Lesson Ideas to Accompany Chapter 11 of *Do Elephants Have Knees?*

Archaic Chickengators

Reflection: Swimming Chickens

The frog friends Jessica, Marilyn, and August mistook a pebble for chicken egg. They watched it hatch into a baby chicken that promptly took to the water. The egg had been laid by an alligator, not a chicken, of course. The fanciful story introduces major divides among land vertebrates and excuses the frog friends' misconception as a natural state of affairs. To an amphibian, chickens and gators are equally good archosaurs. What very basic traits distinguish archosaurs from amphibians? What do they have in common that may have misled the frogs?

What images in the story best help to reconstruct ideas of descent from archosaur ancestors?

Do you think a part bird, part croc creature once existed?

Discussion: Archosaur Progeny

"Archaic Chickengators" visits Triassic time in order to introduce a diverse group of early reptilian forms, the archosaurs. Archosaurs have never achieved the notoriety in the popular imagination held by dinosaurs. However, the recent reconstruction of *Canufex carolinensis*, a croc that could walk on its hind limbs, has boosted the public awareness of this over-looked group. The great Permian extinctions that preceded Triassic time left the earth's habitats open to newly evolving creatures. Archosaurs diversified into descendants well known in the present and famously extinct at the end of Cretaceous time (approximately 65 million years ago).

What groups of creatures supposedly descended from archosaur stock? Which characteristics unite them (feel free to search on-line to answer)? What fundamental differences divide them?

Many paleontologists argue that birds are avian dinosaurs. Others hold reservations and question just how and when birds became recognizable as a group whose progeny have survived quite well into the present. Do you think birds branched from archosaurs independently of the lineage that produced dinosaurs? Or do you agree with the dominant view that birds are very specialized dinosaurs—feathered raptors. What interpretation would Jessica, Marilyn, and likely argue?

What makes a bird a bird? Why are the answers to questions about the origins of birds difficult to answer? Birds are similar to, yet different from, reptilian groups. How different and in what ways must they be to no longer belong in the reptile, archosaur or dinosaur, categories?

Exercise: Table of Traits

"Archaic Chickengators" introduces difficult problems of judgment and interpretation in classifying vertebrates both living an extinct. A fossil might clearly exhibit "early bird-like characteristics" and retain "many dinosaurian features." Is it a bird or not? Flightless birds exist. Adult bird beaks are toothless. Bird bones are hollow. At some point, descent with modification reaches the point where, from a human point of view (if not a frog one), something quite distinct has come into existence that did not exist before: the novelty (and beauty) of birds, for example. They are no longer simply an example of crocodile diversity. On what basis are such judgments made?

Below is an unfinished table. Across the top are listed a set of inheritable traits. Down the side are listed a number of creatures arranged in chronological order from the present to the Triassic past. Based on information gleaned from "Archaic Chickengators" or obtained from other sources, try to complete the table. Then look for patterns through time and across creatures. What emerges as a likely scenario of descent—of trends and changes through time? What creatures appear most similar? Which ones share the fewest traits?

Creatures are listed by genus. Presumably, at this level of classification all members of the group will share the same traits. In other words, for the purpose of completing the table and inspecting it for trends or relationships, one chicken is as good as any other (of course, chickens do vary from one to another).

This is a smalltable composed of creatures mentioned in "Archaic Archosaurs." Feel free to add others as well as additional traits. For example, the thecodonts, a primitive group of archosaurs, had "socketed teeth," a useful trait for tearing apart meat.

Exercise: Evolutionary Branching (Phylogenetic Relations)

The Table of Traits displays information useful for inferring relative common ancestry and evolutionary descent. At the simplest level, counting traits contributes to making such inferences. The more traits in common the more likely creatures share a common ancestor more recently in time than they do with other creatures having fewer shared traits. All creatures ultimately share a very ancient common ancestry.

Sometimes the traits used to infer ancestry are "homologous." "Homology" refers to similar skeletal, physiological, or genetic patterns presumed to be inherited but modified during the course of descent from a common ancestor. Limb bones of similar structure and in the same relative positions in a body are homologous. Thus limbs are clues to the degree of shared (or relative recency) of common ancestry. DNA homologies are powerful tools for determining the evolutionary affinities of living organisms. Among fossils,however, DNA is rare and homologies among hard body parts are analyzed to make evolutionary inferences.

Although the Table of Traits does not track homologies, they are implicit in the skull and limb traits. The table, therefore, can be used to construct phylogentic relations. The Reference Sheet from ZEST (*Zoos for Effective Science Teaching*, NY Zoological Society, 1989) explains how to work from such a table through groupings to the construction of a branching tree diagram. The points where branches join indicate a hypothetical common ancestor. For more on constructing these phylogentic relations at a novice level consult *Dinosaurs and Their Living Relatives* (British Museum, 1985).

mya	Creature	Inheritable Traits												
		Backbone	Four Legs	Amniotic Egg	Bipedal	Scales	Feathers	Diapsid Skull	Bird-like Hips	Lizard-like Hips	Clawed Feet	Semi-lunate wrist bone	Furcula (primitive wishbone)	Pygostyle
0	*Lithobates* (Leopard Frog)													
0	*Alligator*													
0	*Gallus* (Chicken)													
68	*Tyrannosaurus* (theropod)													
110	*Deinonychus* (maniraptor)													
125	*Confusiusornis*													
150	*Archaeopteryx*													
155	*Diplodocus* (sauropod)													
251	*Carnufex* (Archosaur)													

Reference Sheet 2

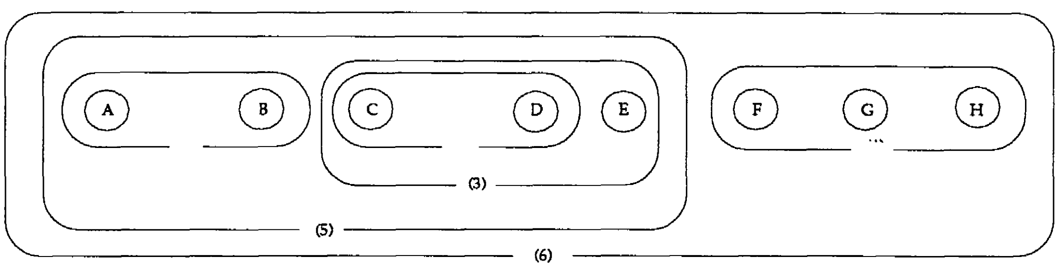
THE USE OF HOMOLOGIES TO DETERMINE PHYLOGENETIC RELATIONS

Step 1: DESCRIPTION of the distribution of homologies among various natural populations or groups of populations

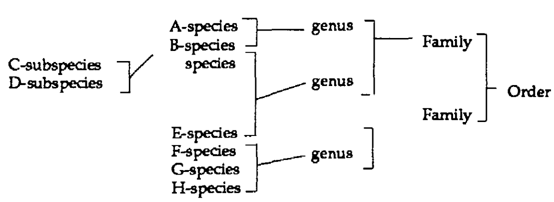
Natural populations or groups of populations	Crocodiles & Charials A	Alligators B	Snakes C	Lizards D	Tuatara E	Land Tortoises F	Freshwater Turtles G	Marine Turtles H
Homologies:								
1. 4-chambered heart	•	•						
2. Paired male hemipenes			•	•				
3. Absence of third-eyelid			•	•	•			
4. Bony shell						•	•	•
5. Elongated body	•	•	•	•	•			
6. Scales	•	•	•	•	•	•	•	•

(Hypothetical comparison of characteristics)

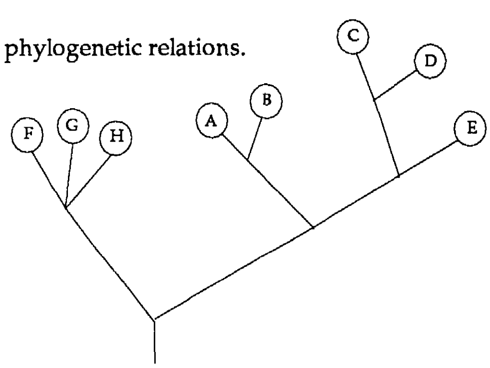
Step 2: GROUPINGS on the basis of homologous structures.



Step 3: PLACEMENT of groups into taxa.



Step 4: FORMULATION of phylogenetic relations.



Reprinted with permission from Project Zoos for Effective Science Teaching (Z.E.S.T.), New York Zoological Society, 1989.

Reference Sheet 1

BIRDS' FEET

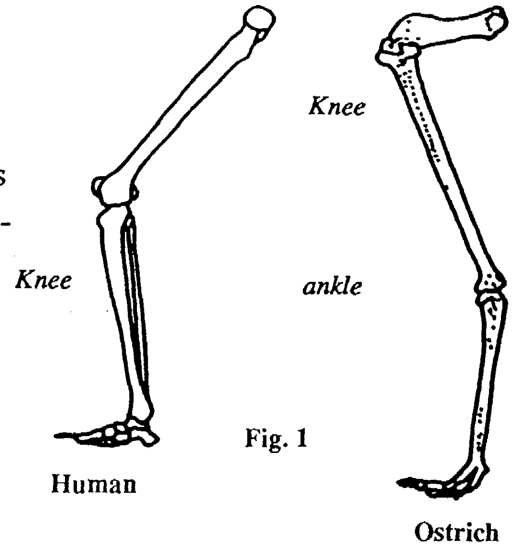


Fig. 1

The bird skeleton has evolved into a light, strong structure. Many bones have fused, as compared to its evolutionary ancestors, and are hollow instead of containing bone marrow. The typical bird leg lacks a fibula and its ankle acts similarly to the human knee (see Fig. 1). The bird femur is reduced and buried close to the body. Birds walk on the ball of their foot and toes. The leg has the ability to rotate so that the feet are always below the bird's center of gravity when walking.

Bird's feet contain from two to four toes. A four-toed arrangement may have one rear toe with three foward facing toes or two forward and two in the rear. Some birds have the ability to rotate a foward toe so that an even grasp of prey can be accomplished.

Bird feet may be used in a feeding activity such as scratching away debris; as killing tools which pierce prey with sharp talons; for perching in trees; or as locomotor organs in running, hopping, or swimming. There is often an evolutionary trade-off in foot design, as good killing or swimming feet do not adapt well to walking. Feet made for running can not also be used for killing and vice versa.

Birds of prey, such as hawks and eagles, spend much of their time soaring, looking for suitable food. They rarely walk long distances because their feet are adapted for killing and grasping their victims (see Fig. 2). The osprey foot contains four toes, each armed with a sharp talon. It uses these feet to grasp fish and has the ability to reverse one of its forward facing toes so that it can more easily carry its prey to shore.


Fig. 2 Osprey Foot

Swimming birds' feet contain structures to increase their surface area so that they act as efficient paddles. They are either webbed or lobed. The grebe has a lobed arrangement (see Fig. 3). The toes contain flaps on both sides but are not connected. When pushed against the water in a power stroke, the lobed flaps present a wide surface area. As the foot is retracted in its recovery stroke, the lobes "feather", which reduces their surface area, allowing for greater efficiency.

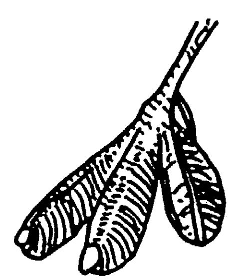


Fig. 3 Grebe Foot

Continued on next page

Reprinted with permission from Project Zoos for Effective Science Teaching (Z.E.S.T.), New York Zoological Society, 1989.