Chapter 47: Animal Development

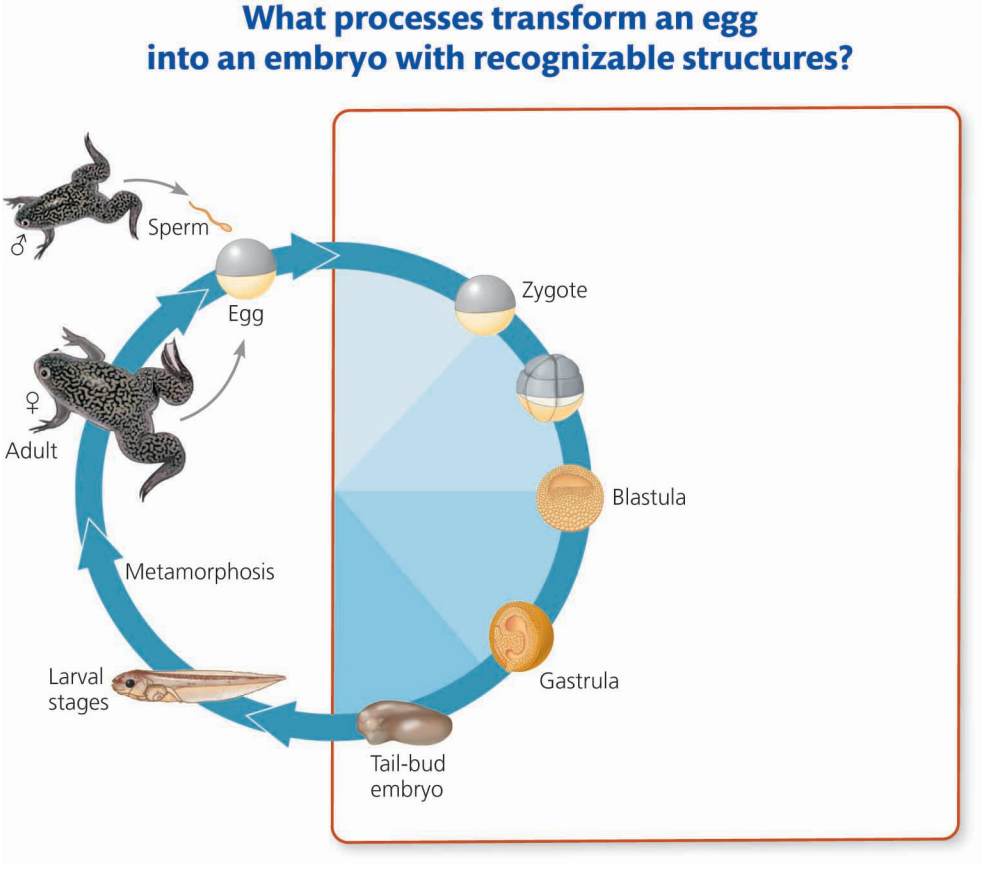
47.1 Summarize the initial stages of development common to diverse animal species.

47.2 Explain how changes in cell shape and location, as well as cell death, result in morphogenesis.

47.3 Compare and contrast major mechanisms for regulating cell fate during development.

One of the most fascinating aspects of biology is watching a fertilized egg be transformed into a new individual organism. The basic embryological stages are common across a range of animal species and include fertilization to form a *zygote* → *blastula* → *gastrula* → *embryo* → *adult.* This chapter will show how these stages lead to new individual, whether it is a frog or a human.

Study Tip: Using Figure 47.1 as a guide, label and explain the following stages in the embryonic development of a frog: f*ertilization*, *cleavage*, *gastrulation*, and *organogenesis*. Keep in mind that these same events occur in the development of the human embryo as well.



Concept 47.1 Fertilization and cleavage initiate embryonic development

LO 47.1: Summarize the initial stages of development common to diverse animal species.

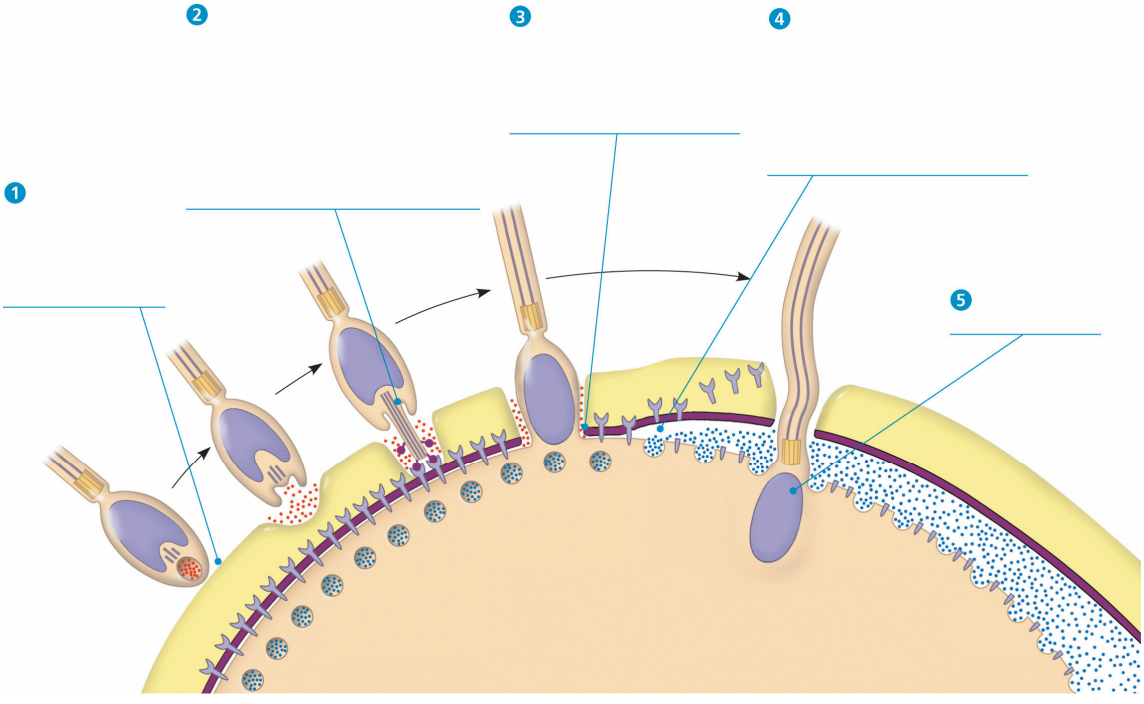
1. What is the *acrosome* of a sperm? What does it contain?

   The process of fertilization requires cell-cell recognition, which involves the binding of membrane receptors. It is also important that only a single sperm nucleus will enter the egg. How is this accomplished? The next few questions will help you understand these processes.

2. The following figure shows sea urchin fertilization.

   a. Label the following structures: *sperm acrosome*, *sperm nucleus*, *jelly coat of egg*, *sperm-binding receptors*, *cortical granules*, *vitelline layer*, *egg plasma membrane*, and *fertilization envelope.*

   b. Explain what occurs in each of these steps at the appropriate numbers: *contact*, *acrosomal reaction*, *contact and fusion of sperm and egg membranes*, *cortical reaction*, and *sperm entry*.



3. The fusion of the egg and sperm plasma membranes allows sodium ions to flow into the egg. How does this result in a *fast block to polyspermy*?

4. Why is the "lock-and-key" recognition between the sperm and egg important?

5. Why is the prevention of *polyspermy* so important?

6. Describe the *cortical reaction* and how it leads to a *slow block to polyspermy* by forming a fertilization envelope.

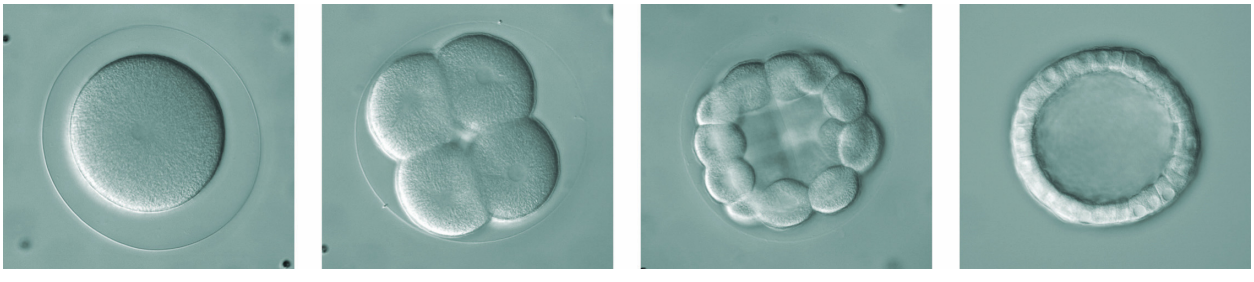
7. Sperm binding activates a signal transduction pathway in which calcium ions are released from the endoplasmic reticulum. What are the two outcomes of the elevated calcium ion level?

8. Now that you have studied sea urchin fertilization, study the section Fertilization in Mammals and make a list of what you consider the essential differences. You should have at least three (maybe four?) differences.

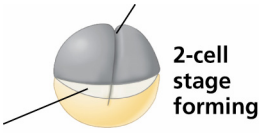
9. What event marks the end of the fertilization stage and the beginning of cleavage?

10. The early mitotic divisions of the zygote cells are called *cleavages*. It is important to know that molecules in the cytoplasm are now partitioned in varying amounts to different cells, and this will affect their future development. What is unique about the cell cycle during *cleavage*?

11. On the following figure label and describe each of the following: *fertilization envelope*, *zygote*, *blastomere*, *blastula*, and *blastocoel*.



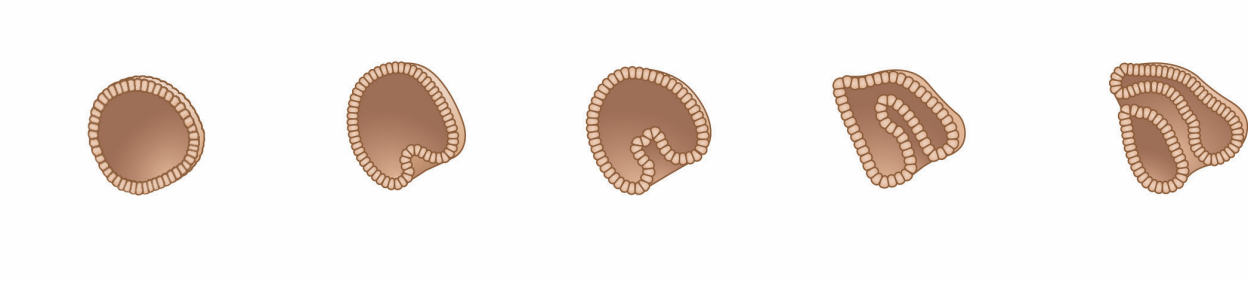
12. The cell division pattern is uniform for sea urchins, but many other animals have an asymmetrical pattern of division as seen in Figure 47.7 of your text. Note that the four cells on the top of the embryo are smaller than those in the lower hemisphere. Label the *animal pole* and *vegetal pole*, the *gray crescent*, and the *cleavage furrow* in this figure of the 2-cell stage of a frog embryo.



Concept 47.2 Morphogenesis in animals involves specific changes in cell shape, position, and survival

LO 47.2: Explain how changes in cell shape and location, as well as cell death, result in morphogenesis.

13. The early cleavages are followed by *gastrulation*. Visualize punching a partially inflated ball with your fist. This would result in a layer of the ball being pushed to the inside. In essence, this is what occurs in *gastrulation*. These layers establish the future embryonic *germ layers*. Therefore, remember this: *Gastrulation* establishes the *germ layers*. Label the following diagram of the cross-section of an animal embryo. Indicate the *blastocoel*, *archenteron*, and *blastopore.* Below each stage of gastrulation explain what is occurring.



14. The bottom half of Figure 47.8 in your text will not be helpful to you unless the terminology makes sense. With that in mind, answer the following questions:

    a. What is the difference between *diploblasts* and *triploblasts*? (p. 680 will help)

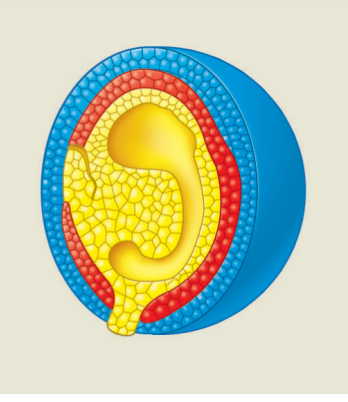
    b. What is the difference between a *protostome* and *deuterostome*? (p. 681 will help)

    c. In protostomes the mouth forms from the _____ while in deuterostomes the mouth forms opposite the _____.

15. Use Figure 47.9 in your text to list the major derivatives of the three embryonic *germ layers* in vertebrates.

Ectoderm (Outer Layer)	Mesoderm (Middle Layer)	Endoderm (Inner Layer)

16. Using Figure 47.10, Gastrulation in a frog embryo, label the late gastrulation cross section figure. Notice how the germ layers are formed.



17. Moving to gastrulation in chicks, describe how the germ layers form from the *primitive streak.*

18. To understand gastrulation in humans, begin with a careful examination of Figure 47.12 in your text, then answer the following.

    a. Fertilization occurs in the _____ while development of the human embryo occurs in the _____.

    b. What is the *blastocyst*?

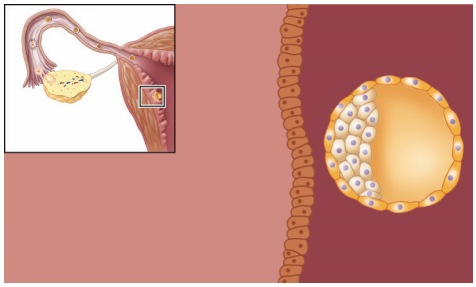
    c. What will the *inner cell mass* of the blastocyst become?

    d. What is the *trophoblast* and what is its significance?

e. What tissues form the *placenta*?

f. What is the role of the placenta?

g. Label the *blastocyst* in the following figure to show the *blastocoel*, *inner cell mass*, and *trophoblast*.



19. What is the evolutionary significance of shelled or amniotic eggs?

20. Would the extraembryonic membranes of reptiles and mammals be considered homologous or analogous structures? Explain your answer.

21. Define the following:

a. organogenesis

b. notochord (include the germ layer involved in formation)

c. induction

22. How does the *neural tube* form in the embryo and what structures will be formed from the neural tube?

23. *Somites* are formed by mesoderm cells. What structures will be formed from somites and how does this play a role in segmentation?

24. Reorganization of the cytoskeleton is a major force in changing cell shape during development. Explain how microtubules and microfilaments form the neural tube.

25. How does the cytoskeleton play a role in cell migration during morphogenesis?

26. What is the role of *apoptosis* in embryological development? Give two specific examples of programmed cell death.

Concept 47.3 Cytoplasmic determinants and inductive signals regulate cell fate

LO 47.3: Compare and contrast major mechanisms for regulating cell fate during development.

27. This is a good time to go back to Chapter 18, pp. 382–383. Concept 18.4, entitled Cytoplasmic Determinants and Inductive Signals, will be useful as you work with this new material. Use Concept 18.4 to answer the following questions.

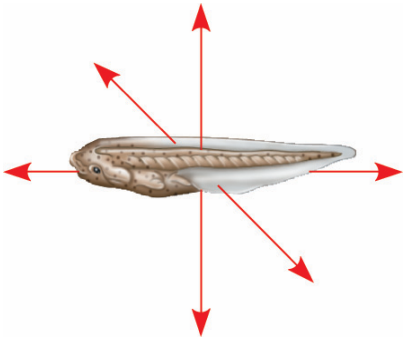
    a. Explain how cytoplasmic determinants influence the course of early development. Use Figure 18.17(a) in your text to draw a two-cell embryo showing the unequal distribution of cytoplasmic determinants.

    b. Sketch the box in the (b) part of Figure 18.17 in your text, and then use your sketch to explain induction.

    c. Before leaving Concept 18.4 explain the difference between *determination* and *differentiation*.

28. Use *P granules* to explain the role of cytoplasmic determinants in *fate mapping* in *C. elegans*.

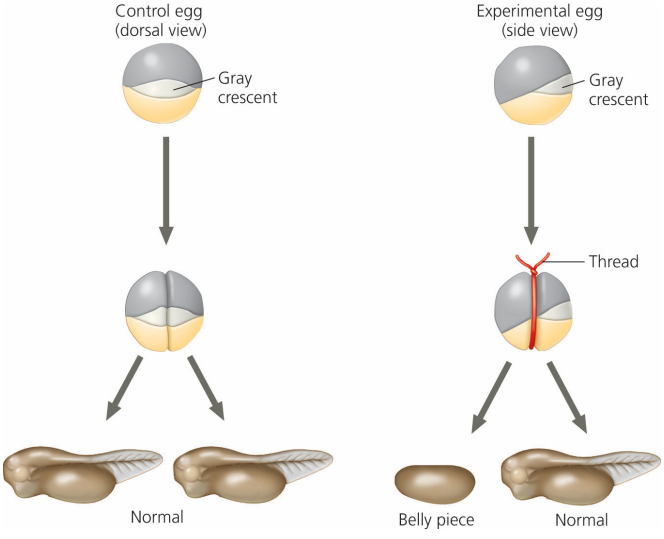
29. Throughout a study of development, there are some anatomical directional terms that you need to know. Label the following parts on this diagram: *anterior*, *posterior*, *right*, *left*, *dorsal*, and *ventral*.



30. How are the anterior/posterior and dorsal/ventral axes determined in frog embryos?

31. What does it mean to say that a cell is *totipotent*? How long do mammalian cells remain totipotent?

32. Using Inquiry Figure 47.23 explain why two normal embryos result when the two blastomeres on the left are separated, but not when the two blastomeres on the right are separated.



33. Using *Spemann's organizer* as an example, explain induction.

34. After reading the section entitled Formation of the Vertebrate Limb and Figure 47.25 in your text, explain the role of *pattern formation* and *positional information* in the development of the wing in a chick embryo.

35. How do *monocilia* and *motile cilia* play a role in cell fate?

36. The last paragraph of this chapter is a summary of development worth reading aloud. Please do so now. (If people will look at you like you are weird, it is OK to read the paragraph silently.)

Test Your Understanding, p. 1066.

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

7. _____