BIOL 4020: Vertebrate Biodiversity

Auburn University Lab Manual

Fall 2020

Contents

1 Lab Breakdown 2
2 Project Proposal 6
3 Field Notebook 13
4 “Fishes” 16
5 Amphibians 23
6 Diapsids 30
7 Mammals 43

Lab Breakdown

Instructor: Randy Klabacka: rlk0015@auburn.edu

Sections: 1: Mon 12:00 – 2:50

2: Tue 12:30 – 3:15

3: Wed 12:00 – 2:50

Grade Breakdown:

Category	
Attendance & Participation	80
Project Proposal	40
Field Notebook	40
Exams (16 pts each, 5 exams)	80
Total	240

* Due to the COVID-19 pandemic, labs (with the exception of field trips- see Field Notebook Section) will be conducted remotely using Canvas and zoom. You can complete all of the labs on your own time with the exception of: (1) the lab introduction, (2) your assigned field trip, (3) the proposal workshop, and (4) the proposal panel. To see which field trip you are assigned to, see the document on Canvas under <InsertPathToDocumentHere>. The lab introduction, proposal workshop, and proposal panel will be conducted over zoom during your scheduled lab time. Details on these items will be provided later. Here is the zoom meeting information:

- zoom meeting id: 954 8133 6875
- zoom meeting pw: VB4020

For many of the other labs, you will be required to watch a pre-recorded lecture given by one of your TA's and complete the activities specified for that week's lab module (see "Modules" tab on Canvas to see the lab modules for each week).

Attendance & Participation:

- Participation: $\tilde{7}$ points per lab
- Each lab has a corresponding lab module on Canvas with instructions on how to obtain points for that lab. Obtaining attendance/participation points for each lab is dependent on completion of the elements within each lab module.
- Each lab module will close at the beginning of the following lab (e.g., the Lab Module for Lab 2 will close once the Lab Module for Lab 3 opens). Lab modules open at the start of lab (i.e., 12:00 pm on Monday for Section 1) and end at the beginning of the following lab (e.g., 11:59 am on the following Monday for Section 1).
- Failure to attend/participate in a lab results in a loss of all points for that lab.

Project Proposal:

- Rough Draft: 15 points
- Final Draft: 25 points
- Additional details for this assignment are in the Project Proposal Section

Field Notebook:

- 12 hours of in-field observation are required to receive full credit for this assignment
- Hours from lab field weeks contribute to this amount (4 trips: 8 hours)
- 4 points will be deducted for each hour a student is short of the 12 total hours
- Additional details for this assignment are in the Field Notebook Section

Exams:

- 4 exams (20 points each)
- Exams will be administered electronically over Canvas and will include:
  1. Photo identification (common names acceptable)
  2. Natural history facts discussed in lab/field
  3. Major points from publications discussed in lab
  4. Phylogenies for focal taxa

Week of	Lab Module	Topic	Items due before class
Aug 17	Lab 1	Live zoom overview*	
Aug 24	Lab 2	Intro to Fishes	
Aug 31	Lab 3	Field Trip- Euphapee Creek	Discussion Template
Sep 7	*No Lab*	*Labor Day*	
Sep 14	Lab 4	Intro to Amphibians	**Fish Exam**
Sep 21	Lab 5	How To Science	Proposal Ideas
Sep 28	Lab 6	Field Trip- Opacum Pond	Canvas Discussion
Oct 5	Lab 7	Intro to Diapsids	**Amphibian Exam**
Oct 12	Lab 8	Field Trip- Wood Duck Preserve	Proposal Rough Draft
Oct 19	Lab 9	Proposal Workshop*	Canvas Discussion
Oct 26	Lab 10	Intro to Mammals	**Diapsid Exam**
Nov 2	Lab 11	Field Trip- Oxbow Pond	Proposal Submission
Nov 9	Lab 12	Proposal Panels*	Proposal Review
Nov 16	*No Lab*	*Study for exam!*	**Mammal Exam**

* denotes labs with live zoom meetings
zoom meeting id: 690 238 9071
zoom meeting pw: VertBio20
zoom meeting link: ZoomLink

Field Behavior and Safety: On field trips, we enter the habitats that are home to diverse organisms. It is expected that you will show respect by handling organisms with care, replacing flipped logs to their original position, refrain from littering, and avoid shouting. At all times you must stay with the group as a whole-

i.e., you must be able to see other lab members at all times. Given the current pandemic, it is also required that you wear a face mask and maintain 6 ft of physical separation. You are also required to wear close-toed shoes into the field, and it is recommended that you have sun protection and wear clothing that you can get wet/dirty! You will be hiking through dirt, mud, and water. Expect to get knee-deep in water on all field trips. Be cautious and aware as you walk through the woods. Your safety is your responsibility on these trips- if you feel uncomfortable doing something out of concern for your safety, do not do it!

Academic Honesty and Inclusion: This lab welcomes, respects, and serves students of diverse backgrounds and perspectives, and it is expected that students respect one another. Any acts of aggression or misconduct based on race, color, veteran status, religion, age, rural/urban/national origin, sex or sexual orientation, gender identity, or disability will not be tolerated. Academic dishonesty in any form will also not be tolerated. Given the current status of the global pandemic, you will have more independence than is typically granted in this lab. We ask that you honor the independence granted with your honesty on all lab assignments and exams.

Project Proposal

Proposal Ideas:	3 pts (part of Lab 4 participation)	**Due:**	Before Lab 6
Rough Draft:	15 pts	**Due:**	Before Lab 8
Final Draft:	25 pts	**Due:**	Before Lab 11
Proposal Review:	7 pts (part of Lab 12 participation)	**Due:**	Before Lab 12
Panel Discussion:	5 pts (part of Lab 12 participation)	**Due:**	During Lab 12

Project Proposal Overview:

All science begins with a question. Scientists take a question and design an experiment to find an answer. They then execute the experiment, analyze the results, and draw conclusions. However, there is an important step between the designing and the executing- getting money! Most projects require funding (for equipment, animals, reagents, people, etc.). In the United States, most science focused on vertebrate biodiversity is funded through research grants. A research grant is a sum of money awarded to a scientist to fund a proposed project. Most grants are awarded based on a written proposal. One such proposal that is relevant to your academic level is the Graduate Research Fellowship Program (GRFP), a fellowship funded by the United States National Science Foundation (NSF). This fellowship provides an annual student stipend of $34,000 for three years in addition to a $12,000 cost of education. Students can apply as an undergraduate and then once as a graduate student (in either their first or second year as a grad student). In other words, you get a "freebee" chance as an undergrad that doesn't count against you! The application includes one 3-page personal statement and one 2-page research proposal. For this project, you will be writing a 2-page research proposal similar to that of the GRFP. Your project can include any sub-field of biology (e.g., biochemistry, evolution, ecology, behavior, etc.), but must be centered on vertebrate biodiversity (e.g.,no biomedical or

agricultural projects). The most difficult part of this assignment might be coming up with a question, so it is best to start thinking about ideas early!

Official GRFP Program Solicitation:

- https://www.nsf.gov/pubs/2019/nsf19590/nsf19590.htm
- The solicitation contains a lot of information. You are only writing the 2-page "Graduate Research Plan" document. For more information and tips, see the links below

Resources for Writing a Good Proposal:

- https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=6201&org=DGE&from=home
- https://www.nsf.gov/ehr/Pubs/grfpoutreach2020.pdf
- http://www.malloryladd.com/nsf-grfp-advice.html
- https://www.alexhunterlang.com/nsf-fellowship
- http://www.christineliuart.com/writing/2018/8/31/advice-for-applying-to-the-nsf-grfp

Proposal Ideas Assignment:

You are required to prepare at least three proposal ideas by Lab 5 as part of your participation points for the Lab 4 Module. Each idea should consist of (1) a question, (2) a hypothesis, (3) a very basic experimental design [this can be a drawing], and (4) what kind of data you will collect. This assignment will be worth 3 points, and grading will be based on completion (i.e., as long as you turn something in that addresses each point, you will get full credit). However, taking this assignment seriously will put you on the right track to designing a solid proposal. During the first few weeks of the semester, be thinking of possible projects. This might be the most difficult part of the project proposal! To find an idea that interests you, it is recommended that you read scientific literature of projects that interest you. As you read, look for statement such as "Future work should..." or "...still needs to be investigated." As you read projects that interest you, you are more likely to discover a question that needs to be addressed. If you are struggling to come up with ideas, email one of your TA's and include your interests (e.g., "I'm struggling to come up with a project proposal idea. I really like birds and am interested in animal behavior, could you provide me with some resources to help guide my thoughts?"). The points earned from this assignment will contribute to the Attendance & Participation portion of the lab. You will turn this assignment in as part of the Lab 4 module.

Rough Draft:

Your rough draft should address each point within the **??**, but doesn't necessarily need to be written out in paragraph form (i.e., you can use bullet points). However, the grade for this assignment is not based on completion. It must be evident to the TA's that you have put a legitimate effort into the proposal.

Final Draft:

Your final draft should address each point within the **??**, and should be written in paragraph form according to the GRFP guidelines (Paragraphs: Single-spaced; Font: 12-pt Times New Roman; Margins: 1"). Your grade will be based on how well you address each point in the rubric in addition to how you responded to the comments made on your rough draft.

Proposal Review and Panel Discussion:

After everyone has submitted their project proposal Final draft, each student will be assigned to a proposal panel to decide on a proposal to "fund" (to make things fun, "funding" will be 3 substitution points for the project proposal). Each student will be assigned a proposal to review as part of the Lab 12 Module. You need to review in-detail the proposal assigned to you, but you are also required to read all proposals assigned to your panel in order to assess the strength of your proposal relative to the rest in your panel. Part of your Lab 11 module will be to submit your proposal review. The review should be based on the following criteria: (1) Is background information informative? (2) Is the hypothesis clear and testable? (3) Is the experimental design clear? (4) Are the methods appropriate? (5) Do the predictions make sense? (6) Does the project merit funding? [e.g., Is the question important, and will project results positive OR negative push forward scientific understanding?] (7) Is the project feasible? Lastly, you should rank your proposal within one of the following groups: "Excellent", "Good", "Fair", or "Poor". This review will be turned in as part of your Lab 11 module. The Lab 12 module will include a live zoom meeting with your panel during lab time, wherein you will discuss each proposal and decide (over vote) which proposal merits funding.

Optional Research Project (Bonus Points):

You may also earn bonus points by completing a research project. Because many of the proposed projects (including your own) may not be feasible to complete in a single semester, you are also free to choose a project proposed by another student to work on for extra credit. Feasible projects proposed by vert bio students will be listed on Canvas after Lab 6 (with their names removed), and several topics are also listed below. To earn extra credit for a project, you must (1) collect data, (2) analyze the data, and (3) create a project writeup (summarizing the background information, methods of data collection and analysis, results (including a figure), and a discussion/conclusion.) **If you decide to go forward with the Optional**

Research Project, it is highly recommended that you contact your TA's and let them know your plan. You can earn up to 40 points for completing the optional research project (see **??**)

Feasible Project Ideas:

It is very likely that you are interested in

- Is fish body type associated with water flow rate?
  - Collect fish from multiple areas within the same stream (collecting from multiple streams recommended).
  - ID species and measure fish (length, height, width).
  - Measure flow rate of water at each site where fish are collected
- Are invasive <¡insert vertebrate organism here> expanding their distribution?
  - Using an online database, assess the potential expansion of a given invasive vertebrate organism looking at reports over time.
  - The Global Biodiversity Information Facility contains data for many vertebrate species. If you are interested in birds, the eBird database is an excellent tool (you'll have to create a profile and request to access the database, but all academic requests are granted).
  - Figuring out how to collect and manage this data will be challenging, but that's part of the research experience!

Table 2.1: Rough Draft Rubric

Introduction (3 pts)	
Is background information relevant and clear?	1 pt
Are supporting claims cited with peer-reviewed literature?	1pt
What specific question is being asked?	1 pt
Objective (2 pts)	
Is the hypothesis clearly defined?	1 pt
Is the study system appropriate to address the hypothesis?	1 pt
Methods (8 pts)	
Figure for experimental design.	1 pt
Is the experimental design clearly described?	1 pt
What are the independent and dependent variables?	1 pt
Are methods sound and logical to address the hypothesis?	1 pt
Are previously implemented methods cited?	1 pt
Are obvious pitfalls evident?	1 pt
What data will you collect?	1 pt
What tools/equipment will you need to collect data?	1 pt
Predictions (3 pt)	
Figure for anticipated results.	1 pt
What results would support your hypothesis?	1 pt
What results would refute your hypothesis?	1 pt
Intellectual Merit (1 pts)	
What is the significance of the project?	1 pt
Total	17 pts

While the point total shows 17 possible points, 2 are substitution points
The total number of possible points for this assignment = 15

Table 2.2: Final Draft Rubric

Introduction **(6 pts)**	
Is background information relevant and clear?	2 pts
Are supporting claims cited with peer-reviewed literature?	2 pts
What specific question is being asked?	2 pts
Objective **(3 pts)**	
Is the hypothesis clearly defined?	2 pts
Is the study system appropriate to address the hypothesis?	1 pt
Methods **(10 pts)**	
Figure for experimental design.	2 pts
Is the experimental design clearly described?	1 pt
What are the independent and dependent variables?	1 pt
Are methods sound and logical to address the hypothesis?	1 pt
Are previously implemented methods cited?	1 pt
Are obvious pitfalls evident?	1 pt
What data will you collect?	2 pts
What tools/equipment will you need to collect data?	1 pt
Predictions **(4 pt)**	
Figure for anticipated results.	2 pts
What results would support your hypothesis?	1 pt
What results would refute your hypothesis?	1 pt
Intellectual Merit **(2 pts)**	
What is the significance of the project?	2 pts
Total	25 pts

Table 2.3: Optional Research Project Rubric

Introduction (3 pts)	
Is background information relevant and clear?	1 pt
Are supporting claims cited with peer-reviewed literature?	1 pt
What specific question is being asked?	1 pt
Objective (3 pts)	
Is the hypothesis clearly defined?	2 pts
Is the study system appropriate to address the hypothesis?	1 pt
What were your predictions?	1 pt
Methods (8 pts)	
Figure for experimental design.	1 pt
Is the experimental design clearly described?	1 pt
What are the independent and dependent variables?	1 pt
Are methods sound and logical to address the hypothesis?	1 pt
Are previously implemented methods cited?	1 pt
Are obvious pitfalls evident?	1 pt
What data will you collect?	1 pt
What tools/equipment will you need to collect data?	1 pt
Results (4 pt)	
Figure for results.	10 pts
Description of results in the text.	10 pts
Discussion/Conclusion (4 pt)	
Do the results support/reject your hypothesis?	5 pts
What is the significance of the project?	2 pts
What future work needs to be done?	3 pts
Total	40 pts

Field Notebook

Field Notebook Overview:

- To fulfill a central purpose of this lab (helping you understand and appreciate vertebrate biodiversity), we will be taking trips to the field to observe vertebrate animals in their natural environments. In addition to the trips we take as a class, you are required to obtain additional hours on your own field "expeditions." Central to field biology is keeping useful notes of what you observe. This section provides everything you need to include in your field notebook to receive full credit.
- $*$ Due to the COVID-19 pandemic, we will not be taking entire lab sections to field sites via university transport. Instead, three students per section will be pre-assigned dates (field assignments are on Canvas) when they will ride to sites via university transport. All members within the vehicle are required to wear a face mask, and the windows will be down for the duration of the trip (no trip is longer than 30 minutes). Other students are welcome to join trips, but must take their personal vehicles. We will record video highlights of lab trips and post these on canvas. These video highlights may include taxa and natural history facts that can be included on your exams.

Assignment Requirements:

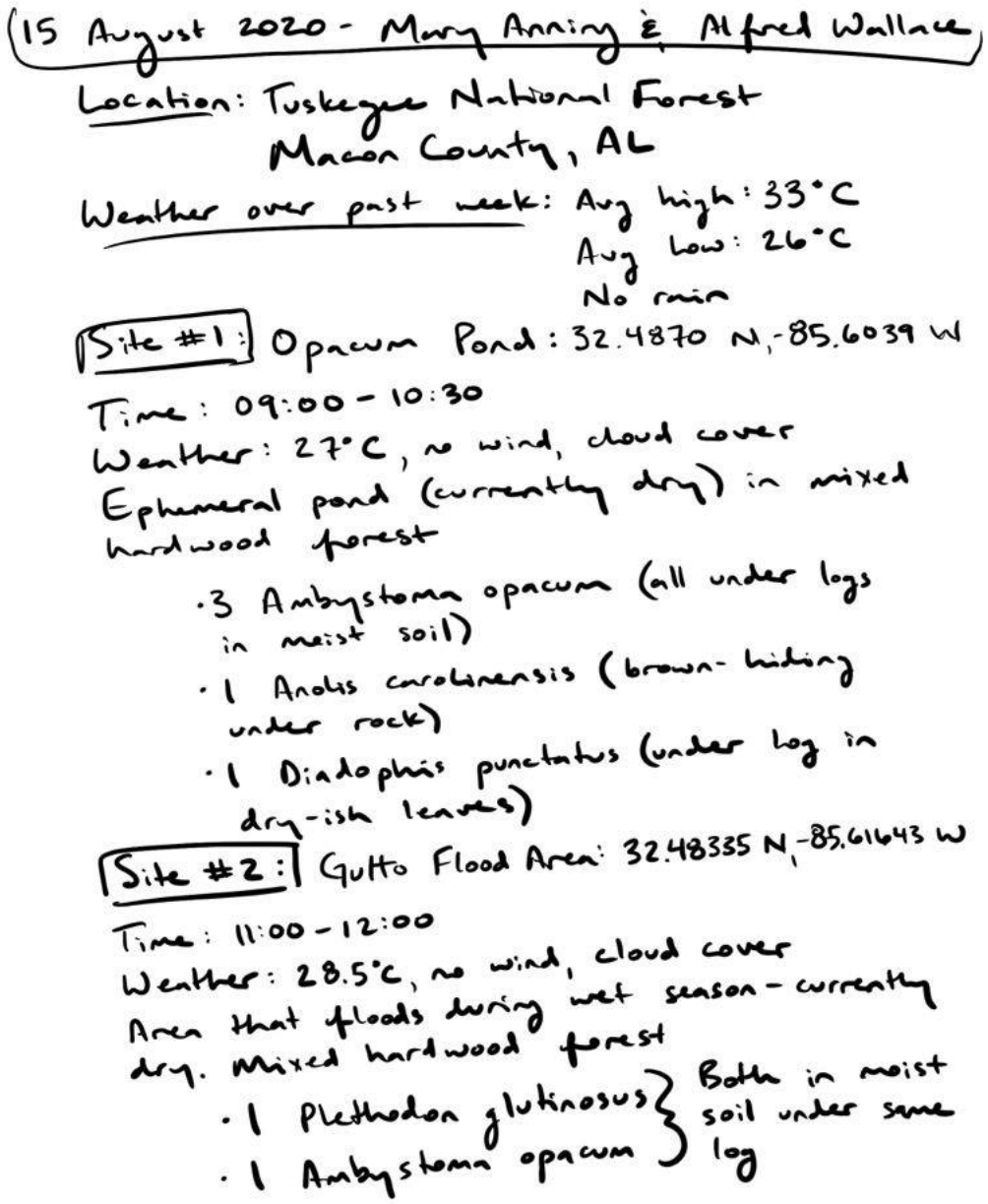
- To receive full points, you must log 12 hours dedicated to in-field observations. These hours must be dedicated to searching for vertebrate animals, identifying the animals (taking a photo will help), and observing behavior. Field observation hours cannot be a secondary activity (i.e., the primary purpose of you going to a site must be to observe vertebrate animals).
- To receive full credit, each journal entry requires an appropriate heading and Detailed observations (see below)

- It is recommended to use a weather-proof field journal, but any notebook the size of a paperback novel is adequate.
- 4 points will be deducted for each hour a student is short of the 12 total hours
- Being physically present on lab trips counts toward the 12 hours
- If you are uncomfortable or unable to log all needed hours, additional hours can be obtained by contributing to iNaturalist (but this must be approved beforehand by a TA)

Journal Entry Requirements:

- heading:
  - Your name
  - Date
  - General location (locality name, County, State)
  - Specify what the weather has been like over the last few days
  - Number of people
- for each site visited:
  - Time
  - Weather (temperature, cloud cover, humidity, sind)
  - Specific location (locality name, GPS coordinates)
  - Habitat Description
  - For each species (not individual) observed:
    - provide number of each identified species
    - If you are unable to positively identify the species you may indicate uncertainty by giving the genus followed by sp. (abbreviation of species) or by putting c.f. (abbreviation of confer: meaning "compare") before your best guess for the species. For example, *Homo sp.* or *Homo c.f. sapiens*.
    - describe the microhabitat where individuals were found
    - note any intersting behavior or natural history
    - indicate when you took a photograph of a species

Journal Entry Example:



15 August 2020 - Mary Anning & Alfred Wallace

Location: Tuskegee National Forest
Macon County, AL

Weather over past week: Avg high: 33°C
Avg low: 26°C
No rain

Site #1: Opacum Pond: 32.4870 N, -85.6039 W

Time: 09:00 - 10:30
Weather: 27°C, no wind, cloud cover
Ephemeral pond (currently dry) in mixed hardwood forest

- 3 Ambystoma opacum (all under logs in moist soil)
- 1 Anolis carolinensis (brown- hiding under rock)
- 1 Diadophis punctatus (under log in dry-ish leaves)

Site #2: Gutto Flood Area: 32.48335 N, -85.61643 W

Time: 11:00 - 12:00
Weather: 28.5°C, no wind, cloud cover
Area that floods during wet season - currently dry. Mixed hardwood forest

- 1 Plethodon glutinosus } Both in moist soil under same log
- 1 Ambystoma opacum }

“Fishes”

Evolutionary trees to know:

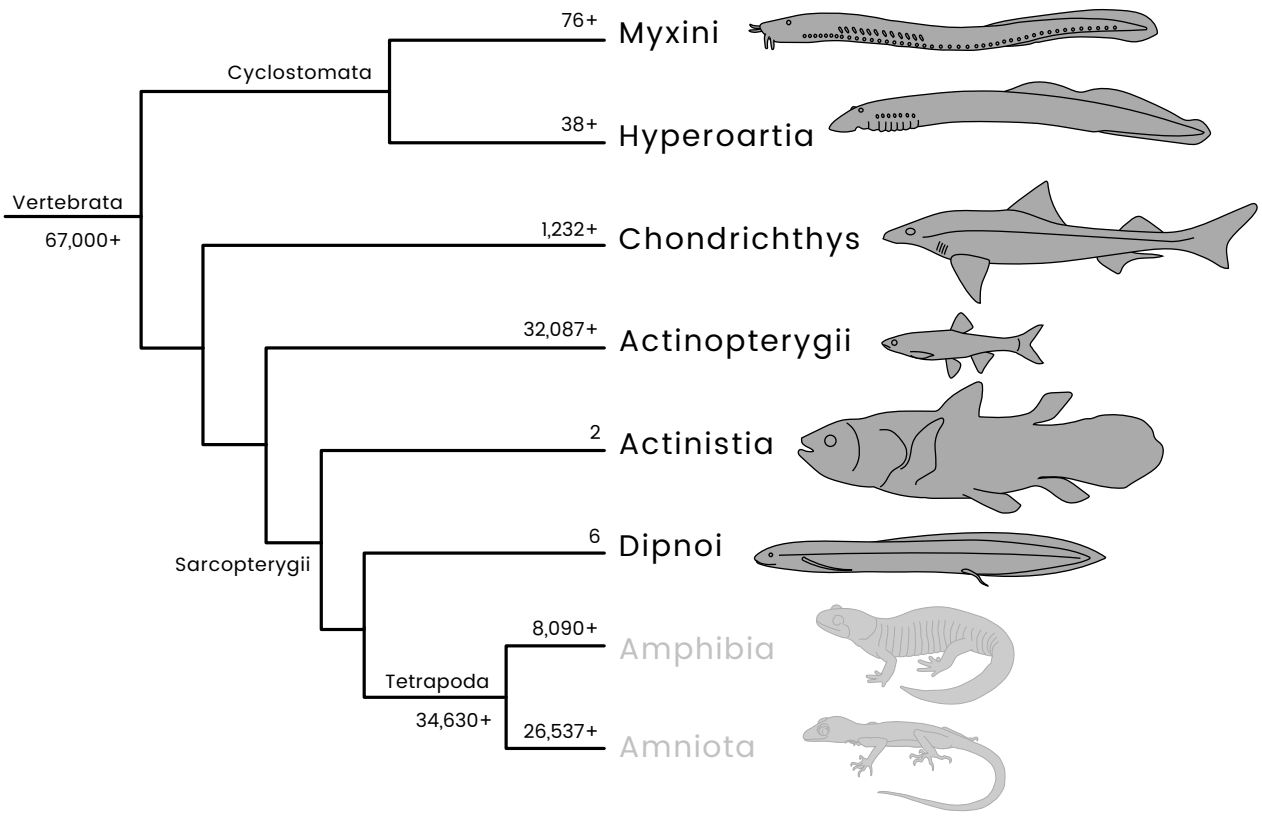


Figure 4.1: How “fish” relate to other vertebrates

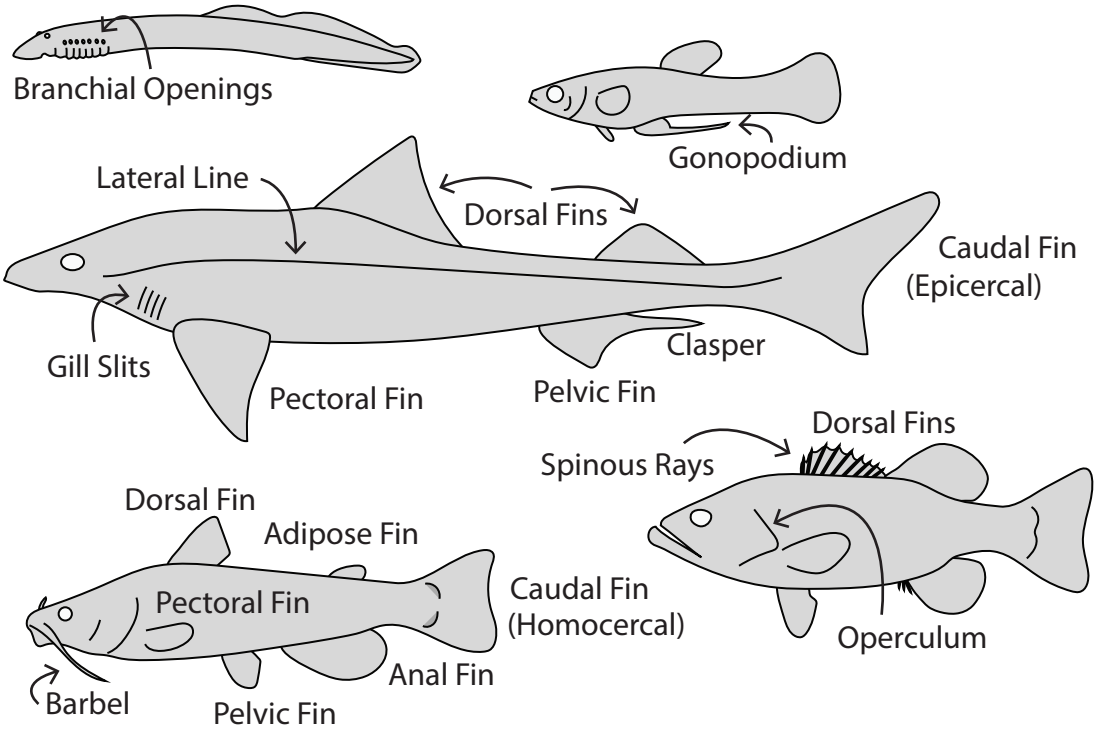


Figure 4.2: Fish anatomical terms to know

Focal taxonomic groups (⋆ groups you need to be able to photo ID and place in a phylogeny)

Cyclostomata (Jawless fish) No vertebral central, no pectoral / pelvic fins with endoskeletal support, gill openings pores rather than slits, elongated body

- **Myxini** (hagfish) ⋆

  12 pairs of gill openings, mucous glands lateroventraly along the body, Paired of sensing tentacles

- **Hyperoartia** (lamprey)⋆

  7 pairs of gill openings, single mediodorsal nostral, funnel-shaped mouth surrounded by oral disk

Gnathostomata (jawed fish)

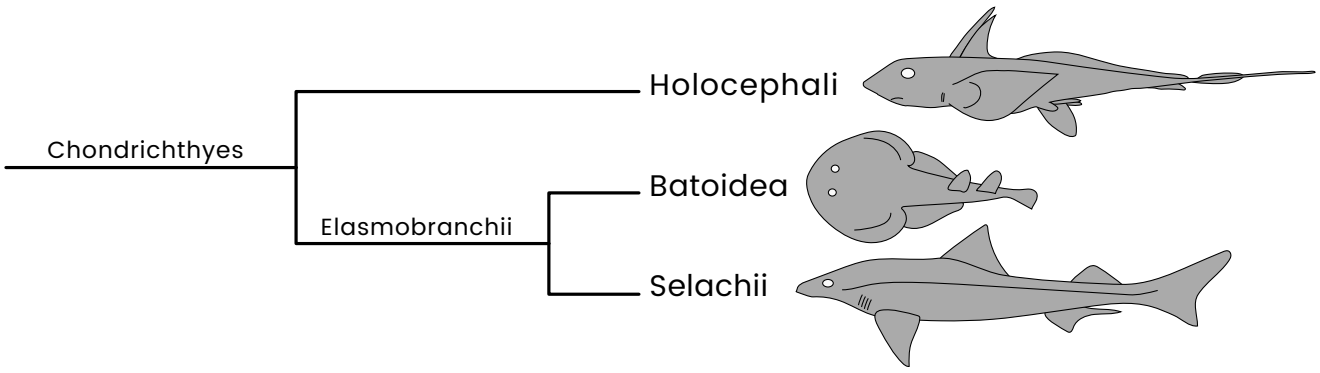


Figure 4.3: Major groups within Chondrichthys

Chondrichthys (Cartilagenous fish) Endoskeleton made primarily of cartilage, placoid scales, no swim bladder

- **Holocephali** (Chimaera)⋆

  Operculum over 4 gill arches, teeth are grinding plates, no cloaca (anal anurogenital openings separate)

- **Elasmobranchii**

  Heterocercal tail, internal fertilization via claspers

  - **Selachii** (Sharks)⋆

    Heterocercal tail, 5-7 exposed lateral gill slits anterior to pectoral fins

  - **Batoidea** (Skates & Rays)⋆

    Dorsoventrally flattened body, expanded pectoral fins fused to the head

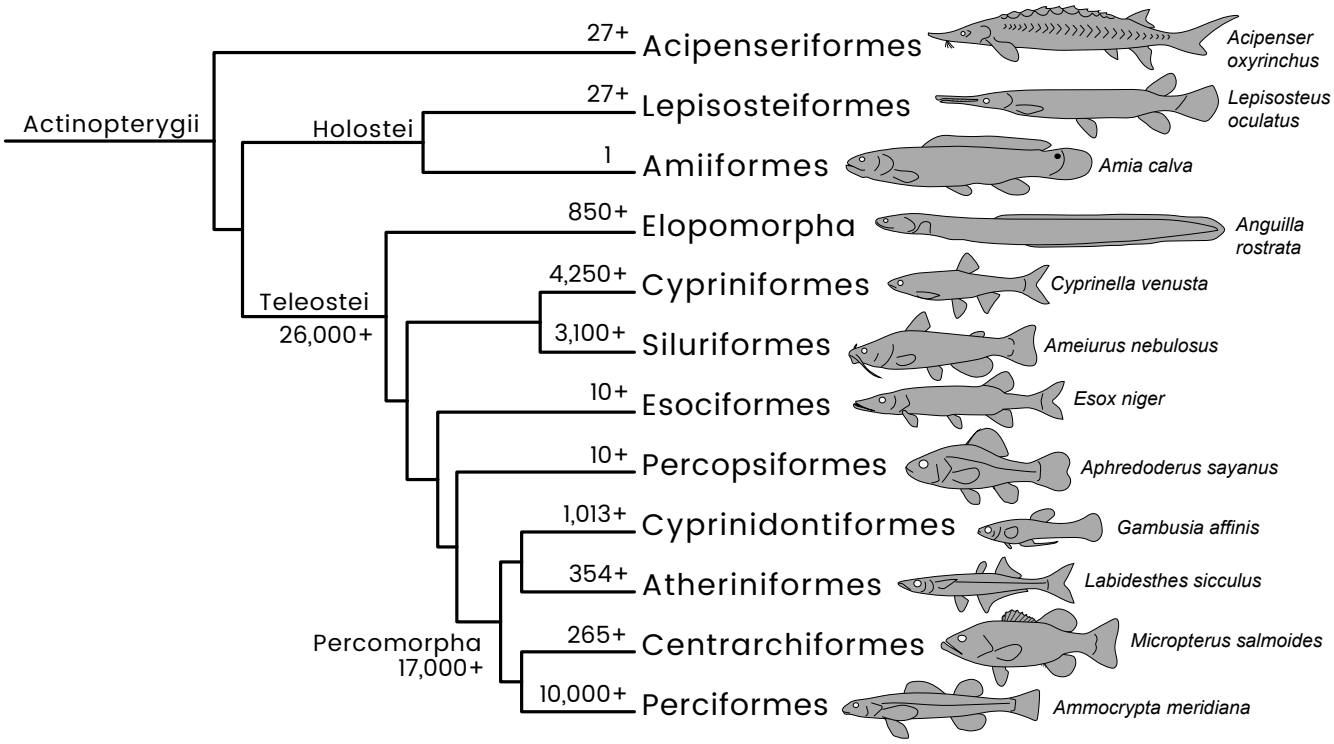


Figure 4.4: Major groups within Actinopterygii

Actinopterygii

Raylike supports in fins, radial bones of pectoral girdle all attached to the scapulocoracoid complex

- **Acipenseriformes**

  Heterocercal tail, only dermal bones of head and pectoral girdle ossified

  - **family ACIPENSERIDAE** (sturgeons)

    Robust body armed with 5 longitudinal rows of large bony plates, pronounced snout with 4 sensitive barbels, largest freshwater fish

  - ***Scaphirhynchus platorynchus*** (shovel-nosed sturgeon)⋆

    highly endangered, 4 lobes on lower lip, fringed barbels on front of mouth

  - **family POLYODONTIDAE** (paddlefish)

    paddle/spatula-like snout, virtually naked skin, greatly extended operculum

  - ***Polyodon spathula*** (American paddlefish)⋆

    grows up to 7 ft, filter-feeder

- **Lepisosteiformes** (gars)⋆

  elongate jaws with teeth, elongate body with dorsal and anal fins located caudally, abbreviated

heterocercal tail, swim bladder can be used for respiration

- ***Lepisosteus oculatus*** (spotted gar)

  olive brown to black, spots on body, head, and fins

- **Amiiformes** (bowfin)

  swim bladder can be used for respiration, round snout

  - ***Amia calva*** (bowfin)⋆

    body nearly cylindrical, long dorsal fin, abbreviated heterocercal tail, gular plate

- **Elopomorpha**

  Leptocephalus larvae

  - **Anguilliformes** (eels)

    body elongate, lack pelvic fins, pelvic girdle is often absent and when present is remote from skull

  - ***Anguilla rostrata*** (American eel)⋆

    long anal and dorsal fins

- **Cypriniformes**⋆

  Kinethmoid bone for jaw protrusion

  - **family CATOSTOMIDAE** (suckers)

    Pelvic fins abdominal, 1 dorsal fin, dorsal fin rays 10 or more, large mouth suckers ventral

  - ***Carpiodes velifer*** (highfin carpsucker)⋆

    Long sickle-shaped dorsal fin, projection on lower lip

  - ***Hypentelium etowanum*** (Alabama hogsucker)

    Cylindrical body, very pronounced ventral sucker, top of head between eyes flat or concave

  - **family CYPRINIDAE** (minnows and carp)

    no teeth on jaws, modified teeth on gill arches, fin rays soft and flexible, pelvic fins abdominal

  - ***Cyprinella venusta*** (black-tail shiner)⋆

    large black spot at base of caudal fin

  - ***Pimephales vigilax*** (bullhead minnow)

    blunt snout, leading ray stout and detached from first principle ray, light tail spot

  - ***Notropis ammophilus*** (orangefin shiner)

    8 dorsal rays, prominant orange fins

- **Siluriformes** (catfish)⋆

  Single spinous ray at beginning of dorsal and pectoral fins, adipose fin, pectoral girdle modified to form locking mechanism for pectoral fin spine

  - ***Ictalurus punctatus*** (channel catfish)

    caudal fin forked, 9 pelvic rays, deeply forked tail

  - ***Ameiurus nebulosus*** (brown bullhead)⋆

    8 pelvic rays, caudal fin not deeply forked, white or yellow chin barbels

- **Esociformes**

  Elongate body, tootless maxilla, posterior dorsal and anal fins

  - ***Esox niger*** (chain pickerel)⋆

    duckbill-like snout, snout longer than postorbital length of head, abdominal pectoral fins

- **Percopsiformes**

  ctenoid scales, spines on medial fins reduced or lost

  - ***Aphredoderus sayanus***⋆ (pirate perch)

    anus anterior between pectoral fins in adults (not in juveniles)

- **Cyprinidontiformes**⋆

  unlobed caudal fin, low-set pectoral fins

  - **family POECILIIDAE** (live-bearers)

    small fins, caudal fin rounded, mouth small and directed upward, males have anal fin displaced forward with gonopodium formed from 3 anal rays, elaborate reproductive strategy

  - ***Gambusia affinis*** (western mosquito fish)⋆

    6 dorsal fin rays

  - **family FUNDULIDAE** (killifish)

    elongate body somewhat laterally compressed with head dorsoventrally flattened, mouth small and turned upward, lower jaw extends beyond upper

  - ***Fundulus olivaceus*** (black-spotted topminnow)⋆

    Dorsal fin origin posterior from anal fin origin, prominant black stripe with dorsal spotting

- **Atheriniformes** (silversides)

  2 dorsal fins well separated (first with weak spines), anal fin longer than second dorsal fin, elongate and slightly compressed body

  - ***Labidesthes sticculus*** (brook sliverside)⋆

    origin of first dorsal fin near origin of anal fin

- **Centrarchiformes**⋆

  2 dorsal fins, 3 or more spines on anal tail, siny dorsal fin confluent with soft dorsal fin

  - ***Lepomis cyanellus*** (green sunfish)⋆

    maxilla reaches beneath eye, pectoral fin short and rounded

  - ***Micropterus salmoides*** (largemouth bass)⋆

    large mouth with lower jaw projecting, smaller spiny dorsal fin separated by notch from the second dorsal fin

- **Perciformes**⋆

  spines in dorsal and anal fins

  - **family COTTIDAE** (sculpins)

    skin mostly naked, high eyes directed upward, body robust with large head

  - ***Cottus carolinae*** (banded sculpin)

    mottled brown with dark vertical banding, broad head, body narrows caudally

  - **family PERCIDAE** (perches and darters)

    two dorsal fins, dorsal fins separated bya space, 2 anal spines

  - ***Ammocrypta meridiana*** (southern darter)⋆

    elongate body, blunt snout, caudal fin truncate

Sarcopterygii Radial bones of pectoral girdle not all attached to the scapulocoracoid complex

- **Actinistia** (lobe-finned fish)⋆

  skull divided anteriorly and posteriorly, widely distributed 400 million years ago

- **Dipnoi** (lung fish)⋆

  elongated and laterally compressed body, respire by gills and lungs

- **You!** (Along with all other tetrapods)

Amphibians

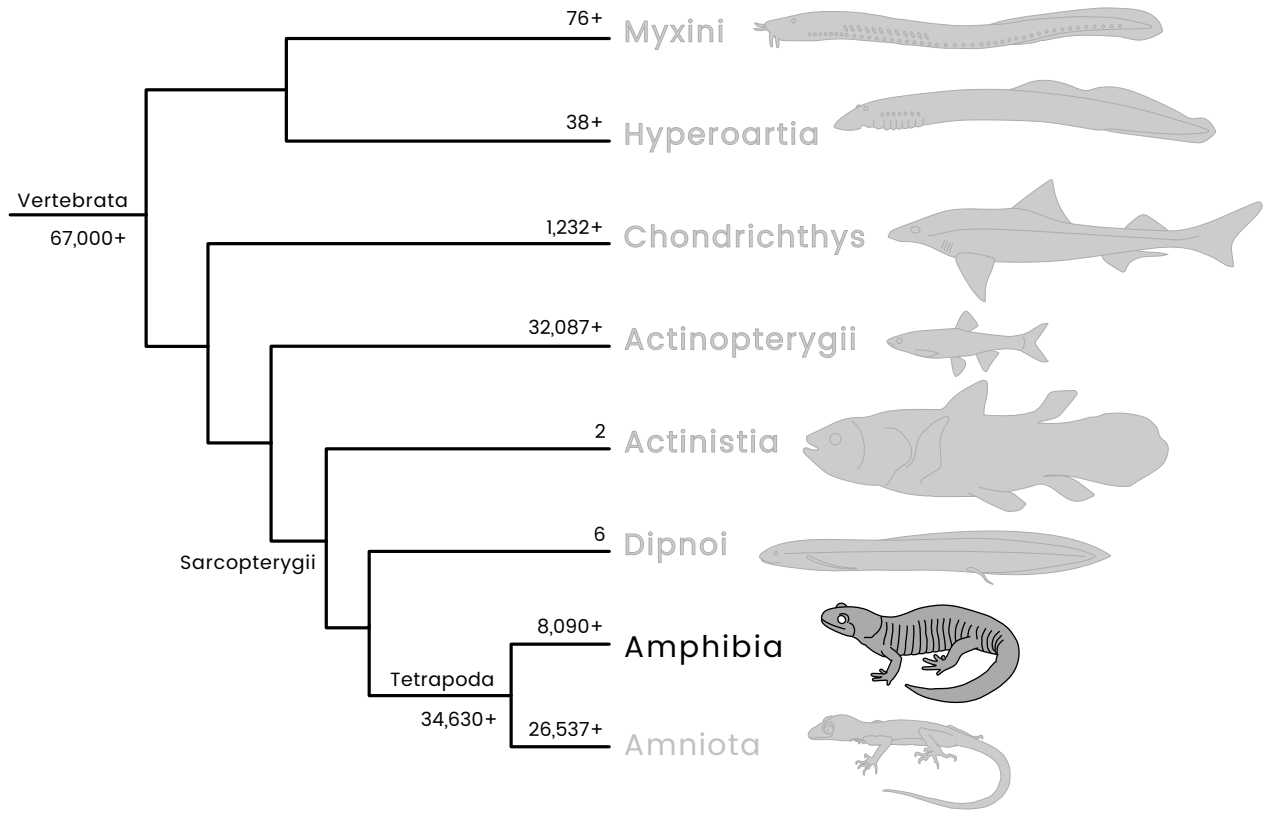


Figure 5.1: Amphibian placement within Vertebrata

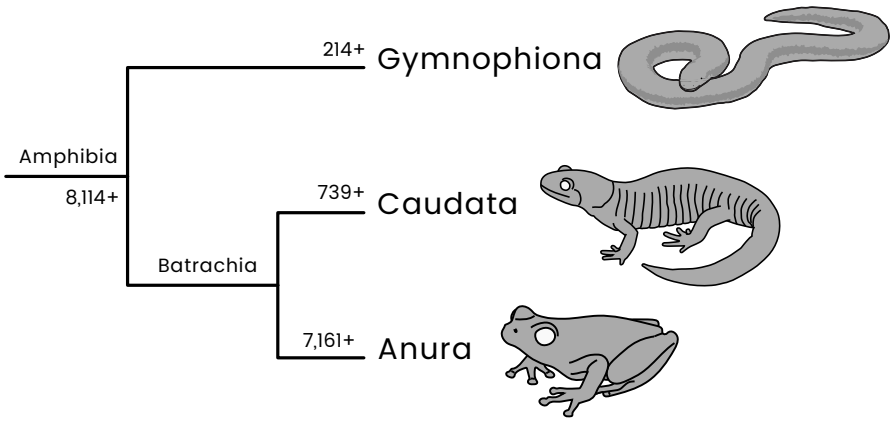


Figure 5.2: Amphibian Relationships

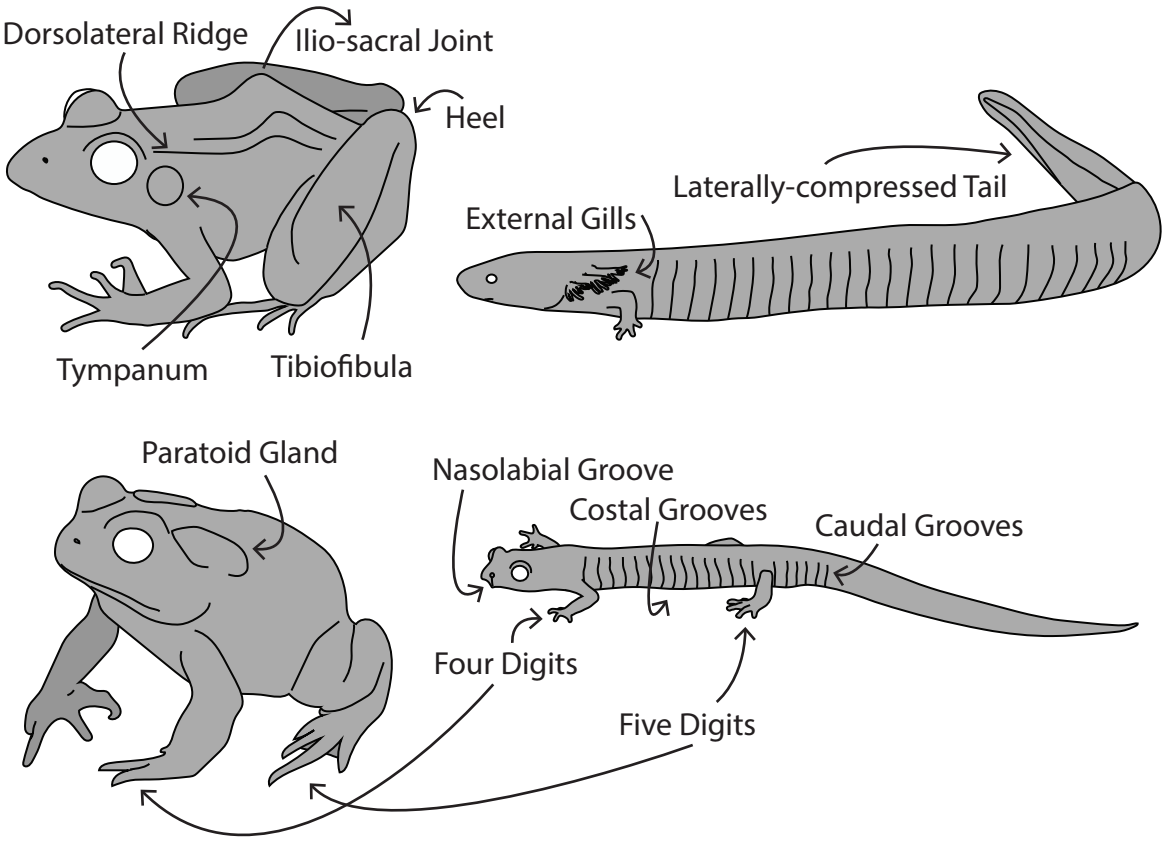


Figure 5.3: Amphibian anatomical terms to know

Focal taxonomic groups

(⋆ groups you need to be able to photo ID and place in a phylogeny. § denotes species for which you need to audio ID calls.)

Gymnophiona (Caecilians) No limbs, cylindrical body, tail short or absent, cloaca towards end of body, strong skull with pointed snout, pair of tentacles between eyes and mouth (olfactory), bodies distinctly segmented by annuli (each segment contains a single vertebra)

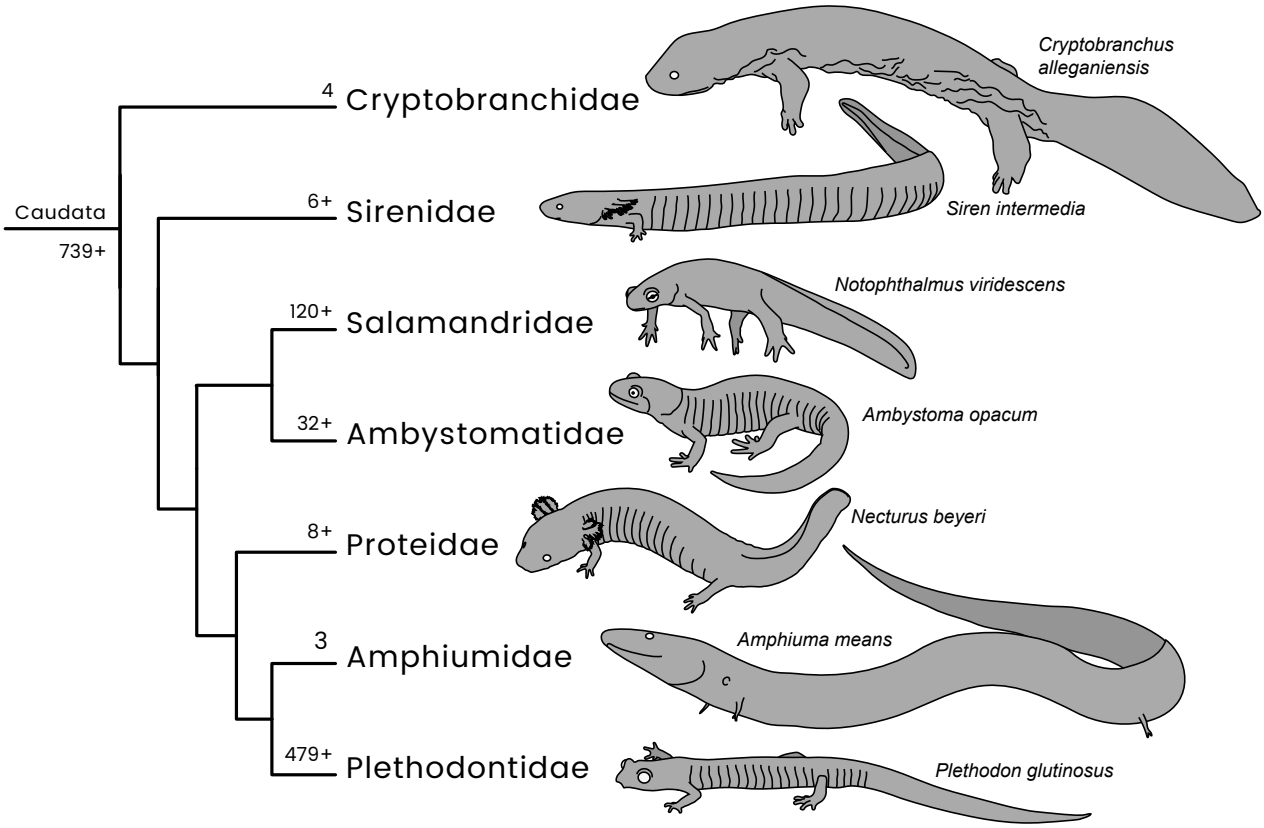


Figure 5.4: Caudata Relationships (abbreviated)

Caudata (Salamanders) tailed, body not globular

- **family CHRYPTOBRANCHIDAE** (giant salamanders)⋆

  largest living salamanders, stout bodies, four short and well-developed limbs, laterally compressed tail, single pair of gill slits

  – ***Chryptobranchus alleganiensis*** (American hellbender)⋆

    Flat head, fringe of skin along sides of body, external gill openings but no visible gills, reduced

eyes

- **family SIRENIDAE** (sirens)

  No hind limbs, external gills

  - ***Siren intermedia*** (lesser siren)⋆

    Less than 36 costal grooves

- **family SALAMANDRIDAE** (newts and European salamanders)

  Four limbs, no gill openings, no nasolabial groove, ridge down middorsum, no costal grooves (or costal grooves above ribs), rough skin

  - ***Notophthalmus viridescens***⋆ (Eastern newt)

    Adult stage: olive / yellow ground color, spotted (red spots in reproductively active males);

    Eft stage: red or orange ground color with red spots

- **family AMBYSTOMATIDAE** (mole salamanders)

  Costal grooves present, dorsum round and lacking ridge, no nasolabial grooves, heavy bodied, heavy tailed, lack gills and gill slits and have moveable eyelids

  - ***Ambystoma opacum*** (marbled salamander)⋆

    black ground color with white/silvery crossbands on dorsum (some of which are ocassionally broken- more pronounced in males)

  - ***Ambystoma maculatum*** (spotted salamander)⋆

    black ground color with orange/yellow dorsal spots or blotches

  - ***Ambystoma mexicanum*** (axolotl)

    larval traits retained (no moveable eyelinds, external gills), model organism

- **family PROTEIDAE** (water dogs)⋆

  External gills, four well-developed limbs, moderately robust body, laterally compressed tails

  - ***Necturus beyeri*** (Gulf Coast waterdog)

    cylindrical body, four toes on front and hind limbs, spotted body (light spotting in adults)

- **family AMPHIUMIDAE** (congo eels)⋆

  External gill slits, four reduced limbs (with 3 or fewer toes)

  - ***Amphiuma means*** (two-toed amphiuma)

    2 toes on each limb

- **family PLETHODONTIDAE** (lungless salamanders)⋆

  Nasolabial grooves, four well-developed limbs with 4-5 toes, no ridge down mid-dorsum, slim body

– **genus *Desmognathus*** (dusky salamanders)⋆

face with light stripe from eye to angle of jaw

– ***Eurycea cirrigera*** (two-lined salamander)

yellowish to orange-brown dorsum with dark dorsolateral stripe from snout to near tail tip

– ***Plethodon glutinosus*⋆** (Southern slimy slamander)

elongate body, ground color brown to black with light spots or flecks

– ***Pseudotriton ruber*** (red salamander)

dull to bright red with black flecks

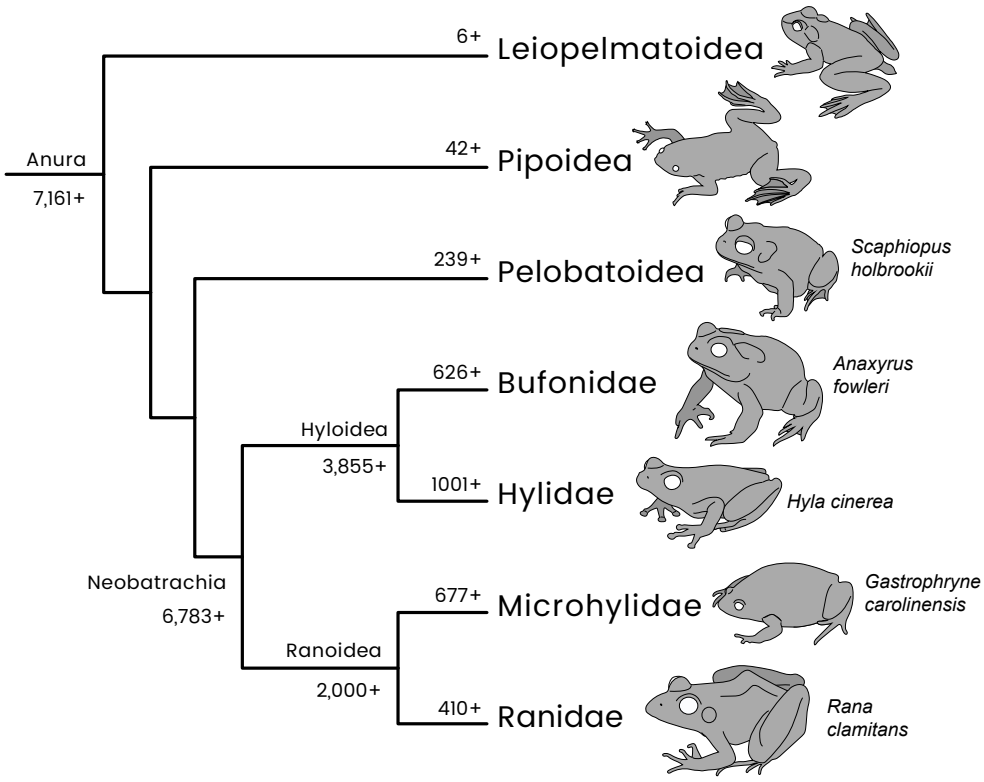


Figure 5.5: Anura Relationships (abbreviated)

Anura (Frogs) tailless with globular body

- **Leiopelmatoidea**
  - **genus*Ascaphus*** (Tailed frog)

    modification of cloaca and tail muscles produces intromittent or copulatory organ in males
- **Pipoidea**

- **family PIPIDAE**

  dorsoventrally depresed bodies and large muscular hindlimbs with webbed feet

  * ***Pipa pipa*** (Suriname toad)

    extreme dorsoventral compression with squared head, females carry eggs and developing tadpoles on their backs

  * ***Xenopus laevis*** (African clawed frog)

    somewhat egg-shaped body, fully webbed toes, three toes on each foot have conspicuous black claws

- **Pelobatoidea**

  - **family SCAPHIOPODIDAE** (spadefoot toads)

    squat body, warty (but soft) skin, large keratinous-edged crescent-shaped tubercle on outer edge of eat hind foot, webbed hind feet

    * ***Scaphiopus holbrooki*** (Eastern spadefoot)⋆ §

      vertically elliptical pupils, absent or indistinct paratoid glands

- **family BUFONIDAE** (true toads)⋆

  squat body, short hind limbs, enlarged toepads, 2 spade-like tubercles on hind feet, round pupil, pronounced paratoid glands, skin dry and warty, throats of males usually dark

  - ***Anaxyrus fowleri*** (Fowler's toad)⋆ §

    Paratoid gland touches postorbital ridge, three or more warts in each of largest spots, common "backyard" toad

- **familiy HYLIDAE** (tree frogs and allies)

  long hind limbs, usually enlarged toepads

  - **genus*Acris*** (cricket frogs)⋆ §

    Rear of thigh with one or two longitudinal stripes, front of snout with lighvertical lines, hind webbing half-way along fourth toe

  - **genus*Hyla***

    Hind webbing half-way along fourth toe, greatly expanded toe disks

    * ***Hyla cinerea*** (green tree frog)⋆ §

      bright green with white/yellow lateral racing stripe

    * ***Hyla avivoca*** (bird-voiced tree frog)⋆ §

      coloration variable (gray to green), back of thigh pale yellow to greenskin of dorsum smooth to slightly papillate or pustulate

- **genus*Pseudacris*** (chorus frogs)

  No webbing on hind toes, tips of digits expanded

  * ***Pseudacris crucifer*** (spring peeper)⋆ §

    distinct x pattern on dorsum, small toe pads

- **familiy RANIDAE** (true frogs)⋆

  No toe pads, extensive toe webbing, expanded tympanic membrane

  - ***Rana catesbeianus*** (American bullfrog)⋆ §

    Tympanic membrane larger than eye, no dorsal-lateral ridge (ridge ends at tympanum), largest frog in North America

  - ***Rana sphenocephalus*** (Southern leopard frog)⋆ §

    Dorsal-lateral ridge reaches groin, rounded dark spots on dorsum, pointed snout

  - ***Rana clamitans*** (bronze frog)⋆ §

    Dorsal-lateral ridge doesn't reach groin, tympanum same size as eye

- **familiy MICROHYLIDAE** (narrow-mouth frogs)⋆

  supradigital scutes. Members of this family have lipophilic alkaloids (derived from ant diet) that can be highly toxic⋆note: this family isn't on the tree, but is nested within **Hyloidea**

  - ***Gastrophryne carolinensis*** (narrow-mouth toad)⋆ §

    Small, tiny head with pointed snout, no webbing between digits

Diapsids

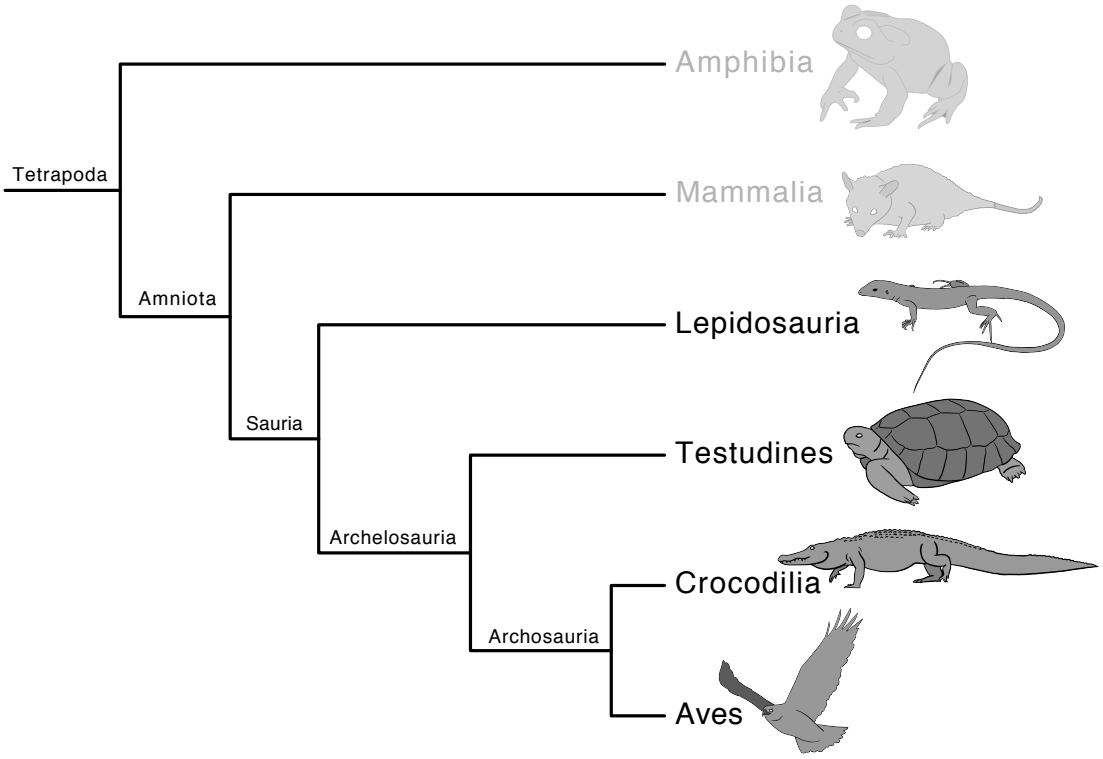


Figure 6.1: Amniote Relationships

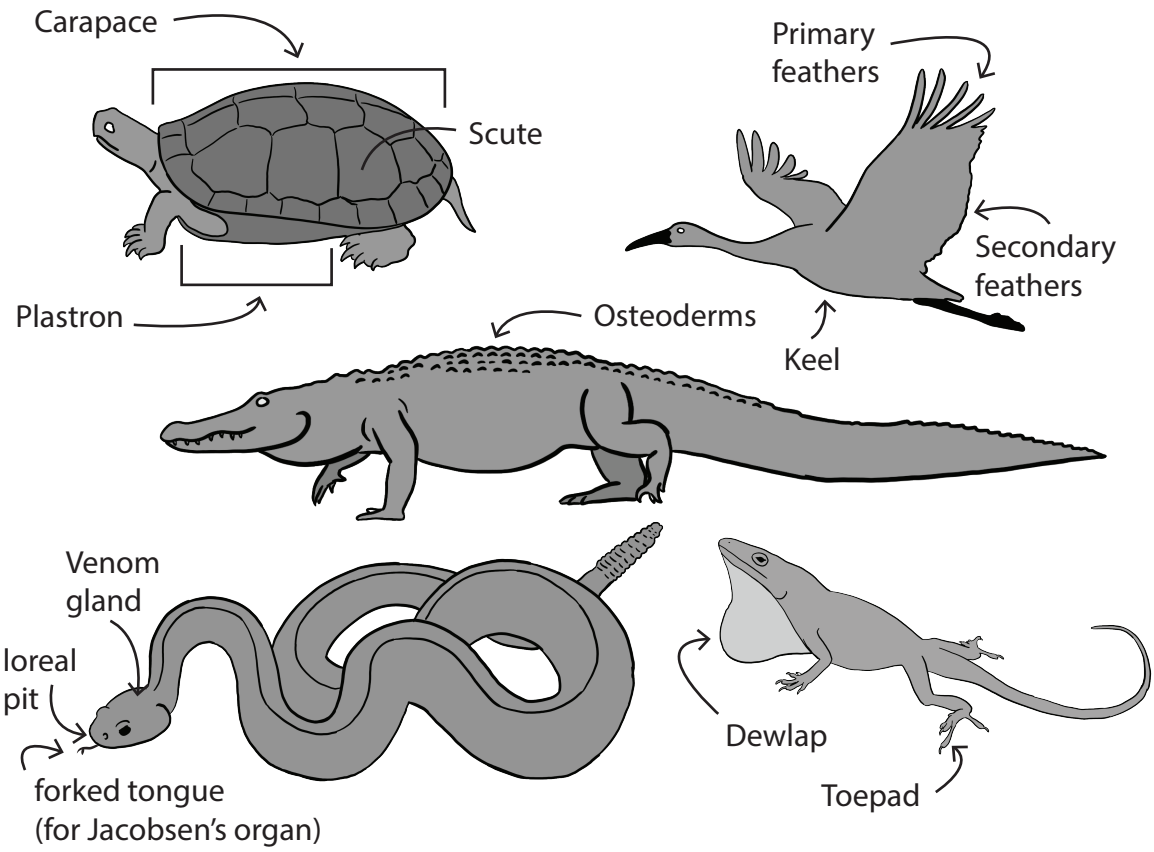


Figure 6.2: Diapsid anatomical terms to know

Focal taxonomic groups

(⋆ groups you need to be able to photo ID and place in a phylogeny. § denotes species for which you need to audio ID calls.)

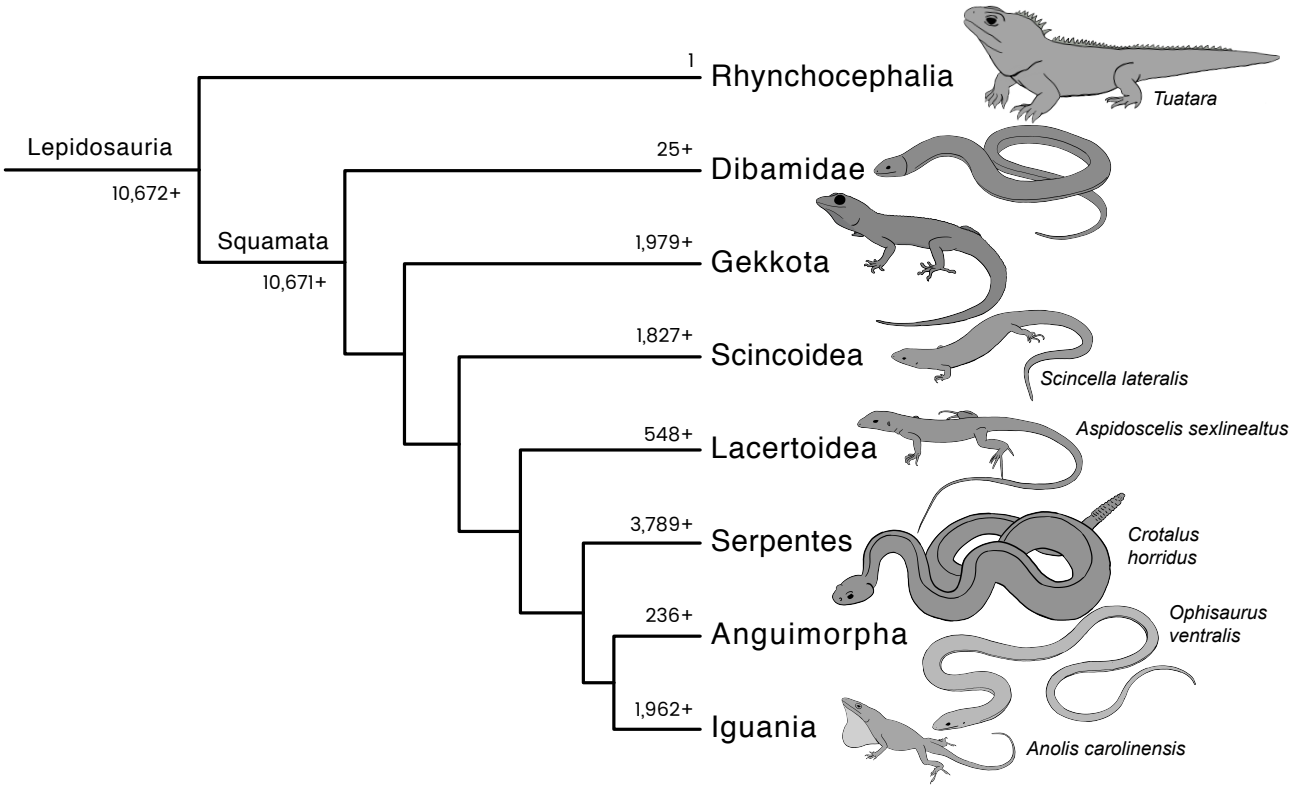


Figure 6.3: Lepidosaur Relationships

Lepidosauria Transverse cloacal slit, regular cycles of shedding, tongue distally notched, paired copulatory organs, well-developed quadrate conch, ectepicondylar foramen in the humerus (median nerve and brachial artery passage), pleurodont dentition

Rhynchocephalia

Once distributed globally (most abundant group in South America during Cretaceous). No well defined hemipenes- paired copulatory organs are slight outpushings of cloacal walls. Gastralia present.

- Family **SPHENODONTIDAE** (tuatara⋆)

  Only extant Rhynchocelphalian (one genus, two species). Ancestral diapsid skull (two temporal fenestra on either side of skull). One or both of these holes have been lost in lizards and snakes, respectively. Highly developed pineal gland (regulates circadian rhythm). Teeth fused to skull (sphenodont dentition), and become dull with time. A single row of teeth on the lower jaw fit between two rows on the upper jaw, a trait unique among all tetrapods. Tuatara can live upwards of 100 years. * No alcohol-preserved specimen, just skull replicate.

Squamata

Highly developed hemipenes (paired copulatory organs), Jacobsen's organ separated from nasal capsule, femoral and preanal glands, no gastralia, triradiate squamosal

- Family **DIBAMIDAE** (blind skinks)

  In these elongate lizards, males have tiny flap like hindlimbs and females are completelylimbless. They also lack external ear openings. All of these features are likely adaptations totheir fossorial lifestyle. They are found in Mexico and in Southeast Asia. Largely limbless (small flap-like hindlimbs in males). * No specimen.

- **Gekkota** (geckos)⋆
  - Family **GEKKONIDAE** (spectacled geckos)

    Two species have been introduced to Alabama. They are readily identified by their lack eyelids and setae-covered toe pads. Toe pads with tiny hair like structures called setae. These toe pads enable them to climb vertical surfaces.

- **Scincoidea**
  - Family **SCINCIDAE** (skinks)

    Dorsal scales smooth, shiny, and cicloid
    - ***Scincella lateralis*** (ground skink)⋆

      small skink, reduced limbs, bronzy color body with dark dorsolateral stripe. Transparent disc in lowereyelid.
    - ***Plestiodon fasciatus*** (five-lined skink)⋆

      Female has 5 broad light stripes down a black body; Male has traces of stripes,reddish jaws, juveniles have bright blue tails and 5 lines.

- **Lacertoidea**

  Includes amphisbaenians, racerunners/whiptails, and tegus
  - Family **TEIIDAE**

    Have velvety textured dorsal scales and large, rectangular ventral scales, Pointed snout, Forked tougue, tail over 2x SVL, highly active foragers
    - ***Aspidoscelis sexlineata***⋆ (six-lined racerunner)

      six light lines on back, small dorsal scales. Large limb and ventral scales

- **Anguimorpha**

  Group that contains the only venemous lizards (Helodermatidae and Varanidae) and Anguids.

- Family **ANGUIDAE**

  Elongate lizards with reduced limbs or limbless. Scales usually rectangular. Lateral fold in most taxa.

  * ***Ophisaurus ventralis*** (eastern glass lizard)⋆

    No legs, has ear openings and moveable eyelids, smooth scales, dark dorsum light venter, generally gray-green.

- **Iguania**

  Diverse group that includes acrodonts (Agamidae, Chamelonidae) and pleurodonts (Iguanidae, Corytophanidae, Crotaphytidae, Dactyloidae, and Phrynosomatidae)

  - ***Anolis carolinensis*** (green anole)⋆

    Have subdigital lamallae bearing setae much like gekkota. Males have prominent dewlaps. No pattern, relatively small individual scales, capable of changing between green and brown skin color, reddish dewlap, long slender body shape.

- **Serpentes** (snakes)

  - family **VIPERIDAE** (vipers)

    Crotalinae (restricted to Eurasia & Americas) have heat-sensing pit between eye and nostril; paired single tooth on maxilla (mobile fang) that functions to deliver potent venom (many species possess neurotoxic, hemotoxic, and cytotoxic venom- some with a cocktail), broad head, vertical pupil. Many species are viviparous.

    * ***Crotalus horridus*** (timber rattlesnake)⋆

      variable but always with dark chevron-like cross bands on light background that gets darker towards tail, reddish brown middorsal stripe, dark postocular line

  - family **ELAPIDAE** (elapids)

    Venomous snakes endemic to tropical and subtropical regions. Some snakes are aquatic (e.g., kraits). Longest venemous snake (king cobra). Fixed fangs at front of upper jaw for injecting venom, which is largely made up of neurotoxic compounds.

    * ***Micrurus fulvius*** (eastern coralsnake)⋆

      Have smooth scales, black snout, and aposomatic red and yellow banding pattern. They have a hand full of mimics which in the U.S. can be differentiated by the order of colored bands. A useful rhyme is "Red touching black, friend of Jack. Red touching yellow, kill a fellow."

  - family **COLUBRIDAE**

Lack heat-sensing pits; have multiple teeth onmaxilla. Make up 78% of world's snakespecies.

* ***Pantherophis spiloides*** (gray rat snake)⋆

  "loaf of bread" body shape, variable but light grayish body with darker blotches downback, divided anal plate.

* ***Nerodia sipedon*** (midland brown water snake)⋆

  keeled scales, belly has double row of crescents, back has dark markings that are narrower than the light spaces between them.

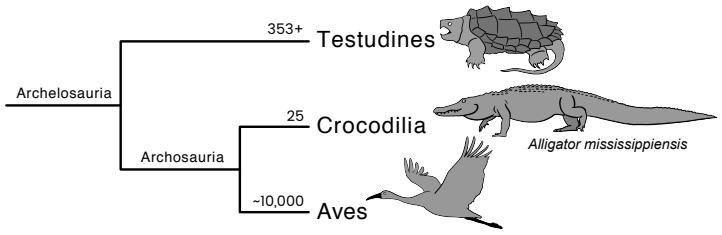


Figure 6.4: Archelosaur Relationships

Archelosauria While phylogenetic conclusions from morphological analyses conflict with those from genetic analyses, most systematists place testudines as sister to the group encompassing crocodylians and aves (Archosauria). This larger group (Archelosauria) lacks diagnostic anotomical characters, but thorough molecular data consistently recover the three groups together.

Crocodilia

Robust skull, long snout, strongly toothed jaws, short neck, robust cylindrical trunk, laterally compressed tail, short but strongly developed limbs with webbed feet. Largest living reptiles. Bony plates (osteoderms) covered by keratinou skin provide armor to neck, trunk, and tail. All crocodylians are oviparous with internal fertilization, and have temperature-dependent sex determination.

- ***Alligator mississippiensis*** (American alligator)⋆

  Broad snout, large body, fourth mandibular tooth hidden when mouth is closed.

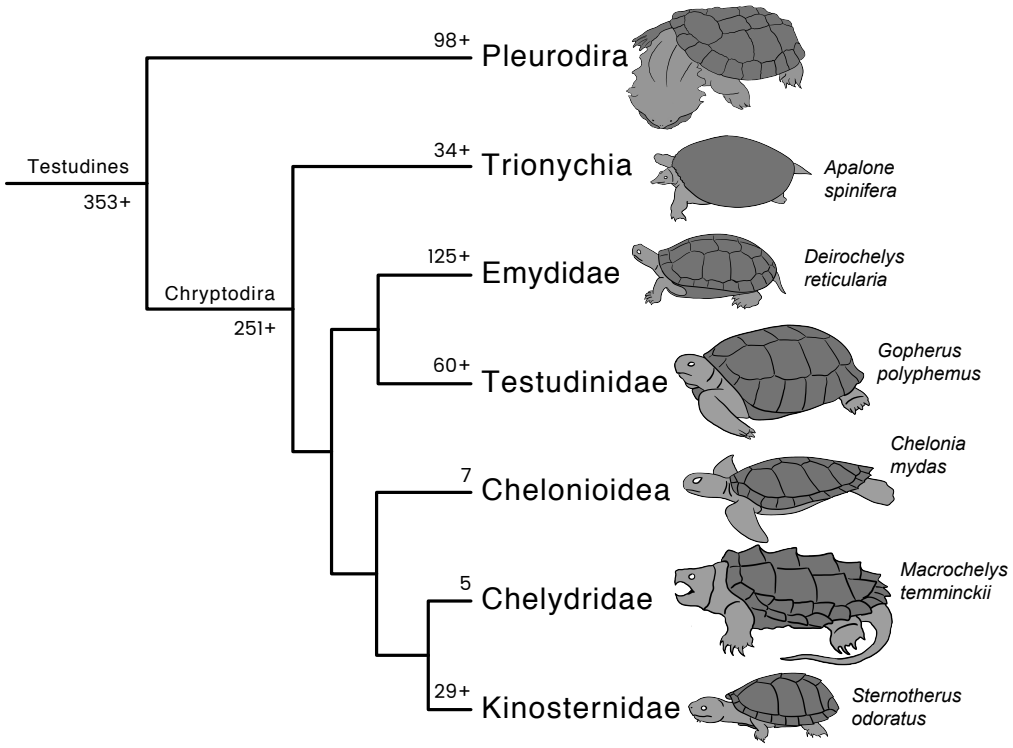


Figure 6.5: Testudine Relationships

Testudines

Reptilian tanks- no other tetrapod with bony shell that encloses the pectoral and pelvic girdles. The carapace (dorsal portion of the shell) is made up of 8 trunk vertebrae fused with ribs and overlying dermal bones. The plastron (ventral portion of the shell) is made up of the sternum and gastralia fused with external dermal bones. The neck is made up of 8 cervical vertebrae. All turtles are oviparous with internal fertilization, and many have temperature-dependent sex determination.

- **Pleurodira** (side-neck turtles)

  Withdraw head and neck laterally within the outer margin of the shell

- **Cryptodira** (S-neck turtles)

  Withdraw head and neck within shell in S-shape

  - **Trionychia** (softshell turtles)

    Flat, pancake shells, no epidermal scutes

    * ***Apalone spinifera*** (spiny softshell)⋆

      Anterior carapacial tubercles often pointed or spine-tipped. Hatchlings with spotted carapace that becomes uniformally dark with age

- Family **EMYDIDAE** (pond turtles)

  Moderately domed carapace, tear-drop shaped carapace

  * ***Deirochelys reticularia*** (chicken turtle)⋆

    Pair of dark spots on bridge, sholder-to-snout length as long as plastron

- Family **TESTUDINIDAE** (tortoises)

  Terrestrial; forelimbs shovel-like for digging, hind feet elephantine for walking.

  * ***Gopherus polyphemus*** **(gopher tortoise)**⋆

    Carapace is oblong, flat-topped, and drops off abruptly on the sides and at the rear.

- **CHELONIOIDEA** (sea turtles)

  Limbs modified into flippers, streamlined shell

  * ***Chelonia mydas*** **(green sea turtle)**⋆

    Scutes of carapace not overlapping, 4 pleural scutes

- **CHELYDRIDAE** (snapping turtles)

  Large head, flattened carapace, long tails (about as long as carapace)

  * ***Chelydra serpentina*** **(alligator snapping turtle)**⋆

    Long tail, hooked beak, Three large longitudinal ridges on carapace. Largest turtle in North America

- **KINOSTERNIDAE** (mud and musk turtles)

  Plastron with 10 or 11 scutes, defined overhanging beak, potato-like (oblong) shape

  * ***Sternotherus odoratus*** **(common musk turtle)**⋆

    paired barbels on both chin and neck.

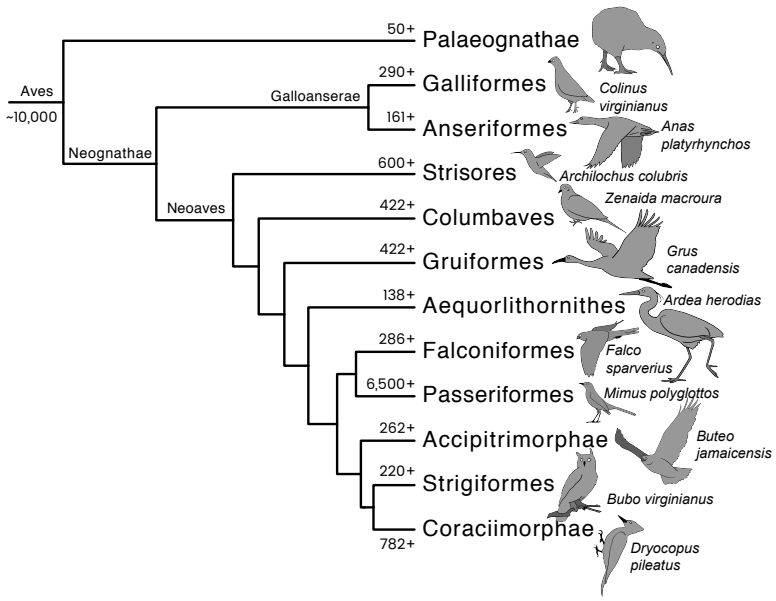


Figure 6.6: Ave Relationships

Aves

Front limbs modified into wings, scales modified into feathers (for thermoregulation and flight), bone structure and density reduced to reduce weight for flight.

- Family **PALAEOGNATHAE**

  Flightless birds with rigid palate. Largest bird (ostrich) and the small kiwi both belong to this group.

- Family **NEOGNATHAE**

  Fused metacarpals, elongate third finger

  – **Galliformes**

  Heavy-bodied, ground-feeding birds (including turkey, grouse, chicken, quail, pheasent). This lineage survived the K-T mass extinction. It is hypothesized that their small ground-dwelling nature allowed them to outlive their abundant airborne relatives.

  * ***Colinus virginianus*** (northern bobwhite)⋆ §

    small quail with rounded bodies, small head, rounded tail, and short wings. Males have a bold black-and-white head pattern. Females have a buffy throat and eyebrow.

  – **Anseriformes**

  Water-adapted birds (including ducks, geese, and swans), which niche is hypothesized to have helped them survive the K-T mass extinction.

* ***Anas platyrhynchos*** (mallard)⋆ §

  Heavy-bodied dabbling duck native to North America, Eurasia, and North Africa. Breeding males have glossy bottle-green heads and a demarcating white collar, pale gray belly, purple-tinged brown breast, and a bill that is yellow-orange and tipped with black. Female is predominantly mottled. Both males and females have iridescent blue-purple speculum (wing) feathers.

– **Strisores**

Torpor (hibernation-like state) along with other unique metabolic traits are common in this group of birds (including nightjars, swifts, hummingbirds, potoos, frogmouths)

* ***Archilochus colubris*** (Ruby-throated hummingbird)⋆

  The Ruby-throated Hummingbird is a small hummingbird with a slender, slightly downcurved bill and fairly short wings that don't reach all the way to the tail when the bird is sitting. Ruby-throated Hummingbirds are bright emerald or golden-green on the back and crown, with gray-white underparts. Males have a brilliant iridescent red throat that looks dark when it's not in good light.

– **Columbaves**

Relatively new description of a group that includes pigeons, doves, mesites, and cuckoos, turacos, and bustards

* ***Zenaida macroura*** (Mourning dove)⋆ §

  Plump-bodied and long-tailed, with short legs, small bill, and a head that looks particularly small in comparison to the body. The long, pointed tail is unique among North American doves. Mourning Doves often match their open-country surroundings. They're delicate brown to buffy-tan overall, with black spots on the wings and black-bordered white tips to the tail feathers.

– **Gruiformes**

Group of wading birds (including cranes, crakes, rails). Globally distributed.

* ***Fulica americana*** (American coot)⋆

  The American Coot is a plump, chickenlike bird with a rounded head and a sloping bill. Their tiny tail, short wings, and large feet are visible on the rare occasions they take flight. Coots are dark-gray to black birds with a bright-white bill and forehead. The legs are yellow-green. At close range you may see a small patch of red on the forehead.

* ***Grus canadensis*** (Sandhill Crane)⋆

Sandhill Cranes are very large, tall birds with a long neck, long legs, and very broad wings. These are slate gray birds, often with a rusty wash on the upperparts. Adults have a pale cheek and red skin on the crown.

- **Aequorlitornithes**

  Water and shore birds (including flamingos, grebes, shorebirds, loons, penguins, herons, pelicans, gulls). Globally distributed. These birds were grouped relatively recently.

  * ***Ardea herodias*** (Great Blue Heron)⋆

    Largest of the North American herons with long legs, a sinuous neck, and thick, daggerlike bill. Head, chest, and wing plumes give a shaggy appearance. In flight, the Great Blue Heron curls its neck into a tight "S" shape; its wings are broad and rounded and its legs trail well beyond the tail. Great Blue Herons appear blue-gray from a distance, with a wide black stripe over the eye. In flight, the upper side of the wing is two-toned: pale on the forewing and darker on the flight feathers. A pure white subspecies occurs in coastal southern Florida.

  * ***Leucophaeus atricilla*** (Laughing Gull)⋆ §

    Laughing Gulls are medium-sized gulls with fairly long wings and long legs that impart a graceful look when they are flying or walking. They have stout, fairly long bills. Laughing Gulls are medium gray above and white below. Summer adults have a crisp black hood, white arcs around the eye, and a reddish bill. In winter, the hood becomes a blurry gray mask on a white head. The legs are reddish black to black. Immatures are much browner and more subtly patterned than adults; they take 2-3 years to gain adult plumage.

- **Accipitrimorphae**

  Large birds of prey (including New World vultures, eagles, hawks, eagles, osprey, and secretarybird).

  * ***Cathartes aura*** (Turkey Vulture)⋆

    Turkey Vultures are large dark birds with long, broad wings. Bigger than other raptors except eagles and condors, they have long "fingers" at their wingtips and long tails that extend past their toe tips in flight. When soaring, Turkey Vultures hold their wings slightly raised, making a 'V' when seen head-on. Turkey Vultures appear black from a distance but up close are dark brown with a featherless red head and pale bill. While most of their body and forewing are dark, the undersides of the flight feathers (along the trailing edge and wingtips) are paler, giving a two-toned appearance.

* ***Buteo jamaicensis*** (Red-tailed Hawk)⋆ §

  Red-tailed Hawks are large hawks with typical Buteo proportions: very broad, rounded wings and a short, wide tail. Most Red-tailed Hawks are rich brown above and pale below, with a streaked belly and, on the wing underside, a dark bar between shoulder and wrist. The tail is usually pale below and cinnamon-red above, though in young birds it's brown and banded. "Dark-morph" birds are all chocolate-brown with a warm red tail. "Rufous-morph" birds are reddish-brown on the chest with a dark belly.

– **Strigiformes** (owls)

  Mostly solitary and nocturnal birds of prey typified by an upright stance, a large, broad head, binocular vision, binaural hearing, sharp talons, and feathers adapted for silent flight. Feed primarily on small mammals, insects, and other birds. Global distribution (with exception of polar ice caps and some remote islands).

  * ***Bubo virginianus*** (Great Horned Owl)⋆ §

    These are large, thick-bodied owls with two prominent feathered tufts on the head. The wings are broad and rounded. Great Horned Owls are mottled gray-brown, with reddish brown faces and a neat white patch on the throat.

– **Coraciimorphae** (woodpeckers and kingfishers)

  * ***Megaceryle alcyon*** (Belted Kingfisher)⋆

    Belted Kingfishers are stocky, large-headed birds with a shaggy crest on the top and back of the head and a straight, thick, pointed bill. Their legs are short and their tails are medium length and square-tipped. These kingfishers are blue-gray above with fine, white spotting on the wings and tail. The underparts are white with a broad, blue breast band. Females also have a broad rusty band on their bellies. Juveniles show irregular rusty spotting in the breast band.

  * ***Dryocopus pileatus*** (Pileated Woodpecker)⋆ §

    The Pileated Woodpecker is a very large woodpecker with a long neck and a triangular crest that sweeps off the back of the head. The bill is long and chisel-like, about the length of the head. In flight, the wings are broad and the bird can seem crowlike. Pileated Woodpeckers are mostly black with white stripes on the face and neck and a flaming-red crest. Males have a red stripe on the cheek. In flight, the bird reveals extensive white underwings and small white crescents on the upper side, at the bases of the primaries.

– **Falconiformes** (falcons and caracaras)

Small to medium-sized diurnal birds of prey with cosmopolitan distribution

* ***Falco sparverius*** (American Kestrel)⋆

  The slender American Kestrel is roughly the size and shape of a Mourning Dove, although it has a larger head; longer, narrow wings; and long, square-tipped tail. In flight, the wings are often bent and the wingtips swept back. American Kestrels are pale when seen from below and warm, rusty brown spotted with black above, with a black band near the tip of the tail. Males have slate-blue wings; females' wings are reddish brown. Both sexes have pairs of black vertical slashes on the sides of their pale faces—sometimes called a "mustache" and a "sideburn."

– **Passeriformes** (perching birds)

More than half of all bird species. Three toes point forward and one points back.

* ***Corvus brachyrhynchos*** (American Crow)⋆ §

  A large, long-legged, thick-necked bird with a heavy, straight bill. In flight, the wings are fairly broad and rounded with the wingtip feathers spread like fingers. The short tail is rounded or squared off at the end. American Crows are all black, even the legs and bill. When crows molt, the old feathers can appear brownish or scaly compared to the glossy new feathers.

* ***Mimus polyglottos*** (Northern Mockingbird)⋆ §

  A medium-sized songbird, a bit more slender than a thrush and with a longer tail. Mockingbirds have small heads, a long, thin bill with a hint of a downward curve, and long legs. Their wings are short, rounded, and broad, making the tail seem particularly long in flight. Mockingbirds are overall gray-brown, paler on the breast and belly, with two white wingbars on each wing. A white patch in each wing is often visible on perched birds, and in flight these become large white flashes. The white outer tail feathers are also flashy in flight.

* ***Cardinalis cardinalis*** (Northern Cardinal)⋆ §

  The Northern Cardinal is a fairly large, long-tailed songbird with a short, very thick bill and a prominent crest. Cardinals often sit with a hunched-over posture and with the tail pointed straight down. Male cardinals are brilliant red all over, with a reddish bill and black face immediately around the bill. Females are pale brown overall with warm reddish tinges in the wings, tail, and crest. They have the same black face and red-orange bill.

Mammals

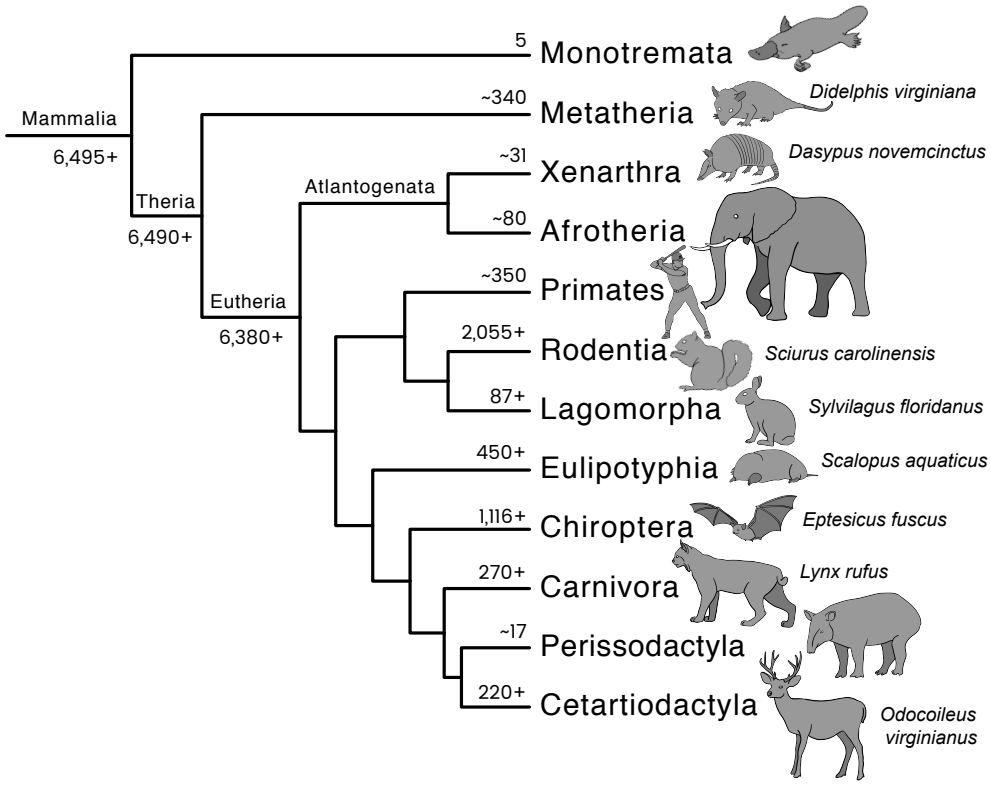


Figure 7.1: Mammalian Relationships

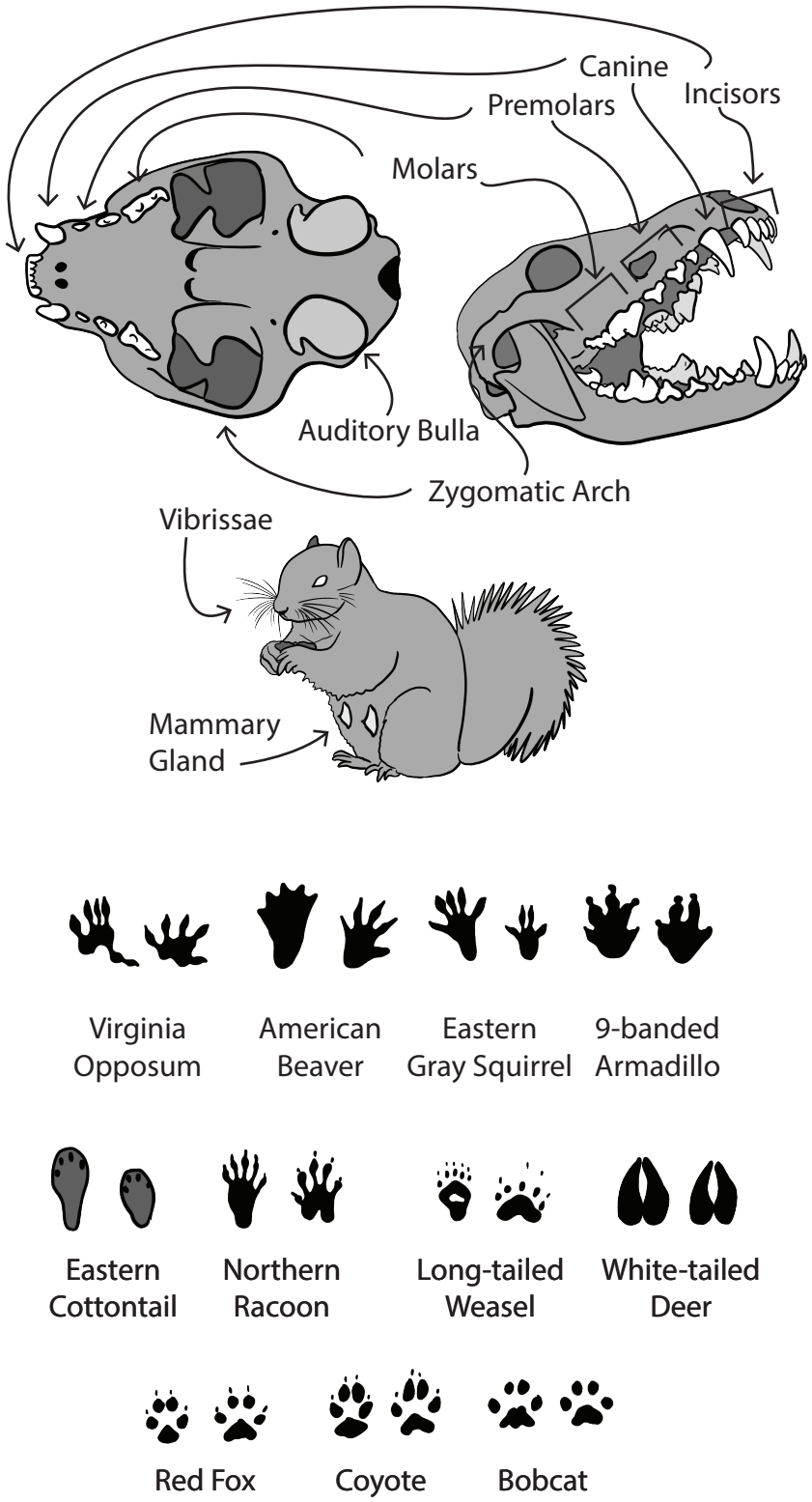


Figure 7.2: Mammalian anatomical terms to know

Focal taxonomic groups

(⋆ groups you need to be able to photo ID and place in a phylogeny. § denotes species for which you need to know skulls.)

Mammalia All mammals have hair or fur, mammary glands, unique four chambered hearts, muscular diaphragms, and three ear ossicles.

- **Monotremata** (monotremes)

  Lay eggs and have only a single urogenital opening (cloaca)

  - ***Ornithorhynchus anatinus*** (duck-billed platypus)⋆

    Have long leathery snout shaped like bill of a duck (used for electrosensory and tactile foraging). Venemous spur on hind foot. Single urogenital opening (cloaca).

  - Family **TACHYGLOSSIDAE** (echidna)

    Have spines over most of body, long slender snout. Single urogenital opening (cloaca). skull: Elongate, rounded snout; laterally bulging brain case. Palate extends backwards to the level of the ears.

- **Metatheria** (marsupials)

  Bony ectotypmanic bulla encasing the middle ear; thick coarse fur, enlarged hind legs, muscular tail, well developed pouch in females (for housing underdeveloped fetus [joey] post birth)

  - ***Macropus*** (kangaroos and wallabies)

    thick coarse fur, enlarged hind legs, muscular tail, well developed pouch in females.

  - ***Didelphis virginiana*** (Virginia opossum)⋆ §

    white face, naked prehensile tail, whitish gray to black fur, well developed pouch in females, highest number of teeth among North American land mammals, large zygomatic arch, strong saggital crest, small braincase. Incomplete auditory bulla.

- **Eutheria** (placental mammals and ancestors)

  Bony ectotypmanic bulla encasing the middle ear; an enlarged malleolus ("little hammer") at the bottom of the tibia, the larger of the two shin bones; the joint between the first metatarsal bone and the entocuneiform bone (the outermost of the three cuneiform bones) in the foot is offset farther back than the joint between the second metatarsal and middle cuneiform bones—in metatherians these joints are level with each other.

- **Xenarthra** (armadillos, anteaters, and sloths)

  additional (xenarthrous) joints of lumbar vertebrae; fusion of the ischium to the anterior caudal vertebrae; a secondary scapular spine; extensive retia mirabile in the limbs; paired postrenal venae cavae; and ossified sternal ribs. Their well-developed claws are used for digging, clinging to tree branches, and defense.

  * ***Dasypus novemcinctus*** (nine-banded armadillo)⋆ §

    armor of bony dermal plates, long tubular skull, peg-like teeth.

  * ***Myrmecophaga tridactyla*** (giant Anteater)

    long tubular head, bushy tail, skull (longer than armadillo), no teeth.

- **Afrotheria** (enrecs, aardvarks, hyraxes, elephants, and sea cows)

  8 lumbar vertebrae, four allantoic vessel chambers, and the snout is unusually long and mobile in several Afrotherian species (although this may not be a trait shared by ancestry).

  * ***Trichechus manatus*** (West Indian manatee)⋆ §

    found in warm coastal waters, slow moving aquatic herbivore, continuous teeth replacement from behind, skull lacks sagital crest.

- **Eulipotyphla** (hedgehogs, shrews, and moles)

  small animals with long narrow pointed and usually mobile snouts. They feed on invertebrates, insects and earthworms, and vegetable matter. Small skulls with no distinct canine teeth. Their dental formulae are variable and adapted to hold and crush invertebrates.

  * ***Scalopus aquaticus*** (eastern mole)⋆ §

    similar to shrew in general appearance, but with large forelimbs for digging and teeth uniform light (not dark at tips).

- **Chiroptera** (bats)

  Have wings, premolars and molars dissected for slicing invertebrates or fruit. Most insectivorous bats have a divided premaxillae, giving the front of the skull the appearance of horizontal movablejaws.

  * ***Eptesicus fuscus*** (big brown bat)⋆ §

    dark brown fur, black membranes, blunt tragus (a fleshy, finger-like projection coveringthe entrance to the ear), U-shaped gap between incisors.

- **Carnivora** (cats, hyenas, dogs, seals, and bears)

  Have one pair of premolars and molars (carnassials) enlarged for slicing meat, No toothless space between cheek teeth and front teeth.

* ***Lynx rufus*** (bobcat)⋆ §

  reddish tan fur with black spots, short tail with black top, skull more compressed front toback, more rounded than other carnivore skulls, diastema or "gap" posterior to canine-teeth.

* ***Urocyon cinereoargenteus*** (gray fox)

  black-tipped tail, black "racing stripe" down back, cat-like face, Lower edge of ramus with distinct step , or break, just in front of angle. Shorter snout than red fox. U-shaped temporal lines (vs V-shaped temporal lines in red fox)

* ***Procyon lotor*** (northern raccoon)⋆ §

  black mask, ringed tail. Their forepaws are unusually dextrous and sensitive and resemble slendor human hands but come equipped with 20 non-retractable sharp claws. The dental formula is incisors 3/3, canines 1/1, premolars 3-4/3-4, molars 2/2-3 = 36-42 teeth. Their skulls are thick and heavy and have relatively short rostrums (shorter than canids, longer than felids). Coronoid process higher than condyles; coronoid process concave on posterior side

* ***Lontra canadensis*** (North American river otter)⋆ §

  dark brown coarse upper fur, silvery fur below, thick tail, webbed feet, skull dorso-ventrally compressed, palate extends beyond tooth row.

– **Perissodactyla** (horses, zebras, rhinos, tapirs)

  Odd toed, no canine teeth

– **Cetartiodactyla** (deer, pigs, hippos, camels, cows, antelopes, and whales)

  Even toed, "cloven hooved"

* ***Odocoileus virginianus*** (white-tailed deer)

  No incisors, lacrimal bone contacts nasal bone, shallow lacrimal pit, fenestrations = latice-like openings on rostrum of skull, short nasal bones, no upper incisors or canines. * mount and skull

* ***Bison bison*** (American bison)⋆ §

  body dark brown all over, hump over shoulders, massive head, horns in both sexes, once highly abundant in North America.

* ***Tursiops truncatus*** (bottlenose dolphin)⋆ §

  thecodont and homodont dentition, large cranium, external nares located medial-dorsally, gray swash on side.

- **Primates**

  Specialized auditory bulla known as petrosal bulla (bulla fused to petrosal bone) to protect middle ear.

- **Rodentia** (rodents)

  Have one pair elongate and ever-growing incisors, distinct space between incisors and cheek teeth

  * ***Sciurus carolinensis*** (eastern gray squirrel)⋆ §

    Coronoid process short, gray fur, very bushy tail, the "common" squirrel; skull with extra peg-like tooth inmolariform tooth row.

  * ***Glaucomys volans*** (southern flying squirrel)⋆

    Coronoid process short, very soft fur, gray brown above white below, loose skin along side (patagium) forms gliding surface, strictly nocturnal.

  * ***Castor canadensis*** (American beaver)⋆ §

    very large size, thick brown fur, flattened hairless scaly tail, very large orange incisors, distinct bump on lower end of remus beneath cheek teeth.

- **Lagomorpha** (rabbits, hares, and pika)

  Have two pairs of incisors, one pair of evergrowing and elongate the second pair small and peg-like, fenestrations = latice-like openings on rostrum of skull

  * ***Sylvilagus floridanus*** (eastern cottontail)⋆ §

    mixed brown and buff fur above, noticeable rusty spot on nape, whitish feet andunderside.