# 28.3 Reproduction

**THINK ABOUT IT** Sexual reproduction can be dangerous. Just ask a male praying mantis—who may be devoured by his mate. Or a male peacock, whose success in courting a female depends on his growing and lugging around a huge tail that makes it harder for him to escape predators. Or a male emperor penguin, who incubates an egg for months on antarctic ice in temperatures far below zero. Or a female deer, who carries around the ever-increasing weight of her developing young for seven months, while she runs from predators such as coyotes and seeks food for herself and the young she carries. Yet, most animal species engage in sexual reproduction during at least part of their life cycles. Why?

## Asexual and Sexual Reproduction

***How do asexual and sexual reproduction in animals compare?***

Many invertebrates and a few chordates can reproduce asexually.

**Asexual Reproduction** Animals reproduce asexually in many ways. Some cnidarians divide in two. Some animals reproduce through budding, which produces new individuals as outgrowths of the body wall. Females of some species, such as the whiptail lizard in **Figure 28–14,** can reproduce asexually by producing eggs that develop without being fertilized. This process is called parthenogenesis (pahr thuh noh JEN uh sis). Parthenogenesis produces offspring that carry DNA inherited only from their mothers. This means of reproduction occurs in some crustaceans and insects but very rarely in vertebrates.

**Asexual reproduction requires only one parent, so individuals in favorable environmental conditions can reproduce rapidly. But since offspring produced asexually carry only a single parent's DNA, they have less genetic diversity than do offspring produced sexually.** Lack of genetic diversity can be a disadvantage to a population if its environment changes.

### Key Questions

- ***How do asexual and sexual reproduction in animals compare?***
- ***How do internal and external fertilization differ?***
- ***Where do embryos develop?***
- ***How are terrestrial vertebrates adapted to reproduction on land?***

### Vocabulary

oviparous • ovoviviparous • viviparous • placenta • metamorphosis • nymph • pupa • amniotic egg • mammary gland

### Taking Notes

**Outline** Before you read, use the headings and key concepts in this lesson to make an outline about animal reproduction. As you read, add details to your outline.

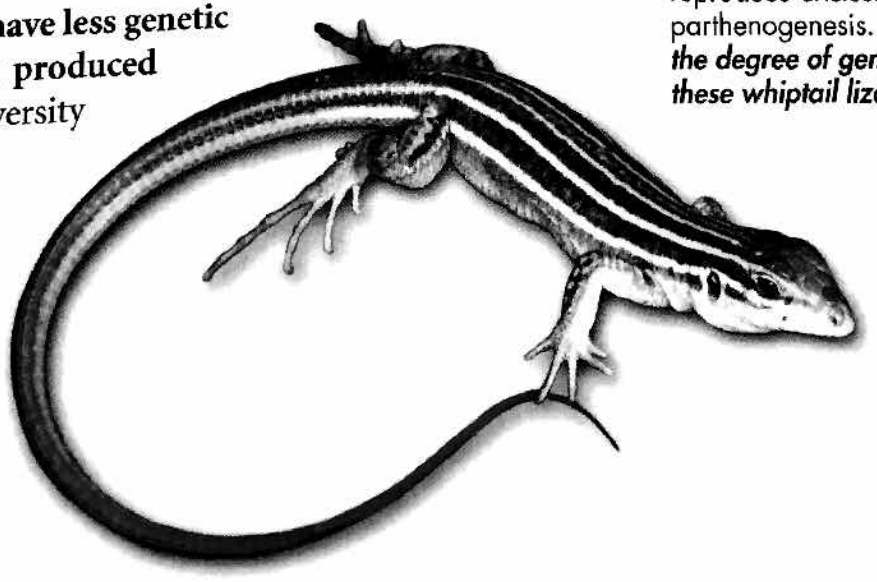


**FIGURE 28–14 Parthenogenesis** Some whiptail lizard species reproduce exclusively by parthenogenesis. **Infer** ***Describe the degree of genetic diversity in these whiptail lizard species.***

## MYSTERY CLUE

**When investigators analyzed the baby shark's DNA, they found that it was homozygous for all the traits they examined, including two rare traits. Why was that unusual?**

**Sexual Reproduction** Recall from Chapter 11 that sexual reproduction involves meiosis, the process that produces haploid reproductive cells, or gametes. Gametes carry half the number of chromosomes found in body cells. Typically, male animals produce small gametes, called sperm, which swim. Females produce larger gametes called eggs, which do not swim. When haploid gametes join during fertilization, they produce a zygote that contains the diploid number of chromosomes.

**Sexual reproduction maintains genetic diversity in a population by creating individuals with new combinations of genes.** Because genetic diversity is the raw material on which natural selection operates, sexually reproducing populations are better able to evolve and adapt to changing environmental conditions. On the other hand, sexual reproduction requires two individuals of different sexes. So, the density of a population must be high enough to allow mates to find each other.

In most animal species that reproduce sexually, each individual is either male or female. Among annelids, mollusks, and fishes, however, some species are hermaphrodites (hur MAF roh dyts), which means that some individuals can be both male and female or can convert from one sex to the other. In some species, individuals can produce eggs and sperm at the same time. Usually, these animals don't fertilize their own eggs, but exchange sperm with another individual. Some species, such as the clownfish in **Figure 28–15**, may change from one sex to the other as they mature.

**Reproductive Cycles** A number of invertebrates have life cycles that alternate between sexual and asexual reproduction. Parasitic worms and cnidarians alternate between forms that reproduce sexually and forms that reproduce asexually.

Parasitic worms such as blood flukes mature in the body of an infected person, reproduce sexually, and release embryos that pass out of the body in feces. If the embryos reach fresh water, they develop into larvae and infect snails, in which they reproduce asexually. Then the larvae are released, ready to infect another person.

Many cnidarians alternate between two body forms: polyps that grow singly or in colonies and medusas that swim freely in the water. The life cycle of a common jellyfish, *Aurelia*, is shown in **Figure 28–16.** In these jellyfish, polyps produce medusas asexually by budding. The medusas then reproduce sexually by producing eggs and sperm that are released into the water. After fertilization, the resulting zygote grows into a free-swimming larva. The larva eventually attaches to a hard surface and develops into a polyp that may continue the cycle.

**In Your Notebook** *Explain why a genetically diverse species can adapt more easily to disease and change.*

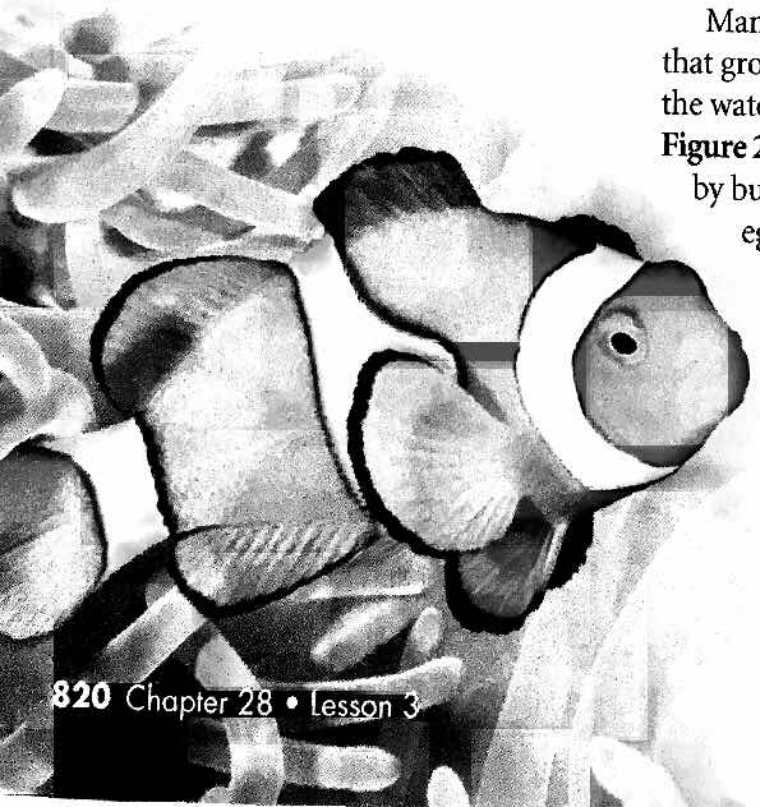


**FIGURE 28–15 Hermaphrodites** In this species of clownfish, *Amphiprion percula*, all individuals are born male and change to female as they grow. In some other hermaphroditic species, individuals are born female and change to male as they grow, or are both sexes at the same time.

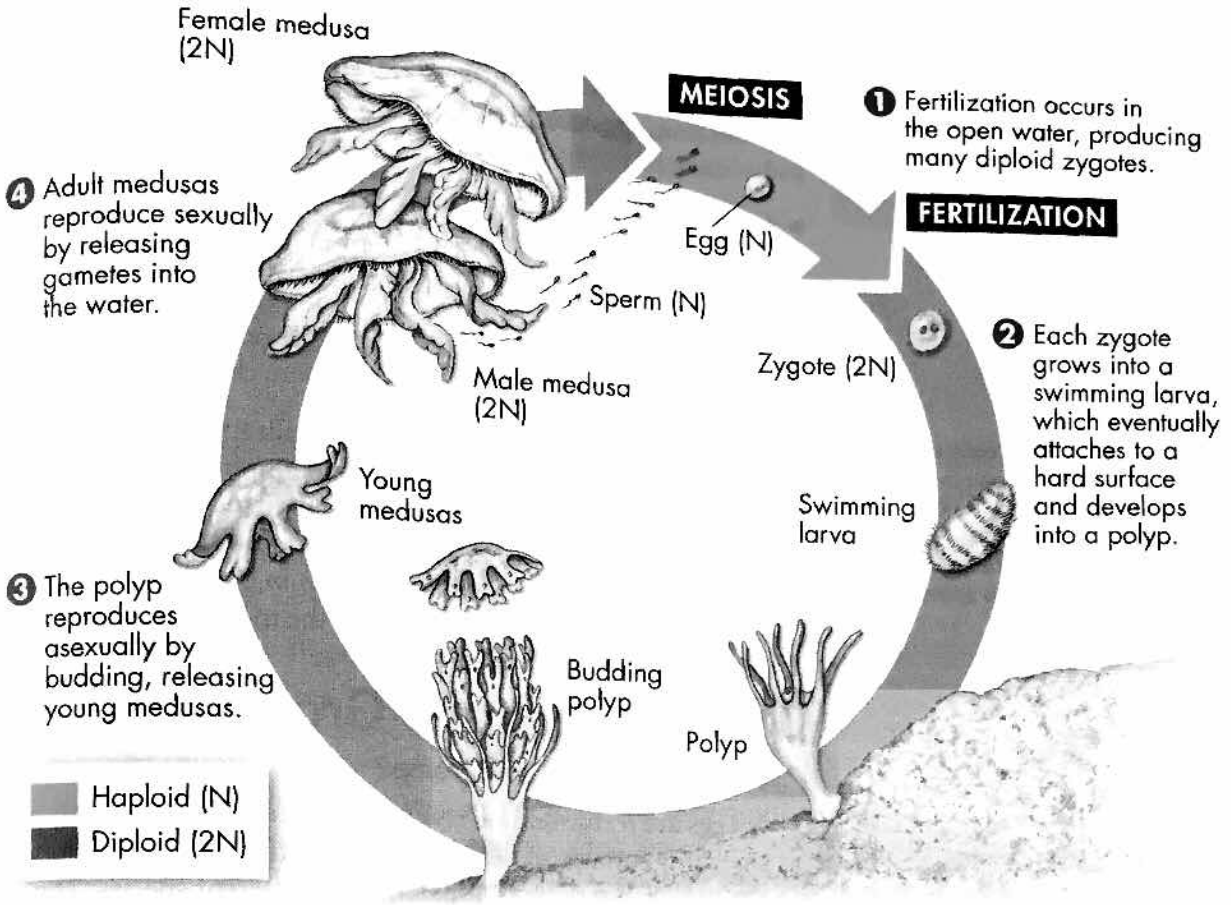



**FIGURE 28–16 Alternating Reproductive Cycles** The reproductive cycle of *Aurelia*, a jellyfish, alternates between asexual and sexual reproduction. A zygote is produced sexually by medusas and grows into a larva. The larva develops into a polyp that buds, reproducing asexually. The polyp releases a medusa.

## Internal and External Fertilization

***How do internal and external fertilization differ?***

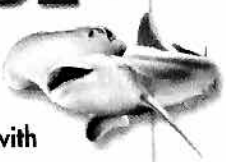
In sexual reproduction, eggs and sperm meet either inside or outside the body of the egg-producing individual. These alternatives are called internal and external fertilization, respectively.

**Internal Fertilization** Many aquatic animals and nearly all terrestrial animals reproduce by internal fertilization. **During internal fertilization, eggs are fertilized inside the body of the egg-producing individual.**

▸ ***Invertebrates*** Invertebrates that reproduce by internal fertilization range in complexity from sponges to arachnids. The eggs of sponges and some other aquatic animals are fertilized by sperm released by others of their species and taken in from the surrounding water. In many arthropod species, males deposit sperm inside the female's body during mating.

▸ ***Chordates*** Some fishes and amphibians, and all reptiles, birds, and mammals, reproduce by internal fertilization. In some amphibian species, males deposit "sperm packets" into the surrounding environment; females then pick up these packets and take them inside their bodies. In many other chordate species, males have an external sexual organ that deposits sperm inside the female during mating.

**MYSTERY CLUE**



**None of the females in the tank had had contact with a male for three years, long before they were mature enough to reproduce. And female bonnetheads had never been known to store sperm for longer than five months. So what happened?**

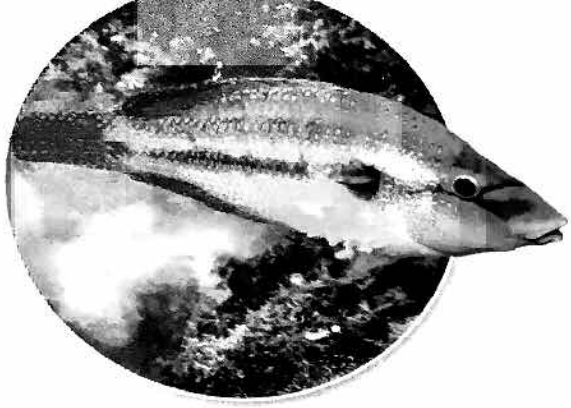


**FIGURE 28–17 External Fertilization** One type of external fertilization results from spawning. When aquatic animals spawn, females release eggs and males release sperm at the same time. **Infer** ***What is the cloudy substance behind this spawning male wrasse?***

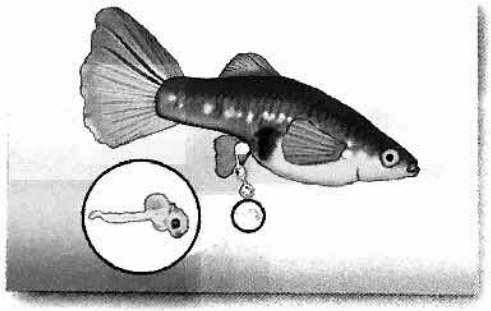
**External Fertilization** A wide range of aquatic invertebrate and vertebrate species reproduce by external fertilization. **In external fertilization, eggs are fertilized outside the body of the egg-producing individual.**

► ***Invertebrates*** Invertebrates with external fertilization include corals, worms, and mollusks. These animals release large numbers of eggs and sperm into the water. Gamete release is usually synchronized with tides, phases of the moon, or seasons so that eggs and sperm are present at the same time. Fertilized eggs develop into free-swimming larvae that typically develop for a time before changing into adult form.

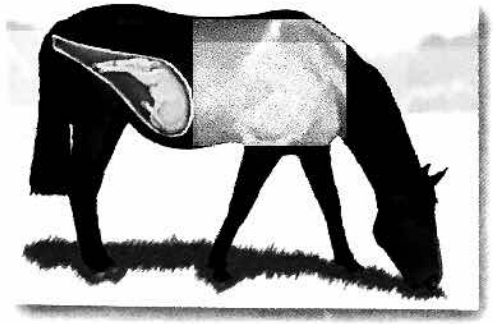
► ***Chordates*** Chordates with external fertilization include most non-vertebrate chordates and many fishes and amphibians. In some fish species, such as the wrasse in **Figure 28–17,** males and females spawn in a school, releasing large numbers of eggs and sperm into the water. Other fishes and many amphibians spawn in pairs. In these cases, the female usually releases eggs onto which the male deposits sperm.

**FIGURE 28–18 Embryo Development**

**Robin - Oviparous**



**Guppy - Ovoviviparous**



**Horse - Viviparous**

# Development and Growth

***Where do embryos develop?***

After eggs are fertilized, the resulting zygote divides through mitosis and differentiates as described in Chapter 25. This development occurs under different circumstances in different species. The care and protection given to developing embryos also varies widely.

**Where Embryos Develop** Embryos develop either inside or outside the body of a parent in various ways. **Animals may be oviparous, ovoviviparous, or viviparous.**

► ***Oviparous Species*** **Oviparous** (oh VIP uh rus) species are those in which embryos develop in eggs outside the parents' bodies. Most invertebrates, many fishes and amphibians, most reptiles, all birds, and a few odd mammals are oviparous.

► ***Ovoviviparous Species*** In **ovoviviparous** (oh voh vy VIP uh rus) species, embryos develop within the mother's body, but they depend entirely on the yolk sac of their eggs. The young do not receive any additional nutrients from the mother. They either hatch within the mother's body or are released immediately before hatching. Young swim freely shortly after hatching. Guppies and other fishes in their family, along with some shark species, are ovoviviparous.

► ***Viviparous Species*** **Viviparous** (vy VIP uh rus) species are those in which embryos obtain nutrients from the mother's body during development. Viviparity occurs in most mammals and in some insects, sharks, bony fishes, amphibians, and reptiles. In viviparous insects, and in some sharks and amphibians, young are nourished by secretions produced in the mother's reproductive tract. In placental mammals, young are nourished by a **placenta**—a specialized organ that enables exchange of respiratory gases, nutrients, and wastes between the mother and her developing young.

**How Young Develop** Most newborn mammals and newly hatched birds and reptiles look a lot like miniature adults. Infant body proportions are different from those of adults, and newborns have more or less hair, fur, or feathers than adults have. But it is pretty clear that a newly hatched snake is not going to grow up to be something totally different, such as an eagle!

For many other groups of animals, however, it's not as clear. As most invertebrates, nonvertebrate chordates, fishes, and amphibians develop, they undergo metamorphosis. **Metamorphosis** is a developmental process that leads to dramatic changes in shape and form.

▸ ***Aquatic Invertebrates*** Many aquatic invertebrates have a larval stage, which looks nothing like an adult. These larvae often swim or drift in open water before undergoing metamorphosis and assuming their adult form. Members of some phyla, such as cnidarians, have a single larval stage. Other groups, such as crustaceans, may pass through several larval stages before they look like miniature adults.

▸ ***Terrestrial Invertebrates*** Insects may undergo one of two types of metamorphosis. Some insects, such as grasshoppers, undergo gradual or incomplete metamorphosis, as shown in **Figure 28–19.** Immature forms, or **nymphs** (nimfs), resemble adults, but they lack functional sexual organs and some adult structures such as wings. As they molt several times and grow, nymphs gradually acquire adult structures.

Other insects, such as butterflies, undergo complete metamorphosis. Larvae of these animals look nothing like their parents, and they feed in different ways. Larvae molt and grow, but they change little in appearance. Then they undergo a final molt and change into a **pupa** (PYOO puh; plural: pupae), the stage in which an insect larva develops into an adult. During the pupal stage, the entire body is remodeled inside and out! The adult that emerges looks like a completely different animal. Don't let your familiarity with caterpillars and butterflies dull your wonder at this change. If land vertebrates underwent this kind of metamorphosis, a larva that looks like a snake could, in fact, grow up into an eagle!

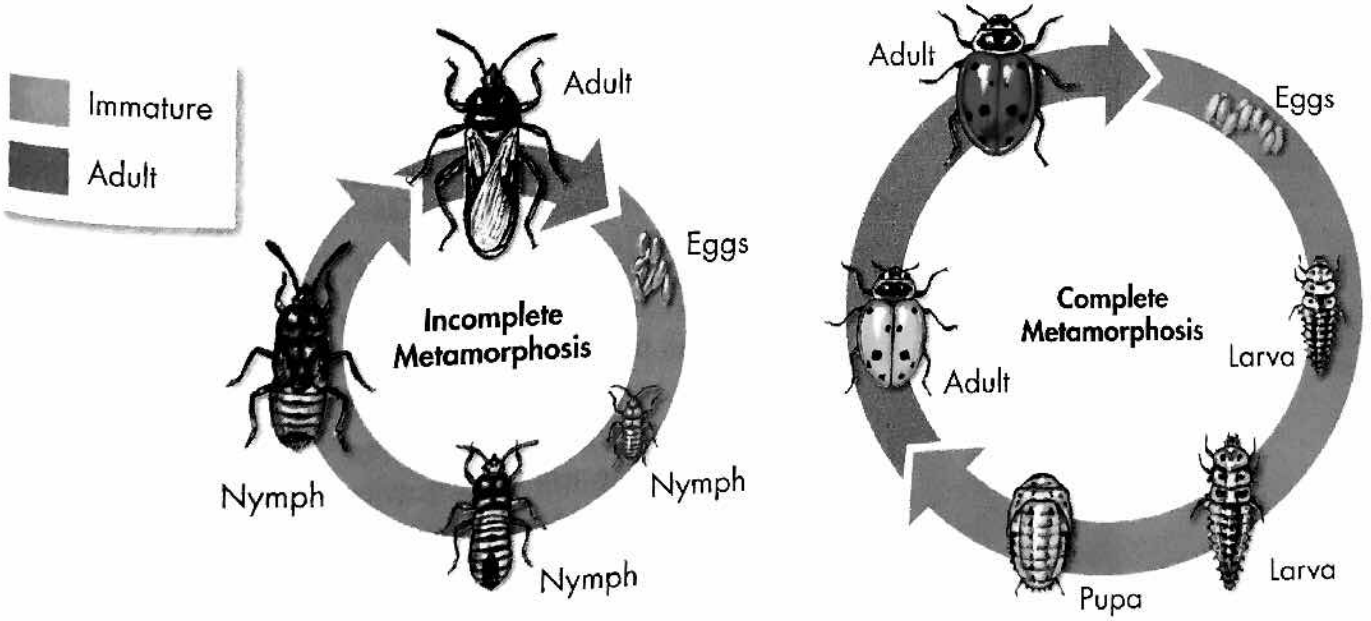



**FIGURE 28–19 Insect Metamorphosis** Insects usually undergo metamorphosis during their growth and development. The chinch bug (left) undergoes incomplete metamorphosis, in which the nymphs look similar to the adults. The ladybug (right) undergoes complete metamorphosis. The developing larva and the pupa look completely different from the adult.

**FIGURE 28–20 Amphibian Metamorphosis** Amphibians typically begin their lives in the water and metamorphose into adults that live on land. Frog tadpoles, such as the one in the photo, start out with flippers, gills, and a tail and mature into adults that have legs, lungs, and no tail.

Control of metamorphosis in arthropods is accomplished by hormones. Recall that hormones are chemicals produced in one organ of an organism that affect that organism's other tissues and organs. In insects that undergo complete metamorphosis, high levels of a juvenile hormone keep an insect in its larval form. As the insect matures, its production of juvenile hormone decreases. Eventually, the concentration of juvenile hormone drops below a certain threshold. The next time the insect molts, it becomes a pupa. When no juvenile hormone is produced, the insect undergoes a pupa-to-adult molt.

► ***Amphibians*** Amphibians typically undergo metamorphosis that is controlled by hormones. This metamorphosis changes amphibians from aquatic young into terrestrial adults. Tadpoles, such as the one in **Figure 28–20,** are one type of amphibian larvae.

**In Your Notebook** *What chemicals control metamorphosis in arthropods and amphibians?*

**Care of Offspring** Animals' care of their offspring varies from no care at all to years of nurturing. Most aquatic invertebrates and many fishes and amphibians release large numbers of eggs that they completely ignore. This reproductive strategy succeeds in circumstances favoring populations that disperse and grow rapidly.

But other animals care for their offspring. Some amphibians incubate young in their mouth, on their back, or even in their stomach! Birds and mammals generally care for their young. Maternal care is an important mammalian characteristic, and the bond between mother and young is often very close, as the pandas in **Figure 28–21** demonstrate. Males of many species also help care for young. Parental care helps young survive in crowded, competitive environments. Typically, species that provide intensive or long-term parental care give birth to fewer young than do species that offer no parental care.

**FIGURE 28–21 Care of Offspring** Long-term, intensive care of offspring is a characteristic of mammals, such as the mother panda in the photo. A wild panda cub will stay with its mother for up to 18 months while she protects it and teaches it how to be a panda.

# Reproductive Diversity in Chordates

***How are terrestrial vertebrates adapted to reproduction on land?***

Chordates first evolved in water, so early chordate reproduction was suited to aquatic life. The eggs of most modern fishes and amphibians still need to develop in water, or at least in very moist places. As some vertebrate lineages left the water to live on land, they evolved a number of new reproductive strategies. These strategies now enable the fertilized eggs of many terrestrial chordates to develop somewhere other than in a body of water.

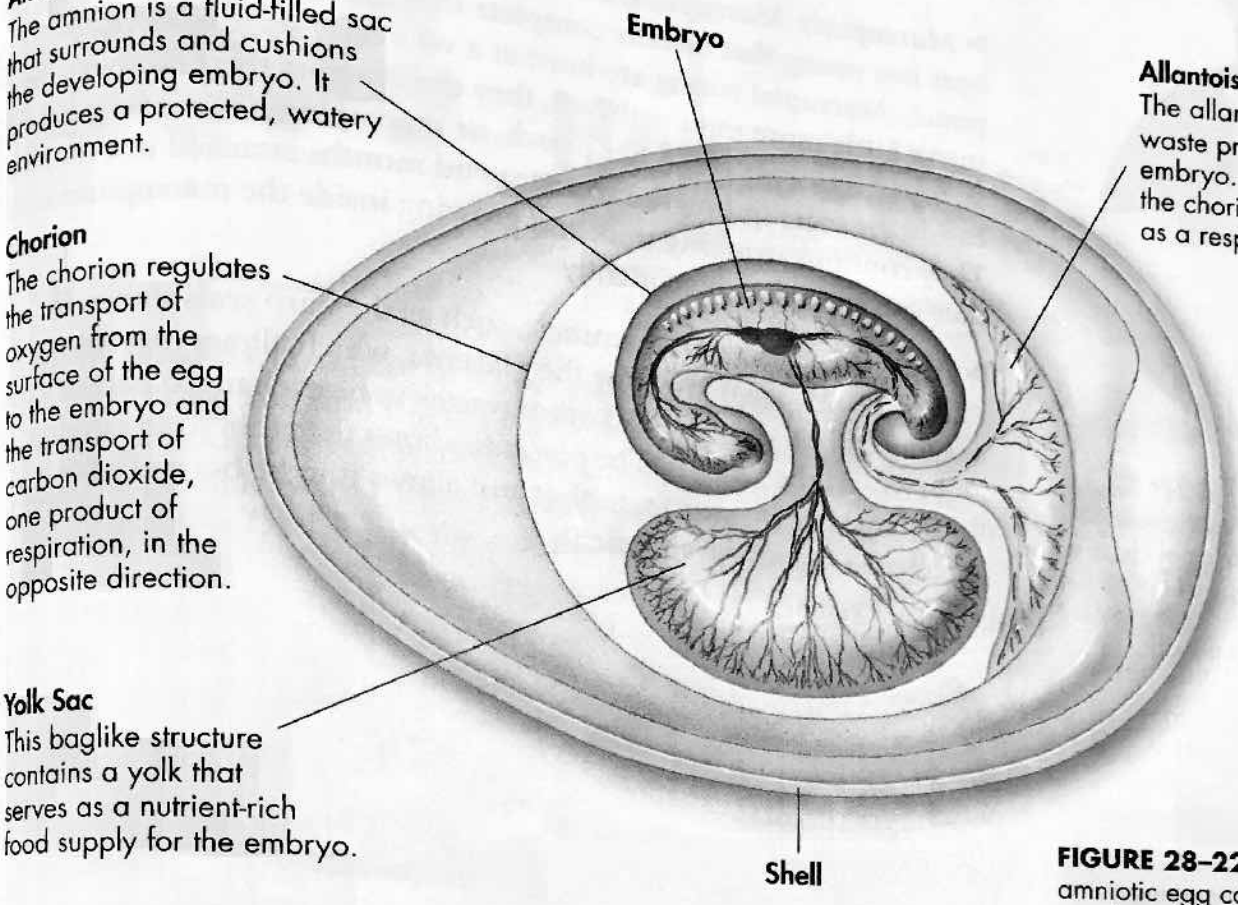



**FIGURE 28–22 Amniotic Egg** An amniotic egg contains several membranes and an external shell. Although it is waterproof, the eggshell is porous, allowing gases to pass through. The shell of a reptile egg is usually soft and leathery, while the shell of a bird egg is hard and brittle.

**The Amniotic Egg** **Reptiles, birds, and a few mammals have evolved amniotic eggs in which an embryo can develop outside its mother's body, and out of water, without drying out.** The **amniotic** (am nee AH tik) **egg** is named after the amnion, one of four membranes that surround the developing embryo. The amnion, yolk sac, chorion, and allantois membranes of the amniotic egg, along with its shell, provide a protected environment in which an embryo can develop out of water. You can learn about the functions of the membranes in **Figure 28–22.** The amniotic egg is one of the most important vertebrate adaptations to life on land.

**Mammalian Reproductive Strategies** Mammals have evolved various adaptations for reproducing and caring for their young. **The three groups of mammals—monotremes, marsupials, and placentals—differ greatly in their means of reproduction and development, but all nourish their young with mother's milk.**

▶ ***Monotremes*** Reproduction in monotremes, such as the echidna in **Figure 28–23,** combines reptilian and mammalian traits. Like a reptile, a female monotreme lays soft-shelled, amniotic eggs that are incubated outside her body. The eggs hatch in about ten days. But like other mammals, young monotremes are nourished by milk produced by the mother's **mammary glands.** Female monotremes secrete milk, not through well-developed nipples like other mammals, but through pores on the surface of the abdomen.

**FIGURE 28–23 Monotremes** There are only five species of monotremes, four of which are spiny echidnas similar to the one above. Monotremes lay eggs but, like all mammals, feed their young with milk produced by the mother.

**FIGURE 28–24 Marsupials** Marsupial young, such as this joey peeking out of its mother's pouch, are born at a very early stage of development. They complete their development nursing in their mother's pouch.

► ***Marsupials*** Marsupials, such as the kangaroos in **Figure 28–24,** bear live young that usually complete their development in an external pouch. Marsupial young are born at a very early stage of development. Little more than embryos, they crawl across their mother's fur and attach to a nipple in her pouch, or marsupium (mar soo pee um). Inside the marsupium, the young spend months attached to a nipple. They continue drinking milk and growing inside the marsupium until they can survive independently.

► ***Placentals*** Placental mammals, such as the harp seals shown in **Figure 28–25,** are named for the placenta, which allows nutrients, oxygen, carbon dioxide, and other wastes to be exchanged between the embryo and the mother. The placenta allows the embryo to develop for a long time inside the mother and allows it to be born at a fairly advanced stage of development.

**FIGURE 28–25 Placental Mammals** Placental mammals, such as harp seals, are nourished through a placenta before they are born and by their mother's milk after they are born.

# 28.3 Assessment

## Review Key Concepts

**1. a. Review** Compare asexual reproduction and sexual reproduction in terms of the genetic diversity resulting from each.

**b. Infer** Why might sexual reproduction, as opposed to asexual reproduction, produce a population better able to survive disease or environmental changes?

**2. a. Review** Define the two types of fertilization.

**b. Predict** Why would you expect species that employ external fertilization to reproduce in the water?

**3. a. Review** Define the three ways in which embryos develop.

**b. Compare and Contrast** What is the difference between a nymph and a pupa?

**4. a. Review** What structure enables reptiles and birds to reproduce outside of water?

**b. Interpret Visuals** In your own words, describe the functions of two of the membranes shown in **Figure 28–22.**

## WRITE ABOUT SCIENCE

### Creative Writing

**5.** Write an advertisement for an amniotic egg. Draw and label the parts of the egg, including each of the membranes and the shell. Describe the purpose of each structure and how it's ideally suited for its function.