NCSE National Center for Science Education

Journey to Flight

Overview

Dinosaurs, pterosaurs, birds, oh my! Unlock an evolutionary mystery about the origins of flying. Explore the evolution of flight with a phylogenetic tree of prehistoric and living creatures. Use character trait observations and DNA sequences as evidence to re-create the tree and solve the mystery.

Learning Goals

1. Participants will learn how to read and analyze a phylogeny while exploring how flight arose independently three times throughout vertebrate evolution.
2. Participants will experience the process of making and testing phylogenetic hypotheses in a manner that is validating and friendly.
3. Advanced participants will be able to explore the concepts of homoplasy and of molecular vs. morphological trees.

Materials

- *Journey to Flight* title page
- Phylogenetic tree board game
- *Young Learners* observation card
- *General* observation card
- Dry erase marker
- (7) plastic animals to represent each species
    - *Dinosaur*
    - *Pterosaur*
    - *Bird*
    - *Lizard*
    - *Crocodile*
    - *Whale*
    - *Bat*
- (7) species cards with attached DNA sequence
    - *Dinosaur*
    - *Pterosaur*
    - *Bird*
    - *Lizard*
    - *Crocodile*
    - *Whale*
    - *Bat*
- *Last Common Ancestor* card
- *Mammalian Lineage* card
- *Diapsid Lineage* card

Set-up

Lay out the game board and 6 of the animals (leave out the crocodile for now). Put the observation cards and the species cards to one side (again, leave out the crocodile).

Procedure

1. Encourage play and observation with the toys.
2. When the participants feel ready, invite them to make a group of three, a group of two, and one that cannot be grouped. (For young learners, this will likely be "Pterosaur, Bat, Bird" "Dinosaur, Lizard" and "Whale"). Encourage them to explain why they made this grouping, but don't tell them the right answer.
3. Help visitors place the species on the corresponding places on the game board. Start by placing the group of two at the top of the board, then help them place the group of three. Make sure you validate the participants by (correctly) calling their placements a hypothesis.
4. Ask them if they want to explore their hypothesis further. Hand them the Young Learners observation card and the 6 species cards (for the full game, see "Advanced Learners" modification below). Help them make observations about the animals to fill out the cards.
5. Ask them whether, based on these observations, they would like to change their hypothesis. If they are struggling, ask them how many species have 2 cranial fenestra. Help them observe that there are two species to one side of the first branching point, and four species to the other side. Validate that changing your hypothesis based on data is exactly what real scientists do.
6. Ask them what it means that there are three different groups that fly. Ask them why flight may be an effective evolutionary strategy. Discuss function vs phylogeny, as appropriate.
7. If they are still interested in playing, ask them if they want a challenge. Hand them the crocodile species card and encourage them to place it on the phylogeny.

Definition of Success: *Participants should be able to learn the mechanisms of phylogenetic reconstruction while finding success in creating and revising phylogenetic hypotheses*.

Modifications and Guiding Questions

Advanced Learners

This version of the activity makes several changes, most notably:

1. More formal morphologic terminology
2. Inclusion of homoplastic characters
3. Use of morphologic and molecular characters

You should be able to tell based on your initial interaction which observation cards are more appropriate. Young Learners cards span all ages, and the most important outcome is that participants are able to experience science success.

Modified Procedure

1. After filling out the cards, there may be no one solution that resolves the tree. Ask them why this may be the case. Ask them if there is an additional resource that can be used to resolve the phylogeny.
2. Help them pull out the tabs on the species cards and read the DNA. Ask them to decide which sequences are most similar.
3. Ask them why dinosaurs and pterosaurs don't have DNA. How might morphological and molecular characters both help in assisting resolving a tree?

NCSE Phylogeny Research Project

NCSE is working with partner sites across the country to understand how to best teach phylogeny. If your institution is interested in participating, please reach out to Emma Doctors for research procedures. We welcome participation by institutions of all sizes and have made the procedure easy to implement.

Further Resources

- Tree of Life: Web Project
- Phylogenetic Trees: Understanding Genetics- The Tech Interactive
- Vertebrate Flight: Introduction- UCB
- The Origin of Flight: Vertebrate Flight-UCB
- The Evolution of Flight: Vertebrate Flight-UCB
- The Origin of Flight in Birds: UCB, Interactive Student/Teacher Site
- Image of Dinosaur and Bird Phylogenetic Tree: Science Direct
- Episode 6: Evolution of Flight: Common Descent Podcast

Optional (Facilitator)

- Phylogenetic Tree: Science Direct
- What is Phylogenetics: UW
- Constructing an Animal Phylogeny Tree: Lumen: Boundless Biology
- Creating a Phylogenetic Tree: Youtube Video
- The Evolution of Flight in Animals: U.M. Lindhe Norberg Department of Zoology, University of Göteborg, Sweden.
- The Origin and Diversification of Birds: Science Direct
- Phylogenomic Analyses Elucidate the Evolutionary Relationships of Bats: Science Direct

NGSS Standards

3-LS4-2 Biological Evolution: Unity and Diversity

Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.

MS-LS4-2 Biological Evolution: Unity and Diversity

Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

HS-LS4 Biological Evolution: Unity and Diversity

HS.Natural Selection and Evolution

HS-LS4-4 Biological Evolution: Unity and Diversity

Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

Associated Vocabulary

- Clade = a group of biological taxa (such as species) that includes all descendants of one common ancestor
- Character = one of the attributes or features that make up and distinguish an individual
- Diapsids = organisms that have 2 holes in their skull
- Digit = finger or toe bone of a vertebrate
- Homoplasy = correspondence between parts or organs acquired as the result of parallel evolution or convergence
- Last common ancestor = the most recent descendent from a group of organisms
- Mandibular fenestra = holes in jaw
- Phylogeny = the evolution of a genetically related group of organisms as distinguished from the development of the individual organism
- Taxa = biological classification of a group of organisms. Ex. dinosaurs
- Temporal fenestra = holes in skull