



SPOTLIGHT



Metamorphosis



SPOTLIGHT: METAMORPHOSIS

What if you could change into a totally different form? What if you could grow wings and fly? What if you could gain new powers—like lifting 50 times your weight or jumping 5 times your height? That's the stuff of science fiction and comic books. But it really happens when animals go through metamorphosis.

A body is not fixed like a statue. Bodies change as they grow—whether it's a kitten growing into a cat or a child growing into an adult. But near-total change is rare—unless of course you're an insect, jellyfish, frog, or other animal that goes through metamorphosis.

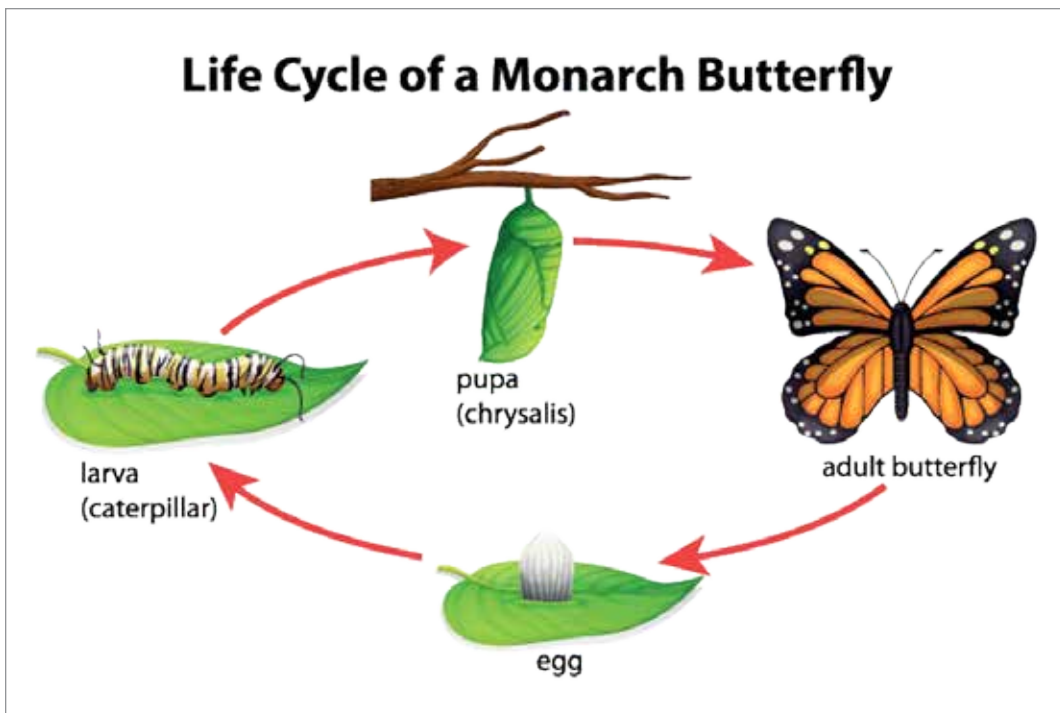
Zoologists use the term metamorphosis to describe what happens when the young, or juvenile, body of an animal goes through a radical change in form to become an adult.

An excellent example of metamorphosis is a caterpillar transforming into a butterfly. If you saw a caterpillar and a butterfly side by side, you might not realize they were the same creature. They look almost completely different. And they occupy different niches in their habitat, with the caterpillar stuck on land and the butterfly able to take to the air.



TOP: (Freerk Brouwer/
Shutterstock)

BOTTOM: Life Cycle
of a Monarch Butterfly
(Blue Ring Media/
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So how do they make this huge transformation? Butterflies and many other insects, such as ants and bees, have four major stages in their life cycle: egg, larva, pupa, and adult.

The basics go like this: The adult butterfly lays tiny eggs, usually on a leaf, stem, or another part of a plant. Each egg is just one fertilized cell, but it has blueprints for the physical shape of the developing insect (in its DNA) and food in the form of a yolk to provide energy for growth. The mother butterfly spends a lot of time hunting for the exact right plant to lay eggs, because once they hatch, many caterpillars will only eat one type of greenery.

It only takes a short time for a small larva—called a caterpillar in the case of butterflies—to emerge from the egg. Born right on its food source, the caterpillar quickly gets to its favorite activity: eating. The life of the caterpillar is simple: It eats, poops, and grows. In fact, it grows so much that it repeatedly gets too big for its skin. A caterpillar typically needs to shed its skin five or six times as it grows. The process of shedding its skin is called molting, and each phase between molts is called an “instar.”

Caterpillars are not very speedy and they’re out there in the open—which makes them easy targets for predators. To help them survive, caterpillars have evolved two strategies: hiding in plain sight (camouflage) and chemical warfare (toxins). Caterpillar camo comes in many forms—some caterpillars look like bird poop, others like twigs,

LEFT: Butterfly eggs are tiny but visible to the human eye—about one-half to two millimeters in length. (Mau Horng/Shutterstock)

RIGHT: This photo montage shows a caterpillar emerging and then eating what remains of its egg. Protein! A newly hatched caterpillar is known as the first instar. (Cathy Keifer/Shutterstock)



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and still others have large eyespots to make them look scary to anyone thinking of attacking. Caterpillars that use toxins for defense sometimes have bright colors, effectively saying “Warning: Eat Me at Your Own Risk.” These toxic caterpillars can make birds and other predators sick if eaten.

After a few weeks, the caterpillar is ready to start its big transformation. It finds a safe place (such as the underside of a leaf) and spins a tiny pad of silk. Using Velcro-like hooks on its back end, it attaches itself to the silk pad and hangs upside-down. This time, when the caterpillar sheds its skin, there is a pupa underneath. A butterfly pupa is called a chrysalis. Soft at first, the outside of the chrysalis hardens in about an hour, creating a protective shell. As the pupa hangs there, the insect doesn’t eat or interact with the outside world. All the action is inside the pupa.



If you were to watch a sped-up film of what happens inside a chrysalis, it would look like part of the caterpillar’s body was turning to mush. What’s happening is that the caterpillar is digesting much of its own body—using some of the same secretions it used to digest leaves and other food. The digested body parts provide the energy for metamorphosis. Here’s how:

Among the parts of the caterpillar’s body that don’t turn to mush are tiny clusters of special cells that can grow into butterfly parts. These special cells are called

TOP LEFT: A monarch caterpillar prepares for metamorphosis. (Brandon Alms/Shutterstock)

TOP CENTER: The caterpillar wriggles out of its skin—which is all scrunched up at the top—revealing the shell of the pupa (chrysalis) underneath. (hwongcc/Shutterstock)

TOP RIGHT: As the butterfly forms inside the chrysalis, its wings begin to show through the shell. When the adult butterfly breaks free—leaving just a pale husk behind—it must dry its wings before taking flight. (Matee Nuserm/Shutterstock)

BOTTOM: While their larvae have mouths for chomping on leaves, adult butterflies have proboscises for sipping the nectar of flowers. (chanwangrong/Shutterstock)



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imaginal discs. These stealthy cells have been hiding inside the caterpillar's body all along—and they are just waiting for a trigger that tells them to grow. (The trigger is a drop in the production of juvenile hormone.)

The imaginal discs grow into wings, six segmented legs, compound eyes, antennae, and the proboscis that the butterfly uses to sip nectar. When the adult butterfly emerges from the chrysalis, it weighs about half its caterpillar self. That just goes to show how much of the caterpillar's body had to be broken down into energy to fuel the transformation.

Other insects go through a four-stage life cycle, too. While they follow the same basic pattern—egg, larva, pupa, and adult—the details of their lives can be very different. For example, honeybee larvae don't go off on their own and fend for themselves like butterfly larvae do. Adult honeybees care for wiggly, wormlike larvae in nurseries inside their hive. The larvae are fed literally hundreds of times a day and they grow FAST.

Honeybee larvae are ready to transform five days after hatching. When it's time, the adult bees seal them into the hexagon-shaped honeycomb cells in which they were born and the larvae "pupate," spinning little cocoons (with silk produced from their salivary glands). To spin a cocoon around itself, a larva turns dozens of somersaults

inside the honeycomb cell. There, the larva goes through metamorphosis—a process that takes 13 days—changing from a little white grub into an adult honeybee with six legs, a stinger, wings, and black and yellow stripes.

About 88 percent of all insect species have a four-stage life cycle and go through complete metamorphosis. The remaining 12 percent—



The queen bee lays one egg in each of several cells. When the eggs hatch, the larvae are fed by adult worker bees (shown here). The larvae get a diet of "royal jelly" (a high-protein liquid produced by the adult bees) and "bee bread" (honey mixed with pollen). When the larvae have gone through five molts and grown over 1,000 times their original size, the adults will cap their cells with pollen and beeswax. Once the metamorphosis is complete, the new adult bees will chew their way out of their cells. (Lehrer/Shutterstock)





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The Grand Canyon displays layer upon layer of sedimentary rock. The most ancient layers at the bottom are more than 500 million years old. The youngest layer, the 270-million-year-old Kaibob limestone, is at the top. The sediments that form limestone are not from rock, but from the broken down shells of sea creatures. (Martin M303/ Shutterstock)

including dragonflies and grasshoppers—have a three-stage life cycle and go through what is called simple metamorphosis. The three stages are: egg, nymph, and adult. The key difference between complete and simple metamorphosis is there is no dormant, or “resting,” stage. Nymphs are born looking somewhat like their adult forms, and with each molt they take on more adult characteristics.

Dragonflies go through a dramatic three-stage metamorphosis. When the nymphs first hatch, they look like small beetles. But they’re aquatic and have gills so they can breathe under water in ponds and rivers. As the dragonfly nymphs grow, they shed their skin (molt) several times and with each molt, they grow longer and start developing “wing buds.” A nymph may molt 8 to 15 times before it’s ready to emerge from the water. For the final molt, the nymph crawls out of the water and clings to the stalk of a plant. It sheds its skin and then starts pumping a blood-like substance into its four wing buds—which expand and turn the now-adult dragonfly into one of the most amazing fliers on the planet.

The final molt is often triggered by a change in season or temperature. In some cases, nymphs of one species in a pond or stream may all transform on the same day. Mayflies are famous for their mass emergences each spring. Sometimes there are so many that they create blizzard-like conditions and can even be tracked by radar.





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Frogs have a three-stage life cycle, too: egg, larva, and adult. The mother frog deposits her eggs in a pond or other wet environment. When the eggs hatch, tiny larvae (tadpoles) emerge. Tadpoles, of course, are aquatic—they have gills and long tails, and they swim around like fish. But toward the end of the tadpole phase, changes happen: Legs and lungs begin to form, the tadpole's tail shrinks, and its mouth widens. When metamorphosis is complete, the adult frog is so changed that it hops out of the water and lives on land from then on. Once legless, its legs are now so powerful that they make up one-quarter of the frog's body mass. Some frogs can leap 10 to 20 times their body length.



Adult frogs head down to the pond or another wet environment and lay their eggs in masses (called spawn). The black dots are fertilized cells that will develop into tadpoles—unless the eggs are eaten by predators. (DJTaylor/ Shutterstock)

Tadpoles have flat tails for swimming and small mouths to eat algae, plant matter, and tiny aquatic animals. (Matej Ziak/ Shutterstock)

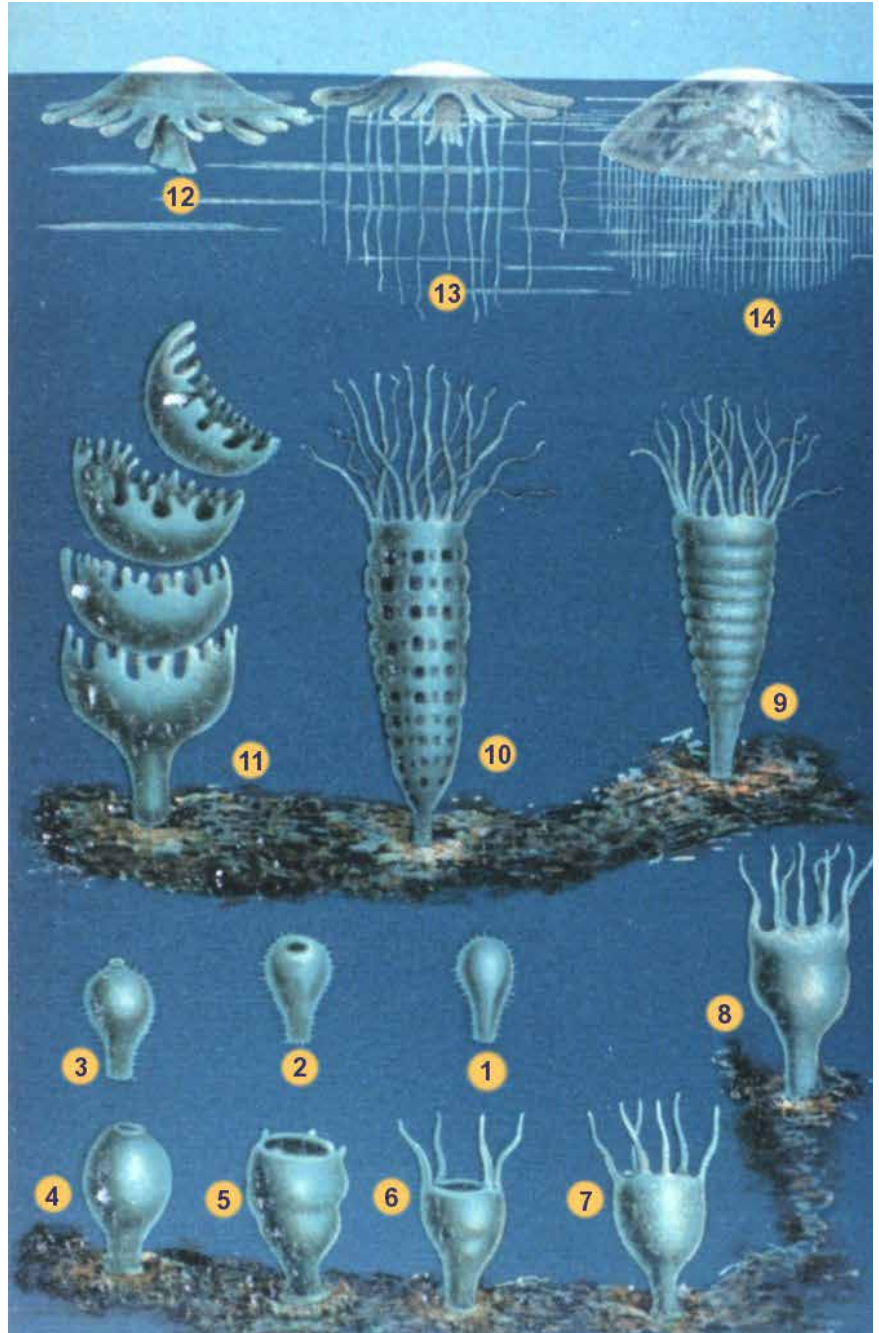
This tadpole is going through metamorphosis. So what is it doing out of the water? This Amazon rain forest species can leave the water as soon as it develops lungs. As a froglet, it can crawl through the trees with its tail still on until metamorphosis is done. (Dr. Morley Read/ Shutterstock)

All grown up, these two adult frogs have muscular legs and mouths that are as wide as their heads. As adults, they dine almost exclusively on insects. (Eduard Kyslynsky/ Shutterstock)



Jellyfish are freaky to begin with. But their metamorphosis is even freakier. You're probably familiar with adult jellyfish, with their umbrella-shaped bodies and tentacles. The adult form is actually known as the medusa because of its resemblance to Medusa—the angry snake-headed goddess in Greek mythology. But that's not the only form. Jellyfish start their life as tiny free-swimming planulae that quickly attach to a surface and grow into a polyp. The polyps are cup-shaped with mouths and tentacles. The polyp just sits there—trapping passing food—until a change in water temperature triggers it to morph and start “budding off.” Little disks of new jellyfish bud and break off from the polyp. The disks grow into adult jellyfish that can swim around on their own—and sometimes lash out with stinging tentacles.

Written by Margaret Mittelbach



How many species of jellyfish are there? Over 1,000—with many more waiting to be discovered. This species, *Mastigias papua*, lives in a saltwater lake in Indonesia. (Andaman/ Shutterstock)

This chart shows the metamorphosis of a jellyfish: From stage 1 to 3, it's a free-swimming larva, called a “planula.” At stage 4, it attaches to a surface and becomes a polyp, growing into what looks like an upside-down jellyfish. At stage 9, the polyp starts to morph, turning into what looks like a stack of disks. By stage 11, the disks are budding off as “ephyra,” essentially juvenile forms of the adult stage. (Image via Wikipedia)

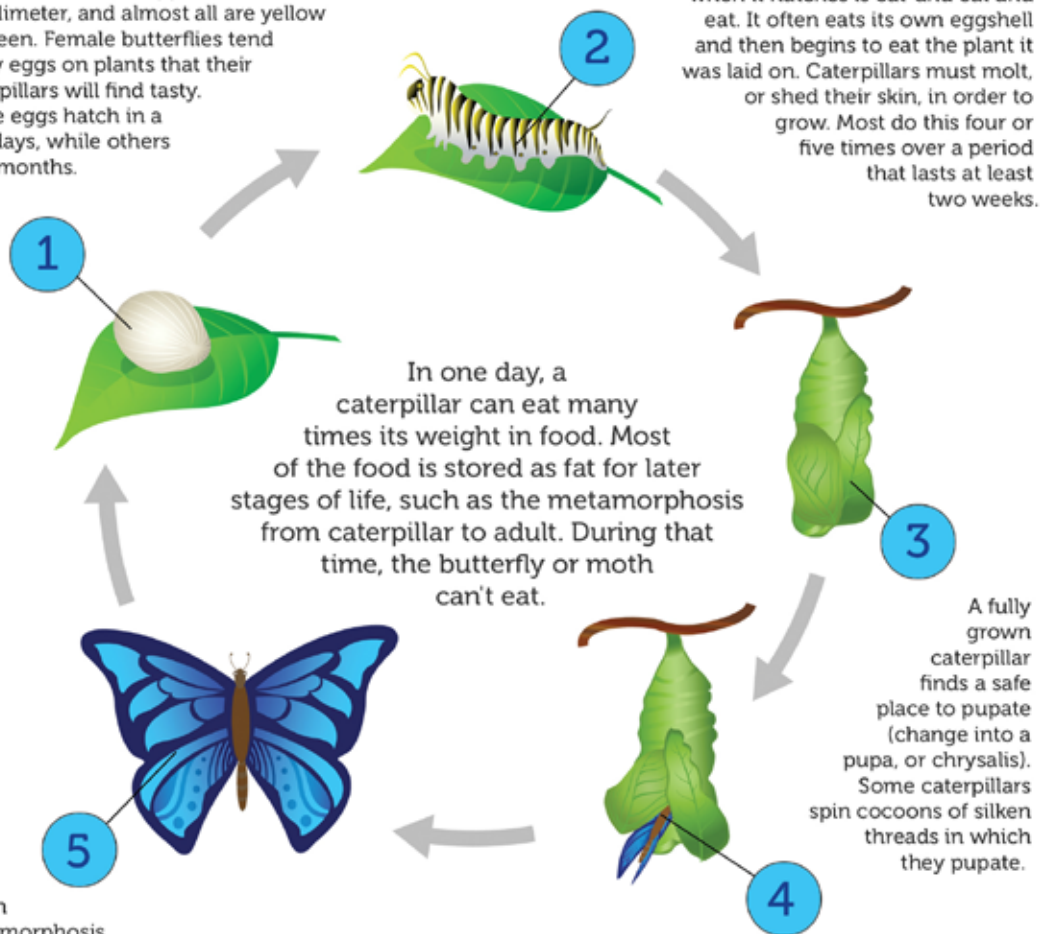
The Life Cycle

The life span of an adult butterfly or moth is amazingly short. A few adults live as long as 18 months, while most last no more than two weeks. Each of them, though, goes through the biggest change known to nature. Their metamorphosis from a caterpillar into an adult is a miracle to behold!



All butterflies and moths start off as eggs. Some of the tiniest eggs are smaller than a millimeter, and almost all are yellow or green. Female butterflies tend to lay eggs on plants that their caterpillars will find tasty. Some eggs hatch in a few days, while others take months.

The first thing a caterpillar (or larva) does when it hatches is eat—and eat and eat. It often eats its own eggshell and then begins to eat the plant it was laid on. Caterpillars must molt, or shed their skin, in order to grow. Most do this four or five times over a period that lasts at least two weeks.



When metamorphosis is complete, the adult butterfly or moth breaks out of its pupa shell or cocoon. Its wings and body are still soft, so it pumps blood into its newly formed wings. Within about half an hour, the exoskeleton hardens and the wings become rigid. The new adult's task is to find a mate.

Inside, the creature is undergoing amazing chemical changes, and gradually the adult butterfly or moth emerges.

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Take 5 Quiz: Metamorphosis

1. What is metamorphosis?

- a. When an animal changes its habitat
- b. When an animal is born from an egg
- c. When an animal uses camouflage to change its appearance to hide from predators
- d. When an animal changes its shape or form

2. More than 80 percent of all insects go through complete metamorphosis.

What are the four stages in their life cycle?

- a. egg, nymph, instar, adult
- b. egg, larva, pupa, adult
- c. protoplasm, egg, pupa, adult
- d. egg, wiggler, megamorph, adult

3. Some insects, like dragonflies, go through three-stage “simple” metamorphosis. What is the main difference between simple and complete metamorphosis?

- a. These insects don’t lay eggs but give birth to nymphs.
- b. These insects don’t grow wings.
- c. There is no dormant, or “resting,” stage in the life cycle of these insects.
- d. Like Peter Pan, these insects never become adults.

4. What are frog larvae called and where do they usually live?

- a. planulae live in saltwater
- b. nymphs live in mud and wet sand
- c. tadpoles live in ponds and other freshwater habitats
- d. froglets live in rotting logs and under fallen leaves

5. Before a jellyfish becomes a free-swimming adult, it goes through a stage where it’s stuck in one spot. What is that stage called?

- a. polyp
- b. planula
- c. disk
- d. Medusa





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