



A personal reflection on changes in marine science education over the past sixty years

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Abstract

Changes and needs in marine science (and natural science in general) training over the past six decades are discussed. Among these are: new technological advances; the loss of -ology courses; the loss of field courses and sense of place opportunities for students; the need for a more interdisciplinary approach to training natural science students; a need to better expose our students to threats to Earth's biocultural diversity; a need to include more humanities in our student training, including addressing diminished readership and appreciation of the great books; the nature of creativity; the perils of the internet; and university emphasis on faculty overhead dollars and high-profile publications at the expense of student training and more creative research.

Keywords: marine science; natural sciences; science training; higher education; sense of place; creativity; books; humanities; university structure

Prelude

I began writing this essay with the intent of discussing how marine science has grown and changed over the past 60 years. However, I quickly realized that the topic has already received a good deal of attention (e.g. Vermeulen 2013, Egerton 2014, 2019, Dayton 2020, Manzella et al. 2022; NOAA Ocean Exploration website 2023; Challenger Society for Marine Science website), including a brief review of deep-sea research I included in a biography of Howard Sanders for the US National Academy of Sciences (Brusca and Williams 2022). But what has largely been ignored are the changes in marine science *training*—undergraduate and graduate—over this period, so that will be my focus instead. I will draw from personal experiences and examples to explore the question: Are we doing the best we can do in our teaching of marine sciences, or natural sciences in general?

Although my emphasis will be on US universities, the issues I raise certainly exist at universities worldwide. Some of the topics I cover in this essay include: loss of -ology courses; loss of field courses and sense of place opportunities for students; the need for a more interdisciplinary approach to training natural science students; a need to better expose our students to the threats to Earth's biocultural diversity; a need to include more humanities in our student training, including addressing diminished readership and appreciation for the great books, the kinds of books that can change one's career thoughts or even one's life; the nature of creativity; perils of the internet, the sound-bite culture, and social media; and university emphasis on faculty overhead dollars and high-profile publications at the expense of student training, experiential oppor-

tunities, and research publications of deeper significance and lasting value.

Being independent by nature, when I graduated from high school in central Los Angeles in 1962, I immediately packed my bags for college and never looked back. I had been accepted at California Polytechnic State University, San Luis Obispo (aka Cal Poly). My love of learning led me to dreams of a life in higher education, while growing up in a family that valued wilderness camping had instilled a love of nature. Over the next six decades, I devoted my professional career to academics, though, as I hope to describe in this essay, I managed to avoid the trap of a narrow or insular academic lifestyle.

Over the past sixty years, I have witnessed some major shifts in: how university students are trained in the marine sciences and biology; the social and communal lifestyles of students; the nature of graduate and postgraduate training and research; and how universities are run and what their priorities are. I have worked at two research universities (University of Southern California, University of Arizona), one state college (College of Charleston), and three research-oriented natural history museums (Los Angeles County, City of San Diego, and the Arizona-Sonora Desert Museum). These experiences have given me a broad perspective across the education and research landscapes. Working at these different institutions, I trained undergraduate and graduate students, helped develop degree curricula, directed one of the largest marine science graduate programs in the country, and watched shifts in research methods, topics, and funding—I saw some recurring themes that I will bring out in this paper.

My own marine science career is a reasonable snapshot of six decades of changing times, having begun as an invertebrate taxonomist, then moving into phylogenetics and biogeography, then marine ecology and conservation ecology, then bio-cultural diversity, and eventually coastal archaeology and anthropology. For the past 35 years, I have authored four editions of a major college reference and textbook, *Invertebrates* (Brusca et al. 2023), the most widely used book on the topic (available in four languages). *Invertebrates* have helped tens of thousands of students engage with and learn about that highly diverse 96% of the animal kingdom that lacks backbones. At the time of this writing, Google Scholar counts over 5000 professional journal citations of *Invertebrates*.

Introduction

Prior to the 1980s, most colleges and universities still taught a suite of -ology courses to undergraduates; in fact, a certain number of those courses were typically required to graduate. As an undergraduate at Cal Poly, I took courses in invertebrate zoology, ornithology, mammalogy, herpetology, marine ecology, vertebrate field biology, embryology, animal physiology, and others. College graduates in biology entered the world with a good deal of knowledge about the natural world, or what today we might call natural history. Much has been said of today's university students who receive their degrees in Marine Science, Biology, or Ecology and Evolutionary Biology (EEB) having learned little about the zoological and botanical diversity of the planet, or even their own backyard, let alone the phylogenetic and ecological context of the model organism they worked on for their degree, so there is no need for me to further beat that drum. However, the larger shame of it is, because most of these courses or their equivalents simply no longer exist, students cannot take them now even if they wanted to. Being the author of a popular invertebrate zoology text, I am deeply aware that this course has been taught at fewer and fewer US institutions with each passing year—although the course is still very popular and commonly required in universities of Europe, Asia, and Latin America. In talking with my international colleagues about this, they typically respond something like, “I cannot imagine calling yourself a biologist if you have never taken a course on invertebrates.”

There were three aspects of my undergraduate program at Cal Poly that put me on a solid, lifetime trajectory in marine science. The first was a superb instructor named Dave Montgomery, who taught invertebrate zoology and marine ecology, both courses with heavy field components. Montgomery had us at different beaches every weekend, up and down the California coast. I discovered California's many marine field stations, all of them with inexpensive dormitories and libraries full of fascinating books and old monographs (with their hand-drawn-colored plates and distinctive smell when opened). There seemed to be endless opportunities for a marine biologist in coastal California. It was thrilling, inspiring, and motivating. Never underestimate the profound importance of a good teacher/mentor. The second thing I was exposed to was the encyclopedic zoology offered by tidepools, which, as the tides recede, become living museums of virtually every animal phylum on the planet (well, at least 29 of the 31 described phyla). And the third thing I learned (again, thanks to Montgomery) was that biology can be really fun, especially field biology, which instills in students a strong sense

of place. There is nothing comparable to these three attributes in strictly lab settings or non-field courses. You can not experience or understand a tidepool online. Intense exposure to fieldwork and the revelation of the great diversity of life seen in a tidepool (or a lake, stream, dense forest, or fertile soil) for an undergraduate can be life-changing and providential. An absence of field biology experiences for students can leave them uncertain about what they want to study, what kind of a career they might most enjoy, and what truly excites them—let alone what those 31 phyla of animal life actually look like alive and wriggling in one's hands. The importance of embracing a sense of place cannot be overstated. Students today spend far more time looking at their screens than observing nature (or reading books).

The invertebrates course that Dave Montgomery taught was rigorous: a detailed overview of every animal phylum, with an emphasis on functional and comparative anatomy. We used Barnes' *Invertebrate Zoology* (1963) for our text, but Montgomery told me if I really wanted to learn about invertebrates, I should read the great multi-volume treatise by Libbie Hyman, *The Invertebrates* (1940–1967). The Cal Poly library had only one set, and most of the volumes were always checked out. I threw myself into those books and eventually managed to buy the entire set of five (they were about \$18 per volume in the 1960s). The sixth and final volume, on four of the eight molluscan classes, did not appear until quite late in Hyman's life. In this final volume, she admitted her error in replacing the terms ectoderm and entoderm on the grounds that they were embryological terms and further advised that her earlier preference for the term gastrodermis be dropped. She also admitted that “Acoela are not as primitive as I had thought and much of their lack of cell walls is secondary.” Of course, we now know that the “Acoela” was never a monophyletic group or legitimate taxon, but simply a catchall of miscellaneous phyla that happened to lack a distinct adult body coelom. Our knowledge changes, but the important point of this story is that Libbie Hyman had the grit to clearly state all this and admit her ideas were in error. What a learning lesson for an undergraduate to read this doyenne of invertebrate biology acknowledge and describe her mistakes. Even then, I thought of her as a great scientist for this admission, among many other reasons.

Libbie Hyman devoted most of her life to reading and synthesizing practically all of the research on invertebrates that existed. She even adapted figures from that original research for her comprehensive volumes. Those drawings would go on to be used in many invertebrate textbooks for generations to come. I was so impressed by Hyman, whom I never met, that it made me want to learn how to synthesize information about invertebrates myself. Almost unconsciously, my admiration for her ability to synthesize vast amounts of data inspired me to do the same, ultimately leading to my own text on invertebrate biology (Brusca et al. 2023). Beginning with the second edition, this text has provided the animal framework for such widely used classification standards as ITIS (Integrated Taxonomic Information System) and the Catalog of Life (Ruggiero et al. 2015). Where our hearts go, our thoughts go, and where our thoughts go, our lives go.

Books were a huge part of undergraduate science courses and training until around the late 1990s, at which time they began to be replaced by the digital world. Before the turn of this century, most students graduated from college having accumulated a sizeable library. This library meant a great deal

to serious science students; it was like money in a savings account, and they relied on those books as references to turn to in the future whenever they wished. They walked around campus with their backpacks slung heavy on their backs, filled with books—a sight one no longer sees.

Fast forward the clock, and we witness the advent of other, huge, new technologies (besides digitization) that changed the way marine science is done. Although ship-board scientific research continues, the age of fundamental ship-based exploration is largely over, with a few exceptional situations such as seafloor exploration in response to the issuance of deep-sea mining permits for mineral-rich nodules (Meyer et al. 2023, Rabone et al. 2023, Washburn et al. 2023). Satellite- and drone-obtained oceanographic data have largely replaced data “hand-collected” near shore or on the open sea. Our understanding of genetics and ease of acquiring DNA sequence data have revolutionized virtually all aspects of biology, biogeography, ecology, and conservation research. And the emerging field of environmental DNA (eDNA) promises another quantum leap forward (e.g. Pochon et al. 2023, Mac Loughlin 2024 et al. 2024). Online databases of scholarly work (e.g. Web of Science, Scopus, Google Scholar, Biodiversity Heritage Library, Research Gate) have made searching for published work highly efficient, improving both speed and reliability. Supercomputers, using machine learning and AI, can now analyze volumes of data never thought possible 30 years ago. Operating on the frontier of speed known as the exascale, the newest computers are capable of 1.1 exaflops (10^{18} flops), or 1.1 billion billion operations per second, and new machines will soon reach 2 exaflops. Thousand-fold jumps in supercomputing speed and power have occurred every decade or so since the early 1990s. Zettascale (10^{21} flops) machines are in the planning stages. Combined with AI, the potential seems almost limitless.

But all these forward-looking improvements should not come at the expense of training our students in the field. Paradoxically, technology connects us with the world while simultaneously distancing us from nature and trapping us behind our screens. Because I feel so strongly about the importance of offering students opportunities to engage in a sense of place, I will give further voice to the subject.

Field Courses and Sense of Place

“There is no mysterious essence we can call a “place.” Place is change. It is motion killed by the mind, and preserved in the amber of memory.” J. A. Baker, *The Peregrine: The Hill of Summer and Diaries: The Complete Works of J. A. Baker.* .

Earth is experiencing both a biological and a cultural diversity crisis, as more and more species, cultures, and languages go extinct (Barnosky et al. 2011; Vidal and Brusca 2020a,b, Rozzi et al. 2023). An essential characteristic of the Anthropocene is, in fact, the process of biocultural homogenization, which includes the loss of both biological and cultural diversity. This biocultural diversity crisis is exacerbated by “extinction of experience,” which means these losses to the planet (and to our own species) are going largely unnoticed by most people, including students in institutions of higher education.

Despite this, most colleges and universities continue to move farther and farther away from offering students the kind of experiential opportunities that reveal first-hand the

earth- and humanity-changing events that are taking place. This, even when it is well known that exposing students to participatory, multi-sensory field education can be a powerful force in expanding their minds and shaping the world and the way we identify, address, and solve Earth’s interconnected problems. Environmental education plays a major role in the formation of attitudes about biological and cultural (biocultural) diversity. Now, more than ever, schools at all levels, and teachers/professors at all levels, have an imperative to not just teach the nuts and bolts of their discipline from lecterns and digital media, but to fully engage students in the field as well as exposing them to the social sciences, philosophy, ethics, and creative aspects of the natural world and how humans interact with it. In other words, how the world actually works. Field experiences and biocultural education should go hand-in-hand with lectures and reading assignments. Such an approach is sometimes referred to as “field environmental philosophy,” because it integrates sciences, humanities, arts, and ethics to teach about ecological, cultural, and political dimensions of Earth’s biocultural diversity (Vidal et al. 2010, Rozzi 2023). In short, the most successful “teaching” about a place can be achieved not through formal instruction, but from immersion in locality (a real locality, not an AI-generated one or “virtual reality”).

No region on the planet remains untouched by humankind, so successfully managing current threats to marine resources and ecosystems is largely dependent on our ability to understand and manage human behavior. Recently, we have seen increased growth in research to understand the human dimension of marine resource use and its associated implications for management. However, marine research and training have largely given short shrift to the critically important role of “sense of place,” and its part in influencing the success and efficacy of management interventions. We must do a better job teaching sense of place if we are to prepare students for careers in the environmental sciences.

Lynch (1960) was among the first to use the term sense of place, referring to the symbolic and memorable aspects of urban environments. Codifying the concept of sense of place in a scientific fashion began in the 1970s, originally developed by phenomenological researchers, notably through the work of Tuan (1974, 1977). Subsequently, naturalists elaborated on the concept in a variety of ways, including psychology (Proshansky et al. 1983), anthropology (Altman and Low 1992), and sociology (Brehm et al. 2006). Tuan (1977) and van Putten et al. (2018) emphasize the process by which people observe and experience and, in so doing, attach meaning to an environment, a process that transforms abstract space into a unique place.

Using outdoor education as a way to instill a sense of place in students (or any learner) requires an appreciation of relations, including emotional bonds between self, others, and nature (van Putten et al. 2018, Leather and Thorsteinsson 2021). Duggan et al. (2023a,b) describe sense of place as an overarching wisdom derived from and encompassing numerous concepts. A person’s sense of place is developed from, and is composed of, psychological, sociocultural, and biophysical dimensions (Rubás et al. 2023). The psychological dimension is based on one’s personal relationship to and feelings about a place. The sociocultural dimension is based upon a person’s relationship and understanding of people living in the place, past and present. The biophysical dimension is determined by the biological and physical aspects of the place.

If we are tasked with teaching students in the field of marine science (or any other realm of natural science), it is incumbent upon us to instill, at least to some degree, environmental literacy. In this, the importance of sense of place is indisputable; it is a deeply important quality of scientific literacy, citizenship, and aesthetics. The components of environmental literacy are prior affective disposition, cognitive knowledge, and environmentally responsible behavior (Rubás et al. 2023). The sense of place paradigm is a suitable means to shape all three of these elements. The growing success of citizen science around the world is testimony to the efficacy of sense of place as a tool to connect humans to nature in positive ways, not that “open science” should be viewed as a panacea for addressing all the flaws in modern science (Mirowski 2018).

Humans evolved in wide-open grasslands, and this is thought to be why our eyesight developed to study distant horizons for landforms, game to hunt, and predators to avoid. We are one of the few species with this acute long-distance vision. Seeing the horizon or a vast landscape (or waterscape) allows us to better grasp nature in context and understand our place in it. We see broader patterns and systems. We often feel a sense of humility in the face of a vast horizon. Who has not felt such emotions standing at a grand overlook, watching a sunset over the sea, or hiking to the top of a mountain? Our internal sense of place in the world readjusts to welcome its vastness.

Achieving a sense of place is a process by which individuals identify, understand, and attach to a location, including the meanings, values, and feelings that they associate with it. Learning in this context is more effective and long-lasting than in a classroom. While sense of place is an important concept in many disciplines (e.g. architecture, urban planning, policymaking, psychology, anthropology, and human geography), it is nowhere more important today than in natural and human ecology and our understanding of biocultural diversity. Being immersed in nature helps mold an individual’s intellect, identity, and emotional-social personality. The human senses are the most essential factor in such spatial experiences but in fact, a sense of place is an intellectually, socially, culturally, and psychologically constructed relationship (Turgay and Sariberoglu 2022, Zhang et al. 2022). A strong sense of place links people to the ecological-social system of an area, a concept that has received considerable attention by researchers (Hashemnezhad et al. 2013, Masterson et al. 2017, 2019, Duggan et al. 2023a,b).

Tuan (1977) made a distinction between *spaces*, applicable to a range of locations, and *places*, more local, personal, and storied. The “seashore,” e.g. is a space, but a seashore on the coastline of the Gulf of California (Sea of Cortez) is a distinct place with many unique attributes: the sea made famous through a book by John Steinbeck (*The Log from the Sea of Cortez* 1941), the only semi-enclosed sea in the eastern Pacific and the only evaporative basin in the entire Pacific Ocean, a region of extraordinary biodiversity and productivity, a UNESCO World Heritage Site, etc. A sense of place for a specific location allows one to *connect* all aspects of place—the land and sea, the ecosystem, the people and culture, its history, aesthetics. Doing so means not rushing your students through the field experience, not “ticking off” localities, but giving them time to immerse in the environment, spend contemplative moments there, read about it beforehand and afterwards (fiction that is set in the place can be especially mind-expanding), and so forth. This is an approach that entertains

the philosophy of experience—a deep dive into human beings’ sense of place. The best approach to acquiring a sense of place is one that integrates science, art, humanities, and ethics (Orr 2004, Jónsson et al. 2020). Art has the power to inspire scientific inquiry, often in unconventional ways that can challenge scientific paradigms. Vincent van Gogh’s revolutionary use of light and color in his paintings, e.g. strongly influenced the development of color theory and physics.

In today’s digital society and constipated higher education landscape, the formation of a student’s relationship to place has become an educational challenge, and its application is widely insufficient. The digital world has largely replaced lived, sensorial reality, with the narrative being mediated by unknown persons with specific (and usually unknown) agendas. With digital technology becoming the dominant lifestyle, people tend to indulge too much in the virtual experience of a place without actually being there. This excessive digital consumption gives an unreal sense of spatial experience to today’s generation, which is increasingly devoid of *in situ* natural experiences. We typically no longer “feel” nature; we consume it digitally, in two dimensions, not actually sensing it. In doing so, we look but we do not see; we listen but we do not hear. Like being entombed in a glass box, seeing nature but not fully perceiving it. But our minds know it is not real because we can switch it off at any moment. Today, we are increasingly disconnected from everyday interactions with our environments and the living organisms (including humans) that inhabit them. Simply put, most of today’s students are out of touch with nature and largely separated from it.

Teaching a sense of place requires adopting mindful field experiences that open learners up to the experiential, aesthetic, and psychological aspects of a location. Exercises that require the student to return on their own can be especially meaningful as they give the opportunity for self-immersion, perhaps in solitude, that might provide for deeper reflection and self-awareness of their senses and emotions—seeing, smelling, touching, and feeling the place—as Aldo Leopold (1949) described in the *Sand County Almanac* and Henry David Thoreau expressed in *Walden* (1854). This is the “slow pedagogy” of place-based education described by Leather and Thorsteinnsson (2021). Being immersed in the environment alone, or nearly so, can give the experience meditative qualities, deepening the “messages one receives from nature”—we sense the place before we respond cognitively. As May Sarton so eloquently put it, “There is no place more intimate than the spirit alone” (*Inner Landscape*, 1938). Tuan (1977) describes this as “achieving a concrete reality when our experience is total,” through all the senses as well as with the active and reflective mind. Such deep connections with a place can leave one with strongly personal, private ideas about a locality or an environment. A month living and working aboard an oceanographic research vessel certainly provides such an immersive experience, as does a summer at a marine field station. Such experiences are becoming rare for students, with some notable exceptions such as Sea Education Association (<https://sea.edu/>). Even in group field trips the environment still dominates the spaces between the students, awakens them, and immerses them.

There are a few good models for marine science programs that emphasize field courses in the USA. One of the best is the College of Charleston (South Carolina). Their Graduate Program in Marine Biology averages around 50–60 students, all of whom take their classes at the college’s Grice Marine

Laboratory on James Island. In addition to being physically surrounded by the sea, students take a core course series that includes a great deal of field work. By the time they graduate, they have a deep understanding of the variety of coastal habitats of southeastern USA. The graduate program spills over to the undergraduate curriculum, such that younger students interested in marine science also have ample opportunity for coastal field work and can even major in marine biology. Living and working among the sea islands of South Carolina is a full-immersion sense of place experience.

Often today, a student will say to me, “I would love to go into the field with you on your next field trip.” Not because it is me, but because they have little idea what a field trip actually is but it sounds fun to them. And I am one of the few people they know who still “goes into the field.”

People’s emotions become more mature and positive after interacting with natural environments (Marcus 2021), and the link between creativity and emotions has been confirmed (Hutton and Sundar 2010). Better geospatial thinking leads to higher levels of creativity, or the ability to generate new ideas and to discover and create new things (Zhang et al. 2022). Sense of place education has a critical role in improving students’ geospatial thinking skills, and, in return, student creativity directly facilitates both their geospatial thinking and their sense of place (Zhang et al. 2022). Creativity is an all-important asset that can help students navigate uncertain futures and that plays a critical role in the cognitive, emotional, and behavioral development of individuals. In the business world, creativity is deemed crucial to innovation and success in the rapidly changing global economy (Anderson et al. 2014). For a scientist, there is no doubt that creativity helps drive success (as also for the artist).

The Impact of Books

“Books are magic. They create something out of nothing. They transform. They endure. A great book affects you more, stays with you longer, and is more personal than any other art form. Books have reach. Books have challenged authority and created more mass movements than paintings and music and movies combined.” Jeff Hartman, *How to Win the Nobel Peace Prize*, 2024.

Students and scholars need to gain wisdom, not just accumulate knowledge. Gaining a sense of place is an excellent way to open doors to individual wisdom. But there are other doors, such as the arts and especially literary fiction. Our education process increases our knowledge of specific areas, but in doing so also creates inherent biases associated with that information—by the very process of teaching, all educators bias their students. We can reduce that bias and provide broader perspectives by introducing students to relevant and substantially different forms of literature, and in doing so, we help them garner wisdom. However, studies have shown that fewer than two-thirds of Americans read books, and even those who do average only about 15 minutes per day reading. By comparison, they spend over three hours per day watching videos. Of those who do read, only 40% read fiction, and only 15% of those read literary fiction (the other 85% primarily read the commercial genres of mystery or romance novels). This means just 4% of Americans read literary fiction. Twenty-one percent of US adults can not read at all (they are illiterate)—that is 32 million Americans. And 54%

have a literacy below the sixth-grade level (National Literacy Institute 2024; <https://www.thenationalliteracyinstitute.com/literacy-statistics>). The USA is no longer a country of readers; it is a country of dwindlingly literate screen timers.

A great literary novel can offer readers many things. Of course, it will spin a good yarn and entertain, but it will also educate or teach the reader something new, and, importantly, the best of them will challenge readers—by pushing them outside their comfort zone, outside their normal day-to-day world and conversations. Great literature is often meant to be provocative. It reveals other ways of living or thinking about things that may be new to the reader. It often depicts aspects of human nature that are well known, but rarely talked about. As when listening to great music, reading good fiction allows one to “unself”—to step outside one’s personal identity and into the world of others in an intimate way. Music, literature, and the visual arts are the transcendent languages of time; they throw light upon the mysteries of humanity. If a poem or novel is well written, it allows the reader to temporarily become “another,” to be in the heart and mind a narrator or the characters in a story. Good writing leaves the reader’s mind changed, for a while or perhaps forever. These are some of the ways that reading a book can allow a person to escape the confines of self and see the world through truly different eyes. Great art, music, and literature speak directly to the human spirit, just as does immersion in the natural world.

One of the most important lessons that educators and most students learned during the twentieth century was the importance of reading books. All kinds of books. And as academics, we all know that if you want to be a good writer, you need to be a good reader. But books also do something else immensely important. They stimulate our imagination. Which, in turn, generates creative thinking that can spill over in countless different ways: in our research, our understanding of the earth and of humanity, in politics and civics, in carving out a unique path for ourselves, and in learning how to embrace empathy and compromise to establish healthy bonds with others.

Sometimes we are fortunate to pick up a book for the first time and sense it intriguing enough to read, only to discover it fundamentally changes our view of the world. For a scientist or a student who wishes to become a scientist, these moments can be inflection points that change their way of thinking forever. Even years after, when we have forgotten all about the book, the ideas and new ways of thinking about nature, science, or life in general persist in our minds. But first, we must pick up the book.

It has been my experience that today’s students, both undergraduates and graduates, rarely read books. Some do not read books at all, not even fiction (and certainly not literary fiction). Their “reading” consists wholly of screen time and sound bites. I would argue that screen time can never be a substitute for holding an engaging book in one’s hands, becoming immersed in the ideas presented (fiction or nonfiction), making notations in the margins, and letting the author’s writing and ideas take one into a new realm, a new place and time, a new way of seeing the world.

It is not just the intrusive and addictive qualities of smart phones and other digital devices/media that are driving students away from reading. As Pamela Paul noted in the *New York Times* (9 March 2023), English classes in middle and high school—now reformulated as English Language Arts (ELA)—and the Common Core State Standards (CCSS), a national curriculum introduced in 2010, have severely down-

graded English literature. Although adopting CCSS was not required, 41 states did so. Dissatisfaction with the CCSS has since led some states to repeal the standards. The CCSS and STEM (Science, Technology, Engineering, and Mathematics) teaching paradigms, sadly, de-emphasize literature. They do not require reading any complete works of literature. And, by grade 12, CCSS requires that 70% of assigned texts be non-fiction. The remaining fiction that students are now assigned is more likely to be short stories, short excerpts from literature, and digital material, not novels (Griffith et al. 2018). The world of great literary fiction and immersing children in the full arc of storytelling has largely gone out the window. All this, Pamela Paul notes, carries over to college, where, over the past couple decades, the study of English has fallen by a third. This amounts, in my opinion, to yet another failure of the American public school system.

It is worth noting that none of the ELA teachers I have spoken with favor the increase in nonfiction. Dana Maloney (2021), an ELA teacher for 32 years, wrote (danamaloney.com): “When we read imaginative literature—whether prose, poetry, or drama—we explore what it means to be alive and to be human. As one of my students remarked years ago, “Literature humanizes us.” We help students understand themselves, others, and the world. We help students crisscross the globe, step into other people’s shoes to see the world through their eyes, and more. Through all of this, we also help students deepen understandings of themselves and of their lives.”

Books have had a profound effect on my life and career, whether they were specifically required for a course I took, recommended by a mentor, or discovered on my own.

It probably goes without saying that Ed Ricketts’ two great books, *Between Pacific Tides* (1939) and *Sea of Cortez: A Leisurely Journal of Travel and Research* (1939; co-authored with John Steinbeck) were fundamental, grounding books in my career as an invertebrate biologist and marine scientist. Many marine biologists of my generation would probably say the same. These were books that taught the thrill of tidepooling and invertebrate zoology not with lists and tables, but with prose. And, of course, they led me to all the other books by John Steinbeck (Ed Ricketts’ best friend), which I devoured while learning about Central California’s often-sordid agricultural history. To this day, I still consider Steinbeck’s *The Grapes of Wrath* (1939) to be the greatest American novel ever written. Both Steinbeck’s and Ricketts’ vision and writing were deeply imbued with a sense of interdisciplinarity and breaking down the barriers between science and the humanities (Beegel et al. 1997, Brusca and Haskin 2020, Shillinglaw 2020).

The writings of Ricketts and Steinbeck and the fieldtrip weekend musings with Dave Montgomery infused in me, early on, an appreciation for the fact that science does not need to be exclusive of art, including literature. In fact, the more the two can be melded, the better. In my case, I have tried to express this through my writing. Early on, it was science-topic essays in the popular literature, later science books oriented to both the scientist and the lay audience, and eventually, when I retired and had the time, it was expressed in essays and editorials for magazines and newspapers, and in historical novels with strong science themes. Punching holes in the envelope of the academic silo most universities train us to live within is a worthwhile way to stay creative, greatly increase your relevancy as a scientist, and to write for more than the two-

dozen specialists who care about our individual research papers. There is a powerful homogenizing effect that academia has on our way of thinking but creative choices can always be made rather than simply continuing to walk passive and predictable steps along the well-trod, routinized communal university science pathway.

Alister Hardy’s (1965) extraordinary two-part book, *The Open Sea: Its Natural History*, also had a huge influence on me. I know of no other book, old or new, that captures both the science and the enthusiasm for biological oceanography better than this volume. Brimming over with lovely line drawings, color, and black-and-white prints, and a text that is both informative and engaging, this is the kind of book one can easily dive into and not stop reading until the final page. And that is just what I did. It is a book that takes you to sea on Hardy’s virtual oceanographic ship. It is, in a sense, the oceanic equivalent to *Between Pacific Tides*. My love for the sea had doubled by the time I had finished reading Hardy’s amazing book. It was largely responsible for my own many years of ship-based ocean research and exploration, including seven months aboard the *R/V Eltanin* exploring Antarctic sea ice, numerous expeditions to the Caribbean, Sea of Cortez, and Galapagos aboard the *R/V Alpha Helix*, and scuba-based research along the coast of west Africa on a converted diamond trawler.

But aside from the science books that captured my mind, a number of other books published in the 1960s deeply changed my view of myself and life in general. The 1960s were, of course, a time of creative flowering for writers, a time of exploring new ideas about America (or revealing old ideas not yet clearly articulated), our culture, and ourselves. Alan Watts’ *The Book. On the Taboo Against Knowing Who You Are* came out in 1966. I had just finished my bachelor’s degree in biology and was working for a large biochemistry company called CalBioChem in Los Angeles. It was mindless, routine, and benchwork—simply following chemistry recipes others had developed. I was spending much of my free time going to concerts, and I also experimented a good deal with various drugs, including LSD, psilocybin, and mescaline. I tried to use hallucinogens in a “scientific,” or investigative fashion, seeking different settings, different outdoor environments, and different strengths. Psychedelic compounds are known to promote cortical structure and functional neuroplasticity through the activation of serotonin-2A receptors (Karaki et al. 2014; Moravčíková et al. 2018; Egger et al. 2023). Those experiences offered me new ways to see the world and explore ideas, made me unafraid to take risks, taught me mindfulness and deep concentration, and convinced me to keep my psyche alive and open and not get trapped in the silo of academia that so many university professors seemed trapped in. These experiences also taught me that some things are difficult to access by intellect alone and can best be seen through a process of self-surrender. When I read Alan Watts’ book, it struck me deeply. Watts’ ideas followed naturally upon Joseph Campbell’s insightful treatise, *The Hero with a Thousand Faces* (1949), further validating the notion of common human myths and collective themes that have passed through humankind in all cultures for millennia. Campbell’s other two blockbuster meditations, *The Power of Myth* (1988) and *The Hero’s Journey* (1990), dug even deeper into these universal themes of human nature.

Watts was a British philosopher who adapted the Hindu philosophy of Vedanta to explain the nature of being, helping

us understand that everyone is connected to the rest of the world—the sea of humanity, the environment, the land, and the oceans. Watts describes his book as an attack on the notion that we are all individual egos carried about in bodies of flesh and bone. In the process of his narrative, he does a fine job of breaking through the narcissistic wall that many of us seal ourselves in, especially in the academic world.

Robert Pirsig's *Zen and the Art of Motorcycle Maintenance* influenced me so much I read it three times the year I graduated with my PhD (1974). And shortly after, when I obtained my first academic position (Assistant Professor at USC), I put it on a list of required readings for new graduate students coming into my lab. It was the perfect transition novel from the frenzied, fragmented, experimental years of the 1960s into a reasoned world of Western thinking (and having a real job). Even today, I believe this book should be required reading for all college seniors majoring in science.

Great books—books that evoke profound new ways of thinking—never get old or go out of fashion. They can always engage the intellect and the imagination in timeless ways. The writings of Rabindranath Tagore, “India’s Goethe,” and a Nobel Laureate in Literature stir the soul as much today as they did in the late nineteenth century. And no one gave more grace or eloquence to the lives of ordinary people than did Pulitzer Prize-winning poet Lisel Mueller in the twentieth century.

One Hundred Years of Solitude by Colombian writer Gabriel García Márquez (1967 Spanish; 1970 English) introduced me to the delight of magical realism. To ideas about what in life is meaningful and what is not, and what is profound. And what in life we can laugh at. It taught me how to think outside the science bubble I was beginning to live in and how to consider alternate realities; this was a theme that would be with me for the rest of my life.

Kurt Vonnegut’s perfectly written novels, *Slaughterhouse-Five* (1969) and *Breakfast of Champions* (1973), gave me the missing context I needed to wrap my head around the human avarice I saw all around me, the unadulterated greed and false sense of morality that are rampant in the world. Yes, it is true, evil and all its collaborators still thrive in the cathedrals of humankind.

I found anything written by Kahlil Gibran, Hermann Hesse, T. S. Eliot, Isaac Asimov, George Orwell, Ray Bradbury, Jorge Luis Borges, or Ken Kesey broadened my thinking and worldview. Kurt Vonnegut’s *Cat’s Cradle* (1963), Robert Heinlein’s *Stranger in a Strange Land* (1961), Rachel Carson’s *Silent Spring* (1962), and Marc Reisner’s *Cadillac Desert* (1993) expanded my understanding of the human-nature interface and helped me see how people and governments not paying attention to the facts, to science, can lead to disastrous outcomes.

During graduate school, my passion for books and reading enlarged. Three benchmark books on the emerging field of phylogenetic biology bent my mind in totally creative ways, causing me to envision the tree of life in a fundamentally new and more rigorous fashion: *Phylogenetic Pattern and the Evolutionary Process: Method and Theory in Comparative Biology* (Eldredge and Cracraft 1980); *Systematics and Biogeography. Cladistics and Vicariance* (Nelson and Platnick 1981); and *Phylogenetics: The theory and Practice of Phylogenetic Systems* (Wiley 1981). It would come to be that these three books were benchmarks that offered guiding principles in biological research that we all take for granted today. They, too, were required reading of new grad students in my lab for many years.

There are few elements so overlooked in the development of a well-rounded young scientist as the importance of reading good books. The right book can change a student’s view of his/her hopeful field of study and even their view of the world. And the combination of field experiences and good books can stoke fires of creativity in a learner. The best mentors lead their students to good books, including the art of literary fiction. Storytelling, one of the oldest of all human traits, and the capacity of humans to construct and manipulate stories, may be the crowning achievement of human intellect (Bower and Morrow 1990). Nature, art, music, and human relationships give life meaning, and a solid sense of the humanities can help scientists communicate better with students, other scientists, and the general public. As Rudyard Kipling noted, “Words are, of course, the most powerful drug used by mankind.”

Unfortunately, these are difficult times for the humanities in higher education. Colleges are cutting humanities programs, university libraries are reducing the size of their collections, students and policymakers are pushing for “more practical” job-oriented majors, and business has the most popular undergraduate major (Neem 2019, 2023, Roberts-Grmela 2023).

On Creativity

“There lies a green field between the scholar and the poet; should the scholar cross it he becomes a wise man; should the poet cross it he becomes a prophet.” Kahlil Gibran, *Sand and Foam. A Book of Aphorisms*. Alfred A. Knopf, 1995

Creativity can be defined as the process of using one’s imagination and skills to develop new and unique ideas. However, creativity is a difficult concept to universally define and study, and researchers do not fully agree on any single definition. Kharkhurin (2015), noting that creative science remains a poorly studied field in general, concluded it had reached an epistemological cul-de-sac. Indeed, a review of the field suggests there is little agreement on what the sources of creativity might be (DiLiello and Houghton 2006). Shaw et al. (2023) claim openness to experience and extraversion are related to and predictive of creative behaviors. Gruber (1988) views creativity as an emergent property resulting from a complex system of interacting and interrelated factors. May (1994) sees creative urges being induced by symbolic immortality. On the other hand, Kharkhurin (2015) argues that the ultimate source of creativity is transcendent attributes that lie outside the individual, and for that reason, our current approaches to understanding creativity fall short. We fail to understand this phenomenon, Kharkhurin argues, because it is possible that the source of creativity lies beyond human cognition. The philosophical, mystical, and religious approaches to understanding creativity were also explored by Runco and Albert (2010). And certainly, a large majority of artists ascribe their creative capacity to inspiration, which supposedly finds its origin in supernatural, mystical, or even mythic sources (Garberich 2008). However, the existential, transcendent, spiritual, and metaphysical aspects of the human psyche are not easily researched by contemporary scientific methods.

Despite the uncertainties noted above, many studies have shown that thinking style positively affects the creative capacity of individuals, strongly suggesting that lived experiences play an important role in whether or not a person becomes creative (Piaw 2014, Giao and Vinh 2015, Hanh et al. 2021).

And as teachers, do we not want to help cultivate creativity in our students?

Son and Nguyen (2023) found that four factors have a positive impact on the creative capacity of young scholars: intrinsic motivation, creative self-efficacy, thinking style, and a supportive environment. Universities do a poor job of systematically addressing these issues. Ward (2007) speaks to the creative cognition perspective in which an individual's creative involvement can be stipulated by known and observable fundamental cognitive principles such as the capacity of one's memory systems, memory retrieval, mapping old knowledge onto new or novel situations, conceptual structures, and knowledge combination and manipulation. Kharkhurin (2014) proposes a model of creativity that reflects four attributes: novelty, utility, aesthetics, and authenticity. Authenticity corresponds to the transcendental sphere, novelty to the intellectual sphere, utility to the active sphere, and aesthetics to the emotive sphere. The transcendental sphere represents an authentic impulse to create. The intellectual sphere sets forth idea conception. The emotive and active spheres stimulate idea realization and production.

It seems to me that children are born with a natural sense of creativity, driven by innate wonder, curiosity, imagination, and often a kind of fearless willingness to experiment, to "try anything" to figure out their world. But there is an existential threat to this childhood creativity called "growing up." Most of our childhood wonder and creative thinking are driven out of us in our youth by parents, teachers, and other adults in our environment who believe they are instructing us in the practicalities of adulthood. But their efforts can actually create growing lacunae between self-discovery and imagination. This process of molding youngsters to fit into the world trains them to think along predetermined pathways that can suppress creativity. And in today's world, much of the digital environment picks up where the parents left off, channeling developing minds in ways that suppress creativity. Thus, creativity must be rediscovered. Young adults (and adults of any age) must find themselves in learning environments that re-engage the process of experimentation and thoughtfulness in order to regain and fructify their lost creativity. This, then, is one of the key roles of teachers—to help young adults find ways to regain their childhood creativity, and to be unafraid to step outside peer-driven and cultural norms. One of the best ways to do this is to put our students into environments that stimulate and generate creativity, such as immersive field encounters. Hence the huge success of such experiences as NOLS (National Outdoor Leadership School) and other outdoor, experiential-based learning programs. The digital world is no match for immersion in the real environment.

Whatever the creative wellspring might be, studies have shown that creative self-efficacy leads to individuals having confidence in taking risks and trying new ways to get things done (Son and Nguyen 2023). Risky decisions represent a cost-benefit tradeoff in which the possibility of a negative outcome must be weighed against the possibility of a beneficial outcome. This trade-off is subjective and depends on the individual's willingness to accept risk, the psychology about which we know very little. But we do know that creative individuals have big imaginations, are more adaptive, and are more willing to take risks. Thus, it is not surprising that creativity has been said to be essential for competitive advantage (Walton 2003). In the world of science, there is no question that creativity gives one a leg-up, from simply competing for grants

or jobs to stepping outside the norm to strike out in entirely new directions. It is the most creative minds that break with standard paradigms, move fields forward rapidly, and make big discoveries.

The combination of creativity and good literary writing can also play an important role in creating syntheses of complex fields such as ecology, which, today, is a loose collection of highly fragmented subdisciplines lacking a coherent framework, general theory, or even a general synthesis (Molles 2008). As Molles notes, "our challenge as researchers and educators is to structure and present our discipline in a way that takes into account the way humans see the world, absorb and retain information, and think." Storytelling, a highly stylized form of communication practiced by all cultures since the dawn of humankind, may reflect something of the structure and functioning of the human brain, and for these reasons might be an excellent way to assemble an ecological synthesis (Brown 1991, Molles 2008).

Reprise

"There is only one solution if old age is not to be an absurd parody of our former life, and that is to go on pursuing ends that give our existence meaning." Simone de Beauvoir, *Old Age*, Deutsch, Weidenfeld and Nicolson, 1972

Sir Isaac Newton [1643–1727] wrote that he saw himself appearing "like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me." Two centuries later, Charles Baudelaire [1821–1867] wrote, "Genius is nothing more nor less than childhood recovered at will." Albert Einstein [1879–1955] said, "Creativity is intelligence having fun" and "Imagination is more important than knowledge." The moments of discovery and exaltation of great thinkers come not from a head full of facts alone, but from a way of looking at the world, a way of seeing hidden connections that is made possible by a lifetime of accessing the creative imagination that lurks in the mind. Creativity appeals its case to the future by its attraction to what remains just beyond one's strictly intellectual grasp. It is what leads to important and creative science, to overturning long-held paradigms, and to bold ideas and experiments, such as the Atlantic Ocean Coupled Coastal Temperature and Biodiversity Observation Network, with over 2000 sensors to be embedded in the environment at 320 locations all around the 21 500 km of Atlantic Ocean shoreline, in both hemispheres (Reese 2023). Or the "Amazon Observatory" (officially, the Andes Biodiversity and Ecosystem Research Group, ABERG) with eight 1-ha study plots along a 15-km-long transect stretching from 4020 m high grassland to the Amazon lowland rainforest at just 100 m elevation (Fraser 2023). Imagine the creativity in such audacious ideas as those described in E. Schwitzgebel's 2004 book *The Weirdness of the World* (Princeton University Press).

But still we ask, where does such creativity come from?

In 1985, I received a multi-year grant from a small private foundation in Los Angeles to support my fieldwork in Costa Rica. The plan was to make collections of marine crustaceans from a Coral Reef on the Caribbean coast, which was suffering from agricultural runoff from the many banana plantations along the shore. The plantation runoff was literally killing the reef, which is a National Park, but the government

seemed helpless to do anything about it, presumably due to the political strength of the US-owned fruit companies. I would compare the Crustaceae of this dying coral reef habitat to that of a “pristine” reef in the Caribbean. I decided to use Central American flagship airlines, which stopover in several country capitals on their routes south and north, allowing passengers to hop on/hop off at no extra cost. I would use the opportunity to explore more of Mesoamerica.

In anticipation of more extensive travels in the region, I located a copy of John L. Stephens’ famous two-volume book, *Incidents of Travel in Central America, Chiapas, and Yucatán* (1969). The book’s illustrations, both black-and-white etchings and remarkable panoramic color paintings by Frederick Catherwood, had instantly become as popular as the narrative itself. The story describes visits by explorers Stephens and Catherwood to numerous remote, ancient, little-known Maya cities hidden in the jungle, notably the great Petén Rainforest, second in size only the Amazon Rainforest. I could not have chosen a better book to read to prepare myself for traveling in the region. The Stephen’s classic tome is the “Ricketts” and the “Hardy” of New World anthropology and archaeology. The story of those two uncommon explorers altered my perception of New World history and instilled in me a passion to understand Mesoamerican cultures, both ancient and contemporary. Largely because of the Stephens book, I decided that every trip I made to Costa Rica would include stopovers in Guatemala, Nicaragua, and Mexico. In Guatemala, I rented cars to explore the remote high-mountain villages, the land of the Quiché Maya. I made a point of never taking any of my field crew along, who were often on the same flights as me, because I wanted complete freedom to follow my instincts as I drove from one highland village to another. No creativity suppression! The cloud forests of Guatemala close in on the highways with a fierce denseness of pines, and, above 8000 feet elevation, the spectacular sacred *Oyamel* fir takes over the landscape. One’s sense of place is clothed in carpets of moist green vegetation, brimming with animal life. I discovered unique and unexpected gifts of both solitude and companionship in the mountains everywhere I went. I had experiences that took me down paths to otherwise unreachable views of reality, new ways of looking at the world that enlivened my thinking. There is, in Mérida, a small museum devoted entirely to Frederick Catherwood’s magnificent color paintings from those explorations, and they have one of only a dozen or so sets of the original prints. Thirty-five years later, these experiences led to two award-winning historical novels based on Maya and Aztec cultures (Brusca 2019, 2023). Strong sense of place stays with you forever, running deep in the fabric of a person and stimulating both memories and creativity. Behind every journey is a reason, though often unseen at the moment.

In December of 1997, my fiancée and I moved from Charleston (South Carolina) to Tucson. She had been admitted to a PhD program at the University of Arizona to study under the prominent phylogeneticist David Maddison. I was thrilled at the prospect of returning to “The Old Pueblo.” I took a one-year leave without pay from the College of Charleston, but knew I would not be returning to South Carolina. The move to Tucson allowed me to re-acquaint myself with the Sonoran Desert, and also to re-engage with the University of Arizona’s EEB Department (22 years after graduating from there with my own PhD). Once back in Tucson, I began re-reading the classic literature of the region, regain-

ing my sense of place and, thus, enthusiasm for the Sonoran Desert. The best of this includes: *Camp-Fires on Desert and Lava* (Hornady 1908); *New Trails in Mexico* (Lumholtz 1990); *Land of Lava, Ash, and Sand: The Pinacate Region of Northwestern Mexico* (Ronald L. Ives 1989); and *The Sierra Pinacate* (Julian D. Hayden 1998). These are timeless works that give readers an historical context as well as superb natural history lessons. As I reimmersed myself in the Sonoran Desert, my years of anthropological exploration in Mesoamerica in the 1980s began to flash like a heliograph, and I soon began gravitating toward archaeology and cultural anthropology. It eventually led to entirely new kinds of research (Brusca and Vidal 2020, 2021, Mitchell et al. 2020, 2024, Vidal and Brusca 2020a,b, Brusca 2024). Being open to change, following one’s instincts, and allowing time for immersion in the environment (and literature) gives one the ability to retool, embrace big shifts in thinking and research, and, most importantly, to reinvigorate one’s creative life and work, to weave something entirely new from the threads of one’s past, from culture, and from experiences. Ideas—those most sacred things of human sentience—are called forth in the enchanted loom of the mind.

Shortly after my return to Tucson, Doug Futuyma and I were asked to provide an extramural review for the University of Arizona’s Department of Ecology and Environmental Biology (EEB). I discovered the university to be a significantly changed institution from my own graduate student days there in the early 1970s. Like most US research universities, it had become “corporate.” US universities today, with their financial-business operating paradigms, have evolved to optimize flawed approaches and flawed systems in which administrative and faculty incentives disadvantage students and keep stipends and salaries low, while expending inordinate amounts of money on administrative salaries and athletic programs. The system is sinking under its own weight of high-paid administrators, a vast proliferation of vice presidents, and expensive physical plants and sports programs. The University of Arizona, e.g. has 21 vice presidents (plus 22 deans and a number of provosts) and an athletic program budget of ~\$100 million (U.A. website 15 January 2024; Chihak 2024). Universities used to be run largely by people who loved and admired teaching and who were sincerely interested in academic topics. Now there are vast cohorts of administrators who are mainly focused on data analytics, financial development spreadsheets, and online search terms—much of which is why David Graeber’s (2013) analysis led him to the harsh but accurate term, “bullshit jobs.” Administrators like to brag about how their academic departments are some of the best in the nation, yet they do very little to financially support those departments. It is on the backs of the faculty and the grants they raise to pay for their students and postdocs; departments gain national recognition through these faculty efforts, and it has very little to do with university administrators. Faculty are rewarded primarily for the amount of extramural funding they bring to the university and by statistically driven citation indices that have nothing whatsoever to do with the significance or deep and lasting impact of their research. The “publish or perish” paradigm in academia drives postdocs and professors to prioritize quantity of publications over quality (Lawrence 2007). Deeply ingrained in academic culture, this standard favors high volumes of work at the expense of more in-depth or innovative research (Lawrence 2008, Garwood and Lawrence 2011). It stifles creativity and discourages investment in high-risk but high-potential-reward

projects. Quantity trumps quality. Meanwhile, students suffer from runaway tuition costs and administrative bloat.

I believe that US research universities had thrown the baby out with the bathwater when it comes to teaching their students in the natural sciences. Students and postdocs apprentice to more senior scientists with training exchanged for (1) ridiculously low wages, commonly with no benefits, and (2) typically with the primary goal being to further the advisor's academic career. The acts of teaching and mentoring students, at all levels, are mostly given lip service by administrators but typically not rewarded during tenure and promotion considerations, so faculty often diminish their efforts in that regard. University presidents and administrators are rewarded for securing new buildings and research centers and having winning sports teams, but not for providing for the students or the faculty. Thus, stipends and salaries remain low, no matter the amount of gift money raised by the university. To survive the long apprenticeships, many students must take out repeated loans for living expenses. Without university support, many must leave academia for a salary sufficient to simply support their families.

I might add that anyone who thinks college sports pay for themselves is delusional, and if they believe sports drives significant donations toward academic programs (once the real purpose of higher ed) I have a bridge in Brooklyn I would like to sell them (e.g. Zimbalist 2023, Chihak 2024). University presidents pump millions of dollars into their athletic programs, sometimes driving up huge campus debt (as of 15 January 2024, the University of Arizona's athletic programs had borrowed \$87 million from the university's budget, none of it repaid, and the university was facing a \$177 million deficit). College athletics are commonly subsidized by mandatory student fees, have budgets that can exceed \$100 million annually, and provide head coach salaries in the millions (far exceeding faculty or administrative salaries) (Chihak 2024). For colleges and universities with major athletic programs, the tail now wags the dog. Instead of spending millions striving to be number 1 in athletics, colleges and universities should be spending that striving to be number one in academics. Competitive college sports should be established as revenue units that pay for themselves, not parasitize the overall institutional budget.

The pressure to succeed in universities today can channel professors down narrow, routinized pathways, "ticking off the boxes" toward promotions, their lives becoming so ritualized and anastomosed from doing the same thing year after year to fit the academic mold that their creative compass becomes demagnetized and their imagination fossilized. Their creative spirit is guilty of treason against itself. When it is "time" for retirement, they no longer have the tools needed to muster up a new vision of themselves, to deracinate from the alter of their long-kept laboratory, so they just keep working on and on, walking down the same research track they have been on for decades and know so well, their inspiration and innovation having been kidnapped by academic routines, leaving them only to chop nature into smaller and smaller bits in an attempt to understand it, but having lost sight of the relationships among those bits and the rest of the world. They no longer see the big picture that natural history provides (Dayton and Sala 2001, Dayton 2003, Fleischner 2005, Weigl 2009; Able 2016). It is easy to mistakenly think we are finished products when, in fact, we are really forever works in progress.

University scientists have also long been negligent in their communication with the public, and they must take a large

share of the blame for the predicament we find ourselves in today, in which public confidence in US higher education has plummeted to just 38% and only 57% of Americans believe that science has had a positive effect on society (Thorp 2023). We are now living in an age when presidential candidates vow to suspend government-sponsored research on infectious diseases and call climate change a hoax. We can publish all the professional articles we want, but so long as we continue to communicate only amongst ourselves, we are preaching to the choir. We must look for new ways to communicate our science to the public and to speak out against anti-science attitudes and beliefs. And, importantly, we must instill this in the students under our mentorship and guidance.

What is the upshot of all this? Although faculty probably will not be able to count on their administrators to give them much support or recognition for these endeavors, it might be up to the most inspired and inventive among us to find ways to get some of those -ology courses back on the books, get students into the field, and try to help encourage creativity in young learners. In doing so, we might rediscover something wonderful about ourselves and our own capacity and creativity. Even in "old age," there remains a good deal of the brain's circuitry still undedicated, simply awaiting the arrival of new opportunities, although it may take a while to sort things out. There are US National Science Foundation programs that provide grants that include funding for student field training. And any department that offers graduate degrees should be ashamed if they do not maintain line-item budgets that include at least some graduate student fellowships. We need to expose our students to multidisciplinary approaches that expand beyond scientific facts to include the humanities, human history, and sociopolitics. Explain to your students how reading good books can make them a better scientist and a better person. Faculty serve their students well by recommending to them the books that were transformative in their own thinking when they were young aspiring scientists. Appreciation of legacies of human thought and creativity, captured forever in books, opens doors to future questions and revolutionary ideas.

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