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.

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

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.

BIOLOGY.com Search Lesson 28.3 GO • Lesson Overview • Lesson Notes

Getting Started

Objectives

28.3.1 Compare asexual and sexual reproduction.

28.3.2 Contrast internal and external fertilization.

28.3.3 Describe the different patterns of embryo development in animals.

28.3.4 Explain how terrestrial vertebrates are adapted to reproduction on land.

Student Resources

Study Workbooks A and B, 28.3 Worksheets

Spanish Study Workbook, 28.3 Worksheets

BIOLOGY.com Lesson Overview • Lesson Notes • Assessment: Self-Test, Lesson Assessment

For corresponding lesson in the **Foundation Edition,** see pages 678–683.

Activate Prior Knowledge

Ask student volunteers to list ideas and concepts that they learned about sexual and asexual reproduction in previous lessons on cell division and meiosis. Write the list on the board, and explain to students that they will be applying their knowledge during this lesson on animal reproduction.

Answers

FIGURE 28–14 These whiptail lizards have little or no genetic diversity.

NATIONAL SCIENCE EDUCATION STANDARDS

UNIFYING CONCEPTS AND PROCESSES

I, V

CONTENT

C.2.b, C.3.a, C.5.d, C.6.b, C.6.c

INQUIRY

A.2.a

UbD Teach for Understanding

ENDURING UNDERSTANDING Animals have evolved diverse ways to carry out basic life processes and maintain homeostasis.

GUIDING QUESTION What are the different strategies animals have evolved to help them produce offspring?

EVIDENCE OF UNDERSTANDING *After students complete the lesson, assign the following assessment to show their understanding of the difference between asexual reproduction and sexual reproduction.* Have each student write a brief article, that could appear in a general-circulation magazine, explaining the difference between sexual and asexual reproduction. Tell students the article should identify an advantage and a disadvantage of each.

Teach

Lead a Discussion

After students have read the information on this page and reviewed **Figure 28–16,** discuss how some animals alternate between asexual reproduction and sexual reproduction. Ask students why they think having an alternating reproductive cycle might be advantageous for some organisms. *(Sample answer: Having an asexual stage helps the organism reproduce quickly when needed, but still allows them the genetic diversity that results from sexual reproduction.)* Then, review each step of the cycle shown in **Figure 28–16.** Begin by having students focus on the fertilization of gametes, which produces a zygote that develops into a polyp.

DIFFERENTIATED INSTRUCTION

LPR **Less Proficient Readers** If students struggle with the large amount of text on this page and in **Figure 28–16,** have them work in pairs to write a list of main ideas and create a simplified version of the visual. Then, have two pairs work together to discuss the similarities and differences between their lists of main ideas and drawings.

MYSTERY CLUE

Review with students the meaning of *homozygous,* which they learned in Chapter 11. Discuss why most organisms are homozygous for some traits and heterozygous for other traits. Then, talk about why it is interesting that the baby shark was homozygous for every trait the researchers examined. Students can go online to **Biology.com** to gather their evidence.

Answers

IN YOUR NOTEBOOK A genetically diverse species is more likely to have members with adaptations that allow them, and therefore, the species, to survive changing environmental conditions or disease.

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.

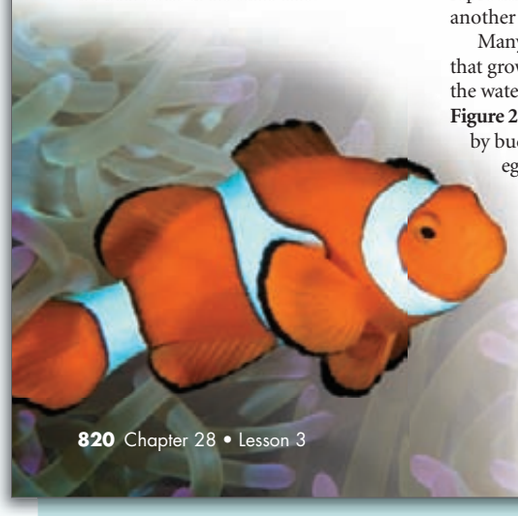
Reproductive Cycles A number of invertebrates have life cycles that alternate between sexual and asexual reproduction. Parasitic worms and cnidarians alternate between forms that reproduce sexually and forms that reproduce asexually.

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.



Biology In-Depth

INVERTEBRATE HERMAPHRODITISM

In Greek myth, Hermaphroditus, the son of Hermes and Aphrodite, caught the eye of a nymph of the spring in which he was bathing. She fell in love with him, and they melded into one being—half male and half female. Likewise, a hermaphroditic animal contains both male and female organs and thus can produce both eggs and sperm. Hermaphroditism is common in invertebrates such as worms, some gastropods, some leeches, and barnacles. Self-fertilization is possible, but usually, during sexual reproduction, two separate individuals exchange sperm. As a result, eggs in both organisms become fertilized. That result is an advantage of hermaphroditism, because two organisms, not one, are impregnated by each encounter and because genetic variation is maintained. Such an event is called mutual cross-fertilization. Other hermaphrodites practice self-fertilization. Scientists are investigating the evolutionary advantages of that approach.

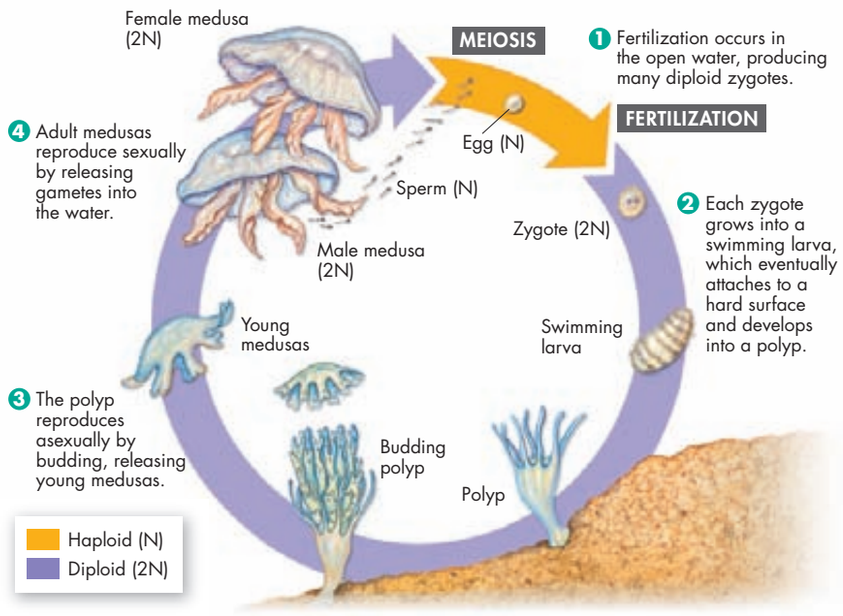


FIGURE 28–16 Alternating Reproductive Cycles The reproductive cycle of *Aurelia*, a jellyfish, alternates between asexual and sexual reproduction. A zygote is produced sexually by medusas and grows into a larva. The larva develops into a polyp that buds, reproducing asexually. The polyp releases a medusa.

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?

Check for Understanding

ONE-MINUTE RESPONSE

Write the following prompt on the board, and give students about a minute to write a quick response.

- Compare and contrast asexual and sexual reproduction. Describe a life cycle that alternates between the two.

ADJUST INSTRUCTION

If students' responses are incorrect or incomplete, lead a short class discussion to review the basic differences between asexual and sexual reproduction. Then, have small groups of students talk about alternating reproductive cycles so students can hear the concepts discussed in different ways.

Lead a Discussion

Point out that fertilization occurs only in sexual reproduction. Among animals that reproduce sexually, the egg can either be fertilized outside the body or inside the body of the egg-producing individual, which is usually identified as the female of the species.

Ask Name some invertebrates that reproduce by internal fertilization, and name some invertebrates that reproduce by external fertilization. *(Sponges, arachnids, and many other arthropod species reproduce by internal fertilization. Corals, worms, and mollusks reproduce by external fertilization.)*

DIFFERENTIATED INSTRUCTION

L1 **Struggling Students** Some students may have difficulty visualizing how external fertilization could occur. Direct their attention to **Figure 28–16,** which includes an example of external fertilization, or to **Figure 28–17,** which shows a fish releasing sperm. As students look at the cycle in **Figure 28–16,** explain that the male medusa releases sperm and the female medusa releases eggs into the open water, where fertilization occurs.

ELL Focus on ELL: Extend Language

INTERMEDIATE AND ADVANCED SPEAKERS

Have students fill out a **Venn Diagram** to organize information about internal and external fertilization. In the shared portion of the diagram, they should record that both are forms of sexual reproduction, both include fertilization of eggs by sperm, and both include some invertebrates and chordates. Students can record contrasting details of each after labeling one side Internal Fertilization and the other External Fertilization. Accept short phrases from intermediate speakers, but require advanced speakers to write sentences in their Venn diagrams.

Study Wkbks A/B, Appendix S33, Venn Diagram. **Transparencies,** GO18.

MYSTERY CLUE Suggest students look in this section for a way that some vertebrates can reproduce asexually. Students can go online to Biology.com to gather their evidence.

Teach continued

Build Science Skills

Tell students there are both similarities and differences among species regarding the growth and development of their embryos. Explain that the science skill of comparing and contrasting can be used to identify these similarities and differences. Ask each student to write a sentence comparing, or identifying a similarity, among the three types of development: oviparous, ovoviviparous, and viviparous. Then, have students write a sentence contrasting, or identifying differences between, embryo growth and development among the three types. Call on volunteers to share their sentences with the class.

DIFFERENTIATED INSTRUCTION

ELL English Language Learners Write these three terms on the board, dividing each into word parts: *ovi-parous, ovo-vivi-parous,* and *vivi-parous.* Explain that *ovi* and *ovo* mean "egg," *vivi* means "alive," and *parous* means "giving birth to." Work with students on the pronunciation of these terms, and use the meanings of the word parts to help explain what each term means.

LPR Less Proficient Readers Have students organize information about where embryos develop in a **Compare/Contrast Table.** Have them write these four column headings: Characteristics, Oviparous Species, Ovoviviparous Species, and Viviparous Species. The rows should include: Definition/Description, How Young Are Nourished, and Examples. After students have finished filling in the table, suggest they work in small groups to check one another's tables.

Study Wkbks A/B, Appendix S20, Compare/Contrast Table. **Transparencies,** GO3.

Answers

FIGURE 28–17 large numbers of sperm

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 nonvertebrate 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.

Quick Facts

FISH PARENTS

Most oviparous fishes provide no care for their young; they simply produce hundreds, or even millions, of fertilized eggs and "let nature take its course." Most eggs do not develop into young fishes; they are eaten or damaged. Some oviparous fishes, however, do care for their young. Some fishes build nests to protect the fertilized eggs. Siamese fighting fishes build nests of bubbles, and sticklebacks use fragments of aquatic plants, twigs, and other debris. Some cichlids hold their eggs and young in the mouth. Seahorses hold fertilized eggs in a pouch until the eggs are ready to hatch. Fishes that care for their young usually do not produce as many eggs as those that simply lay the eggs and leave.

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!

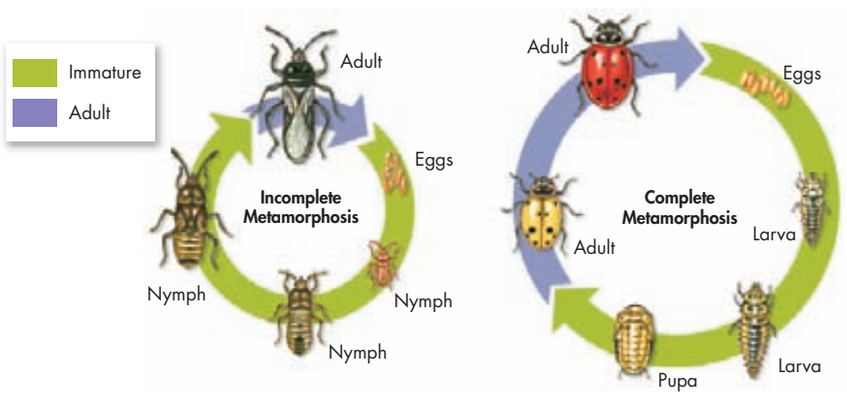


FIGURE 28–19 Insect Metamorphosis Insects usually undergo metamorphosis during their growth and development. The chinch bug (left) undergoes incomplete metamorphosis, in which the nymphs look similar to the adults. The ladybug (right) undergoes complete metamorphosis. The developing larva and the pupa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

Use Visuals

Use **Figure 28–19** to start a discussion on insect metamorphosis. Emphasize that other kinds of animals also develop through metamorphosis.

Ask If you observed a very small grasshopper that closely resembled a larger grasshopper, would you identify it as a nymph or a pupa? *(a nymph, because grasshoppers undergo incomplete metamorphosis, which doesn't include a pupal stage)*

Ask The caterpillars of monarch butterflies form a chrysalis in which they develop into their adult form. What developmental stage is the chrysalis an example of? *(the pupal stage)*

DIFFERENTIATED INSTRUCTION

LPR **Less Proficient Readers** Many students would benefit from observing insect metamorphosis first hand. Place food, such as a piece of overripe banana, in an open jar, and leave it for a few days in a place where flies can have access to it. Then, wave the flies away and cover the jar with a nylon stocking or similar porous material. Within a few days, students will be able to observe maggots on the food. Explain that maggots are fly larvae. In time, they will metamorphose into pupae, and, eventually, emerge as adults.

L3 **Advanced Students** Ask interested students to find images and information about metamorphosis in frogs. Have them make a presentation to the class about the life cycle of frogs. Students may be able to find a video online showing how tadpoles develop into adult frogs.

UbD Check for Understanding

HAND SIGNALS

Ask students the following questions, and have them show a thumbs-up sign if they think they can answer the question correctly, a thumbs-down sign if they definitely can't, or a waving-hand sign if they're not sure.

- How are ovoviviparous species different from viviparous species?
- What is the purpose of a placenta?
- What is the difference between complete and incomplete metamorphosis?

ADJUST INSTRUCTION

For any question that received a thumbs-down or waving-hand sign, ask students to find the answer in their text and write a one-sentence response to the question.

Teach continued

Lead a Discussion

Ask volunteers to describe their observations of how pet cats or dogs take care of their kittens or puppies. Then, discuss other observations they've made of animals caring for their young, such as birds feeding chicks in a nest.

Ask How is it that some offspring of animals that provide little parental care survive? *(These animals produce so many offspring that some are bound to survive.)*

Ask Why do you think maternal care is an important mammalian characteristic? *(Mammals don't produce large numbers of offspring, and maternal care helps ensure that some offspring survive into adulthood.)*

DIFFERENTIATED INSTRUCTION

L1 **Struggling Students** Help students understand how some animal species can succeed without caring for their young by directing them back to **Figure 28–17.** Explain that the great numbers of eggs and sperm released by these organisms ensure that some offspring will survive.

Answers

IN YOUR NOTEBOOK Hormones control metamorphosis in both arthropods and amphibians.

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.

Quick Facts

IT TAKES A VILLAGE TO RAISE AN ELEPHANT

Elephants have complex social interactions and behaviors associated with raising their young. The gestation period for elephants is about 22 months. Females first start mating around the age of 20 years. They will continue to have calves every two to four years until they reach about 50 years of age. Calves are highly dependent on their mothers for food for the first two years. These calves are cared for not only by their mothers but also by the other females in the herd. Older females help new mothers. Younger females play with the babies. When a young elephant has been weaned, it enters a sort of adolescence. Young males leave the herd, often joining bachelor herds. Young females stay with the herd and help care for newborns, which helps prepare them to become mothers.