Darwinian Theory in Historical Context and Its Defense by B.D. Walsh: What is Past is Prologue

Carol M. Anelli

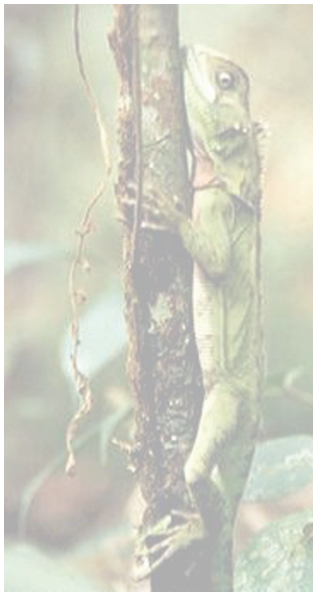
It is not easy… to enter fully into the mind-set of the early Victorians, in which both religion and science presupposed the glory of God to be manifested in nature. Nor is it easy to comprehend the intensity of their commitment to the fixity of species, or to imagine the intellectual and emotional upheaval that Darwin's work would cause.
—Philip Appleman (2001)

Notwithstanding the current controversy in the United States surrounding the teaching of evolution, it is indeed difficult today to comprehend the upheaval that the *Origin of Species* wreaked among Darwin's contemporaries. Darwin's letter in 1844 to the botanist J. D. Hooker affords some appreciation, in that Darwin admitted that divulging his evolutionary views felt tantamount to "confessing a murder" (Darwin 1903). But why should it have been so? In this article, I explore that question, focusing on the reception of Darwinian theory in the 19th century. I also advance the argument that striking parallels exist between natural theology of the 19th century and "intelligent design" today, or, to put it more broadly, "What is past is prologue." We stand to gain from a retrospective of the difficulties faced by evolutionary theory in Darwin's time.

To provide a historical framework, I begin with an overview of Darwin's experiences and the changes that his thinking underwent during the years preceding publication of the *Origin*. Next, I discuss religious beliefs prevalent among Darwin's contemporaries, including those of prominent entomologists. Those views are contrasted with the writings of the 19th century entomologist B. D. Walsh, a vociferous defender of Darwinian theory. I also discuss current issues surrounding the teaching of evolution *vs.* intelligent design, provide some thoughts on scientific *vs.* religious endeavor, and close with suggested approaches toward public acceptance and understanding of Darwinian theory.

Darwin's pre-*Origin* Years

Darwin attended Cambridge University at a time when it functioned as an arm of the Church of England. As a student there, he was required to affirm his belief in the Anglican Church's Thirty-Nine Articles (Darwin 1959, Desmond and Moore 1991, Browne 1995). This posed no problem for the young Charles, who matriculated at Cambridge with the intention of entering the ministry. Although he later abandoned his pursuit of Holy Orders, when he graduated in 1831, he held orthodox Biblical views and believed firmly in the fixity of species (Darwin 1959, Browne 1995, Appleman 2001, Ruse 2003). At 22, he also was poised to embark on a two-year, around-the-world voyage aboard the H.M.S. *Beagle*. The trip would take



three years longer than expected (Browne 1995), but Darwin's intellectual journey would turn out to be immeasurably greater.

During his extensive travels, Darwin collected assiduously, performed various researches and observations, and studied several key publications, and the knowledge he acquired soon conflicted with his traditional beliefs. The turning point came in March 1837, when Darwin realized that all past and present life forms shared a common ancestry and that species could transmutate (*i.e.*, evolve) (Desmond and Moore 1991, Browne 1995). By 1839, he had developed the main outline of his theory, but the public would not learn of it until its presentation in an 1858 paper co-authored with Alfred Russel Wallace, who had independently conceived of the same theory. Historians have posited several reasons for Darwin's twenty-year procrastination (Hull 1973, Mayr 1982, Ruse 1982, Bowler 1990, Desmond and Moore 1991, Appleman 2001), but all concur that a significant factor in his delay was the anticipated controversy that his theory would provoke among most of his naturalist colleagues as well as the lay public. Much of the discordance was due to Victorian conflation of religious belief with scientific endeavor.

Natural Theology and William Paley

The early Victorians exhibited an unbounded enthusiasm for natural history and regarded the collection and study of seashells, botanical specimens, insects, and other natural curiosities as a way to honor and know the Creator by looking "through nature up to nature's God" (Barber 1980). This spiritual approach gained great popularity with the publication in 1802 of *Natural Theology* by the Reverend William Paley, who drew heavily upon the work of naturalist/clergyman John Ray (1691) (Moore 1993). Paley's book, required reading for students at Cambridge (Browne 1995), advanced the so-called "argument from design." Paley saw the perfect adaptations ("contrivances") of various organisms as evidence of the existence of a designer (Creator), just as finding a watch upon a heath would evidence the existence of a watchmaker.

Even Darwin acknowledged that he had been "charmed and convinced by the long line of argumentation" in Paley's *Natural Theology* (Darwin 1959). Indeed, a few days before publication of the *Origin*, he commented in a letter to John Lubbock,[1] "I do not think I hardly ever admired a book more than Paley's 'Natural Theology'. I could almost formerly have said it by heart" (Darwin 1903). (Ironically, Darwin occupied Paley's rooms as an undergraduate in Christ's College at Cambridge [Browne 1955].)

The Paleyean argument was so familiar to Victorians that authors could cite it without explanation (Barber 1980). It pervaded all branches of natural history; and in class-conscious England, entomology represented a most egalitarian pursuit of natural theology because numerous specimens could be housed in the most modest abodes with little money needed to maintain them (Barber 1980). Natural history was not taught in schools, but when Victorians gathered in the evening around a microscope (available for only a few guineas), the activity was perceived as "rational entertainment"—it provided useful information and moral uplifting (Allen 1976, Barber 1980). It also brought one closer to God.

Kirby and Spence's *Introduction to Entomology*

An Introduction to Entomology, by Reverend William Kirby and William Spence (1860), was first published in 1815 and epitomizes the tenet of natural theology. This work, the earliest popular book on insects written in the English language, went through seven editions. It was well known to Darwin and other naturalists (Allen 1976, Desmond and Moore 1991), including Henry David Thoreau, who cited it in *Walden* (1854).

In their preface to the first edition, Kirby and Spence asserted that natural history had too often been used perversely "to derive arguments either against His being and providence, or against the religion revealed in the Holy Scriptures."

In their preface to the first edition, Kirby and Spence asserted that natural history had too often been used perversely "to derive arguments either against His being and providence, or against the religion revealed in the Holy Scriptures." They intended their book as a counterattack and invoked terminology recognizable to Victorians imbued with natural theology:

> One of [the authors'] first and favourite objects has been to direct the attention of the readers "from nature up to nature's God."…every department of [entomology] illustrates the great truths of religion, and proves that the doctrines of the *Word* of God…are triumphantly confirmed by His *Works*. (Kirby and Spence, 1815, preface to first edition, p. xii)

On the issue of providing rational entertainment and mental discipline, Kirby and Spence argued that entomology, of all the branches of natural history, was "unquestionably the best":

> …no study affords a fairer opportunity of leading the young mind by a natural and pleasing path to the great truths of Religion, and of impressing it with the most lively ideas of the power, wisdom, and goodness of the

[1]Sir John Lubbock, later Baron Avebury, author of *Ants, Bees, and Wasps* (1882).

Creator. (Kirby and Spence, preface to first edition, 1815, p. xv)

Kirby and Spence (1860) also placed entomological study within the *scala naturae*, a customary linear scale of nature in which all natural objects formed a fixed continuum of advancement, with humans at the pinnacle:

> [We] must claim for the entomologist some degree of precedence before the mineralogist and the botanist. The mineral kingdom, whose objects are neither organized nor sentient, stands certainly at the foot of the scale. Next above this is the vegetable, whose lovely tribes, though not endued with sensation, are organized. In the last and highest place ranks the animal world, consisting of beings that are both organized and sentient. (Kirby and Spence 1860, p. 2)

But how could one defend the study of insects when these organisms clearly ranked beneath the vertebrates? According to Kirby and Spence (1860, p. 3), "[all] the works of our Creator are great, and worthy of our attention and investigation, the lowest in the scale as well as the highest." They also proffered a justification invoked to this day by entomologists:

> If…rank were to be estimated by *number* of species or individuals of a species, the pre-eminence could be claimed by insects, which, from the calculations made by various entomologists, probably amount to 400,000 or even more, perfectly distinct from each other; while for all the other classes of animals together, 30,000 species would be a high estimate. (Kirby and Spence 1860, p. 3)

Kirby and Spence provided many practical reasons for the study of insects, for example, ready availability and an unparalleled opportunity for taxonomic discovery. But these were mere perks, because insects possess all the "art and contrivance" of larger animals in the complexity of their organ systems, and through their manners they teach us indefatigable industry, judgment, prudence, and other laudable virtues. These designs and behaviors made a spiritual declaration to all who study insects:

> "*The hand that made us is divine.*" We are the work of a Being infinite in power, in wisdom, and in goodness. (Kirby and Spence 1860, p. 10)

To the current reader, Kirby and Spence's repeated invocations in a textbook of entomology may appear surprising or at least unusual. But at the turn of the 19th century, lay people and most scientists believed that God created the heavens on 18 October 4004 B.C. and Adam five days later at 9 a.m. (Ruse 1982, Pennock 2000, Appleman 2001). By this view, the earth was relatively young, geological catastrophes such as the Biblical flood accounted for species extinctions (evidenced by the fossil record), and the Almighty specially created new species to be adapted to the prevailing conditions (Moore 1993).

Catastrophism theory eventually gave way to uniformitarianism, which built on principles espoused by the 18th century Scottish geologist James Hutton (Dott and Prothero 1994). Uniformitarianism held that changes in the earth's surface occur incrementally and relatively slowly as the accumulated effects of observable processes (*e.g.*, erosion) acting in the past as they do in the present. This theory gained tremendous impetus with Charles Lyell's three-volume classic, *Principles of Geology* (1830–1833) (Moore 1993). Historians cite *Principles* as among the pivotal scientific works read by Darwin aboard the *Beagle* (Bowler 1990, Desmond and Moore 1991, Browne 1995). Lyell's *Principles* provided Darwin with a valid argument for an ancient earth of gradual changes and a geological framework for the geographic distribution of species (Bowler 1990). Having embraced these views, Darwin developed the concept that species could evolve modifications gradually through a long geological timeframe and that new species could arise through the mechanism of natural selection (Mayr 1982).

B. D. Walsh and Darwinian Theory

Benjamin D. Walsh (1808–1869) was Darwin's contemporary at Cambridge University. Walsh, too, subscribed to the Thirty-Nine Articles, read Paley's *Natural Theology*, and fully intended to become an Anglican minister until he left Cambridge and England forever in 1838 (Sheppard 2004). Like many Victorians steeped in natural theology, Walsh and Darwin were avid coleopterists and reveled in the beetle-collecting mania then taking their nation by storm (Desmond and Moore 1991). The two men met briefly at Cambridge when, in Walsh's words, he was invited to view Darwin's "noble collection of British Coleoptera" (Darwin 1903).

Walsh subsequently immigrated to Illinois and returned to entomological study in earnest about 1857–1858 (Sheppard 2004). In November 1859, the *Origin of Species* appeared in London bookstores; the U.S. edition was published in May 1860 (Desmond and Morris 1991). By his own account, when Walsh read the *Origin*, his first perusal "staggered" him, and the second convinced him of the soundness of Darwin's theory (Darwin 1903). In April 1861, Walsh opened a correspondence with Darwin to share with him certain of his entomological publications that he believed provided supportive evidence for Darwin's theory. Walsh soon became one of Darwin's strongest advocates in the United States (Pfeifer 1974), not only promoting and defending Darwinian theory, but also making original contributions to it. Darwin cited Walsh's contributions to evolutionary theory in later editions of the *Origin* and in other of his books (Sheppard 2004).

Before the *Origin*, answers to "why" or causal questions in natural history were answered in accord with the most fundamental precept of natural theology: "because God ordains it" (Barber 1980,

Mayr 1982). Kirby and Spence's *Introduction to Entomology* is replete with such examples, as in this passage on insect metamorphosis:

> A question here naturally presents itself—Why are insects subject to these changes? For what end is it that, instead of preserving, like other animals, the same general form from infancy to old age, they appear at one period under a shape so different from that which they finally assume; and why should they pass through an intermediate state of torpidity so extraordinary? I can only answer that such is the will of the Creator, who doubtless has the wisest ends in view, although we are incompetent satisfactorily to discover them. (Kirby and Spence 1860, p. 40)

This particular supernatural explanation was often given voice in the entomological literature, and Walsh disparaged it repeatedly:

> To say, by way of explanation of these and similar phenomena, that they are so because the Great Author of Nature has willed them to be so, is no explanation at all..." (Walsh 1864a, p. 635)

Walsh frequently decried the Creative Theory (*i.e.*, natural theology), which he considered scientifically unacceptable and uninformative:

> I leave the believers in the Creative Theory to account for all these facts as they best can, or, if they prefer it, to repose calmly and blandly in the bosom of the Shandean Philosophy,[2] viz: that it has pleased God to make everything thus and so, and that is enough for us. (Walsh 1867, p. 240)

Walsh readily excoriated any scientist who proposed supernatural explanations for natural phenomena; and unquestionably the most influential among them was avowed creationist Louis Agassiz, a legend in comparative anatomy, paleontology, ichthyology, and glaciology. Agassiz (1863) made thinly veiled references to the *Origin of Species* in his work, *Methods of Study*, calling it "repugnant…to our better nature." Walsh (1864b, p. 223) retorted sharply, "This may be a very good reason for not reading a book, but it is a very poor reason for attempting to refute it without first reading it carefully through at least once." In his lengthy publication devoted to defending Darwin, Walsh (1864b) exposed and condemned Agassiz's misstatements and misrepresentations:

> The "Origin of Species" is a strong book, well weighed and carefully thought out, written by a strong man familiar with all the discoveries of modern science and himself the honored author of many new scientific discoveries. It is utterly impossible, even for a naturalist of such distinguished attainments as Prof. Agassiz, to upset this new theory, like a child's house built out of cards, by the mere weight of his personal authority. (Walsh 1864b, p. 223)

Darwin, who typically allowed others to fight his battles (Darwin 1959, Desmond and Moore 1991), enthusiastically thanked Walsh for his efforts. He also acknowledged Walsh's published sparrings over evolution with entomologist Samuel Scudder, then Agassiz's student (Sheppard 2004).

In contrast to Walsh, many of Darwin's contemporaries scorned his theory for a host of reasons, several of which involved natural selection (Hall 1973, Mayr 1982, Bowler 1990). The majority of Victorians, unaware of advances in geology, interpreted the Bible literally and believed the earth to be 6,000 years old

An outstanding field entomologist and astute observer, Walsh noted variations and patterns in nature, recognizing that constancy of characters among related insect groups evidenced descent with modification. He underscored the significance of such findings in his publications, as in this passage on pleural stripes in odonates:

> The important point to observe is, that wherever any of these dark thoracic stripes exist, their *locus* is definitely fixed. So that if we believe that each species of, e.g., the 37 described species of Hetaerina and of the 86 described species of Gomphus was separately created, and not derived by hereditary descent from some one primordial form, we are compelled to believe that the Great Author of Nature, for some inscrutable purpose, confined himself in ornamenting each species of these two extensive genera to mere modifications of one single design or pattern. A human artist who should so confine himself would be immediately accused of poverty of imagination. (Walsh 1863, pp. 270–271)

Walsh argued cogently and often that the "Derivative" (*i.e.*, Darwinian) Theory provided the only plausible, scientific explanation for certain of his entomological observations. In making his case he often used Darwin's approach, now called the hypothetico-deductive method (Mayr 1982). He would amass a series of observations or facts from which he would generalize and postulate a hypothesis, deduce a prediction, and ask whether the prediction held upon further investigation. For example, Walsh observed the tendency for phytophagous larvae of a given insect genus to "more or less exclusively" use a particular genus of plants

[2]Walsh was referring to a series of very popular, satiric British novels about a gentleman named Tristram Shandy, written by Laurence Sterne. Interestingly, a film based on the novels was released in January 2006 (http://www.comingsoon.net/).

as hosts. He saw this pattern repeated in genera belonging to several insect orders and interpreted it as evidence of Darwinian evolution. In 1864, he discussed the phenomenon in the lepidopteran genus *Dryocampa*:

> Why then, out of five or six [species of] *Dryocampa,* do as many as three or four inhabit the Oak? Why are they not scattered round amongst our Elms and Ashes and Cherries and Plums and Thorns and Crabs and Willows and Poplars and Beeches? The Theory of Chances demonstrates that this cannot be a merely fortuitous event. There MUST be some cause for it. What is the cause? The Creative Theory is dumb, or tells us that it is so, because it is so; the Derivative Theory answers promptly, clearly and loudly, that it is because all *Dryocampadae* sprang ages ago from some one pre-existing species, which inhabited the Oak or some pre-existing form closely allied to the Oak; and that certain nascent types, in the course of ages, ceased more or less, and at a more or less early period, to feed on the Oak, so as to become isolated from their brethren at a comparatively early date, and have consequently deviated…from the primordial type…" (Walsh 1864a, p. 638)

In contrast to Walsh, many of Darwin's contemporaries scorned his theory for a host of reasons, several of which involved natural selection (Hall 1973, Mayr 1982, Bowler 1990).The majority of Victorians, unaware of advances in geology, interpreted the Bible literally and believed the earth to be 6,000 years old—clearly insufficient time for natural selection to act. In addition, in the late 1860s the physicist William Thomson (later Lord Kelvin) estimated the age of the earth to be about 100 million years, far from the "deep" time concept advanced by Hutton and Lyell and required for natural selection to act.

Skeptics also asked how natural selection, an undirected, nonteleological force, could account for the wondrous and complex adaptations so evident in the Almighty's handiwork. And they questioned where God was in this process. Furthermore, if natural selection acted gradually, as Darwin proposed, how could one explain the sudden appearances and gaps in the fossil record? Then there were methodological problems—at a time when practitioners and enthusiasts actively debated the nature of science, Darwin's hypothetico-deductive approach did not align with the traditional methodology of physics and mathematics. In 1867, Fleeming Jenkin dealt a serious blow to the theory with his review of the *Origin*, claiming that any useful adaptation evolved by individuals would be "diluted" with each successive generation whenever the "favored" individuals bred with nonmutated mates. (Mendel's work, which postulated the existence of particulate, heritable traits, and the chromosomal theory of inheritance, would not emerge until after Darwin's death at the turn of the 20th century.)

What is Past is Prologue

In the nearly 150 years since the initial publication of the *Origin of Species*, advances in biology, geology, and related scientific disciplines have provided critical answers to questions that plagued Darwin. We can now appreciate Walsh's prescient words, penned upon learning that his work would be cited in the *Origin*: "I am sure of immortality; for I don't think that book will ever perish" (quoted in Sheppard 2004).

Evolution stands today as the unifying theory of biology, and the famous statement by evolutionary geneticist Dobzhansky (1973)—"Nothing in biology makes sense except in the light of evolution"—gains credence with each new discovery. Assisted by technological advances in myriad scientific fields, the explanatory and predictive power of evolutionary theory has never been stronger. Thus in 2005, *Science* magazine selected "evolution in action" as its "breatkthrough of the year" (Kennedy 2005). Evolutionary principles are routinely applied to problems in human health and disease, for example, the design of flu vaccines and drugs to combat HIV-AIDS. Researchers have exploited the genetic makeup we share with invertebrates, using these organisms as models to understand gene expression, function, and regulation in humans. To cite just one fascinating example, two laboratory favorites—the nematode, *Caenorhabditis elegans*, and the (so-called) fruit fly, *Drosophila melanogaster*—serve as models for a robust area of research on mechanisms underlying human addiction to alcohol, cocaine, and nicotine (Wolf and Heberlein 2003). Chapman (2000) reviews a number of 20th century landmarks in entomological research that have had major impact on the biological sciences.

Evolutionary principles are routinely applied to problems in human health and disease, for example, the design of flu vaccines and drugs to combat HIV-AIDS. Researchers have exploited the genetic makeup we share with invertebrates, using these organisms as models to understand gene expression, function, and regulation in humans.

Studies with nematodes and insects provide valuable insights into human drug abuse because all organisms, living and extinct, share a common ancestry from which they evolved. This tenet of Darwinian theory is accepted by the vast majority of scientists, but not so among a significant number of Americans. A Gallup poll conducted in November 2004 queried people about the evidence for Darwinian evolution. Only 35% of respondents said that evolution is well supported by evidence, compared with 35% who said it is not, and 29% who said they did not know enough to reply (1% had no opinion) (NCSE 2004). In a *USA Today*/CNN/Gallup poll conducted in September 2005, 53% of respondents agreed with the statement,

"God created human beings in their present form exactly as described in the Bible," compared with only 31% who agreed that, "Human beings have evolved over millions of years from other forms of life, and God guided this process" (USA Today 2005).

In speaking of Darwinian theory in contemporary America, the late Stephen Jay Gould (1999) pointed out the "embarrassing paradox of a technological nation entering a new millennium with nearly half its people actively denying the greatest biological discovery ever made." Added to this paradox is the fact that about two-thirds of people surveyed by the National Science Foundation in 2001 thought that creationism and evolution should be taught alongside one another in public schools (NSF 2002). In short, many Americans place creationism on a scientific par with evolution and question the reality and significance of evolution as a *process*. (I emphasize the word *process* because while scientists may debate evolutionary mechanisms, it is well accepted that organic evolution occurred in the past and is ongoing today.) As recent events indicate, intelligent design represents the greatest challenge to Darwinian theory in K–12 curricula.

Intelligent design has its modern origin in the book, *Darwin's Black Box,* by biochemist Michael Behe (1996). Behe argues that at the biochemical/cellular level, organisms exhibit "irreducibly complex" systems that could not have arisen by Darwinian evolution. As he explains,

> An irreducibly complex system cannot be produced directly by numerous, successive, slight modifications of a precursor system, because any precursor to an irreducibly complex system that is missing a part is by definition nonfunctional. (quoted in Miller 1999, p. 133)

According to Behe (1996), the result of his biochemical investigations is "a loud, clear piercing cry of '*design!*'" In fact, so "unambiguous" and "significant" is his result that

> it must be ranked as one of the greatest achievements in the history of science. The discovery rivals those of Newton and Einstein, Lavoisier and Schrödinger, Pasteur, and Darwin. (Behe 1996, pp. 232–233)

Behe does not conjure a traditional Deity, but biochemical complexity is proof of the existence of a designer to Behe, just as the complex vertebrate eye was proof of the existence of the Creator to William Paley. Other scientists have noted the clear parallels between modern and Paleyean design "theory" (Miller 1999, Scott 1999).

Intelligent design should not be confused with Biblical fundamentalism because it allows for an ancient earth and, to some extent, evolution. However, it makes no predictions, advances no hypotheses, and is not falsifiable; therefore, by definition, it is not a scientific enterprise. Nevertheless, its proponents have successfully appealed to Americans' religious sensitivities and their notions of "fairness" and "equal time" (Demere and Walsh 2000) and have made inroads toward teaching intelligent design as an alternative to evolutionary theory.

This pedagogy was roundly rejected by a resolution passed by the ESA membership at its 2005 annual meeting (ESA 2006). As scientists, we can (and should, in my opinion) applaud this resolution, which joins similar actions taken by the National Academy of Sciences, the National Association of Biology Teachers, and numerous other scientific organizations and societies. But it seems unlikely that these pronouncements will increase public understanding and acceptance of evolutionary theory and allay the concerns of people of faith. If this is so, then what is to be done?

What is to be Done?

To begin, we should remember that the major religions of the Western world are not in conflict with evolutionary theory. That said, as Gould (1999) pointed out, "denigration and disrespect will never win the minds (not to mention the hearts)" of those who see evolution as incompatible with their faith. Cell biologist Ken Miller, a devout Catholic who has argued on the side of organic evolution in numerous debates, echoes this view. Miller (1999) further asserts that for a religious person, the decision of whether to accept evolution is not a matter of scientific evidence or validity. "It hinges instead on the *complete* effect that acceptance…has on their own lives and *their* view of life itself (Miller 1999, p. 167)." He contends that much of the public sees evolution as a philosophical worldview "hostile and even alien to their lives and values" (p. 167).

Science aims to provide nonsupernatural explanations for our world and the universe, which operate on interactions between matter and energy. By definition, this makes science a materialistic enterprise. As such, science provides a different way of comprehending reality than religion, which is faith-based and therefore, to some degree, supernatural. As underscored by Gould (1997), Miller (1999), and even Dobzhansky (1973) before them, science and religion occupy different cultural and intellectual domains and each offers it own way of knowing. It is therefore not surprising that the National Academy of Sciences (NAS 1999), and most scientists who have written on the subject, emphasize that one should not look to science to answer religious questions, and *vice versa*.

Intelligent design should not be confused with Biblical fundamentalism because it allows for an ancient earth and, to some extent, evolution. However, it makes no predictions, advances no hypotheses, and is not falsifiable; therefore, by definition, it is not a scientific enterprise.

Walsh and Darwin lived in an era when many naturalists invoked the creative theory to explain their observations. If Walsh was prescient in his staunch support of Darwin's revolutionary theory, he was similarly progressive in arguing for a distinction between matters of faith *vs*. science. The following excerpts from his entomological correspondence bear this out:

> …in science we want to eliminate faith as much as possible, excellent as faith is in all religious matters….(Walsh to Hagen 11 Sept. 1868; unpublished letters, quoted by permission of the Ernst Mayr Library, Museum of Comparative Zoology Archives, Harvard University)

> I feel very highly complimented by your finding fault with my pamphlet[3] for being "too logical." I don't see how that is possible, seeing that it is on a scientific subject. A drama or a novel or a sermon may be too logical, for in the first two imagination is the main requisite, & in religion faith is the one grand essential. You must believe 3=1, not only in spite of its being impossible, but because it is impossible, & if you don't, why the pious Athanasian Creed tells you that "without doubt you will perish everlastingly." But in my point of view, Science ought to have nothing to do either with faith or with imagination, but should be pure and undefiled reason....(Walsh to Scudder 17 Dec. 1864; unpublished letters, quoted by permission of Museum of Science, Boston)

Earlier, I noted the results of recent polls taken of the American public. To those results, we can add studies indicating that most students harbor deeply held misconceptions and misunderstandings about science and evolution.

As an educator, one of my foremost goals is to heighten awareness of the nature of science and the relevance of evolutionary theory in our daily lives. To that end, I concur with Miller (1999) and Scott (1999) that we must acknowledge and respect the religious views of those whom we seek to enlighten. We should inform them that many of today's great scientists accept evolution and profess a powerful and abiding belief in a supreme being, as did many of their predecessors. Labov (2005) lists educational resources and activities that promote student and public understanding of evolution, and Kliman and Johnson (2005) discuss four fundamental concepts regarding evolution that all liberal arts curricula should foster.

Recent findings suggest that a pedagogy that actively engages students' prior learning about creationism and evolution is more effective than are traditional approaches (*e.g.*, uninterrupted lecturing and other passive learning strategies) (Verhey 2005). This corroborates more broadly based evidence that student-centered discussion, inquiry-based methods, critical thinking, and historically rich curricula promote student comprehension and retention and embody "good practices" for teaching and learning (Boyer Report 1998, Alters and Nelson 2002, AAC&U 2004, Allen and Tanner 2005).

Today's students can become tomorrow's scientifically informed members of society, active in their communities, serving on public school boards of education. We can help make this vision a reality through extension talks and publications, formal classroom instruction, guest presentations to the community, and mentorship of youths and young adults. Our commitment to this educational undertaking aligns with the 2005 ESA resolution, which states that

> for the United States to remain intellectually and economically competitive in the 21st century, its science must be conducted according to time-tested and globally acceptable standards. Evolutionary theory meets those standards and provides the foundation on which the biological sciences can most productively continue to advance. We should expect no less in the quality of science education in this country. (ESA 2006)

As an educator, one of my foremost goals is to heighten awareness of the nature of science and the relevance of evolutionary theory in our daily lives. To that end, I concur with Miller (1999) and Scott (1999) that we must acknowledge and respect the religious views of those whom we seek to enlighten. We should inform them that many of today's great scientists accept evolution and profess a powerful and abiding belief in a supreme being, as did many of their predecessors.

Acknowledgments

For permission to quote from unpublished correspondence of B. D. Walsh, I thank the Museum of Science, Boston; and the Ernst Mayr Library, Museum of Comparative Zoology Archives, Harvard University, Cambridge, MA. I also thank the anonymous reviewers for their efforts on my behalf.

References Cited

AAC&U (American Association of Colleges and Universities). 2004. Taking responsibility for the quality of the baccalaureate degree. AAC&U, Washington, DC.

Agassiz, L. 1863 [1970]. Methods of study in natural history. Arno Press, New York.

Allen, D. E. 1976. The naturalist in Britain. Princeton University Press, Princeton, NJ.

Allen, D., and K. Tanner. 2005. Infusing active learning into the large-enrollment biology class: seven strategies, from simple to complex. Cell Biol. Ed. 4: 262–268.

Alters, B. J., and C. E. Nelson. 2002. Perspective: teaching evolution in higher education. Evolution 56: 1891–1901.

Appleman, P. 2001. Darwin: on changing the mind, pp. 3–20. *In* P. Appleman [Ed.]. Darwin. W.W. Norton, New York.

Barber, L. 1980. The heyday of natural history, 1820–

[3]Here Walsh was referring to his 1864b publication.

1870. Doubleday, Garden City, NY.

Behe, M. J. 1996. Darwin's black box: the biochemical challenge to evolution. Free Press, New York.

Bowler, P. J. 1990. Charles Darwin: the man and his influence. Basil Blackwell, Cambridge, MA.

Boyer Report (Boyer Commission on Educating Undergraduates in the Research University). 1998. Reinventing undergraduate education: a blueprint for America's research universities. http://naples.cc.sunysb.edu/Pres/boyer.nsf/

Browne, J. 1995. Charles Darwin: a biography. Vol. 1, Voyaging. Princeton University Press, Princeton, NJ

Chapman, R. F. 2000. Entomology in the twentieth century. Annu. Rev. Entomol. 45: 261–285.

Darwin, C. 1903. More letters of Charles Darwin, Vol 1. F. Darwin and A. C. Seward, Eds. D. Appleton and Company, New York.

Darwin, C. 1959. The autobiography of Charles Darwin, with original omissions restored. N. Barlow, Ed. W. W. Norton, New York.

Demere, T. A., and S. W. Walsh. 2000. Facts, faith, and fairness. http://www.ncseweb.org/resources/articles/4414_facts_faith_and_fairness_12_7_2000.asp

Desmond, A., and J. Moore. 1991. Darwin. Michael Joseph Ltd., London.

Dobzhansky, T. 1973. Nothing in biology makes sense except in the light of evolution. Am. Biol. Teacher 35: 125–129.

Dott, R. H., Jr., and D. R. Prothero. 1994. Evolution of the earth, 5th ed. McGraw-Hill, New York.

ESA (Entomological Society of America). 2006. Resolutions passed by the ESA membership December 19, 2005, Fort Lauderdale, Florida. ESA Newsletter January, p. 4.

Gould, S. J. 1997. Nonoverlapping magisteria. Nat. Hist. 106: 16–22.

Gould, S. J. 1999. Darwin's more stately mansion. Science 284: 2087.

Hull, D. L. 1973. Darwin and his critics. Harvard University Press, Cambridge, MA.

Kennedy, D. 2005. Breakthrough of the year. Science 310: 1869.

Kirby, W., and W. Spence. 1815. An introduction to entomology, 1st ed. Longman, Green, Longman, and Roberts, London.

Kirby, W., and W. Spence. 1860. An introduction to entomology, 7th ed. Longman, Green, Longman, and Roberts, London.

Kliman R. M., and N. A. Johnson. 2005. What every undergraduate should know about evolution (and why). BioScience 55: 926–927.

Labov, J. B. 2005. From the National Academies: ongoing challenges to evolution education: resources and activities of the National Academies. Cell Biol. Ed. 4: 269–272.

Lyell, C. 1830–1833 [1872]. Principles of geology, 11th ed. D. Appleton, New York.

Mayr, E. 1982. The growth of biological thought. Harvard University Press, Cambridge, MA.

Miller, K. R. 1999. Finding Darwin's God. HarperCollins Publishers, New York.

Moore, J. A. 1993. Science as a way of knowing. Harvard University Press, Cambridge, MA.

NAS (National Academy of Sciences). 1999. Science and creationism: a view from the National Academy of Sciences, 2nd ed. National Academy Press, Washington, DC.

NCSE (National Center for Science Education). 2004. Public view of creationism and evolution unchanged, says Gallup. http://www.ncseweb.org/resources/news/2004/US/724_public_view_of_creationism_and_11_19_2004.asp

NSF (National Science Foundation). 2002. Science and engineering indicators, Vol. 1, Chapter 7. NSF, Arlington, VA. http://www.nsf.gov/statistics/seind02/pdf/c07.pdf

Paley, W. 1802 [1836]. Natural theology. C. Knight, London.

Pennock, R. T. 2000. Tower of babel: the evidence against the new creationism. MIT Press, Cambridge, MA.

Pfeifer, E. J. 1974. United States, pp. 168–206. *In* T. F. Glick [Ed.]. The comparative reception of Darwinism. University of Chicago Press, Chicago.

Ray, J. 1691. The wisdom of God manifested in the works of creation. S. Smith, London.

Ruse, M. 1982. Darwinism defended. Addison-Wesley, Reading, MA.

Ruse, M. 2003. Darwin and design: does evolution have a purpose? Harvard University Press, Cambridge, MA.

Scott, E. C. 1999. The creation/evolution continuum. http://www.ncseweb.org/resources/articles/9213_the_creationevolution_continu_12_7_2000.asp

Sheppard, C. A. 2004. Benjamin Dann Walsh: pioneer entomologist and proponent of Darwinian theory. Annu. Rev. Entomol. 49: 1–25.

Thoreau, H. D. 1854 [1989]. Walden. J. L. Shanley, Ed. Princeton University Press, Princeton, NJ.

USA Today (USA Today/CNN/Gallup Poll). 2005. http://usatoday.com/tech/science/2005-10-10-evolution-debate-centerpiece_x.htm

Verhey, S. D. 2005. The effect of engaging prior learning on student attitudes toward creationism and evolution. BioScience 55: 996–1003.

Walsh, B. D. 1863. Observations on certain N.A. Neuroptera, by H. Hagen, M.D., of Koenigsberg, Prussia; translated from the original French M.S., and published by permission of the author, with notes and descriptions of about twenty new N.A. species of Pseudoneuroptera. Proc. Entomol. Soc. Phil. 2: 167–272.

Walsh, B. D. 1864a. On the insects, coleopterous, hymenopterous, and dipterous, inhabiting the galls of certain species of willow. Part 1st—Diptera. Proc. Ent. Soc. Phil. 3: 543–644.

Walsh, B. D. 1864b. On certain entomological speculations of the New England school of naturalists. Proc. Entomol. Soc. Phil. 3: 207–249.

Walsh, B. D. 1867. On the insects, coleopterous, hymenopterous, and dipterous, inhabiting the galls of certain species of willow. Part 2nd and last. Proc. Ent. Soc. Phil. 6: 223–288.

Wolf, F. W., and U. Heberlein. 2003. Invertebrate models of drug abuse. J. Neurobiol. 54: 161–178.

Carol Anelli (formerly Sheppard), Associate Professor of Entomology, teaches about evolution in historical and current contexts for the General Education Program and Honors College at WSU.