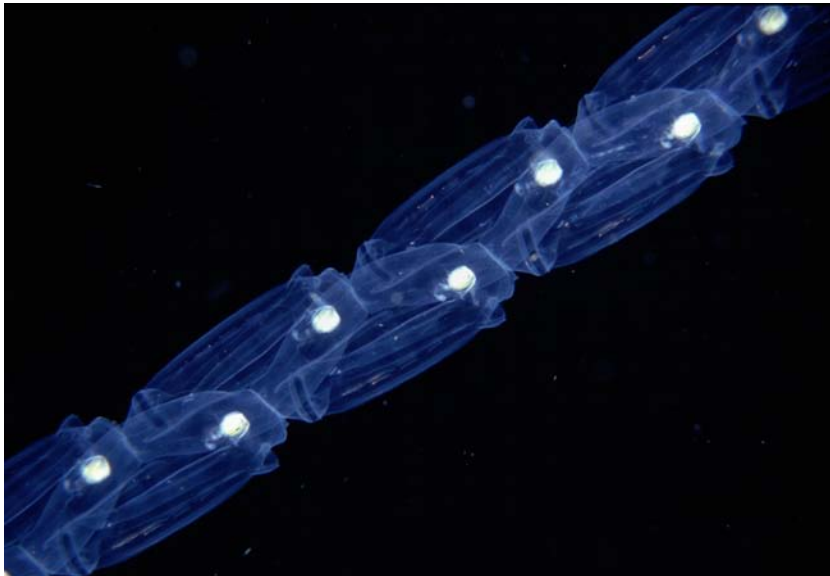
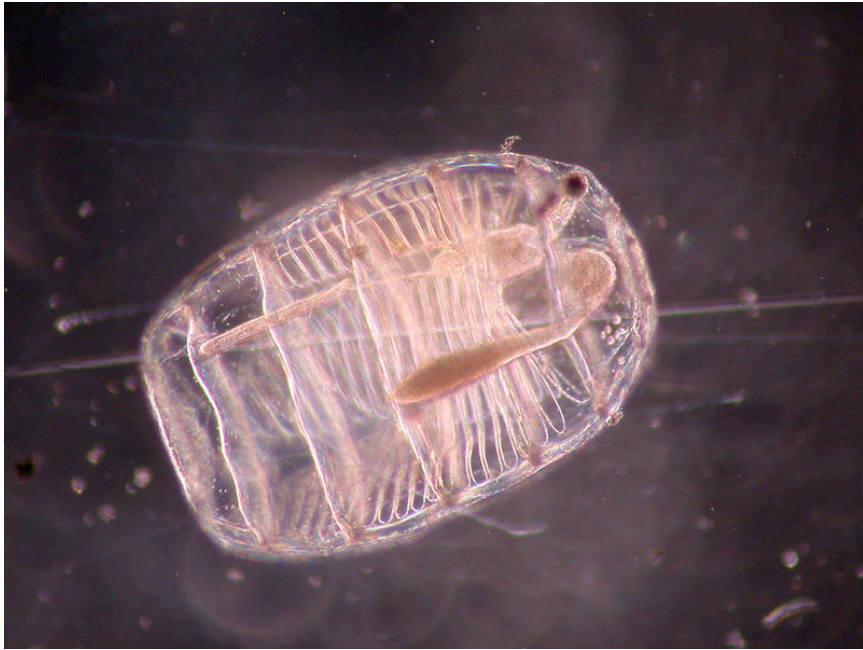
Rhenocystis from the Devonian of Germany. This image illustrates the difficulty of deciding which end is up. From *The Natural Canvas*

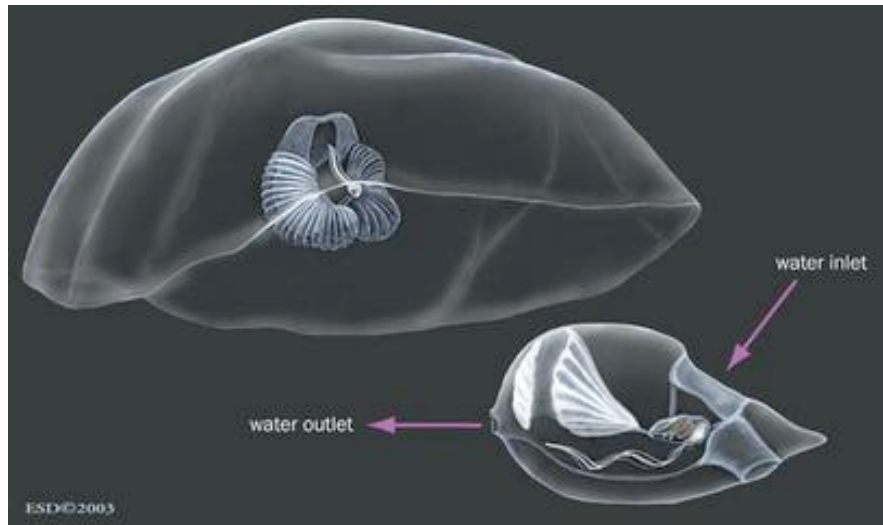
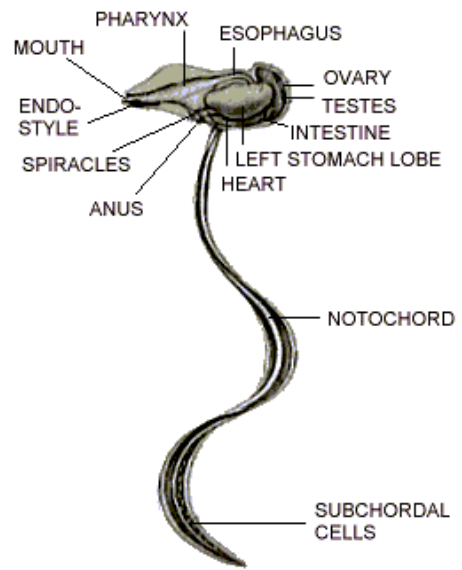
Colorized, but otherwise unretouched, tomographic reconstruction of *Jaekelocarpus*, a Pennsylvanian homalozoan with possible gills. Dominguez *et al.* (2002).



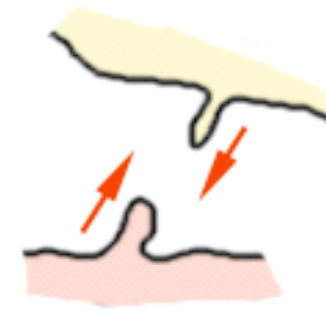
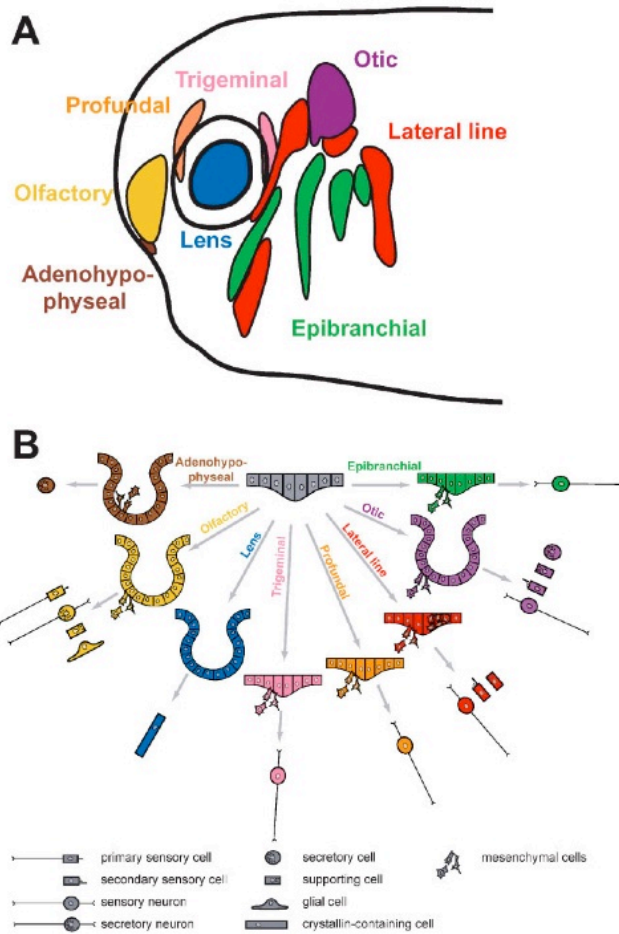






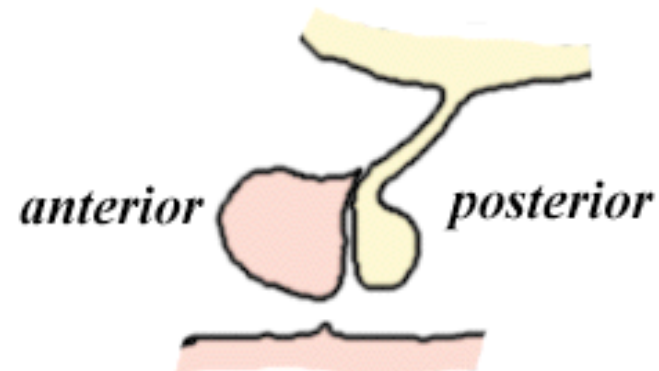


Pituitary Development



diencephalon

Rathke's pouch



En todos los vertebrados, existen pares de placodas ectodermicas hacia la zona de la cabeza, “islas” de células engrosadas que dan origen a neuronas sensoriales de la nariz (placodas olfatorias), del oído (placoda otica), de la línea lateral (organo mecanoreceptor de peces) y epibranchiales, que contribuyen neuronas sensoriales a los pares de nervios craneales VII, IX, y X

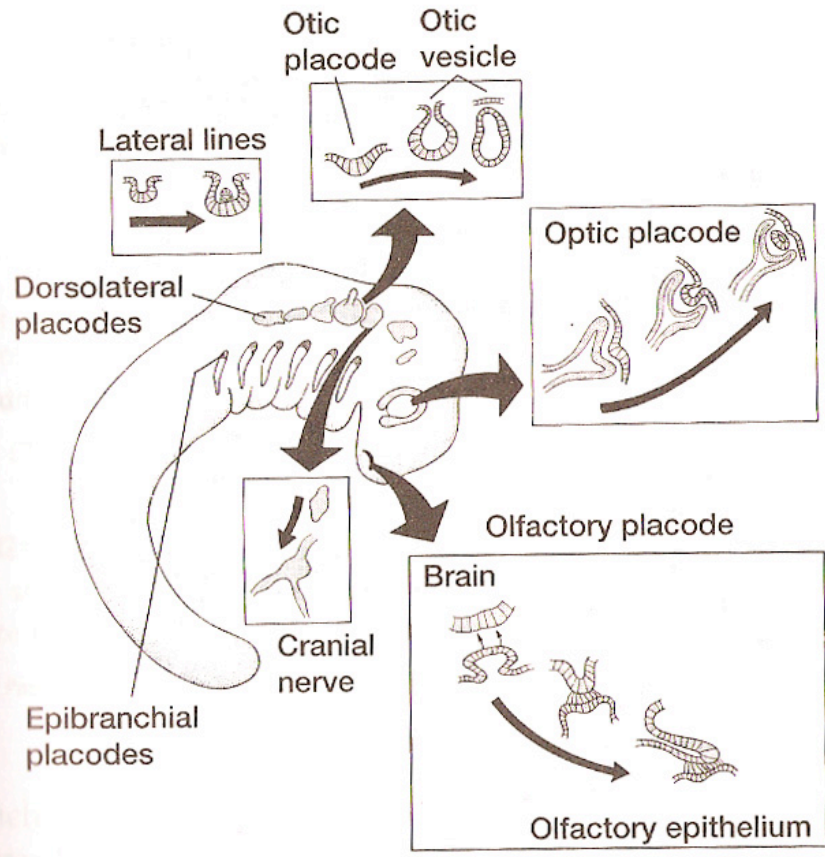


FIGURE 5.28 Ectodermal placodes in a representative vertebrate. There are two paired sets of ectodermal placodes, the dorsolateral and the epibranchial placodes, as well as the olfactory and the optic placodes. All form sensory organs or receptors.

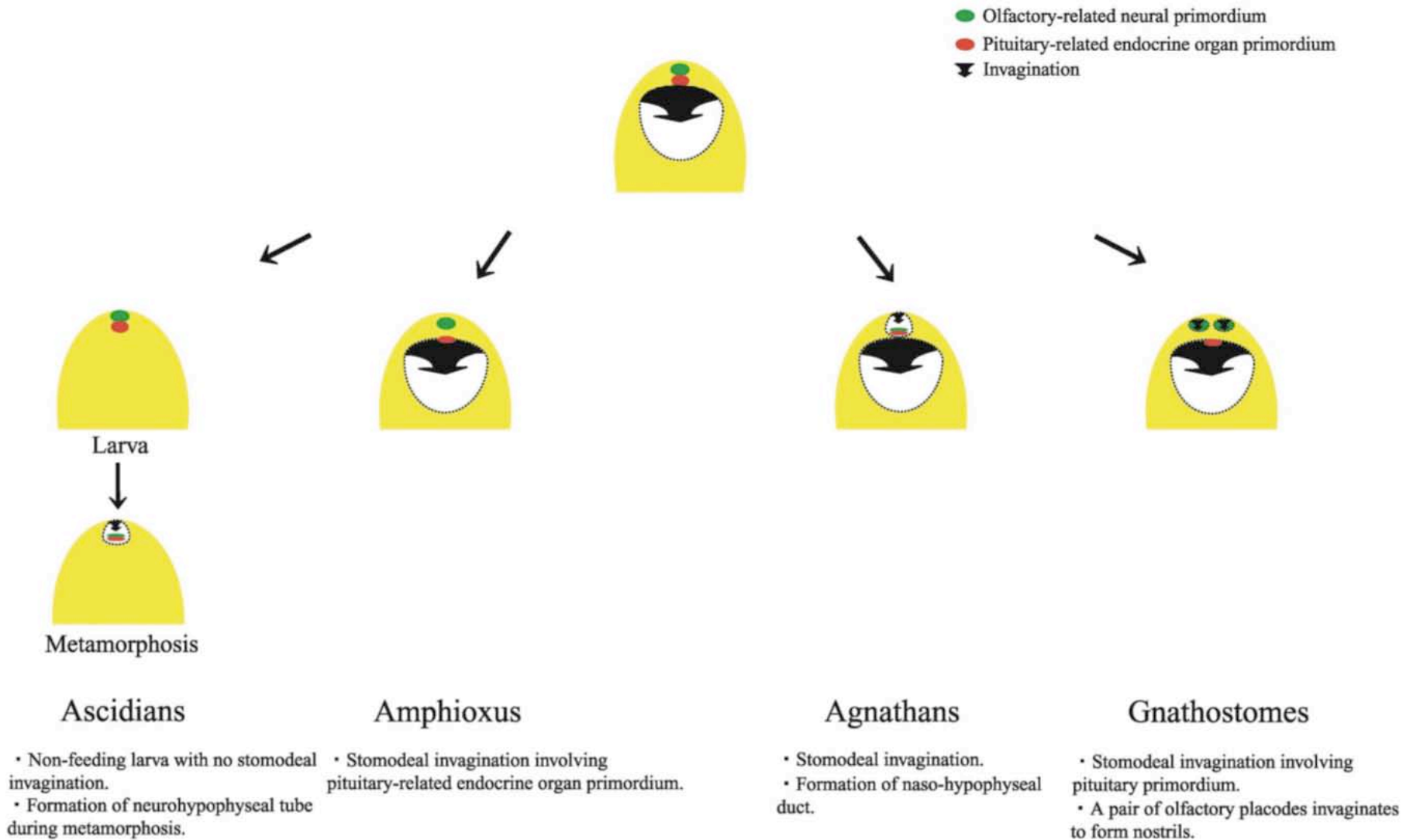


Fig. 5. A model explaining the topological diversity of pituitary-related endocrine organs among chordates. In premetamorphic ascidian larvae, stomodeal invagination does not occur. Instead, a short duct, the incipient neurohypophyseal duct, appears at the front of the neural tube and grows inward towards the atrium. The pre-oral pit of amphioxus larvae is involved in stomodeal invagination, and Hatschek's pit, the potential amphioxus counterpart of the vertebrate pituitary, is situated in the roof of the buccal cavity. Agnathans have two distinct invaginations during their embryonic development: a stomodeal invagination and the one that arises during formation of the nasohypophyseal duct. Gnathostomes have a pair of olfactory placodes, and a pair of nostrils accordingly. Pituitary primordium is incorporated into the buccal cavity as Rathke's pouch, so that the pituitary is finally situated in the roof of the buccal cavity, as is the case for amphioxus.

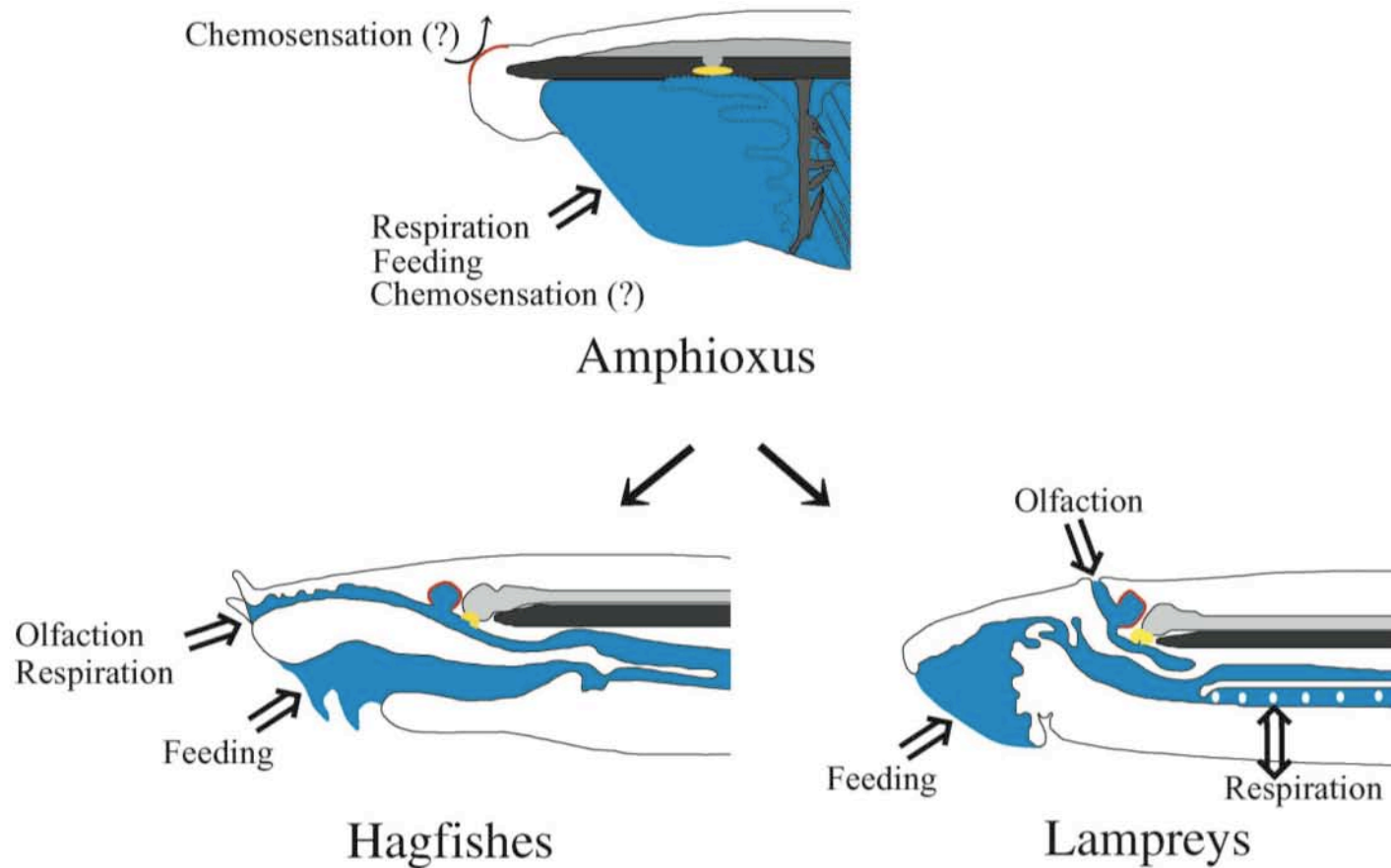
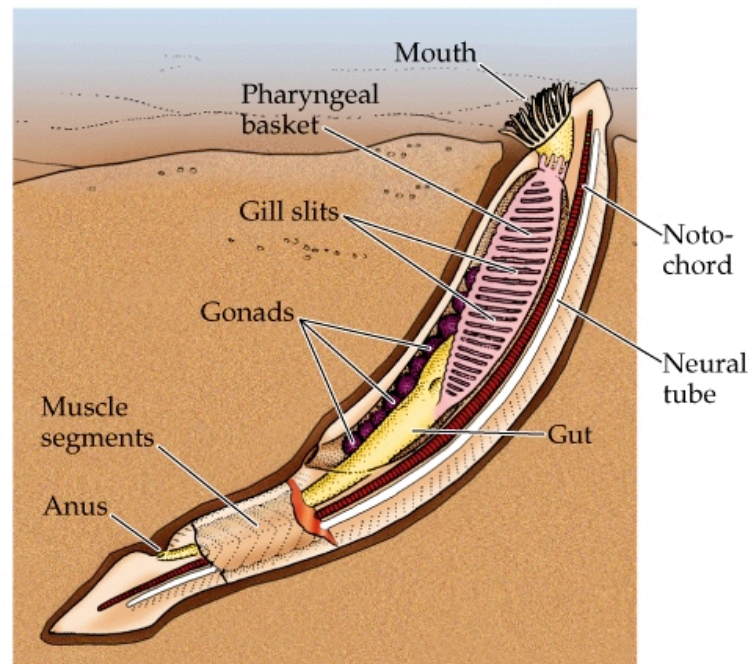
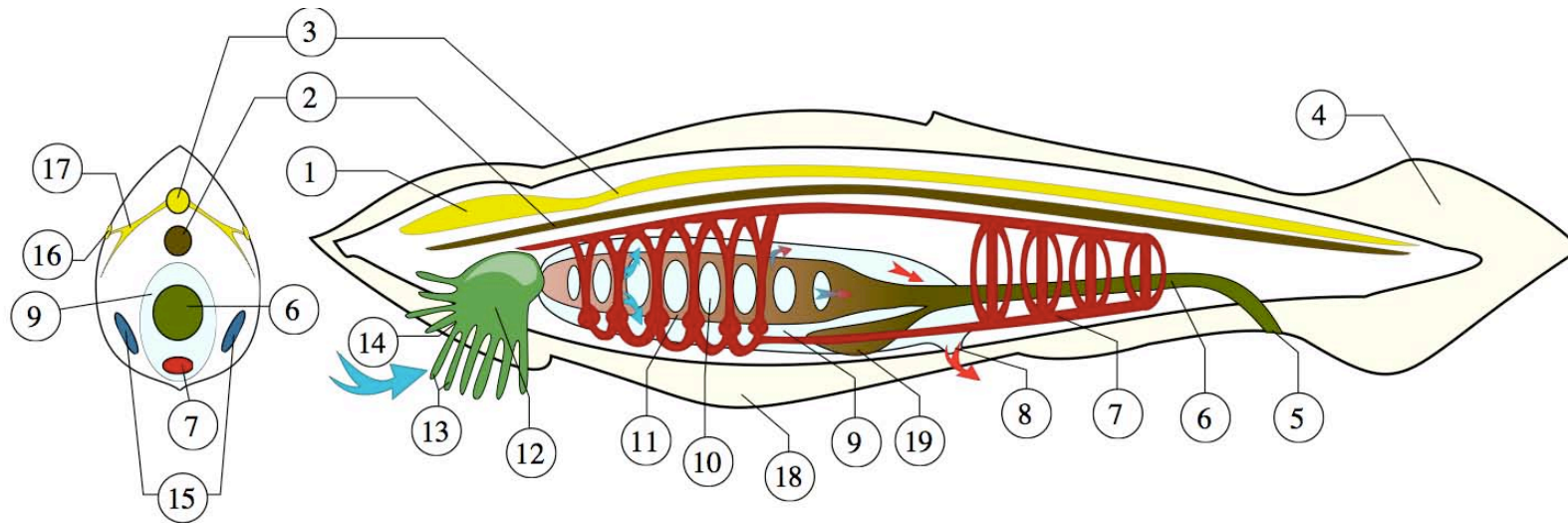


Fig. 4. Possible role of the nasohypophyseal duct in the morphological and functional evolution of head structures. Modified from Kuratani *et al.* (2001). Arrows indicate the inward water flow. In amphiioxus, respiratory, feeding, and probably chemosensory currents flow through the inhalation aperture. Frantz (1923) suggested that chemosensory cells are present on the velar tentacles (see Fig. 2F), and Satoh (2005) suggested the occurrence of an olfactory-related chemosensory cell population at the tip of the rostrum. Hagfishes take in respiratory and olfactory currents through the nasohypophyseal duct. In the lamprey, the nasohypophyseal duct has a blind end, so that respiratory currents enter and leave from the gill slits. Note that the mouths of agnathans are specialized for feeding, which may explain their wide range of feeding adaptations, including scavenging and parasitism. Epithelium marked in red indicates the olfactory-related chemosensory cell population, whereas that in yellow indicates the pituitary-related endocrine organ.



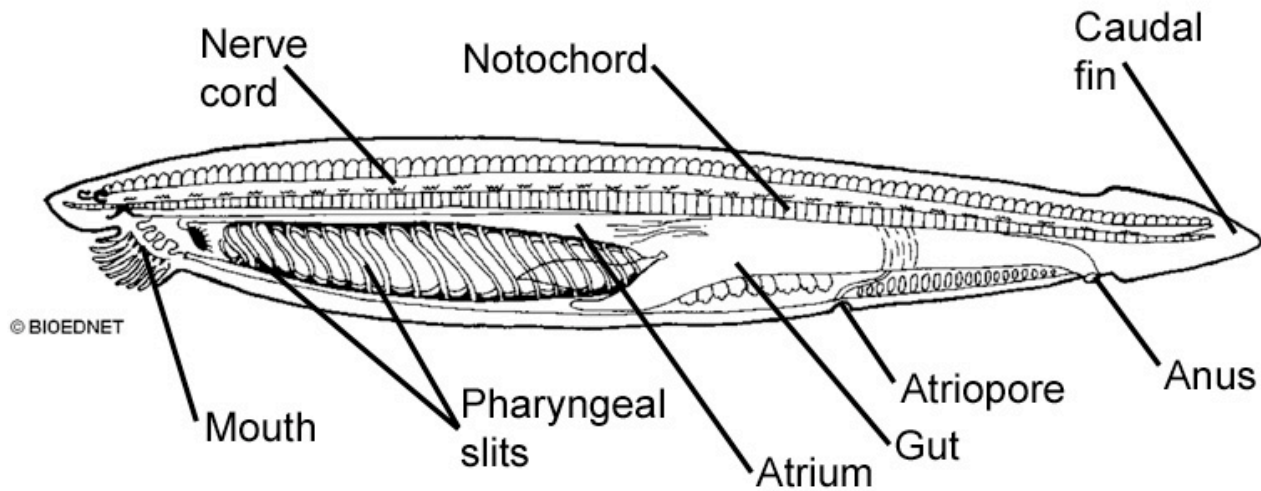
Musculatura segmentada



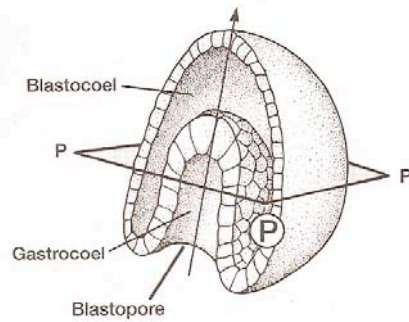


1 - vesícula cerebral; 2 - notocorda; 3 - cordón nervioso; 4 - aleta caudal; 5 - ano; 6 - tubo digestivo; 7 - sistema circulatorio; 8 - poro abdominal; 9 - cavidad suprafaríngea; 10 - abertura branquial; 11 - faringe; 12 - cavidad bucal; 13 - mimosa; 14 - abertura bucal; 15 - gónadas; 16 - sensor de luz; 17 - nervios; 18 - pliegue abdominal; 19 - bolsa hepática

Cephalochordata



Gastrulación en Amphioxus (Chordata)

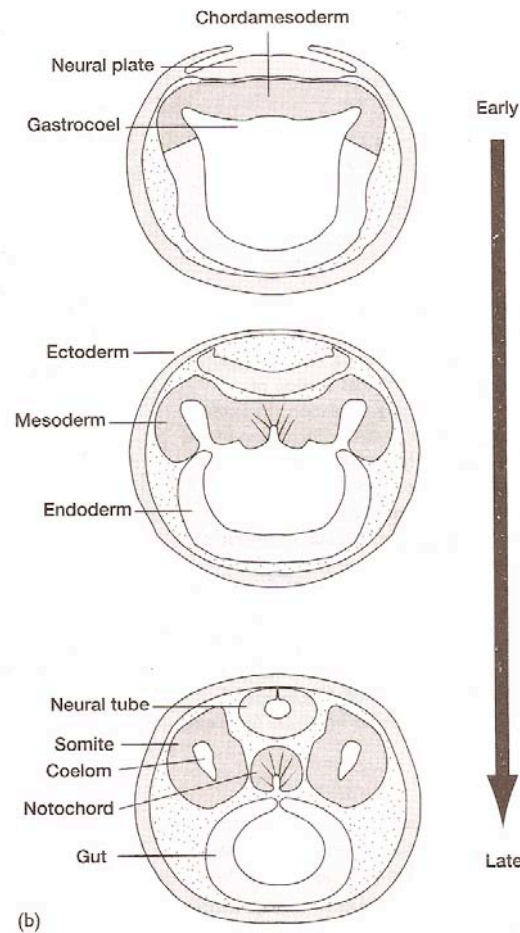


En la región anterior, de manera enterocélica, el techo del arquenteron da origen a los somitos, una serie de bloques mesodermicos pareados (dan lugar a la musculatura axial segmentada), y al notocordo, una barra longitudinal axial de tejido conectivo y muscular en amphioxus (solo conectivo en vertebrados). Lo mismo ocurre para los somitos anteriores en ciclostomos (peces sin mandibula) y en peces cartilagosos (tiburones, rayas y quimeras)

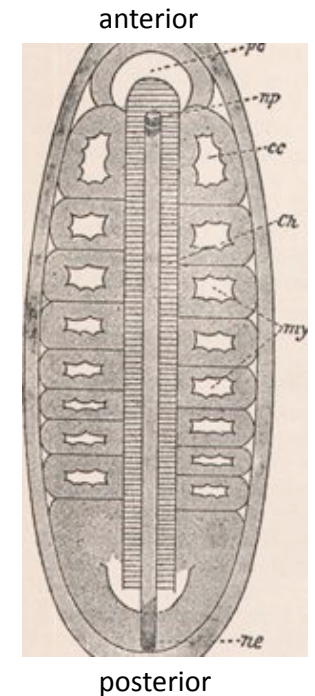
La cavidad de los somitos de la región más posterior se forma de manera esquizocelica. En vertebrados óseos, todos los somitos se forman de manera esquizocélica.

En la región anterior puede decirse que el endodermo da lugar al mesodermo, y por tanto puede hablarse de un mesendodermo. En cnidarios, hay zonas de endodermo ("estómago" cnidario) que expresan genes de mesodermo y que pueden desarrollarse como musculatura, por lo que se dice que el origen evolutivo del mesodermo está en el endodermo.

Corte transversal



Vista superior (dorsal)



En el ectodermo dorsal hay una "placa neural" de ectodermo engrosado que por invaginación entra al embrión, conformando un tubo neural, que da lugar al sistema nervioso central. Este proceso se llama "neurulación". Amphioxus se caracteriza porque además dos extensiones epidérmicas (no neurales) se encuentran por sobre la placa neural que desciende

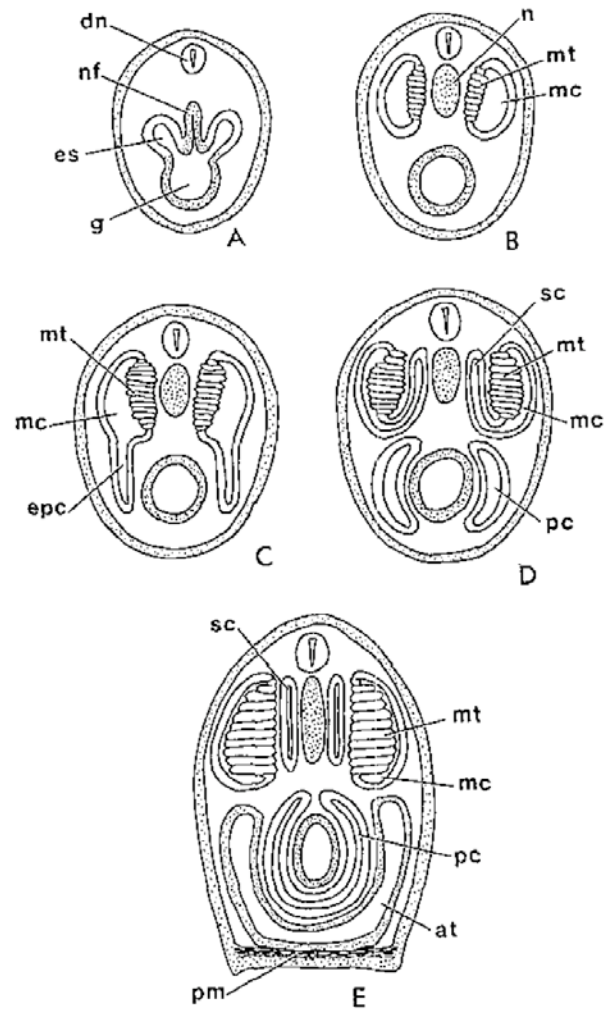
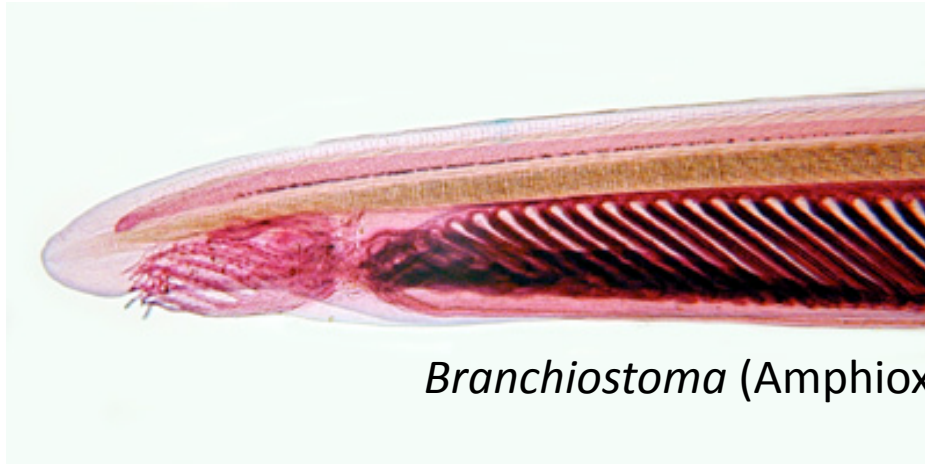


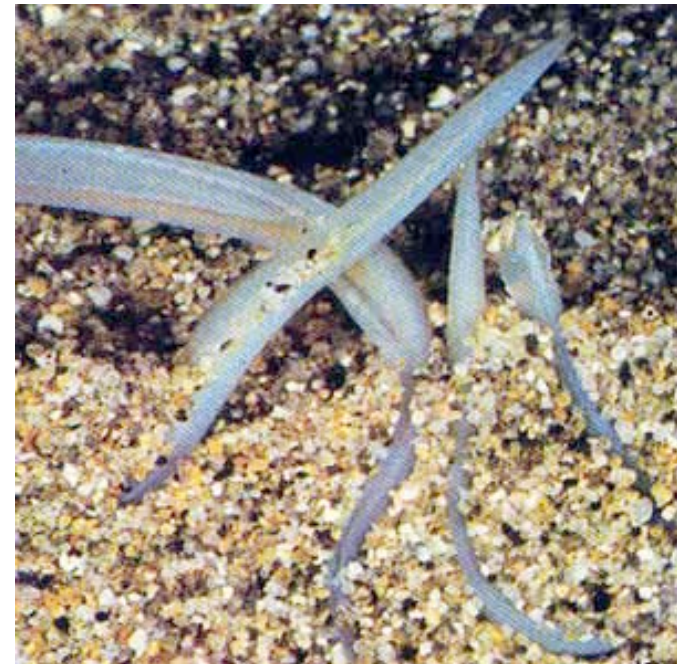
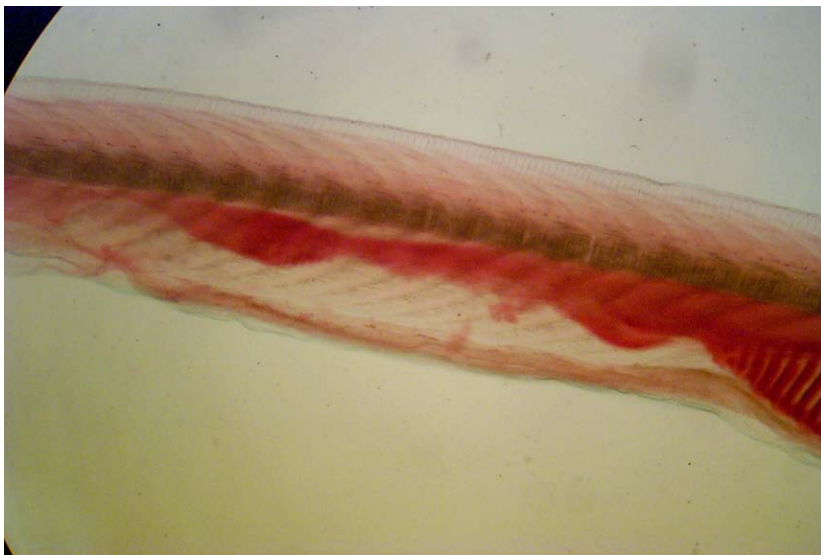
FIG. 1. Diagrammatic cross sections of developmental stages of amphioxus showing major muscles and the relationships between major coeloms. Developmental times given are for *Branchiostoma floridae* raised at 25°C. (A) Early embryo (13 hr). (B) Mid-embryo. (18 hr). (C) Late embryo (26 hr). (D) Larva (2 day). (E) Postmetamorphic juvenile (6 weeks). Abbreviations in alphabetical order are: at, atrial cavity (an ectodermal invagination that is unrelated to the heart); dn, dorsal nerve cord; es, evaginating somite; epc, evaginating perivisceral coelom; g, gut; mc, myocoel; mt, myotome; n, notochord; nf, notochordal fold; pc, perivisceral coelom; pm, pterygeal muscles; sc, sclero-coel.

In the 1980's, Northcutt and Gans proposed THE NEW HEAD HYPOTHESIS on the origin of vertebrates.

The closest living relatives of the vertebrates are considered practically 'headless'. They are sedentary filter feeders. Amphioxus lives buried in sand, and only swims to escape.

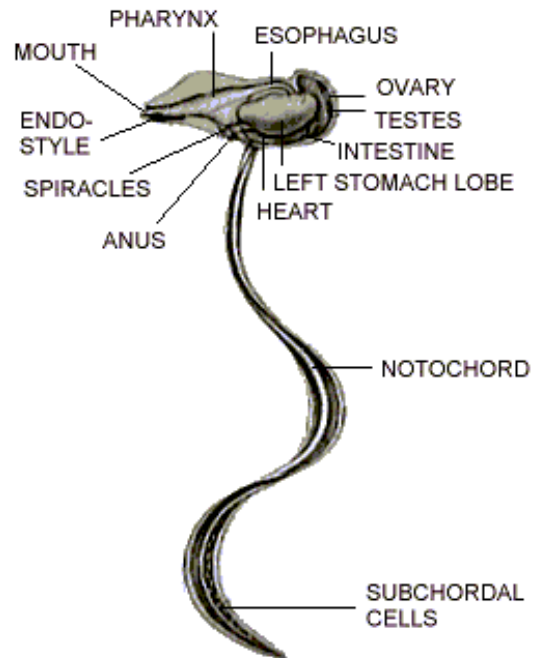


Branchiostoma (Amphioxus)

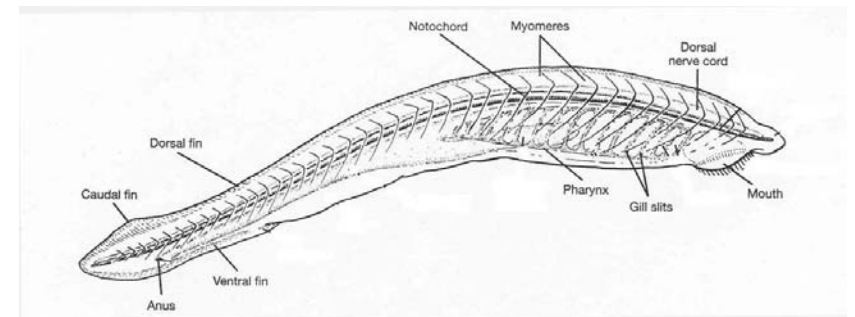


Dentro de los chordata, datos moleculares recientes han cuestionado la visión traidicional de que los cephalochordata son mas cercanos a los vertebrados que los urochordata .

Urochordata



Cephalochordata



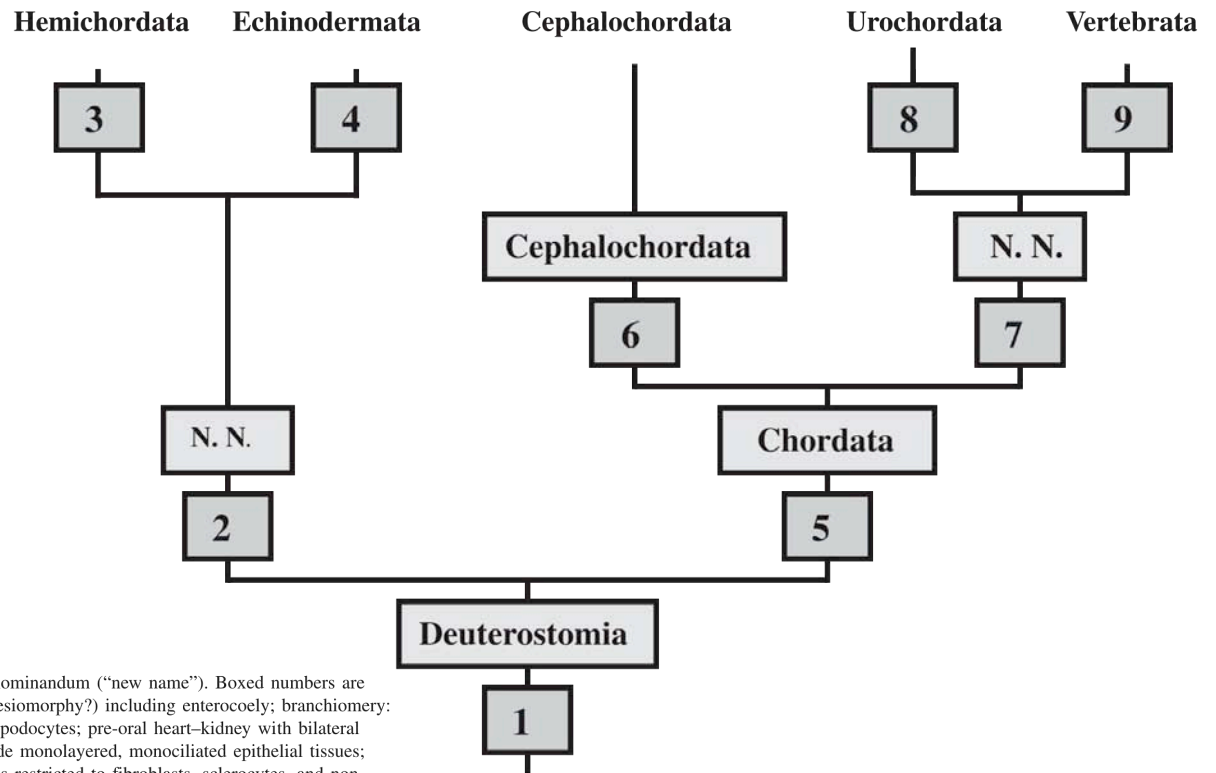
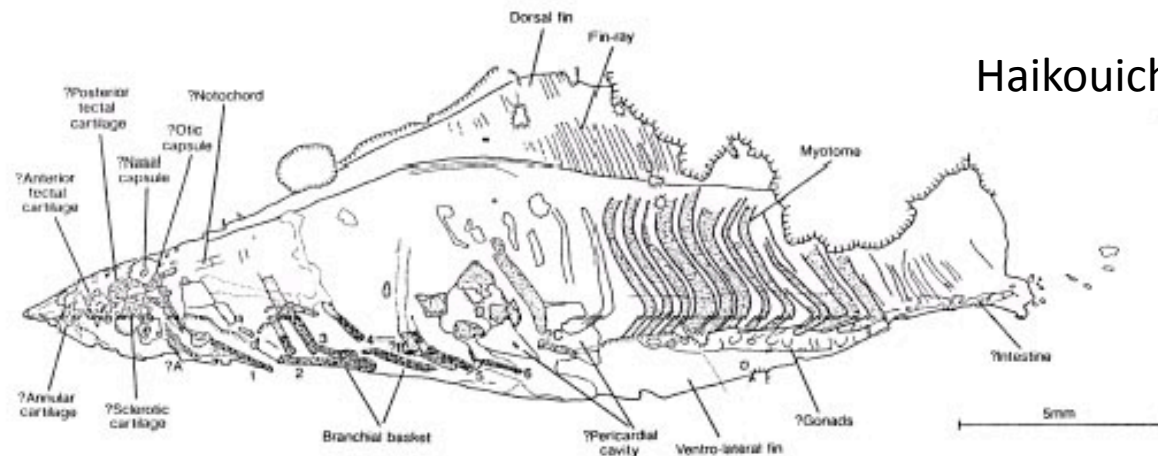
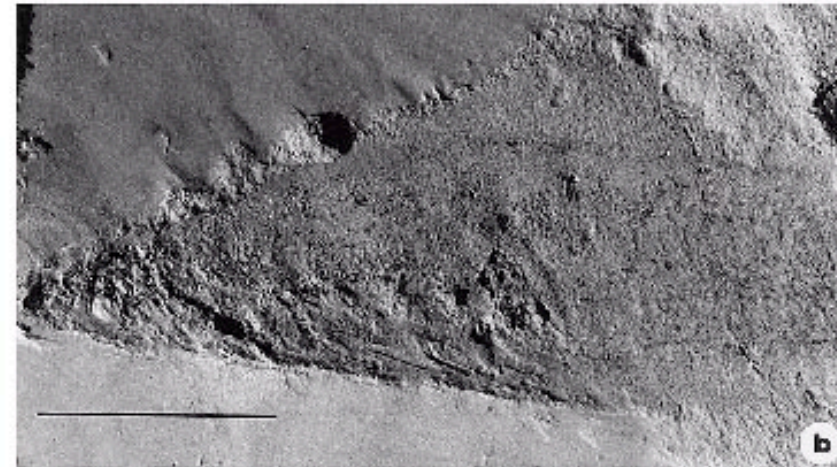
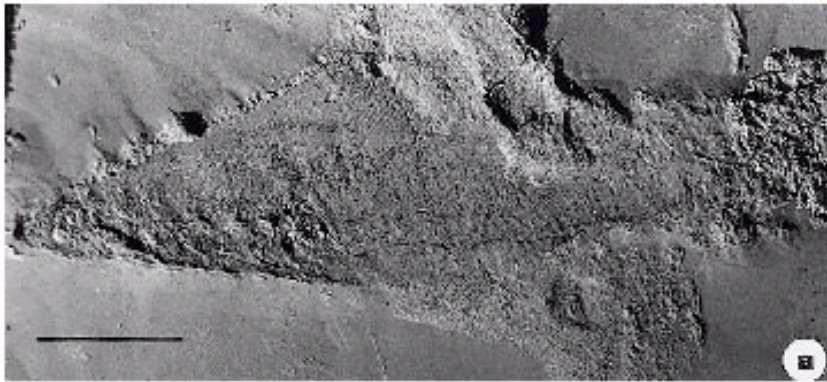


Fig. 34. A phylogeny of Deuterostomia based chiefly on morphology. N.N. is nomen nominandum (“new name”). Boxed numbers are apomorphies. 1, Deuterostomia: the blastopore becomes the anus; epithelial folding (plesiomorphy?) including enterocoely; branchiomery: undivided (primary) gill slits (as circular or oval pores) lack a skeleton, branchiomeric podocytes; pre-oral heart–kidney with bilateral nephridioducts; hepatic cecum (or ceca?) from anterior intestine. (Plesiomorphies include monolayered, monociliated epithelial tissues; intercellular junctions are zonula adhaerens and septate junctions; connective-tissue cells restricted to fibroblasts, sclerocytes, and non-circulating hemocytes; principal hemal vessels dorsal and ventral, flow anterior in dorsal vessel, posterior in ventral vessel; trimery; musculature composed of epitheliomuscle cells in monolayered myoepithelium; motoneurons confined to epidermal nerve net; motor innervation by diffusion of transmitters across epidermal (neuroepithelium) basement membrane to somatic coelomic lining (myoepithelium); metanephridial system.) 2, N. N.: valved mesocoel ducts (collar ducts Enteropneusta; stone canal Echinodermata). 3, Hemichordata: stomochord; post-anal appendage (tail); dorsal anus (developmentally in Enteropneusta). 4, Echinodermata: water-vascular system; calcitic stereom ossicles in connective-tissue dermis; mutable connective tissue; (gill slits/branchiomery lost in extant taxa but present in extinct *Cothurnocystis*). 5, Chordata: segmented (metameric) mesoderm (primitively in register with branchiomeres?); notochord arising developmentally from two rows of chordal cells that intercalate to form a stack of coins; chordal cells with intracellular vacuoles and intercellular pockets; dorsal hollow nerve cord, including anterior brain with photoreceptive and static sensory structures; non-migratory neural crest; myomeral motoneurons confined to dorsal cord; adenohypophysis consisting of ectoderm + mesoderm; pharyngeal mucous net filter feeders with endostyle; dorsoventral axis inversion *or* reversal of blood-flow direction; pre-oral heart lost, new post-oral ventral heart; new ventral anus?; fins; swimming by means of lateral undulations of trunk tail; *Pax-1* expression confined to pharynx (endoderm). 6, Cephalochordata: notochord to rostral extremity; chevron-shaped myosepta; left–right myomere pairs out of register; bilateral asymmetry in most tissues and organs; primary gill slits divided by tongue bars; branchiomeric cyrtopodocytes and nephridioducts; muscular stack-of-coins notochord with myoglobin. 7, N.N.: loss of pre-oral kidney; septate junctions replaced by tight junctions; swimming musculature partly a functional syncytium; brain with coronet cells (saccus vasculosus); neuromast cells; mesodermal mesenchyme forms novel structures; migratory neural crest (Jeffery et al. 2003); non-epithelial musculature; notochord differentiates beyond stack-of-coins stage; hemal system with functionally distinct circulating corpuscles; multiciliated epithelial cells; adenohypophysis consisting of ectoderm + endoderm; *Pax-1/9* (Urochordata) or *Pax-1 Pax-9* (Vertebrata) expression in developing pharynx *and* musculature (somites). 8, Urochordata: loss of metamerism, coelom (including enterocoelic somites), filtration nephridia (metanephridial system), gut/anus in locomotory “tail”, many ancestral chordate genes (most adults also lose trunk/tail, including notochord, nerve cord, brain, locomotory musculature); non-molted exoskeletal tunic (apomorphically molted in doliolarians and appendicularians); budding, involving mesenchymal mesoderm, produces colonies (deuterostome plesiomorphy?); periodic heartbeat reversal; post-stack-of-coins notochord with enclosed extracellular canal, intracellular vacuoles absent; 9, Vertebrata: stratified epithelia; endothelium-lined hemal vessels; cephalized brain with paired sense organs; processes of motoneurons extend from nerve cord, via ventral roots, to innervate myomeral musculature; metameric nephrons (metanephridial system) join common urinary duct; post-stack-of-coins notochord composed of stratified vacuolated cells enclosed in a bounding epithelium; cartilaginous gill skeleton (arches) derived from neural crest; many duplicated ancestral chordate genes.

Milokunmingia y Haykouichthys, del cámbrico inferior, revelan la adquisición de arcos branquiales pareados, ojos pares, cápsulas óticas, y una musculatura axial más compleja en forma de “z”, en tanto que en Amphioxus, tiene forma de “v”.



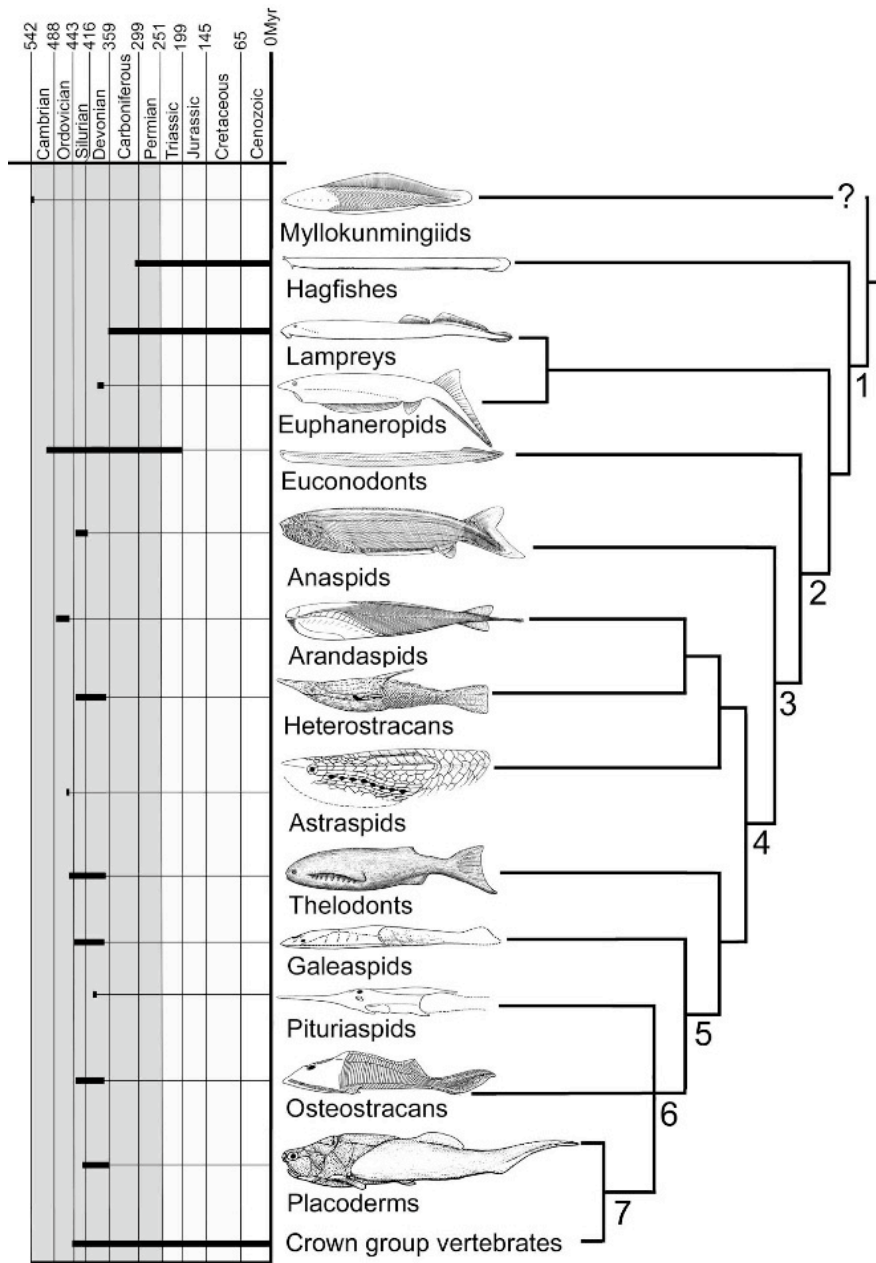
Haikouichthys

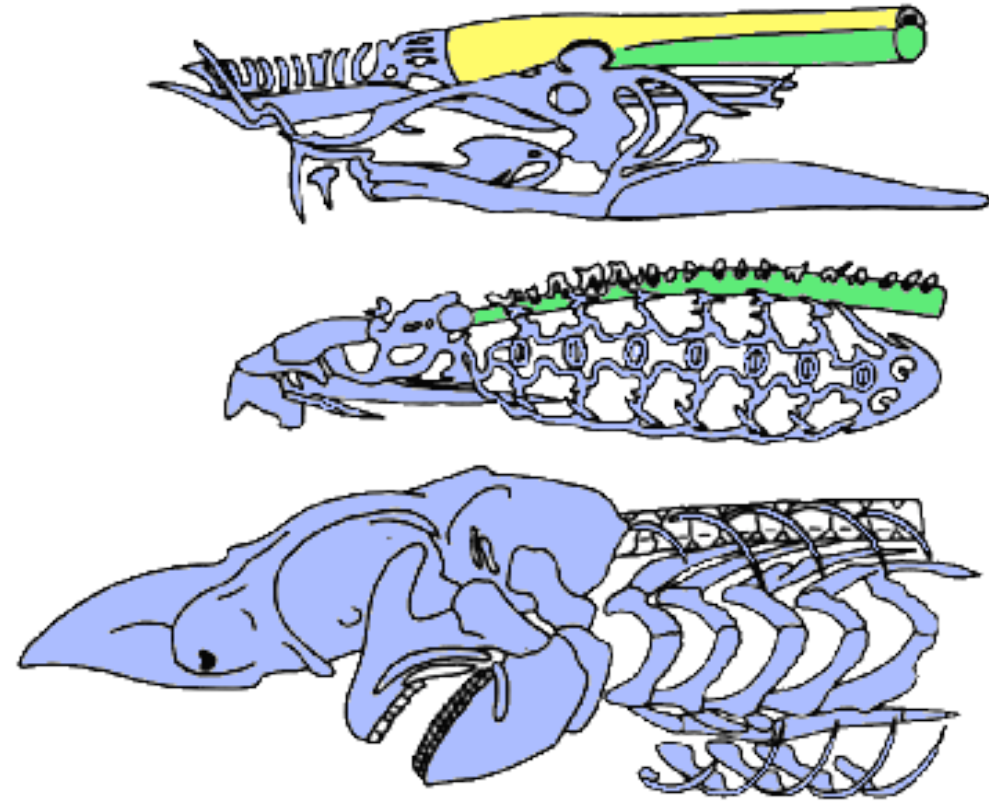


Millokunmingia

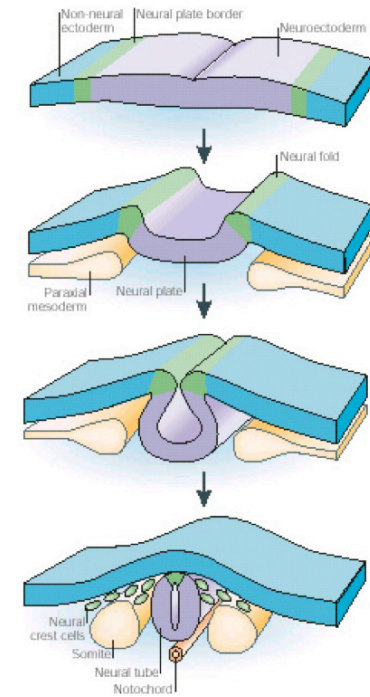
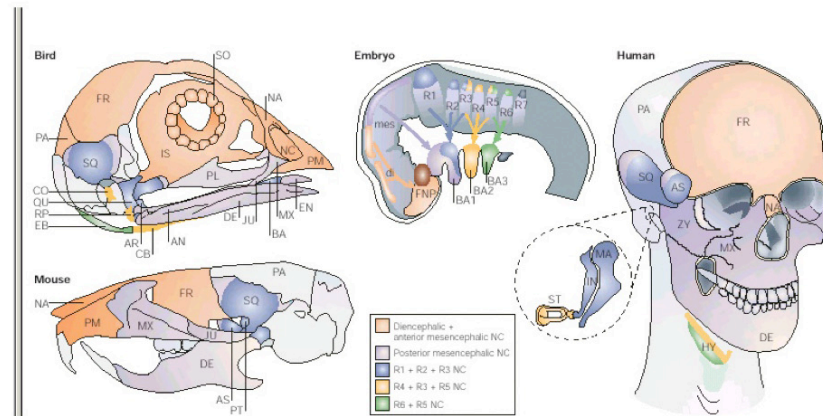
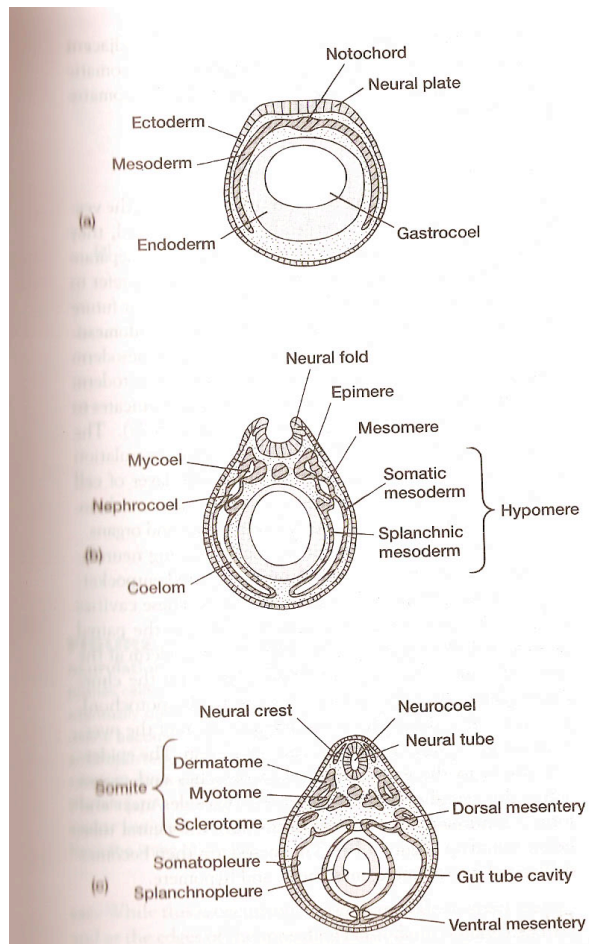


Millokunmingia



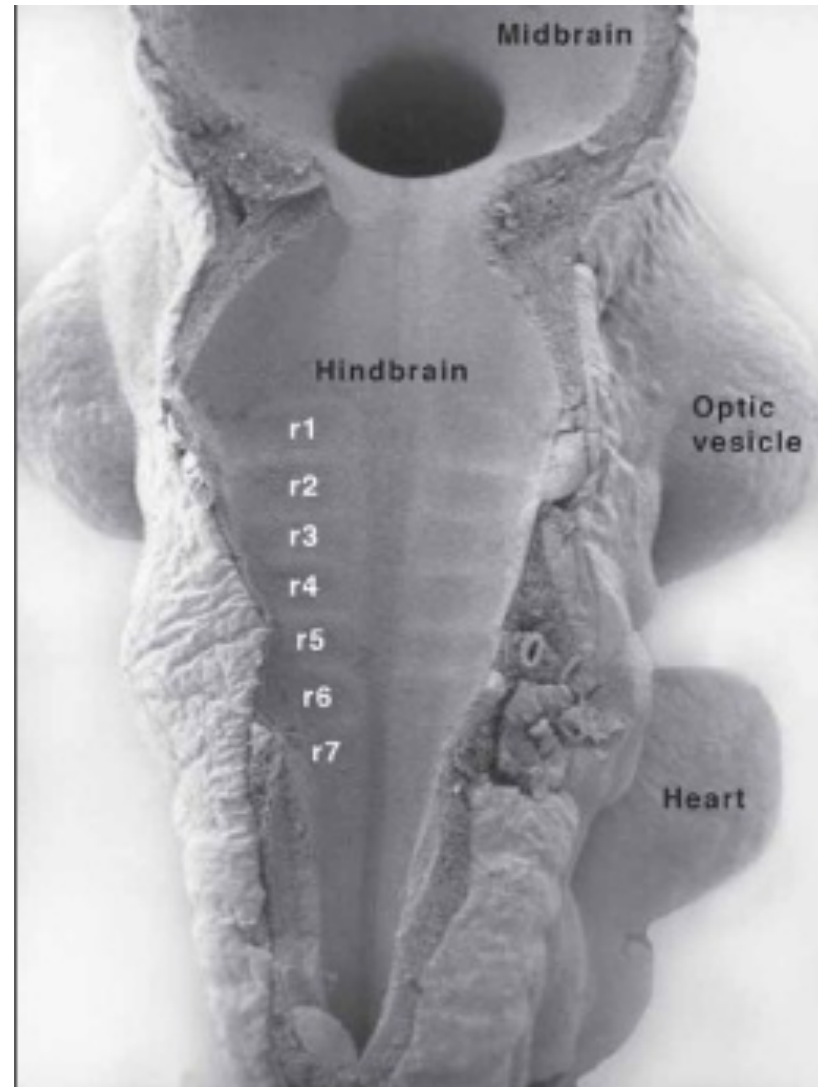


En todos los vertebrados se desarrolla además una **cresta neural**. Esta se origina a partir de bordes laterales engrosados de la placa neural, que acaban en la posición dorsal del tubo neural. Desde ahí migran hacia el interior del embrión, dando lugar en todo el cuerpo a melanocitos (celulas de pigmentación) y a los ganglios de los nervios sensoriales del sistema nervioso periférico. En la región cefálica, la cresta neural da origen a la mayoría de los huesos del cráneo. Se ha postulado que la cresta neural y las placodas ectodérmicas fueron clave en el origen de los vertebrados, especialmente en relación a la especialización de la cabeza en sensorialidad/alimentación



Morphological segmentation of the neural tube: Rhombomeres (vertebrates)

Much of the neural crest that develops into the branchial arches and most of the skull is derived from the rhombomeres of the embryonic hindbrain

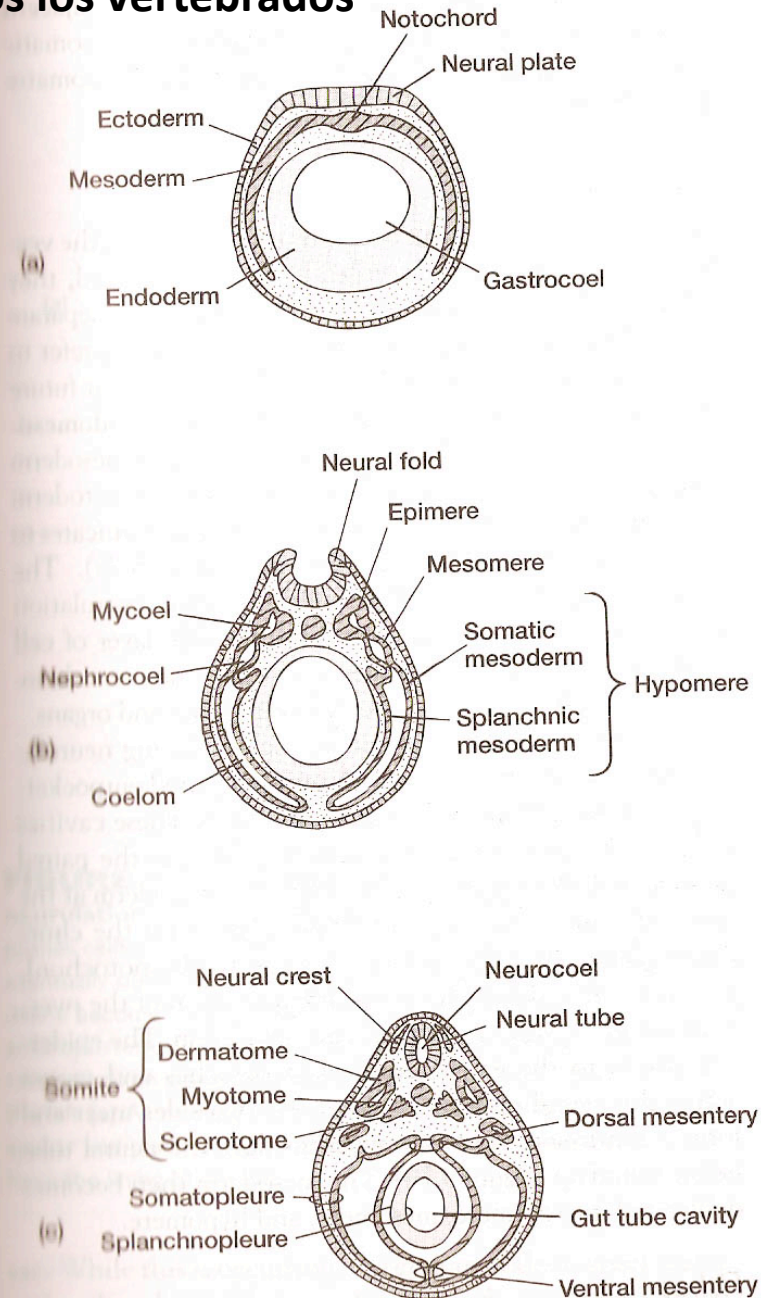


Aspectos morfogénéticos compartidos por todos los vertebrados

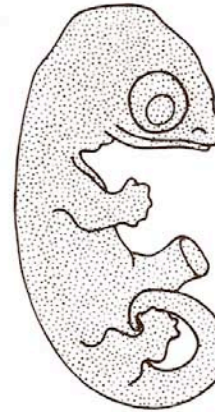
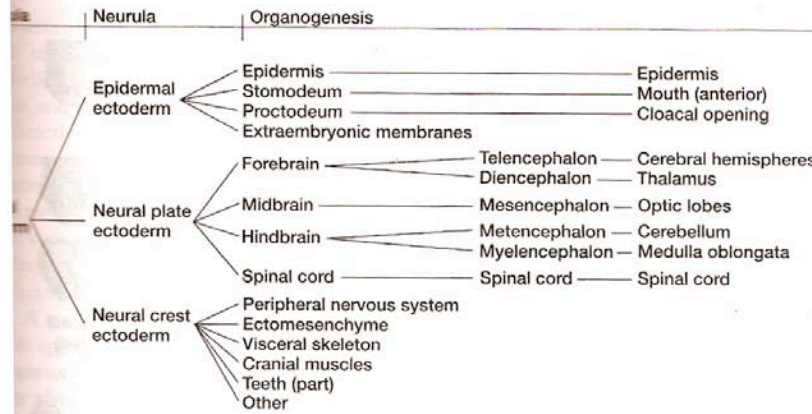
En vertebrados en general, el mesodermo puede dividirse en tres zonas: 1) El epímero dorsal, que da origen a los somitos 2) El mesómero, que da origen a riñones y gónadas. 3) El hipómero, que da origen a las paredes musculares del cuerpo y de las vísceras. El hipómero posee un aspecto lateral, la somatopleura, y un aspecto ventral, la esplacnopleura.

El epimero y mesomero son segmentados, el hipomero es continuo

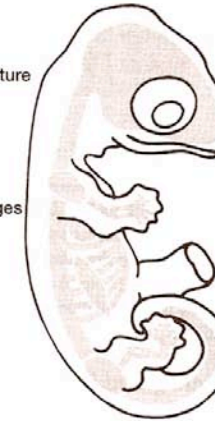
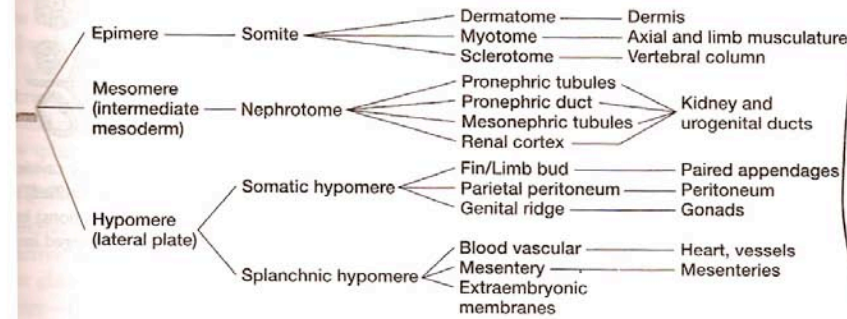
El somito se divide en tres: dermatomo (da origen a la dermis de tejido conectivo laxo que existe debajo de la epidermis), miotomo (da origen a musculatura de vertebras y extremidades) y esclerotomo (da origen a las vertebras)



Ectodermo



Mesodermo



Endodermo

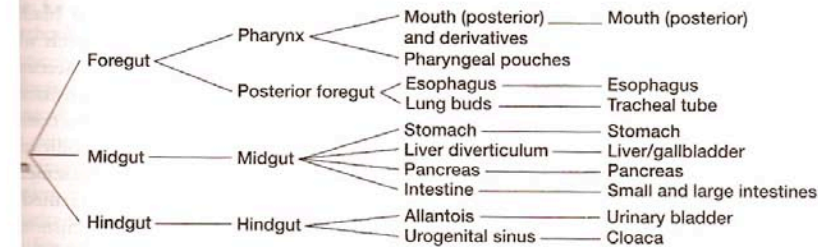
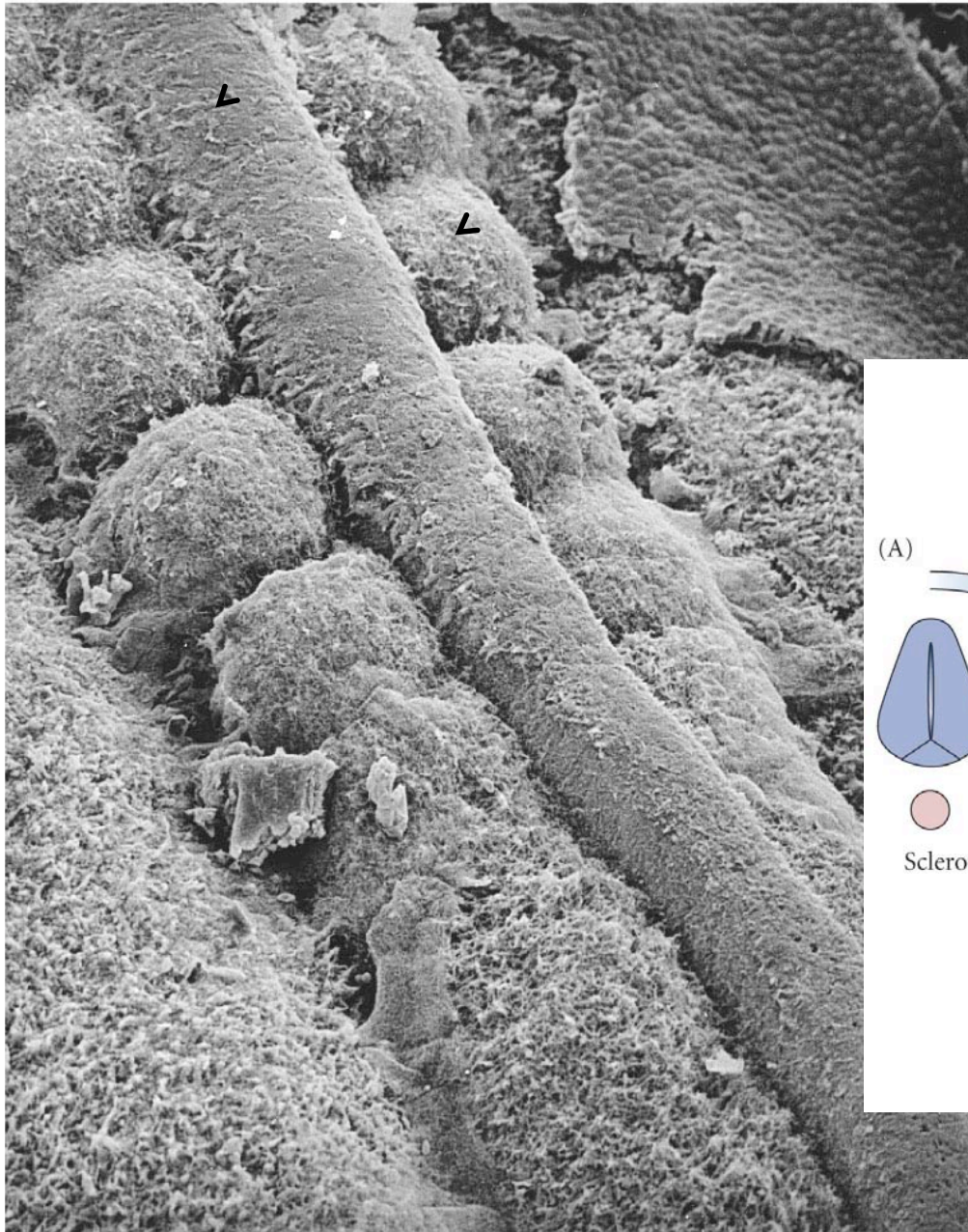


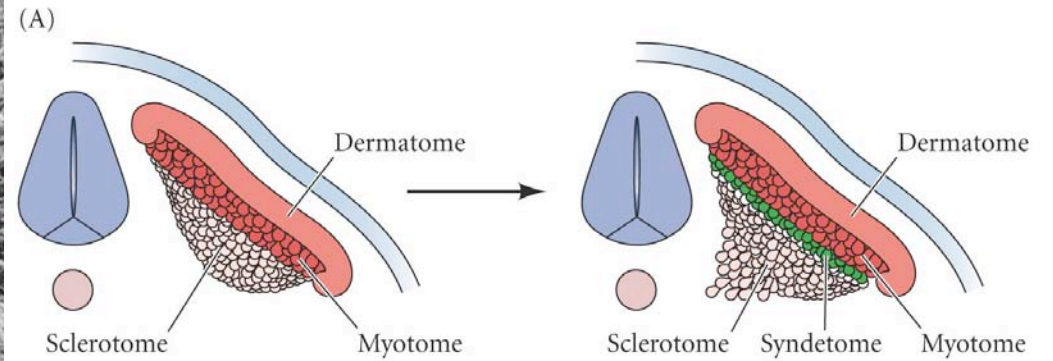
FIGURE 5.17 Organogenesis. The three primary germ layers are delineated during gastrulation and neurulation. Thereafter, they become differentiated into various body regions, and these regions produce the major organs of the vertebrate body. The embryonic origin of each organ or part of an organ can be traced back to these specific germ layers. In general, ectoderm produces the skin and nervous system; mesoderm the skeleton, muscle, and circulatory system; and endoderm the digestive tract and its visceral derivatives.

Neural tube

Somites



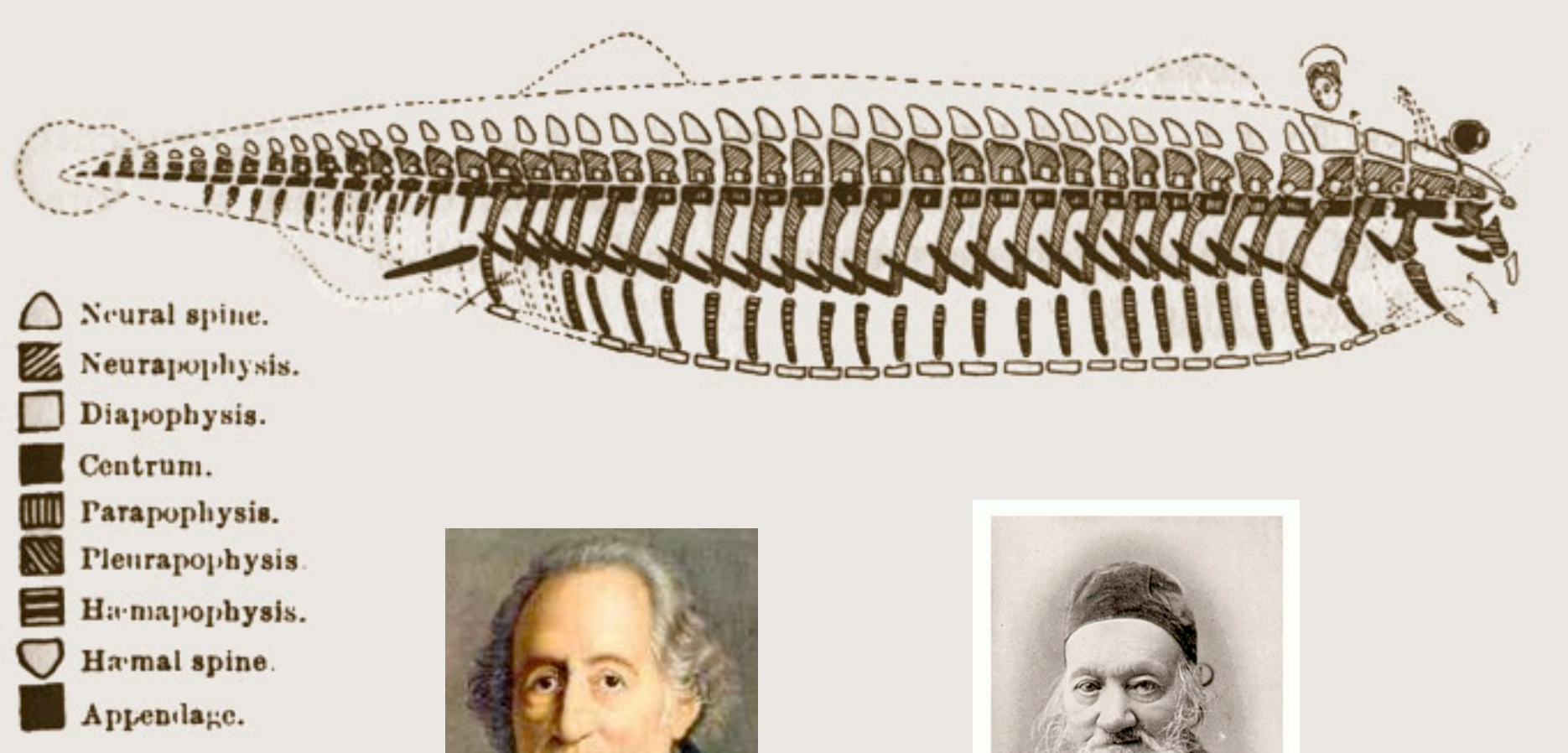
Vertebrae have a mesodermal origin, from the sclerotomal subsection of somites



DEVELOPMENTAL BIOLOGY, Eighth Edition, Figure 14.19 (Part 1) © 2006 Sinauer Associates, Inc.

The vertebral theory of the skull: The skull as composite of vertebrae

Specially similar: The branchial arches.

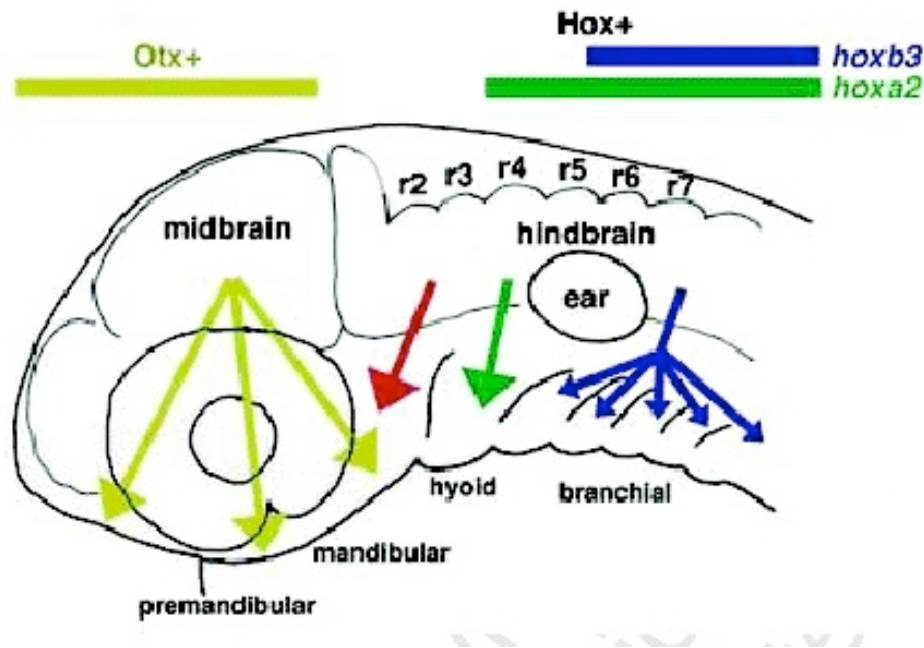


Goethe



Owen

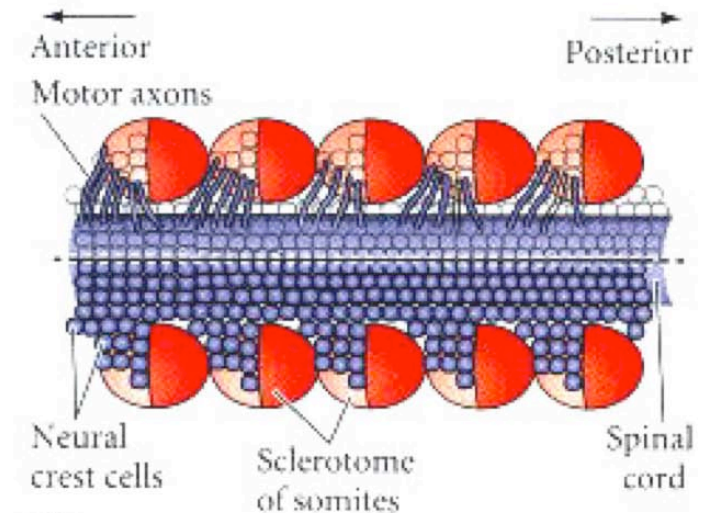
Newly described resemblances of rhombomeric neural crest to sclerotomes



Alternating domains of:

Coincide with neural crest migration along:

(B)



(C)

Neuropilin / Collapsin (Semaphorin)

Anterior / Posterior sclerotome

Even / Odd Rhombomeres

Myxinoidea (anguilas babosas)

Viven enterrados en la arena y se alimentan de carroña e invertebrados

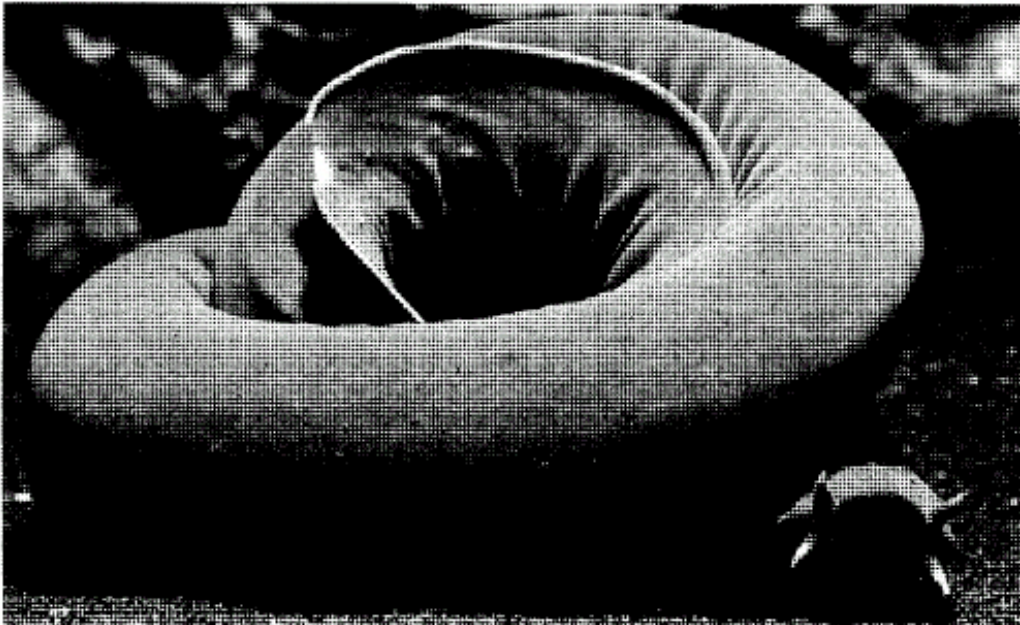
No poseen línea lateral (Estructura longitudinal provista de neuronas sensoriales electroreceptoras y mecanoreceptoras).

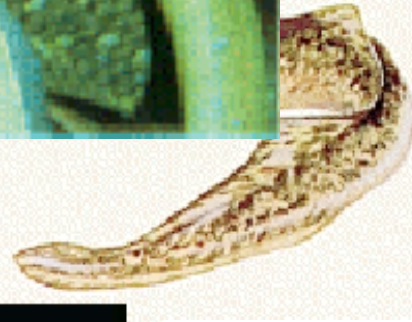
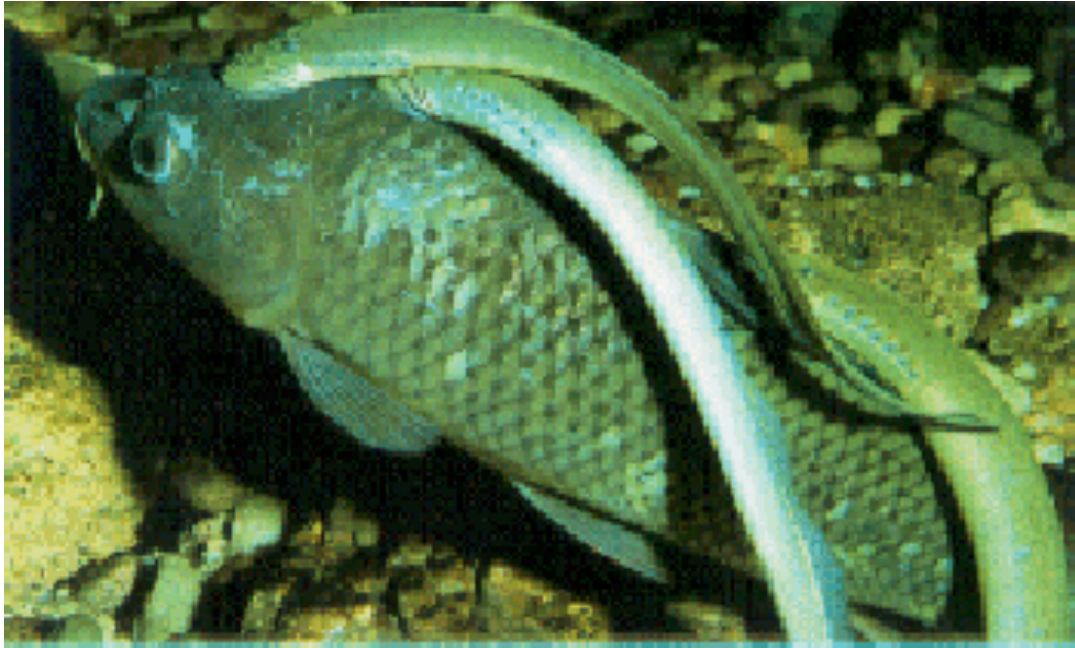
El ojo es simple y no tiene musculatura.

El cerebro carece de tectum óptico, cerebelo y nervios óculo motores.

Posee un oído interno simple con un solo canal semicircular.

Lóbulos olfatorios del cerebro bien desarrollados.



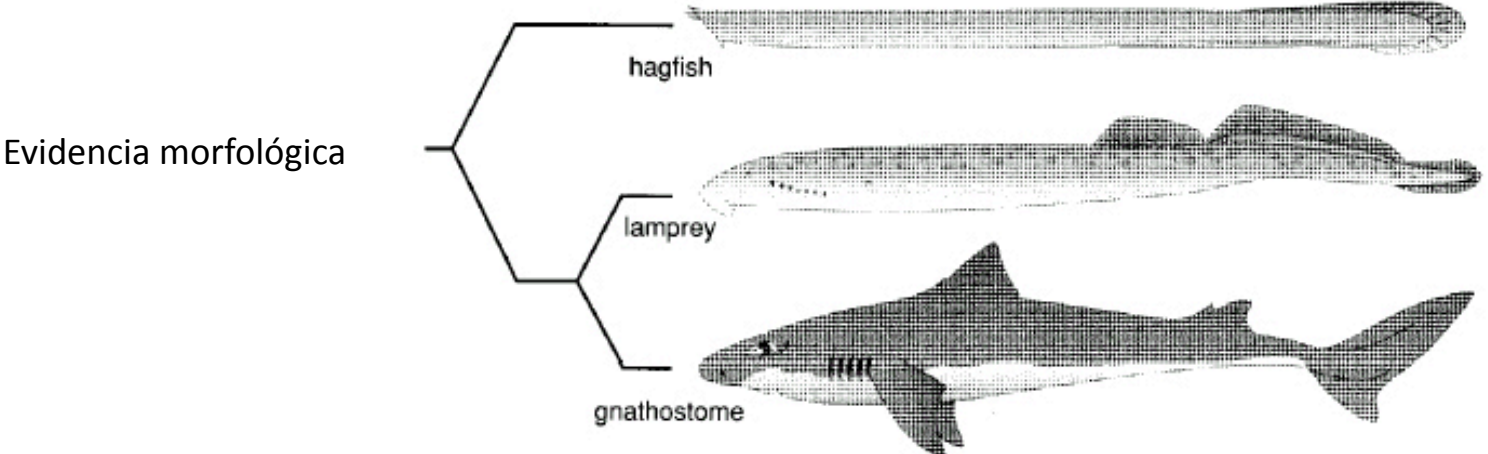
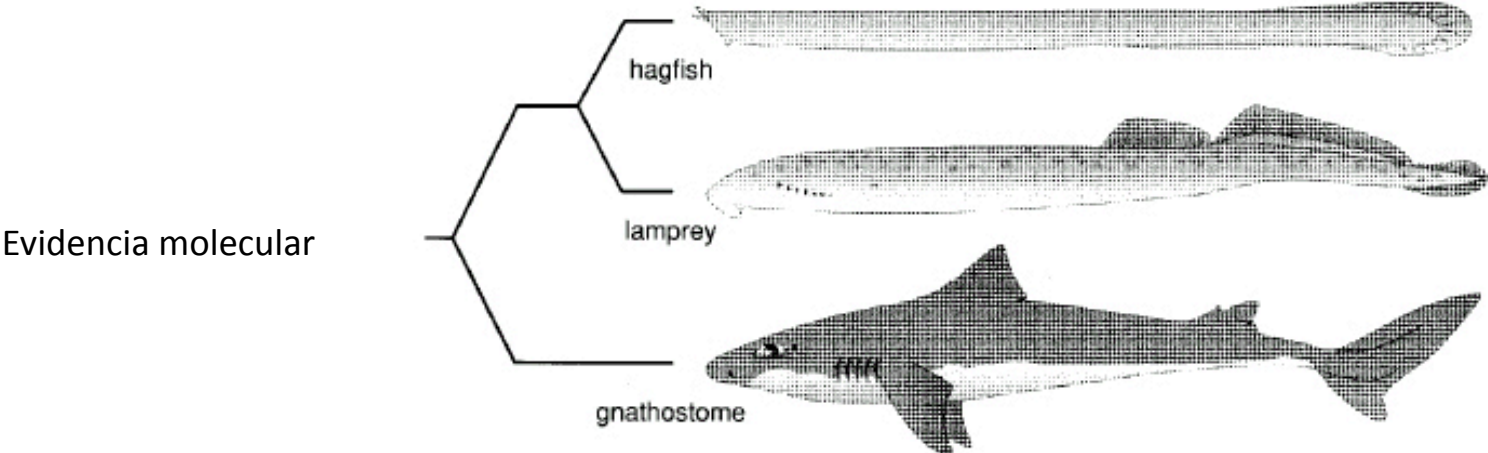


Ciclostomata: Petromyzontidae

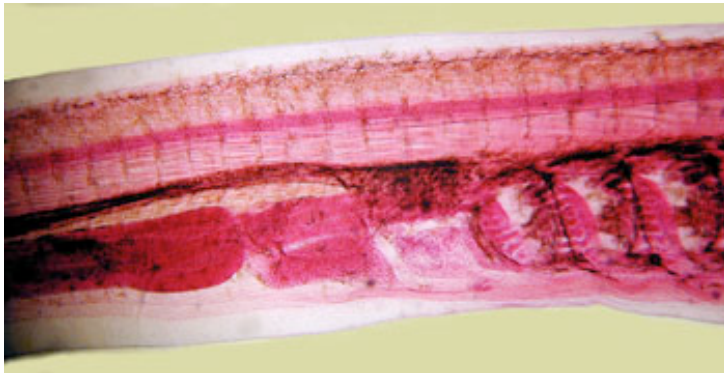
Poseen dientes queratinosos en el arco branquial mas anterior (arco 1). Sin embargo este arco branquial no ocluye (cierra) la boca. Se debate si debe considerarse que poseen “mandibulas”. Las lampreas, poseen pequeñas estructuras vertebrales cartilaginosas, musculatura de las aletas, control del latido cardiaco via el nervio vago, ojos provistos de lente y de musculatura extrínseca, verdaderos linfocitos, linea lateral, adenohipófisis compleja. Son anádromos.



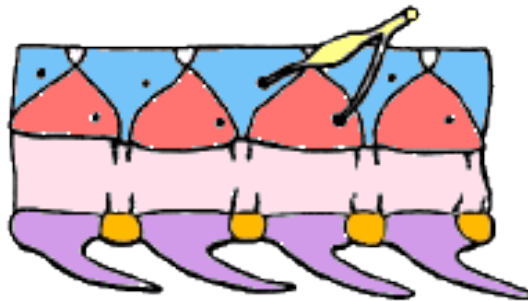
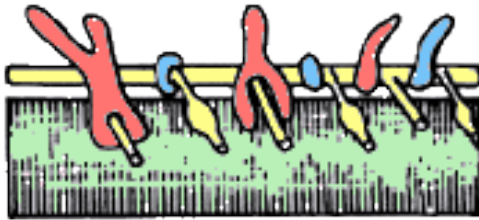
Existe una polémica sin resolver sobre si los lampreas son más cercanos a los peces con mandíbula o a los myxines.



Mientras que las myxines se desarrollan de maneras directa, las lampreas tiene una forma larval, la larva amoceta, que vive enterrada y filtra, muy similar a Amphioxus

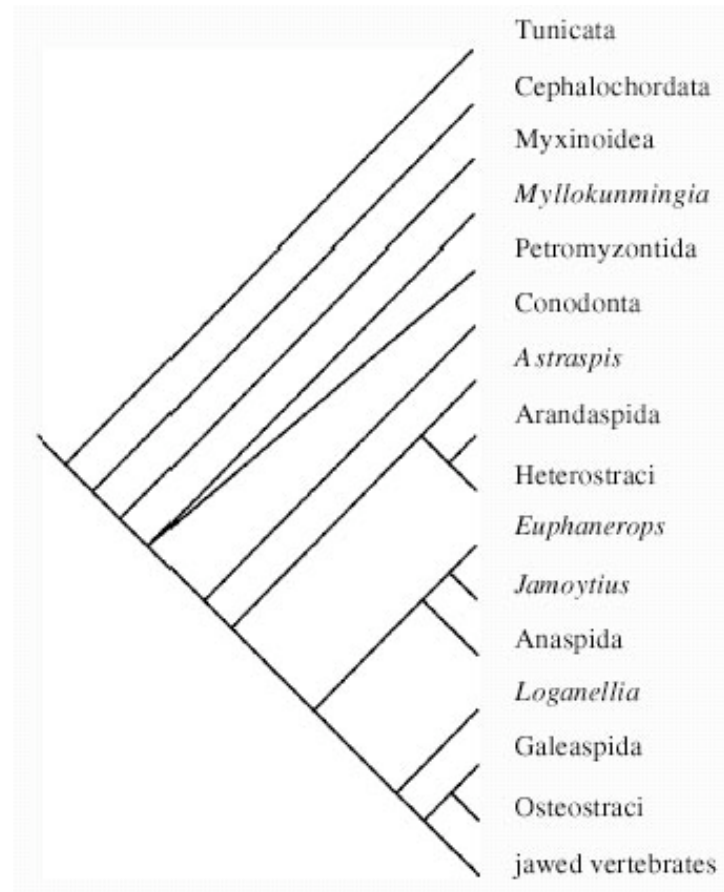
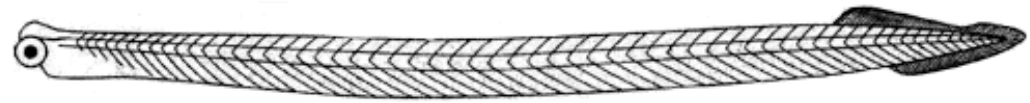
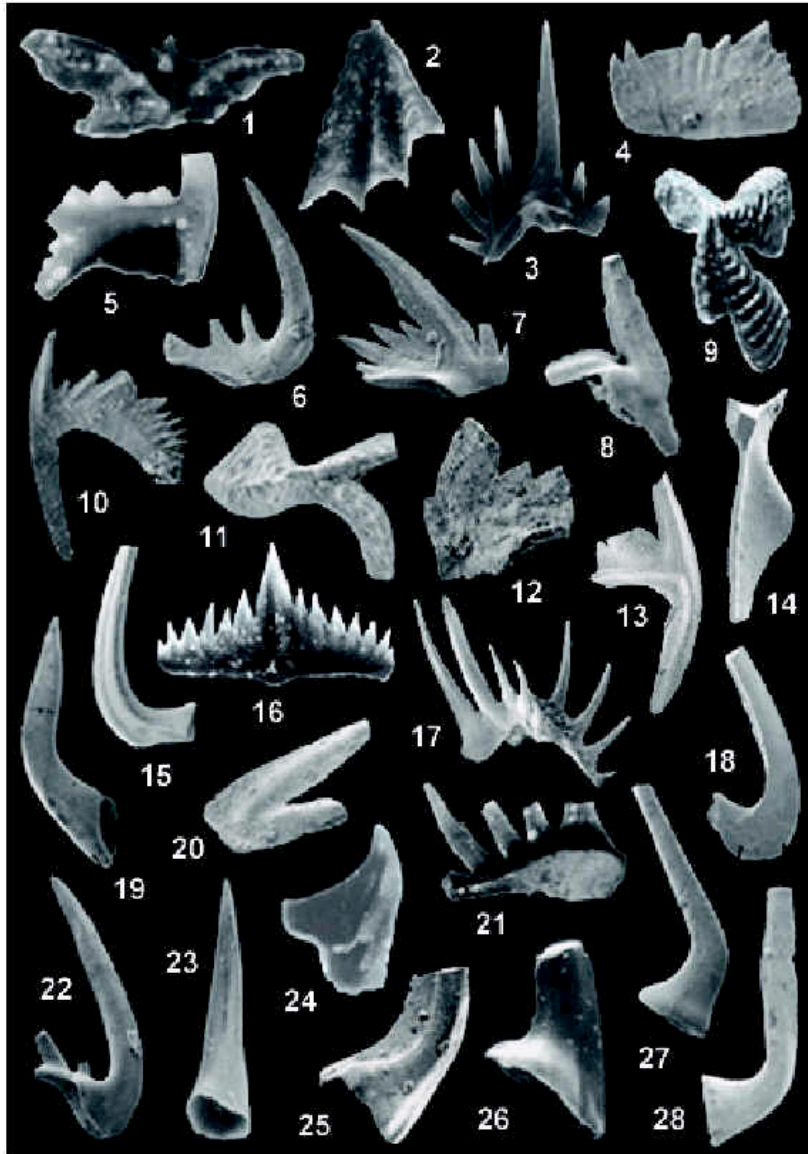


Lamprea de río



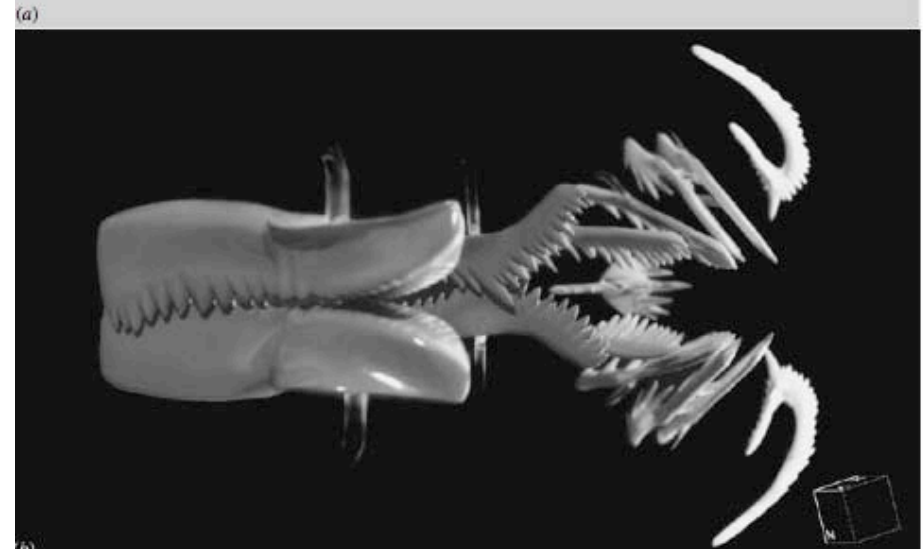
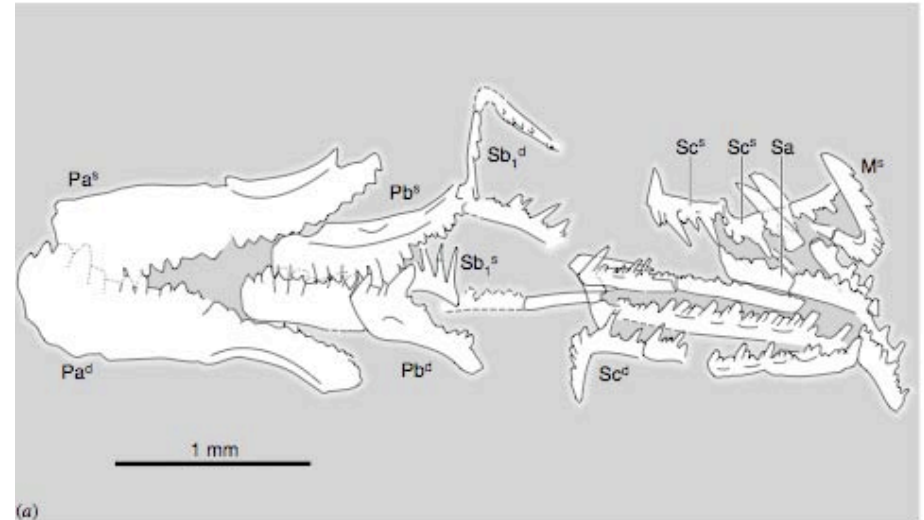
The vertebrates are characterized by a vertebral column; that is, a variable number of endoskeletal elements aligned along the notochord (green) and flanking the spinal cord (yellow). In lampreys (top), the vertebral elements are only the basidorsal (red) and the interdorsals (blue). In the gnathostomes, there are in addition ventral elements, the basiventrals (purple) and interventrals (orange), and the notochord may calcify into centra (pink). (After Janvier 1996).

Los conodontos, conocidos desde el cámbrico por sus dientes fósiles, son más cercanos a los gnathostomos que las myxines y lampreas. Presentan dientes con esmalte (enamel) y grandes ojos con musculatura asociada. Importantly, los dientes presentan evidencia de desgaste.





Los dientes en conodontos se encuentran en la línea media (lado izquierdo contra derecho en vez de “arriba” contra “abajo”). La relación de estos dientes con los arcos branquiales cartilagosos sólo es inferida; se cree que el primer arco puede haber sostenido los elementos más anteriores. Si bien presenta dientes, la arquitectura general no puede homologarse fácilmente a la de una verdadera mandíbula. No se les considera como verdaderos mandibulados (a diferencia de los Gnathostomados actuales)



anterior

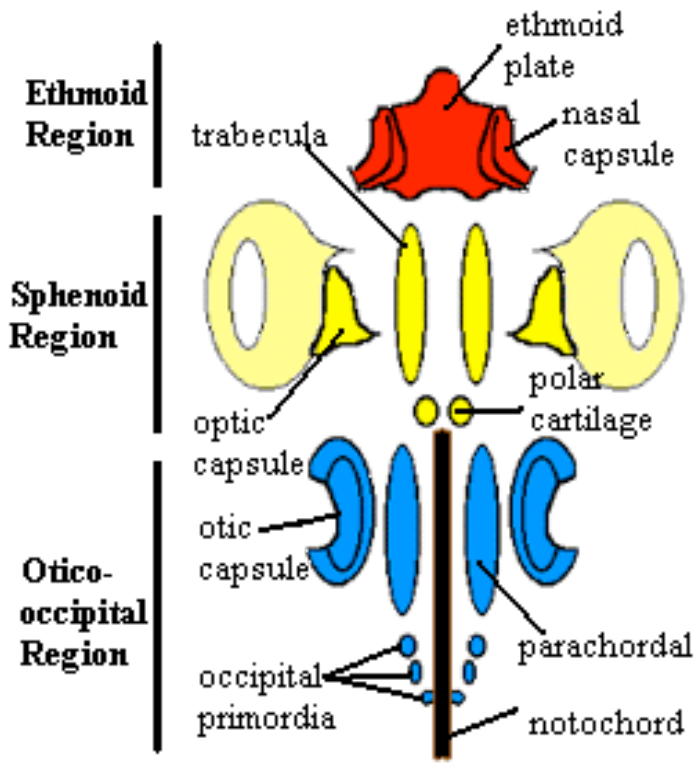
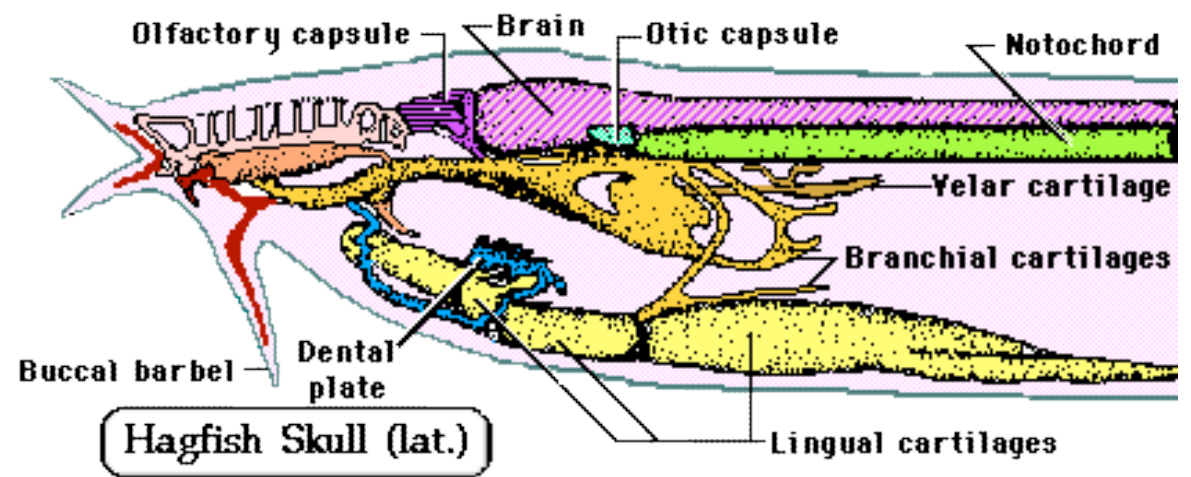
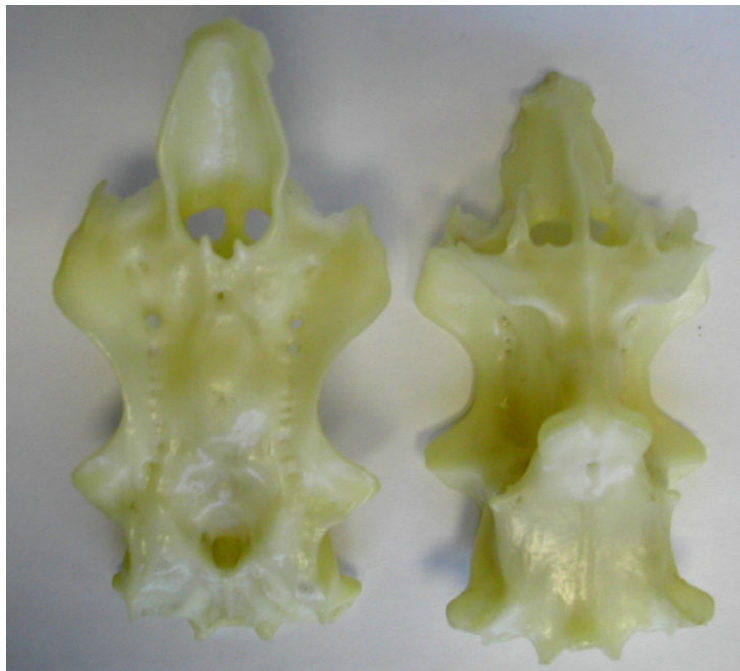
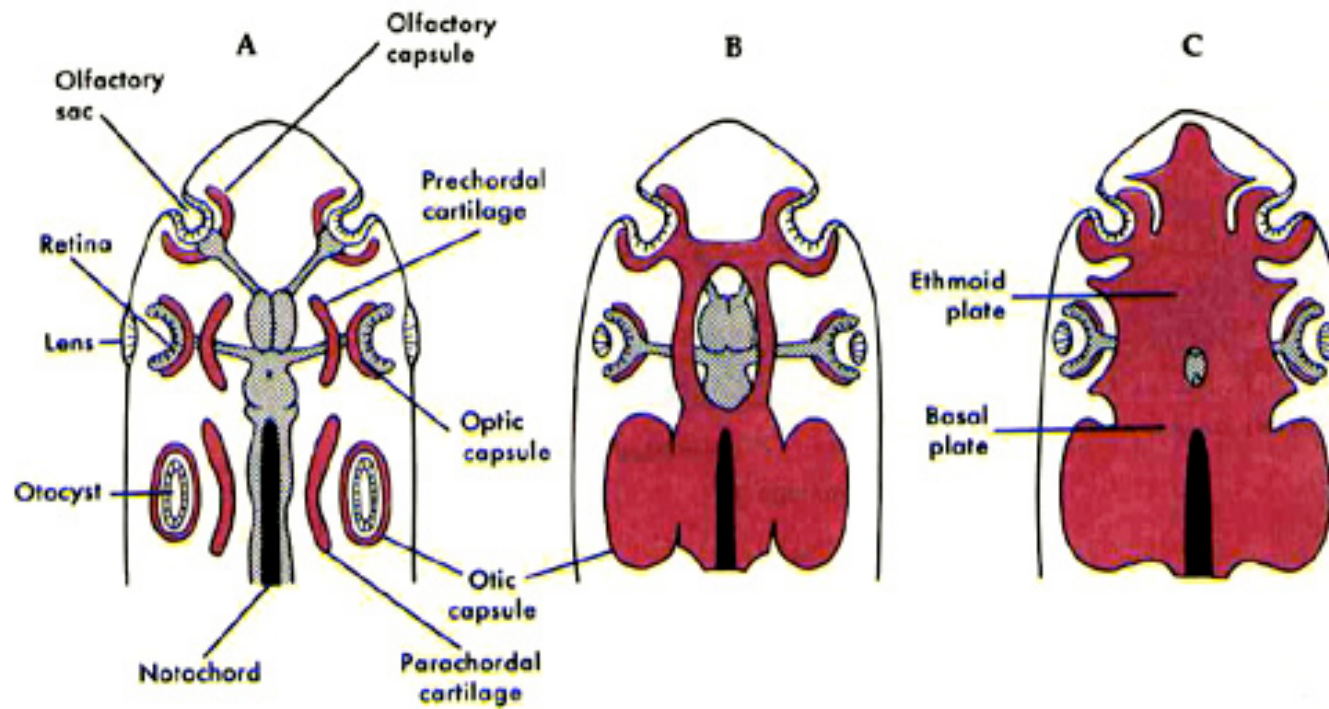


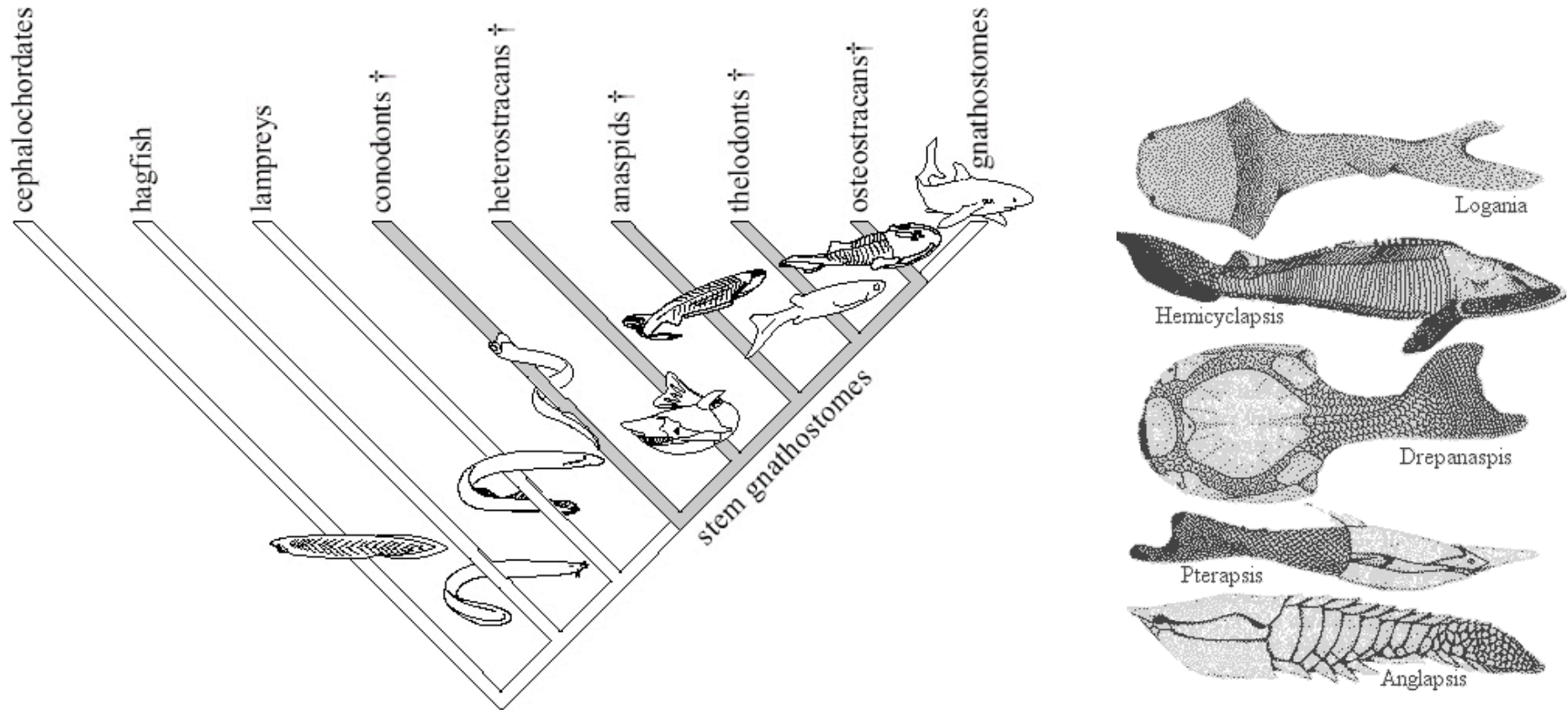
Figure 3. Schematic view of vertebrate braincase development



Neurocráneo (endocráneo)



Antiguamente, Myxines, Lampreas y Ostracodermos se designaban como “agnata” debido a la ausencia de mandíbulas. Actualmente se habla de los ostracodermos como “stem gnathostomes” (mandibulados troncales) para recalcar que estos son más cercanos a los peces mandibulados modernos (gnathostomos) que a las formas vivientes sin mandíbula (lampreas y myxines). Los Ostracodermos son más cercanos a los gnathostomos que a los ciclostomos, entre otras cosas debido a que comparten con gnathostomos la capacidad de producir distintos tipos de hueso:
ORIGEN DEL DERMATOCRÁNEO



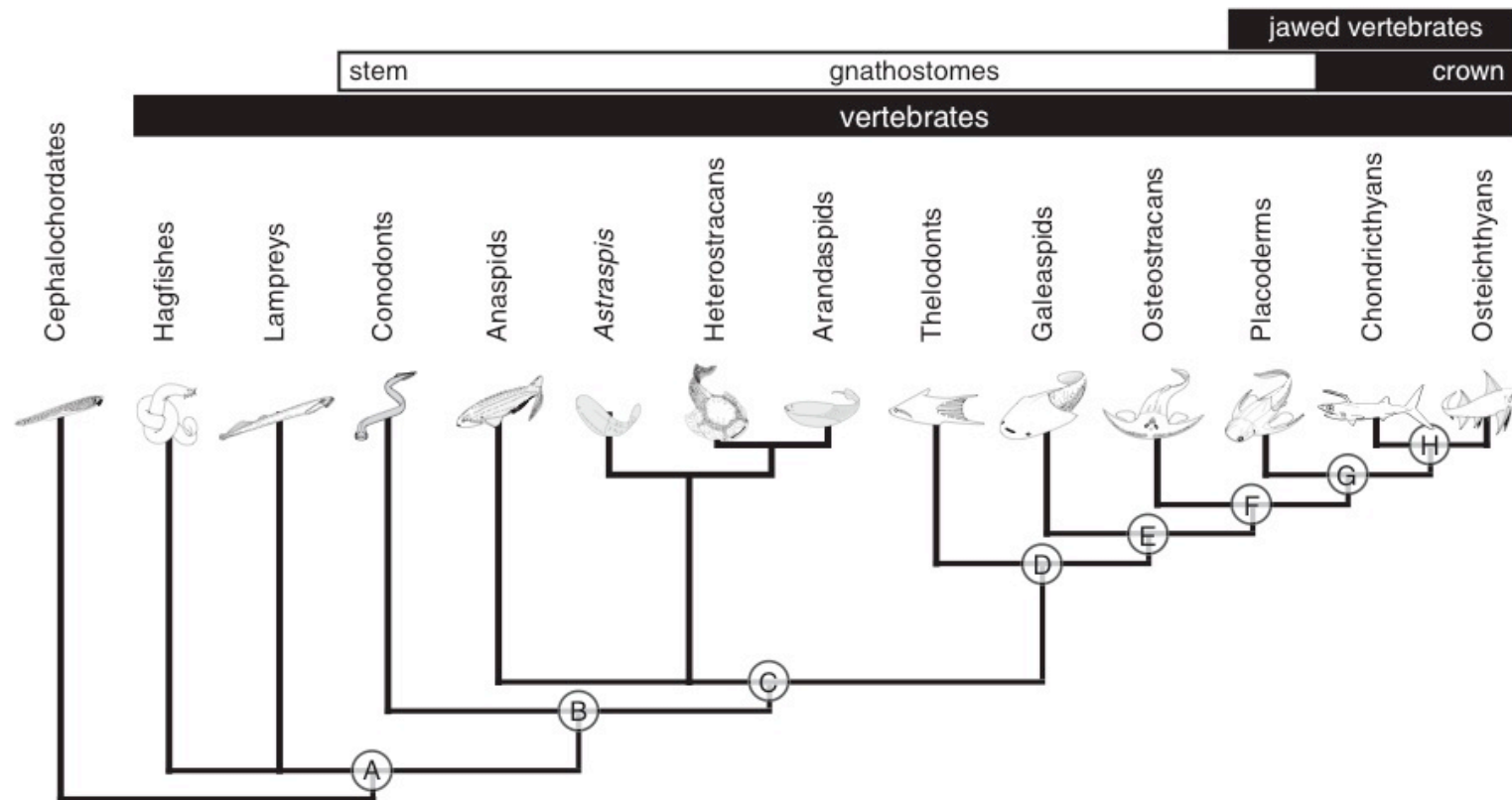
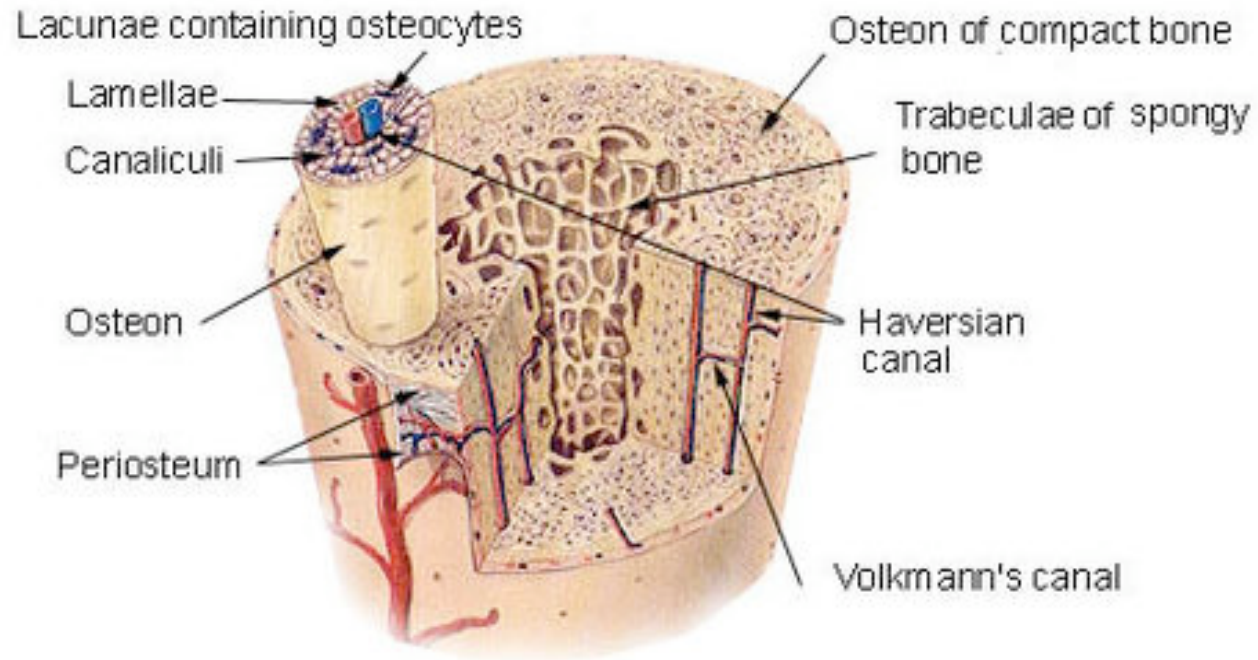
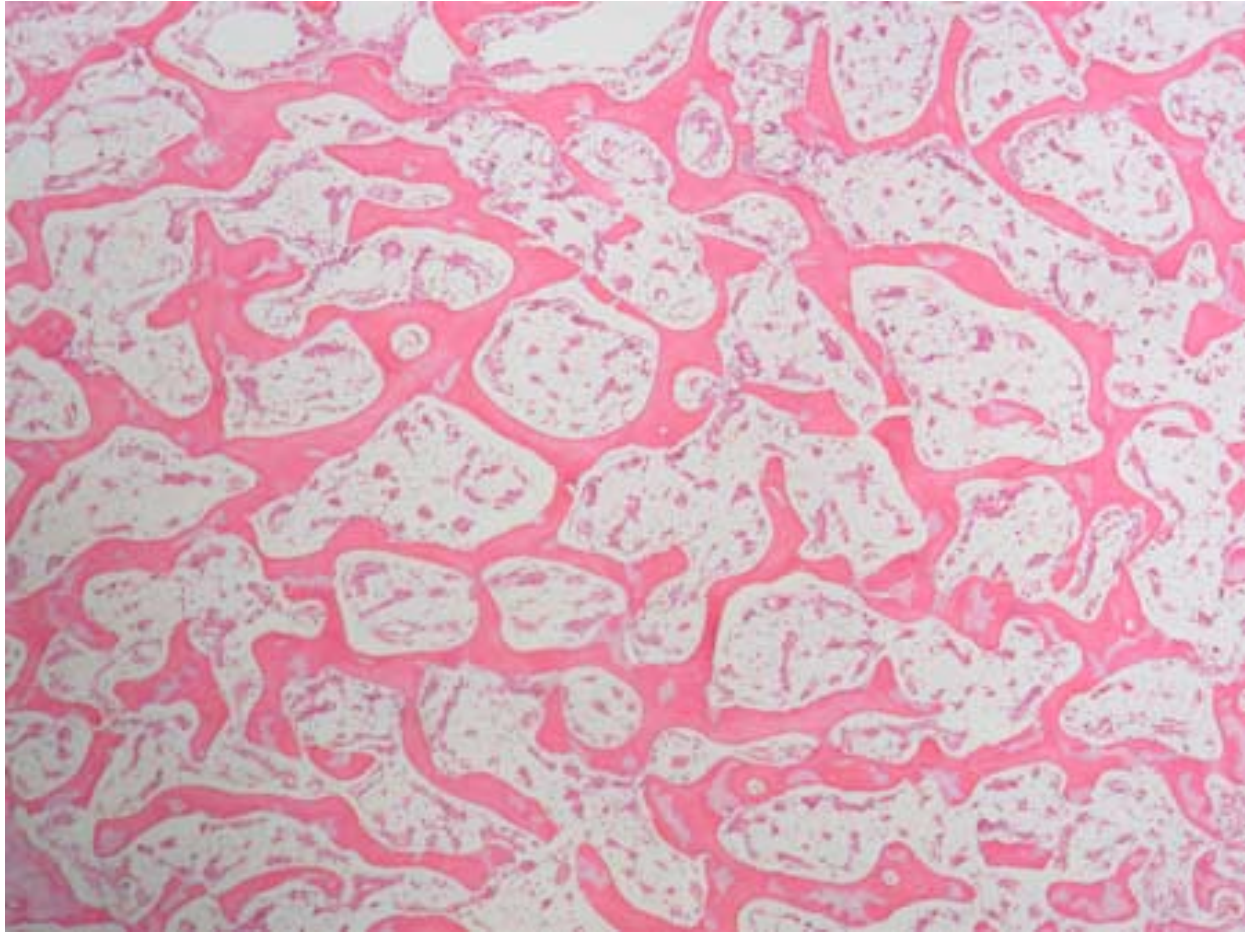


Fig. 1. Phylogeny of vertebrates adopted in this paper, based on the phylogenetic analyses of Donoghue and Smith (2001). Note the distinction between gnathostomes and jawed vertebrates. The letters (A–H) denote nodes at which significant steps in vertebrate skeletal evolution occurred, as inferred through ACCTRAN optimization of data from the terminal taxa. (A) Origin of a vertebrate skeleton including a notochordal sheath, fin rays, neurocranium and viscerocranium, though entirely composed of unmineralized cartilage. (B) Origin of a mineralized skeleton, dentine and enamel comprising the odontode developmental module, first manifest in the viscerocranium. (C) Origin of a mineralized dermoskeleton composed of odontodes supported by extensively developed bone, imposing mineralization upon the collagenous layers of the dermis. (D) Odontodes associated with the viscerocranium, including either the gill arches or the nasohypophyseal openings. (E) Origin of a mineralized neurocranium composed of globular calcified cartilage. (F) Mineralized neurocranium encompassing equivalents of the scapula and coracoid, as well as the pericardial region, composed of cellular perichondral bone; cellular dermal bone also first encountered in the dermoskeleton. (G) Mineralized viscerocranium, axial skeleton, appendicular skeleton and fin radials. (H) Endochondral bone.

Secretory Calcium-Binding Phosphoproteins (SCPP's)

Compact Bone & Spongy (Cancellous Bone)





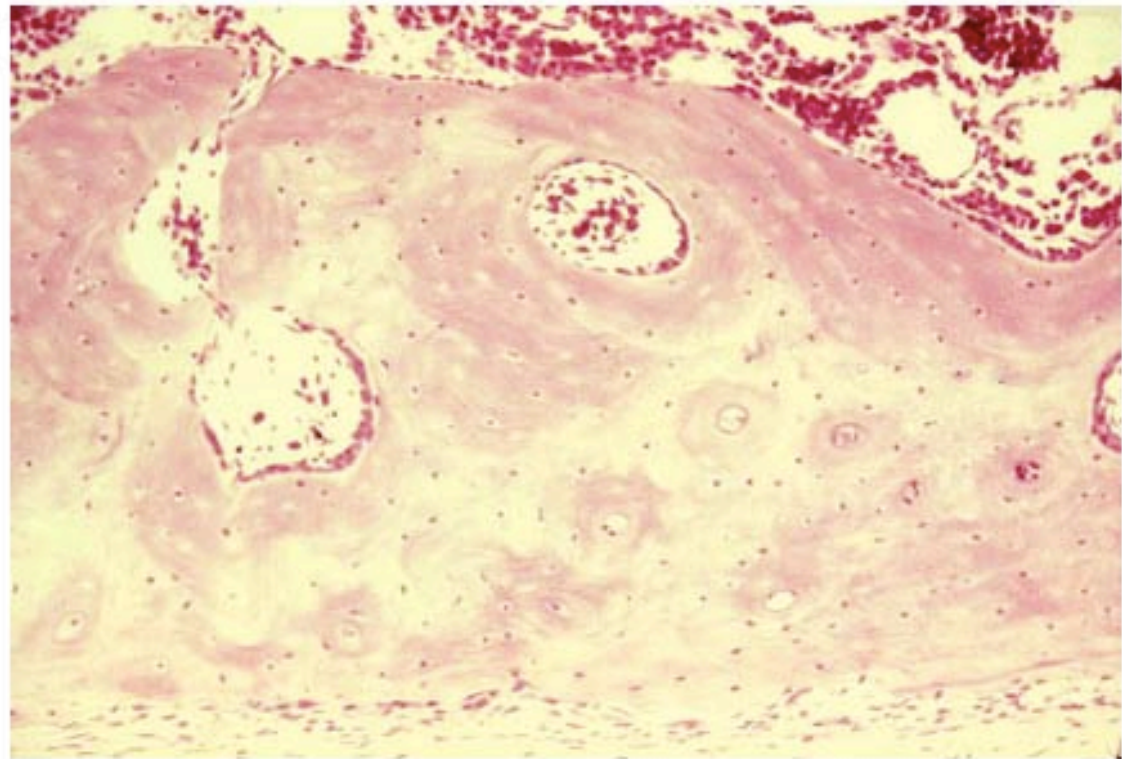
Bone:

<http://ect.downstate.edu/courseware/histomanual/bone.html>

Histology Lab Manual

Structure List

- marrow cavity
- periosteum
- osteon
- endosteum
- inner circumferential lamellae
- outer circumferential lamellae
- lamellae

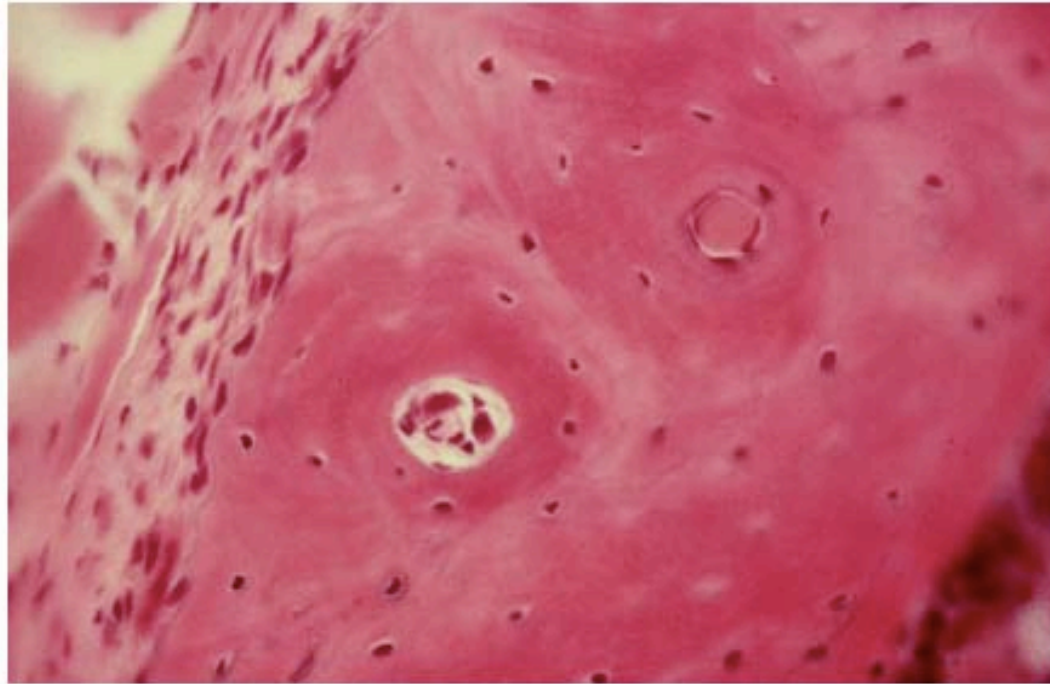




Histology Lab Manual

Structure List

haversian canal
osteon
osteocyte
periosteum



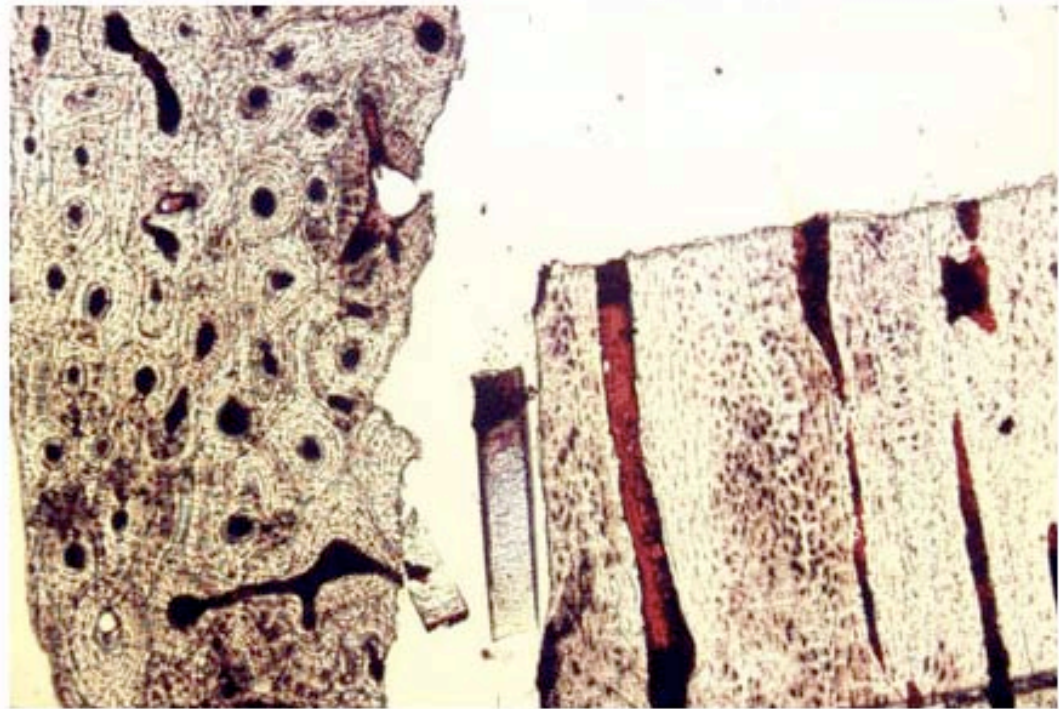
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Histology Lab Manual

Structure List

- cross section
- longitudinal section
- haversian canal
- Volkman's canal
- osteon



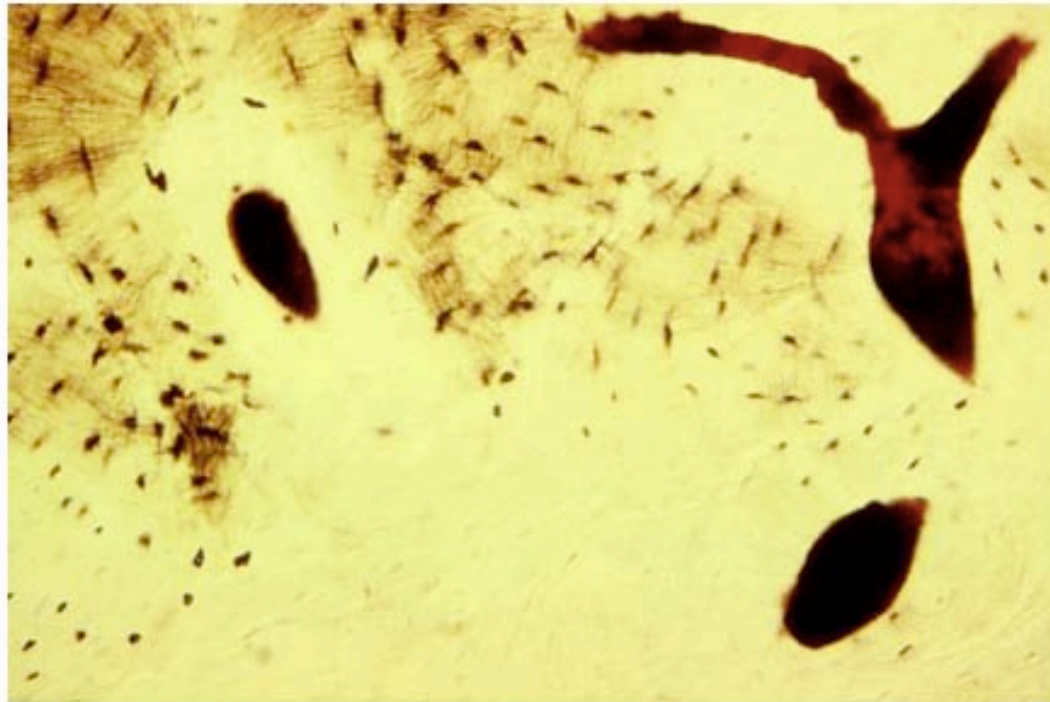
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Histology Lab Manual

Structure List

- Volkman's canal
- haversian canal
- lacunae
- interstitial lamellae
- concentric lamellae



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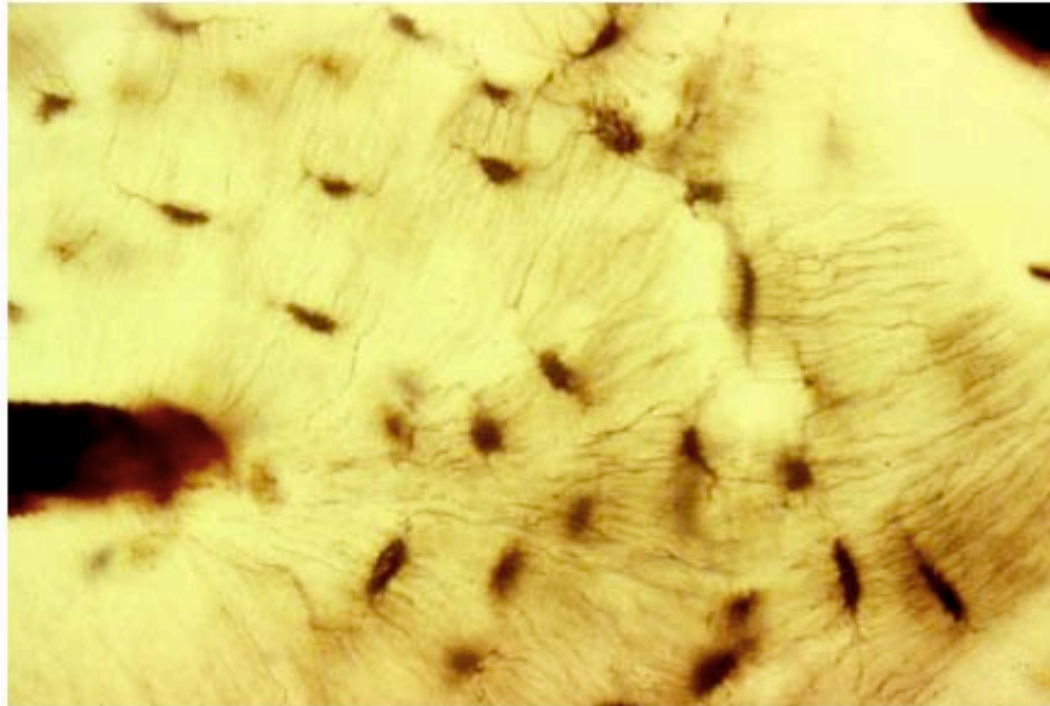




Histology Lab Manual

Structure List

lacunae
canaliculi



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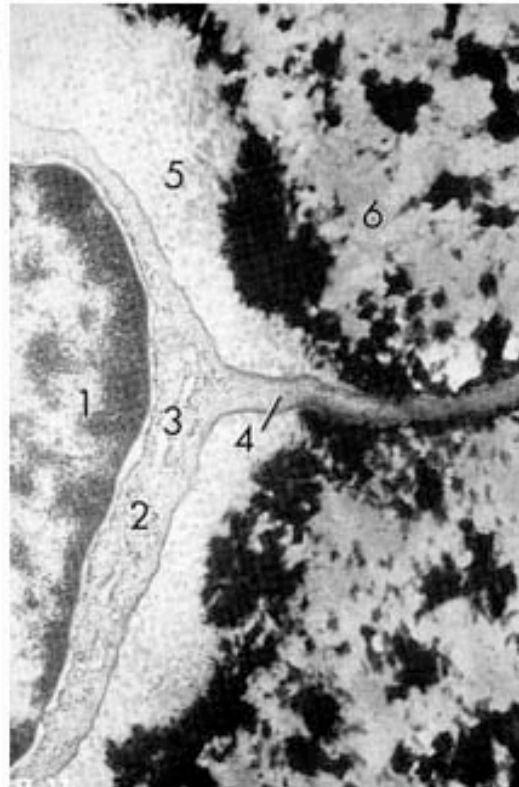




Histology Lab Manual

Structure List

- nucleus of osteocyte
- process of osteocyte in canaliculus
- cytoplasm of osteocyte
- bone matrix
- lacunae



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Histology Lab Manual

Structure List

bony spicule
connective tissue



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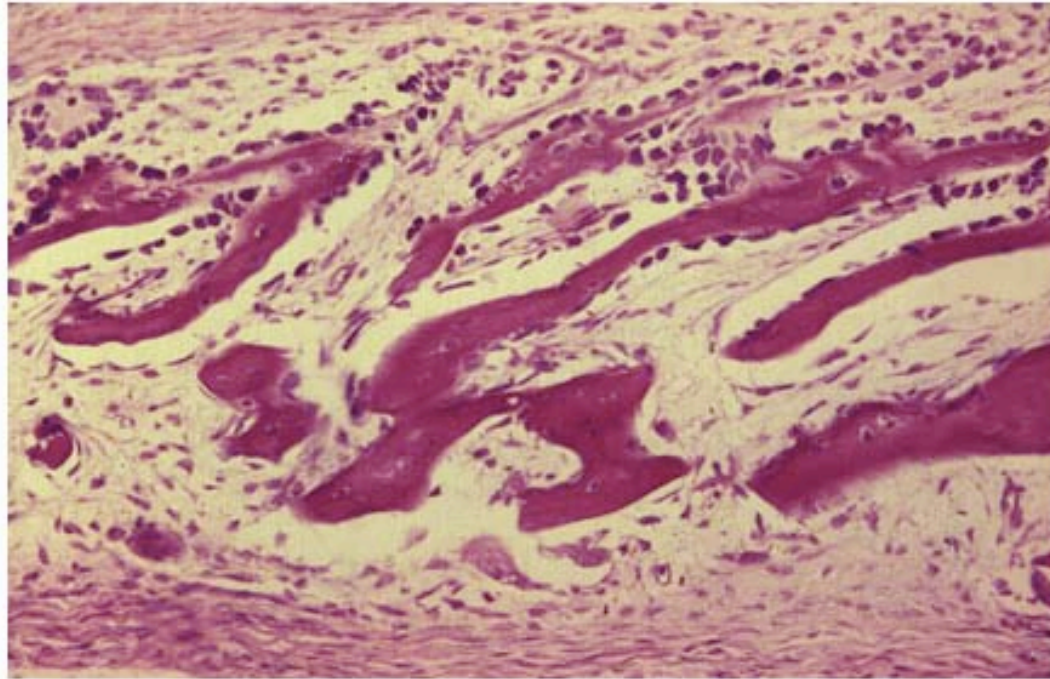




Histology Lab Manual

Structure List

osteoid
osteocyte
bone
"mature" spicule
osteoblasts



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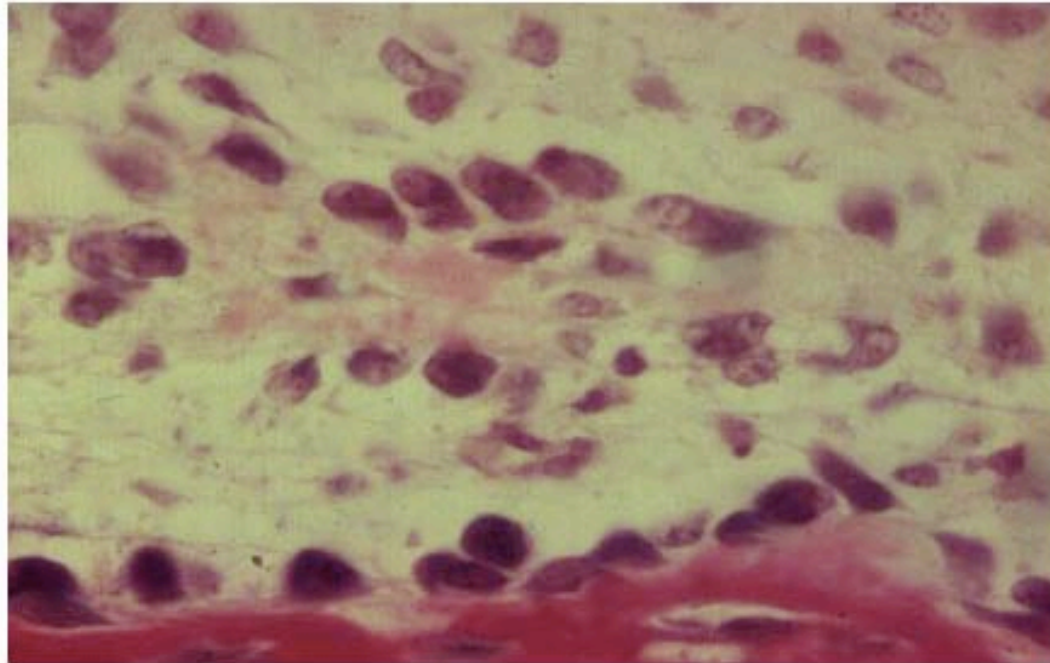




Histology Lab Manual

Structure List

osteoblast
osteoid
bone



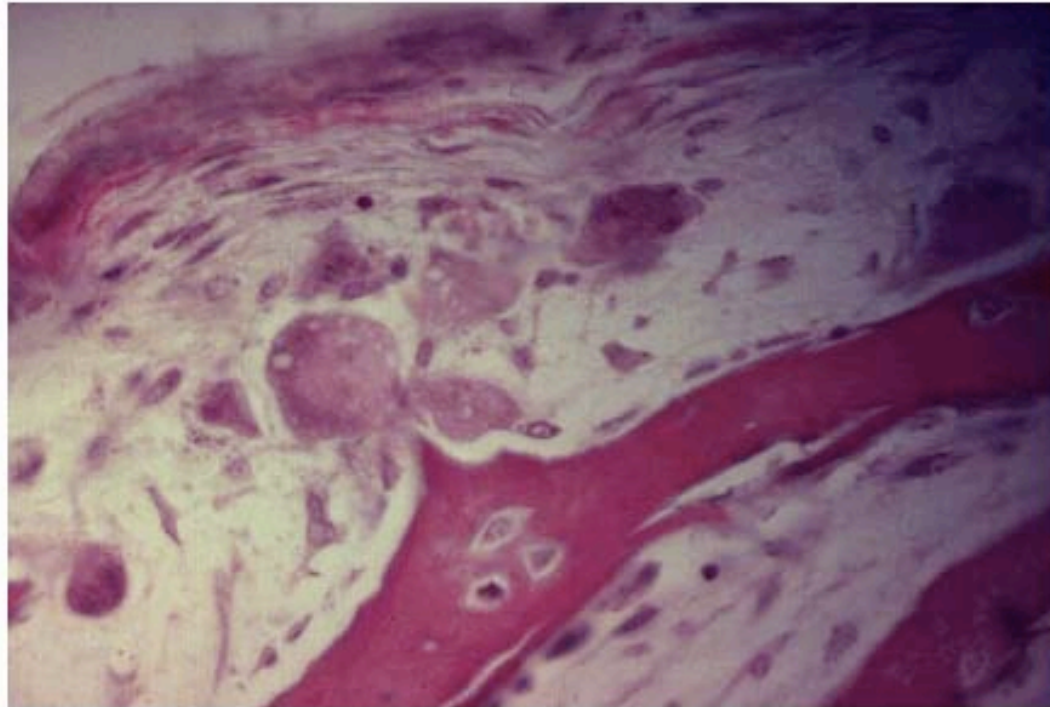
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Histology Lab Manual

Structure List

osteoclast
osteocyte
osteoblast
bone
Howship's lacunae

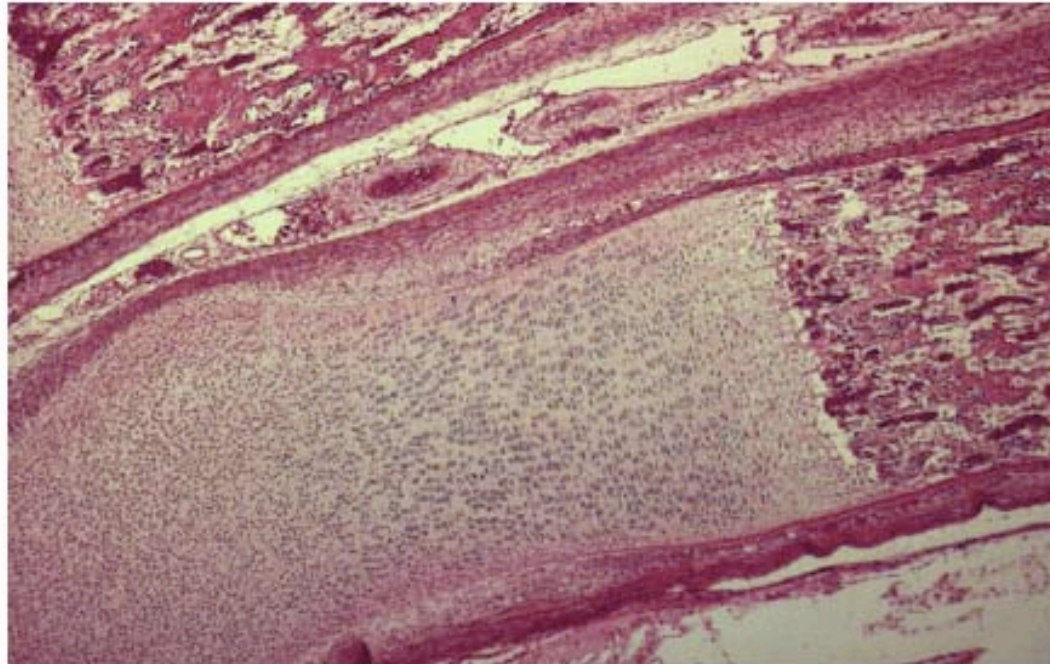


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Histology Lab Manual

Structure List

epiphysis
growth plate
bony collar
diaphysis
perichondrium
periosteum
trabeculae of bone



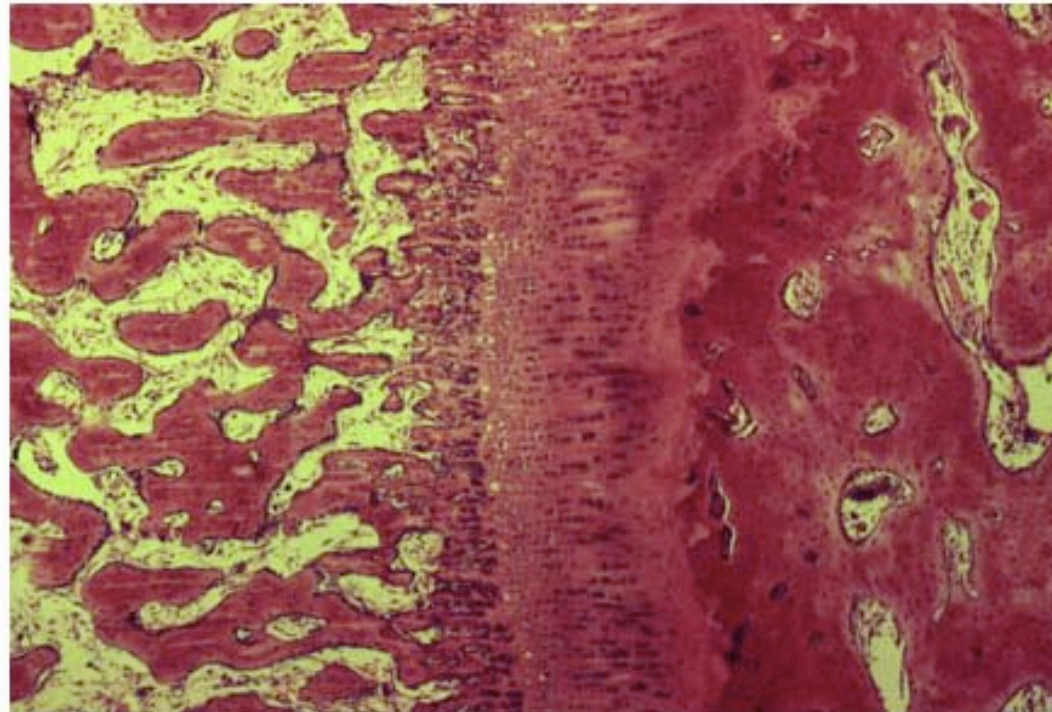
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Histology Lab Manual

Structure List

growth plate
primary marrow cavity
secondary marrow cavity
diaphysis
epiphysis



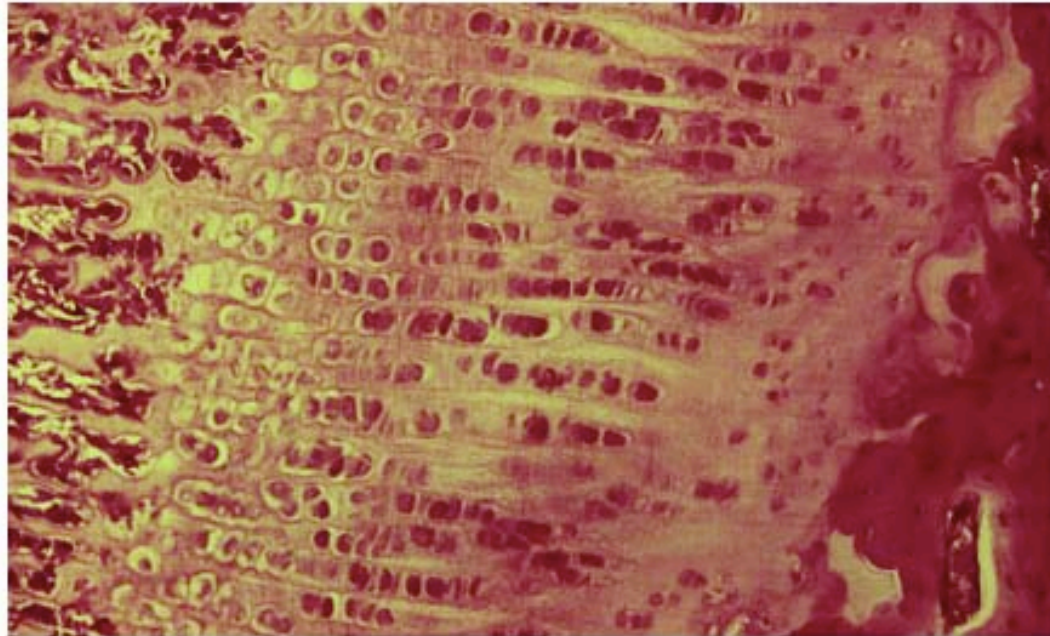
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Histology Lab Manual

Structure List

bone/epiphysis
zone of reserve cartilage
zone of proliferation
zone of hypertrophy
zone of calcification
zone of ossification



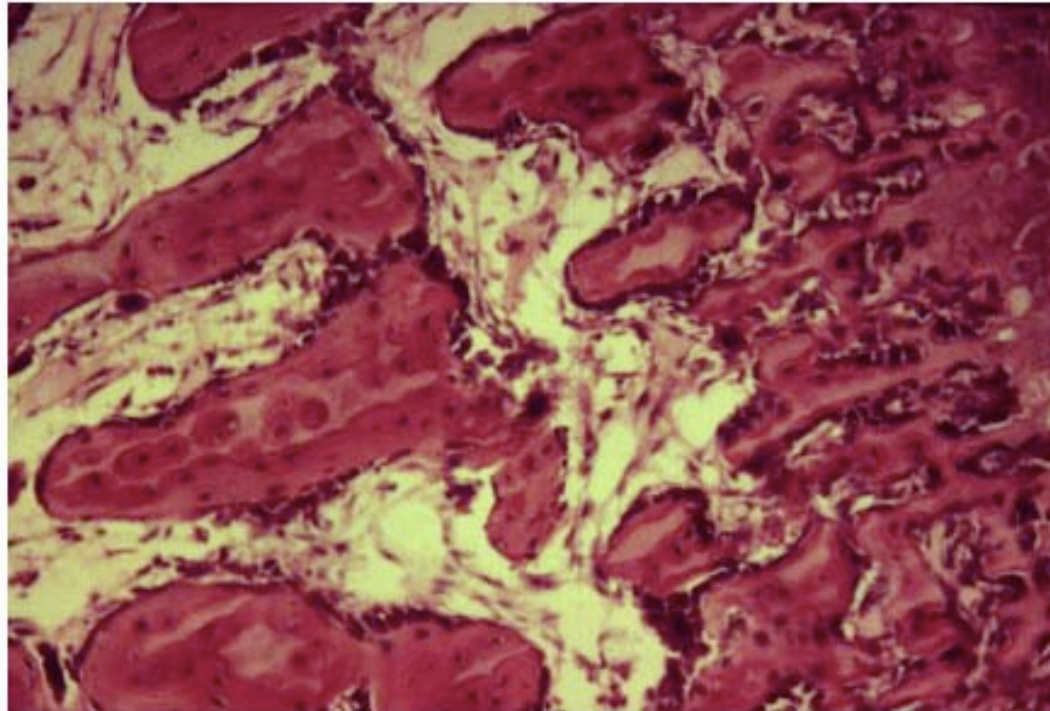
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Histology Lab Manual

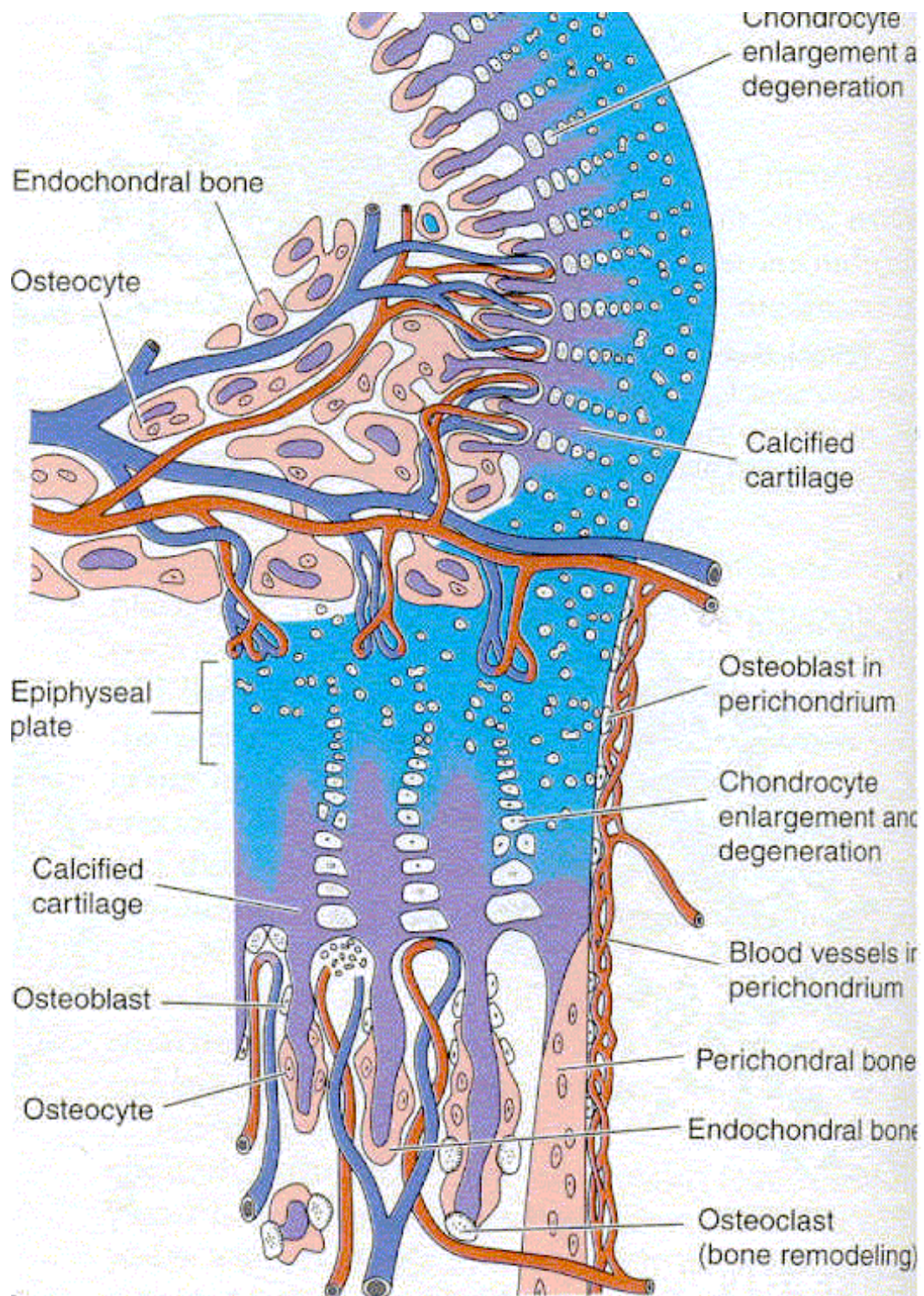
Structure List

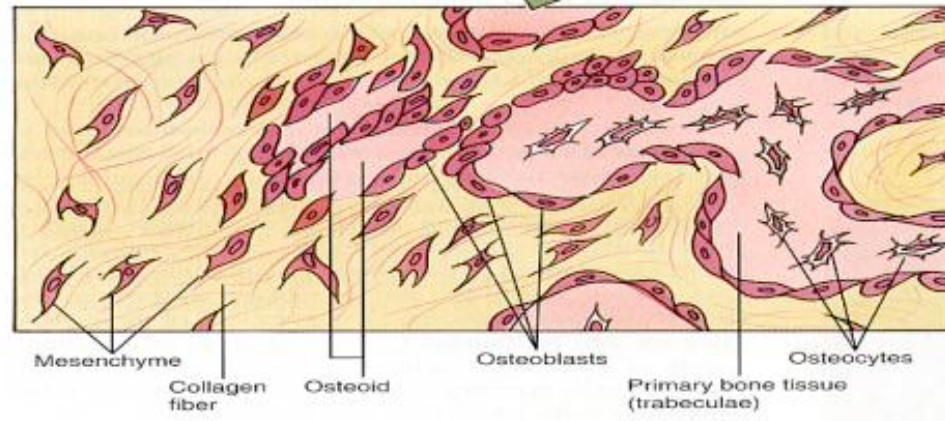
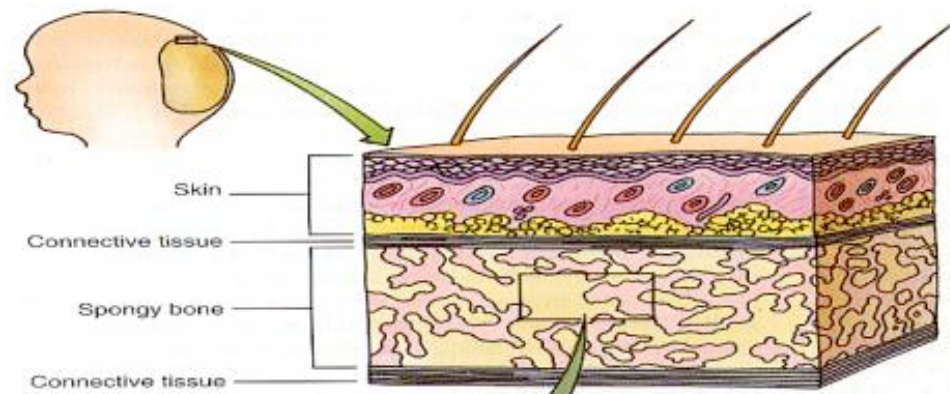
calcified cartilage
bone
osteoblasts
zone of ossification



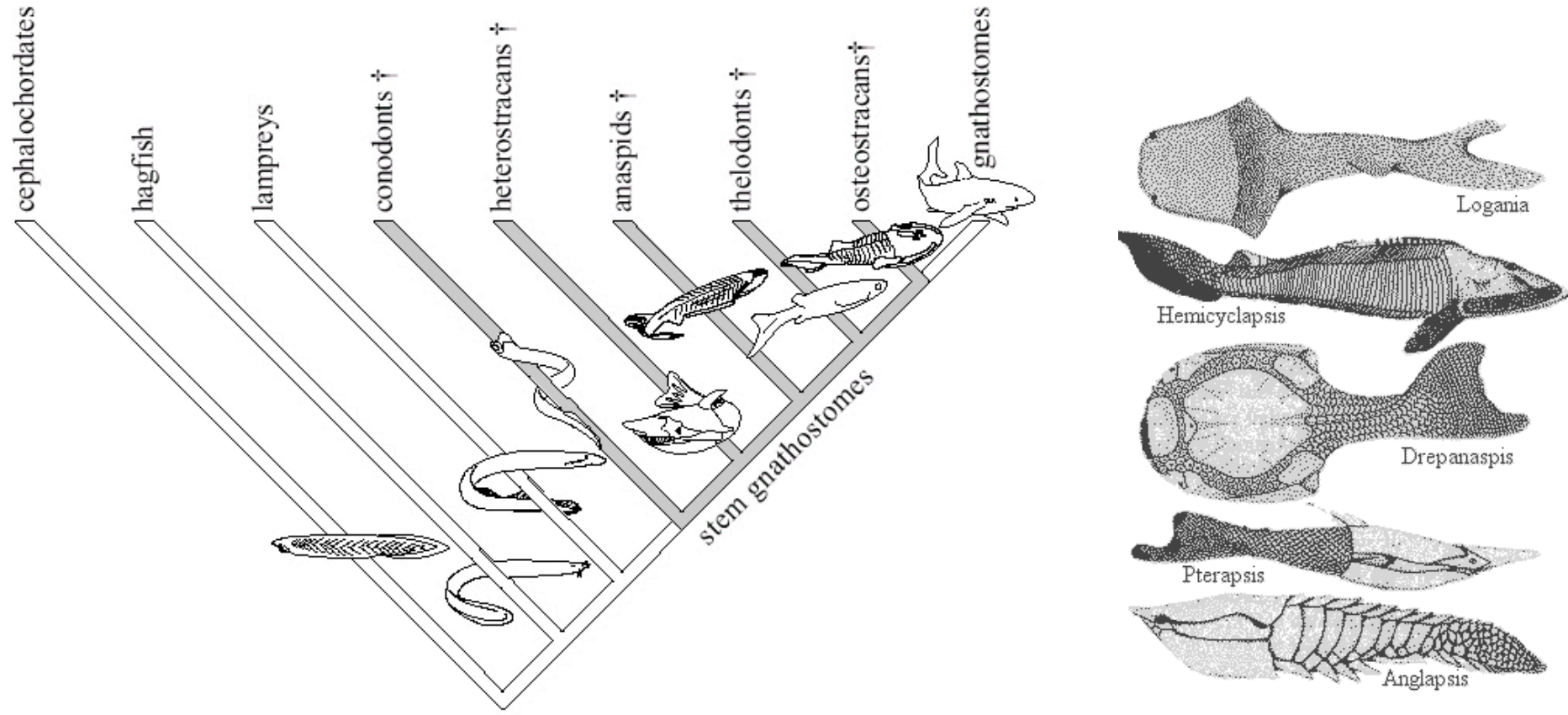
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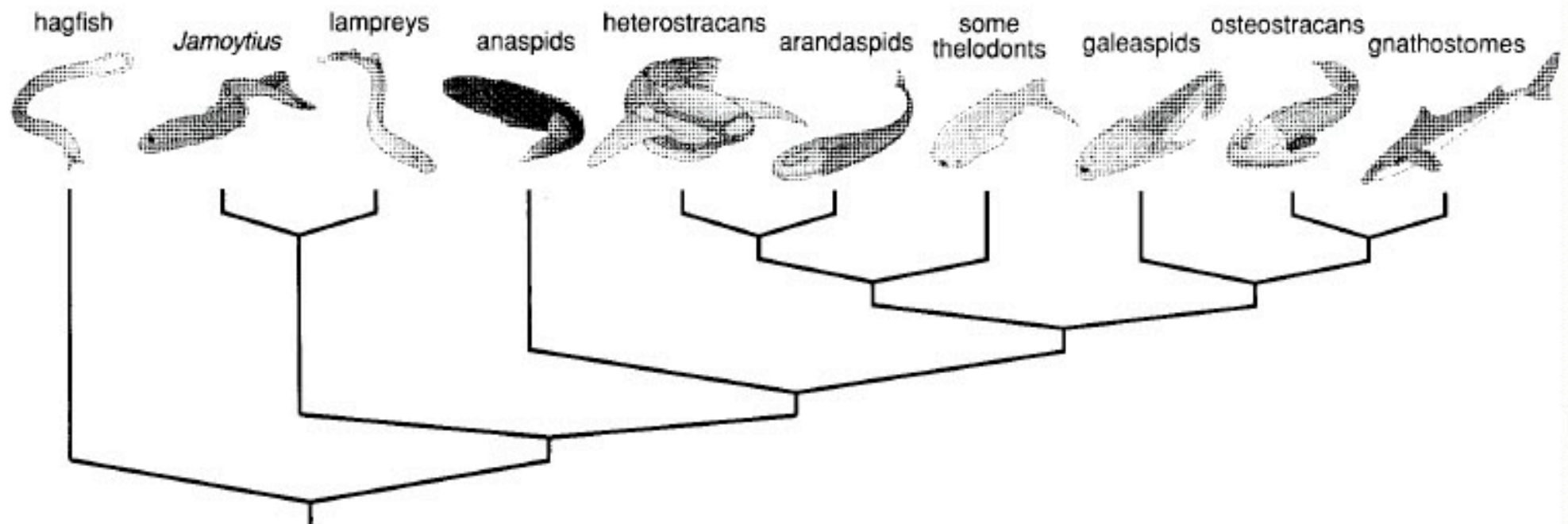
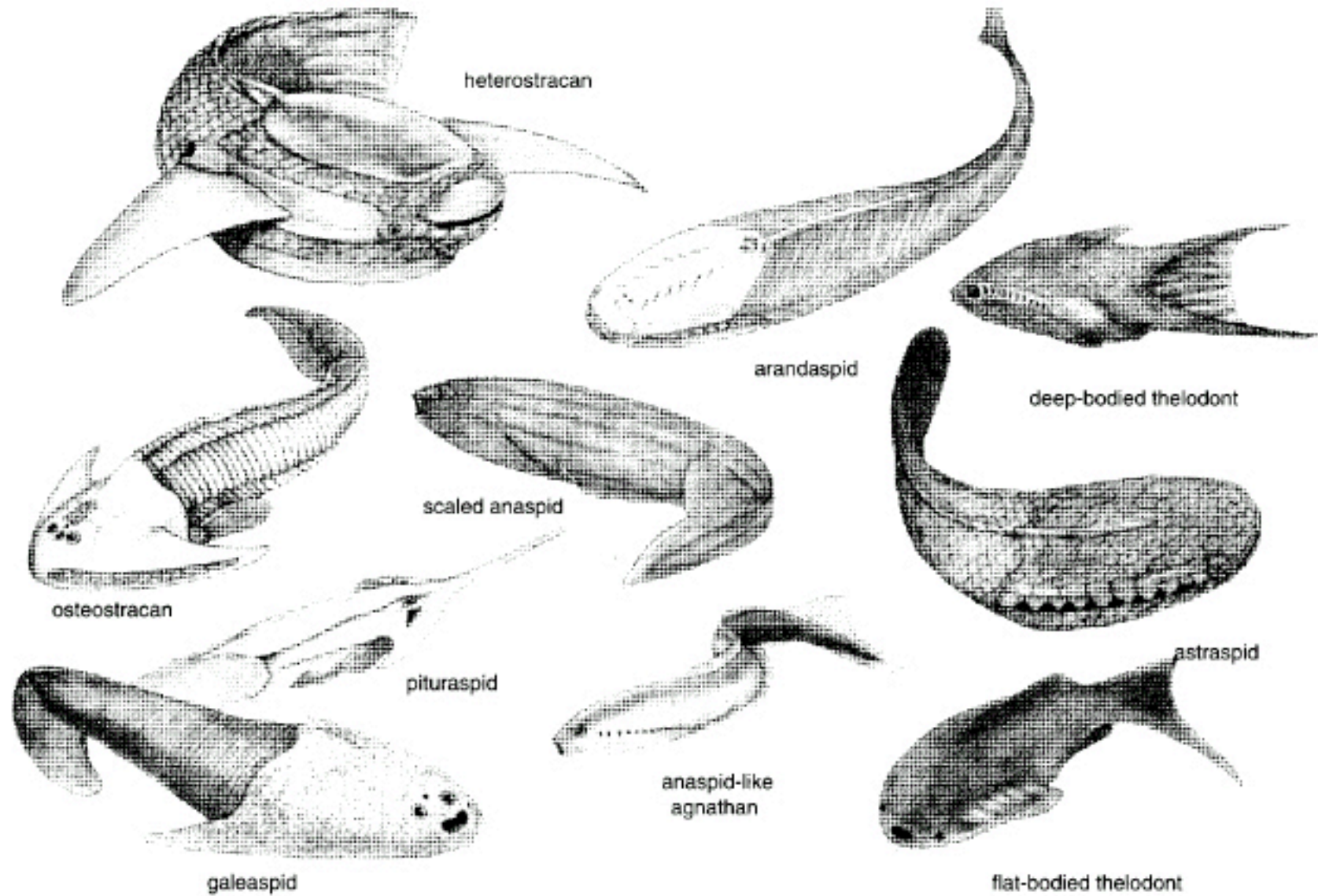
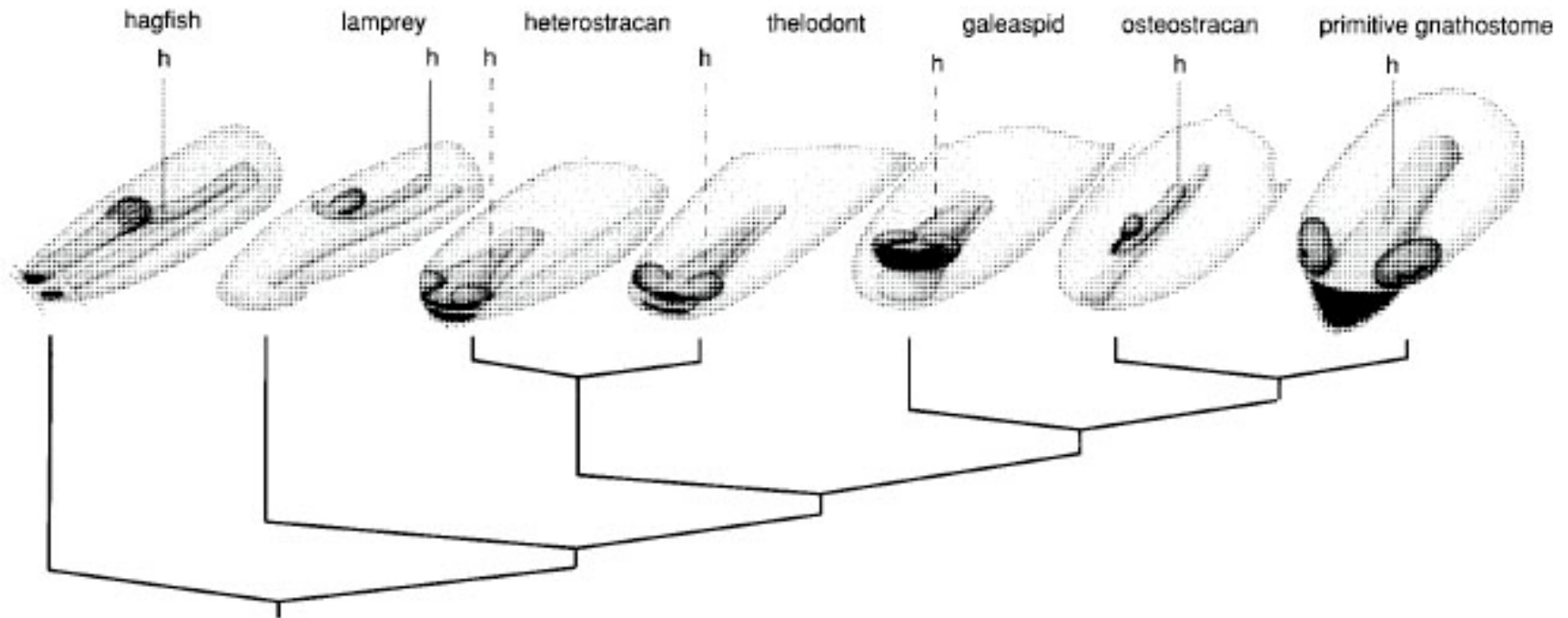


Figure 8. Phylogenetic tree based on a cladistic analysis of 56 anatomical features suggests that most of the ostracoderms are more closely related to modern jawed vertebrates than they are to modern jawless vertebrates. Of the ostracoderms, the osteostracans appear to be the most closely related to the jawed vertebrates. Among the modern groups, the jawed vertebrates are more closely related to the lamprey than either is to the hagfish. The fossil jawless fish, *Jamoytius*, appears to be a close relative of modern lampreys. Hagfishes are the most primitive known living or fossil vertebrates. Such phylogenetic trees allow paleontologists to determine which characteristics are primitive and which are evolutionarily derived.

Grupos de Ostracodermos



En Ciclostomos y Ostracodermos, Se destaca la presencia de un ducto nasohypofisial que se comunica con las narinas y a partir del cual se desarrolla la hipófisis.



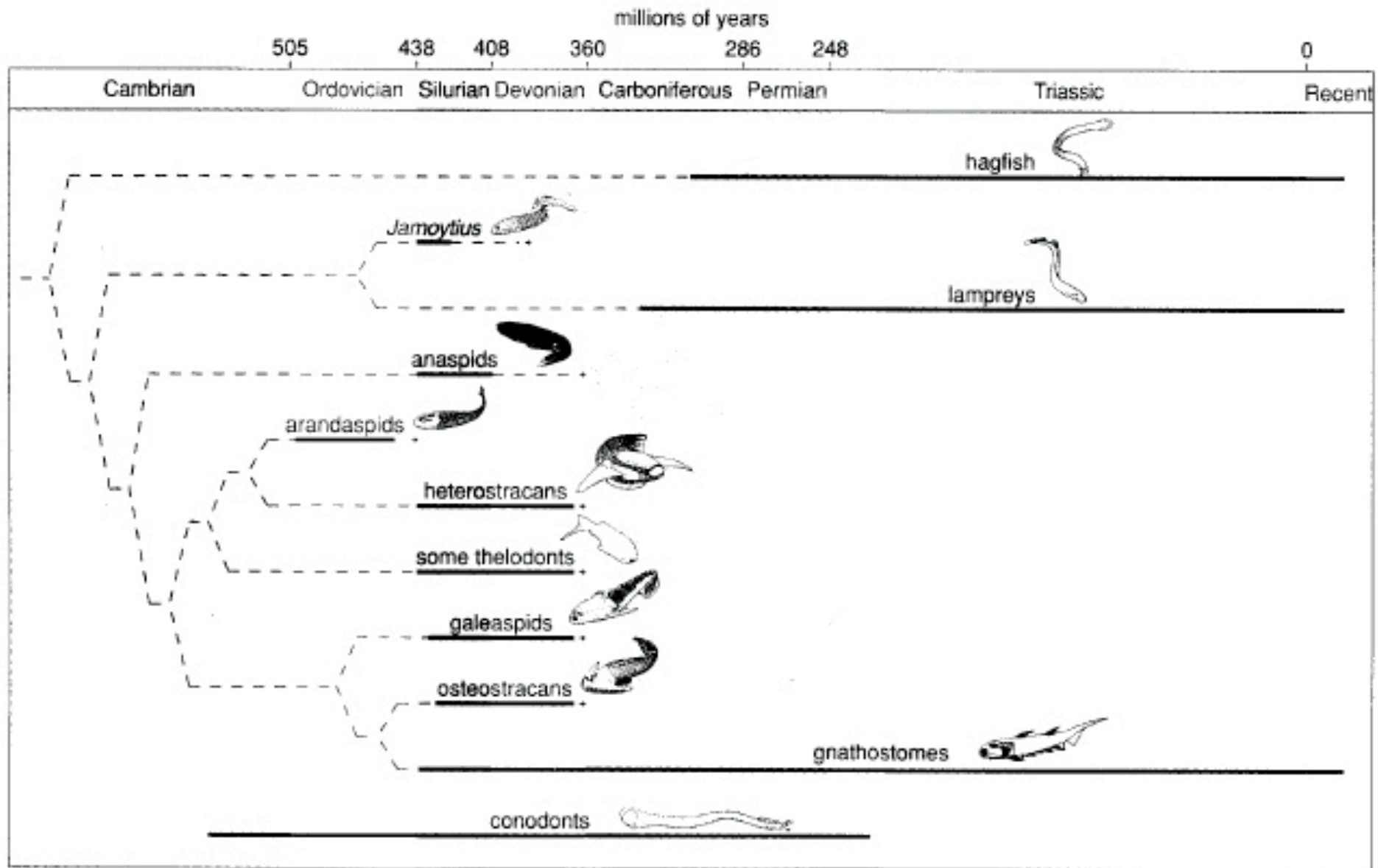


Figure 15. Stratigraphic distribution of living and fossil groups of vertebrates suggests that undiscovered vertebrate ancestors (*dashed lines*) lived in the Cambrian period, more than 500 million years ago. Conodont elements are found in Cambrian deposits, but their evolutionary relationship to the known vertebrates is not clear. The first jawed vertebrates, here represented by an acanthodian, appeared more than 400 million years ago in the Silurian period.

Anáspidos

Ostracodermos de agua dulce.

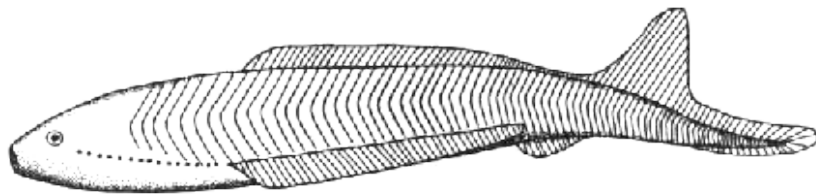
Cola dirigida hacia abajo.

Algunos anáspidos poseen escamas, otros son “desnudos”

Sus fósiles se han recuperado en Europa y América del Norte.

Jamoytius comparate con las lampreas un anillo circular alrededor de la boca, ojos grandes y arcos branquiales similares.

Poseen aletas laterales pareadas en forma de cinta, detrás de la línea de aperturas branquiales



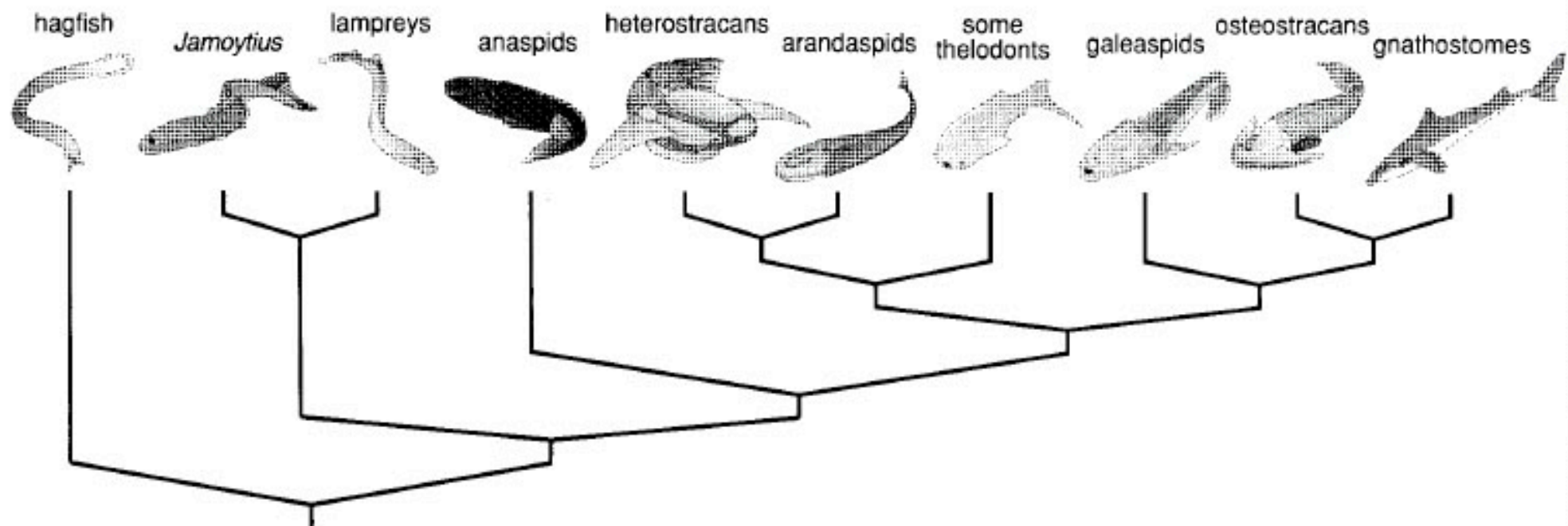


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Arandáspidos

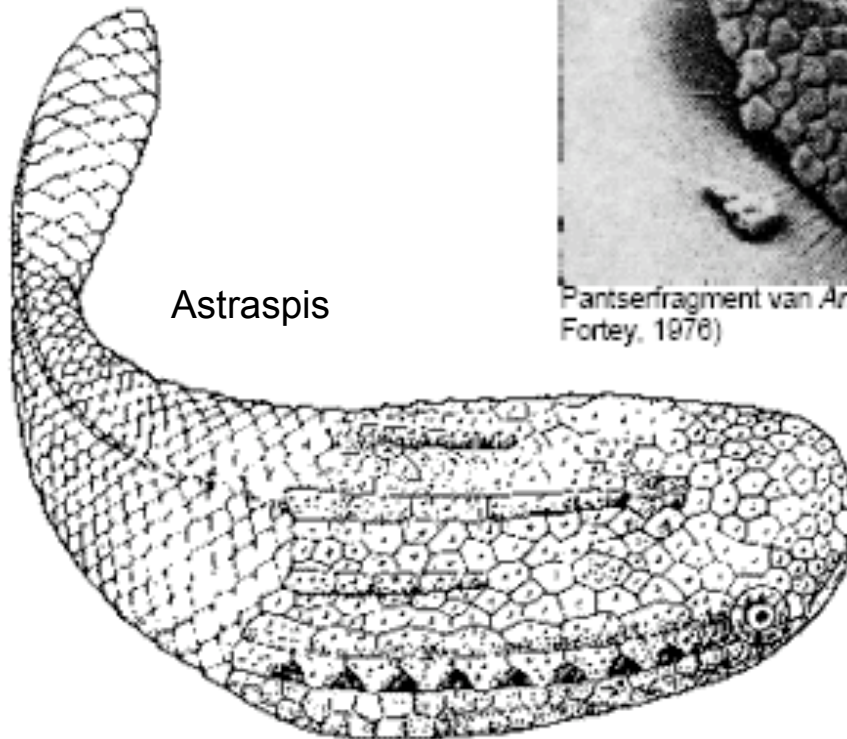
Placa dorsal y ventral en la cabeza y están separadas por varias placas branquiales.

Placas dermales compuestas de diminutas unidades poligonales que se añadían a los bordes de las placas (incapaces de crecer por si mismas). Esta podría representar una forma primitiva de crecimiento ya que está hecho de hueso sin células (aspidina).

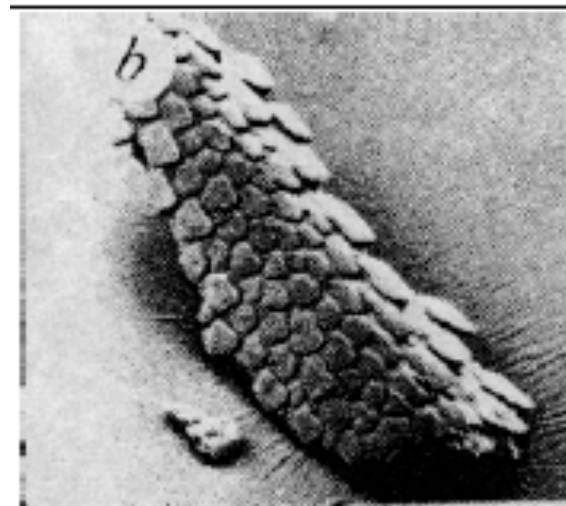
Se han hallado en América del Sur, Australia.



Sacabambaspis



Astraspis



Pantserfragment van *Anatolepis* (Bockelie & Fortey, 1976)



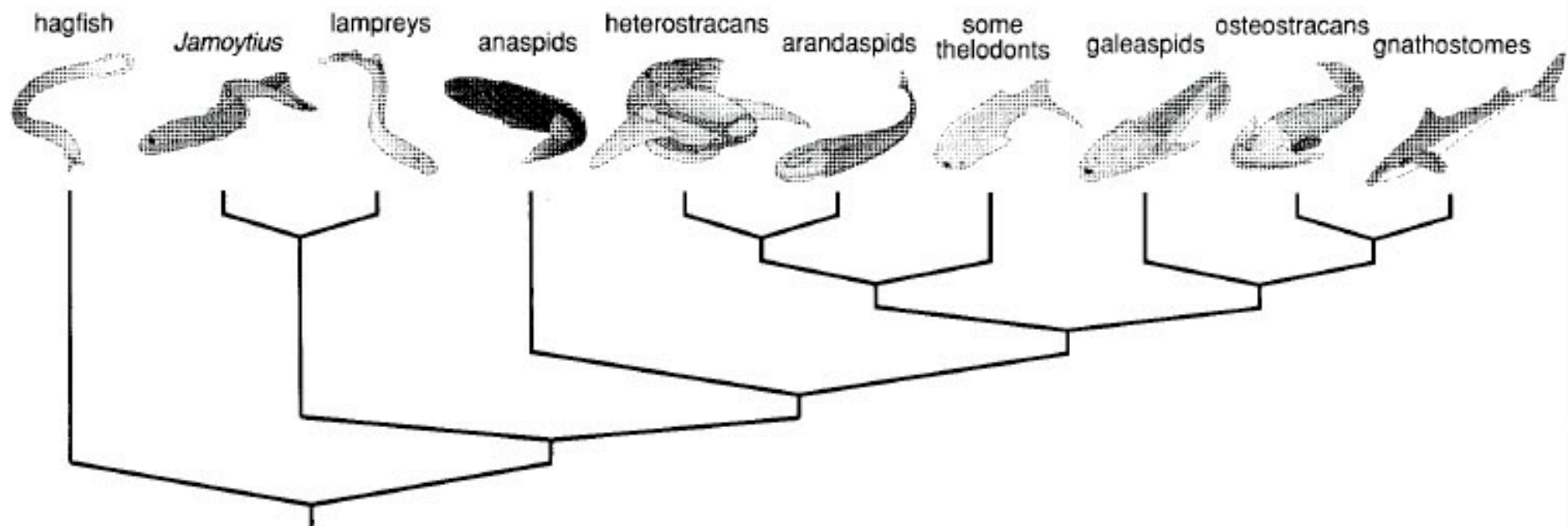


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Heterostraci

Son de aguas costeras semi saladas y algunos depósitos posiblemente de agua dulce.

Se han hallado en: América del Norte, Europa, Siberia.

Aparentemente carecen de endoesqueleto Esqueleto dérmico bien desarrollado, cubre cabeza, cuerpo y cola.

Placa dorsal y ventral en la cabeza.

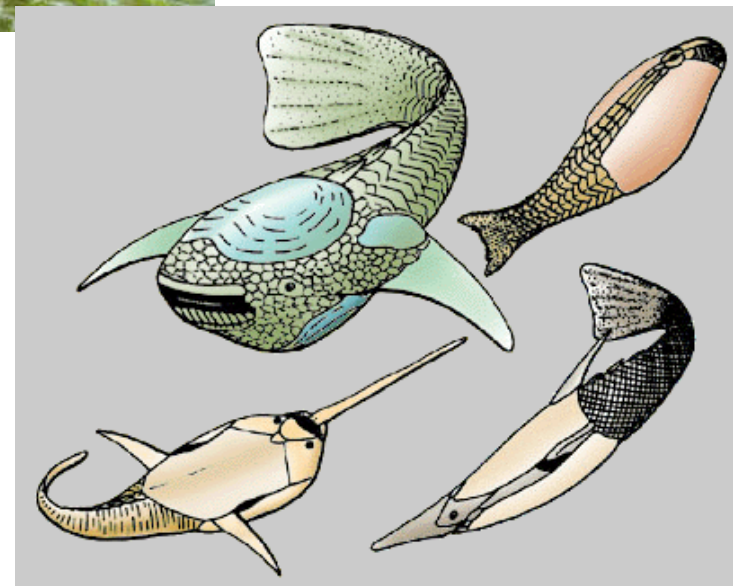
Cada placa está hecha de un tejido de hueso sin células llamado Aspidina (también presente en escamas de otros ostracodermos, incluyendo anáspidos y galeáspidos). Poseen una sola apertura branquial



Doryaspis



Drepanaspis



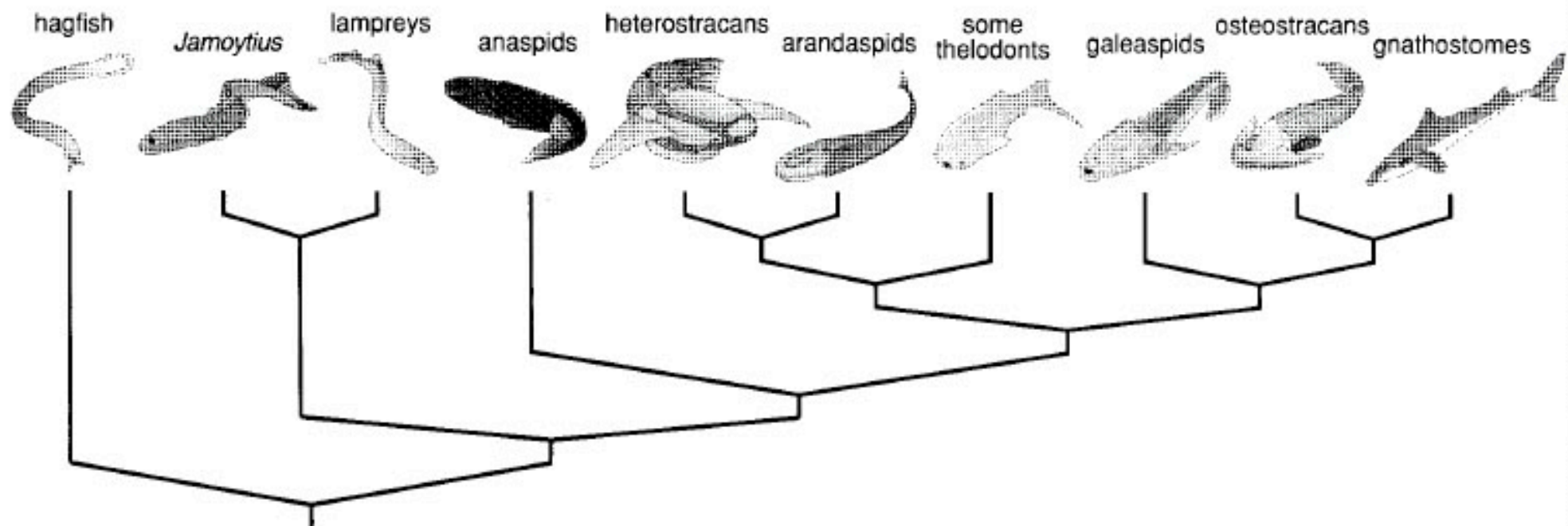


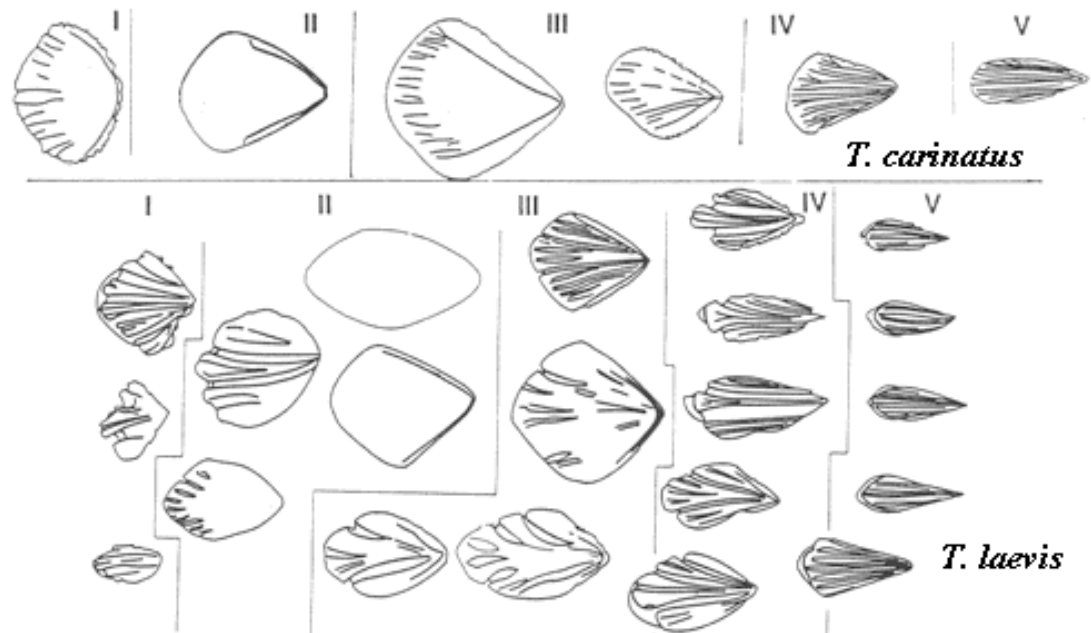
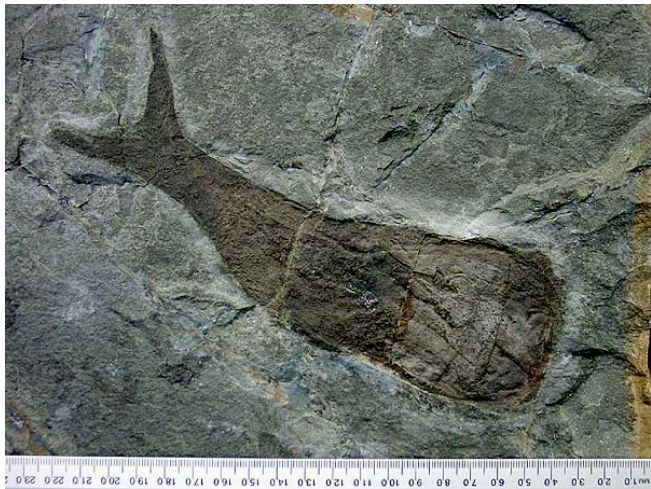
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Telodontos

No poseen placas y tienen escamas pequeñas de diversa morfología.

Existen dos grupos de telodontos: aplanados con cola hacia abajo y profundos con la cola bífida.

Se han hallado escamas en todo el mundo.



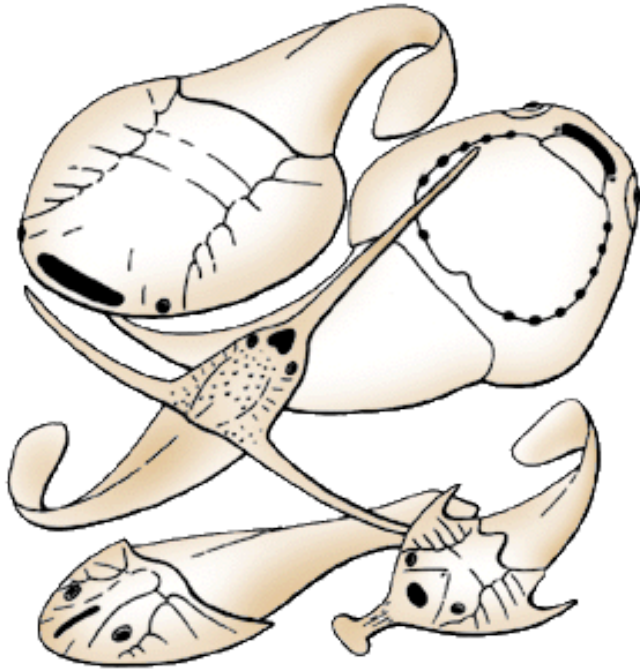
Scale populations of two *Thelodus* species. From Turner (1999).

Galeáspidos

Poseen la apertura nasohipofisial justo frente de los ojos, como en mixinoideos, y al igual que ellos, comunica con la faringe.

Aperturas branquiales por la superficie ventral

Sus fósiles se han encontrado en China y Vietnam.



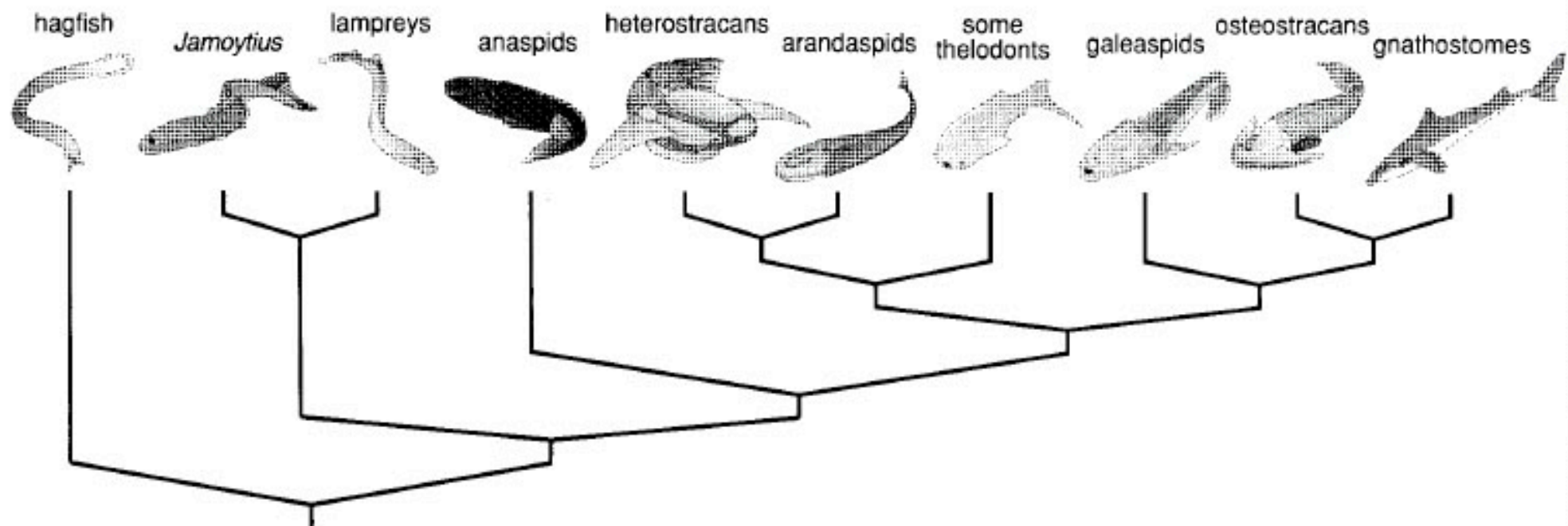


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Osteostraci y Pituriaspidos: el origen de las aletas pares

Aletas pareadas

Cola doblada hacia arriba, flexible

Campos sensoriales en los márgenes de la coraza cefálica y justo detrás de los ojos, asociados a la línea lateral

Poseen una sola gran coraza dorsal.

La boca y las aperturas braquiales se disponen ventralmente.

Se han hallado en: América del Norte, Europa, Siberia y Asia Central

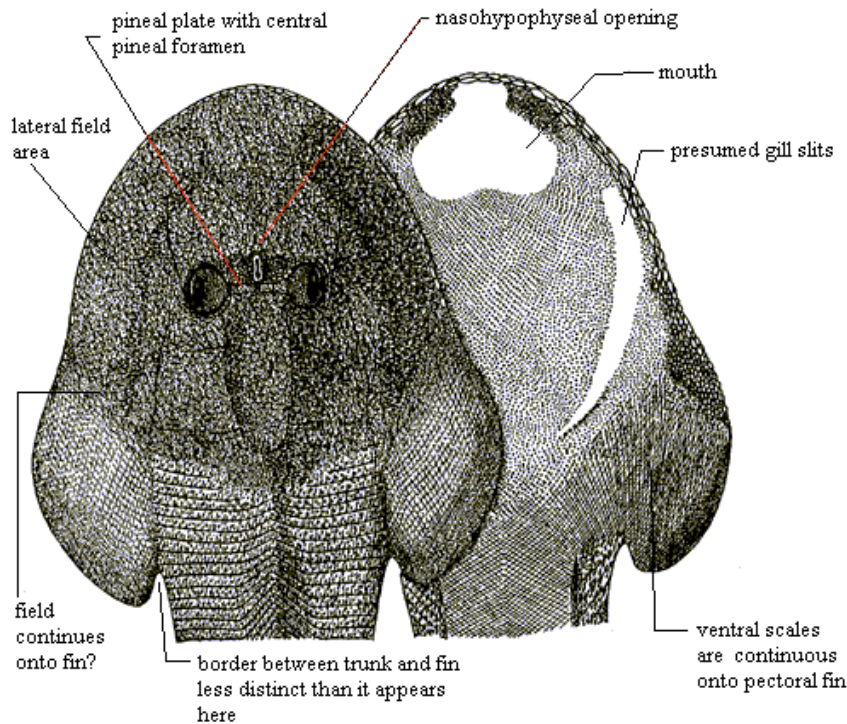
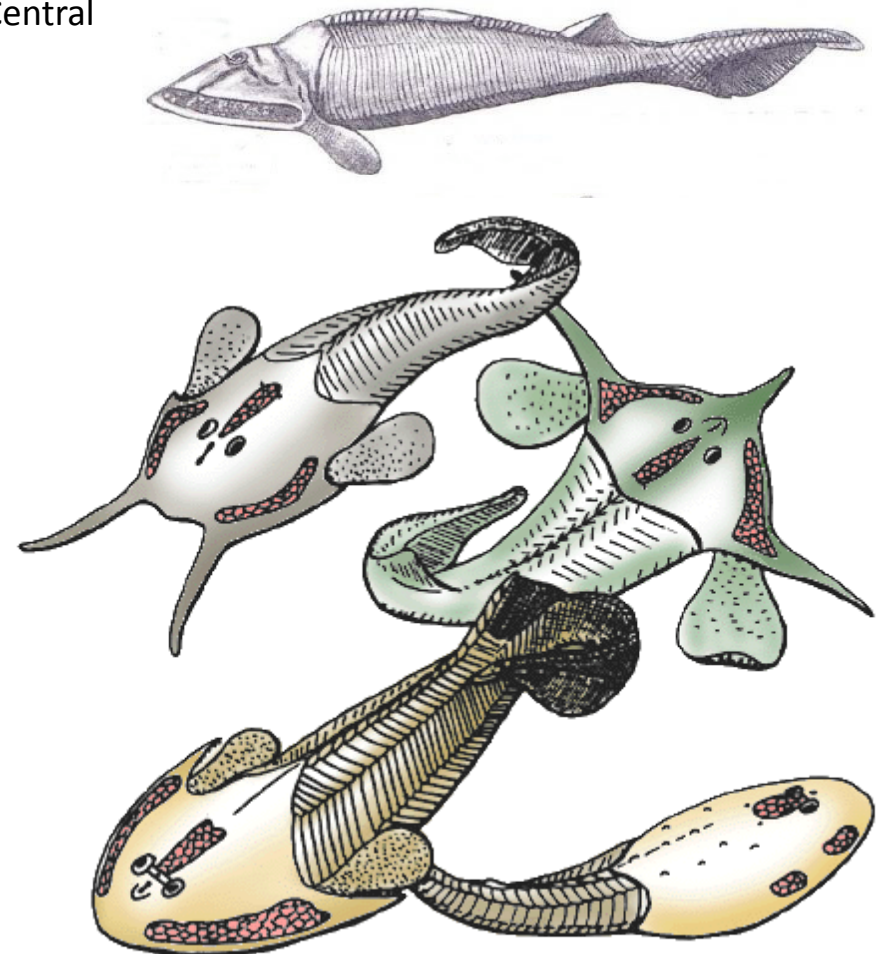
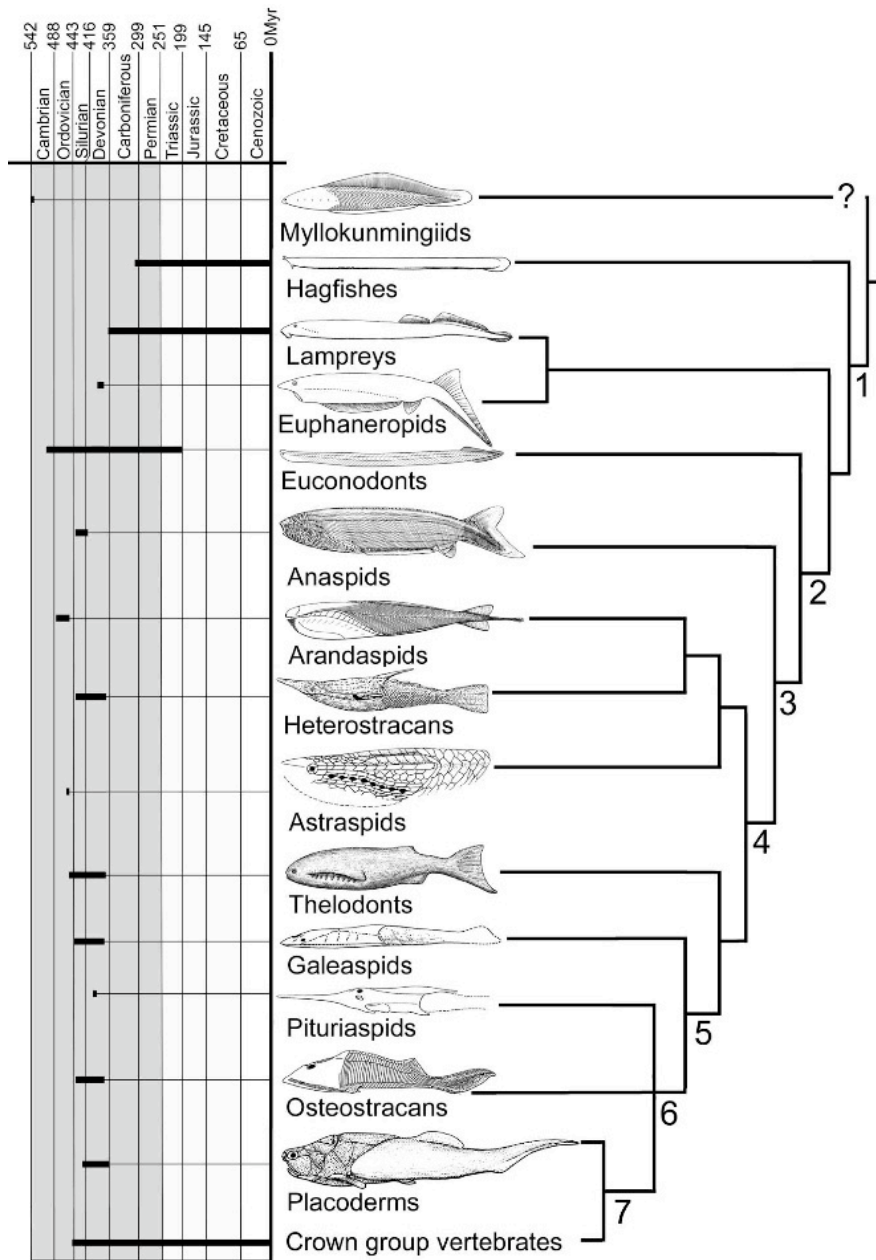


Fig. 1. *Ateleaspis tessellata* headshield and pectoral fins in dorsal and ventral views, modified from Ritchie (1967).





Pituriáspidos

No tienen ducto nasohipofisial.
 Se desconoce la ubicación de los narinas.
 Se han hallado en Australia.

