Life Sciences/HHMI Outreach Program

Summer 2006 Workshop in Biology and Multimedia for High School Teachers
Penguins

A Great Study in Evolution!
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What? Are they really birds?

PART I: FOCUS ON PENGUIN ADAPTATIONS

- Penguins are a biological contradiction! They are birds but don’t have the usual characteristics associated with birds. Rather, they have some very specialized feature that are all their own. We will discuss some of the differences between them and their airborne cousins.

PART II: LABORATORY: PENGUIN ADAPTATIONS IN ACTION

- As you will see, penguins are a great example of evolution. Armed with the information discussed in class, you will use the Penguin Lab Kit material to construct a penguin adaptation. You will present your modeled adaptation with an explanation of it to the class.

PART III: ARTICLE SUMMARY ON EVOLUTIONARY TRENDS IN PENGUINS

- For homework, you will read an online National Science Foundation article on the changing global environment and the effects on penguins. You will then write a 15 sentence reflection on what you learned from the article.
Why study penguins as an example of evolution?

INTRODUCTION - ask the students “What do you KNOW about penguins?” and write their answers on the board:

• They are very highly specialized!

• They are birds but cannot fly!

• They are excellent swimmers! Some can even walk or “march” long distances!

• One species lives on the equator!

• Some live in Antarctica!

• Bucking the reproductive tradition of most animals, some mate for life!

• So, what exactly is going on with these peculiar creatures?

• The answer is evolution…”
Classification

Kingdom: Animalia  One of only 5 kingdoms that includes all animals.

Phylum: Chordata  Includes all animals with a vertebral column.

Class: Aves  This vertebrate class includes all birds on Earth.

Characteristics of Class Aves

• Birds have a external covering of feathers.
• Birds are endothermic.
• Birds have front forelimbs that are modified into wings.
• Birds give birth by laying eggs.

Order: Spheniscidae  Includes all penguins- living and extinct.

Family: Spheniscidae  This is the only family in the order Spheniscidae.

Genus & species  There are 17 different penguin species.
How it all started…

• The current belief in science dates the first bird-like creatures to approximately 150 million years ago.

• It is believed that these birds evolved from reptile dinosaurs.

• The fossil of a creature called Archaeopteryx was found in Germany in the 1860s. It is the oldest known bird fossil.

• Archaeopteryx had 3 toes armed with claws and long legs. Skeletal evidence suggest that it walked on those legs. It had the head of a reptile with jaws. Archaeopteryx’s tail was the key as it had the feature characteristic of birds - feathers.

• With the extinction of the dinosaurs approximately 65 million years ago, there was opportunity for these evolving birds to rule the skies.

• From these first birds came the incredible diversity we see today as birds spread out to almost every environment on the planet.
Figure 1 The origin of birds within the theropod dinosaurs\textsuperscript{1}. Xu \textit{et al.}\textsuperscript{3} describe a four-winged dromaeosaur, \textit{Microraptor gui}, which they hypothesize glided from tree to tree. They further propose that gliding evolved initially in the four-winged ancestor of the birds, dromaeosaurs, and troodontids. Subsequently, the hindwings were lost with the origin of powered, flapping flight in the ancestor of \textit{Archaeopteryx} and other birds.

\textbf{Origin of birds from dinosaurs} \\
• It is thought that there are close to 10,000 bird species on Earth today. They exist in a wide variety on environments all over the planet.

• As birds colonized new places, their behavior and physical structures were impacted and changed by the environment over the course of many generations. They became better suited to living in that place, feeding on the resources available to them, and mating with other members of the same species. This is evolution.

• Penguins evolved over time to live in cold places (with the exception of the Galapagos penguin). Not everywhere they live is freezing but their food sources are found in cold water, so they had to adapt to live in place where this water was found.

• It is believed that penguins are most closely related to their fish-eating seabird cousins- the albatrosses, petrels, and shearwaters.
So, what happened to these birds?

**Flight**

*Birds have the ability to fly due to their feathered wings.*

- Penguins are flightless because of modification of their wings into flippers for swimming. They appear to “fly” through the water. They are excellent swimmers with some species spending up to 75% of their lives at sea.

- The feathers of penguins are highly specialized. They are short, broad, and closely spaced to create a waterproofing effect. Additionally, they contain tufts of down that insulate the body from the cold.

*Birds have the ability to fly due to their light hollow bones.*

- The bones of penguins are quite different—they are, in fact, dense and heavy in order to overcome buoyancy and allow for diving.

- Penguins also have a layer of fat for insulation and body warmth.
• Downy bird feather like the ones that insulate penguins from the cold
So, what happened to these birds?

**Beaks**

*Birds have beaks designed to enable them to efficiently consume their food source. The beaks of different birds have modified over time to the food they eat.*

- Most penguins consume fish or squid or crustaceans. Their beaks have evolved to enable them to eat this prey and still keep them hydrodynamic.

- Because penguins eat marine fish, squid, and crustaceans, they live in places that have cold, nutrient-rich water that contains their prey.

- Additionally, their life at sea requires them to have a way to rid their bodies of salt. They have salt glands in their bills that excretes salt removed from their bodies from seawater that is consumed.
So, what happened to these birds?

**Body Shape**

*Birds have a streamlined body shape which makes them efficient flyers.*

- Penguins have a fusiform, streamlined body for fast and efficient swimming. They “fly” through the water!

- Like most marine animals, they are counter shaded. They are dorsally dark and ventrally white which enables them to blend into their aquatic surroundings from both above and below. Their specific markings and color depend on the species.

- They have very short thick legs with webbed feet. This allows them to swim more efficiently and, in some cases, protect their eggs. The disadvantage is their awkward walk on land.

- Their tail is wedge-shaped and short enabling it to assist in balance.
Just the facts please …

• There are 17 different species that live in various places on every continent in the Southern hemisphere.

• The size range varies from 16 inches to 3.5 feet. Their weight can range from 2 lbs to almost 90 lbs!

• In the wild, penguins are found exclusively in the Southern hemisphere. Common places they are found are Australia, South Africa, and South America. They are common in zoos all over the world.

• There is one penguin species found in one of the warmest place on the planet (the equator) - the Galapagos penguin. There is one penguin species found in the coldest place on the planet (Antarctica)- the Emperor penguin.

• Some penguins create burrows for themselves and live in them, like the tiny Little Blue (Fairy) penguin- the smallest of the penguins. Others live on ice sheets or on beaches, like the African penguin.
Penguin look different from birds AND one another!!

- There are 17 species of penguins that share some common features such as the inability to fly, waterproof feathers, and countershaded coloration.

- They are found throughout the Southern hemisphere in a variety of climates. Due to this, they can have some very different modifications.

- What can you ascertain about where they live by looking at their physical features?

www.mbayaq.org/PDF_files/aquarium_penguin_species.pdf

Penguin page courtesy of Monterey Bay Aquarium,  Copyright Monterey Bay Aquarium Foundation.
Part II: Adaptations in Action

• You and your partner can use anything you want in the Penguin Kit to **construct** and **demonstrate** an adaptation that penguins have evolved to help them survive. Each group must have a different setup, so feel free to get creative!

• The Penguin Kit has various resources in it for you. For example there is colored construction paper, cardboard, glue, cotton, wire, scissors, aluminum foil, toothpicks, popsicle sticks, markers, mirrors, colored pencils, etc. Be nice and share this material with other groups! Take only what you need- you can go back and get more material as you need it.

• Your creation will be presented to the class with an explanation of how it helps penguins survive in their environment. Make sure you test it to see that it works before you present it.

• Have fun!
PART III: ARTICLE & REFLECTION ON RECENT EVOLUTIONARY TRENDS IN PENGUINS

• For homework, you will need to go to a link provided below and read this recent National Science Foundation article on the changing global environment and the effects on penguins.


• You will then write a reflection of approximately 15 sentences on what you learned from the article.
Resources used in this lesson


www.buschgardens.org/infobooks/Penguins/home.html

PowerPoint lecture from Professor Scott Edwards, LS/HHMI Summer Workshop 2006