UNIVERSITAS INDONESIA

Veritas, Probitas, Iustitia

FMIPA

BIOLOGI

Reptile Diversity

Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Indonesia

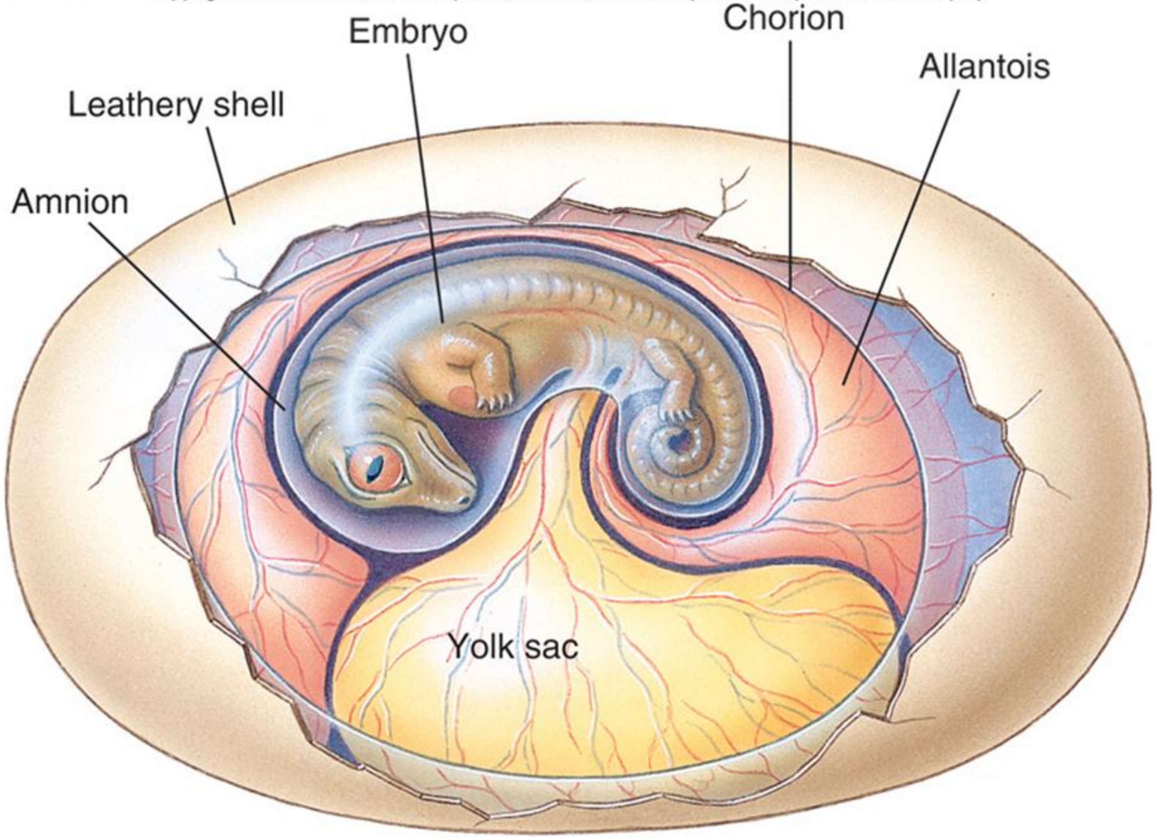
Outline

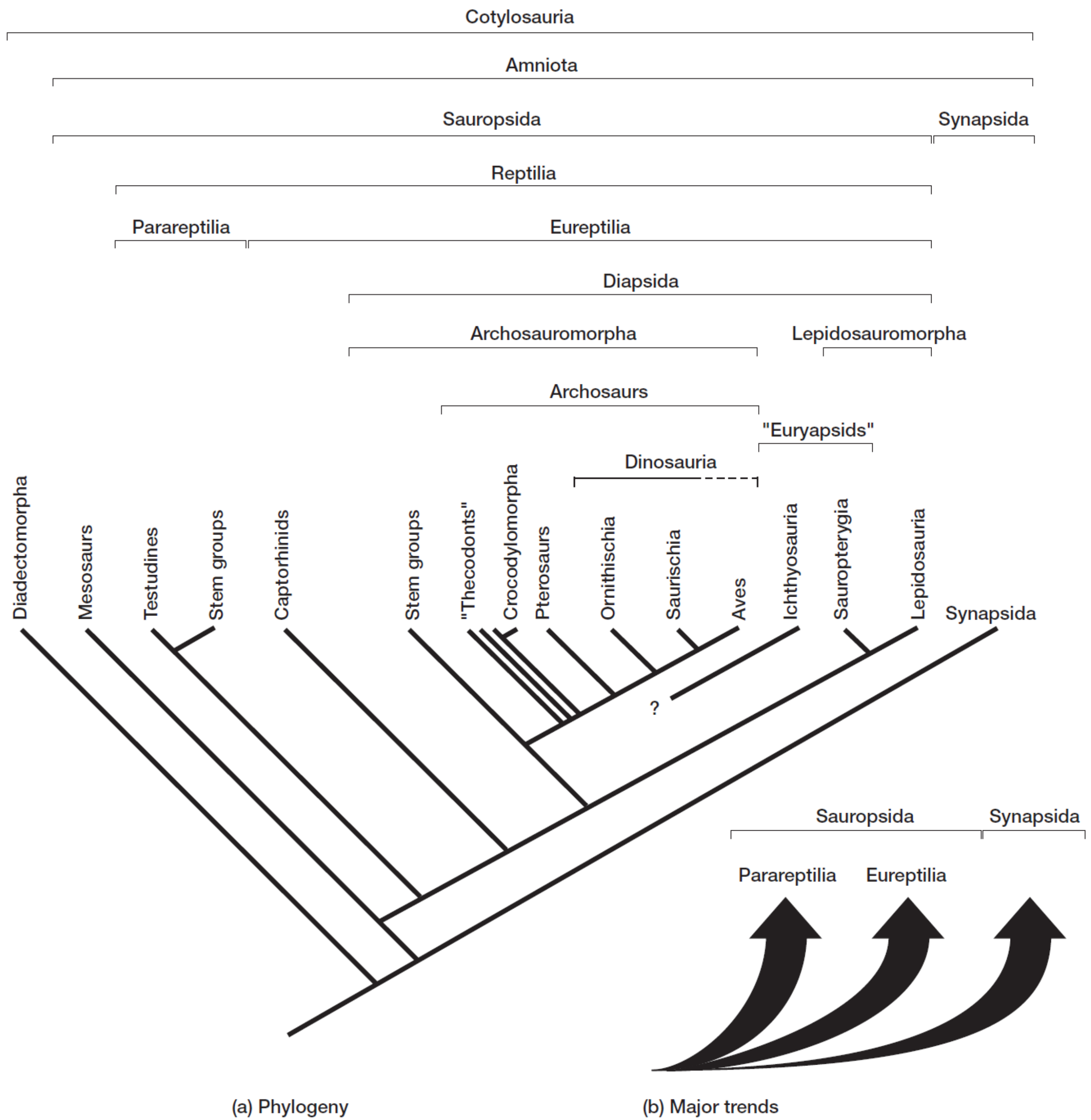
- Origin and Early Evolution of Amniotes
- History of Reptiles.
- Reptiles Diversity.

Amniotes and Amniota

- **Amniote** → a tetrapod that forms eggs inside a membrane.
- **Amniota** → a formal name for the clade of tetrapods that includes all living amniotes (mammals, reptiles, and birds) and their common ancestor.

Figure 26.04





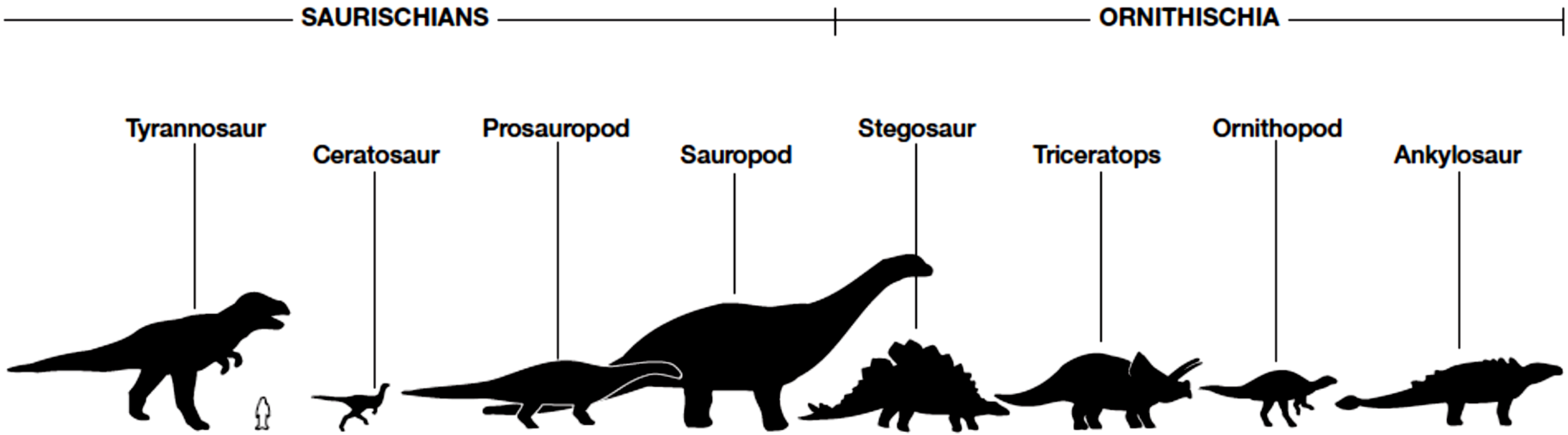
Amniotes Phylogenetic Relationships

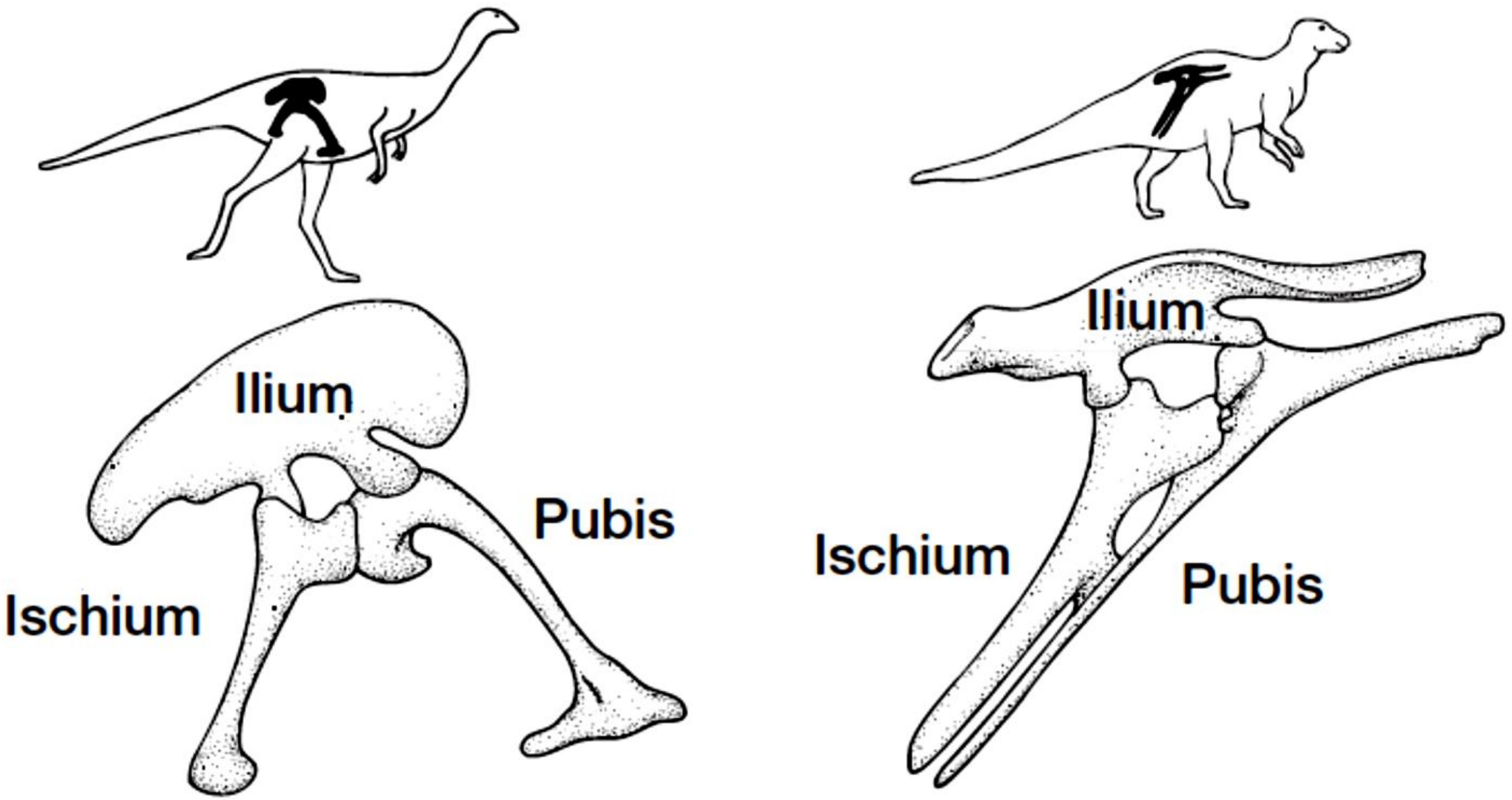
- The amniote radiation is composed of two major lineages, the **Sauropsida** and **Synapsida**.
- The sauropsids diversified along two major lineages, the **Parareptilia** and the **Eureptilia**.
- The **Synapsida** is a monophyletic lineage producing many various forms, including therapsids and modern mammals.

Natural History

- These first amniotes were *Archaeothyris* (synapsid), *Hylonomus*, and *Paleothyris* (reptiles) --> Late Carboniferous.
- The dinosaurs are a large group of reptiles that lived from 230 to 65 million years ago.
- The dinosaurs:

1. Saurischia → theropods (walked on their two hind legs and were mostly meat-eating and the sauropods that walked on all fours and ate plants)
2. Ornithischia → dinosaurs that ate plants and had hip bones that looked like those found in present-day birds

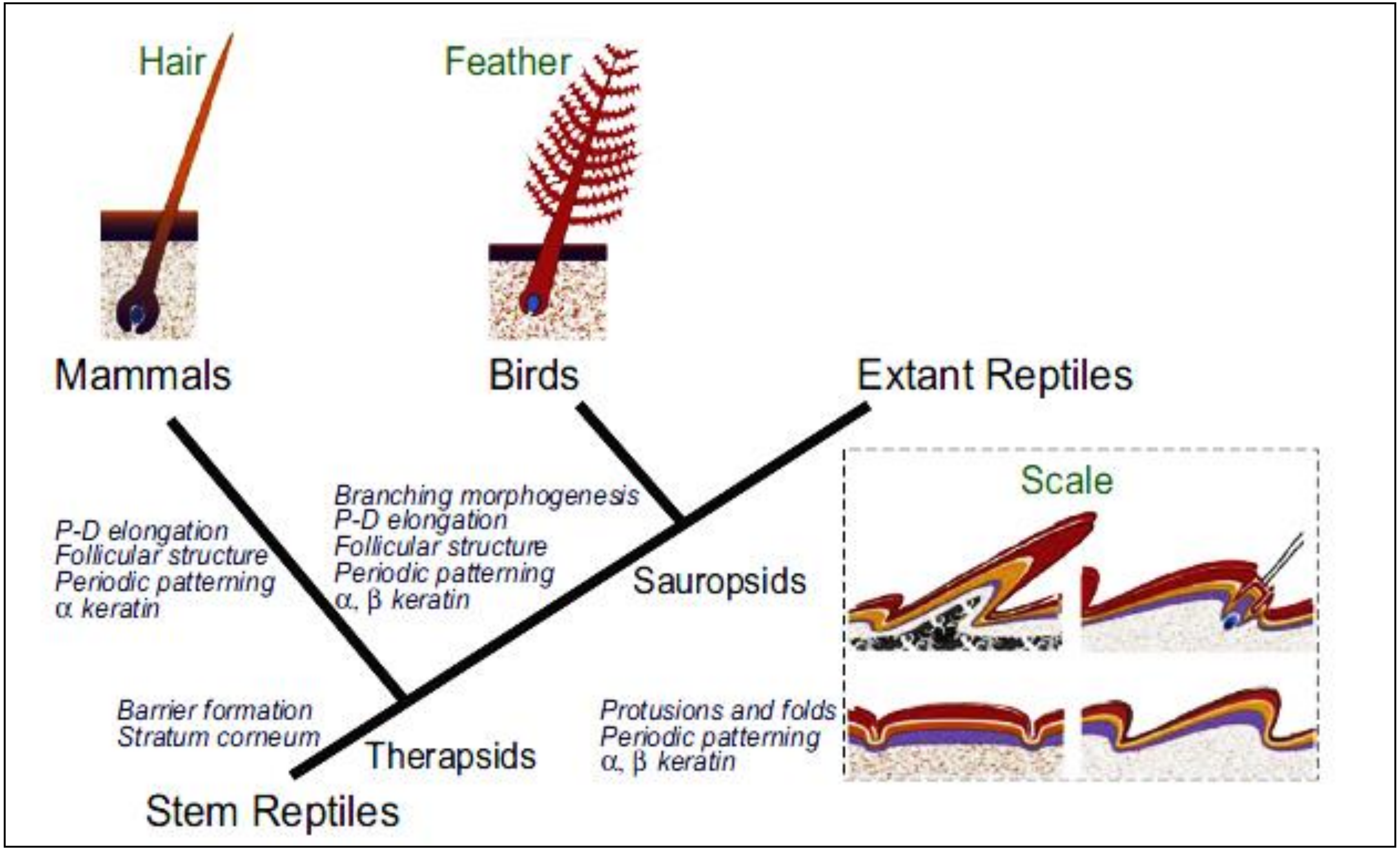

SAURISCHIANS
ORNITHISCHIA
Tyrannosaur
Ceratosaur
Prosauropod
Sauropod
Stegosaur
Triceratops
Ornithopod
Ankylosaur



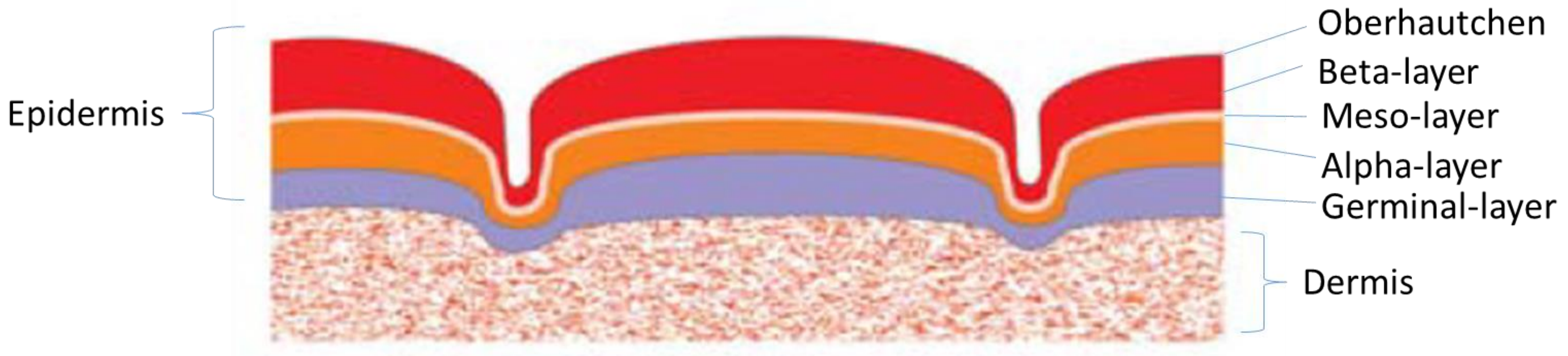
(a) Saurischian hip (b) Ornithischian hip

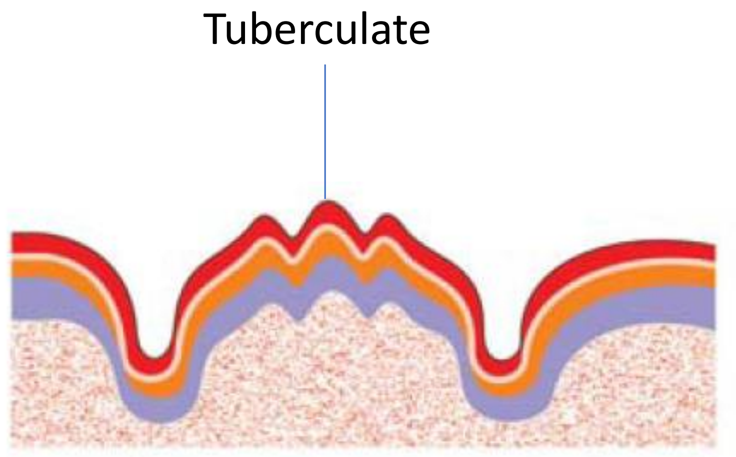
Integumentary Structures

- The epidermis is thicker with numerous differentiated layers above the stratum germinativum.
- Two patterns of epidermal growth occur :
  1. The cells of the stratum germinativum divide continuously throughout an individual’s life, stopping only during hibernation or torpor.
  2. Epidermal growth is discontinuous but cyclic, occurs in lepidosaurs (Squamata & Tuatara) → ecdysis.
- Integumental glands of reptiles are usually restricted to certain areas of the body:
  1. Femoral glands along the underside of the hindlimb in the thigh region → lizards
  2. Scent glands → Crocodiles and some turtles; alligators (one pair of scent glands opens into the cloaca, another pair opens on the margins of the lower jaw)


Hair
Feather
Mammals
Birds
Extant Reptiles
Scale
Branching morphogenesis
P-D elongation
Follicular structure
Periodic patterning
α, β keratin
P-D elongation
Follicular structure
Periodic patterning
α keratin
Sauropsids
Barrier formation
Stratum corneum
Therapsids
Protusions and folds
Periodic patterning
α, β keratin
Stem Reptiles

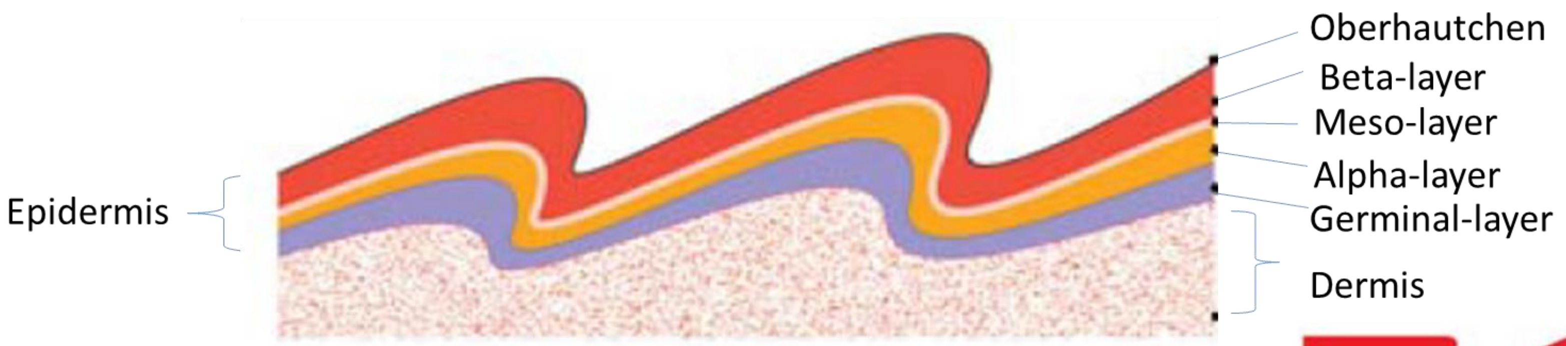
Non-overlapping tuberculate type scales





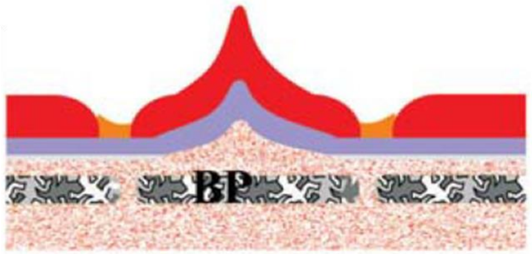
- There are non-overlapping scales which do not appear to exhibit anterior-posterior polarity.
- They are seen in the scales on the head of snakes and lizards.
- The round scales (tuberculate scales) on the sides of the body.

Overlapping Scales

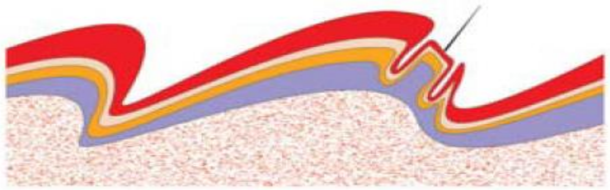


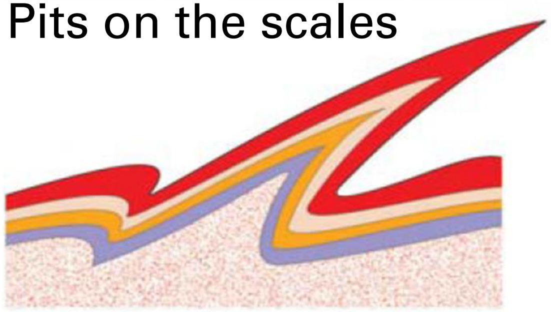
The horn on the head

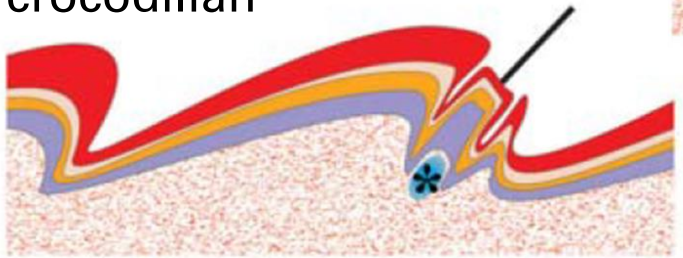
Scales on the limb of crocodilian



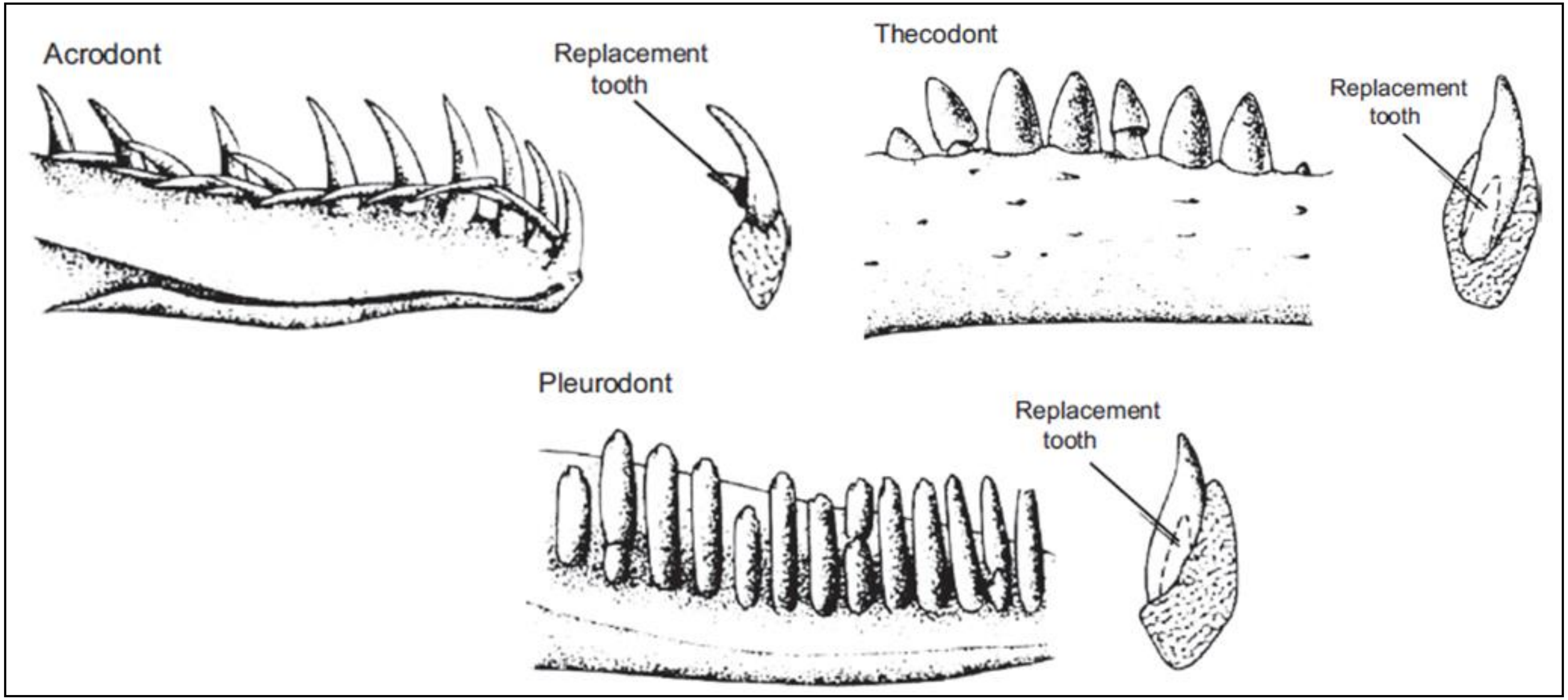
Keeled scales


Pits on the scales


Frills


Tactile sensory organ on the hinge side of a scale

Reptile Teeth



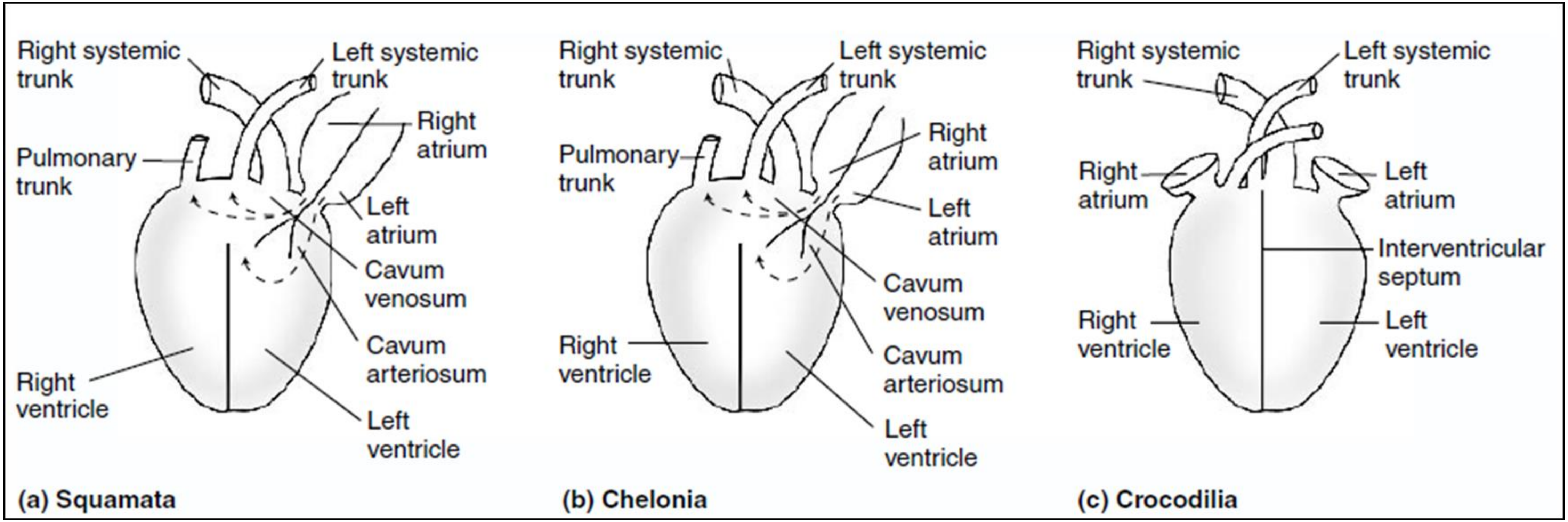
- sit on top of the jaw (acrodont)
- embedded in the jaw (thecodont)
- on the side of the jaw (pleurodont)

Nerves and Sense Organs

- The parapineal organ (parietal eye); the posterior is the pineal organ (epiphysis) → an endocrine gland. A parapineal organ is prominent in *Sphenodon* and in many lizards, in which it serves as a photoreceptor.
- The vomeronasal organ is a separate pit to which the tongue and oral membranes deliver chemicals, absent in turtles and crocodiles.
- Infrared receptors (thermoreceptors), detect warm blood vessels beneath the thick skin of their prey:
  1. boas → lie within epidermal scales along the lips
  2. pit vipers → a pair of infrared receptors called facial pits (loreal pits)

Heart and Vascular Network

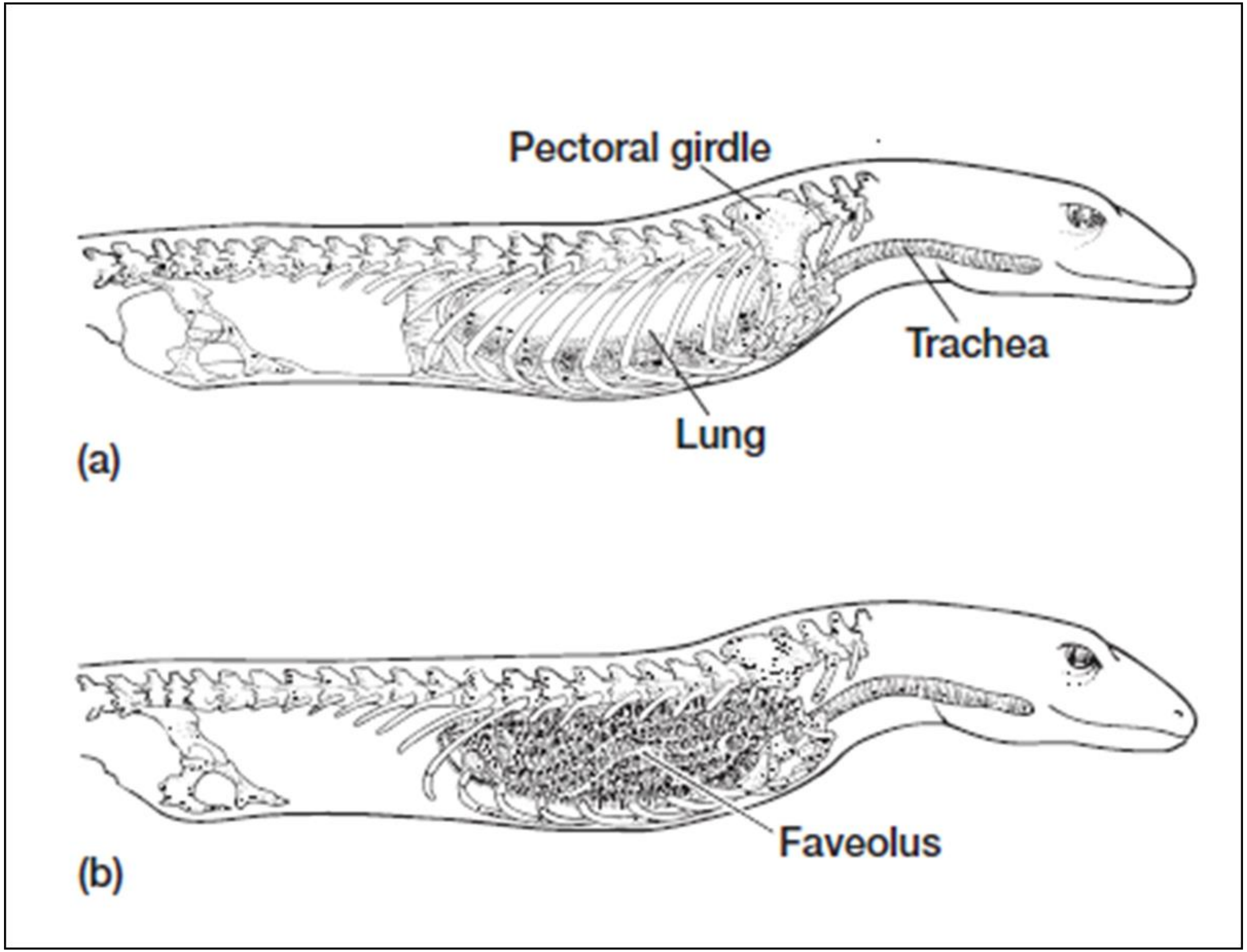
- Reptiles exhibit three different modes of circulation:
  1. The ventricle of reptiles other than crocodilians is incompletely divided into dorsal and ventral chambers by a horizontal septum.
  2. The pulmonary trunk leaves the right ventricle. Both systemic trunks exit from the left ventricle in the Squamata (snakes and lizards); in turtles, however, one systemic trunk leaves the left ventricle and the other leaves the right ventricle.
  3. the interventricular septum is not complete, and because both atria open into the left ventricle, blood can flow from the left ventricle into the right ventricle.



Right systemic trunk
Left systemic trunk
Right atrium
Pulmonary trunk
Left atrium
Cavum venosum
Cavum arteriosum
Right ventricle
Left ventricle
(a) Squamata
Right systemic trunk
Left systemic trunk
Right atrium
Pulmonary trunk
Left atrium
Cavum venosum
Right ventricle
Cavum arteriosum
Left ventricle
(b) Chelonia
Right systemic trunk
Left systemic trunk
Right atrium
Left atrium
Interventricular septum
Right ventricle
Left ventricle
(c) Crocodilia

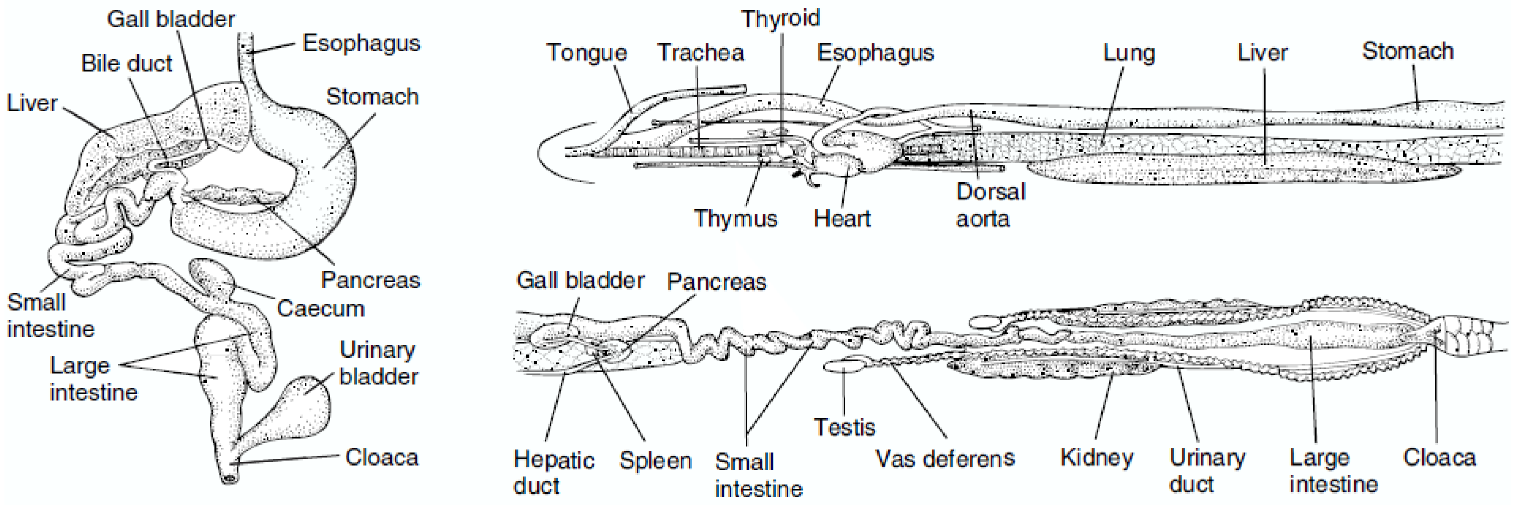
Respiratory Organs

- The lungs of most reptiles are located in the **pleuroperitoneal cavity.**
- In turtles and most lizards, the lungs consist of numerous large chambers, each composed of many individual subchambers, called **faveoli.**
- **Pharyngeal (buccopharyngeal) gas exchange** → particularly well developed in soft-shelled turtles (Trionychidae)
- **Cloacal gas exchange** → occur in many turtles in the families Chelydridae, Testudinidae, and Pelomedusidae.
- **Cutaneous gas exchange** has been reported in several turtles, including the soft-shelled turtle (*Apalone* sp.), musk turtles (*Sternotherus odoratus* and *S. minor*), mud turtles (*Kinosternon subrubrum*), snapping turtles (*Chelydra serpentina*), and pond sliders (*Trachemys scripta*).


Pectoral girdle
Trachea
Lung
(a)
Faveolus
(b)

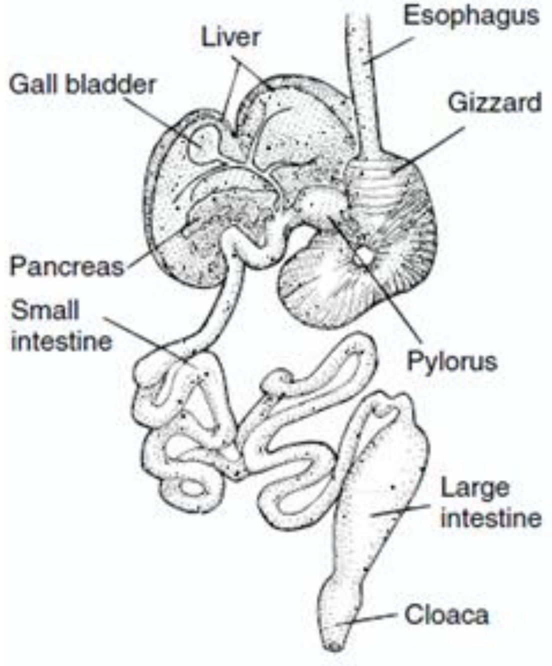
Digestive Organs

- The jaws of most reptiles are covered by nonmuscular, immovable, thickened lips. The jaw margins of turtles, however, are covered with a shell of keratin and, together with the jaws, form a beak.
- The stomach is elongate in lizards and snakes, and a distinct large intestine is usually present. In some herbivorous lizards, a cecum is present near the junction of the small and large intestines.
- The stomach narrows to a thick muscular sphincter, the pylorus or pyloric valve. This valve controls the movement of the food bolus from the stomach into the small intestine.



(a) **Lizard**

(b) **Snake**



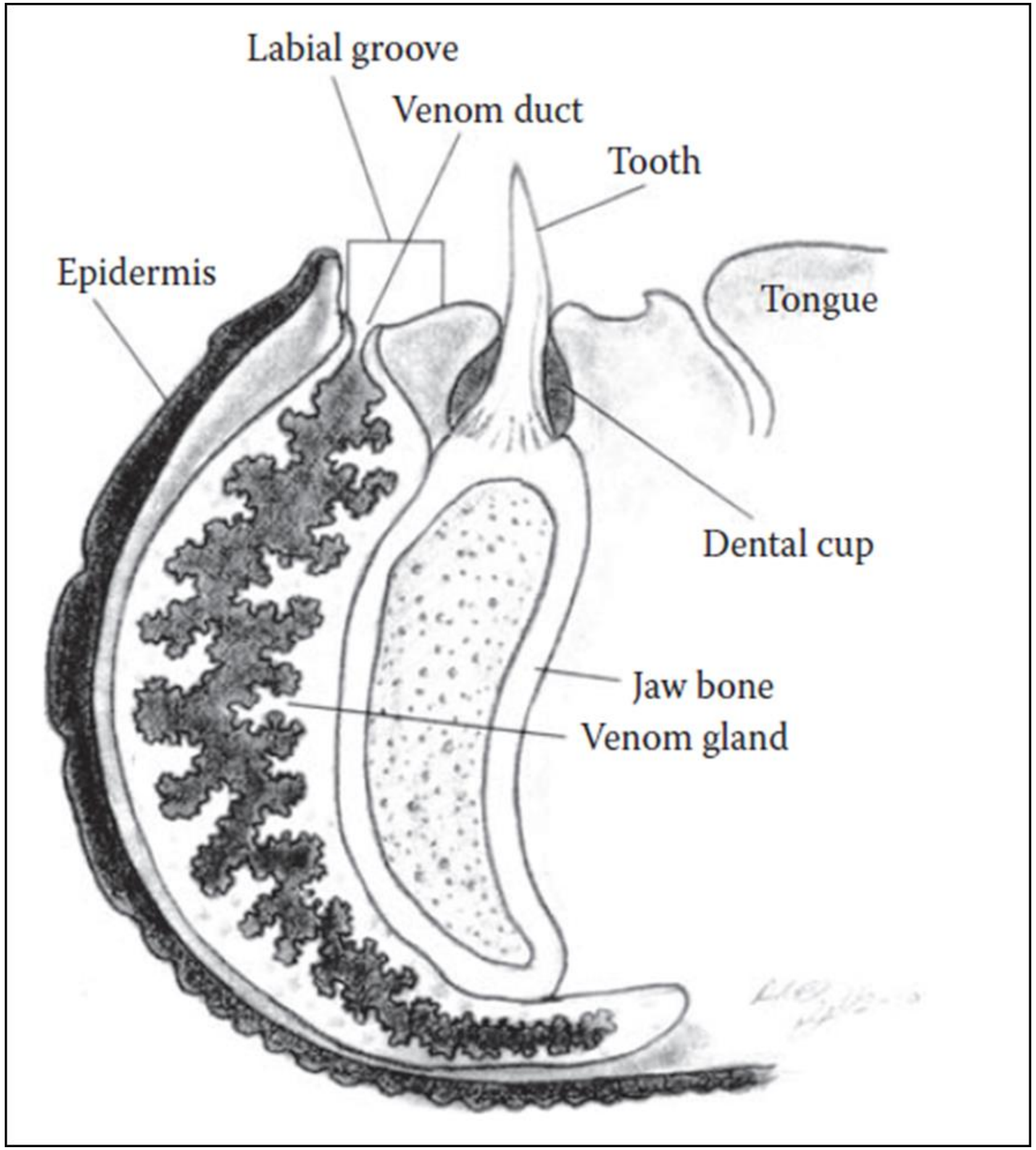
(c) **Alligator**

Venom System Origin and Evolution (1)

- Venom:
  1. "A secretion produced in specialized cells in one animal, delivered to a target animal through the infliction of a wound and that disrupts endophysiological or biochemical processes in the receiving animal to facilitate feeding, defense or competition by/of the producing animal" (Fry et al. 2009a, 2012a).
  2. A simple to complex secretion produced in a specialized gland that is typically delivered via specialized envenomation systems, including a secretory gland, often (but not always) specialized teeth (Vonk et al., 2008).
  3. Introduced (commonly injected) into recipient tissues in order for deleterious effects to occur, while poisons are typically ingested (Mackessy, 2002a).

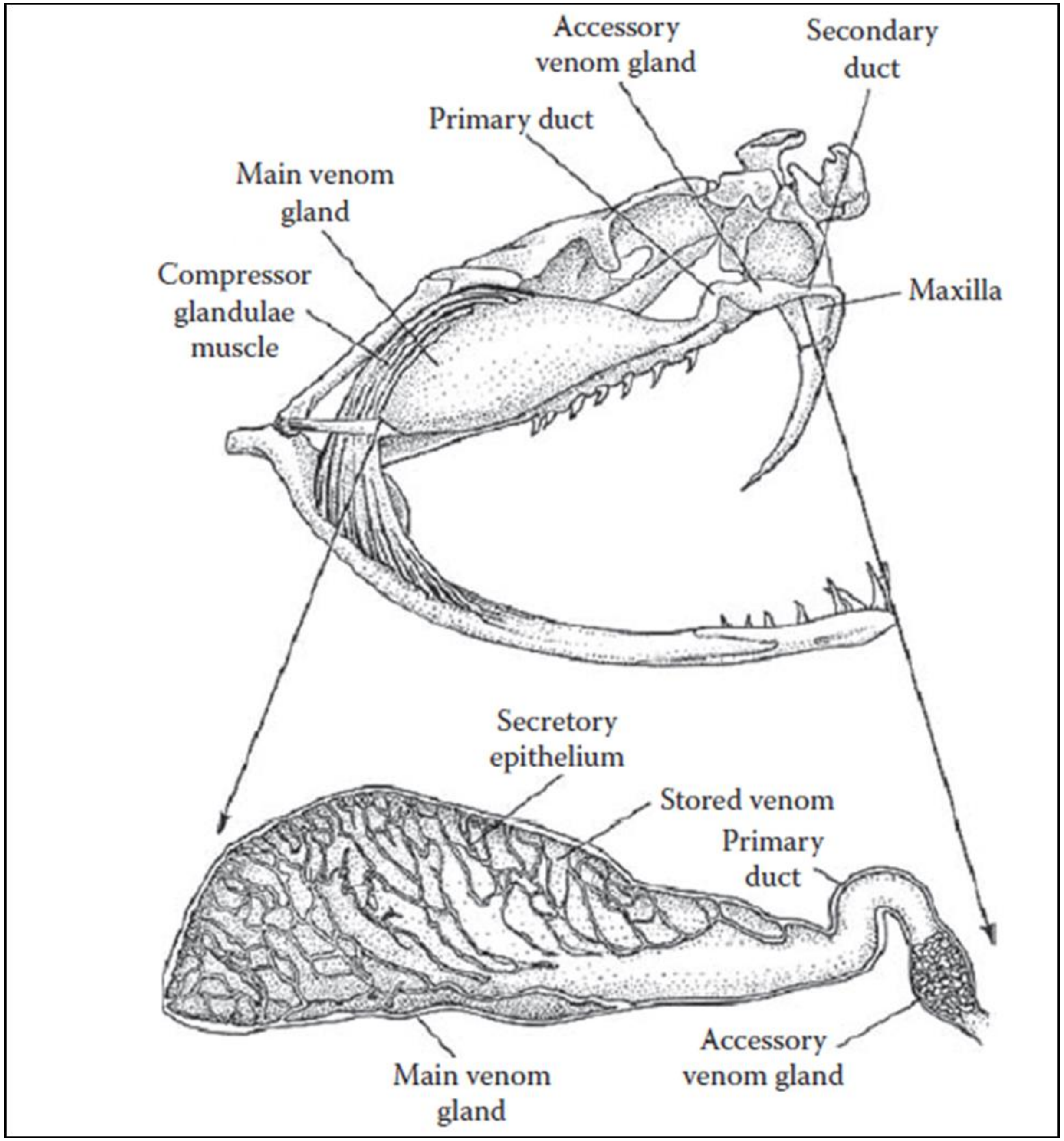
Venom System Origin and Evolution (2)

- Helodermatid Lizards
  1. The venom apparatus apparently serves a defensive function, as these lizards are slow moving, with the lowest metabolism of any lizard, and fed largely upon swallowed with little resistance.
  2. The venom gland, a specialized mandibular gland, lies along the lower jaw, opening into multiple ducts (*Heloderma suspectum*) or a single duct (*H. horridum*) that conduct venom to the mandibular tooth row.
  3. Mandibular and maxillary teeth are grooved, but not tubular, perhaps aiding flow or distribution of oral secretion. The venom gland encapsulates multiple lobules emptying into a slightly expanded central lumen, but there is no evidence of storage of large volumes of venom in reservoirs, as in many venomous snakes

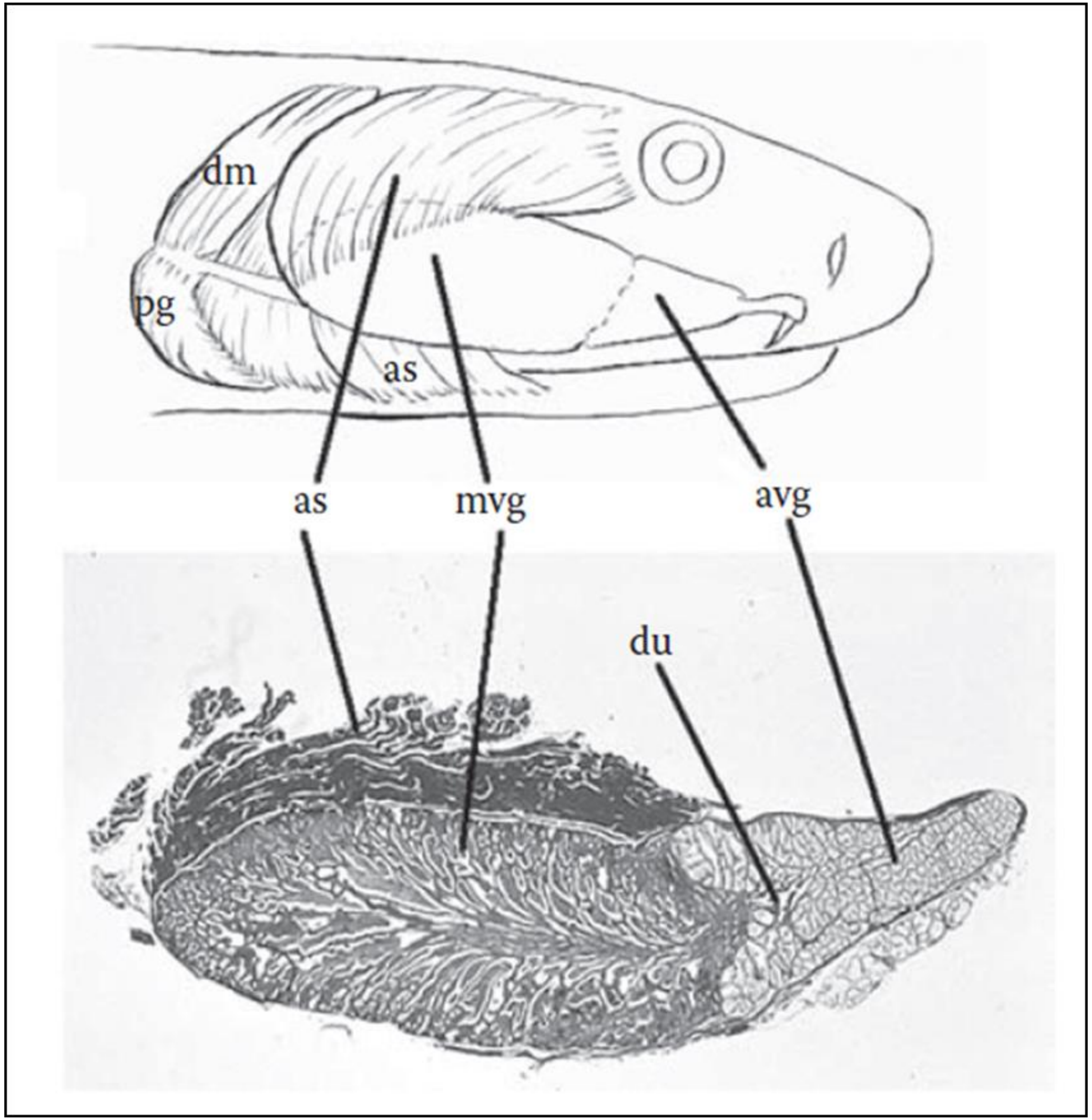

Labial groove
Venom duct
Tooth
Epidermis
Tongue
Dental cup
Jaw bone
Venom gland

Venom System Origin and Evolution (3)

- Elapids and Viperids:
  1. Venom of elapid, viperid, and atractaspid snakes is produced in and delivered by a specialized venom apparatus along the upper jaw that includes specializations of glands, muscles, teeth, venom, and behavior.
  2. The venom glands of elapid (including sea snakes and allies) and viperid snakes exhibit some variability in morphology and size, but all share a similar basic design in that there is a main venom gland and an accessory gland.
  3. In viperids, the main venom gland empties via a single primary duct into the accessory gland, and from here via a secondary duct into the base of the tubular fang.
  4. In most elapids, the accessory gland is next to the main venom gland and surrounds the primary venom duct emptying the main venom gland.
  5. In some sea snakes, the main and accessory glands do not abut one another but instead are separated, connected by the primary venom duct.



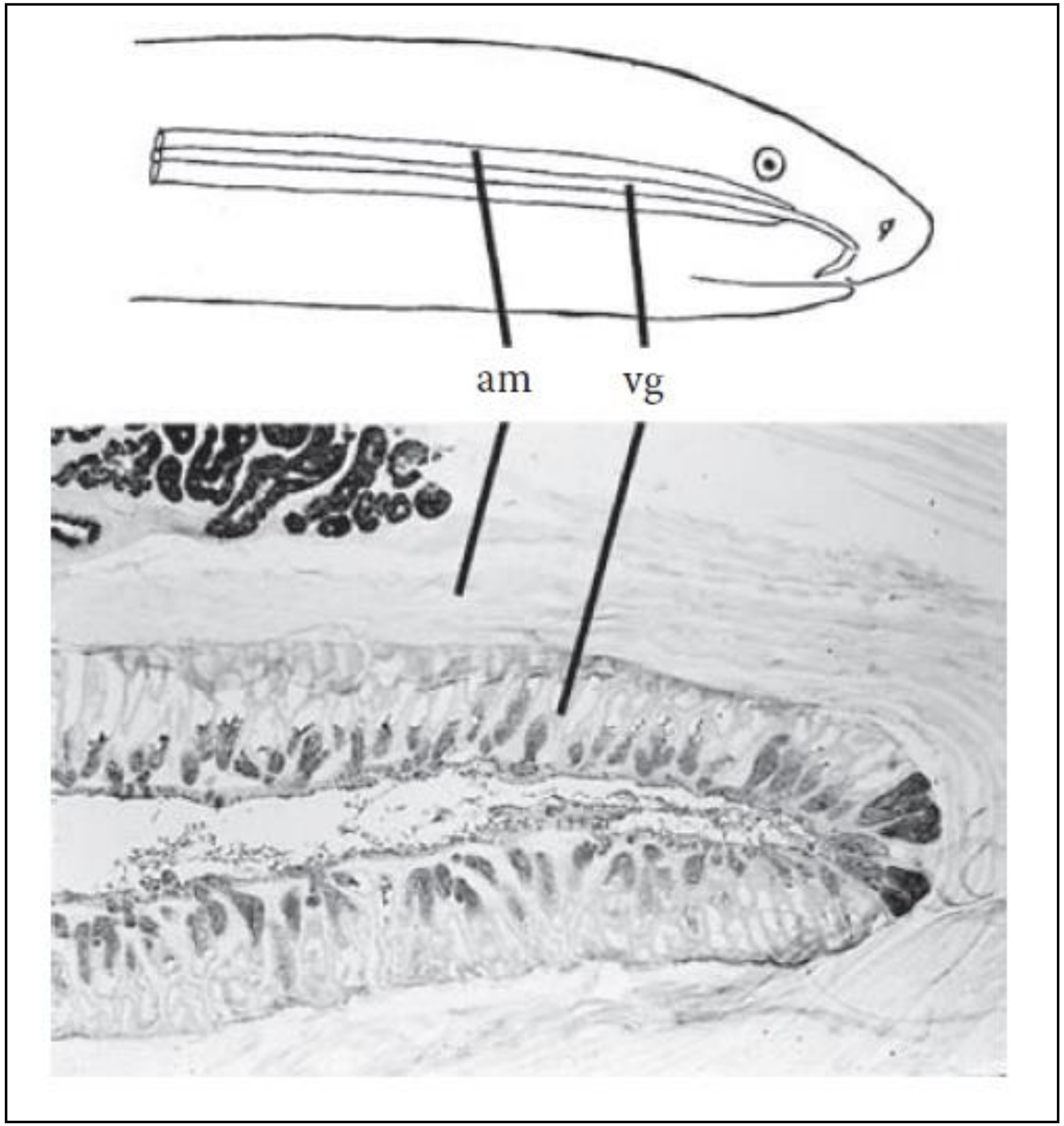
Accessory venom gland
Secondary duct
Primary duct
Main venom gland
Compressor glandulae muscle
Maxilla
Secretory epithelium
Stored venom
Primary duct
Accessory venom gland
Main venom gland



dm
pg
as
as
mvg
avg
du

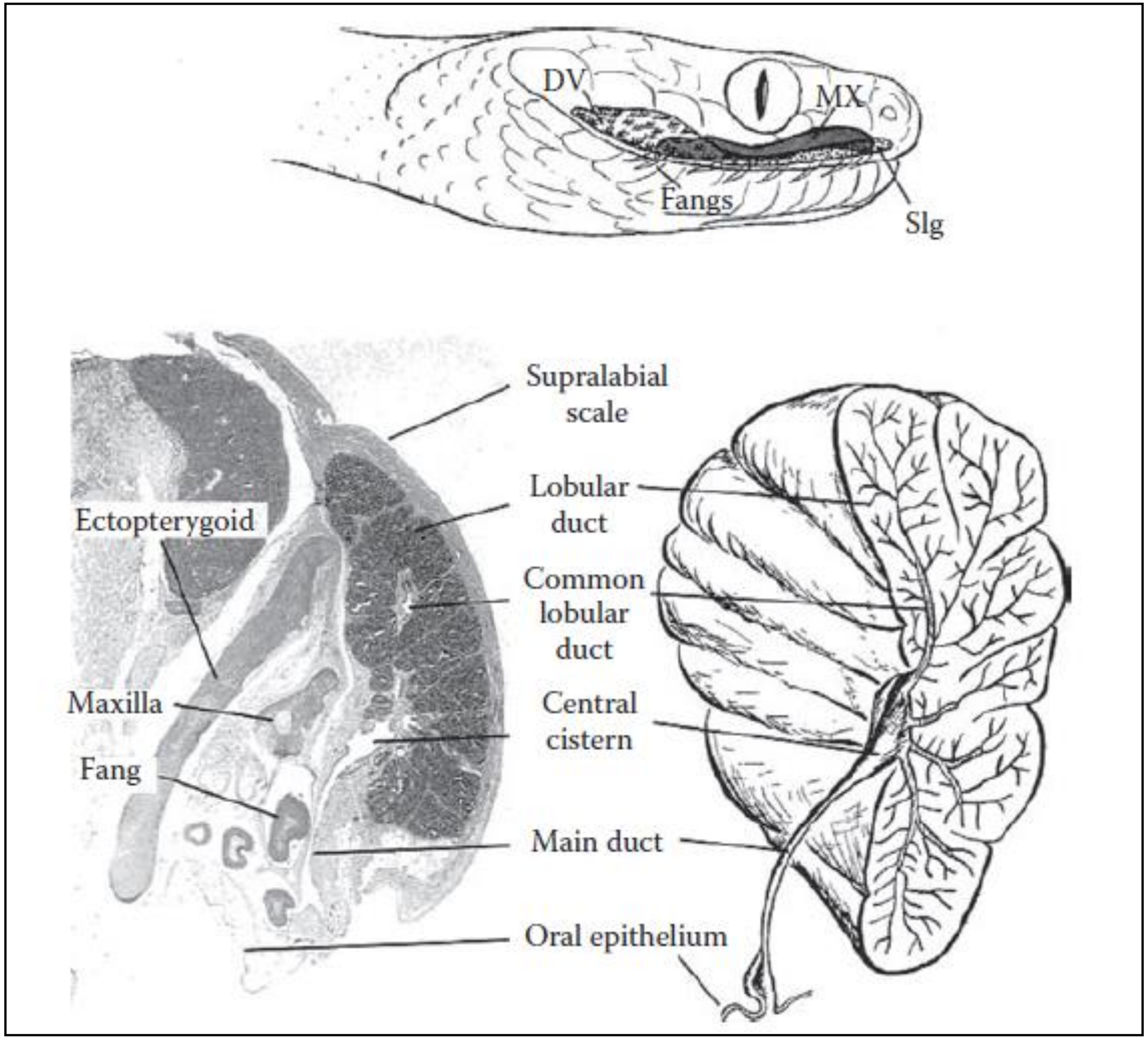
Venom System Origin and Evolution (4)

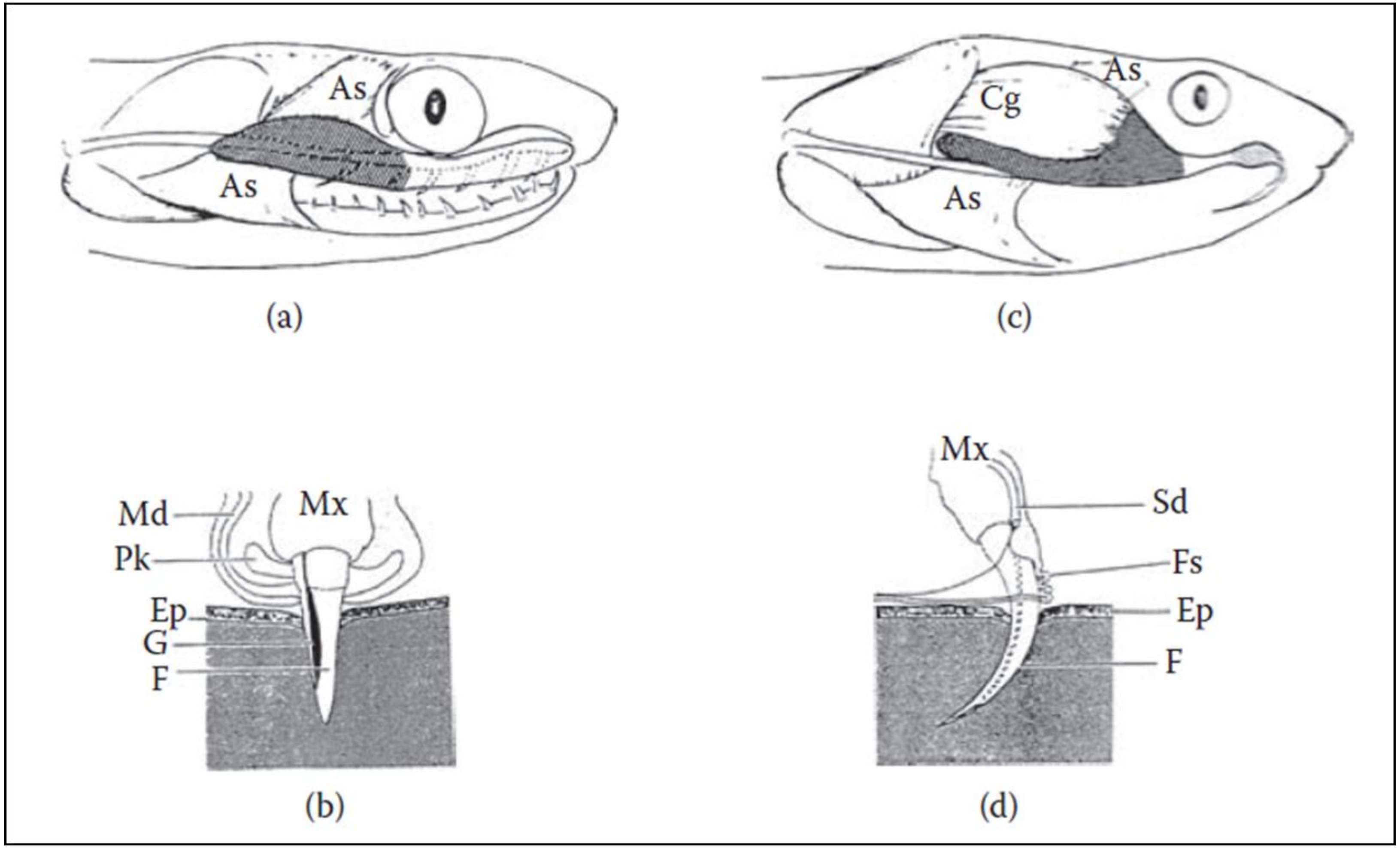
- Atractaspidids:
  1. Atractaspidids have a different venom gland arrangement. The centrally located lumen is elongated and surrounded by spoke-like tubules. In some species the gland may be located in the temporal region, but in other species it extends posteriorly out of the region and along the sides of the body.
  2. The venom gland of atractaspidids lacks a discrete accessory gland and possesses a different histochemical profile.


am
vg

Venom System Origin and Evolution (5)

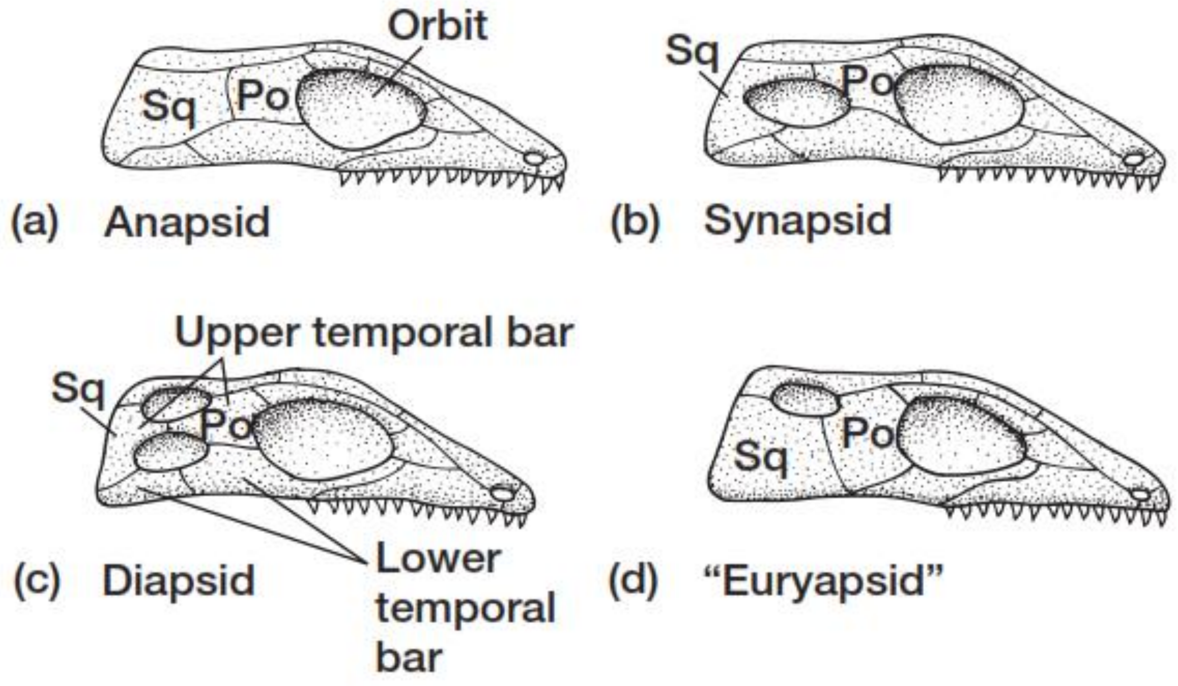
- Colubrids
  1. The structure of venom glands in viperid and elapid snakes is considerably different than the jaw and gland apparatus of colubrids, and many species even lack its homologous counterpart, the Duvernoy’s gland.
  2. About 17% of colubrid snakes lack evidence of a Duvernoy’s gland, although in some groups as many as 90% of those examined were without a Duvernoy’s gland.
  3. Colubrids with a Duvernoy’s gland exhibit a gland with structure significantly different from the venom gland of front-fanged snakes


DV
MX
Fangs
Slg
Supralabial scale
Lobular duct
Common lobular duct
Central cistern
Main duct
Oral epithelium
Ectopterygoid
Maxilla
Fang



As
As
(a)
Cg
As
As
(c)
Md
Mx
Pk
Ep
G
F
(b)
Mx
Sd
Fs
Ep
F
(d)

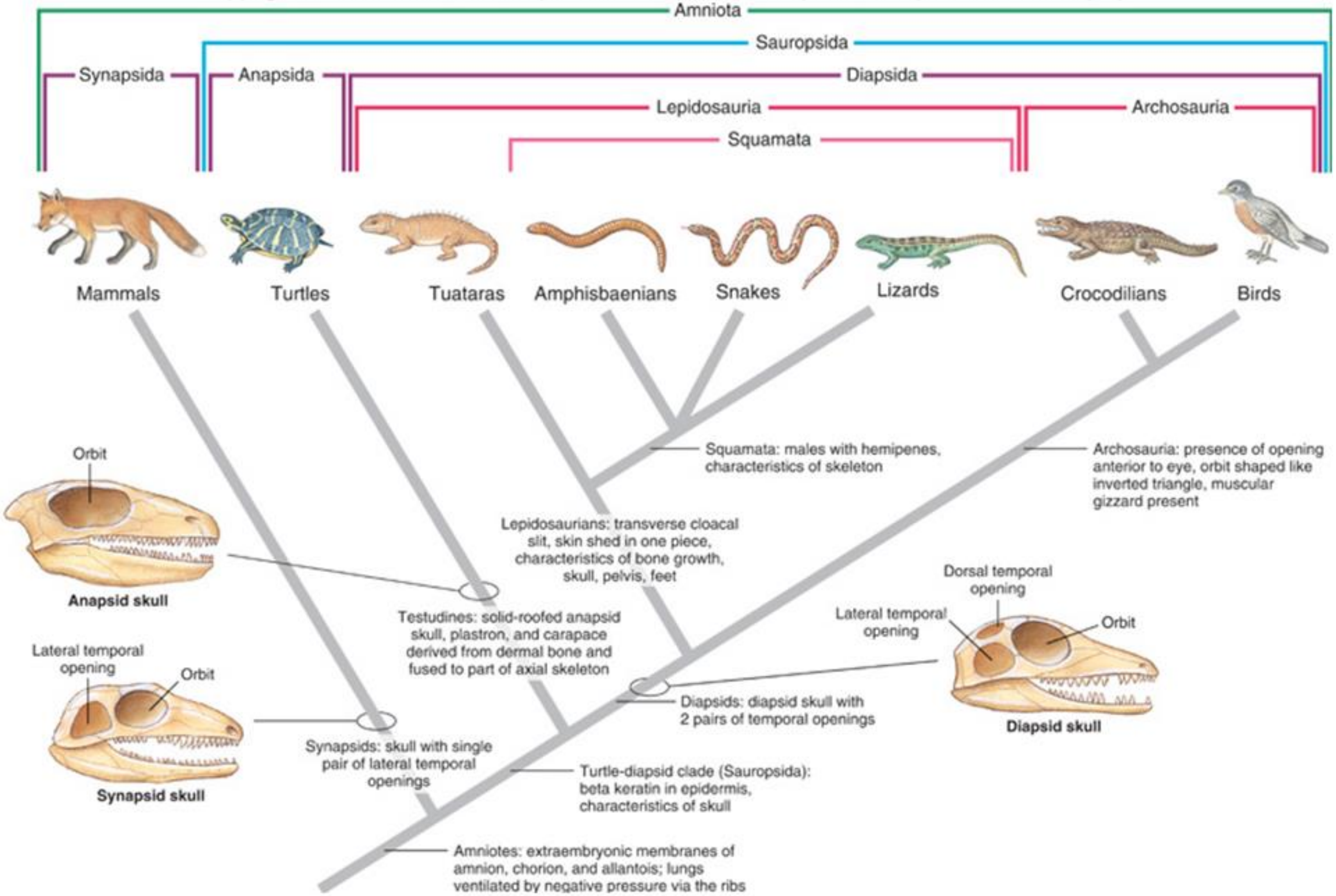
Amniote Skull Types



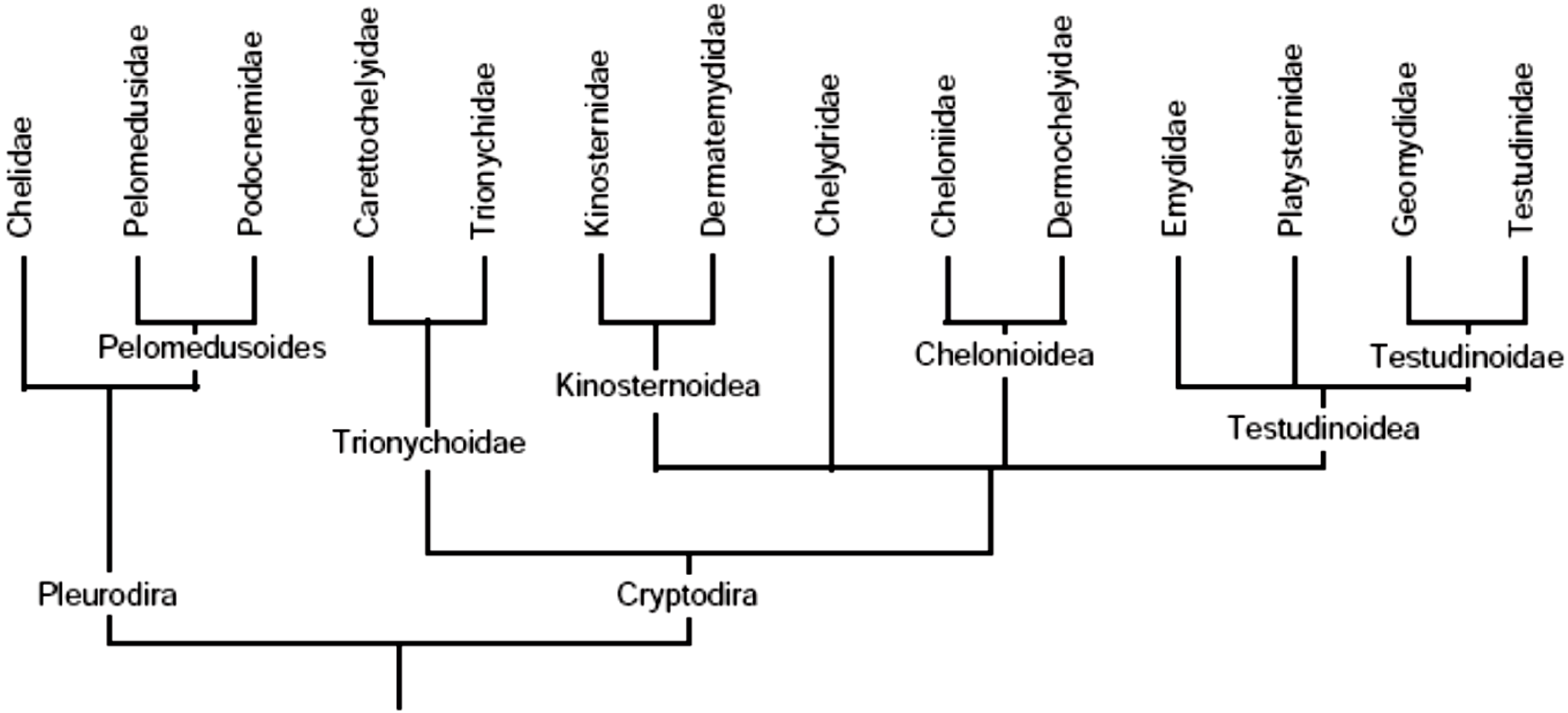
Differences among the skulls occur in the temporal region behind the orbit. Postorbital (Po) and squamosal (Sq) bones varies.

a) The anapsid skull has no temporal fenestrae.
b) The synapsid skull has a bar above its single temporal fenestra.
c) The diapsid skull has a bar between its two temporal fenestrae.
d) The "euryapsid" skull has a bar below its single temporal fenestra → derived from a diapsid skull that lost its lower temporal bar and opening.

Figure 26.02

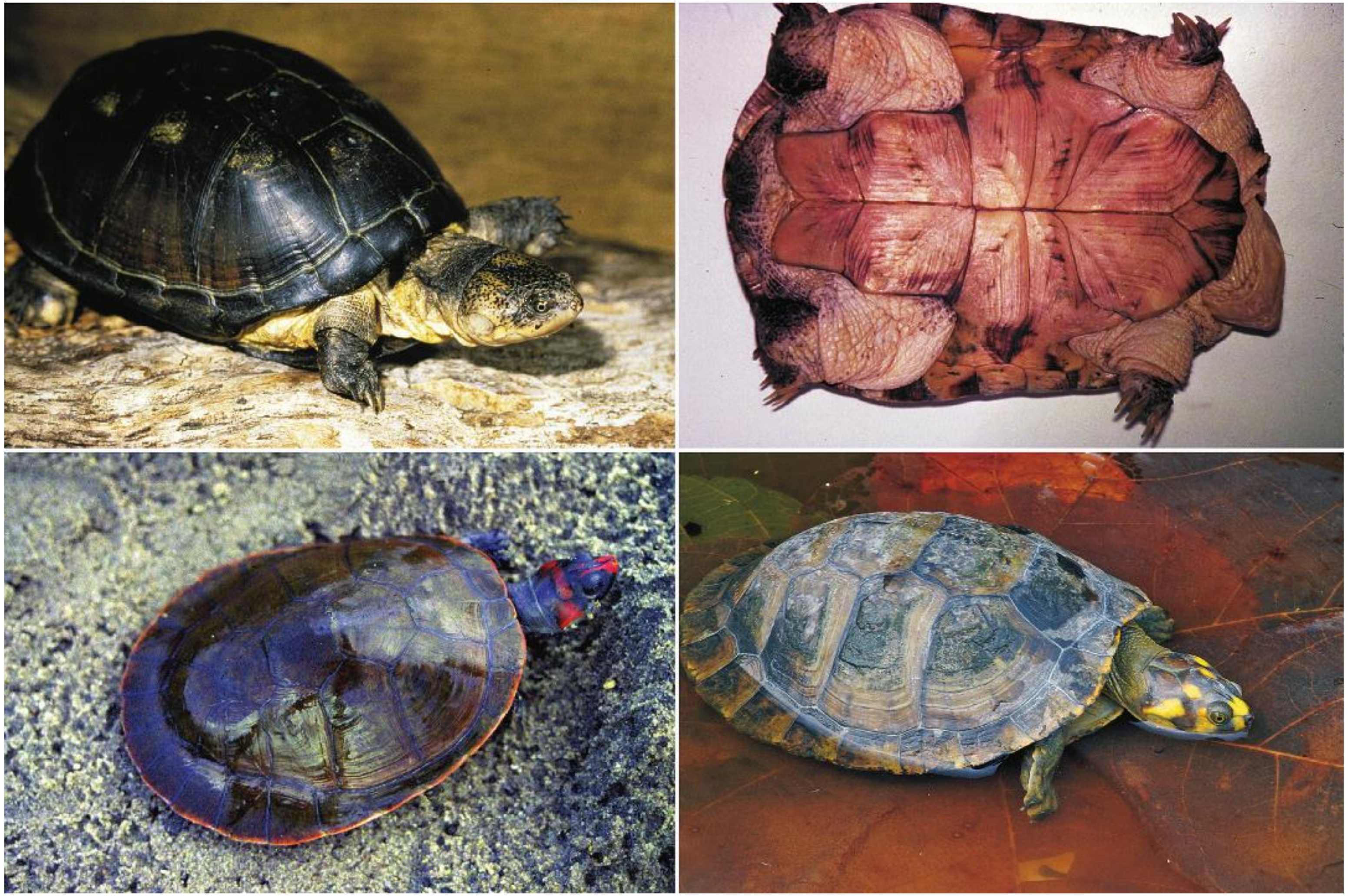

Amniota
Sauropsida
Synapsida
Anapsida
Diapsida
Lepidosauria
Archosauria
Squamata
Mammals
Turtles
Tuataras
Amphisbaenians
Snakes
Lizards
Crocodilians
Birds
Squamata: males with hemipenes, characteristics of skeleton
Archosauria: presence of opening anterior to eye, orbit shaped like inverted triangle, muscular gizzard present
Orbit
Anapsid skull
Lepidosaurians: transverse cloacal slit, skin shed in one piece, characteristics of bone growth, skull, pelvis, feet
Dorsal temporal opening
Lateral temporal opening
Orbit
Testudines: solid-roofed anapsid skull, plastron, and carapace derived from dermal bone and fused to part of axial skeleton
Lateral temporal opening
Orbit
Diapsids: diapsid skull with 2 pairs of temporal openings
Diapsid skull
Synapsids: skull with single pair of lateral temporal openings
Synapsid skull
Turtle-diapsid clade (Sauropsida): beta keratin in epidermis, characteristics of skull
Amniotes: extraembryonic membranes of amnion, chorion, and allantois; lungs ventilated by negative pressure via the ribs

Order Testudines (Chelonia)



Side-neck turtles (Pleurodira), such as *Phrynops gibbus* (left), can withdraw their head and neck only within the outer margin of the shell, whereas hidden-neck turtles (Cryptodira), such as *Malaclemys terrapin* (right), withdraw the neck and head within the shell. (L. J. Vitt)

Representative chelid side-neck turtles.
Clockwise from upper left: Juvenile of Geoffrey's side-necked turtle Phrynops geoffroanus, Chelidae (L. J. Vitt); mata mata, Chelidae (L. J. Vitt); narrow-breasted snake-neck turtle Chelodina oblongata, Chelidae (R. W. Barbour); northern Australian snake-neck turtle Chelodina rugosa, Chelidae (C. K. Dodd, Jr.).



Representative pelomedusoid side-neck turtles.

Clockwise from upper left: Adanson's mud terrapin *Pelusios adansoni*, Pelomedusidae (R. W. Barbour); helmet turtle *Pelomedusa subrufra*, Pelomedusidae (G. R. Zug); yellow-spotted river turtle Podocnemis unifilis, Podocnemidae (L. J. Vitt); red-headed river turtle *Podocnemis erythrocephala*, Podocnemidae (T. C. S. Avila-Pires).

The two extant chelydrid turtles.

From left: Alligator snapping turtle *Macrochelys temminckii* (L. J. Vitt); common snapping turtle *Chelydra serpentina* (L. J. Vitt). Note the moss growing on the back of the common snapping turtle.

Representative trionychoid turtles.
Clockwise from upper left: Pignose turtle *Carettochelys insculpta*, Carettochelyidae (R.W.Barbour); Indian soft shell turtle *Nilssonia gangeticus*, Trionychinae (E.O.Moll); spiny softshell turtle *Apalone spinifera*, Trionychinae (L. J. Vitt); Burmese flap-shell turtle *Lissemys scutata*, Cyclanorbinae (G. R. Zug).

Representative kinosternoid turtles.
Clockwise from upper left: Mesoamerica river turtle *Dermatemys mawii*, Dermatemydidae (D. Moll); Tabasco mud turtle *Kinosternon acutum*, Kinosterninae (G. R. Zug); yellow mud turtle *Kinosternon flavescens*, Kinosterninae (L. J. Vitt); narrow-bridged musk turtle *Claudius angustatus*, Staurotypinae (R. W. Barbour).

Representative emydid and platysternid turtles.
Clockwise from upper left: European pond turtle *Emys orbicularis*, Emydinae (R. W. Barbour); chicken turtle *Deirochelys reticulata*, Deirochelinae (L. J. Vitt); red-eared slider *Trachemys scripta*, Deirochelinae (L. J. Vitt); big-headed turtle *Platysternon megacephala*, Platysternidae (R. W. Van Devender).

Representative tortoises.
Clockwise from upper left: Berlandier's tortoise *Gopherus berlandieri*, Testudinidae (R. W. Van Devender); Asian brown tortoise *Manouria emys*, Testudinidae (R. W. Barbour); yellow-footed tortoise, Geochelone denticulata (L. J. Vitt); red-footed tortoise, *Geochelone carbonaria*, in defensive posture (L. J. Vitt).

Order Rhynchocephalia

Full body (left) and head (right) of the tuatara *Sphenodon punctatus* (P. Ryan).

- Sphenodontidans differ from squamates by
  1. the presence of gastralia;
  2. a narrow quadrate with greatly reduced or lateral concha;
  3. lower temporal fenestra enclosed or partially so;
  4. jugal in the mid-temporal arch touching the squamosal posteriorly;
  5. prominent coronoid process on the mandible;
  6. several anterior teeth of the palatine series enlarged;
  7. dentary and mandibular teeth generally enlarged, regionalized, and fused to dorsal margin of bone;
  8. the premaxillary teeth replaced by chisel-shaped extensions of the premaxillary bones that have given rise to the tuatara's other vernacular name, half-beaks

Order Squamata

- Suborder Sauria—The Lizards
  1. About 3,300 species of lizards are in the suborder Sauria (Gr. sauro, lizard).
  2. In contrast to snakes, lizards usually have two pairs of legs, and their upper and lower jaws unite anteriorly.
  3. The few lizards that are legless retain remnants of a pectoral girdle and sternum.
- Suborder Serpentes—The Snakes
  1. About 2,300 species are in the suborder Serpentes (L. serpere, to crawl). Although the vast majority of snakes are not dangerous to humans, about three hundred species are venomous.
  2. The pectoral girdle and forelimbs are totally absent; where present, the pelvic girdle and hindlimbs are rudimentary and visible externally as small horny“spurs,”one on each side of the cloaca opening.

Representative agamid lizards.
Clockwise from upper left: Spotted butterfly lizard *Leiolepis guttata*, Leiolepidinae (R. D. Bartlett); rhinocerus agama *Ceratophora tennentii*, Agaminae (C. Austin); Australian water dragon *Lophognathus longirostris* (E. R. Pianka); Dabbs mastigure *Uromastyx acanthinura*, Leiolepidinae (L. L. Grismer).

Representative chamaeleonids.

Clockwise from upper left: Cameroon stump-tailed chameleon *Rhampholeon spectrum* (C. Mattison); brown leaf chameleon *Brookesia superciliaris* (C. Mattison); cape dwarf chameleon *Bradypodium pumilis* (D. Hillis); south-central chameleon *Furcifer minor* (R. D. Bartlett).

Representative iguanid lizards .

Clockwise from upper left: Green basilisk *Basiliscus plumifrons*, Corytophaninae (L. J. Vitt); collared lizard (female) *Crotaphytus collaris*, Crotaphytinae (L. J. Vitt); Boulenger's dwarf iguana *Hoplocercus spinosus*, Hoplocercinae (L. J. Vitt); green iguana *Iguana iguana*, Iguaninae (L. J. Vitt).

Representative extant Helodermatids.
From left: Gila monster Heloderma suspectum, Helodermatidae (L. J. Vitt); Mexican beaded lizard Heloderma horridum (C. Schwalbe).

Representative extant varanids.
From left: Earless monitor *Lanthanotus borneensis*, Lanthanotinae (L. W. Porras); Gould's goanna *Varanus gouldii*, Varaninae (E. R. Pianka).

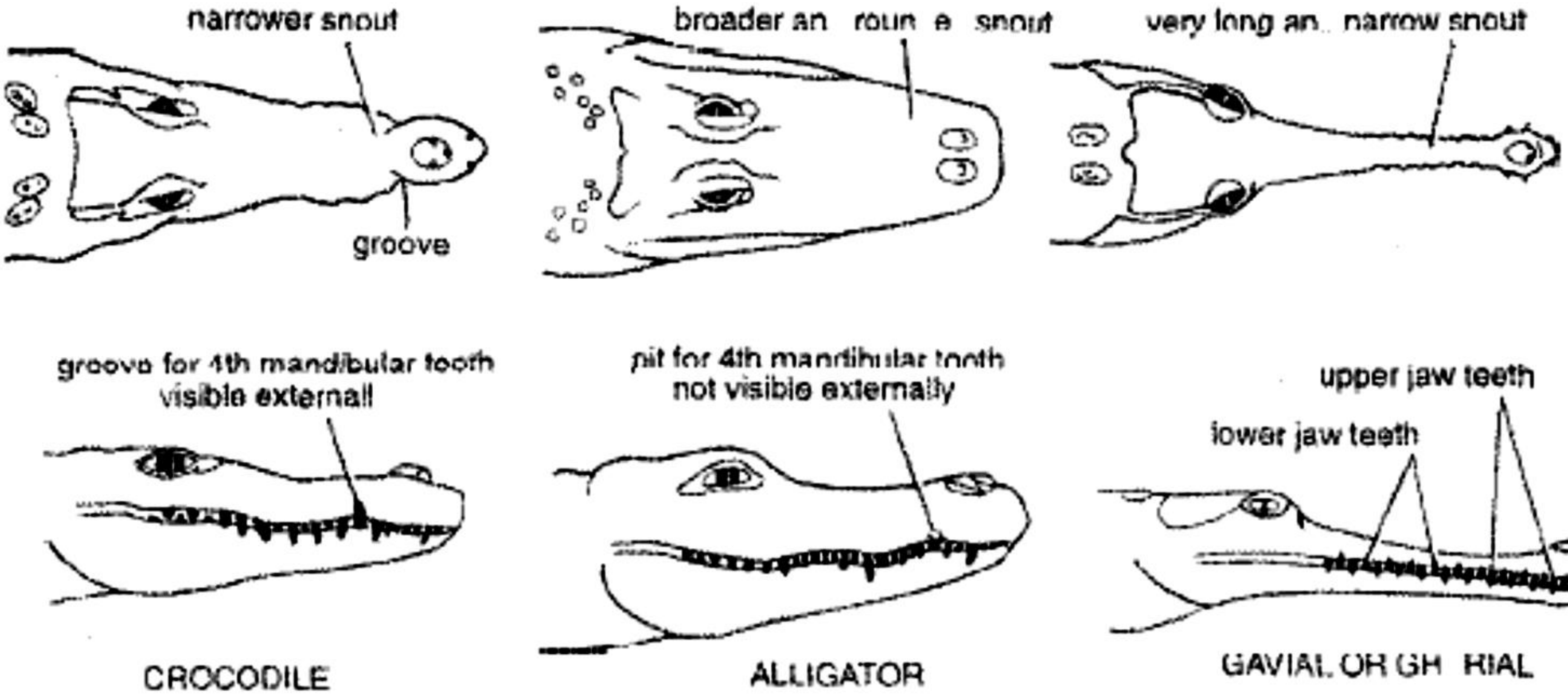
Representative boid snakes in the subfamily Boinae.
Clockwise from upper left: Boa constrictor Boa constrictor (L. J. Vitt); Brazilian rainbow boa (L. J. Vitt); garden tree boa (L. J. Vitt); juvenile emerald tree boa (L. J. Vitt).

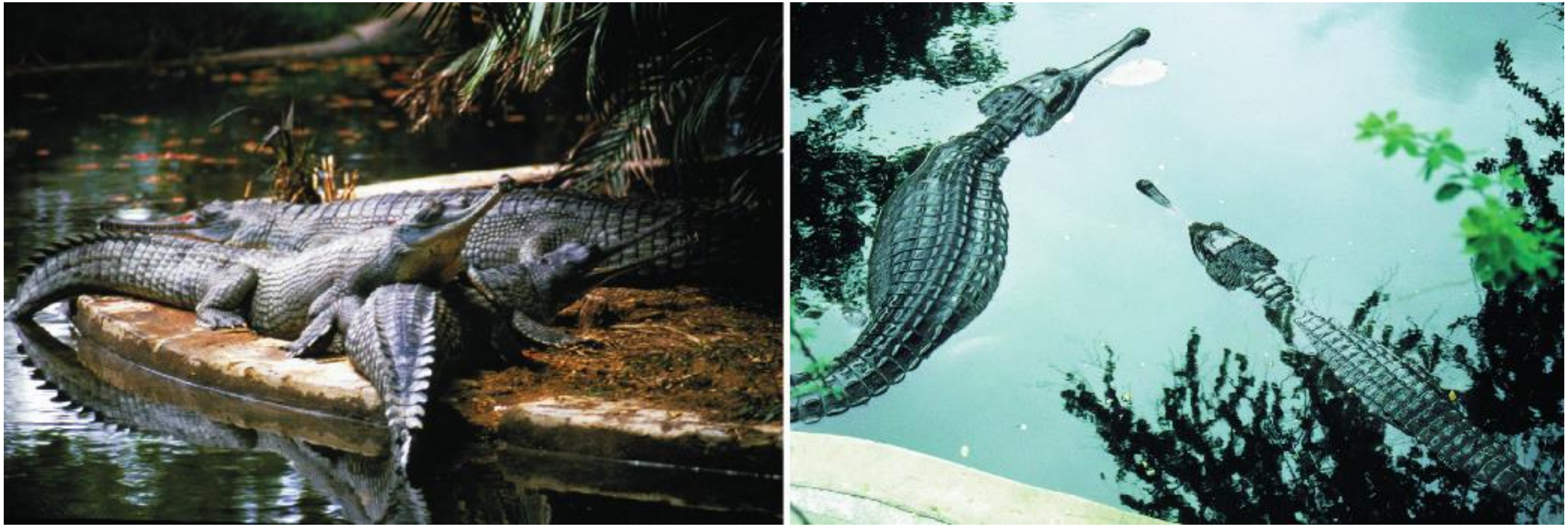
Representative viperids.
Clockwise from upper left: Prairie rattlesnake *Crotalus viridis*, Crotalinae (L. J. Vitt); speckled forest pit viper, *Bothriopsis taeniata*, Crotalinae (L. J. Vitt); Brazilian lance-head pit viper *Bothrops moojeni*, Crotalinae (L. J. Vitt); ottoman viper *Vipera xanthina*, Viperinae (R. W. Barbour).

Representative colubrids.
Clockwise from upper left: Gomes's pampas snake Phimophis eglasiasi, Xenodontinae (L. J. Vitt); Aesculapiam false coral snake Erythrolamprus aesculapii, Xenodontinae (L. J. Vitt); keel-back water snake Helicops angulatus, Xenodontinae (L. J. Vitt); southern hognose snake Heterodon simus, Xenodontinae (L. J. Vitt).

Representative elapid snakes.
Clockwise from upper left: Cerrado coral snake *Micrurus brasiliensis* (L. J. Vitt); Phillipine karait *Hemibungarus calligaster*, Elapinae (R. M. Brown); yellow-lip sea krait *Laticauda colubrina*, Hydrophiinae (G. R. Zug); curl snake *Suta suta*, Hydrophiinae (T. Schwaner).

Order Crocodilia





The two species of gavialids.
From left: Gharial *Gavialis gangeticus* (C. A. Ross) and the "false" gharial *Tomistoma schlegelii* (G. Webb).

Representative alligatorids.
Clockwise from upper left: Chinese alligator *Alligator sinensis*, Alligatorinae (C. K. Dodd, Jr.); spectacled caiman Caiman crocodilus, Caimaninae (J. P. Caldwell); Cuvier's dwarf caiman *Paleosuchus palpebrosus*, Caimaninae (J. P. Caldwell); black caiman *Melanosuchus niger*, Caimaninae (L. J. Vitt).

Representative crocodiles.
Clockwise from upper left: Saltwater crocodile *Crocodylus porosus* (G. R. Zug); Saltwater crocodile *Crocodylus porosus* floating (R. Shine); Johnstone's crocodile *Crocodylus johnstoni* (R. Shine); dwarf crocodile *Osteolaemus tetraspis*, Crocodylinae (A. Britton).