

# DARWIN AND HIS LOVE AFFAIR WITH ORCHIDS

CAROL SIEGEL

THE EARLIEST PORTRAIT of Charles Darwin shows a happy six-year-old clutching a big pot of flowers. From youth to old age, plants and flowers were the passion of Darwin's life, his consuming interest and greatest love. He spent more time studying them than anything else. He wrote seven major works on plants including a ground-breaking book on orchids which provided living proof of his revolutionary vision of evolution. In brilliant detail, he showed how plants grew, outwitted rivals, and survived to produce another generation. He was fascinated by the intricate mechanisms continuously evolving to make insects and birds, the wind and the sea do the business of plant reproduction. He especially used orchids to show how complex structures could be explained by the mechanism of natural selection and not by the handiwork of God. Orchids were his proof of the reality of evolution.

Everybody thinks he knows Darwin, the "inventor" of evolution, the most famous scientist of all times. As David Quammen cleverly noted, "If the scientific community issued bank notes ... the face on the dollar bill would be Darwin's." Yet few people know that Darwin spent eight years of his life studying barnacles. He adored long walks and fancy pigeons. He revered life but loved to go shooting. He was frequently ill yet fathered 10 children and published dozens of books and articles. He slept under the stars with the gauchos in South America, ate armadillos, and spoke Spanish. He believed inbreeding was dangerous yet married his first cousin. He wrote important geological books and had insights into plate tectonics and the formation of coral atolls. He studied earth worms, human expression, genetics and plant hormones. No field of science, whether of life, earth or man, was too small or too big not to be permanently changed by Darwin's experimentation and research. He did little experiments and thought big thoughts and changed the world. How did Charles Darwin get to be this iconic innovator and controversial figure?

## Erasmus Darwin Sets the Example

He came from an intellectually distinguished but unorthodox family, the pattern for his life. His paternal grandfather Erasmus Darwin, a giant of a man, cast a long shadow across Darwin's life. He was a renowned physician and authority on Linnaean plant classification, authored several medical and botanical books, and wrote witty erotic botanical poetry! Moreover, he invented a copying machine, a steam turbine, a wire-drawn ferry, a canal lift, and an automated water closet and was the first to discover the reason for cloud formation and cold and warm fronts. A free thinker, he maintained a deep commitment to evolution and the enlightenment and was attacked for doubting the Bible.

In his second long poem, *The Temple of Nature*, he even traced man's development through fish and birds from the ocean. Darwin did not inherit Erasmus's heavy drinking or his womanizing, but he did give Charles a legacy of scientific speculation. Darwin always felt a kinship with his polymath grandfather, and his scholarship bears an eerie resemblance.

## The Boy They Called "Gas"

As a boy, Charles learned more about science on his own than in seven years at Dr. Samuel Butler's school. An undistinguished student, he thought the school did nothing for the development of his mind. His father



Thought to be a portrait of Charles Darwin and sister Catherine by Ellen Sharples.

despaired of his ever making anything of himself and warned him, "You care for nothing but shooting, dogs, and rat-catching and you will be a disgrace to yourself and all your family."

Yet even as a boy, he had a passion for collecting birds, insects and rocks. He wanted to know the names of all the plants and mischievously told his schoolmates that they were written inside the flowers! He and his brother Erasmus turned a tool shed at the school into a science laboratory, and together they made all sorts of smelly gases and compounds. After smelling the noxious chemicals coming out of the tool shed, his classmates started calling him "Gas," a not-particularly flattering nickname that stuck. His teachers accused him of wasting time on useless subjects; Charles said it was the best part of his education and had taught him the meaning of experimental science.

## The Medical Student and the Morbid Fear of Blood

Darwin began his love of natural research and publishing while in medical school. Convinced that his lazy son needed direction, Robert Darwin took him out of school two years early to follow in his own footsteps and become a physician, training at Edinburgh University. Unfortunately, Charles had a morbid fear of blood and fled from the two gory operations he witnessed, vowing never to return. Loathing his medical studies, he continued his explorations into the natural world. Edinburgh was home to a Natural History Museum, second only to the British Museum where Darwin could browse, take notes and stuff birds. There he met Robert Edmund Grant, a brilliant intellectual who had given up medicine to study marine life. He



Darwin's Beetle Display Case

encouraged Darwin to go out with the oyster fishermen and collect marine specimens. Darwin's notebooks from that time rarely mentioned his personal or school life, but they were filled with observations on sea creatures. Grant influenced Darwin, only an undergraduate, to present to the Plinian Society his first original research, on *Flustra* (sea mats). His mentor introduced him to research, dissecting, and microscopes.

Most importantly, Grant's ideas on evolution would permanently influence Darwin. A free thinker and an uncompromising evolutionist, Grant believed that different forms of life had been developed over time and not been created by a spiritual power. He traced plant and animals back to simple algae and polyps and thought that they had a common evolutionary parent. This was subversive science and universally condemned by the church. It was cutting edge stuff, and Darwin listened.

## A Mouth Full of Beetles

Charles was obviously not cut out to be a doctor. It was decided that he should leave Edinburgh and go to Cambridge to study for the Anglican Church. The family could buy him a living, and even a dullard like Darwin could be successful. He went to Christ's Church at Cambridge, but, as usual, what fascinated him was the natural world.

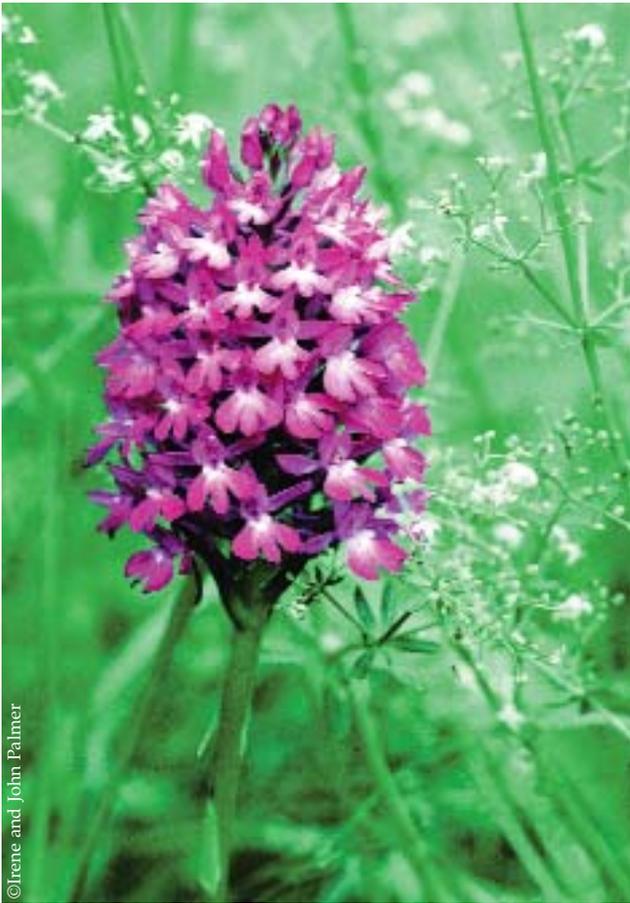
He was always an avid collector. A beetle craze was sweeping England as the Industrial Revolution made city people nostalgic for nature. Darwin and his cousin William Darwin Fox became obsessed with beetle collecting. There were many undiscovered beetle species at Cambridge, and they discovered rare and unusual beetle species, their contributions cited in James Francis Stephen's *Illustrations of British Entomology*. Darwin later recounted how, on one of his beetle adventures, he tore off some old bark from a tree and saw two rare beetles which he grabbed with his hands. Then he saw a new one, and he popped the beetle in his right hand into his mouth. The beetle sprayed an acrid liquid into his mouth, and he lost all three beetles, but not his passion for collecting insects, which was to be very important to him in future plant research. While onboard the *Beagle*, on just one day, he collected 68 different kinds of beetles!

## The Man Who Walked With Henslow

At Cambridge, an introduction to the Reverend John Stevens Henslow would change his botanical life forever. Henslow was an all-around naturalist famous for his botany lectures, and Darwin never missed one in three years. Despite his extensive botanical writings, Darwin never regarded himself as a trained botanist, modestly calling himself a "botanical ignoramus"; despite this, Henslow had given him a valuable botanical education. Darwin became an ardent follower of Henslow and spent so many hours in the field with him studying and collecting plants that he became known at college as "the man who walks with Henslow." Charles Darwin said that meeting Henslow "was the luckiest day of my life."

Henslow's views on botany were unorthodox, and he was more interested in what we now call ecology than taxonomy. His fascination with the relationship between a plant and its environment influenced Darwin's later work on the geographical distribution of species. Henslow taught Darwin to learn by his own discovery, dissecting and recording living plants and flowers instead of just cramming facts. Two or three times a semester, he took students on a long walk to investigate plants in the field. Darwin spent decades of his later life studying plants in the field using the scientific method just as Henslow had taught him.

He began his love affair with orchids when he



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*Anacamptis pyramidalis* is pollinated by butterflies and moths.



©Irene and John Palmer

*Anacamptis pyramidalis* and Skipper butterfly with pollinia.

should have been studying divinity. At Cambridge, he first used a microscope to study pollen grains of *Anacamptis morio* (syn. *Orchis morio*), the Green-winged orchid. He found that the pollen grains of that orchid were wedge-shaped and later found that the pollen grains of other flowers had all different shapes. He was fascinated that they were fastened at their narrow ends by a highly elastic thread. This early research would bear fruit decades later as Darwin would ultimately write the definitive book on orchids and the unbelievable mechanisms of their flowers.

### Five Years on the H.M.S. *Beagle*— The Chance of a Lifetime

In 1831, at just 22-years-old, Darwin got a letter from Henslow telling him he had recommended him as the naturalist on the H.M.S. *Beagle*. Darwin had always yearned to travel. After reading Alexander von Humboldt's *Personal Narrative*, a 3754-page account of a turn-of-the-century trip to South America, he longed to see exotic nature and far-away lands. This was his chance.

At first, Darwin's father refused to let him go, complaining that it would be a waste of time and money and yet another change of profession. His Uncle Josiah Wedgwood pleaded Darwin's case, and an exultant Darwin was allowed to sail. (However, *Beagle* Captain Robert Fitzroy almost didn't hire him because he thought Darwin's nose showed that he didn't have the stamina to withstand a long journey!)

For five years, he studied the flora, fauna and geology of temperate, subtropical and tropical areas around South America visiting Brazil, Uruguay, Argentina, Chile, Peru, New Zealand, Australia, South Africa and a number of small oceanic islands including the Galapagos, the Azores, and Cape Verdes. He later called it "by far the most important event of my life." It laid the foundation for the work of the rest of his life. When he returned home in 1836, he never left Great Britain again and spent all his time experimenting, writing and publishing, all inspired by those five years he had spent as a field naturalist on the other side of the world.

During his travels, he began to think about the origin of



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*Anacamptis pyramidalis* and Burnet Moth with pollinia

species and evolution. He was impressed with the subtle change of species as he moved southward. One species would be replaced by another similar but slightly different species. In Patagonia, he spent long hours digging fossil bones of extinct mammals out of river banks. Fossils convinced him that species changed, and some became extinct as others were created. An earthquake in Chile made him think about earth movement over the stream of time and the uplift of the Andes. When he returned to England, he doubted that species were fixed and unchanged. He would not publish his thoughts on this subject for twenty years, but it was on the Beagle that he had the experiences that underpinned his theory of evolution.

### *Origin* Ignites a Storm of Controversy

In 1859, he published *On the Origin of Species By Means of Natural Selection*, and he was lashed with criticism. He was abused from the pulpit for implying that God had not specifically, permanently and definitively created every detail of life. His use of the word “natural” meant that it was not a “supernatural” hand that directed life. Darwin had implied that the design did not necessarily imply a Designer. Many people were outraged. We should not be surprised. Even today, a good number of modern people passionately maintain that every living creature is part of an unchanging divinely pre-ordained plan. David Quammen states that in 2005, the Pew Research Center for People and the Press polled 2000 Americans and found that 42% agreed with the statement, “Living things have existed in their present forms since the beginning of time,” rejecting Darwin’s view of evolution as though he had never lived.

Darwin was especially attacked for proposing his theory without absolute proof. He countered that the book was too short to provide detail. He immediately turned to orchids to provide detailed examples of how evolutionary mechanisms worked- his ultimate test case. The book that followed the *Origin*, *On The Various Contrivances by Which British and Foreign Orchids Are Fertilised by Insects and on The Good Effects of Intercrossing* was published on May 15, 1862. The very word “contrivances” in his orchid book title implied that orchid mechanisms were simply produced by chance, igniting controversy with just the title. It was the first of several books providing supporting evidence for his theory of natural selection. He proposed that the orchid’s beauty was not the result of God’s creation, but the result of a series of beautiful adaptations of their structures over time that attracted insect pollinators, and he gave specific examples. Asa Gray, famous American botanist, remarked that there would have been less controversy over *Origin* if the orchid book had been published first.

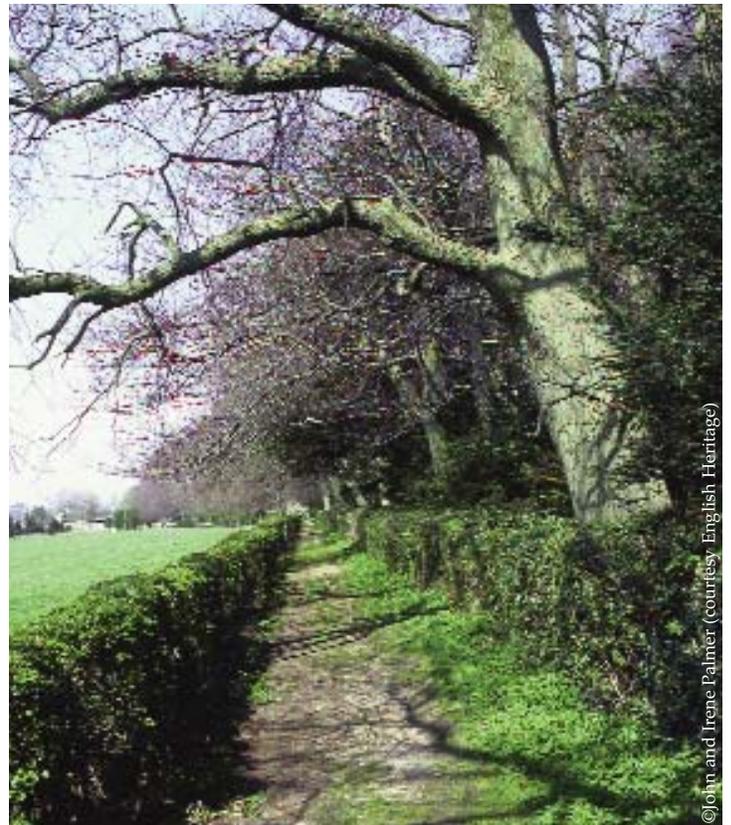
As early as 1838, Darwin wrote that he felt that insects cross-fertilized orchids which helped keep species constant and also provided variation for adaptation. He began to study orchids with their sexual



HMS Beagle in the Galapagos painted by John Chancellor.

structures so beautifully adapted to attract insect pollinators. It had only been 60 years since it had been discovered that flowers had different sexes, and few had observed insects pollinating orchids; it had been thought by many they pollinated themselves. Darwin was inspired by Christian Konrad Sprengel’s 1793 book on insects and flowers, one of the first to suggest that insects pollinated orchids.

In the *Origin*, Darwin noted that crossing plants produced variation. Even plants that self-pollinated needed an occasional cross to maintain vitality. Since life was a struggle for existence, not every individual or species would survive. Any variation that helped an individual survive would tend to be passed on to off-



Sandwalk near the end of their Down House estate.

spring. Life was a battle, and each species had to be modified or improved or it would become extinct, and sex gave life the variety to do this. He illustrated specific orchid modifications which had arisen to promote insect pollination to provide that variation and demonstrated the interdependent evolution of orchids and their insect pollinators.

Darwin counted the seed in several orchid seed pods and estimated that each plant produced enough seed to cover an acre of ground. The great-grandchildren of that plant would, if unchecked, cover all the land of the earth. However, the struggle for life would weed out all but those which were most fit to survive.

## Darwin and Orchidmania

How Darwin loved his orchids! As Janet Browne remarked in *Charles Darwin: the Power of Place*, "Even Darwin was surprised at his ardor for orchids that came over him in the middle of 1861, something like an unexpected love affair late in life." Darwin loved studying them and was addicted to their curious "beautiful facts." He said, "I cannot fancy anything more perfect than the many curious contrivances." He put aside a book on carnivorous plants and research on variations to experiment and unlock orchid secrets. He confessed, "I am like a gambler and love a wild experiment." He called it a "hobby horse that has given me great pleasure to ride," and said, "I am intensely interested in the subject just as at a game of chess." In one of his last letters about orchids, he exclaimed, "They are wonderful creatures, these Orchids. I sometimes think with a glow of pleasure, when I remember making out some little point in their method of fertilization. They are more play than work."

It was a great time to be writing about orchids. Orchidmania was sweeping England, and orchids were flooding into the country by the millions from exotic, far-off places. Collecting orchids was a passion, and expensive, exotic orchids were the ultimate status symbol, like owning a jet plane today. Darwin tapped this fever for orchids and convinced his publisher Murray that a book on orchids would feed into this orchidmania. Eventually Darwin published two editions, translated into French and German, but despite critical acclaim, he never sold more than 6000 English-edition books by 1900. Although the orchid book is groundbreaking and important, the mass of detail is difficult and slow botanical reading.

## Darwin Studies the Sex Life of Orchids

It was easy for Darwin to get British orchids for his experiments. There were orchids near his home, and Darwin remarked that Kent appeared to be the most favorable county in England for orchids. The family loved to walk to a place they called "Orchis Bank," (Downe Bank) half of a mile from Darwin's home, Down House. Because the technique for growing orchids from seed would not be known for decades, he



Down House – Darwin's Home

had to dig up whole plants from the field. Charles and his wife Emma and their children were a common sight carrying tin cans and biscuit boxes filled with orchids they had dug up to study. The Fly-Orchid (*Ophrys insectifera*) and the green flowered Musk Orchid (*Herminium monorchis*) grew everywhere among the junipers while *Cephalanthera* and *Epipactis* grew under the beech trees. They also loved to explore for orchids at Sandwalk near their end of their Down House estate where the Early Purple Orchid (*Orchis mascula*) bloomed in a wooded area. It was this plant he used to discuss the basic physiology of orchids in his orchid book. Within a mile of his house, nine orchid genera, including thirteen species flourished. *Anacamptis morio* was sufficiently abundant to be a conspicuous feature in the vegetation and *Neotinea maculate* (syn. *Orchis maculata*) was abundant in the woodlands. In addition, *Neottia nidus-avis* and *Platanthera chlorantha* were found around Downe. Even today, eight species of orchids that Darwin recorded continue to grow on Orchis (Downe) Bank. Interestingly, thirteen orchid species still grow in the area, although some are different from those that grew there in Darwin's time. *Anacamptis morio*, the most abundant species in his time, was probably lost due to pasture "improvement" with herbicides and additional nitrate fertilizers.

On vacation to the fishing village of Torquay, he spent hours on his hands and knees watching insects visit the native orchids. He noticed that the lower lip of orchids was designed as a landing strip for insects with hairs, ridges, keels, and spurs as lures. He noted that the flowers of each species had evolved a unique form that attracted specific pollinators. Moreover, the pollen sacs were glued to the proboscis in exactly the right position to be removed by the stigma of the next flower. He believed and later proved that crossing orchids produced stronger plants and flowers, and he was amazed at the intricate devices that orchids had developed to achieve that end.

At first, he had use of George Turnbull's greenhouse and gardener at the Rookery on the other side of the



*Anacamptis morio* once abundant near Down House is now lost.

village, but in 1862, he built his own at Down House, an extension of his cold lean-to greenhouse. He spent an hour or two every morning and afternoon examining plants and doing experiments. He wrote to Hooker at Kew Gardens for plants to stock the hothouse saying, "I long to stock it, just like a school boy." His butler went there with a cart and came home with 160 orchids. Darwin apologized to Joseph Hooker for depleting the national treasure and exclaimed, "You cannot imagine what pleasure your plants give me... Henrietta (his daughter) and I gloat over them." He loved to visit his greenhouse before his daily walk, and in later years had several more built.

The whole family was involved in the orchid study. His son George remembered being sent to Cudham on a summer night to catch and count moths visiting plants on Orchis Bank followed by an evening at the table surrounded by catalogues identifying species. Charles sent his younger boys out over the Devon hills

to search for orchid specimens, directing them from the path with his walking stick. His sons William and Frank did much of his drawing and dissecting and were very adept at botany. The family set up experiments with bell jars and nets for controls and caught bees and moths to examine for pollinia. They artificially pollinated flowers with pencils and fine bristles and counted seeds. They carried on experiments with 200 different kinds of orchids, irritating various parts of the flower to see what would release the sticky pollinia. Then, they would insert the pencils with the pollinia attached into other flowers to see how they would stick to stigmatic surfaces. Orchids were a family affair, and they were all deeply involved in their father's passions.

Darwin studied the behavior of British orchids and tropical orchids sent to him from far-off lands. He had many friends in the orchid world and kept up a lively correspondence with them all. He was showered with exotic orchids from Hooker at Kew, from Veitch and Lindley as well as from explorers Sir Robert Schomburgk and James Bateman. Lady Dorothy Nevill, an aristocratic, political hostess with a large orchid collection, sent him exotic live hothouse plants in exchange for a signed portrait to hang in her sitting room. Alexander More, on the Isle of Wight, put orchid plants on an overnight train for the butler to pick up in the morning and store in Darwin's greenhouse. Friend Joseph Hooker introduced him to garden directors in America and the botanical brothers Roland and Henry Trimen working in South Africa and Ceylon respectively. Darwin sent an inquiry to *Gardeners' Chronicle* about where pollinia attached to insects and received a flurry of responses. One envelope that seemed empty revealed when shaken, several insect mouthparts with pollen masses attached. It was a great time to study orchids, and he was entranced.



*Orchis mascula* bloomed near Sandwalk



*Neottia nidus-avis*, one of 13 orchid species growing around Down House.



Darwin found *Platanthera chlorantha* was pollinated by moths.



©Irene and John Palmer (courtesy English Heritage)

Darwin's Experimental Beds and Greenhouse.

## Looking For an 11-Inch Tongue for an 11-Inch Nectary

Darwin is most remembered for his startling predictions about the orchid *Angraecum sesquipedale*. Darwin became the laughing stock of England when he predicted that there was somewhere a moth with a ten-to-twelve inch tongue to pollinate the very long nectary of *Angraecum sesquipedale*. The large star-shaped flowers with snow-white waxy petals stunned the world when Reverend William Ellis sent them out of the wilds of Madagascar to England in 1854. Eerie and exotic, they captured the imagination of the orchidologist James Bateman who sent several to Darwin to study.

Darwin saw this flower as the culmination of tens of thousands of small adaptations. He felt that there must be an unknown Sphinx or Hawk moth that had co-adapted to reach the nectar in the lower three inches of the very long nectary, and entomologists laughed at him. In his book, he boldly predicted:

"...in Madagascar there must be moths with proboscides capable of extension to a length of between ten and eleven inches! This belief of mine has been ridiculed by some entomologists, but we now know from Fritz Mueller that there is a sphinx-moth in Southern Brazil which has a

proboscis of nearly sufficient length, for when dried it is coiled up into a spiral of at least twenty windings."

Forty years later, scientists found the sphinx moth and called it *Xanthopan morganii praedicta* because Darwin had predicted it. Entomologists stopped laughing.

Moreover, Darwin found that when the moth recoiled his proboscis after feeding, he seemed annoyed at the pollinia clinging to the base of his tongue. He futilely tried to clean it off, creating a slight time delay. During this time, the pedicel of the pollinia was exposed to air and rose up until was at an angle of 80 degrees to the center line of his tongue, the perfect angle to fit into the stigma of the next flower it reached. This prevented self-pollination because the moth did not have the pollinia in the right position for pollination until it left the first flower. Darwin felt that this could be explained by blind evolution and was not necessarily an example of God given design.

## Scheinsaftblumen and the Hidden Nectar

Sprengel in *Secrets of Nature* had maintained that insects had little intelligence because they pollinated orchids with no nectar. He was disgusted by orchids that were "scheinsaftblumen" or "sham nectar producers." Darwin had the highest regards for insects and set out to solve the puzzle of why the insects were visiting flowers without apparent nectar. Darwin dissected the nectaries of *Anacamptis morio* and *Dactylorhiza maculata* and found no nectar. For 23 days, he examined the open flowers after hot sunshine, after rain, at midnight and early morning. He put the spikes in water, irritated the nectaries with a bristle, and exposed them to fumes. Some of the pollinia disappeared, and some did not, but still there was no nectar even under a microscope. He repeatedly saw flies insert their tongues in the apparently nectarless flowers.

Puzzled, he did another experiment where he dissected the nectaries. He found a cavity between the inner and outer members that was filled with nectar and could be easily penetrated. This was a revolutionary finding. Darwin felt that the extra time that it took to look for the nectar and pierce the inner membrane allowed the viscid disc of the pollinia to harden onto an insect and move into a position that would make it more receptive to the stigma of the next flower.

Today, it is known that there are several completely nectarless species of orchids that indeed do dupe naïve young insects into doing their reproductive business. Biologists believe that the extra time and effort the insect expends fruitlessly probing for nectar is sufficient for the pollinia to become securely attached. The advantage to the orchid, beyond not having to provide any nectar, is that the insects tends to fly a little further before trying another flower, which assists in outbreeding.



©Mitsuhiko Imamori

*Angraecum sesquipedale*  
and pollinator *Xanthopan morganii praedicta*.



*Angraecum sesquipedale* and the 11-inch nectary.



Darwin's Hawkmoth and the 11-inch proboscis.

## The Three That Became One

Darwin was fascinated with the South American orchid *Catasetum* which he described as "the most remarkable of all Orchids." He explained the mechanism by which a bent stalk of pedicel was connected to a sticky disc. When touched, projecting antenna released the bent pedicel which flung the pollinium like an arrow, sticky disc first, at the insect. He experimented using whalebone springs to imitate this action. He stated:

"I touched the antennae of *C. callosum* whilst holding the flower at about a yard's distance from the window and the pollinium hit the pane of glass and adhered to the smooth vertical surface by its adhesive disc."

He was the first to demonstrate dimorphism (different forms of male and female flowers) in *Catasetum* orchids. Most orchids are "perfect" or hermaphroditic and contain both male and female parts in the same flower. Nobody knew that *Catasetum* was an exception. In 1836, Robert Hermann Schomburgk said he had seen one plant growing with three flowers from different

genera that usually grew separately. John Lindley, father of orchid classification, was appalled and said that this had shaken botany to its foundation. The three different flowers were categorized as *Catasetum tridentatum*, *Monacanthus viridis*, and *Myanthus barbatus*. Darwin got the three flowers from the Trinidad Botanic Gardens and dissected and compared their parts. He declared the *Catasetum* a male, the *Monacanthus* a female, and the *Myanthus* a hermaphrodite, all forms of the same orchid, *Catasetum tridentatum*. He later discovered that more males than females are produced on undersized plants in shady areas. Females are less common and are produced on robust plants in optimal conditions since fruit requires higher energy and a great expenditure by the plant.

He found that *Mormodes* and *Cycnoches*, although they did not possess antennae, had many things in common with *Catasetum*. He experimented with ejecting pollinia from *Mormodes ignea* and found after 12 tries that there was a tiny hinge the size of a needle's eye on top of the anther case. After probing the pollinia at this spot, he could get the pollinia to shoot out against the crest of the lip at exactly the place where the insect would normally land. There was a different trig-



©Ron Parsons

Darwin demonstrated dimorphism in *Catasetum macrocarpum*.



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*Coryanthes speciosa*, the Bucket Orchid.



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*Pterostylis longifolia* lip snaps shut to trap the pollinator.

ger for *Mormodes luxata* where pressure needed to be applied at the apex of the column. To Darwin, this showed the diversity of mechanisms even in the same genera.

Darwin was also fascinated with the genus *Cycnoches*. James Harry Veitch, noted nurseryman, gave Darwin two apple-green flowers of *C. ventricosum*. Darwin discovered that the mature anther filament propelled the pollinia when touched. The pedicel then curled into a hoop to protect the anther after ejection. After fifteen minutes, the pedicel straightened out and the anther case was shed. Darwin posited that the chance of fertilization was greater when the pollinia was correctly positioned and covered with sticky stuff for stigmatic reception in another flower. As Eric Hsu said, "The aerial dance of *Cycnoches ventricosum*'s pollination mechanism undoubtedly transfixed Darwin."



©Ron Parsons

Darwin was fascinated by the aerial dance of *Cycnoches ventricosum*.

## The Drunk in the Bucket

Darwin was astounded by the pollination mechanism of *Coryanthes speciosa*. He said that even he would have found it unbelievable if it hadn't been witnessed multiple times by Dr. Cruger, Director of the Botanical Gardens at Trinidad. The orchid lip was converted in a big red bucket filled with a slightly sweet liquid that dripped down from two appendages on either side of the column. Euglossine bees, he said, fought to gnaw on crests of the lip, becoming intoxicated and falling into the bucket. Drunk, they lay in the bucket, unable to fly, getting "an involuntary bath." The bee then had no way out except to climb out of the bucket past a narrow opening where the labellum and the column join, forcing him to pick up the pollinia.

## Orchis Mascula and the Rotating Pollen Masses

Darwin used *Orchis mascula* to describe basic orchid reproductive physiology. Although his findings are common knowledge to the orchid world today, in his time his findings were illuminating and ground-breaking. He had experimented with scores of orchids, covering some with glass domes and leaving others uncovered. He found that the orchids in covered domes produced no seeds while those left uncovered produced seed. He pollinated orchids with their own pollen and found that they almost never produced fertile seed. With the help of other scientists, he discovered that 23 species of moths had been found with orchid pollinia attached to their proboscis. He showed from his experiments that orchids needed insects for seed production and that the pollinia was adapted to be removed by these insects as they probed for nectar. As insects drank nectar, the pollinium was glued to the insect

before they flew to another flower.

He further found that the pollinia moved within seconds after being removed. When pollinia of *Orchis mascula* were attached to the front of the insect, the pollinia were standing straight up. Pollinia in that position cannot enter the stigma of the same flower, preventing self-pollination. In the next 30 seconds, the pollen mass moved downwards and forwards, the ideal position for entering the stigma of another flower. It took about 30 seconds for the insect to visit another flower by which time the movement was complete. When insect landed on another flower, the pollen masses attached pass under the male parts and stuck to the female parts resulting in cross-fertilization, the point of the whole exercise.

## The Saddle and the Pyramid Orchid

Darwin loved to study the Pyramid Orchid, *Anacamptis pyramidalis* (syn. *Orchis pyramidalis*). He found it was pollinated by both butterflies and moths. He thought the bright purple color attracted butterflies, and the strong odor attracted moths. Just as with *Anacamptis morio*, the pollinia moved 45 degrees to be in the best position to be thrust into the stigma. However, the Pyramid Orchid had a different arrangement of its parts. The flowers had just one disc shaped like a saddle with two pollinia on its seat. When the moth withdrew its tongue, the saddle with the two pollinia became attached. When the saddle was exposed to the air, two flaps rapidly curled inward to embrace the moth tongue. Darwin timed it and found it took nine seconds. In another nine seconds, the flaps curved even further inward, forming a solid ball. Darwin said, "I have shown this little experiment to several persons and all have expressed the liveliest admiration at the perfection of the contrivance by which this Orchid is fertilized."

When the moth landed on another flower, there were two prominent ridges which sloped downward and narrow. Nectar guides prevented the tongue from being inserted obliquely or the saddle would have been inserted obliquely and would not have struck the two stigmatic surfaces of the flower effectively.

## A Boat with Milky Fluid

Earlier on, Darwin was fascinated by the spiral arrangement of the flowers of the genus *Spiranthes*. Could the spirals act as guides to lead the insect up the flower? He did note that the pollen in the flowers was often ready before access to the female parts was open, preventing self-fertilization. At Torquay, he also noted that bees visiting these flowers started at the bottom where the most mature flowers were with access to the female structures. Therefore, bees could leave pollen from other flowers on the open stigmas, and then pick up pollen from the top of the flowers to deposit at the bottom of some other *spiranthes*. This mechanism, too, prevented self-fertilization.

He found another interesting "contrivance" when studying *Spiranthes spiralis*, the Autumn Lady's Tresses orchid. The orchid had a disc shaped like a boat, held in place by a fork at the top of the rostellum. A membrane covered the boat like a deck and inside was a cargo of pollen masses with elastic threads gathered at one side like oars. When a bee proboscis touched a furrow in the middle of the boat, the rostellum would split along its length freeing the boat. A milky fluid would ooze out, and the bee would lift the boat out with its cargo of orchid pollen.

## No End of Beautiful Contrivances

Darwin was stunned by the number of different ways orchids were adapted for pollination. *Pterostylis trullifolia* and *P. longifolia* each had a hood enclosing the column. When an insect landed on the lip, it sprung up like a drawbridge, trapping the insect inside. After an hour and a half, the drawbridge would lower. The only way out of the trap was to crawl through a narrow opening where they would pull out the pollinia. Moreover, he described how small insects lick nectar on the lip of *Neottia ovata* (syn. *Listera ovata*), the Twayblade, until their heads struck the rostellum which exploded, shooting out pollinia which were cemented to the head. Darwin's son George visited a patch of the Twayblades near their home and noted that they were always covered with spider webs. The spiders seemed to know that little insects were attracted to the flowers. Darwin described the special adaptations of score of orchids, adding tremendously to the body of orchid knowledge.

## Eleven Years to Find Out Why

Darwin's book on orchids had explored HOW plants promoted cross-fertilization. His book on cross-fertilization explored WHY plants bothered to do this. He proved with thousands of experiments carried on to the tenth generation that crossed plants were bigger, produced more seed, and were more vigorous than selfed-plants. They were simply better and more fit to survive. In 1876, after eleven long years of experimental work, he published the complementary volume to the orchid book and called it, *The Effects of Cross- and Self-Fertilization in the Vegetable Kingdom*. The latter book was prompted by a chance observation of the amazing decline in vigor of the offspring of *Linaria vulgaris* (yellow-flowered Common Toadflax) after even one instance of self-fertilization. He experimented with two plants that happened to be in his greenhouse, *Mimulus luteus* (the Blotched Monkey Flower) and *Impomoea purpurea* (the climbing Morning Glory). Again and again, plants that were self-pollinated were shorter and produced less seed than cross-pollinated plants. The orchid book had shown how beautiful were the means of cross-fertilization. This book showed just how important they were.

## The World Honors Darwin

Darwin died in his bed in Down House on April 19, 1882 and was laid to rest in Westminster Abbey. His last words were said to be, "I am not in the least afraid to die." The Abbey was crowded for his funeral, and every scientific society was there. Tributes filled columns and pages of every newspaper in the world. A Darwin medal was struck, and a Darwin prize instituted. A beautiful statue of him was placed in the Natural History Museum in London, and a tulip was named for him in Holland. He was acknowledged as the man who had changed scientific thinking forever. He certainly had changed the orchid world. As Merle Reinikka noted, "Much of what orchidology now knows of the relationships of orchids and insects is based on Darwin's discoveries over a 100 years ago."

## Darwin's Landscape Laboratory

Charles Darwin chose the setting of an "entangled bank" to summarize his theory of evolution in the *Origin*. Experts agree this was inspired by Darwin's "Orchis Bank"; today it is the Downe Bank Nature Reserve owned by the Kent Wildlife Trust. Darwin's former home and the surrounding countryside, including Downe Bank, were nominated to UNESCO as a World Heritage Site in 2009. The decision to inscribe was deferred for further consideration.

The Smithsonian Institute's 15th Annual Orchid Show commemorated Darwin's orchid work in their show called *Orchids through Darwin's Eyes*. Darwin truly opened our eyes to the beauty and complexity of orchids and forever changed the orchid world.\*



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*Spiranthes spiralis* is also called the Autumn Lady's Tresses



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*Neottia ovata*



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*Neottia ovata*  
and ichneumon wasp pollinator.



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*Neottia ovata*

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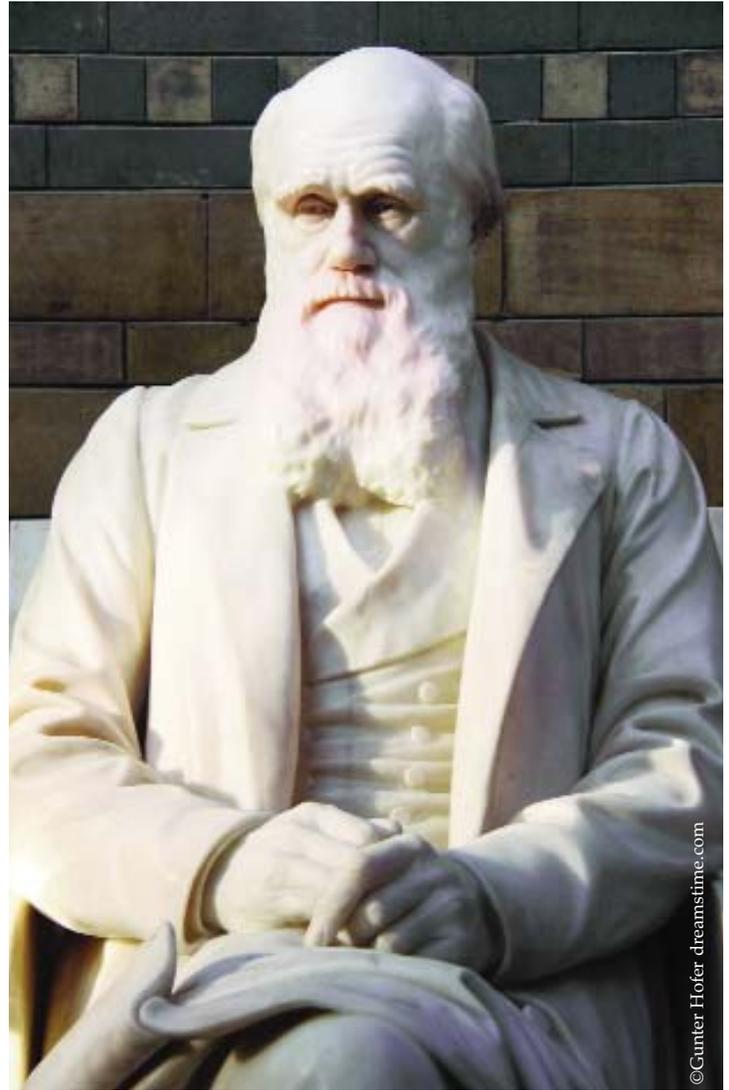
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Statue of Darwin

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