Exploring the KU Natural History Museum

Convergent Evolution

Target Audience: Middle school and above

Differentiated Instruction Summary

Strategy	Levels	Content/Process/Product	Grouping(s)
Cubing	Learning modalities • Level 1 – Visual (spatial) • Level 2 – Kinesthetic (physical) • Level 3 – Verbal (linguistic)	Process Product	Whole group Small groups Peer partners Homogeneous Heterogeneous

* Varied grouping options can be used for this activity, depending on student needs and chaperone ability.

Objectives: Explore examples of convergent evolution in vertebrates.

Pre-assessment/Prior Knowledge: Prior to their visit, students should be familiar with the idea of convergent evolution, overall evolutionary relationships/classification of vertebrate groups and basic anatomy of those groups.

Activity Description: Students explore the idea of convergent evolution through museum exhibits through different learning modalities.

Materials Needed:

- Student
  - Cubes (three levels, see attached)
  - Paper and pencils (alternatively you could use flipchart paper and markers, whiteboards and dry erase markers)
  - Optional (cell phones or other recording device for visual or kinesthetic levels)

Note: Format to record/present findings determined by individual teacher. Provide clear instructions about expectations for documenting participation, particularly for verbal/spatial and body/kinesthetic levels (e.g. stage direction, audio/video recording).

- Teacher
  - Content Outline
  - Cube labels
  - Cube template

Content: Convergence Overview

Convergent evolution refers to the similarities in biological traits that arise independently in organisms that are not closely related, e.g. wings in birds, bats and insects. Similarity among organisms and their structures that was not inherited from a common ancestor is considered to be *homoplasy*. This can be contrasted with *homology*, which refers to similarity of traits due to common ancestry.

For evolutionary biologists, *homoplasies* can evolve in different ways, and sometimes the distinctions between these categories can become blurred (see graphic below).

- Convergence is when two lineages with different evolutionary histories share similar characteristics independently of each other, often referred to as analogies.

- Parallel evolution two traits that are already similar—typically due to shared ancestry, e.g. the development of a similar trait in related but distinct groups that do not form a clade.
- Evolutionary reversals result from lineages re-evolving a previously evolved trait such as stick insects which evolutionary lost their wings as a clade (a trait they shared with their common ancestor with other insects) and then later re-evolved wings in some species.

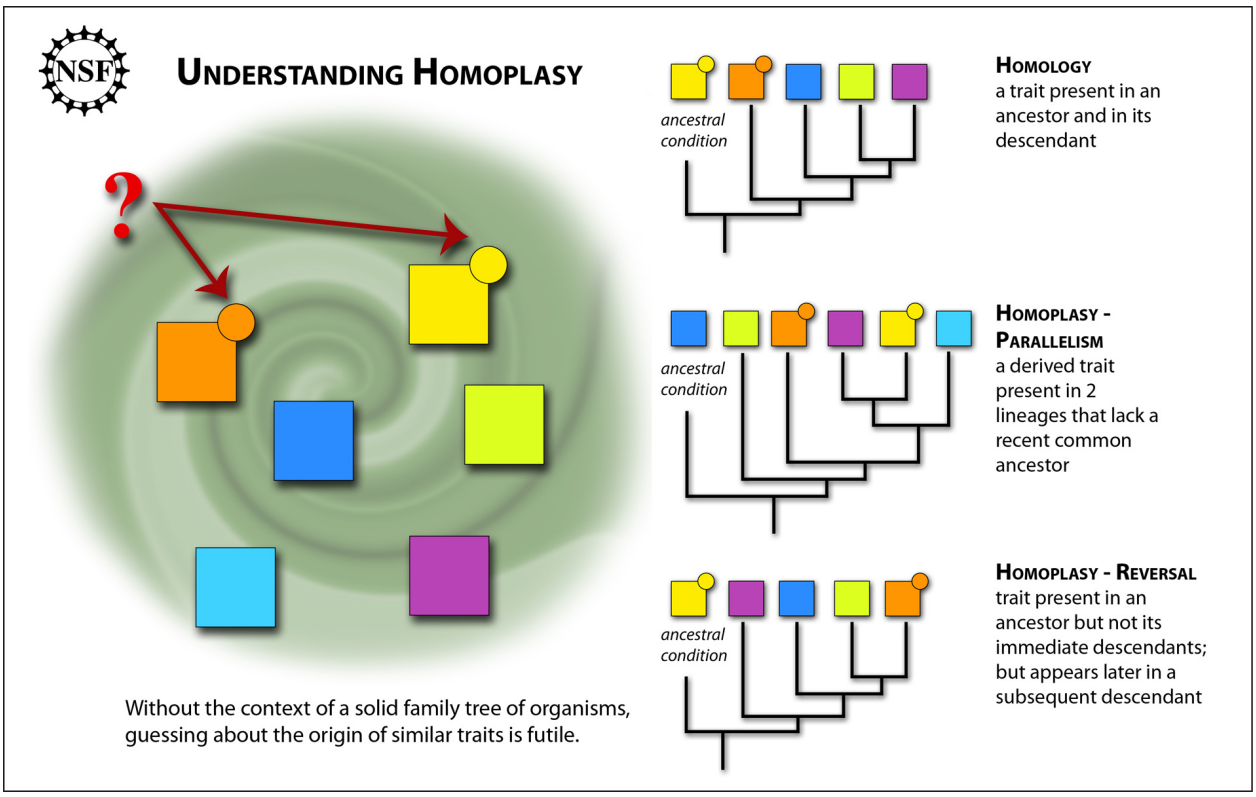


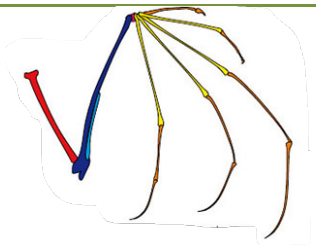
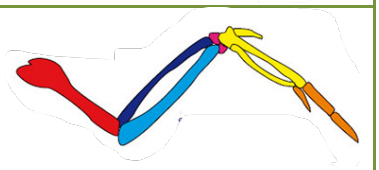
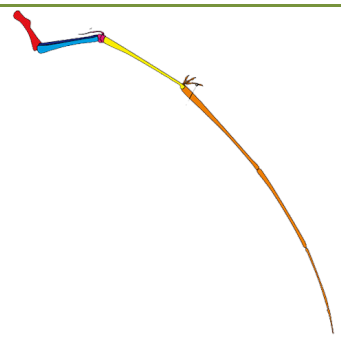
Image taken from NSF news Release 11-041 Homoplasy: A Good Thread to Pull to Understand the Evolutionary Ball of Yarn (http://nsf.gov/news/news_images.jsp?cntn_id=118776&org=NSF)

Convergence in Vertebrates

Two classic examples of convergence in vertebrates are: (1) the independent evolution of wings in birds, bats and pterosaurs, and (2) the overall similarity of body form in aquatic forms—fish, cetaceans (whales and dolphins), and ichthyosaurs (aquatic reptiles). Despite the overall similarity of vertebrate wings, differences in the specific skeletal structure that form the wings demonstrate that they arose independently in separate lineages. Although aquatic vertebrates have similarities in overall body shape, an examination of the skeletal features highlights the distinct groups, and for tetrapods (non-fish) the modification of characters they share with their terrestrial ancestors.

Exploring the KU Natural History Museum

Content: Convergent Evolution of Flying Vertebrates

Example Organisms	Convergent Feature	Divergent Features	
Bat (6th Floor)	Forelimb modified for flight	Wing formed by forelimbs (humerus, radius and ulna) and elongated digits in hand (manus); covered in membrane	
Birds 4th Floor (Panorama) & 6th Floor		Wing formed limb bones (humerus, radius and ulna), fused digits in hand (manus); covered in feathers	
Pterosaur 3rd Floor		Wing formed by elongated forelimb bones (humerus, radius, ulna), fused digits in hand (manus); covered in membrane	

Content: Convergent Evolution of Aquatic Vertebrates

Example Organisms	Convergent Features
Fish (e.g. *Xiphactinus*) 3rd floor fossil galleries	• Overall fusiform (torpedo) body shape • Paddle shaped pectoral/forelimbs • Flatted tail used for propulsion • Doral fin
Ichthyosaurs (aquatic reptile) 3rd floor fossil galleries	
Cetaceans (aquatic mammals) 5th floor *Explore Evolution* gallery	

Content: Shared Characters of Different Vertebrate Groups

Shared characters	Fish	Ichthyosaurs & Terrestrial Reptiles	Cetaceans & Terrestrial Mammals
Pectoral girdle	Attached to skull	Not attached to skull	Not attached to skull
Limb structure	Series of rays and fins	Single upper bone, two lower bones	Single upper bone, two lower bones
Lower jaw	Multiple bones	Two bones	Single bone
Body flexion	Lateral	Lateral	Dorsal-ventral
Temporal Fenestrae	N/A	One upper (modified diapsid)	One lower (synapsid)

Content: Other Examples of Convergent Evolution in Vertebrates

Example Organisms	Convergent Features
Alligator/Crocodiles & Phytosaurs 3rd Floor	Wide, flattened bodies; elongated toothy snouts
Mosasaurs & Plesiosaurs 3rd Floor	Elongated bodies; paddle shaped forelimbs and hindlimbs

Exploring the KU Natural History Museum

Materials: Cube Labels

Convergence Cubing Labels – Level 1 (Visual)

DRAW an outline of a fish & an ichthyosaur, and circle similar shaped body parts	SKETCH the bones that form the wings in two unrelated flying vertebrates (similarity due to convergence)	CREATE a Venn diagram to depict three convergent and three divergent characters between a fish, an ichthyosaur, and a whale
BUILD a diagram that includes *Xiphactinus*, an ichthyosaur, and two other vertebrates to show which are more closely related	PLOT on a museum map the distribution of convergent aquatic vertebrates throughout the museum – fish, aquatic reptiles, and cetaceans (whales & dolphins)	DRAW a human stick figure to represent a generic vertebrate body. MARK three body parts/sections in which we see convergence in aquatic vertebrates

Convergence Cubing Labels – Level 2 (Kinesthetic)

SWIM like a *Xiphactinus* fish, then an ichthyosaur, and then a dolphin (hint: look at their tails)	MODEL/ACT OUT an example of a convergent feature that evolved in animals	MODIFY a piece of paper (e.g. spare cube) to show similarities and differences between fish, an ichthyosaur, and cetaceans (whales & dolphins)
FEEL the shape of your arm and hand bones, and then compare that to the bones in bird and bat wings on exhibit	MIME the features/characters that someone could use to know that a whale is not a fish	Similarities in a fish & ichthyosaur are due to convergence, not shared ancestry. FIND a lizard & shark, and then USE your limbs to represent the relationships between all four animals.

Exploring the KU Natural History Museum

Convergence Cubing Labels – Level 3 (Verbal)

DESCRIBE the shape of a fish and an ichthyosaur	TELL an evolutionary story about an example of convergence in flying or gliding animals	SING a song about why we see convergence in the evolutionary history of unrelated aquatic vertebrates – fish, aquatic reptiles, and cetaceans (whales & dolphins)
PRESENT an argument for the evidence that features seen in fish, ichthyosaurs and cetaceans (whales & dolphins) are convergent	WRITE a poem that describes how someone could know that a whale is not a fish	CREATE a chart that outlines three convergent features in an ichthyosaur & dolphin, and three shared characters due to common ancestry between an ichthyosaur & terrestrial reptile

Rubric: Convergent Evolution

Level	Needs further support	Meets Expectations	Exceeds Expectations
Visual	Limited information provided (e.g. only a few parts marked or highlighted, did not complete task)	Completed task, and strong content provided and framed within evolutionary context	Depiction includes additional details beyond required tasks (e.g. additional characters, labeled anatomy, explanatory information about features)
Physical	Depiction is vague (e.g. different swimming motion are indistinct) and/or includes incorrect information	Completed task, and strong content provided and framed within evolutionary context	Depiction includes rich details and/or explanatory information
Verbal	Limited information (e.g. story does not provide evolutionary context)	Completed task, and strong content provided and framed within evolutionary context	Includes rich details and/or explanatory information in depictions