

SOURCE Lesson Plans Detail

Animal Adaptations

Topic	Evolutionary Adaptations
Program	Brown Science Prep
Developed by	Michael Fernandopulle
Developer Type	Undergraduate students

Overview / Purpose / Essential Questions

Adaptations are the macroscopic building blocks of biological evolution. In this lesson, students will learn what adaptations are, how they occur, and why they are necessary. Students will also be exposed to deeper knowledge about specific adaptations through study of the axolotl salamander and chameleon. Finally, students will have the opportunity to utilize their knowledge to solve three multifaceted word problems concerning adaptations.

Performance / Lesson Objective(s)

Students should be able to determine which adaptations suit particular environmental conditions, use critical thinking and problem-solving skills, and work through simple logic problems.

Lesson Materials

Evolutionary Adaptations Presentation

Lesson Motivation

Cultivate a richer understanding of biological change, continuity, and complexity while emphasizing the importance of broadly applicable critical thinking and problem-solving skills

Lesson Activities

1st half: lecture format
2nd half: group problem session

Procedure

Part I: Informational Background

-Key terms: anatomy and physiology (*ask students to offer definitions, then explain*) (anatomy=structure, physiology=function)

· Gauge prior knowledge (**first have students offer own answers to these questions*)

- o What is an adaptation? Give examples.
 - Anatomical, behavioral, or physiological characteristics of a particular species that enable survival in its environmental niche
 - Whale blubber, lion teeth, tarsier eyes
- o What does it mean to adapt?

- **Change in response to external pressure (general)**

- Practical examples: adjusting to swimming pool temp, increased appetite in response to increased physical activity, feeling tired later after regularly staying up to study, etc.

- ***Important: favorable anatomical, physiological, or behavioral characteristics are conserved (continuity)**

- o How does adaptation occur?

- Mutation, breeding selection, increased success of certain allele

- o In the long run, is adaptation an active or passive process? In the short run? Are there different kinds of adaptation?

- Long run=heritable→passive (genetic)

- Thick coat of fur for animals that live in cold climates

- Short run=individual→active or passive

- Active (behavioral)= i.e. building a shelter in response to a storm
- Passive (physiological)= i.e. thermoregulation, increased appetite

- What do organisms adapt to? (Differential environmental pressures)

- o What do organisms have to deal with in the (blank) and what adaptive mechanisms are necessary? (*possibly have students draw, call attention to distinctive components*)

- Rainforest?

- Humidity, abundance of other organisms, heat
- Efficient water excretion, relationships with other animals (predator/prey, symbiosis, etc.), thermoregulation

- Desert?

- Dry, isolation from other animals, heat
- Efficient water conservation, defense from other animals, thermoregulation

- Mountains/high elevations?

- Low oxygen levels, treacherous landscapes, cold
- Efficient oxygen consumption, feet adapted to rock surfaces, thermoregulation

- o Interaction with other individuals

- Predator/prey (what anatomical, behavioral characteristics might be necessary or helpful?)

- Hunting
- Escaping

- Mating

- Reproductive isolation (temporal, habitat, behavioral, mechanical, gametic)

- Short Examples (*show pictures, ask students how these animals' anatomical, behavioral, physiological characteristics aid in adaptation to their environments*)

- o Frilled Dragon (*Chlamydosaurus kingii*)

- Habitat: savannah woodlands of Australia, southern New Guinea
 - Leathery skin conserves moisture
 - Arboreal tendencies make use of trees, long tail maintains balance
- Predators: large snakes, dingoes, owls, foxes, birds of prey
 - Large colored frill creates illusion of large size, startles potential predators

- o Platypus (*Ornithorhynchus anatinus*)

- Habitat: small streams and rivers on Australian east coast
 - Dense fur traps layer of air, keeps animal warm
 - Webbed feet: swimming
 - Duck-like snout: electroreceptors detect electric fields generated by muscle contractions (hunting)
- Fun fact: 1 of two species of mammal that lays eggs (called monotremes)

- o Extremophile Archaea

- Habitats: deep-sea hydrothermal vents, geysers, lakes with high concentrations of salt, etc.
 - Ex. Halobacteria, acidobacteria
 - Specially adapted to live in extremely harsh environments

- **Extended example 1: the Chameleon (*show picture or video of chameleon*)**

- o Habitat: tropical and mountain rainforests, savannas, sometimes deserts and steppes (grasslands w/out trees, i.e. prairies)

- o Notable Characteristics (*how might these help the chameleon adapt to its environment?*)

- Slow, wavy, deliberate movements
 - Blend with surroundings, evade capture by predators
 - Appear to be leaves blowing in the wind
- Independently-moving eyes with near-360° vision range
 - Detect predators
- Tongue up to twice length of body
 - Catch prey from chosen vantage points
- Prehensile tail (can grasp things)
 - Tree climbing

- Zygodactylous feet (two toes face forward, two backward)
 - Tree climbing
- o Color Change (**Chromatophores**)
 - *Show video of chameleon color change*
 - Pigment-containing and light reflecting cells found in amphibians, fish, reptiles, crustaceans, and cephalopods (mollusks)
 - Tissue order (*show simple diagram*)
 - First: transparent outer skin
 - Second: two layers of red and yellow pigment-containing cells (erythrophores and xanthophores, respectively)
 - Third: layers of blue and white light-reflecting cells (iridophores and leucophores, respectively)
 - Fourth: Fibers of black/dark brown melanin (pigment that colors human skin) spread throughout the chromatophore layers (melanophores)
 - Nervous and muscular mechanisms actively transport pigments and reorient reflective plates within chromatophores
 - Show and briefly explain diagram of cephalopod chromatophore
 - **Called “physiological color change” (Why?)**
 - HOW chromatophores effect color change
 - Nervous signals prompt muscle fibers to contract or expand sacculus containing pigment granules
 - Particular colors arise from combination of expansion and contraction with light filtering based on pigment layers
 - Examples: ¹chameleon with contracted melanophores and erythrophores, expanded iridophores, and partially expanded xanthophores will appear green (partial expansion of yellow cells allows blue light to pass through layer, yellow+blue=green) ²angry chameleon fully expands xanthophores and erythrophores, appears bright orange (blocks blue light from below)
 - o *Try more examples to see if the students understand the concept*
 - WHY chameleons change color
 - NOT—primarily, at least—for camouflage
 - Light
 - o Brown chameleon may turn green while basking to reflect bright sunlight
 - Temperature
 - o Cold chameleon may turn darker in order to absorb more heat
 - Mood
 - o Anger, fright, calm, all may result in different color patterns
 - o Signal to other chameleons
 - Mating

- o Brings out the flashiest colors in males
- o One species changes from brown to purple to light blue, eyelids turn yellow with green spots
- Why we care
 - Applications in medicine and basic science
 - o Understanding melanoma (skin cancer), albinism
 - o Melanophores as biosensors for rapid disease detection
 - *Military application: active camouflage

Extended example 2: The Axolotl Salamander

- o Habitat: Cool, shallow, high-altitude freshwater lakes in central Mexico surrounded by dry, inhospitable land (*show pictures*)
- o Notable Characteristics (*how might these help the axolotl adapt to its environment?*)
 - Neoteny
 - Reaches sexual maturity without metamorphosing
 - Retains larval features such as gills, dorsal fin that extends to tail
 - Develops rudimentary lungs → evidence of evolutionary step backward
 - *Why: harsh surrounding terrestrial environment = low survival rate for terrestrial salamanders*
 - Regeneration (*show picture*)
 - Regenerates any amputated appendage completely, in correct proportions, with no scar tissue
 - Can regenerate less vital parts of brain, heart, spine, whole legs
 - *Possible reason: small fragile animals, regeneration increases survival rate*
 - Transplants
 - Near-complete amenability to transplants from other individuals
 - Can restore donor limbs, eyes, parts of brain to complete functionality
 - *Possible reason: biochemically linked to regeneration ability*
- o Regeneration
 - Forms structure called a “blastema” (*show picture*)
 - Aggregation of de-differentiated cells that forms at amputation site
 - o Originates from cells all around injury (cartilage, skin, muscle, etc.)
 - Progenitor cells, not stem cells (*talk about stem cells, pluripotency, multipotency, unipotency, etc.*)
 - o Retain positional identity
 - Regulated by reactivation of Hox genes

- Master regulatory genes in embryonic morphology
- **Cells at amputation site revert to embryonic state to regenerate appendage**
- o Why we care
 - Regenerative medicine (ointment applied to amputated limb stump→promote re-growth)
 - Dysregulated Hox expression can lead to carcinogenesis
 - Research topic: methods to limit axolotl regeneration→prevent/slow/halt carcinogenesis (mentors for upper grades may consult accessory powerpoint if they wish to discuss this point further)

Part II: Problem-Based Learning

Wrap up / Conclusion

-adaptation is the keystone of evolution
 -natural selection fashions organisms to best suit their environment
 -habitat loss is extremely destructive and problematic
 solicit feedback on problem-based lessons

Supporting Web Information

<http://en.wikipedia.org/wiki/Adaptation>
<http://en.wikipedia.org/wiki/Amapá>
http://en.wikipedia.org/wiki/Vieques,_Puerto_Rico
<http://en.wikipedia.org/wiki/Venezuela>

Pre Assessment Plan

Give an example of an animal adaptation.

Post Assessment Plan

Ask for an animal adaptation again.

The problem based learning exercise.

Alignment Info

Audience(s)	High school students
STEM Area(s)	Biology
Standard(s)	<i>Life Sciences (RI GSE) LS1.5–6.1a</i> Students demonstrate understanding of biodiversity by... recognizing that organisms have different features and behaviors for meeting their needs to survive (e.g., fish have gills for respiration, mammals have lungs, bears hibernate). <i>Life Sciences (RI GSE) LS1.7–8.1a</i> Students demonstrate understanding of biodiversity by... giving examples of adaptations or behaviors that are specific to a niche (role) within an ecosystem. <i>Life Sciences (RI GSE) LS1.7–8.1b</i> Students demonstrate understanding of biodiversity by... explaining how organisms with different structures and behaviors have roles that contribute to each other's survival and the stability of the ecosystem. <i>Life Sciences (RI GSE) LS1.5–6.2a</i> Students demonstrate understanding of structure and function–survival requirements by... describing structures or behaviors that help organisms survive in their environment (e.g., defense, obtaining nutrients, reproduction, and eliminating waste). <i>Life Sciences (RI GSE) LS1.7–8.2a</i>

	Students demonstrate understanding of structure and function-survival requirements by... explaining how the cell, as the basic unit of life, has the same survival needs as an organism (i.e., obtain energy, grow, eliminate waste, reproduce, provide for defense). <i>Life Sciences (RI GSE) LS1.7-8.2b</i> Students demonstrate understanding of structure and function-survival requirements by... observing and describing (e.g., drawing, labeling) individual cells as seen through a microscope targeting cell membrane, cell wall, nucleus, and chloroplasts. <i>Life Sciences (RI GSE) LS1.7-8.2c</i> Students demonstrate understanding of structure and function-survival requirements by... observing, describing and charting the growth, motion, responses of living organisms
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Grade Level(s)	High School
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