Teaching evolution through human examples: Adaptation to altitude

Grade Levels: 9-12 Duration: 8 class periods

Overview:

Lesson 1, Changing Populations: In this brief lesson, students use their prior knowledge to explain adaptation to extreme environments in icefish. They also propose an explanation for why some physiological traits differ between Tibetans living at high altitudes and other humans living at low altitudes. After gaining experience in other lessons, students will revise and improve their initial ideas.

Lesson 2, The High Life: Students practice developing scientific explanations using evidence to make sound arguments that distinguish between adaptation and adjustment (acclimation). Students learn about physiological adjustments to maintain oxygen homeostasis in lowlanders moving to higher elevations. At the end of the lesson, students are challenged to design an experiment to distinguish adjustment and adaptation to altitude.

Lesson 3, Evolution in Tibet?: Students use data collected from study subjects to develop scientific arguments for each of the major components of evolution by natural selection. Students then are in a position to develop a complete explanation of Tibetan adaptation to altitude. Students next apply their understanding to other scenarios as they describe the evidence they would need to collect to demonstrate natural selection.

Lesson 4, High-Altitude Models: Students learn how to use the Hardy-Weinberg equilibrium model to make predictions about populations in the future and how biologists use an understanding of the model to better understand how populations are changing over time. Students apply their understanding of the Hardy-Weinberg equilibrium model to problems related to the adaptation of Tibetans to altitude. Students then use a population genetics simulation to conduct and analyze an investigation on an evolutionary question of their choosing. In the process, students learn about genetic drift, another important evolutionary mechanism.

Lesson 5, Living High Across the World: Students compare physiological data on Andeans, Ethiopians, and Tibetans. After recognizing that these three groups differ in their physiological adaptations to altitude, students explore the results from recent genetic studies and recognize that different genes show signs of positive selection in all three groups. All three groups, however, show selection on genes in the hypoxia-inducible factor (HIF) pathway. Students investigate the HIF pathway and its role in helping individuals living at high altitudes. Students learn that HIF is a highly conserved genetic pathway, and they use phylogeny to think about when the pathway evolved. The lesson concludes by asking students to put together a proposal for documenting natural selection in a population other than the Tibetans.

Aims:

Lesson 1. During this lesson, the student will:

- document their initial explanations for change over time in two contexts
- recognize that needs-based explanations are common but not consistent with scientific explanations (optional).

Though the AABA Education Committee compiled this lesson summary, it has not evaluated this lesson for alignment with the Next Generation Science Standards (NGSS). To assess if a lesson aligns with NGSS, we recommend using the EQuIP Rubric for Science, available at nextgenscience.org.

Lesson 2. During this lesson, the student will:

- review some physiological changes that occur as people from low elevations move to high elevations,
- explore examples of human physiological feedback mechanisms to maintain dynamic homeostasis,
- use multiple sources of data to engage in scientific argumentation and develop scientific explanations,
- explicitly identify differences between adaptation and adjustment,
- propose and analyze an experimental design to differentiate adaptation and adjustment.

Lesson 3. During this lesson, the student will:

- use multiple sources of data to engage in scientific argumentation and develop a scientific explanation for natural selection,
- be able to apply the major principles of evolution by natural selection to Tibetan adaptation to altitude,
- practice applying the major principles of evolution by natural selection to additional examples.

Lesson 4. During this lesson, the student will:

- use their understanding of the Hardy-Weinberg equilibrium model to solve problems related to adaptation to altitude,
- be able to use a population genetics simulation to investigate and interpret evolutionary mechanisms such as genetic drift and natural selection,
- reflect on how mathematical models add to the evidence for evolution.

Lesson 5. During this lesson, the student will:

- use evidence to conclude that Andeans, Ethiopians, and Tibetans have all separately evolved adaptations to high altitude (convergent evolution);
- recognize that altitude adaptation in each group involved a different suite of genes, but the HIF pathway is involved in each;
- use phylogeny to infer that the HIF pathway is a core biological process in animals that has been conserved for over 550 million years;
- demonstrate what they have learned by making a proposal of the data they would collect to investigate whether or not evolution by natural selection occurred in a population other than the Tibetans.

Materials needed:

handouts, computer with internet access, colored marbles, container for marbles, colored pencils; additional optional material detailed in lesson plans

Keywords:

human, adaptation, altitude, genetics, DNA, allele, population genetics, Hardy-Weinberg equilibrium, natural selection, Tibetan, evolution

Source:

Teaching Evolution through Human Examples Project, Smithsonian Institution

LINK TO LESSON

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