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Emergent Properties: Interdisciplinary Team Teaching in Literature and Biology

Nels C. Pearson and Ashley Byun McKay

with student authors James Ballanco, Heather Boyd, Greg Burke, and Shawne Lomauro

Abstract

In this essay, we reflect on the outcomes of our interdisciplinary, team-taught, undergraduate core course in modern literature and evolutionary biology--a course designed to study the problems of identifying the emergence of distinctly "human" beings. The essay reflects on the positive, unexpected outcomes that we experienced, especially in student writing, via the metaphor of "emergent properties," a biological term that refers to how new and complex traits, behaviors, or life forms emerge from the interaction of "simpler units" which in themselves would not produce these properties. Given that so much of the course content came from the students themselves—in particular, from their interest in the question of human consciousness as an evolved trait—we have incorporated excerpts from student essays that were produced for the course. These excerpts are preceded by student reflections and accompanied by observations about the compelling fashion in which students synthesized not only scientific and literary content, but also objective and subjective writing styles.

Keywords

interdisciplinary teaching, team-teaching, classroom practices, Arts and Sciences, student writing

Introduction

This essay concerns the unique learning experiences which emerged from a team-taught, interdisciplinary course called "Minds and Bodies" at Fairfield University, a Jesuit liberal-arts institution of 4,000 students in Fairfield, Connecticut. Part of a core course sequence for first and second-year students in the Honors Program, "Minds and Bodies" is taught annually, but with different faculty teams. As professors of biology and English literature, ours was a particularly unusual pairing and as such, we were both enthusiastic and apprehensive about how we could combine these two fields into a single cohesive course. Deciding upon objectives and learning outcomes was especially challenging, as we realized just how deep the differences were between

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Literature's metaphoric and philosophical mode of understanding nature and Biology's empirical mode. Resisting the urge to teach these as separate ways of looking at nature—to present them simply as two “different disciplinary lenses”—was a daily challenge.

The course that we ultimately developed centered upon the question of whether there is a mind or soul distinct from the biochemical brain and body. We approached the question from both evolutionary and philosophical angles, introducing students to the difficulty of distinguishing distinctly human traits and cognitive faculties from those in the animal kingdom while also engaging them in the humanist dilemma of the inability to affirm metaphysical absolutes or origins. Alternating between case studies in animal evolution and philosophical responses to evolution and genetics in 19th and 20th-century literature, our goal was to initiate student reflection on the possibility that human capacities such as love, language, or justice are not unique to our species, but properties that emerge along an evolutionary continuum.

In Biology, an “emergent property” is a new and often unpredictable trait that arises through interactions of the individual components of a system. Independent of the system, the individual component would not exhibit that particular property, behavior or function. As the semester progressed, we and our students became increasingly interested in how the emergence of complex biological properties such as male sexual displays and bird flocking might also explain how humans developed certain traits such as emotion, social behavior, cognitive function, and perhaps even what we refer to as the “mind.” Although we had not planned it to be a focus of the course, we found ourselves increasingly occupied by this topic: could human consciousness, and associated traits such as love and free will, be the emergent products of mere biochemical and cellular interactions, and if so, then might this not help to resolve the opposition between the autonomous

self and the inflexible laws of nature that had troubled writers like Mary Shelley, Alfred Tennyson, and Fyodor Dostoevsky? Could it explain how free will would actually evolve according to a natural law (traditionally its philosophical nemesis)? Our main purpose, here, is not to provide a detailed answer to that question (although our student contributors, below, engage it from different perspectives). Rather, it is to propose what this spontaneous development indicated in and of itself, namely, that the phenomena of emergent properties was actually happening in the class. That is to say, as the philosophical components of literary study and the empirical components of Biology interacted, a new matrix of innovative and often unexpected topics and ideas was evolving, especially in student writing and discussions. As in nature, our content had emerged spontaneously out of a collocation of life forms.

This unplanned content included students working through their personal discomfort regarding the ambiguity of what it means to be human (especially when “hard science” was helping to fuel the problem rather than solve it), developing novel social and political perspectives and new views on spirituality and the autonomous self (including the challenge of integrating science into a religious viewpoint), and having vociferous arguments about how to resolve the apparent contradiction between distinct consciousness and natural law. Because of the interdisciplinary nature of the course, we had agreed to encourage a range of possible writing styles, with the one stipulation that students develop their ideas through the balanced integration of citations from both scientific and literary sources. When we read the results, we noticed that the unique evolution of our course's subject matter or topical focus was reflected not only in the content of student's essays, but also in their form. Just as their subjects were original, so too did their writing cross discursive borders between source-driven research writing, the personal or reflective essay, and thesis-driven interpretive and

analytical argument. Indeed, we often noted that it was when students were using close readings of literature to illuminate or interrogate concepts in genetics and evolution, and vice versa, that their compelling synthesis or juxtaposition of scientific and literary modes of inquiry was most evident.

Below are excerpts from four student essays, each of which illustrates these general observations about the course and its outcomes. These essays were among the best in the course, but the main reason we select them is that they best demonstrate the original combinations of scientific and literary concepts or approaches that the students themselves had generated. A few of the essays we received could be considered more technically proficient or rhetorically consistent than these, but less innovative, while many others were neither as original nor as technically sound. What really struck us as different about all the papers was that so many of them could only have been produced by independent thinking about the different ways that course concepts fit together. Even the least provocative among them tended to have a compelling, untypical insight. The ones below had many. Each excerpt is preceded by a student reflection on his or her processes of thinking, writing, and discovery and framed by our own comments and perspectives.

Heather Boyd

The process of writing this paper was overwhelming at times as I reflected on the nature of humanity and attempted to ground rather large ideas in biology and literature. These thoughts infringed upon my indoctrinated view of mankind. Often, I struggled to articulate what I was slowly coming to understand. Through conversations with my professors and then by my writing, I was able to wrestle with the implications of my findings. If I accept that every action I take is rooted in biology, how can I also believe that a supreme being created me as an unique individual with free will? By experiencing this process of confusion and, at times, frustration, I was able to unlock ideas which I had

believed should be thought about in purely religious terms. Ironically, the answer I found did not undermine my belief in God or the dignity of the individual, but did result in an even more awe-inspiring view of the world.

Literary works repeatedly reflect upon the implications of the considerable evidence which refutes the existence of uniquely human traits. Even the capacity for language, emotions, and complex intelligence, three traits generally assumed to be exclusive to humans, appear to be subject to natural law. This likelihood raises several philosophic questions that authors Ian McEwan and Fyodor Dostoevsky grappled with in their respective novels *Saturday* and *Notes from Underground*. Their important concern is this: if the complexity of human language, the depth of human emotions, and the degree to which humans can learn and reason are all determined by genes, then what choices are left to free will?

According to Tom Siegfried (2008), “Free will is not the defining feature of humanness, modern neuroscience implies, but is rather an illusion that endures only because biochemical complexity conceals the mechanism of decision making” (para. 3). In his novel *Saturday*, Ian McEwan (2005) explores this challenge to the notion of autonomous consciousness. The main character, neurosurgeon Henry Perowne, believes that every human action is attributable to genetics:

One kilogram or so of cells actually encodes information, holds experiences, memories, dream and intentions. He doesn't doubt that in years to come, the coding mechanism will be known, though it might not be in his lifetime. Just like the digital codes of replicating life held within DNA, the brain's fundamental secret will be laid open one day. (p. 262-263)

At the end of *Saturday*, Perowne uses this understanding of genetic inevitability to assess Baxter, a London street criminal, as suffering from Huntington's disease. By acknowledging that this disease predisposes

an individual to behavioral and psychiatric problems, Perowne is able to ignore Baxter's attack on his family and operate on him. But McEwan leaves the question open: isn't Perowne's decision to operate on Baxter still precisely that: a willful choice to act ethically?

That depends on how, exactly, we define "free will". According to Siegfried (2008), "The issue is understanding the complex circulation of molecular information that is massaged and manipulated at various stations by neural systems tuned to multiple decision-making considerations. That process *is* free will, even if it isn't really free" (para. 9). In the end, the neurochemistry of the brain controls decision-making. Free will is merely the end, not the means to an end. In other words, if a person defines free will as being able to make decisions, then the fact that neurological firings in the brain lead a person to making the decision is irrelevant.

Accepting that free will is subject to natural law is a central theme in Fyodor Dostoevsky's *Notes from Underground* (1994). Dostoevsky describes the ranting of a man who is confronted with this very conundrum—"Once it's proved to you that you descended from an ape, there's no use making a wry face, just take it for what it is" (p. 13). "It" pertains to the fact that human beings are subject to the same natural law as apes. In the *Encyclopedia of Philosophy*, Edward Wasiolek (1967) discusses the fear of the underground man: "If the laws of nature really exist, then 'free will' is an illusion that will be dispelled by reason" (p. 411). The reason behind any choice, even the choice to deny this irrefutable truth, is biological. This circular logic drives the underground man mad as he cannot stop asking questions and over-thinking his situation.

I cannot help but wonder why the assumption that human beings are subject to natural law offends so many people. I cannot refute that the choices I make are determined by natural law or that that my experience of empathy, love, and grief is traceable to chemicals. But Natural law's innate tendency for variation

has also led to the birth of individuality. Every brain is unique. Although human brains consist of the same fundamental components, from slight variations, different personalities and tendencies emerge. If your brain is unique, and your brain is part of the unique person that you are, then why do some people have a problem accepting the truth about free will?

Heather's essay is a compelling mixture of reflective and analytical writing. Using her citations as signposts to mark the specific places where her thinking was challenged, her larger objective is to offer a more personal review of how she came to understand the paradoxes of natural law and the human will. We liked the way that this form helps to show her not merely receiving knowledge, but engaging it in deep dialogue with an existing religious viewpoint that she didn't allow to be static or inflexible. The possible reconciliations that she offers, in the idea that variation is a key component of evolution and in the sense of awe regarding the "magnificence" of evolutionary processes, are important discoveries that the class had begun to make, thanks in large part to Heather's contributions.

Although these realizations were hard to come to, I am starting to see the grandeur in my new understanding of free will. I once had believed that knowledge of biological processes, genetics, and natural selection was irrelevant to my philosophic view of humanity. I was entirely wrong. The process of reconciling spirituality and science is an integral part in one's exploration of their life philosophies. Furthermore, spirituality cannot be used in place of natural law or to explain what science has yet revealed. I believe that spirituality exists outside of natural law. Some people think that believing that human choices are shaped by natural law means that human beings are not in control of their destiny, but rather, everything is predetermined. Even Dostoevsky grappled with this same concept. My sense of purpose has yet to falter even in the face of the irrefutable truth that human behavior is subject to the same natural law

that govern all plant and animal life as I do believe I can make choices and change the world around me.

James Ballanco

My paper focuses primarily on the phenomenon known as consciousness. I wanted to prove that consciousness is merely a complex biological function—thus disproving that it is a manifestation of some God-given human superiority. To do this, I looked for examples in literature, supported by modern science, in which the human mind showed that it was subject to the laws of nature. I struggled as I wrote this because the conclusion I came to was both provocative and unsettling. It seemed wrong to suggest that human beings are only as free as certain biological processes allow. In the end, I looked to the writing of Tennyson to support the idea that an absence of free will can actually be thought of as a soothing gift that might even be embraced.

Human consciousness can be thought of as an emergent property that has evolved over many generations. This complex trait emerges through the interactions of nerve cells or neurons, and supporting cells known as glia. In “Animal Intelligence and the Evolution of the Human Mind,” Dicke and Roth (2008) review evidence that the unique cognitive abilities of the human brain over the animal brain are not due to any large scale alteration of brain architecture but rather, due to microscopic upgrades in these fundamental units. More neurons and thicker myelin sheaths both which allow the human brain to process more information faster has probably played a key role in allowing our brains to reach a level of complexity that is not biologically possible in other animals (paras. 13-17).

Is the human mind a set of simple neural interactions that, when examined as a whole, results in the emergent property which we understand as consciousness? Has consciousness emerged as a result of evolution in the same way as other seemingly complex traits such as the heart or human fingerprints? In Ian

McEwan’s novel *Saturday* (2005), neurosurgeon Henry Perowne seems to subscribe to this belief:

“...the brain’s fundamental secret will be laid open one day...Could it ever be explained, how matter becomes conscious? . . .the secret will be revealed...the explanations will refine themselves into an irrefutable truth about consciousness” (p. 262-263).

Though there is not yet concrete evidence of how our biological matter becomes conscious, there are many examples that seem to illustrate that human consciousness is indeed a trait that emerges according biological laws.

Being a biological function subject to natural law, human consciousness can be impaired, altered, or even temporarily suspended in accordance with biological properties and interactions. For example, during sexual intercourse, levels of the neurotransmitter dopamine are greatly increased in the brain. Dopamine, the body’s reward system, results in a feeling of ecstasy that results in a temporary lapse of consciousness (Robinson, 2006). This idea is mirrored in *Saturday* when the narrator describes Henry’s experience of sexual intercourse with

James’s approach seemed to us highly original: McEwan’s novel certainly cries out to be analyzed in terms of actual neurochemical research, but given our specialized fields, chances are that no scholar has yet done so. James not only moves smoothly between paraphrase of current scientific studies and interpretive close reading of literature, but extends his observations across several different literary works, showing a continuity of concerns running through Tennyson, McEwan, and the science of the brain. His essay also captures one of our own favorite discoveries in the class, which is the unexpectedly efficient way that biology and literature can be combined to help us explore the question of what the mind “is,” and from what it derives.

his wife: “Now he is freed from thought, from memory, from the passing seconds and from the state of the world. Sex is a different medium, refracting time and sense, a biological hyperspace as remote from conscious existence as dreams, or as water is from air” (McEwan, 2005, p. 52). Here, Henry’s temporary loss of consciousness serves as a cathartic exercise. However, it also shows how drastically human consciousness can be influenced by changing levels of dopamine [. . .]

Though human consciousness can be altered by natural processes, better evidence for its evolutionary emergence may lie in the ways that humans have learned to control it. For example, the use of anesthesia during surgery demonstrates the way biological elements can be used to turn consciousness on and off. To study how consciousness can be altered by means of anesthesia, researchers from the University of California-Irvine performed experiments (1999) using positron emission tomography (PET). Their findings suggested that halothane, an inhalant anesthesia, decreased activity between the thalamus and the mid-brain (as cited in “Anesthesia,” 2009). Thus “wake-up” signals cannot be processed, resulting in unconsciousness (paras. 5–6). This ability to manipulate consciousness is portrayed in *Saturday*, when Perowne is thinking about the surgery his wife Rosalind needed to correct her vision. He remembers how the anesthesiologist injected the needle and “then she was gone” (McEwan, 2005, p. 44), illustrating how astonishingly easy it is to control human consciousness. Perowne finds an odd comfort in the principle that this memory reconfirms, namely that consciousness, and the yearning self that we associate with it, are functions of brain chemistry. [. . .]

There is no question that humans possess many notable differences from animals but those differences may only be in degree rather than in kind. It is undeniable that humans, just as animals, are bound by biological limitations that challenge any simple understanding of individuality. In his long poem *In Memoriam*, Alfred

Lord Tennyson (2004) understands that it is futile for him to blame nature for the death of his friend and that death is a part of natural law over which he has no influence. He writes, “I curse not nature, no, nor death / for nothing is that errs from law” (p. 7–8). He accepts that all aspects of the world are subject to this same natural law by stating that nothing can exist if it deviates from that law. For in the end, everything dies. And at that time, the exalted human consciousness ultimately is reduced to nothing more than “a weight of nerves without a mind” (Tennyson, 2004, p. 7).

Greg Burke

The male bower bird is renowned for its ornate and completely individualistic nests which it builds to attract a mate. During class, one student made an unsubstantiated remark that this behavior can be explained by the bird’s genes and therefore there is no choice or creativity involved in this very unique action. Upon hearing this I realized that we, as humans, assume that we alone have choice and creativity. If we can defer any examples of such traits in the rest of the animal kingdom by ascribing them to mere genetics that are “out of their control,” we can remain at the top of our own self constructed pyramid or Scala Naturae. This was the first bias that presented itself to me and caused me to begin asking more questions.

One fundamental and universally accepted saying is, “you can’t find what you are not looking for.” I came to realize that this remains particularly true in science. The most significant barrier in our ability to identify animal traits lies within the perceptive boundaries of being human. If an animal has an ability or a trait that we do not, then we cannot fairly perceive or associate with that trait. It will go either unnoticed or insufficiently understood. An illustration of this bias is seen in studies that have shown that female and male scientists can interpret particular interactions between opposite genders in a species in very different ways and “that where males [scientists] see dominance, females see equality” (Bekoff, 2002, p. 77). If we cannot even avoid

projecting our human gender identities onto animals, then how can we ever be sure that we are truly perceiving what is present in the organisms we study?

Once an observation is made, regardless of how unbiased it might be, it then is subject to anthropomorphism, a humanization of non-human behaviors, actions, or traits. To understand how anthropomorphism limits what we can understand about animals, just think about *Hallucigenia*, a Middle Cambrian aged fossil form the Burgess Shale formation in British Columbia, Canada. This creature's name comes from the fact that it is one of the strangest looking species ever found in nature. Scientists had great difficulty trying to make sense of the animal: "how can you describe an animal when you don't even know which side is up, which end front and which back?" (Gould, 1990, p. 154). This frustration illustrates the idea that with no perspective or point of reference other than our own, identification and interpretation of animal traits may be inadequate.

Sometimes we assign human reactions and emotions to animals in an effort to associate with our non-human companions on a human level. For example, in McEwan's novel *Saturday* (2005), neurosurgeon Henry Perowne will "never drop a live lobster into boiling water" (p. 128) since its set of polymodal nocipetor sites are similar to ours, and he extrapolates from this that the lobster must perceive pain in the same ways that we do. By humanizing an animal, we create a closeness to another species and sometimes a sense of solidarity, but this practice arguably just reflects our own consciousness rather than the experiences of the life forms we perceive.

As I became more aware of how this bias operates, I also became hopelessly conscious of inherent human biases in general, and how impossible it is to understand anything, even our own selves, objectively. I found myself continually questioning all things that I once took as truth and it began to frighten me. I soon real-

Greg's discovery that scientific methods are subject to inevitable bias is essentially epistemological (i.e., a discovery of how we form knowledge). It is also an example of interdisciplinary "emergence" because his initial curiosity about this problem, which would not typically be cultivated in an empirically-based course of study, was instead ignited by fiction and poetry that insistently asked whether or not humans can know themselves objectively. In turn, however, it was only by studying the actual "hard" science that Greg saw this literary theme take on meaning and become real. His ideas reveal a dynamic interchange between the two subjects that also corresponds to the formal features of his writing, as he moves between adroit deployment of scientific vocabulary and an almost confessional level of personal/reflective writing.

ized, much like Dostoevsky's underground man, "that to be overly conscious is a sickness, a real, thorough sickness" (Dostoevsky, 1994, p. 6). All that I have learned this semester suggests that humans may not be so distinct from animals. We seem to place ourselves at the top of *Scala naturae* because we value most highly those traits which we believe unique to us. However, it seems that we are part of the same spectrum as other animals and that this supposedly natural hierarchy has been turned on its side. Am I then subject to the same fate as my animal brothers? Or, as Tennyson asks, "Are God and Nature then at strife, / That Nature lends such evil dreams? / So careful of the type she seems, / So careless of the single life" (Tennyson, 2004, p. 40). Does this mean life is meaningless? This possibility has kept me up at night and I wonder if I have to just "go ahead and accept it, there's nothing to be done, because two times two is mathematics. Try objecting to that!" (Dostoyevsky, 1994, p. 13). Indeed, how can I possibly argue with what seems to be the truth? The implications of this seem outrageously bleak to me, but I do not see the point in arguing if it is, in fact, the truth. And so I am left alone in a fog trying to find my way to a light I am not sure exists.

Shawne Lomauro

Academia is much like a two edged sword. Learning is a passion, but along with it comes a responsibility of knowledge, so strong, that it can make you question why we seek to expand our horizons of thought. This feeling of angst has become a typical part of my academic life, so researching and delving into it only seemed like a normal reaction. The nexus of literature and biology gave me just the platform to begin this exploration. The use of human language gives the optimal viewpoint into the lengths that human thought and creativity can go. Meanwhile, evolutionary biology allowed me a space in which to question the necessity and, ultimately, the diminishing returns of that ability. While studying what I began to call the destructive capacity of human thought, the vast array of emotions I felt along my path to knowledge only seemed more normal. Deeper knowledge, it seems, is truly a Promethean gift.

The underground man's misery, set beside his assertion that he is more intelligent than all other men, shows that higher levels of intelligence as seen in the human species may indeed be detrimental to our development and success. The underground man claims, "I'm guilty of being more intelligent than all those around me" (Dostoyevsky, 1994, p. 88). Although he recognizes within himself the ability for higher intelligence, that intelligence reaches a point of diminishing returns. He cannot better himself with this knowledge, and it instead leads to his isolation and demise. This predicament also suggests that other animals have the biological capacity for higher levels of cognition, but such an adaptation has not yet occurred. This has potentially startling ramifications, given that, at least according to evolutionary theory, beneficial characteristics tend to repeat themselves independently within nature. For example, the highly advantageous camera eyes found in humans and in octopi is believed to have evolved independently in these two lineages, suggesting that advantageous traits evolve multiple times in nature. The wing, and subsequent benefit of flight, have inde-

pendently evolved in species such as bats, birds, and insects. The fact that intelligence itself has not been reproduced—despite the fact that "Human intelligence may be best likened to an upgrade of the cognitive capacities of nonhuman primates rather than an exceptionally advanced form of cognition" (Dicke & Roth, 2008, para. 1)—suggests that it may not be as much of a beneficial characteristic as it is generally believed to be. In other words, it is possible that intelligence as seen in the human species is not a benefit to long-term growth.

In our current socially constructed realities, it seems as though intelligence needs to be checked by some type of greater force in order to maintain a state of nonviolent and peaceful equilibrium. Kathleen Gibson (2002), for example, points out that "higher orders of intentionality are mental constructs that create relationships among ideas and embed ideas within each other to form higher order constructs" (p. 16). This hierarchy of intentionality can ultimately lead to deception. According to Daniel Dennett's rubric of intentionality (1998), for example, "x believes that p' represents first order intentionality; 'x wants y to believe that x is hungry' represents second order intentionality; and 'x wants y to believe that x believes he is all alone' represents third order intentionality" (as cited in Gibson, 2002, p.

Shawne's essay is probably the best example of interdisciplinary thought as an emergent property. It combines associative, interpretive and critical thought in compelling ways. As she interprets the theme of burdensome knowledge in Dostoevsky via close reading, she also associates it with scientific studies of deception or confusion in the communication of intention. She then contextualizes these ideas not in philosophical reasoning about the paradoxes of knowing, but in terms of observations that Biologists are just beginning to make about the ways that human intelligence may not be a fully adaptive, environmentally successful trait. Finally, she applies this entire matrix of ideas to a third discipline, that of social justice, a topic that is deeply relevant to her academic and personal life.

16). If gone unchecked, this increasing complexity of intentionality can have adverse ends insofar as deception can lead to things such as tension and fighting.

It can also lead to an isolating “madness,” as it can be argued that it is this third order intentionality that plagues the life of the underground man. The underground man’s desire for the reader to believe that he is all alone in his miserable-ness is a depiction of the third order of intentionality. He notes, “Now I’m living out my life in a corner, trying to console myself with the stupid, useless excuse that an intelligent man cannot turn himself into anything” (Dostoyevsky, 1994, p. 86). If we analyze this claim in terms of the three orders of intentionality, we notice that the underground man is both exercising the third order and pushing beyond it. He is trying to convince the reader not only that he is alone, but also that he believes himself to be completely detached from the rest of society. This is evidence of the capacity for deception inherent in the third order, because indeed he cannot be detached from society if he is relating his aloneness to someone else. He is also arguably moving beyond the third order, and not just participating in it, when he tries to convince *himself* that he is in his current predicament because only foolish men are successful, and that he is too intelligent to turn himself into anything. His predicament therefore encapsulates a sobering challenge not only to the notion that our intelligence is preferred by evolution, but also to the belief that we can employ it to engineer a just society.

Conclusion

These outcomes remind us that much of the content generated in interdisciplinary teaching and learning is difficult to predict—that it takes shape out of the ideas, tangential questions, strange and unique leaps of associative thought that arise from the collocation of different modes of inquiry and knowledge. However, they also may suggest that this unpredictability is more

biological than we might suppose. Like biological emergence, it arguably happens not because two distinct elements or in this case, two self-contained “disciplines” are interacting, but because the disciplinary limits cease to contain or control the live elements or components within them. The concepts, skills, and objectives that we tend to think of as comprising a discipline begin to interact independent of their original systems, evolving into a new, interactive system of inquiry and expression. Upon reflection, perhaps it was our decision to not force traditional learning outcomes in either Biology or English literature upon our students. We eventually came to accept that in a course such as *Minds and Bodies*, the learning cannot and should not be constrained through rigid predetermined objectives but rather allowed to emerge naturally; the real challenge is finding a way to encourage that emergence and as professors, accepting the unpredictability. Cardinal Newman (1959), who also used a biological metaphor to describe the integration of core learning in the Jesuit tradition, was perhaps thinking of something similar when he proposed that “all branches of knowledge [in a core curriculum] are . . . not isolated and independent of one another, but form together a whole system; . . . they run into each other, and complete each other” (p. 221). The important difference, as we experienced it, is that this “whole system” is neither closed nor predetermined. ■■

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