THE DIVIDE BETWEEN HUMANITIES AND SCIENCE

Why It Matters and How it Can be Repaired

Edited by
Richard C. Brusca

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This book first published 2025

Ethics International Press Ltd, UK

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

Print Book ISBN: 978-1-83711-013-1

eBook ISBN: 978-1-83711-014-8

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Cover art, *Undercurrent* (detail), 2017, by Daniel Zeller. Ink and acrylic on paper, 18 x 23 inches

Preface

You've most likely not seen a book quite like this before. It describes consilience between science and the humanities by revealing a secret: while university scholars wring their hands trying to imagine how consilience might be achieved, it turns out a lot of creative people have been doing it all along. It's simply what they do, how they think and see the world, where they live in their minds and hearts. The essays in this volume are testimony that E. O. Wilson's dream of consilience has been manifest all along; we just had to look in the right places for it.

The 16 essays in this volume (by 21 contributors) come from scientists, educators, artists of all stripes, businesspeople, and deep thinkers. They represent a wide breadth of views by people in different professions who appreciate the wisdom and human benefit to be gained by integrating science and humanities.

It seemed only fitting to open this book with a poem by Sam Illingworth, written specifically for this volume. *Threads of Knowing* explores the intersection of sciences and the humanities and how, in both, we engage in a shared search for understanding. Professor Illingworth's poem reflects the idea that knowledge, whether scientific or artistic, is a continuous weaving of ideas across boundaries, both seen and unseen. Sam's words remind us of the importance of focusing on the union of seeking and knowing.

As editor of the volume, I decided to take a 30,000-foot-view of why consilience between science and humanities is important, with examples of how this is being accomplished by some of our best thinkers. Thus, my opening chapter ("The Integration of Humanities and Science").

The first section of this book, "Bridging Humanities and Science in (and Outside) the Classroom," includes essays by nine deeply invested higher education professionals, beginning with Sylvia Torti, a brave and visionary education leader who provides concrete examples of how higher education can interweave these two great human endeavors in creative ways. Sylvia, a trained biologist, essayist, and fiction writer, and President of College of the Atlantic in Maine, offers up a firebrand notion of how higher education needs to change to meet our rapidly changing world—*all education must be ecological in nature* she argues. Sylvia provides ideas and hypotheses that make good sense, but we'll see how the conservative academe reacts. Students at her college will be trained equally in both science and humanities following her creative recipe for success in this Brave New World we are facing.

W. F. Gilly describes the process he and his Steinbeck-scholar wife Susan Shillinglaw went through developing courses that sought to bring science and humanities and philosophy together through the lens of John Steinbeck's legendary *Log from the Sea of Cortez*. This important, detailed, and extraordinarily useful accounting offers a blueprint for others who may wish to develop similar courses.

Kelly Presutti, Verity Platt, Johannes Lehman are three professors at Cornell University, from different departments that one would not expect to be collaborating on a course. But they clearly believe that bringing science and the humanities (in this case, art, theater, and dance) together can generate a powerful teaching milieu. Partnering with a colleague from Cornell's Performance and Media Studies, students (mostly STEM) react personally to the realities of climate change, write new narratives about environmental change, and grow wiser through creativity, connection, and personal transformations they experience during the semester.

Shelly L. Brown-Jeffy, Nadja B. Cech, and Omar H. Ali (of the University of North Carolina at Greensboro) describe their courses that combines ecology, history, and urban spaces through traditional and non-traditional activities that include game-playing, wandering through art museums and big-box stores, and exploring a forest ecosystem. A sociologist, a chemist, and a historian take their students out of the classroom and into the real world, empowering them to play an active role in their own learning and development. In doing so, the students become better learners, are more open to asking questions, and discover how their curiosity grows. Their experiences even led to a pop-up exhibit in downtown Greensboro that displayed the students' writing, photographs, art, and recordings. Fieldwork, it seems, may truly be one of the most powerful tools educators have.

Vera Meyer the scientist (aka V. meer the artist) believes that collaboration among scientists and artists can refill C. P. Snow's vacuum with life, metaphorically and literally—in her case, with fungi! Fungi are curious organisms to everyone, they take students out of the classroom and into the field, they are beautiful and morbid, and they are full of intriguing mysteries awaiting investigation.

The second section of this book, "Integrating Art and Science," begins with an essay by Josie Iselin, an artist and instructor in San Francisco State University's School of Design, who describes her art-science campaign to generate interest, knowledge, and conservation for the spectacular giant Pacific bull kelp, *Nereocystis leutkeana*. Josie's passion for storytelling and art raises awareness of natural history and important conservation issues and is well known to residents of the Pacific Coast of North America.

Kysa Johnson's engaging essay describes her journey as an artist (and more) and how she became fascinated by patterns in nature that are too small, or too big, to be seen with the naked eye. Kysa's work gives

life to the unseen or obscure designs of nature. Her large installations have won praise and many awards. Like Daniel Zeller, Kysa discovers and renders the meaningful threads of connection between the unseen, but real, and the everyday world in which we live. Both strive to bring the hidden patterns of the cosmos into the human visual field. Although both are visual artists—Johnson's work captures the actual patterns she discovers in nature while Zeller's work is more abstract—but the powerful similarities in their work speak to some universal, natural truth that lies just beyond our grasp.

Environmental artist and writer Andrea Polli uses highly inventive approaches to raise public awareness of environmental issues. Her public artworks have been installed at over two-dozen locations, including a wind-powered light work covering the Rachel Carson bridge in Pittsburg and building-scale works across Europe and the U.S. Her contributed essay here describes a unique venture that combines weather science, art, and public exhibition in thoroughly creative ways that educate both students and the general public about climate science.

Daniel Zeller was born in California but as art became his passion he migrated across the country to New York, where he now lives. His work is utterly unique, and even when generated in two dimensions it has a three-dimensional (or four-dimensional) quality (see this book's cover image). It is highly organic and speaks to the complex and unbreakable connections that bind together everything in the natural world. He has exhibited internationally for many years and his spectacular work can be found in the collections of MoMA and the Whitney Museum in New York, the Museum of Contemporary Art in Los Angeles, NASA, the National Gallery in Washington D.C., and many other fine museums and galleries.

In the third section, "Thoughts on Integrating Science and the Humanities," six deep-thinking individuals offer up their ideas about the business of consilience. Chris Enke dives deep into the nature of scientific knowledge, and how science differs from philosophy. Both, he concludes, are ways in which nature can be expressed and understood by humankind. And both are uniquely human endeavors. Chris notes that a scientific theory has two parts: one part is the statement of the "law" in the form of an equation or logical declaration—a simple expression of a pattern in nature we observe, but providing no rationalization for that behavior. The second part is the explanation we devise for why nature acts that way. The law is the "what" and the explanation is the "why." He also notes that only *people* do science, and they have breakthrough ideas because of their creativity and imagination which are distinctly human traits. He further argues that if we want to repair the divide between science and humanities, science journalists (and the lay public in general) need to understand the boundaries of science, what a scientific hypothesis actually is, and the seeming paradox of science and philosophy.

Ecologist Tom Fleischner, founding director of The Natural History Institute, which embodies the essence of consilience between science and the humanities, writes a reflection on the importance of natural history. He considers how, in the past, the humanities and sciences were not relegated to entirely different silos on college campuses as they are today. Tom argues that the greatest leaps in societal science have come from those moments in history when science and the humanities are in sync.

The extraordinary writer Mary Ellen Hannibal writes lyrically of the novelist, poet, and lepidopterist Vladimir Nabokov. His escape from Russia, tumultuous times in Europe, destiny awaiting him in America. When the Nabokov family had to flee their natal St. Petersburg,

Vladimir found himself a man without a country, traveling across Europe, his suitcases filled with books and butterflies. Despite his outward claims of keeping his science and his art separate, it was never really so. Butterflies and literary fiction, it seems, were indelibly intertwined, like a coiled fiber in his being. Ecologist Lisa Harris is also a photographer, essayist, and short-story writer. Lisa's essay for this book draws inspiration from her garden, which she discovers is an excellent metaphor for finding consilience between humanities and science.

Gary Nabhan, in his very personal essay, confesses that, despite his love of humanities and the natural sciences, he's been trapped in a no-man's-land, an ecotone between the two. A place he calls the *radical center*. A place that suits him well and has certainly led to a lifetime of impressive creativity—Gary's been awarded more "creativity prizes" than one can tally, including the MacArthur "Genius" Grant. This place of creative tension between traditional disciplinary silos seems to be where holism is fostered. A place most of the contributors to this volume understand. John Gregg's thoughtful essay reflects on universal patterns in nature, from the microscopic to the stellar, expressing in words what Kysa Johnson's work expresses in art. From neural patterns in the brain, to Fibonacci sequences in nature, to dancing atoms and spiraling galaxies, John informs us: "Zoom in or zoom out, it doesn't matter—the same truths are everywhere."

I want to thank Howard Browman and Paul Dayton, who encouraged me to express my thoughts on changes I've seen in science education, research, and university culture over the past sixty years (Brusca 2024, ICES Journal of Marine Science). That little essay prompted speaking and writing invitations and led to conversations with many other professionals with shared sentiments … and ultimately to this book.

List of Contributors

Omar H. Ali. Dean of Lloyd International Honors College and Professor of African American and African Diaspora Studies and History, The University of North Carolina at Greensboro.

Shelly Brown-Jeffy. Associate Professor, Department of Sociology, The University of North Carolina at Greensboro.

Richard C. Brusca. Executive Director Emeritus, Arizona-Sonora Desert Museum, Tucson, and Designated Campus Colleague, University of Arizona.

Nadja Cech. Patricia A. Sullivan Distinguished Professor of Chemistry and Biochemistry, The University of North Carolina, Greensboro.

Chris Enke. Emeritus Professor of Chemistry, University of New Mexico and Michigan State University.

Thomas Lowe Fleischner. Founder, Senior Advisor, and Director Emeritus, Natural History Institute; and Faculty Emeritus, Prescott College.

W. F. Gilly. Professor, Stanford Doerr School of Sustainability, Stanford University, California.

John Gregg. Founder, Western Flyer Foundation, and Marine Geologist, Mackay School of Mines, University of Nevada, Reno.

Mary Ellen Hannibal. Journalist and author. Mary Ellen teaches at the California College of the Arts and the Fromm Institute at the University of San Francisco.

Lisa K. Harris. President, Harris Environmental Group, Inc., Tucson, Arizona.

Sam Illingworth. Professor of Creative Pedagogies, and Poet, Edinburgh Napier University.

Josie Iselin. Co-Director of Above/Below, an ocean literacy campaign, and lecturer in School of Design at San Francisco State University.

Kysa Johnson. Artist.

Johannes Lehmann. Liberty Hyde Bailey Professor of Soil Biogeochemistry, School of Integrative Plant Science, Department for Global Development, and Atkinson Center for a Sustainability, Cornell University, and Institute for Advanced Studies, Technical University Munich, Garching, Germany.

Vera Meyer. Professor of Applied and Molecular Microbiology, Institute of Biotechnology, Technische Universität Berlin, Germany, and artist.

Gary Nabhan. Ethnobotanist, agricultural ecologist, writer.

Verity Platt. Professor of Classics and History of Art, Cornell University, and Director of the Humanities Scholars Program.

Andrea Polli. Mesa Del Sol Endowed Chair of Digital Media, Professor, College of Fine Arts and Associate Professor, School of Engineering, The University of New Mexico.

Kelly Presutti. Department of History of Art and Visual Studies, Cornell University.

Sylvia Torti. President, College of the Atlantic, Maine.

Daniel Zeller. Independent artist since 1994.

Threads of Knowing

Sam Illingworth

Between sky-rivers
and the root-shifted earth,
the question drifts –
not of borders, but crossings.
Where iron-lore is etched,
fingers seek the weave.
Each atom a sky-shard,
each tale carved
from dust's own edge.
In the warp of tides and voices,
we begin to trace the unseen:
how the mind-flare echoes
across the folds of time,
how sea-keepers stir
ancient fires beneath
the water's skin.
Here, where paths
of thought entwine
a mark begins –
to fuse
the stone-weighted word
with the ember-light
of knowing.
And in this place,
under the drift
of wandering worlds
we find the reach to ask
not only how we search,
but why we seek to know.

Introduction

Richard C. Brusca

The unique genetic, physical, and social attributes of human beings that distinguish them from all other animals are fairly well known, even if not fully understood. Among these are: a large rounded braincase and enlarged, highly folded cerebral cortex, enabling high intelligence, cognition, ideation, and capacity for abstract thought, conceptualization, and reasoning; complex and evolving languages[1]; introspection and moral sensibilities; elaborate story telling; highly developed agriculture and industry; and the complex use of tools (most notably mathematics, arguably the most powerful of all human tools). The most profound expression of this humanness is our desire and ability to create. The three primary ways we create are through

[1] Language is distinct from communication. A number of vertebrates have good communication. Hyraxes, for example, use complex calls for mate attraction, and wolves, cetaceans, parrots, gibbons, and chimps use calls to mediate complex social interactions. The closest thing to a non-human language may be the "songs" of humpback whales. Just as human vocalizations are structured by a hierarchy of phonemes, words, phrases, sentences, and narratives, so too are the songs of humpback whales. Sung only by males, the songs travel through the ocean for miles. The songs are also culturally transmitted. In the southwestern Pacific, a totally new song emerges every few years that is adopted across the sea to the eastern Pacific. But only humans have a language-brain processing capacity to grammatically combine long strings of words, symbolic representations, and multiple concepts into an essentially infinite variety of meanings and ideas. Only human language is so deeply representational that we understand, and our language denotes, how one thing can be another thing. Human language allows not only for information sharing, but the discussion of complex topics, the planning of future goals, and reflection upon the past. Interestingly, the precise time when humans first began to talk to each other and what enabled them to do so are still not known.

science, engineering, and the humanities. Creativity—developing original ideas and concepts—emerges from our high level of thought, capacity for abstraction, and our deep sense of time, especially our ability to imagine future time. Humans are also the only animal species on the planet that create complex music, theater, literature, poetry, and mathematical concepts. Uniquely, we also have desires and set goals—an indicator of our ability to deeply conceptualize expectations.

The brilliant literary novelist Cormac McCarthy, in what may be his only nonfiction essay, reflected deeply on these matters in *The Kekulé Problem: Where Did Language Come From?* (2017). The essay begins by questioning the nature of the unconscious mind, noting that unconsciousness must be a far older trait than human language; at least as old as the origin of the primate lineage, and likely older (we've all seen our dogs dreaming—presumably their unconsciousness at work!). The essay's title comes from the famous story of Friedrich August Kekulé's discovery of the nature of the benzene molecule, said to have come to him in a dream; that is, from his unconscious. His dream was of a snake coiled in a hoop with its tail in its mouth, and when he awoke it immediately dawned on him that the form of the benzene molecule was a ring. The puzzle to McCarthy was, if Kekulé's unconscious knew the answer to the question that he had struggled with for so long, why hadn't it simply told him in words? Why rely on ancient Greek uroboros symbology? Why indeed does the unconscious speak to us in symbols, images, and metaphors, and not in our manifestly beautiful language. McCarthy's answer was that the unconscious is an ancient trait and the actual process of thinking is largely an unconscious affair (something Einstein also alluded to). Language, a far more recently derived trait, can be used only to sum

up what the unconscious (thinking) has arrived at. But thinking itself is not a language-based affair.[2]

The humanities are often thought of as the artistic aspect of creativity—art, music, literature, dance, theater, etc. But, in the broader sense the humanities also include languages and communication, history, philosophy, ethics, cultural studies, religions, and our abiding desire to understand the world and the universe. In short, studies of the humanities are, as the name implies, studies of humanness. Evolutionary psychologist Steven Pinker, one of today's brightest lights and most creative thinkers in psychology, linguistics, and the human condition, stated, "Our system of law, government, our economy, our assumptions about education, childrearing, and the relation between the sexes all have a rationale that was first worked out by thinkers in what we now call the humanities. Humanities are touchstones for our private and public discourse" (Pinker 2012).

This idea of humanness being defined by thought and creativity has been expressed by many writers. Even the influential modernist Virginia Woolf [1882-1941] touched on it when she wrote (in *Mrs. Dalloway*): "The compensation of growing old is that the passions remain as strong as ever, but one has gained—at last!—the power

[2] There are sporadic research papers that hint of invertebrate species having consciousness, e.g., honeybees becoming "pessimistic" after a "stressful" experience, cuttlefish remembering the past and planning for the future. However, it's hard to evaluate these kinds of studies because the nature of consciousness itself is still unclear. There are at least 22 theories of consciousness (A. K. Seth & T. Bayne, 2022, Nat. Rev. Neurosci. 23, 439), and there is general agreement that they all lack strong resolution. For nonhuman primates, such as chimpanzees, there is a high level of confidence that consciousness is present. But for the other vertebrates and some invertebrates, the best we might be able to claim is that there is a realistic possibility that consciousness is present.

which adds the supreme flavour to existence—the power of taking hold of experience, of turning it around, slowly, in the light." Woolf refers to the human trait of deep reflection across time, a process about which we have little understanding. Like reflection, we also know very little about creativity itself. Where does it come from and how it is generated? The question of what compels an artist to seek new ways to interpret humanity or nature remains one of our greatest mysteries. Woolf believed that the wellspring of creativity lies in the qualitative difference between experiences that produce anguish and those that instill gratification. But surely there could be as many sources of creativity as there are thinking people on the planet. A critical source of creativity must be the ability to recognize associations between very different sorts of knowledge or evidence—a process often galvanized through "mind wandering." Chance also plays a role in creativity. Think of Louis Daguerre's discovery of photography, Wilhelm Röntgen's discovery of x-rays, or Alexander Fleming's discovery of antibiotics (Lehmann and Gaskins 2019). But none of these chance events would have led to new, transformative discoveries had not the persons involved been deeply curious (and persistent). Thus, curiosity must also be a prerequisite for creativity. Yet most scientific experiments today are designed to reduce chance to the lowest probability, and unexpected results can lead to simply repeating the experiment. Brusca (2024), speaking of biology, notes that, "the combination of field experiences and good books can stoke fires of creativity in a learner." 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 discouragingly argues, because it is possible that the source of creativity lies beyond human cognition.

The stark contrast in how great artists find their creative inspiration can be illustrated by two of the great Germanic masters, Wolfgang Amadeus Mozart [1756-1791] and Friedrich Nietzsche [1883-1885]. Mozart wrote, "When I am, as it were, completely myself, entirely alone, and of good cheer—say, travelling in a carriage, or walking after a good meal, or during the night when I cannot sleep; it is on such occasions that my ideas flow best and most abundantly" (Ghiselin 1952). Nietzsche, in his last book, *Ecce Homo: How One Becomes What One Is* (written in 1888, published posthumously in 1908), described the creative process that led to writing his great four-volume philosophical fiction *Also sprach Zarathustra* (1883-1892). At the time, Nietzsche was living on the coast not far from Genoa. He was in ill health and it was an unusually cold and rainy winter. His house was so close to the shore that the noise of the rough seas rendered sleep impossible for him. He was, at times, quite miserable. In *Ecce Homo* he wrote of this period (Ghiselin 1952): "These circumstances were the very reverse of favorable; and yet, despite them, and as if in proof of my theory that everything decisive arises as the result of opposition ['What doesn't kill us makes us stronger'], it was during this very winter and amid these unfavorable circumstances that my *Zarathustra* was born. In the morning I used to start out in a southerly direction on the glorious road to Zoagli. In the afternoon, whenever my health permitted, I would walk around the whole bay from Santa Margherita to beyond Porto Fino. It was on these two roads that all *Zarathustra*, and particularly Zarathustra himself as a type, came to me—perhaps I should rather say—invaded me." As if an augur, Nietzsche wrote: "Perhaps the whole of Zarathustra may be classified as music … a renaissance in me of the art of hearing"—foreshadowing Strauss's 1896 tone poem (*Also sprach Zarathustra*/*Thus Spoke Zarathustra*) that would be inspired by his novel.

That Mozart composed his masterpieces from a place of joy is evident in the ebullient nature of his work. And that Nietzsche's story of Zarathustra came from a darker place is conspicuous in its abstruse nature and shadowy overtones. Zarathustra, more commonly called Zoroaster in the West, was a wandering philosopher who spoke to such weighty matters as the struggle between good and evil, the death of God, the will to power, and eternal recurrence (a philosophical concept that time repeats itself in an infinite loop, and that exactly the same events will continue to occur in exactly the same way, over and over again, for eternity). The character Zarathustra was one of the early models for many similar, but more light-hearted books that followed (e.g., Thomas Mann's *The Magic Mountain* [1924], Hermann Hesse's *Siddhartha* [1922], Khalil Gibran's *The Prophet* [1923]). Nietzsche's books have been described as "nihilistic destruction combined with a life of increasing isolation." Yet both Mozart and Nietzsche stand as pinnacles of creativity in their accomplishments.

It is ironic that creativity is a fundamental aspect of humanness and yet is so poorly understood, hard to pin down, and difficult to untangle. A review of the field suggests there is little agreement on what the sources of creativity might be (DiLiello and Houghton 2006). Researchers do not even agree on a single definition of creativity. In fact, Whitehead (1978) claims the word "creativity" only appeared about one hundred years ago. Kharkhurin (2015), noting that creativity remains a poorly studied field in general, concludes it has reached an "epistemological cul-de-sac."

Humanities courses help teach students, including STEM (science, technology, engineering, and math) students, how to think creatively—and to reason and analyze complex situations. The core concepts of the humanities offer practical skills that are crucial in professional settings, such as critical thinking, cross-cultural

understanding, good writing, and clear communication. Studying the humanities, students have the opportunity to get to know themselves and others better. Through studying language, behavior, the arts, and history, students become more well-rounded individuals, can connect with and understand others better, and can embrace a larger contextual view of the world. Understanding the humanities helps us approach and analyze imperfect, subjective, and labyrinthine information. It steers us away from xenophobia, and toward understanding and empathy. It broadens our minds in ways that are healthy for both individuals and society.

Institutions of higher education have long advocated the benefits of a multidisciplinary approach in pedagogy. Colleges/schools of "arts and science," or colleges/schools of "letters and science," used to be common in higher education. In fact, *most* universities and colleges (hereafter, just "universities") once grouped their academic programs in this way. However, over the past few decades this approach has been greatly reduced, giving way to separate schools of arts and sciences. Today, Wikipedia lists only 79 such programs in U.S. higher education institutions (out of about 4,000 degree-granting postsecondary institutions in the U.S.). It's not clear how well humanities and science were ever *literally* integrated in American schools of arts and sciences, but there are a few institutions that today try to blend them in useful and creative ways (see examples below). Overall, actually integrating humanities and science in single courses seems to have always been rare. More typically students select a discipline, take most of their courses in that discipline, and then take a few courses from other disciplines. Scholars have pointed out that this type of multidisciplinary approach is flawed (Carrell et al. 2020). Getting exposure to a few topics outside their discipline does not teach them how to connect the dots, draw conclusions, and determine why a class or discipline outside their focus area is relevant to their

education goals. STEM students often remark, when taking liberal arts courses, that the only reason they are taking the class is because they "have to take it to graduate." This attitude speaks to the great divide between humanities and science, and it speaks to the desirability of HDSTEM (humanities-driven STEM) pedagogy.

Numerous scientists and teachers have written about the importance of integrating the humanities into STEM education—sometimes called STEAM (science, technology, engineering, art, and math) or HDSTEM—and merging humanities back into science in general. In particular, see Carrell et al. (2020) who argue that humanities should be at the forefront as the impetus and lens for contextualizing STEM research and discovery. Humanistic STEM blends the study of science with interest in and concern for human affairs, welfare, values, ethics, and culture. The idea is to produce well-educated science students who also have a solid appreciation of the humanities, and vice-versa. Slingerland (2008) argued that the humanities are at an impasse, and in order for them to progress they must take seriously contributions from the natural sciences.

A few books have appeared over the past 25 years that address the issue of consilience between science and humanities, beginning with Wilson's (1999), and these are intellectually satisfying reading. However, they have been written in an academic style that is most easily digested by academic scholars, and none of them provide descriptions of how consilience is actually being achieved today. They mostly avoid the pragmatic, and instead take a hypothetical or philosophical approach that emphasizes research programs (e.g., Bateson 2002, Slingerland 2008, Slingerland and Collard 2012, Varela et al. 2017). While both theory and pragmatism are needed to grapple with the issues, the latter is more practical for educators, as well as for humanists striving to see better ways to connect their work to the

sciences. To change the current paradigm of "two cultures" will require we begin at the K-12 level. By the time most students graduate from college, the separation is manifest.

Slingerland and Collard (2012) is an important scholarly volume with contributions from nearly 40 professionals, mostly higher-education professors. While being up to date and informative, it is written primarily for university researchers, not for an audience of teachers or practitioners. One of the most important takeaway messages in the Slingerland and Collard volume is that finding consilience between science and humanities research must involve more than just interdisciplinarity—it must be the development of a new, shared framework for these two great human endeavors. This is certainly true with regard to scholarly research projects, where research plans need to be developed by both sides. However, consilience is already being practiced in the world of teaching (both K-12 and university) as well as through practical application. A good example is the work of Sam Illingworth, who uses poetry and games to engender meaningful dialogue between scientist and non-scientist, and to offer scientists a humanist view of their subjects through insightful poetry. Sam is also founder of the peer-reviewed journal *Consilience*.

A number of institutions are now working to narrow the gap between science and the humanities, including MIT's Center for Advanced Visual Studies (https://act.mit.edu/event/cavs-55/) and Experiments in Art and Technology, a collaboration begun by scientists at Bell Telephone Labs and New York artists (https://en.wikipedia.org/wiki/Experiments_in_Art_and_Technology). Even CERN (the European Organization for Nuclear Research, home of the Large Hadron Collider) invites artists to spend time at the institution, facilitating collaborations with scientists to understand and visualize/represent

the structure of the cosmos. Art has the capacity to make complex science visible in society.

There are many examples in this book of what consilience between humanities and science can look like, but here is a favorite theme of mine. Imagine if students in a university ecology course took a field trip to obtain soil samples from several very different terrestrial habitats and spent a week or two analyzing and comparing the soil strata and types, and the biological features associated with each. They gain a sense of place collecting the samples and, in addition, having been told at the beginning of the course to read Steinbeck's *Grapes of Wrath*, they are then tasked to write an essay on the nature of soil, how soils can become degraded by bad agricultural practices, how those processes led to the Dust Bowl era, which in turn resulted in massive migration of farmers from the Midwest to California, and the socioeconomic forces that then changed their lives and impacted society.

Or imagine a biology course in which students study invertebrates. They take a field trip to the seashore to study tidepools (or to a lake shore, or river shore) where they estimate biological species diversity of the invertebrates in some quantitative fashion. They gain a sense of place but, in addition, having been assigned Steinbeck's *The Log from the Sea of Cortez* to read, as they analyze their data they form discussion groups that talk about the key philosophical passages in the book that reflect on the nature of biodiversity and people's different views on it (and they are asked to explain what Steinbeck meant by his admonishment: "It is advisable to look from the tidepool to the stars and then back to the tidepool again").

And, of course, there is no better way to expand young people's minds than travel abroad. Imagine if every university required their science and humanities majors to spend a semester abroad. As educators, we

should strive to create in our students a sense of wonder—in both the noun and verb spirit of the term. In the individual contributions to this book, you will see many examples of what a merging of humanities and science can aspire to be.

In fact, in recent years there has been a proliferation of art-science collaborations, some by scientists who have come to understand how the arts can enhance their work, some by artists who are also scientists, and some by artists who have learned the science through study of their subject matter on their own. A number of these are described in this book. The National Endowment for the Arts recently published an excellent issue (*A Kind of Beauty*) on the creativity that comes from cooperation between the arts and sciences (https://www.arts.gov/stories/magazine/2013/3/kind-beauty). Based on a 2010 joint workshop between the Arts Endowment and the National Science Foundation, the two agencies are now actively encouraging grant applicants to consider pursuing art+science projects.

A wonderfully detailed 2018 U.S. National Academies report notes the growing tension in universities between a liberal education and escalating specialization in individual disciplines. Students, parents, and politicians have increasingly focused their aspirations on vocationally-driven approaches to higher education. This has occurred while, at the same time, employers (especially in "high tech" areas) have emphasized that learning outcomes associated with an integrated education, such as critical thinking, communication (especially writing skills), teamwork, etc. are more, not less, desirable. The National Academies report recommends that higher education should intentionally strive to integrate knowledge in the arts, humanities, physical and life sciences, social sciences, and technology. Professors should help students understand the connections among these disciplines and recognize that all forms of inquiry are "branches

from the same tree," as Albert Einstein called them. We should teach our students that all human knowledge is fundamentally connected.

With the above considerations in mind, this volume expresses not so much the pedantic view of inoculating STEM research with humanities, as it conveys the views of individuals who are actually doing so, and who produce creative works that reveal the nature of how blending humanities and science can be effectively accomplished. In other words, these essays are written less with the academic approach than the applied, by people who have found ways to successfully harmonize these two great realms of human pursuit. In this sense, each chapter might even be considered a case study.

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The Integration of Humanities and Science

Richard C. Brusca

Why There Is a Need to Integrate Humanities and Science, in Teaching and in Practice

By the middle of the 19th century the divide between sciences and humanities had begun to be recognized, and it grew through the 20th century with deep consequences. Coincidentally, the term "scientist" also seems to have been coined in the mid-19th century, by Cambridge University historian and philosopher William Whewell. Most science studies tend to differ from most humanity studies in their use of a Popperian hypothetico-deductive framework, following a process of hypothesis formulation, generation of predictions, prediction testing (with a goal of falsification), controlled experiments that have repeatability, and strong quantification and statistical testing. In contrast, humanities research is dominated largely by qualitative information. In addition, in the natural sciences evolutionary questions tend to dominate; not so in humanities research.

The growing dominance of the sciences in public education in the Western World is one of the major reasons for the decline of humanities in higher education. In 1959, British scientist (a physical chemist) and novelist C. P. Snow [1905-1980] delivered his now-famous Rede Lecture in the Senate House, University of Cambridge. The influential lecture was subsequently published as *The Two Cultures and the Scientific Revolution*. The lecture and book expanded on an article Snow had published in the *New Statesman* in 1956, also

titled "The Two Cultures." The essence of Snow's ideas can be summarized by this oft-repeated passage from his essay:

> "A good many times I have been present at gatherings of people who, by the standards of traditional culture, are thought highly educated and who have with considerable gusto been expressing their incredulity at the illiteracy of scientists. Once or twice, I have been provoked and have asked the company how many of them could describe the Second Law of Thermodynamics. The response was cold: it was also negative. Yet I was asking something which is the scientific equivalent of: *Have you read a work of Shakespeare?* I now believe that if I had asked an even simpler question—such as, *What do you mean by mass, or acceleration*, which is the scientific equivalent of saying, 'can you read?'—not more than one in ten of the highly educated would have felt that I was speaking the same language. So the great edifice of modern physics goes up, and the majority of the cleverest people in the western world have about as much insight into it as their neolithic ancestors would have had."

Snow's lecture condemned the British educational system as having, since the Victorian era, over-rewarded the humanities at the expense of science and engineering education—noting that these had been decisive in winning the Second World War. In contrast, Snow claimed that German and American schools prepared their citizens equally in the sciences and humanities, and better scientific teaching enabled these countries to compete more effectively in the modern age. Snow's speeches and writings had a profound effect on British public schools and lent support to a strong shift of instructional emphasis away from the humanities and toward the sciences. Even studies of the history of humanities and history of science seem to belong to two very different

cultures. Snow's views have been criticized as having driven a still deeper wedge between science and the humanities. Stephen Jay Gould (2003) argues that Snow's concept of "two cultures" is not only off the mark, it is a damaging and short-sighted viewpoint that has likely led to decades of unnecessary fence-building.

In the 20th and 21st centuries, only a few fields of academic study traditionally integrated science and the humanities (e.g., anthropology, psychology). In recent decades, only a few scientists/ humanists have worked comfortably across these two great arenas of human endeavor—think of E. O. Wilson, Stephen Jay Gould, Steven Arthur Pinker, Janisse Ray, Gary P. Nabhan, Richard Dawkins, Sam Illingworth, David Edwards, Alan Lightman, Steven L. Goldman, Oliver Sacks, and Brian May. May was lead guitarist for the rock band Queen, but also has a PhD in astrophysics from Imperial College London and in 2013 published a benchmark paper describing the nature of space dust found between the Sun and Mars. May was appointed a Commander of the Most Excellent Order of the British Empire in 2005 for services to the music industry and for charity work in animal welfare. He served as Chancellor of Liverpool John Moores University from 2008 to 2013, was a science collaborator with NASA's *New Horizons* Pluto Mission, and contributed to NASA's OSIRIS-Rex mission. He was knighted by King Charles III in 2023.

Of course, historically, the field of "natural history" encompassed both disciplines and the greatest scholars of the past whose work epitomized the innate ability to integrate humanities and science are familiar names, e.g., Leonardo da Vinci, Santiago Ramón y Cajal, Friedrich Schiller, Samuel Morse, Erasmus Darwin, Georg Forster, Johann Wolfgang von Goethe, Ernst Haeckel, Alexander von Humboldt, H. G. Wells, Henry David Thoreau, John James Audubon, Ansel Adams, John Steinbeck, Ed Ricketts, Aldo Leopold, Rachel

Carson, Edward Abbey, Ralph Eugene Meatyard, N. J. Berrill. Their work was so powerful that it changed the direction of thought in much of the Western World. John Steinbeck's [1902-1968] *Grapes of Wrath*—arguably the greatest novel in America's literary canon—exposed the story of Midwest soil erosion leading to an era of farming migrants that resulted in their exploitation by large farming enterprises in California. Rachel Carson [1907-1964] was one of the greatest humanists-scientists of the 20th century. In 1952, she sent her letter of resignation to the U.S. Fish & Wildlife Service requesting "retirement in order to devote my time to writing." With a series of courageous open letters she wrote, Carson held the government accountable for its shameless exploitation of nature. Her 1951 book, *The Sea Around Us*, taught readers environmental awareness through prose and science that ranged from the oceans primeval beginning to the latest scientific discoveries. It became a huge success, on the bestseller lists for eighteen months, that won both the National Book Award and the Burroughs Medal in nature writing and has been translated into 28 languages. The film version was released in 1953 and won an Oscar for Best Documentary. Her writing came from a gifted and literary place that walked the line between the scientific and the poetic. Carson's writing opened the door to a whole new genre of conservation books written for the lay public.

Just twelve years before her death, Carson met the remarkable Dorothy Freeman and the two developed a deep and loving relationship. Freeman became instrumental in helping Carson keep her struggles with depression at bay and continue writing. In the spring of 1960, just as she was finishing the draft chapters in *Silent Spring* (1962) dealing with the carcinogenic effects of chemicals, Carson was diagnosed with breast cancer. She died in 1964, shortly after her testimony before President John F. Kennedy's Science Advisory Committee that proved instrumental in establishing the first

regulatory policies on pesticides. Carson told the committee that underlying all of the problems of introducing contamination into our world is the question of moral responsibility—responsibility not only to our own generation but to those of the future. *Silent Spring* was published just 18 months before Carson died. It led to the creation of Earth Day and the founding of the U.S. Environmental Protection Agency. Before she died, Carson reminded us that, "Wonder is our greatest antidote to self-destruction."

In my experience today's university students, both undergraduates and graduates, rarely read such great books, or any books by the above-noted naturalists/writers, or any of the great literary novels of our times. Many students do not read books at all, not even fiction (and certainly not literary fiction). Their "reading" consists wholly of screen time snippets. Studies have shown that fewer than two-thirds of Americans overall read books, and even those who do so 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 formulaic commercial genres of mystery or romance novels). This means just 4% of Americans read literary fiction. Twenty-one percent of adults in the U.S. cannot read at all (they are illiterate)—that is 70 million Americans! And 54% have a literacy below the equivalent of a sixth-grade level (National Literacy Institute 2024). The collapse of literacy in the U.S. surely has something to do with the plunging ability of Americans to critically evaluate contemporary science and politics, and their growing lack of ability to discriminate between real facts and "fake facts" (or propaganda). The political and social implications of this are obvious.

In 2020, only 17 percent of 13-year-olds surveyed said they read for fun almost every day; down from 27 percent in 2012, and 35 percent

in 1984 (McMurtrie 2024). The latest release of NAEP (The Nation's Report Card) federal test scores (January 2025) tells a sad tale, especially for reading (Dana Goldstein, for the *New York Times*, 29 January 2025). American school children's reading skills continue to plummet. For 8th graders, 33% have "below basic" reading skills; the largest it has been in the exam's 30-year history. The percentage of 4th graders "below basic" is 40%, the highest in 20 years. These declines in foundational literacy skills cut across all lines of race and class. Parents no longer encourage or model reading for their children (McMurtrie (2024), and the "testing culture" that now permeates K-12 classrooms discourages deep reading, instead emphasizing excepts for key test questions rather than reading entire works. America is facing a crisis of literacy collapse. Today's students enter college significantly deficient in humanities subjects, including reading skills (Supiano 2024). Stripling (2024) wrote that professors tell him students are arriving at college woefully unprepared, many lacking the necessary endurance to read long passages, and some question the point of reading at all. This has been my experience as well. Almost all American teenagers use social media regularly, and they spend an average of nearly 5 hours a day just on these platforms (NY Times online, 25 September 2024). Imagine if they spent that time reading good books! The U.S. is no longer a country of readers; it is a country of dwindling-literate screen-timers. But we are the deciders here; we can let technology pull us closer to a larger world, or we can allow it to simply trap us in front of our tiny screens like prisoners.

It is not just the intrusive and addictive qualities of smart phones and other digital devices/media that are driving students away from reading. Students today are simply not adequately taught to read, at home or at school. In addition, the loss of field courses, or field experiences of any kind, in universities are stifling students' understanding of the nature of the world. It is well known that

outdoor education is a highly effective way to instill a sense of place in students (or any learner) and drives 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 "over-arching wisdom" derived from and encompassing numerous concepts. 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, Blonder et al. 2023). Building on efforts of diverse, young climate activists, Elwell et al. (2025) describe the power and importance of giving children a pathway to embrace nature early on, and then steering them to grow through environmental education, encouraging a sense of involvement and eventually the agency for participation in sustainability stewardship and governance. Natural History is the oldest continuous human tradition, yet there has never been a moment in human existence when it was practiced so little as today (Fleischner 2011). Schmidly (2005) makes a strong case for re-introducing Natural History in American university curricula. Like immersion in a natural environment, art, music and literature also help us regain our sense of beauty and wonder and our respect for the world. Enough of these experiences can take a person down a path to an otherwise unreachable understanding of reality.

As in England, in the U.S. 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 the humanities, notably English literature. Although adopting CCSS was not required, 41 U.S. states did so. Dissatisfaction with the CCSS has since led some states to repeal the standards. The CCSS and STEM teaching paradigms in the U.S. strongly de-emphasize the humanities. They do

not require reading any complete works of literature. By grade 12, CCSS requires that 70% of assigned texts be nonfiction. The little 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). Today's students are entering college having never read a complete book, not even in high school (Horowitch 2024). Common Core (and the heavily criticized No Child Left Behind Act of George W. Bush, but ended by the Obama administration) emphasize informational text passages and standardized tests, not reading. As a result, middle and high school teachers have simply stopped asking their students to read entire books (Horowitch 2024). Educators have stopped teaching the novels we've long revered. America's schools have sacrificed young people's ability to grapple with long-form texts, and as a result students arrive at college with a far smaller vocabulary and much less understanding of language than in the past. They have trouble staying focused on what they read, unable to do so even through a sonnet (Horowitch 2024).

It seems the world of great literary fiction and immersing children in the full arc of storytelling largely no longer exists in K-12 teaching. All this carries over to college, where, over the past few decades, the study of English has fallen by a third and incoming freshmen are astonishingly poor readers and writers. Anecdotal observations of declines in reading skills are corroborated by analytical data. The 2019 NAEP (National Assessment of Education Progress) found that two-thirds of American children could not read at a proficient level. And the widening gaps between stronger and weaker students has grown. With STEM education garnering an increasing share of educational resources and attention, humanities teachers are left wondering how to respond to the growing power and exclusivity of math and science.

Universities are cutting humanities programs, their libraries are reducing the size of their collections, students and policymakers are pushing for "more practical" job-oriented majors, and business has become the most popular undergraduate major in the U.S. (Neem 2019, 2023, Roberts-Grmela 2023). Humanities have been falling out of favor worldwide. Between 2015 and 2018, the share of bachelors, masters, and doctoral degrees awarded in humanities fields fell 5%, 11%, and 9% respectively on average in the OECD countries. In the US, the proportion of undergraduate students studying the humanities tumbled approximately 30% between 2005 and 2020 (Goldstein 2021). U.S. bachelor's degrees awarded in the humanities declined nearly 16 percent between 2012 and 2020 (Chronicle of Higher Education, 25 September 2024), whereas between 2009 and 2013 the percentage of U.S. university students graduating with science and engineering degrees increased by 20% (Tizon 2013, Humanities Indicators 2017). The 2016 U.S. President's budget for STEM education increased to $3 billion with little investment in humanities education (OMB 2016). A growing number of elected officials are now advocating for the elimination of state funding for students majoring in humanities, and far-right commentators attack degrees in these disciplines from ideological positions and claim they lack "vocational relevance" (Beam 2016, Cohen 2016, Vaziri et al. 2019, Chronicle of Higher Education 25 September 2024). This downgrading of the humanities, and its complete separation from STEM courses, has led to students themselves being completely unaware of the added value that humanities courses could bring to them.

The years 2023 and 2024 saw severe cuts of faculty and academic programs in the humanities at U.S. public universities. The most severely affected departments/programs have been English, philosophy, foreign languages, literature, and drama (Friedman

2024). In the Summer of 2024, Delta State University (Mississippi) announced the closure of the College of Arts and Sciences and the elimination of 21 degree programs, including English and history. St. Cloud State University (Minnesota) cut 42 degree programs and 50 minors, including sociology, gender and women's studies, and economics. A new conservative-extremist "anti-woke" education law in Florida is driving many humanities courses to be slashed from curricula at the state's twelve universities. Classes deemed to teach "identity politics," or that include "theories on systemic racism, sexism, oppression, and privilege" must be changed or eliminated. This includes courses in anthropology, religions, East Asia, sociology, intercultural communication, gender, labor, and globalization. As I write this, the University of Connecticut is looking at every major that has not graduated at least 100 students over the past five years, with an eye toward cutting many of them. Do you see the self-fulfilling prophecy here. Students have been told not to get degrees in humanities or they won't find a job, so enrollments go down, then administrators complain those degree areas aren't popular and can be eliminated by budget reduction decisions. At risk for closure are programs in philosophy, women, gender, sexuality studies, literature, English, culture, and language. This is the same thing that happened at West Virginia University in 2023. Not even that once-great bastion of academic excellence, the University of Cambridge, has remained above this downgrading of pedagogical scholarship (Butterfield 2024). Faculty rightly fear their institutions are eliminating access to a comprehensive liberal-arts education and forcing students into job-targeted programs.

The separation of science from the humanities in Europe seems even deeper and more accepted than in the U.S. The EASSH (European Alliance for Social Sciences and Humanities), with 70 member organizations from across Europe and over 100,000 researchers,

promotes itself as the "largest advocacy and science policy organization for the social sciences and humanities in Europe," but they offer almost no information about the hard sciences. Similarly, HERA (Humanities in the European Research Area), a network of 26 national funding agencies, seems completely isolated from science. CHANSE (Collaboration of Humanities and Social Science in Europe), a "joint initiative of 27 research funding organizations from 24 countries," is similarly siloed and appears to have little to do with science.

Despite the fact that humanities and sciences have a strongly coupled history, their trajectories continue to diverge. Most universities continue to move farther and farther away from offering students the kind of educational and experiential opportunities that reveal first-hand the interconnected and comingled earth- and humanity-changing events that are taking place. Scholars of humanities and science seem more than ever to belong to Snow's two separate cultures, and there are few institutional efforts to find common ground that would allow integrated investigations of their shared concerns. But should not values, virtues, ethics, and social justice stand side-by-side with scientific goals and practices? Are these attributes not essential to good, trustworthy science?

Edward Slingerland (2008) argues that there is a serious need for coalescence between the humanities and science. He notes that most universities today are divided into two sovereign states—the humanities and the sciences—usually located nowhere near one another on campus, supported by separate funding agencies, and characterized by different methodologies and theoretical assumptions. He points out that the primary rationale behind this division is an "old-fashioned and decidedly metaphysical belief: that there are two utterly different types of substances in the world—mind

and matter—which operate according to distinct but different principles." In order for the humanities to progress, Slingerland argues, it must take seriously contributions from the natural sciences, in particular research on human cognition.

One might presume that highly-educated academicians and scholars would be the last people to promote the separation of science and art, and yet, sadly, most seem to do so. Most of my science colleagues would never consider blending humanities into their science classes to any significant extent, even those who have a *separate* appreciation for literature or art—never the twain shall meet (let alone intermingle). And woe be the science professor who actually takes on literature or art as a serious endeavor, has a gallery showing of their work or publishes a literary work. It can actually diminish them as a serious science scholar in the minds of some of their highly-siloed colleagues. From my experience, few university professors are activists. They prefer to leave that to the students. They often frown on their science colleagues who become activists. Why is this? Perhaps for the same reason they frown on colleagues who become artists. After all, most art and literature isn't innocent but a form of activism—statements about humanity or culture or ideas or the status quo. Those are the academics who will likely always promote the idea that these two great human undertakings should never be blended but must remain separate (and who will never read this book). However, Edwards (2008) perceptively argued that people who can transcend the cultural and intellectual boundaries between science and the arts become more creative and productive. Kahlil Gibran (1995) said it more poetically: "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."

Creative thinkers have sought consilience between art and science for a very long time. E. O. Wilson's well-known book *Consilience: The Unity of Knowledge* called for this unification, but he unfortunately sunk his own ship by insisting that consilience can only be achieved "by methods developed in the natural sciences." In fact, there are multiple pathways to the great reintegration process, both through science and the humanities, with equal respect for both sides, as you will read in this book. Jonah Lehrer's *Proust Was a Neuroscientist* and David Edward's *Artscience: Creativity in the post-Google Generation* both argue that science can be as equally well informed by humanistic studies as vice-versa. Lehrer argues that "real truths" are no less valid within the humanities than those approximated by scientific methods, even though the processes may differ. He notes, for example, that Auguste Escoffier's methods of cooking presciently anticipated the discovery of umami, the fifth taste. In fact, both science and art anneal curiosity; both are firebrands of the creative mind.

The truth is, in art and literature, just as in science, one of the most powerful tools is putting your work out there, challenging participants to observe and freely respond. Both are evaluated and critiqued. The science research world is largely "self-regulated" through a process of peer review, so to retain its collective integrity it is up to the science community itself to do the very best it can to promote good work, critically review the research of others, and always lean into probity and our highest ethical selves. This process of open review also works in the arts, only the ultimate arbiter is the general public. In fact, one of the greatest challenges to both artists and scientists is how to simultaneously express themselves and also communicate with society. It seems to me artists do a much better job of it.

Earth is experiencing both biological and cultural crises, as more and more species, cultures, and languages go extinct (Barnosky et al. 2011; Vidal and Brusca 2020a,b , Rozzi et al. 2023). Loss of language is one of the first signs of societal/cultural decay. In fact, an essential characteristic of the Anthropocene is the process of biocultural homogenization, which includes the dramatic loss of both biological and cultural diversity. This biocultural diversity crisis is exacerbated by "extinction of experience," which means those losses to the planet (and to our own species) are going largely unnoticed by most people, including students and university professors. The greatest challenges we face in the contemporary world—loss of biocultural diversity, global economic and social inequity, the rise of fundamentalism and nationalism, failing nations, the overwhelming social pressures emerging from climate change, pressures from mass migration and growing refugee crises—must be addressed not through science alone, but through a wise combination of science and the humanities. In its 2024 Global Risks Report, the World Economic Forum ranked Artificial Intelligence-amplified misinformation as one of the most severe risks that the world currently faces. Popular psychological theory posits that people adopt conspiracy beliefs to fulfill underlying psychological needs, which renders the believers impervious to counterevidence. It is also going to take a balance of both science and humanities to deal with rising threats from AI.

Now, more than ever, as public trust in science has plummeted and social discord is shaking the very foundations of democracy, 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 engage students in both their field of expertise as well as exposing them to the arts, literature, philosophy, ethics, and other creative aspects of the natural and human worlds, and how those interact in complex and often unrecognized ways. Both science

and the humanities show us how the world actually works; either one alone is insufficient. Humankind has a moral, intellectual, and practical responsibility to expose science students to the humanities and vice-versa. The profound works of literature, art, and philosophy can shape our imaginations and, led by good science, can best guide us in addressing life's most profound challenges in a manner that reflects humanity's greatest potential. Exposure to the humanities can encourage open-mindedness and re-calibrate our vanity; it offers a broad perspective on the world that simultaneously expands our humanness and grounds us. Without exposure to the humanities, people are diminished, less fulfilled in life, and are less likely to rise to their higher selves.

How Humanities and Science are Being Successfully Integrated

U.S. News and World Report's 2025 best national U.S. higher education rankings put Princeton University, Massachusetts Institute of Technology (MIT), Harvard University, Williams College, Spelman College, and the University of California Los Angeles (UCLA) at the top of their list. Of these, Williams College seems to come closest to achieving a mission of integrating humanities and sciences—it offers all students degree programs that blend the two fields. All students take at least three courses in the humanities, three in social sciences, and three in science and math. They also take at least two writing-intensive courses and one to improve their ability to reason mathematically and abstractly. In addition, the college's tutorial program is limited to 10 students per course who meet with a professor two on one to demonstrate weekly progress in assigned reading proficiency, written acuity, and ability to respond to oral cross-examination. Each department is required to offer at least one such tutorial course during each academic year. This is all in addition

to majoring in a core area and, instead of a separate minor, a "concentration" that includes courses that pull from many departments and disciplines. Williams College offers a well-rounded interdisciplinary undergraduate education that may exceed that of any other U.S. university/college.

Spelman College offers an Independent Major designed to accommodate the goals of students with broad interdisciplinary interests that cannot be satisfied within one of the traditional majors. UCLA has a College of Letters and Science in which undergraduates can design their own "Individual Major" (in consultation with faculty advisors), and which allows students to take coursework from different departments across the College. There may be few truly interdisciplinary courses, but at least students can get a degree with classes from a broad mix of disciplines. Although Harvard still boasts of a distinguished "Faculty of Arts and Sciences," it continues to offer separate degree-granting programs in these areas (e.g., Arts and Humanities; Social Sciences; Climate, Ecology & Biodiversity; Human Health). MIT was founded in response to the increasing industrialization of the United States, and based on a European polytechnic university model it stresses laboratory instruction in applied science and engineering. However, it also offers a Bachelor's degree in Humanities and Science by way of an interdisciplinary program and has a thriving Art, Culture, and Technology Program (ACT) that fosters close links to multiple other programs, centers, and labs. MIT's "Creating Art, Thinking Science" course is open to both undergraduate and graduate students and is supported by the MIT Center for Art, Science, and Technology (CAST).

Texas Tech University Honors College has developed inter-disciplinary team-taught courses that use the humanities as a foundation and integrates STEM concepts and principles. The

University of Alabama-Birmingham Honors College also makes an effort to offer interdisciplinary courses. Interdisciplinary approaches integrate disciplines, removing the wall that separates them, but they usually require a commitment to determined team-teaching. It isn't easy to break out of the long history of siloed academic course designs. The University of Arizona is home to one of the world's few Astrobiology centers, which focuses on the study of both the origins of life and the nature of consciousness. They have partnered with the Center for Consciousness Studies in a collaboration designed to combine expertise from a range of disciplines. Together, their work explores the connection between consciousness and the evolution of life, while also investigating how molecular biochemistry relates to consciousness. By integrating insights from planetary sciences, biology, neuroscience, philosophy, and the humanities, they aim to better understand the evolution of consciousness and how our inner experiences are linked to the physical world. The work bridges two of humanity's most profound questions: How did life begin, and what does it mean to be conscious?

Eric Adler's book, *The Battle of the Classics: How a Nineteenth-Century Debate Can Save the Humanities Today*, argues in favor of multicultural humanism and proposes core curricula that avoid overreliance on the Western Canon. Adler notes that works of rich intellectual, aesthetic, and moral significance are linked to a wide variety of human civilizations, and a proper humanistic education should introduce students to them. The great challenge is how to reintegrate the sciences and the humanities in ways that are acceptable to scholars in both fields and such that both fields benefit. Some promising portals in this regard are the journals *History of Humanities* (published by the Society of the History of the Humanities: https://www.journals.uchicago.edu/toc/hoh/current), *Consilience* (an online journal exploring the spaces where the sciences and the arts meet:

https://www.consilience-journal.com/), and *Leonardo* (an international channel of communication for artists who use science and developing technologies in their work, MIT Press: https://direct.mit.edu/leon). Also, the print/online magazine *Nautilus* does a wonderful job of blending science and humanities across many disciplines (https://nautil.us/about-us/?_sp=593685a6-aa62-4bf9-b71c-20bdbc41f23a.1738600054667). Another outstanding example of an activist approach in this regard is the nonprofit Natural History Institute (www.naturalhistoryinstitute.org) based in Prescott (Arizona), whose mission is to "Integrate Art, Science, and Humanities." They accomplish this through their excellent website, their art/exhibition gallery, their Natural History Journal (a series of online articles about natural history and art), and a broad variety of public events.

Lehmann et al. (2023) note that identifying a creative question is the first step in all creative thinking, and that "arts thinking" is typically more creative because it can be more playful and less goal oriented, and can thus lead to new modes of questioning. Scientific thinking most often aims at addressing an existing question, serves a scientific purpose in solving the question, and must have predictably. Thus, they advise that in order to increase creativity in science, the value of arts thinking should be incorporated into the generation of science questions. This, they argue, would lead to more novelty, rather than only redundancy and utility.

One tends to think of university culture in the Western World as being highly progressive, malleable, expansive, creative. But in fact, it tends to be just the opposite, especially in the life sciences and social sciences. Western universities have actually changed in hardly any fundamental way from the 19th century German model upon which they are largely based. Today, the slightest proposed change in university structure will illicit heated debate in any departmental

meeting; and traditional structure will likely win out. This, despite the reality of a rapidly changing world that we professors are, theoretically, supposed to be preparing our students for. So it is with most research professors, who rarely make dramatic changes in their research style or topic throughout their entire university tenure. Some do, but these creative individuals are the exception. Many university researchers work on the same system throughout their career, often the same one they did their PhD research on. This reductionistic approach can add important details to their particular research system. But by working within the same system decade after decade, shaving one's investigations thinner and thinner, it can also happen that the work becomes something akin to an uninteresting tautology with the research having lost site of the bigger picture altogether. However, once tenure has been achieved, there is a new door that opens for creative individuals. The "prayer cycle" for a *creative* academic might look like this: *Matins:* a career is launched; *Vespers:* initial career apogee is reached; *Compline:* a newborn pulse of creativity leads to entirely new directions of thought and productivity; *Nocturns:* creativity leads to crossing-over between disciplines, each informing the other, with the discovery that humanities can inform and enhance science and vice versa.

A very thoughtful paper by Izdebski et al. (2016) examines the challenges facing natural scientists, historians, and archaeologists in merging their different approaches and vocabularies to develop cooperative research agendas. These differences include terminological misunderstandings, different philosophies of project design, and different publication cultures. They criticize E. O. Wilson (*Consilience* 1998) for insisting on a science-methodology approach in attempting to merge these differing cultures, including the use of parsimony (Wilson's "simplest possible explanation"). Overall, they find Wilson's approach to be discouraging for humanities and social

science scholars. This is a sentiment widely seen in humanities writing post-Wilson and it represents a backlash of sorts. Izdebski et al. (2016) suggest the option of switching to a more narrative approach and using less discipline-dependent jargon to find consilience among the sciences and humanities, noting scientists' preference for brevity Vs. historians preferring to pay more attention to the literary aspects of academic writing. Like history, archaeology is also more narrative-driven than the hard sciences, but the two can find compromise when archaeologists, anthropologists, and "hard scientists" have a cooperative research agenda and coauthor their results (for example, see Mitchell et al. 2020, 2024; research developed and undertaken by a team of archaeologists, anthropologists, biologists, geologists, and radiochemists).

Few writers have spoken more elegantly than Martin Kemp, Professor Emeritus at the University of Oxford, who writes on the long-standing interplay of art and science. His two 2006 books are ambitious and enlightening looks into Leonardo da Vinci's mind and genius (*Leonardo da Vinci: Experience, Experiment and Design*) and the nature of creativity using profiles of extraordinary artists/scientist over a 500-year span of time (*Seen/Unseen: Art, Science, and Intuition from Leonardo to the Hubble Telescope*). Kemp also writes a column in the journal *Nature*, called "Science in Culture."

If you were a science teacher in the Los Angeles area with a teaching unit on climate change between October 2024 and January 2025, you might have missed an exceptional opportunity to bring art and history into your classroom. The Huntington Library, Art Museum, and Botanical Gardens had a magnificent exhibition, Anglo-American in focus, on how artists (and scientists) viewed threats of climate change between 1780 and 1930. The exhibit, titled "Storm Cloud: Picturing the Origins of Our Climate Crisis," used the library's considerable art and

book collection to show the inextricable interconnectedness of the arts and sciences, emphasizing how much art has historically been part of science. Asking students to write an essay on this show would have challenged them to think about the humanities and science as two equally-important expressions of humankind's attempts to understand our world. Challenging participants to observe is one of the greatest and most powerful tools of both science and art. The very best education is one that does not merely deliver information, but makes a student's life and spirit grow. Ralph Waldo Emerson [1803-1882] told us, "Art throws light upon the mystery of humanity."

The annual Princeton University Art of Science exhibition explores relationships between art and science (https://artofsci.princeton.edu /about/). Works are selected for their aesthetic excellence, for their scientific or technical interest, and for their capacity to inspire creativity across disciplines, cultures, languages, and age groups. Art of Science opens scientists to new ways of thinking about their own research and offers a lens through which the general public can engage with both science and art—two fields that can often feel inaccessible to the non-expert. When viewed through the lens of art, these works push our knowledge of human experience, enhance and challenge our understanding of the natural world, and expand what we consider art and whom we think of as artists. The aim of Art of Science is to explore the symbiosis of two fields that are essential expressions of human creativity.

The Cultivating Ensembles (CE; formerly CESTEMER) community gathers people who create compelling learning environments by deeply engaging across the arts, humanities, and STEM. CE activities include bi-annual conferences, Coffee Chats, and Community Meetings that create inclusive, interactive spaces that bring together individuals with different sensibilities and interests in science,

technology, engineering, mathematics, and medicine to celebrate the interwoven nature of science, technology, humanities, and arts as human activities. CE aims to nurture relationships that redefine traditional boundaries using the human lens to understand how we make, practice, and communicate science and research (https://www.cultivatingensembles.org/).

Some of the most creative, entertaining, and humorous film shorts in science education are the Italian-American actress Isabella Rossellini's four video series on animal reproduction: *Green Porno*, *Seduce Me*, *Mammas*, and *The Spawn of Green Porno*. The daughter of Ingrid Bergman and Roberto Rossellini, Isabella was responsible for the concepts, scripts, and design of the creatures in her highly creative educational videos; she directed all episodes and is the primary actor in these series. Another excellent educational biology video series is Deep Look's *Nature Unseen*, produced by KQED in San Francisco (https://www.kqed.org/newsletters/nature-unseen). Rossellini's series are perfect for high school while *Nature Unseen* is excellent for college undergraduates in both the humanities and the sciences.

Writer Maria Popova is a master at weaving together science and the humanities in enlightening and poetic ways. In her Introduction to *The Universe in Verse*, delightfully illustrated by Ofra Amit, Popova astutely writes, "Poetry and science are instruments for knowing the world more intimately and loving it more deeply." The short essays in this book range from the mystery of dark matter and the infinity of pi to the resilience of trees and the intelligence of octopuses. Almost any science course could assign readings from Popova as a way to add a sparkling breath of humanities to their classroom. And Marcia Bjornerud even makes rocks seem interesting by mixing her personal stories and philosophy with geology (Bjornerud 2024). These are

minds that live in that brilliant and effervescent world of both right and left brain.

There seems to be an entire genre of fiction emerging these days in which writers tell positive stories about scientists who solve large Earth and cosmic problems in realistic ways. Some of these writers are themselves scientists. Among these new fiction writers are Andrea Barrett, Neal Stephenson, Connie Willis, Kim Stanley Robinson, Ursula K. Le Guin, Richard Powers, Jonathan Lethem, Ted Chiang, and Carl Sagan [1934-1996].

Sam Illingworth, Professor of Creative Pedagogies at Edinburgh Napier University, elegantly shows how poetry can help teach complex science ideas. His books (e.g., Illingworth 2019, 2022, 2024) and his blog and podcast (*The Poetry of Science*) illuminate how beguiling poetry can capture, in short stanzas, the most complex of science topics—everything from astrophysics to Alzheimer's disease, and from Atmospheric Chemistry to Acoustics.

Malcolm Shick (2008) noted that "students majoring in the humanities scarcely plumb the sciences." Shick, who taught marine biology classes for decades, worked to frame his course in a wider aesthetic and historical context using memorable visual images, literature, and music. Guy Davenport (1997) noted that, "the vision by which we discover the hidden in nature is sometimes called science, sometimes art" and "Ignorance of natural history has become an aesthetic problem in … the arts."

Content does not discriminate art from science because they do not differ on their ideas or their subjects, only in how they explain or illuminate the world and the cosmos. Both the sciences and the humanities have the same goal: to observe and interpret the world in ways that help others understand things—they just rely on different

methods. And both can challenge preconceived notions of truth. A lumberjack, an artist, and a philosopher can look at a grand old oak tree and see entirely different things—logs, poetry, and the wisdom of ages. Are they not all correct in what they see?

Albert Einstein [1879-1955] was an accomplished pianist and violinist, and he offers a classic example of how music, mathematics, and science connect. He frequently explained that his greatest insights did not come from logic or mathematics, but from intuition and inspiration—as it does for artists. He is quoted as having said, "The greatest scientists are artists as well," "When I examine myself and my methods of thought, I come close to the conclusion that the gift of imagination has meant more to me than any talent for absorbing absolute knowledge," and "All great achievements of science must start from intuitive knowledge" (Calaprice 2000). At a conference in Kyoto in 1922, Einstein described his intuitive thought processes as using images to solve problems, only later finding words or equations to express them (Pais 1982). He thought about problems not in logical symbols or mathematics, but in images, feelings, and musical architecture (Wertheimer 1959). His son, Hans, said, "whenever [my father] felt that he had come to the end of the road or into a difficult situation in his work, he would take refuge in music, and that would usually resolve all his difficulties."

The brilliant German theoretical physicist Max Planck [1858-1947], whose discovery of energy quanta won him the Nobel Prize in Physics in 1918, was the originator of quantum theory, which revolutionized understanding of atomic and subatomic processes. He was also a gifted musician who sang, played piano, organ and cello, and composed songs and operas.

Of course, the concepts of music—notes, chords, key signatures, time signatures—are built upon strong mathematical principles. The Greek

philosopher Pythagoras worked out the foundation of Western music in the sixth century BCE by discovering the mathematics of harmony. The beauty and symmetry of his discovery so moved him that he thought the entire universe must somehow be governed by it. He and Johannes Kepler called it "Music of the Spheres." Oliver Sacks (2008) wrote, "Music has great power … Propensity to music—musicophilia—shows itself in infancy, is manifest and central in every culture, and probably goes back to the very beginnings of our species."

The inherently mathematical nature of music is easily seen in the popular style known as a canon—a form in which two (or more) voices sing the same melodic line but start at different times. It becomes musical when the two voices harmonize. (Think of "Row Row Row Your Boat.") Tony Phillips (for the American Mathematical Society) explains it this way: Mathematically speaking, the operation that produces voice 2 from voice 1 is a translation in time. If the pitch sequence that describes the melody for voice 1 is represented by a function, $f(t)$, and if we let t represent the number of measures, then voice 2 would be represented by the function $g(t) = f(t\text{-}2)$. So, for example, at the beginning of the third measure (time $t = 2$), the pitch of voice 2 would be $g(2) = f(0)$, and the pitch of voice 1 at the beginning (time $t = 0$). The translation operation that makes g out of f is studied in an elementary functions course, because it is one of the important ways of making new functions out of old or of tailoring a given function to fit a new situation. Johann Sebastian Bach's [1685-1750] famous *Musical Offering* contains ten canons all based on a musical theme given to him by Frederick the Great. In each of these canons a musical line is played twice (or four times in Canon 10). The second version is always transformed with respect to the first by shifting in time, but it may also be shifted in pitch, turned upside-down, stretched, or played backwards. Each of these transformations occurs

in the mathematics of elementary functions; they are examples of how new functions can be made out of old, and of how a function can be tailored to fit a new situation. Here are the equations for the first five canons and their transformations in Bach's *Musical Offering*.

- $g(t) = f(t\text{-}1)$ and Canon 2
- $g(t) = f(t\text{-}1) + H$ and Canon 5
- $g(t) = -f(t\text{-}0.5) + K$ and Canon 3
- $g(t) = -f((t\text{-}0.5)/2) + L$ and Canon 4
- $g(t) = f(18\text{-}t)$ and Canon 1

If you doubt the power of music to speak honestly, clearly and with certainty, consider this. B. B. King or The Rolling Stones open a song with just three or four notes; it's all you need to be transported to someplace unique, someplace you already know in the depths of your mind. Think of the unmistakable opening three chords of *Wild Horses*. Even the first few chords of Patti Smith's gritty cover of *Gimme Shelter* evokes these instantaneous feelings and memories—evidence that it's the music, not the singer or the musician, that strikes that fundamental part of one's brain. That just three or four chords immediately stimulates the deepest cognitive parts of one's mind, evoking recollection of memories and feelings from many years past, is testimony to the elemental nature and primordial place of music in humanity.

Or consider the unmistakable opening of Aaron Copland's *Fanfare for the Common Man*, with its startling and immediately-recognized tam-tam crash extended in time by two pounding strokes of the timpani and bass drum. Not just scientists, but great musicians and artists also speak the truth. Sometimes it's easier to see truth in art or music than in science; sometimes it flashes like a heliograph in the night for anyone to see. Music, like nature, enlivens our soul. Some have said music is the transcendent language of time.

Music can easily be integrated into STEM teaching even without understanding its fundamentally mathematical nature, and the internet is teaming with songs about science (Crowther 2012). Bob Newsome uses the website "Fizzics Education" to teach science through the power of music. The website "Sing about Science and Math" hosts a database of over 7,000 songs about science. The Edutopia site is a wonderful resource for teaching STEM topics integrating music theory and lyrics.

Using music to leverage math in support of STEM-related subject matter is an easy, yet rarely used tool. Even ecology topics such as soil erosion, climate, and agriculture practices can easily be infused with music and sociology; just think of Woody Guthrie's album, "Dust Bowl Ballads" (*Tom Joad*, *Dust Bowl Refugee*, etc.) or his powerful sociological ballad to Spanish-speaking migrants, *Plane Wreck at Los Gatos*. High school biology classes can benefit from songs that teach about the skeletal system (https://sciencepoems.net/bones-of-the-human-body-music-video/) or incorporate mnemonics to help students remember the food chain (https://www.hourof knowledge.com/2014/06/episode-43-mnemonics-and-the-food-chain/).

Even street theater can be used to teach science—through art and acting. The annual Arizona Insect Festival, founded by Wendy Moore, a professor of entomology at the University of Arizona, features giant paper-mâché flowers of important local food crops (e.g., onions, chiles, squash, figs) that are pollinated by native insects. Graduate students and professors in white lab coats (with labels reading "I'm an entomologist") narrate stories for the public of how the pollination process takes place, while others dressed in elaborate native insect costumes demonstrate the intricate pollination behavior for the audience. Inspired by Isabella Rossellini's *Green Porno* series, the concept was envisioned and developed by one of Moore's graduate

students, Alex Lombard, who brilliantly and effectively weaves science, art and theater into pop-up educational treats for learners of all ages.

And speaking of performance art, few people know that the Oscar-nominated film actress Hedy Lamarr [1914-2000] was a scientist-engineer-inventor who, when she wasn't acting, worked with her co-inventor George Antheil (himself an Avant-Garde composer) inventing and patenting a technique for radio communicators to rapidly switch frequencies to protect allied torpedoes from being spotted by Nazi radio detectors. Her work was partly the foundation for everything from GPS to Bluetooth technology.

Yamilée Toussaint figured out how to integrate dance into STEM. Growing up on Long Island, Toussaint had always been passionate about two seemingly unrelated things: dancing and mathematics. She pursued a college degree in mechanical engineering at MIT, where she was one of only two black women and also head of the dance team. She now teaches math at a high school in Brooklyn where, in 2012, she created the *STEM From Dance* nonprofit that integrates dance with STEM education. Today, the program works with girls of color ages 8 to 18 in nine cities across the U.S. Using dance, she is helping young girls begin to see themselves as engineers and scientists (https://stemfromdance.org/about-us).

Tsang (2019) argues that humanities education, as compared to STEM education, may be better able to provide students with the most in-demand twenty-first century workplace skill: innovation. Tsang compared U.S. humanities and STEM students' college gains in their "propensity toward innovation" (PTI) and the academic factors that contribute to it, finding that humanities students experience greater in-college gains in PTI.

University faculty rarely get their students out of the classroom today. It takes extra time and effort and can increases the course budget. It's so rarely done that when it happens it can make news, such as when Karen Curls and Lyle Gibson began taking a couple dozen students from Metropolitan Community College at Penn Valley (Missouri) on four-day bus tours of civil-rights sites in the south (The Chronicle of Higher Education, 27 September 2024). But what a tremendous and memorable, probably even life-changing experience for those students. When I taught a course on biodiversity I took 15 or so students on three-day field trips to Washington D.C. to visit the Smithsonian museums, including a day-long behind-the-scenes tour of the National Museum of Natural History. The huge scale and scope of their research collections impressed students with the concept of biodiversity in ways no lecture could ever hope to accomplish. I also delved strongly into sociology as I described the critical role of women in developing nations as the primary protectors and managers of local biodiversity, and the challenges women face in most of those countries.

People's emotions become more mature and positive after interacting with natural environments (Marcus 2021). And there is a direct link between emotions and creativity (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 it can play a critical role in the cognitive, emotional, and behavioral development of individuals.

One of my favorite bumper stickers states, "Read a novel—and learn more about life." Janisse Ray (2024) calls books portals of literature from which "we learn about the possibilities of life." Maria Popova said, "Words are events, they do things, change things. They transform both speaker and hearer." Students (and scholars) need to gain wisdom, not just accumulate knowledge. Gaining a sense of place and reading good literature are both excellent ways to open doors to individual wisdom. Books 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. As Jeff Hartman (2024) wrote, "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." Literature expands one's mind, one's understanding of the world, and one's vocabulary. Great books lift and enrich our spirit and, as Yehudi Menuhin reminded us, what marks a great man is the spiritual climate he creates in his soul.

We can reduce the biases that our students bring with them and provide broader perspectives by introducing them to relevant and substantially different forms of literature. In doing so, we help them see other points of view and garner wisdom, while at the same time instilling in them the foundation and building blocks for greater creativity. Great books—books that evoke profoundly 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 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. But don't think all poetry is happy; try reading Ruth Stone's *What Love Comes To* (2011). Can sad or angry poetry still be beautiful?

Carl Sagan [1934-1996] wrote, "What an astonishing thing a book is. It's a flat object made from a tree with flexible parts on which are imprinted lots of funny dark squiggles. But one glance at it and you're inside the mind of another person, maybe somebody dead for thousands of years. Across the millennia, an author is speaking clearly and silently inside your head, directly to you. Writing is perhaps the greatest of human inventions, binding together people who never knew each other, citizens of distant epochs. Books break the shackles of time. A book is proof that humans are capable of working magic."

Let me clarify the meaning of "literary fiction"—or simply, "literature." Literary fiction is narrative about the human experience, what can be learned from it of the nature of life and humanity's condition. It thus comprises stories of people—how they think and view the world, their hardships and their triumphs, their battles between good and evil, between sickness and health. Such stories are character driven, as opposed to the commercial genres of mystery and romance novels, which are plot driven (characters being of secondary importance). Literary fiction can have a plot, or not. Some of the greatest writing is utterly plotless—think of Pulitzer Prize-winning author Cormac McCarthy's last two novels, the stylistically complex *Stella Maris* and *The Passenger*. Both were plotless stories describing the thin line between sanity and insanity walked by two brilliant siblings whose father helped develop the atomic bomb.

Literary fiction often has two (or even three) layers; one is the apparent subject while the other is a deeper subject (text and subtext). 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 books 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 (e.g., sex, mental illness, death). 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, poetry, drama, and the visual arts are the transcendent languages of the times; 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. Art, music, and literature speak directly to the human spirit, just as does immersion in the natural world. Embracing the humanities and immersing ourselves in nature work synergistically to increase our psychological health, our creativity, and our wisdom.

There are few elements so overlooked in the development of a well-adjusted young scientist as the importance of reading good books. The right book can change a student's view of a hopeful field of study and even their view of the world. These transformative junctures often represent important conceptual advances for an individual. Reading good books can also boost one's emotional intelligence. The best mentors lead their students to great books, fiction and nonfiction. After all, storytelling is 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). Stories help us understand culture—an important part of our education as we mature (a never-ending process). Nature, art, music, and human relationships give life meaning, and a solid sense of the humanities can thus help scientists communicate better with students, other scientists, and the general public. Music is what life sounds like, and Rudyard Kipling claimed words are the most powerful drug used by humankind.

Janisse Ray (2024) notes that stories reconcile us with our mythic and heroic capabilities; they reconcile us to history, to the future, and to the rest of the world. "The writer rows across the pass, from the real and earthly to the mystical and magical, gathers some golden things, and then returns. Back and forth, across a pass, from this world to another—that's how a writer works." And, "I believe that the purpose of a story is to serve the evolution of human consciousness." These are heady thoughts and high aspirations for storytellers, and I unconditionally agree with Ray's sentiments.

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 Manuel 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 distinctly human trait and highly stylized form of communication practiced by all cultures since the dawn of humankind, likely reflects 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).

For most of our history creating and telling stories was strictly oral, but with the invention of writing stories came to be preserved as etchings, script, or print. I often tell want-to-be memoirists that everyone's story is important. Stories are what create and preserve both family and global culture. They codify history. Stories are what gives humanity its collective memory. Stories help us understand ourselves, and help others see different worlds. Our stories reconcile us with our tragedies and our successes, and with our inner hero.

Goethe [1749-1832] considered his scientific theory of colors his greatest achievement—not his poetry—illustrating how close artistic and scientific minds may align. Sir Isaac Newton [1643-1727] wrote that he saw himself appearing "like a boy playing on the seashore, 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—a childhood now equipped for self-expression with manhood's capacities." Albert Einstein said, "Creativity is intelligence having fun" and "Imagination is more important that 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, often paradigm-changing science and to bold ideas and experiments. These concepts lie squarely in the realm of the humanities. Embracing the humanities is not just a pleasing luxury in higher education; it is

an essential part of a well-rounded schooling and something that should continue throughout one's life.

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Contributor Biographies

Omar Ali is Dean of Lloyd International Honors College and Professor in the College of Arts & Science, The University of North Carolina at Greensboro. A graduate of the London School of Economics and Political Science, he received his Ph.D. in History from Columbia University. The author of seven books on the political, legal, and scientific contributions of Africans and people of African descent across the global Diaspora, he is the recipient of several teaching awards, including being named the Carnegie Foundation North Carolina Professor of the Year in 2016. https://www.uncg.edu/employees/omar-ali/

Shelly L. Brown-Jeffy is an Associate Professor of Sociology at the University of North Carolina at Greensboro. She has research interests are in the area of STEM, education, social policies, and social inequality. Dr. Brown-Jeffy's major research interests focus on where inequality originates and how it influences quality of life for individuals and groups, and she is currently the Principal Investigator of a National Science Foundation Advance Grant. One of her research interests centers on the differences in educational outcomes among different racial, ethnic, and socioeconomic groups. She also examines how our social world structures our social reality. https://www.uncg.edu/employees/shelly-brown-jeffy/

Richard C. Brusca is a biologist, conservation ecologist, cultural anthropologist, essayist, and author of two award-winning novels. He is Executive Director Emeritus of the Arizona-Sonora Desert Museum and a Designated Campus Colleague, University of Arizona. Rick is the author of over 230 research publications, essays, editorials, and books, including the largest-selling text on invertebrate zoology

(*Invertebrates*, Oxford University Press; available in four languages). His books have won many awards, including Best Textbook of the Year, Southwest Book of the Year, the Tabasco Best Southwest Cookbook Award, the 2024 IPPY/Independent Press Award for Hispanic Fiction, and the 2022 BIBA Award for Best Literary Fiction. Rick has served on more than a dozen nonprofit boards and helped found three NGOs. Although he has organized and conducted field expeditions throughout the world, in over 50 countries, he has maintained his research programs in the Sonoran Desert and Mexico for more than 40 years. Rick is a National Geographic Explorer and a recipient of the U.S. Department of Defense Civilian Service Medal. He is also an elected Fellow in the American Association for the Advancement of Science (AAAS), the Linnean Society of London (FLS), and the California Academy of Sciences. http://www.rick brusca.com

Dr. Nadja B. Cech is Distinguished Professor of Chemistry at the University of North Carolina Greensboro. For more than two decades, she has led a National Institutes of Health (NIH) funded research laboratory, working with students and collaborators to identify medicinally useful molecules from plants and fungi. Her research group has published 150 papers, which have been cited more than 10,000 times. Dr. Cech is the recipient of the 2024 Schwarting Award from the *Journal of Natural Products* and the 2022 Board of Governors Teaching Excellence Award from the University of North Carolina System. https://chem.uncg.edu/cech/

Chris Enke grew up in Minneapolis, Minnesota and he always wanted to be a teacher. His teenage fascination with electronics broadened into a PhD in chemistry from the University of Illinois, Champaign-Urbana. His bachelor's degree was from a small liberal arts college, an experience that has enriched his life and work. Chris's

first academic job was at Princeton University, but when the Chemistry Department abandoned his teaching and research area, he accepted an offer from Michigan State University. After twenty-eight years of mostly cloudy days in East Lansing, the sunshine and beautiful setting of Albuquerque called, and Chris enjoyed a dozen years teaching at the University of New Mexico. His principal contributions are the early computerization of scientific instruments and the invention of a revolutionary form of tandem mass spectrometer. Now professor emeritus at New Mexico and Michigan State, he remains active in writing and collaborative research. A list of his publications, offices, and awards are available on Wikipedia and his website. Not as well documented is his long interest in the philosophy of science. Chris appreciated the invitation to offer his resolution to the perennial science/philosophy paradox of trust, and he holds hope that his thoughts provide fuel for the repair this book aims to advance. https://www.chrisenke.net/

Thomas Lowe Fleischner is a naturalist and conservation biologist. He is a leading voice advocating for the importance and rejuvenation of natural history. He was the founding director of the Natural History Institute in Prescott, Arizona, and continues to serve as the Institute's Senior Advisor and Director Emeritus. He is Faculty Emeritus at Prescott College, where he taught interdisciplinary Environmental Studies for 29 years. Tom is the author of numerous articles and professional papers, and author or editor of five books, including: *The Way of Natural History*; *Nature, Love, Medicine: Essays On Wildness and Wellness;* and the forthcoming *Astonished By Beauty: Natural History As a Practice of Connection.* He co-edited a special issue of the academic journal *Ecopsychology* on "Reciprocal Healing: Nature, Health, and Wild Vitality." Past ecological research has focused on marine mammals, marine birds, and the impact of livestock grazing on arid lands. Recently, he has led and coordinated efforts to

recognize the high biodiversity values of the Mogollon Highlands Ecoregion of the American Southwest. An elected Fellow of the Linnean Society of London, he has served as Chair of the Natural History Section of the Ecological Society of America, on the Board of Governors of the Society for Conservation Biology, and as President of its Colorado Plateau Chapter. He co-founded the North Cascades Institute in Washington State. http://tfleischner.net/

William F. Gilly. William Gilly is a Professor of Oceans in the Stanford Doerr School of Sustainability. He has been based at Stanford's Hopkins Marine Station on Monterey Bay since 1980, where he has studied behavior and neurophysiology of many invertebrates but primarily squid. He began exploring the central Gulf of California in the mid 1980's and launched a research program there on Humboldt squid in 2001. He has been teaching ocean science and literature of both regions for the last 20 years with his wife, Susan Shillinglaw, an expert on John Steinbeck and professor emerita at San Jose State University. Gilly is the author of more than 125 research papers and is currently working on the control of skin-color change in squid by neuromuscular organs called chromatophores and on long-term oceanographic changes and ecological consequences in the Gulf of California.

John Gregg. John Gregg has been involved in the geotechnical and environmental sampling business for 40 years. He is currently involved in the design and implementation of deep-sea sampling systems at great depths in oceans around the world. When John was ten years old, he picked up a copy of *The Log from the Sea of Cortez* and was forever changed by it. In 2015, he purchased the *Western Flyer* and founded the Western Flyer Foundation to continue the legacy started by John Steinbeck and Ed Ricketts in 1940.

Mary Ellen Hannibal is an award-winning environmental journalist and the author of five books. Of her book *The Spine of the Continent: The Race to Save America's Last, Best Wilderness*, Publisher's Weekly wrote "this is what science writing should be: fascinating and true." Mary Ellen's most recent book, *Citizen Scientist: Searching for Heroes and Hope in an Age of Extinction*, was named a best book of the year by the San Francisco Chronicle and won a Nautilus book award. Hannibal is also author of "Nature in the City," a spatiotemporal map synthesizing more than 40 layers of the terrain and unfolding change over time. She is a regular contributor to various periodical publications including The New York Times, Science, Sierra, Nautilus, and Bay Nature. Awards and fellowships include an Alicia Patterson Foundation Fellowship, a Stanford University Media Fellowship, the American Association for the Advancement of Science's Science and Society Award, and Stanford University's Knight-Risser Prize for Western Environmental Journalism. A frequent speaker, she performed a Stanford TEDx talk in 2017 and her "big" TED talk, on butterflies, the human soul and citizen science, released in 2020. www.maryellenhannibal.com

Lisa K. Harris is a fifth-generation gardener. Her more than 200 published scientific articles, essays, and short stories all include plants and often are conservation-themed. She writes about wildlife ecology, adventure travel, parenting daughters, and dealing with life's speedbumps. She is the co-editor of "Cumulative Effects in Wildlife Management" (2011), a textbook on the National Environmental Policy Act. Her work has been nominated for a Pushcart Prize and Best of the Net. Dr. Harris owns and manages Harris Environmental Group, Inc., a consulting firm that works throughout the western U.S. and strives to make the world a better place. Harris earned two HASS degrees from the University of Chicago and a STEM degree from the

University of Arizona. Follow Dr. Harris and the quail at @HarrisLisaKim and LisaKHarris.com.

Sam Illingworth is a Professor of Creative Pedagogies at Edinburgh Napier University, specialising in the intersection of science and the arts. With a PhD in Atmospheric Physics, he is an award-winning science communicator and poet, and founder of *Consilience*, the world's first peer-reviewed science poetry journal. Discover more about his work at www.samillingworth.com.

Josie Iselin is a photographer, author, and designer of many books, with the last few focusing on the world of seaweed and kelp. Her most recent book, *The Curious World of Seaweed* (Heyday Books 2019) is the basis for a traveling exhibition of prints by the same name. She is the co-director of Above/Below, a campaign working to bring the recognition afforded the forests on land to the kelp forests below the ocean's surface. Above/Below's signature effort is a web-based book titled *The Mysterious World of Bull Kelp*. Released in November 2023, it has been accessed by over 22,000 kelp-curious learners (as of January 2025). For over twenty years Josie has used her flatbed scanner and computer for generating imagery. She teaches in the School of Design at San Francisco State University. Synthesizing the scientific stories of the Pacific rocky coasts is her overriding passion, bringing thoughtfulness and stewardship to these extraordinary places of discovery. https://www.josieiselin.com/about

Kysa Johnson is an artist whose drawings, paintings, and installations explore patterns in nature that exist at the extremes of scale, using them as a way to reflect on history and our place in the physical universe. Kysa graduated with honors from the Glasgow School of Art in Glasgow, Scotland. She has exhibited at, among other venues, The Aldrich Museum of Contemporary Art, The Tang Museum, The DeCordova Museum, Dublin Contemporary, The Nicolaysen

Museum, The Katonah Museum of Art, The Hudson River Museum, The 2nd Biennial of the Canary Islands, the U.S. National Academy of Sciences, Morgan Lehman Gallery, Scott Miller Projects, Nancy Littlejohn Gallery and Halsey McKay Gallery. Her work has been described and documented in numerous publications, including ArtForum, The New York Times, Interview Magazine, The New Yorker, and San Francisco Chronicle. Kysa's work is included in many public collections including MIT, Google, Microsoft, The Progressive Collection, Deutsche Bank, and Credit Suisse. She is a New York Foundation for the Arts Fellow and a Pollock Krasner Grant recipient. https://www.kysajohnson.com/

Johannes Lehmann is the Liberty Hyde Bailey Professor of Soil Biogeochemistry at Cornell University, where he investigates the fundamental building blocks of soil organic matter, its role in soil health, and the circular economy. He has appointments in Cornell's School of Integrative Plant Science, Department for Global Development, and Atkinson Center for Sustainability. To tackle global change challenges, he develops radical collaboration approaches utilizing art-science learning. He has authored more than 300 journal publications, has been named Highly-Cited Researcher by Thomson Reuter since 2014, is a member of the U.S. and German (*Leopoldina*) National Academies of Sciences, and is a Hans Fischer Senior Fellow of the Institute of Advanced Studies at the Technical University Munich. https://cals.cornell.edu/johannes-lehmann

Vera Meyer is Professor of Applied and Molecular Microbiology at the Technische Universität Berlin. She is a fungal biotechnologist with a strong interest in optimisation of fungal cell factories, with the aim of a more effective use of fungal metabolic potentials for the production of drugs, enzymes, and biomaterials. Together with her team, she develops as well as combines methods from systems biology

and synthetic biology. Her inter- and transdisciplinary research projects combine natural and engineering sciences with art, design, and architecture, and create biobased scenarios for possible living environments of the future. Vera Meyer is also active as a visual artist under the pseudonym V. meer and uses the means of art to make society more aware of the potential of fungi for a sustainable future. In 2020, she co-founded the interdisciplinary SciArt collective MY-CO-X. https://www.v-meer.de/

Gary Nabhan is a contemplative ecologist and Arab-American Laureate honored by the Takreem Foundation, as well as author of 34 books bridging sciences and the humanities. https://www.gary nabhan.com/

Verity Platt is a Professor of Classics and History of Art at Cornell University, where she also directs the Humanities Scholars Program for undergraduates. She is the author of *Facing the Gods: Epiphany and Representation in Graeco-Roman Art, Literature, and Religion* (Cambridge 2011) and *Epistemic Objects: Making and Mediating Classical Art and Text* (Oxford 2025). She teaches courses on the environmental humanities and, as co-curator of Cornell's plaster cast collection, has also curated several exhibitions on classical art. classics.cornell.edu/verity-platt

Andrea Polli is an environmental artist working at the intersection of art, science, and technology. She is a Professor in the College of Fine Arts and the School of Engineering at the University of New Mexico (UNM). While her works span a wide range of media, from traditional to technological, her methods are united by a goal to make unseen patterns of the earth, nature, and society visible, audible, and tangible. She is co-editor of the book *Far Field: Digital Culture, Climate Change, and the Poles*, with chapters related to her U.S. National Science Foundation residency in Antarctica in 2007/2008 where she worked alongside atmospheric scientists studying the effects of climate

change. Her contribution to the present book discusses some of her meteorological art/science research. www.andreapolli.com

Kelly Presutti is Assistant Professor of Art History and affiliate faculty in Environment and Sustainability at Cornell University. Her work looks to art as a site of negotiation between humans and their environment, from the nineteenth century to today. Her book, *Land into Landscape: Art, Environment, and the Making of Modern France* (Yale, 2024) considers the role of visual representation in transforming distinct landscapes across nineteenth-century France.

Sylvia Torti is an ecologist and writer and currently serving as President of College of the Atlantic, Bar Harbor, Maine. She holds a PhD in biology from the University of Utah. In addition Dr. Torti is a creative writer. Her first novel, *The Scorpion's Tail*, won the Miguel Mármol Award for best debut fiction by an American of Latina heritage. Her second novel, *Cages*, won the Nicholas Schaffner Award for Music in Literature. Her short stories and essays have been published in numerous magazines and edited volumes. https://sylviatorti.com/sylvia-torti

Daniel Zeller is an artist working almost exclusively in the medium of drawing. His abstract work derives from a multitude of sources, exploring the visual language we use to describe and interpret the world around us. He exhibits internationally with solo shows at Pierogi in Brooklyn, Daniel Weinberg in Los Angeles, G-Module in Paris, Michel Soskine Inc. in Madrid, and Galerie Claude Bernard in Paris. Among other institutions, his work is included in the collections of MoMA and the Whitney Museum in New York, LACMA, and the Museum of Contemporary Art in Los Angeles, NASA, the National Gallery in Washington DC, and the Albright-Knox Gallery in Buffalo. He is a Civitella Rainieri Fellow and a Pollock Krasner Grant recipient. https://www.danielzeller.net