



## C R I T I C A L F O C U S

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### Darwin: The Microscopist Who Didn't Discover Evolution

There are two theories for the origins of all the living things that surround us: They evolved or they were created. Ever since humanity began to philosophize, people have realized that evolution is an abundant reality—and yet some 40% of present-day Americans believe in creation. It is one of the most mind-boggling statistics that the Gallup Polls have unearthed. Even more surprising is the way we imagine evolutionary theory to have originated—surely it began with Charles Darwin? Oh, no it didn't. Evolution was known to the ancient Greeks and Romans. Empedocles (490-430 B.C.) wrote about it, as did Lucretius (100-55 B.C.), while Aristotle (384-322 B.C.) coined the term "Great Chain of Being." Darwin was a late arrival. Evolutionary ideas had been around for 2,000 years before he was born.

Mention Darwin to me as a microscopist, on the other hand, and you seize my attention immediately. For someone who never qualified in science at university, Darwin was also a qualified writer on a wide range of subjects. I am a great admirer, and part of this must be because he

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*Evolutionary ideas had been around for 2,000 years before Charles Darwin, the "father of evolution," was even born.*

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Charles Darwin, age 31, painted by George Richmond in 1840.

1872, when the sixth edition of the book was published—but by that time it was a familiar term and had been widely used by others.

I do see Darwin as a dedicated microscopist, be-

was a skilled and diligent microscopist. But why is he universally promoted as one of the world's greatest iconoclasts? Evolution was not his idea, yet "Darwinian evolution" is a buzzword. Indeed the question, "Are you, or are you not, a Darwinist?" seems to mark out the real biologists from those beyond the pale. It reminds one of Sen. Joseph McCarthy and his famous question: "Are you, or have you ever been, a member of the Communist Party?" If you don't espouse Darwinism, then the biological establishment won't want you.

Not only was evolution around centuries before Darwin, but the concept of "survival of the fittest" first appeared in print long before he wrote on the subject. When the *Origin of Species* appeared in 1859, the word "evolution" was nowhere in the contents. Darwin did not have the word anywhere in his text until



Down House, in the village of Downe, was Charles Darwin's home for 40 years and where he wrote his book on evolution, *Origin of Species*. It is often overlooked that other authors and researchers had discussed evolution before Darwin.

cause he used microscopes throughout his adult life and for many decades he relied on simple (i.e., single lens) microscopes purchased from the London father-and-son manufacturers Bancks—the same firm that made microscopes for Darwin's friends, including Robert Brown and Joseph Hooker. Darwin once described his new microscope to Hooker as a “splendid plaything.” That's a revealing description and shows what a dyed-in-the-wool microscopist he truly was. (Anyone who says their new microscope is a “suitable item of equipment” rather than a joyous toy should consider a career in banking).

Hardly anything has been written on Darwin as a microscopist. I published a paper on the subject in the Royal Microscopical Society's magazine *InFocus*, September 2009 (pp 18-28). There is also a book, *Darwin's Microscope*, that will get your pulse racing. However, it isn't about his microscopy at all, but is a collection of poems by Kelley Swain that look obliquely at Darwin's life.

Enthusiasts can visit the Darwin museum at Down House south of London, which is presented as looking just as it did when Darwin left it. The facts are very different. In 1907, it became Downe School for Girls and remained so until 1922, when another girls' school took over and occupied it until 1927. The school building was then purchased by a surgeon, Sir George Buckston Browne, who opened it as a museum in 1929 after it was refurbished at his own expense. Down House was acquired by English Heritage in 1996 and reopened in April 1998. I have visited it many times and chaired meetings there. My friend Stephen Jay Gould flew over just to speak at a conference I was

organizing at the house. Original items from Darwin's time have been returned over the years, and other items that are similar to the original furnishings have been purchased. Walking through the house today, it is hard to imagine it stripped bare and repainted as hordes of pubescent young women marched through its hallowed corridors for so many years. The present-day home is a reconstruction, a fact that visitors may not easily discover.

Like most microscopists, Darwin was introduced to the instrument as a teenager. He received his first microscope when he was a student at Christ's College in Cambridge, where he had enrolled in 1827. It was a gift from his friend John Maurice Herbert. Much is made of Darwin's Cambridge degree, even though he never qualified in any scientific subject. Funded by his father, he had been sent to Edinburgh to study medicine but proved not to be a good student and left in his second year without qualifying. As a last resort, he went up to Cambridge where he studied theology—presumably on the principle that you could always look up the answers in the Bible. The intellectual environment at Cambridge gave Darwin a good choice of friends, even though they were unconnected with his academic course. He spent time with his cousin William Fox, who introduced him to beetle collecting (which was fashionable at the time), and some of Darwin's drawings were included in the book *Illustrations of British entomology* by James Francis Stephens, which appeared in 1828. In his final semester, Darwin met Prof. Adam Sedgwick, an expert geologist. He also went for walks with Prof. John Henslow with whom he began to share an interest in botany.

## VOYAGE OF THE BEAGLE

It was because of Henslow that Darwin went on his voyage aboard the Beagle. If we read his statement in the *Origin of Species* of 1859, Darwin claimed to have been “on board H.M.S. Beagle, as naturalist.” That is incorrect. The ship had an officially appointed naturalist, Robert McKormick, who also served as the ship's doctor. Darwin was on board as the traveling companion of the ship's master, Capt. Robert FitzRoy. Darwin privately wrote that his appointment was “not a very regular affair.” FitzRoy had invited Henslow to come as his companion, but because of family commitments, Henslow had to decline the offer—and he recommended Darwin to travel in his place.

It is often imagined that the Beagle was a merchant vessel on a civil voyage of discovery, but she was a Cherokee-class brig, a Royal Navy warship.

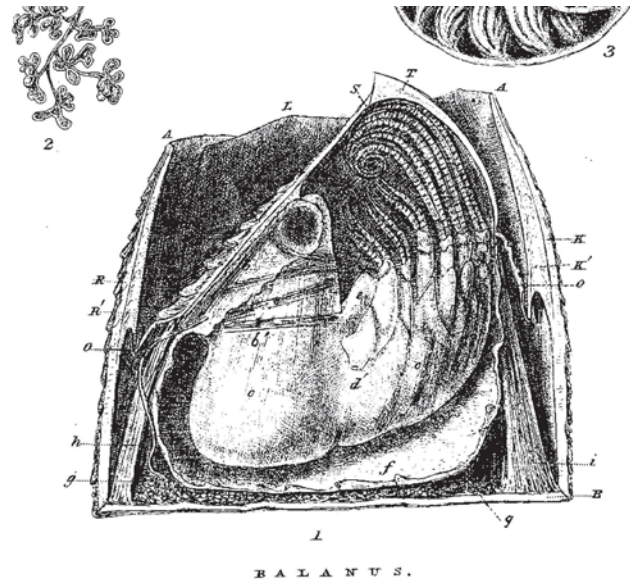
Darwin was absorbed by the many exotic life forms he encountered on that famous trip. He was able to go ashore at will to collect and explore to his heart's content. He came to realize how coral atolls were formed and later wrote a book entitled *The Structure and Distribution of Coral Reefs*. In Chile, he witnessed an earthquake; on the Galápagos Islands, he dined on the flesh of the giant tortoises and later wrote up how the shape of their shells seemed to match the lifestyle imposed by the different islands. The Galápagos finches, he concluded, were similar to those on the mainland but had clearly changed over time. He wrote up his observations and noted: "Such facts undermine the stability of Species." He then changed it to read: "Such facts would undermine the stability of Species." There was no implication here that the presumed changeability of species was a novel concept, just that his observations substantiated the view.

Henslow, meanwhile, issued extracts from Darwin's geological letters to members of the Cambridge Philosophical Society in December 1835. We still reveal current research at those meetings. Indeed, I have been a Fellow of that Society for over 20 years and presented findings on Darwin as a microscopist at a more recent meeting of the Society. When Darwin returned to Cambridge a year later, his name was becoming known in the university, and he was elected a Fellow of the Royal Society in 1839. Darwin published his accounts as *Journal of Researches into the Natural History of the Countries Visited during the Voyage of the H.M.S. Beagle around the world from 1832-6*, which appeared in London in 1845 from publisher John Murray. The accessible style and exotic nature of the voyage brought a wide readership, and suddenly Darwin had a new career—as an author of popular science.

## STUDIES IN MICROSCOPY

He continued to be firmly rooted in microscopy. Throughout his travels, Darwin had carried with him a small single lens microscope; he began using a compound microscope only in his later years. Among the subjects for his study were the microscopic structure of flowering plants and seeds. He also worked for many years on the cirripedia, the barnacles, and became the world authority on these intriguing little creatures. Darwin compiled *A Monograph on the Cirrhipedia*, published in four volumes between 1851 and 1854, which became a standard work.

Evolution came to a head with the voyages of a brilliant young explorer, Alfred Russel Wallace. He worked as a surveyor and then a school teacher before



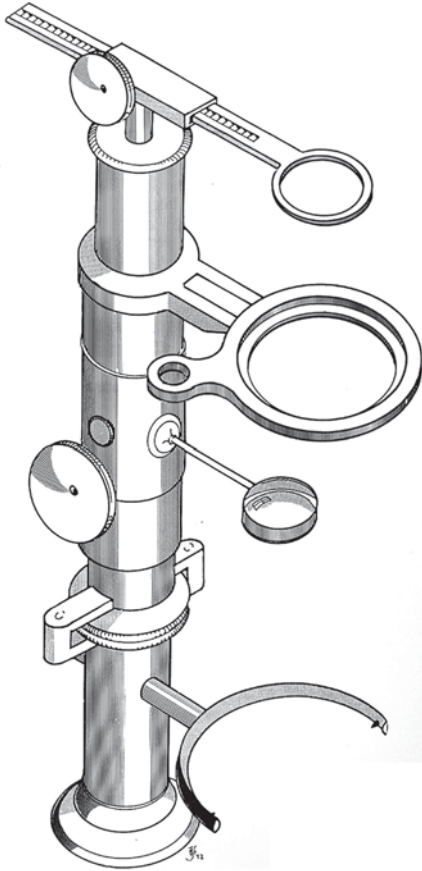
Darwin's studies of marine invertebrates as a teenager gave rise to systematic research on barnacles from 1846 to 1854. His monograph of these creatures became the standard reference work, and these drawings show high standards of dissection.

setting out to explore the Amazon River. The idea was to collect specimens for commercial sale to enthusiasts back in Britain, but his ship was destroyed by fire and all the collections went up in flames. Wallace entered a successful insurance claim for the lost specimens and used the money to advance his career. He published works on palm trees and monkeys and was soon off again exploring and collecting in Southeast Asia.

While staying in Borneo, Wallace wrote a paper, "On the Law Which has Regulated the Introduction of Species," which was published in the *Annals and Magazine of Natural History* in September 1855. This was the year before Darwin began work on natural selection. He wrote: "Every species has come into existence coincident both in space and time with a closely allied species" and noted (as he had done in his book on the Amazon monkeys) that geographical separation seemed to lead to species becoming distinct. Darwin's earlier observations of the Galápagos finches ran parallel to this account, of course, and as soon as Wallace had finished writing his great paper on evolution, "On the Tendency of Varieties to Depart Indefinitely from the Original Type," he mailed it at once to Darwin asking him or his opinion. Darwin received it on June 18, 1858 and discussed it with his friends.

It was a difficult time for Darwin and his family. His baby son had just died, and two of the children





For his research, Darwin used this type of simple, single-lens microscope (top), made by Robert Bancks of London in the 1820s. These compact botanical microscopes, which were stored inside a mahogany box, gave a remarkably high image quality. The model of brass microscope (left) preserved in the Darwin museum at Down House has a fine-focusing adjustment, which shows clearly in this drawing by the author. A substage condenser lens is located near the coarse focusing control.

were seriously ill. In London, his friend the distinguished microscopist Robert Brown had just died. Brown was Vice President of the Linnean Society, and on July 1, 1858, a special meeting was organized to elect a successor. There was time available for additional scientific presentations, and so it was agreed that the Honorary Secretary would read Wallace's paper on evolution, followed by extracts from Darwin's letters on the subject. Neither Wallace nor Darwin was present, and in his report on the year, the President of the Society said the meetings for 1858 had not "been marked by any of those striking discoveries which at once revolutionize, so to speak, our department of science." That puts him on the same status as the A&R man at Decca who turned down The Beatles.

### NOTIONS OF THE "FITTEST"

Surprisingly, this was not the first time that evolution had been written about in the Darwin family. Charles had a distinguished grandfather named Erasmus, who has been lovingly documented by my

admired friend Dr. Desmond King-Hele, a distinguished physicist and a specialist on space research. In his spare time, King-Hele has written extensively on Erasmus Darwin, a leading medical doctor who wrote a great work on life entitled *Zoonomia*, two great volumes that embraced many subjects—including evolution. The book was published in 1794 and included these words:

Since the earth began to exist, perhaps millions of ages before the commencement of the history of mankind, would it be too bold to imagine, that all warm-blooded animals have arisen from one living filament, which the first great cause endued with animality, with the power of acquiring new parts, attended with new propensities, directed by irritations, sensations, volitions, and associations; and thus possessing the faculty of continuing to improve by its own inherent activity, and of delivering down those improvements by generation to its posterity.

There you have it: evolution in a nutshell.

Erasmus went further, and even posited survival of the fittest as the mechanism involved: “The strongest and most active animal should propagate the species, which should thence become improved,” he wrote. Think of it—here we have the nature of evolution spelled out decades before Charles began his work.

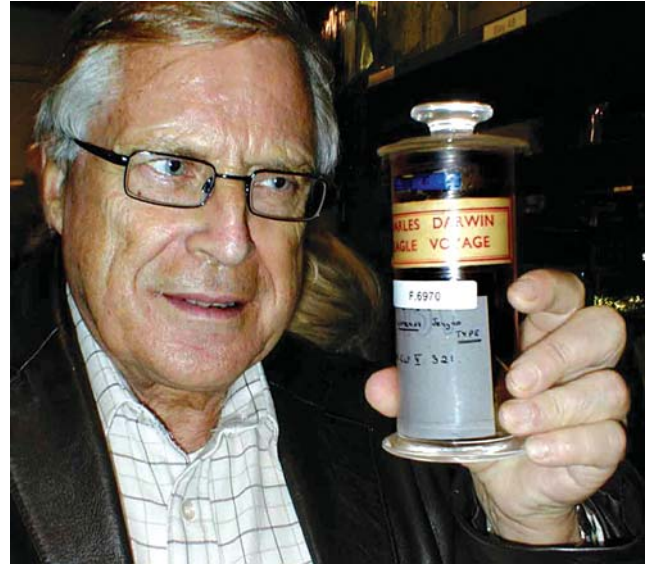
The notion of “survival of the fittest” does not even appear in the Linnean Society papers by Wallace and Charles Darwin of 1858, yet here it was spelled out more than 60 years earlier. Darwin was challenged about this, and said that he had of course read *Zoonomia*, but stated that his grandfather’s ideas had no influence on his own. The truth is that evolution, far from being Darwin’s invention, was current thinking throughout his lifetime. He was not introducing a revolutionary new concept, for the idea of evolution by survival of the fittest had been growing for decades. A French traveler and philosopher, Pierre Louis Maupertuis, had written about the idea even earlier in his book *Vénus physique*, published in 1745. Translated into English, it reads:

Chance, you might say, produced an innumerable multitude of individuals; a small number found themselves constructed in such a manner that the parts of the animal were able to satisfy its needs; in another infinitely greater number, there was neither fitness nor order: all of these latter have perished.

There we see “survival of the fittest” spelled out clearly and published a century before Darwin was active. It is clear from the words of Maupertuis that the idea of natural selection was known far earlier than it is popular to imagine, yet for all its originality his work has been largely forgotten. King-Hele suggests to me that the disappearance of his work could be due to suppression by Voltaire, to whose lover Maupertuis taught mathematics. She was Gabrielle Émilie Le Tonnelier de Breteuil, the Marquise du Châtelet, herself a brilliant mathematician who translated Isaac Newton’s *Principia* into French. Even today, hers is regarded as the best French translation of that great work. Little wonder Voltaire regarded Maupertuis with envy.

Here is another quotation, also dating from before 1800:

At length a discovery was supposed to be made of primitive animalcula, or organic molecula, from which every kind of animal was



Many of Darwin’s specimens from the H.M.S. Beagle voyage to the Galápagos Islands are preserved at the University of Cambridge, England. Although Darwin wrote that he was the naturalist on the trip, he was actually the captain’s travelling companion. The naturalist aboard was Dr. Robert McKormick.

formed; a shapeless, clumsy, microscopical object. This, by the natural tendency of original propagation to vary to protect the species, produced other better organized. These again produced other more perfect than themselves, till at last appeared the most complete of species, mankind, beyond whose perfection it is impossible for the work of generation to proceed.

This was retrieved by Milton Wainwright of the University of Sheffield, England. The words were written by Richard Joseph Sullivan in his book *A View of Nature*, published in London in 1794. Erasmus Darwin knew the writings of Maupertuis and probably knew of Sullivan, too. It is clear that the notion that life developed over many millennia was becoming widespread at the time, and so was natural selection. Remember, *Zoonomia* also contains these words: “The strongest and most active animal should propagate the species, which should thence become improved.” Erasmus Darwin revisited the topic of evolution in his poem *The Temple of Nature*, published in 1802:

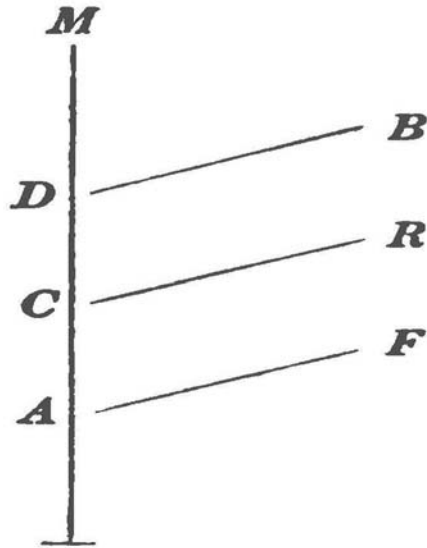
First forms minute, unseen by spheric glass,  
Move on the mud, or pierce the watery mass;  
These, as successive generations bloom,  
New powers acquire and larger limbs assume;

SCALE OF ANIMAL KINGDOM. (The numbers indicate orders:)	ORDER OF ANIMALS IN	
RADIATA (1, 2, 3, 4, 5) - - - - -	{ Zoophyta - - - - - Polyparia - - - - -	
MOLLUSCA (6, 7, 8, 9, 10, 11) - - -	{ Conchifera - - - - - Double-shelled Mollusks - - - - -	
ARTICULATA {	{ Crustacea - - - - - Annelida - - - - - Crustaceous Fishes - - - - -	
		{ Annelida (12, 13, 14) - - - Crustacea (15, 16, 17, 18, 19, 20) Arachnida & Insecta (21—31)
Pisces (32, 33, 34, 35, 36) - - -	True Fishes - - - - -	
		{ Piscine Saurians (ichthyosaurus, &c.) Pterodactyles - - - - - Crocodiles - - - - - Tortoises - - - - - Batrachians - - - - -
Reptilia (37, 38, 39, 40) - - -		
Aves (41, 42, 43, 44, 45, 46) - - -	Birds - - - - -	
VERTEBRATA {	47 Cetacea (Bone of a marsupial animal) - - -	
	48 Ruminantia	
	49 Pachydermata - Pachydermata (tapirs, horses, &c.)	
	50 Edentata	
	51 Rodentia - Rodentia (dormouse, squirrel, &c.)	
	52 Marsupialia - Marsupialia (raccoon, opossum, &c.)	
	53 Amphibia	
	Mammalia {	54 Digitigrada - Digitigrada (genette, fox, wolf, &c.)
		55 Plantigrada - Plantigrada (bear) - - - - - Cetacea (lamantins, seals, whales) -
	56 Insectivora - Edentata (sloths, &c.) - - - - - Ruminantia (oxen, deer, &c.) - - -	
57 Chiroptera		
58 Quadrumana - Quadrumana (monkeys) - - - - -		
59 Bimana - Bimana (man) - - - - -		

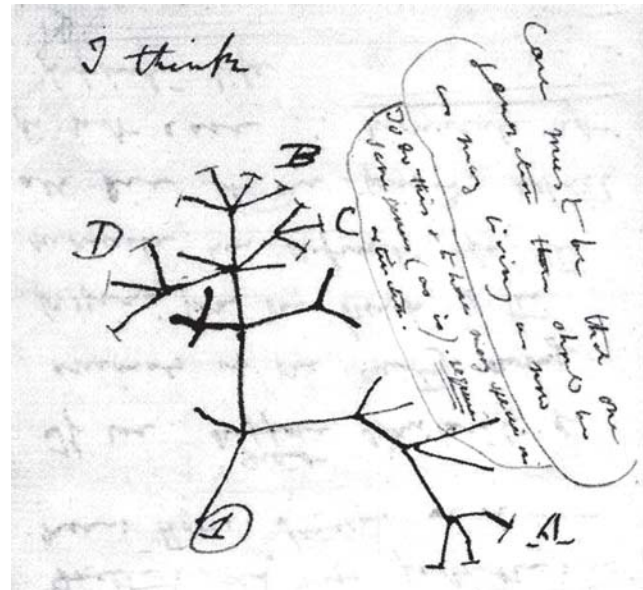
Robert Chambers published this evolutionary tree in 1844, showing the descent of specialized species from simpler forms of life. His book *Vestiges of the Natural History of Creation* was published anonymously to protect himself from controversy.

Whence countless groups of vegetation spring,  
And breathing realms of fin and feet and wing.

By 1810, Jean-Baptiste Lamarck was publishing his views in France and came up with a theory that was quickly rejected. Lamarck claimed that organisms evolved because of adaptations made in response to the experiences of successive generations. The reason a giraffe has a long neck, his theory argued, is because successive generations had stretched to reach up for leaves. Survival of the fittest, by contrast, holds that selection in favor of longer-necked animals took place as those with shorter necks were eliminated by starvation. We all know the two versions, and we all now dismiss Lamarck and his views as misguided. But Darwin did not—for him, the inheritance of acquired characteristics was entirely possible. This surprising view was called “pangenesis” by Darwin, and he included many examples of the phenomenon in the last chapter



Chambers published this bifurcating diagram to show evolutionary relationships. In this figure from his *Vestiges* book, fish (F), reptiles (R) and birds (B) are seen to be evolutionary side-branches of development towards the mammals (M).



In July 1837, Darwin had sketched this diagram of an evolutionary tree. His notes from the time show that he was questioning the transmutation of species and how they might progress. Many other scientists had been wondering the same thing.

of the book *Variation in Plants and Animals under Domestication*, published in 1875. The argument was that cells within an organism would produce “gemmules,” microscopic particles containing inheritable information that accumulated in the germinal cells. This runs con-



trary to what is conventionally called Darwinian evolution. This is a remarkable revelation: In some ways, Darwin supported Lamarckism.

The fact that natural selection was not part of the papers by Wallace and Darwin is unexpected, but more surprising still is the fact that this theory had already been advanced by an experimenter whose name is largely forgotten. He was an arboriculturist named Patrick Matthew. Like Darwin, he went to Edinburgh University; and like Darwin, he left without a degree. Matthew settled back at home in Errol, a small Scottish town, where he showed considerable proficiency as a grower of fruit trees. He experimented with cross-breeding, and notably, with grafting. These activities gave him insights into heredity, and in 1831 he published an important book, *On Naval Timber and Arboriculture*, which contained information that was much of specialist interest. He considered the qualities of timber needed for the construction of sailing ships and wrote on fungal diseases. He even makes reference to mycorrhizae of trees, a subject of interest today.

In the book's appendix, Matthew introduced the crucial concept of natural selection: "There is a law universal in nature, tending to render every reproductive being the best possibly suited to its condition." He added:

Nature, in all her modifications of life, has a power of increase far beyond what is needed to supply the place of what falls. Those individuals who possess not the requisite strength, swiftness, hardihood, or cunning, fall prematurely without reproducing . . . their place being occupied by the more perfect of their own kind.

This was in print, and widely available, 27 years before Darwin's ideas were first presented. When the matter was raised with Darwin, he wrote: "I freely acknowledge that Mr. Matthew has anticipated by many years the explanation which I have offered on the origin of species under the name of natural selection." And he offered to revise accordingly: "If another edition of my book is called for, I will insert a notice to the foregoing effect."

In the event, Darwin went on to write: "An obscure writer on forest trees clearly anticipated my views . . . though not a single person ever noticed the scattered passages in his book." That is a clear misstatement—Patrick Matthew was far from obscure. His ideas were widely understood, and many libraries banned his book. In the fourth edition of the *Origin of Species*, Dar-

win himself wrote: "In 1831, Mr Patrick Matthew, published his work on Naval Timbers and Arboriculture, in which he gives PRECISELY the same view of the origin of species as that provided by Mr. Wallace and myself in the Linnean Journal, and as that enlarged in the present volume." When I discussed this in my column for the London magazine *Boz* in 1998, the name of Patrick Matthew was unfamiliar to my readers.

## EVOLUTION'S FIRST BOOK

When was the first great book on evolution published? This was in 1844 and it was entitled *Vestiges of the Natural History of Creation*. Robert Chambers was the author and his views were clear: All forms of life had evolved over time, and they had done so according to natural laws, not by divine intervention. He included in his text an evolutionary tree—the first ever to appear in print—that makes an interesting comparison with the hand-drawn example in Darwin's private notebook. Another advocate was Rev. Baden Powell, Professor of Geometry at Oxford University. In his *Essays on the Unity of Worlds*, published in 1855, Powell wrote that all plants and animals had evolved from earlier, simpler forms, though principles that were essentially scientific. Powell was a sound scientist and a gifted microscopist, and although he was a cleric, he believed that if miracles had been reported, then they must either have a scientific explanation or they must be myths.

Powell later contacted Darwin and complained that his own views on evolution should have been cited in Darwin's book. Darwin did admit the influence of Thomas Malthus, who published several editions of *An Essay on the Principle of Population* between 1798 and 1826. In the opinion of Malthus, a leading British scholar, competition was an important factor regulating the growth of societies. Darwin conceded to his readers that his ideas were not original. In the introduction to *The Descent of Man*, he emphasized: "The conclusion that man is the co-descendant with other species of ancient, lower, and extinct forms is not in any degree new."

We have been raised to hero worship Darwin, yet we can now see that evolution was far from being his original idea; indeed, it was summarized by his grandfather Erasmus in a previous century. The essential notion—survival of the fittest—was missing from his early accounts of evolutionary mechanisms, but had been published decades earlier by an experimenter whose work Darwin knew. A formal theory of evolution was produced by Wallace, and Darwin himself

reminded his readers that his idea was far from original. Today, in an age of spurious celebrity, none of this matters. Darwin is set on a pedestal as though he were Einstein or Copernicus, and anyone doubting adherence to this conventional view risks ostracism. In science, as much as in religion, we can find extreme views that fly in the face of realities.

To me, Darwin's important legacy is his list of published books. They represent a remarkable devotion to popularizing science. Apart from the *Origin of Species*, he wrote on the geology of South America and on volcanic islands (1844), on the fertilization of orchids (1862), the movements of climbing plants (1865), the effects of cultivation on variation of plants and animals (1868), the *Descent of Man* (1871), insectivorous plants (1875), the effects of cross fertilization in plants (1876), and *The Different Forms of Flowers on Plants of the Same Species* (1877). His last book, *The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits* (1881), was a bestseller and sold more copies during his lifetime than the *Origin of Species*.

## LOYAL TO THE SINGLE LENS

As a microscopist, Darwin was devoted to the Banks' single lens microscope for his research, as he preferred the compact and easily transportable design of this exquisite little instrument. His fine achromatic microscope, made by James Smith in 1846, is still preserved at the Whipple Museum for the History of Science in Cambridge. Darwin insisted that high-power examination should always be supplemented by looking at the same specimen at lower magnifications. This is wise advice. I always look closely at a microscopical preparation first with the naked eye, and this is often of crucial importance. To rely solely on high magnifications, wrote Darwin, is "injurious to natural philosophy," and I am sure he was correct in this assertion.

His recommendations on the use of a microscope by travelers were included in a Royal Navy manual entitled *A Manual of scientific enquiry; prepared for the use of Her Majesty's Navy: and adapted for Travelers in General*, edited by John Herschel in 1849. On pages 389-395 we find, "Use of the Microscope on Board Ship" by Charles Darwin. His experience had shown the importance of having a firm, fixed stage:

The stage ought to be firmly soldered to the upright column and have no movement; besides the strength thus gained, the stage is always at exactly the same height, which aids practice in the delicate movements of the hand.

The stage should be able to receive saucers, three inches in internal diameter. A disc of blackened wood, with a piece of cork inlaid in the centre, made to drop into the same rim which receives the saucers, is useful for opaque and dry objects: there should also be a disc of metal of the same size, with a hole and rim in the centre to receive plates of glass, both flat and concave, in diameter one inch and a half, for dissecting minute objects; a plate of glass of three inches diameter lets in too much light and is otherwise inconvenient. Close under the stage there should be a blackened diaphragm, to slip easily in and out, in order to shut off the light completely; in this diaphragm there may be a small orifice with a slide, to let in a pencil of light for small objects.

The variety of backgrounds obtained in this manner seems surprising to present-day microscopists. However, this substantiates Darwin's insistence on using low-power lenses to scrutinize a specimen. He was also moving away from the convenience of a simple microscope. The botanical (or aquatic) microscopes then in vogue screwed into the lid of the box that contained the instrument when not in use. Darwin now recognized the flaws in this design and advocated a far more secure footing:

The whole microscope should be screwed into a solid block of oak, and not into the lid of the box as is usual. The mirror should be capable of movement in every direction, and of sliding up and down the column; on one side there must be a large concave mirror, and on the other a small flat one; these mirrors ought to be fitted water tight in caps, made to screw off and on; and two or three spare mirrors ought undoubtedly to be taken on a long voyage, as salt water spilt on the mirror easily deadens the quicksilver. A small cap is very convenient to cover the mirror when not in use, and often saves it from being wet. The vertical shaft by which the lenses are moved up and down should be triangular (as these work much better than those of a cylindrical form), and there should be on both sides large milled heads; with such, there is no occasion for fine movements of adjustment, which always tend to weaken the instrument. The horizontal shaft should be capable of revolving, and should be moved to and fro by two milled heads (for the



right and left hands), but the left milled head must be quite small, to allow of the cheek and eye approaching close to the lenses of high power.

Darwin also recognized the importance of the measurement of specimens:

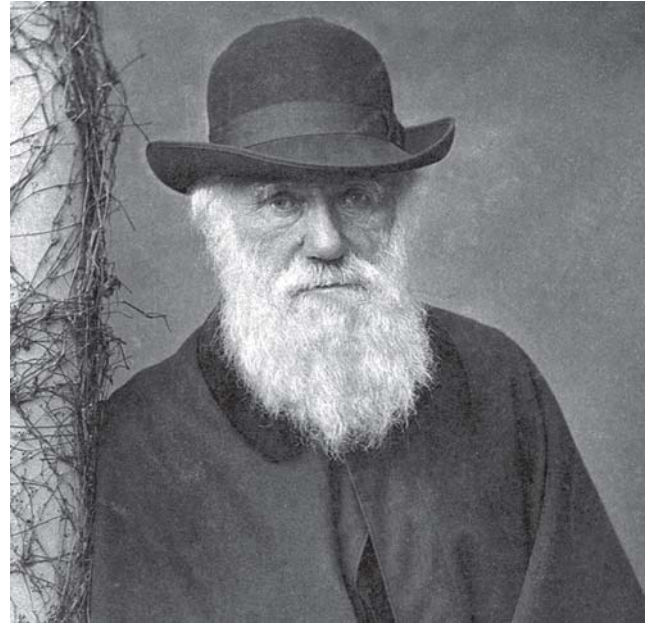
The observer should be provided with three slips of glass, or still better with three circular plates, made to drop into the stage of his microscope, and graduated into tenths, hundredths, and thousandths of an inch, to serve as micrometers, on which to place and measure any object he is examining. Some watch-glasses are very useful as temporary receptacles for small sea-animals. Minute parts after dissection can be preserved for years in very weak spirits of wine, by covering them, when placed on slips of glass, by small portions of very thin glass (both sold for this purpose), and cementing the edges with gold-size.

Darwin's specimens and his permanent microscopical preparations are preserved to this day at the Zoology Museum at the University of Cambridge. His account of a microscope for use aboard ship is one of the most detailed early summaries of a microscope used in the field. Illumination was often a problem; he states:

As it is often rather dark in the cabins of ships, a large bull's-eye glass on a stand (such as are sold with most compound microscopes) would be most useful to condense the light from a lamp on an opaque object, or to increase it when transmitted.

Darwin's name has become embroiled in controversy in recent decades, and is held in low esteem in schools where creationism is a fashionable belief. How curious is this: He has become as associated with evolution as French fries are with a cheeseburger. Yet the idea of evolution long predates Darwin's writings—and even his specific theory had been published long before he began writing.

Now that extremists wish to eliminate the teaching of evolution, should we seek to ban creationism in schools? Not in my view. Each side holds their opinions with the strength of conviction and I believe that



A well-known photograph of Darwin taken at Down House in 1881. He suffered years of illness and often took arsenic as a medication later in life. He died the following year at age 73.

both views should be taught to teenagers. The evidence that gave rise to the modern scientific understanding is readily available to all, and this is an object lesson in how science evolves. Trying to abolish creationism is like trying to ban a record or a book—it immediately makes it desirable.

Charles Darwin didn't discover evolution. His book on worms outsold the volume on evolution. He had no science degree, he did not introduce the idea of "natural selection," and he wasn't the H.M.S. Beagle's naturalist. Rather than the "father of evolution," he should be known to us as an indefatigable investigator, an expert observer and a diligent microscopist. Darwin was gifted with an incisive and diligent mind and backed with a private family income. He was one of the finest writers of popular science of his age, and his wide-ranging interests have illuminated many branches of biology. Yet in the modern world, the theory for which he is best known has been attacked in schools across the land.

How would I respond? Easily. If anyone seriously believes that God created everything that we see around us, then, by definition God created evolution. Darwin, the Victorian microscopist, most certainly didn't.