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Adversity and Perseverance: Alfred Russel Wallace

Science textbooks are often criticized for distorting how science is actually done. The scant attention to the life and work of scientists is one of many ways that science textbooks convey mistaken notions about what being a scientist and doing science is like. When textbooks sometimes note an individual scientist's contribution to our current understanding of the natural world, they usually focus only on the most notable historical figure and ignore the contribution of others. This wrongly conveys that science is a solitary undertaking, and that advancements in our understanding of the natural world are due to single individuals. This misconception is evident in the way biology textbooks often address the important work of Charles Darwin, and ignore or quickly pass over the work of Alfred Russel Wallace.

Alfred Russel Wallace was born in Wales on January 8, 1823, his middle-name accidentally misspelled on the register and never changed. Born into an Anglican family, his parents mishandled their inheritances from well-to-do uncles and as a result sent their boys off to work. Alfred ended his formal schooling at the age of thirteen, going off to live with his older brother as a carpenter's apprentice. The job never took, and in 1837 he moved in with another brother to work as a land surveyor. This proved to be a fortunate decision, for the Industrial Revolution had been surging in Britain. Demand for new railroad tracks put a high demand on surveyors, and Wallace was able to earn a stable living. Along the way he developed an interest in geology, collecting and mapping rocks as he went along. Wallace also developed an interest in plants, and he read as much as he could on these two subjects.

In 1844, a widely popular book, *Vestiges of the Natural History of Creation*, changed the direction of Wallace's life. Written by Robert Chambers, *Vestiges* combined the most recent scientific studies with theology. People of all walks read the book, from the queen down to the shopmaiden. Chambers' argument was that species 'progressed' up an evolutionary ladder according to God's rules. Every adaptation that passed along generations led to some final goal. Reviews, comments, and conversations regarding *Vestiges* permeated Victorian society for a time. Convinced that species did evolve, Wallace determined his life goal would be to figure out *how* species went along this progression. Thus, Wallace's world travels, unlike Darwin's aboard the Beagle, were significantly motivated by, what Wallace thought, were compelling arguments for the evolution of species.

- **The idea that species may be related to one another and that they might evolve was introduced well before Darwin and Wallace's time. In 1844, *Vestiges* was just one of several ideas that had been put forward regarding the evolution of species.**

Wallace determined that he would be a naturalist, an explorer who penetrated deep into foreign jungles and rivers to collect and preserve biological specimens. However, he had neither the money nor the training to be a naturalist. After reading Darwin's *Voyage of the Beagle*, Wallace determined his best shot would be a trip to Brazil, navigating up the Amazon to where no European had been before. There, he thought, would be unmatched biodiversity in a relatively cheap land governed by colonial rule. He and his friend, Henry Bates, hired an agent to represent their collections. Every specimen would draw four pence, of which the agent took one pence. Thus, to make a middle-class wage, they needed to collect, preserve, and ship over 3,000 specimens a year, and that did not include the costs of financing the trip.

They sought out respected adventurers for lessons in taxidermy and preservation. They learned shipping methods from the India Museum in London. They learned preservation from their agent, Samuel Stevens. Preservation was paramount to the adventurer's list of skills, otherwise all their hard work would arrive in England putrid and decayed, useless for study. Some specimens had to be bathed in alcohol, but

some organisms simply distorted in the harsh substance. They carried many other tools as well, as the historian Ross Slotten writes:

> The basic equipment of the collector included knives, scissors, scalpels, pliers, a large assortment of pins of various sizes, needles, a hammer, a small hatchet, cotton, paper, a folding net, a hoop net, a water net, forceps, a digger, glass phials, large and small packing cases, and a great number of pillboxes, all of which could be purchased from Stevens' shop on Bloomsbury Street near the British Museum.

On top of this, the most important supply was arsenic soap. Negligibly toxic to the collector, the arsenic soap was key to removing the ants, spiders, fleas, and other insects that could ravage animal skins. Then came the preparation of the sample. A description, again provided by Slotten:

> All adherent fat was scraped away: if any remained, the skin was strewn with powdered tan, made from willow or oak bark, or another potent astringent that dissolved fat without penetrating other tissues, before the application of the arsenic soap. The ears, lips, and feet of the larger mammals were doused with turpentine to accelerate the drying and destroy potentially destructive insects. When completely dry, the skin was rolled up, hair innermost, beginning with the head. To prevent damage from abrasion, dried grass or moss was inserted during the rolling process. The skin had to be unrolled periodically and checked for moisture. If possible, it was further exposed to the sun and sprinkled once again with turpentine. If insects were detected, strong tobacco, or better, aromatic spices were added.

Thus prepared, Wallace and Bates headed to the Amazon. The expedition could only be described as near catastrophe. Arriving in the town of Pará in May 1848, the conditions were not what they expected, and animals were scarce around town. When they did stumble across an animal, Wallace was such a poor aim with his shotgun that he either missed completely or utterly decimated his victim. The two pushed inland, tensions rising and tempers flaring. Within the first year, Bates and Wallace had an argument and parted ways. Alone in the Amazon, Wallace pressed down the Rio Negro. He contracted malaria, periodically enduring hallucinogenic fevers that forced him to land for days. More than once his crew left, upset at the dangers and lack of food. Wallace persisted, learning the Portuguese and local languages and making friends. At one point he connected with his younger brother Edward, another son sent off by his parents to make money. Within a year Edward contracted yellow fever and died.

By July 1852, Wallace had collected and shipped off a great amount of specimens, and decided to return home for a break. He boarded the ship *Helen* along with his journals and many of his live and preserved specimens for the month-long journey. Tragically, the *Helen* caught fire in the middle of the Atlantic, and sunk with all of Wallace's journals. Adrift for ten days, he and other survivors were picked up by the *Jordeson*, a vessel already low on food. The crew hunted rats as they pulled into the English Channel, where they were hit by a storm and nearly sunk. In October 1852, Wallace returned home, and vowed to never again leave British soil. He recorded his feelings in *A Narrative of Travels on the Amazon and Rio Negro*:

> It was now, when the danger appeared past, that I began to feel fully the greatness of my loss. With what pleasure had I looked upon every rare and curious insect I had added to my collection! And now everything was gone and I had not one specimen to illustrate the unknown lands I had trod, or call back the recollection of the wild scenes I had beheld.

Wallace held his promise for only a year. After publishing his experiences in the abovementioned book and producing a few scientific articles, Wallace determined that he again needed to sail. What prompted him this time was a very specific flaw he noticed in his and other naturalists work—hardly any

species had been categorized by their geographical boundaries. For instance, many explorers would note that some bird would inhabit the banks of the Amazon River, but Wallace recalled that many birds would inhabit only one bank. One example Wallace remembered from the Amazon was the hyacinthine macaw, reported to be a strong flier. The macaw, however, inhabited a very small range. Why would a strong flier not be widespread? Wallace's answer was that food supplies changed over distance, so the macaw purposefully limited itself to a very specific range.

Determined to do another expedition to gather species and catalogue their geographical boundaries, Wallace decided to sail for Malaysia in 1854. Largely controlled by the British and allied Dutch, Wallace could again go where very few explorers had ever set foot. His excitement for departure had to be pushed back, however. Britain had just entered into the Crimean War with Russia, disrupting ship routes. After waiting for months, Wallace hopped aboard a boat set for Cairo, making the pre-canal trek across the desert with Muslim traders before setting off again to Singapore. In 1855, Wallace took up base in Borneo where he spent fifteen months collecting extensive specimens and studying orangutans.

Wallace noted that orangutans kept to a given territory. This was simply one example of a widely observed phenomenon that related species appear in close geographical proximity to one another. Moreover, Wallace was aware that fossils of what appeared to be closely related organisms appear in the same geological layer. To account for these observations, he put forward the idea that "Every species comes into existence coincident in time and space with a preexisting closely allied species." Spending the rainy season indoors caring for an infant orangutan he rescued from a swamp, he put forward this idea in a paper titled, "On the Law Which Has Regulated the Introduction of New Species." The Sarawak Law, as it came to be known, was the equivalent of Darwin's principle of divergence.

- **In science, the word "law" refers to a statement of a relationship. The word "principle" sometimes, but not always, means the same thing. Many people wrongly think that scientific theories will, with sufficient evidence, become scientific laws. However, rather than conveying the certainty of an idea, the terms "law" and "theory" refer to what particular science ideas do. Scientific laws convey relationships between phenomena. Scientific theories make sense of laws by providing an explanation for those relationships. Both laws and theories are developed to account for natural phenomena. When first conceived, all scientific knowledge (including laws and theories) has a speculative character.**

This statement caused a stir when it reached England in September 1855. Some of the more open-minded creationists, like Charles Lyell was at the time, maintained that if any extinction and evolution happened, God would make one species die off and then replace it with a new and different species. Wallace, however, said that the old and new species existed at the same time, which was a very unsettling idea for some naturalists—it clearly implied modification of organisms from one species into another perhaps without supernatural intervention. As justification, Wallace pointed out that the broadest categories of organisms, like felines for example, were widespread over the earth, while the smaller categories of species had specific locations, such as the Bengal Tiger or African Lion. In these specific locations, fossils of extinct species were found near similar existing species, showing some sort of relation between the two. Wallace commented that this could only be the result of evolution—so much variation could not logically be the result of endless continued creations. Many scientists rejected Wallace's Sarawak Law arguing that it was too much speculation with too little evidence. Wallace had predicted this very problem in his paper, saying,

> If we consider that we have only fragments of this vast system, the stem and main branches being represented by extinct species of which we have no knowledge, while a vast mass of limbs and boughs and minute twigs and scattered leaves is what we have to place in order, and determine the true position originally occupied with regard to the

> others, the whole difficulty of the true Natural System of classification becomes apparent to us.

In June 1856 Wallace visited Bali, where he got so caught up in collecting that he missed his intended ship to the Celebes. Stranded for a month, Wallace toured the local straits between the islands of Bali and Lombak. The fifteen-mile crossing was no problem, the islands being in constant sight of each other. What stood out to Wallace, however, was that these two nearby islands had completely different animal species—Bali having the flora and fauna (e.g. placental mammals) native to Asia, and Lombak having that of Australia (e.g. marsupial mammals). In *The Malay Archipelago,* Wallace wrote, "I believe the western part to be a separated portion of continental Asia, the eastern the fragmentary prolongation of a former Pacific continent." Wallace argued that the islands of Bali and Lombock were the most demonstrative of the two divisions of the archipelago, "differing as essentially in their animal life as Europe does from America." This is when Wallace drew his famous "line" (i.e. referred to as the "Wallace line") for the first time. Wallace, his mind always on geographical boundaries, had stumbled upon what he maintained was clear evidence that natural factors dominated evolution. If controlled by a divine hand, then what reason would a creator have for making different sets of animals for such similar islands? Wallace did catch the next ship to the Celebes and then eventually moving to the islands of Ternate and Gilolo, where he would formulate his own version of the theory of natural selection.

Spending about a month on the two islands, Wallace was again stricken by malarial fever. In his autobiography, he recalls being bedridden, staring at the ceiling, thinking about all of his work.

> The problem then was not only how and why do species change, but how and why do they change into new and well-defined species, distinguished from each other in so many ways; why and how do they become so exactly adapted to distinct modes of life; and why do all the intermediate grades die out (as geology shows they have died out) and leave only clearly defined and well-marked species, genera, and higher groups of animals?

As with all creative processes, how and why previously disparate ideas suddenly coalesce for scientists is unclear. While lying there considering his work with animals, Wallace's thinking turned to humans. Perhaps subtly at first, but then more forcefully, he recalled the work of Thomas Malthus (the same book that was key in Darwin's thinking). The late eighteenth century clergyman Malthus had written his *Essay on the Principle of Population* some fifty years earlier, where he pointed out that much of mankind had been involved in a "struggle for existence," in which populations warred and dealt with famine and disease. Particularly, Malthus had the primitive Asiatic tribes in mind when he spoke of 'struggle,' and Wallace had been traveling the very area in question investigating the same things. Suddenly, he came to an idea that explained how and why species change in ways that are adapted to their environment, and why intermediate grades go extinct. Wallace recounts then writing the entire theory within two days.

Calling his paper "On the Tendency of Varieties to Depart Indefinitely from the Original type; Instability of Varieties Supposed to Prove the Permanent Distinctness of Species," he argued that two factors controlled evolution: first, his Sarawak Law of divergence, and second, that the winners of the struggle for existence would lead to new species. This explained several factors—those most likely to die would be the weakest. The modifications would be most apparent during periods of stress—climate change, war, famine, etc. Convinced he now understood the natural mechanism of evolution, Wallace sent his paper to his trusted colleague Darwin for his and other scientists' assessment.

Darwin opened Wallace's letter in his country house in June 1858. Reading Wallace's words, Darwin felt very uncomfortable with how similar his colleague's ideas were to his own. By this time, Darwin had spent over twenty years coming to understand and provide evidence for the mechanisms of natural selection and divergence. He had written two unpublished preliminary manuscript essays in 1842

and 1844, but until this point he had never felt rushed to present his work. Now with Wallace closing in, Darwin acted. To his merit, Darwin could have never told anybody of Wallace's work, but he did inform Charles Lyell and another mutual friend Joseph Hooker. In fact, Darwin was so concerned about honesty that he asked Lyell, "As I had not intended to publish any sketch, can I do so honorably because Wallace has sent me an outline of his doctrine? I would far rather burn my whole book, than that he or any other man should think that I had behaved in a paltry spirit." After convening a group of scientists, Lyell and Hooker compared Darwin and Wallace's notes, giving Darwin his rightful priority in the matter. When word reached Wallace, he showed no anguish, just gratitude that he had arrived at a similar conclusion as his well-respected acquaintance Darwin. On July 1, 1858, Hooker and Lyell, presented Wallace's manuscript, together with excerpts from Darwin's manuscripts and letters, to the Linnaean Society of London. That August, the *Journal of the Proceedings of the Linnean Society of London* published a paper by Darwin alongside Wallace's. One year later, Darwin published his abstract, *Origin of Species*. Thus, it was made clear that Darwin had originally formulated his theory twenty years earlier, preserving the primacy of his findings. This sequence of events has resulted in widespread recognition of Charles Darwin, but unfortunately very little recognition of Wallace's contributions.

Darwin was, by all accounts, polite and generous to his young colleague, and the two men corresponded for many years. In 1870, Darwin wrote to Wallace, "I hope it is a satisfaction to you to reflect—and very few things in my life have been more satisfactory to me—that we have never felt any jealousy towards each other, though in one sense rivals." For his part, Wallace treated Darwin with the greatest respect. In an 1868 letter to Darwin, Wallace wrote, "As to the theory of Natural Selection itself, I shall always maintain it to be actually yours and yours only." He went on to acknowledge that Darwin had worked the theory out years in advance in "details I had never thought of" and seemed convinced that his paper would have been seen as nothing more than "ingenious speculation," while Darwin's *Origin of Species* revolutionized the study of Natural History.

1. **Both Darwin and Wallace developed the same theory to account for their interpretations of the data they had observed. How can you account for Wallace's view that his putting forth the theory of evolution would have been seen as simply an "ingenious speculation" rather than the revolutionary effect of Darwin's *Origin of Species*?**

2. **Data does not tell scientists what to think! However, what does the above illustrate about the importance of data in science?**

As amicable as the relationship between Darwin and Wallace was, they differed fundamentally in the way that they viewed the power of natural selection. Wallace and Darwin's thinking was not identical. Like the species they studied, their ideas greatly diverged. Wallace returned in 1862, tired and ready to publish numerous articles. By then, Darwin's life had been engulfed in defending and promoting the *Origin of Species* and preparing his next work, *The Descent of Man*. In *Descent*, Darwin wanted to show how natural selection and sexual selection applied to human evolution. Wallace, however, disagreed entirely.

Darwin argued that while natural selection was the primary force at work, other processes also came into play. He had the important insight that organisms possessed many features that were not adaptations and not directly related to survival. While Darwin maintained that an organ built under the influence of selection for a specific role may be able to perform many other unselected functions, Wallace thought the opposite. Wallace wrote, "None of the definite facts of organic selection, no special organ, no characteristic form or marking, 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." Wallace argued that if we could not see the utility of a given organ or characteristic, it must be due to our own ignorance of its intended purpose or origin.

Darwin and Wallace also disagreed on the role of sexual selection in evolution. Darwin proposed sexual selection as a mechanism that could account for the presence of features that might be irrelevant, or even harmful, in the struggle for existence, but that played an important role in successful mating. For example, the bright red plumage of the male Cardinal could be dangerous to his existence, since it might stand out in the presence of a predator. However, that same bright red plumage could be attractive to the female Cardinal, thus, increasing the likelihood of a successful mating and therefore, the propagation of the species. Darwin theorized two types of sexual selection: competition between males for access to females, and female choice of mate. Wallace disliked the idea of sexual selection for three reasons: first, it compromised the idea of natural selection as the struggle for life itself, rather than merely the struggle for copulation (though the idea of male combat was sufficiently close to his conception of a battle for existence as to be acceptable); second, the concept of sexual selection placed too much emphasis on the role of 'choice', particularly female choice, in the struggle for existence; third, and most importantly, it allowed the development of important features that were irrelevant, if not downright harmful, to the functioning of an organism that, in Wallace's view, was a superbly-designed machine.

- **Note that while Darwin and Wallace disagree on the details regarding how biological evolution occurs, they both accept the overarching idea that species do evolve. Today, while many disagreements between Darwin and Wallace have been settled on Darwin's side, other details continue to be debated (e.g. Gradual evolution vs. Punctuated Equilibrium) without affecting the overwhelming evidence in favor of biological evolution.**

Wallace's unshakeable confidence in the exclusive action of natural selection caused Darwin to have second thoughts about his theory of sexual selection. In an 1870 letter to Wallace, Darwin wrote:

> I grieve to differ with you, and it actually terrifies me and makes me constantly distrust myself. I fear we shall never quite understand each other… You will be pleased to hear 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.

The biggest split between Darwin and Wallace, however, came with the question of human origins—in particular, they disagreed on human intellect. Darwin suggested that human intellect evolved according to the demands of the environment in which a group of humans found themselves. The intellect of the "savage," that is, the uncivilized tribesman living in the wilds of Africa, for example, had not evolved as far as the intellect of the sophisticated white European living in civilized society. It was commonly thought at this time that the brain of the savage was small and poorly organized. Wallace, on the other hand, maintained that all human groups had naturally equal abilities to develop their intellect. Instead, he suggested that the difference in sophistication resulted not from a lack of intellectual capacity, but rather from a failure to use existing capacities. As an example, Wallace pointed to the native peoples who had been trained to play complex instruments and music in Britain's colonial military bands.

3. **Today, the scientific community has rejected Darwin's view regarding the relative intelligence of races. So while his overarching theory and many of its details are still accepted, other notions have been modified or rejected. How does this illustrate that the scientific community is more willing to revise their thinking regarding biological evolution than many critics assert?**

That is not to say that Wallace did not consider European culture to be superior, as most of his contemporaries did. Indeed, he shared many of the same ethnocentric opinions of that time. But Wallace maintained that natural selection could not be at work in human intellect because it does not operate *before* it is needed. For example, he asked how higher math could be an environmental adaptation. Efforts

had shown that the 'primitive' mind could learn higher math, an adaptation obviously irrelevant for hunter-gatherer societies. Why would primitive man have a more highly developed brain than he either needed or used? If it is developed in anticipation of a future need, there must be some other phenomenon at work. Wallace suggested that this other phenomenon must be some higher being at work, "…a superior intelligence [that] has guided the development of man in a definite direction, and for a special purpose." Having begun with agnostic views, Wallace had now become a proponent of natural theology. That the human brain possessed these unexplained powers—such as higher math, morality, spirituality, etc—meant that human evolution must have been inspired by a divine presence at one point. This combination of spirituality and evolution was well-accepted by many of his contemporaries.

Darwin was shocked and appalled by this abrupt change in direction by Wallace, who had fully supported the idea of natural selection up to the point of human intellect, but not beyond. In 1869, Darwin wrote to Wallace, "I hope you have not murdered too completely your own and my child." But, Wallace didn't see that he had "murdered his child," because it was his view of natural selection that led him to reject it as the mechanism for human intellect, not an unwillingness to extend natural selection to human beings. Certainly, Darwin did not agree with Wallace's conclusions on human intellect, writing in a letter to Wallace, "If you had not told me, I should have thought that had been added by someone else. As you expected, I differ grievously from you, and I am very sorry for it." From that point on, Wallace ruefully referred to his theory of human intellect as "my special heresy."

Much of the information available to Darwin and Wallace was also known among other naturalists. However, Darwin and Wallace possessed the intellectual background, life experiences, and insights to invent an idea that would satisfactorily account for these and other data. Neither Darwin nor Wallace was the first to propose that species are related, but they were able to provide a plausible mechanism for that relationship. Furthermore, Darwin had collected massive amounts of data that the theory and mechanism successfully accounted for.

4. **While science is often portrayed as being done by lone geniuses, what does this historical narrative illustrate about the social nature of science? How do science textbook's emphasis on individual scientists distort how science really works?**

Today, however, the theory of evolution that is remembered is Darwin's. In the late 1800s, any talk of evolution demanded mention of his books. When conservative religious groups attacked evolution, it was Darwin's theory they deemed 'atheist.' When modern genetics combined with evolutionary theory, it was called the "Darwinian Synthesis." While both Darwin and Wallace's theories of evolution through natural selection are considered incomplete by modern standards, Darwin is almost always remembered as the theory's sole founder. Wallace, however, reached almost the same conclusion in a much different manner. He was the iconic Victorian explorer—always moving, learning, ready for adventure. His contribution of biological specimens was unmatched in his day. His story almost lost, the example of Alfred Russel Wallace shows how different paths can lead to the same conclusion, and even that conclusion can be utilized in different ways.