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A conversation on education in the classical tradition

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Recovering Wonder: Science in the Christian Classical School

LINDA DEY, EDITOR

Science involves so much more than facts about how the natural world operates. What scientists see and how they interpret what they see are influenced by their worldviews. Knowledge, scientific knowledge included, is not made up of discrete bits of information. No scientist is free from presuppositions which color his interpretation of the phenomena he is trying to explain. It's important then that we understand these assumptions about man and nature held by a scientist and those around him during the period of history when he did his work.

One example helps show this to be true. It was about ten years ago when I discovered that the account I had read and accepted about why Galileo got in trouble with the Church was a post-Enlightenment retelling of the story. It was a conversation with Dr. Kalthoff, who has an article in this issue, that set me straight. Galileo was arguing for the heliocentric view of the universe; he was convinced based on his observations that the earth was just another planet circling the sun. The Church was threatened by this idea because they had accepted the teachings of Aristotle which they believed supported a Christian view of sinful man's place in the universe. Aristotle taught that earth was the unmoving center of the universe stuck there due to the heaviness of the elements from which it was made. Earth was a place of change and decay. Beyond the orbit of the moon, however, the planets moved in perfect circular orbits through the fifth element, ether, creating the harmonious music of the spheres. Above the moon everything was perfect and unchanging. From this point of view Galileo was proposing a promotion for the earth when he moved it out into the ether among the other planets.

After the Enlightenment the story changed; it was asserted that the Church censured Galileo because he had *demoted* the earth by moving it out of the center of the universe. Berthold Brecht's play *Galileo* gives us a spectacular statement of this view: *"So you have degraded the earth…I won't be a nobody on an inconsequential star briefly twirling hither and thither. I tread the earth…and there is no motion to the earth, and the earth is the center of all things, and I am the center of the earth, and the eye of the Creator is upon me!"* These words put into the mouth of the Old Cardinal in the play assume that people living in the 1600's shared the Enlightenment humanist understanding of what it means to be "at the center of things," a mistake anyone who's read Dante wouldn't make! As Nancy Pearcey and Charles Thaxton point out in their most helpful book *The Soul of Science, "In medieval cosmology, human significance was rooted not in the earth's central location but in the regard God shows for it. Hence the idea that the Copernican theory threatened the Christian teaching of human significance is an anachronism. It reads back into history the angst of our own age."*

Among other things, using the holistic approach to science set forth in this issue of The Journal will help our students have a fuller and more accurate view of how we've arrived at our understanding of ourselves and the world in which we live.

Linda Dey
Editor

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A New Natural Philosophy: Implementing the Vision of C.S. Lewis

by Ravi Jain

Though I have not finished reading *Brave New World* by Aldous Huxley, its contours already feel intimately familiar. Many science fiction stories since then seem to have borrowed either slightly or generously from that 1932 cautionary tale. Movies such as *Logan's Run* (1976), *Gattaca* (1997), or *The Island* (2005) each sprung to mind when I began reading *Brave New World*. Huxley's book appears to have provided the central plot for this genre; other stories just fit into its serial installments. The commendation of euthanasia for the good of the collective or because there is no hope is described not only in *Logan's Run* but occurs in movies like *Soylent Green* or *Children of Men*. The ability to overcome mankind's weaknesses through eugenics as in *Gattaca* and/or through proper conditioning has been a theme since Plato's 'noble lie.' But not until the twentieth century did innumerable stories presume the government would one day raise every child as 'a bastard in a bureau'. And the crude depiction of the human body as mere instrumentality to support disembodied souls (wills?) with wholly interchangeable parts finds creepy expression in *The Island* although movies like *The Matrix* and *Inception* brilliantly explore the more general theme of disembodiment. C.S. Lewis described this genre well, "the author criticizes tendencies in the present by imagining them carried out to their logical limit. *Brave New World* and *Nineteen Eighty-Four* leap to our minds."[1]

The Abolition of Man by C.S. Lewis was published in 1943 just eleven years after *Brave New World.* The book had caught his attention as Lewis referred to it thrice in his short essay "On Science Fiction". In Chapter Three of *The Abolition of Man* Lewis' description of the problem overwhelmingly resembled the world Huxley described, that of the conditioners and the conditioned. Lewis identified that what is meant by power over nature more typically means the power of some men over others through the control of nature. His innocuous point is that in the world of the 1940's not everyone had access to a radio or could enjoy air travel. His darker observation is that in the 1940's these technologies were not primarily used for mere leisure but for the devastation of World War II. The question then of how to escape the inevitable outcome of technology becoming the power of the few over the many was only one of the challenging questions Lewis had asked in this final chapter. His real concern was, I think, not to halt technological advances but to clarify that power over nature does not amount to real knowledge of nature, nor does it lead to wisdom.[2] For that, another side of nature calls for our attention and perhaps even submission—not that we might impose our will upon her (and upon others through mastery of her), but that she might impress her categories upon us. Lewis said,

> For the wise men of old the cardinal problem had been how to conform the soul to reality, and the solution had been knowledge, self-discipline, and virtue. For magic and applied science alike the problem is how to subdue reality to the wishes of men: the solution is a technique; and both, in the practice of this technique, are ready to do things hitherto regarded as disgusting and impious such as digging up or mutilating the dead.[3]

For Lewis it seemed that modern man's conception of nature (his ontology) and the science it had begotten (his epistemology) were the primary culprits in shaping the Brave New World. Today these show few signs of letting up.

At the end of *The Abolition of Man*, C.S. Lewis asked his readers to, "imagine a new Natural Philosophy." He warned that "if the scientists themselves cannot arrest this process before it reaches the common Reason and kills that too, then someone else must arrest it." Lewis called science to repent and held out hope that, "from science herself the cure might come." To honor and heed Lewis' call for a repentant science, the 2015 "Recovering the Nature of Science" SCL preconference introduced three themes: a holistic curriculum, an incarnational pedagogy, and an interdisciplinary approach. By attention to these themes our schools may orient their natural science programs to the promotion of Lewis' "New Natural Philosophy" under the Lordship of Christ. Implementing these distinctives can help our science curricula move from fostering scientism and skepticism towards faith in the incarnate Word; from materialism and idealism to hope in the resurrection and new creation; from determinism and domination to love in covenantal charity. These themes can guide natural science again towards the pursuit of wisdom and virtue.

A Holistic Curriculum

The first theme regards the curriculum: how can it be made more holistic and not habituate a scientistic or reductionist mindset in students? In previous generations, besides natural science, natural history and natural philosophy were also taught. What are these other curricular categories and do they need to be recovered? Moreover, in addition to the liberal arts, attention was given to the common arts and the fine arts as well. How might these all play a role in our recovery of nature?

The Liberal Arts Tradition written by Kevin Clark and me detailed the need to teach natural science within the context of natural philosophy. But the book did not speak explicitly of the role of natural history within the Western curriculum. Since the time of Aristotle there have been two impulses within natural philosophy.[4] The first was natural history, a focus on the observation of phenomena. The second was natural science, a demonstrable knowledge of the causes of phenomena. Harvard historian of science, Steve Shapin in his book *The Scientific Revolution* notes that natural history observed three things: the ordinary course of nature, nature's irregularities or monsters, and nature contrived to act by the artifice of man (experiments).[5] While contemporary schools encourage or demand their natural science classes to have a robust laboratory component, where are students being asked to observe nature in her ordinary course? When are they to keep track of nature's surprises? Natural history has been all but lost as a discipline even though Darwin himself considered his vocation that of a natural historian. The lost emphasis on observing nature in the raw has left our students with a false impression of what nature really is, a false ontology. We only conceive of her through artificial experiments and then ask the students to attend to only the natural phenomena that are highly regular and predictable.

According to James K.A. Smith, the impressive Christian thinker Charles Taylor "suggests that those who convert to unbelief 'because of science' are less convinced by the data and more moved by the form of the *story* science tells and the self-image that comes with it (rationality=maturity)."[6] Thus it is critical that natural science teachers attend to the "form of the *story*" that they tell and not merely to the content; for they are the front line storytellers. One easy way schools can do this and reintroduce a natural historical element into classrooms without disrupting the many goods of natural science is by having students use sketchbooks to observe nature both in her ordinary course and in her surprises as well as in crucial experiments. Recall Mary Shelley's kindly Elizabeth who attended to "the majestic and wondrous scenes which surrounded [her] Swiss home—the sublime shapes of the mountains; the changes of the seasons; tempest and calm; the silence of winter…[and] contemplated with a serious and satisfied spirit the magnificent appearances of things." It was Dr. Victor Frankenstein who merely "delighted in investigating their causes."[7] Drawing may then offer another way to see and to contemplate that allows nature to impose her categories upon the student, helping "conform the soul to reality."

A holistic curriculum ought not to recover only the liberal arts but the common and fine arts as well. *The Liberal Arts Tradition* described how all seven of the liberal arts provide the tools of learning, both the arts of language and the arts of mathematics. Recapturing the significance of these arts for contemporary education is of crucial importance. But since the 12th century, Hugh of St. Victor had identified the common arts as important for education as well (these are sometimes called the vulgar or servile arts). The common arts, i.e. agriculture, architecture, cooking, blacksmithing, et al, are the skills needed for civilization by all men everywhere throughout the world. Note that these common arts help man to provide food, clothes, shelter, and safety to his family or town. During the scientific revolution these activities, like blacksmithing or navigation, became more appropriate for natural philosophers to investigate. For example, the longitude prize awarded in England in the 18th century for new navigation techniques energized many of the brightest minds of the time.

While the medieval list of common arts need not constrain the examination of later technologies such as lens-grinding, steam engines, or even microchips, it does offer an instructive trajectory. Note that one motivation for better optics and lenses (hence microscopes and telescopes) was to improve navigation, and the steam engine was invented by those within the metallurgical tradition of the blacksmiths. Consider the transformational role attention to a garden and a few farm animals could have on the students' understanding of nature. Introducing the skills needed for the other common arts such as spinning, weaving, and sewing for tailoring; or threshing, millery, and butchery for cooking; or tracking or trapping for hunting provides extensive exposure to the details of physical situations which then provoke wonder and curiosity about the natural world. One can build a mobile foundry to melt aluminum for about $10, and the contemporary 'maker' subculture offers innumerable projects for teachers to explore. Gameboys, cell phones, and drones operate only by magic for students, and without pressing on to the rigors of electrical engineering and computer science, students will likely never uncover the inner workings of these. In contrast, the curiosity aroused by the common arts is the kind more likely to sustain investigations into the causes of the phenomena which students encounter in high school natural science. By attending to these they might also develop an entirely new vision of the role *techne* (art) and technology play in a civilization. Consider the lament of Professor James Taylor, author of *Poetic Knowledge*, when he considered the plight of contemporary college students, "an entire preindustrial culture was missing from these students' experience, and in its place was our familiar modern life, artificial and insulated more and more from direct experience with nature and reality."[8] In order to cultivate a proper vision of nature and the role of human art and technology within it, our natural science curricula should build from a basis in the common arts as well as the liberal arts.

An Incarnational Pedagogy

In addition to a holistic curriculum, an incarnational pedagogy calls teachers to appreciate the nature of the child and avoid a kind of mere technique in education. Christ became like us and laid aside his prerogative that he might live among us. The Word became flesh. This is the same disposition that teachers ought to have towards students. Attending to the nature of the children, body and soul, involves shaping loves, midwifing ideas, and cultivating practices. Shaping loves is most important to keep kids from the exasperation warned against in Ephesians 6:4. All learning occurs within a network of relationships. Relationships with peers, with parents, with God, and with teachers all matter, and love must be cultivated in these. How could homework assignments such as, "go on a family picnic and identify five wildflowers," change the family dynamic around homework? Moreover, the teacher can hold out beauty inherent in the subject. Causing students to wonder at the order in nature is truly having them marvel at the incarnate *Logos*, the second person of the Trinity. This beauty begets a love that can sincerely be directed towards Christ in whom all things hold together.

Midwifing ideas is the Socratic ideal for teaching. Natural science teachers tend to use lecture and laboratory as the only two pedagogical modes. These are appropriate at times, but do the kids understand themselves more broadly as pursuing great and significant questions during these moments? Moreover, do they feel like they are arriving at the ideas themselves? Are the ideas being born from them or are they just repeating what they have been told? A pedagogy that focuses on following the question through the interrelationships among observation, reasoning, and assumptions within communities of faith and practice provides a richer pedagogical experience—a kind of global guided inquiry. Finally, what practices do we cultivate among the students? The observation of nature with a sketchbook and the recovery of the common arts are soul-shaping practices. Are there others? Reading the great discoverers unearths many more practices for the students. Perhaps some students will conclude they should pray more fervently upon encountering Pascal's prayer life. Tracing Galileo's interactions with the Duke of Tuscany may embolden some to consider how natural science and leadership or politics intermingle. Certainly the 20th century interplay between technology and war offers an interesting case study. By reading the histories of the great scientists, practices are suggested to students that can disciple them unto wisdom as well as genius.

An Interdisciplinary Approach

The last theme of the Recovering Nature project is an interdisciplinary approach. I have written previously in the SCL Journal about "Science and Poetry," detailing how Tennyson's phrase "Nature red in tooth and claw" preceded Darwin's theory by nearly ten years.[9] I did not mention though how a theory of the multiverse and one of evolution date back to the ideas of the ancient Greeks, not to mention heliocentrism as well. The Presocratic thinker Anaximander suggested that men evolved from fish (or a fish-like common ancestor?) and also claimed an infinite number of universes as continually coming into existence and passing away. I do not mind natural scientists talking about the multiverse, so long as they recognize that they are participating in the very ancient discourse of natural philosophy. The question then arises whether they are doing such philosophy well or poorly. Too often it seems that natural scientists gloss over the foundational questions of their discipline, adopt simplistic dogmatic stances prematurely, and then surmise that their conclusions are certain and indubitable no matter how unconventional or bizarre. Scientists blithely extend the idea of deterministic mathematical law ever outward to prove notions that then undermine the very possibility of such a law. It strikes me as more prudent to consider the consequences of such extensions before spending decades working out the mathematical complexities. This is especially true in an era in which so much research has been regarded as of dubious quality.[10] Moreover, if many of these theories have been discussed for generations, though in slightly different garb, then history is an essential discipline for the natural scientist. Thus, at the bare minimum, natural science must explore its interdisciplinary boundaries with literature, mathematics, philosophy, and history if not for the sake of helping the students integrate their knowledge, then for the sake of true understanding in natural science itself.

Moreover, as Christians confess that in Christ all things hold together, theology becomes an indispensable discussion partner. By continuing to hold up the deep questions of natural science before the light of Christ, much is illuminated. The wave-particle duality of quantum physics is famously suggestive of the Trinity. The Heisenberg uncertainty principle and chaos theory raise questions about causality and determinism—these mirror questions regarding God's sovereignty and human responsibility. And the mind-body problem has, since at least the Nicene Creed, resembled the mystery of the Incarnation. Truth does not exclude mystery but embraces it. Faith in the incarnate Word, hope in the resurrection and new creation, and love in covenantal charity are important virtues by which we may tether our investigations of the natural world to the mystery of Christ. Thus theology as the queen of the sciences still has a crucial role to play in the study of natural science and natural philosophy.

A New Natural Philosophy

Why then must science repent? At one level, "If the scientists themselves cannot arrest the process… then someone else must arrest it," before it abolishes man and leads to one 'brave new world' or another. At a second level, the implementation of a holistic curriculum and an incarnational pedagogy allows the students to develop habits that are more life-giving and humanizing. And finally if we wish our students to grow wise, then we simply must appreciate that natural science is not a merely 'positivistic' discipline isolated from all others. On the contrary, it grows by attention to poetic knowledge as gained by communities of faith and practice; by engagement with literature, philosophy, and history; and by submission to theology, the queen of the sciences. Thus we do well to give the students structures which embrace a holistic curriculum, an incarnational pedagogy, and an interdisciplinary approach. For all these reasons it is time to heed Lewis' call. This is not an easy project. But let us pray that by God's grace Christian Classical Schools may become a source of renewal for the "New Natural Philosophy" that Lewis imagined.

Coda: As an outgrowth of this project www.recoveringnature.org has been started. It is a collaboration tool for those trying to implement such a vision in a classroom or school. The three central projects of the website are: 1) Shared Lesson Plans, 2) Establishing the Narrative, and 3) Reimagining Curriculum. All interested are welcome to participate further there.

Endnotes

[1] C.S. Lewis, "On Science Fiction" in *Of Other Worlds: Essays and Stories* (New York, NY: Harvest/HBJ, 1966), 62.
[2] Owen Barfield, Lewis' close friend and fellow Inkling, called this kind of knowledge, "dashboard knowledge" in his masterful book, *Saving the Appearances*.
[3] This last line is almost certainly a reference to Mary Shelley's *Frankenstein*.
[4] Etienne Gilson was the first to bring to my attention this double influence of Aristotle. See *Being and Some Philosophers*, 50.
[5] Steven Shapin, *The Scientific Revolution* (Chicago, IL: University of Chicago Press, 1996), 71.
[6] James K.A. Smith, *How (Not) to Be Secular* (Grand Rapids, MI: Eerdmans, 2014), 77.
[7] Mary Shelley, *Frankenstein*, p32.
[8] James S Taylor, *Poetic Knowledge* (Albany, NY: State Univ. of New York Press, 1998), 149.
[9] SCL Journal Spring 2015, "Science and Poetry," Ravi Scott Jain.
[10] See "The Metaphysicians" in *The Economist* on March 15, 2014 regarding the influence of Stanford professor John Ionnadis' very controversial 2005 paper "Why most published research findings are false." Ionnadis has more recently claimed in the peer reviewed journal PLOS Medicine that "Currently, many published research findings are false or exaggerated, and an estimated 85% of research resources are wasted." October 21, 2014.

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Recovering the Nature of Science: Some Guiding Principles and Practices for Middle School

by Jason Faulkner

Confession and Repentance

"Mr. F, can we blow something up today?" When I began teaching middle school science nine years ago, a certain sixth grade boy asked me this question at the beginning of almost every class. It was earth science, by the way.

Day after day I laughed off the eager boy's request and told him that he would have to wait for eighth grade physical science before we could "blow stuff up." Somehow in my mind it seemed more appropriate to indulge a teenage boy's craving for explosions once he had been introduced to the more "advanced" sciences—once he could tell me what an atom is. Truth be told, I think I enjoyed fueling his curiosity by dangling bits of "secret knowledge" in front of him, promises about the true nature of things, revelations that would give him more control, more power—the power to blow stuff up.

A few years into teaching, however, my default disposition toward the field of science and science education—and, by extension, the natural world—began to sit uncomfortably with me. There seemed to me a conflict between how I had been taught to view the purpose of science and what Scripture teaches about man's epistemological relationship to God and His creation.

It wasn't until I began hearing the voices of C. S. Lewis, Parker Palmer, David Hicks, among others[1], that my presuppositions about the purpose and limits of scientific study, fossilized under years of conventional education, gradually began to be unearthed.

As I continued this excavation, it became increasingly clear that I had been committing two major sins in my teaching. First, I was training my students to view "science" as discretized, disembodied knowledge coupled with precise methodology. The rich *stories* of scientific enterprise that lay beneath the veneer of the modern science textbook—the messy tales of men like Robert Boyle and Isaac Newton, striving to synthesize empirical observations with a Christian ontology—these stories had no place in my classroom.

My second sin was more subtle, though perhaps more injurious. Mirroring my own posture toward knowledge, I motivated student learning not by reverence and love for God and creation, but rather by the appetite of *curiosity*.[2] To borrow Lewis' phrasing, rather than presenting the study of the natural world as a means by which to "conform [my students'] souls to reality," I offered science as objectified knowledge with which my students could join the progress of modernity and "subdue reality to the wishes of men."[3]

Last fall, the SCL Alcuin retreat provided a fresh alignment for my journey as a middle school science teacher in a classical Christian school. I had uncovered those long-buried presuppositions about science and science education, but the readings and discussions at Alcuin acted like the archeologist's brush, bringing further clarity to how I might begin this process of recovering the true nature of science in my classroom.

Guiding Principles[4] and Applications

I have recapitulated my takeaways from various readings and the Alcuin discussions into what I will call "guiding principles for a recovery of science education," four of which I will discuss presently, including examples of implementation in two middle school science classes. These principles are governed by a fundamentally Christian ontology—an affirmation and sanctification of the material world, bound up in the goodness of creation, the incarnation of the Son, and the resurrection of the Son.[5] Moreover, this governing ontology is *participatory*— that is, "being is a gift from the transcendent Creator such that things exist only insofar as they participate in the being of the Creator—whose being is goodness. Within this framework, the vocation of things is both imitation and reference."[6] This "restoration of the sense of natural interiority, of the metaphysical 'depth' to all things," gives back to the world its "sacramental quality, its dimension of mystery."[7] Such a distinctively Christian ontology must reframe our epistemological approach to the natural world, an approach which I hope to articulate in these guiding principles and examples of practices.

The first guiding principle for a recovery of science education is that we must model for and inculcate in our students a humble, reverent, and charitable disposition toward creation and the study of creation. Our students' growth in their knowledge of the natural world should lead them toward a life marked by responsible dominion of God's creation, which looks more like cultivation than coercion.

One way to inculcate this charitable disposition is through nature study, according to the tradition of Charlotte Mason, in which our younger students take part at my current school. I used to think that nature study was just a "cute" way to do science with young children, not understanding its value beyond that. Then I had kids of my own, and I began to see the beauty of God's world anew through their eyes. Once I watched my two girls examine a cicada carcass for nearly half an hour, turning it over, poking it with a stick, holding it delicately in their tiny hands. I have come to realize that young children do not have to be taught to wonder at creation—it is their nature to be wooed by the reality of God's world. In the words of Anna Comstock, an early 20th century educator and leader in the nature study movement, "Nature study aids both in discernment and in expression of things as they are."[8]

If you pick up the nature study sketchbook of one of our young elementary students, you will see in their attention to detail, color, and form a truly humble, reverent, and charitable disposition toward creation. Young children seem to have the power to see and express natural beauty in ways that adults have long forgotten.

But when nature study is displaced by "science class" in the later elementary years, reverent observation tends to give way to curious analysis. Some of this change is appropriate—children should begin to ask *why* and desire to know *how.* But I wonder if we are rushing them to this analytical stage a bit too eagerly and, perhaps unwittingly, opening the door to atomism while simultaneously stifling the cultivation of a charitable disposition toward God's world *as it is.*

"The expression of things *as they are,*" Comstock says. I should have mentioned, my girls never pulled that cicada apart to see what it was made of.

Taking my lessons from nature study, I have begun to reintroduce some reverent observation in middle school science. For example, before we begin a unit on heat transfer, I place a lit candle in front of each of my students. I then provide white sheets of construction paper and colored pencils, followed by succinct instructions: "draw the flame."

It never fails: some students immediately begin drawing not the flame in front of them, but the vague representation of "a flame" that lives in their memory. Others make an attempt at capturing the form of *their* flame, but with sparing detail. I allow this activity to continue for several minutes, then clarify my instructions: "Stop what you're doing and put your pencils down. Now, spend a few minutes studying the flame in front of you. After that, make a very careful and detailed drawing of what you have observed, using the full time we have remaining." With these new instructions, the entire mood of the room changes; one could hear a pin drop as students work studiously to capture vivid detail.

The next day I ask the students to describe in writing the flame they had sketched. The students are able to produce effortlessly—with no flames or sketches of flames visible--descriptions that are not only accurate in detail but artistic in expression. This exercise does not teach them *what* a flame is or *how* a flame works, but after two days of study they certainly *know* a flame—poetically, in a way that moves them not toward intellectual pride but rather toward adoration. *This* is the foundation on which we build our more analytical study of heat.

This mention of adoration leads to **the second guiding principle for a classical, Christ-centered approach to science education: the study of creation should be affirmed as a form of worship of the Creator. Science instruction should be situated within doxological bookends.**

A few years ago I stumbled upon the awe-inspiring macro-photographs of snowflakes by Russian photographer Alexey Kljatov.[9] I created a slideshow of his snowflakes set to the music of Beethoven's *Moonlight Sonata.* During a day on which we serendipitously had some residual snow on the ground, I welcomed my students into my classroom by playing the slideshow for them. Afterwards, the students were eager to collect some snow from outside and view the crystals under a microscope. After observing the fleeting beauty firsthand, I asked them to write a reflection. I have included just a few here:

"The detail God has put into these snowflakes makes me want to know more about the wonderful things He can do."

"To see the beautiful detail in a snowflake reminds me that I am fearfully and wonderfully made."

"The snowflakes are not much different from us. We both have the same purpose: to glorify God."

We are wise to "consider the lilies" and encourage our students to do the same. Such an incarnational epistemology invites our students into a knowledge of God and His creation that not only complements but transcends scientific knowledge.

This reference to a more human way of knowing leads to the **third guiding principle toward redeeming science education: Against the positivism of the modern textbook, we must re-humanize science. That is, we must tell the story of science, examining closely the philosophical and theological implications of scientific thought as it has evolved with human consciousness throughout history.** A winsome re-narration of this rich and messy history appropriately tarnishes the shine of scientific knowledge while also redeeming the coherence between the pursuits of science and the pursuit of Christ.

Last year my eighth graders researched and presented on the history of atomism instead of taking a semester exam. They studied thirty different people—from Democritus to Heisenberg—and explored their contributions to the ontology of atomism, considering also theological implications. Together we became better acquainted with man's struggle throughout history to wrap his mind around the nature of being.

The same students not only learned to apply Boyle's Law, but also read about Robert Boyle himself. We did the same for Mendeleev during our study of the Periodic Table and Lavoisier during our study of chemical nomenclature. Students learned that Boyle funded Christian missions to the Far East; that Mendeleev was the youngest of seventeen children whose mother cared so much about his education that she took him across Russia from Siberia to Moscow to attend a better school; that Lavoisier, despite being renowned in his own time for his scientific brilliance, died by the guillotine during the height of the French Revolution. In stories, the objectified knowledge of science becomes reconnected to actual people who lived in space and time. My students' interest in and appreciation for the truths uncovered by the cycle of scientific enterprise found new life when these truths became connected to a narrative, one that now can be seen as just a micro-narrative in the grander story of man's relation to creation and Creator.

But latching on to these truths—this new knowledge about the natural world—can have a dangerously intoxicating effect. As history has shown, "where knowledge grows without wisdom and without reverence, it threatens both our humanity and our world."[10] Thus the fourth guiding principle is necessary: a normative framework should gird all of scientific study. More important than the question of can we do something with our knowledge is the question of ought we to do something with our knowledge.

We began second semester of earth science last year by reading the second chapter of Lewis' *The Magician's Nephew,* where we find Digory engaged in a frustrating discussion with his Uncle Andrew, moments after Digory's friend Polly touched a mysterious ring in the uncle's study and disappeared. While Digory is preoccupied with the whereabouts of his companion, Uncle Andrew insists on lecturing him on the merits and costs of scientific advancement by way of a self-aggrandizing explanation of his own research, which led to the magic rings and Polly's current predicament as the newest subject in his experiment. Accused by Digory of being "rotten," Uncle Andrew replies,

"Men like me, who possess hidden wisdom, are freed from common rules just as we are cut off from common pleasures. Ours, my boy, is a high and lonely destiny."

Digory advocates for Polly as well as other innocent creatures that have vanished to an uncertain fate, but Uncle Andrew replies,

"Can't you understand that the thing is a great experiment? The whole point of sending anyone into the Other Place is that *I want to find out what it's like."* (emphasis mine)

At the completion of our reading, I asked my students to answer the question: "In Uncle Andrew's perspective, what is the purpose of scientific investigation?" This prompt launched us into a rich discussion of Lewis' main argument from *The Abolition of Man,* giving us that normative framework for scientific study.

I followed this discussion with a picture study of Joseph Wright's *An Experiment on a Bird in the Air Pump*[11], a beautiful reprint of which hangs on a canvas in my classroom. In this painting Wright depicts a scientist surrounded by a gathering of folks, each of whom displays a varied reaction to his recreation of one of Robert Boyle's air pump experiments. The pump contains a bird, being deprived of air, and the scientist looks out at the viewer of the painting, hand on the air valve, almost inviting the viewer to decide the fate of the bird. The battle between curiosity and charity is palpable, and that scientist looks out at my students every day, beckoning them to take a position.

He beckons me as well.

Endnotes

[1] In addition to the works cited below, I am heavily indebted to the works of Parker Palmer (*To Know as We are Known: Education as a Spiritual Journey),* James K.A. Smith *(Desiring the Kingdom; Imagining the Kingdom),* James Taylor *(Poetic Knowledge),* Owen Barfield *(Saving the Appearances),* Stratford Caldecott *(A Science of the Real),* and Nancy Pearcey & Charles Thaxton *(The Soul of Science).*

[2] Augustine differentiated between *curiositas,* which he considered a vice—the "lust of the eyes cloaked under the name of knowledge and learning,"—*and studiositas,* which he considered a virtue and the opposite of *curiositas, Confessions, 10.35.54*

[3] C.S. Lewis, *The Abolition of Man,* p. 77.

[4] I stand on the shoulders of giants like Ravi Jain, Robbie Andreasen, and Chris Hall, whose pioneering work in recovering the nature of science has aided me significantly in the articulation of these principles.

[5] This ontology is articulated well in chapter 6 of James K.A. Smith's *Introducing Radical Orthodoxy.*

[6] Ibid, p. 191.

[7] Stratford Caldecott, *A Science of the Real, Communio V. 25.3*

[8] Anna Comstock, *The Handbook of Nature Study,* p. 1.

[9] Alexey generously provides full resolution photographs for free download on his Flickr page.

[10] David Hicks, *Norms and Nobility,* p. 145.

[11] I owe much gratitude to John Mays, who first introduced me to the work of Joseph Wright and the significance of this painting in particular.

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What Hath Dante to do with Biology?

by Robbie Andreasen

The short answer is, within the modern conception of biology, nothing. No piece of literature fits within the *modern* framework of biology. Even history does not really fit. Of course Darwin is talked about in the chapter on evolution, and Mendel is mentioned in the introduction to genetics. Perhaps Harvey is mentioned in the chapter on the circulatory system, but not much else. But this is hardly meaningful. Why is this? For two reasons: first, it is because the modern biology textbook, along with any other science textbook, is what we understand about that subject at this point in time. The twists and turns of the past are not necessary when compared with the volume of science information to know right now. Secondly, science is seen as an independent subject. Philosophical foundations do not need to be considered, and theology has no influence on it at all. Modern science at best is merely about living well in the here and now or looking to the future. How can this system fit into classical education? In short, it cannot. However, there is a way to restructure biology so that it can fit within a classical model which makes Dante both relevant and necessary to the curriculum. Biology can be taught in a way that is faithful to the integrity of the discipline of biology as well as following an historical progression that allows philosophy, history, and literature to be integrated into the curriculum and thus be conducive to our classical model. The older categories of natural history and natural philosophy have a way of being recovered.[1] It is all in the sequencing of the material.

Basically the content of modern biology is done backwards and needs to be turned around. The first quarter should start with the human body and not microbiology. The systems of the body are learned along with the processes, e.g. circulation, necessary for sustaining human life. In my class we focus on the integration of parts and processes as opposed to going into depth for particular parts. It is sufficient for my students to know the 11 systems, the parts within those systems, their purpose, and how they interconnect with each other. The final test of the quarter is a one-question essay, "You eat a ham and cheese, lettuce, tomato, mayo, and mustard sandwich. How does this affect every system in your body? Discuss every system, its parts, purposes, and their integration. Also discuss the six main nutrients found within the sandwich and their importance for the body."

In the second quarter the animal kingdom is discussed starting with the vertebrates and then the invertebrates. Major taxonomic groups are discussed, e.g. amphibians, along with how each group handles the same life processes students learned regarding their own bodies. All animals need to perform the same type of processes, but they do them in different ways. The way to test this is to give students pictures of representative creatures along with a life process. Students need to give the taxonomy of the creature along with how it handles that specific life process. The final topic discussed is plants including taxonomy, parts, and reproduction.

What is the historical significance of this progression of material in biology? Prior to the invention of the microscope these were the only biological topics that were understood. Historically this is knowledge from the ancient civilizations in the Near East, Greece, Rome, and also that from the Middle Ages. It is during the first semester when students discuss that even though people, animals, and plants have been seen during these time periods, they have not all been seen in the same way. The Greeks valued philosophical wisdom and the soul more than the understanding of natural processes. The Romans preferred practical gadgets like aqueducts and plumbing to the philosophical ideas of the Greeks. People in the Middle Ages saw nature as emblematic of spiritual realities, much like Scripture talking about creation praising God or trees and rivers clapping their hands.[2] All throughout was the idea of essentialism or forms, those unchangeable essences found throughout Creation. Another idea from ancient Greece was the great chain of being that sequenced Creation into a straight line and served as a kind of taxonomic structure. These ideas are like threads throughout the curriculum. The class is a biology class and not a history of science class, but these ideas can be interwoven throughout when the material is sequenced in this way.

This leads to the third quarter, which starts with cells and the microscopic life of protists, bacteria, viruses, and fungus (yes, fungus is mostly multicellular, but this is the best way to sequence it). Following the completion of the diversity of life we discuss how the theory of evolution arose in order to account for such diversity. Evolution is discussed in terms of what Darwin understood in order to see why the theory of evolution quickly became the underlying theory for all of biology. The history of the worldview of the Middle Ages and its change through the scientific revolution up until the late 19th century is also discussed--and this is where Dante comes in--the details of which will be enumerated below. The last part of the third quarter is when students study ecology in the Everglades. It is important to take advantage of the natural resources in your area. The Everglades is a unique ecosystem, and the bugs are not that bad at the end of the third quarter, so that is the best time to go.

The fourth quarter is when biology will focus on all of those things nobody in the 19th century understood, the processes within cells and genetics. These processes include photosynthesis, cell respiration, mitosis and meiosis. For the historical timeline it is back to the 19th century to start with Gregor Mendel and go through genetics to DNA and the process of making proteins. This completes the material of biology and now allows the class to re-evaluate the theory of evolution while examining the evolutionary history of life. It is now possible to see how the various positions on evolution and the Bible that are currently taken have roots that go back hundreds of years.

As seen with the first semester, there is an historical progression to this sequencing of the material of biology that allows for not only maintaining the integrity of biology as a subject but also providing space for the integration of other disciplines such as history, literature, and philosophy. There are several other benefits as well. There is a progression of material from concrete to abstract. The ninth graders in biology class are really just older middle-schoolers. Their world does not extend much beyond their noses, so the easiest way to hook them into the material of biology is to get them to understand how their own body works. Their minds at the beginning of the year are less able to handle the abstract nature of cell processes. These are learned in the fourth quarter when it can be tied to concrete material they have already learned. This resequencing also allows us to recapture not only the older categories of the natural science tradition but also the natural history tradition. The topics of biology are treated within their commonly understood boundaries, similar to how they have always been done within the natural history tradition. The natural science tradition, or the exploration of causes, e.g. evolution, is considered after the exploration of the categories it is attempting to explain and is not assumed from the outset.

Another benefit of this progression includes reducing the heat and the pressure of the origins discussion. This happens because this modern discussion is seen in the larger context of a conversation that extends back to ancient Greece when natural philosophers were asking: "What came first, mind or matter?" If the conversation has been going on for so long and a complete resolution has not yet been reached, and if you do not have all of the answers by the end of ninth grade (or ever), it is okay. Each position of science and faith can be discussed in its strongest form allowing for an understanding of how history, philosophy, and science have been influencing each other over the centuries and thus making these issues increasingly complicated. Pressure is also reduced through this progression because evolution, which is often the underlying assumption of the text, is not made the automatic assumption of the class. Think about the progression of the modern science textbook: chemistry, cells, cell processes, microbiology, and then macrobiology; there is an underlying evolution assumption built in. If you reverse this sequence, then that underlying assumption goes away, and the theory of evolution can be discussed as a proposed explanation for the phenomena observed instead of assuming the cause of evolution as true, complete, and unproblematic and then fitting the phenomena to it.

So how does Dante fit in? Dante provides a glimpse into the medieval worldview. Recall that *Inferno* begins with Dante being alone in a dark wood, separated from the love of God (represented by the sun) and surrounded by three beasts, which represent sin. There are multiple clues within the text about why this is a comedy or that Dante will come to a good end: it is the year 1300; it is dawn; Aries is in the sky indicating the moment of creation; and it is Good Friday. In summary, the cosmos is speaking to Dante and telling him that even given his lost condition, he will come to a good end. There is a harmonious structure to the cosmos where everything is in a beautiful balance and order. The spheres of the planets move around the earth because of their love for God, and they sing the music of the spheres.[3] There is a cosmos that exists and not an endless, lonely universe. The cosmos (from the same root whence we get cosmetics) is the beautifier of God, showing forth the beauty of the Creator. There is a balance between the planets and the metals they form on the earth along with the four humors that flow within people. Lastly, from Dante we realize that it is love that drives people and not just the influence of the cosmos. The disordered loves of people drive them to the inferno, and the disordered loves of believers are purged in the trials of purgatory so that they can be filled with the love of God that they desire.[4]

This starts to change during the Renaissance and the scientific revolution. The language the cosmos speaks becomes the language of mathematics. Copernicus realizes that the math behind planetary motion becomes easier if the sun is in the center. Few people care, especially if he is only trying to save the appearances and make predictions easier. Kepler comes along and realizes that the math gets even more accurate if the sun is in the center (or at a focus) and the paths of the planets are ellipses instead of perfect circles. No big deal, as long as the attention is on making the math easier. Galileo, however, had the audacity to say that the universe moves the way Kepler describes it *in reality.* Newton comes along and figures out that the same math that can describe motion on the earth describes the motion of the heavens. What is called the mechanical philosophy becomes the dominant idea for understanding the universe. God is now seen as a great engineer that built a wonderful machine we are to study and now we glorify Him by figuring out its laws.

Life, however, could not be explained by the mechanists. Living things had to be accounted for by God's direct action into creation. Living things were too complicated and thus God must have had to stick His hand into creation to make living things instead of creating a law that accounted for them. So the 18th and early 19th centuries gave rise to the Romantic reaction against mechanism. Then Darwin developed his theory of how new species originate by the mechanism of natural selection, thus linking all organisms together through descent from a common ancestor. Now the mechanistic philosophy was complete (focus on material and efficient causes), and the total reversal of the worldview from Dante and the Middle Ages to our current one was finished. The cosmos that moved by love is now a vast emptiness of objects operating by law-like mechanism. People who were image bearers of God with disordered loves are now just sophisticated animals struggling for survival, or 'nature red in tooth and claw.'[5] Pride as the deepest of sins becomes the self-esteem of success.[6] Material things that were pointers to spiritual realities become meaningless cogs in a pointless machine. Beauty, and finally goodness and truth, become relative.[7] Ironically, while Darwin built his theory of evolution on the idea that all nature is at war, current evolutionary theorists understand that nature also works by cooperation and interdependence. So the cosmos of Dante that was moved by love is perhaps lost unnecessarily. It may be a perspective that needs to be recovered. Perhaps there is a place for natural philosophy and the exploration of formal and final causes within creation and not just the material and efficient.

So what hath Dante to do with biology? When biology is taught in an historical progression, Dante helps students understand the medieval worldview so that Darwin can be understood as the completion of the worldview of our modern culture. As classical educators we want to innoculate our students against the modern worldview of meaningless materialism, the pride of self-esteem, the separation of God from His creation, and the lack of integration of disciplines found in modern education. Teaching biology using the above sequence of topics allows for the integration of knowledge and helps students understand the worldview shift that has taken place from the Middle Ages to now. This provides a platform for seeing things differently. Discussion of origins that is ripe for creating division is situated within an historical context, thus reducing tension and allowing for understanding the complexities of the issue. Scripture is filled with verses of creation speaking. Perhaps exploring Dante in biology class can open students' minds to seeing the creation outside the confines of modern science and thus hearing what the book of nature has to say.

Endnotes

[1] See Clark and Jain, *Liberal Arts Tradition.*
[2] Psalm 98:8; Isaiah 55:12
[3] Think of "This is my Father's World" and how all nature sings and around me rings the music of the spheres or myths where the world is created by song e.g. *The Silmarillion* by Tolkien.
[4] For more information see Louis Markos' talks from SCL 2014 as well as his book *Heaven and Hell: Visions of the Afterlife in the Western Poetic Tradition.*
[5] From the poem *In Memoriam* by Alfred Tennyson.
[6] *Dangerous Passions, Deadly Sins: Learning from the Psychology of Ancient Monks.* Dennis Okhlom.
[7] *Awakening Wonder: A Classical Guide to Goodness, Truth, and Beauty.* Steve Turley.

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Only Natural: Poetic Resonance between the Common and Liberal Arts

by Chris Hall

The lengthy split on its well-worn seat and the obtuse cant of its wobbly back attested to two things. First, the frequency of its use, and second, its immanent consignment to the dumpster. A note prominently attached to the pitiful figure read: "Can anything be done to save this?" The old footstool had shown up in my lab, part science space and part old school shop, with a heart-felt, hand-written hope for help.

In no time, the old footstool had become a lesson. It was brought back to the kindergarten classroom from whence it came, where the students gathered around its decrepit form to hear a tale of what it would soon become. Glue was applied, along with some speed clamps. Sanding took place, followed by some spot fixes and buffing. Strategic woodscrews placed tension here or there where it was needed most. To top it off, a new candy coating of bright yellow paint. The restored stool re-entered service within the week, but it occurred to me that the functionality of that stool far surpassed that of its physical form alone.

For these kindergarteners, and more than a little bit for their teacher, that stool was a model of redemption, and of the liberating power of the common arts. Without a little knowledge, hope had been lost. Brokenness was beyond repair. But with a little shop savvy and some elbow grease, what was lost was made anew, and in the process, changed the way these students understood their relationship to the physical world around them.

The liberal arts were named at a time when the most important skill for freemen was to be able to participate in civic matters, which required moving beyond the concerns of simple crafts to the art of statecraft. There is no debate about whether or not the liberal arts are important for us to impart to our children today, but what if our culture has moved us so far from the experience of the *real* that a driving need of our children today, particularly our youngest learners, is to balance their experience in the liberal arts with a return to learning about the non-virtual world through their hands and their senses? And even more pressing: what if their education for the Kingdom demands this paradigm shift as much as their education for the world of men?

Richard Louv, in his 2005 book *Last Child in the Woods,* coins the term "nature deficit disorder" to describe the increasing lack of natural experience that children face today as their entertainment becomes centered around electricity-driven virtual realities[1]. In losing touch with the natural world, the very world which Jesus uses to frame up so many parables, our students are losing touch with the source of their physical and metaphorical daily bread. They are losing the ears by which they *could* hear. Jaron Lanier, pioneer of digital media, in his book *You Are Not A Gadget* laments that "A new generation has come of age with a reduced expectation of what a person can be, and of who each person might become" due to the de-humanizing effects of recent technological saturation[2]. In losing touch with a real social landscape and pursuing the fruits of vainglory, our students are placing themselves first and their neighbors second. And perhaps the most quoted of all, C.S. Lewis laments in the third chapter of *The Abolition of Man* that the modern aims of applied science are more akin to that of the medieval magician, who sought to bend nature to his own desires, than to the wisdom of the men of old, who sought to know nature that they may be in resonance with wisdom, with God[3]. In losing our humility and recasting our place in the natural world through the social imaginary of a detached, omnipotent science, are we training our students to be the wild vines in the vineyard?

We need to ask ourselves: if we teach our students in the purely modern, secular way, are we foregoing the opportunity to show them nature in light of charity, holism, and thanksgiving? Can we develop a pedagogy that maintains the rigor necessary to become world-class scientists while also preserving a vision, not only of creation but of the practice of science itself, that is deeply *in dominio Dei?*

Fortunately, John Milton had an answer to these questions in 1644. Speaking squarely from the middle of the time period in which our modern paradigms about science were being formed, Milton advocated a holistic educational experience based upon the liberal and the common arts working in concert:

> And having thus passed the principles of arithmetic, geometry, astronomy, and geography, with a general compact of physics, they may descend in mathematics to the instrumental science of trigonometry, and from thence to *fortification, architecture, engineering, and navigation*…. To set forward all these proceedings in nature and mathematics, what hinders but that they may procure, as oft as shall be needful, *the helpful experiences of hunters, fowlers, fishermen, shepherds, gardeners, apothecaries*;…. And this will give them such a real tincture of natural knowledge, as they shall never forget, but daily augment with delight.[4]

Milton is advocating nothing less than a meeting in the middle between the liberal and the common arts. The trivium and quadrivium form the academic foundations, while the common arts form the "tincture of natural knowledge", the experiences in real application, that will allow the student to become not only fully functional, but fully charitable, in the world. The lessons of the book are not detached from the lessons of the heart through the hands, and in so doing, the head, heart, and hands are united in a holistic education.

What Are The Common Arts?

John Scotus Erigena	Hugh of St. Victor
Tailoring, weaving	
Agriculture	Medicine
Architecture	
Warfare, hunting	
Trade	Navigation
Cooking	Theatre
Blacksmithing, metallurgy	

Consider this list in light of typical school settings, and it becomes clear that every discipline could be refracted through a common art. Warfare is generally precluded, but the skills of hunting could just as easily be taught by switching one set of optics for another: trade rifle scopes for cameras by creating a photography elective, and teach students how to set up for shots in the wild. Medicine makes its way into PE/Gymnastics through training in First Aid and CPR. Simulations in history class can lead to excellent experiences in trade: could your school develop an internal economy that honors the biblical admonitions to love your neighbor and avoid usury?

However, the easiest of all applications is in the science classroom. Each of these arts involves a rooted, real-world, applied understanding of physics, chemistry, biology, and/or earth science. Framing instruction in science could be as simple as hinging your curriculum on these arts and letting the information fall into place within the context of formation: as each is practiced, the science that undergirds each is explored and experienced first hand.

Three examples of applied common arts in our science program at The Covenant School are the Skills of the Tracker, multi-generational gardening, and the Ancient Technology Project.

Skills of the Tracker: Hunting Without Hunting, for Children

Our youngest learners are literally primed to *make* sense of the world by *using* their senses. These God-given gifts, meant to be used in an orderly way, are there to help them perceive the world all around.

They are also primed for narratives. Stories impart wisdom, and through them, students learn to make sense of what they experience. Narrative frameworks set the interpretive frameworks by which future experiences can be understood.

Imagine if our youngest learners learned science not in the lab, but in the garden, where senses and story are the gateways to a whole world of experiences, and you have the essence of the Skills of the Tracker units.

These experiences run progressively through grades 1-3. At the first level, students start with a story: *Owl Moon,* by Jane Yolen. This beautifully written and illustrated story about a father and daughter out on a winter's night calling in an owl frames the experiences to come. Students learn that they need to be silent, to be brave, to "make their own heat", and to follow the lead of a mentor who knows what to do in order to be successful. Students are taught how to walk silently, how to extend their hearing with "deer ears" and to use blurred vision to capture animal movement in the visual clutter of the leaf canopy. They practice hearing bird language, and interpreting the calls that our local birds make as they forage, call companions, and flee from danger. They learn the rudiments of natural history by taking time to sketch what they see outside, and not just the big picture: sometimes they are called to pay careful attention to the tiniest objects, which reveal their complexity when not quickly passed over. Through this experience, coupled with Scripture readings that highlight and place what they see in context, students learn rigorous scientific observation without learning to see the world as something to be dominated. They graph their findings, use field guides, keep field journals, and use the tools of science, but they do not catch the narrative that says that science is there for us to dominate nature. Rather, they learn that science is a way to see God smiling back at us from the garden no matter where we turn.

In the later grades, students continue to hone their basic skills while also exploring tracking pits, the movement of the sun (and its relation to timekeeping), observing from a single spot through all the seasons, and more. As they engage these experiences, they learn the scientific facts and processes within a context that is larger than the information itself. They also learn within a framework that is inherently cross-curricular: history plugs in at every step, as well as reading, writing, mathematics, and the fine arts.

Multi-Generational Gardening: Agricultural Mentorship

In keeping with the Christian practice of hospitality and the building of community, we are taking steps towards a multi-generational approach to gardening. In a chapter of his book *The Dumbest Generation* called "Betraying the Mentors", Mark Bauerlein laments the loss of mentorship in a culture of self-expression. Mentors are seen as getting in the way of expression, rather than as guides who have already walked these paths before, and are here, in charity, to share their wisdom.[5]

In seeking to actively undermine this cultural paradigm while also building our school community, we have asked not only parents, but grandparents, to share their expertise with our young students in our box and field plot gardens. From vegetable whisperers to flower powerhouses, we are drawing our constituents into our common space to share knowledge and to cultivate beauty. We are also actively breaking the standard school year cycle by asking our end-of-year 2nd graders to plant the corns, beans, and squash they will share with next year's 2nd graders in their annual 2nd-3rd potlatch supper.

All of these practices refine the sense that mentorship is valuable. It can come at many different levels and in many different forms, and as such, it forms cross-connections within our community and timeframes that might otherwise go unnoticed, or simply become lost, in the hustled pace of modern living.

Ancient Technology Project: History Meets Science Meets Shop Class

Our 6th grade students finish a History unit on Ancient Greece and Rome at about the same time they finish a Science unit called Awesome Architecture, which deals with the basics of atomic physics, chemistry, and mechanics. Bringing these two units together is as simple as asking one question: How would a modern understanding of materials help us to recreate ancient technologies using authentic materials? The answer to this question involves applied science, history, and power tools.

After picking an artifact to create, say a Roman *lorica segmentata*, students research a historically-accurate design, trace its history, and prepare a list of materials necessary to build a working model. Students render complete rough draft plans on paper, including all measurements and expanded diagrams of engineering challenges. While they are doing so, they alternate class days between the library and the shop, where they learn the basics of tool safety, selection, and technique. Students prototype portions of their design, test them, and make improvements upon their design before crafting a final artifact for presentation to parents and other school constituents at our annual STEM Night. Their presentations not only involve their craft, but also a refinement of their eloquence: students are provided a list of questions ahead of time that they must prepare to address.

There are plenty of success stories and failures along the way. Students realize, not just by instruction but through their hands, that wood has a grain or that metal is microcrystalline by working these materials themselves. They apply their knowledge of chemistry and mechanics to devise ways to craft, solve problems, analyze failures, and improve designs, all the while cultivating the virtues of fortitude, prudence, patience, and careful observation.

Students also acquire a skill set and disposition that is lacking in our disposable culture: things can be fixed, and we have the capacity, if we have the knowledge and the frameworks of understanding, *to* fix. This is as liberal as you get: it frees the self from being utterly at the whim of those who know how, while coupling the knowledge of the hands with that of the heart and of the head.

This is also STEM at its best, while mitigating its worst. There are no pre-fabbed materials, virtual problems, or even the simplicity of telling a machine what to do. This is craft. It requires all the logic, all the problem-solving, plus an additional embodied element of craftsmanship that is lacking in many modern, boxed programs.

Doug Stowe, a blogger who writes "Wisdom of the Hands", posted the following quote. It was subsequently quoted by Matthew B. Crawford as an opener for the first chapter of his 2009 book *Shop Class As Soulcraft: An Inquiry Into The Value of Work.*

> [I]n schools, we create artificial learning environments for our children that they know to be contrived and undeserving of their full attention and engagement.... Without the opportunity to learn through the hands, the world remains abstract, and distant, and the passions for learning will not be engaged.[6]

Contained within this quote are all the reasons why the common arts are resonant with the liberal arts. Without a context, we run the risk of decontextualizing what we teach, and in so doing, unwittingly perpetuating frameworks which allow for scientism to become a force within our culture. If we can reclaim some ground by re-instituting the common arts within our programs, we not only foster the best of the head, heart, and hands within our students, but we also give them a freedom that cannot be had simply by the exploration, no matter how broad or how deep, of a world of abstract ideas alone.

Endnotes

[1] Louv, *Last Child In The Woods*, pg. 10.
[2] Lanier, *You Are Not A Gadget*, pg. 4. Interesting to note that he is referring to the effects that Web 2.0 culture is having on us, in particular what is euphamistically called "open culture". He goes on to describe how it is anything but what the name implies.
[3] Lewis, *The Abolition of Man*, pg. 76.
[4] Milton, "Of Education", excerpted from Gamble, *The Great Tradition*, pg. 472.
[5] Bauerlein, *The Dumbest Generation*, pg. 167.
[6] Stowe, Doug. "Wisdom of the Hands" (blog), October 16. 2006. Quoted from Crawford, Matthew. *Shop Class As Soulcraft*, pg. 11.

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The Stones Cry Out...and the Flowers...and the Birds...and the Clouds: Discovering God (and Ourselves) through Science and Nature Studies

by Harlan Gilliam

Here at Regents School of Austin our campus is blessed to have a science and nature center. It includes a barn with stalls for farm animals, a large chicken coop, an amphitheater-like area for outdoor events, a classroom with tables and benches, and a sizable garden area for students to plant both fall and spring crops. Each class in grades K through 4 has on its weekly schedule a science and nature studies period in which the center is the classroom.

The nature center began about 13 years ago as a labor of love. A number of Regents families sought and received permission to reclaim an under-utilized corner of the school property that had been the site of a homestead and farm for several generations. The original farmhouse was gone and the barns and outbuildings were in disrepair. The families organized volunteer workdays and raised funds in order to give the students at Regents the fabulous facility now known as the Regents Science and Nature Center.

With the facility in place the teachers were invited to bring their students and plant gardens, take nature walks, or visit the animals at the barn. Many came and learned. Some came often, some came occasionally, and some came not at all. I worked here part of the time, when I wasn't farming, to help the students with their gardens.

When Rod Gilbert became our Head of School, he decided all students should have the opportunity to learn at the Nature Center. He added Science and Nature Studies to the class schedule for kindergarten through sixth grade. I came on full time to work with the classroom teachers and develop curricular connections for the students. This will be our eighth year on the class schedule and we continue to grow and flourish.

The Regents Mission Statement is at the core of all activities and lessons. It states:

"The mission of Regents School is to provide a classical and Christian education, founded upon and informed by a Christian worldview, that equips students to know, love, and practice that which is true, good, and beautiful, and challenges them to strive for excellence as they live purposefully and intelligently in the service of God and man." Each lesson or activity should include elements that lead to understanding (to know), attract attention and stimulate the emotions (to love), and reinforce the acquiring of wisdom that informs the will (to practice). Using (and honing) our skill of observation and tapping into our curiosity, we begin to explore our world. With grade level science curricula and a Bible we discover the creatures and materials that are a part of our amazing planet. We are participating in what is probably the original pedagogy! Rom. 1:19-20 states; "…what can be known about God is plain to them, because God has made it plain to them. For since the creation of the world His invisible attributes- His eternal power and divine nature- have been clearly seen, because they are understood by what has been made." As we begin to discover "His invisible attributes…" we can begin to see ourselves in a more biblical way. After all, He has made us in His image! Pursuing a deeper understanding of God by studying the created world leads directly to a better understanding of ourselves as bearers of His image. It leads to a better understanding because it is the habitat designed specifically for us. This is surely at the heart of any true educational endeavor- to know our God and to know ourselves. Science and nature are simply the vehicle for this journey.

In Kindergarten we begin the year in Genesis with the creation account. We study the five senses and see how they can gather information about our environment. We study insects, the solar system, wildflowers, oceans, and we grow lots of carrots in the fall.

First graders learn about the animal kingdom.

We begin with insects, learning key characteristics and observing life cycles. We make our way through some of the more notable classes; arachnids, fish, mammals, reptiles, birds, and amphibians; learning key characteristics and finding out that some characteristics are unique and some are shared. With each subject the students make an entry in their science and nature sketchbooks. A drawing, along with sentences relating the characteristics, becomes a record of our lessons and experiences with the animal kingdom.

Second grade science is focused on the plant kingdom. After an initial lesson on the variety within the plant kingdom, we narrow our focus to the flowering plants. The study is introduced to the students as "Parts of the Plant!" followed by the student's dramatic "DAH, DAH, DAAHHH!". We begin with seeds and discover the two types of flowering plant- monocots and dicots. We also see three main jobs (supply, support, storage) of each part. Lessons continue on with roots, stems, leaves, flowers, and fruit which brings us back to seeds. At each part we see the differences between monocot and dicot and look for the three main jobs. Along the way we check the Bible for insight into how the parts help us to understand God, His kingdom, and ourselves. Some examples:
Seeds- Gen. 1:11-12; 1 Pet. 1:23; Mark 4:30-32. Roots-Prov. 12:3; Eph. 3:17. Stems- John 15:1-5; Isa. 11:1. Leaves- Gen. 1:30. Flowers-Ps.103:15; 1 Pet. 1:24. Fruit-Gal.5:22-23; Luke 6:44-45.

Second graders also study the fungus kingdom for a month right after Christmas break. (It's an invisible kingdom that is always around us, even in the air we breathe, and we only notice it when it produces fruiting bodies. What does that sound like a metaphor for?)

Third graders begin with simple machines and ancient Egypt. We do an archeological dig and build life-size working shadoufs. The students bring food scraps from home and make compost in order to study the decomposition cycle. We observe the changes, learn the three states of matter, investigate the creatures involved with magnifiers and microscopes, and are in awe of the Creator who has thought of everything! We then move on to earth science where we find out about our amazing spaceship Earth (where we get to ride on the outside!). Moving through space at an approximate speed of 575,000 miles per hour we learn about the crust, the mantle, and the core. We learn of rocks and minerals, tectonic plates, earthquakes, and volcanoes. AWESOME! There are so many scripture lessons here.

Fourth grade studies pond life at our large pond complex. Complete with waterfalls, a stream, a bog, and 3 large fish ponds there is plenty to keep us busy. We put on waders and get in which leads to many exclamations of "best day at the garden, ever!". Fourth graders also learn about sound and light. We finish the year with a study of body systems.

Now, a few words about why we teach. Romans 12:2 states "Do not be conformed to this world, but be transformed by the renewing of your mind…" The Regents Mission Statement, mentioned above, is basically a restating of this scripture. With the mind we think, we believe, we understand, and we form our individual worldview. We live in a fallen world and a culture that continually hammers us with information. Most of this information is void of any mention of or reference to the Kingdom of God. The implication of this Scripture is that without renewing our minds we will not know God, His will and Kingdom, or ourselves. Eph. 4:11-13- "It was He who gave some as apostles, some as prophets, some as evangelists, and some as pastors and teachers, to equip the saints for the work of the ministry, that is to build up the body of Christ until we attain to the unity of the faith and of the knowledge of the Son of God- a mature person, attaining to Christ's full stature." Teaching is a calling given by Jesus. Some might say that this scripture pertains only to the church but we are the church and all of life is included in our relationship with God. As someone has said, "All is sacred. Nothing is secular." I agree. This means that no matter what topic you happen to be teaching, it can only be understood properly by recognizing its relationship to God, His kingdom, or ourselves who are made in His image. In the verses from Ephesians above, it states that the reason He gave teachers is to help us move towards "attaining Christ's full stature." No pressure! The first thing to realize is that we are all on this journey together. Some of us are just farther along which positions us to be of service to those coming after. Nature studies allow for us to discover God together. Instead of stories *about* God we see His creativity on display. I have found that it usually takes less than one minute for the students to find something that excites, amazes, or raises questions. This is much more than a fun activity for students. This is discovering who we are by learning about the environment/habitat in which we were physically designed to live. A turtle is designed to live in a pond spending its time seeking food, sunning itself , and interacting with other turtles. If you take the turtle as a baby and raise it in a box in the corner of your bedroom, away from the pond, other turtles, or even the sun, it will never be able to truly function as it was designed. Similarly, we have taken ourselves out of our natural habitat and now live in carpeted, climate-controlled boxes staring at screens. Is it any wonder that we struggle with confusion on nearly every front? Confusion about where we came from. Confusion about what is objectively true, good, and beautiful. Disconnected from the Garden and the Creator by sin, we strive to find comfort. Comfort for our bodies through climate control, comfort for our souls through décor and diversion, and comfort for our spirits through cloistering ourselves away from the fallen world. Just going outside will not automatically fix everything, but time in nature and nature studies, as an integral part of a person's upbringing and education, can provide many opportunities to learn who we are and grow into the people God has made us to be.

Before God made man in His image, He made a place for man to live. That place was a garden. Romans 8:19 states,"For the creation eagerly waits for the revealing of the sons of God." The creation not only displays the glory of God but, also, the effects of the fall. Weeds, thorns, drought, creatures which bite or sting, oppressive heat, or freezing cold all testify to the fact that something is not right. Romans goes on to say, in verse 22, "For we know that the whole creation groans and suffers together…" Psalm 19:1 says "The heavens declare the glory of God…" When God wanted to make a point with Abraham, He used the stars or the sand. When He announced the birth of Messiah, he did so in a field. Jesus took His first breath in a barn among the livestock.

God speaks to us in three distinct ways; through the Bible, by the Holy Spirit, and through His creation. We can help our students know God, themselves, and His Kingdom if we just get back to the garden. If you listen carefully, you will hear the stones cry out "Great is the Creator!" and you can hear the Father saying, " I love you."

As Director of the Regents Science and Nature Center for the last 7 years Harlan Gilliam has worked with classroom teachers in grades K – 4 developing a hands-on science curriculum and facilitating opportunities for students to discover God, His kingdom, and themselves through Scripture and nature studies. Harlan grew up in the Big Bend country of west Texas where he first became fascinated by nature. Married 32 years to Lisa and proud father of Sophie, he continues to pursue his passion for all that is true, good, and beautiful.

Evolution and Reductionism

by Greg Grooms

"In our world," said Eustace, "a star is a huge ball of flaming gas."
"Even in your world, my son, that is not what a star is, but only what it is made of."

-C.S. Lewis in *The Voyage of the Dawn Treader*

The dilemma of modern humans, according to the late Walker Percy, is that we live in an era in which we understand more about the universe in which we live than ever before and less about what it means to be human than ever before. We are in his words like a child "who sees everything in his world, names everything, knows everything except himself."

This dilemma shouldn't come as a surprise to anyone. After all we are complicated beings. On one hand we are marvels of mechanical cause and effect. The hand, the eye, and the ear are so complex that in the minds of many they bear witness to a creator. The complexity of the human brain alone rivals that seen in all the rest of the visible universe. On the other hand we are spiritual/mental/emotional beings. Consider Bach's choral works, Shakespeare's plays, Kepler's laws of planetary motion. Are they merely the by-products of matter? More than one philosophical naturalist has remarked on the irony that if humans are indeed merely accidents of an impersonal universe, then in us oddly the universe has begun to contemplate itself.

In an effort to simplify our self-explanations, we've tended to reduce one facet of our being to the other. To the Platonic Greeks we were ghosts somehow trapped in a machine, and the machine was less important than the ghost if for no other reason than it is disposable. We do die after all. It's a view of people that produced Gregorian chant and Gothic architecture amongst other beauties, but at the same time tends to strip the actions of physical people in a physical world of their value.

The modern world has moved in the opposite direction. As we understand the material world better, our bodies have become ever more central to us, and as we've understood them better, we've enjoyed the fruits of that understanding too, notably modern medicine. I'm here today in part because my father's life was saved when at age ten he contracted pneumonia and was treated with antibiotics, the wonder drugs of his day. But the man-as-machine worldview was also responsible at least in part for making the 20th century the greatest century of war the world has ever known.

At the heart of this ever-shifting self-examination for the last century-and-a-half has been Darwin's theory of evolution. While it attempts to fill in a large blank in our resume-- how did we get here?- it focuses exclusively on our physical side and in so doing fiercely challenges any dualistic understanding of human nature. Charles' theory not only provides a non-supernatural explanation of our origins, it functionally demands naturalism. What distinguished his theory from that of Erasmus, his grandfather, was that Charles' theory required no divine monkeying around to make it work. Not only is there no need for God to create each species from scratch, there's no need for Him to be involved in the evolution of any organism into another species. It works without Him; there is no supernatural involved. That's what makes it a *naturalistic* theory.

It's at this point that Darwin's theory weighs rather heavily into our modern human dilemma, for if we are the product of natural forces only, then we must be no greater than the sum of our natural parts. Thomas Nagel (philosophy, NYU) put it bluntly in *Mind and The Cosmos: "Materialism requires reductionism…"*

Some definitions may be in order here. Reductionism is the belief that the spiritual/mental/emotional aspects of human nature can be fully explained in terms of biology, chemistry, mathematics, and physics. It is not a belief that Nagel shares. When he says, "materialism" he means something similar to naturalism, but not exactly the same thing. Naturalism starts with rejecting the supernatural, and Nagel is all in favor of that. In his essay "The Last Word" he wrote:

> *I want atheism to be true and am made uneasy by the fact that some of the most intelligent and well-informed people I know are religious believers. It isn't just that I don't believe in God and, naturally, hope that I'm right in my belief. It's that I hope there is no God! I don't want there to be a God; I don't want the universe to be like that.*

Nagel doesn't see God in the big picture, but he does see more than mere matter. He rejects materialism, but not naturalism, in hopes of bringing another category into the discussion of the nature of the universe: mind. Not the human mind, mind you, but some other non-supernatural element of the universe that might account for the glories of human nature that stubbornly resist reduction to mere matter. His suggestion hasn't been well-received, but his logic, I think, is quite clear at least on one point. If we are the results of merely material causes, then we must be material, too. The only other option is that at some point in the process, something new emerged, which is an unsatisfying proposition, one materialists have had a good time making fun of for years.

An old cartoon by Sidney Harris illustrates this quite well. It features two men standing in front of a blackboard. Both sides of the board are filled with equations, but the middle is empty except for the words "Then a miracle occurs." One man points to the words and says, "I think you should be more explicit here in step two."

Darwin's theory is a materialistic theory and demands that all such gaps be filled with materialistic explanations. There is no room in it for a divine spark, no *pouvoir de la vie,* nothing non-material in substance or process. (Not that it does a very good job of filling them.) Nagel again in *Mind & Cosmos*; "*I would like to defend the untutored reaction of incredulity to the reductionistic neo-Darwinian account of the origin and evolution of life. It is* prima facie *highly improbable that life as we know it is the result of a sequence of physical accidents together with the mechanism of natural selection. We are expected to abandon this naive response, not in favor of a fully worked out physical/chemical explanation but in favor of an alternative that is really a schema for explanation, supported by some examples.*") This insistence poses a substantial obstacle to most theories of theistic evolution.

Historically theories of theistic evolution have been unpopular both amongst secular scientists and many theologians. The former argue with some acuity that if Darwin was right, then there's no place for God in the process. Theologians with a biblical bent respond that if Darwin was right, then the Bible is wrong. Thus proposed syntheses of Darwin and Christian theism more often than not have fallen upon deaf ears, that is, until recently.

The work of men like Francis Collins and Denis Alexander mark a sea change in attitudes toward theistic evolution. Collins is a distinguished scientist (Director of the National Institutes of Health) and a believer; Alexander is likewise a believer, a scientist (PhD. in Neurochemistry) and director of the Faraday Institute for Science and Religion at Cambridge University. Both share a personal and professional interest in the relationship between science and faith.

In his book *The Language of God* Collins warmly and winsomely argues that evolution fully explains how we came to be and the Scriptures fully explain how we find meaning in a relationship with God through Jesus Christ. After outlining a theistic theory of evolution, Collins concludes "*But this synthesis has provided for legions of scientist-believers a satisfying, consistent, enriching perspective that allows both the scientific and spiritual worldviews to co-exist happily within us. This perspective makes it possible for the scientist-believers to be intellectually fulfilled and spiritually alive, both worshipping God and using the tools of science to uncover some of the awesome mysteries of His creation.*" In *Creation or Evolution* Alexander likewise argues that a faithful reading of the Scriptures need not pose any obstacle to affirming a human evolutionary history. In his preface: "*I have written this book mainly for people who believe, as I do, that the Bible is the inspired Word of God from cover to cover… I therefore make no attempt in this book to defend the role of the Bible as the authoritative Word of God, but simply assume that this is the starting point for all Christians. If that is not your starting position, I hope at least that the book will help you see how the Bible and science can live together very happily.*"

Neither book attempts to answer all of the scientific and theological questions arising from the study of nature and the Scriptures; I certainly shall not attempt to do so here. My purpose in mentioning them in this essay is much simpler. You see, in embracing Darwin both Collins and Alexander embrace his materialism too. Not philosophically, of course-- both believe in God--but functionally in that God plays no part in the evolutionary process other than setting Darwin's system up. Collins states it quite bluntly: *"Once evolution got under way, no special supernatural intervention was required."*

Here's where the rubber meets the road, so to speak, for if we buy Darwin lock-stock-and-barrel, excluding God from the process of human creation, must we not embrace reductionism, too? Think of it like this. If I plan an assembly line to make gingerbread men, get the materials, organize it and set it in motion, what will its results be? Gingerbread men only. The mere fact that an intelligent being is behind it all doesn't change the fact that, if I start with matter and shape it by impersonal forces, then what results will be material. Nothing more.

The question of what C.S. Lewis thought about evolution has been argued for years and will doubtless continue to be argued for years to come. I'll not try to settle it here, but I will quote a passage from *The Problem of Pain* in which he acknowledges at least implicitly the point I'm trying to make here.

> *For long centuries God perfected the animal form which was to become the vehicle of humanity and the image of Himself. He gave it hands whose thumb could be applied to each of the fingers, and jaws and teeth and throat capable of articulation, and a brain sufficiently complex to execute all the material motions whereby rational thought is incarnated. The creature may have existed for ages in this state before it became man: it may even have been clever enough to make things which a modern archaeologist would accept as proof of its humanity. But it was only an animal because all its physical and psychical processes were directed to purely material and natural ends.* ***Then, in the fullness of time, God caused to descend upon this organism, both on its psychology and physiology, a new kind of consciousness which could say 'I' and 'me,' which could look upon itself as an object, which knew God, which could make judgments of truth, beauty, and goodness, and which was so far above time that it could perceive time flowing past.*** (Emphasis mine)

Here Lewis acknowledges the possibility that God might make a suitably complex human body through Darwinian evolution, but he also recognizes that for that being to be truly human something else has to occur. God has to add something to the mix that will not only define what people can do, but who they are.

Denis Alexander recognizes this problem, too, but tries to solve it without miraculously changing the nature of human beings. He reduces the image of God in humans to two categories, neither of which mitigate the reductionistic results of Darwinian evolution. "First, the delegation of divine authority does seem to be a key element of the term [human]… A further important aspect of being "made in God's image is that it involves relationship with God." I fear Alexander confuses cause and effect here. We are not made in the image of God because we have a relationship with Him; we can have a relationship with Him *because* we are made in His image. I have a relationship with my cat, Wampuss, too, but despite this she is only a cat and will never be more than that. Unlike Wampuss, humans have the capacity for rational thought, self-consciousness, moral convictions, choices, language, love, creativity and a host of other less-describable qualities that stubbornly resist reduction to mere matter and oppose reductionistic theories of evolution as fiercely as materialism opposes miracles.

If I'm right, then Alexander, Collins *et al* are firmly in the grip of Percy's dilemma. They are caught between a rock and a hard place, between their allegiance to a materialistic evolutionary process and a reductionist view of human nature that as followers of Jesus, they would rather avoid. It's a precarious position, but not one without remedy. They may together with believers throughout the ages affirm their commitment to science and to a scientific understanding of nature, while at the same time remembering that there are realities in a created world that are not reducible to mere matter and never fully explainable in scientific terms. The resurrection of Jesus is one such reality. Our own existence is another.

Endnotes

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Classical Christian Education and the Future of Science

by E. Christian Kopff

Classical Christian educators are often asked how their curriculum prepares students for jobs in science and technology. History shows that while classical education prepares its graduates for any profession, it was central in the creation of modern science. Advocates of STEM education say it prepares graduates for a world where good jobs will be in areas indicated by the acronym STEM: science, technology, engineering and mathematics. Classical education, however, teaches the arts of mathematics, the quadrivium, with four different subjects: arithmetic, geometry, astronomy and music. The superiority of the quadrivium is acknowledged by those who see the need to supplement STEM subjects with an arts component (STEAM).

The quadrivium, however, is only half of classical education. The other half is the trivium, the arts of language: grammar, dialectic and rhetoric. The trivium aims at mastery of the fundamentals of language, then of logical thinking and finally of winsome and persuasive discourse. The arts of language are essential for anyone who wants to participate actively as a citizen in governments with consensual institutions. Citizens need to be able to think clearly and express themselves grammatically and persuasively. The narrowly pre-professional STEM curriculum ignores this important vocation. Furthermore, even if it were to be true—which is not proven and not likely—that all good jobs in the future will be in STEM areas, many of these will involve using language. This includes teachers, researchers who must write grant proposals for committees of scientists with other specializations, and writers who explain the significance of the results of scientific research to non-scientists. A STEM or even STEAM curriculum without mastery of the arts of language is a recipe for personal frustration and national disaster.

Classical Christian education is not only useful for those looking for STEM jobs. History indicates that it provided the intellectual environment in which science prospered. From the invention of science by the ancient Greeks and its development under the Roman empire, during late Antiquity and the Middle Ages and on into the early modern and modern age until the middle of the twentieth century, science has been associated with classical culture and classical education, in fact, for most of this period, with classical Christian education.

Let us limit ourselves to the modern period. Marie Boas Hall called the first period of the Scientific Revolution *The Scientific Renaissance* (1960). She showed that modern science began with Renaissance humanism, the cultural initiative to re-establish contact with classical antiquity. Renaissance humanists discovered, interpreted and translated ancient texts, including Greek scientific manuscripts. They studied ancient science, corrected its errors and misconceptions, and then made new discoveries.

Renaissance humanists had classical Christian educations. Peter Dear in *Revolutionizing Science: European Knowledge and its Ambitions, 1500-1700* (2009), after discussing medieval science, goes on to explain the classical curriculum, trivium and quadrivium. The classical curriculum taught the arts of language (trivium) and mathematics (quadrivium) so students could speak, think and compute. They revered the past as the source of beauty and truth. Michelangelo promised in his contract that his Pietà would emulate the beauty of ancient art. Machiavelli's *Discourses on Livy's First Decade* ransacked the Roman republic for ways to restore freedom to Italy. Protestants like Luther and Calvin tried to reform the church by reading the Bible.

Sixteenth century scientists had the same classical education as other Renaissance humanists. Science then was self-consciously a return to the ideas and texts of ancient science. Copernicus (1473-1543) knew that he was reviving the heliocentric hypothesis of Aristarchus of Samos (third century BC). His book did not start from scratch, but was a careful revision of Ptolemy's *Almagest* (second century AD). The great doctor Andreas Vesalius (1514-64) devoted years to editing the works of the ancient Greek doctor Galen (second century AD) before publishing his seminal work on physiology, *On the Structure of the Human Body*, in 1543, the same year Copernicus's *De Revolutionibus* was published.

As Peter Dear wrote, "Like Copernicus, Vesalius presented his work as a restoration of an ancient practice; also like Copernicus, he pointed out flaws in the work of his great model from antiquity; and like Copernicus the rationale for his project emerged directly from humanist values and ambitions."

Classical Christian education continued to foster scientific research. Johannes Kepler (1571-1630) was a Copernican who read the texts of the Pythagoreans and Plato. Like them, he believed that mathematics was essential for understanding the physical world, even when this method led him to postulate that the planets moved in ellipses instead of circles. His fellow Copernican Galileo (1564-1642) denounced him for breaking with the ancient tradition of positing circular motion for the heavenly bodies. He too quoted Plato and the Pythagoreans. Scientists like Kepler and Galileo studied geometry in Euclid's ancient text to understand the natural world, as Plato had urged in *Timaeus* and *Republic* VII. Thomas Hobbes in *Leviathan* (1651) called geometry "the only science God hath seen fit to bestow upon mankind." Newton composed *Principia* (1687) in Latin with geometrical proofs as part of the same tradition.

There is a wide gap between popular opinion and the scholarly consensus on the role of Christianity and the classics in the explosive creativity of the seventeenth-century Scientific Revolution. Voltaire in the eighteenth century and twenty-first century polemicists and federal judges have presented the Scientific Revolution as rejecting tradition and explaining the world as mechanical and godless. In fact, the leaders of the Scientific Revolution were classically educated Christians.

In 1938 sociologist Robert K. Merton studied the founders of the Royal Society in 1660. So many were Puritans that he hypothesized they all were. They were certainly Christians. Merton's careful study of the Royal Society, a key institution in the Scientific Revolution, showed the "warfare" of science and religion did not exist then. In 1988 historian Steven Shapin wrote, "No historian of science now seriously contends that religious forces were wholly, or even mainly, antagonistic to natural science. When Merton wrote his thesis, that was not the case."

The memo had not reached Judge Jones when he composed his decision in Kitzmiller et al. v. Dover Area School District (2005): "Expert testimony reveals that since the scientific revolution of the sixteenth and seventeenth centuries, science has been limited to the search for natural causes to explain natural phenomena."

Scholars have continued to confirm Merton's results. Stephen Gaukroger in *The Emergence of a Scientific Culture* (2006) argued that in the seventeenth century "Christianity set the agenda for natural philosophy" or science. In 2009 Margaret J. Osler agreed: "For many of the natural philosophers of the seventeenth century, science and religion—or, better, natural philosophy and theology—were inseparable, part and parcel of the endeavor to understand our world."

Scientists then were also influenced by their study of the ancient classics. Copernicus, Tycho Brahe, Kepler, Galileo and Newton were products of classical Christian education. They studied ancient authors and could read and write Greek and Latin. Kepler and Galileo quoted Plato's *Meno* and *Timaeus*. The atomic theory Newton used in his optics was based on Gassendi's recovery of ancient Epicureanism. Classical Christian education shaped science then and continued to educate scientists for centuries.

Today scientists hide their faith in the closet unless they become so famous, like Francis S. Collins, that it cannot damage their careers. Seventeenth-century scientists openly proclaimed that their discoveries confirmed their faith. Robert Boyle (1627-1691), for example, discovered Boyle's Law in chemistry. Gaukroger wrote, "For Boyle the whole point of pursuing natural philosophy in the first place is that it reveals to us the handiwork and purposes of God in a way that goes deeper than anything we can achieve by use of natural reason." Boyle established a lecture series to defend the coherence of science and Christianity.

The first Boyle lectures were not delivered by a professional scientist, but by England's greatest classicist, Richard Bentley. Bentley did not see his Christian faith or knowledge of ancient authors as obstacles to science. On the contrary, he argued that Isaac Newton's *Principia* (1687) confirmed God's existence. Newton responded to a letter from Bentley, "Sir, When I wrote my Treatise about our System, I had an Eye upon such Principles as might work with considering Men, for the Belief of a Deity; nothing can rejoice me more than to find it useful for that Purpose."

In the appendix he added to *Principia* in 1713, Newton wrote, "This most elegant system of the sun, planets and comets could not have arisen without the design and dominion of an intelligent and powerful being…. He rules all things, not as world soul but as lord of all. And because of this dominion he is called Lord God Pantokrator." The classically educated Newton composed

Principia in Latin with geometrical proofs to show that an omnipotent God had designed the universe. Newton shared with other contemporary scientists a confidence in the compatibility of classics, science and Christianity. (Today, of course, Newton could not teach science in public schools.) The classical Christian education that shaped scientists like Kepler, Galileo, Boyle and Newton was then and still is the best education for scientists.

Sceptics object, "Of course the greatest scientists then had classical Christian educations. All this proves is that they were educated. There was no serious alternative back then. It was only in the eighteenth century that the case for vocational training was made by men like Tom Paine and Benjamin Rush, who argued for a modern education that rejected the trivium in favor of STEM subjects (science, technology, engineering and mathematics) for a world that wanted the fruits of science and technology."

History does not usually allow us to study events with a control group. One exception is nineteenth-century Germany with its two distinct educational paths. One path preserved the classical Christian curriculum (supplemented with more Greek) taught in the classical or humanist Gymnasium, from which students went on to the university. The other path was devoted to STEM subjects and a modern language (usually French) taught in technical high schools, from which students went on to a professional school or a job in industry. This critical mass of technically trained graduates working in factories protected by the tariff spurred German industrial growth in the generation before World War I.

The decades on either side of WWI also witnessed brilliant discoveries in Physics: the concept of quanta, the theories of special and general relativity and the development of Quantum mechanics. One might expect most important work in Physics to be done by graduates of the technical school system. Nearly the opposite is true. Max Planck, Werner Heisenberg, Erwin Schrödinger and Niels Bohr were classically educated. Einstein attended a Swiss technical high school, but he spent his first six years at a classical school, where his sister remembered his best subjects as Mathematics and Latin: "Latin's clear, strictly logical structure fit his mindset." Latin and arithmetic are the fundamental arts of language and mathematics found in the classical curriculum.

When Einstein published his four great articles of 1905, his editor was Max Planck, the discoverer of quanta. According to the Encyclopedia Britannica, "When Planck was nine years old…Planck entered the city's renowned Maximilian Gymnasium, where a teacher, Hermann Müller, stimulated his interest in physics and mathematics. But Planck excelled in all subjects, and after graduation at age 17 he faced a difficult career decision. He ultimately chose physics over classical philology or music because he had dispassionately reached the conclusion that it was in physics that his greatest originality lay." Classical Christian educators will notice that his favorite subjects belong to the Seven Liberal Arts: Latin (and Greek) grammar from the trivium, mathematics, science and music from the quadrivium. In a speech delivered shortly after Planck's death, physicist Werner Heisenberg, also a graduate of the Max Gymnasium, said, "I believe that in the work of Max Planck, for instance, we can clearly see that his thought was influenced and made fruitful by his classical schooling."

Heisenberg then explained how his own science was shaped by his classical education. After World War I Heisenberg was drafted into the militia. In his spare time he read Plato's *Timaeus* in the original Greek. He had been bothered by the notion that the fundamental particles of nature were little hard things with irregular shapes, the atoms of the ancient scientists, Democritus and Lucretius. Recently scientists had observed light behaving sometimes like particles, but at other times like waves. In *Timaeus* Plato argued that nature made most sense when viewed mathematically, not physically. Plato's advice to follow the math even when it contradicted common sense helped Heisenberg toward his discovery of the Heisenberg Uncertainty Principle in quantum mechanics. As a young scientist, Heisenberg reports, "I was gaining the growing conviction that one could hardly make progress in modern atomic physics without a knowledge of Greek natural philosophy."

Classical Christian education formed the minds of important scientists from the sixteenth to the twentieth century (and long before as well). They learned from ancient wisdom to make important discoveries. Americans should not desert a curriculum that has been successful for so long. If they do, they may learn that the relationship of classical Christian education and science is integral and that science will not and cannot flourish apart from the educational ideal and curriculum that fostered it.

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Science, Non-Science, and Nonsense: Toward the Legimate Science Classroom

by Mark A. Kalthoff

Recent years have witnessed no shortage of controversy regarding the nature and proper content of primary and secondary school curricula. The science classroom has offered no exception. Indeed, ever since the famed Scopes "Monkey" Trial of 1925, parents and teachers, politicians and lawyers, scientists and clergy, journalists and pundits, have weighed in with sundry suggestions, proposals and mandates regarding the teaching of science.[1] The results, contend some observers, suggest less progress in legitimate learning, than in production of lame legislation and loony litigation. In many cases, once the shouting subsides, terms of dispute can be stated rather simply: Such-and-such a topic, whatever interest it may hold for some, does not belong in the science classroom because the topic in question is not science; and *only* science belongs in the science classroom. A recent example of this kind of public kerfuffle was the 2005 Kitzmiller v. Dover trial in Harrisburg, Pennsylvania Federal District Court, in which the public school teaching of "Intelligent Design" theory was found to be an unconstitutional violation of the first amendment's establishment clause. My concern is not to consider the merits or flaws with Intelligent Design or any other contested theory or ideology, be it from the left or the right. Instead, this essay considers a premise upon which much curricular debate rests and it suggests something about the educational implications that follow from a recognition that this premise is, in fact, false.

In 1976 the English philosopher Alan Chalmers came out with a very nice little book under the title *What is this Thing Called Science?* He concluded the volume ironically by criticizing his own title: "[T]he question that constitutes the title of this book is a misleading and presumptuous one," he wrote. "It presumes that there is a single category *science,* and implies that various areas of knowledge, physics, biology, history, sociology and so on, either come under that category or do not. I do not know how such a general characterization of science can be established or defended."[2] About the same time, other philosophers of science reached similar conclusions. The distinguished philosopher of science, Larry Laudan, for example, observed that ever since Plato, "philosophers have sought to identify those epistemic features which mark off science from other sorts of belief and activity. Nonetheless, it seems pretty clear that philosophy has largely failed to deliver the relevant goods. . . . [I]t is probably fair to say that there is no demarcation line between science and non-science, or between science and pseudo-science, which would win assent from a majority of philosophers. Nor is there one which *should* win acceptance from philosophers or anyone else . . ."[3] Philosophers of science have persisted in this thesis to the present day. How did they reach such a conclusion? And what are the implications for the science classroom? First, the story of the failed attempts to distinguish science from everything else is long and complicated.[4] Further, scholarly "awareness of the contingency and fluidity of the boundaries between the sciences and the humanities," continues to generate conversation.[5] Although the scope of this essay does not permit a complete retelling of the narrative, it opens with a review of the tale's general themes before consideration of the educational implications.

The tale begins with ancient attempts to distinguish knowledge (*episteme*), on the one hand, from mere opinion (*doxa*), on the other. Here Aristotle led the way in his *Posterior Analytics* by distinguishing knowledge (or science) from opinion according to the principle that knowledge furnishes apodictic certainty.[6] Another ancient demarcation criterion was sometimes advanced upon the distinction between *techne* (the skill of one able at an art or craft or "know-how") and *scientia* (demonstrative understanding or "know-why"). One may be a capable auto repairman, for example, without possessing genuine understanding of the chemical and thermodynamic principles of the internal combustion engine. Hence we distinguish between the craftsman and the scientist by virtue of the scientist's comprehension of first principles. Thus there emerged in the ancient world two candidates for demarcation: one grounded upon the separation between apodictic certainty of science and fallible opinion of extra-scientific issues; the other distinguished between understanding and mere know-how.[7]

By the end of the seventeenth century, however, scientists had come to disregard the distinction between understanding and know-how as a viable demarcation line. Newton, for example, is famous for rejecting attempts to understand the cause of gravity or to answer why-questions about it. Instead, he remained content to *describe* mathematically *how* gravitation functioned (whatever it was).[8] The result was that scientists came to regard the distinction between science and non-science as the distinction between infallible knowledge and fallible opinion.

Such a view of the scientific enterprise could not withstand the overwhelming theme of the history of science, namely that scientific theories are *not* infallible. They are fallible, subject to correction and open to revision. If they were not, then the history of science would be in the odd position of declaring every revised or replaced scientific theory unscientific. This would render the history of science the history of non-science. The clear implication was that scientific belief, because it is not infallible, ultimately is a species of opinion.[9]

Still philosophers remained convinced that even if scientific belief is only a kind of opinion, it must be a special kind of opinion that is ultimately distinct from superstition. To demonstrate this, philosophers knew that they had to craft that distinction upon some other criterion than the alleged "certainty" of scientific knowledge. Surely, they believed, science could be set off from everything else, if not by virtue of the certainty it offered, then, perhaps, because it followed a distinct *methodology,* something they called *the scientific method.* Consider this view as expressed by the great English statistician Karl Pearson in his late-nineteenth-century work *The Grammar of Science:* "The scientific method is the sole path by which we can attain to knowledge. The very word 'knowledge' indeed only applies to the products of the scientific method in the field. Other methods . . . may lead to fantasy as that of the poet or metaphysician, to belief or superstition, but never to knowledge."[10] Strong words these are. It seemed perhaps that this thing called *the scientific method* would emerge as the decisive tool by which man could definitively set science apart from everything else and acknowledge it as the single source of knowledge. This would require, however, a rigorous and universally held explication of science's unique method. On this line of thinking any activity that was recognized as scientific would presumably employ the same method as every other ostensibly scientific activity. This is where the rub came. Philosophers simply could not agree on just what that *scientific method* was. Was science an activity that restricted its theories to observable entities? Was it an activity that exclusively employed inductive reasoning? Was it an activity unique in its capacity for making predictions? Consensus could not be reached.[11] "Absent agreement on what 'the scientific method' amounted to, demarcationists were scarcely in a position to argue persuasively that what individuated science was its method." Moreover, philosophical conceptions of scientific method often suffered from ambiguity or they substantially departed from the methods actually employed by practicing scientists.[12] The outcome of this situation, as Larry Laudan eloquently stated was "more than a little ironic":

> At precisely that juncture when science was beginning to have a decisive impact on the lives and institutions of Western man, at precisely that time when 'scientism' (i.e., the belief that science and science alone has the answers to all our answerable questions) was gaining ground, in exactly that quarter-century when scientists were doing battle in earnest with all manner of 'pseudo-scientists' (e.g. homeopathic physicians, spiritualists, phrenologists, biblical geologists), scientists and philosophers found themselves empty-handed. Except at the rhetorical level, there was no longer any consensus about what separated science from anything else.[13]

Not surprisingly then, the twentieth century saw the emergence of a new set of demarcationist strategies. The best early case of this new set of strategies emerged during the 1920s and 1930s through the efforts of the so-called Vienna Circle of philosophers to forge a semantic conception of the scientific enterprise, sometimes called "logical positivism." Science could be distinguished from non-science, logical positivists argued, because only the statements of science were meaningful. Meaningful statements were those that could, at least in principle, be verified. Hence the hope for setting apart science from non-science was placed upon this "verifiability criterion of meaning" which can be briefly stated as follows: a proposition is meaningful, and therefore scientific, if and only if the proposition is empirically verifiable.[14] Accordingly, a statement such as "God created the world and saw that it was good" is neither true nor false, but simply meaningless because it is not possible, even in principle, to say how such a proposition could be empirically verified. On the other hand the statement "Water freezes at 0° C" is empirically verifiable, and therefore meaningful, and thus scientific. Unfortunately for the logical positivist program, however, their own verifiability criterion of meaning could not pass its own test and was rendered meaningless; for to what possible empirical test could this criterion of meaning be subjected? How could anyone, then, presume to demarcate science from non-science by appealing to a meaningless principle? Or as another critic put it, "To say that only factual statements have validity is to be not only dogmatic but self-contradictory, since the statement itself is not factual."[15] The abject failure of logical positivism to demarcate science from non-science ran even deeper than this. While it certainly ruled out some "undesirable" metaphysics from the ranks of science, it failed to exclude other patent nonsense that happened to meet its criterion of meaning. For example, the proposition "The earth is flat," while clearly absurd, happens to be empirically verifiable in principle (even though the evidence mitigates against it); and therefore it is a meaningful statement that cannot be deemed "unscientific" according to the logical positivist demarcation criterion.[16]

Following the implosion of logical positivism, philosophers proposed that the search for a qualitative standard by which to isolate the scientific enterprise should be abandoned in favor of a quantitative benchmark. Maybe "scientific status is a matter of degree rather than kind."[17] What sort of things might we consider here? Candidates include the degree to which a science is "well-tested." For example, one might contend that the theories of terrestrial mechanics are more testable (and thus more scientific) than those of astrology. Perhaps instead, one might appeal to a pragmatic scale. The more scientific an activity, it might be argued, the more useful and reliable will be its products. Some have advanced the notion that science is comparatively progressive and cumulative in its knowledge. Unlike religion, for example, science can claim a rate of "cognitive progress" by which it is set apart from non-scientific activities that accrue knowledge only very slowly, if at all. Still others suggest that a scientific activity will result in more predictions of unanticipated outcomes than a non-scientific activity. It turns out, however, that every such quantitative benchmark – testability, pragmatic benefits, cognitive progress, predictive capacity and others – demonstrably fails as a viable demarcation criterion.[18] Although the scope of this essay does not permit exploration of how each one does fail, philosophical attempts to justify the quantitative approaches all reach the same conclusion: regardless of the criterion applied, each ends up including within the domain of "science" much that is intuitively and generally regarded as "extra-scientific," and conversely each ends up excluding as "extra-scientific" much that is widely regarded as "scientific."

What, then, are we to do? Are we to conclude that there is no such thing as science? Or at least, if there is, that we have no way of telling it apart from anything else? I do not think such despair is in order. Do we have to retreat to some sociological definition and say, "Science is just whatever scientists do"? This would be of little help, of course, because it would merely recast the question to ask who the scientists are.[19] Or perhaps we fall back on a tacit intuitive answer: "Science is like obscenity. Although we cannot define it, we know it when we see it." None of these ultimately satisfy. Consequently, at least in the context of education, we are driven to the only sane conclusion. We must stop asking whether or not an issue, belief, subject, or activity is "scientific." Instead we must ask whether or not it is *legitimate* to discuss an issue, belief, subject or activity (regardless of its alleged "scientific" status) within a classroom that is ostensibly devoted to such topics as physics, chemistry, biology or geology.

Legitimacy and the Contemporary Situation

The issue of scientific legitimacy is distinct from the demarcation problem. As we have seen, the demarcation problem is a theoretical problem without solution. The question of legitimacy is a practical problem with a tangible solution that must be worked out through a collective effort linking the arena of public discourse to the philosopher's tower, and the scientist's bench. Although the legitimacy question is not without solution, its solution may change over time. As the philosopher of science Del Ratzsch has put it, "The nature and boundaries of scientific legitimacy were neither found carved in stone somewhere, developed purely *a priori*, nor just always known innately by humans. Rather, conceptions of . . . scientific legitimacy that we currently take to be correct have histories and have developed along with science."[20] Unlike the demarcation problem, the issue of legitimacy cannot *not* be solved. The question is whether it will be solved actively (and responsibly) or passively (and irresponsibly). It simply is the case that all manner of subjects are treated by scientists while they are speaking as scientists. Quibbling about whether or not we can classify the subjects about which they speak as "science" has proved an exercise in futility. Rather, our need is to determine whether or not any topic, even if it seems "extra-scientific" by whatever demarcation criterion adopted, may be a legitimate focus for study and discussion by science students.

This is so important because scientific and so-called "non-scientific" issues are interminably intermingled in both theory and practice. Scientists past and present repeatedly have incorporated into their ostensibly "scientific" discourse pronouncements about purpose, ethics, the deity, worldviews, meaning, duty, morality, chance, design, mind, metaphysics, ontology, teleology, good, evil, and so on. The question is not whether such practice is scientific. The question is whether it is legitimate to do so. Before exploring that question, permit me to recite a few examples to acquaint us with the kind of utterances I have in mind.

Ernst Mayr, perhaps the twentieth-century's greatest biologist, argued in his book, *This is Biology: The Science of the Living World*, that contemporary moral and political issues are properly matters for biological discourse. He asserted that "an understanding of evolution can give us a *worldview* that serves as the basis for a sound *ethical system* that can maintain a *healthy human society* . . ."[21] Worldview? Ethical system? Healthy society? This is hardly the stuff of old-fashioned pure and simple biology. Such topics have traditionally been the purview of priests, ethicists, and policy experts. But Mayr contends they are matters for the student of biology. Perhaps they are. At least they cannot be ruled out according to any received criterion of demarcation.

Now consider for a moment conclusions of several biologists who offer pronouncements that they believe to follow directly as conclusions from their biological science:

Ernst Haeckel (1877): "The cell consists of matter called protoplasm, composed chiefly of carbon, with an admixture of hydrogen, nitrogen and sulphur. These component parts, properly united, produce the soul and body of the animated world, and suitably nursed become man. With this single argument the mystery of the universe is explained, the Deity annulled and a new era of infinite knowledge ushered in."[22]

Douglas Futumya (1983): "Some shrink from the conclusion that the human species was not designed, has no purpose, and is the product of mere material mechanisms – but this seems to be the message of evolution."[23]

Michael Behe (1996): "The result of these cumulative efforts to investigate the cell . . . is a loud, clear, piercing cry of '*design!*' The result is so unambiguous and so significant 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. The observation of the intelligent design of life is as momentous as the observation that the earth goes around the sun or that disease is caused by bacteria or that radiation is emitted in quanta."[24]

Francis Crick (1988): "Biologists must constantly keep in mind that what they see was not designed, but rather evolved."[25]

Michael J. Denton (1998): ". . . the *unique fitness* of the laws of nature for life is entirely consistent with the older teleological religious concept of the cosmos as a specially designed whole, with life and mankind as its primary goal and purpose. . . the emerging picture provide[s] powerful and self-evident support for the traditional anthropocentric teleological view of the cosmos."[26]

George Gaylord Simpson (1949): "Man is the result of a purposeless and natural process that did not have him in mind. He was not planned. He is a state of matter, a form of life, a sort of animal, and a species of the Order Primates, akin nearly or remotely to all of life and indeed to all that is material."[27]

Of course there are many more such quotations. Richard Dawkins proclaims that "Darwin made it possible to be an intellectually fulfilled atheist" while another biologist insists that "the universe is a purposeful creation."[28] We could go on and on ping-ponging back and forth quotations attesting to the scientific evidence or lack thereof for meaning, purpose, design, values, et cetera.

Let my intent be clear. I am not concerned here to argue, as some do, that the preceding quotations are dastardly intrusions of scientists into the domain of metaphysical and religious discourse, although they might be just that. Rather since rigid demarcation fails, we should openly acknowledge the fact that the various disciplines, while distinct, are not wholly separable from one another. This means we must learn to navigate those borderlands where scientific discourse overlaps most often with other human concerns. The question becomes one of legitimacy. Is it or is it not legitimate to include in science classrooms discussions of contested issues and ideas that scientists believe, nonetheless, to follow directly from their scientific practice?

There are, of course, those who answer in the negative. Yet, to my knowledge, those who do, rest their opposition to discussions of such things as good and evil, meaning and purpose, design and beauty, etc. upon the nonsensical presumption that science and non-science can be competently demarcated from one another. As already noted, such questions about meaning and purpose whether they ought to or not, do in fact have a place in science because scientists have given them a place, repeatedly talking about purpose, issuing ethical imperatives, and offering normative claims in the name of science.[29] Further, scientists do, in fact have scientific methods for addressing the idea of "purpose." Forensic scientists, detectives, lawyers, insurance fraud investigators, U.S.-government funded SETI researchers, and others all rely on sophisticated scientific methods for detecting purposeful activity. This is not the place to tease out the various conceptions of purpose. That topic could easily command yet another essay. Still it should be easy enough to see that it is one thing to *determine whether* a given event was the product of intention or purpose. It is another thing to *identify* the intention or purpose behind the event as benign, beneficent, malevolent, natural, super-natural, etc.

So we return to the question: Is it legitimate to include in science classrooms discussions of issues and ideas that scientists believe to follow directly from their scientific practice, even if some of these issues lurk on the borderlands shared with presumably "extra-scientific" concepts like purpose, meaning, beauty, and design? Permit the proposal of a tentative answer that defends the inclusion of such issues on a carefully limited basis, while avoiding the pitfalls of an "anything goes" free-for-all in the classroom.

Legitimacy and Liberal Education

The great Samuel Johnson rightly noted,

> Prudence and justice are virtues, and excellences, of all times and all places; we are perpetually moralists, but we are geometricians only by chance. Our intercourse with intellectual nature is necessary; our speculations upon matter are voluntary, and at leisure. Physiological learning is of such rare emergence, that one man may know another half his life without being able to estimate his skill in hydrostaticks or astronomy; but his moral and prudential character immediately appears.[30]

I submit that the chief end of education is to furnish and discipline students' minds and to equip them for human flourishing and constructive participation in civil society. If I am right, and if Samuel Johnson was correct about the perennial need for virtue, if he was correct about the secondary need for technical specialization, and if he was correct when he also asserted that "whether we provide for action or conversation, whether we wish to be useful or pleasing, the first requisite is . . . knowledge of right and wrong," then I submit that *all* teachers, of whatever subject matter (even biology, physics, astronomy, or hydrostatics), need to understand these things and be committed to them. Otherwise their primary educational duty cannot be fulfilled.[31]

I am not suggesting that the science classroom abandon the periodic table for the ten commandments, that learning acid-base titration techniques be replaced by speeches on moral philosophy, or that Mosaic cosmogony replace study of natural selection. I am suggesting that limiting the science classroom to such activities as studying the periodic table, learning titration techniques, or understanding a natural process like descent with modification, while necessary, cannot be sufficient, even for science education. I am suggesting that to realize the primary pedagogical aim of preparing students for virtuous and constructive participation in civil society, we must not retreat exclusively into the comfortable disciplinary hinterlands of specialization and technique, as if science can be hermetically sealed from other issues. It rarely can. Instead teachers must lead students into the sometimes risky no-man's land where science overlaps with religion, with ethical and metaphysical theory, with public policy, and with epistemology. For it is there that some of the most important educational work can and must happen. To retreat from it through fear of transgressing a dubitable demarcation line between science and non-science is not just a technical philosophical mistake, but a potentially dangerous omission.

In short, I propose a vision of education that begins with a particular view of mankind and ends with a corresponding understanding of liberal education. Both biologists and theologians acknowledge our identity as *homo sapiens*. The Latin *homo* means "mankind or man." The word *sapiens*, from the Latin *sapientia,* means "wisdom" and "discernment." To be truly human thus requires the cultivation of wisdom and discernment, that is the cultivation of what the ancients called the *cardinal* virtues – Prudence, Justice, Fortitude, and Temperance. Cardinal here is from the Latin *cardo,* meaning "hinge." In short, the realization of all other human goods and of our full flourishing hinges or turns upon the acquisition of these virtues, especially wisdom.[32]

There is another view of mankind. We might call it *homo sciens,* from the Latin *scientia* from which we get the word science. *Homo sciens* knows lots of stuff. The stuff he knows begins with the assumption that man is, like everything else he sees, a material thing. To be fully human, on this view, is to stockpile material things, to amass knowledge of material things, and to acquire expertise in the techniques of manipulating material things. In the end, this view of mankind underwrites the cynical conclusion of the twentieth-century American journalist H. L. Mencken who declared that human beings are no more than "an endless series of miserable and ridiculous bags of rapidly disintegrating amino acids."[33]

What is man? Any view of education must begin with a working answer to this question. *Homo sciens* can do things. He knows stuff. He is the master of means. *Homo sapiens* knows what to do and why to do it. He understands ends. The story of the modern era has been the story of the waning of *homo sapiens* and the waxing of *homo sciens*.[34] As we have acquired the tools to do more and more, we have lost the wisdom needed to tell us what ought to and ought not to be done. The way to restore a salutary balance between these two visions of man is to foster an integrated view of education, a view that sees education as more than merely imparting information and techniques. We need a view that explores the disciplinary borderlands and is suspicious of the alleged sufficiency of narrow specialization. Richard Weaver put it so well when he noted, "Specialization of any kind is illiberal in a freeman. A man willing to bury himself in the details of some small endeavor has been considered lost . . . specialization develops only part of a man; a man partially developed is deformed."[35]

In her insightful discussion of *Evolution as a Religion,* the philosopher Mary Midgley remarked upon the popular ideal of scientists as objective inquirers:

> Scientists ought to be so impartial that they either do not have anything so unprofessional as a world-picture at all, or, if they have one, do not let it affect their work. But this is a mistaken ideal. An enquirer with no such general map would only be an obsessive . . . Merely to pile up information indiscriminately is an idiot's task. Good scientists do not approximate to that ideal at all. They tend to have a very strong guiding imaginative system. Their world-picture is usually a positive and distinctive one, with its own special drama.[36]

My present concern is to recommend that scientists and science teachers embrace a sufficiently large world-picture to help foster what John Henry Newman called, in his classic treatment of liberal education *The Idea of a University,* a "philosophical habit of mind." Newman described this educational ideal:

> An assemblage of learned men, zealous for their own sciences, and rivals of each other, are brought, by familiar intercourse and for the sake of intellectual peace, to adjust together the claims and relations of their respective subjects of investigation. They learn to respect, to consult, to aid each other. Thus is created a pure and clear atmosphere of thought, which the student also breathes . . . He apprehends the great outlines of knowledge, the principles on which it rests, the scale of its parts, its lights and its shades, its great points and its little, as he otherwise cannot apprehend them. Hence it is that his education is called "Liberal." A habit of mind is formed which lasts through life, of which the attributes are, freedom, equitableness, calmness, moderation, and wisdom; or what . . . I ventured to call a philosophical habit.[37]

This ideal can only be achieved when science does not presume to be the only kind of knowledge, when moral categories and virtues are not just things we teach students about in comparative religion classes, but things we teach students to embrace in every class. Students cannot embrace things they do not know. Both science students and humanities students must study issues at the borders between the sciences and the humanities; for to comprehend a subject requires knowledge of its relations to other subjects. Fostering this relational perspective is the duty of all teachers.[38]

One practical avenue toward achieving this perspective comes from admitting that scientific knowledge is not the only valid form of knowledge, that one can have genuine knowledge of such things as duty and virtue. "We have to allow there is another kind of knowledge besides the explicit, exact and testable kind . . . Traditional skills, intuitions, scientific systems, poetic and religious insights and the understanding of moral values are all fed from the same root." This is what the philosopher and physical chemist Michael Polanyi called "tacit knowing."[39] We could profit from considering his perspective.

Finally, and even more practically, our science classrooms would do well to include discussion of select issues that surface in public discourse with which our students must eventually wrestle and reckon. Perhaps the best and diciest contemporary example, which I mentioned at the opening of my remarks, has emerged in the case of "intelligent design" theory (ID). One of ID's most vigorous critics is the political philosopher Larry Arnhart. Despite his conviction that intelligent design is wrong, he puts forth a recommendation for teaching ID in the science classroom:

> Allowing our public school students to study and debate creationist criticisms of Darwinism in their biology classes would promote a better understanding of scientific argumentation and of the moral and political implications of science. If students were allowed to study some readings from the intelligent design theorists along with Darwin's writings and some contemporary defenses of Darwin, they could better judge the evidence and arguments . . .
>
> Science education in the public schools often consists of mindless memorization of scientific formulas so that students have no understanding of how one goes about weighing evidence and arguments for and against scientific ideas. Moreover, students rarely see the emotional excitement associated with scientific controversies that have moral, political, and religious implications. A lively classroom debate over Darwinism would be a great improvement, and it might actually prepare students to become citizens capable of judging scientific disputes that have deep consequences for human life.[40]

Both politicians and philosophers appear to concede the merit in Arnhart's proposal. The explanatory statement accompanying the 2002 Elementary and Secondary Education Authorization Act included the following language: "A quality science education should prepare students to distinguish the data and testable theories of science from religious or philosophical claims that are made in the name of science. Where topics are taught that may generate controversy (such as biological evolution), the curriculum should help students to understand the full range of scientific views that exist, why such topics may generate controversy, and how scientific discoveries can profoundly affect society."[41] Philosopher of science Del Ratzsch takes head on the tendency of most scientists to exclude the notion of supernatural design from the discussion table:

> [A]ttempts to support blanket, normative prohibitions on even considering supernatural design in science seem without exception to fail for various reasons. Attempts to justify such prohibitions on pragmatic grounds seem to do little better. The intuition that science cannot deal with the supernatural, so must systematically ignore it, seems a bit like advising swimmers in the Amazon that since they cannot see pirhanas from the bank nor survive a pirhana attack once in the water, they should plunge right in, pretending that there are none. Perhaps better advice might be to work on learning some pirhana recognition techniques.[42]

We live in one world, not separate scientific and religious worlds, but one world. Consequently, the differing perspectives from which the sciences and humanities view our one world must be accommodated by the minds of individual human students in which these different perspectives are fostered.

Consider these remarks from a Canadian newspaper by Michael Ruse, an internationally respected and widely-published philosopher of biology who has written extensively on evolutionary biology: "Evolution is promoted by its practitioners as more than mere science. Evolution is promulgated as an ideology, a secular religion – a full-fledged alternative to Christianity, with meaning and morality. . . . Evolution is a religion. This was true of evolution in the beginning, and it is true of evolution still today."[43] Now, Dr. Ruse may have gone over the top. He may be as far off the mark as one can get. He may, on the other hand, be right on target. This is not the issue. The issue is that students who may read his words in the newspaper at breakfast before school should be able to ask their science teachers to help them sort these things out. Science teachers should be eager to devote class time to doing so. But they cannot do it correctly unless they are permitted to do so and properly equipped for the task. Our schools will better serve their primary educational mission of furnishing and disciplining minds if they welcome, indeed encourage, opportunities to consider contested issues in the science classroom. Sometimes valuable pedagogical lessons lurk in the disciplinary borderlands. And there is no questioning the fact that divisive public policy issues are often thorny to the degree they are interdisciplinary. Acknowledging this in the science classroom is one way to prepare students for wise participation in contemporary civil society.

Endnotes

[1] For one important historical case see, Mark A. Kalthoff, "Inerrant Wind? Lies and Lessons about the Ways We Teach and Remember the Scopes Trial," in Michael P. Federici, ed., *Rethinking the Teaching of American History* (Louisville: Butler Books, 2012), 75-99.
[2] A. F. Chalmers, *What is this Thing Called Science? An assessment of the nature and status of science and its methods.* 2nd edition. (St. Lucia, Queensland: University of Queensland Press, 1982), 166.
[3] Laudan, 338. For other examples of philosophers and sociologists of science wrestling with the demarcation problem and its implications see papers collected in the following volumes: Rachael Laudan, *The Demarcation Between Science and Pseudo-Science, Working Papers in Science & Technology* Vol. 2, number 1 (April 1983), Virginia Tech Center for the Study of Science in Society; Marsha P. Hanen, Margaret J. Osler, and Robert G. Weyant, *Science, Pseudo-Science and Society: Papers presented at a conference sponsored by the Calgary Institute for the Humanities, and held at the University of Calgary, May 10-12, 1979* (Waterloo, Ontario: Wilfrid Laurier University Press, 1980); and Roy Wallis, *On the Margins of Science: The Social Construction of Rejected Knowledge, Sociological Review Monograph* 27 (Keele, Staffordshire: University of Keele, 1979).
[4] Laudan, "The Demise of the Demarcation Problem." See also, John Losee, *A Historical Introduction to the Philosophy of Science*, 2nd ed. (Oxford: Oxford University Press, 1980), passim.
[5] Jeroen Bouterse and Bart Karstens, "A Diversity of Divisions: Tracing the History of the Demarcation between the Sciences and the Humanities," *Isis* 106 (June 2015): 341-352.
[6] *Posterior Analytics,* Book A, Section 2, 20 in *Aristotle's Posterior Analytics,* trans. Hippocrates G. Apostle (Grinell, Iowa: The Peripatetic Press, 1981), 2ff.
[7] Laudan, 338-340. Here he concludes, "Coming out of Aristotle's work, then, is a pair of demarcation criteria. Science is distinguished from opinion and superstition by the certainty of its principles; it is marked off from the crafts by its comprehension of first causes. This set of contrasts comes to dominate discussions of the nature of science throughout the later Middle Ages and the Renaissance . . ."
[8] In his General Scholium to the *Principia,* Newton wrote, "But hitherto I have not been able to discover the cause of those properties of gravity from phenomena, and I frame no hypotheses . . ." Isaac Newton, *Mathematical Principles of Natural Philosophy,* vol. 2, trans. Andrew Motte, translation rev. Florian Cajori (Berkeley: University of California Press), 547.
[9] Laudan, 340.
[10] Karl Pearson, *The Grammar of Science,* quoted in Drusilla Scott, *Everyman Revived: The Common Sense of Michael Polanyi* (Grand Rapids: Wm. B. Eerdmans Publishing Co., 1985), 21.
[11] In addition to Laudan p. 341, see David Oldroyd, *The Arch of Knowledge: An Introductory Study of the History of the Philosophy and Methodology of Science* (New York: Methuen, 1986), especially chaps, 3-5.
[12] Laudan, 341.
[13] Ibid., 342.
[14] See Hans Reichenbach, "The Verifiability Theory of Meaning," in Herbert Feigl and May Brodbeck, eds., *Readings in the Philosophy of Science* (New York: Appleton-Century-Crofts, 1953), 93-102; and Rudolf Carnap, "Testability and Meaning," in Feigl and Brodbeck, 47-92; A. J. Ayer, ed., *Logical Positivism* (New York: The Free Press, 1959), especially Rudolf Carnap, "The Elimination of Metaphysics Through the Logical analysis of Language," 60-81 and Carl G. Hempel, "The empiricist Criterion of Meaning," 108-129; and Alfred Jules Ayer, *Language, Truth and Logic* (1946; rpt. New York: Dover Publications, 1952).
[15] Michael D. Aeschliman, *The Restitution of Man: C. S. Lewis and the Case Against Scientism* (Grand Rapids: Wm. B. Eerdmans Publishing Co., 1983), 20.
[16] See Laudan, 345.
[17] Ibid.
[18] For a fuller discussion and critique of these demarcation candidates see ibid., 346-348. Here Laudan concludes: "Some scientific theories are well tested; some are not. Some branches of science are presently showing high rates of growth; others are not. Some scientific theories have made a host of successful predictions of surprising phenomena; some have made few if any such predictions. Some scientific hypotheses are *ad hoc;* others are not. Some have achieved a 'consilience of inductions'; others have not."
[19] For an important sociological consideration of the ways the boundaries between science and non-science have been

contested see Thomas F. Gieryn, "Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists," *American Sociological Review* 48 (December 1983): 781-795. See also the discussion of "folk science" in Jerome R. Ravetz, *Scientific Knowledge and its Social Problems* (New York: Oxford University Press, 1971), 386-402.
[20] Ratzsch, *Nature, Design and Science,* 79.
[21] Ernst Mayr, *This is Biology: The Science of the Living World* (Cambridge: The Belknap Press of Harvard University Press, 1997), 270. Italics are mine for emphasis.
[22] Ernst Haeckel, quoted in Loren Eiseley, *Darwin's Century: Evolution and the Men who Discovered It* (Garden City, NY: Anchor Books, 1961), 346.
[23] Douglas J. Futuyma, *Science on Trial: The Case for Evolution* (New York: Pantheon Books, 1983), 13.
[24] Michael J. Behe, *Darwin's Black Box: The Biochemical Challenge to Evolution* (New York: The Free Press, 1996), 232-233.
[25] Francis Crick, *What Mad Pursuit* (New York: Basic Books, 1988), 138.
[26] Michael J. Denton, *Nature's Destiny: How the Laws of Biology Reveal Purpose in the Universe* (New York: The Free Press, 1998), xi-xii.
[27] George Gaylord Simpson, *The Meaning of Evolution: A Study of the History of Life and of Its Significance for Man,* rev. ed. (New Have: Yale University Press, 1967), 345.
[28] Richard Dawkins, *The Blind Watchmaker: Why the evidence of evolution reveals a universe without design* (New York: W. W. Norton, 1986), 6; Walter R. Hearn, "Evidence of Purpose in the Universe," in John Marks Templeton, ed. *Evidence of Purpose: Scientists Discover the Creator* (New York: Continuum, 1996), 68.
[29] I have not included quotations from this history of pre-eighteenth-century natural philosophy that might also serve to illustrate the ways teleological conceptions have figured in the development of science. This has been the subject of some scholarly effort, however, and is not irrelevant to the point at issue. The works of such seminal figures as Isaac Newton, Robert Boyle, John Ray, William Harvey, and Johannes Kepler offer evidence of the teleological thinking in concert with their science. See, for example, Richard S. Westfall, *Science and Religion in Seventeenth-Century England* (New Haven: Yale University Press, 1958); Emerson Thomas McMullen, *William Harvey and the Use of Purpose in the Scientific Revolution: Cosmos by Chance or Universe by Design?* (Lanham: University Press of America, 1998); Robert Boyle, *A Disquisition about the Final Causes of Natural Things* (1688); Owen Gingerich, "Dare a Scientist Believe in Design?" in John Marks Templeton, ed. *Evidence of Purpose: Scientists Discover the Creator*(New York: Continuum, 1996), 21-32; and John Hedley Brooke, *Science and Religion: Some Historical Perspectives* (Cambridge: Cambridge University Press, 1991), 192-225.
[30] Samuel Johnson, *Lives of the English Poets,* Vol. I (1906, rpt., London: Oxford University Press, 1968), 72.
[31] Ibid.
[32] For a fuller treatment of this see Josef Pieper, *The Four Cardinal Virtues* (Notre Dame: University of Notre Dame Press, 1966).
[33] H. L. Mencken, *A Mencken Chrestomathy* (New York: Alfred A. Knopf, 1949), 130.
[34] Aeschliman, *The Restitution of Man,* 20.
[35] Richard M. Weaver, *Ideas Have Consequences* (Chicago: University of Chicago Press, 1948), 56.
[36] Mary Midgley, *Evolution as a Religion: Strange hopes and stranger fears* (New York: Methuen & Co., 1985), 3.
[37] John Henry Cardinal Newman, *The Idea of a University,* ed. Martin J. Svaglic (Notre Dame: University of Notre Dame Press, 1982), 76.
[38] For more on Newman's understanding of science and religion see Mark A. Kalthoff, "A Different Voice from the Eve of *The Origin:* Reconsidering John Henry Newman on Christianity, Science, and Intelligent Design," *Perspectives on Science and Christian Faith* 53 (March 2001): 14-23.
[39] Quotation from Scott, *Everyman Revived,* 46. For Polanyi's views on knowledge see Michael Polanyi, *Personal Knowledge: Towards a Post-Critical Philosophy* (Chicago: University of Chicago Press, 1958); and idem, *The Tacit Dimension* (New York: Doubleday, 1966).
[40] Larry Arnhart, "Evolution and the New Creationism: A Proposal for Compromise," *Skeptic* Vol. 8, No. 4, 2001: 52.
[41] H.R. 1 – "No Child Left Behind Act of 2001," Joint Explanatory Statement of the Committee of Conference, Title 1, Part A, Item 78, online at http://edworkforce. house.gov/issues/107th/education/nclb/conference/stateofman/title1pa.htm. See also, Tamara Henry, "Wording in education bill sparks evolution concerns," *USA Today,* 25 July 2001, online edition, http://www.usatoday.com/news/washdc/july01/2001-07-25-creationism.htm.
[42] Ratzsch, *Nature, Design, and Science,* 126. Here Ratzsch continues with another provocative analogy: "The intuition that humans have a tendency to see the supernatural where it is not, and should thus systematically refuse to recognize the supernatural under any circumstances, seems a bit like holding that since many people seem to see flying saucers where there are none, we should refuse to admit the existence of any such, even were they to land on the Capitol lawn and proceed to blow away the Washington Monument. Perhaps better advice might be to learn what sorts of cases to ignore and what sorts to attend to."
[43] Michael Ruse, "Saving Darwinism from the Darwinians," *National Post* (13th May 2000), B3.

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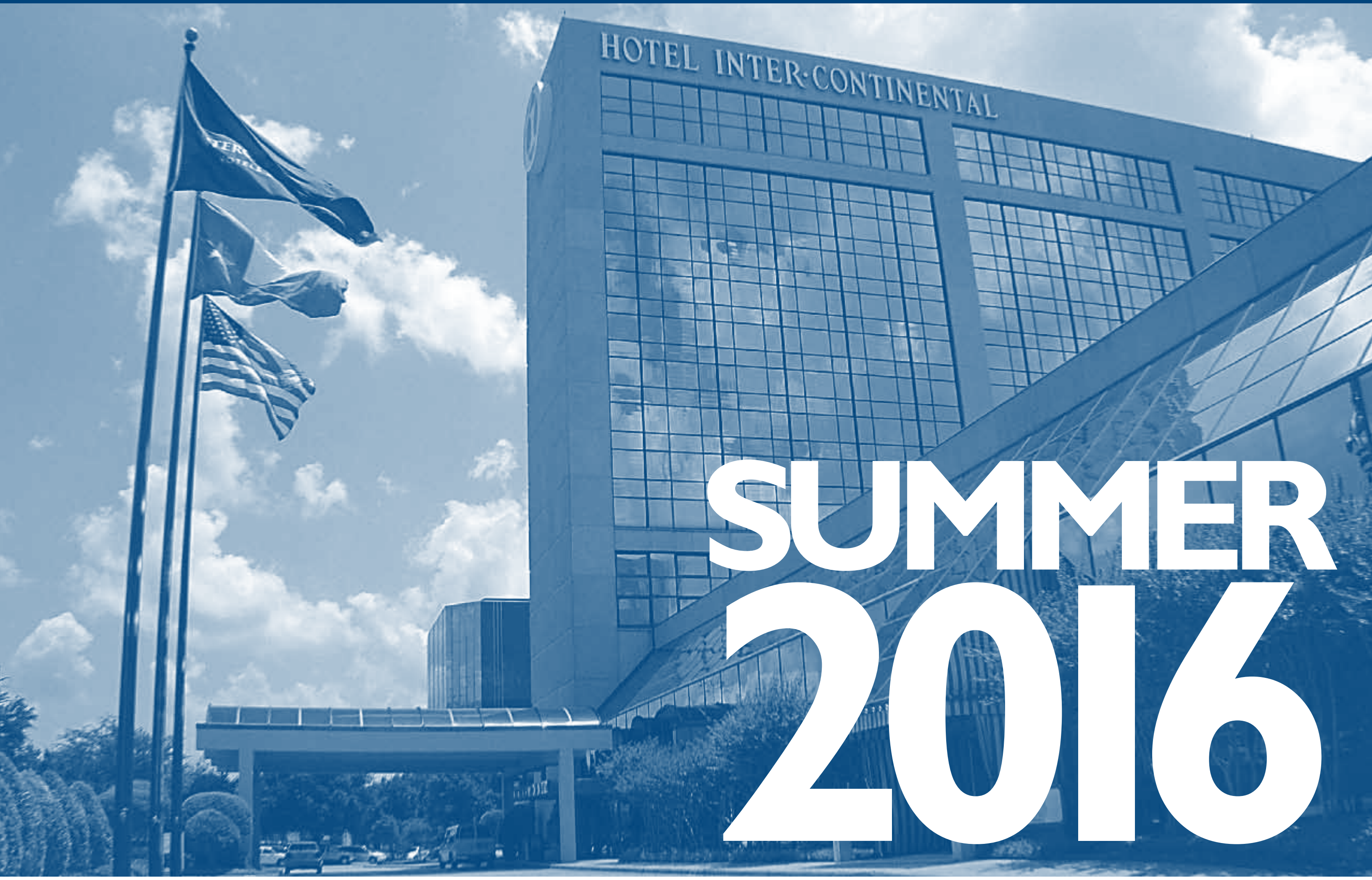

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