Chapter 34: The Origin and Evolution of Vertebrates

34.1 Identify key derived characters of chordates.
34.2 Describe the evolutionary history of vertebrates.
34.3 Describe gnathostomes and explain the evolutionary advantages of having jaws.
34.4 Explain how the first tetrapods may have arisen.
34.5 Identify key derived characters of amniotes and give examples of amniote groups.
34.6 Differentiate between monotremes, marsupials, and eutherian mammals.
34.7 Identify key hominin lineages and describe their characteristics.

This chapter focuses on vertebrate groups and their evolution. We have selected key information in this chapter to give you an overview of the evolution of chordates. A biologically literate person should know features that make life on land possible for animals, as well as adaptations that have occurred over time leading to the many diverse groups. How are amphibians different from reptiles? Is a salamander a reptile or an amphibian? Why?

Study Tip: Like Chapter 33 on the evolution of invertebrates, this chapter on chordates is organized by the evolution of unique characters. Match the Key Concepts on p. 718 with the phylogenetic trees in Figures 34.1 and 34.2 in your text. As each evolutionary novel feature appears, notice the increasing diversity of organisms.

Both mammals and reptiles have an amniotic egg, but what separates the mammals from the reptiles?

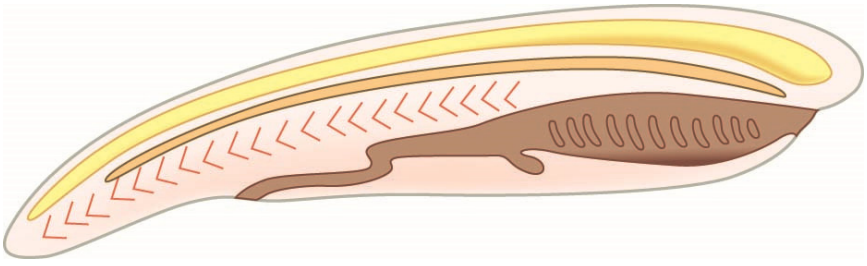
Concept 34.1 Chordates have a notochord and a dorsal, hollow nerve cord

LO 34.1: Identify key derived characters of chordates.

1. We are *vertebrates*. What *phylum* do we belong to?

2. Based on Figure 34.2 in your text, what phylum would be considered the closest relative to phylum Chordata? _____ Why?

3. Here is a figure showing the four key chordate characteristics. Label and explain each one.



4. One of the important characteristics is a notochord. What is a *notochord*?

5. For us, as vertebrates, what remains of the notochord? Take note of the fact that a notochord is *not* a spinal cord!

6. *Chordates* are the first group to show a *dorsal nerve cord*. Which embryonic layer forms the nerve cord?

7. *Pharyngeal gill slits* are one of the chordate characteristics you noted in question 3. What do the gill slits become in tetrapods?

8. Lancelets are the _____ group to all other living chordates. Why are lancelets considered chordates?

9. a. Explain the phylogenetic status of tunicates.

   b. What happens to most of the chordate characteristics as tunicates change from larvae to adults?

10. Discuss the role of *Hox* genes in lancelets' neural development as a model for vertebrate brain development.

Concept 34.2 Vertebrates are chordates that have a backbone

L0 34.2: Describe the evolutionary history of vertebrates.

Review "shared derived characters" and know how they differ from "shared ancestral characters." See p. 560.

11. a. Living vertebrates share a set of derived characters that distinguish them from other chordates. How does the duplication of *Hox* genes as a derived character affect vertebrate evolution?

    b. The *neural crest* is another derived character of vertebrates. Explain its importance.

12. What is structurally unique about lampreys and hagfishes compared to other vertebrates?

13. Explain how lampreys feed and what impact this has had on the fishing industry in the Great Lakes.

Concept 34.3 Gnathostomes are vertebrates that have jaws

LO 34.3: Describe gnathostomes and explain the evolutionary advantages of having jaws.

14. *Gnatho* means "jaw," and *stome* means "mouth." This group includes the sharks, fishes, amphibians, reptiles (including birds), and mammals. List the three derived characters of gnathostomes and cite the importance of each.

15. What animals are in the clade Chondrichthyes?

16. What does the name *Chondrichthyes* mean? What material makes up the skeleton of a member of this clade?

17. Why do sharks have to swim continuously?

18. Sharks and other vertebrates including snakes have a variety of strategies when it comes to fertilizing eggs. Explain the differences between the following types of development.

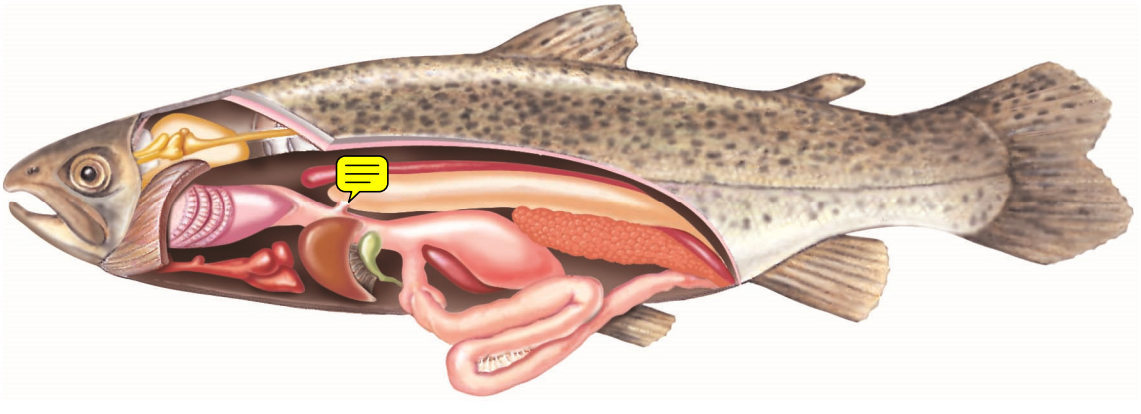
Fate of Fertilized Eggs	Explanation
Oviparous	
Ovoviviparous	
Viviparous	

19. What is a *cloaca*? What three body systems empty into a cloaca?

20. The "fishes" with a bone skeleton are aquatic Osteichthyes. How do they breathe?

21. What is the function of a swim bladder?

22. The anatomy of this trout will give you an opportunity to see where the major organs can be found in bony fish and where the paired fins are located. Label all the structures.



Now you should be able to have a scholarly discussion with your dinner companions the next time you eat fish!

23. Why was the discovery of a coelacanth such a surprise to both scientists and the general public?

Concept 34.4 Tetrapods are gnathostomes that have limbs

LO 34.4: Explain how the first tetrapods may have arisen.

24. One of the most significant events in vertebrate history was the evolution of tetrapods. What does *tetrapod* mean?

25. Using Figure 34.20 in your text of the "fishapod" named *Tiktaalik*, sketch the pectoral fin skeleton and label the bones.

a. How do the bones of *Tiktaalik* compare to the bones in your arm?

b. How do the skeletal features of *Tiktaalik* illustrate Darwin's concept of descent with modification?

c. What is the most significant derived character of tetrapods? (The derivation of this character is clearly shown in Figure 34.21 in your text.)

26. The amphibians form three clades. List them and give a defining feature and an example.

Amphibian Clade	Defining Feature/Representative Example

27. What does the name *Amphibia* mean?

28. Frogs have a life cycle with an aquatic larval stage, the *tadpole*. How do tadpoles breathe? What do they eat?

29. What changes occur in the adult frog's anatomy during metamorphosis?

30. Fertilization in amphibians is _____. The eggs lack a shell, and mortality is very high.

31. What two factors tie many amphibians to moist, high humidity environments?

32. What factors have led to the worldwide decline in amphibian populations?

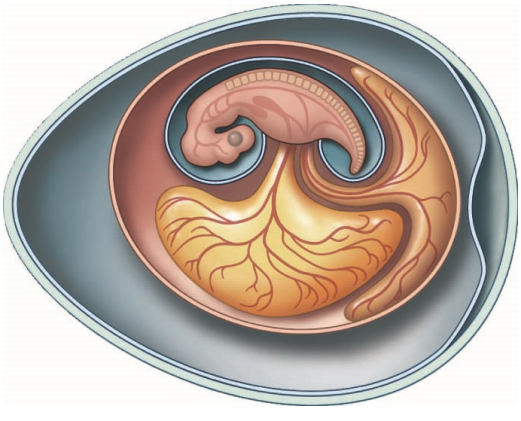
Concept 34.5 Amniotes are tetrapods that have a terrestrially adapted egg

LO 34.5: Identify key derived characters of amniotes and give examples of amniote groups.

33. a. What is the major derived character of the amniote clade?

    b. How has it enabled reptiles (and a few mammals) to occupy a wider range of terrestrial habitats than amphibians?

34. Use Figure 34.26 in your text to help label the four *extraembryonic membranes* seen in an *amniotic egg* and explain the role of each one.



35. What animals are in the *reptile* clade?

36. Make a list of the characteristics of most reptiles. For each, give the evolutionary advantage of the characteristic.

37. Which members of the reptile clade are *ectothermic*? Which are endothermic?

38. If you have a pet dog or cat it requires feeding every day, but a snake is only fed once a week. Explain why this is so.

39. Three extinct linages of reptiles remain active areas of research. Discuss the characteristics of each.

    a. Pterosaurs

    b. Dinosaurs

    c. Theropods

40. Here is a short list of some reptile groups. For each group, give some important features that make them unique.

    turtles

    lizards

    snakes

    alligators and crocodiles

    birds

41. Many of the characters of birds are adaptations that facilitate flight. What are four avian adaptations for flight?

Adaptations for Flight

42. What evolutionary advantages are offered by flight?

43. Discuss the statement that birds are the only living dinosaurs.

Concept 34.6 Mammals are amniotes that have hair and produce milk

LO 34.6: Differentiate between monotremes, marsupials, and eutherian mammals.

44. Make a list of the characteristics of mammals that have made them a successful clade. Put an asterisk (*) next to the traits that are shared derived characters of mammals.

45. There are three groups of mammals. Contrast the groups based on how they bear young and give an example of each group.

Mammalian Group	Reproduction	Example
Monotremes		
Marsupials		
Eutherians		

46. Examine Figure 34.41 in your text. Explain why the marsupials in the left column so closely resemble the eutherians on the right.

47. Exploring Figure 34.42 in your text, note that all eutherian mammalian orders are classified into four clades. In your opinion, which clade has the most surprising group of related animals? (Justify your selection.)

48. Primates are grouped with which two other major orders in the figure?

49. List the derived characters of primates.

Concept 34.7 Humans are mammals that have a large brain and bipedal locomotion

LO 34.7: Identify key hominin lineages and describe their characteristics.

50. Discuss the derived characters of humans.

51. Paleoanthropologists have unearthed fossils of approximately _____ extinct species that are more closely related to humans than chimpanzees.

52. It is important to avoid two common misconceptions about early hominins. Discuss each.

    a. Misconception 1

    b. Misconception 2

53. What is meant by the text statement that australopiths are a paraphyletic group?

54. Discuss the evolutionary significance of these three trends in hominin evolution.

    a. Bipedalism

    b. Tool use

    c. Brain volume (Look at the chart in the *Scientific Skills Exercise* on p. 751.

55. The genus *Homo* shows new trends exemplified in the following two species. Discuss those trends.

    a. *Homo habilis*

    b. *Homo ergaster*

56. What is the evolutionary relationship, especially as relates to gene flow, between Neanderthals, *Homo sapiens*, and Denisovans? (Figure 34.51 in your text will be helpful.)

57. All living humans have ancestors that originated as _____ in _____.

58. Explain the difference between the common misconception that life evolved in a ladderlike fashion with humans at the top compared to the more accurate branching phylogeny.

Test Your Understanding, p. 756.

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____