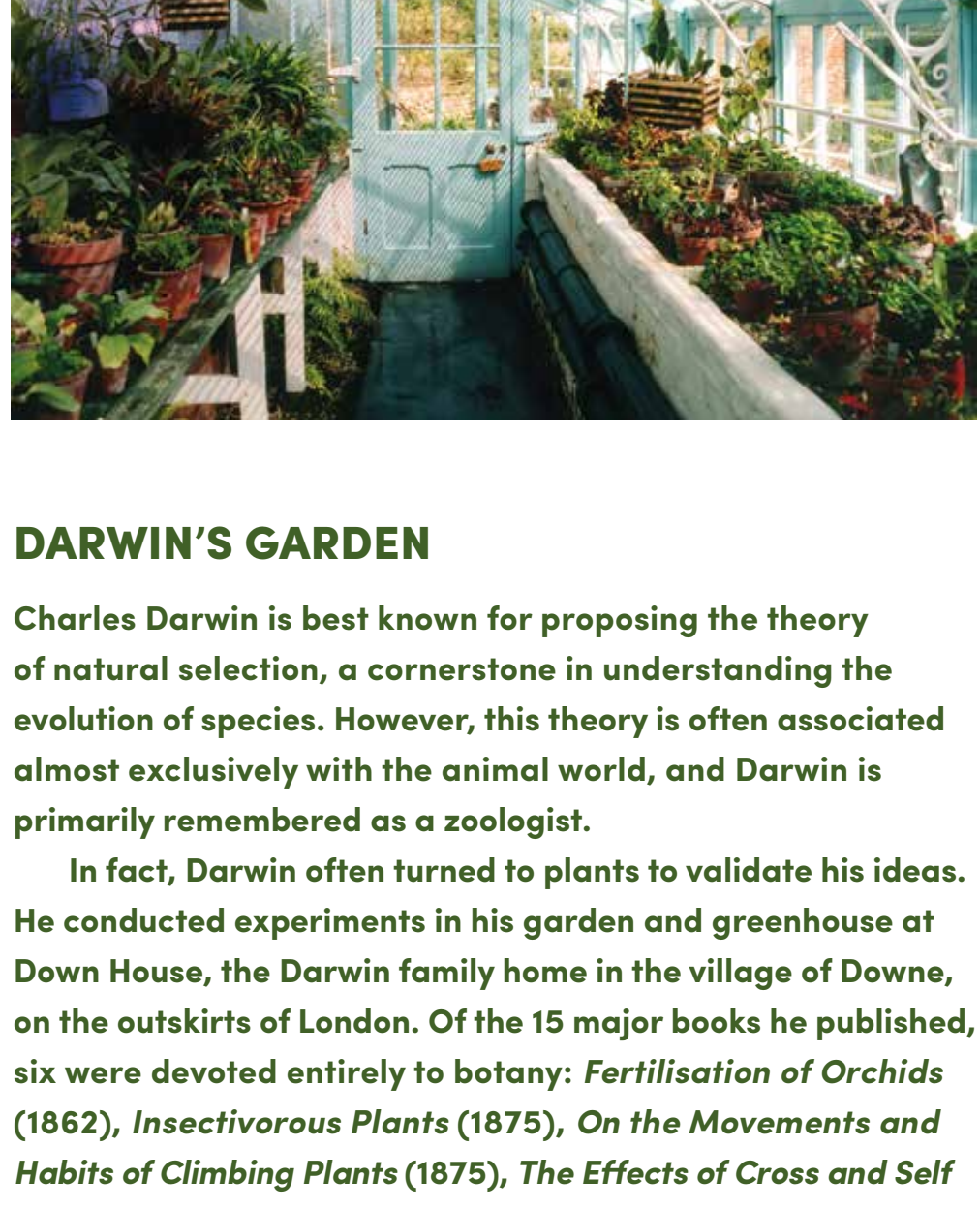


BOTANICAL PLANTS AS EVIDENCE OF DARWIN'S EVOLUTION



The greenhouse at Charles Darwin's home in Downe, where he conducted many of his experiments.

DARWIN'S GARDEN

Charles Darwin is best known for proposing the theory of natural selection, a cornerstone in understanding the evolution of species. However, this theory is often associated almost exclusively with the animal world, and Darwin is primarily remembered as a zoologist.

In fact, Darwin often turned to plants to validate his ideas. He conducted experiments in his garden and greenhouse at Down House, the Darwin family home in the village of Downe, on the outskirts of London. Of the 15 major books he published, six were devoted entirely to botany: *Fertilisation of Orchids* (1862), *Insectivorous Plants* (1875), *On the Movements and Habits of Climbing Plants* (1875), *The Effects of Cross and Self Fertilisation in the Vegetable Kingdom* (1876), *The Different Forms of Flowers on Plants of the Same Species* (1877) and *The Power of Movement in Plants* (1880).

DARWIN THE ORCHID LOVER

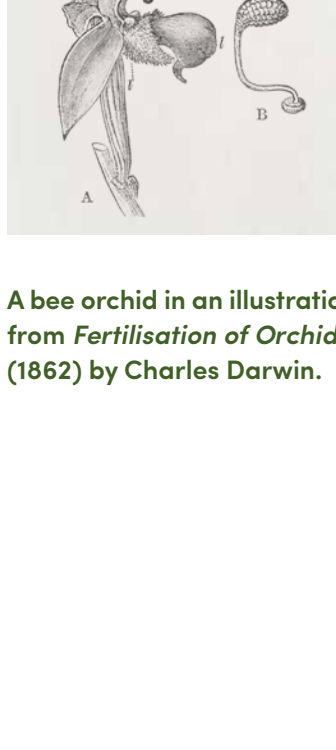
Three years after publishing *On the Origin of Species* (1859), Darwin released *Fertilisation of Orchids* (1862). The purpose of this book was to demonstrate that orchids are also the result of natural selection.

To support this, he studied numerous orchid families and the intricate reproductive mechanisms they use. He observed that, despite possessing both male and female organs, the flowers avoid self-fertilisation and favour cross-fertilisation through spectacular flowers designed to attract insects.

From *Ophrys* species, which lure insects with their colours and scents, to the *Epipactis* orchids of the saltmarsh embankments, which use their labellum as a trap to ensure pollination, Darwin studied dozens of species with extraordinary dedication. The ones that fascinated him most were the *Catasetinae*, which eject pollinia—small masses of pollen—like arrows, so they stick to insects.



Cattleya x elegans
Oncidium tigrinum
Cattleya purpurata
Cattleya perrinii
Cypripedium calceolus



Down House, near the village of Downe to the south of London, was Charles Darwin's home. Engraving published in *The Illustrated London News* (1887).



Angraecum sesquipedale



Ophrys apifera



A bee orchid in an illustration from *Fertilisation of Orchids* (1862) by Charles Darwin.

DARWIN'S MOTH

Orchids, which fascinated Darwin after he published *On the Origin of Species*, ultimately became powerful evidence for his theory. When studying the species *Angraecum sesquipedale*, with its large white flowers and a nectar spur nearly 30 centimetres long, Darwin predicted that there must be a moth with a proboscis of similar length to feed on the nectar. This hypothesis was confirmed in 1903 with the discovery of the moth *Xanthopan morgani* subsp. *praedicta*, which, as Darwin had speculated, has a proboscis of more than 20 centimetres.

ORCHID MIMICRY

One of the most fascinating cases Darwin studied involved orchids of the genus *Ophrys*, commonly known as "bee orchids", since their flowers mimic the appearance and scent of female bees. When a male attempts to mate with the flower—a behaviour called "pseudocopulation"—the pollen attaches to it. Upon visiting another flower, the male deposits the pollen there, which facilitates cross-pollination.

Unfortunately, Darwin was unable to verify this process with bee orchids in the United Kingdom, where the plants tend to self-pollinate. The phenomenon was clarified about 50 years later, when botanists Maurice-Alexandre Pouyanne and Pius Font i Quer observed that the movements bees made with the flowers mirrored those they used when trying to mate, thereby confirming this extraordinary behaviour.

EVOLUTIONARY INGENUITY

Through his experiments with orchids, Darwin demonstrated that even the most surprising plant mechanisms have a natural explanation. Thanks to natural selection, these flowers have developed survival strategies that are as ingenious as they are beautiful. Orchids reveal not only the creativity of nature, but also the remarkable capacity of living beings to adapt and evolve.

- **Angraecum sesquipedale**
Epiphytic orchid endemic to Madagascar, characterised by a long nectary spur and highly specialised pollination by the moth *Xanthopan morgani* subsp. *praedicta*.
Work by Joan Viana Madueño, 2026
Worbla (thermoplastic material), acrylic paint, and polyurethane foam.

- **Vanilla:**
The aroma of vanilla comes from the fruit of the *Vanilla planifolia* orchid, rather than from the flower, as might be expected. The aromatic compounds are odourless in the green pod, and are released only during ripening and curing. This process produces vanilla, responsible for its characteristic sweet fragrance.

- **Lizard orchid:**
The lizard orchid (*Himantoglossum hircinum*) emits an intense, unpleasant odour, similar to that of a male goat. From a botanical point of view, this smell is produced by volatile compounds released by the flower. Its function is to attract specific pollinating insects through a highly specialised chemical strategy.

THE DISCOVERY OF CARNIVOROUS PLANTS

Among Darwin's most astonishing discoveries are carnivorous plants. In his autobiography, titled *The Life and Letters of Charles Darwin, Including an Autobiographical Chapter* (1887), he wrote: "In the summer of 1860 I was idling and resting near Hartfield, where two species of *Drosera* abound; and I noticed that numerous insects had been entrapped by the leaves. [...] and on giving them insects saw the movements of the tentacles."

Based on this observation, Darwin began to suspect that these plants trapped insects to feed on them. To test this hypothesis, he conducted experiments with all kinds of substances, including fingernails, mucous secretions, bits of hard-boiled egg and even small pieces of roast beef from his sandwich. He discovered that *Drosera* secretes a substance capable of breaking down organic matter and absorbing its nutrients. "The fact that a plant should secrete, when properly excited, a fluid containing an acid and ferment, closely analogous to the digestive fluid of an animal, was certainly a remarkable discovery", he wrote. Fifteen years later, these experiments culminated in *Insectivorous Plants* (1875).

INSECT HUNTERS

The book *Insectivorous Plants* (1875) is one of Darwin's most surprising works. One of its great achievements lies in its explanation that carnivorous plants trap insects because they grow in inorganic nutrient-poor soils and waters, especially deficient in nitrogen and, to a lesser extent, phosphorus—elements they obtain in abundance from the bodies of their prey. To test this idea, Darwin devoted years to constant observation, often assisted by his son Francis Darwin, who also went on to become a renowned scientist. With perseverance and meticulous attention to detail, he carried out a study of extraordinary precision: the chapter devoted to the genus *Drosera* alone spans more than two hundred pages.

ULTRA-SENSITIVE PLANTS

Darwin wrote to Charles Lyell, a prominent and respected geologist:

I will and must finish my *Drosera* manuscript, which will take me a week, for, at the present moment, I care more about *Drosera* than the origin of all the species in the world. But I will not publish on *Drosera* till next year, for I am frightened and astounded at the result. [...] It is not curious that a plant should be far more sensitive to the touch than any nerve to be the human body?

And he confessed to botanist Asa Grayal:

I have been infinitely amused by working at *Drosera* [...]. You will laugh; but it is, at present, my full belief [...] that they detect [...] the 1/2880 part of a single grain—a unit of weight equivalent to 0.0648 grams—of ammonium nitrate (and move their tentacles as a result).

THE MARVELLOUS DROSERA

Drosera plants stand out for their adaptability; they adjust their digestive enzymes depending on the type of prey. In high-mountain areas, for example, where wingless insects are more common, they produce enzymes different from those found in lower-altitude environments, where there are more flying insects. They also modify their photosynthetic pigments in response to light; in very sunny locations, they develop reddish anthocyanins to protect against radiation, while in shaded areas, they increase chlorophyll levels to capture as much light as possible. In addition, their leaves move slowly to aid in capturing and digesting prey.

AQUATIC CARNIVOROUS PLANTS

In his research on carnivorous plants, Charles Darwin devoted special attention to the genus *Utricularia*, a group of aquatic plants that capture small prey with a remarkable biological mechanism known as the utricle.

Darwin was fascinated by the complexity of this structure: each utricle is a tiny, sealed bladder with a highly sensitive valve. When a microorganism touches one of the bristles around the valve, the trap opens in a fraction of a second and the resulting vacuum sucks the prey inside. The valve then closes and digestion begins through enzymes secreted by the plant. Their prey includes protozoa, water fleas, aquatic insect larvae, rotifers and microcrustaceans.

- **Phytoplankton:**
These are autotrophic microorganisms, including microalgae and cyanobacteria, that float in water and carry out photosynthesis to survive. They are the primary producers of aquatic ecosystems and are responsible for generating approximately half of the Earth's oxygen.

- **Zooplankton:**
These are small animal organisms and protozoa that drift in freshwater and marine environments. They form a crucial link in the food chain, converting the energy of algae (phytoplankton) into food for fish, whales and carnivorous plants such as *Utricularia*.

- **Utricularia:**
Darwin studied *Utricularia*, fascinated by the ingenious complexity of its utricles, which he described as specialised organs that create a vacuum to suck in and digest microorganisms in milliseconds when they detect movement. Paradoxically, this plant occupies the top of the trophic chain. Its ingenuity and trophic role blur the line between the plant and animal worlds, just as Darwin sought to demonstrate.

DARWIN'S COWSLIPS

One of Darwin's great puzzles was the fertilisation of flowers: if they possessed both male and female organs and were capable of self-fertilisation, how could plant variability be explained? To investigate this, he studied cowslips, common plants of the genus *Primula* that display a surprising characteristic: they have two distinct floral forms, one with a long style and short stamens, and the other with a short style and long stamens. It had previously been considered a simple variation, but Darwin suspected an evolutionary function. By crossing the two forms, he discovered that fertility was highest between opposite forms, while self-fertilisation produced few seeds.

Thus, he identified a mechanism that enhances variability and, in turn, the adaptability of plants. Darwin's cowslips became a key model for understanding floral evolution and formed the central theme of the book *The Different Forms of Flowers on Plants of the Same Species* (1877).

- Longitudinal section of a long-styled flower of *Primula veris*.
Work by Joan Viana Madueño, 2026
Worbla (thermoplastic material) and acrylic paint.

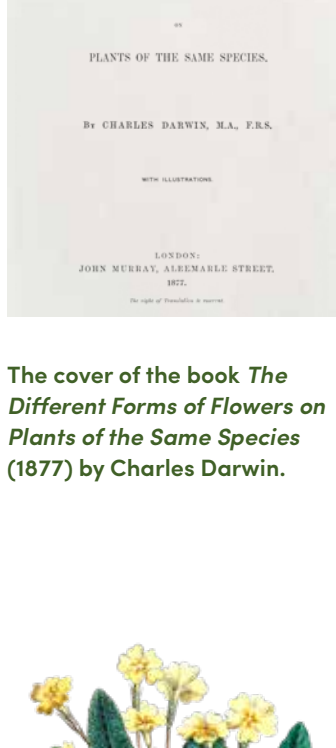
- Longitudinal section of a short-styled flower of *Primula veris*.
Work by Joan Viana Madueño, 2026
Worbla (thermoplastic material) and acrylic paint.



Primula veris



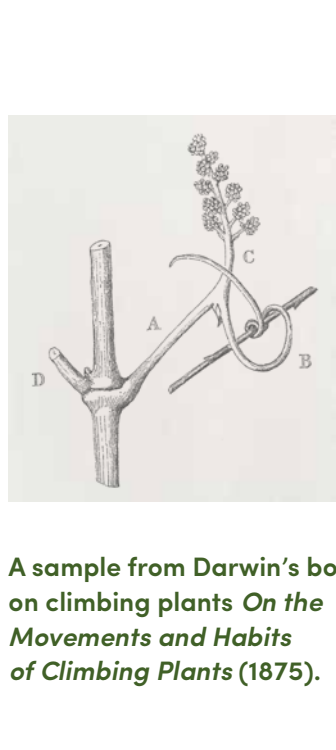
A drawing from Darwin's book on carnivorous plants, *Insectivorous Plants* (1875).



Utricularia vulgaris



Primula veris



An illustration from *The Different Forms of Flowers on Plants of the Same Species* (1877) by Charles Darwin, showing the tristylous *Lythrum salicaria*.



Linum perenne



The cover of the book *The Different Forms of Flowers on Plants of the Same Species* (1877) by Charles Darwin.



Primula vulgaris



Passiflora caerulea



A sample from Darwin's book *On the Movements and Habits of Climbing Plants* (1875).

Zea mays

Pea varieties, illustrated in the book *The Variation of Animals and Plants Under Domestication* (1868) by Charles Darwin.

Mimosa pudica

In *The Power of Movement in Plants* (1880), Darwin cites *Senna corymbosa* as an example of leaves that characteristically fold at night.

Cattleya tigrina
Passiflora caerulea
Paphiopedilum barbatum
Primula auricula

- **Longitudinal section of a long-styled flower of Primula veris.**
Work by Joan Viana Madueño, 2026
Worbla (thermoplastic material) and acrylic paint.

- **Longitudinal section of a short-styled flower of Primula veris.**
Work by Joan Viana Madueño, 2026
Worbla (thermoplastic material) and acrylic paint.

THE FLOWERS OF THE PURPLE LOOSESTRIPE

Fascinated by these discoveries, Darwin continued to study other species and found an even more extraordinary case in purple loosestrife (*Lythrum salicaria*), a common riparian plant across Europe. In this species, there were not just two floral forms, but three, distinguished by the length of the style: long, medium or short. Darwin observed that only specific crosses between these forms produced abundant seeds, while others were far less fertile—a remarkably precise evolutionary strategy that promotes cross-pollination and enhances genetic variability.

THE DANGERS OF SELF-FERTILISATION

In his book *The Effects of Cross and Self Fertilisation in the Vegetable Kingdom* (1876), Darwin studied how different forms of reproduction affect plant vigour. For many years, he compared self-fertilised individuals with those cross-pollinated by hand between different plants. He observed that cross-pollination produces healthier, more fertile plants, while self-fertilisation results in weaker offspring and fewer seeds. These findings demonstrated that cross-pollination increases genetic variability and vigour, two essential ingredients for natural selection. Darwin also showed that many floral features that prevent self-fertilisation, such as the arrangement of stamens and stigmas, are adaptations designed to promote cross-pollination and ensure the survival of the species.

THE FLOWERS OF THE COMMON MORNING-GLORY

Darwin cultivated specimens of the common morning-glory (*Ipomoea purpurea*, Roth, 1787) in the greenhouse at Down House and spent several years experimenting with them. He separated the flowers and applied two strategies: some were allowed to self-pollinate, while in others he manually transferred pollen from one plant to another. He was extremely surprised at the results. The second-generation plants grown from self-fertilised seeds grew more slowly and had far less vigour, while the plants resulting from cross-pollination produced numerous healthy, vigorous offspring.

DARWIN THE TAXONOMIST

Darwin studied *Primula veris* and *Primula vulgaris*, using them in cross-pollination experiments. At the time, many botanists believed they were not distinct species, but merely varieties of the same plant. Through his work, Darwin demonstrated that these primroses exhibit a system of incompatibility based on two different floral forms—a condition known as heteromorphism—which causes reproductive isolation between them. This resolved a long-standing debate: the two are in fact separate species. Darwin's research laid the foundations for modern studies on heterostyly, reproductive isolation and speciation in plants.

THE ART OF CLIMBING

In 1875, Charles Darwin published the monograph *On the Movements and Habits of Climbing Plants*, in which he explained that these plants climb other plants or fixed structures to gain greater exposure to light. He noted that plants that develop anchoring mechanisms have a competitive advantage, which helps explain the great diversity of climbing species. Darwin classified them into four main groups: plants with hooks, which only function in dense vegetation; plants with rootlets, capable of clinging to rocks or tree trunks; plants that twine around a support; and plants with sensitive organs or tendrils, which are modified leaves. These tendrils rotate continuously until they hit an object, quickly attach and coil into a spiral, forming a grip so strong that it can withstand the force of violent storms.

THE POWER OF MOVEMENT

His research was so fruitful that, in 1880, at the age of seventy-one, he published a book jointly with his son Francis: *The Power of Movement in Plants*. In this work, they demonstrated that the mechanisms previously described for climbing plants—such as the constant coiling of tendrils until they hit an object and the spiral anchoring—were not unique to these species, but could also be observed in many other plants. The book explained that seemingly simple plant movements are in fact universal adaptive strategies, enabling plants to capture light more effectively, respond to stimuli and survive in competitive environments.

DARWIN THE HORTICULTURIST

In 1868, Charles Darwin published a pair of substantial volumes titled *The Variation of Animals and Plants Under Domestication*. This work offers a detailed account of humanity's efforts to modify animals and plants to suit its needs and preferences. Darwin's aim was to demonstrate that, if the human species had been able to domesticate wild plant (and animal) varieties and render them more productive and palatable for humans, thereby creating a remarkable diversity of agricultural and livestock forms, then the effects of geological time on the evolution of species must be far greater. To this end, he studied varieties of wheat, maize, cabbage, fruit trees and other crops to show their wild origins and the different varieties produced through selective breeding by farmers.

DARWIN'S PEAS

Darwin experimented with peas to study various traits, such as the shape and colour of the flowers. However, he failed to recognise what Gregor Mendel had discovered shortly before in these same plants: the laws of inheritance. Constrained by his erroneous theory of pangenesis, which proposed that each organ produces gemmules that travel through the bloodstream to the gametes, Darwin's experiments prevented him from identifying Mendelian patterns. As a result, he overlooked a fundamental insight that would have further strengthened his own evolutionary theory, serving as a reminder that even geniuses can make mistakes.

THE “SENSES” OF PLANTS

Charles Darwin showed an extraordinary interest in many aspects of plant physiology, including phototropism—the orientation of plants towards light—and published several scientific papers on the subject. Phototropism works through photosensitive pigments and auxins that enable plants to detect light and nearby supports. This helps plants locate structures to climb, orient their growth, regulate the movement of tendrils, and even trigger the formation of rootlets. Plants also perceive touch and even movement, a phenomenon known as thigmotropism. They detect mechanical stimuli such as contact, air vibrations, pressure and friction, and respond through physiological or growth-related changes. In fact, some plants are so sensitive that they can even sense the passage of an insect's wings across their surface.

THE SHAME PLANT

Darwin was also intrigued by plants capable of spectacular movements, such as *Mimosa pudica*, known for closing its leaves at the slightest touch. Fascinated by these swift movements, he studied them in detail to understand how these plants respond to external stimuli and how this ability serves an adaptive defence role against herbivores. In fact, this plant shows a real capacity for learning and memory: it can recall past experiences and modulate the movement of its leaves to protect itself from potential threats. This combination of light sensitivity, touch perception and learning capacity illustrates that plants respond to their environment in surprisingly sophisticated ways.

BIODIVERSITY IN DANGER

Charles Darwin showed extraordinary dedication and an exceptional capacity for analysis. He based his study of plants on the theory of evolution he himself had developed, so he sought to understand how behaviours and adaptations emerged and how they contributed to the survival of the best-adapted organisms.

This evolutionary perspective remains essential today, especially when we consider the conservation of biodiversity; coexistence among species is fragile, as evidenced by the alarming decline of pollinators. This decline is disrupting previously stable balances, jeopardising the reproduction of thousands of plant species and reminding us that biodiversity loss also entails the loss of adaptive capacity, and of the future itself.

Acknowledging this reality is compelling us to rethink our relationship with nature and to recognise that protecting biodiversity is not only about preserving the planet, but also about safeguarding the continuity of our own evolutionary history.