Evolution of Body Size in Bears

How to Build and Use a Phylogeny

Lesson II

Using a Phylogeny

Objectives for Lesson II:

1. Overview of concepts

1. Simple ancestral state reconstruction on the bear phylogeny
    - class activity

1. Ancestral state reconstruction of polyploidy in birches.
    - In pairs

Students will use the following example:

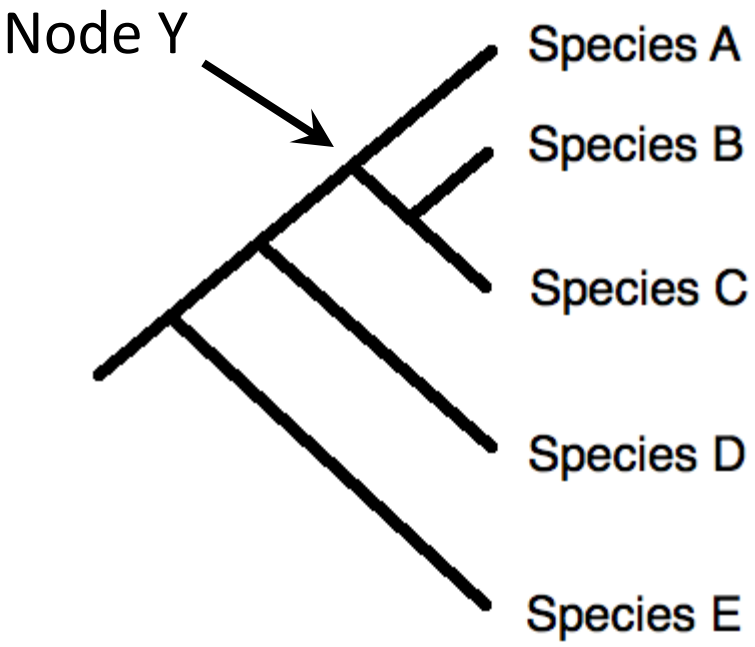
- Examining frequency of polyploidy in *Betula* (birches), based on Mayrose *et al*. (2011) *Science*

Character Evolution

- Character evolution is the study of how a trait like color has evolved across a phylogenetic tree
- Character states impact an organism's ecology - where it lives, what it eats, how often it reproduces etc...
- Understanding the evolution of a trait through time reveals the origin of current biodiversity.

Terms Review:

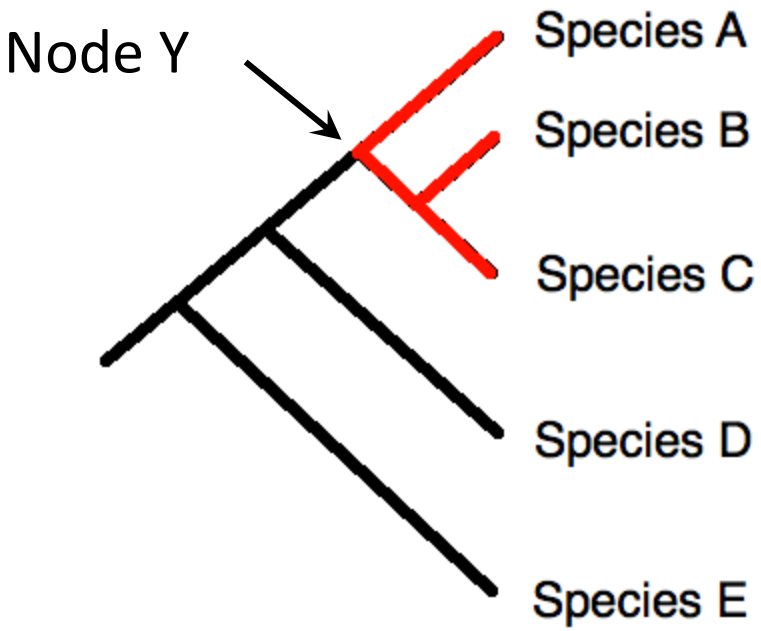
- A *phylogeny* describes the evolutionary relationships of a set of organisms. It is often based on morphological traits or, more commonly, DNA sequences.



- Species B and C are *sister* taxa
- Species E is an *outgroup* to ABCD
- Node Y is the *ancestor* to A, B & C

Terms cont…

- *Ancestral state reconstruction* is a method to estimate the character state of an ancestor based on phylogenetic relationships and character states of present-day organisms

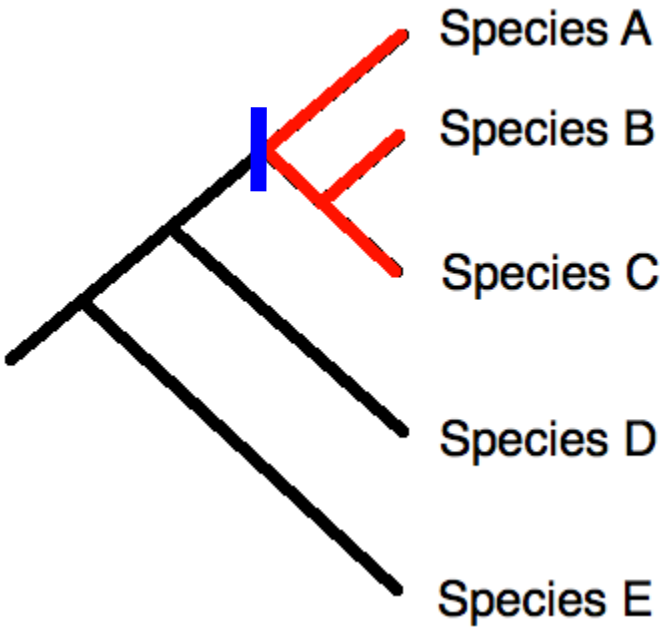


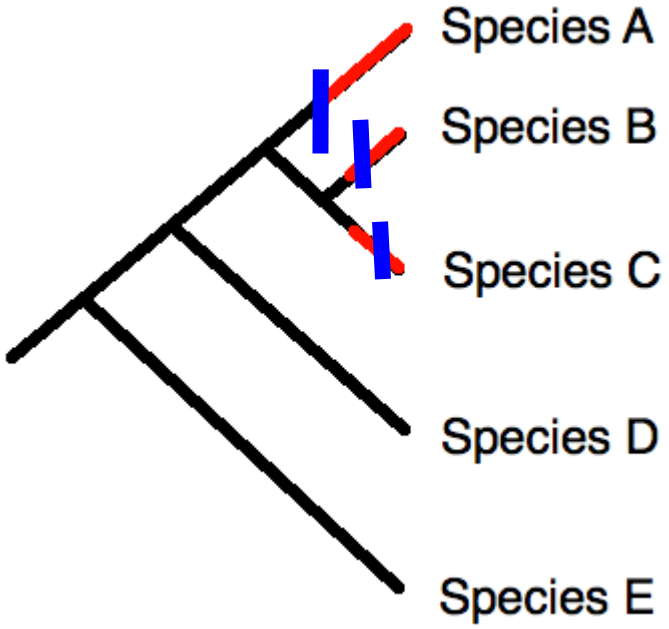
- In this example, the *character* is color & the *character state* is red or black
- Species A, B & C share the same character state (red). In this reconstruction, the character state red evolved in the ancestor at Node Y

Ancestral state reconstruction

- There are multiple methods to reconstruct ancestral states.
- *Parsimony* is one of the simplest methods.
- Parsimony attempts to **minimize** the number of character state changes across the phylogeny

- Character state change





• One character state change

Most parsimonious

• Three character state changes

Ancestral state reconstruction

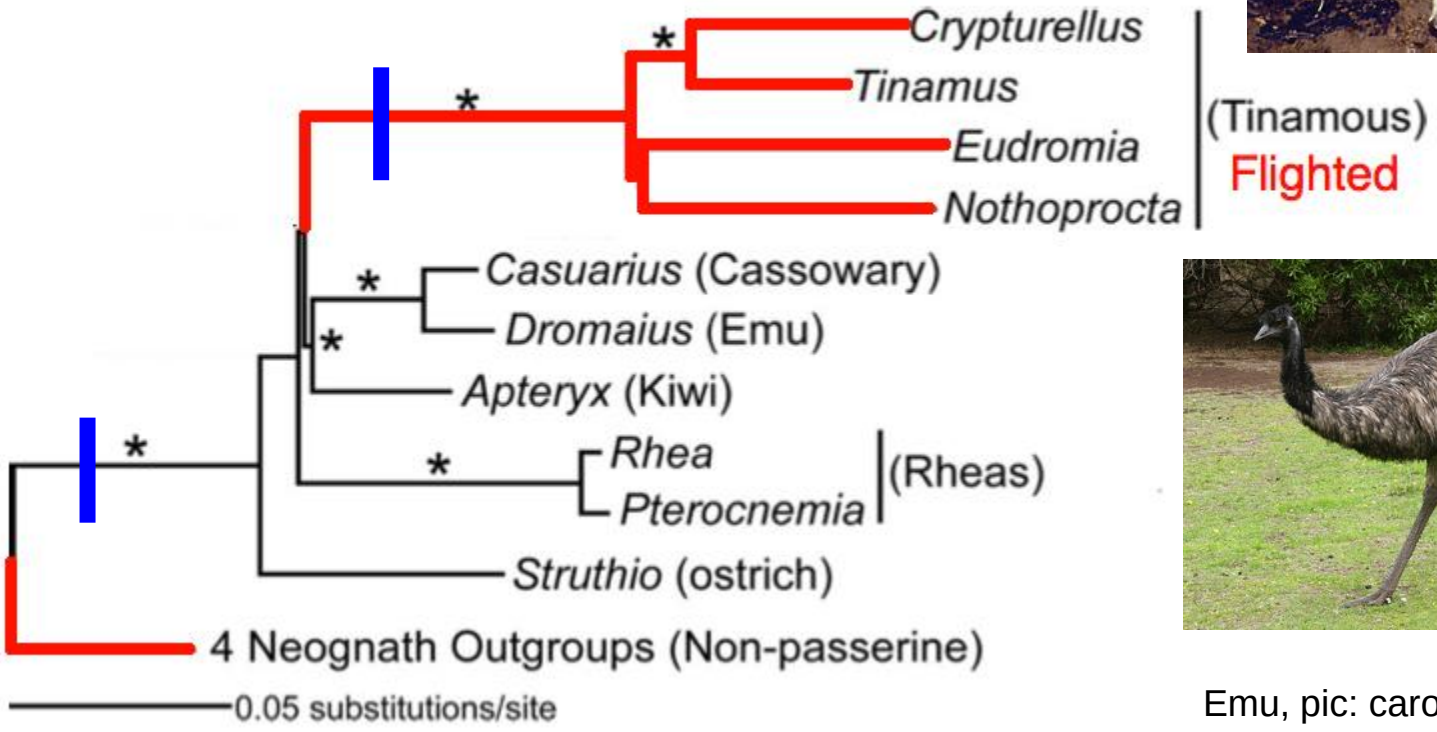
- All methods of ancestral state reconstruction have assumptions

- *Parsimony* assumes that characters have evolved in a way that involves the fewest possible changes.

- There are examples when parsimony reconstruction is NOT the most likely

Ratite Birds

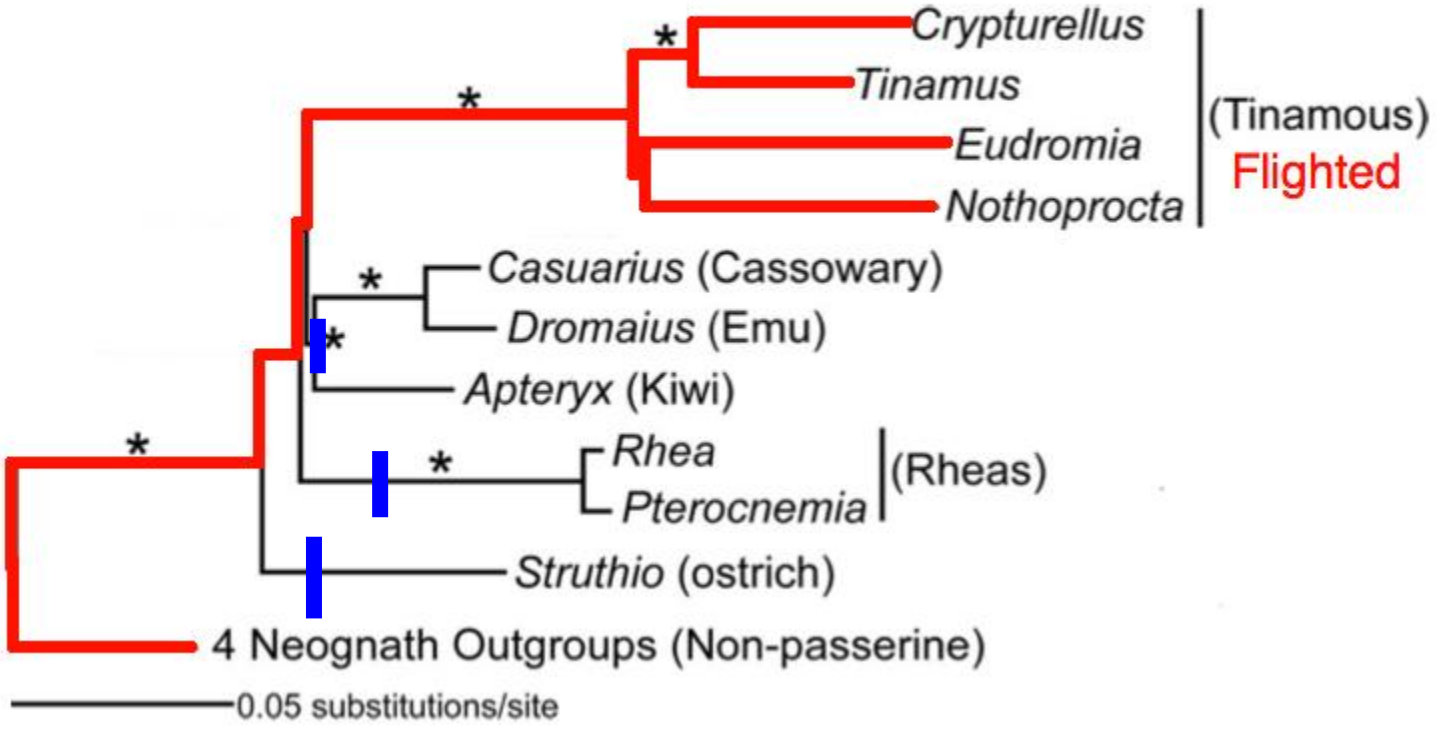
Great tinamou, pic: Patrick Coin (1992)



Emu, pic: carolinaemu.com

Modified from Harshman et al (2008) *PNAS* 105:13462-13467

Non-parsimonious reconstruction - most likely



Ancestral state reconstruction

- The data used to generate a phylogeny and the character mapped onto the tree must be *independent*.

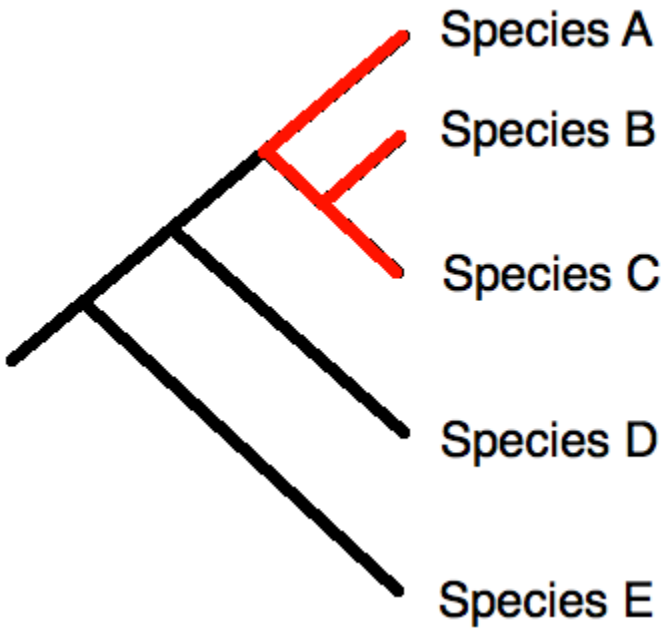
- You cannot use ancestral state reconstruction for a character you used to build the tree (circular).

Uses of ancestral state reconstruction

- Indicate character state of ancestor
- Does a trait change often or rarely across the tree? Is a trait *labile* (changes frequently/easily) or *conserved* (changes infrequently)?
- Is the state change associated with an increase or decrease in diversification rates?

Examples...

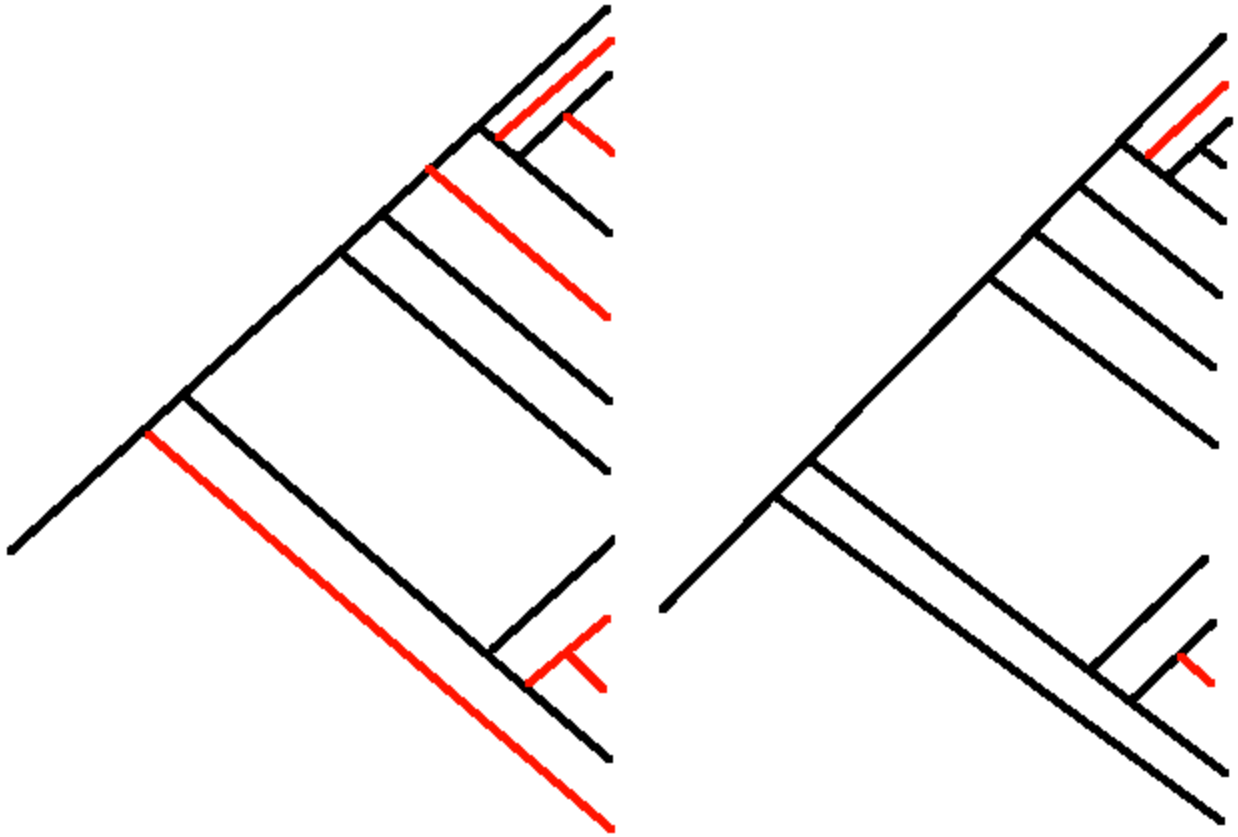
What is the character state of the ancestor?



Eg. When & how did migration originate in Wood-warblers?
(Winger et al. 2012. *Proc.Roy.Soc.B.* **279**: 610-618)

Examples...

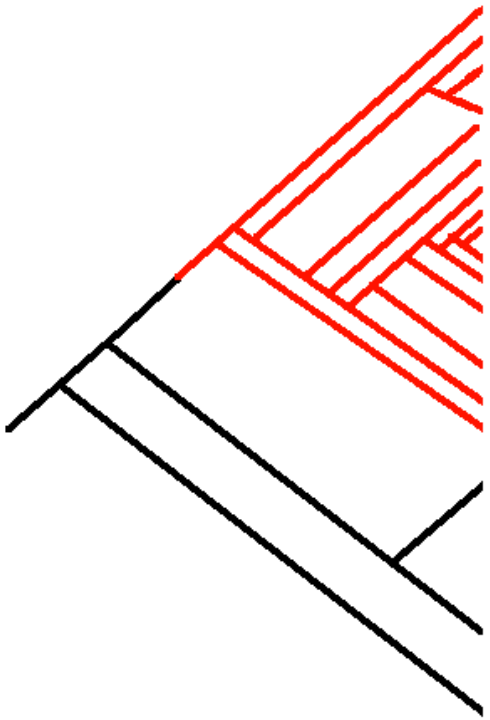
Is a character labile or conservative?



Eg. Are behavioral traits more or less conserved than morphological and physiological characters?
(Blomberg et al. 2003. *Sys.Bio.* **57**: 717-745)

Examples...

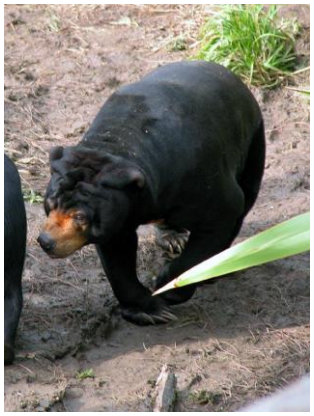
Is a character state change associated with a change in diversification rate?

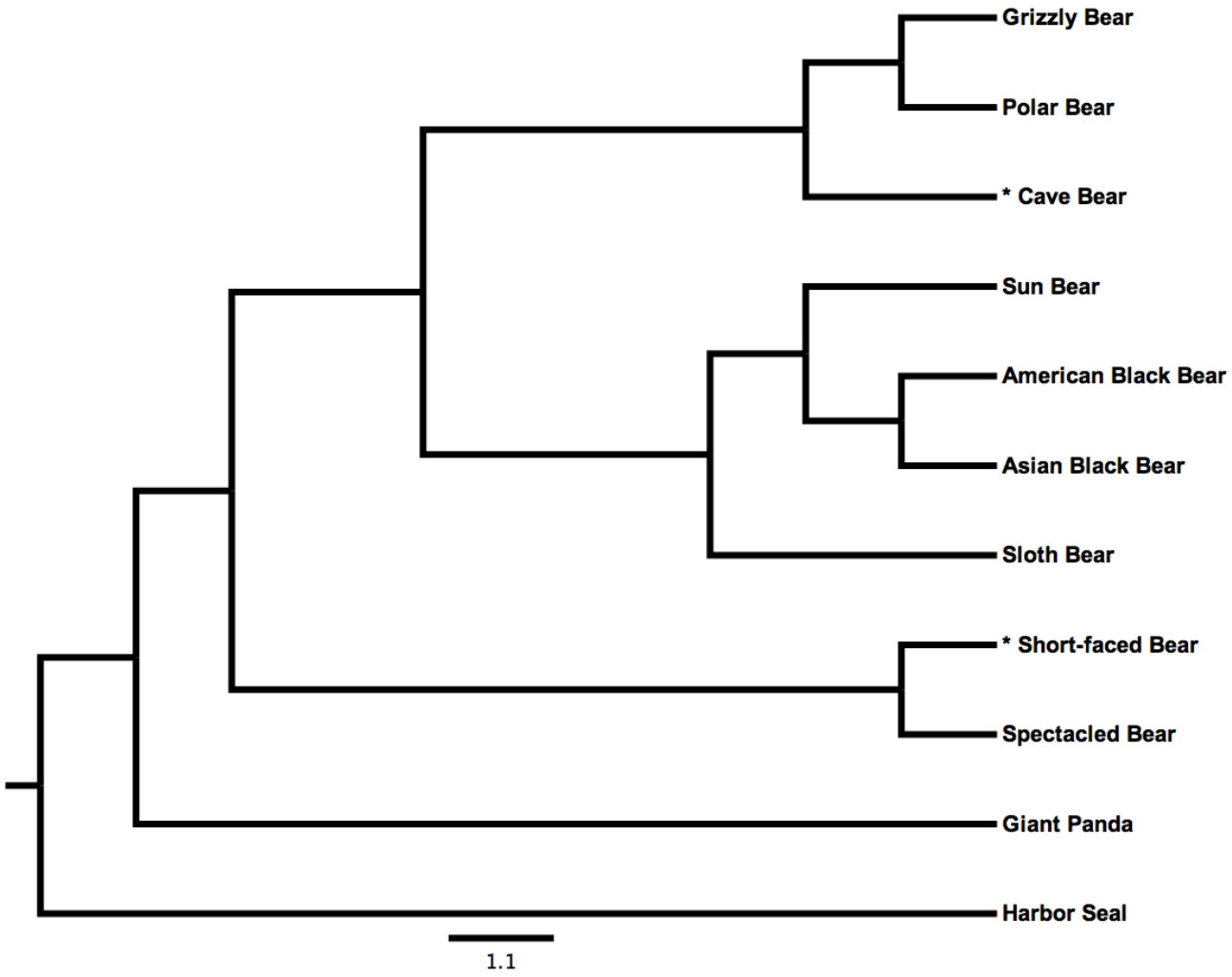


Eg. Are key innovations in angiosperms associated with an increased rate of diversification?
(Sanderson & Donoghue. 1994. *Science.* **264**: 1590-1593)

Biology of Bears

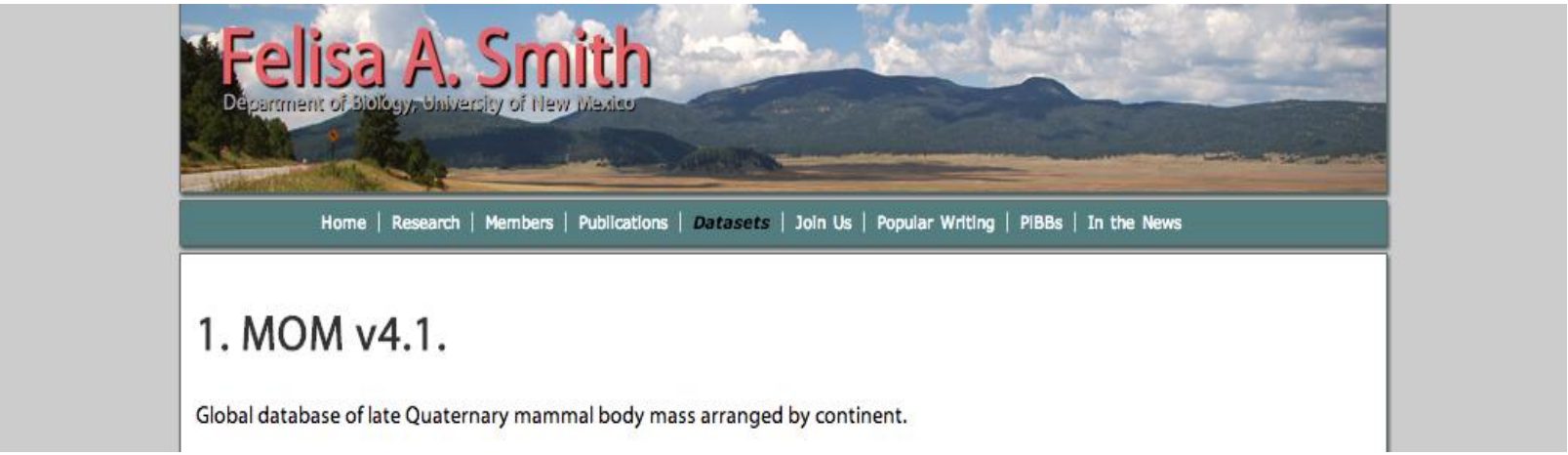
- 8 living species (and many extinct species)
- Widespread (mostly Northern Hemisphere and parts of Southern Hemisphere)
- Carnivores
- Closest relatives are dogs (canids) and seals





* = extinct species

Body Mass Database:

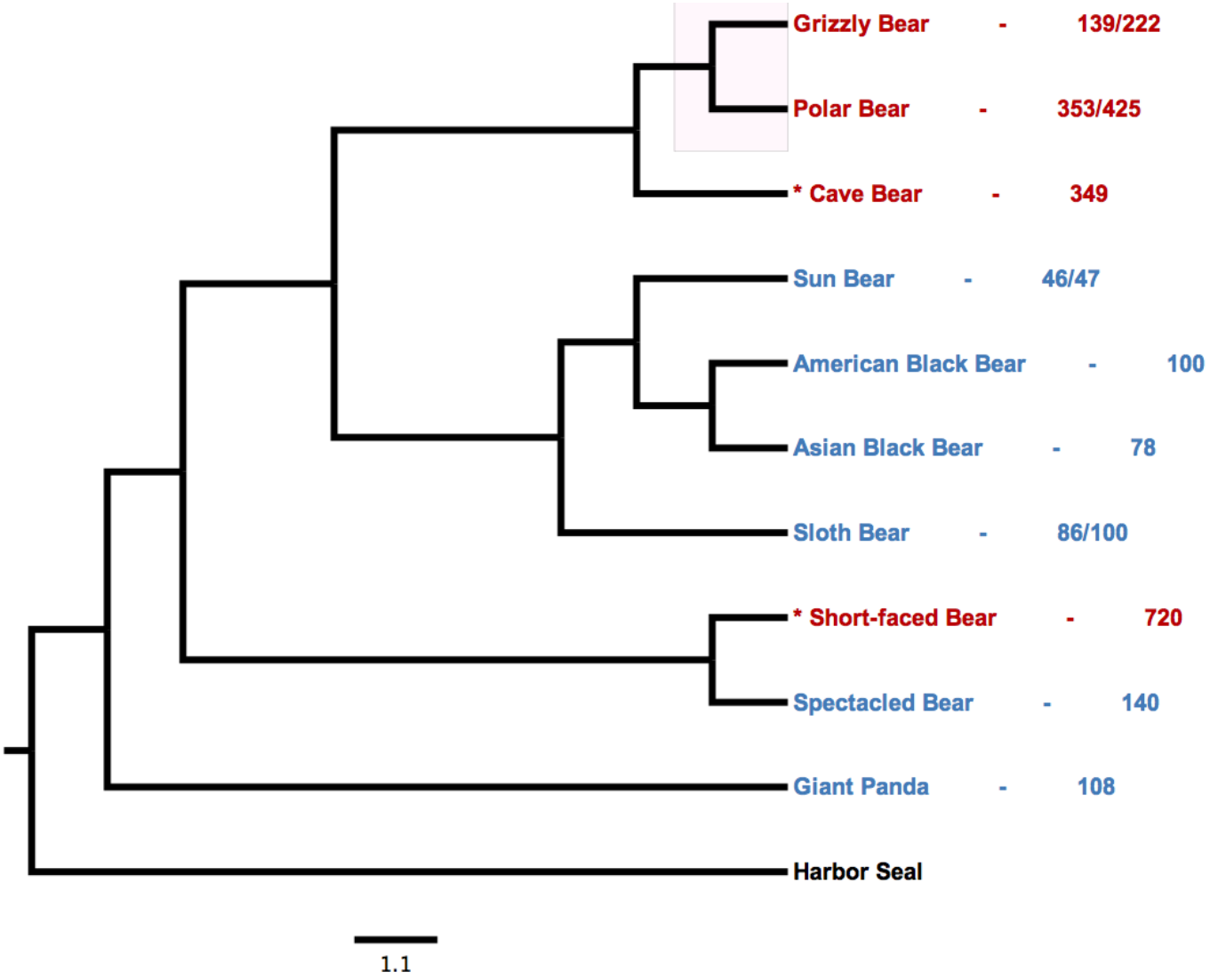


http://biology.unm.edu/fasmith/Datasets/

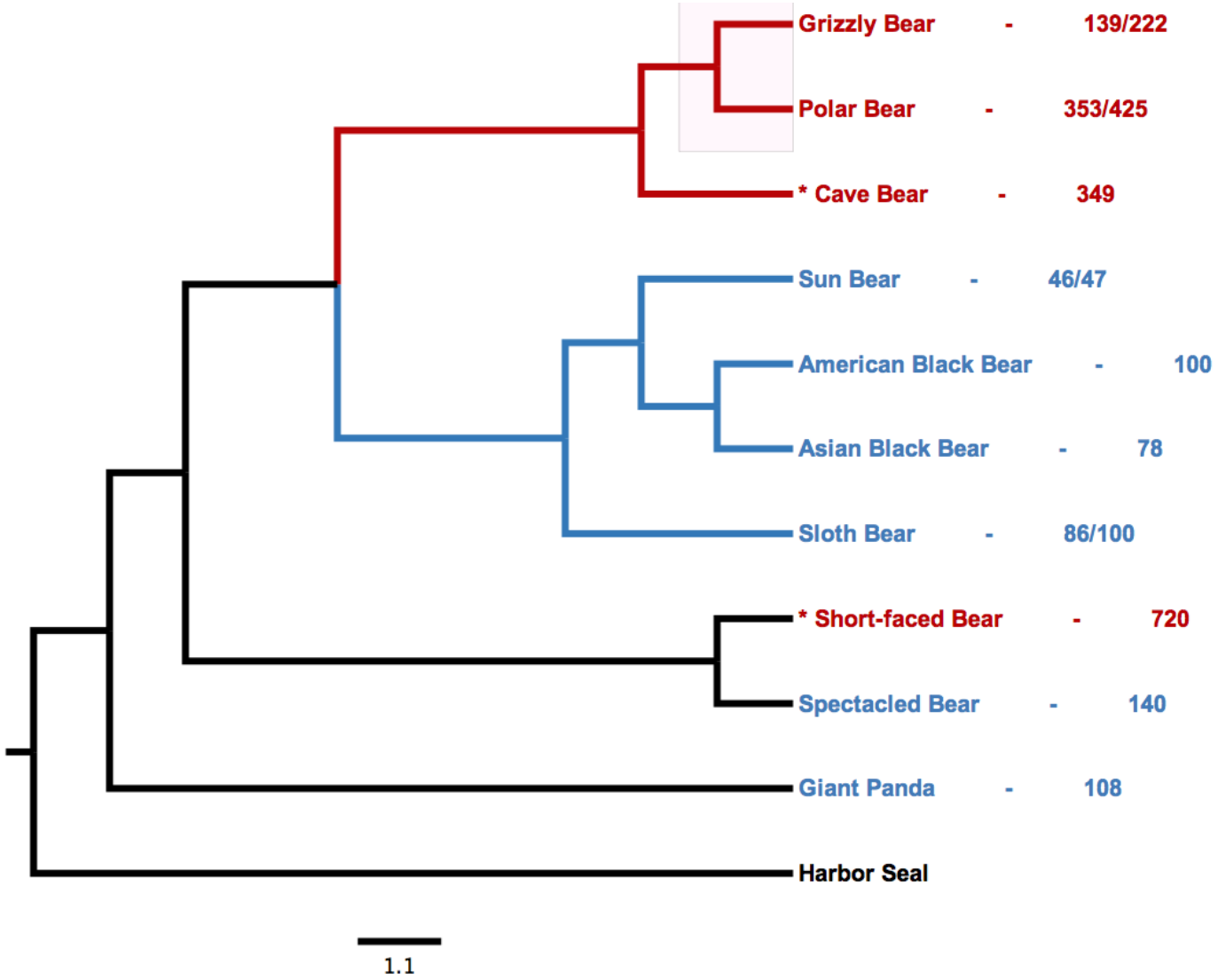
- Body mass is a *continuous* trait. For simplicity, we are going to lump bears into two groups: **large** and **small**.

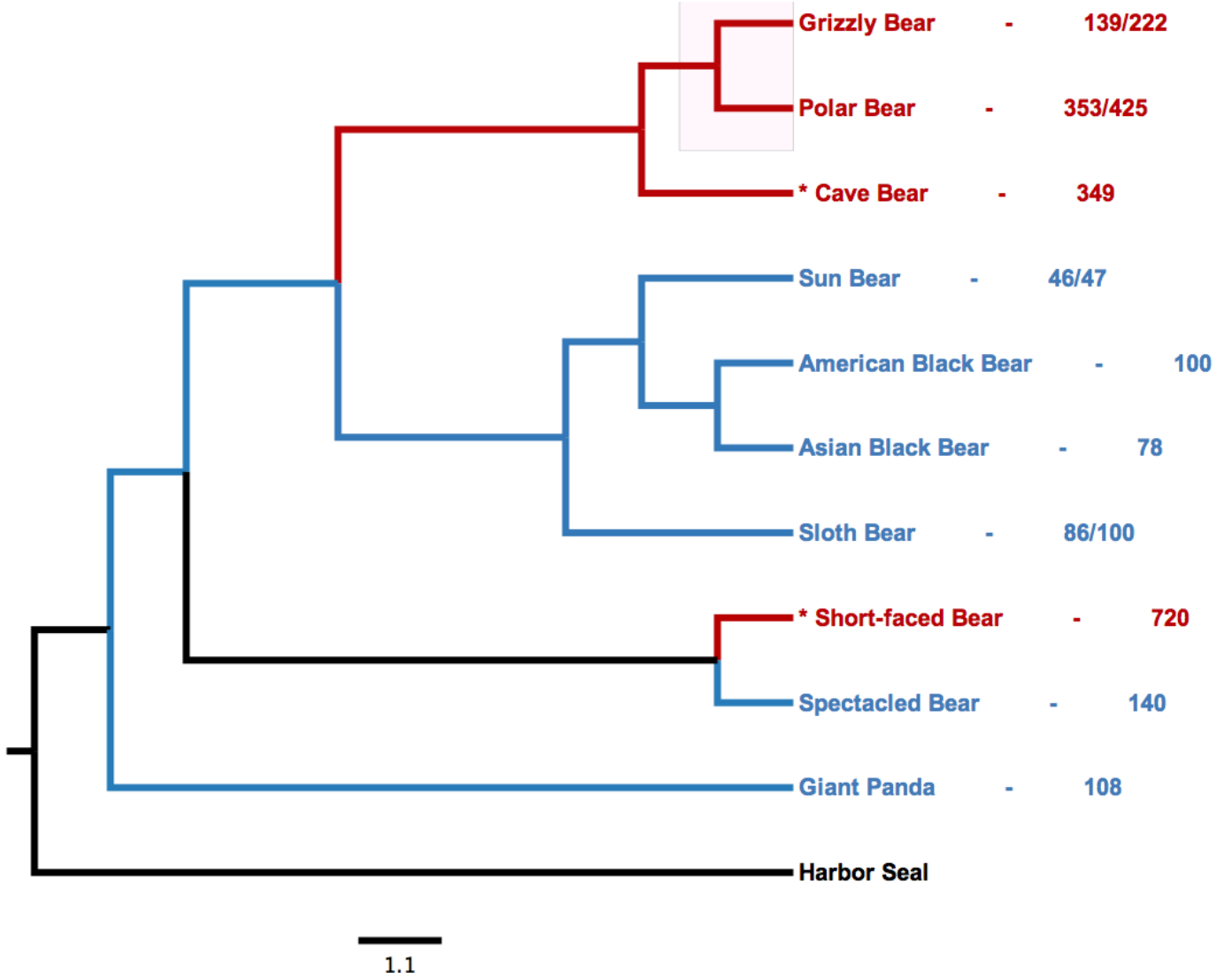
- **large** bears > 200 lbs
- **small** bears < 200 lbs

- We will then conduct a simple ancestral state reconstruction of body mass in bears.



*** Average masses (male + female) are shown. Masses for extinct species are estimates based on the fossil record. See MOM metadata for more information.*


Grizzly Bear - 139/222
Polar Bear - 353/425
* Cave Bear - 349
Sun Bear - 46/47
American Black Bear - 100
Asian Black Bear - 78
Sloth Bear - 86/100
* Short-faced Bear - 720
Spectacled Bear - 140
Giant Panda - 108
Harbor Seal
1.1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- Based on our parsimony approach, the ancestor of all bears appears to have been a **small**-bodied bear (that is, <200kg).

- Now form a hypothesis for why some bears have evolved larger body sizes.

- Any ideas??

Evolution of large body size could be due to:

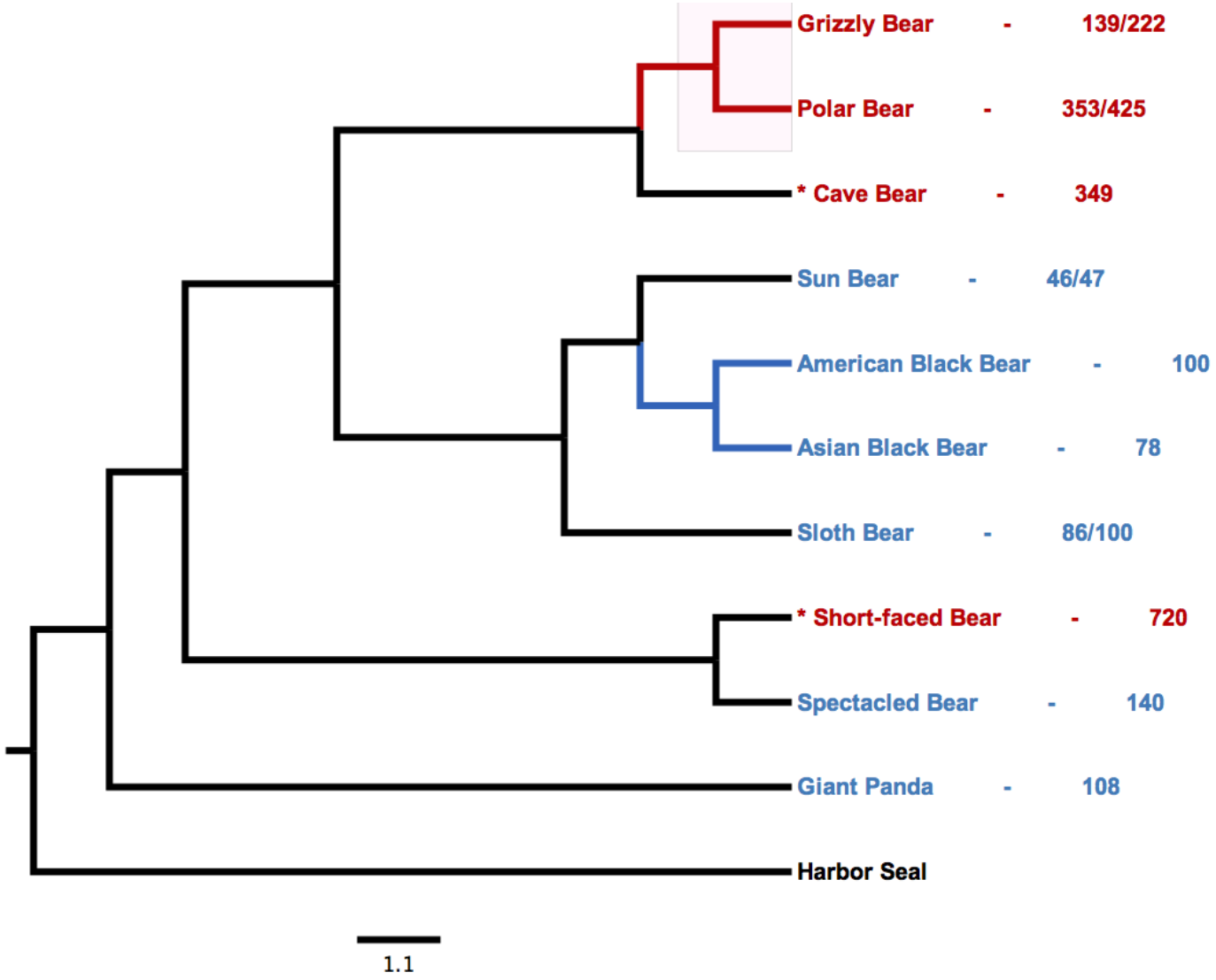
- adaptation to high-latitude environments

- adaptation to ice-age climates
  (larger size aids in retention of body heat)

OR

- adaptation to larger prey sizes

The End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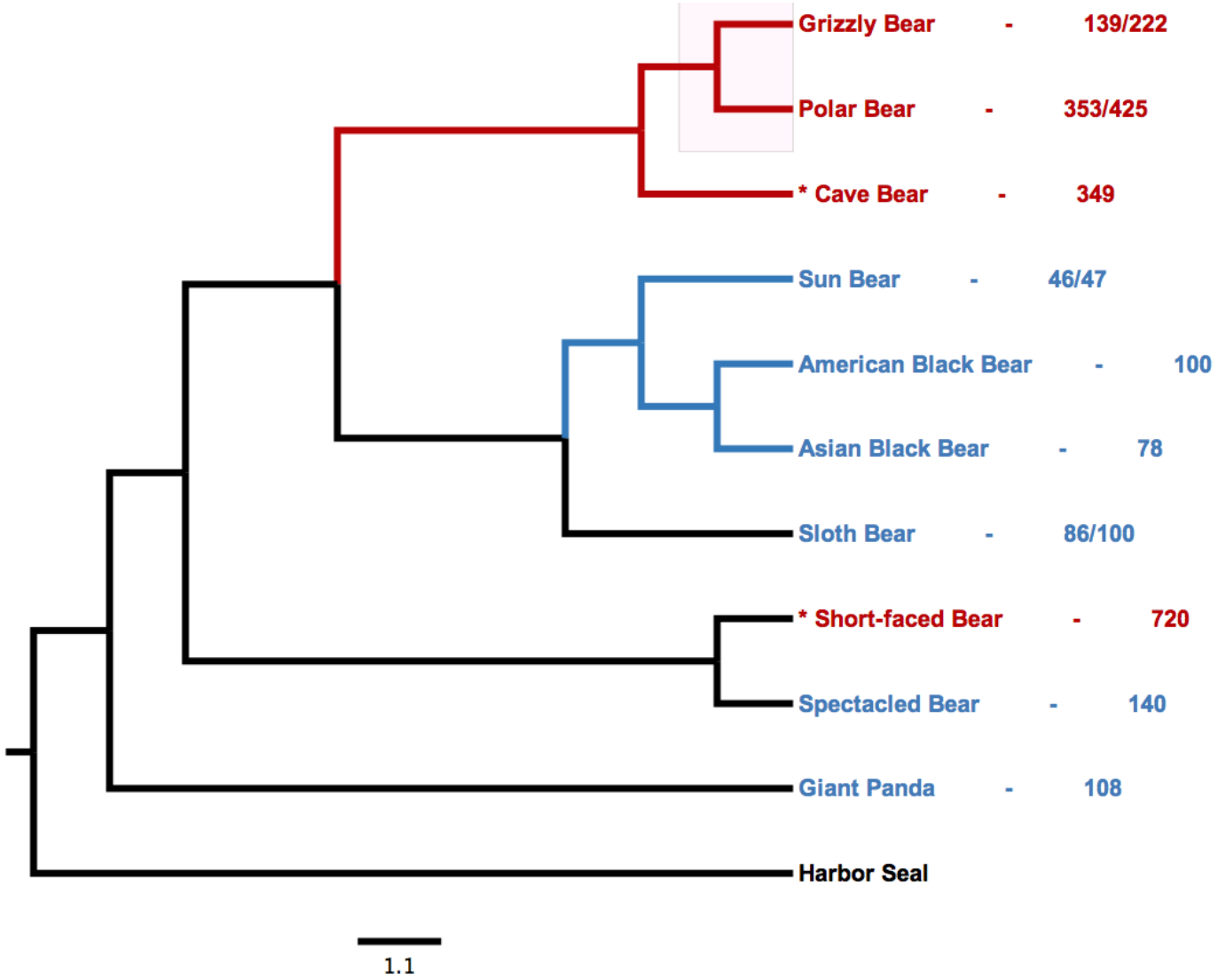
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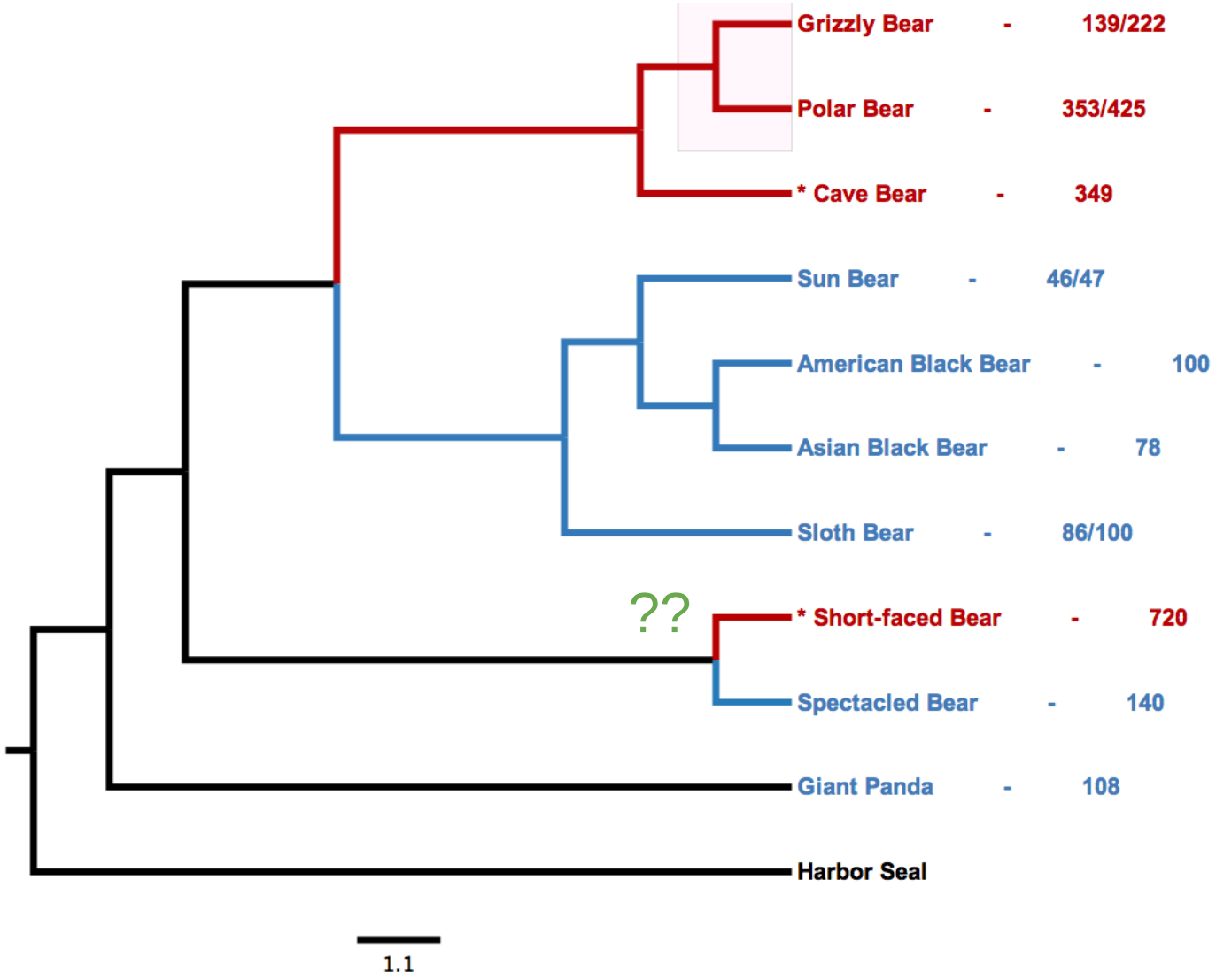
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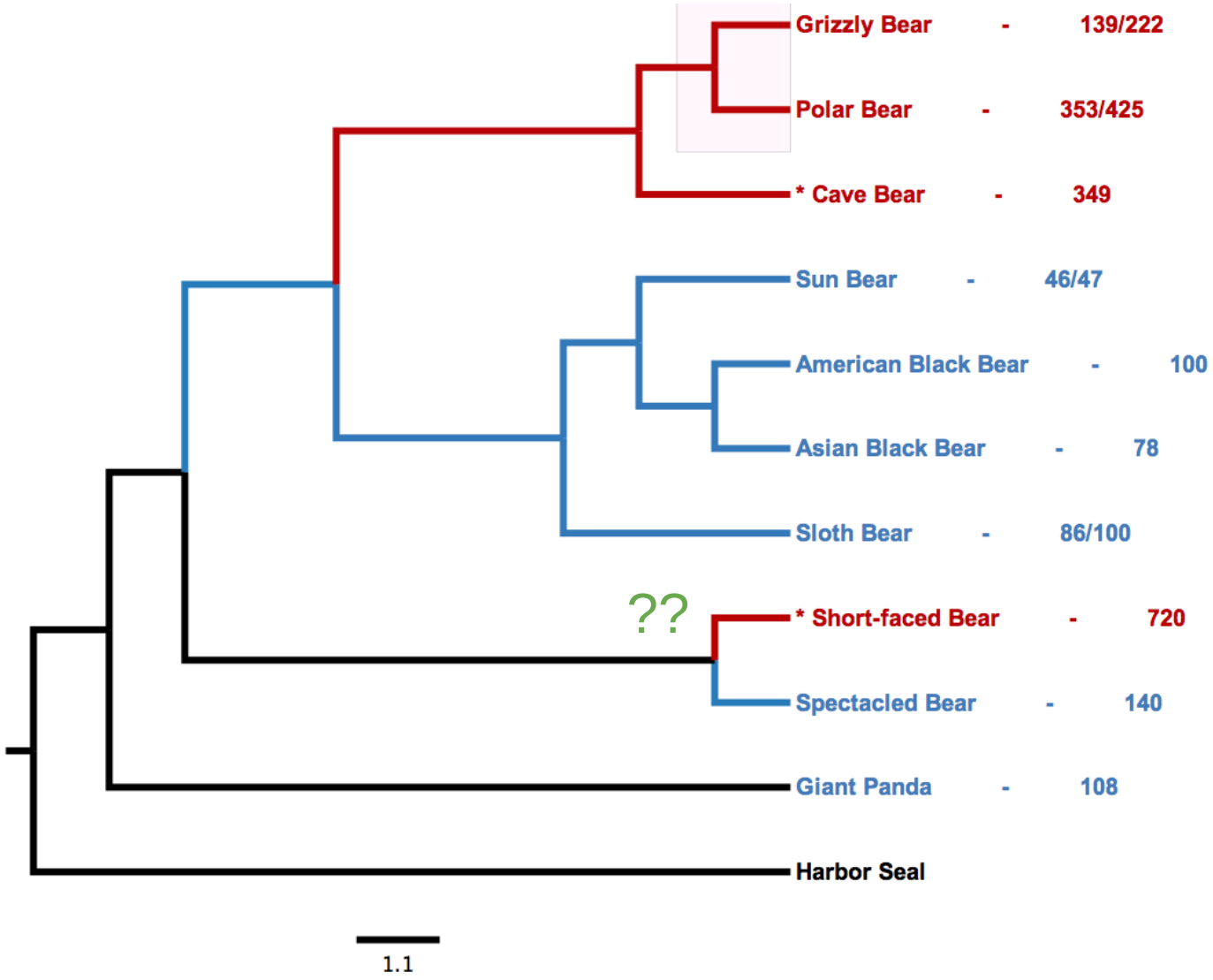
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