Name:_____Period:_____

Exploring Phenotypic Plasticity

You have likely at some point seen photos of the adorable Arctic fox with its white fur. The photos below show the same species of Arctic Fox, *Vulpes lagopus*, at different times of the year.

1. The ability to grow differently colored fur based on the season provides Arctic foxes with a selective advantage. What do you think that is?

2. The Arctic fox exhibits "phenotypic plasticity." Propose a definition for each term (or look it up).

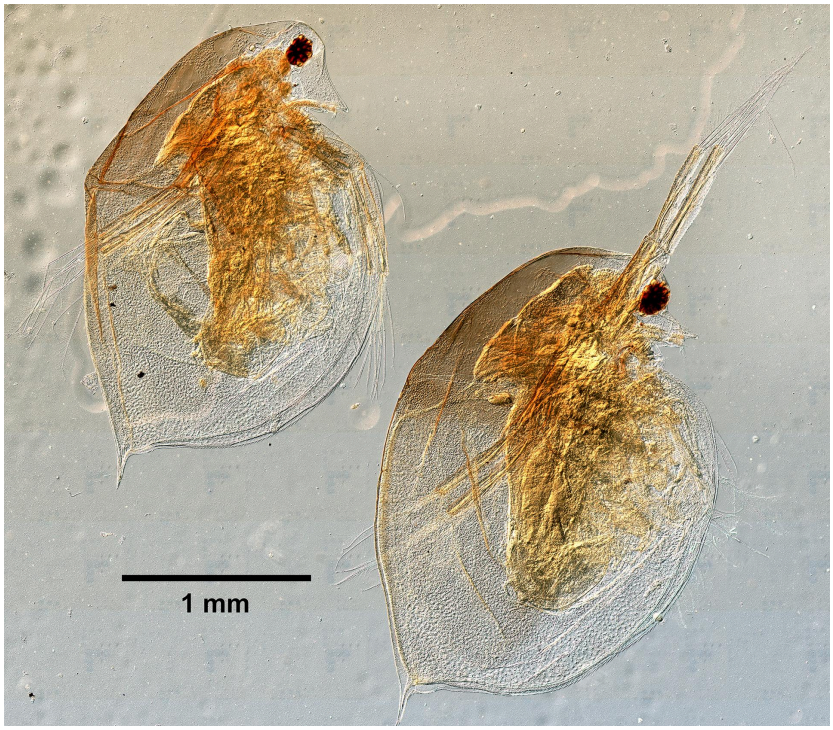
Phenotype	
Plasticity	

Genotype refers to the underlying genetic code, or alleles, that codes for traits, such as fur color. A genome-wide association study (GWAS) identified two color morphs associated with the ***MC1R* gene**. The two common color morphs are the white and blue. White arctic foxes have completely white winter fur and brown fur in the summer. The blue morph is dark brown year round.

3. Consider the two variations in the arctic fox. Where would you expect to find a greater frequency of the white morph compared to the blue morph?

Phenotypic Plasticity in Invertebrates

Daphnia cucullata are tiny aquatic invertebrates. Scientists observe that they can grow longer helmets and tail spines when there are predators nearby. When a juvenile daphnia detects chemical cues from predators they develop these defense mechanisms. Daphnia in water without predators will grow into adults that have less armor.



https://upload.wikimedia.org/wikipedia/commons/1/18/Daphnia_%28YPM_IZ_063600%29_001.jpeg

4. What advantage might this ability to grow longer helmets and tail spines provide to the Daphnia?

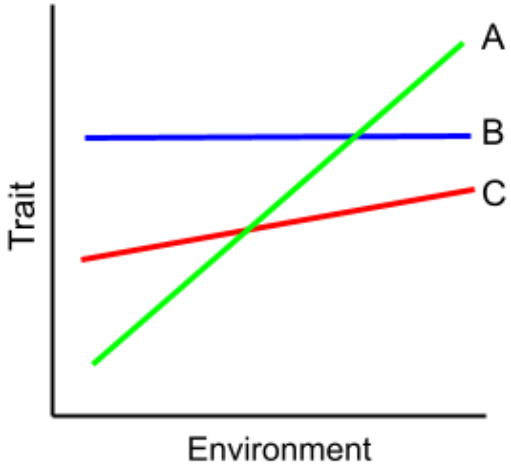
Evolution is considered a series of "trade-offs." An evolutionary trade-off is a situation in which evolution cannot advance one part of a biological system without distressing another part of it. In biology, and more specifically in evolutionary biology, tradeoffs refer to the process through which a trait increases in fitness at the expense of decreased fitness in another trait.

For example, having a strong immune system is advantageous for protection against diseases, but it also may increase the odds of autoimmune diseases, where the body's immune system attacks its own cells.

5. If helmets and spikes can protect against predation, why wouldn't ALL daphnia have this adaptation. Consider what they might be "trading" for this added armor.

Plasticity Varies by Traits and by Species

The graph below shows three traits within populations that have varying degrees of phenotypic plasticity. Phenotypic plasticity refers to some of the changes in an organism's behavior, morphology and physiology in response to a unique environment.



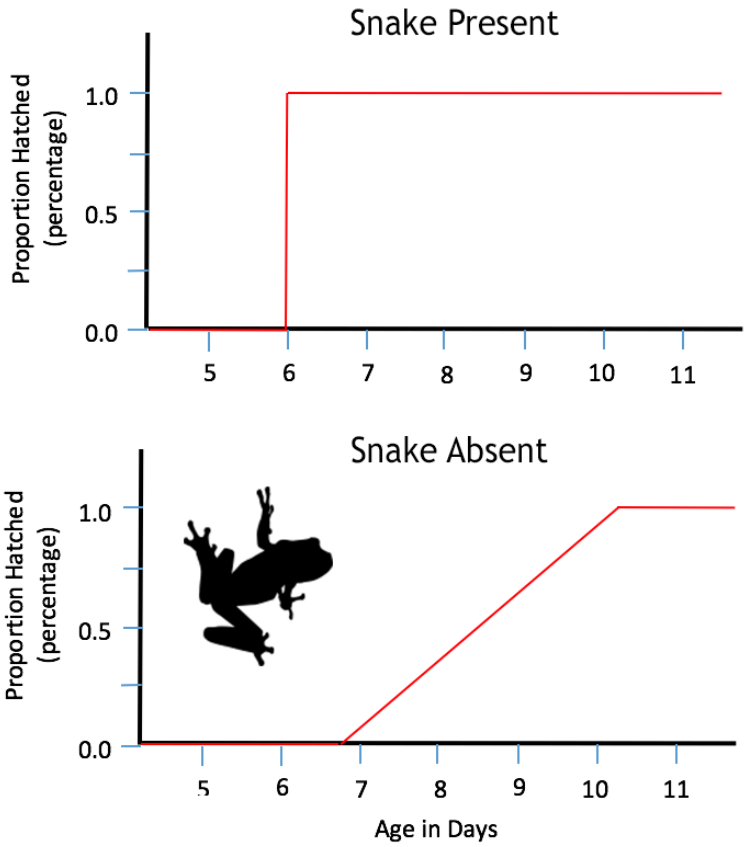
Examine the graph which illustrates levels of plasticity for three species.

6. Which line (A, B, or C) represents a trait with no plasticity? Explain your choice.

7. Which line (A, B, or C) would represent a high degree of plasticity, such as what was observed in the daphnia population? Explain your choice.

APPLICATION: The graphs illustrate the hatching times for red-eyed tree frogs where predatory snakes are present or absent.

8. Explain how the tree frogs provide an example of phenotypic plasticity.



Phenotypic Plasticity or Evolution?

Evolution can be defined as a change in all allele frequencies within a population. These changes occur at a genetic level as individuals with advantageous traits survive and reproduce more offspring.

In rock pocket mice, scientists observe that the groups of mice living on rocky substrates have dark fur, but the mice living on sandy substrates have light colored fur. DNA analysis reveals that a mutation in the *MC1R* gene resulted in the dark pigmentation. A similar mutation occurred in this gene in the blue morph coloration in arctic foxes.

9. What evidence would need to be gathered to determine that coloration in white arctic foxes is a result of phenotypic plasticity rather than evolution by natural selection?

10. **Summarize** the difference between evolution by natural selection and phenotypic plasticity.

Resources:

https://commons.wikimedia.org/wiki/File:Arctic_Fox_Attentive_in_Summer_Coat_(43863665170).jpg
https://commons.wikimedia.org/wiki/File:Arctic_Fox_Looking_Across_(33067136578).jpg

https://en.wikipedia.org/wiki/Phenotypic_plasticity#/media/File:Hatch_rates_for_red-eyed_tree_frog_tadpoles_depends_on_predation.png

https://royalsocietypublishing.org/doi/10.1098/rspb.2021.1452#:~:text=The%20two%20common%20colour%20morphs,brown%20with%20lighter%20ventral%20sides

https://en.wikipedia.org/wiki/Phenotypic_plasticity#/media/File:Hatch_rates_for_red-eyed_tree_frog_tadpoles_depends_on_predation.png

https://www.livescience.com/55297-how-water-fleas-grow-body-armor.html

Two cysteine substitutions in the MC1R generate the blue variant of the Arctic fox
https://pubmed.ncbi.nlm.nih.gov/15982782/ -

Icons obtained from: http://www.phylopic.org/