Selection Directions

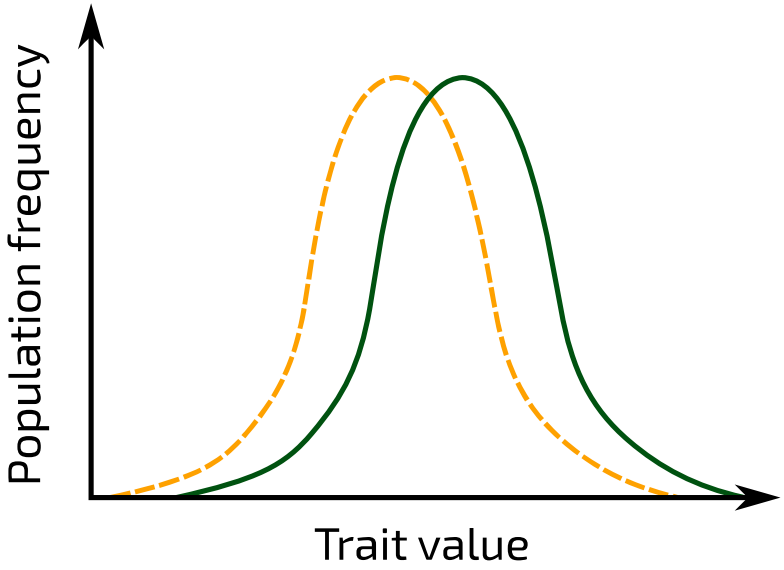
A Level

The effects of natural selection can be measured by observing changes in the distribution of a trait. This is particularly useful for traits that display continuous variation. Depending on how the distribution changes, natural selection can be classified into different types.

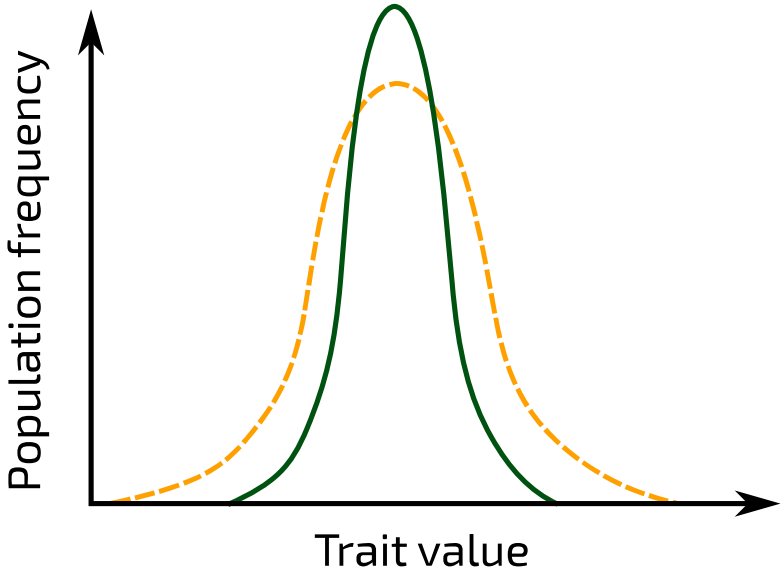
Part A Types of natural selection

The three images below each show a different type of natural selection acting on a trait that displays continuous variation.

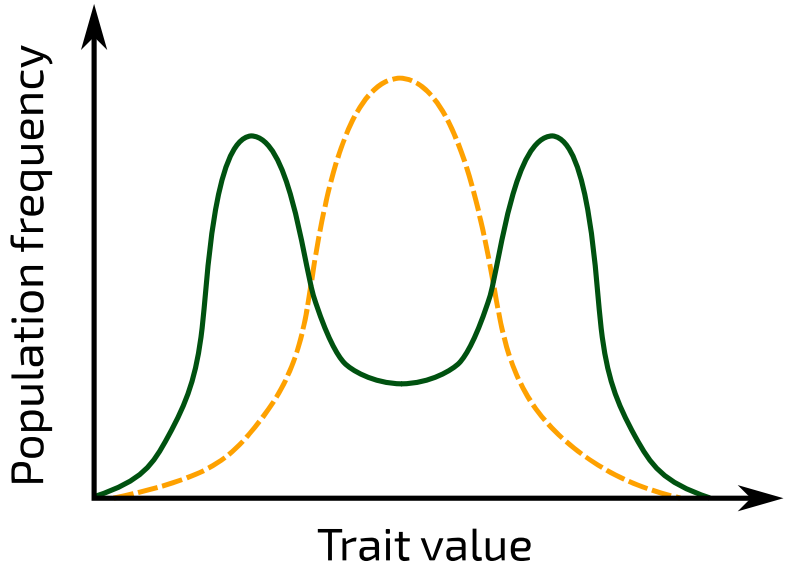
In each image, the yellow dashed line shows the frequency distribution of a trait in the previous generation, and the green solid line shows the frequency distribution of that trait in the current generation.



A



B



C

Match the type of natural selection to the images above.

- A: [ ]
- B: [ ]
- C: [ ]

Items:

artificial selection **stabilising selection** **directional selection** **disruptive/diversifying selection** **genetic drift**

Which type of selection is the most likely to lead to speciation?

- A
- B
- C

Part B Examples

Examples of different types of natural selection are given in the table below.

Example	Description
A	In a population of moths, larvae range in colour from very dark to very bright. Very dark larvae avoid predation by being hard to see, whereas very brightly-coloured larvae avoid predation by imitating the colours of poisonous caterpillars. As a result of this, after a few generations, there are fewer intermediate-coloured larvae. More of the larvae in the population are now very dark or very bright.
B	In one population of stag beetles, males have a mean antler length of $15\,\text{mm}$. There is a lot of variation in this population. However, males with very small antlers do not get to mate with females, and males with very large antlers are less able to escape from predators. As a result of this, after a few generations, there is less variation in antler length. The mean antler length is still $15\,\text{mm}$.
C	A population of lizards has a mean mass of $1.1\,\text{kg}$, with variation showing a normal distribution around this peak. However, small lizards are able to hide from predators, and large lizards are able to fight off predators, but medium-sized lizards can do neither. As a result of this, after a few generations, most lizards are either small or large, with very few medium-sized lizards. The mean mass is still $1.1\,\text{kg}$.
D	A population of birds has a mean beak length of $53\,\text{mm}$. In this population, birds with smaller beaks are better at extracting food from small spaces, and so their survival is improved. As a result of this, after a few generations, the mean beak length is $44\,\text{mm}$.

Match each example above to the the type of selection.

- **A**:
- **B**:
- **C**:
- **D**:

Items:

disruptive selection **directional selection** **stabilising selection**

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Taxonomy

A Level

Taxonomy is the practice of naming and classifying organisms into hierarchical groups.

Carl Linnaeus founded the taxonomic system (Linnaean taxonomy) that is still used today, though it has been modified over time. Linnaeus classified organisms into hierarchical groups based on shared physical characteristics.

Although the system is still in use today, biologists now classify organisms based on their evolutionary relationships to each other rather than their physical characteristics. In some cases, this fits with Linnaean taxonomy, but in other cases it does not.

Part A Linnaean taxonomy

Drag the taxonomic levels in the correct order on the right, with the highest level on the top and the lowest level on the bottom.

Available items

- Kingdom
- Family
- Class
- Order
- Phylum
- Species
- Genus

Part B Classification example

Match the taxonomic level to the name in the table below for humans.

Taxonomic Level	Name
Kingdom	
	Chordata
Class	
	Primates
	Hominidae
Genus	
Species	

Items:

Human **Family** **Phylum** ***Homo*** **Order** ***sapiens*** **Domain** **Animalia** **Mammalia** **Plantae**

Part C Evolutionary taxonomy

One of the problems with Linnean taxonomy is that it does not necessarily match actual evolutionary relationships and groups.

The five kingdoms in Linnaean taxonomy are:

- Prokarya (prokaryotes)
- Protoctista (protists)
- Plantae (plants)
- [ ]
- Animalia (animals).

However, the latter four kingdoms are all more closely related to each other than any of them are to prokaryotes. By looking at the evolutionary tree of all life on earth, we can see that it forms three main branches, which we call [ ]: Bacteria, [ ], and Eukarya (eukaryotes).

Similarly, the seven vertebrate classes in Linnaean taxonomy are:

- Agnatha (jawless fishes)
- Chondrichthyes (cartilaginous fishes)
- Osteichthyes (bony fishes)
- Amphibia (amphibians)
- Reptilia (reptiles)
- [ ] (birds)
- Mammalia (mammals)

However, we now know that birds evolved from a group of reptiles (dinosaurs), and so describing birds and reptiles as separate classes does not match the actual evolutionary relationships.

Items:

Archaea **Aves** **genera** **Birdia** **Fungi** **species** **domains**

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Speciation

A Level

Part A Species definition

A species is defined as a group of organisms that are capable of breeding together to produce [ ] offspring. If two organisms breed together to always produce [ ] offspring (or cannot produce any offspring together), these organisms are considered separate species.

A species is usually comprised of many [ ], which may be geographically separated from each other. However, individuals from these separate groups would be able to breed together if they were in the same location, which is why they are classified as members of the same species.

This definition of a species has some problems. For example, it does not apply to organisms that reproduce [ ]. It also does not apply well to plants, which are generally more able to produce fertile hybrids than animals are.

Items:

communities **sexually** **sterile** **asexually** **populations** **fertile**

Part B The process of speciation

Speciation is the process by which one species splits into two (or more) species. For this process to happen, [ ] must occur between populations i.e. something must prevent individuals from one population from breeding with individuals from another population.

[ ] speciation is when this happens due to populations being geographically separated from each other.

[ ] speciation is when this happens within the same geographical area. In this case, the population may split into two separate populations due to a behavioural difference e.g. differences in mating behaviours or mate preference.

Once the populations are isolated from each other, different mutations can accumulate in the populations because of natural selection and/or [ ]. Eventually, the genomes of individuals from the separate populations will have become different enough that they cannot produce [ ] offspring together. At this point, the two populations will be classified as different species.

Items:

genetic drift **fertile** **Sympatric** **Allopatric** **reproductive isolation** **sterile**

Part C Adaptive radiation

An adaptive radiation is a particular type of speciation in which:

- one species evolves into [ ] species
- speciation occurs [ ] than usual
- each species adapts to occupy a different ecological [ ] (e.g. Darwin's finches adapting to eat different foods)

Adaptive radiation most often occurs on islands or in lakes that have not previously been occupied by organisms of that taxonomic group, which means there are abundant resources and little competition.

Items:

many **faster** **trophic level** **niche** **no more than two** **slower**

Phylogenetic Trees

A Level

A phylogeny is the evolutionary history of an organism or a group of organisms. A phylogenetic tree (also called an evolutionary tree) is a diagram that illustrates this evolutionary history of a group of organisms, and the evolutionary relationships within the group. Phylogenetic trees can be drawn in different ways, as shown in **Figure 1**.

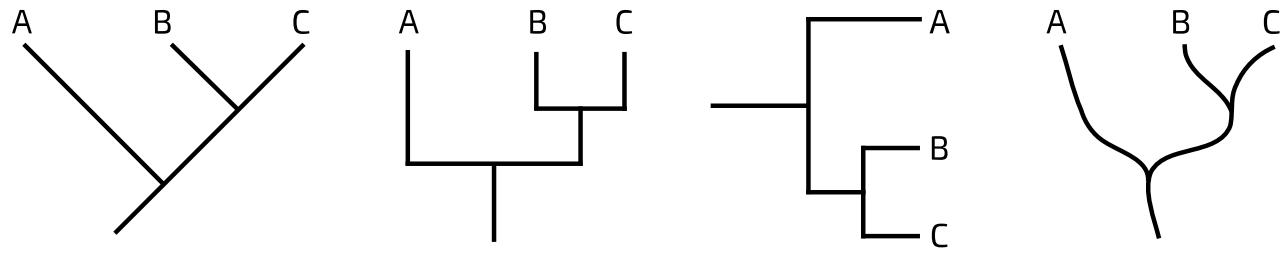
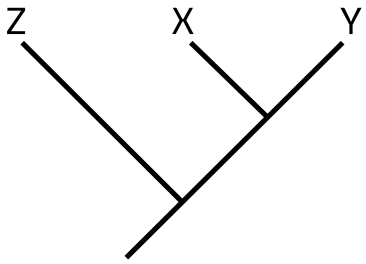


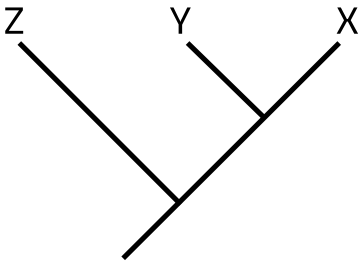
Figure 1: The phylogeny of three species (A, B, C) is shown in four different phylogenetic trees. All four trees show the exact same phylogeny but in different ways. Species B and C form a cluster of two species, and species A is the "outgroup".

In each of the phylogenetic trees above, **B** and **C** could switch places and the phylogeny would be the same - **B** and **C** would still be more closely related to each other than either are to **A**.

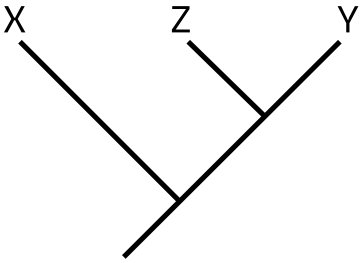
Part A Three species



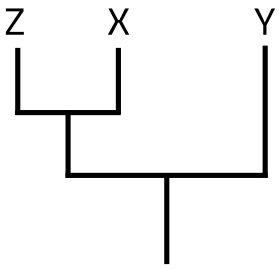
The image above is a phylogenetic tree of three species (X, Y, Z). Which of the phylogenetic trees below show the same phylogeny as above? Select all that apply.



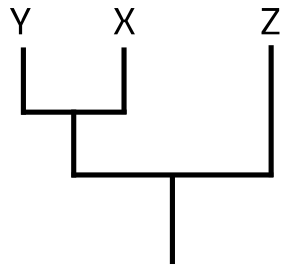
A



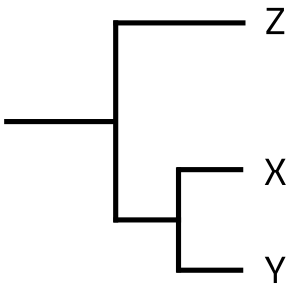
B



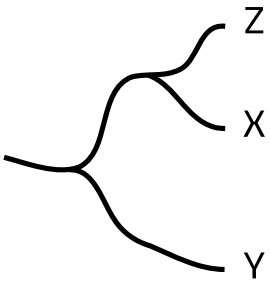
C



D



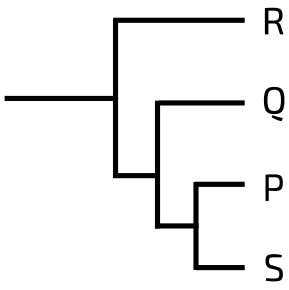
E



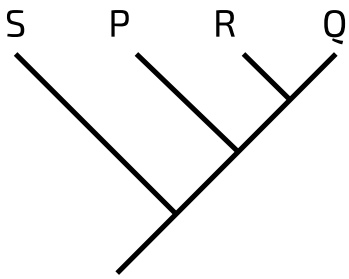
F

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E
- [ ] F
- [ ] none of the above

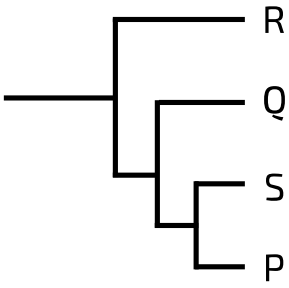
Part B Four species



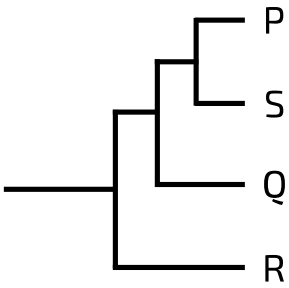
The image above is a phylogenetic tree of four species (P, Q, R, S). Which of the phylogenetic trees below show the same phylogeny as above? Select all that apply.



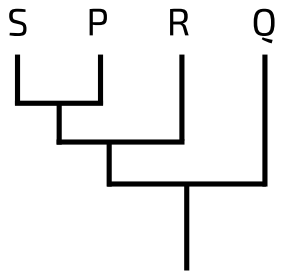
A



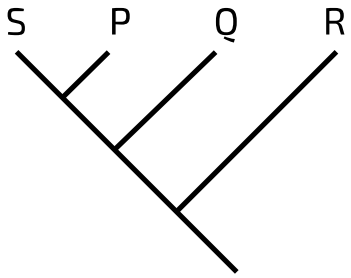
B



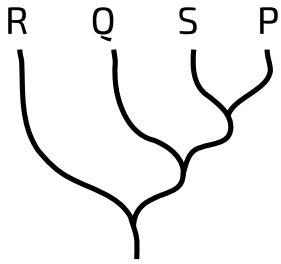
C



D



E



F

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E
- [ ] F
- [ ] none of the above

Part C Tree structure

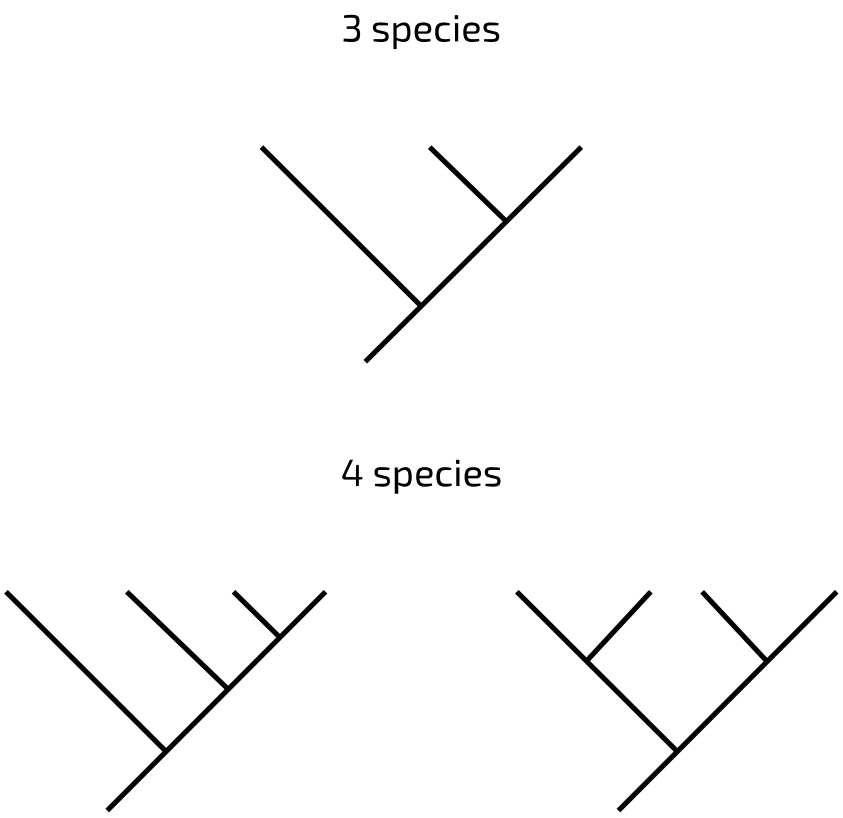


Figure 2: Tree structures. A phylogeny of three species only has one tree structure: two of the species will cluster as one group, and the third species will be an outgroup. A phylogeny of four species has two possible structures. One species may be an outgroup to the other three species (in which one species is an outgroup to the other two species), or there may be two clusters, each contain two species.

As shown in **Figure 2**, a phylogeny of three species only has one possible tree structure, whereas a phylogeny of four species has two possible tree structures.

How many tree structures are possible in a phylogeny of five species?

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Evolutionary Relationships

A Level

Part A Bony fishes

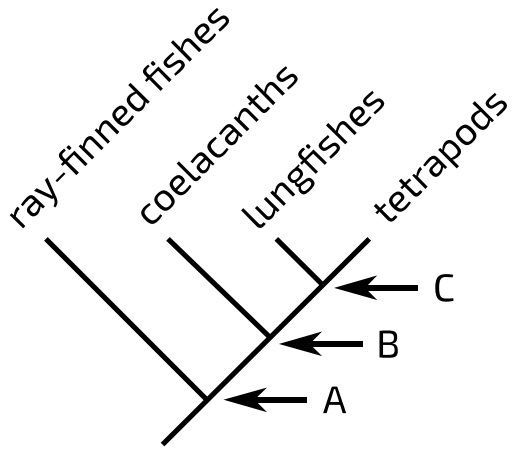

Figure 1: A simplified phylogenetic tree of bony fishes. Arrows (A,B,C) label "nodes" on the phylogeny. Each node represents the last common ancestor of the branches that project from that node.

Based on **Figure 1**, which of the following statements are correct? Select all that apply.

- [ ] In **Figure 1**, tetrapods and ray-finned fishes could be switched and the phylogeny would be the same.
- [ ] In **Figure 1**, tetrapods and lungfishes could be switched and the phylogeny would be the same.
- [ ] Coelacanths are more closely related to ray-finned fishes than coelacanths are to tetrapods.
- [ ] Tetrapods are more closely related to lungfishes than either are to coelacanths.
- [ ] Lungfishes are more closely related to coelacanths than lungfishes are to tetrapods.
- [ ] Node **A** represents the last common ancestor of coelacanths, lungfishes, and tetrapods.
- [ ] Node **B** represents the last common ancestor of coelacanths, lungfishes, and tetrapods.
- [ ] Node **C** represents the last common ancestor of coelacanths, lungfishes, and tetrapods.

Part B Tetrapods

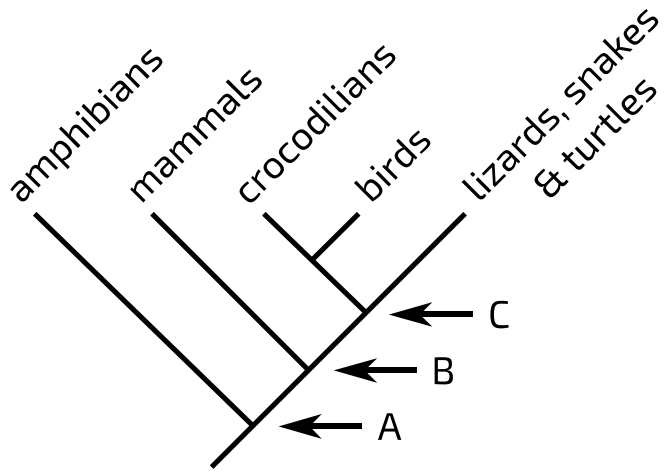

Figure 2: A simplified phylogenetic tree of tetrapods. Arrows (A,B,C) label "nodes" on the phylogeny. Each node represents the last common ancestor of the branches that project from that node.

Based on **Figure 2**, which of the following statements are correct? Select all that apply.

- [ ] In **Figure 2**, birds and crocodilians could be switched and the phylogeny would be the same.
- [ ] In **Figure 2**, amphibians and mammals could be switched and the phylogeny would be the same.
- [ ] Crocodilians are more closely related to lizards than lizards are to birds.
- [ ] Mammals are more closely related to amphibians than either are to snakes.
- [ ] Crocodilians are more closely related to birds than birds are to turtles.
- [ ] Node **A** represents the last common ancestor of crocodilians and birds.
- [ ] Node **B** represents the last common ancestor of crocodilians and birds.
- [ ] Node **C** represents the last common ancestor of crocodilians and birds.

Part C Primates

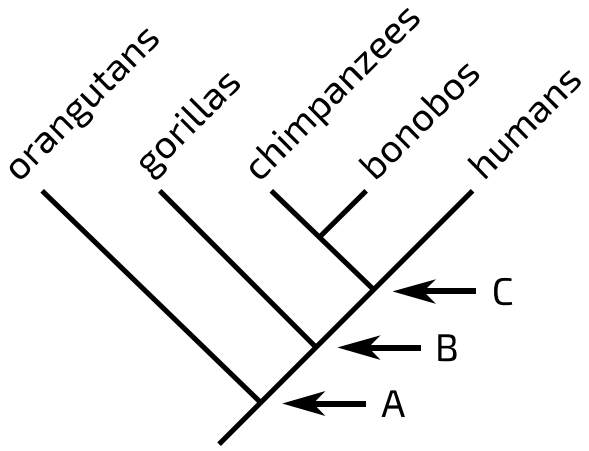

Figure 3: A simplified phylogenetic tree of primates. Arrows (A,B,C) label "nodes" on the phylogeny. Each node represents the last common ancestor of the branches that project from that node.

Based on **Figure 3**, which of the following statements are correct? Select all that apply.

- [ ] In **Figure 3**, gorillas and humans could be switched and the phylogeny would be the same.
- [ ] In **Figure 3**, bonobos and chimpanzees could be switched and the phylogeny would be the same.
- [ ] Chimpanzees are more closely related to humans than chimpanzees are to gorillas.
- [ ] Orangutans are more closely related to gorillas than either are to bonobos.
- [ ] Humans are more closely related to bonobos than humans are to chimpanzees.
- [ ] Node **A** represents the last common ancestor of humans and gorillas.
- [ ] Node **B** represents the last common ancestor of humans and gorillas.
- [ ] Node **C** represents the last common ancestor of humans and gorillas.

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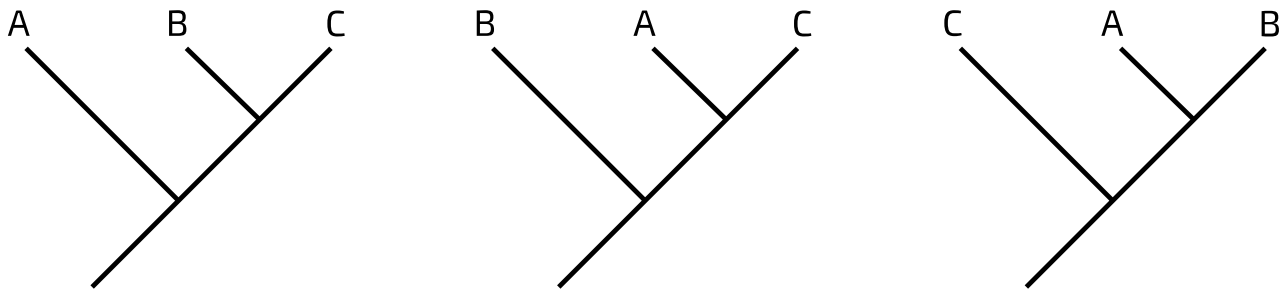
Phylogenetic Possibilities

A Level

The image below shows all of the possible phylogenies for a group of three species (A, B, C).



How many possible phylogenies are there for a group of four species?

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