

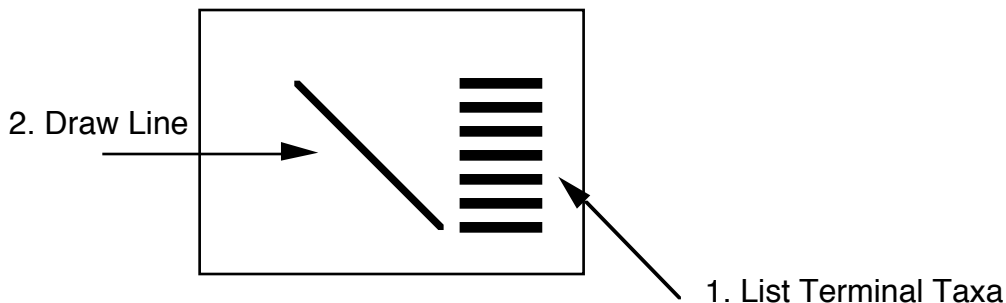
BIOL 461 Cladogram Exercise 2: Indented Classification Skills – Not due yet but related to today’s exercise – Complete on your own paper, include your name. I have used vertebrates because: 1) they are perfectly good metazoans; 2) you are a bit more familiar with them than most other metazoans; 3) we won’t cover them much otherwise.

Question: How does one construct a cladogram from the following indented phylogenetic classification?

Tetrapoda (tetrapods)
 Amniota (amniotes)
 Mammalia (mammals)
 Prototheria
 Theria
 Sauropsida (sauropsids)
 Sauria (diapsids)
 Testudines (turtles)
 Amphibia (amphibians)
 Batrachia
 Anura (anurans)
 Caudata
 Gymnophiona
 Caeciliidae
 Ichthyophiidae
 Rhinatrematidae
 Typhlonectidae

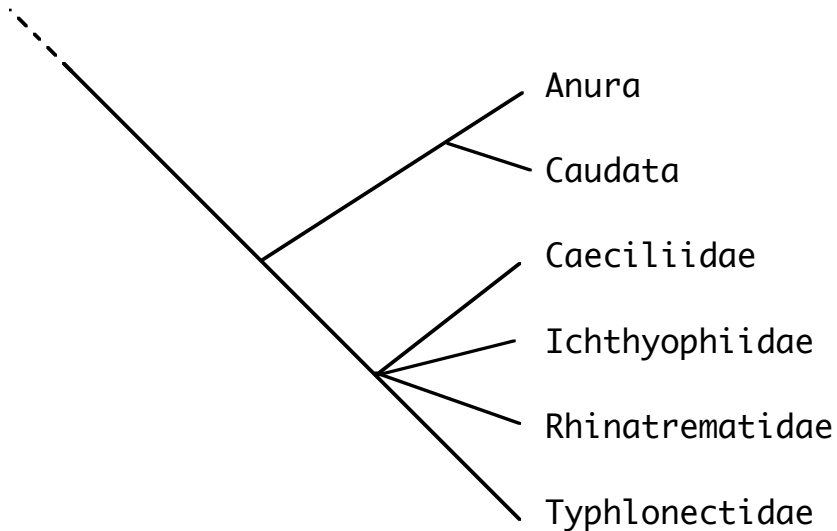
To complete this exercise, follow these steps exactly without turning the page over until you complete step 5:

- 1) Get out a blank page and a pencil with an eraser (recommended).
- 2) Put an asterisk after each terminal taxon (see above). Terminal taxa are those that don’t have anything indented immediately below them (i.e., in the very next line).
- 3) With your paper sideways (in landscape orientation), list the terminal taxa only in a single vertical column along the right margin of the bottom two thirds of your page.
- 4) Draw a line diagonally across the page from the upper left corner to the last-listed terminal taxon.



- 5) Connect up terminal taxa that are sister taxa. There can be more than two sister taxa that join at the same ancestral node, for example, in the case of ancestral taxon Gymnophiona (See “polytomy” note at end of

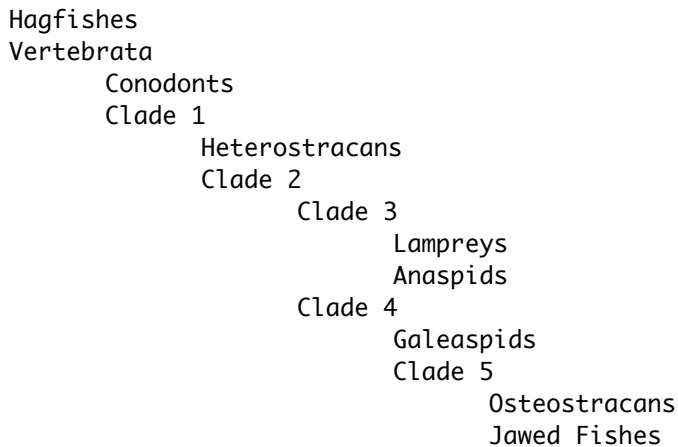
exercise). Note that not all of the nodes connecting sister taxa will lie on the diagonal line. For example, if you drew the node connecting Anura and Caudata on the diagonal line then you drew the cladogram incorrectly. You should have started the cladogram as below:



- 6) Continue connecting the terminal taxa and ancestral nodes together so that you are joining clades. Pay attention to which clades are sister taxa, according to the phylogenetic classification. Sister taxa are always at the same level of indentation. For example, Batrachia and Gymnophiona are sister taxa within the ancestral taxon, Amphibia (called "Lissamphibia" in many systems).
- 7) Finally, remember to leave a "dangling root" continuing beyond the most inclusive (deepest) node to indicate that these organisms are assumed to share a common history with other organisms outside this clade. A dangling root is simply the "tail" at the base of the lowest node of your cladogram, when you turn your paper so the names are on the top.

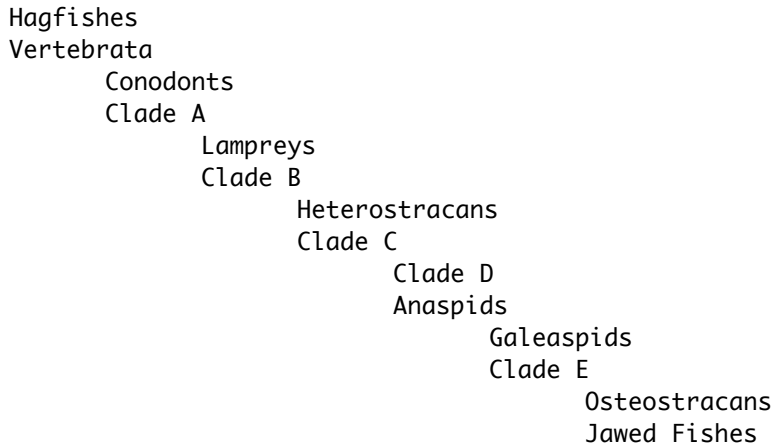
Comfortable? Try the following. On the next page are two competing classifications. Follow the above rules to draw each cladogram. Note that the hypothesized sister taxon relationships are mostly the same but differ in particular cases.

Craniate Classification 1:



Craniate Classification 2. Simplified from Philippe Janvier's cladograms at <http://tolweb.org/tree?group=Vertebrata&contgroup=Craniata>

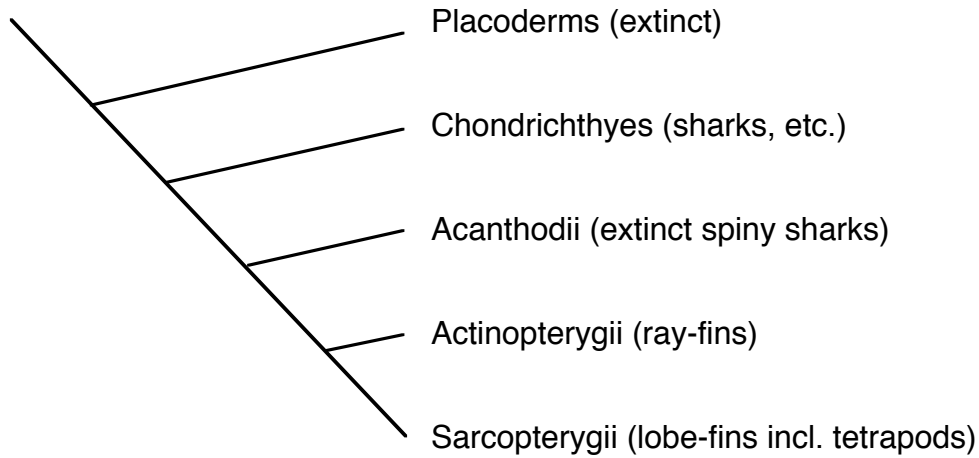
Please note: See the last page for the revived hypothesis of cyclostome (including living hagfishes and lampreys) monophyly. This would suggest that hagfishes are actually vertebrates, like lampreys, and together they belong to the sister taxon of vertebrates: Cyclostomi.



Finally, provide the answers to the following study questions:

1. What is the sister taxon of lampreys in each classification?
2. What is the sister taxon of heterostracans in each classification?
3. From the Web or the book, what is the evidence supporting Unnamed Clade 5 in either classification?

4. Turn the cladogram of jawed fishes (clade Gnathostomata) below into an indented classification. Practice by writing the corresponding indented classification below, and then copy it to the paper you turn in.



Extra Challenge 1: You do not have to turn this part in but I will check it for accuracy if you do. I will provide a solution after you turn them in but see if you can do these on your own.

Extra Challenge 2: Can you turn the unranked classification of chordates on the following page into the corresponding cladogram? Use a ruler and fine pencil! Start by listing the terminal taxa as I have demonstrated in class.

Abbreviated classification of living chordates

Chordata

Urochordata

Ascidiacea

Thaliacea

Larvacea

Cephalochordata: lancelets

Craniata

Non-vertebrate craniates (all extinct)

Vertebrata

Cyclostomi (Note: The “cyclostome monophyly” hypothesis)

Myxinoidea: hagfish

Petromyzontida: lampreys

Gnathostomata

Chondrichthyes

Holocephali: chimerae

Elasmobranchii: sharks, skates and rays

Osteichthyes

Actinopterygii

Cladistia: bichers and ropfish

Actinopteri

Chondrostei: paddlefish and sturgeons

Neopterygii

Ginglymodi: gars

Halecostomi

Teleosti (incl. most "fishes")

Sarcopterygii

Actinastia: coelacanth

Choanata

Dipnoi: lungfish

Tetrapoda

Lissamphibia

Gymnophiona: apodans, caecillians

Batrachia

Caudata: salamanders, newts, etc.

Anura: frogs and toads

Amniota

Reptilia (or Sauropsida)

Testudines: turtles

Sauria

Lepidosauria

Squamata: lizards and snakes

Rhyncocephalia: beakheads

Archosauria

Crocodylia: crocodiles, alligators

Aves: birds

Mammalia

Monotremata: monotremes

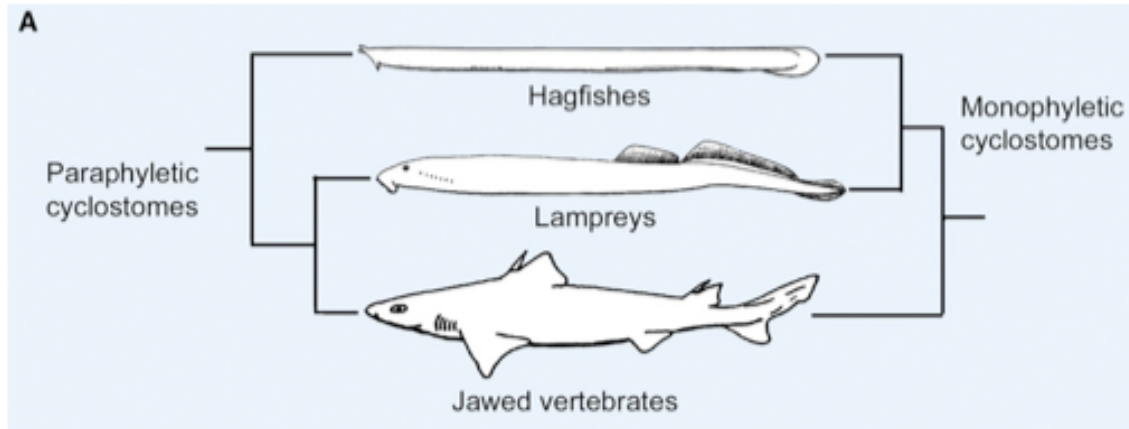
Theria

Metatheria: marsupials

Eutheria: placentals

For your information, I have referred to a trend based on recent molecular AND morphological data to recognize the monophyly of cyclostomes. Both the “cyclostome paraphyly” (hagfishes are craniates but not vertebrates) and the “cyclostome monophyly” (hagfishes are vertebrates with a secondarily reduced backbone) hypotheses are summarized here:

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Please see here for more details:

[http://www.cell.com/current-biology/pdf/S0960-9822\(11\)00783-4.pdf](http://www.cell.com/current-biology/pdf/S0960-9822(11)00783-4.pdf)

<http://tolweb.org/Vertebrata/14829>

<http://tolweb.org/Craniata/14826>

We discussed in class briefly some of the extinct groups of jawless fishes (yellow crosses below). Below is how they might be related to hagfishes and lampreys, the only living jawless fishes. You can substitute Cyclostomi for the abandoned “Agnatha” taxon name. The former is preferred because it emphasizes what members of this hypothesized clade share as derived features, not what they lack (i.e., agnatha means “no jaws”).

