

Lizard Evolution Virtual Lab (Howard Hughes Medical Institute, 2019; <https://www.biointeractive.org/classroom-resources/lizard-evolution-virtual-lab>)

Heads up and right this way to discovery! Evolutionary and general biology students, teachers and lizard-lovers of all ages, HHMI-Biointeractive has put together a clever, articulate, and richly informative virtual lab to teach central concepts of evolution to high school and college students as well as AP/IB classes. Students use actual field-biology research techniques, data collection, and statistical methods in the investigation, along with documentation and classification of lizard traits and speciation in this captivating suite of activities.

The website, HHMI Lizard Evolution Virtual Lab, is divided into four modules: Ecomorphs, Phylogeny, Experimental Data, and Dewlap Colors. In the Ecomorphs module, students examine pictures of eight lizards in their natural habitats (tree, twig, grass, and bush), four from Puerto Rico and four from Hispaniola (Haiti and the Dominican Republic, for the uninitiated), and group them according to appearance.

Students then can gather phenotypic information about specific traits in order to make sense of their lizard classification. A video explains how scientists x-ray the lizards and scan their toe pads. After viewing a tutorial, students use a nifty measuring

app to get body and hind-limb lengths and toe-pad sizes of the lizards to notice differences and similarities. They can view their compiled data set and use statistics to analyze and compare it with classmates' data. With the new trait data, students revise their initial groupings and think about the effects of natural selection in similar habitats in the two different geographic areas.

In another module, students enter mitochondrial DNA sequences for the eight species into a website and build and annotate a phylogenetic tree to determine their evolutionary relationships. The tree convincingly shows that lizards with different traits living in different habitats on Puerto Rico are more closely related than they are to lizards on Hispaniola with similar traits. In other words, similar habitats on different islands select for the evolution of identical traits, demonstrating convergent evolution.

Why do different lizard species on the same island not mate and reproduce? How does speciation occur? Colorful accessories, for reptiles as well as humans, add the spice to your basic green, gray, or brown! The color of the skin flap (dewlap) under the male lizard's chin is important for attracting females and for ensuring that neighboring species only mate with their own, thus maintaining a species' reproductive isolation. How different are two species' dewlap shades? Students can

compare dewlaps to a sliding color bar scale to obtain precise, quantitative data for two Puerto Rican anole species; they can then calculate the means, standard deviations, and standard error of the mean and get the significance of their dewlap difference data using confidence intervals (a statistics tutorial is provided). Besides the color difference between the species, the females must also be able to see the dewlaps against the background coloration.

These visually dazzling and informative virtual activities can either be done during class (time suggestions for each of the four modules are provided) or assigned for homework. Quiz questions are also included. Data can be printed out or saved, and any activity can be revisited. The website also suggests cross-curriculum and NGSS connections. The "Educators" tab includes a list of key concepts and detailed suggestions for using the lab in instruction. A five-page student handout about the activity is also provided for download.

This virtual experience is a great way to teach about evolutionary concepts, including phylogenies, evolutionary histories, and common ancestry.

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