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COMMENT

The long reach of Hermann J. Muller: How Muller influenced the development and content of secondary school biology curricula

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ABSTRACT

The Cold War provided incentive for radiation geneticists from the United States (U.S.) to offer guidance on scientific/public health issues. A notable case involved the U.S. National Academy of Sciences (NAS) recommendations concerning radiation-related heredity/cancer risk assessment, which have guided regulatory agencies from the 1950s to the present. A neglected, generally unknown, yet important strategic direction, involves influence exerted over the development of secondary school biological education programs in the U.S. With U.S. federal government funding, the American Institute for Biological Sciences (AIBS) led the development of a major revision of secondary school biological sciences' curricula, called the Biological Science Curriculum Study (BSCS), with the first education product widely adopted in 1963. The BSCS textbook content was directed by Arnold Grobman and Bentley Glass, leaders of the academic genetics community, especially those who participated in the Manhattan Project and the NAS Genetics Panel and how they engaged the involvement of the Nobel Laureate, Hermann Muller, to transform the actions of the BSCS committee to create an educational framework in which evolution was the overriding and integrative theme. Muller would ensure that the BSCS curriculum was based on the Dobzhansky rubric that "Nothing in biology makes sense except in light of evolution." Muller also led these geneticists in a failed attempt to integrate "reform" eugenics principles and practices into the BSCS curriculum While Muller's influence on hereditary/cancer risk assessment has been extraordinary, his role in framing what biology students were taught, and how it would influence their concept of life, beliefs about humanity's place in the universe, and how humans could or should direct their evolution, has remained largely unknown.

KEYWORDS
Biology curriculum; BSCS; eugenics; evolution; genetics; science education

Introduction

The Biological Sciences Curriculum Study (BSCS) project was directed by the American Institute for Biological Sciences (AIBS), a coordinating organization for a large number of professional biological societies in the United States (U.S.). In 1955, some two years before the launching of the Sputnik satellite by the Soviet Union, the AIBS created a Committee on Education and Recruitment. Within a year, members of this committee identified as top priority the need to reform high school biology education. During this period, Bentley Glass served as president of the AIBS, and Hidden Cox was the executive director. Oswald Tippo,[1] then a professor at Yale University, was chair of the Education Committee and is recognized as creating the BSCS initiative (Anonymous 1959; Bybee 2001). The U.S. National Defense Education Act of 1958, which was established in response to Sputnik, provided funding to the National Science Foundation (NSF) that supported the AIBS BSCS project.

Timing was important in the success of the BSCS initiative. The AIBS approached the NSF for funding of a major revision of biological education curricula for high school students about one year after the NSF had been "preconditioned" in this area by having supported similar, but more limited efforts, in the physical sciences and mathematics.

The key to the laser-like focus on evolution for the BSCS curriculum was largely determined by three individuals: Arnold Grobman, Bentley Glass and, most importantly, Hermann J. Muller, a de facto collaboration that was considerably advanced by Muller's

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longstanding professional and personal relationship with these two highly compatible administrative, scientific, and ideological BSCS leaders. Furthermore, Muller was unique, being the titular head of the radiation genetics community in the U.S., a Nobel Laureate, and something of a social activist. He also had profound evolution-related research interests that were pivotal to the principles of eugenics[2] (Carlson 1981). Of considerable importance is that Muller exercised a dominating, intimidating, and unrelenting personality style to advocate his scientific beliefs and societal priorities, as noted by his biographer and former graduate student (Carlson 1981), close friends such as James Crow (1989), and many others who knew Muller well. These personality traits, honed over a long professional lifetime, were applied to the BSCS initiative. In many respects, Muller had waited opportunistically to change biological education in the U.S., and at this point, had instrumental individuals in place and funding necessary to articulate his vision. In essence, the professional collaboration became a tripartite cabal, certainly with important help from others, but clearly under the personal and administrative leadership of Muller.

Due to the principal role of the three key individuals in the development of the BSCS curriculum, this paper will be framed within the context of their personal and professional lives and how this curriculum was driven by these three leaders. It will be initially shown how each of their individual educational and work experiences leads to their group collaborations and synergies in the creation of the BSCS curriculum, with its strong integrative focus on evolution. The article then tries to capture how the concept of evolution was considered within the development of the BSCS curriculum and the key role of Muller to demand and rescue the evolution framework from its being watered down by the various curriculum committees to ensure its dominant role in biological education and how he was supported by Glass and Grobman. The evolution curriculum of Muller was also intended not only to be the fundamental conceptual construct for the biological sciences but also the vehicle to introduce and integrate the concept of eugenics within the curriculum. How this was attempted, the controversies that it entailed, and the eventual failure to explicitly integrate eugenics into the BSCS curriculum will be assessed.

The Arnold Grobman connection

University of Florida biology (i.e., herpetology) Professor Arnold Grobman was hired by the AIBS to become the Director of the BSCS program. This BSCS project started in early 1959 at the University of Colorado at Boulder (Green 2012). It is important to appreciate how Grobman became involved with Muller and radiation-induced mutations, as this professional collaboration would transform his strategic framework for the development of the BSCS secondary school biological sciences curriculum. Grobman and Muller both shared a common relationship to Curt Stern, professor of genetics at the University of Rochester, and co-participant in the Manhattan Project. Stern was also the Biology Department's Graduate School administrator, overseeing a number of Grobman's academic activities. Likewise, Stern was Muller's close professional associate, and it was Stern who obtained permission from the Atomic Energy Commission (AEC) to hire Muller on the Manhattan Project, despite Muller's communism-supportive views and his leaving the U.S. to reside in the Soviet Union from 1934 to 1938. Grobman was awarded his Ph.D. from the University of Rochester in 1943 for studies of salamander biology. That same year, Grobman was hired to teach anatomy and physiology to naval recruits at the University of Rochester as part of the war effort. The timing was such that the U.S. AEC was initiating a large-scale research effort as part of the Manhattan Project at the University of Rochester under the initial leadership of Stafford Warren. Stern would become one of the project leaders in radiation-induced gene mutation (Calabrese 2019). By the spring of 1944, Grobman transitioned from teaching anatomy to working full time on the effects of ionizing radiation on mutations in mice, under the direction of Stern's colleague, geneticist Donald R. Charles. Grobman was hired for the Charles' project due to his knowledge of comparative anatomy, although he had no experience with radiation, genetic damage/mutations, murine genetics, or reproductive biology. In 1943, Hermann J. Muller, then a professor at Amherst College, joined the Stern research group as a paid consultant to his Manhattan Project research. The Stern and Charles groups were familiar with each other, and professional and personal relationships developed during the Manhattan Project research period. Grobman would again meet Muller in 1946, as both became founding members of the Society for the Study of Evolution. Grobman would subsequently reconnect with Muller in 1951 with a detailed letter exchange; he ultimately convinced Muller to write a promotional review of his book, *Our Atomic Heritage* (Grobman 1951), which was based on the Charles led research from the Manhattan Project that supported

Muller's linear dose response for radiation-induced gene mutation (Calabrese 2019). Grobman would eventually leave the University of Rochester to become an assistant professor of biology at the University of Florida, soon after the conclusion of World War II, and later became director of the Florida State Museum in 1956. Several years later, he was hired to be the director of the BSCS program (Green 2012).

The Bentley Glass connection

A crucial event in the BSCS project was the appointment of Johns Hopkins University professor Bentley Glass as Chair of the BSCS Steering Committee to provide leadership to the writing, evaluation, and promotion of the project's textbook products. Of considerable, yet generally under-appreciated importance to the tenor of this enterprise, is that Glass had undertaken doctoral studies under Muller's mentorship at the University of Texas at Austin. Glass received his Ph.D. in 1932 at a time when Muller was experiencing considerable criticism and pressure from the University of Texas administration for his leadership of an illegal student organization that was revealed by the FBI to be a front for the U.S. Communist Party (Calabrese et al. 2025).

With Muller's help, Glass was awarded a National Research Council Fellowship for postdoctoral studies in Europe (Erk 2005, 2009). Glass originally planned to work with Curt Stern in Berlin, but this fell through as Stern refused to return to Berlin following the International Genetics Congress in the U.S. (i.e., Cornell University) in August 1932 due to the rising antisemitic sentiment in Germany at the time. Muller intervened and secured a post-doctoral position for Glass with Otto Mohr in Norway. Mohr would later become one of the nine individuals who nominated Muller for the Nobel Prize, which he received in 1946 (Calabrese and Shamoun 2025). Muller then arranged for Glass to join him at the Kaiser Wilhelm Institute in Berlin, where Muller was working within the Timofeeff-Ressovsky's genetics program (Erk 2005).

Muller's assistance to Glass during his formative years as a doctoral student and subsequently during his early postdoctoral training resulted in Glass exhibiting great loyalty to Muller, as evidenced by their numerous subsequent associations. Glass and Muller would serve together on different national and international committees, including the U.S. NAS BEAR I Genetics Panel (from 1955 to 1964). This Panel was significant as it developed recommendations that the U.S. government should change from a threshold-based to a linear dose response model for radiation hereditary effects and cancer risk assessment, a recommendation that was then adopted by government regulatory agencies in the U.S. and many other countries (Calabrese 2019).

After working in Berlin, Glass returned to the U.S. and assumed a second postdoctoral position at the University of Missouri for about a year before entering the academic job market. He ultimately accepted a position at Stevens College, a women's junior college in Missouri, in 1934, due in large part to the paucity of academic jobs available during the Depression era. During this period of employ, Glass would try to stay professionally active in scientific research, working with Lewis J. Stadler at the University of Missouri on studies examining whether X-rays could produce genetic translocations by simultaneous chromosome breakage and reunion or whether chromosome breakage was followed by a reunion of broken ends only after a certain time interval had occurred (Glass 1944). Notably, no publications were produced from these efforts. After 4 years at Stephens, Glass moved to Goucher College in Baltimore, Maryland, a 4-year women's undergraduate institution where he would remain for about nine years. Since the first 13 years following his postdoctoral training were spent in non-research, teaching appointments, it might be assumed that a high-level academic career had passed Glass by. Yet, unexpected circumstances would create novel opportunities for Glass.

While at Goucher, Glass regularly attended biology seminars at Johns Hopkins University. In so doing, he became friendly with Johns Hopkins professor Raymond Pearl, a leader in the U.S. eugenics movement and founder of *The Quarterly Journal of Biology* (*QJB*), Glass's favorite professional journal while a graduate student. Pearl died in 1940, and his wife sustained the journal's activities until a new editor was appointed. This editor was Benjamin Willier, an embryologist and chair of the biology department at the University of Rochester. Upon his new appointment as editor of *QJB*, Willier became the Biology Chair at Johns Hopkins. Glass would become the assistant editor of the *QJB*, working directly with Willier. Eventually, some seven years later, Willier hired Glass at Hopkins. This would enable Glass to transform his career at the age of 41. With the prestige of John Hopkins University and proximity to Washington, DC, Glass was afforded routine interactions with personnel from federal agencies, such as the NIH and AEC, and organizations such as the U.S. NAS/AIBS, the editorial staff of the journal *Science*, and other influential professional groups with whom he would develop strong professional ties. These opportunities would overcome Glass's rather modest research record (i.e., a career H-index of only 16[3]). Glass was able to become a senior editor at the journal *Science* in 1948 and became acting Editor-In-Chief in 1953. In addition, he became a member of the AEC advisory committee for radiation and a member of the NAS BEAR I Genetics Panel. The latter appointment may have been related to the fact that the AIBS was a quasi-creation of the NAS, with Glass being the executive director of the AIBS. To be sure, such professional connections were critical, if not fundamental, to the sustaining of Glass's career growth and success.

It is important to note several influential factors relating to evolution, eugenics, BSCS, and Glass's professional life story. While at Stephens College in 1934, Glass was appointed to the Union of American Biological Societies' "Biology in Secondary School Committee." This committee was chaired by Oscar Riddle, a strong advocate of eugenics who worked at Cold Spring Harbor under the direction of Charles. B. Davenport, one of the most notable American eugenicists (Brown 1942; Green 2012). In 1942, the Glass committee published a report entitled *The Teaching of Biology in Secondary Schools of the United States: A Report of Results from a Questionnaire* (Riddle et al. 1942). This was significant in that it identified the critical need to integrate evolution into high school biology curricula to a far greater extent than had previously been the case. The report indicated that "evolution is taught in notably less than half of the high schools. Even when 'taught', this principle is frequently diluted beyond recognition or it is so joined to traditional beliefs as to preclude a new ripple of thought" (Green 2012). This report would also be cited by Muller in his rather controversial paper entitled: *One Hundred Years Without Darwinism Are Enough,* which was first presented to an audience of science teachers in Indianapolis, Indiana, on November 28, 1958 (Muller 1959).

During this period, Glass attempted to reinvigorate his genetics research, publishing his first paper on the effects of X-rays on 10-hr-old fruit fly embryo somatic cells, with emphasis upon the induced effects of bristled protrusions at the center of the eye. The research was conducted at Cold Spring Harbor with his former advisor, Muller, providing the fruit fly eggs for the experiments. While this was Glass's only research paper during the decade of the 1940s, during the 1950s, he subsequently developed a modest research program focusing on the effects of radiation on genetic alterations in fruit flies and produced several publications on high-dose X-ray-induced translocations.

Glass joined Grobman as chairman of the Curriculum Study Group in the BSCS (later called the Steering Committee), to ensure AIBS control of the project, as Glass had long been the AIBS executive director, and eventually became its first president (Rudolph 2002; Erk 2005). Glass also had a longstanding professional relationship with the president of the NAS, Detlev Bronk, whose organization had provided continued administrative/financial oversight and office space for the AIBS. Moreover, as a senior editor of the journal *Science* and Editor-In-Chief of the *QJB*, Glass was strategically positioned to further promote the BSCS initiative (Erk 2005, 2009).

The beginnings of BSCS

During this time (1958–1959) of BSCS startup activities, there was much celebratory preparation for the 100th anniversary of the publication of Charles Darwin's *Origin of the Species* with an impressive 5-day program of events being held at the University of Chicago in November 1959, which conjoined a virtual "who's who" cadre of American geneticists. The program also invited high school biology educators from across the U.S. to attend the celebration as part of an overall strategy for biology educational reform, with a keen curricular emphasis upon evolution (Green 2012). Indeed, these activities were significant to the BSCS curriculum strategy, as they highlighted the important research and educational roles that geneticists play in science and society. It also directly provided a nexus for the de facto celebration of evolutionary (and implicitly eugenic) principles with academic leadership of US secondary schools, thereby providing a viable vector for inculcating adolescents in the U.S., and, given the U.S. prominence in global educational trends at the time, very likely more broadly elsewhere.

The genetics community was in a position to put its stamp of endorsement and direction both on cancer risk assessment and the scope and flavor of biology education at the secondary school level in the U.S. (if not worldwide). They were determined that evolution needed to be the central core, fundamentally underpinning the mantle of biology education (Glass 1958, 1967). While seemingly benign, if not appropriate at face value, this served a broader educational goal, as this also afforded opportunity to indoctrinate students on a science of biology that emphasized that humans need to control the direction and rate of evolution via intentional practices of eugenics (Green 2012). Philosophically, there was the seemingly evident intent that the teaching of evolution would be free of religious or quasi-religious elements (e.g., discussions of intelligent design). However, the BSCS curriculum also offered leaders such as Glass and Muller a venue for a more subtle form of proselytizing in practice, namely, a chance to change how the world thinks about life, its meaning, and human capability (Rudolph 2002; Green 2012), if not the need to direct its course toward identified social ends.

Muller and evolution, heredity, and cancer risk assessment

Over the past 15 years, several papers have been published on the historical foundations of hereditary and cancer risk assessment, elucidating activities of the radiation genetics community starting nearly a century ago in 1930, when Muller first proposed a "Proportionality Rule" to describe a linear dose response for ionizing radiation-induced gene mutation. The Proportionality Rule would be transformed into the linear non-threshold (LNT) dose-response single-hit model for cancer risk assessment (Timofeeff-Ressovsky et al. 1935). Of considerable importance for enhancing these developments was that Muller received the Nobel Prize in 1946 for being the first to induce gene mutation based upon his prior work in fruit fly models with high doses/dose rates of ionizing radiation.

Muller strongly influenced the radiation genetics community's challenge to the longstanding use of the threshold model, although the LNT model has recently been debated and contested (Calabrese 2017, 2019, 2022a, 2022b, 2024). These recent debates have challenged prior recommendations of the U.S. NAS and decisions by the U.S. EPA to adopt the LNT perspective in risk assessment.

Detailed investigations of the scientific foundations of Muller's Proportionality Rule revealed that it was based on his understanding of evolution and the role of mutation and natural selection in what would later become integrated with the so-called "modern synthesis" for evolutionary mechanisms (Green 2012). In addition to Muller's strong research interest in evolution and mutation and their applications to risk assessment, the use of Mendelian-based genetic principles to minimize genetically based diseases and enhance biological performance in animal models and humans was becoming popularized as a positive aspect of eugenics. From the mid-1910s, many U.S. colleges and universities began to offer courses in eugenics. Indeed, eugenics was strongly embraced by many in the genetics community, including Muller (Calabrese and Shamoun 2025). However, over time, the more aggressive and race-based aspects of the early eugenics movement were significantly tempered. Muller (1936) was one of the international leaders of this "reformed" eugenics movement, publishing an influential book in 1936 entitled *Out of the Night* and drafting a major paper published in *Nature* in 1939 that is often referred to as the "Eugenics Manifesto" (Crew et al. 1939). Following the end of World War II, the discrediting of the National Socialist regime's bastardized eugenics brought the negative—if not nefarious—dimensions of radical eugenics into stark relief. Nevertheless, Muller and many of his colleagues would continue to promote applications of eugenics (e.g., germinal choice), and eugenics concepts and their social and scientific utility remained a passion for Muller until he died in 1967. Muller vociferously advocated for the establishment of sperm banks for intellectual elites to purposefully foster and enhance what he believed to be a genetic basis for intelligence within the human population (Carlson 1981).

While Muller had considerable success in influencing the environmental and policy communities' views and postures on cancer risk assessment (Calabrese 2019), his interest in, advocacy for, and leadership in eugenics has generally not been acknowledged or regarded, as these actions and related publications have been ridiculed and excoriated in several institutional settings to date (Hales 2024) and thus stand in notable contrast to Muller's other, more well-known scientific achievements and accolades.

When Muller received his Nobel Prize immediately after World War II, none of the nine individuals who nominated him from 1932 to 1946 had expertise in his area of radiation-induced gene mutation and thus were—at least by their apparent *bona fides*—not well-positioned to properly evaluate his research. However, most of those individuals *were* highly committed eugenicists. As a matter of fact, the Nobel Prize committee, as well as the Nobel voting membership of the Karolinska Institute, were dominated by acknowledged eugenicists (Calabrese and Shamoun 2025). These observations suggest that Muller's awarding of the Nobel Prize may have been influenced, at least in part, by his international leadership in reform eugenics, such that his Nobel Prize award might be seen as an implicit nod to promoting a form of eugenics (Calabrese and Shamoun 2025).

A doctoral dissertation by Green (2012) suggested that Muller had a substantial impact on the scientific education of secondary school teachers, which was based on his philosophy to advance evolution and eugenics teachings within the secondary school curriculum. This generally unrecognized aspect of Muller's professional life ranks among his most significant—albeit problematic, if not frankly negative—achievements, as this has directly affected the education of all students over the past 60 years, not only in the U.S. but in many countries worldwide. The present paper extends the earlier work of Green (2012) by integrating the Green's research focus with the historical foundations of cancer risk assessment, wherein the professional careers of key leaders of the BSCS project converged to become scientifically and professionally unified, thus enabling the BSCS project to adopt a framework that ensured the centrality of evolution (and with it, implicit, if not explicit, eugenics ideas and ideologies) in secondary school biological sciences curricula.

Muller's activities in BSCS

By 1960, Muller was in the last decade of his life, and he eventually died of a debilitating cardiac condition on April 5, 1967. Yet, the influence of his work was far from over, and in some respects, it was just beginning. On November 18, 1960, he accepted an invitation from Grobman to join the BSCS Steering Committee.[4] Muller recognized the potential significance and value of this opportunity and sent Grobman his recent paper entitled: "*The integrational role of the evolutionary approach throughout education*" as soon as it was published (Muller, April 12, 1960). In this essay Muller confidently claimed that evolution is the central principle in both the life sciences and humanities and rather ominously stated that if humanity is to succeed, it must take evolution into its own hands—a strong indication of his desire to further advance his so-called "reform" eugenics practice to be at the forefront of educational endeavor, and in this way, bear iteratively increasing and generational social influence.

Muller's view obtained an integration of cosmic, biological, and cultural evolution, which sought to create a "unified truly modern worldview." Upon reading the paper, Grobman obtained 40 reprints from Muller, which he then distributed to the Steering Committee members and senior leadership of the BSCS program (Green 2012). In so doing, Grobman (1960) solidified his support of Muller's views, a stance corroborated by Glass, who emphasized that "I am, at the philosophical level, in full agreement" (BSCS 1961).

Importantly, the AIBS' two academic leaders' professional paths and personal relationships converged with Muller. Thus, the two most prominent figures in the AIBS (i.e., Grobman and Glass) would embrace Muller's visions and viewpoints in the development of the secondary schools' biological sciences curriculum.

Muller to the "rescue"

Just two and a half months after joining the BSCS Steering Committee, Muller, now a full-fledged BSCS member, attended the Fourth Meeting of the Steering Committee on February 2–3, 1961 (BSCS 1961). During that meeting, Muller evaluated drafts of three newly proposed BSCS versions of biology textbooks, each of which had a somewhat different and distinct thematic focus and emphasis (i.e., "Yellow" being focused upon cellular processes; "Blue" upon molecular mechanisms; and "Green" addressing ecological systems and factors). Muller was quite disappointed that each of these drafts inadequately articulated and detailed constructs and concepts of evolution, which he vociferously asserted as crucial to the BSCS. It appears that Muller was eager to air his concerns early in the first meeting he attended, as shown by the meeting's minutes (BSCS 1961, 4).

According to Rudolph (2002), even though there was strong consensus to include evolution in the BSCS curriculum, there was considerable vocal dispute concerning optimal strategies for how this should be accomplished. With debate simmering and unresolved, Muller exercised his considerable prestige to directionally resolve the dispute during the February 2–3, 1961, meeting of the BSCS Steering Committee. Toward such ends, Muller stated that he was "disappointed to find the evolutionary thread missing in the versions appearing so far." He expressed deep dissatisfaction that the evolution principle was thus minimized to the point of becoming essentially an afterthought. Muller argued that the evolution principle "should come at the beginning, all the way through and again at the end" (BSCS 1961). Muller was concerned that the curriculum group was losing its way, and missing the big picture of biology, if not life itself, and that evolution needed to be seen as "the trunk, the bottom, the top and everything" (BSCS 1961). According to Muller, the BSCS curriculum would be a failure if it did not convey this core importance of evolution to both teachers and their students. Muller specifically highlighted the "green," ecologically focused draft version of the textbook, which had not introduced the evolution concept until chapter nine. Muller emphatically stated that this was "too late" (BSCS 1961).

During this face-to-face meeting of the Steering Committee, Muller was insistent that evolution needed to be the fundamental, integrative, and central theme of any of the respective textbook versions. Muller was frustrated and tried to project influence based on his prominence in the global scientific community as a Nobel Laureate. Muller did not appear to appreciate that the writing of each textbook was a collaborative effort undertaken by 13 to 15 individuals, a multidisciplinary cadre of college professors and high school teachers, which required multiple drafts, dispute resolutions, and numerous compromises, surely not easy tasks, nor cavalier endeavors (Rudolph 2002). Glass tried to placate dissent, stating that "evolution theory depends upon genetics and until genetics was introduced it seemed difficult to introduce evolution. This is one place where the theme had to be woven from the beginning" (BSCS 1961). This sentiment was strongly supported by Grobman. Yet, the unrelenting Muller would argue that the only foundational biological theme is evolution, reiterating his claim that it stands as "the bottom, the top and everything" relevant to life (BSCS 1961). Muller, in effect, told the Steering Committee and writers what had to be done, that any additional explanations were merely excuses, and that the delays they incurred were not acceptable.

Muller's perspective had a profound influence on the other biologists at the Steering Committee meeting, and the Committee acted promptly to correct its focus upon the evolution concept, in favor of Muller's version, which was robustly and publicly endorsed by Bentley Glass, the group leader. In an apparent effort to please Muller, Glass became so enthusiastic with his former mentor's perspective that he proposed creating a fourth textbook version to complement the other three versions' molecular, cellular, and ecological perspectives (BSCS 1961). Glass's idea for a separate textbook focusing entirely on evolution was, of course, endorsed by Muller (BSCS 1961). However, Committee members argued that such a version based on evolution may affect and reduce the evolutionary subject content in the other versions. In the end, the committee held fast to the original proposal of three versions of text, voting 22-0 against Glass's motion. Of note is that the Committee also voted to revise each version in accordance with the unifying evolutionary framework espoused by Muller.

Muller keeps the evolution "pressure" on

After the critical February 2–3, 1961 Steering Committee meeting, Muller continued to emphasize his ardent argument for the primacy of evolution in secondary biological science education by sending reprints of four of his articles and an accompanying letter to each of the textbook writers (see February 23, 1961 letter from Muller to the writers [Muller 1961a] and letter to Grobman March 3, 1961 [Muller 1961b]). The articles were entitled: "Life," "Evolution by mutation," "Evolution and genetics," and "Genetic nucleic acid: the key material in the origins of life," and the letter was Muller's attempt to offer a compelling statement by appeal to his authority. In essence, the letter informed the BSCS textbook writers that Glass, then chair of the Steering Committee, was fully supportive of his recommendations for the BSCS curriculum (without telling the group that he had been Glass's graduate school advisor). Muller was so insistent and uncompromising in advocacy of his position that he made the impassioned request that: "The genetic-evolutionary point of view should be presented as the central theme, or trunk, preceding and running through all the other topics of biology, interconnecting them and providing a unifying interpretation of them." The consensus of the February 2–3, 1961, Steering Committee meeting was that much could and therefore should be done to implement it.

Some three months later, the Fifth Steering Committee meeting took place on May 13–14, 1961, which would establish the plan for the 1961 summer writing conference (Green 2012). A June 21, 1961 letter by Glass re-articulated the importance of integrating his nine key themes in biology secondary education, which he first reported in the February 2–3, 1961 Steering Committee meeting (BSCS, 1961). These were: (1) the nature of science inquiry, (2) an intellectual history of biological concepts, (3) the essentiality of genetic continuity, (4) the importance of regulation and homeostasis, (5) the complementarity of structure and function, (6) the biological roots of behavior, (7) relationship of the organism to the environment, (8) diversity of type and unity of pattern, and (9) changes in organismal structure and functions over time, viz.-evolution. Of these, and supporting Muller's position, Glass emphasized that evolution was the greatest amongst these themes and thereby "may well be regarded as the most pervasive, most significant biological theme of all."

Glass placates Muller: Creating the evolution "Theme Committee"

Glass established a biological Theme Committee to assess and guide the development of the textbooks, to ensure that evolution would be integrated and emphasized throughout the three BSCS versions. A Theme Committee member, Archie Carr (1909–1987), who was a close colleague of Grobman at the University of Florida and a sea turtle expert, wrote on July 6, 1961 (Carr 1961), that natural selection "is the one concept in biology that has universal carryover." It was the "… force that drove evolution, being the key foundation for Darwinism and its modern synthesis." Carr stated that "natural selection has been here all the time, and it is the responsibility to put this notion across because no one else will." Carr (July 6, 1961) advocated his scientific thinking within philosophical domains as he asserted that natural selection was essentially knowledge of the greatest worth, and therefore needed to replace students' "fetal teleology"—a statement that Green (2012) interpreted as Carr's desire to convert/transform students from their "immature notions of design in the universe" to a perspective/belief in the universality of natural selection which, according to Green (2012), was a materialistic process.

Grobman initially invited six scientists/scholars to be members of the critical Theme Committee, with Glass serving as chair, a decision made to ensure that the focus upon evolution that Muller endorsed would be neither diluted nor lost. These individuals had strong historical and professional ties to the AIBS, all being long-time members and, in some instances, leaders of that organization. These included Ralph Cleland,[5] Garrett Harden, Colin Pittendrigh,[6] Alex Novikoff,[7] Fritz Went,[8] and Ralph Gerrard.[9] Of note was that Harden,[10] Pittendrigh, and Cleland declined the invitation, while several others, such as Archie Carr, Edward Colbert, and Richard Aulie, accepted membership, replacing those declining. Colbert was a highly regarded paleontologist who was also associated with the American Museum of Natural History. In 1955, he wrote *Evolution of the Vertebrates*, a landmark book on vertebrate paleontology. Colbert was also listed as an advisor to the BSCS project in April 1959, with the group overseeing time, life, and change (i.e., evolution). Aulie was a high school science teacher in the Chicago area who became interested in evolution-based educational themes and the controversy between creationists and evolutionists, writing multiple scholarly papers on this topic (Aulie 1972, 1983). The remaining members (i.e., Alex Novikoff, Fritz Went, and Ralph Gerrard) did not evidence direct involvement with the concept of evolution in research and/or educational practices. Nonetheless, as can be seen with the aforementioned quote by Carr, opinions and philosophical perspectives were strongly held, even in the absence of recognized professional expertise in the area. Each member was certainly exceptional in their professional area of achievement and thus would offer scientific credibility to the activity. To be sure, Grobman and Glass desired that an evolutionary perspective be dominant, and they probably did not wish to incur Muller's criticism, which could often be sharp, personal, and unrelenting (Carlson 1981).

By May 1961, the Theme Committee was in place (Green 2012) to implement Muller's directives and dispositions. In this regard, Glass served largely as his intermediary, and the Committee was testimony to the respect for Muller's leadership of the BSCS process. Yet, it was also indicative of the power that Muller exercised in intimidating colleagues, even in public, when he deemed it necessary. Indubitably, Glass had observed such behavior from Muller over decades of bearing witness to his public disputes and professional emasculation of James V. Neel during the BEAR I Genetics Panel meetings (Calabrese 2020). It is not difficult to imagine that Muller would have made life far more difficult for the BSCS program at large, and for Grobman and Glass in particular, had they not acquiesced to his wishes to implement his version of an evolution-based curriculum.

A decade later, in a reflective letter written to a colleague, Grobman (1974) highlighted Muller's role in BSCS textbook development. On September 6, 1974, Grobman wrote to Judith Grabiner, a California State College professor, who had just published an article in *Science* entitled: "Effects of the Scopes Trial" (September 6, 1974), that: "There were some voices during that period, however, H.B. Glass and H.J. Muller, come immediately to mind. Before the BSCS was organized, I remember Dr. Glass telling me that Ella Thea Smith's book was the best high school biology book available. "***Dr. Muller greatly influenced the scope of the BSCS books, especially, the Blue version, because of his deep concern about the failure of high schools to teach evolution*" (emphasis added) (Grobman 1974).

Some 40 years later (July 25, 2011), Green (2011) conducted an in-person interview with Grobman, who was then 93 years old, with considerable focus on Muller's role in the BSCS project. Grobman stated that "I remember distinctly at one of the meetings of the Steering Committee, when we were talking about evolution in the program and a reference was made to the fact that current biology texts before the BSCS didn't include evolution, and Muller got up, clapped his hands, and he said, 'Damn it, 100 years without evolution is [are] long enough'. You remember Muller was the man who worked with *Drosophila* and discussed the inheritance of mutations." Grobman would go on to say that Muller "was displeased with the first efforts … of the BSCS textbooks because they didn't have enough evolution in them. the very first ones … .the first version and then he said that he wanted more evolution in them and then the next writing conference, they wrote more evolution into the books." Green then stated that: "I didn't understand that … .I thought they were infused with evolution from the beginning" Grobman answered, stating that "they did have evolution from the beginning, but it wasn't as obvious as it could be, so for example, they changed the titles of the chapters to the evolution of the cell, the evolution of this, the evolution of that, so that the word evolution was used more often." During the interview, Grobman continued to discuss the impact Muller had on the BSCS process and his insistence that evolution take center stage. His point was clear: Muller, at this later stage in life, still exercised and exerted enormous influence.

Eugenics under the radar

A review of the membership of the American Eugenics Society (AES) offices indicates that Glass was a member of the Board of Directors from 1958 to 1968 and was also President during the time of the BSCS curriculum development (Green 2012). Many major figures of the U.S. genetics community were members of the AES and published in their journal.[11] These included Muller and his genetics colleagues who served on the NAS BEAR I Genetics Panel. One was Dobzhansky, a long-time Columbia University colleague of John A. Moore and a leader in the BSCS program for the development of the Yellow version of the textbook.

In 1960, the Yellow textbook version, directed by Moore (who had since moved to the University of California, Riverside), contained a section entitled "eugenics". This was before the formal appointment of Muller to the Steering Committee, thus reflecting how pervasive the eugenics concept was within the genetics community at the time. The 1960 Yellow draft version also contained two other eugenics-like sections, including one focused on "improving genetic lines" and another addressing "eliminating undesirable genes", an area of well-established concern within the eugenics field. The 1960 Yellow version also introduced the concept of human artificial insemination. During a 1960 conference presentation, Glass indicated that an inclusion of a section about sperm donation (Glass 1961, January 4) and preservation—topics for which Muller had long and strongly advocated (Carlson 1981)—might be included in the next version of the BSCS textbooks. The Glass (1961) comments during the 1960 summer BSCS writing conference, seen below, reveal explicitly how Glass was prioritizing the role of eugenics in the secondary school curriculum:

> In our new courses which we hope will be widely adopted, if they prove successful, there is great deal more emphasis upon population genetics and upon the study of mutations, and the evaluation of human mutations in terms of socially desirable and undesirable characteristics. Genetic considerations are given place, and I think it is not beyond possibility that discussion of sperm banks might actually be introduced into the revision of these textbooks.

In the summer of 1960, Glass honed in on the BSCS vision of eugenics during a presentation to teachers who had volunteered to teach the initial drafts of the biology course that had been developed over the past several months. Glass predicted that by 1990, "man will certainly have learned to accelerate his own evolution in a desired direction. The question, and issue was, what direction will be desired" (Rudolph 2002). Glass was well acquainted with Muller's strong advocacy for germinal preservation as a eugenics' tactic for directing human evolution. Muller (1961c) published a major paper on this topic in *Science* in September 1961, soon after he joined the BSCS Steering Committee. This served as another manifestation of Muller's influence over both Glass and the BSCS program. A section of Muller's paper on "eliminating undesirable genes" assessed the efficiency of the practice of removing harmful/undesirable, dominant genes from the population, which Muller portrayed in contrast to the difficulty of removing harmful/undesirable recessive genes. The Yellow textbook explicitly stated what was asserted to be the near impossibility of eliminating genes that are rare in a population. Through such rhetoric, reform eugenicists explicitly distanced their views—and themselves—from the widespread legislatively based sterilization programs of the U.S. during the 1920s.

An impediment to Muller's eugenics initiative

Despite massive criticism of the eugenics concept in the aftermath of revelation of National Socialist practices in Germany during the 1930s and 40s, and the fact that dozens of states in the U.S. had passed sterilization laws with little scientific justification, scientific thought leaders like Muller would try to preserve the eugenics concept to guide human evolution, albeit in what was regarded as a more scientifically based and socially acceptable form. But the so-called "old guard," including Muller, was aging and/or dying, and the new generation of geneticists was trying to "distance" their community from their past-admired mentors, who seemed to still cling to hopes of a eugenically based framework to direct human evolution. The inclusion of eugenics terminology in the draft Yellow version of the BSCS textbook revealed that Muller and his followers still enacted some degree of control.

While Muller may have been pleased with the publication of his major article on germinal preservation and eugenics-guided evolution in *Science* (as it emphasized his core beliefs), he and Glass were in for a surprise. Three months later, *Science* would publish seven letters to the editor from prestigious members of the scientific community who showed little respect for Muller's status, vehemently criticizing and admonishing his germinal preservation-based "positive" eugenics plan. It is valid to imagine that if seven such letters were published, it is likely that there were numerous others from which these were selected as being a reasonable representation of a notable sentiment in the field. Despite Muller's attempt to sustain his perspective (Muller 1961d), the criticisms were too deep and broad for any effective restoration of Muller's position. These exchanges in *Science* would be soon followed by the removal of the explicit advocacy of eugenics in the next Yellow version draft of the BCSC textbook, and there were no such inclusions in the other subsequent drafts. Hence, Muller's hope for a major evolution-eugenics coup to gain scientific and philosophical hegemony within the biological sciences curriculum had taken a serious, grievous hit, and it was one from which it would not recover.

In light of this major criticism and rejection of the eugenics concept, the Muller/Glass collaboration sought a fallback strategy. As noted by Green (2012), although Muller and Glass were certainly eugenicists, they were knowledgeable, if not shrewd enough to recognize that the time was nigh to change their tactics, especially given that there was little time left to resolve this unanticipated setback before the BSCS textbooks would be published and distributed to the educational market. Muller and Glass settled upon removing all references to the term "eugenics" in the three textbooks, yet still found subtle ways to incorporate diffused eugenic concepts that would appear reasonable and perhaps not readily identifiable as such (Green 2012). For Muller and Glass, this was a major impediment in that their goal was a complete transformation of secondary education and social philosophy that would be based upon evolutionary and eugenics concepts. Nevertheless, the concept of evolution did become a central theme and the contemporary foundation for biological sciences education. It could be argued that for Muller, Glass, and their eugenically minded colleagues, the eugenic component of the planned calculus was not only about education, but rather about the importance of inculcating a broad audience with the belief that eugenic practices could—and should—be implemented to direct human evolution. At its core, this can be viewed as sociological and political aspirations. In many respects, the acceptance of evolution and its centrality, as important as it was, may be seen as only a means to an end for Muller and Glass; and thus, ultimately, for both, the intellectual, philosophical, sociological, and political glass was left merely half-full.

Of course, within this context, it is always difficult to understand the real intentions of the principals, such as Muller and Glass. For example, it may be asked whether Muller was still an old-school eugenicist of the 1920s, and whether his revisionist, more socially acceptable language was simply a tactical tool to advance his philosophical and political agenda or was he truly the transformed, reformed eugenicist that his writings depicted and so argued? In Glass's case, his repeated claims to be a reformed eugenicist, similar to Muller, may be best considered in light of a commentary that he offered in *Science* in 1971:

> I reiterate that the right that must become paramount is not the right to procreate, but rather the right of every child to be born with a sound physical and mental constitution, based on a sound phenotype. And again, just as every child must have the right to full educational opportunity and a sound nutrition, so every child has the inalienable right to a sound heritage. Perhaps that can be achieved on a voluntary basis, through educational understanding genetic diagnosis and wise counseling. That, of course would be preferable. But if such means prove insufficient for the task, social compulsion may indeed be the only alternative, whether we like it or not.

These comments are striking and prompt the question: Who was the "real" Glass? Was he the hard-core eugenicist or a far more metered reformist? Based on his writings, Glass appears to unmask his true philosophical identity, which he had so long kept successfully hidden. Perhaps this is best elucidated in the words of physician and ethicist Kass (1971) who asserted that: "Bentley Glass convicts himself by his own defense."

Muller's interest in the BSCS was strongly linked to his vision of a societally based transformative eugenics.

Green (2012) claimed that Muller's involvement with the BSCS was not simply a favor to Glass but rather was reflective and representative of his career-long interest in eugenics. Muller saw evolution education as essential for the common person so that they could be inspired to make society-enriching reproductive choices, which would improve the human gene pool over time. Muller thought that through its development of evolution educational curricula, the BSCS could seize the opportunity to combat ideological threats to the pursuit of science, such as those posed by Lysenkoism in the Soviet Union and religious fundamentalism in the U.S.

Muller's passion for the concept of eugenics can be seen in his public writings and private communications. For example, Muller (1960, 279) stated that:

> Hereafter, if man is to succeed, he must take his evolution into his own hands. He can then be what he himself wills, provided he has the wisdom and humanity to choose the true and the good. What is the true and the good then becomes his greatest and deepest problem, but it must be tackled–-tackled in the light of all the past and of his newer knowledge of the basis of things. In other words, we must become evolution minded, all of us. And the realization that we can, if we will, stand on the threshold of an evolution that will dwarf all that has come before can become our greatest hope and inspiration. One of the main jobs of education should be to open the eyes of our youth to this great ideal, which should serve to orient them and to integrate the mass of otherwise bewildering and seemingly conflicting knowledge that they are expected to assimilate.

Green (2012) argued that strong elements of reform eugenics were inserted into the BSCS curriculum in the three different versions of its texts. However, the content was a "light" or reformed style of eugenics, as BSCS leaders had to ensure that the textbooks would be published and widely adopted. At this point, it was now 1963, and the concept of eugenics had incurred serious criticism, especially in light of the role of eugenics in Nazi medicine and the Third Reich at-large. Geneticists like Glass and Muller were visibly active leaders in their promulgation of a version of a scientifically directed view of eugenics that could be framed within the bounds and freedoms of a U.S. democracy. In this light, Muller and Glass needed to alter their eugenics language, strategies, and tactics to exert an impact on human decision making, the health of society, and human evolution. Despite their attempts to do so, the next generation of geneticists distanced themselves from the term and constructs of eugenics, changing their professional eugenics' societies and journals to have names such as social biology, using other descriptive terms that retained many of eugenics' directives and expressing them in an intentionally masked way so as not to generate negative attention. This general strategy is also evident in BSCS textbooks that contain subtle inferences to and manifestations of eugenics (Green 2012).

This revised, broadened BSCS strategy made evolution its central theme. It was anticipated that the BSCS textbooks would be challenged by many groups, including creationists, in the U.S. court system. The bedrock issue for the BSCS program was getting evolution accepted and established, and a more explicit expression of eugenics' concepts in future textbooks would therefore depend upon the outcome and resolutions of the aforementioned challenges. Thus, Muller got much of what he desired as regards the primacy of evolution in educational curricula, but was far less successful in advancing explicitly eugenic rhetoric and narratives. Of course, Muller would not easily surrender his position, and had multiple strategies for directing focus upon the creation of other opportunities for what he called "positive" eugenics (e.g., as he became engaged in the creation of a sperm bank for Nobel Prize winners and others considered of high intelligence). And, as can be seen from Glass's quote (see above), while he may be viewed as a "kinder and gentler" version of his Ph.D. advisor (viz.- Muller), he was neither less focused nor less determined.

The academic-governmental ideological complex

An important, but unappreciated aspect of the BSCS evolution-eugenics educational initiative was its intellectual and ideological partnership with the U.S. NSF, the government funding agency responsible for supporting the massive, multiple-year project. Rudolph (2002) noted that an early AIBS grant application to the NSF for the BSCS project included the eugenics goal of directing the course of human evolution. He stated that the BSCS initiative "would help drive the future evolution of humankind." Building upon these interactions with the BSCS project over its five-year developmental period, a 1963 NSF staff paper incorporated significant eugenics goals of Muller and his colleagues to guide subsequent programmatic educational and research activities (NSF, May 1963, cited in Rudolph 2002). In this way, Muller's reach extended beyond his radiation genetics colleagues and the leadership of the U.S. NAS (e.g., as seen in the activities of the U.S. NAS BEAR I Genetics Panel and radiation risk assessment recommendations) to key leadership elements of the NSF and vital executors in the field, namely high school biology teachers who would ensure that Muller's vision would reach the target audiences of subsequent generations of students. As noted by Rudolph (2002), Muller saw life as a "peculiar chemical set-up which results in replication, mutation (non-adaptive), and, by natural selection of the mutations, the evolution of the diverse and highly complicated adaptive systems" (Muller remarks undated concerning the content of a high school biology course, cited in Rudolph 2002, 189), a view he believed high school students must appreciate. Muller's perspective was the prime motivation for sustaining evolutionary biology as the keel to enable and direct his construct(s) of eugenics.

It is additionally important to understand that Muller's actions and leadership were rooted in and motivated by his philosophical beliefs in a socialist and atheistic Marxist communism, which was aligned with his concerns and consternation about "antiquated religious traditions" that he felt were the root of the "failure of our people to take evolution seriously" (Muller 1959). Muller's views were sufficiently challenging to societal culture that the U.S. NAS (1984, 1999) and Institute of Medicine (2008) published a series of reports explicating that acceptance of evolutionary theory was in no way incompatible with traditional religious beliefs.

Ethical improbity—Muller's "additional" legacy beyond the Nobel Prize

The 1963 BSCS Blue Version (Molecular) (Chapter 17) provided a significant profile of Hermann J. Muller, showing his photograph and including a figure depicting the schematic presentation of his research studies, for which he was ultimately awarded the Nobel Prize. On page 388, the text indicates that Muller, of the University of Indiana, and Lewis J. Stadler, of the University of Missouri, induced gene mutation via administration of X-rays to fruit flies and barley, respectively. However, it was Muller whose research ascended to primacy in notoriety, since he published first, and as a result was awarded the Nobel Prize.

Of note is that the BSCS text omitted critical aspects of the Muller narrative, which the authors of the present paper opine require clarification. To wit, Muller's gene mutation research was not subjected to peer review (Muller 1927; Calabrese 2024). Rather, he published a "discussion" of what amounted to his first two focal experiments, as the third had not yet been initiated. About three months later, during September 1927, Muller presented his findings at the Fifth International Genetics Congress in Berlin, Germany. The paper that Muller presented at the Congress was published in the Conference Proceedings without peer review (Muller 1928a). In contrast, Stadler (1928) published his data-based manuscript in *Science*, which underwent peer review, as per the standard procedures and protocols of the journal and research community at large. Further, some four years later, Stadler learned that he had not induced gene mutations, but instead, had produced modest to very large gene deletions wherein holes had been made in chromosome architectures by excessive doses and dose rates of the X-ray treatments. This insight was gained in research by Barbara McClintock, a University of Missouri colleague of Stadler who had developed improved cytogenetic methods that significantly enhanced the resolution of chromosome structure (Calabrese 2015, 2017, 2019). When McClintock applied her new methods to Stadler's X-rayed plant samples, she realized that his radiation treatments had created significant holes in the chromosomes' structures but did not induce point gene mutations. Stadler (1932), therefore, concluded that since he had induced sizable gene deletions, rather than point mutations, perhaps Muller may have also committed a similar interpretational error.

This was a concern for Muller when he returned from the Genetics Congress in Berlin, as Edgar Altenberg, a long-time friend and colleague, challenged him to prove that he hadn't been simply producing gaping holes in chromosome architectures (Muller 1928b). Muller recognized the importance of resolving this issue and assigned Frederick Hanson, who was on sabbatical, to assess whether X-rays could induce "reverse" mutations as a possible way to address Altenberg's question, and in this way show that the gene was still intact (Calabrese and Giordano 2023). Muller and his department chair, John Patterson, continued Hanson's research to no avail (Patterson and Muller 1930) as it would prove to be nonproductive (Lefevre 1949, 1950). During this period, Stadler's data strongly reaffirmed the McClintock perspective that Muller had incorrectly interpreted his findings. Stadler (1932) made a major presentation, in the presence of Muller, at the Sixth International Genetics Congress at Cornell University, wherein he indicated that he and Muller had erred in their interpretation of earlier gene mutational findings, such that the results indicated an absence of induced gene mutation. This interpretation was consistent with the negative mutational findings of Snell (1935) in a murine model, which was conducted under Muller's direction. By 1956, Muller finally acknowledged in writing that Stadler's perspective was supported by the data, and that he had in fact produced mostly chromosomal alterations (e.g., rearrangements, translocations, and especially gene deletions) without evidence of mutation (Muller 1956). In a historical review, two prominent, former close colleagues of Muller acknowledged that Stadler had won the longstanding and significant debate with Muller about the induction of gene mutation (Crow and Abrahamson 1997). More recent assessments measuring nucleotide changes further supported Stadler's interpretation (Calabrese 2017). Hence, based upon scientific assessment, it appears that Muller did not induce genetic mutations, and in this light, it becomes dubious as to whether the award of the Nobel Prize for such work was appropriate. In retrospect, this question becomes further complicated by elucidation and critique of Muller's professional behavior. Muller avoided peer review to gain primacy for his research; clearly, the journal *Science* altered its protocols to afford Muller an advantage, seemingly at the expense of others. In addition, Muller had a demonstrable record of acting in ethically questionable ways to advance his self-interest. For example, Muller failed to cite the gene mutational findings of Gager and Blakeslee (1927) that were published 6 months before his paper in *Science* (Muller 1927). Muller also failed to acknowledge the earlier findings of Curt Stern that revealed a linear arrangement of genes on *Drosophila* chromosomes, but instead asserted that he (Muller) was responsible for this discovery. Stern challenged Muller, however, eventually forcing him to write an apology and clarification in the literature (Calabrese 2015). The BSCS textbook development continued to perpetuate the myth that Muller induced gene mutation, and the countenance of this narrative can—and should—be regarded as a deliberately deceptive misrepresentation of the research record and given this known lack of veracity, ethically malfeasant.

The BSCS text gave almost equal credit to Stadler and Muller for inducing gene mutation. Yet, Stadler would ironically spend the final two decades of his life showing that he and Muller had not done so. The section of the BSCS Blue Version that describes these events is consistent with Muller's influence. It is representative of how he acted with evident self-interest toward self-advancement (if not aggrandizement), actions for which he was subsequently exposed for their unprofessional conduct and ethical improbity (Calabrese et al. 2025). Of further historical significance is that such deceptions by the BSCS continued long after Muller died in 1967, with the same historical and scientific errors being propagated at least through the fifth edition of the Blue Version, which was published some 22 years later, in 1985. This incorrect historical reference of the Muller/Stadler story was not present, however, in the eighth edition published in 2001.

Conclusion

The present paper brings to light that Hermann Muller strongly influenced the philosophy, content, and direction of secondary school biological education in the U.S. and worldwide. Muller's leadership resulted in the U.S. government-funded BSCS textbooks establishing evolution as the central and integrative theme of all aspects of biological education, from the early 1960s to the present. As substantial an achievement as this was, Muller sought far more to directly yoke this evolutionary framework to worldwide societal applications, including control of the direction and rate of human evolution by employing eugenic constructs and methods to influence a range of culturally tailored strategies and tactics. Despite Muller's efforts—and those of his colleagues—to incorporate a version of eugenics within secondary school educational curricula through their powerful influence and prominence, such attempts were ultimately unsuccessful, being challenged, and Muller and his colleagues' activities largely exposed for their imprudent attempts to manipulate and redirect legitimate scientific inquiry to accommodate and align with their ideological views for political and societal reform. Thus, Muller's legacy persists, beyond—and perhaps despite—his being awarded the Nobel Prize.

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Notes

1. Tippo would be important to the BSCS project as well; he would soon move to the University of Colorado at Boulder to become Provost, being then in a position to facilitate substantial dedicated space for the BSCS project. Tippo also took part in various advisory activities within BSCS and would eventually move to the University of Massachusetts at Amherst, becoming chancellor, at a time when the present co-author (E. J. Calabrese) came to know him, without knowledge of his BSCS leadership.
2. Eugenics is a set of beliefs and practices that are designed to improve the genetic quality of animal species and humans. Within an historical context, eugenicists sought to alter the frequency of various human phenotypes by inhibiting the fertility of those considered inferior or encouraging those with superior traits to reproduce. Eugenics became broadly adopted within the genetics community and became widely integrated into biological curriculum at the university level (Selden 1999). Many states in the US adopted legislation to sterilize persons who were believed to be genetically defective. By the early 1930s this aggressive form of eugenics lost much support, being largely replaced by a so-called kinder, gentler form of eugenics, called reform eugenics, which emphasized education over coercion as seen in the Eugenics Manifesto of 1938 that Hermann Muller drafted, and was later published in Nature (Crew et al. 1939).
3. The H-index is obtained from the Web of Science data base and indicates the frequency of article citation. In the case of Glass, it indicates that he has had 16 papers that have been cited at least 16 times.
4. According to Green (2012), Muller's indirect involvement in the BSCS initiative became activated earlier than the November 18, 1960 date. That is, James A. Moore, who was leading the Yellow version, sent Muller a letter on March 16, 1960 with Muller writing back on April 2, 1960 with a detailed narrative (three pages) of his ideas on biological education. Muller's correspondence, not surprisingly, show him to be strongly pushing the idea that evolution needed to be the central and unifying principle for the BSCS curriculum, and it needed to be directly tied to a society-based eugenics strategy. He was expecting that these ideas would be taken up in earnest by the textbook writers for the first Summer Writing Conference in 1960. However, Muller didn't realize that key leaders did not agree with him that evolution should be the "main" theme. For example, minutes of a June 12–13, 1959, meeting on the Laboratory Innovation Committee reveal that Glenn Richards from the University of Minnesota stated that "Evolution is not so important as to have everything woven into it." Addison Lee from the University of Texas stated that "We agreed that evolution is not the theme all the way through. I don't believe that evolution must be the theme of the course. It is very important and as a theme" (Green 2012, 159).
5. Cleland: Ralph Cleland was the chair of biology at the University of Indiana/Bloomington. He was Muller's department chair. Cleland was one of the founding members of the AIBS and maintained a highly involved and prolonged association with the AIBS. In 1959 the AIBS listed Cleland as being an advisor to the BSCS project in the area of reproduction, growth and development (Roney 1959). Cleland was a member of the original AIBS organizing committee being chair in 1948 (Bronk 1972).
6. Pittendrigh: He obtained his Ph.D. under the direction of Theodosius Dobzhansky at Columbia University in 1947. He became notable for his fundamental discoveries concerning circadian rhythms using insect models and is considered the originator of the concept (Menaker 1996).
7. Novikoff: He made numerous significant discoveries relating to various cellular organelles. He was the first to identify lysosomes and he discovered the concept of autophagy. He was widely considered a serious potential Nobel Prize candidate, but he was affected by his affiliation with the Communist Party during the Cold War (Holmes 1989).
8. Went: He become famous for the discovery of auxins in plants while a professor at Caltech. This research had a transformative influence on the direction of agricultural research. He later became director of the Missouri Botanical Gardens (Went 1974). Went became an AIBS Officer in October 1961 (AIBS 1961).
9. Gerrard: He was a physiologist of considerable achievement, with particular focus on neurophysiology. He was long time influential member of the AIBS (Cullinan 1952) (See remembrance of his life: Libet and Reynolds 1974).
10. Harden: Glass would find a way to use the supportive talents of Harden, inviting him to write a book review of the BSCS textbooks in the *Quarterly Review of Biology* for which Glass was a long-time Editor-in-Chief. Note that Glass failed to share with the readership that he was the Chair of the BSCS Steering Committee and had invited Harden to serve on the BSCS Evolution Theme Committee. These failures of Glass created false impressions of journal, editor and reviewer objectivity. Some six decades later these actions of Glass would be widely seen as ethical failures (Calabrese 2021). Glass would also arrange to have the BSCS textbooks reviewed by other close colleagues, such as William H. Fleming, James D. Ebert and Garret Harden (referenced as Fleming et al. 1976), ensuring very positive reviews, never indicating his professional relationship to the reviewers and his role in the BSCS project. For example, not only was Ebert a graduate of Johns Hopkins, having Glass as a professor but he became an AIBS Officer in October, 1961 (AIBS, 1961), without informing the reader of his relationship to the organization that produced and owned the BSCS books. These collective activities that were led by Glass, Muller's graduate school advisee, dishonestly promoted Muller and the AIBS and its potential financial rewards in book royalties have never been adequately discussed.

11. A part list of leading geneticists who were members of the American Eugenics Society: Albert Blakelee, William Castle, Everett Dempster, Edward East, Raymond Fidock. Theodosius Dobzhansky, Bentley Glass, Garrett Harden, C. C. Little, Hermann J. Muller, Clarence Olver, Frederick Osborne, Theophilus Painter, Harold Plough, John Patterson, George Snell, Lawrence Synder, Tracy Sonneborn, Curt Stern, Bruce Wallace, Sewall Wright. The American Eugenics Association journal, *The Eugenics Quarterly,* was a popular publication vehicle for the radiation geneticist members of the NAS BEAR I Genetics Panel, including Beadle, Crow, Muller, Neel and others in the 1950s and 1960s.

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