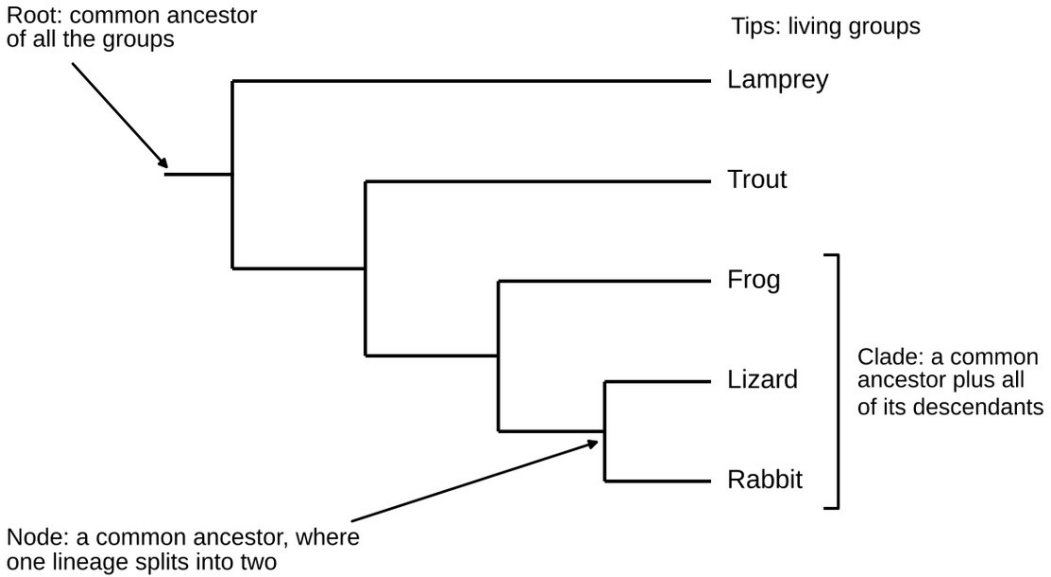
Cladograms and Phylogenetic Trees

Essential Question

How do scientists model how species are related?

Parts of a Cladogram

- A cladogram is a branching model of relationships
- Each node is a common ancestor
- A clade is an ancestor and all of its descendants
- The root is the common ancestor of the whole tree



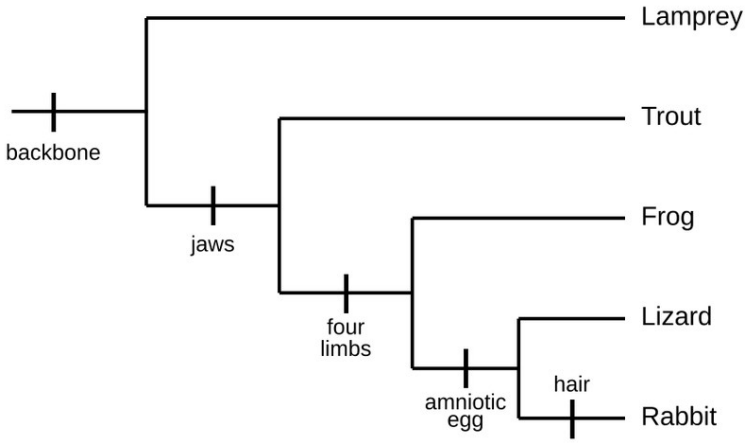
Building a Cladogram from Traits

- Use shared derived traits, new traits in a lineage
- Groups with more shared derived traits are closer relatives
- The group with the fewest traits branches off first
- That group is the outgroup

Group	Backbone	Jaws	Four limbs	Amniotic egg	Hair
Lamprey	Yes	No	No	No	No
Trout	Yes	Yes	No	No	No
Frog	Yes	Yes	Yes	No	No
Lizard	Yes	Yes	Yes	Yes	No
Rabbit	Yes	Yes	Yes	Yes	Yes

Reading a Vertebrate Cladogram

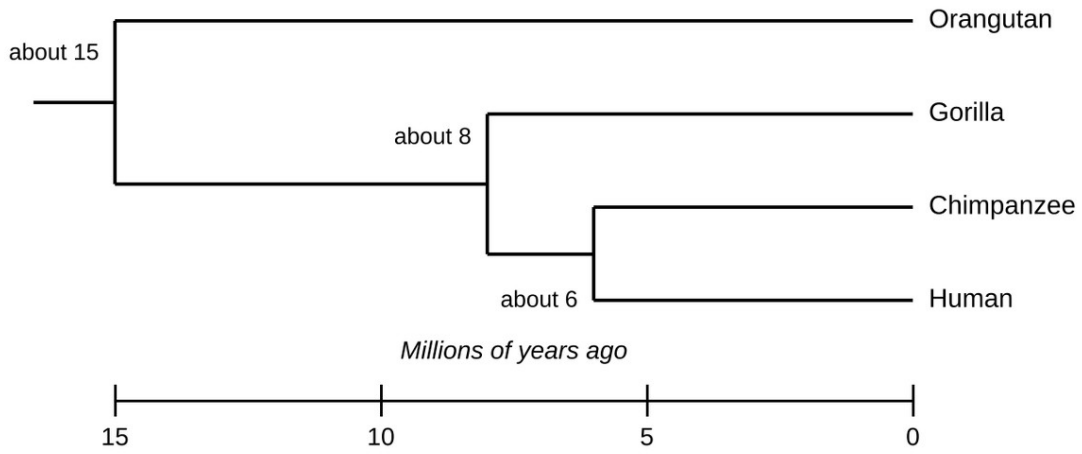
- Each bar marks where a trait first appears
- All groups to the right of a bar share that trait
- Lizard and rabbit share a more recent ancestor
- Frogs lack the amniotic egg



Each bar marks where a new trait first appears. All groups to its right inherit it.

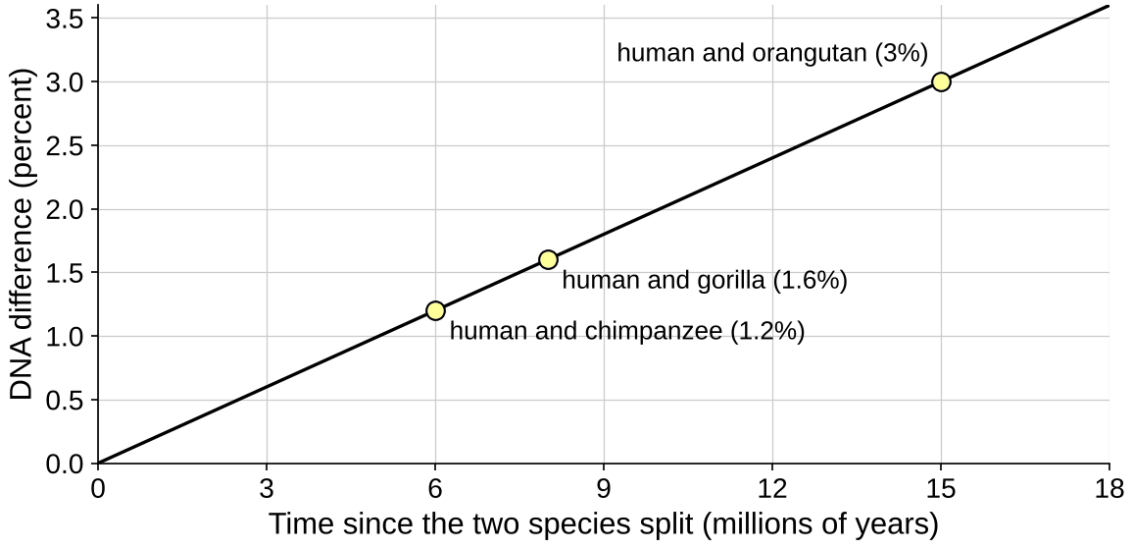
Phylogenetic Trees and Time

- A phylogenetic tree can include a time scale
- Branch points show when groups split
- Chimpanzees are humans' closest living relatives
- The orangutan split off first



Molecular Clocks

- Mutations build up in DNA at a fairly steady rate
- More DNA differences mean more time since the split
- Rate = DNA difference ÷ time since the split
- Time since split = DNA difference ÷ rate



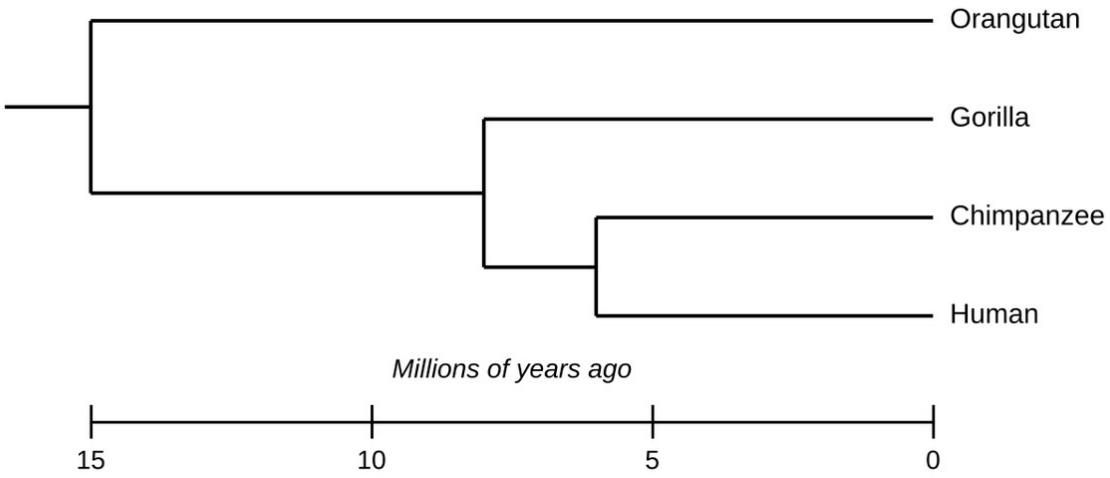
Example: Build a Plant Cladogram

Use the table to build a cladogram of the five plant groups. Which group is the outgroup, and which two groups are the closest relatives?

Group	Embryo protected by parent	Vascular tissue	Seeds	Flowers
Green alga	No	No	No	No
Moss	Yes	No	No	No
Fern	Yes	Yes	No	No
Pine	Yes	Yes	Yes	No
Rose	Yes	Yes	Yes	Yes

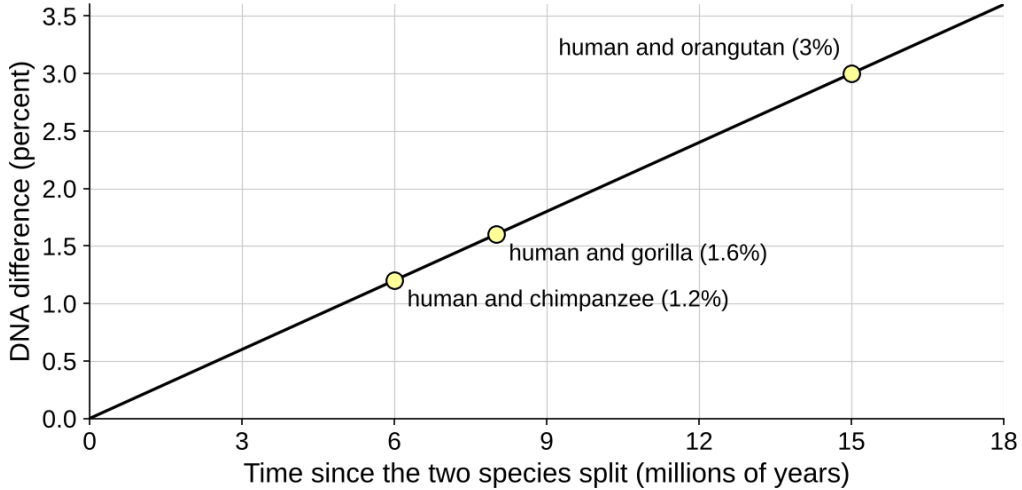
Example: Reading an Ape Tree

Use the tree. (a) What is the closest living relative of humans? (b) About how long ago did the ancestors of humans and gorillas split? (c) Is a human more closely related to a gorilla or to an orangutan?



Example: Using a Molecular Clock

The graph shows that DNA differences between primate species grow by the same amount each million years. Find the clock rate from the human and orangutan point. Two other primate species differ by 2.4% in their DNA. About when did they split?



Cladograms and Phylogenetic Trees

Big Ideas

- A cladogram shows common ancestors, not a ladder
- Nodes are common ancestors; a clade has all descendants
- Shared derived traits show relatedness
- The outgroup branches off first
- A molecular clock: time = DNA difference ÷ rate