

Pollination



The deep orange male parts and light green, club shaped female parts stick out from a 'Stargazer' lily.

Pollination is an important step in sexual reproduction of flowering plants and gymnosperms. Male flower parts – stamens – produce a sticky powder called pollen. Pollination is the process by which pollen is transferred from the male to the female reproductive parts of the plant. Once the pollen reaches the female flower part – the tip of the pistil, or the stigma, which is often sticky (or the micropyle in gymnosperms) – the pollen tube grows a long tube down to the base of the pistil, to the ovule to allow the sperm to fertilize the eggs in the ovary. After fertilization is complete, then fruit and seeds can develop.

Self-pollination occurs when pollen from a plant's stamen is transferred to that same plant's stigma. Cross-pollination is when pollen from one plant's stamen is transferred to a different plant's stigma (but of the same species). This outcrossing allows genetic recombination to potentially create new and better adapted plants.

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There are two main ways pollination is achieved. Abiotic pollination occurs without the involvement of other organisms, while biotic pollination relies on a living vector, a pollinator, to move pollen. (A pollinator is not the same a pollenizer, which is a plant that is a source of pollen.)

Only about 20% of plants are pollinated without the assistance of animals, and wind pollination is the most common way this happens. Water is an important carrier of pollen for aquatic plants. Wind pollination is the predominant method of pollination for grasses, most conifers (cone-bearing plants, such as pine trees) and many deciduous trees.



Pollen is shed from the anthers of 'Stargazer' lily (L) and peacock orchid (R).



Flowers of *Miscanthus sinensis* 'Golden Light' (L); *Pennisetum alopecuroides* 'Foxtrot' (LC); an unidentified grass (RC); and *Panicum virgatum* 'Heavy Metal' (R).

The wind picks up pollen from one plant and blows it onto another. Because this is such a random event, wind-pollinated plants produce copious amounts of pollen in order to assure some pollen will reach its target. This is one reason why ragweed is notorious for causing hay fever. Wind-pollinated plants usually have long stamens and pistils. But their flowers are generally small, not colorful or fragrant, since they do not need to attract pollinators.



The inconspicuous flowers of ragweed (L and LC) shed enormous amounts of pollen (RC and R).

Most plants, including nearly 80% of the 1,400 crop plants grown around the world for food and industrial products, rely on animals to carry their pollen grains from flower to flower. Anything that moves the pollen is called a pollinator. Most of the about 200,000 different pollinators are insects, but some birds, bats and a few other animals act as pollinators. These animals visit the plant to get food, either the pollen itself or nectar, and in the process they get pollen on their bodies. When they move to another flower to feed, some of the pollen may rub off onto the new plant's stigma. Flowers of these plants have specific traits, such as beautiful colors, interesting shapes or noticeable scents, to attract pollinators.

The vast majority of pollinators are flying insects. Bees (in the order Hymenoptera) are the largest and most important group of pollinators. They are well adapted for efficient pollination, with fuzzy bodies that carry an electrostatic charge that help pollen grains adhere to their bodies. They also have specialized pollen-carrying structures, usually on the hind legs or lower abdomen. The bees collect the pollen, a concentrated source of protein, to feed their young.



A halictid bee carrying pollen in a mass on its hind leg.

The honey bee (*Apis mellifera*) is probably the most familiar bee to the average person, and the most important of the commercial pollinating agents. This domesticated insect collects pollen by rubbing up



The honey bee, *Apis mellifera*.

against the anthers and then scraping its body to pack the pollen in the “pollen baskets” on the hind legs. As it travels from flower to flower, some of the pollen grains on its body are transferred onto the stigmas. Honey bees require lots of food for the brood in their large colonies at times. When they are deliberately gathering pollen they are up to ten times more efficient as a pollinator than when primarily gathering nectar and only unintentionally transferring pollen.

The honey bee was brought to North America by settlers from Europe, joining the nearly 4,000 species of wild bees that are important pollinators of native plants. These other species of bees vary in their behavior and pollen-gathering habits. A few of these are cultured and sold for managed pollination, including bumble bees, orchard mason bees and leaf cutter bees. Bumble bees live in colonies of up to a few hundred individuals, but only the queens survive the winter to rebuild the colony again the following spring. They are important pollinators of alpine flowers at and above the timberline where other bees are absent.



Bumble bees visiting flowers; a bumble bee with pollen dusting its face (R).

Other common bees include andrenids, or digger bees (they nest in the ground); carpenter bees (appear similar to bumblebees, but with hairless, shiny abdomens); halictid bees; and megachilids or leaf cutter bees that use round pieces of leaves in their nests – leaving perfectly round holes in plant leaves.



Other bees visiting a *Passiflora* flower (L); oxeye daisy (LC); and *Gaura lindheimeri* (RC). Closeup of pollen collected on leg (R).

Flowers that are bee pollinated often are sweetly scented to attract their pollinators. Many flowers have markings to guide the bee into the flower, increasing the chance it will encounter pollen grains as it searches for nectar. These nectar guides are visible only in ultraviolet light, outside the visible spectrum of light (to humans) so we don't notice them, but the bees can see the markings.

Other Hymenoptera – wasps and occasionally ants – can be pollinators. Many species of wasps, especially sphecids and vespids, including yellow jackets and paper wasps are good pollinators. They are particularly active in the fall, especially on goldenrods.



Various wasps visiting flowers.

Beetles (Coleoptera), including blister beetles, soldier beetles, and some scarabs, are most important as pollinators in the tropics and desert areas. They are attracted to wide flowers with little nectar and copious pollen. They tend to be messy, chewing up the flowers and leaving droppings all over.



Locust borer (Cerambycidae) on goldenrod (L) and goldenrod soldier beetle on 'Prairie Sun' *Rudbeckia*, Wisconsin (LC); an unidentified scarab beetle on a daisy flower, Atacama desert, Chile (RC); blister beetles on *Oenothera* sp. in Anza Borrego desert, California (R).

Lepidoptera – moths and butterflies – pollinate plants to a small degree. Some moths are important for some wildflowers, while skippers and various pretty butterflies such as monarchs and swallowtails are common visitors on garden flowers.



A sulfur on zinnia (L); a skipper on lantana (LC); a hummingbird moth (*Hemaris thysbe*) at *Verbena bonariensis* (RC); and a white-lined sphinx moth visits penstemon flowers (R).

There are a number of flies (Diptera) that are important pollinators of certain plants. Syrphid or flow-



A variety of different syrphid flies on flowers.

ers flies are frequently seen on many types of garden flowers. Bombyliid flies, midges and a few other types of flies also visit flowers and may be the only pollinators for some plants. For example, midges in the genus *Forcipomyia* are the primary pollinators of the flowers of the cacao tree, without which there would be no chocolate.

Blow flies or carrion flies are important pollinators of certain plants. Flowers pollinated by these flies produce a putrid scent attractive to these scavengers that would normally lay eggs in decaying plant or animal material. A large group of plants that have stinky, dark-colored flowers are the stapeliads (tribe Stapelieae in the Apocynaceae) of the deserts of Africa, India and the Middle East.



A bibionid fly on a *Celmisia* flower, New Zealand (L); bluebottle fly (C); smelly-flowered stapeliad *Caralluma foetida*, Kenya (R).

Other insects that are seen on flowers, such as minute pirate bugs, thrips and plant bugs, are rarely consistent pollinators, but may transfer pollen accidentally.

Pollination by birds (ornithophily) occurs in over 60 flowering plant families. Most people in the US are familiar with hummingbirds as pollinators. In the Midwest there is only one common species, the ruby-throated hummingbird. They are easily attracted to feeders and quickly become accustomed to human presence. The solitary adults feed on nectar from many species of flowers, but also catch tiny insects on the wing as a source of protein. A few of their favorite flowers include red beebalm (*Monarda didyma*), cardinal flower (*Lobelia cardinalis*), and trumpet vine (*Campsis radicans*).



Female ruby-throated hummingbirds feeding on *Cuphea* 'David Verity' (L) and *Lobelia cardinalis* (R).



Female rufus hummingbird at penstemon (L) and male Anna's hummingbird at beebalm (R), Mendocino Co., California.

There are about 330 other species of hummingbirds, however. Most occur in tropical and subtropical Central and South America, with 16 in North America. Nearly all of these 16 can be found in the southwest part of the US. Seven or eight species are seen in the western US. Anna's hummingbird is one of the most common in California.

They don't suck nectar, but rather slurp it up with their long, grooved tongues. Although



Long-tailed Hermit at torch ginger in Costa Rica (L); Male Glittering-bellied Emerald feeding on *Melocactus* sp. near Morro do Chapéu, Brazil (LC); Swallow-tailed Hummingbird at a tall mallow bush near Mato Verde, Brazil (RC); and Planalto Hermit at the cactus *Micranthocereus polyanthus*, near Brejinho das Ametistas, Brazil (R).

most have long, straight bills, many have bills to match the flower morphology of their favorite plants (long, curved beaks or short, straight beaks).

On other continents, sunbirds (Asia and Africa) and honeyeaters (Australia, New Zealand, and Pacific Islands), fill the ecological niche of hummingbirds (hummingbirds only occur in North and South America). American orioles and honeycreepers also feed on nectar and can serve



Red-legged Honeycreeper at orange feeder, Costa Rica (L); Double Collared Sunbird on aloe flower stem, Kirstenbosch Botanical Garden, Cape Town, South Africa (C); and Kadavu Honeyeater on old coconut palm inflorescence, Kadavu Island, Fiji (R).

as pollinators. Plants pollinated by birds tend to be brightly colored (often red) and rarely are scented, as few birds have a good sense of smell and find food visually. These flowers typically have long narrow tubes and lots of nectar.

Bats are important pollinators of some night-flowering plants, particularly in the tropics. These plants typically have white petals and are fragrant. Nectar-feeding bats have long noses and tongues for getting nectar from flowers, as well as special enzymes for digesting the high-protein pollen that accumulates on their faces. Their tongues can be extended up to a third of the bat's body length. A few



Common long-tongued bat feeding on agave flowers in Bonaire, Netherlands Antilles. This bat also pollinates columnar cacti and other plants on the island.

other vertebrates, including monkeys, lemurs, opossums, rodents and lizards, may act as pollinators for some plants in other parts of the world.

People can also transfer pollen from one flower to another. Gardeners and plant breeders use cotton swabs or small brushes to make specific crosses or improve yield. In greenhouses, workers shake tomato plants to release pollen that otherwise would be accomplished by wind action. (A bumblebee can also do this quite effectively by vibrating its wing muscles when landing on a flower, so bumblebee colonies are sold for this purpose as a more cost-effectively alternative to human labor.)

Occasionally pollinators by-pass the normal path to the pollen and take nectar without any chance of pollinating the flower. Nectar robbing sweat bees, honeybees and bumblebees will chew a hole in the base of the flower, especially trumpet-shaped ones, to get to the nectar.



Bees as nectar robbers: bumble bee (L) and honey bees (R) drilling a hole through the calyx of *Salvia guaranitica* to get to the nectar without entering through the opening where pollen would be deposited.

And not all flower visitors are pollinators – there are some predators, such as crab spiders and ambush bugs, that sit on flowers, lying in wait to capture pollinators that visit their flower!



A crab spider is barely visible waiting beneath a petal on a daisy (L); a crab spider with a syrphid fly (C); and mating ambush bugs with a captured honey bee (R).

– Susan Mahr, University of Wisconsin - Madison

Additional Information:

- Pollinator Partnership – A resource for farmers, growers, and consumers about pollination and biodiversity at www.pollinator.org/
- Pollinators, Flower and Garden Ecology – a two-page handout from Life Garden at www.lifegarden.org/pdf/Pollinators.pdf