

Indianapolis Literary Club
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 Stephen J. Jay, essayist

Discovering the Nature of Things

The anthropologist, Wade Davis, said nothing in his lifetime has done more to liberate the human spirit from the parochial tyrannies of history as the discovery of DNA's structure, in 1953, and the iconic photo, *Earth Rise*, by astronaut, William Anders, on Apollo 8, Dec. 24, 1968.^{6, 41, 49,}

⁶⁰ To Davis, these discoveries established "...the essential connectedness of humanity," –a reflection of our insatiable need to research the unknown.

My aims this evening are:

1. To reflect on humans' quest for truth through discovering.
2. To describe the foundations of natural science in Indiana and how they enabled Indiana University (IU) to build a world-class research program in genetics by mid-20th c.
3. To suggest how we might sustain excellence in science, in very uncertain times.

Origins of Truth-Seeking

Over millennia, living things, in their own way, have been truth-seeking discoverers.²⁴⁴ Those that lose powers of discovery, whether humans, trees, or tadpoles, fail to thrive. Plato and Aristotle had different ideas about the origins of knowledge. To Plato, it was innate within the body's nature; to Aristotle it resided in nurture. This nature-nurture debate continues today but researchers consider it implausible and focus on interdependent processes; neither genes nor the environment alone govern human development.^{102,136}

Longfellow reflected our truth-seeking nature, *The Builders*, where all discoveries are valued and rarely made alone but by countless, often unrecognized persons.¹³⁸

"All are architects of Fate,
 Working in these walls of Time;
 Some with massive deeds and great,
 Some with ornaments of rhyme.

Nothing useless is, or low;
 Each thing in its place is best;
 And what seems but idle show

Strengthens and supports the rest.

For the structure that we raise,
Time is with materials filled;
Our to-days and yesterdays
Are the blocks with which we build.”

Two hundred years before Longfellow, Isaac Newton said, “If I’ve seen further, it’s by standing on the shoulders of giants.”¹⁷⁶ We can trace the fascinating connections of ‘giants’ who were “The Builders” of natural history, and in a metaphorical relay race of discovery, the baton passed from ancient philosophers, to the Black Death (1347-1350)^{58,210} that spurred the Renaissance (14th-16th c), from which humanism and science evolved in the Age of Enlightenment, (18th c.) where empiricism flowered in our founding fathers’ creation of the Constitution and Declaration of Independence.^{34,50a,50b.50c.}

Descriptions of the physical world changed with the taxonomist, Linnaeus, in the 1750’s,¹³⁷ the theories of evolution of Darwin and Wallace, in the 1850s, and Mendel’s pea-breeding experiments, in the 1860s.^{24,32,154,156,157,245} Their ideas filled journals and books, such as Melville’s, *Moby Dick*, (1851) an intellectual bridge from pre-Darwinian, non-scientific philosophy to Darwinian science.^{107,246} Captain Ahab’s romantic portrayal of the revengeful White Whale contrasts with the skeptic, Ishmael, who uses science to describe *Moby Dick* during the voyage of the *Pequod*, a nautical literary journey of natural sciences from antiquity.

A Millennial Golden Thread of Discovering.

Aristotle (384-322 BCE) said life develops according to plans-- hereditary information carried in the form of messages.^{27,162} Nobelist, Delbruck, (1969) said that Aristotle should get a posthumous Nobel prize for discovering the principle implied in DNA as the “unmoved mover” that creates, encodes and transmits information and the plan for life.^{61,62,76} The Roman poet and Epicurean philosopher, Lucretius, (Titus Lucretius Carus, 94 B.C.E-55 B.C.E.), 200 years after Aristotle, wrote *De rerum natura, the Nature of Things*, a poem that emphasizes simplicity, beauty and pleasure with virtue, friendship and happiness, “not irrational religious fears that warp human life”.^{50,64,87,99,100,139-142.} Describing a rational and orderly world, Lucretius presents a modern description of *atomism*.²¹⁴ Nobelist Richard Feynman, (1965) admired Lucretius’ sentence with the most scientific information in the fewest words: “all things are made of atoms.”^{99,224.}

A former Papal Secretary, Poggio Braccionlini, recovered a volume of the *De rerum natura*, in 1417, in a German Benedictine abbey.⁹³ Lost for 1000 years, the poem became a classic of the Renaissance and influenced da Vinci, Galileo, Bacon, Shakespeare, Ben Johnson, Montaigne, and Darwin, among others. Thomas Jefferson said, “I too am an Epicurean... his doctrines contain everything rational in moral philosophy which Greece and Rome have left us.”^{105.} The phrase, “Life, Liberty and the Pursuit of Happiness” reflects Epicurean sentiments, and a Pulitzer Prize

winner said: “The atoms of Lucretius had left their traces on the Declaration of Independence.”⁹⁹⁻¹⁰¹. Yeats called a passage in the poem, “the finest description of sexual intercourse ever written.”^{39,50,204,212}.

Aristotle and Lucretius laid foundations of natural science which was woven into John Adams’ Massachusetts Constitution of 1780, and the U.S. Constitution in 1789. In Indiana, the seeds took root in the 1770s, with discoveries of George Rogers Clark (1752-1818),^{123,223} who searched for mammoth bones for future President Thomas Jefferson whose “supreme delight was the tranquil pursuit of science.” (Jefferson1809) Clark and Jefferson collaborated with renowned naturalists, John James Audubon (1785-1851) and Constantine Rafinesque. (1783-1840)^{10,11,199}. The stage was set for creation of three pillars of natural science foundations: Indiana’s Constitution (1816), the New Harmony Settlement (1824) and Indiana University. (1820-1838)

Indiana becomes a state with a constitution: 1816

Indiana’s Constitution of 1816 was informed by the Massachusetts and U.S. Constitutions and Declaration of Independence. It was preceded by the first scholarly organization, the American Philosophical Society, founded by Benjamin Franklin, and including Founding Fathers: George Washington; Thomas Jefferson; James Madison, Alexander Hamilton, John Adams and natural scientists, Darwin, Audubon, Pasteur, and Thomas Edison. These men, scientists and statesmen alike, were steeped in the humanities and science and viewed democracy and science as integral to advancing knowledge and civilization--an American “engine” of the Enlightenment, to create novel ideas to address needs of individual citizens, the public and government.

Indiana’s Constitution specifically addressed education, research, and natural history:¹⁰⁹. Article 9 states: “... it shall be the duty of the General Assembly to “... encourage intellectual, (and) scientific ... improvement ... promotion ... of arts, sciences ... and natural history...” and to “...provide ...a state university, where tuition (is) gratis and ...open to all .”

New Harmony, Indiana, 1825:

The second pillar of natural sciences came with the purchase, in 1825, of New Harmony, by Welsh humanitarian-industrialist, Robert Owen, who promoted experimental utopian communities.^{4,18,33}. Historians cite three science milestones in America: John Winthrop’s first science laboratory in the Colonies, in 1633.⁵¹ The discoverer of oxygen, Joseph Priestley’s, lab in Pennsylvania, 1794, and the purchase of New Harmony.

Owen created “one of the significant intellectual migrations of history” after meeting with Congress and the President-elect John Quincy Adams and three former U.S. presidents.⁴ He led a brain-trust down the Ohio, in December 1825, on the keelboat, *Philanthropist* --the ‘*Boatload of Knowledge*’.^{81,122,128,130,181,186,175a,250,251}. Robert Owen and wife, Caroline, had five children who followed their parents to New Harmony,^{86,108,193,205} which became a beacon for scholars, including researchers, geologists, philosophers, artists, educators and advocates for women’s suffrage, abolition of slavery and universal education. Francis, “Fanny” Wright, Scottish

playwright and a leader of the American Popular Health and “Free Thought Movements,” co-edited the widely circulated *New Harmony Gazette*.⁹⁴ Her acquaintances included the Marquis de Lafayette, Thomas Jefferson and James Madison.^{26,119,160,247} The poet, John Keats’ niece, Emma Frances Keats Speed- Mrs. Phillip Speed, a friend of Oscar Wilde,^{52,54} lived at New Harmony with her father, George Keats, the younger brother of John Keats.^{10,11}

The New Harmony natural scientists interacted with renowned scholars from American and abroad. Charles Lyle, whose geology text was carried by Darwin on the *HMS Beagle*, was a friend of David Dale Owen and his wife and visited them at New Harmony, in April 1846.^{19,33,149-151} Louis Agassiz, the “founding father of America’s Science tradition”, corresponded in 1855 with Robert Dale Owen regarding their interests in turtle embryology, asking Owen to preserve in alcohol, eggs of turtle species in Indiana known to Owen.^{114,182}

Owen’s eldest son, Robert Dale, an IU Trustee in the mid-1800s,¹¹³ represented Indiana’s First District in Congress and introduced the bill establishing the Smithsonian.^{184,185} He and brother, David Dale, (1807-1860) were founders of the U.S. Geological Survey, whose early home was New Harmony.^{121,187,188,221} Robert Owen’s youngest son, Richard, (1810-1890) a physician-scientist, became a professor of natural history at IU, introducing evolution in the curriculum, in 1864.^{4,110,115,126,180,181,250} Known as one of IUs preeminent “Big Four” intellectuals, with Ballantine, Kirkwood, and Wylie, Richard Owen became President of Purdue University, in 1872. A “virtuous and wise”⁴ scholar, military leader, and humanist, Colonel Owen, commanded 4000 Confederate prisoners at Camp Morton, in Indianapolis; Confederate survivors recognized him fifty years later for his humane leadership at Camp Morton, presenting a bronze bust of Owen for the Indiana State House. U.S. Vice President Marshall said, in 1913, “the spectacle of prisoners of war paying such a tribute to their captor is one without precedent in history and one which should be an inspiration to all people”⁴.

Indiana Seminary-College-University (1820, 1828, 1838): Indiana University evolves into a research university by early 1900s.

The third pillar of Indiana’s natural sciences foundation was creation of the Indiana Seminary in 1820 that became Indiana College, (1828) and, Indiana University, in 1838.^{14,15,111-113,248} At its founding, IU had 13 students, and, for the next 50 years, few students, faculty, and nil reputation. That changed under the leadership of Richard Owen, David Starr Jordan and President William Lowe Bryan, who, with a strong research background, himself, presided over the transformation of IU from a small liberal arts college into a research university by recruiting talented students, faculty and administrators.^{35-38, 59,82.}

David Starr Jordan, who was educated at Cornell and mentored by Louis Agassiz,^{124,125,127,129,183.} succeeded Richard Owen whom he said “... was the highest type of teacher, naturalist, scholar, soldier and man,” beloved by all.”⁸ After teaching at Shortridge High School and Butler University, Jordan, who became a preeminent biologist, physician, poet, philosopher, and a eugenicist, chaired the Department of Natural Science (1879-1891) until being named IU’s youngest President, in 1884.

Dr. Bryan oversaw creation of IU School of Medicine, in 1908, and the appointment of Dr. Charles P. Emerson, a Johns Hopkins trained physician whose mentor was the leading physician in North America, William Osler.^{84,85,161} For 20 years, Emerson morphed Indiana University School of Medicine from a trade school into a medical school and teaching hospital that focused on excellence in bed-side teaching, patient care, and research.

The foundations in natural science scholarship laid by Richard Owen (1860s,) were expanded by Jordan and Jordan's mentee and successor, Carl Eigenmann, (1863-1927) Chairman of Zoology, (1891-1927) and a preeminent evolutionary biologist.⁷⁷⁻⁸⁰ As the first dean (1894-1927) of IU's graduate school, Eigenmann, recruited leading faculty scholars for 33 years.^{77, 250} He hired the Harvard educated, gall-wasp taxonomist, Alfred Kinsey, whose evolutionary biology expertise was overshadowed by his work in human sexual behavior.^{115,131,132} No doubt Dr. Kinsey was a student of Yeats and Lucretius, ' *De rerum natura*.

In a historic action, Carl Eigenmann recruited Fernandus Payne (1881-1977) to IU, in 1909, as a fruit-fly cytologist and geneticist.¹⁰² An Indiana farm boy, Payne was educated at IU (1905-1906) and earned his doctorate degree at Columbia University, (1909) mentored by world- class researchers, America's first cell biologist, EB Wilson and T.H. Morgan, who created the fruit-fly (*Drosophila*) breeding lab to study genetic mutations and won the Nobel Prize. (1933)^{110,133,251,252} When Eigenmann died, in 1927, IU's Fernandus Payne became chair of Zoology and dean of the graduate school, building on the foundations of evolutionary biology laid by his predecessors, Richard Owen, Jordan and Eigenmann.

An IU Legend: Fernandus Payne:

Payne's legendary tenure at IU was 60 years; he retired at age 90. Born near Shelbyville, in 1881, in a log cabin, one of six children in a broken family, he lived in foster homes and taught school to earn IU's tuition.^{189,251,252} As dean of the Graduate School, (1927 -1951) Payne brought international acclaim to IU, recruiting world-class faculty in animal and plant genetics,^{42,220} successes aided by the preeminent and visionary university Presidents, William Lowe Bryan, (1902-1937) and Herman B Wells (1937-1962) whose leadership lasted for almost 100 years.^{40,241,242,250}

From Richard Owen's pioneering work, to Jordan, Eigenmann and Payne, the culture and practice of learning, teaching and research at IU were re-envisioned. Advances in teaching paralleled those in research; students and faculty engaged in both. Given Payne's research and administrative genius, it's fitting that, in 1953, after he had helped create (with Frank Edmondson PhD) the IU Department of Astronomy PhD program, the International Astronomical Union named an asteroid after him, "Fernandus (2496)", discovered at the Goethe Link Observatory near Brooklyn, IN. Dr. Payne's interests in science included genes and the stars.^{191,250}

Timeline for Genetics Discoveries:

IU's prominent genetics researchers witnessed the evolution of genetics and molecular biology in America, foundations based on mid 19th c. theories of Darwin and Mendel.^{24,32,55,154,156,157,245,249} The terms "chromosome", "gene" and "genetics" were coined. In 1900, Mendel's research of 1865, that was 'lost' for 35 years, was "rediscovered".^{55,56,156,213} The American, William J. Spillman, (1863-1931) was one of four scientists who confirmed Mendel's laws; his career was shaped in Indiana, at Vincennes University, where his mentor was Dr. Enoch A. Bryan, brother of IU's William Lowe Bryan.²¹⁸ In 1893, Enoch Bryan became President of Washington State University, recruited Spillman to join his faculty, where Spillman became a distinguished leader in American agricultural research, practice and economics.^{217,219}

The achievements of the scholars that Eigenmann and Payne recruited to IU included many (6) members of the National Academy of Sciences²²⁰ and four Nobel Laureates. Let me offer snapshots of "giants" among these researchers who would win the Nobel Prize in medicine: geneticists, Hermann Muller (1946), Renato Dulbecco (1975), Salvador Luria (1969); and James Watson (1962).^{110,232}

Muller: (1890-1967) IU 1945. Nobel 1946.

Hermann J. Muller (1890-1967) was born in New York City, in 1890, of part Jewish ancestry and is recognized as a founder of the genetic school of molecular biology.^{92,95,163-168,170,172,196} Like Payne, he received his Ph.D. at Columbia (1916) under the fruit-fly mutation expert, T.H. Morgan. Muller, described as a "5'2" science geek," proposed^{133,158} that he might speed mutation rates by exposing flies to bursts of energy. He proved his theory, in 1927: low- dose radiation increased gene mutation rates; genetics research and society were forever changed.⁷⁵ The idea that x-rays could change heredity stunned the public.^{98,165}

Muller's successes came despite his troubled personal life. Genetics research raised controversies, including eugenics, and Muller spoke publicly about its potential use and abuse. He said (1932), "eugenics might yet perfect the human race, but only in a society consciously organized for the common good."¹⁶² Without this, eugenics would be "the means for the powerful to control the weak." Muller's personality was often abrasive, his politics divisive. He edited an underground newspaper at the University of Texas that promoted then controversial topics: civil rights, voting rights for women, education and health care for immigrants.⁸³ The FBI labeled him a subversive; his work, marriage and faculty relations suffered.¹⁶⁹ As his research funding shrank, Muller left Texas (1932) for the Kaiser Wilhelm Institute; but, with Hitler's rise, Muller fled to the Soviet Union (1934) to direct genetics at the Academy of Sciences. But, Stalin threatened researchers and Muller escaped to Edinburgh, Scotland, then returned to America.¹⁷²

In 1945, dean Payne and his Hopkins trained geneticist, Tracy Sonneborn, recruited Muller to IU where Muller spent his happiest years.^{95,163,172, 197,215,216} His Nobel Prize came a year later and forever changed molecular biology and public health policies.^{167,242} Low- dose radiation was dangerous- exposure regulated. We owe the practice of shielding the gonads during medical or dental procedures to Muller.^{198,211,220,221}

Muller also advocated for control of nuclear weapons and sought to defuse threats of nuclear war; he was one of nine Nobel Laureates to sign (July 9, 1955) the Russell-Einstein anti-war peace manifesto.^{182a,202.} Indiana's Booth Tarkington was an outspoken supporter of controlling nuclear weapons,^{155,195.} and Senators Richard Lugar and Sam Nunn crafted their successful bipartisan Nunn-Lugar "Soviet Nuclear Threat Reduction Act" of 1991.^{22,120a.} Muller's advocacy of control of nuclear weapons was an idea echoed by the 1946 Nobel Peace Prize winner, Emily G. Balch, (1867-1961)^{17.} Who, with Nobelist, Jane Addams and Hoosier, Alice Hamilton, urged peace at the Hague, in 1915.^{3,104,120.} These women were among the first from America to warn of the rising fascism of Hitler, in the early 1930s.

Luria: (1912-1991) Nobel 1969

Salvador Luria was born in Turin, Italy, in 1912, into a Jewish family that suffered under fascism.^{144,147,148.} Luria became a physician (1935) but focused on radiation biology.^{143.} Under Mussolini's anti-Jewish "Racial Manifesto" (1938), Luria's family was protected by gentile friends. Luria fled to Paris, biked to Marseilles, under strafing from the Luftwaffe, and, escaped (September 1940) to America. Receiving a Rockefeller Foundation Fellowship, he came to IU (1943) because of its center of genetics led by dean Payne, who became Luria's research mentor. In 1946, 17- year old James Watson enrolled as Luria's first graduate student, studying the effects of radiation on bacterial viruses. Luria recruited Renato Dulbecco from Italy and they worked in collaboration with Watson and Herman Muller—all future Nobel Laureates.^{42.}

Luria's career spanned six decades of research, teaching and advocacy.^{145.} He received the Nobel Prize, in 1969, for research into the genetic structure of viruses. Luria's respect for his mentor dean Payne is shown in personal correspondence where he reflects on the "Payne Spirit ---the consciousness of being in the main path out of mediocrity, a feeling of appreciation for what is relevant and of impatience for what is trivial - in science and in administration."^{146,189,190,252.} Luria encouraged his students to read widely, not just in science. He taught a course in world literature, wrote essays on humanism, and won the National Book Award in 1974. (*Life: the unfinished experiment*)

Like Muller, Luria was committed to social and economic justice, reflecting his first-hand experiences with fascism.^{147.} When he won his Nobel Prize, the New York Times said his name was on the political blacklist of the National Institutes of Health. In his 1984 autobiography, Luria made this prescient comment, "...the world of science may be the only existing participatory democracy."

Renato Dulbecco (1914-2012) Nobel 1975

Renato Dulbecco, a classmate of Luria, studied medicine at University of Turin, and in 1942, served in the Italian army, was wounded in Russia and when Mussolini fell to Germany, he joined the resistance against the Nazis.^{65.} His brilliant research career began, in 1947, at IU with Salvador Luria, his mentor. Dulbecco's Nobel Prize came, in 1975, for his study of tumor viruses, one of the first clues to the genetic nature of cancer.^{66-70.}

In 1986, he called for the historic effort to sequence the human genome.⁶³ The pioneering Human Genome Project was completed in 2003.⁴³ Dulbecco advocated for using science to prevent threats to society. In his Nobel lecture, in 1975, he spoke of the dangers of human made toxins in the environment that can cause gene mutations leading to cancer.^{71,72} He urged regulations to discourage their use, lamenting difficulties in getting society to recognize their potential harm.⁶⁸ A gentleman and accomplished pianist, Dulbecco published research until he was 94.⁶⁹

Watson: 1962

James Watson (1928-) was born in Chicago, with a passion for birdwatching.^{232,233,236} At the University of Chicago his aspirations were in ornithology, but on reading Erwin Schrodinger's book, *What Is Life?* (1945)^{206,207} his interest in birds changed to genes.²³⁹

Physicist, Schrodinger, influenced by Muller's mutation research, thought genes carried a "code script" for the individual's development.^{207,213} Such ideas were supported by science in the lead-up to WWII- in mathematics, engineering, physics, biology, cryptography, computer science, and information theory.¹⁰³ RADAR (Radio Detection and Ranging Technology) was based on "information theory" used for tracking targets and for breaking German Enigma cipher codes at Bletchley Park. In 1948, Norbert Wiener coined the term "cybernetics" to denote regulatory systems in machines or cells, or genes which were believed to contain "information" in a molecular "tape" that could program the organism.^{103,240,243}

As Watson entered graduate studies at IU as a teen, Schrodinger's theory of "code script" and related research regarding human development, provided invaluable context for Watson's interests in DNA.^{47,48} As Luria's first doctoral student, Watson receiving his PhD in 1950, mentored by IU Nobel Laureates, Muller, Luria, and Dulbecco.^{67,68} Luria arranged for Watson to go to Cambridge University where he and Francis Crick collaborated to describe the molecular structure of DNA.²¹³ Watson, Crick and Wilkins reported their 'spiral staircase' structure of DNA, April 25, 1953.^{13,75,236} The global impact of this discovery- perhaps an echo of Emerson's "... shot heard 'round the world." (*Concord Hymn*)

In a footnote, Rosalind Franklin, a year earlier, (May 2, 1952) took an x-ray diffraction image of DNA, called, *Photograph 51*. Without her knowledge, this image was shown to Watson and Crick who quickly deduced that DNA had a helical structure.^{213,231} Watson, Crick and Wilkins received the Nobel Prize, in 1962.^{209,237,238} Franklin, who died in 1958 at 37, was eligible but did not receive the Prize. Some suggest she was a victim of the 'lone genius' myth perpetuated by the Nobel Committee's arbitrary 3-person rule.^{135,200,235} Franklin was also a victim of gender bias: she wasn't allowed in the lunchroom with her male colleagues, at King's College, London.^{90,162,231}

Watson's subsequent career was productive and controversial. He directed the NIH Human Genome Project proposed by his former IU colleague, Dulbecco, and Watson led the prestigious Cold Spring Harbor Laboratory.¹⁷¹ But, last year, when he was 90, the lab revoked his titles

because of his repeated racist statements.^{106,235} As his speaking invitations and income evaporated, he sold his Nobel Prize medal for \$4.1 million.^{214,234.}

Final Aim

My final aim this evening is to suggest how IU created a world-class genetics program and what's needed to sustain such excellence. Today's 'engines' of biomedical sciences are Academic Health Science Centers, (AHSCs) hospitals and universities, whose missions are quality research, teaching, clinical care and prevention of disease. There're about 120 such centers today in the U.S.^{30,44,74,159} In 1893, John's Hopkins created the first research, teaching and care, system in the U.S.^{5,7,89.}

Historically, world- class research universities have shared attributes: visionary leadership, a culture of high-quality ethical research and sustainable funding and public support. From the 1870s to the 1940s, IU developed these features through leadership and recruiting of top talent. The majority of the research leaders who guided IU's early advances were educated at world-class faculties: Columbia, Cornell, Johns Hopkins, Harvard, University of Chicago, and University of Pennsylvania, and top European universities. "Quality begets quality."^{42.}

U.S. News & World Report Ranking of research universities.

Today, IU and IUPUI and Indiana University School of Medicine are ranked in the top one-third of clinical biomedical research institutions in the U.S. and the world.^{175,226,227.} IU ranks in the top 9% of 1,500 research institutions in 81 countries; IU School of Medicine ranks in the top quartile of 600 institutions globally and among 185 (48/185, 25.9%) U.S. medical schools.

Lasker Foundation Awards and Nobel Prizes

Top university faculty members may receive prestigious honors: from the National Academies of Science (NAS), the Lasker Foundation and the Nobel Foundation. In 2018 and 2019, IU alums won the prestigious Lasker Award for research in epigenetics^{92,117.} and for development of the monoclonal antibody (Herceptin) against a gene causing breast cancer.¹¹⁶ IU's Nobelist (1975), Dulbecco, was one of the first to research tumor viruses and the genetic material of the cell.⁶⁶⁻⁷⁰

The Nobel Prize in medicine has been awarded to only to 219 researchers in the world since 1901.^{178.} The U.S. leads the world with 93,^{192.} Harvard with 43. In the Midwest, University of Chicago leads with 12, University of Michigan 6, and University of Minnesota and IU, each 4.^{178.} At least one of IU's recent Lasker winners will likely win the Nobel Prize. The Nobel Committee chooses awardees based on whether research is original, captures the imagination, stands the test of time and changes how the scientists think about their field.^{135.} The Nobel Prize has critics: lack of diversity in gender, race and geography. Twelve (5.5%) of 216 winners in medicine have been women.^{88,153.}

As an aside, at my alma mater, University of Texas Southwestern, Dallas, Dr. Donald Seldin, a visionary researcher-administrator, built research foundations at a new school of medicine and, within 35 years, it was one of the top medical research universities in the world: six Nobelists in medicine, since 1985.^{23, 28,28,135,175,228,229,230} Fernandus Payne from IU and Dr. Seldin shared attributes: they were original thinkers, charismatic teachers and mentors, and brilliant administrators, who became magnets for top quality students and faculty; to them excellence was not an act but a habit.⁷³ It took about three decades to cultivate the soil for top quality medical research at these institutions. Payne and Seldin careers spanned six decades; both retired in their 90s.

Threats to Discovering 2020

The societal benefits of biomedical research are incalculable. Twentieth c. health, especially post- WWII, has improved with advances made with investments by government and the private sector, coupled with science and evidence-based public health policies.¹⁷⁴ But, today, disparities exist in healthcare and public health; U.S. longevity rates have decreased compared with other higher income countries.^{1,2,9,12,31,203} The pressing threats to sustaining excellence in clinical biomedical research and public health include:

1. Decreased federal NIH research funding. (share of GDP today --12% below 2003).
^{9,23,177,222,225.}
2. Complex, and often dysfunctional, financing of health sciences and services.
3. Recent underperforming of university endowments.^{45,46,118,177,228.}
 - a. IU endowment \$2.39 billion; IUPUI \$ 852 million---U TX SW \$1.01 billion (2017)
 - b. IU Ranks 17th in U.S. endowment in public universities but is 7th among Big Ten Schools: 1. U TX (system) \$30b; 2. TX A&M \$13b; 3. U MI \$11b; 4. U CA \$11b; 5. U VA \$6b; 6. Ohio State; \$5b; 7. Penn. State \$4b; 8. U Pitt \$4b; 9. U MN \$3b; 10. U NC \$3b; 11. U WI \$2.9b; 12. Mich. State \$2.9b; 13. U WA; 2.7b; 14. U Ill \$2.6b; 15. PU \$2.5; 16. UCLA \$2.5b; 17 IU \$2.39b.¹¹⁸
4. Anti-Immigration policies.^{134.}
5. The perplexing and perilous anti-rule-of-law, and anti-science beliefs and actions in society and government.^{179.}

These trends erode America's century of global leadership in advancing the health sciences.
^{45,46,177.} We need to better communicate the societal health and economic benefits of sustaining excellence.^{16,203.}

Conclusions:

Anthropologist, Davis, cited the photo, *Earth Rise* and the discovery of DNA as demonstrating our truth-seeking nature. Today, six decades after these discoveries, we've witnessed unprecedented advances in the science of space and molecular biology: The *New Horizons* space

probe launched 2006 by an Atlas V rocket, found and photographed *Ultima Thule (extreme limit of discovery)*, thirteen years later, Jan 1, 2019, a 21- mile-long object (contact binary), 4 billion miles from Earth, the farthest spacecraft contact in human history. ¹⁷³.

And, in molecular biology, recent gene-editing technology, called CRISPER, a ‘molecular scalpel,’ allows correcting gene mutations, as anticipated by Hermann Muller, ^{53,167,182a}. and has applications in life-threatening genetic diseases, organ transplantation, production of disease and drought resistant crops and biofuels. While men have long dominated genetics research, two women created CRISPER technology, Dr. Emmanuelle Charpentier, graduate of Pasteur Institute (Paris) and Omea University in Sweden and Dr. Jennifer Doudna (Dowdna) from University of California Berkeley. (2012) ^{53,97,194,208,249}. They will likely be considered for the Nobel Prize.

The discoveries of *Ultima Thule*, in outer space and the molecular, *CRISPER*, in ‘inner space’, reflect the creative and urgent needs of humans to seek truth through discovery, the need to separate fact and fiction, always leavened with values, defined by science humanist, Jacob Bronowski, as “those deeper illuminations in whose light justice and injustice, good and evil, means and ends are seen in fearful sharpness of outline.” ²⁹.

The story of how Indiana University created, in the 19th and early 20th c., a world- class program in molecular biology should stir pride among Hoosiers young and old. ^{38,57,76,91,197}. Today, in deeply troubled and uncertain times, can Indiana and America sustain rich traditions in discovering as intended by our Founding Fathers, where guiding principles of intergenerational equity were valued--one generation using tenets of democracy, including the rule of law and values of science to advance civilization, to promote the health, wealth and quality of life for citizens and the planet. ^{50a}.

James Madison and Thomas Jefferson left us their practical and wise counsel: “the advancement and diffusion of knowledge is the only Guardian of true liberty....” ^{152,201}. The scientific humanist, Jacob Bronowski, echoed this idea, stressing the “the habit of truth,” a fundamental for advancing civilization, “always minute yet always urgent”, always asking, “Is this so?” ²⁹.

End

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Discovering the Nature of Things

Essayist Stephen J. Jay M.D.

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- **Thomas Borlik**, Indiana Astronomical Society Historian, Goethe Link Observatory Historian provided excellent information regarding IU persons involved with the donation of Goethe Link Observatory to IU in 1948, including J.A. Franklin, IU Treasurer at the time.
- **Angela Courtney**, Head of Arts and Humanities, Librarian for English and American Literature Librarian Arts & Humanities, Herman B Wells Library. Indiana University offered assistance in locating Herman Wells' correspondence related to IU genetics and molecular biology development in the early -mid1900s and his leadership in recruiting world- class scientists in biology, genetics, molecular biology and related fields.
- **Kellie Kaneshiro**, Assistant Director, Library Technology, Indiana University School of Medicine Ruth Lilly Medical Library, provided information, Feb 26, 2019, regarding Mary Ann Gardner's (1928-2010) gift to IUSM Lilly Library of a TC Steele painting and personal letter from Steele to Goethe Link MD, thanking him for caring for Steele's son. A pioneer in medicine and natural sciences, Dr. Link contributed to the founding of IUSM and donated his Goethe Link Observatory, built 1937-1939 near Brooklyn, IN, to Indiana University in 1948, with support of IU's prominent Harvard educated astronomer, Frank K. Edmondson, dean Fernandus Payne and IU President, Herman Wells.
- **Phillip A. Gardner M.D.** March 2, 2019, kindly provided personal reflections on the Gardner family's close relationship with Dr. Goethe Link and his wife, Helen. Phillip Gardener's father, Austin Gardner, M.D., a well-known Indianapolis surgeon, performed surgeries with Goethe Link MD (1879-1981), a preeminent surgeon, pioneering aeronaut, and amateur astronomer whose life-long passion was medicine and the natural sciences. Dr. Austin Gardner and other prominent Hoosier medical leaders in Indiana acknowledged Dr. Goethe's remarkable life, in the Journal of the Indiana State Medical Association, July Vol 63; 1970. Dean Fernandus Payne and Frank K. Edmondson PhD, created the first doctoral program at IU Department of Astronomy, after Dr. Link donated his observatory. The Indiana University Asteroid Program received recognition from the International Astronomical Union when they named (with input of Dr. Frank Edmondson) an asteroid, "2496 Fernandus", after dean Fernandus Payne, on Oct 8, 1953, at the Goethe-Link-Observatory, in Brooklyn Indiana. Although an internationally known leader in genetics, Payne played a leading role at IU in all science-based departments, including astronomy.
https://archive.org/stream/journalofindiana632unse/journalofindiana632unse_djvu.txt.

- **Dina Kellums**, Director Wells Library E460, Bloomington, IN, provided excellent information regarding IU Archives collections and specific information regarding the Robert Owen family's interactions with IU. Collection sources regarding New Harmony history, researchers' correspondence with IU leaders were identified. Also, Ms. Kellums noted sources of documents regarding mid-late 19th c. IU evolutionary biology curriculum, and in addition, archival information regarding President Wells' involvement in recruiting top biology researchers to IU. While only a small sample of this information could be reviewed, it shows that New Harmony scientists, including Owen family members, were influenced by world thought leaders such as Darwin, Wallace and Lyle. Richard Owen pioneered the reshaping of IU's science curriculum, in 1964, reflecting new thinking about Darwin and evolutionary biology.
 - **Becki Leibolt, Purdue University Library Archives and Tyler Gause, Purdue University Copyright Office**, Purdue University Libraries, kindly provided me (December 2019) a previously out-of-print book, (The Archives of Purdue March 1946) a biography of Richard Owen (Scotland 1810, Indiana 1890) by Professor of History, by Victor L. Albjerg who was a Purdue University faculty member from 1926-1962.
 - **Ryan Rokicki, Executive Director, Working Men's Institute, New Harmony**, Indiana, April 20, 2019, kindly helped me decipher a hand-written letter from the preeminent scientist, Louis Agassiz, to Richard Owen, at New Harmony. The letter is about Agassiz and Richard Owen's interest in turtle embryology. The letter is dated ? Jul 1855, From Cambridge, Mass. to New Harmony, IN.
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Below are general non-technical references. A complete list of references (no. ~250) is available. Please contact me and I will provide a digital list that includes scientific papers, scholarly books, interviews, essays; news clips, audio links and correspondence.

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End Essay, Acknowledgments and References:

Discovering the Nature of Things.

Indianapolis Literary Club, January 21, 2019

Essayist: Stephen J. Jay M.D.