



NATURAL HISTORY

9/15

**SPECIAL ISSUE:
HONORING
ALFRED RUSSEL
WALLACE**

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ON THE FRONT AND BACK COVERS

Anthony Smith's centenary statue of Alfred Russel Wallace (details) depicts the naturalist sighting a spectacular new species of birdwing butterfly. Donated by the Wallace Memorial Fund, the statue stands outside the Darwin Centre at London's Natural History Museum.

Photographs © Anthony Smith
anthonymithart.co.uk

THE NATURAL MOMENT

**RAINDROPS KEEP
FALLING ON MY HEAD**

Photograph by Anup Shah



◀ See preceding two pages



Two living species of orangutans inhabit shrinking rainforests: *Pongo pygmaeus* in Borneo and *P. abelii* in Sumatra. To photograph orangutans in northern Sumatra, Anup Shah traveled to Gunung Leuser National Park, where he encountered an adult female named Pesek and her daughter, April, catching raindrops in their mouths. Water is abundant in the environment, but perhaps the mother felt a little thirsty, or just playful enough to taste the light shower. The daughter, primed to learn by observation, followed her example.

As their identification by personal names implies, Pesek and April have a history with humans. Pesek was cared for at the former Bohorok orangutan rehabilitation center at Bukit Lawang; after her release in the wild she gave birth to April. In cooperation with government initiatives, many organizations currently work to preserve orangutans through habitat protection, reintroduction of confiscated pets to the wild, education, and scientific research. Among them are the Sumatran Orangutan Conservation Program (www.sumatranorangutan.org) and, with projects in Borneo,

the Orangutan Foundation International (orangutan.org) and the Orangutan Foundation UK (www.orangutan.org.uk).

One of the first Western naturalists to observe orangutans was Alfred Russel Wallace, who in 1865 encountered them in Borneo. His experiences collecting specimens of the ape appear in his book *The Malay Archipelago*, which he subtitled, in fact, *The land of the Orang-utan, and the Bird of Paradise*.

One female Wallace killed had an infant, and “while carrying it home,” he wrote, “it got its hands in my beard, and grasped so tightly that I had great difficulty in getting free.” Wallace chronicled the (ultimately unsuccessful) attempt to nurture it. He was able to give it some comfort, however, in the form of a young long-tailed macaque, which he placed in the same box. “They immediately became excellent friends, neither exhibiting the least fear of the other.” In the photo above, Anup Shah has documented a recent encounter between a young orangutan and two long-tailed macaques.

Born in Kenya to Indian parents, **Anup Shah** grew up visiting Nairobi National Park and later embarked on a career in wildlife photography. With an emphasis on work in Africa and Asia, he has collaborated with both his brother, Manoj Shah, and his wife, Fiona Rogers. Among his recent books are *Serengeti Spy: Views from a Hidden Camera on the Plains of East Africa* (Harry N. Abrams, 2012) and, with Fiona Rogers, *Tales from Gombe* (Firefly Books, 2014). To see more of his work visit www.shahrogersphotography.com.



NATURAL HISTORY

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Welcome . . .

to an intellectual and pictorial feast celebrating the life and thought of Alfred Russel Wallace (1823–1913). Cofounder of the theory of evolution by natural selection in 1858, Wallace has been overshadowed by his senior partner, Charles Darwin, yet during his lifetime he was acclaimed as one of the world's greatest scientists. Wallace had explored tropical jungles in the Amazon and Indonesia for twelve years, discovered thousands of new species, and worked out worldwide patterns of the distribution of animals and plants.

Natural History's special commemorative issue is part of the Alfred Russel Wallace Centenary Celebration, funded by the John Templeton Foundation. Our lead article is "An Appreciation" of Wallace by David Attenborough, who is celebrating sixty years of producing wildlife programs for the BBC. At the age of ten, he had read *The Malay Archipelago*, Wallace's classic account of his travels, and decided to seek out the mysterious birds of paradise that had so inspired the naturalist. His efforts in turn inspired Edwin Scholes and Tim Laman to spend the past decade following in Wallace's footsteps. They generously share their magnificent photographs with us.

It has been a delight to serve as Guest Editor of this issue, partnering with my longtime friend and colleague, *Natural History* Editor Emeritus Vittorio Maestro. We found it gratifying indeed that so many top scholars and writers enthusiastically contributed their time, talents, and resources to this issue. As one of them put it, "Anything for Wallace!"

Richard Milner, Guest Editor and
Director, Alfred Russel Wallace Centenary Celebration



Alfred Russel Wallace, in a photograph taken about 1869

COLORIZED BY EDVOS/© G. W. BECCALONI

nature.net

ARW Online

The granddaddy of all Wallace websites, including all of the naturalist's published writings, is Charles Smith's Alfred Russel Wallace Page, people.wku.edu/charles.smith/index1.htm. Another comprehensive site is John van Wyhe's Wallace Online (wallace-online.org). Thousands of letters to and from Wallace may be perused at Wallace Letters Online, www.nhm.ac.uk/wallacelettersonline, the website organized by George Beccaloni (see his selection in this issue). See also his websites wallaceletters.info and wallacefund.info.

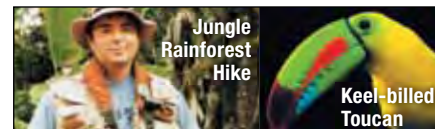
Richard Milner's website darwinlive.com/wallace/amnh.html offers a nontechnical introduction to Wallace and listing of the Alfred Russel Wallace Centenary Celebration events. For a full playlist of the Centenary lectures given November 12, 2013, at the American Museum of Natural History see www.youtube.com/playlist?list=PLUraVH7k-FH9tATJuDRpjZmHVy92K9fa. At www.eeb.ucla.edu/arwallace, learn about Feele Lee's associated Wallace Centennial Celebration at UCLA on November 15, 2014. To watch

all the talks see www.youtube.com/playlist?list=PL25S7KICfH-UOU8PUpAHfQkdJznofwZ-0.

"Alfred Russel Wallace and the Birds of Paradise," an audio of David Attenborough's talk at the American Museum of Natural History in 2013, can be downloaded at www.amnh.org/explore/news-blogs/podcasts/alfred-russel-wallace-and-the-birds-of-paradise-with-sir-david-attenborough. See also "The Forgotten Story of Alfred Russel Wallace," a BBC slideshow narrated by Attenborough (www.bbc.co.uk/science/0/24837130).

In a National Geographic Live! video, Tim Laman and Edwin Scholes (featured in this issue) describe how they followed in Wallace's footsteps to document all the birds of paradise (www.youtube.com/watch?v=OcCP4_R8QBw). You can watch Bill Bailey on Alfred Russel Wallace from the Natural History Museum (www.youtube.com/watch?v=KT2YbugYcjq). Other videos are: "The Forgotten Voyage: Alfred Russel Wallace and His Discovery of Evolution by Natural Selection" (www.youtube.com/watch?v=Z1eQ6DadodA) and "The Origin of Species: The Mak-

ing of a Theory" (media.hhmi.org/biointeractive/films/OriginSpecies-Theory.html).



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Alfred Russel Wallace

An Appreciation

By David Attenborough

This young man didn't have much going for him, really.

Born in 1823, he's twenty-five in this picture [at right]: slim and a little over six feet tall. You might guess from his clothes that he's not very well off, and you'd be right. His father had a small income, but he was a fairly idle man who didn't look after his children, and this gangly youth was the eighth out of nine.

His name was Alfred Russel Wallace.

He was born in a small town in Wales, and soon after, the family moved to the village of Hertford, just north of London. He left school when he was fourteen to work as a carpenter for one of his brothers and then as a land surveyor for another. During that time he read widely and voraciously and began to take a naturalist's interest in the countryside, particularly in the wildflowers. It was the start of studies and thoughts that would eventually make him one of the greatest naturalists that the world has ever seen.

In 1844 he moved to Leicester to work as a teacher. There he met another young budding naturalist called Henry Bates, who shared his passion for the natural world. Bates was an avid beetle collector, who collected a thousand species of beetles within ten miles of the city. What possible reason, both wondered, could there be for so many kinds of beetles? (Fifteen years earlier, another young British beetle collector—Charles Darwin—had also been fascinated by the same conundrum.)

Wallace and Bates began to dream of pursuing their interests into the tropics, where nature was most glo-



Alfred Russel Wallace in 1848, age twenty-five, just before he left for the tropics of Amazonia

rious and most varied. Why not go to the Amazon and pay for their expedition by collecting specimens of birds and insects and selling them through a London agent? That was a real commercial possibility, for there was a flourishing market in Victorian England in natural history curiosities. So off they went.

After exploring and collecting along the Amazon together for a while, they split up. For the next four years Wallace continued by himself along the Rio Negro. He lived rough. He endured recurrent bouts of malaria. But he worked with extraordinary intensity, not only collecting the specimens on which he depended for his livelihood, but also

making detailed scientific notes of his observations and speculations. After four years of hard work, he decided to return to Britain. He had found many new species that would sell well to collectors, and he had innumerable field notes, maps, diagrams, and species lists, which would be of great value to scientists. So he set off from the east coast of Brazil for Britain.

Three weeks out, the ship caught fire. Almost all Wallace's notes and specimens were lost in the flames, together with a small menagerie of live monkeys and birds that he was bringing back to impress scientists in London. For ten days he drifted in the Atlantic in a lifeboat until eventually he and his shipmates were rescued off Bermuda.

You might think that after his harrowing experiences as a traveling naturalist, once he got back home safely he would say, "Well, that's enough of that." But next, at age thirty-one, he set out by himself to try his luck in the Far East, funded in part by the insurance money

from his incinerated collection. Among other quests for rare and near-legendary animals, such as the orangutan, he wanted to see and collect birds of paradise. He had long been fascinated by these glamorous, romantic birds—and their spectacular, wonderfully colored plumes would fetch premium prices.

Birds of paradise had been haunting the European imagination for hundreds of years. The first skins arrived there in 1522, brought back from Magellan's circumnavigation of the world. They were very strange. Gauzy golden plumes, unlike any feathers that anyone had seen before, sprouted from their flanks, and they had neither feet nor wings. Magellan's men had been given them in the Spice Islands, the Indonesian islands known today as the Maluku. They had been brought there from farther east by traders from New Guinea and other islands. The hunters who had caught the birds had removed the wings and

feet in order to emphasize the glory of the flank plumes. The Malukans, however, who had never seen the birds alive, maintained that the wings and feet were missing because the birds never needed such things. Their home was high in the sky where they floated in paradise, and people only found them when they died and fell to Earth. Magellan's men repeated these stories, and European naturalists believed them

By the nineteenth century, of course, neither Wallace nor any other European naturalist accepted such preposterous tales. But only one, a Frenchman, had ever seen the living birds in the wild, and none had seen them flaunting their fantastic plumes in display. Wallace became obsessed with tracking them down. One fateful day in 1857, in the Aru Islands off New Guinea, a group of tribal hunters led him to a tall tree in the forest where the birds were known to perform their courtship displays all year round. Wallace drank in the scene as his reward for years of struggle and deprivation



In an engraving from Wallace's *The Malay Archipelago* (1869), Aru islanders use blunt-tipped arrows to bring down greater birds of paradise without causing visible wounds.

and later described it in his 1869 book, *The Malay Archipelago: Land of the Orangutan, and the Bird of Paradise:*

On one of these trees a dozen or twenty full-plumaged male birds assemble together, raise up their wings, stretch out their necks, and elevate their exquisite plumes, keeping them in a continual vibration. Between whiles they fly across from branch to branch in great excitement, so that the whole tree is filled with waving plumes in every variety of attitude and motion. . . . The Bird of Paradise really deserves its name, and must be ranked as one of the most beautiful and most wonderful of living things.

I read this passage in Wallace's book as a boy, and yearned to go out and see such a scene for myself. There are some forty-odd species in the family Paradisaeidae, and they are so extraordinarily varied that it is difficult indeed to believe that all belong to the same family. Some are as big as crows, others as small as thrushes. I first tried to film them back in 1955. We got

some shots of Count Raggi's bird of paradise, a species closely related to the greater bird of paradise, the species that Wallace had seen. But they were barely usable. The bird was perched on a branch, silhouetted against the sky. It was very early in the morning. And we only had black-and-white film. In later years I did better and eventually produced a film featuring a dozen different species in display. But then, in an extraordinary series of eighteen expeditions over eight years, Edwin Scholes and Tim Laman succeeded in recording every species of the family in magnificent detail. A sample of their work appears in this special Wallace issue of *Natural History* [see page 24].

It was while Wallace was pursuing birds of paradise, back in 1858, that he had an idea that was to bring him immortality. He was living in the jungle in a small, cramped hut when he came down with a bout of malaria or dengue fever. As he lay in his hammock in a high delirium, the question that had first occurred to him years

before, with his friend Bates, rolled around in his mind. Why are there so many different kinds of beetles, so many different kinds of birds of paradise, and so many different kinds of butterflies? And the answer came to him. Animals produce many more young than survive. Only some will live long enough to reproduce. Most will die without leaving offspring. If conditions change, either because the species moves to a new environment or because the environment changes, then the species itself will change over time. And he promptly summarized his thoughts in an essay on the theory of evolution by natural selection, as it came to be called.

He sent it to Charles Darwin, with whom he had been in intermittent correspondence and whom he admired for his travel book about the voyage of HMS *Beagle*. The letter eventually arrived in Darwin's comfortable home in Kent, in the English countryside. A greater contrast to that little hut in the Spice Islands you could hardly imagine!

Wallace's letter and essay was, to Darwin, a bombshell. He himself had envisioned species forming and transmuting by natural selection nearly twenty years earlier. Since then he had steadily accumulated a mountain of evidence to support his theory. He didn't want to be scooped, but neither did he want people to think he had stolen his ideas from Wallace. What to do?

His friends Joseph Hooker of the Royal Botanic Garden at Kew and Charles Lyell, the geologist, came up with a solution to this problem. They decided to take Wallace's essay—it was not long but it was very detailed and very convincing—and put it together with some drafts Darwin had written several years earlier. In 1858 both papers were read at the same meeting of the Linnean Society. Neither Darwin nor Wallace could be there—Darwin because his young son had just died, and Wallace because he was far away in the Maluku. They were both given credit as co-authors of the theory.

Wallace, continued to travel through the Indonesian islands adding to his collections. Only those who have trekked through dense rainforests and sailed through tropical archipelagos in rickety little boats can visualize the sort of things Wallace had to do. Col-



RICHARD MILNER

Curl-crested toucans, drawn by the screams of one he has wounded, mob Henry Walter Bates, Wallace's collecting partner in Amazonia. The illustration is from Bates's The Naturalist on the River Amazons (1863).

lecting and preparing his specimens, was arduous work. The skins and the feathers had to be carefully preserved intact—an extraordinarily difficult task. Pinning all his butterflies was a huge undertaking, even aided by his young assistants. Wallace made sixty to seventy separate journeys in local boats. He was sick with malaria many times. After eight years in the Malay Archipelago, he was a tired man; the time had come to go home.

Wallace had managed to collect 110,000 insects, 7,500 mollusk shells, 8,050 bird skins, and 420 mammal and reptile specimens. He had observed five different species of birds of paradise, and discovered a new member of the family that was to be named after him: Wallace's standardwing. And because in his travels among the islands he had kept such accu-

rate notes and observations about everything he saw, he was able to form a picture in his mind of the distribution of all these different animals. As early as 1856 he realized that there was an invisible line running roughly north and south across the middle of the Indonesian archipelago. On the eastern side, there were kangaroos and opossums. Among the birds there were honeyeaters and mound-building birds called megapodes. And there were eucalyptus trees. In Java and Borneo, however, on the west side, there weren't any marsupials. Instead, there were placental mammals like monkeys and tigers and elephants and deer. Nor were there any eucalyptus trees. In 1858 he wrote to his friend Bates, with whom he conducted a regular correspondence:

In this archipelago there are two distinct faunas rigidly circumscribed, which differ as much as do those of Africa and South America, and more than those of Europe and North America, yet there is nothing on the map or on the face of the islands to mark their limits. . . . I believe the western part to be a separated portion of continental Asia, while the eastern is a fragmentary prolongation of a former west Pacific continent.

With that observation he founded the science of biogeography. A century later, the division was found to be due to the way tectonic plates and continents drift across the surface of our planet. The animals of Australia developed in isolation, and part of their homeland had

slowly drifted westwards and collided with the Asiatic plate. I've crossed that line many times, and on the surface there is nothing to suggest such a division. But one morning you wake up and you can listen to birds you've been hearing all over Java and then suddenly you hear a screech of a cockatoo, and you know that you've crossed Wallace's Line.

Meanwhile Darwin rushed to write the extended explanation of the theory of natural selection that he had been planning ever since he had written the first short essay summarizing his idea. He completed it in thirteen months, and it was published on the 24th of November 1859—its full title: *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*. It caused a sensation. There were angry, vigorous debates, and the church was up in arms.

Wallace got back to Britain three years later, in 1862, and at last met Darwin. You might have thought there was embarrassment or perhaps hostility or resentment one way or another. Not at all. The two men had great respect for each other, untinged by any sign of jealousy. Darwin wrote to Wallace, "You would, if you had had my leisure done the work just as well, perhaps better, than I have done it." Wallace on the other hand wrote to Bates, "I do honestly believe that with however much patience I had worked up & experimented on the subject I could never have approached the completeness of his book,—its vast accumulation of evidence,—its overwhelming argument, & its admirable tone & spirit. I really feel thankful that it has not been left to me to give the theory to the public."

It mustn't be supposed, however, that he necessarily agreed with everything that Darwin said. Paradoxically, one of the great areas where they disagreed with each other was about birds of paradise. Darwin, who had never seen a living bird of paradise, sat in his house in Kent, thinking about them, and he came to the conclusion that the females were capable of assessing the quality of beauty—and that the reason the males had these magnificent plumes was to impress potential mates. Wallace refused to believe that birds would have aesthetic sense and rejected Darwin's notion of sexual selection. Today, experimental work and much more detailed observations have shown that Darwin was correct on this question, and Wallace was wrong.

Wallace was properly honored in his country: the Royal Geographical Society and the Royal Society awarded him their medals. Yet, despite its proper name as the Darwin-Wallace theory, evolution by natural selection became popularly known as "Darwin's theory." Wallace even facilitated his own eclipse by calling his 1889 book on evolution *Darwinism*. Remarkably, scholars searching through all the books and all the correspondence haven't been able to find one word of resentment on Wallace's

part. After Darwin's death in 1882, he became the grand old man of natural history. He never was afraid of taking up a theory or indeed an issue simply because it was unpopular, if he thought it was right. He advocated radical views about feminism and the right of women to vote. He dabbled in spiritualism.

A little more than a hundred years ago, in 1913, Wallace died at the age of ninety. He was in my estimation a great man on a number of counts. First of all he was a great field naturalist. Few who have never tackled that sort of job can ever realize how daunting, how wearying, how demanding that is, and to do it for eight years in the most extreme conditions is extraordinary.

He was also a great scientific thinker. His recognition of the Line that was given his name and his associated theories about biogeography would have been sufficient to establish his reputation, even if he had not independently put forward the theory of evolution by natural selection—the foundation of all biological sciences ever since, without which the natural world makes no sense whatever. He came to it later than Darwin, but they gave it to the world together in 1858.

But above all, perhaps, I respect Wallace because of the humility, the generosity of spirit, the bravery, the endurance, and independence of mind he displayed, and the charity and good manners with which he dealt with everybody he met—whether they were tribesmen in the Aru Islands or gentlemen in Victorian England.

In my estimation he was a very, very great man.



JOHN STILLWELL/PRESS ASSOCIATION IMAGES

As befits his role as president of Butterfly Conservation, a British organization, **David Attenborough** is pictured here with a Southeast Asian great Mormon butterfly, attracted to his nose by a generous daubing of banana. Attenborough is the celebrated television naturalist whose series include *Life on Earth*, *The Living Planet*, *The Trials of Life*, *The Life of Birds*, *The Life of Mammals*, *Life in the Undergrowth*, and *Life in Cold Blood*. His documentary work allowed him to fulfill his boyhood ambition to follow in Wallace's footsteps to observe birds of paradise in the wild, and his most recent book, coauthored with Errol Fuller, is *Drawn from Paradise: The Natural History, Art and Discovery of the Birds of Paradise* (Harper Design, 2012). Attenborough is also founder of the Attenborough Nature Reserve, owned and managed by the Nottinghamshire Wildlife Trust to promote the conservation of native species. Among his many awards and honors, Attenborough was knighted in 1985.



Odyssey of a Naturalist

Wallace eagerly explored places and ideas.

BY ANDREW BERRY

Alfred Russel Wallace, age 39, in Singapore, 1862, at the end of his eight years exploring Southeast Asia

Alfred Russel Wallace

is one of the most appealing figures in all the history of science. His status as an unfairly forgotten underdog helps: he was, with Charles Darwin, the codiscoverer of evolution by natural selection, arguably the most important idea in biology, but, while today Darwin's name is synonymous with the theory, Wallace is mostly relegated to the footnotes of biology textbooks. But perhaps the biggest reason for Wallace's appeal is his story. He came from a disadvantaged background, endured harrowing and demoralizing setbacks in his struggle to establish himself as a scientist, but nevertheless, forever upbeat and resilient, persisted to become one of the era's most lauded thinkers. Moreover, despite his successes, he never forgot his roots, becoming politically active in a wide variety of causes on behalf of "the working men of England," as he referred to them in the dedication of one of his socialist tracts. Also, throughout his long life, Wallace remained almost preternaturally modest: for example, what could have become an ugly priority dispute with Darwin became instead a close friendship, with Wallace titling his major book on evolution *Darwinism*.

Wallace was born January 8, 1823, near Usk, in southern Wales, into a large middle-class family in economic

free fall. His father had a facility for losing money—they were only in Usk because, as Wallace related, it was "a place where living was as cheap as possible"—and Wallace's childhood was a tale of indignities imposed by poverty. He left school at the age of fourteen and soon after went to work as an assistant to his brother William, a land surveyor. It was tramping across the British countryside on these surveying missions that first introduced Wallace to the natural world, as he became curious, in a naive, amateurish way, about the plants he encountered. His interest in natural history was put on an altogether more serious footing, however, when, in Leicester in 1844, he met another young self-taught naturalist, Henry Walter Bates (who would later find fame as the discoverer of "Batesian mimicry," in which harmless species evolve to look like toxic ones to gain protection from predators). Bates

quickly converted Wallace to his own passion, beetles, and both were soon "ardent beetle-hunters," as Wallace put it.

Before long, however, the limitations of the relatively depauperate British fauna made Wallace and Bates think about going farther afield. They were also inspired both by a desire to explore the heretical proto-evolutionary theories of the time and by contemporary scientific travelogues, including Darwin's *Voyage of the Beagle*. But how could they fund an overseas expedition? They contracted with a London natural history agent to sell the specimens—exotic bird skins, fantastic gaudy butterflies—they would ship home. In 1848, the pair arrived in Brazil, where they split up to maximize their effectiveness as collectors, with Wallace exploring the upper reaches of the Rio Negro.



Alone, often sick, dealing daily with the flies, and with the mildew and pests that conspired to destroy his precious specimens, Wallace experienced a brutal introduction to tropical biology. In 1849 his younger brother Herbert came out to assist and contracted yellow fever, from which he died. In 1852, his own health broken, Wallace decided to head home. The prospect of a triumphant return must have sustained him through his darkest hours, as he imagined the impact of his arrival in scientific London. Those hard-won specimens would be his passport to the scientific big time. Even better, he was bringing home a small menagerie of living animals: think of walking into a London scientific salon with a rainbow-billed toucan on your arm!

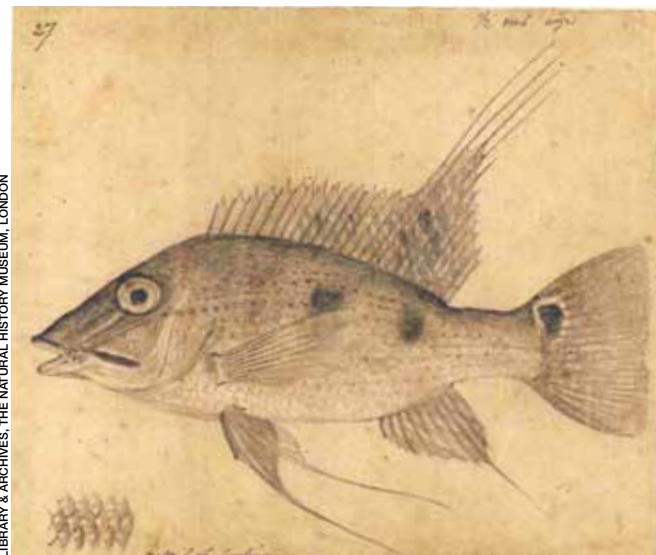
But the triumphant return was not to be. Poorly stowed cargo caused his ship to catch fire in the middle of the Atlantic, and the captain gave the order to abandon ship as the tinder-dry wooden hull went

Wallace (center, wearing hat) negotiates for natural history specimens in the Aru Islands off New Guinea. Titled *Dobbo in the Trading Season*, this illustration from *The Malay Archipelago* was based on Wallace's own sketch.



Wallace's watercolor of a female rhinoceros hornbill from Borneo, ca. 1855

up in flames. In the hope that the conflagration would attract other shipping in the area, the ship's two lifeboats circled the burning wreck, giving Wallace a ringside seat to what is surely one of the most poignant episodes in the history of science. The birds and monkeys he had cared for as he traveled downriver across the continent were sprung from their cages by the fire and went out to the



Wallace made this pencil sketch of a three-spotted eartheater (*Satanoperca daemon*) he caught in the Rio Negro, a tributary of the Amazon. It is one of more than 200 fish drawings that he rescued as his ship burned and sank on the way back to England.

bowsprit, the last part of the ship to be enveloped by the flames. There, confronted with an infinite ocean on one hand and with the flames on the other, they panicked, flinging themselves back into the fire.

Wallace and the crew spent the next ten days adrift in open boats before being picked up. Throughout, his Victorian stiff upper lip never quivered: "During the night I saw several meteors, and in fact could not be in a better position for observing them, than lying on my back in a small boat in the middle of the Atlantic."

Not surprisingly, when he finally made it back to Britain, Wallace's first response was to declare himself unwilling ever again to put to sea. But it quickly became apparent that he had no choice if he were to realize his dream of becoming a bona fide member of the Vic-

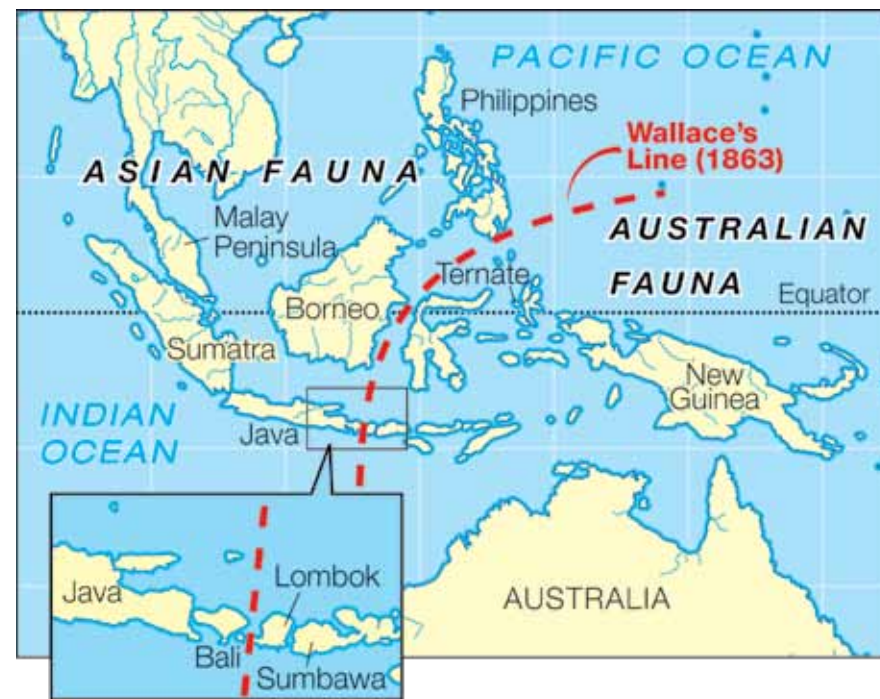
torian science elite: he would have to do it all over again. Within eighteen months of his return from Brazil, then, Wallace was aboard a ship bound for Singapore.

The eight years that Wallace spent in what was then called the Malay Archipelago—all the way from the Malay Peninsula to the western reaches of New Guinea—were, he recognized, the "central and controlling incident" of his life. Here, the skills he had learned in the Amazon finally paid dividends. Among them was his most successful book, *The Malay Archipelago* (1869), which rates as the most readable and exciting of all the great early scientific travelogues. But the real dividends were scientific. First, there was the collecting. Wallace's achievements here were extraordinary: for example, by his own reckoning, he discovered some 200 new species of birds—that's about 2 percent of all bird species. His naturalist's eye coupled with an awareness of geography acquired during his early years as a surveyor resulted in his identifying the discontinuity between the Australasian biota (where, for example, there are no monkeys) and the Asian one (no marsupials). He noted that the boundary—later called (not by Wallace) "Wallace's Line" or "the Wallace Line"—ran

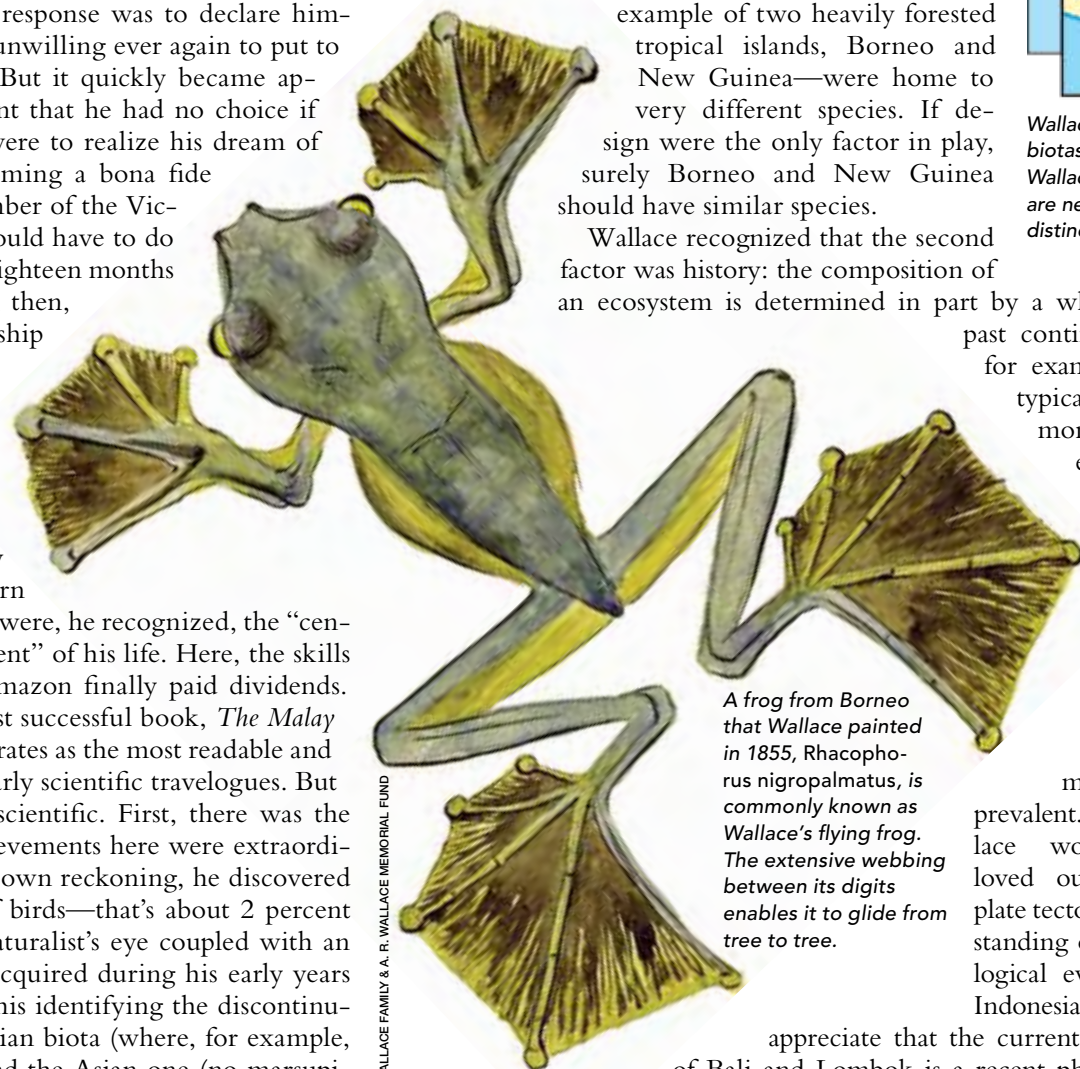
between two contiguous islands, Bali and Lombok, and he was inevitably puzzled about how such differences could arise between geographically close locations.

As he thought through these problems, he came to recognize that two factors governed the geographic distribution of species. First was what his religious contemporaries called "design"—that is, "adaptation" in the language of evolutionary biology—whereby a species is fitted, or suited, to its environment. A desert-dwelling plant, for instance, has an array of adaptations to minimize water loss. But Wallace saw that locations with similar climates—he gave the example of two heavily forested tropical islands, Borneo and New Guinea—were home to very different species. If design were the only factor in play, surely Borneo and New Guinea should have similar species.

Wallace recognized that the second factor was history: the composition of an ecosystem is determined in part by a whole set of



Wallace was the first to identify the geographical boundary between the Asian and Australian biotas. Although the faunal boundary is more permeable than a single line suggests, Wallace's observations have been borne out by studies of continental drift. Islands that today are neighbors, such as Bali and Lombok, were once widely separated, and thus followed distinct evolutionary trajectories.



A frog from Borneo that Wallace painted in 1855, *Rhacophorus nigropalmatus*, is commonly known as Wallace's flying frog. The extensive webbing between its digits enables it to glide from tree to tree.

past contingencies—for example, there typically are no monkeys present in locations that have never been connected to regions in which monkeys are prevalent. How Wallace would have loved our modern plate tectonic understanding of the geological evolution of Indonesia! We now

appreciate that the current proximity of Bali and Lombok is a recent phenomenon (by geological standards) and that the Australasian and Asian regions have converged via continental drift.

But the scientific discovery for which Wallace's journeys are most remembered was evolution by natural selection. This in fact was a two-step process. He had already published several scientific papers on natural history, but, in 1855, while in Sarawak, a kingdom in northern Borneo, he produced his first grand, big-picture paper, "On the Law which Has Regulated the Introduction of New Species." It became known as the Sarawak Law, and it represents a stunning scientific debut. He italicized the paper's take-home message: "Every species has come into existence coincident both in space and time with a pre-existing closely allied species." In other words, living species that resemble each other (that is, are closely related) tend to be found in the same geographical area and, similarly, fossil species that resemble each other tend to be found close to each other in geological strata. We now know that all kangaroos live in Australasia, for instance, because they are all descended from an ancestral kangaroo. The origin of species was, Wallace had recognized, a genealogical process. But a complete understanding of the process of evolution required a mechanism whereby that genealogical generation-to-generation change could be entrained to produce useful traits—adaptations.

In February 1858, while bedridden with fever (probably malaria) in the Moluccan (now Maluku) Islands, Wallace glimpsed the missing mechanism: natural selection, the process whereby competition for limited re-



The harbor at Ternate Island, above, became Wallace's base of operations, from which he mailed, to Charles Darwin, his paper on the theory of evolution by natural selection. Left: Despite locals' belief that this old house was Wallace's, historians say the original is long gone.

Darwin's colleagues, botanist Joseph Hooker and geologist Charles Lyell, intervened with a solution that they hoped would both preserve Darwin's priority and do right by Wallace. At the July 1st meeting of the Linnean Society of London, they read both versions of the natural selection theory in a single presentation—separate expressions by the two “indefatigable naturalists.” After that meeting, Darwin knuckled down to produce *On the Origin of Species* in little more than a year. What of Wallace, still half a world away, who was not consulted? Did he feel ill-used by this unorthodox arrangement to protect Darwin's priority? Not in the least. He was thrilled to have been suddenly elevated to Charles Darwin's coauthor. At last, he had made it.

Alfred Russel Wallace is flanked by his wife, Annie, and their daughter, Violet. The couple also had two sons, one of whom died in childhood.



© A. R. WALLACE MEMORIAL FUND & GEORGE BECALONI

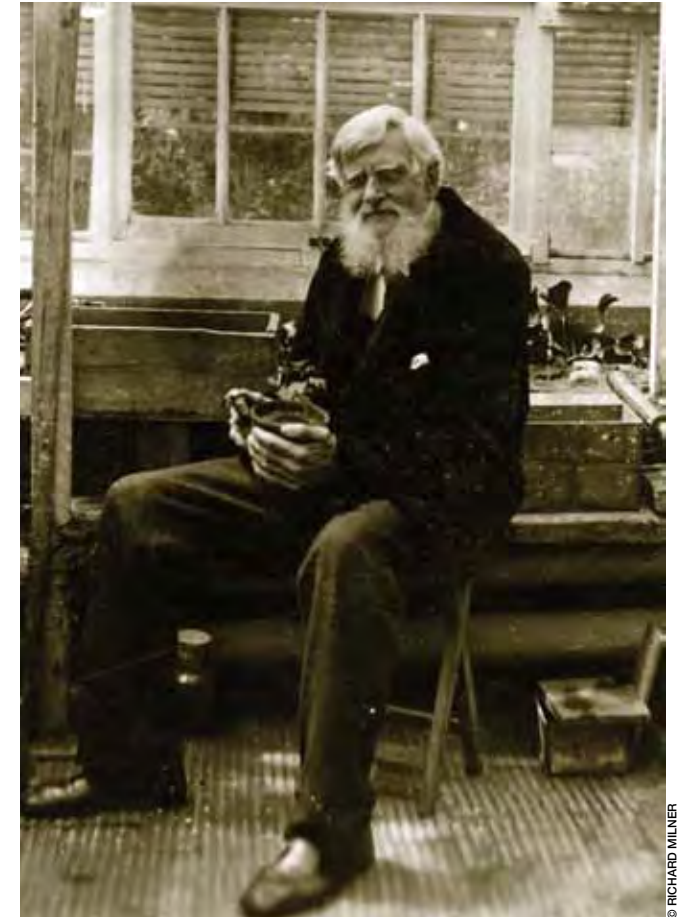
Wallace returned to England in 1862, this time without mishap, bringing two spectacular living birds of paradise that became a major attraction in London. He had made money from his collections and was now a highly regarded scientist. He managed in short order to compromise both those achievements.

He seems to have inherited his father's lack of facility with money, and was reduced to grading exams for a living. It was not until many years later, when Darwin successfully sought a government pension

for Wallace, that his money concerns were to go away. Scientifically, Wallace was remarkably active after his return. Wallace being Wallace, we are only now beginning to appreciate the significance of some of his insights. In 1865, for example, he gave what is in effect the modern definition of “species”: “Species are merely those strongly marked races or local forms which when in contact do not intermix, and when inhabiting distinct areas are generally believed to have had a separate origin, and to be incapable of producing a fertile hybrid offspring.” Undergraduates today typically learn that this so-called “Biological Species Concept” was developed in the 1940s by ornithologist Ernst Mayr.

But Wallace also departed from the scientific straight and narrow in ways that sometimes irked his colleagues, gradually becoming ever more heterodox over the second half of his life, until his death on November 7, 1913. He became a spiritualist and even tried (unsuccessfully) to convince Darwin's famously sharp-witted “bulldog,” Thomas Henry Huxley, to come with him to a séance. In part because of his spiritualism, Wallace declared in 1869 that natural selection could not account for human evolution. Darwin was horrified, writing, “I hope you have not murdered too completely your own and my child.”

Wallace disagreed with Darwin on sexual selection, too. Despite these differences, Wallace and Darwin remained firm friends, and it is instructive to read their argumentative correspondence. The exchange is intense, but



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Wallace in the greenhouse of his home in Dorset: This photograph was presented to Quentin Keynes by Richard Wallace, with the dedication, “From the grandson of Wallace to the great-grandson of Darwin.”

the mutual respect is palpable. Perhaps one of the greatest lessons Wallace can teach us is how to go about doing science. When Darwin was preparing to publish *The Descent of Man* (1871), he wrote apologetically to Wallace: “Fate has ordained that almost every point on which we differ should be crowded into this vol[ume].”

Wonderfully, Wallace was unfazed: “I look forward with fear & trembling to being crushed under a mountain of facts!”

Born in London, **Andrew Berry** studied zoology at the University of Oxford and received his doctorate in evolutionary genetics from Princeton University. He is now a lecturer in Organismic and Evolutionary Biology at Harvard University, Cambridge, Massachusetts. He is the editor of *Infinite Tropics: An Alfred Russel Wallace Anthology* (Verso, 2002) and of a new edition of Wallace's *The Malay Archipelago* (Penguin Classics, 2014).



Yours very truly
Alfred R. Wallace

BY GEORGE BECCALONI

Suppose that you've dipped into Alfred Russel Wallace's classic chronicle of his 14,000-mile odyssey through Southeast Asia (*The Malay Archipelago*, 1869), his adventures in the Amazonian rainforest (*A Narrative of Travels in the Amazon and Rio Negro*, 1853), and his detailed autobiography (*My Life*, 1905), and still have a thirst for more. Try accessing the great naturalist's thoughts and feelings through his 2,600 surviving letters, which until recently were scattered across the archives of some 150 institutions worldwide. About seven years ago, I began to pursue my dream of gathering together all letters both from and to Wallace, and applied for a grant to track them down, scan and transcribe them, and make them freely available online. The result was the Alfred Russel Wallace Correspondence Project and the project's digital archive, Wallace Letters Online. Here is a small sampling of excerpts from a few of my favorite Wallace letters, ranging from scientific correspondence with his naturalist colleagues to his personal family communications.

On Being Characterized as an "Enthusiast"

So far from being angry at being called an Enthusiast it is my pride & glory to be worthy to be so called. Who ever did any thing good or great who was not an enthusiast? The majority of mankind are enthusiasts only in one thing, in money-getting; & these call others enthusiasts as a term of reproach, because they [the enthusiasts] think there is something

in the world better than money getting. . . . [I]t strikes me that the power or capability of getting rich is in an inverse proportion to a man's reflective powers & in direct proportion to his impudence. [*Temate, Dutch East Indies, April 25, 1859, to his brother-in-law Thomas Sims WCP371*]

On Watching from a Lifeboat as His Ship Burned on the Way Home from South America

It now presented a magnificent and awful sight as it rolled over looking like a huge caldron of fire, the whole cargo forming a fuming mass at the bottom. . . . My collections . . . were in the hold & were irrevocably lost. And now I began to think, that almost all the reward of my four years of privation & danger was lost. All my private collection of Insects & birds since I left Pará was with me, & contained hundreds of new & beautiful species which would have rendered (I had fondly hoped) my cabinet, as far as regards American species, one of the finest in Europe. . . . But besides this I have lost a number of sketches drawings, notes & observations on Natural History besides the three most interesting years of my journal, the whole of which unlike any mere pecuniary loss, can never be replaced;—so you will see that I have some need of philosophic resignation to bear my fate with patience and equanimity. [*Aboard the rescue ship Jordeson, September 19, 1852, to botanist Richard Spruce WCP349*]

Selections from the Wallace Correspondence Project

On Desiring to Take a Stroll in Alexandria

I found myself in the midst of a vast crowd of donkey's [*sic*] & their drivers all thoroughly determined to appropriate my person to their own use and interest. . . . One would hold together two donkeys by their tails while I was struggling between them—& another forcing together their heads, would thus hope to compel me to mount upon one or both of them. . . . One fellow more impudent than the rest I laid flat upon the ground and sending the donkeys staggering after him, I escaped a moment midst hideous yells and most unearthly cries. . . . Bethinking myself now that donkey riding was a national institution and seeing a fat [Y]ankee . . . mounted, being like myself hopeless of any other means of escape, I seized upon a bridle in hopes that I should then be left in peace[.] But this was the signal for a more furious onset, . . . a dozen animals were forced suddenly upon me & a dozen hands tried to lift me upon their respective beasts. . . . I hit right & left. . . . Now then behold your friend mounted upon a Jack-ass . . . a boy behind holding by his tail and whipping him up. . . . [A]nd off we go among a crowd of Jews and Greeks—Turks and Arabs and veiled women and yelling donkey boys to see the City. . . . [Y]ou may think this account exaggerated, but it is not, the pertinacity vigour and screams of the Alexandrian donkey drivers no description can do justice to. [*Steamer Bengal, Red Sea, March 26, 1854, to his friend George Silk WCP352*]

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On a Typical Day's Fieldwork with His Assistant

Singapore is very rich in beetles & before I leave I think I shall have a most beautiful collection—I will tell you how my day is now occupied. Get up at half past 5. Bath & coffee. Sit down to arrange & put away my insects of the day before, & set them safe out to dry. Charles [Allen] mending nets, filling pincushions & getting ready for the day. Breakfast at 8. Out to the jungle at 9. We have to walk up a steep hill to get to it & always arrive dripping with perspiration. Then we wander about till two or three generally returning with about 50–60 beetles, some very rare & beautiful. Bathe, change clothes & sit down to kill & pin insects. Charles [ditto] with flies bugs & wasps, I do not trust him yet with beetles. Dinner at 4. Then at work again till six. Coffee—Read—if very numerous work at insects till 8–9 then to bed— [*Bukit Tima, Singapore, May 28, 1854, to his mother WCP354*]

On Parenting an Orangutan

I was out shooting in the jungle and saw something up in a tree . . . I fired at it and down fell this little baby in its mothers arms. . . . [I] have preserved her skin & skeleton and am endeavouring to bring up her only daughter and hope some day to introduce her to fashionable society at the Zoological Gardens. . . . Of course, baby cannot walk yet, but I let it crawl about on the floor a little to exercise its limbs, but it is the most wonderful baby I ever saw and has such strength in its arms that it will catch hold of my trousers & hang underneath my leg for a quarter of an hour together without being the least tired, all the time trying to suck, thinking no doubt it has got hold of its poor dear mother. . . . I may safely say, what so many have said before with much less truth, "There never was such a baby as my baby"—and I am sure nobody ever had such a dear little

duck of a darling of a little brown hairy baby before! [*Sadong River, Sarawak, Borneo, June 25, 1855, to his sister Frances Sims WCP359*]

Darwin Connects Formerly Isolated Facts

[T]he millions of facts in the numerical relations of organic beings,—their geographic distribution,—their relations of affinity, the modifications of their parts & again,—the phenomena of intercrossing,—embryology & morphology,—all are in accordance with his theory & almost all are necessary results from it,—while in the other theory, they are all isolated facts having no connection with each other & as utterly inexplicable & confusing as fossils are in the theory that they are special creations and are not the remains of animals that have once lived. It is this vast chaos of facts, which are explicable & fall into beautiful order on the one theory,—which are inexplicable & remain in chaos on the other, which I think must ultimately force Darwin's views on any & every reflecting mind. . . . The human mind cannot go on for ever accumulating facts which remain unconnected & without any mutual bearing & bound together by no law. [*Delli, Timor, March 15, 1861, to his brother-in-law, Thomas Sims WCP3351*]

Advice to Darwin on How to Write about Natural Selection

My dear Darwin, I have been so repeatedly struck by the utter inability of numbers of intelligent persons to see clearly or at all, the self acting & necessary effects of Nat[ural] Selection, that I am led to conclude that the term itself, & your mode of illustrating it, however clear & beautiful to many of us are yet not the best adapted to impress it on the general naturalist public. . . . I think it may be done without difficulty & very effectively by adopting [Herbert]

Spencer's term . . . "Survival of the Fittest." This term is the plain expression of the fact;—nat[ural] selection is a metaphorical expression of it, and to a certain degree indirect & incorrect, since, even personifying Nature, she does not so much select special variations, as exterminate the most unfavourable ones. . . . It is evidently also necessary not to personify "nature" too much,—though I am very apt to do it myself,—since people will not understand that all such phrases are metaphors. [*Hurstpierpoint, Sussex, July 2, 1866, to Charles Darwin WCP1871*]

On the Solace of Nature

The wonders of nature have been the delight and solace of my life. From the day when I first saw a Bee-orchis (*Ophrys apifera*) in ignorant astonishment, to my first view of the grand forests of the Amazon; thence to the Malay Archipelago, where every fresh island with its marvellous novelties and beauties was an additional delight—nature has afforded me an ever increasing rapture, and the attempt to solve some of her myriad problems an ever-growing sense of mystery and awe. . . . I sincerely wish you all some of the delight in the mere contemplation of nature's mysteries and beauties which I have enjoyed, and still enjoy. [*Broadstone, Dorset, January 12, 1912, to University of Colorado biology students taught by his friend Theodore Cockerell WCP4244*]



George Beccaloni, Curator of Orthopteroïd Insects at London's Natural History Museum, is the founder and director of the Alfred Russel Wallace Correspondence Project (WCP), which for

the past two years has been supported by the John Templeton Foundation as part of the Alfred Russel Wallace Centenary Celebration. Visit wallaceletters.info for an overview of the WCP; the letters can be viewed in facsimile and transcription by browsing www.nhm.ac.uk/wallacelettersonline.

Pheasants under Glass

A market in exotic specimens enabled Wallace to fuel his scientific career.

BY ERROL FULLER

Alfred Russel Wallace

came from a family that, spuriously or not, traced its ancestry back to the great Scottish patriot William Wallace, who died so horribly on the scaffold in 1305. The family members were well educated, and the young Alfred was encouraged to read widely. At an early age he came under the influence of social reformers, such as the Welsh utopian socialist Robert Owen, and political revolutionaries, such as Thomas Paine. The family was comparatively poor, and in an age when privilege meant so much, Wallace's career choices were somewhat limited. It was perhaps this very disadvantage that led Wallace to make a very unusual career choice, one that would take him to far-flung and exotic parts of the world and expose him to individuals, situations, creatures, and ideas that could hardly be imagined by the vast majority of his British contemporaries.

His career choice was driven by all kinds of fast-moving changes in the Western world, and most of all by the ability of Westerners to explore and experience the wonders of the rest of the world. The rapid growth of interest in what, for Europeans and Americans, were remote lands created all sorts of opportunities for entrepreneurs, industrialists, and traders of all kinds, spawning fashions for exotic products. And to the modern eye, perhaps no area seems more eccentric than the

A Victorian display case contains more than 300 hummingbirds of many species. It was created circa 1850 by the London taxidermist George Ashmead, whose studio in fashionable Mayfair was located near the present site of the Embassy of the United States. Background: Birds of paradise are featured in an assortment of study skins.

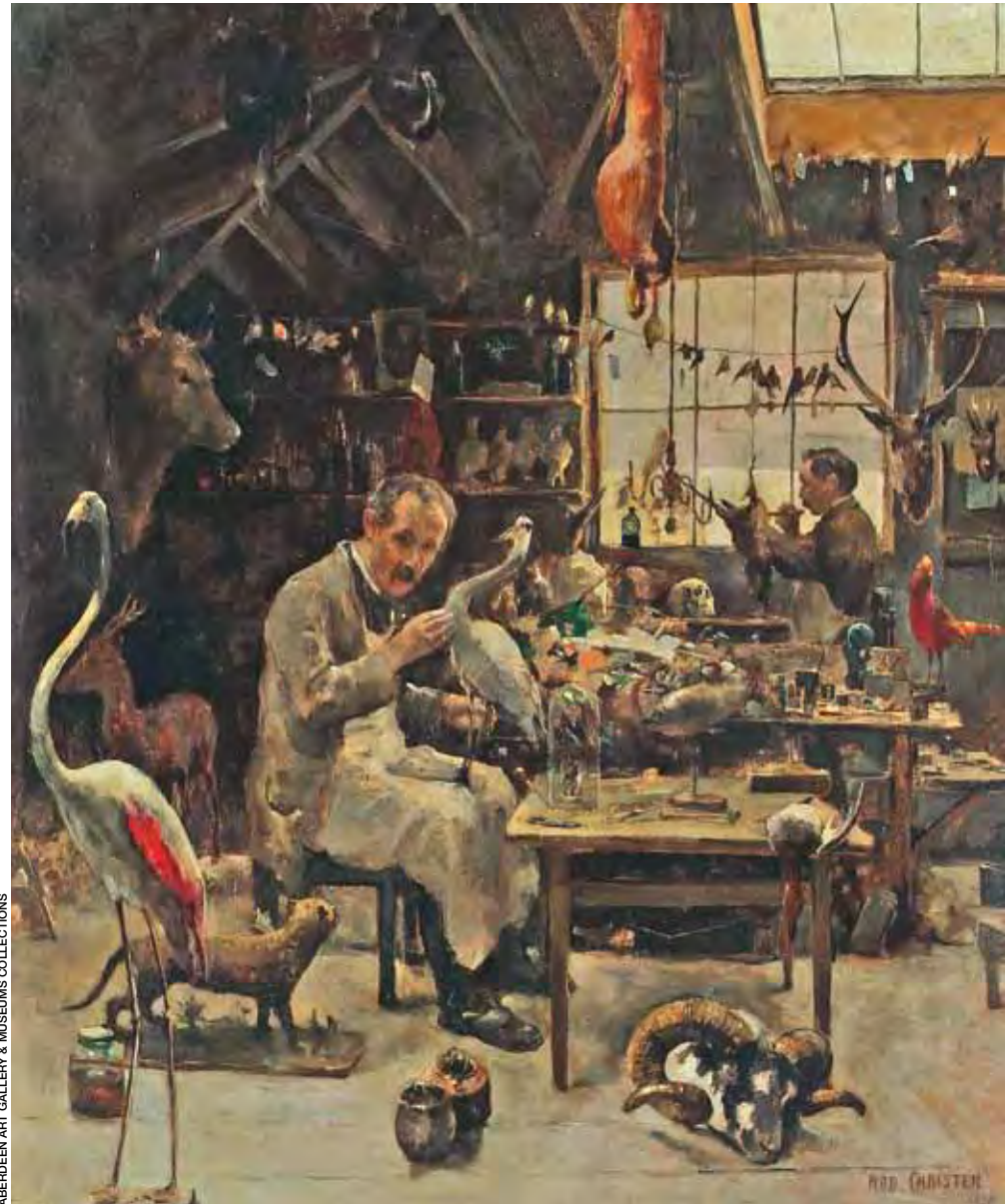
great fashion surge for the curiosities of natural history. Wallace decided that life as a junior clerk (essentially the only kind of occupation that he was likely to get) was



Detail of the cabinet: Each bird was skinned and preserved in the field before being shipped to London, where it was then mounted in a lifelike attitude.

not for him, and inspired by the memoirs of explorers, travel writers, and naturalists, he dreamed up a realistic way for a poor lad to live a life of adventure and still earn a living. And the way he chose was this: he would travel to far-off, little-known, and dangerous parts of the world to hunt birds, mammals, and insects, and then he would send their preserved remains back to Britain, where they could be sold for encouraging amounts of money.

From today's perspective the scheme seems hare-



ABERDEEN ART GALLERY & MUSEUMS COLLECTIONS

George Sim in his Workshop, Aberdeen, an 1890 painting by the Swiss artist Rodolphe Christen, gives an idea of a successful nineteenth-century taxidermist's studio. When the fashion for taxidermy waned, Sim founded a furrier business that survived until 1980.

brained. How could anyone hope to make money from such a plan? But to understand its essential viability, one must take into account nineteenth-century aspirations, fads, and interests. And the obsession with natural history was huge.

This was a time when the map of the world could be drawn with some confidence. The coasts of South America, Africa, and Asia had been mapped with reasonable accuracy by the mid-nineteenth century. Australia and New Zealand had been discovered, as had most of the islands of the Pacific. To European and American eyes,

often the more colorful this display, the better. Of course, the scale of the piece was dependent upon the financial means of the household. A humble cottage might have something modest and common—a squirrel or a small songbird in a relatively unambitious case—whereas a wealthier household might possess something more exotic and altogether more splendid: a glass dome containing a pair of Central American quetzals. An even grander home might boast an enormous cabinet housing several hundred hummingbirds [see photograph on page 18].

This was the market that Wallace set out to supply. He was hoping, of course, that museums and institutions

such places aroused feelings of wonder, fear, even titillation—and certainly curiosity. This curiosity needed feeding. So artifacts of all kinds were constantly being brought back from these far-away places, and naturally it was the great naval powers of the time—Britain, France, the United States, Holland—that facilitated these imports.

In among the raw materials, the spices and exotic foods, the ceramics, the ethnographical trophies, perhaps no other area aroused as much general interest as natural history. Nowadays we tend to think of skeletons, stuffed birds and mammals, and drawers full of dried insects as the preserve of museums, but during the nineteenth century such products were very much in vogue.

In Britain, for instance, homes ranging from humble country cottages to the great stately houses would regularly have (as part of their normal interior décor) a display of stuffed birds. Usually this took the form of a glass-fronted cabinet or an ornamental glass dome within which the carefully preserved creatures were arranged in a decorative and superficially lifelike man-



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While collecting in South America, Wallace sent this skin of a chestnut-eared aracari, a kind of toucan, back to England. Later, when his ship burned at sea, most of his preserved specimens were "irretrievably lost."

would also become customers, but he was well aware that a massive private sector could be tapped into. And so Wallace left Britain for "exotic parts." The first collecting trip that he undertook was to South America, where he went in the company of the now celebrated naturalist and explorer Henry Bates.

Imagine you are somewhere in South America in the mid-nineteenth century and your goal is to sell specimens of a wide selection of birds to connoisseurs in Britain. First, to obtain many different species you will have to visit many far-flung localities in various types of terrain. You must devise differing trapping strategies, according to characteristics of each particular species. Your methods must ensure that no damage comes to the creatures during the process of capture—at least none that is visible. And each of the exquisite and fragile little creatures must be ruthlessly killed, but, as

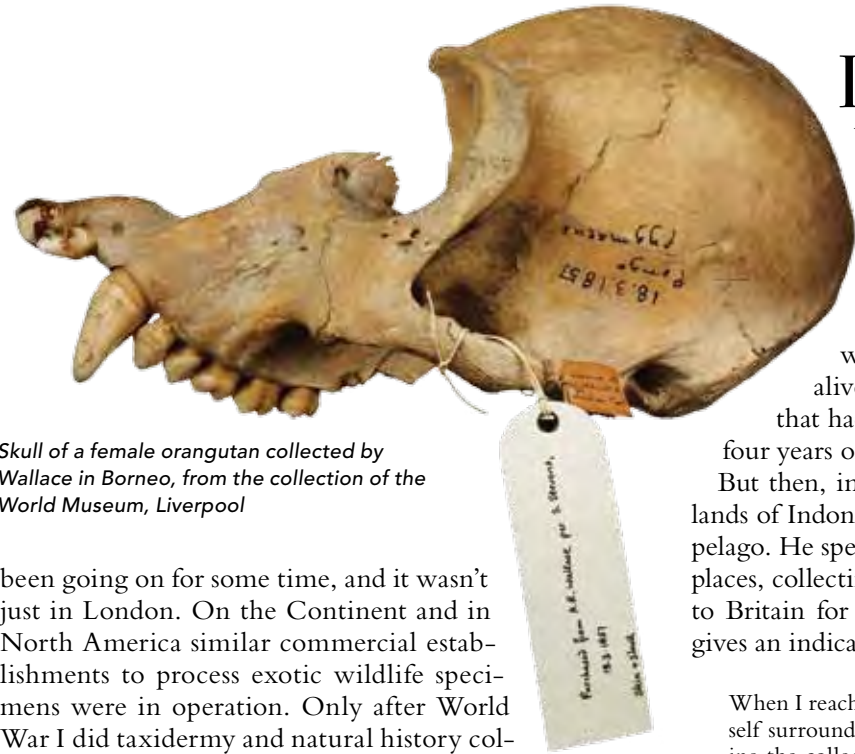


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like a recognized sculptor or painter, caters to the super-rich and fashion conscious. He has a studio with assistants, who are trying to learn the trade from their master. He sells his wares from one of the smartest addresses in town. He is highly respected.

By the time Wallace made his decision to become a natural history collector, this kind of enterprise had

Wallace collected this fungus weevil in Borneo, during his travels in what was then termed the Malay Archipelago.



Skull of a female orangutan collected by Wallace in Borneo, from the collection of the World Museum, Liverpool

been going on for some time, and it wasn't just in London. On the Continent and in North America similar commercial establishments to process exotic wildlife specimens were in operation. Only after World War I did taxidermy and natural history collecting drop out of fashion.

So the world in which Wallace hoped to earn a living, the world that shaped his ideas and experiences, was very different from our own. It was also different, of course, in terms of hardship and danger. Wallace had no airplane, no GPS, no mobile phone to get him



Wallace's standardwing, *Semioptera wallacii*, is a species of bird of paradise discovered by Wallace and named for him. This specimen, from the author's collection, was prepared and tagged by Wallace.

out of trouble, no tour operator to plan his route. Only very rarely did he have access to anything we would recognize as a hotel. Once he left Britain he had to rely on his resourcefulness, which included his ability to win the confidence—even friendship—of sometimes hostile or even dangerous peoples in various parts of the world. Over and over again his writings reveal that native people grew to see him almost as one of their own, and it was surely his natural empathy that in later life led him to espouse egalitarian causes such as women's suffrage.

In 1852, when Wallace decided to return to England from South America, he packed up thousands of specimens of insects, birds, and mammals that he hadn't already sent back to Britain, along with a small live menagerie of monkeys and tropical birds, and boarded a vessel bound for home. But disaster struck: the ship caught fire at sea and sank. Rescued from a lifeboat with his shipmates, Wallace was lucky to be alive, but all his carefully prepared specimens that had been on board—most of the fruits of his four years of labor and deprivation—were lost.

But then, in 1854, he went traveling again, to the islands of Indonesia—the area known as the Malay Archipelago. He spent eight years wandering around new wild places, collecting more specimens and sending them back to Britain for sale. A passage he wrote after his return gives an indication of the scale of his operation:

When I reached England in the spring of 1862, I found myself surrounded by a room full of packing-cases, containing the collections that I had from time to time sent home for my private use. These comprised nearly three thousand bird-skins, of about a thousand species; and at least twenty thousand beetles and butterflies, of about seven thousand species; besides some quadrupeds and land-shells. A large proportion of these I had not seen for years; and in my then weak state of health, the unpacking, sorting, and arranging of such a mass of specimens occupied a long time. [From the preface to *The Malay Archipelago*, 1869]

Note that he says these were “for my private use”; the tally does not take into account the thousands of specimens he sent or brought back for sale to collectors.

Among Wallace's prizes from the East were specimens of several species of birds of paradise. For these he had had to go to New Guinea and surrounding islands. Some of the native peoples he encountered had a fearsome reputation for violence, but he was able to establish close relationships. The men of the Aru Islands liked him so much that they wanted to understand him. As Wallace recounted in *The Malay Archipelago*:

Two or three of them got round me and begged me for the twentieth time to tell them the name of my country. Then, as they could not pronounce it satisfactorily, they insisted that I was deceiving them, and that it was a name of my own invention. One funny old man, who bore a ludicrous resemblance, to a friend of mine at home, was almost indignant. “Ung-lung!” said he, “who ever heard of such a name?—ang-lang—anger-lang—that can't be the name of your country; you are playing with us.” . . . They then attacked me on another point—what all the animals and birds and insects and shells were preserved so carefully for. They had often asked me this before, and I had tried to explain to them that they would be stuffed, and made to look as if alive, and people in my

Resplendent quetzals, from Central America, were showcased like jewels to decorate wealthy homes. The quetzal is the national bird of Guatemala and the name of its currency.

country would go to look at them. But this was not satisfying; in my country there must be many better things to look at, and they could not believe I would take so much trouble with their birds and beasts just for people to look at. They did not want to look at them; and we, who made calico and glass and knives, and all sorts of wonderful things, could not want things from Aru to look at. They had evidently been thinking about it, and had at length got what seemed a very satisfactory theory; for the same old man said to me, in a low mysterious voice, “What becomes of them when you go on to the sea?” “Why, they are all packed up in boxes,” said I. “What did you think became of them?” “They all come to life again, don't they?” said he; and though I tried to joke it off, and said if they did we should have plenty to eat at sea, he stuck to his opinion, and kept repeating, with an air of deep conviction, “Yes, they all come to life again, that's what they do—they all come to life again.”



Errol Fuller is a writer, artist, and naturalist who lives in Tunbridge Wells, Kent. Raised in South London, he whiled away many hours as a youngster in the Natural History Museum. Now his own home houses a collection of Victorian taxidermy (see www.youtube.com/watch?v=mijDFfLNRFU). Fuller's books include *Lost Animals: Extinction and the Photographic Record* and *The Passenger Pigeon* (both from Princeton University Press, 2014), and a pictorial history of taxidermy, *Voodoo Salon* (Summers Place Auctions Press, 2014; link for orders at www.summersplaceauctions.com). He is also coauthor, with David Attenborough, of *Drawn from Paradise: The Natural History, Art and Discovery of the Birds of Paradise* (Harper Design, 2012). For more information visit errolfuller.com.

RODDY PAINE PHOTOGRAPHY

RODDY PAINE PHOTOGRAPHY



A close-up photograph of a male greater bird of paradise perched on a dark, textured tree branch. The bird's body is a rich, iridescent brown. Its most striking feature is its large, fan-like tail, which is composed of numerous long, thin feathers that shimmer with iridescent colors, primarily yellow and green, with some blue and purple tones. The bird's head is turned slightly to the right, showing a dark brown face with a prominent yellow patch on its forehead and a green patch on its cheek. The background is a soft, out-of-focus green, suggesting a natural, forested habitat. The lighting is bright and natural, highlighting the intricate details and vibrant colors of the bird's plumage.

“SO BEAUTIFUL

Male greater birds of paradise display in a lek, a favored arena in which they congregate and compete for the attention of females. In this species, the birds return to the same branches of a favorite tree.

AND GRAND”

Seeking birds of paradise in Wallace’s footsteps

BY EDWIN SCHOLES

PHOTOGRAPHS BY TIM LAMAN



Our island guide Eli Karey offered us clear instructions for what needed to be done. “Before you climb the tree in the morning, you must get wax from your ear on your finger and rub it on the tree trunk. You must do this so the birds will come!”

This traditional wisdom in the Aru Islands of eastern Indonesia was the reason why, in the darkness of predawn, I found myself looking on as photographer Tim Laman wiggled a sweaty finger in his ear, an amused just-going-with-the-program look on his face. We were standing at the base of a large tree in

an inland forest on Wokam, the largest of the Aru Islands, which lie between New Guinea and Australia. It was September 2010, and we were several days into our expedition to site number forty-one out of the more than fifty localities we would end up visiting during our nearly decade-long effort to find and document all thirty-nine species of birds of paradise in the wild. At this Indonesian outpost we were after the legendary *Paradisaea apoda*, or greater bird of paradise. Laman was finally ready to haul his camera equipment up a climbing rope and station himself within a leaf-shrouded blind high in the canopy.

Under Eli Karey’s supervision, several members of



A male king bird of paradise: This was the first species in the *Paradisaeidae* family personally collected by Alfred Russel Wallace.

his clan had built the canopy blind following traditional customs. According to the Karey brothers, if more than twelve branches are used for the blind's floor, *the birds won't come*. If anything other than the leaves of a certain kind of palm are used for the walls, *the birds won't come*. If the structure is bound with rope instead of vine, the Karey brothers repeated, *the birds won't come*. The challenges of local construction norms aside, the completed structure was quite impressive. Perched high in the canopy, the blind's woven dome mirrored those used by generations

name for the avian family is *Paradisaeidae*.

By Wallace's time, Europeans knew of about twenty species of birds of paradise from traded skins, yet only one Westerner, Frenchman René Lesson, had ever glimpsed any species in the wild, and none had observed their display behavior. So it was a thrill for Wallace to reach the Aru Islands, near the eastern end of what was then termed the Malay Archipelago, and make his first collection of one of the species, the king bird of paradise [see photograph above]. His rapturous

of bird hunters in the Aru Islands. Of course, our plan called for shooting birds of paradise with cameras, not arrows, but we figured it was best to keep our hosts happy and follow the local traditions . . . earwax and all.

In visiting the Aru Islands, Laman and I were following in the footsteps of Alfred Russel Wallace, who had come to find the source of the intriguing bird skins that seafaring traders had long been furnishing to avid collectors. Some of those "trade skins" had made their way to Europe in the sixteenth century, aboard the only ship to return from Magellan's famous voyage around the world. The extraordinary appearance of the birds, and the particular way the Aru Islanders prepared them, with legs and wings removed to accentuate the plumes, caused quite a sensation in certain European circles. It seemed to many that such ethereal creatures could only have come from paradise, the biblical Garden of Eden. The name stuck and has been in use ever since, which is why the scientific



A male King of Saxony bird of paradise: Each male stakes out a solo spot within a larger area in which many males display.

account is also deeply thoughtful, if colored by the prejudices of his time:

Thus one of my objects in coming to the far East was accomplished. I had obtained a specimen of the King Bird of Paradise (*Paradisea regia*), which had been described by Linnaeus from skins preserved in a mutilated state by the natives. I knew how few Europeans had ever beheld the perfect little organism I now gazed upon, and how very imperfectly it was still known in Europe. The emotions excited in the minds of a naturalist, who has long desired to see the actual thing which he has hitherto known only by description, drawing, or badly-preserved external covering—especially when that thing is of surpassing rarity and beauty, require the poetic faculty fully to express them. . . . It seems sad, that on the one hand such exquisite creatures should live out their lives and exhibit their charms only in these wild inhospitable regions, doomed for ages yet to come to hopeless barbarism; while on the other hand, should civilized man ever reach these distant lands, and bring moral, intellectual, and physical light into the recesses of these virgin forests, we may be sure that he will so disturb the nicely-balanced relations of organic and inorganic nature as to cause the disappearance, and finally the extinction, of these very beings whose wonderful structure and beauty he alone is fitted to appreciate and enjoy. This consideration must surely tell us that all living things were *not* made for man. Many of them have no relation to him. The cycle of their existence has gone on independently of his, and is disturbed or broken by every advance in man's intellectual development; and their happiness and enjoyments, their loves and hates, their struggles for existence, their vigorous life and early death, would seem to be immediately related to their own well-being and perpetuation alone, limited only by the equal well-being and perpetuation of the numberless other organisms with which each is more or less intimately connected. [*The Malay Archipelago*, 1869]

Soon after collecting the king bird of paradise, Wallace encountered the most renowned species, the greater bird of paradise, in its



A female (right) inspects a male twelve-wired bird of paradise. Darwin attributed the evolution of characteristic male plumage and display behavior in birds of paradise to sexual selection, the females' aesthetic choice.



plumes, which I believe is quite new information; they are then so beautiful and grand that, when mounted to represent it, they will make glorious specimens for show-cases.”

Wallace’s experiences in the Aru Islands were so positive that he set his sights on the New Guinea mainland, which he believed to be the true home of the birds of paradise. In 1858, he made a grueling voyage to New Guinea’s Dorey Bay (near the present-day city of Manokwari, in the Indonesian province of Papua). There he didn’t encounter or collect nearly as many species as Lesson had before him. Ultimately, summing up all his forays and those of his assistant Charles Allen, he wrote: “Although I devoted so much time to a search after these wonderful birds, I only succeeded myself in obtaining five species during a residence of many months in the Aru Islands, New Guinea, and Waigiou.” Counting one species that Wallace did not recognize as a bird of paradise, and two that he or Allen purchased, altogether he might be said to have collected eight.

A male magnificent riflebird (left) strives to impress an attentive female.

homeland. Not only did he see the species alive, he was the first European naturalist to observe the elaborate courtship display of any living bird of paradise. This depended on his good fortune to be in the Aru Islands during the season when the male birds were endowed with their mating finery. In a letter posted home in 1857, Wallace wrote, “I have discovered their true attitude when displaying their

Laman and I briefly crossed Wallace’s path in search of birds of paradise at the start of our project in 2004, but our first true experience standing in his footsteps came in 2008, in the Maluku Islands of eastern Indonesia. At that time, we visited the legendary port of Ternate, on the island of Ternate, our jumping-off point for an expedition

to nearby Halmahera Island. The port was also Wallace’s point of departure and base of operations for his voyages throughout the eastern part of the Malay Archipelago. We toured a sixteenth-century Portuguese stone fort that would have been standing back when Magellan’s ships were moored in the harbor; we also passed by a modest building where, locals claim, Wallace lived and worked off and on between 1858 and 1860. It was during Wallace’s own expedition to Halmahera (known then as Gilolo) that his ideas about the process of evolution by natural selection crystallized, as he was laid up in camp with a bout of malarial fever. There, in a simple field hut, he drew up the notes that he mailed to Charles Darwin from Ternate a short time later. With that letter, Wallace became the codiscoverer of the unifying theory of all biological science.

Our Halmahera expedition didn’t yield a burst of evolutionary insight, but we did encounter another of Wallace’s important scientific contributions: an unusual bird of paradise he discovered in 1858, which lives only on the northern Maluku islands of Halmahera, Bacan, and Kasiruta. Today the species is known as *Semioptera wallacii* and is often called Wallace’s standardwing. After experiencing ten fruitless days of searching for a site where we might observe several males displaying to females, we found ourselves lying under our mosquito nets on rough floorboards in a small garden hut we had rented, listening to the pounding rain and speculating on Wallace’s fortitude. He must have been one tough dude to be able to put up with similar conditions not just for weeks, but for months on end—and to be able, on top of surviving, to do some really insightful thinking. We were humbled.

Fortunately, we eventually managed to locate an active display area of Wallace’s standardwing, and we completed our mission to document this bird—a real outlier in terms of bird of paradise distribution and behavior. Isolated for millions of years on these Maluku Islands, the standardwing has diverged from its cousins and developed some unique features, including the “standards” (meaning something supported in an upright position, such as a flag) on its wings, and its aerial display [see photograph on page 31]. Darwin explained such features as the outcome of the females’ choice of mates, an example of sexual selection. Whatever variation in ornamentation and behavior the



The male blue bird of paradise displays upside down.

females preferred would be passed on to the next generation, with the result that male evolution would be skewed in the direction of ever more elaborate plumage and ritual display.

Wallace also wrote of the cumulative power of female selection, but eventually disputed Darwin’s view that it was distinct from natural selection, contending instead that “the only way in which we can account for the observed facts is, by the supposition that colour and ornament are strictly correlated with health, vigour, and general fitness to survive.” In this regard he approached a view, common today, that the ability of a male animal to devote energy to flamboyant structures and behavior does, in fact, provide a signal that indicates genetic quality. Darwin’s view



After calling to attract a potential mate, a male superb bird of paradise, left, deploys iridescent blue breast feathers and faux eyespots, and eventually, right, presents a unique vision to a female. The male also prances vigorously about during his astonishing shape-shifting display.



Built by Aru Islanders following traditional techniques, a canopy blind enabled the author and the photographer to observe a lek of greater birds of paradise in a tree nearby.

differed in that he believed that, in order to evolve, extravagant male traits need not serve any purpose beyond being attractive to females.

Several times during our project we made expeditions to the strikingly rugged, uplifted islands in the Raja Ampat group, off northwestern New Guinea. Surrounded by ultramarine waters, they harbor some of the world's richest coral reefs. These islands are also home to two birds of paradise found nowhere else—Wilson's bird of paradise and the red bird of paradise [see photographs at left and on top of page 32].

Our first visit to the Raja Ampat region was in 2004, when we visited Batanta Island. We had a basic camp, with tarps over pole frames to sleep under, firewood for cooking, and a hole in the ground as a latrine. In other words, we had many of the comforts of home and could devote our energy to fieldwork on the birds. This soon became all-consuming: we would put in twelve- to fourteen-hour days in the field, rising way before dawn to hike to display sites of Wilson's bird of paradise. In that species each male clears out a small area on the ground to serve as his individual courtship territory.

After a few days of documenting the Wilson's bird of paradise, we were lucky enough to also find an impressive *lek*, or courting arena, for the red bird of paradise. A lek is an area where multiple males congregate to compete for the attention of females. Males of the red bird of paradise display high in the canopy, and the lek was on one of the largest trees in the forest. Neighboring trees were not tall enough to serve as a blind platform, but this tree was so large that Laman decided to climb it and see what he could do. But first he had to get up it. His bow was not powerful enough to send the arrow with its trailing line over the upper branches, so he had to climb the tree in stages, targeting a lower branch and then working his way up. Finally reaching the level of the display branches, he could see that the crown was so large it would be possible to build a blind on one side, look across the tree's canopy to the arena used by the birds, and still be far enough away not to disturb them. Ultimately Laman's climbing rope measured 165 feet—making this the highest blind he would ever use for photographing birds of paradise.

The lek tree was on a hillside not far from Batanta's south coast, and from Laman's position in it, he could gaze out over the strait to the neighboring island of Salawati, just two or three miles away. On its other side Salawati is very close to the big island of New Guinea, to which it was connected in recent geologic time (some

On display in his individual courting territory, a male Wilson's bird of paradise (bottom) is scrutinized by a female. The bright hues on the crowns of the birds' heads are bare patches of skin whose protein structure—as opposed to pigmentation—determines their color.

10,000 years ago). Salawati harbors the king, lesser, and twelve-wired birds of paradise, the typical lowland species throughout much of New Guinea. Batanta, in contrast, has the red and Wilson's birds of paradise. Even though fruit pigeons and hornbills may cross the strait on a daily basis, the narrow water gap between Batanta and Salawati serves as a major barrier to the birds of paradise, which stay in the forest and never fly over open water.

The Raja Ampat islands are on a chunk of Earth's crust that has been moving along the north coast of New Guinea for millions of years. At some point, the drifting chunk must have bumped up against the big island and picked up some birds of paradise. Subsequently it pulled away, and time and selection led to the origin of distinct species on different islands. Although Wallace didn't know about these geological explanations, he saw the variation in species across these and other islands throughout his collecting expeditions and could appreciate that related species had diverged owing to isolation. Just as the Galápagos Islands helped Darwin gain

A male Wallace's standardwing, right, flaunts the upright, flaglike plumes for which the species is named. Below: A young male paradise riflebird practices fanning his wings upward and revealing the bright inside of his bill. Adult males have glossy black plumage with iridescent patches.



his insights into natural selection, so too the Indonesian archipelago was Wallace's source of inspiration.

The long days spent in blinds waiting for birds of paradise throughout the New Guinea region is what ultimately made our project a success. In addition to photographs, we also captured audio and video recordings of courtship displays, female visits, and even mating, which added substantially to our scientific understanding of bird of paradise natural history. Our modern photographic equipment revealed behavioral details never before documented. No doubt Wallace would have been amazed to see the "true attitude" of so many species with such clarity and detail.

Evident to us was how attentive the females were to the males' displays of plumage and behavior, and how the females took up favorable positions to observe them. Where possible, we took extra steps to understand court-



A male red bird of paradise: The photographer had to climb 165 feet up to capture the bird's courtship display in the forest canopy.

ship displays from the females' perspective. For instance, in 2011, in the mountain forests of the Huon Peninsula in northeastern Papua New Guinea—far from Wallace's stomping grounds—we set out to observe the courtship display of the endemic Wahnes's parotia from the point of view of the female. In this species, the male displays on ground level while the female, perched on a horizontal branch, looks down from above. Previous recordings have only shown the male's display from ground level.

To approximate the female's view, we deployed a remote-controlled camera about ten feet up a tree near the male's court. Another remote-controlled camera was installed to capture a wide view from the side, and more than 200 feet of camouflaged cables—which we called our "bush-ethernet"—were strung through the forest to connect the two cameras to our blind, which faced the court at ground level. I used a laptop to control the remote cameras while Laman manned a camera with a long lens.

The results were better than we'd even hoped. Although we knew the displaying male would look different from above, we were amazed at just *how* different he looked. The quintessential *Parotia* courtship display is commonly dubbed the "ballerina dance," because from ground level the male appears to dance about in a tutu-like "skirt" of feathers. From above, however, "wobbling ovoid" would be a far more accurate description [see *photographs at left*]. Yet the real discovery was the effect produced by the male's specialized iridescent feather patches. With the male in his "ballerina" posture, the breast feathers can be seen from the front or side, and they reflect a greenish color. From above, however, they are hidden from view during most of the display. Then, when the male pulls his head down into his body at the start of a side-to-side "head waggle" phase of the display, these feathers suddenly produce an upward flash of



From her perch on a branch above, left, a female Wahnes's parotia takes in a male's "ballerina" dance—so named for its appearance from the usual human's-eye view. What the female actually sees and judges, however, is the top view, right, highlighted by flashes of yellow iridescent feathers.



To get his "dream shot" of a greater bird of paradise, the photographer camouflaged a remote-controlled camera in leaves and placed it a few feet from the branches where the males would assemble.

yellow. A further surprise was the important role played by a relatively minor iridescent feather patch on the back of the male's head. Viewed from above, this patch prominently traced the side-to-side movement of the head during the head-waggle phase—a movement that otherwise would be hard to detect from that angle. After having seen hundreds of these displays from all the *Parotia* species, we had never understood the significance of this little ornament. It was a real "aha!" moment.

During our final days in the Aru Islands Laman pursued a dream of his, to capture a wide-angle view of a bird of paradise in the canopy overlooking the forest below. As the greater bird of paradise lek tree on Wokam Island was rather open and raised up on a hill, it offered a promising setting. Laman's plan required a remote-controlled camera, concealed within a bundle of leaves, to be placed in the birds' display tree, about four feet from where the males performed their courtships. A long cable would have to be draped through the canopy to connect this "leaf-cam" to a laptop inside the blind in the adjacent tree.

To succeed in his goal, Laman would have to scale the lek tree before dawn, rig the leaf-cam, rappel back down, and then climb the blind tree to operate the leaf-cam laptop and his normal camera from within the canopy blind. That would require hours of working in the dark to avoid disturbing the birds. The possibilities for

failure seemed endless: rain could destroy the exposed gear, the birds might not return to the display tree, the cables (which had to be left out overnight) might be chewed by rodents or become disconnected. Yet everything worked perfectly.

High in the forest canopy, a few miles from the site where Wallace saw a tree full of greater birds of paradise displaying for the first time, the leaf-cam did its job. On the laptop screen within the blind, a sublime scene unfolded from a completely novel perspective. As the dawning Sun cracked the horizon and mist drifted up from the forest into the sky, one of the plumed males perched on an exposed branch, spread his wings, fluffed out his flank plumes, and began to call while bathed in golden sunlight. As Laman triggered the leaf-cam's shutter from the laptop, Wallace's words rang truer than ever before:

"They are then so beautiful and grand."

It was David Attenborough's television documentary on the birds of paradise that led Edwin Scholes (near right) to his university studies, multiple trips to New Guinea, and eventual collaboration with the wildlife photojournalist and field biologist Tim Laman. Scholes lives in Ithaca, New York, where he is



Director of Research and Interpretation at the Macaulay Library of the Cornell Lab of Ornithology. Laman, based in Lexington, Massachusetts, is best known for research and photography expeditions in the Asia-Pacific region. A wide sampling of his work can be viewed at www.timlaman.com, where individual prints of birds of paradise can also be ordered.

MY WALLACE MOMENT

On the trail of birdwing butterflies

BY GARY NOEL ROSS



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I first became aware of Alfred Russel Wallace in the spring of 1961, as a biology major in my junior year at college. The professor of a course in “natural history,” an enthusiastic young ornithologist with a propensity for biogeography, introduced us to Wallace’s six biogeographic regions and the Wallace Line. Given that my passion was for butterflies, he shared with me his personal copy of Wallace’s *The Malay Archipelago*, in which Wallace describes his first field interaction with a birdwing butterfly. It took place in 1859 on Batchian, now Bacan, an island in the Maluku, an archipelago just west of New Guinea.

During my very first walk into the forest at Batchian, I had seen sitting on a leaf out of reach, an immense butterfly of a dark colour marked with white and yellow spots. I could not capture it as it flew away high up into the forest, but I at once saw that it was a female of a new species of *Ornithoptera* or “bird-winged butterfly,” the pride of the Eastern tropics. I was very anxious to get it and to find the male, which in this genus is always of ex-

Wallace’s golden birdwing: Netting this specimen, the first male of the species Wallace captured, gave him “a headache the rest of the day, so great was the excitement produced by what will appear to most people a very inadequate cause.” He named the species *Ornithoptera croesus*; today entomologists recognize five subspecies, each endemic to one or more islands.

about the beginning of January, I found a beautiful shrub with large white leafy bracts and yellow flowers, a species of *Mussaenda*, and saw one of these noble insects hovering over it, but it was too quick for me, and flew away. The next day I went again to the same shrub and succeeded in catching a female, and the day after a fine male. I found it to be as I had expected, a perfectly new and most magnificent species, and one of the most gorgeously coloured butterflies in the world. Fine specimens of the male are more than seven inches across the wings, which are velvety black and fiery orange, the latter colour replacing the green of the allied species. The beauty and brilliancy of this insect are indescribable, and none but a naturalist can understand the intense excitement I experienced when I at length captured it. On taking it out of my net and opening the glorious wings, my heart began to beat violently, the blood rushed to my head, and I felt much more like fainting than I have done when in apprehension of immediate death. I had a headache the rest of the day, so great

treme beauty. During the two succeeding months I only saw it once again, and shortly afterwards I saw the male flying high in the air at the mining village. I had begun to despair of ever getting a specimen, as it seemed so rare and wild; till one day,

was the excitement produced by what will appear to most people a very inadequate cause.

The unbridled exuberance of the young Victorian naturalist-writer hooked me on tropical biology, and I vowed to someday experience a live birdwing butterfly for myself.

Fast-forward twenty-nine years to 1990, when Holbrook Travel, Inc., announced a nearly three-week-long collecting and photographic expedition to Irian Jaya. The easternmost territory of the nation of Indonesia, Irian Jaya, now named Papua, occupies the western half of the island of New Guinea, whose eastern half is the nation of Papua New Guinea. The expedition was to be led by Thomas C. Emmel of the University of Florida, who had previously led expeditions to Papua New Guinea. Emmel was both a fellow butterfly specialist and a longtime personal friend of mine. I signed up immediately.

To prepare for the trip, I reread *The Malay Archipelago* to reacquaint myself with Wallace’s adventures. He spent eight years, from 1854 to 1862, traveling about the chain of more than 25,000 islands, including New Guinea and the Philippines, that separates the Indian and Pacific Oceans as well as mainland Southeast Asia from Australia. Wallace estimated that he traveled 14,000 miles on some sixty to seventy separate journeys, collecting 125,660 specimens, including 13,100 butterflies. Among the latter, of course, were birdwing butterflies.

Birdwings are classified within the swallowtail family. The common name “birdwing” is generally applied to thirty-six species clustered within three genera: *Ornithoptera*, *Trogonoptera*, and *Troides*. All species are sexually dimorphic—many dramatically so: the males are brightly colored, often with large areas of iridescence set against black; females usually are relatively drab, but larger.

Wallace was responsible for scientifically describing four birdwings. The specimen he encountered on Bacan he named *Ornithoptera croesus*, honoring Croesus, the king in ancient Anatolia renowned for his wealth. Today entomologists recognize five subspecies of *O. croesus*, each endemic to one or more islands in the Maluku. All are commonly referred to as Wallace’s golden birdwing, although whether he set eyes on any besides the subspecies on Bacan is not known. Another species he named *O. brookiana*, for James Brooke, the first “White Rajah” of Sarawak, a kingdom (now a Malaysian state) on the island of Borneo. Since placed in the genus *Trogonoptera*, it is known as Rajah Brooke’s birdwing and is the national butterfly of Malaysia. In addition, Wallace named two of the eight subspecies of the oblong-spotted birdwing, *Troides oblongomaculatus*: *T. o. bouruensis* from the Maluku, and *T. o. papuensis* from New Guinea. Of the birdwings named by Wallace, I could hope to collect the latter, since it was, as the name implies, native to Papua.

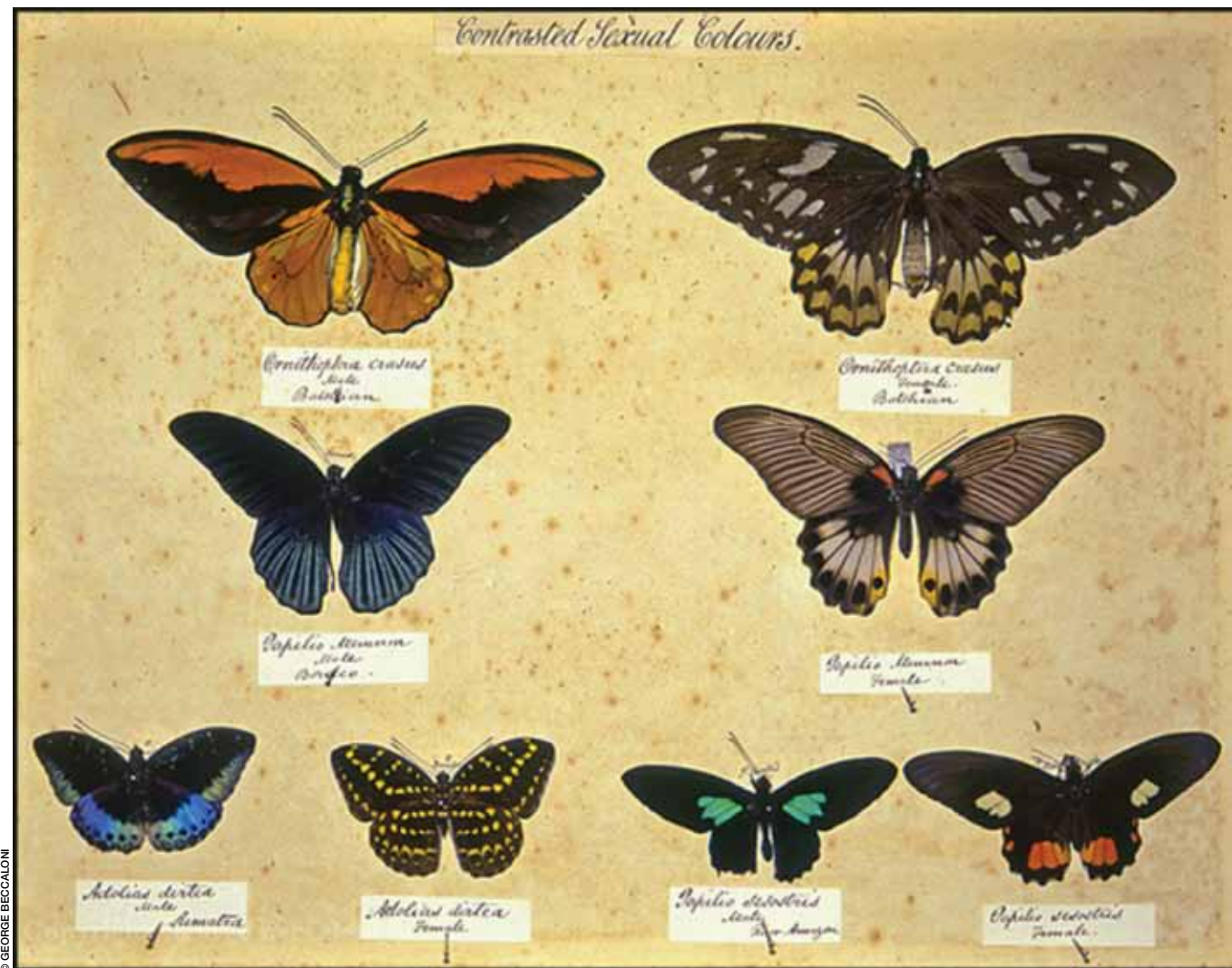
Wallace spent three months in Dorey, New Guinea, a small Papuan and missionary settlement on the northwestern coast. There he was plagued by malnutrition, fevers, colds, dysentery, and insect bites, as well as by a foot infection that kept him housebound for about a month.

Had he been able to travel farther inland, into what is now considered the epicenter for *Ornithoptera* diversity, he more than likely would have encountered such alluringly named members of that genus as the Goliath birdwing, the chimaera birdwing, and the paradise birdwing. And had he trekked into the coastal rainforest of northern Papua and the nearby island of Bougainville, he could have encountered Queen Victoria’s birdwing and Queen Alexandra’s birdwing. Females of the latter have a wingspan of nearly ten inches, making them the titans of the butterfly world. That species is now listed in Appendix I of CITES (the Convention on International Trade in Endangered Species of Wild



Underside of a male Wallace’s golden birdwing shows the contrast in color to the top of the wings [see opposite page]. When perched at rest, the butterfly folds its wings upward, so the underside colors provide camouflage. This specimen was also collected by Wallace.

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A drawer of butterflies, just as Wallace arranged it for his private insect collection, illustrates sexual dimorphism—difference in appearance of the sexes within species. A male Wallace's golden birdwing (top left) contrasts with a larger but less colorful female (top right).

Fauna and Flora), prohibiting its commercial international trade; other birdwings are listed in Article II, requiring permits for export.

October 17, 1990: our group of twenty-three, accompanied by Emmel and the president of the tour agency (Giovanna Holbrook), boarded the overnight flight that took us from Los Angeles via Hawaii to Biak, an island north of the Papua mainland. There we had time for a short collecting foray in the morning before flying 250 miles southeast to the capital, Jayapura, on Papua's northern coast.

As it turned out, my first encounter with a birdwing came sooner than expected, as we rode by bus to a collecting site barely a dozen miles west of the capital. Suddenly from my window seat I glimpsed a large, dark-col-

ored butterfly moving among some hibiscus flowers, and because of the insect's enormous wings, I blurted out, "Female birdwing!" Minutes later, I spotted a brilliant green-and-black butterfly. Emmel commented: "Two species of birdwings are common throughout New Guinea: one is the common green birdwing—*Ornithoptera priamus*—in which the male is a brilliant green and black, whereas the female is black with grayish spotting but larger in size. The second is the oblong-spotted birdwing—*Troides oblongomaculatus*—in which both sexes are black and bright yellow, although females are a bit larger. The two individuals we just viewed are unmistakably those of *O. priamus*." I thought: Not bad for our first full day out and for road sightings!

Our destination was a national park in the foothills of the Cyclops Mountains. Taking a well-worn trail into the lowland forest, we proceeded in single file so that each individual had personal space. I elected to bring up the rear. Within minutes we were all soaking with perspiration. We were practically on the equator, near the ocean, and there wasn't a breath of wind. Before long, I had ex-

hausted my water supply and was beginning to feel a bit queasy and light-headed. But I was distracted by the abundance of butterflies: I could walk no more than a few feet without having to pause to net an unfamiliar species.

Soon, though, I realized I was beginning to suffer from heat exhaustion and dehydration. As I passed over the crest of a hill and began to descend into a small, forested ravine, I heard the welcome sound of running water. Suddenly I noticed a large butterfly—a female common green birdwing, like the one I had spotted from the bus window—flying along the trail toward me. The butterfly was about twenty-five or thirty feet above the trail, too high for my net, but because of the incline, it was getting ever closer to the ground. Would it continue along the trail? I quickly spread my legs for balance, positioned my net in front of me low to the ground with my hands as far back on the handle as possible, and waited. Then, another butterfly began tailing the first. The iridescent green was a dead giveaway: a male of the same species. Could I possibly net the pair with a single swing?

As the two were about to pass within reach, I closed my eyes (uttering a short prayer!), swung my net with as much speed and force as I could, and brought it down. Before I even opened my eyes, I realized that I had succeeded. The wings of the butterflies were so massive and powerful that their beating against the cloth was quite audible—reminiscent of a captured bird or bat trying to escape a paper bag. As I opened my eyes and dropped to my knees, I confirmed that both birdwings were in the net. I examined them with trembling hands; they were in mint condition. I quickly dispatched the two (a strong pinch to the body of soft-bodied insects usually kills them instantly) and placed each in a glassine envelope for deposit in my satchel.

Regaining my sense of time and place, I continued down the path and, within a few minutes, reached a narrow, fast-running rivulet cascading over boulders. I submerged



Specimens of the common green birdwing were netted by the author, under permit, on a group expedition to New Guinea. As is customary, to display them for maximum effect, they are pinned with the wings spread, not a natural resting position. The species is named for the male's coloration (top), but the female (bottom) is dramatically larger.

myself in the cool water and pumped filtered water into my canteen to drink. Feeling better, I reflected on Wallace's impassioned comments about his golden birdwing butterfly. I now felt I grasped what he had experienced. (But I didn't, as he did, suffer a headache for the rest of the day.)

Our transportation for short distances in Papua involved minibuses and

vans, but we also relied on small aircraft to reach certain locations. One was Wamena, a village in the Baliem Valley. It lies deep in the Papua interior at about 5,300 feet elevation, surrounded by high, cloud-enshrouded mountains. The village has a small airport that serves tourists who are interested in meeting the Dani tribe—first contacted by Westerners in the early to mid-twentieth century.

Our arrival made quite an impression on the locals,



A female oblong-spotted birdwing captured by the author in New Guinea belongs to a subspecies that Wallace named, *Troides oblongomaculatus papuensis*.



SARAH VON BLUMENTHAL

Rajah Brooke's birdwing, *Trogonoptera brookiana*, is a species named by Wallace, who discovered it in Borneo. This live male, in the Kuala Lumpur Butterfly Park, Malaysia, has its wings extended in a basking position.

who found our entomological collecting expedition rather novel. We hired local guides for walks into the surrounding forest. Some young boys were so intrigued by our undertaking that they often tagged along, and when we stopped for a rest, they borrowed our nets or even constructed their own from twigs and spiderwebs. With but a little training, some became adept; we usually paid what amounted to about a quarter for each specimen in good condition.

Whenever we passed a Dani settlement, we noticed that many of the huts were surrounded by plank fences bordered with flowering plants. What interested us most was that many of the fences were en-



Caterpillar of an oblong-spotted birdwing feeds on pipevine (*Aristolochia* spp.), the food plant for all birdwing larvae.

twined with pipevine (*Aristolochia*), the larval food plants for all birdwing butterflies. The leaves contain a bitter-tasting toxin that is deadly to many caterpillars but not to birdwing caterpillars, which store the toxin in prominent spines on their backs. Predators soon learn to avoid attacking birdwing larvae and the brightly colored adults.

The residents were growing the flowers and vines to encourage female birdwings to come out of the forest and lay their eggs—the largest in the butterfly world. In a project sponsored by the government, the newly hatched larvae are placed in netted enclosures so that they can feed in safety from predators. After maturing, the larvae pupate on nearby twigs or on the netting itself, and within another two weeks, adult butterflies emerge. A portion of them is then harvested for the international collectors' trade, while others are released to bolster the free-ranging population. This "butterfly ranching" has proved to be profitable for isolated villages in both Papua and—where the practice began—Papua New Guinea. It has also been a boon to butterfly conservation.

As the date of our departure from Papua approached, we returned to Biak Island. While there we took a side trip (in somewhat shaky outboard motorboats) to nearby Supiori Island, where our group split into a few teams. After about an hour, my team of four happened upon a large fallen tree that had left a gap in the canopy. The sunlight reaching the ground encouraged the growth of

a substantial clump of *Clerodendrum speciosissimum*, familiar to Western gardeners as "Java glory bower." The nearly head-high, large-leaved shrubbery was topped with clusters of bright-red flowers that acted as magnets for birdwings. We decided to linger there, and as we rested I was reminded of one of Wallace's passages:

The *Mussaenda* bush was an admirable place, which I could visit every day on my way to the forest; and as it was situated in a dense thicket of shrubs and creepers, I set my man Lahi to clear a space all round it, so that I could easily get at any insect that might visit it. Afterwards, finding that it was often necessary to wait some time there, I had a little seat put up under a tree by the side of it, where I came every day to eat my lunch, and thus had half an hour's watching about noon, besides a chance as I passed it in the morning. In this way I obtained on an average one specimen a day for a long time.

Our sunlit patch proved to be not only an exceptional venue for collecting, but also an arena for observing the insects' behavior. Birdwings normally are "high flyers," preferring open space directly above the forest canopy. I saw that their wing beats were relatively slow—but not shallow—and often interspersed with short glides. To me, they closely mimicked the aerial dynamics of the swallows and swifts, common birds in the region. That early explorers coined the name "bird-winged butterflies" was totally natural. To me, the word that sums them up is "elegant."

Altogether, by our trip's end I had collected 728 specimens of butterflies representing 122 species. And of these, 12 were *Troides oblongomaculatus papuensis*, the subspecies named by Wallace.

Looking at the distributions of the three genera of birdwing butterflies as we understand them today, it seems that the Wallace Line—that invisible frontier that Wallace showed separated Australian and Asian animal life—also applies to the evolution of these butterfly groups. *Ornithoptera*, with thirteen species and many subspecies and forms, are found exclusively east of the line, in Wallace's Australian Region. *Trogonoptera*, with two species—one on the Thai-Malay Peninsula and surrounding islands, the



GARY NOEL ROSS

A member of the author's expedition stands at the ready in a forest opening. The colorful clump of Java glory bower drew down birdwing butterflies flying above the canopy.

other exclusively on Palawan Island in the Philippines—are west of the line, placing them in what Wallace called the Oriental, now the Asian, Region. And *Troides*, with twenty-one species, is also found west of the line, as far as India—with one exception: Wallace's subspecies *Troides oblongomaculatus papuensis*.



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Parting Company

“I hope,” wrote Darwin, “you have not murdered too completely your own and my child.”

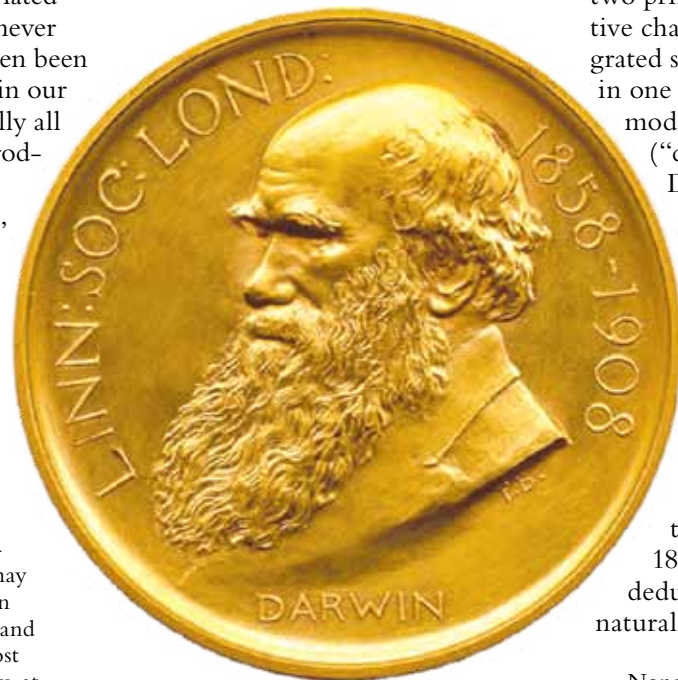
All subtle ideas can be trivialized, even vulgarized, by portrayal in uncompromising and absolute terms. Marx felt compelled to deny that he was a Marxist, while Einstein contended with the serious misstatement that he meant to say “all is relative.” Darwin lived to see his name appropriated for an extreme view that he never held—for Darwinism has often been defined, both in his day and in our own, as the belief that virtually all evolutionary change is the product of natural selection.

Darwin often complained, with uncharacteristic bitterness, about this misappropriation of his name. He wrote in the last edition of the *Origin* (1872):

As my conclusions have lately been much misrepresented, and it has been stated that I attribute the modification of species exclusively to natural selection, I may be permitted to remark that in the first edition of this work, and subsequently, I placed in a most conspicuous position—namely, at the close of the Introduction—the following words: “I am convinced that natural selection has been the main but not the exclusive means of modification.” This has been of no avail. Great is the power of steady misrepresentation.

England did house a small group of strict selectionists—“Darwinians” in the misappropriated sense—and Alfred Russel Wallace was their leader. These biologists attributed all evolutionary change to natural selection. They viewed each bit of mor-

phology, each function of an organ, each behavior as a product of selection leading to a “better” organism. They held a deep belief in nature’s “rightness,” in the exquisite fit of all creatures to their environments. In a curious sense, they almost re-introduced the creationist notion of



Darwin is featured on one side—and Wallace on the other side—of the medal issued by the Linnean Society of London in 1908, on the fiftieth anniversary of the reading of the Darwin and Wallace papers in which evolution by natural selection was proposed for the first time. This unique gold version was bestowed on Wallace; six other scientists received silver medals.

natural harmony by substituting an omnipotent force of natural selection for a benevolent deity.

Darwin, on the other hand, was a consistent pluralist gazing upon a messier universe. He saw much

fit and harmony, for he believed that natural selection holds pride of place among evolutionary forces. But other processes work as well, and organisms display an array of features that are not adaptations and do not promote survival directly. Darwin took particular interest in two principles leading to nonadaptive change: (1) Organisms are integrated systems and adaptive change in one part can lead to nonadaptive modifications of other features (“correlations of growth” in Darwin’s phrase); (2) An organ built under the influence of selection for a specific role may be able, as a consequence of its structure, to perform many other, unselected functions as well.

Wallace stated the hard, hyperselectionist line—“pure Darwinism” in his terms—in an early article of 1867, calling it “a necessary deduction from the theory of natural selection.”

None of the definite facts of organic nature, no special organ, no peculiarities of instinct or of habit, no relations between species or between groups of species, can exist, but which must now be, or once have been, *useful* to the individuals or races which possess them.

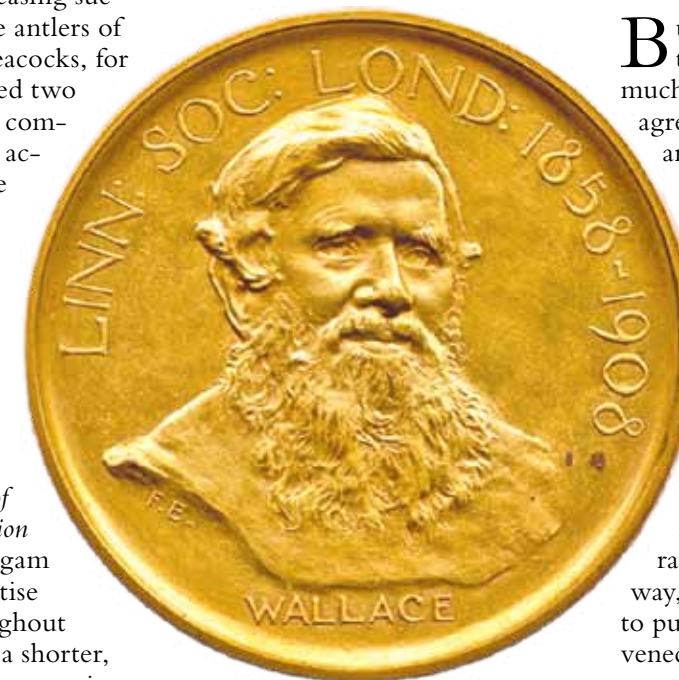
Indeed, he argued later, any apparent nonutility must only reflect our faulty knowledge—a remarkable argument since it renders the principle of utility impervious to disproof *a priori*:

The assertion of “inutility” in the case of any organ . . . is not, and can never be, the statement of a fact, but merely an expression of our ignorance of its purpose or origin.

All the public and private arguments that Darwin pursued with Wallace centered upon their differing assessments of the power of natural selection. They first crossed swords on the issue of “sexual selection,” the subsidiary process that Darwin had proposed to explain the origin of features that appeared to be irrelevant or even harmful in the usual “struggle for existence” (expressed primarily in feeding and defense), but that could be interpreted as devices for increasing success in mating—elaborate antlers of deer, or tail feathers of peacocks, for example. Darwin proposed two kinds of sexual selection: competition among males for access to females and choice exercised by females themselves. He attributed much of the racial differentiation among modern humans to sexual selection, based upon the different criteria of beauty that arose among various peoples. (His book—*The Descent of Man and Selection in Relation to Sex* [1871]—is an amalgam of two works: a long treatise on sexual selection throughout the animal kingdom and a shorter, speculative account of human origins, relying heavily upon sexual selection.)

The notion of sexual selection is not really contrary to natural selection, for it is just another route to the Darwinian imperative of differential reproductive success. But Wallace disliked sexual selection for three reasons: it compromised the generality of that peculiarly nineteenth-century view of natural selection as a battle for life itself, not merely for copulation; it placed altogether too much emphasis upon

the “volition” of animals, particularly in the concept of female choice; and most importantly, it permitted the development of numerous, important features that are irrelevant, if not actually harmful, to the operation of an organism as a well-designed machine. Thus, Wallace viewed sexual selection as a threat to his vision of animals as works of exquisite craftsmanship, wrought by the purely material force of natural selection. (Indeed, Darwin had developed the concept largely to explain why so many differences among human groups are irrelevant to survival based upon good design, but merely reflect



the variety of capricious criteria for beauty that arose for no adaptive reason among various races. In the end, Wallace did accept sexual selection based upon male combat as close enough to the metaphor of battle that controlled his concept of natural selection. But he firmly rejected the notion of female choice and distressed Darwin with his speculative attempts to attribute all features based upon it to the adaptive action of natural selection.)

As he prepared the *Descent of Man*, Darwin wrote to Wallace in 1870: “I grieve to differ from you, and it actually terrifies me and makes me constantly distrust myself. I fear we shall never quite understand each other.” He struggled to understand Wallace’s reluctance and even to accept his friend’s faith in unalloyed natural selection: “You will be pleased to hear,” he wrote to Wallace,

that I am undergoing severe distress about protection and sexual selection; this morning I oscillated with joy towards you; this evening I have swung back to [my] old position, out of which I fear I shall never get.

But the debate on sexual selection was merely a prelude to a much more serious and famous disagreement on that most emotional and contentious subject of all—human origins. In short, Wallace, the hyperselectionist, the man who had twitted Darwin for his unwillingness to see the action of natural selection in every nuance of organic form, halted abruptly before the human brain. Our intellect and morality, Wallace argued, could not be the product of natural selection; therefore, since natural selection is evolution’s only way, some higher power—God, to put it directly—must have intervened to construct this latest and greatest of organic innovations.

If Darwin had been distressed by his failure to impress Wallace with sexual selection, he was positively aghast at Wallace’s abrupt about-face at the finish line itself. He wrote to Wallace in 1869: “I hope you have not murdered too completely your own and my child.” A month later, he remonstrated: “If you had not told me, I should have thought that [your remarks on Man] had been added by some one else. As you expected, I differ grievously from you, and I am very sorry for it.” Wallace,

sensitive to the rebuke, thereafter referred to his theory of human intellect as “my special heresy.”

The conventional account of Wallace’s apostasy at the brink of complete consistency cites a failure of courage to take the last step and admit man fully into the natural system—a step that Darwin took with commendable fortitude in two books, the *Descent of Man* and *The Expression of the Emotions in Man and Animals* (1872). Thus, Wallace emerges from most historical accounts as a lesser man than Darwin for one (or more) of three reasons, all related to his position on the origins of human intellect: for simple cowardice; for inability to transcend the constraints of culture and traditional views of human uniqueness; and for inconsistency in advocating natural selection so strongly (in the debate on sexual selection), yet abandoning it at the most crucial moment of all.

I cannot analyze Wallace’s psyche and will not comment on his deeper motives for hewing to the unbridgeable gap between human intellect and the behavior of mere animals. But I can assess the logic of his argument and recognize that the traditional account is not only incorrect, but precisely backward. Wallace did not abandon natural selection at the human threshold. Rather, it was his peculiarly rigid view of natural selection that led him, quite consistently, to reject it for the human mind. His position never varied—natural selection is the only cause of major evolutionary change. His two major debates with Darwin—sexual selection and the origin of human intellect—represent the same argument, not an inconsistent Wallace championing selection in one case and running from it in the other. Wallace’s error on human intellect arose from the inadequacy of his rigid selectionism, not from a failure to apply it. And his argument repays our study today, since its flaw remains as the weak link in many of the most

“modern” evolutionary speculations of our current literature. For Wallace’s rigid selectionism is much closer than Darwin’s pluralism to the attitude embodied in our favored theory today, which, ironically in this context, goes by the name of Neo-Darwinism.

Wallace advanced several arguments for the uniqueness of human intellect, but his central claim begins with an extremely uncommon position for his time, one that commands our highest praise in retrospect. Wallace was one of the few nonracists of the nineteenth century. He really believed that all human groups had innately equal capacities of intellect. Wallace defended his decidedly unconventional egalitarianism with two arguments, anatomical and cultural. He claimed, first of all, that the brains of “savages” are neither much smaller nor more poorly organized than our own:

In the brain of the lowest savages, and, as far as we know, of the prehistoric races, we have an organ . . . little inferior in size and complexity to that of the highest type.

Moreover, since cultural conditioning can integrate the rudest savage into our most courtly life, the rudeness itself must arise from a failure to use existing capacities, not from their absence:

It is latent in the lower races, since under European training native military bands have been formed in many parts of the world, which have been able to perform creditably the best modern music.

Of course, in calling Wallace a nonracist, I do not mean to imply that he regarded the cultural practices of all peoples as equal in intrinsic worth. Quite the contrary. Wallace, like most of his contemporaries, was an ardent cultural chauvinist who never doubted the evident superiority of European ways. He may have been bullish on the capability of

savages, but he certainly had a low opinion of their life, as he mistook it:

Our law, our government, and our science continually require us to reason through a variety of complicated phenomena to the expected result. Even our games, such as chess, compel us to exercise all these faculties in a remarkable degree. Compare this with the savage languages, which contain no words for abstract conceptions; the utter want of foresight of the savage man beyond his simplest necessities; his inability to combine, or to compare, or to reason on any general subject that does not immediately appeal to his senses.

Hence, Wallace’s dilemma: all savages, from our actual ancestors to modern survivors, had brains fully capable of developing and appreciating all the finest subtleties of European art, morality and philosophy; yet they used, in the state of nature, only the tiniest fraction of that capacity in constructing their rudimentary cultures, with impoverished languages and repugnant morality. But natural selection can only fashion a feature for immediate use. The brain is vastly overdesigned for what it accomplished in primitive society; thus, natural selection could not have built it:

A brain one-half larger than that of the gorilla would . . . fully have sufficed for the limited mental development of the savage; and we must therefore admit that the large brain he actually possesses could never have been solely developed by any of those laws of evolution, whose essence is, that they lead to a degree of organization exactly proportionate to the wants of each species, never beyond those wants. . . . Natural selection could only have endowed savage man with a brain a few degrees superior to that of an ape, whereas he actually possesses one very little inferior to that of a philosopher.

Wallace did not confine this general argument to abstract intellect, but extended it to all aspects of European “refinement,” to language and music in particular. Consider

his views on “the wonderful power, range, flexibility, and sweetness of the musical sounds producible by the human larynx, especially in the female sex.”

The habits of savages give no indication of how this faculty could have been developed by natural selection, because it is never required or used by them. The singing of savages is a more or less monotonous howling, and the females seldom sing at all. Savages certainly never choose their wives for fine voices, but for rude health and strength, and physical beauty. Sexual selection could not therefore have developed this wonderful power, which only comes into play among civilized people. It seems as if the organ had been prepared in anticipation of the future progress in man, since it contains latent capacities which are useless to him in his earlier condition.

Finally, if our higher capacities arose before we used or needed them, then they cannot be the product of natural selection. And if they originated in anticipation of a future need, then they must be the direct creation of a higher intelligence: “The inference I would draw from this class of phenomena is, that a superior intelligence has guided the development of man in a definite direction, and for a special purpose.” Wallace had rejoined the camp of natural theology. Darwin remonstrated, but failed to budge his partner.

The fallacy of Wallace’s argument is not a simple unwillingness to extend evolution to humans, but rather the hyperselectionism that permeated all his evolutionary thought. For if hyperselectionism is valid—if every part of every creature is fashioned for and only for its immediate use—then Wallace cannot be gainsaid. The earliest Cro-Magnon people, with brains bigger than our own, produced stunning paintings in their caves, but did not write symphonies or build computers. All that we have accomplished since then is the product of cultural

evolution based on a brain of unvarying capacity. In Wallace’s view, that brain could not be the product of natural selection, since it could always do so much more than it did in its original state.

But hyperselectionism is not valid. It is a caricature of Darwin’s subtler view, and it both ignores and misunderstands the nature of organic form and function. Natural selection may build an organ “for” a specific function or group of functions. But this purpose need not fully specify the capacity of a structure. Objects designed for definite purposes can, as a result of their structural complexity, perform many other tasks as well. A factory may install a computer only to issue the monthly pay checks, but such a machine can also analyze the election returns or whip anyone (or at least perpetually tie them) in tick-tack-toe. Our large brains may have originated for some set of necessary skills in gathering food, socializing, or whatever; but these skills do not exhaust the limits of what such a complex machine can do. Fortunately for us, those limits include, among other things, an ability to write—from shopping lists for all of us to grand opera for a few. And our larynx may have arisen for a limited range of articulated sound needed to coordinate social life. But its physical design permits us to do more with it—from singing in the shower for all to the occasional diva.

Hyperselectionism has been with us for a long time in various guises, for it represents the late-nineteenth-century’s scientific version of the myth of natural harmony—all structures well designed for a definite purpose. It is, indeed, the vision of foolish Dr. Pangloss, so vividly satirized by Voltaire in *Candide*—“all is for the best in the best of all possible worlds.” As the good doctor said in a famous passage, which predated Wallace by a century, but captures the essence of what is so deeply wrong with his argument:

Things cannot be other than they are. . . . Everything is made for the best purpose. Our noses were made to carry spectacles, so we have spectacles. Legs were clearly intended for breeches, and we wear them.

Nor is Panglossianism dead today—not when so many books in the pop literature on human behavior state that we evolved our big brain for hunting, then trace all our current ills to limits of thought and emotion supposedly imposed by such a mode of life.

Ironically then, Wallace’s hyperselectionism led right back to the basic belief of an earlier creationism that it meant to replace—a faith in the rightness of things, a definite place for each object in an integrated whole. As Wallace wrote, quite unfairly, of Darwin:

He whose teachings were at first stigmatized as degrading or even atheistical, by devoting to the varied phenomena of living things the loving, patient, and reverent study of one who really had faith in the beauty and harmony and perfection of creation, was enabled to bring to light innumerable adaptations, and to prove that the most insignificant parts of the meanest living things had a use and a purpose.

I do not deny that nature has its harmonies. But structure also has its latent capacities. Built for one thing, it can do others—and in this flexibility lies both the messiness and the hope of our lives.

This essay is reproduced, except for an introductory section, from “Wallace’s Fatal Flaw,” first published in the January 1980 issue of Natural History. STEPHEN JAY GOULD (1941–2002) taught biology, geology, and the history of science at Harvard University. His column “This View of Life” was a staple of this magazine from 1974 through 2000.





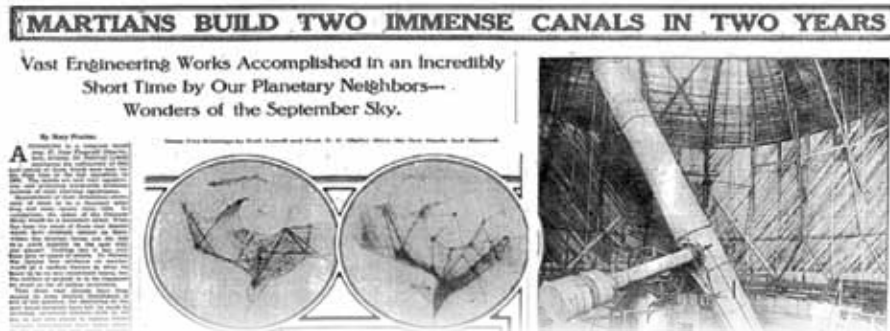
A Pioneer of Astrobiology

The Moon has a starring role this month (see “September Nights Out,” below, for the 4th and 27th), but in keeping with this special issue let me honor Alfred Russel Wallace,

than Earth was inhabited or habitable; that in the Milky Way no star other than the Sun possessed inhabited planets (the existence of stars in other galaxies was not yet established

A Critical Examination of Professor Percival Lowell’s Book “Mars and Its Canals,” with an Alternative Explanation. Lowell had already speculated in *Mars* (1895) that intelligent beings on the dying planet might have built irrigation canals to tap water from the polar caps. Such speculation fueled H. G. Wells’s science-fiction novel *The War of the Worlds* (1897) and later representations of Martians in popular culture. In *Mars and Its Canals* (1906), Lowell elaborated on his theory. Challenging the eminent astronomer’s contentions, however, Wallace argued that the supposed “canals” could be explained as natural phenomena. Lowell ignored, he wrote, “the extreme irrationality of constructing so vast a canal-system the waste from which, by evaporation, when exposed to such desert conditions as he himself describes, would use up ten times the probable supply. . . . The mere attempt to use open canals for such a purpose shows complete ignorance and stupidity in these alleged very superior beings.”

JOE RAO is a broadcast meteorologist and an associate and lecturer at the Hayden Planetarium in New York City (www.haydenplanetarium.org).



The New York Times of August 27, 1911, announced astronomer Percival Lowell’s “rediscovery” of two canals on Mars that he had first reported detecting two years earlier, when Mars was in a similar position for observation. Because these so-called canals—estimated to be a thousand miles long and twenty miles wide—had not been apparent before 1909, Lowell concluded that Martians had recently constructed them.

who deserves recognition as a pioneer thinker in what is now known as astrobiology or exobiology. In *Man’s Place in the Universe: A Study of the Results of Scientific Research in Relation to the Unity or Plurality of Worlds* (1903), Wallace concluded it was probable, based on the evidence, that no planet in the solar system other

in Wallace’s time); and that the position of our Sun, then believed to be nearly central within the Milky Way, was probably a permanent one, and has been “specially favourable, perhaps absolutely essential” to the development of life on Earth.

And in 1907, at the age of eighty-four, he published *Is Mars Habitable?*

SEPTEMBER NIGHTS OUT

4 For viewers in the eastern half of the United States and Canada, the Moon, at nearly last quarter phase, passes in front of (occults) the bright, orange-hued star Aldebaran, which marks the angry right eye of Taurus, the Bull. This occurs around the time both objects rise above the east-northeast horizon. Viewers in the New York City vicinity can see the bright edge of the Moon overtake Aldebaran at 11:55 P.M. eastern daylight time (EDT); the star dramatically pops back into view along the Moon’s dark perimeter at 12:40 A.M. Farther south and west, Aldebaran is already behind the Moon when it rises; only the reappearance can be seen—at 11:39 P.M.

locations, see www.lunar-occultations.com/iota/bstar/0905zc692.htm (subtract four hours from Universal Time to get EDT).

5 The Moon wanes to last quarter at 5:54 A.M. EDT.

10 Having returned to its role as Morning Star at the end of August, Venus has been coming up earlier in a darker sky as each day passes. Predawn risers this morning can see a thin crescent Moon about 2.5 degrees to the left of Venus in the east-northeast, and shining dimly a half dozen degrees to the left of the Moon is orange-yellow Mars.

11 Having passed conjunction with the Sun on August 26, Jupiter rises in the east about an hour before sunrise. By month’s end the giant planet rises more than two hours before sunrise.

13 The Moon is new at 2:41 A.M. EDT. A partial solar eclipse is visible from the southern Indian Ocean, the southern tip of Africa, and much of Antarctica.

18 As darkness falls, Saturn sits about 2.5 degrees to the left of the crescent Moon in the southwestern sky.

21 Venus shines at its greatest brilliancy for the month in the predawn sky. The Moon waxes to first quarter at 4:59 A.M. EDT.

23 At 4:21 A.M. EDT, the Sun, heading south, crosses the celestial equator (Earth’s equator projected onto the heavens). This equinox marks the beginning of autumn in the Northern Hemisphere and spring in the Southern.

25 As dawn breaks, reddish Mars glides 0.8 degree to the north of the bluish star Regulus

in the eastern sky. The duo is 11 degrees to the lower left of Venus and 10 degrees above and to the right of Jupiter.

27 The Moon arrives at perigee (the closest point in its orbit to Earth) at 10:00 P.M. EDT and becomes full only 50 minutes later, making this the largest-looking full Moon of the year—a so-called Super Moon. As the full Moon occurring nearest the fall equinox, it is the Harvest Moon. And on top of this comes a total lunar eclipse. Viewers across the central and eastern part of North America can see the entire umbral eclipse from start (9:07 P.M. EDT) to finish (12:27 A.M. EDT on the 28th), while those farther west can see the Moon rise with the eclipse already in progress. Totality lasts from 10:11 to 11:23 P.M. EDT.

A Wallace Library

Books by Alfred Russel Wallace



Frontispiece ("Orang Utan Attacked by Dyaks") and title page of *The Malay Archipelago*, eighth edition

RICHARD MILNER

The Malay Archipelago: The Land of the Orang-utan, and the Bird of Paradise. A Narrative of Travel, with Studies of Man and Nature (London: Macmillan & Co., 1869); Penguin Classics Edition, edited and introduced by Andrew Berry (London: Penguin Classics, 2014).

Darwinism: An Exposition of the Theory of Natural Selection with Some of Its Applications (London and New York: Macmillan & Co., 1889).

Natural Selection and Tropical Nature: Essays on Descriptive and Theoretical Biology (London and New York: Macmillan & Co., 1891).

My Life: A Record of Events and Opinions (London: Chapman & Hall, Ltd., 1905).

Social Environment and Moral Progress (London and New York: Cassell & Co., Ltd., 1913).

Alfred Russel Wallace's 1886–1887 Travel Diary: The North American Lecture Tour, edited by Charles H. Smith and Megan Derr (Manchester: Siri Scientific Press, 2013).

Wallace Anthologies / Selected Writings

Alfred Russel Wallace: Letters and Reminiscences, by James Marchant (London, New York, Toronto, and

Melbourne: Cassell and Co., Ltd., 1916).

Alfred Russel Wallace: An Anthology of His Shorter Writings, edited by Charles H. Smith (Oxford: Oxford University Press, 1991).

The Alfred Russel Wallace Reader: A Selection of Writings from the Field, edited by Jane R. Camerini (Baltimore: Johns Hopkins University Press, 2001).

Infinite Tropics: An Alfred Russel Wallace Anthology, edited by Andrew Berry (London: Verso, 2002).

Biographies

Alfred Russel Wallace: A Life, by Peter Raby (Princeton: Princeton University Press, 2001).

In Darwin's Shadow: The Life and Science of Alfred Russel Wallace, by Michael Shermer (New York: Oxford University Press, 2002).

An Elusive Victorian: The Evolution of Alfred Russel Wallace, by Martin Fichman (Chicago: University of Chicago Press, 2004).

The Heretic in Darwin's Court: The Life of Alfred Russel Wallace, by Ross A. Sloten (New York: Columbia University Press, 2004).

"The Man Who Wasn't Darwin: Alfred Russel Wallace Charted a Great Dividing Line in the Living World—And Found His Own Route to the Theory of Evolution," by David Quammen. *National Geographic* 214, No. 6 (December 2008): 106–133.

History of Science

"When I Was Alive by Alfred Russel Wallace," by Gareth Nelson. *The Linnean* 11, No. 2 (July 1995): 20–31.

The Song of the Dodo: Island Biogeography in an Age of Extinction, by David Quammen (New York: Scribner, 1996).

Where Worlds Collide: The Wallace Line, by Penny Van Oosterzee (Ithaca, N.Y.: Cornell University Press, 1997).

Natural Selection and Beyond: The Intellectual Legacy of Alfred Russel Wallace, edited by Charles H. Smith and George Beccaloni (New York: Oxford University Press, 2008).

"Alfred Russel Wallace as Ancestor Figure: Reflections on Anthropological Lineage after the Darwin Bicentennial," by Kathleen Bolling Lowrey. *Anthropology Today* 26, No. 4 (August 2010): 18–21.

The Species Seekers: Heroes, Fools, and the Mad Pursuit of Life on Earth, by Richard Conniff (New York: W. W. Norton & Co., 2010).

"Special Alfred Russel Wallace Section," edited by Michael Shermer with Richard Milner. *Skeptic* 20, No. 3 (Fall 2015): 9–41.

Evolutionary Theory

Survival of the Fittest: Celebrating the 150th Anniversary of the Darwin-Wallace Theory of Evolution, edited by Brian Gardiner, Richard Milner, and Mary Morris. *The Linnean Special Issue* No. 9 (2008).

Darwin's Universe: Evolution from A to Z, by Richard Milner (Berkeley: University of California Press, 2009).

Wallace, Darwin, and the Origin of Species, by James T. Costa (Cambridge, Mass: Harvard University Press, 2014).

Naturalists in Paradise: Wallace, Bates and Spruce in the Amazon, by John Hemming (London: Thames & Hudson, 2015).

Spiritualism

"Alfred Russel Wallace, the Origin of Man, and Spiritualism," by Malcolm Jay Kottler. *Isis* 65, No. 2 (1974): 144–192.

"Charles Darwin and Associates, Ghostbusters: When the Scientific Establishment Put a Spiritualist on Trial, the Co-discoverers of Natural Selection Took Opposing Sides," by Richard Milner. *Scientific American* 275, No. 4 (October 1996): 96–101.



A Fitting Image

BY RICHARD MILNER

In the years since Charles Darwin's death in 1882, many sculptures have been created to celebrate the adventurous naturalist and his groundbreaking theory. There's the two-ton marble at London's Natural History Museum, and the bronze Darwin outdoors in Shropshire; there are busts and statues of Socrates-like Darwins, brooding Darwins, and young Darwins. But in the century since he died, in 1913, Alfred Russel Wallace, Darwin's junior partner in the discovery of evolution by natural selection, never got a statue.

In 2012, as the Centenary Celebration of Wallace's death approached, entomologist George Beccaloni, founding director of the Wallace Correspondence Project at London's Natural History Museum, initiated the creation of the first proper statue of Wallace. He commissioned Anthony Smith, a young British sculptor, to design and execute the work, and led the campaign to raise the funds to pay for it. From the start, it was agreed that the naturalist should be depicted as he

ing 126,000 specimens, including thousands new to science. It was there that he conceived of natural selection. But the sculptor's concept is based on a single, heart-stopping moment Wallace described in his book *The Malay Archipelago*. On Batchian Island in 1858, he first saw the enormous butterfly he named *Ornithoptera croesus*, which became known as Wallace's golden birdwing: "The beauty and brilliancy of this insect are indescribable," he wrote, "and none but a naturalist can understand the intense excitement I experienced when I at length captured it."

I began working on a design," writes sculptor Smith, "that would capture the build-up to this memorable moment: Wallace frozen in his tracks, butterfly net in hand, gazing up at the magnificent specimen as it fluttered high in the trees."



Wallace, frozen in his tracks



Anthony Smith prepares the plaster base to receive the clay layer.

appeared in the 1850s—a vigorous and ever-curious species seeker of birds and insects in the rainforests of the Malay Archipelago, the region from the Malay Peninsula to New Guinea.

Wallace explored that vast territory for eight years, collecting an astonish-

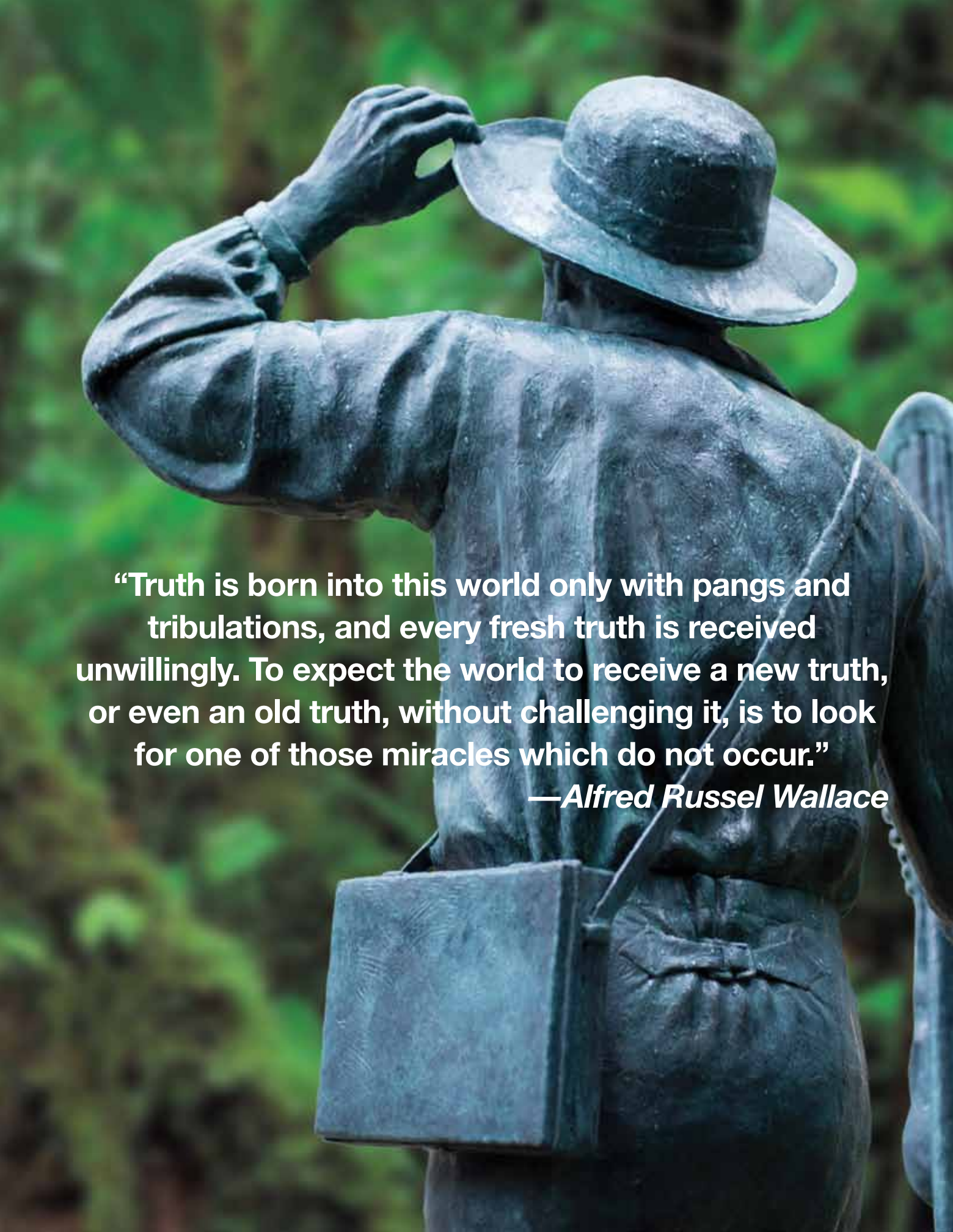
With the aid of a model in appropriate garb playing the role of Wallace, I sculpted the body and clothes in clay onto a plaster base. The most challenging part was, of course, the face. Thanks to Dr. Beccaloni's excellent research, I had lots of high-quality reference images of Wallace at varying ages. From them, I was able to build up an accurate three-dimensional image of Wallace, age around thirty-five.

When the clay statue was finally complete, it was cast in bronze in upper and lower halves, using the "lost wax" method. The halves were joined, a bronze butterfly net and pole placed in Wallace's sure grasp, and the whole given a green chemical patina.

On November 7, 2013, the centenary of Wallace's death, David Attenborough publically unveiled the statue—a long-overdue recognition

of one of science's greatest men, a boyhood hero of Attenborough's. It now stands near the Wildlife Garden outside the museum's Darwin Centre, which houses thousands of Wallace's insect specimens. Mounted above and across from Wallace, on a window of the Centre, is a bronze replica of the golden birdwing butterfly, the eternal focus of his alert, enchanted gaze.

RICHARD MILNER, a historian of science, is director of the Alfred Russel Wallace Centenary Celebration, which is funded by the John Templeton Foundation. His books include *Darwin's Universe: Evolution from A to Z* (University of California Press, 2009) and *Charles R. Knight: The Artist Who Saw through Time* (Harry N. Abrams, 2012). Based in New York City, Milner is an Associate in Anthropology at the American Museum of Natural History.

A bronze statue of a man, likely a pioneer or explorer, is shown from the back. He is wearing a wide-brimmed hat and a satchel slung over his shoulder. His right hand is raised to the brim of his hat. The background is a blurred green, suggesting a natural setting.

“Truth is born into this world only with pangs and tribulations, and every fresh truth is received unwillingly. To expect the world to receive a new truth, or even an old truth, without challenging it, is to look for one of those miracles which do not occur.”

—Alfred Russel Wallace