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**ABSTRACT**

Students, using information gained since 1859, write letters to Charles Darwin critiquing passages from the first edition of *On the Origin of Species*.

**Key Words:** *Letters to Darwin; origin of species; correspondence; nature of science; secondary education.*

If your biology students could write a letter to Charles Darwin, how would they critique the 1859 edition of *On the Origin of Species*? Darwin had extensive correspondence throughout his lifetime, seeking specimens, testing ideas, and maintaining his morale. In fact, newly discovered Darwin personal correspondence turns up every year, adding to the 18 volumes already published (Burkhardt & Secord, 2010). An interesting class exercise is to have students imaginatively add to this correspondence.

They can select passages from the 1859 first edition of *On the Origin of Species* and act as a correspondent with Darwin to clarify some of the ideas in the passages. Table 1 lists passages in which Darwin

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was observing facets of nature without the information that was discovered since 1859. The left-hand column identifies the pages containing the passages that deserve comment, and the right-hand column identifies some of the people responsible for discovering or popularizing the new information. In 1859, Darwin was operating without knowledge of continental drift, transitional fossils, chromosomes, genes, DNA, mutations, and molecular biology.

Darwin had some famous misunderstandings due to the gaps in scientific knowledge in his time, for example his mechanism of inheritance via gemmules (Darwin, 1871), but Table 1 lists only content in the first edition of *On the Origin of Species* (Costa, 2009). Students can adopt the personage and time frame of the scientists in the right-hand column and draft a letter to Darwin, from the future, explaining the new discoveries to him. The student correspondents can compare knowledge at the time of their writing to Darwin's 1859 text and suggest modifications to the text. This exercise shows the tentative and self-correcting nature of science, and the benefit of collaboration and communication in advancing ideas.

**Table 1. What Darwin didn't know.**

<i>On the Origin of Species</i> (1 <sup>st</sup> edition, 1859)	Discoveries since 1859
Pages 17 and 254: all dogs not descended from any one wild species	All dogs from gray wolf by genetic analysis (Vilà, 1997)
Page 86: "natural selection will ensure that modifications consequent on other modifications at a different period of life shall not be in the least degree injurious..."	Antagonistic pleiotropy model states that a trait that is detrimental late in life may still be selected for if it enhances reproductive fitness early in life (Williams, 1957)
Page 87: short-face tumbler pigeon bred so that fanciers must assist in the act of hatching	Bull dogs are bred with phenotypic features that require cesarean section for birth, and lack of selection against a small human pelvis or a large newborn head may have similar effects in humans (Walsh, 2008)

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**Table 1. (Continued)**

<b>On the Origin of Species (1<sup>st</sup> edition, 1859)</b>	<b>Discoveries since 1859</b>
Page 144: "What can be more singular than the relation between blue eyes and deafness in cats, and the tortoise shell color with the female sex..."	Phenotypic traits can be linked due to proximity on same chromosome (Morgan, 1911); and X inactivation and mosaic phenotypic effects for X-linked genes (Lyon, 1961)
Page 134: inheritance of acquired characteristics (but admits on page 135 that mutilations are not inherited)	Separation of soma from germ line cells prevents inheritance of acquired somatic characteristics; experiment on cutting off mouse tails (Weismann, 1889)
Page 184: From observations of explorer Samuel Hearne in Canada, Darwin could see how a bear ancestor could have evolved into a whale	Whales most related to artiodactyls (Thewissen et al., 2001)
Pages 190 and 452: swim bladder, an organ of flotation, was then adapted for respiration as lung	Dorsal swim bladder and ventral lungs not strictly homologous, with complicated evolutionary ties (Perry et al., 2001)
Page 210: the mutualism of ants and aphids due to ants offering cleaning service by removing honeydew from the aphids	Aphids provide honeydew, ants supply protection (Way, 1963)
Page 237: selection for sterile workers in bees due to family level selection	Haplodiploidy and kin selection are the sources of apparent altruism and selection for sterile castes (Dawkins, 1989)
Page 273: First cross causes decreased variation in offspring, and then increased variation with succeeding generations	Particulate nature of inheritance with F1 heterozygosity and dominance causing decreased phenotypic variability in F1, which then increases in second and succeeding generations (Mendel, 1865)
Page 275: The offspring of a male horse and a female donkey (a hinny) looks different than the offspring of a male donkey and a female horse (a mule) due to prepotency	Parent sex specific phenotypic effects can be due to differential X chromosome inactivation or genomic imprinting (Monk & Grant, 1990)
Page 287: reasoning from denudation of the Weald gives 300 million years time from latter Secondary	Historical explanations for age of Earth explored, including Kelvin's 1862 estimate of 93 million years based on heat dissipation from Earth, and current ideas (Burchfield, 1974)
Pages 287 and 309: Darwin accepts Lyell's proposal that land masses oscillate vertically, causing cycles of flooding and water retreat	Isostatic postglacial rebound can cause land to oscillate vertically, mechanism plausible when plate tectonics theory accepted in mid-20th century. Darwin accepted Agassiz's theory from 1839 of ice age glaciations (Herdendorf, 1990)
Page 321: "...apparently sudden extermination of whole families or orders, as of Trilobites at the close of the palaeozoic and of Ammonites at the close of the secondary period..."	Impact extinctions mean there are examples of catastrophism instead of absolute gradualism (Alvarez et al., 1980)
Page 357: dispersion over water was the key in distribution of flora and fauna throughout the continents, as continents were not united "within the recent period."	<i>The Theory of Continents and Oceans</i> , first published in German in 1915, outlined continental drift, which in essence created the land bridges to which Darwin was opposed (Wegener, 1968), and plate tectonics provides the complete modern theory (Dawkins, 2009)
Page 310: "The several difficulties here discussed, namely our not finding in the successive formations infinitely numerous transitional links..."	Fossil evidence for transitional forms for fish-amphibians (including Tiktalik 2004), reptile-bird (including Archaeopteryx 1860, and recent Chinese fossils), artiodactyls–cetaceans, and hominins (Coyne, 2009)
Page 480: "Nature may be said to have taken pains to reveal... her scheme of modification, which it seems that we willfully will not understand."	Even today there is resistance to accepting the fact of adaptive evolution by natural selection, such that only 40% of people in the United States believe that evolution is a fact (Newport, 2009)
Page 484: "...probably all the organic beings which have ever lived on this earth have descended from some one primordial form..."	The base of Darwin's tree of life probably looks more like a web than a linear branching stem because of horizontal gene transfer (Lawton, 2009), but given the near universality of the genetic code there probably was just one instance of the origin of life (Dawkins, 2009)

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