Biological Ethics and Morality in Great Literature

Perspective of a Scientist

by

David S. Haymer

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Dedication

I dedicate this book to those closest to me – my parents, my wife, and our children – all of whom have helped shape the person that I am.

Acknowledgements

I wish to acknowledge by name a few individuals that have been so helpful to me on this journey. First, to Jay Friedheim, a lawyer by profession but a biologist by passion, whose insights first revealed to me how much biology can be found in the Book of Genesis. Next, to the many students and colleagues that it has been my privilege to be associated with – in particular Ms. Keala Mak, Lorna Holmes, Dr. Jeanna D West-Miles, DO and Margaret Walkover, all of whom were of such great help in bringing this project to fruition by reviewing and critiquing my writing on these various topics. I am, of course, solely responsible for any mistakes, omissions or incorrect interpretations of ideas expressed here. Also, a special thanks to Malka Haymer for the illustrations of the 'body bag' and the 'tree of life'.

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Introduction and Overview

We live in a world today that is full of wonderful technology, most of which is intended to improve our lives. Especially in the realm of science, researchers are quickly learning how to harness this technology to accelerate the pace of making new discoveries and the development of new tools that promise to make our lives even better.

Given this rapid pace of innovation and progress, perhaps it is time for researchers and other scientists engaged in this work to stop for a moment and take a breath before going further at the same rate. I am speaking here to biologists in particular, not only because this is the scientific field I am most familiar with, but because today it is the scientific discipline that has been the most radically changed by the incorporation of much of this new technology.

One way that scientists might pause in their work (if they have not already done so) is to read the first two examples of great literature I have included here. The authors of these novels - Brave New World and Frankenstein – brilliantly address many issues common to many contemporary scientific endeavors. These include the desire and/or pressure to be the 'first' to achieve some great innovation, the tendency of scientists to hide their work (at least in initial stages) from public scrutiny and finally, the failure to fully consider the longer-term consequences of their efforts.

I also hope, of course, that scientists will find the third part of this book – the discussion of biological principles found in the Biblical Book of Genesis – to be of interest in coming to understand that

some of these stories can bring valuable ethical and moral perspectives relevant to a better understanding of the nature of life on our planet, and that a religious perspective does not automatically have to be in conflict with scientific thinking. Many famous scientists from past years saw no conflict between the scientific and religious realms of society, and they benefited from having this broader and more inclusive perspective on things.

Finally, I also sincerely hope that non-scientists will read this work and gain new insights into the incredible technological advances that have already been made and are being routinely utilized in areas such as reproductive and synthetic biology. These fields are rapidly reaching a point where some of these applications may take us beyond a point of no return, and while we cannot simply stop doing this work, increased awareness of where these fields are going should hopefully encourage moderation and more thorough consideration of ethical and moral perspectives on these efforts.

Part 1

Biology, Ethics and Morality in Aldous Huxley's Brave New World

Thomas Henry Huxley and his grandsons

If you were asked to list some of the greatest individual contributors to the science of biology, either from the past or right up to the present, you would probably suggest names like Pasteur (Microbiology), Mendel (Genetics), Darwin (Evolution), and Doudna (CRISPR). But can you name a *family* made up of great contributors to this field? I suggest you consider members of the Huxley family and the role they have played in the history of biology.

A good place to begin looking at the Huxley family is through Thomas Henry Huxley (1825-1895). Huxley was a contemporary of Charles Darwin, and he ultimately became most well-known for his staunch defense of Darwin's ideas on natural selection and evolution in the face of vigorous opposition. However, before he became involved with Darwin ideas, Huxley was well recognized for his own work as a scientist. This was important because it gave him credibility when defending Darwin.

Biography and scientific work. Huxley was born into a religious family of modest economic means (1). His family lived in Coventry, England and during his youth, he fortunately had access to a library assembled by his father, a teacher. Huxley was a voracious reader with a talent for drawing, a skill which served him well in his later scientific work. His career as a scientist began when he was accepted as a scholarship student at Charing Cross Hospital in London. In this position he won a gold medal for his studies on anatomy and physiology. Interestingly, this was the area of biology he was most interested in, not evolution. In part because of his need of a paying

job and his interest in anatomy, Huxley decided to undertake work on the HMS *Rattlesnake*, a British ship which took him on an extended trip around the South Seas and to Australia from 1846 to 1850 – this was years after the seminal voyage that Charles Darwin took on another British ship, the HMS Beagle. On the voyage of the *Rattlesnake*, Huxley was able to pursue his interest in anatomy by dissecting and sketching various specimens of the many marine animals brought up in the nets of the ship. After returning to England, he eventually became President of the British Association for the Advancement of Science. As a side note, in addition to his scientific work, he also left an important legacy as a teacher; one of his students included the future novelist H.G. Wells whose later works included *The Time Machine* (1895), *War of the Worlds* (1898) and *Food of the Gods* (1904).

Huxley's direct involvement with Darwin and his defense of evolutionary ideas came about in a somewhat unusual way. As Michael Ruse described in his book *Evolution and Ethics* (2), in his lectures Huxley barely if ever mentioned evolutionary ideas - he remained focused on his anatomical studies. Huxley became interested in the idea of defending Darwin after he learned that the many leaders of the Anglican Church, the dominant church in England at that time, were adamantly opposed to accepting Darwin's ideas. Huxley believed that change was necessary in society, but to him, the Church stood in the way of many needed reforms.

Huxley's approach to science. Huxley was also interested in the idea that Darwin's work could serve as a great example of how a naturalistic approach could be used to understand the living world (1). The naturalistic approach to science was influenced by ideas of

the enlightenment, sometimes known as the Age of Reason. Here, the goal was to understand the natural world and humankind's place in it based on reason and logic as opposed to faith and belief. Following this trend, Huxley ultimately became a leader in the movement to completely separate *natural science*, which was based on empirical observation and experimentation, from what has been called *natural theology* or *theistic science*.

The naturalistic approach presented a challenge for Huxley because the theistic scientific perspective was enormously influential throughout British universities at this time. This approach followed basic scientific principles, but it also closely embraced many Christian religious ideas (2). For example, science students at Cambridge University were required to be familiar with the work of William Paley and others who advocated that the study of nature could be used establish the existence and characteristics of a creative deity.

Over time, these theistic approaches morphed into the concept often known today as *intelligent design*. This perspective postulates that all living things, and their various characteristics, must be due to the design work of an intelligent, all powerful force - a force that has become synonymous with some Christian concepts of "God". Unfortunately, this perspective and many of the principles invoked within the concept of intelligent design require supernatural actions, and these are not testable using traditional scientific methodology.

Darwin's theory, in contrast, appealed to Huxley because it took a radically different approach. It postulates that natural selection determines the path of evolution instead of an intelligent, all-

knowing entity. Furthermore, since first proposed, many of Darwin's ideas have been validated using rigorous scientific methodology. Nevertheless, the conflict between these two very different perspectives remains with us today. However, some advocates have argued that this conflict can be resolved if religion and science are simply recognized to operate in separate and distinct realms that should complement each other (3). But for others, it is not valid to assume that there need to be such sharp distinctions between scientific and religious perspectives. For example, groups such the *clergyletterproject.org* which advocate that science and religion can be compatible in many ways.

For Huxley himself, his belief in the naturalistic approach to science should also not be taken to mean that he completely rejected religion. Rather, he clearly had his own ideas about it. As described in Matthew Stanley's book on *"Huxley's and Maxwell's Demon*" (1), Huxley repeatedly emphasized that he was not against religion, he was against current ideas on theology. Some of his thinking in this area can be seen in the quote below:

"Of all the senseless babble I have ever had the occasion to read, the demonstrations of these philosophers who undertake to tell us about the nature of God would be the worst, if they were not surpassed by the still greater absurdities of the philosophers who try to prove there is no God". (4).

Defending Darwin. Despite Huxley's core belief in having some religious values, he apparently found the outright rejection of Darwin's ideas to be the perfect fodder for him to openly challenge many of the ideas being promulgated by the Church of his time. Huxley seemed to revel in this role, and he ultimately became known as Darwin's "bulldog" because of his willingness to debate

anyone that would not accept Darwin's ideas on natural selection and evolution. This culminated in a famous series of debates held at Oxford University in 1860 during which Huxley fiercely defended Darwinian ideas on evolution. His opponent, Samuel Wilberforce, the Bishop of Oxford, advocated for a literal reading of Biblical accounts of creation, mostly taken from English language versions of the Book of Genesis in the Hebrew Bible (aka the Old Testament).

Huxley's willingness to participate in these debates was important at that time because Darwin himself was reluctant to engage in open discussion about his work, especially when it meant confronting representatives of the Church. Darwin had, with encouragement from his family, explored becoming a clergyman when he attended Cambridge University from 1828 to 1831. However, he did not find pastoral work to be intellectually stimulating, and he left to pursue other interests. One of these other interests included a journey on the British ship HMS Beagle from 1831 through 1836. This trip included a visit to the Galapagos Islands that ultimately inspired so much of his thinking about evolution. After his return, Darwin, normally a quiet and contemplative person, spent years devoting himself to completing his monumental works describing the different organisms and fascinating locations he had encountered on the Beagle's journey, but he hesitated to publish them. In 1859, Darwin finally became more motivated to publish his work when he learned that another naturalist named Alfred Russel Wallace had proposed similar ideas (5).

Huxley's influence on his grandsons. Thomas Huxley's complex ideas on science and religion also exerted a strong influence on his

grandsons, Julian and Aldous Huxley. In between them was the grandson's father, Leonard Huxley, who became a successful physician, but always felt overshadowed by his now famous father. Leonard did, however, bring a great literary perspective into the lives of his sons by marrying Julia Francis Arnold, scion of a notable literary family. Julia's father was a literary scholar, and her sister, Mary Augusta, who published under her married name Mrs. Humphry Ward (Bashford), penned over 20 novels. Interestingly, her most successful novel, entitled *Robert Elsmere*, was a story of a young clergyman who advocated that religion should focus on social concerns over theology (6).

Given this family lineage, it is not surprising that Thomas Huxley's grandsons, Julius and Aldous, both became prolific writers showing interest in science and its relation to society. Like their grandfather, both also rejected much of the contemporary teachings of the Church in England. Each of them, however, chose slightly different paths to fulfill these goals. Julian, the older brother, is most well-known for his great contributions pursuing a traditional scientific career in the field of evolution. He did some writing of fictional short stories involving scientific topics, and somehow also managed to find time to write extensively to express his own ideas on religion. Aldous started out intending to follow in his brother's footsteps in the realm of medical and scientific work, but fate intervened to lead him down a different path. After nearly losing his sight because of an untreated eye infection, he engaged in the writing of a series of short stories and novels to convey his thoughts on science and the role it could play in society. This ultimately culminated in his publication of *Brave New World*, one of world's most widely read novels depicting a future dystopia based on biological manipulation.

Julian Huxley

Julian Huxley (1887-1975), grandson of Thomas Huxley and brother to Aldous Huxley, is possibly one of the most underappreciated biologists of all time. Among his many scientific achievements, Julian Huxley was an accomplished expert on field studies of birds and other species as well as being a prolific science writer. He was also a co-founder of the World Wildlife Fund and the first director-general of UNESCO. But perhaps most importantly, his scientific efforts played a major role in bringing the ideas of Charles Darwin and Gregor Mendel together to achieve a deeper understanding of how inheritance actually worked, and the key role it played in the evolutionary process. Today, we fully accept the intimate connection between these two different areas of biology, but as late as the early 1900s, this was not immediately obvious.

Huxley's Role in Bringing Together Works by Gregor Mendel and Charles Darwin. To more fully appreciate the critically important scientific contributions made by Julian Huxley to bring together the ideas each of these scientific legends, a brief historical foray into their respective biographies seems appropriate. First, Darwin and Mendel both lived at approximately the same time: Mendel from 1822-1884 and Darwin from 1809-1882. Second, Mendel did his most impactful scientific work in the years from 1856 to 1863, while Darwin's most famous book: "On the Origin of Species by Means of Natural Selection" was first published during this same period in 1859. However, despite these overlaps, it is widely believed there was no direct contact between them during

their lives (7). Each of these great scientists worked in relative isolation and on what seemed, at least in retrospect, to be disparate topics. Mendel's work laid down the principles of inheritance that we recognize today as the foundation of the modern genetics, while Darwin's work fundamentally altered our understanding of how evolutionary change happens through the power of natural selection.

Also, despite the apparent lack of direct contact, it is of interest to note that Mendel certainly did know of Darwin's work. He obtained copies of Darwin' books shortly after they had been translated into German, and he also referred to the concept of evolution in his lectures and talks. Darwin, however, almost certainly did not know anything of Mendel or his work (7). Mendel wrote only in German, and he published his work in a relatively obscure Austrian journal. And despite the importance of German as a scientific language at that time, Darwin himself often stated he was "extremely weak" in being able to read material written in German. Finally, although Mendel presented his work in different forums around 1860, his work became widely available to others in the scientific community only after it was "rediscovered" and translated into English by William Bateson in 1905 (8), long after both Mendel and Darwin had died. Bateson's work did serve to firmly establish at least two basic principles of heredity described by Mendel, namely: 1) the principle of segregation and 2) the principle of independent assortment. However, at the time, the description of these fundamental principles was of great interest only biologists struggling to understand how heredity worked. The broader implications of these principles for understanding biological phenomena such as evolution would only come years later, mostly through work begun by Julian Huxley.

Darwin did recognize that a proper understanding of how inheritance worked was certainly important to his notions about the evolutionary process. But in discussing inheritance, specifically on how traits and characteristics might be inherited from one generation to the next, his ideas were mostly wrong. Darwin proposed that minute particles called gemmules were given off by all cells of the body, and that these were somehow responsible for the blending of traits seen in their offspring. For example, in blending inheritance, when a tall parent was mated with a short parent, the offspring would always be intermediate in height. And, although later work would show that the idea of blending inheritance did apply in certain rare cases, Darwin also provided no experimental evidence in support of this notion. This of course did not invalidate Darwin's great contributions linking evolution to natural selection (among other ideas), it simply left a gap that Julian Huxley would need to fill in years later.

Fortunately, Mendel provided important details that would later help Huxley fill in this gap. Mendel's publications included details of results from multiple experiments showing how specific inheritance patterns operated using the pea plants he raised in the garden plots at his monastery. For example, his work convincingly showed that the blending type of inheritance favored by Darwin did not explain how many characteristics in the pea plants, such as seed shape and flower color, were transmitted from one generation to the next. Instead, Mendel showed how underlying units of what he called 'elements' of hereditary material (7) were passed from one generation to the next in a *particulate* manner through gametes such as pollen and ovules (or sperm and eggs). Furthermore, when these gametes combined at fertilization to form the cells of the next generation of plants, it was the pairs of these underlying elements

coming together that would determine the characteristics of their offspring. In describing these inheritance patterns, Mendel coined terms like *dominant* and *recessive* that continue to be used in genetics today. For example, in the pea plants Mendel worked with, he saw that in terms of the inheritance of seed color, the yellow coloration could be predominantly visible over the alternative color of green; in this case he described the color as being dominant. By the same logic, because the green coloration had receded into the background, he referred to this characteristic as being recessive. However, many other important terms used in genetics today such as genes, alleles and chromosomes came into common usage only after Mendel's time.

Huxley's Modern Synthesis. The clearest documentation of Huxley's crucial contributions in bringing together Darwinian and Mendelian concepts can be seen in his 1943 book entitled *The Modern Synthesis* (9). In this book, Huxley begins with a careful review of the basic concepts of evolution postulated by Darwin. These include: 1) the need to have variation in populations, 2) the role of selection by environmental factors acting on this variation and 3) the result that individuals in populations could differ in terms of their ability to survive and contribute offspring to future generations.

Huxley next lays out, in a logical and step-by-step manner, how Mendel's principles fit into these Darwinian concepts. Significantly, Huxley also introduced this material by showing that Mendel's principles are universal in the sense that they can apply to patterns of inheritance for all sexually reproducing organisms, not only the pea plants used by Mendel. This, of course, includes human inheritance. He then showed how the units of

heredity described by Mendel represent a form of particulate inheritance that allows for the preservation and maintenance of the genetic variation needed for selection to act upon in the evolutionary process. This was in direct contrast to the blending inheritance described by Darwin which, over generations, would result in the diminishing or elimination of variation found among individuals in populations.

Huxley also showed how chromosomes, which by this time had been recognized to be the carriers of genes and genetic information in cells, provided additional mechanisms to maintain variation in populations. He further explained how the nature of chromosome inheritance fit perfectly with Mendel's two basic principles of heredity, specifically known as the principles of: 1) segregation and 2) independent assortment. In this realm, Huxley also went beyond Mendel's work to include a chapter on the implications of the phenomenon of chromosome recombination which, at the time, had only been recently described through classic genetic studies of inheritance using *Drosophila melanogaster*. Huxley clearly recognized that the ability of chromosomes to reshuffle genetic material through recombination would provide another mechanism to introduce and maintain genetic variation in populations. This was another concept recognized by Darwin to be central to evolutionary success, but it was one he could not explain. Fortunately, Julian Huxley and others were able to provide plausible mechanisms by which this could happen.

In the latter chapters of this book Huxley also further explained how, over generations, individuals in the population with different characteristics could have differential success in surviving and reproducing. This was especially true in changing

environments, another key component of Darwin's theory. Other chapters dealt with related topics such as how new mutations, mechanisms for species formation and evolutionary trends under adaptation and selection would shape evolutionary progress. Again, Huxley's overriding theme for discussing all this basic genetic information was to show how Mendel's work defining genes as discrete units of heredity could precisely fit into ideas proposed by Darwin in the realm of natural selection and the evolutionary processes.

Many of Huxley's insights were all the more striking because, in his time, the nature of the gene was understood only in conceptual terms. It was known that the genes a person inherited could determine their physical characteristics such as eye color and hair color as well as much of their behavior, but it was not known how this happened at the molecular level. Key to solving this mystery required a better understanding of the chemical nature of genes and how they worked to produce these effects. A few years after publication of the Modern Synthesis, it was shown that genes were made of the biochemical molecule known as DNA, and a few years after that, the basic structure of the DNA was worked out by Watson and Crick. Finally, Marshall Nirenberg and colleagues also worked out the genetic code to reveal how the information in DNA could be used to construct the proteins needed to build and maintain cells and bodies. This new understanding of the nature of a gene in molecular terms further explained and validated much of what Huxley had postulated earlier about how genes were directly involved in the evolutionary processes described by Darwin.

Other contributions by Julian Huxley. Beyond his mainstream scientific work, Julian Huxley also demonstrated an almost prescient ability to look ahead to the future to see how advances in biology might intersect with society. Huxley explored some of these ideas in a short science fiction story he wrote in 1927 entitled *The Tissue-Culture King (10)*. This fictional tale describes the discovery of a research program run by a former British medical student named Hascombe who left England to work an isolated African country. The people of this country had deeply held religious beliefs, including the idea that their King was of divine origin. Taking advantage of these beliefs, Hascombe convinced the King that he could grow cultures of "sacred tissue" taken from him. These would be distributed to his subjects, and that great benefits would flow to each of them though their possession of the sacred cultures. This was, however, designed simply to take advantage of the religious beliefs of these indigenous people, and no specific details were provided on the exact nature of these benefits. Ultimately, Hascombe also went far beyond this to culture tissues in different ways, including efforts to produce and manipulate aberrant forms of human beings. He also became obsessed with the idea that he needed to continue his experiments, regardless of any unintended consequences, even when he was given the opportunity to return to England.

The scientific basis of this story may have seemed fanciful at the time it was written, in part because the science of tissue culturing was very primitive and limited in scope in the 1920s. Remarkably, however, Huxley correctly predicted that tissue culturing would become routine and applicable to many different areas of research. This came to pass in the 1950s when cells were taken from a tumor of a woman named Henrietta Lacks (11). These cells, now known

as *HeLa cells*, laid the groundwork for tissue culturing to become routinely practiced in research laboratories. In fact, the Hela cells grow so well in the laboratory environment that scientists around the world have been able to use them even today for research applications ranging from vaccine development to the growth of skin and organs for possible transplant. However, it is important to note that Henrietta's cells were taken without her knowledge or permission, and that until the book written by Rebecca Skloot became successful and proceeds from its publication were used to establish a foundation to benefit her family, no compensation had ever been provided to them for these revolutionary advances.

Ethical and moral perspectives in Julian Huxley's work

The potential for major ethical lapses in failing to recognize the human elements involved in great research advances described in both the fictional story of the *Tissue Culture King* and in the real-world saga of Henrietta Lacks appears to have also become a concern of Julian Huxley later in his life. In 1969, he co-authored an essay with a fellow conservationist named Max Nicholson which criticized the tendency of modern man to let technology "outrun his powers of forethought and control" (12).

Question:

Do some researchers try to hide their work from the public?

In the Tissue Culture King, Huxley showed show how scientists could be tempted to engage in increasingly controversial experiments by working in distant localities to hide them from public view. A classic real-life example of this became clear in the uncovering of the infamous Tuskegee Syphilis experiment

conducted in the 1930s. Here, several hundred poor, uneducated farmers were deceptively recruited into a study designed to compare the progression of this disease with or without primitive treatments that were available at the time. This study was deliberately conducted in an isolated rural community in Alabama, and nothing that could be recognized as informed consent was obtained from participants. The project was also described as lasting for only 6 months to one year, but somehow ended up continuing for almost 40 years (13).

Furthermore, when it became clear that serious ethical violations had taken place in this study, including the withholding of penicillin from participants as an effective treatment for syphilis after it became available, some of the same US Public Health Service workers involved in the Tuskegee study decided to continue the work in an isolated part of the country of Guatemala in Central America. Here again, major ethical violations took place, but these were all conducted largely out of public view until the story was exposed years later (14).

A more recent example of this behavior may be seen in the manner work was being done on the COVID-19 virus. Here, controversies over the origin of the virus and the circumvention of normal vaccine safety testing protocols have overshadowed aspects of this story that have not received adequate attention. For example, before the worldwide pandemic of 2020 prompted by the presence of this virus, how many people knew had even heard of Wuhan, China? And how many knew that research on this virus was being conducted in a laboratory in this isolated area, supported by the US National Institutes of Health, when high level facilities capable

of handling such dangerous infectious viruses are available in the US?

Huxley's religious thinking and the future of Biology

Finally, despite this somewhat dark foray into the world of science fiction, throughout much of his life Huxley was generally optimistic about the future of science and society. Biographers have described that Julian had an almost evangelical belief that scientific progress could be used for the betterment of the human species (12).

Huxley also believed that the future would include a reconciliation of the conflict between science and religion, a division that was prevalent in society in his lifetime. Huxley considered himself to be a religious person, but, like his grandfather before him, he firmly rejected many of the ideas promulgated by the Christian church of his time. In its place, he envisioned a future society where a strong emphasis on rationale and scientific thinking could replace the need for revelation as a guide for how to live a good life. These ideas are sometimes referred to as Secular Humanism, but Huxley himself expressed his belief succinctly in the last sentence of his book *Religion without Revelation* where he said: "I believe in the religion of life" (15).

It may be ironic that while Julian Huxley was deeply concerned about the future influence of science on society, his scientific legacy may have led to fundamentally altering the science of biology as we know it today. Prior to Huxley's work, biology was a science based largely on observations. With Huxley's New Synthesis of ideas on heredity and evolution, together with the progression of

understanding on the details of the chemical makeup of a gene and how that information could be used to make proteins (the ultimate products of most genes) and build cells and bodies, the groundwork was now laid for biology to transition to a science based on experimentation and possible manipulation. This represented a dramatic shift in how biologists approached their science.

Over time this has manifested, both directly and indirectly, in the development of some of the most far-reaching techniques used in biology today to manipulate living things in the laboratory. In Huxley's lifetime, scientists went from simply being able to define a gene in terms of its physical and chemical structure to achieving a deep understanding of how DNA contributes to the specific attributes of an organism. Next, with the advent of technology known as recombinant DNA, scientists also gained the ability to directly manipulate the DNA of genes piece by piece in the laboratory. This included the ability to move a segment of DNA, representing a gene, from one organism to another to create new generations of genetically modified organisms (GMOs). Newer techniques for genetic modification used today under the heading of 'CRISPR' tools have further enhanced the ability to directly alter the DNA of any living cells (16).

These manipulations were first developed and used mostly for applications in agriculture. However, using the same methodology, it also quickly became clear that it was possible to manipulate the makeup of individual human genes as well. This meant that the science of human genetics was no longer limited to simply studying and predicting patterns of inheritance for hereditary diseases like sickle cell anemia or hemophilia. It was now possible to manipulate genes to potentially devise new cures,

not just treatments, for dealing with these devastating disorders. As a medical application, this new approach is euphemistically referred to as *gene therapy*, but the techniques for intentionally modifying the genetic makeup of humans is conceptually the same as it is for any organism. This technology is also not limited to disease treatment. The same approach also underpins the ability to manipulate the genetic makeup of individuals to produce "designer babies" imbued with cosmetic changes considered to be desirable or fashionable at the whim of their parents. Given this, it is not a stretch to say that as a direct continuation of Julian Huxley's seminal work, for better or worse, we have now come to a point where we can fundamentally change our biology in ways that were unimaginable just a few years ago.

This reality makes the work of Julian's brother Aldous even more important. The Huxley brothers were extremely close, and it is well known that at least initially, Aldous was inspired by Julian's scientific achievements and his ideas about the future of biology. Ultimately, Aldous did not pursue a scientific career, but he did find a way to incorporate scientific ideas into his novels by exploring possible futures for mankind. In writing his most famous novel, *Brave New World,* Aldous focused on another area of science which at that time also held great mystery, that is the biology of development. In this novel, Aldous describes in great detail how the biological manipulation of development could be used by a government as a method to control nearly every aspect of human society. This is an important exploration echoing a series of efforts attempted previously in history to use principles of eugenics to "improve" human beings, ostensibly for the betterment of society.

Aldous Huxley

Aldous Huxley (1894-1963) was born into the Huxley family seven years after his brother Julian. As evident through his extensive correspondence, he maintained a strong bond with Julian throughout his life. Early on Aldous wanted to emulate his elder brother and other members of his family by pursuing a career in science or perhaps training as a physician. However, an undetected eye infection early in his youth caused him to be virtually blind for nearly one year. According to Julian, however, Aldous never complained about this turn of events, but instead used the time to teach himself how to play the piano and read Braille. He even joked that on cold winter nights, the use of Braille allowed him to continue reading even after retreating under blankets to stay warm (17). Fortunately, his diminished eyesight also prevented him from serving in the First World War at a time when almost an entire generation of British males of his age were lost in the carnage of this war.

He eventually did partially recover his sight, but by this time he had given up his ambition of medicine as a career. His brother Julian saw this a blessing in disguise. He recognized that great things were in store for Aldous, and that the day-to-day grind in the practice of medicine would not have suited him. Also, according to Julian, Aldous had an amazing ability incorporate a wide range facts about science and other matters in his writing. This insight came from many different sources, not only the occasional discussions he had with Julian and other biologists of his time (17).

In his writing, instead of dealing with scientific issues directly, Huxley used his ability to integrate and synthesize vast amounts of relevant information to write about the impact of science on society. Huxley freely admitted that the different characters he created for his fictional novels simply served as puppets to convey his main goal of getting people to think about important issues. This literary tendency likely came from his mother, Julia Frances Arnold, a member of a distinguished family of writers (6). Huxley ultimately published a wide range of novels and essays on many different topics, including explorations of philosophy and the ability to enhance human perception through the use of psychedelic substances such as mescalin.

It was his writing of Brave New World, however, that would ultimately propel him to become the most widely recognized member of this illustrious family. This novel is so widely known in part because it has often required reading for students at the high school or college level, but also because it represents an incredibly well-crafted and detailed description of a future dystopian society. Here, Aldous' writing stood in sharp contrast to the general optimism promulgated by his elder brother who believed, for the most part, that technological achievements would help improve society. Julian did, however, eventually end up moving closer to Aldous' perspective when he became more skeptical about the way people would use scientific progress.

And although *Brave New World* is certainly not the only novel predicting a bleak future world, the frightening nature of the society described in this book is also entirely believable in terms of its application of scientific methodology and ability to predict future developments. In 1958 Aldous Huxley himself also

published an extensive essay entitled *Brave New World Revisited* as a commentary on what had, or had not, already come true in his time.

Historical Context for the Novel *Brave New World*

The novel *Brave New World* has been dissected, analyzed and interpreted by many people since it was first published in 1932. Most see it primarily as a novel describing a dystopian future for humankind. This may be true, but it is important to point out that it differs from other famous dystopian novels such as George Orwell's novel *1984* in terms of how society is controlled. In 1984, the government uses fear as a primary motivator to achieve societal goals. In *Brave New World*, Aldous Huxley introduces a government that generally uses more positive motivators to exert control over society. These positive motivators begin with completely separating sexual acts from the process of reproduction and extend all the way to the free availability of drugs to distract people from pondering too deeply about the reality of their lives. Huxley also brilliantly incorporates details on the use of technology to control human development. However, in the Brave New World, this application of technology primarily impacts only certain segments of society, thus allowing his program to avoid some of the pitfalls causing other programs to fail to achieve their stated goals. More details on this will be discussed in the next section of material on the novel itself.

In addition to the technological control over human development, the novel also describes how in this society all individuals were manipulated through classical conditioning to reinforce class distinctions. This dual level of control distinguishes the society of the Brave New World from efforts to shape behavior primarily