

Introduction to Trees

Phylogenetic Biology

Week 1

Biology 1425
Professor: Casey Dunn
Brown University

Front matter...

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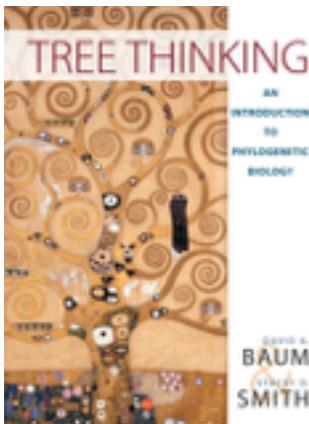
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Sources

Some non-original content is drawn from:



Baum, D and S. Smith (2012) Tree Thinking: and Introduction to Phylogenetic Biology. Roberts and Company Publishers. ISBN 9781936221165

Other non-original content is referenced by url.

What is a phylogenetic tree?

A depiction of the relationships between biological entities that descended from a common ancestor

These entities could be anything from genes to populations to species to groups of related species

p

a

c

q

PlantaeCormophyta

Anthophyta
Angiospermae
Gymnospermae
Cycadophyta

Bryophyta
Phyllophyta
Thallophyta

Fucidae
Sargassaceae
Laminariaceae
Gracilaria-
ceae

Florideae
Gracilariales
rhizinae

Chara-
ceae

Jnophyta
Lichenes

Archeplanta
Tre-
Conferens
Desmidium
Astero-
Codiolum

Pter-
Arche-
planta
chara-
ceae

Phylo-
phyta

Archae-
planteum
vegetabile

X

ProtistaMixo-mycetesPhysarumNemataliaLyngulaTrichia5.RhizopodaEudistomataLeptothrixidaLeptothrixidaBathymetridaeTurbulida8.FlagellataPeridiniumEuglenaVolvox3.DialonaeIridulusVillatuaSteinulae4.MoneresProstomiaLeptothrixGregariniaeIsotomidaeIsotomidae2.Flagel-Mon-ame-lita1.Diad-idae5.Arche-plantaprotisticumProtistaPlantaeAnimaliaRadixcommunisOrganismorumMoneresautogenumAnimaliaVertebrataAnniotaAvesAm-mala-ReptiliaAm-am-Am-

s

b

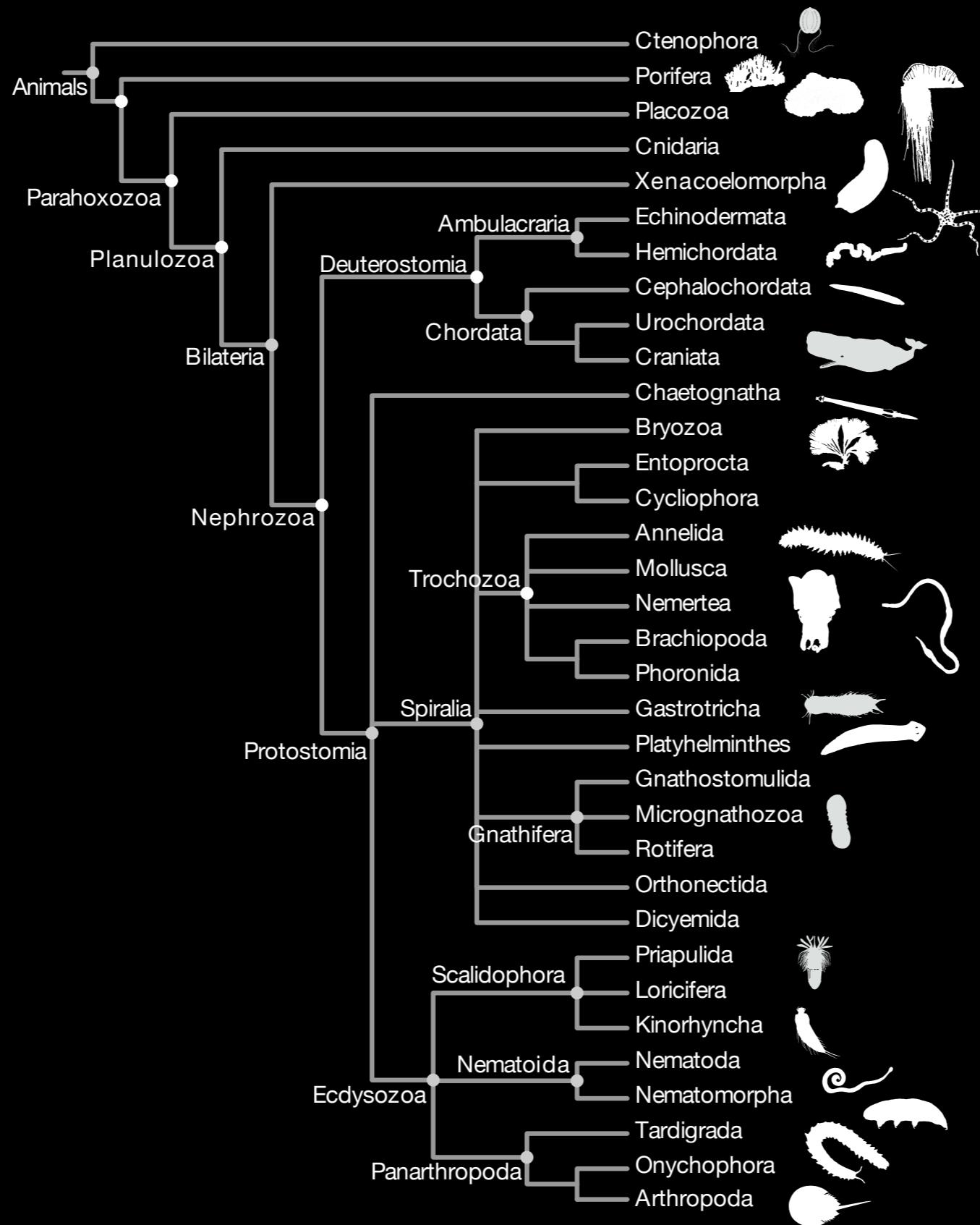
d

t

I, Feld : p m n q (19 Stämme)
 II, Feld: p x y q (5 Stämme)
 III, Feld: p s t q (1 Stamm)
 stellen 3 mögliche Fälle der
 universellen Genealogie dar.

Monophyletischer
 Stammbaum der Organismen
 entworfen und gezeichnet von
 Ernst Haeckel. Sora, 1866.

Animal Phylogeny

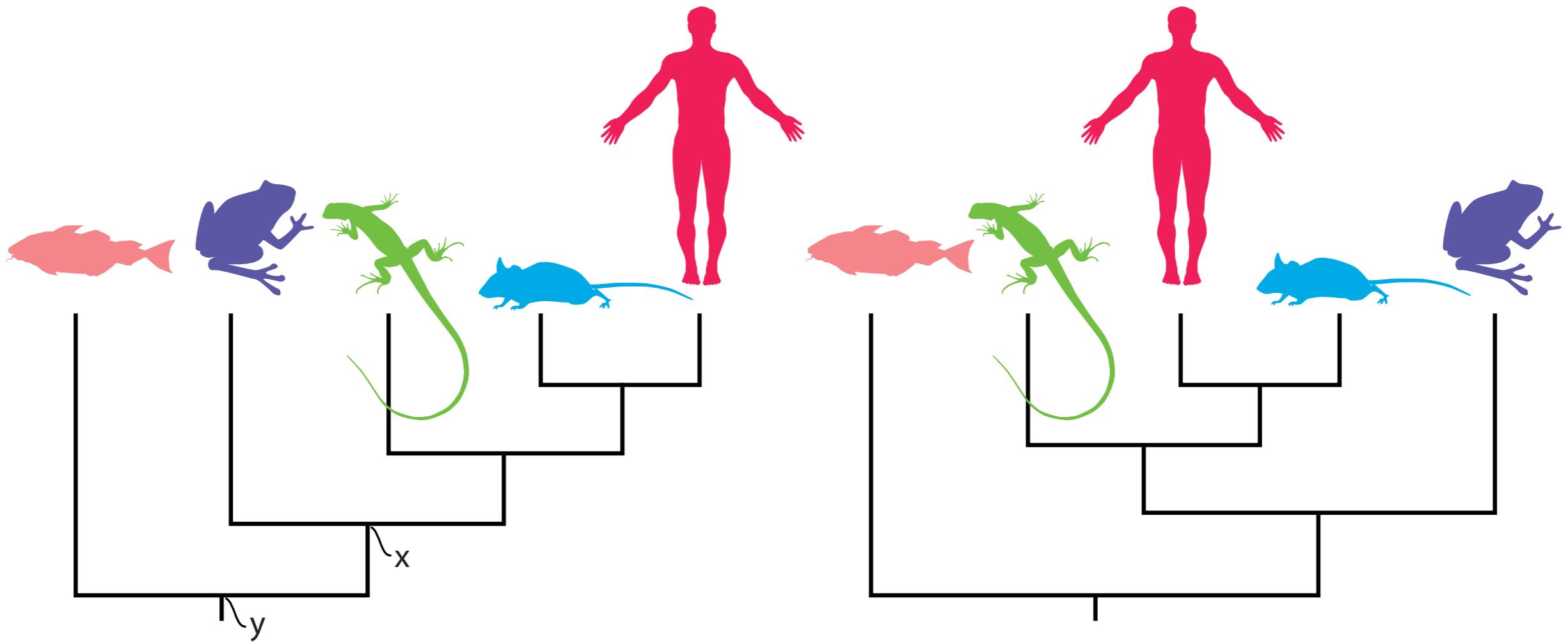


What a phylogenetic tree is not

A diagrammatic depiction of the similarities between organisms

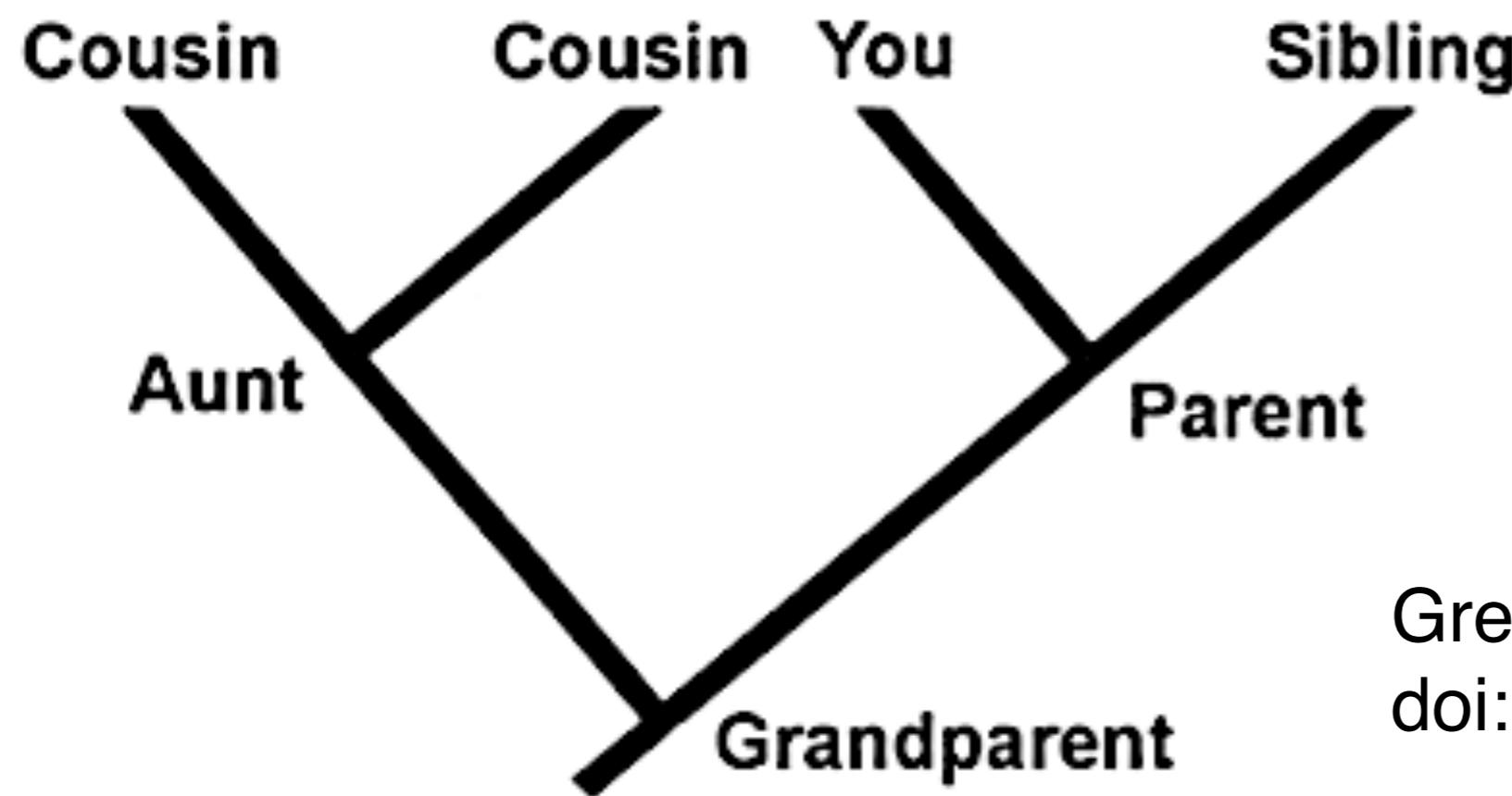
A phylogenetic tree isn't a statement about the specific properties of organisms, it is a statement about their relationships

Reading a phylogenetic tree



Baum *et al.* 2005, doi:10.1126/science.1117727

Tips are not descended from
other tips



Gregory 2008,
doi:10.1007/s12052-008-0035-x

“Contemporary entities are related through common ancestors—they are not themselves ancestors of one another...”

“The reader is not descended from a sibling; rather, both are descended from a shared parent.”

Sponges



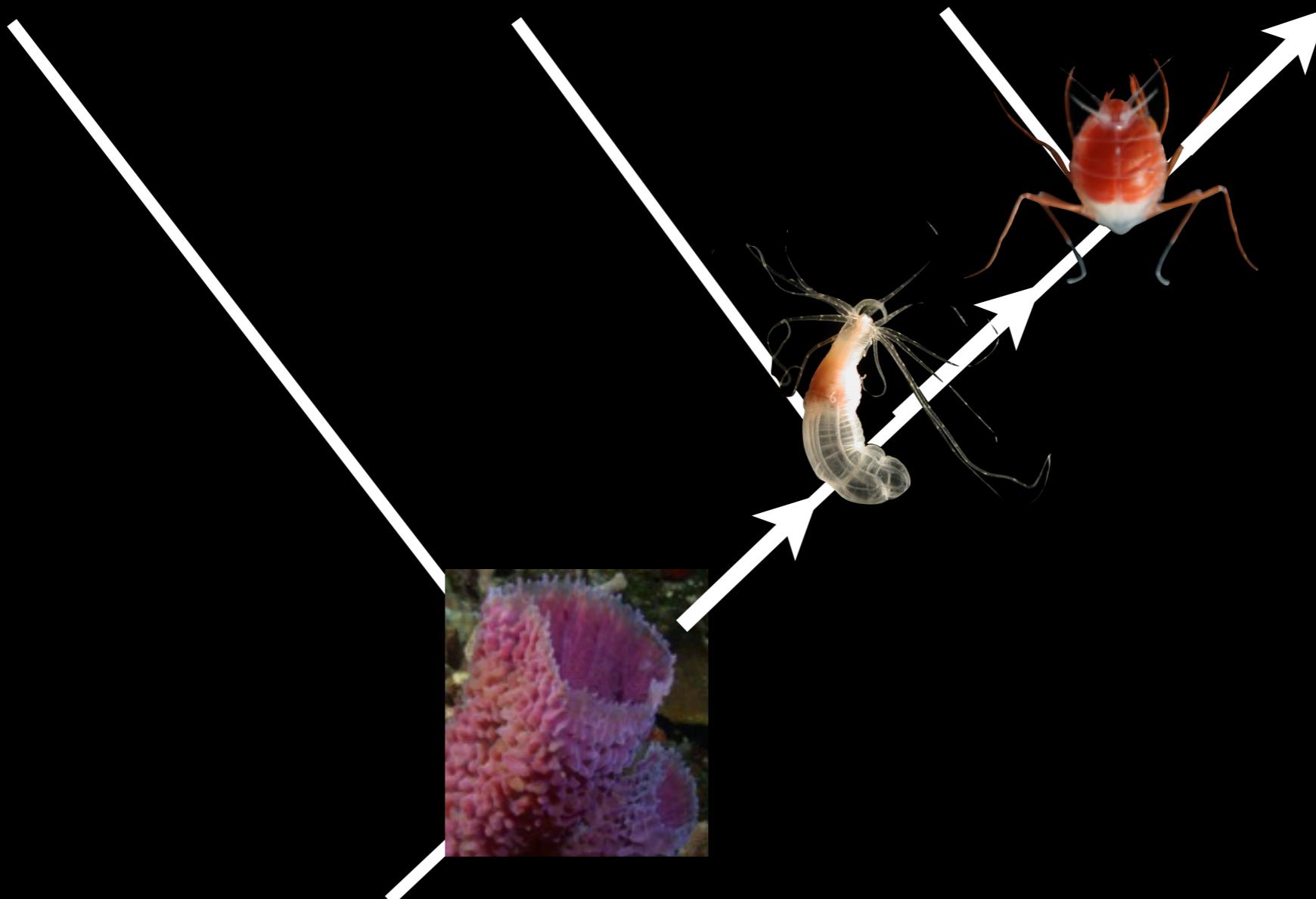
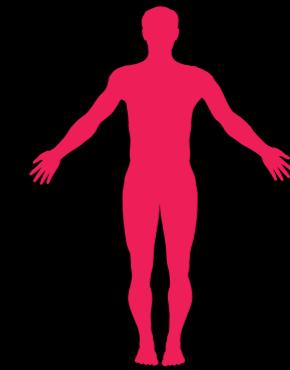
Cnidarians



Arthropods



Humans



Sponges



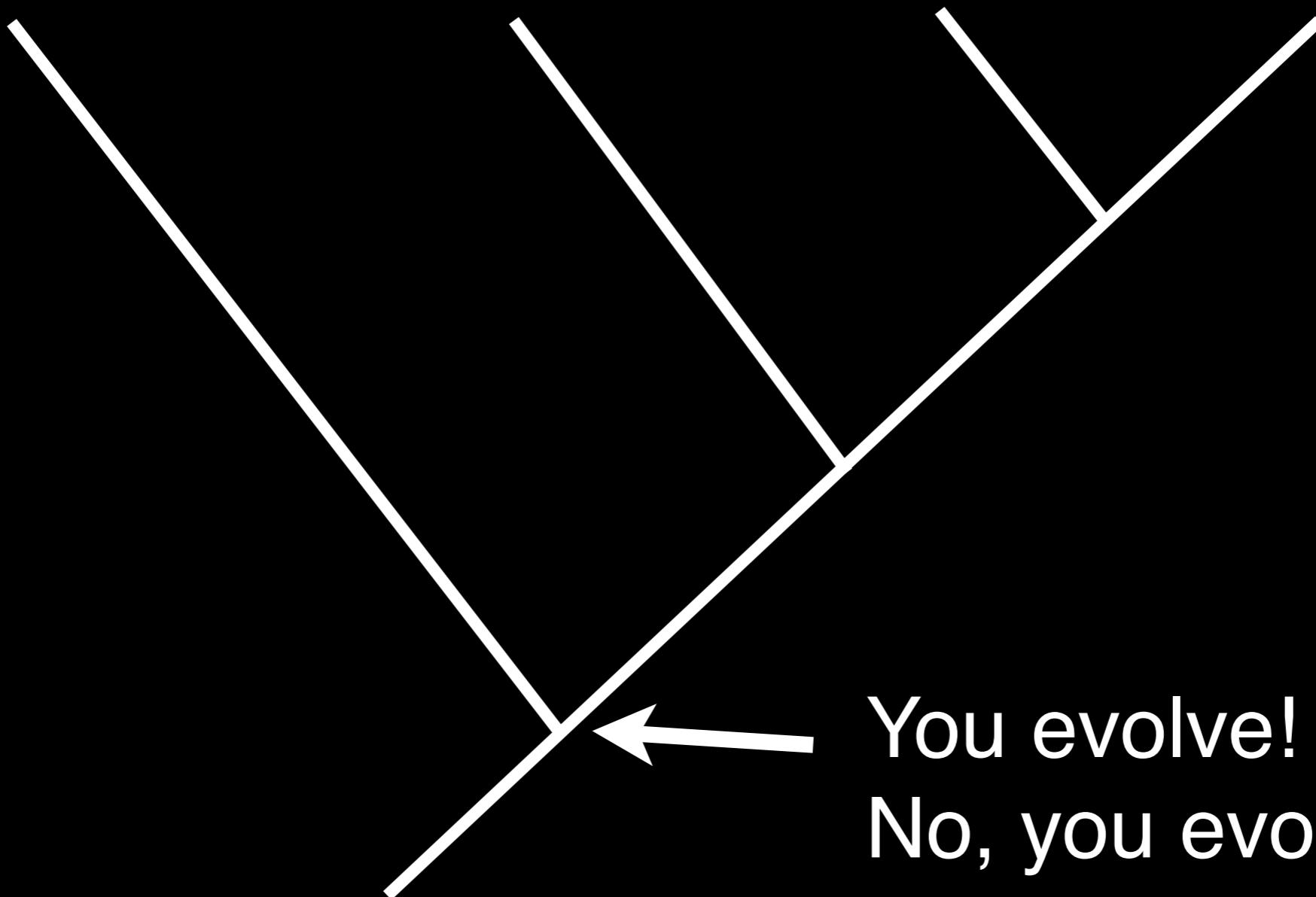
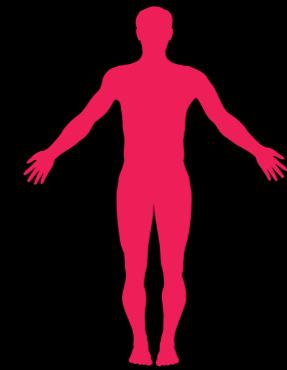
Cnidarians



Arthropods



Humans



Sponges



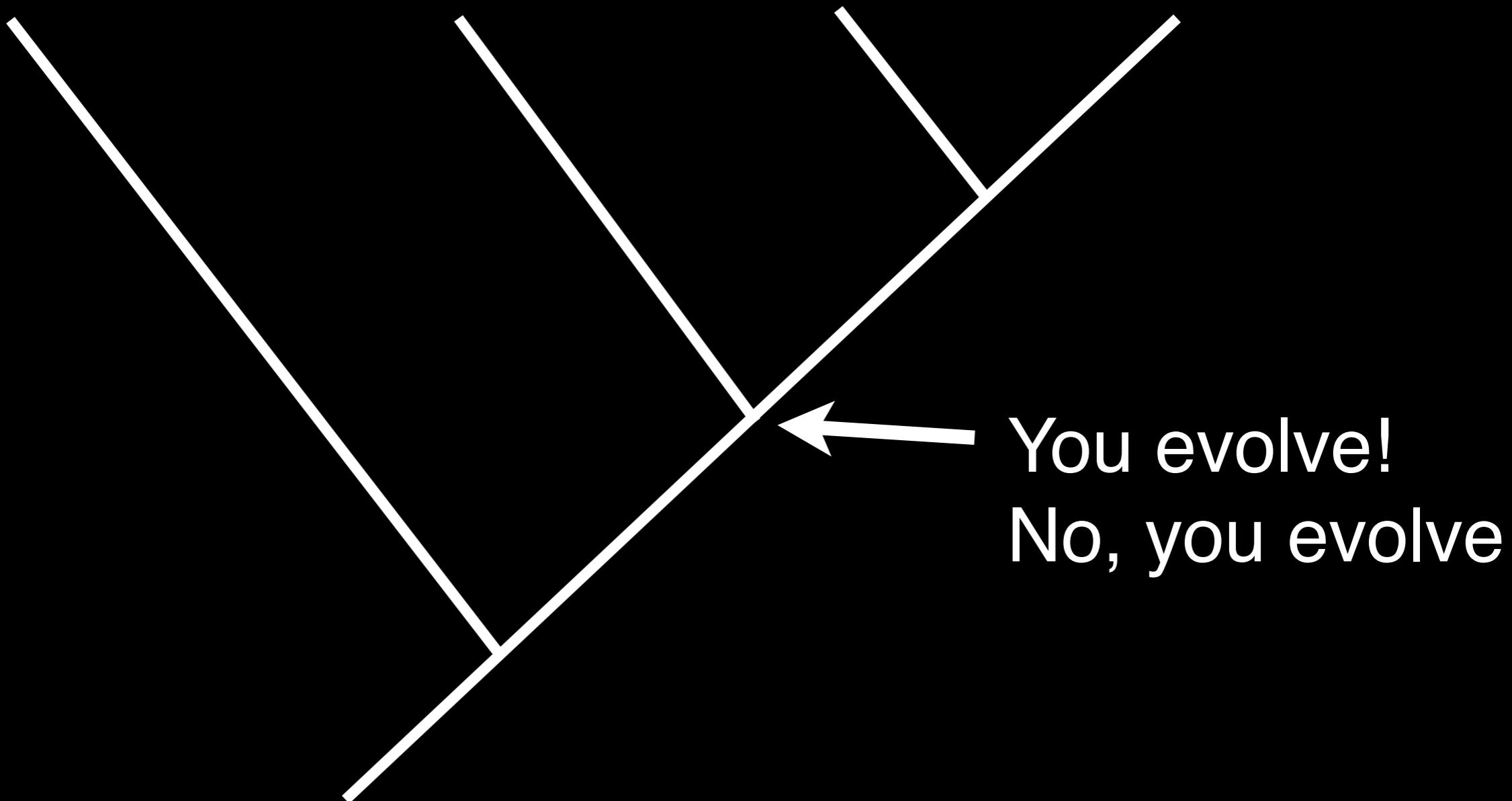
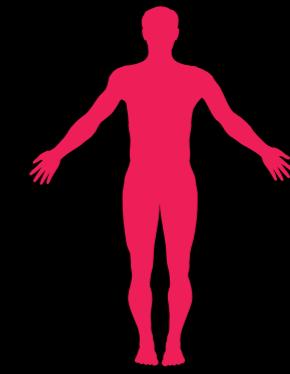
Cnidarians



Arthropods



Humans



Sponges



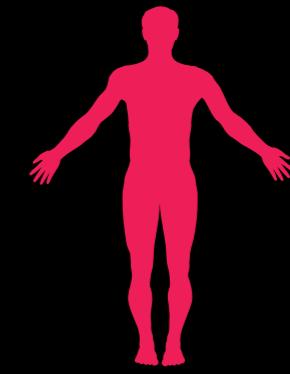
Cnidarians



Arthropods



Humans



You evolve!
No, you evolve!

Sponges



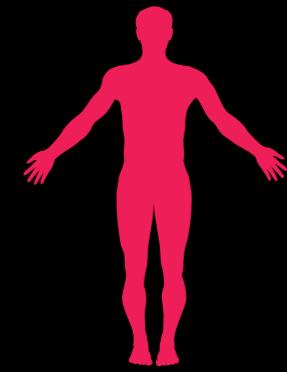
Cnidarians



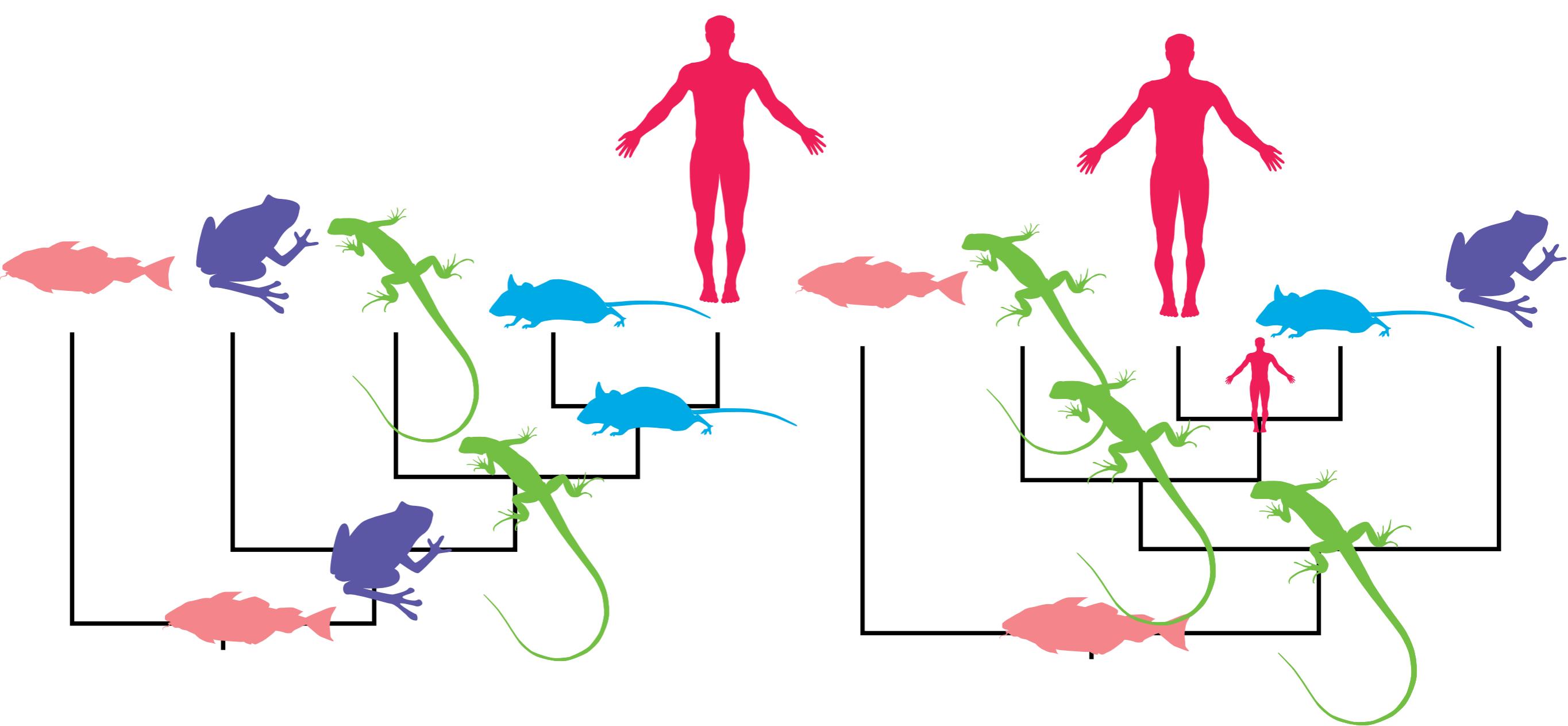
Arthropods



Humans



Which of these organisms
has evolved for the longest time?

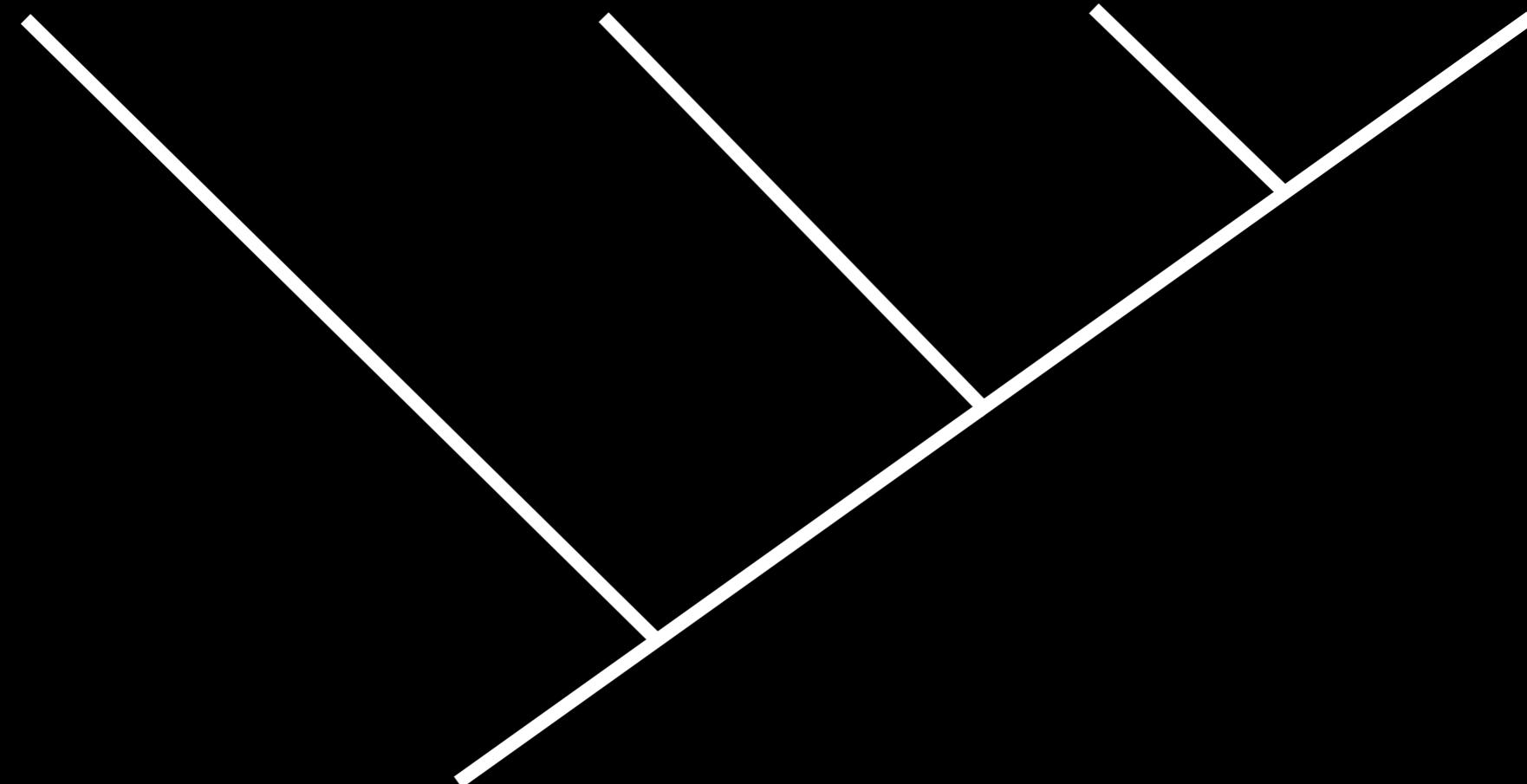
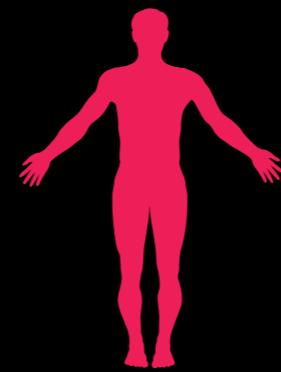


Baum *et al.* 2005, doi:10.1126/science.1117727

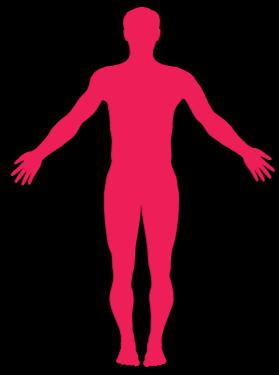
Cnidarians



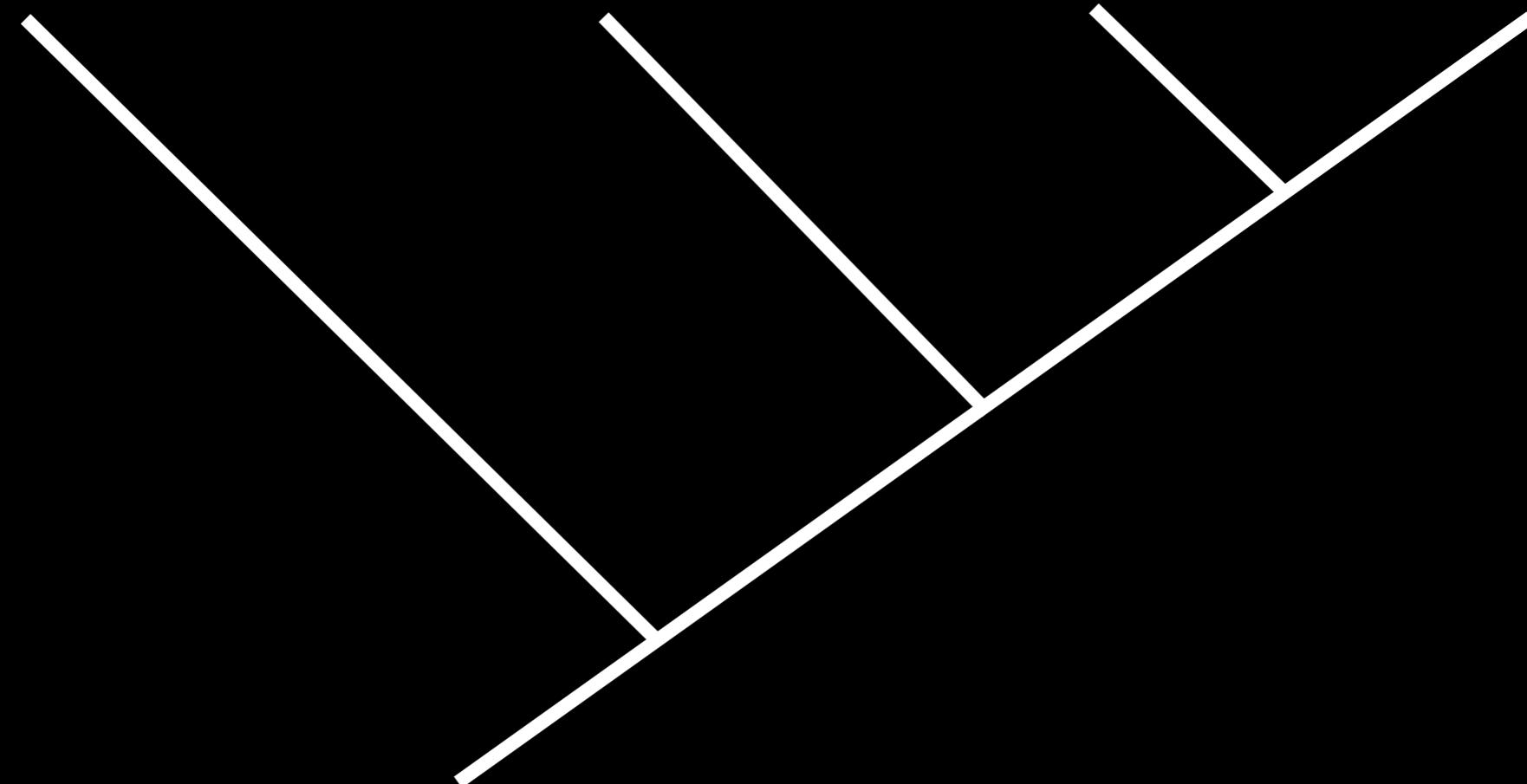
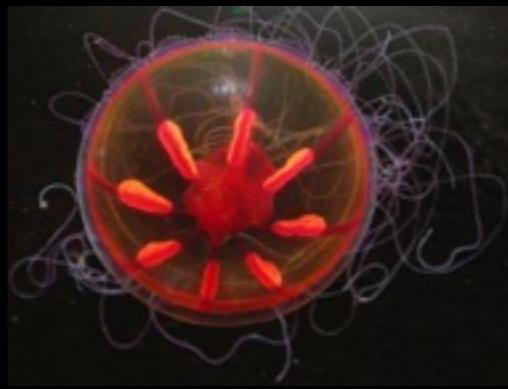
Bilaterians



Bilaterians

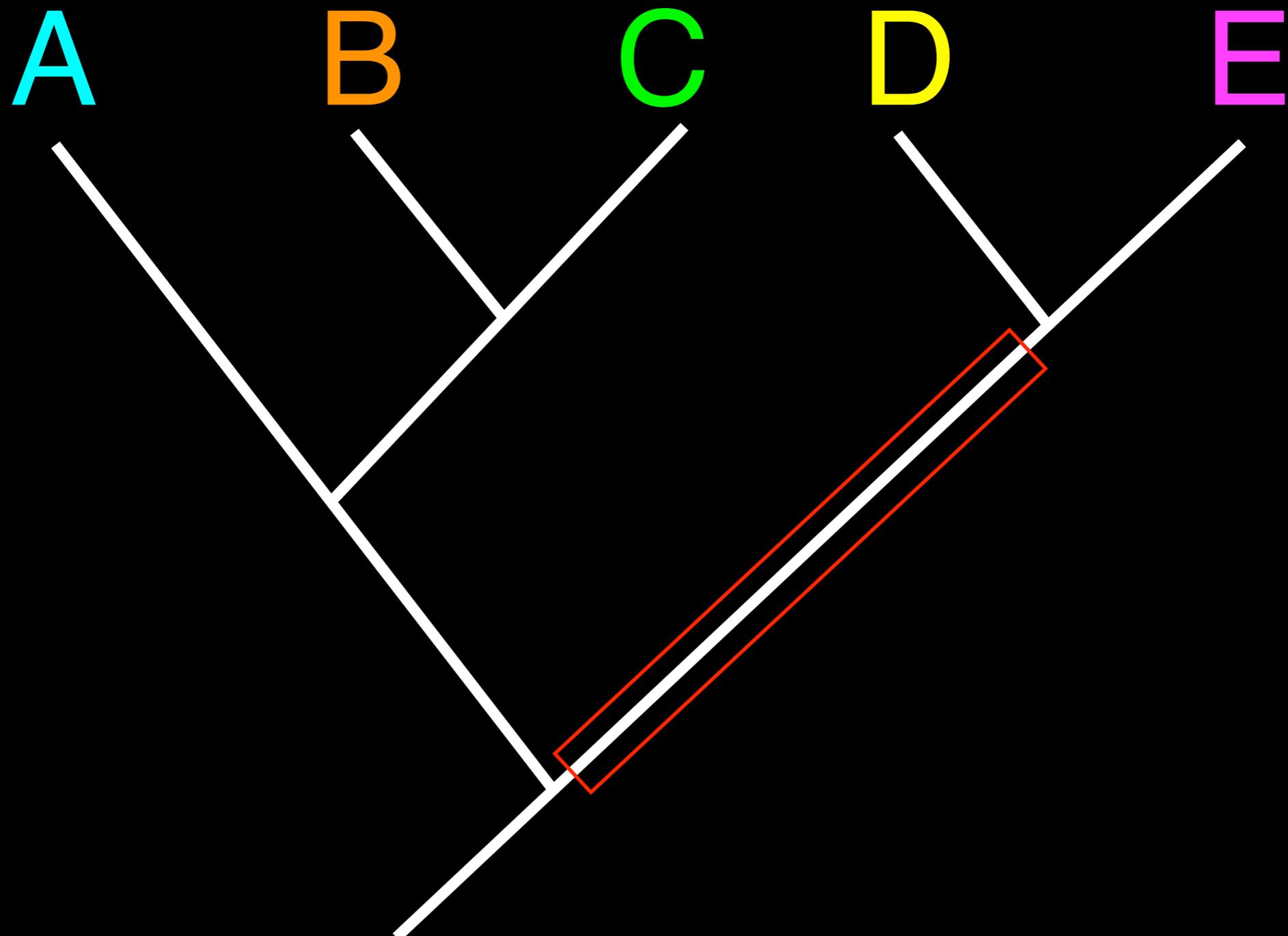


Cnidarians

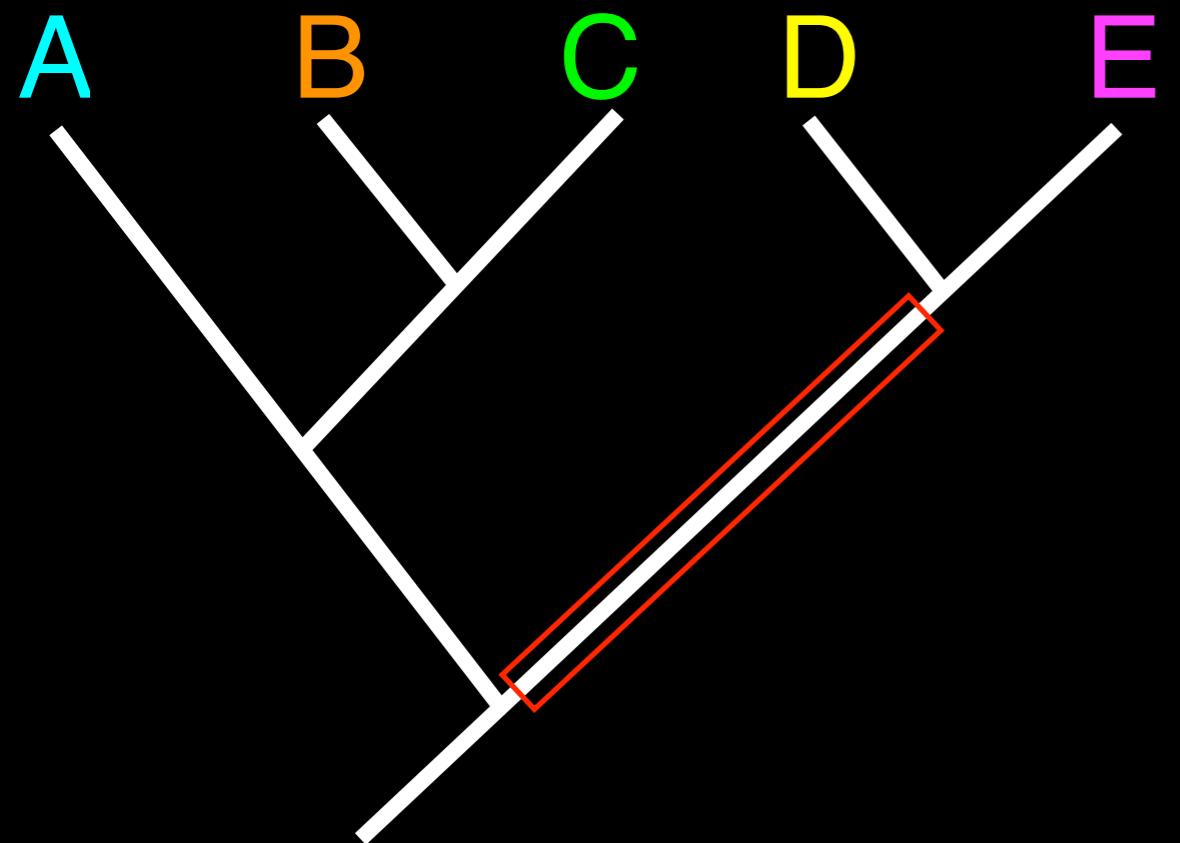


Reading branch lengths

“BRANCHES” of a phylogeny: historical lineages



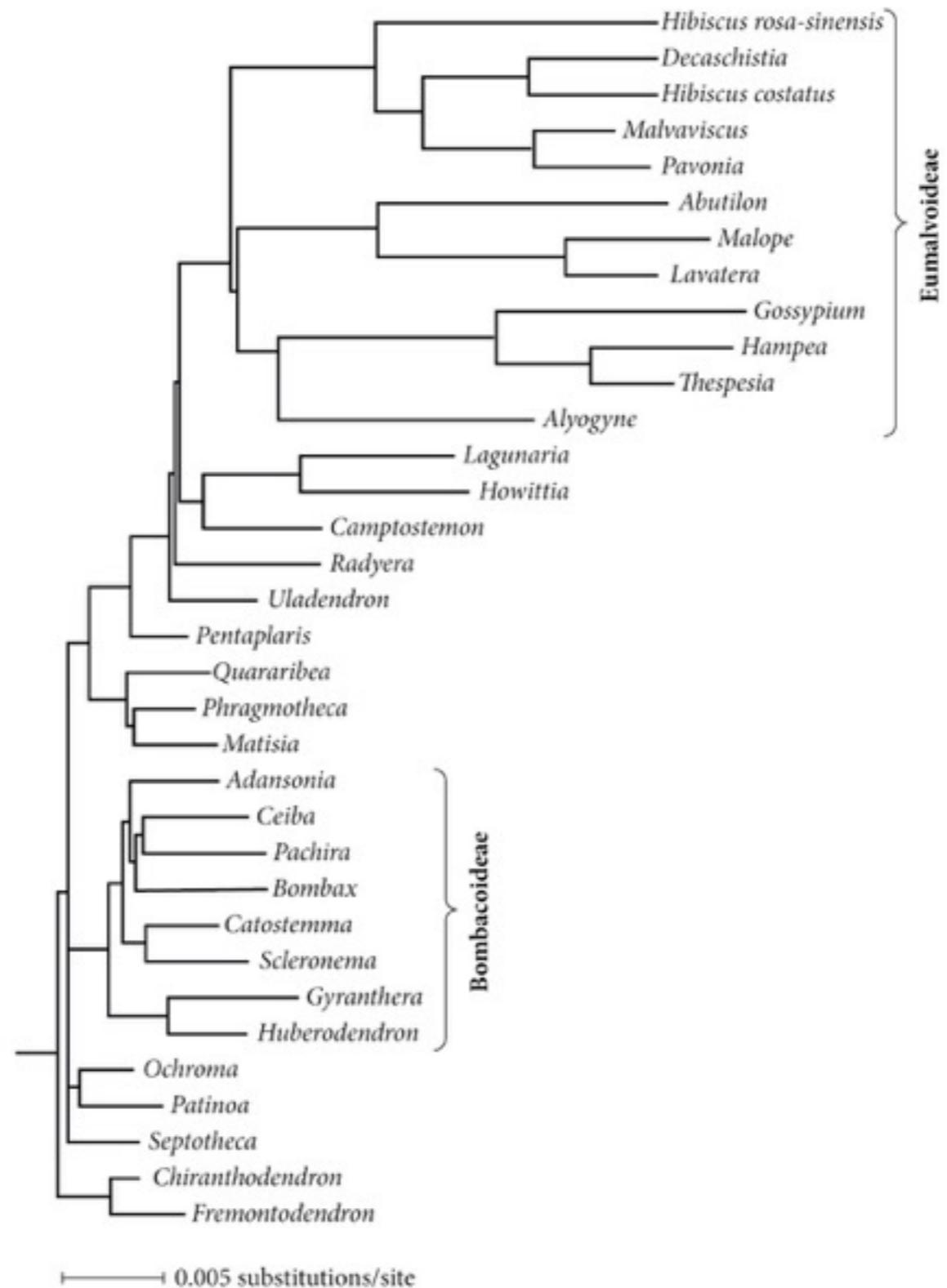
branch lengths often, but not always, mean something

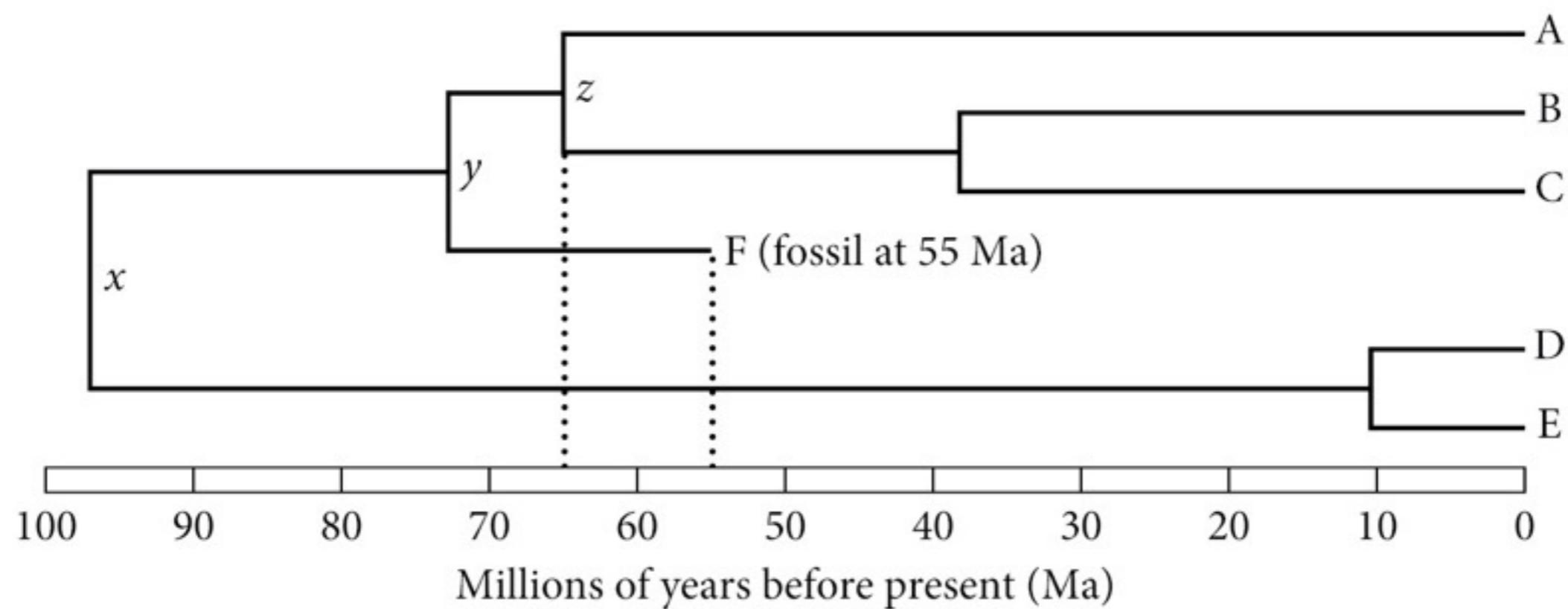


‘cladogram’ - branch lengths meaningless

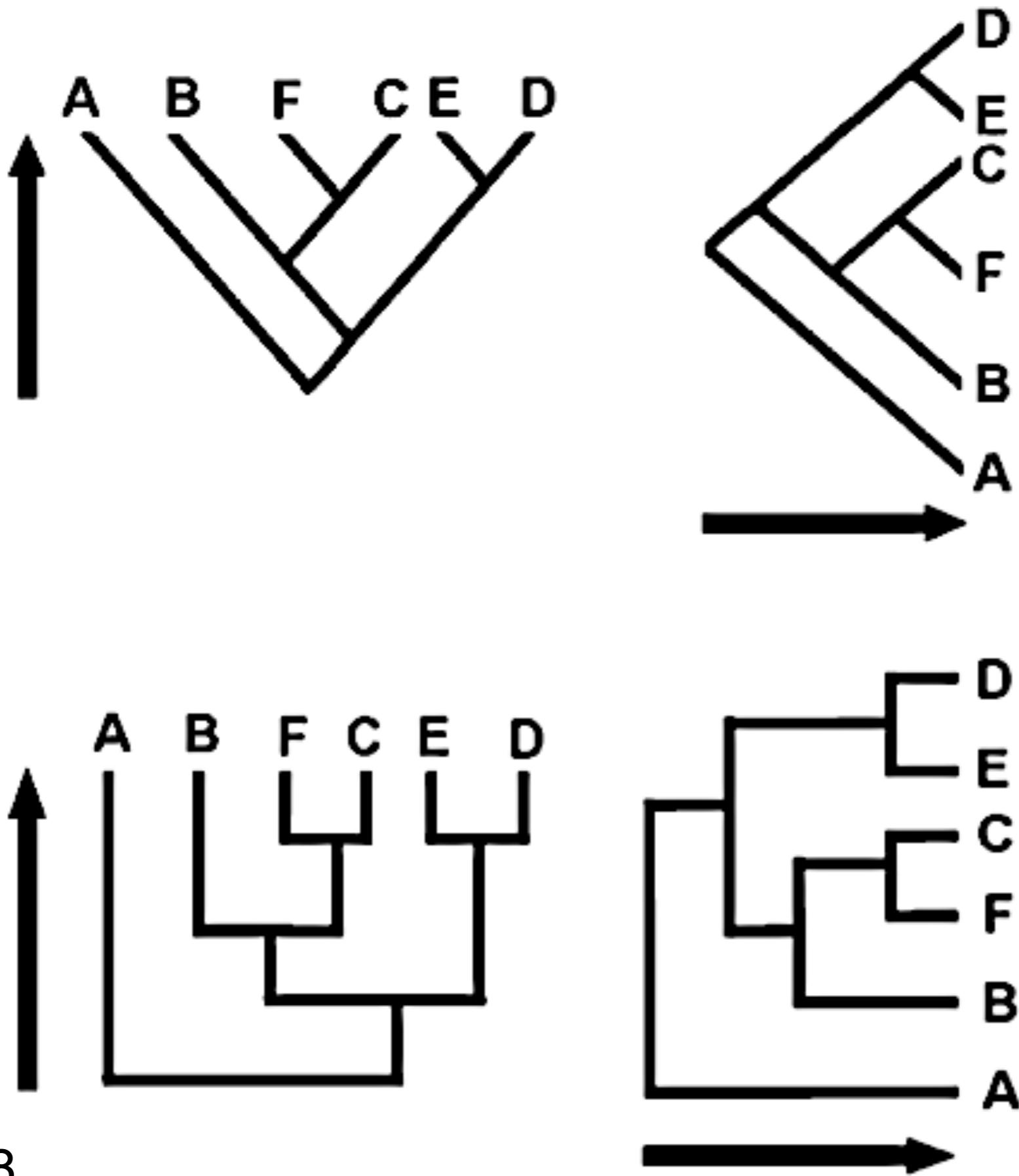
‘phylogram’ - branch lengths proportional to amount of change separating two nodes

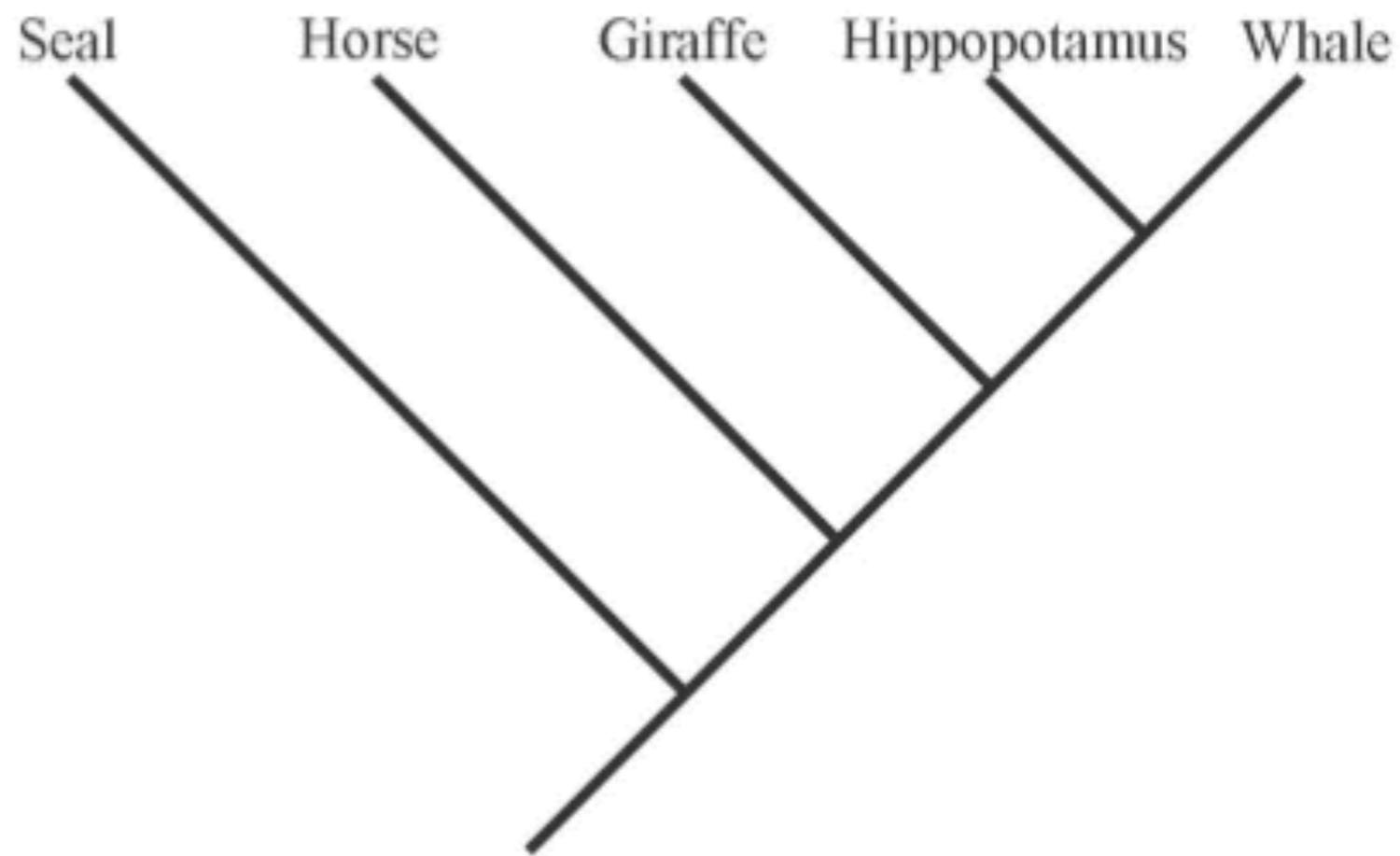
‘chronogram’ - a phylogram scaled to time, relative or real





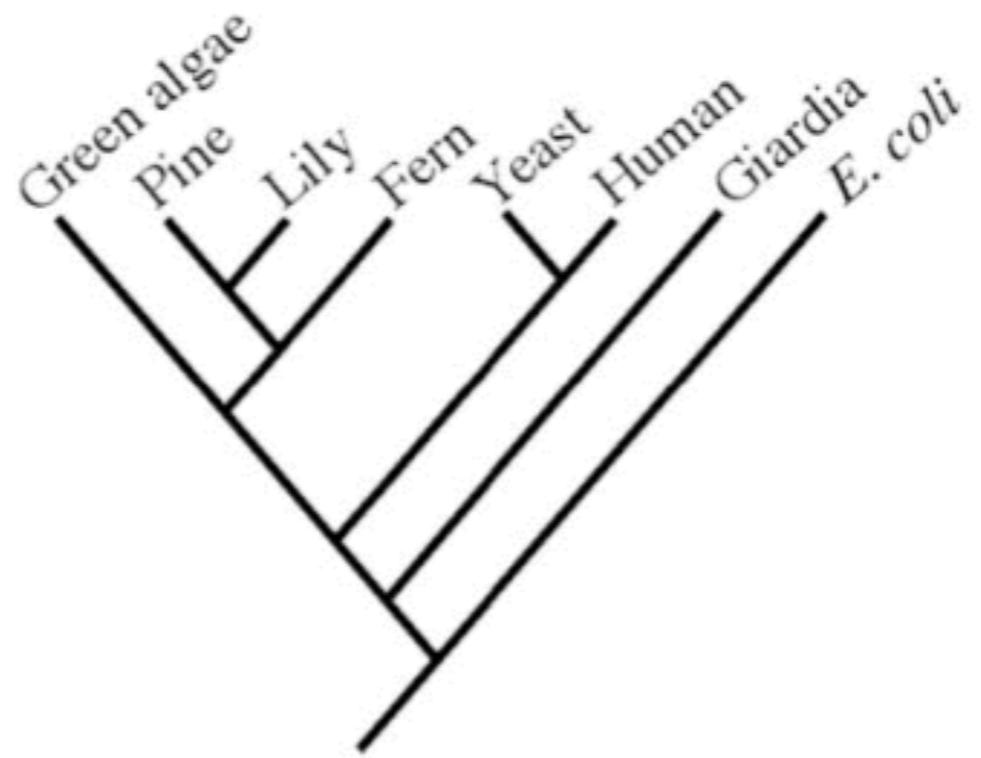
The same tree can be drawn
in many ways



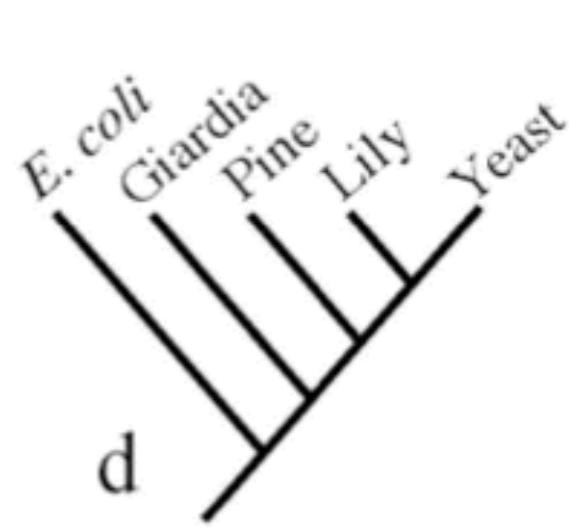
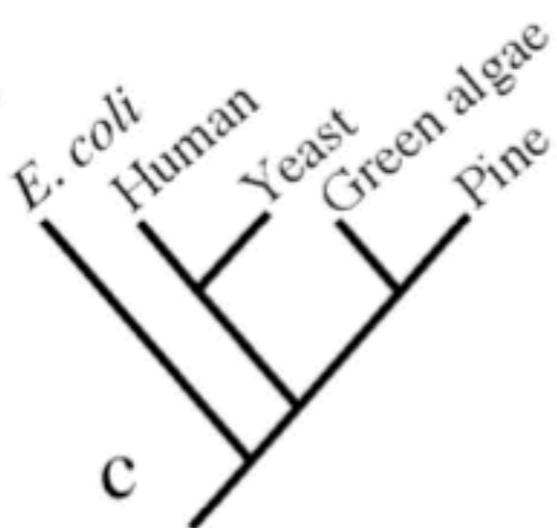
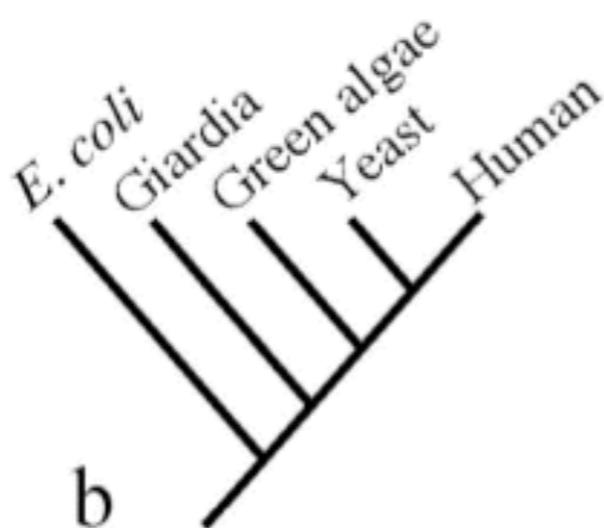
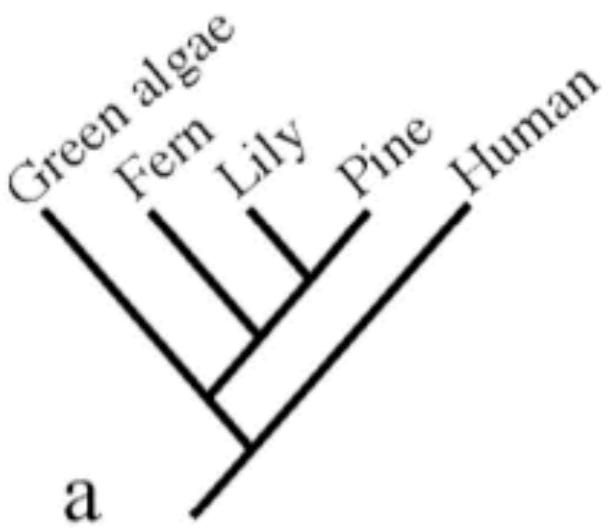


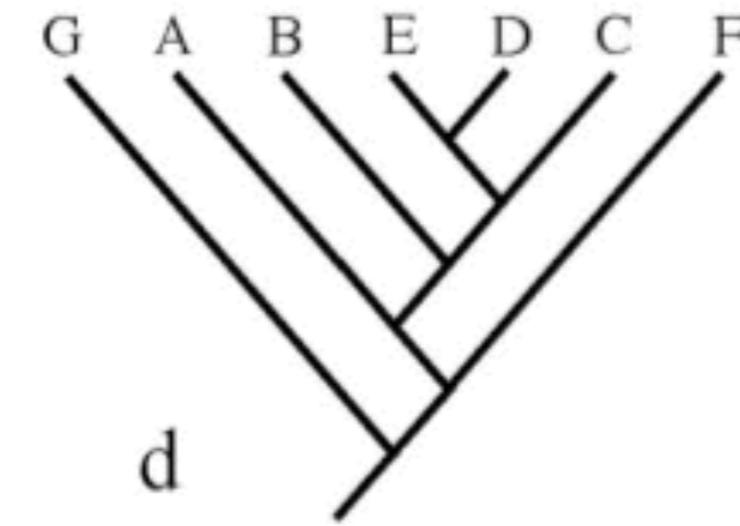
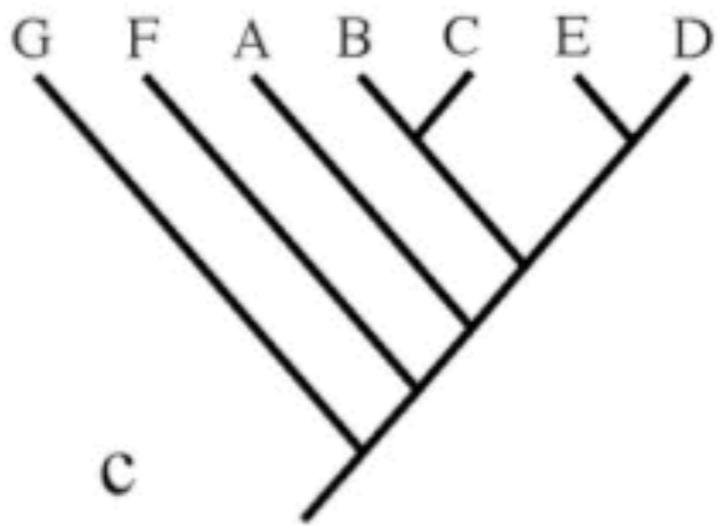
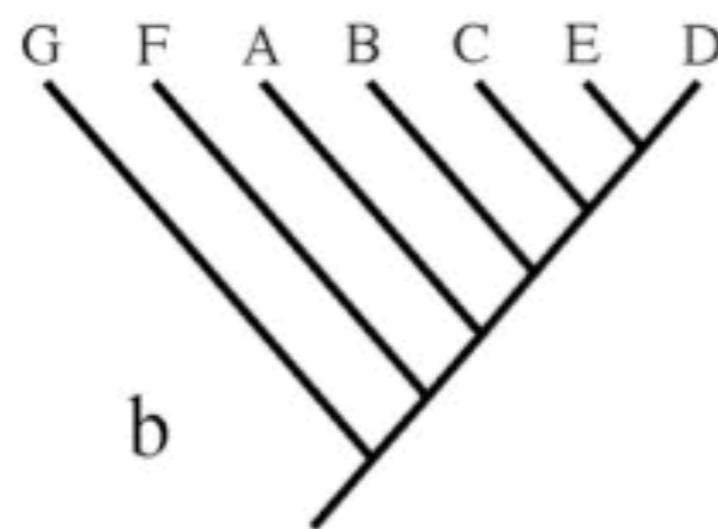
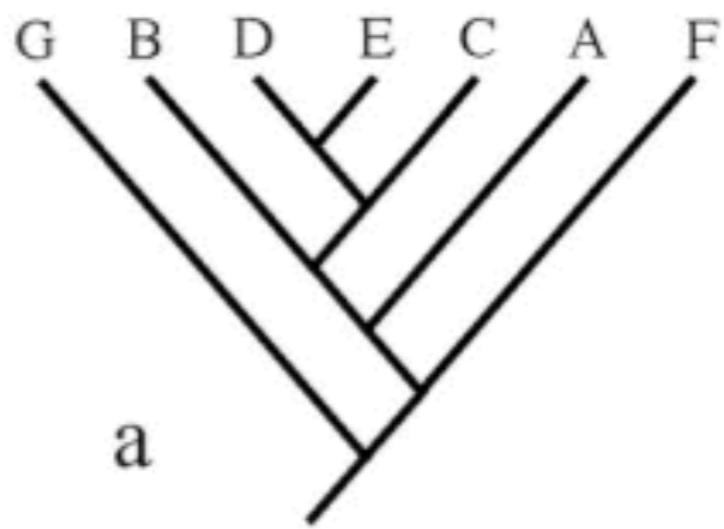
3) By reference to the tree above, which of the following is an accurate statement of relationships?

- a) A seal is more closely related to a horse than to a whale
- b) A seal is more closely related to a whale than to a horse
- c) A seal is equally related to a horse and a whale
- d) A seal is related to a whale, but is not related to a horse

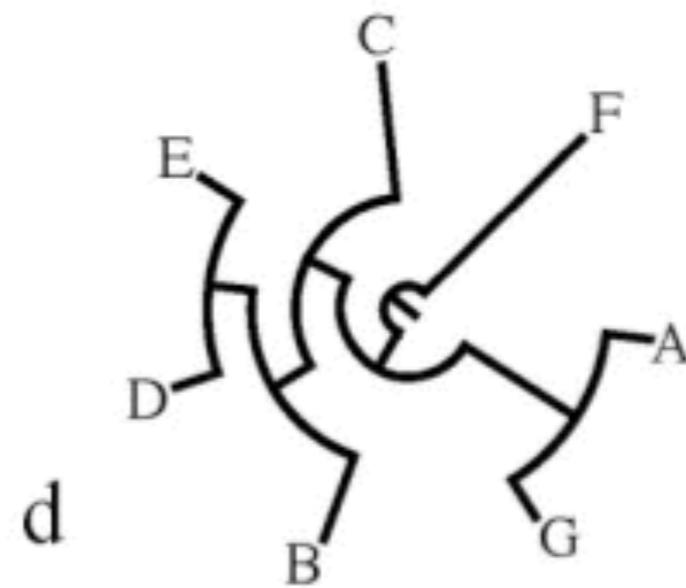
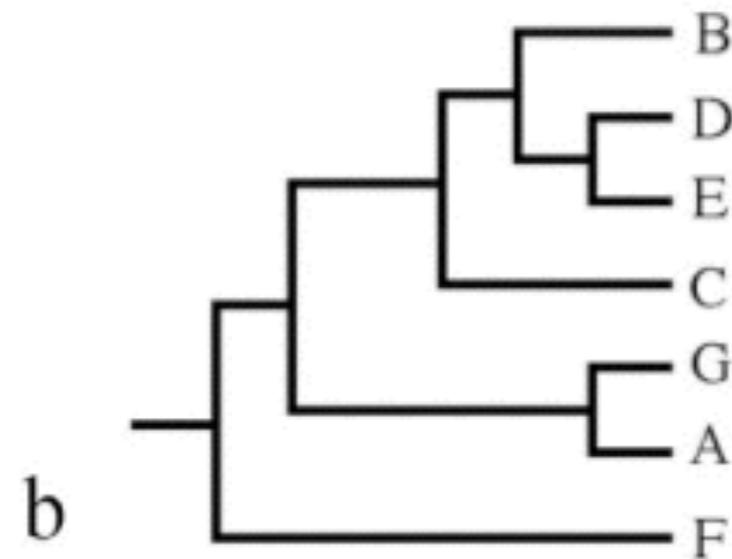
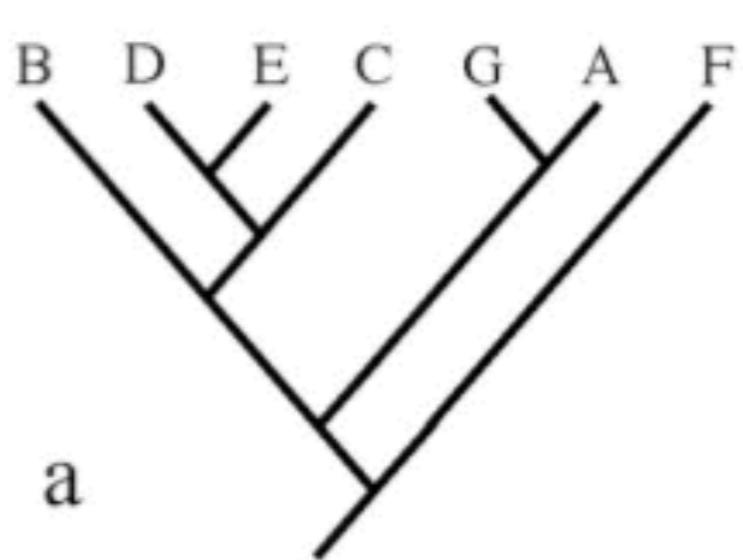


6) Which of trees below is false given the larger phylogeny above?





7) Which of the four trees above depicts a different pattern of relationships than the others?



8) Which of the four trees above depicts a different pattern of relationships than the others?

Building phylogenies

These methods aren't just placing
more similar taxa together!

Similarity can be due to a **pleisiomorphies**-
shared ancestral characters

Trees are built with **synapomorphies**-
shared derived characters

Tree inference methods identify
synapomorphies and use these to infer
relationships

- 1- Collect character data, and identify homologous characters across organisms
- 2- Look for the phylogeny that best explains the character data according to an evolutionary process and an optimality criterion
- 3- Assess how strong the support is for particular relationships

Optimality criteria

Parsimony - Find the tree that minimizes the number of changes needed to explain the character data

Maximum likelihood - Find the tree that maximizes the likelihood of the observed character data given a sequence evolution model

Maximum likelihood cont...

Likelihood is the probability of the data (D) given a hypothesis (H).

In our case, the data is our character information and the hypothesis is a particular tree and model of character evolution

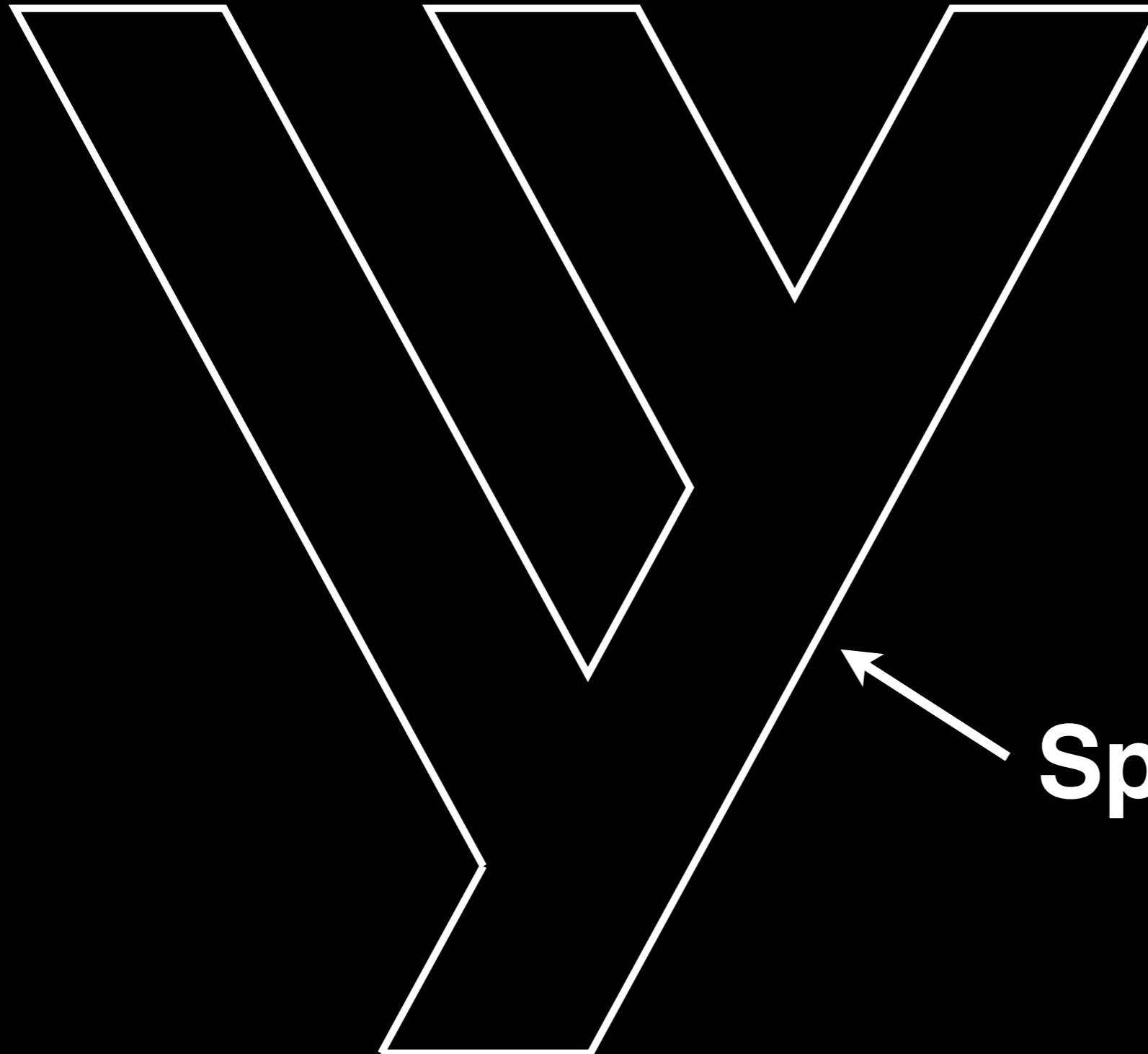
Species A



Species B



Species C



Species tree

Species A



Species B



Species C



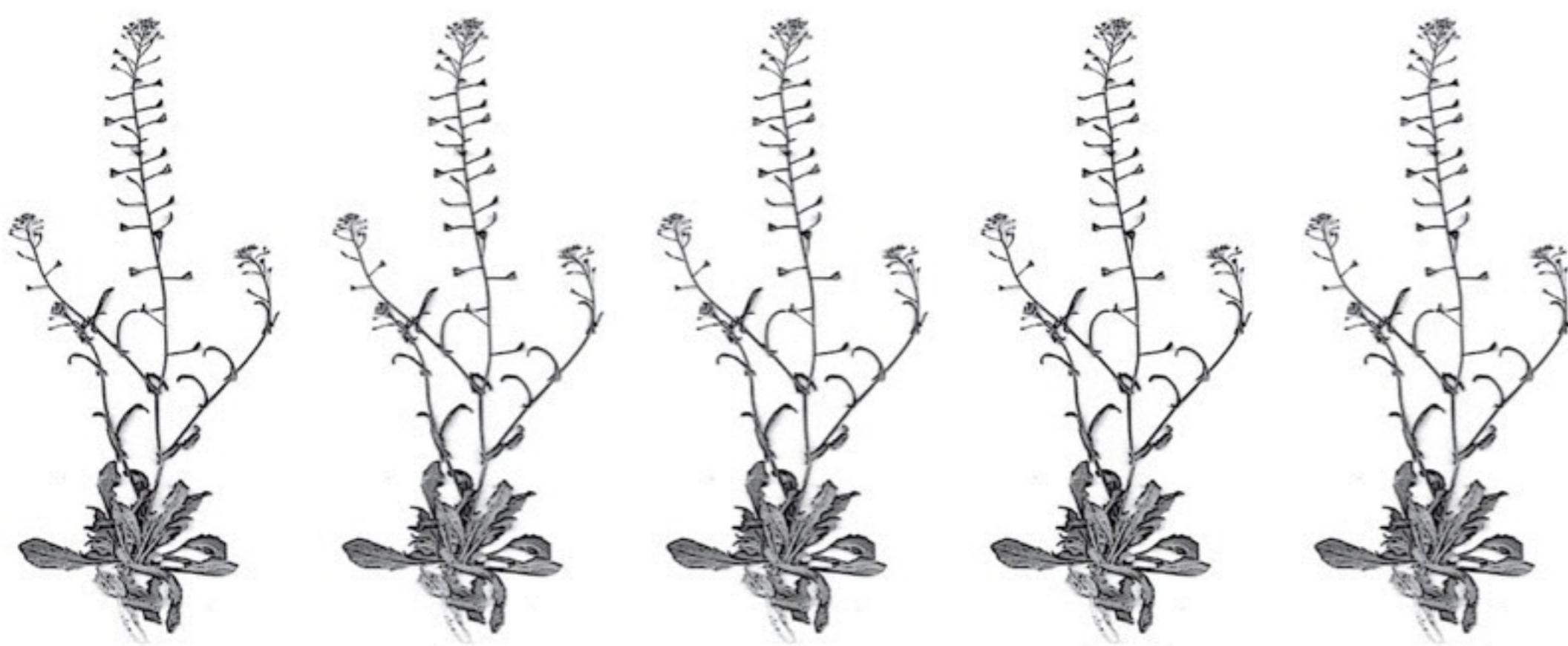
Gene tree

“Orthologs”

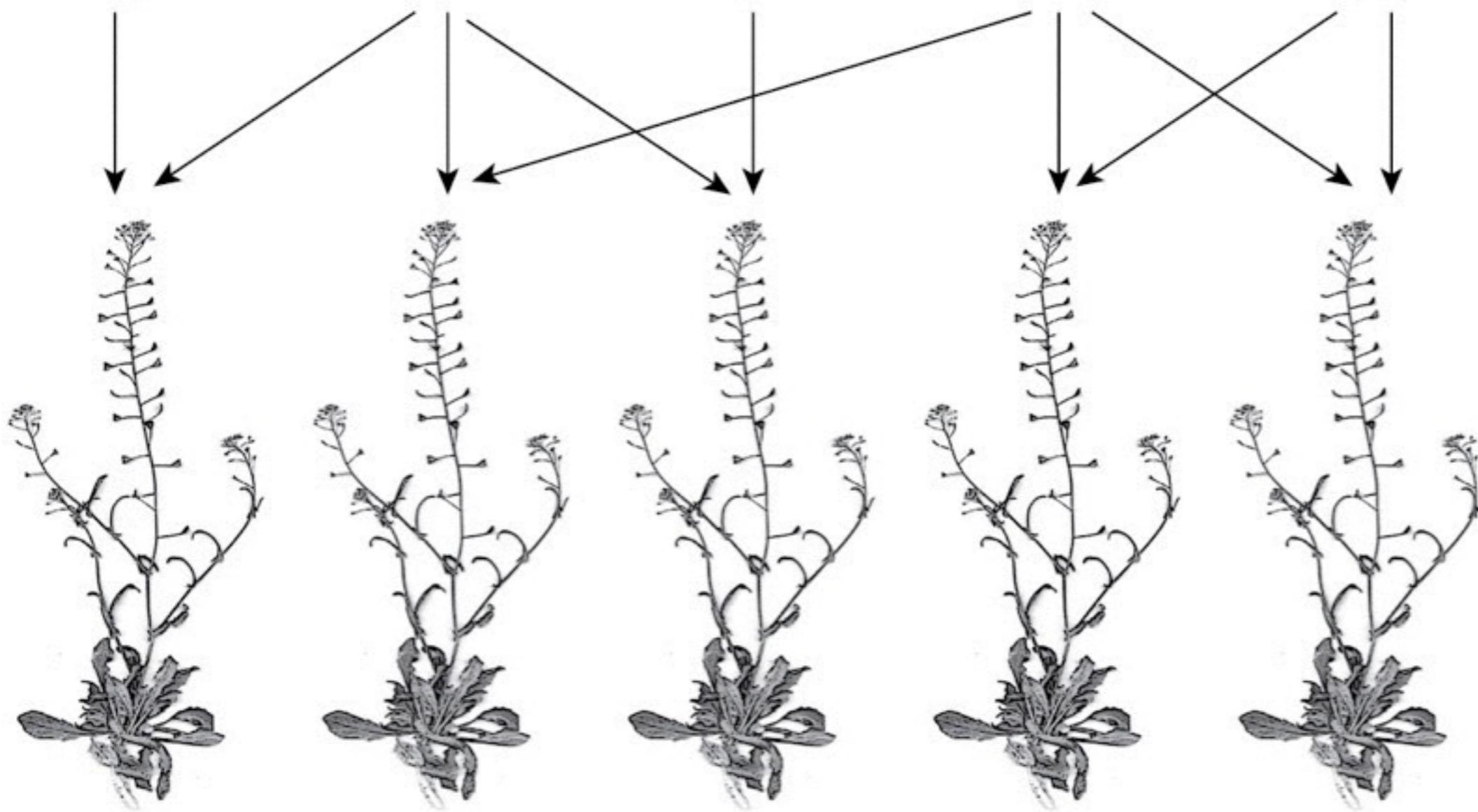
Gene divergence
due to speciation

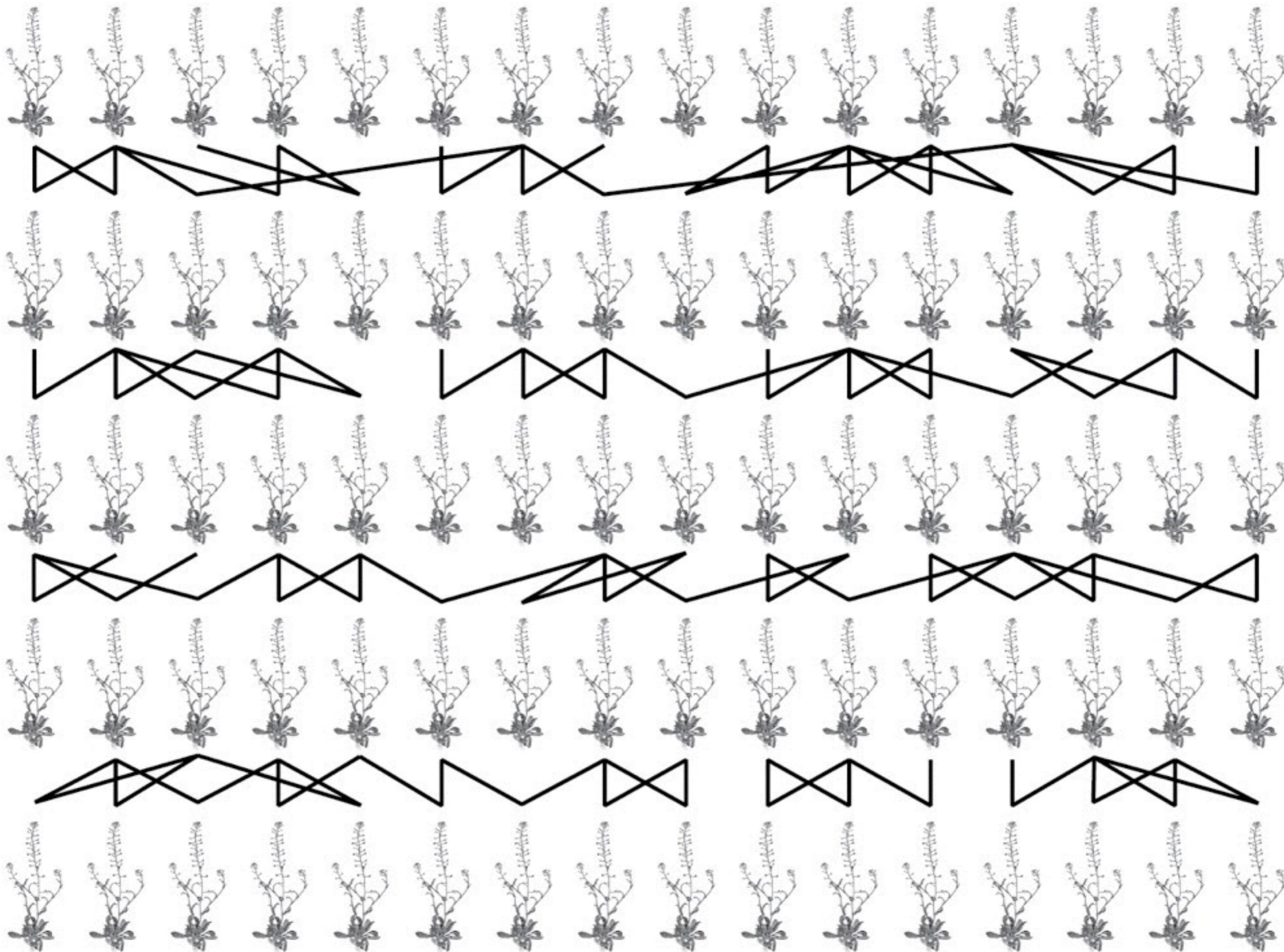
Phylogenies summarize
population
demographics

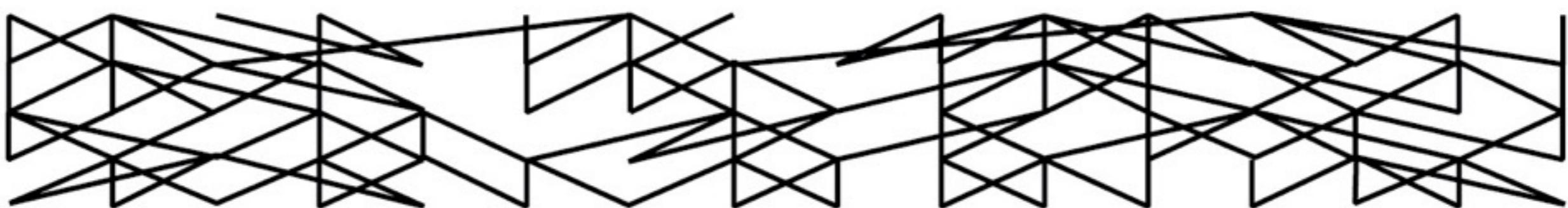
Parents—
Generation 1

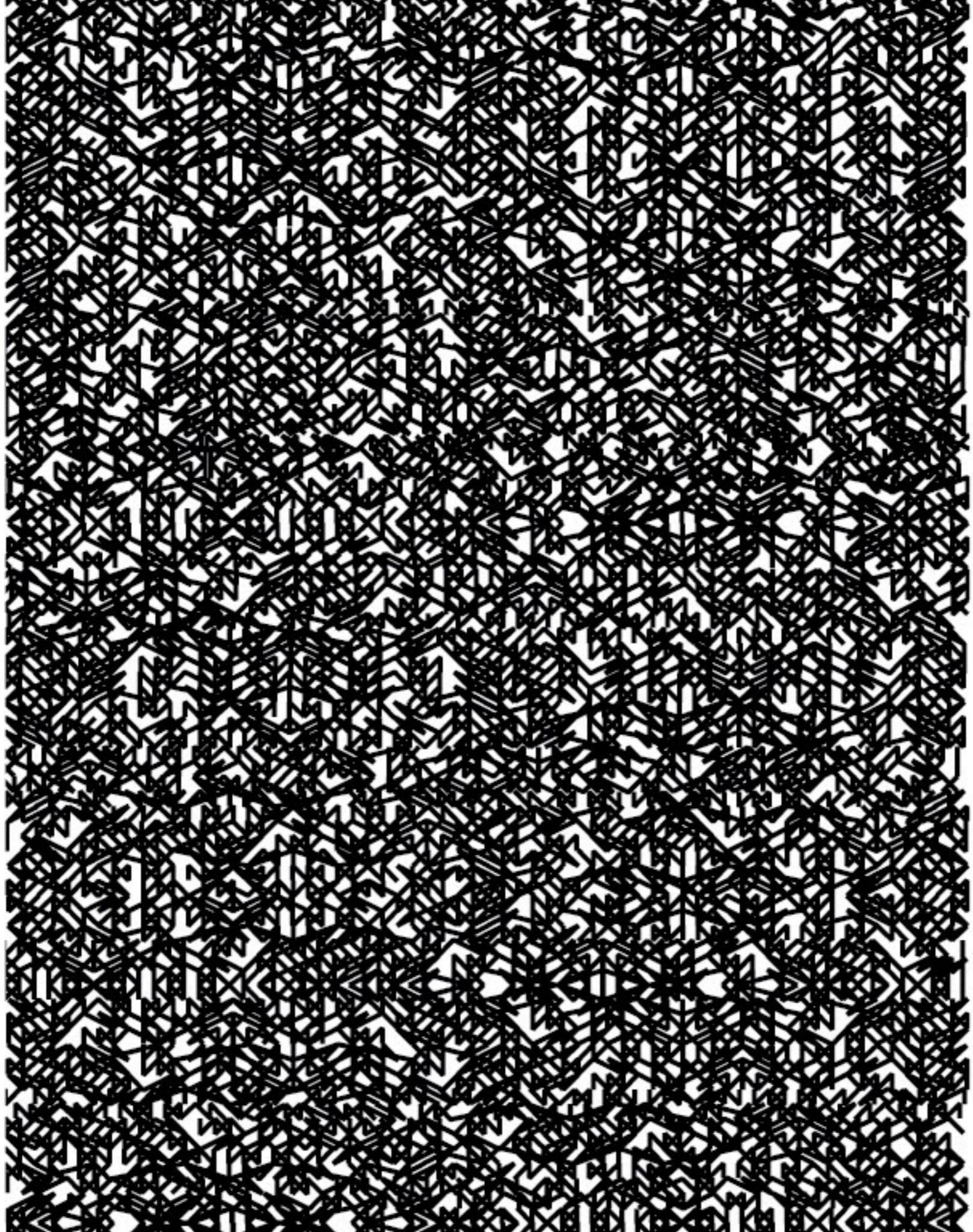


Offspring—
Generation 2











Past



Present

