Alfred Russel Wallace & the Origin of New Species
TEACHING NOTES

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OVERVIEW

This module is designed to be used in a general level (9th grade) high school biology course. It introduces diversity in scientific thinking, personal motives of scientists, and influences of personal experience and relationships in science. Students use Wallace's experiences and data as he develops his theory of the origin of new species. Wallace's perspective is the compared to Darwin's. Finally, students consider how we might credit each for their discoveries.

Students have the opportunity to explore the following features of the nature of science:

a. diversity in scientific thinking
b. the role of personal motives of scientists
c. the importance of personal experiences and relationships of scientists
d. funding
e. communication in developing and presenting a theory
f. priority and credit

Students examine the biological content of evolution with respect to:

a. variation between species
b. biogeography
c. the role of geographic isolation
d. the role of the "struggle for existence"

INTRODUCTION

Most people are familiar with Darwin's contributions to the theory of natural selection as a mechanism for evolution. They may have heard of Darwin's travels on the *H.M.S. Beagle*, his book *On the Origin of Species*, or the influence of Lyell and Malthus on his thinking. However, historians also credit Alfred Russel Wallace, who independently developed a theory on the origin of new species (Brooks 1984; Fagan 2007, p. 111). In this case, students will investigate biological evolution through *Wallace's* story, experiences, and data. Just as Darwin's and Wallace's lives intertwined, so too do their stories in this case study, providing an occasion for discussing the relative credit accorded to eachfor the revolutionary concepts.

The case study text includes excerpts of recollections and letters by Wallace (and Darwin). Teachers may engage students further by printing them and asking volunteers to read each. This also helps to establish the independent "voice" of Wallace within the narrative.

There are also several optional activities based on reading Wallace's original letters. They can offer deeper insight into the human context of the episode.

THINK Exercises

The primary purpose of these questions is for students to develop scientific thinking skills and to reflect explicitly on the nature of science (NOS). The questions are open ended. In many cases, there is actual history as a benchmark (which can be shared after the students' own work), but by no means does it indicate an exclusively "correct" answer. Accordingly, an instructor should avoid overt clues or "fishing" for answers, implying that a particular response is expected or considered "more right." The case study should illustrate the blind process of science-in-the-making. To help promote thinking skills, the teacher should encourage (and reward) thoughtful responses, well articulated reasoning, and respectful dialogue among students with different ideas or perspectives.

Where the present case study echoes NOS features students have encountered in earlier case studies, the relationships should be noted and perhaps contribute to deeper discussion. This form of repetition and integration with prior knowledge significantly deepens learning.

THINK (1-3)
This opening series of questions is designed in part to gradually deepen the level of student participation. For example, at the very outset, the instructor may ask — merely by a causal show of hands — who knows who was Queen of England in 1847. The first question is simple, with many possible short answers. The first activity invites a bit more reflection, but is still quite open. The second question is a bit more challenging, and can be a good occasion to begin small group discussion. The questions that follow, then, may use a combination of discussion among neighbors and the full class.

THINK (1)
The question helps to amplify the role of funding in science (as a feature of the nature of science). Who would support Wallace, an amateur, in "pure" research? Later, one might contrast Wallace's need to work with Darwin's inherited wealth, which allowed him much more leisure time to pursue his studies.

THINK (2)
Asking about types of data or observations highlights the role of theory or problems in guiding science. The relevant facts do not merely announce themselves. Fruitful observations are shaped by clear intentions. One must start with a conceptual scaffolding of some kind (although not always a narrow "hypothesis"), even if it later proves to be incorrect. Here, student responses may also help highlight the relevance

of particular empirical data to general claims.

THINK (3)
First, Wallace's misfortune helps to underscore again the human and thus sometimes emotional dimension of science. While many specimens and scientific records are lost, Wallace can also remember his observations. The episode is also another occasion to discuss funding and motivation in science.

THINK (4)
Wallace's career choice highlights again how science reflects human interests and decisions. Science does not unfold on its own inevitable or predetermined path, but reflects human motivation, and thus cultural interests and trends as well.

THINK (5)
This problem aims to help focus students on a key element in addressing the central problem of new species. Even if students do not develop a clear solution on their own, the reflection helps prime them to appreciate Wallace's interpretation more fully.

THINK (6)
Again, the problem may not have an immediate solution that students can see. At this point, for instance, the limits of populations have not been explicitly profiled — a key element in Wallace's (as well as Darwin's) thinking, as articulated in the text to follow. Still, discussion about alternatives highlights the role of creative thinking in science. One cannot legitimately say that "the data speak for themselves" (as one often hears). Students should be encouraged and rewarded for any well reasoned explanation.

THINK (7)
This question addresses directly the nature of reward and credit in science. Why is credit important? For some, it can motivate novel and sometimes "risky" research, thereby promoting innovation and discovery. Starting in the 17th century, recognition of discoveries was linked to making one's findings public so that others could learn about and benefit from them. Sometimes, however, scientific knowledge may be valuable for commercial purposes only if kept secret. Not everyone may want to share it with others. In other cases, the quest for priority can lead to unfruitful competition, with premature announcements and lack of careful or responsibile work. Should priority matter to credit?

In this episode, was Darwin too modest in his letter to Lyell? Were Lyell and Hooker too forward in presenting Darwin's earlier ideas along with Wallace's? Should Wallace have been consulted first? How might these decisions at the time have influenced history in the long run? Biologists now typically refer to "Darwinism" and "Darwinian" theory: should this be changed?

THINK (8)
While the shared experiences and observations were potentially available to anyone, these particular experiences helped shape common elements in Wallace's and Darwin's thinking. Individual biographical backgrounds thus seemed immensely important in

bringing together those particular experiences and fostering the shared discovery. Attributing discovery to a concrete set of experiences contrasts sharply with a widespread view that credits an ill-defined intellectual prowess, or “genius.”

For example, natural history collecting in childhood fostered an appreciation of the diversity of species, and their hierarchical, or tree-like organization in a classification scheme. The striking experiences of different species separated by rivers led to an implicit understanding of the role of geographical barriers in maintaining the integrity of closely related species. Noting similar species across oceans (based on extensive travel experience) helped highlight the role of geographical continuities (in addition to barriers) on a large scale. Familiarity with species similarities and differences, as frequently exhibited in archipelagoes, further underscored how the hierarchical classification of organisms could reflect a tree-like relationship of ancestry, related to geographical dispersal, isolation, and local change. Finally, reading Malthus’s essay *On Population* was critical for profiling how nature could be a selective agent, reducing variation or diversity, and ultimately leaving gaps between geographically separated lineages. One may note that in both cases, biogeographical relationships were fundamental in the transformational reasoning towards divergent evolution.

NOS Reflection Questions

These reflections function partly for recall and review but also help critically to consolidate and thus complete the central NOS learning in the case study. They are essential to “closing” the lessons and making the NOS thinking explicit and articulate.

1. **the influence of early encounters and life experiences** (THINK 5, 6, 8)

    Here, one may recall the role of the chance meeting with a neighbor who inspired Wallace’s interest in nature and rare species. His friendship with Bates fostered his collection of beetles, and thus an appreciation of the hiearchical classification of organic diversity, as well as skills and interest in collecting. The long friendship with Bates also helped make the dream of an Amazon expedition a reality — with its significant observation about geographical barriers

    Wallace’s wide travels surely helped highlight the biogeographical relationships that were critical to the problems he considered and how he framed thinking about them. Other experiences, as discussed above in the notes on THINK (8), were also significant. As noted there, finding the roots of discovery in a set of concrete experiences contrasts sharply with a widespread view that attributes scientific creativity to sheer intellect or “genius.” By implication, anyone with a unique constellation of experiences might be well positioned to make a significant discovery.

2. **personal motivation** (THINK 3, 4; ACTIVITY 2)

    Here, one might recall Wallace’s love of plants and beetles, and of nature generally. Wallace also persisted in collectign and studying species, even after the huge loss of much of his collections from the Amazon. We might well imagine that Wallace enjoyed his adventures, but he also applied himself to scientific study while doing so.

3. **funding** (THINK 1, 3, 4, 9; ACTIVITY 1)

Wallace first encounters this problem in thinking through how to fund his Amazon expedition. One may also note that his collecting was shaped as much by the practical need to find rare, popular, or dramatic specimens, as by the scientific aim of significance to diversity or species questions. For much of his life, Wallace had to be mindful of merely making a living, before he could consider pursuing science.

The challenge of funding is particularly poignant when one contrasts Wallace to Darwin, who came from a wealthy family. For example, Darwin had the financial resources to *hire* assistants to collect for him while voyaging on the *Beagle*. Through his inheritance, Darwin was also able to raise a family on the income of an estate farm, affording him considerable leisure time to pursue his studies and professional correspondence.

4. **scientific communication** (THINK 3, 7; ACTIVITY 2)

Scientists can build on the work of others because they communicate their findings. Journals and books, of course, are standard repositories. But correspondence can also be an important vehicle for conveying scientific ideas, as well. Many of Wallace's letters from the Amazon to his agent, Stevens, were published in the London natural history magazines, allowing him to communicate his emerging findings. Others he used to reconstruct details in his thinking after losing his notes in the shipwreck. Wallace's presentations at the scientific societies in London were also important — for example, his observation about labeling specimens collected along rivers.

Most dramatic, of course, was Wallace's letter to Darwin in 1858. The two had corresponded a few times earlier. This note was an occasion to share a new idea and to collect comments before publication. But the letter allowed Darwin, Lyell and Hooker to acknowledge the convergence of two scientists in developing virtually the same concept. That led importantly to the formal presentation of the discovery, which Darwin had been withholding previously.

5. **diversity in scientific thinking (by different persons)** (THINK 9)

Just as species can adapt from a pool of genetic variation, so science can benefit from a diversity of conceptual approaches. In some case, contrasting perspectives can cross-check each other and highlight possible errors.

In this case, Darwin and Wallace developed primarily the same theory, but with individual perspectives and variations, as depicted in the table comparing their views. Darwin was extremely sensitive to criticism from others that he could not account for why new organismal variants emerged. (He had no concept, for example, of mutation, chromosomal rearrangements, or changes in gene regulation.) He thus "retreated" to explanations that involved influences from the environment -- now rejected as "wrong." Wallace, by contrast, maintained that one did not need such a detailed explanation for the theory of natural selection to be sound; one needed only to document that variation occurred. On the other hand, Wallace rejected any role for evolution on the human mind, whereas Darwin was extremely interested in behavior and incoroporated such features into his view of evolution, including human morality and sociality. The differing perspectives provided raw material for scientific discourse, and for guiding consideration of further evidence.

6. **priority and credit** (THINK 7, 9)

Credit is customarily given to the first person to present an idea. This episode dramatizes some of the challenges inherent in that custom, and opens discussion of alternative forms of reward and motivation.

In this case, while Wallace and Darwin shared honors in announcing their discovery, historically the bulk of the recognition has been accorded to Darwin. As he noted in his letter to Lyell, much of the work of the theory was in its application. Darwin's book, *On the Origin of Species*, and many subsequent publications attest to the depth of work that Darwin invested in developing the theory, not just introducing it. At the same time, Wallace wrote several important volumes on biogeography which may not be recognized now for their importance. Views about credit are subject to personal cultural perspectives about "fairness" and justice. But one may also want to reflect on how the differences in credit matter to the practice of science itself, or to our understanding of the nature of science.

Supplemental Activities: Reading Wallace's Letters

These activities from the Natural History Museum of London are based on reading some of Wallace's original letters to his family, friends, and colleagues -- both document images and transcriptions available. They further appreciation of the human context of science and science as a career. Questions are included online.

"Wallace is Shipwrecked and Loses His Collections":
http://www.nhm.ac.uk/nature-online/collections-at-the-museum/wallace-collection/item.jsp?itemID=59

"Qualities of a Good Field Assistant and Hand-rearing an Orang-utan"
"Collecting Insects in Singapore"
http://www.nhm.ac.uk/nature-online/collections-at-the-museum/wallace-collection/students2.jsp

"The Insects of the Malay Archipelago"
"Wallace Comments on Darwin's Work"
http://www.nhm.ac.uk/nature-online/collections-at-the-museum/wallace-collection/students3.jsp

"Wallace's Sense of Humour and Admiration for Darwin"
http://www.nhm.ac.uk/nature-online/collections-at-the-museum/wallace-collection/students4.jsp