Why Charlie Darwin Matters Now More than Ever

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Note: *In celebration of Charles Darwin’s 200th Birthday and the 150th anniversary of the publication of his seminal work, On the Origin of Species, this is the first in a series of articles that highlight his relevance for teachers today and provide lesson plans to bring his work into your classroom. We begin with an introduction to Charles Darwin’s life and work through storytelling, a first person monologue as a way to introduce students to several key concepts including inquiry, the nature of science and a basic understanding of what lead Darwin to the concept of evolution.*

Charles Darwin is an icon of modern science. As teachers struggle to inspire the next generation of scientists, as the debate over Creationism and Evolution rages in modern politics, as students look for heroes beyond pop singers and athletes, Darwin becomes more vital than ever before.

Darwin is the ideal model for future scientists in their pursuit of more reliable knowledge. The story of his life and work offer an ideal example of how wonder and curiosity inform scientific inquiry; and how rigorous scientific practice deepens our understanding of the natural world.

Darwin’s research and his brilliantly conceived theory of natural selection form the cornerstone of ALL modern biology. In fact, as Theodosius Dobzhansky, who helped integrate genetics with Darwin’s theories, once wrote, “Nothing in biology makes sense except in the light of evolution.” Evolutionary theory is at the beginning and end of all lines of inquiry from ancient Triassic feathered reptiles to the development of medications for HIV/AIDS. All 50 states agree on the importance of teaching evolution and have mandated that it be taught as an integral part of their life science curricula (…exempting a few state boards of education, which will be explored in more detail in a later article.)

Every student of science should also be a student of the life and work of Charles Darwin for several compelling reasons.

Darwin was the quintessential scientist. He was born in an era when the pursuit of science was not even a recognizable career. Few universities had a science department as we conceive of them today. Yet he was enamored with the process of inquiry. He began as a young boy experimenting with chemicals in the garden shed. He and his brother Erasmus produced such weird and foul smells that Charlie was pinned with the nickname of ‘Gas,’ certainly a point some students will find engaging! As a young man he became an ardent collector of beetles, boulders and barnacles. In his personal evolution as a scientist he learned that science is more than a collection of facts, but a way of asking questions and looking for answers, a way of organizing data to draw conclusions about the underlying laws of nature. His development as a scientist is a model we all can learn from and emulate.

Darwin was constantly engaged in inquiry. He not only asked big questions about the origin of species and the formation of coral reef islands, but he was habitually following everyday lines of thought with hands on

Darwin Tells His Story

Where do I begin? With questions, of course! Questions are the foundation of all good science!

I spent my life trying to answer the big questions, the mystery of mysteries… Did creation happen just once? Or is the story of creation forever and always unfolding? Consider all of the creatures upon the earth today; were they all here since the dawn of time? Or do you believe that new species evolve from the old? If you believe as I do, how is it that new species are formed? What are the mechanisms by which species adapt to changes in the world around them?

In the struggle for survival, what governs the success of some and the extinction of others? What are the laws of nature that shape life upon this planet?

These are the questions I sought to answer and shall answer for you if you dare to ask.

My curiosity began as a young man. I was always wandering in the forest and fields of my Uncle Josiah Wedgewood’s estate, collecting insects and stones.

experimentation. Curious about the diversity and success rates of weeds in his garden, he got his children involved in mapping out the number of sprouts in a small patch of weeds and then charting their growth and survival rates. Curious about differences in the anatomy of different species of domestic ducks and chickens, man-made selection, his gardener and his cook helped Darwin to dissect and compare skeletons of hundreds of specimens destined for the dinner table. His family was most enamored with his experiments on orchids and their pollinators, joyfully assisting him in the cultivation of flowers, hand pollinating orchids, and watching bees and butterflies at work. Scientists from around the world sent Darwin seeds and like most of his publications, his book on orchids broke new ground about a subject no one had ever explored with such patient and persistent questioning. Extending his own work in evolution, he put forth the idea that plants and their pollinators evolve together, a concept known today as co-evolution. His countless experiments are an encouragement to our own lines of inquiry.

Darwin's work ethic was simply astounding. In spite of a debilitating illness that some have theorized was Chagas disease, Darwin kept up a steady communication with dozens of scientists around the world. There are over 14,000 of his letters still extant in museums and private collections. He published articles, pamphlets, and more than 20 books. (His complete works are available at http://darwin-online.org.uk/). He would get hooked into a line of inquiry, and pursue it for years. He dissected hundreds of barnacles and analyzed all of the then known fossil barnacles, ultimately publishing a two volume series that is still seen as one of the most important works on barnacles ever written. He was the first to discover that what were thought to be parasites were actually tiny male barnacles living in a parasite like relationship with the much larger females! His persistence in following truth wherever the truth led him is an inspiration to us all.

The life and work of Charles Darwin is a potent teaching tool to inspire students to do the work necessary to follow their curiosity through the process of inquiry. By sharing Darwin stories, reading about Darwin, and more importantly reading Darwin, we can deepen our understanding of the nature of science and utilize his work as the launching pad for the next generation of discoveries.

Implications for the Classroom
What better way to celebrate the 200th birthday of Charles Darwin than to explore his life. Clearly reinforcing state mandated goals in reading and literacy, document based questions and the history of science, as well as science process skills, the following lesson could be done in a single 48 minute period as part of your celebration of Darwin Day, or it could be the launch of a month long unit on inquiry and the nature of science.

In the following lesson plan you will:

- Begin with a few questions, the start of all good science!
- Tell or read a few Darwin stories. (See the sidebar, visit a few websites or check out the references below.)
- Engage your class in a discussion of what we can learn from Darwin about his theory and his process of discovery.
- For homework, ask students to go home and tell a Darwin tale or two, encouraging them to discuss evolution with their family.
- If time allows, as a follow-up activity, discuss the questions that arise from these discussions and use these questions to initiate student lead inquiry. How can they design an investigation to find their own answers to their questions?

My research began when I was yet in college, at Edinburgh, Scotland, where I began to collect beetles in earnest. No poet ever felt more delighted at seeing his first poem published than I did at seeing my first beetle identified in Stephens' Illustrations of British Insects; under the illustration were the magic words, 'captured by C. Darwin, Esq."

I will not soon forget one afternoon in particular.

As I was walking along, I came upon a tree where some bark was pealing loose. There I spied a beetle. Without a net or collecting jar, I snatched it up in my hand. In almost the same moment I spied a second, distinctive beetle and snatched it up into my other hand. Soon after, under the edge of the bark, I saw a third unique species of beetle. What was I to do? Two hands, three beetles, I popped one beetle into my mouth to free up a hand. In that same instant the beetle squirted an acrid fluid into my mouth. My tongue, lips and the inside of my cheeks burned with this acidic fluid. What would you do? Exactly what the beetle would want you to do. You would spit out the beetle, as did I. The third beetle, the one I was about to scoop up also escaped.

I had to pause, and wonder… How could there be three varieties of beetles under this one piece of bark? Clearly, all three were insects, with their six legs and hard shiny, exoskeleton, but such variety in one small place? Each had adapted to different foods: One had pinchers for eating leaves, one had a snout for sucking sap, and one had larger pinchers for eating other beetles, an herbivore, a parasite and a carnivore. Over time, these species had

Begin with a few questions, the start of all good science!
With the simple introduction that today we are celebrating the 200th birthday of one of the most important thinkers of the modern world, Charles Darwin, and the 150th anniversary of his book, On the Origin of Species, ask students what they know about Darwin. When I say Charles Darwin, what comes to mind? What do you already know about him? Without judgment, letting truth and false impressions rise, allow the conversation to roam for about five minutes. You can also ask, "What do you know about the concept of evolution?"
Moderate a brief dialogue that airs their prior knowledge and possible misconceptions of his work. Inform the class that you are about to share a few stories about Darwin that highlights his revolutionary idea.

Tell or read or listen to a few Darwin stories.
Without further discussion, before you begin reading, ask students to keep in mind the following questions. Warn students that at the end of these stories we will discuss these questions. You may wish to write them on the smart board or overhead projector:

> What is evolution?
> How has the idea of evolution impacted my life?
> What can I learn about the process of science from Darwin's work?
> What did Darwin do as a scientist that led to his theory?

At this point in the lesson you have a few choices:
Allow us to encourage you to tell a few stories. Reading his first major book, "The Voyage of the Beagle" or any good biography of Darwin, one of the first things that jumps out is his ability to illuminate scientific ideas through insightful storytelling. His stories take you there and allow you to gaze over his shoulder as he gathers the evidence for theory. Students can share in the Eureka moment as they piece together the clues alongside Darwin.

Stand up, act it out, if you like you can fake a British accent or even borrow a Santa Clause beard and ham it up. Storytelling brings the stories to life!

Another option is to read a few stories. The story in the side bar is a good place to start. The bibliography below highlights several other stories that are the cornerstones of evolution. As a storyteller, I often read a few versions of the story to piece together a good telling. Based on a performance, the book Charles Darwin and His Revolutionary Idea was written to be read aloud in about 30 minutes, allowing time for conversation afterwards. If you have a classroom set of books, students can read along.

The easiest option is to play the CD audio-book, so the class can listen to the author read.

Whatever you choose, share the stories with the class.

Engage your class in a discussion of what we can learn from Darwin about his theory and his process of discovery.
After the stories are over, divide your class into small groups of four, asking them to choose one person as a note-taker, another as moderator, a third as time keeper, and the fourth is the cheerleader, making sure it stays positive and everyone gets a turn. Give the groups five minutes to make a list of the important ideas in the stories, answering the questions:

changed to survive, *inheriting* traits from their ancestors, but what mechanism selected these species to thrive here?

I later transferred to Trinity College in Cambridge. At Cambridge, I brushed up on my Greek and Latin and Hebrew. I studied the Bible and church history, but I also took every course in Natural history that I could. I met J. S. Henslow a professor of botany. I took all the courses he offered. I took one botany course three times. I became known as "The man who walks with Henslow". Professor Henslow used to say "What a fellow that Darwin is for asking questions!" Henslow challenged me to think about each species of plant and how it fit in the larger scheme of things.

Henslow introduced me to Reverend Adam Sedgewick, a geologist who allowed me to join him on a walk through Wales, a geological survey. This tour was of decided use in teaching me how to make out the geology of a country. He taught me to read the landscape like a book. The stones tell the stories of the history of the land. I was simply amazed at how he could piece together evidence from scattered clues! But the most important thing I learned from Professor Sedgewick was that science is more than a collection of facts, more than a collection of rocks or beetles or dried flowers. Science was a process of asking difficult questions and looking for answers. The facts are important, but science consists in grouping facts so that general laws or conclusions may be drawn from them.

Unbeknownst to me, all of this was preparing me for the journey of a lifetime, five years as the ship's naturalist for the H.M.S. Beagle. I could tell you

What is evolution? How has the idea of evolution impacted my life? What can I learn about the process of science from Darwin's work? What did Darwin do as a scientist that led to his theory?

After the five minutes are up, invite each group to share one idea. Throughout this process, model the concept that good science is based on good questions, by asking lots of questions to lead the conversation, while encouraging students to ask questions.

Next, write V.I.S.T.A. vertically on the board. As a class discuss and define the five foundational concepts of evolution. Ask students to copy the five words and write their own brief definitions of the terms Variation, Inheritance, (Natural) Selection, Time, and Adaptation.

If time allows, discuss how Darwin's life and travels lead him to the theory. Depending on which stories you read or tell, lead the conversations with questions like: What did he discover as he travelled the globe on HMS Beagle? What was so different about the Galapagos Islands and what did he learn there? How did the earthquake in Concepcion shake up his ideas about geological time?

If so compelled, students can be given the assignment of writing a short, 200 word essay that answers either one of these questions, their choice.

> How has the idea of evolution impacted my life?
> What can I learn about the process of science from Darwin's work?

These brief essays can be collected at the end of the period and given two grades, one for clarity of thought and effectiveness in answering their chosen question, the other grade can be for grammar, spelling and mechanics.

For homework, ask students to go home and tell a Darwin tale or two, encouraging them to discuss evolution with their family.
A homework assignment that challenges students to share the idea and therefore deepens their comprehension: Ask them to go home and tell their favorite Darwin story. They can explain/discuss V.I.S.T.A. and their new understanding of evolution with a parent. To facilitate that discussion, students can be given a copy of page 35 from The Voyage of the Beetle (pdf). This illustration, the question and the clue is an excellent condensation of natural selection and a great visual conversation starter. Encourage them to take questions and to write down the best questions and/or questions they cannot answer. For extra credit, students can be asked to get a signature from each person with whom they discuss V.I.S.T.A. Parents can sign the back of the handout, where students can also write down their questions.

If time allows, as a follow-up activity, discuss the questions that arise from these family discussions and use these questions to initiate student lead inquiry. How can they design an investigation to find their own answers to their questions?
As a follow-up exercise, which could be the introduction to a larger unit on inquiry, the class could discuss in depth what questions arise from their family conversations. Moderate a classroom conversation where students share comments and questions from their parents. Write a list of questions on the board. Encourage students to share their own questions about evolution, how it impacts their life, and their natural curiosity about the subject. Tell students that this is a conversation of questions, what do you want to know? What are you curious about? As you were listening or

a hundred stories about my travels. And, if you would like to learn more you may wish to read my book, Voyages of Beagle. This voyage laid the groundwork for my theory on the transmutation of species, now known as evolution.

What is the theory of evolution you might ask? Well, I have already laid out the evidence before you.

If you think about this theory of evolution through natural selection as my point of view or VISTA then maybe you can begin to understand how all of the answers are already there in my stories from the voyage of the Beagle. V.I.S.T.A. my view, stands for *Variation, Inheritance, Selection, Time, and Adaptation*.

The Variation of species via the Inheritance of specific traits, through the process of natural Selection, over a broad expanse of Time, allows the Adaptation of individuals to evolve into new species.

Do you see my point of view, my V.I.S.T.A.? Let me tell you one more story to help make this clearer for you.

On the tropical islands of Malaysia I found the most amazing species of comet orchid that had an unusually long spur or nectary, the chamber at the back of the flower that stores nectar. It was 30 centimeters long. I hypothesized that there must be a bird or butterfly that has a tongue or beak long enough to drink that nectar and pollinate the flower. Over time the tongue of the pollinator must grow longer, must adapt, to pollinate the flower or the flower would not produce seed, so its young could inherit the longer spur. This process of co-evolution where the tongue gets

reading, what questions do you have about Darwin or evolution or his travels?

After ten minutes or so, choose one question as the starting point for a classroom discussion of inquiry. What is inquiry? How can we find the answer to this question? What are the first steps you might take to look for answers? What next? What next? Explain or discuss the word hypothesis, an educated guess, and then discuss what we already know, educated, and then ask students to guess at an answer. How can we design an investigation to test our hypothesis? Discuss both the importance of library research, "What do we already know about this subject?; and field research, "How can we design an experiment to test our hypothesis?"

Here is one recent example of this type of conversation leading to inquiry, and a question that comes up often after a performance of Darwin stories: With the knowledge that Darwin was fascinated with beetles, how is it that three different types of beetles could live in the same habitat? How has each species adapted to their niche? This led to a discussion of how many beetles live around here? I am personally curious about the types of beetles that live in my backyard. Inspired by Darwin, I have begun collecting, even getting the neighborhood kids excited by sharing my butterfly nets and collecting jars, bug books and field guides. Starting with a question, we wander into the library where field guides lead us out into the field. In North Carolina, what different types of beetles live in the mountains, the forests, and the wetlands? What common species are found in all three habitats? Working with the North Carolina Department of Natural Resources, students can monitor the quality of their local streams and contribute data to vital, ongoing scientific studies by simply collecting insects as macro-invertebrate indicator species. I monitor the creek in my backyard and have even helped the Iowa and Illinois DNR present teacher training in water quality assessment using macro-invertebrate indicator species.

longer, meaning the pollinator is more successful, more fit to have young, and the variation of the flower, must grow hand in glove. Now some laughed at the idea that a bird or butterfly could have a foot long tongue. They used this one example in an effort to ridicule the entire theory. They said I must be making it up; if I can imagine an insect with a foot long tongue I could imagine anything. Fifty years later they discovered a sphinx moth that only lives in Malaysia that has a foot long proboscis that it carries curled up. This rare moth is the only pollinator for this rare orchid. It took them fifty years to find the evidence to prove this theory correct!

Excerpted from Charles Darwin and His Revolutionary Idea. Ellis, Brian "Fox" Fox Tales International, 2008. Illustrated by Peter Olson. Used with permission.

(Going two steps further down this road, I do think it important that teachers are engaged in research, share their basic curiosity and ongoing inquiry, even if it is as easy as sharing their hobbies or telling stories about outdoor adventures. Don't get me started talking about my family making maple syrup or my wife's fondness for growing heirloom tomatoes.)

After the larger classroom conversation, students can then go back to their small groups and help each other design an investigation. First, ask each student to independently write down a question that they want to answer. Next, each student can share their question with the group and then the group can spend three minutes helping that student formulate a hypothesis and design an investigation. Taking turns, the group of four helps each student map out their investigation. At the end of this conversation, each student could be asked to turn in a sheet of paper with his or her question big and bold at the top, the educated guess underneath it, and at least three to five steps they might take to look for an answer.

Each question could be the launching pad for research in the library or in the field. Ideally, this could even be the catalyst for a career in science! Allow students to design an investigation and look for answers!

Clearly this is the just the start of a much longer unit than this article allows room for discussion, but just as clearly, Darwin's ideas and his methodology can be an inspiration and a model for real inquiry in the classroom.

In the next issue we shall dive more deeply into current research and the historical record of evolution in an article entitled Kicking the Tires of Natural Selection Theory: The Carriage Still Runs after 150 Years. In the final article in the series we shall explore more backyard science and ways students can participate in global studies of bird populations, behavior and migration, comparing Charles Darwin and John James Audubon:

Audubon's Birds of America Inspires Darwin's Finches of the Galapagos.

About the Authors

Brian "Fox" Ellis is a storyteller, author and school consultant, who has been a frequent keynote speaker at science teacher conferences. He has published 11 books, including Charles Darwin and His Revolutionary Idea, based on his one-man show as Darwin. His award winning children's picture book, The Web at Dragonfly Pond, explores aquatic ecology and the food web. For more information about performances and workshops please visit www.foxtalesint.com

Dr. Anne Weaver's book The Voyage of the Beetle has received critical acclaim for its "playful, creative, and beautifully conceived and executed" description of the natural selection theory and its "loving and erudite" portrayal of Charles Darwin. Dr. Weaver taught college-level classes in human evolution for many years. She continues to write (a second book, Children of Time, is in press), mentor middle school science teachers, and work with local organizations devoted to improving science education. Visit her web site at www.voyageofthebeetle.com

To help you find stories we recommend:

Ellis, Brian "Fox" Charles Darwin and His Revolutionary Idea.
Peoria, IL. Fox Tales International, 2008. Illustrated by Peter Olson. Written in an intimate conversational tone, the reader is invited to listen to Darwin tell his story of the Voyage of the Beagle and the research that lead to his revolutionary theory. As did Darwin, the book answers critics and offers insight into the scientific process. More than 40% of the book is built from direct quotations, another 30-40% is paraphrased passages, and all of the ideas are 100% Darwin. The goal is to allow middle school and high school readers to hear what Darwin had to say, not the misinterpretations or hearsay. A companion audio-book is also available at www.foxtalesint.com

Weaver, Anne H. The Voyage of the Beetle.
Albuquerque, NM. University of New Mexico Press, 2007. Illustrated by George Lawrence. Playful, yet insightful, the book invites the reader to travel along with Charles on his famous voyage on the H.M.S. Beagle. A witty beetle named Rosie offers clues to what Charles called the "mystery of mysteries:" the origin of earth's diverse life forms.

For Adults:

Stone, Irving, The Origin: A Biographical Novel of Charles Darwin.
Garden City, NY: Doubleday, 1988. Irving Stone might be best known for his biographies of Michelangelo and Van Gogh, but his research and lively writing make this one of his best reads. An historical novelist at the peak of his career, writing about our favorite scientist! This book is a great source for stories. Some of the most tellable tales are in chapter 4, covering the voyage of the beagle: pgs 157-340.

Darwin, Charles, On Natural Selection.
N.Y. N.Y.: Penguin Group, 2005. A tightly edited version of On the Origin of Species that makes every effort to maintain Darwin's original outline, cutting away a lot of the denser scientific examples without diluting the overarching concepts. More than Cliff Notes, this book is an easily digested condensation of this intellectual feast. Pages 31-32 include a short story about the transmutation of wolves and cats. Pages 13-14 include a vivid story about the relationships between, flowers, bees, mice and cats.

Quammen, David. The Reluctant Mr. Darwin: An Intimate Portrait of Charles Darwin and the Making of His Theory of Evolution.
N.Y. N.Y. Atlas Books. 2006. A beautifully written and accessible introduction to Darwin and his ideas.

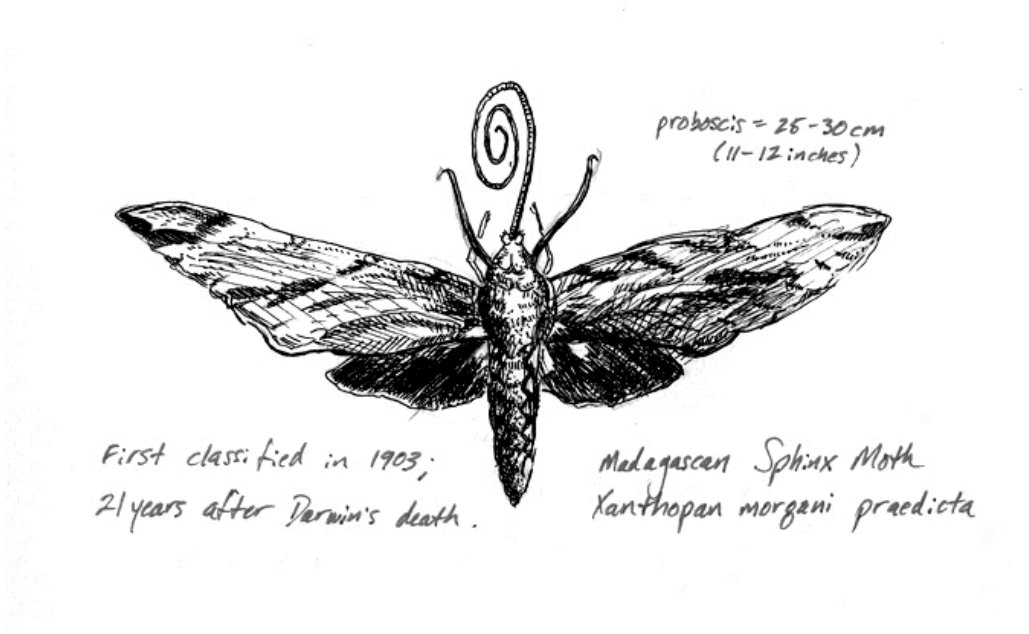
A few favorite web sites:
The Field Museum in Chicago, working with the American Museum of Natural History in New York and the Natural History Museum in London, created a touring exhibit, (where Brian's performance premiered), as well a wonderful set of interactive web pages at http://www.fieldmuseum.org/darwin/

The National Science Teachers Association has developed several interactive lesson plans for teachers to use when teaching about Darwin's Voyage of the Beagle, the Galapagos and Evolution: http://www.nsta.org/publications/interactive/galapagos/resources/page1.html

Scholastic Books presents interactive lessons for exploring Darwin and Adaptation at http://teacher.scholastic.com:80/activities/explorations/adaptation/index.htm

A wealth of commentary and links to other great sites can be found at Blog for Darwin: http://citizenship.typepad.com/blogfordarwin/2008/11/welcome-to-blog-for-darwin.html

But the best all around site with maps, photos, diary entries, biographies of his friends, letters, etc is http://www.aboutdarwin.com/



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