Nanolaw Ethics

A Janus Approach With Contemporary Human Rights

By

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The views expressed are those of the author and do not reflect the official policy or position of the Department of Homeland Security (DHS) or the U.S. Government. DHS cannot attest to the substantive or technical accuracy of the information.[1]

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[1] Pursuant to 5 C.F.R. § 2635.807(b)(2).

> [L]iving technology is not just one more technology; rather it is the perfection of technology as understood by Aristotle. Aristotle's thinking is in this way a key example of a profound and very forceful reassessment of nature and technology.
>
> ~ Søren Riis, Roskilde University, Denmark[2]

[2] Søren Riis, *The Ultimate Technology: The End of Technology and the Task of Nature*, 19 Artificial Life 471, 472 (MIT Press, Cambridge, Massachusetts 2013), doi:10.1162/ARTL_a_00119.

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Chapter 1

Introduction

1.1 Front Matter

This book introduces several subjects that enable a universal ethical solution for nanotechnology. It does this through nanolaw and nanoethics which can be internationally applied in most situations. Since some of the subjects are relatively new and complex, it will introduce them with an ancient story and film. Stories and film, like other art, will also play important roles in the ethical solution later in the book. They will also reveal how nanotechnology and the nanoscale already affects all lives on an unprecedented scale, whether they realize it or not. Ethical regulation of nanotechnology also must address controversial human right issues. Art helps illustrate them not only for the student or layperson, but also legal and scientific experts. Movies and books continue to be banned for sparking controversy in part because they can be more effective in illustrating controversial subjects through uncontroversial means. Stories also illustrate how humans use language, grammar, and words to reveal their cognitive processes. These cognitive processes are nanoscale. A simple story is also part of this book's minimalist ethical solution.

1.1.1 Janus in Ancient Roman and Contemporary Culture

Janus was an ancient major Roman god known as the "God of gods."[3] Unlike most Roman gods, he had no Greek equivalent.[4] The month "January" comes from his name, which marks the beginning of the agricultural year and growth cycle.[5] He was known as the god of transitions and new beginnings and endings.[6] He was often associated with doorways,

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[3] *See, e.g.*, Bessie Rebecca Burchett, Janus in Roman Life and Cult: A Study in Roman Religions 6, 9-12 (George Banta Pub. Co. 1918).

[4] O. Seemann, The Mythology of Greece and Rome 17 (Harper & Bros. 1877, tr. from German).

[5] *Id.* at 86.

[6] *Id.* at 87-88.

passages, and hallways.[7] He had a duality that included transition from war to peace.[8] Janus wholeheartedly welcomed and embraced Saturn, who was a refugee or immigrant.[9] Saturn was the god of time, wealth, and agriculture.[10] Together they combined their traits, one as an immigrant, the other as a native. They ruled through a golden age[11] with their combined strength. They educated Romans on how to farm, produce grapes and to be civilized, including following the law.[12]

The concept of a duality with Janus, looking back to the past and to the future, has been applied in differing ways in scientific research, from nanotechnology[13] and engineering[14] to medicine[15] and law.[16] There are Janus nanoparticles,[17] Janus nanoarchitectures,[18] and a Janus philosophical

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7 *See, e.g.*, Rabun Taylor, *Watching the Skies: Janus, Auspication, and the Shrine in the Roman Forum*, 45 Memoirs of the American Academy in Rome 1-40, 1 (Univ. Mich. Press 2000).

8 *See, e.g.* Seeman, The Mythology of Greece and Rome, *supra* note at 87.

9 *Id.* at 155-56.

10 *See, e.g.* Encyclopedia of Time 209, 293, 543-544 (Samuel L. Macey, ed., Taylor & Francis 2013); and Kathleen N. Daly and Marian Rengel, Greek and Roman Mythology, A to Z 131 (Facts on File, Inc., 2009).

11 *See, e.g.*, Gods and Goddesses of Greece and Rome 153 (Brian Kinsey, ed. Marshall Cavendish Ref. 2011).

12 *See, e.g.*, William E. Dunstan, Ancient Rome 31-32 (Rowman & Littlefield Pub. 2011) ("[H]e taught and persuaded them to live together after an honest sort, in husbandry and tilling the ground, whereas their manners were rude and their fashion savage without law or justice altogether.").

13 Verónica Montes-García and Paolo Samorì, *Janus 2D materials via asymmetric molecular functionalization*, 13 Chem. Sci. 315-328 (Royal Chem Soc. 2022) (discussing the Janus Approach and the Roman two-faced god Janus).

14 D. Jarvis, J. Jarvis, C. W. Yang, R. Sinha and V. Vyatkin, *Janus: A Systems Engineering Approach to the Design of Industrial Cyber-Physical Systems*, 2019 IEEE 17th International Conference on Industrial Informatics (INDIN), Helsinki, Finland, (IEEE 2019) pp. 87-92, doi: 10.1109/INDIN41052.2019.8972051.

15 Kohkichi Hata and William Collins, Editorial: *Color Doppler Imaging and Ovarian Tumor Angiogenesis: The Janus Approach*, 9 Ultrasound Obstet. Gynecol 297-299 (Wiley 1997).

16 Gunther Teubner, *The Two Faces of Janus: Rethinking Legal Pluralism, 13* Cardozo L. Rev. 1443 (1991 - 1992)

17 Marco Lattuada and T. Alan Hatton, *Synthesis, properties and applications of Janus nanoparticles*, 6 Nano Today 286-308 (Elsevier 2011), https://doi.org/10.1016/j.nantod.2011.04.008.

18 Ziyang Wu, Li Li, Ting Liao, Xinqi Chen, Wan Jiang, Wei Luo, Jianping Yang, Ziqi Sun, *Janus nanoarchitectures: From structural design to catalytic applications*, 22 Nano Today 62-82 (Elsevier 2022), https://doi.org/10.1016/j.nantod.2018.08.009.

outlook on nanotechnology.[19] He has been incorporated into countless songs and books named after him[20] and many stores all over the world bear his name.[21] This includes a movie company, *Janus Films*, which began at Brattle Theater in Cambridge, Massachusetts.[22] They restored and remastered old films, merging with the *Criterion Collection*, a well-respected company that is noted for selecting and restoring classic and contemporary films for modern audiences.[23] The films were for world distribution, but they had their start at this small arthouse movie theater in Cambridge. The company had its trademark an image of the bearded two-faced Janus on an ancient old coin.[24] This author watched a few of these old films at Brattle Theater when he lived in Cambridge and Somerville while working in Boston.[25] This helped him escape the drudgery and stress of work and everyday life. Movies are also simply enjoyable. Sometimes, they can teach important lessons.

Janus Films picks which films to remaster and redistribute. This includes a French film, *The Rules of the Game* or *La règle du jeu*, *by Jean Renoir*,[26] which

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[19] Pascale R. Leroueil, Seungpyo Hong, Almut Mecke, James R. Baker, Jr., Bradford G. Orr, and Mark M. Banaszak Holl, *Nanoparticle Interaction with Biological Membranes: Does Nanotechnology Present a Janus Face*?, 40 Chem. Res. 335–342 (2007), https://doi.org/10.1021/ar600012y.

[20] For example, a search on Amazon books produces approximately 2,000 books with Janus as part of the title, and in Apple Music, there are over 50 songs with Janus as part of their title and tens of artists or groups with it has the name or part of their name.

[21] *See, e.g., Janus Books* in Canada which sells second-hand or used books, perhaps bringing them back to life: <https://janusbooks.ca/pages/about-us>.

[22] All Things Considered, Andrea Shea, Janus Films, the Face of Art and Foreign Film, National Public Radio, Nov. 3, 2006 <https://www.npr.org/2006/11/03/6430428/janus-films-the-face-of-art-and-foreign-film>.

[23] *See Our Mission,* The Criterion Collection <https://www.criterion.com/about>.

[24] *See* <https://www.criterion.com/shop/collection/402-janus-films>.

[25] *See* The Brattle <https://brattlefilm.org/>.

[26] See Janus Films, The Rules of The Game, Jean Renoir France, 1939 <https://www.janusfilms.com/films/1043> ("Considered one of the greatest films ever made … a scathing critique of corrupt French society cloaked in a comedy of manners in which a weekend at a marquis' country château lays bare some ugly truths about a group of haut bourgeois acquaintances. The film has had a tumultuous history: it was subjected to cuts after the violent response of the premiere audience in 1939, and the original negative was destroyed during World War II; it wasn't reconstructed until 1959. That version, which has stunned viewers for decades, is presented here in a gorgeous new 4K restoration.").

was heralded as one of the best films of all time,[27] even above or just behind *Citizen Kane*.[28] It was banned by France because it showed the indulgences of its bourgeois before the War; the negative of the film was even destroyed and had to be reconstructed.[29] They also included the film *Andrei Rublev*, an important painter and saint[30] by the great Russian director Andrei Tarkovsky.[31] It was banned in the Soviet Union because it showed a positive role of Christianity as part of Russia's historical identity.[32] They brought films for U.S. audiences from all over the world, from Italy, Spain, Hong Kong, Japan and Senegal, to Poland, Germany, Denmark and India.[33] Some of which were banned because of their take on politics, sexuality or other social themes. *Rublev* and *Rules of the Game* may appear less controversial since they were farther back in time with governments that no longer exist or experienced revolutionary societal change and war, but some more recent ones hit closer to home.

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[27] Ben Kenigsberg, What Makes a French Comedy One of the Greatest Films of All Time? N.Y. Times Jan. 7, 2021 <https://www.nytimes.com/2021/01/07/movies/jean-renoir-rules-of-the-game.html>.

[28] Richard Brody, Why "Citizen Kane" Got Labelled the Best Film Ever Made, The New Yorker, Sep. 2, 2012 <https://www.newyorker.com/culture/richard-brody/culture/richard-brody/praising-kane>.

[29] *See* Janus Films, *The Rules of the Game, supra* note 26.

> Considered one of the greatest films ever made … a scathing critique of corrupt French society cloaked in a comedy of manners in which a weekend at a marquis' country château lays bare some ugly truths about a group of haut bourgeois acquaintances. The film has had a tumultuous history: it was subjected to cuts after the violent response of the premiere audience in 1939, and the original negative was destroyed during World War II; it wasn't reconstructed until 1959. That version, which has stunned viewers for decades, is presented here in a gorgeous new 4K restoration.

[30] *See* Janus Films, *Andrei Rublev,* Andrei Tarkovsky, Soviet Union, 1966 <https://www.janusfilms.com/films/1827> ("Through the harsh realities of fifteenth-century Russian life, vividly conjuring the dark and otherworldly atmosphere of the age: a primitive hot-air balloon takes to the sky, snow falls inside an unfinished church, naked pagans celebrate the midsummer solstice, a young man oversees the casting of a gigantic bell. Appearing here in Tarkovsky's preferred 183-minute cut, as well as the version that was originally censored by Soviet authorities, Andrei Rublev is an arresting meditation on art, faith, and endurance, and a powerful reflection on expressive constraints in the director's own time.").

[31] *The 8th Best Director of All-Time: Andrei Tarkovsky,* The Cinema Archives <https://thecinemaarchives.com/2019/04/23/the-8th-best-director-of-all-time-andrei-tarkovsky/>.

[32] *See* Theodora Clarke, *Cinematic Gold: Tarkovsky's Andrei Rublev,* British Film Institute, Nov. 9, 2015, <https://www.bfi.org.uk/features/cinematic-gold-tarkovskys-andrei-rublev>.

[33] *See* <https://www.janusfilms.com/films/grid>.

One film would include the 1971 film, *Sweet Sweetback's Baadasssss Song* directed by Melvin Van Peebles.[34] At only the cusp of the civil rights movement, it portrayed black power challenging societal and political power in a new artistic style that led it to be being censored in some markets but is today heralded as a classic dealing with racial tensions.[35] Another more recently one is *Do the Right Thing* by Spike Lee in 1989.[36] It was not banned, but it did generate a significant amount of controversy upon its release creating fear that it would incite racial violence.[37] Today it is considered another classic dealing with racial tensions. Another that that this author recalls growing up in Missouri that was banned in 1988 because of religious challenge to some groups; it was Martin Scorsese's *The Last Temptation of Christ*.[38] It also is now in the *Criterion Collectio*n to "be viewed as the remarkable, profoundly personal work of faith that it is."[39] Indeed, this author always took it as a deep work of faith and introspection. It was more realistic. How it offended was always confusing for the author, but many in the small town he grew up in fervently protested it.

One movie that was banned in France near 1966 was the *Battle of Algiers* about the French Occupation of Algeria,[40] which this author viewed in another arthouse movie in Kansas City, the *Tivoli*.[41] In documentary style, it related how all the "terrorists" could be successfully killed, yet the French soon lost power regardless and Algeria gained independence. It began to

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[34] Melvin Van Peebles, Sweet Sweetback's Baadasssss Song, <https://www.criterion.com/films/32000-sweet-sweetbacks-baadasssss-song>.

[35] Steve Rose, *Sweet Sweetback's Baadasssss Song at 50: a radical moment for black cinema,* The Guardian, Mar. 15, 2021, <https://www.theguardian.com/film/2021/mar/15/sweet-sweetbacks-baadasssss-song-at-50-a-radical-moment-for-black-cinema>.

[36] Spike Lee, Do the Right Thing, The Criterion Collection <https://www.criterion.com/films/286-do-the-right-thing>.

[37] Nadia Khomami, *"I'm on the right side of history": Spike Lee on speaking truth to power – and why Beyoncé was robbed,* The Guardian, <https://www.theguardian.com/film/2023/feb/13/im-on-the-right-side-of-history-spike-lee-on-speaking-truth-to-power-and-why-beyonce-was-robbed>.

[38] Martin Scorsese, The Last Temptation of Christ, The Criterion Collection <https://www.criterion.com/films/612-the-last-temptation-of-christ>.

[39] *Id.*

[40] See also Alex von Tunzelmann, *The Battle of Algiers: a masterpiece of historical accuracy*, The Guardian, Mar. 26, 2009 < https://www.theguardian.com/film/2009/mar/26/the-battle-of-algiers-film-historical-accuracy>.

[41] *Tivoli at the Nelson-Atkins Premieres with Special Showing Oct. 21: Beloved Arthouse Theater Resurrected in Iconic Museum*, Nelson-Atkins Museum, Sep. 20, 2019, <https://nelson-atkins.org/tivoli-nelson-atkins-premieres-special-showing-oct-21//>.

be distributed in U.S. theaters on the eve of the U.S. Invasion of Iraq and was screened by the Pentagon 2003 to consider the challenges with occupying Iraq.[42] *Criterion* describes that this film:

> [V]ividly re-creates a key year in the tumultuous Algerian struggle for independence from the occupying French in the 1950sAs violence escalates on both sides, children shoot soldiers at point-blank range, women plant bombs in cafés, and French soldiers resort to torture to break the will of the insurgents. Shot on the streets of Algiers in documentary style, the film is a case study in modern warfare, with its terrorist attacks and the brutal techniques used to combat them. Pontecorvo's tour de force has astonishing relevance today.[43]

The French targeted Arab and Muslim males in their quest 132-year quest to occupy Algeria[44] and this author experienced and watched the U.S. government do similar things in the aftermath of 9/11 as an immigration lawyer, and unfortunately, again today as this book was drafted.[45] These films and others were initially controversial but have been re-evaluated over time and are now considered important works that are studied for their social and cultural contributions.

Perhaps it not fully understood why the name "Janus Films" was chosen by the company's founders, nor why *Janus* was chosen by other companies, song writers[46] or scientists. Regardless of their reason for choosing "Janus," the fact is that they brought classic and contemporary films to modern audiences. Some of this includes colorization, but mostly restoring, refor-

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[42] *See Ethics on Film: Discussion of "The Battle of Algiers,"* The Carnegie Council, May 5, 2009 <https://www.carnegiecouncil.org/media/series/ethics-on-film/ethics-on-film-discussion-of-the-battle-of-algiers>.

[43] Gillo Pontecorvo, The Battle of Algiers, The Criterion Collection <https://www.criterion.com/films/248-the-battle-of-algiers>.

[44] *See How a massacre of Algerians in Paris was covered up,* BBC News, Oct. 17, 2021 <https://www.bbc.com/news/world-africa-58927939> ("It shows the stark anti-Arab racism of the day … Mr Riceputi says the racist nature of the operation cannot be ignored - every person who looked Algerian was targeted."). *See also* Salim Hamidani, *Colonial Legacy in Algerian–French Relations, 13* Contemporary Arab Affairs 69–85 (Univ. Cal. Press 2020), https://doi.org/10.1525/caa.2020.13.1.69.

[45] *See generally* Twibell, *The Road to Internment,* Vt. Law Rev., *infra* note 1522.

[46] For example, a search in the Apple Music application reveals tens or hundreds of songs and groups named after or referring to Janus.

matting, repackaging films and providing supplemental materials.[47] This helped audiences to not only see high film, but to better understand film masters in fresh new ways as these movies continue to pass the test of time.

Analogously, this book seeks to bring some of humanities highest achievements in the past to be "restored" and repackaged as "nanotechnology." It is not just this author doing it. Scientists and all nanotechnological institutions already look at nanotechnology in this way in technology and medicine. However, this book is one of the first to look at law in this way. This new understanding will help apply law and ethical standards to nanotechnology today and in the future. These ethical issues have a duality that Janus also typifies. As this book will discuss, from human artifacts such as glass goblets or super sharp strong swords, or in medicine going back two or three hundred years, these were in fact nanotechnology or nanomedicine, long before the terms came into being. They are like classic films coming back to life that illustrate and bring to life important ideas including political, social, or cultural reflection. These ideas can be controversial. Some countries or localities wanted the movies banned because of these threatening ideas. This is an unfortunately similar reality for nanoethics. Movie distributors also bring movies together for one audience, and similarly, in nanoethics, this book provides a threshold unified ethical analysis internationally. It also seeks to be realistic, not idealist.

These movies also help illustrate something else: Humans are growing to come to terms with race, as well as to some degree, religion, and politics. But it is less so with nationality. Yet, all of these are nanoscale human traits that one has little or no control. A nation's decision to go to war also inflames emotions of native nationalism with foreign nationality, ethnic, racial, and political targeting. These movies also represent controversy. This book is meant for an international audience and all readers will have sensitivity or bias or deem issues to be more or less important than others. The solution for this book is not to shy away from these issues, but to confront them head on in a universal way because they relate not only to nanoethics, but they are issues science and human society must face up to because nanotechnology involves them all.

Additionally, professional nanotechnologists are unlikely to risk funding

[47] *See,* FAQ, The Criterion Collection <https://www.criterion.com/faq>.

or social ostracization to confront, yet they risk giving tools for those who do already what they are doing, with more potent force.[48] That should also make it as concerning that no one is not touched by nanotechnology. Health and the Covid pandemic affected everyone. Covid vaccines, which as discussed below, are created from mRNA nanotechnology. As of an early draft of this book, a new potential for an RNA vaccine (non mRNA) that self-grows without potentially the need for boosters.[49] Gene-edited humans or newborn babies have become legal and ethical concern.[50]

Consequently, although the human rights issues will be raised in the movies above, including issues of race, religion, terrorism or the class struggle brought to light by these movies, it will do so with human rights and references to instead science fiction movies, such as Ridley Scott's *Blade Runner,*[51] Steven Spielberg's *Minority Report,*[52] Spielberg and Stanley Kubrick's *A.I.*[53] or George Orwell's *1984,*[54] which include the deepest controversy and issues of this book.

Nanotechnology of the past and future includes many ethical issues. One of these is not only going forward with nanotechnology, but wrestling with ethical issues if nanotechnology is held back. This will be illustrated below with an article in the *Guardian* newspaper regarding Stephen Hawking and London's Children's Hospital's thoughts on the matter including nanotechnology's promise in curing Leukemia in children by altering their genes with gene therapy.[55] As of the writing of this book the U.S. Food and Drug

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[48] *See Generally* Twibell, *Genes, Memes, Language and Nanomachines,* S. Cal. Interdisc. L.J., *infra* note 152. But see However, there may be a new trend towards scientists becoming more politically active, see News Feature, Daniel Grossman, *Scientists under arrest: the researchers taking action over climate change,* Nature Nanotechnology, Feb. 21, 2023 (Springer).

[49] Elie Dolgin, *Self-copying RNA vaccine wins first full approval: what's next?* 624 Nature 236-237 (Springer 2023), https://doi.org/10.1038/d41586-023-03859-w ("Researchers look ahead to the potential uses and benefits of a technology that has been more than 20 years in the making.").

[50] *See* Pallab Ghosh, *China's new human gene-editing rules worry experts*, BBC News, Mar. 6, 2023.

[51] *See supra* note 1479.

[52] *See supra* note 1478.

[53] *See supra* note 1437.

[54] *See supra* note 1476. The book is discussed, but the movie 1984 is also part of the Criterion Collection: <https://www.criterion.com/films/29140-1984>.

[55] *See infra* § 1.1.4 Janus and Nanoethic Duality.

Administration (FDA) licensed gene editing to treat sickle cell amenia in children with the same technology referenced in the *Guardian* article.[56] *MIT Technology Review* also notes that in controversial gene editing of babies in China to make them resistant to HIV, it may also have enhanced their memory and cognition.[57]

1.1.2 Janus and Nanotechnology's Relevance

Humans have accumulated centuries of scientific knowledge that are pushing the boundaries of what is possible in the future, but with ethical challenge. Janus is this gateway and a way in looking at this duality of the technological promise and ethical challenge of nanotechnology. "Nanotechnology" is simply the science or the engineering of manipulating matter at an extremely small scale, including individual atoms and molecules, to either create new products, materials, or devices to improve existing ones. An example of how tiny the nanoscale is, think of a marble like one played with as a child.[58] Then imagine the Earth as a marble, which would be an incredibly large and massive marble. Then compare them. If the ordinary marble was a nanometer, the diameter of the Earth-sized marble would be a meter.[59]

Nanotechnology is not just one technology. It includes an entire spectrum of techniques, materials and applications that relate to everything from medicine, electronics, artificial intelligence (AI) to agriculture, genetic engineering, and industry, such as energy and steel production. This is also why Janus's work with Saturn is so relatable, as agriculture, economy, and law are broad vast effecting societal components. And if one still does not

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[56] Meg Tirrell, FDA approves two gene therapies for sickle cell, bringing hope to thousands with the disease, CNN, Dec. 8, 2023 ("the CRISPR-based treatment, made by Vertex Pharmaceuticals and Crispr Therapeutics; Lyfgenia, made by bluebird bio, uses an older gene therapy approach. Both were cleared for people 12 and older with histories of vaso-occlusive crises, painful events caused by the disease").

[57] Antonio Regaladoarchive, *China's CRISPR twins might have had their brains inadvertently enhanced,* MIT Technology Review, Feb. 21, 2019 <https://www.technologyreview.com/2019/02/21/137309/the-crispr-twins-had-their-brains-altered/> ("New research suggests that a controversial gene-editing experiment to make children resistant to HIV may also have enhanced their ability to learn and form memories.").

[58] *See, e.g.*, About Nanotechnology, *The Size of the Nanoscale,* National Nanotechnology Initiative, <https://www.nano.gov/nanotech-101/what/nano-size>.

[59] *Id.*

think nanotechnology is relatable, take for instance, the Covid vaccine—its mRNA technology is a product of nanotechnology.[60] It has revolutionized vaccines into a new class[61] and already, there are non-mRNA vaccines being developed improving it further with less side effects.[62] Nanotechnology continues to not only reveal promises against cancer with gene editing treatment,[63] but in general, human genome editing is a primary area of scientific endeavor.[64] Thus, there is little that nanotechnology has not touched and more it proponents wants it to touch. This breadth and scale of nanotechnology is what makes it so revolutionary.

And if one did not think nanotechnology impacts them enough in these ways, nanotechnology is also using parts of that one to develop it: DNA. DNA is a primary tool and a branch in nanotechnology[65] in both biological and non-biological realms such as "polymer science, synthetic biology and medicine."[66] DNA technology can allow to "build such complex structures

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[60] *See, e.g.*, Tseng, H.F., Ackerson, B.K., Sy, L.S. et al. *mRNA-1273 bivalent (original and Omicron) COVID-19 vaccine effectiveness against COVID-19 outcomes in the United States*, 14 Nat Commun 5851 (2023). https://doi.org/10.1038/s41467-023-41537-7.

[61] Chen, S., Huang, X., Xue, Y. *et al. Nanotechnology-based mRNA vaccines*, 3 Nat Rev Methods Primers 63 (2023). https://doi.org/10.1038/s43586-023-00246-7 ("mRNA vaccines have emerged as a revolutionary tool to generate rapid and precise immune responses against infectious diseases and cancers. Compared with conventional vaccines such as inactivated viruses, viral vectors, protein subunits or DNA-based vaccines, mRNA vaccines stand out owing to multiple advantages, including simplicity of design, fast production, enhanced safety and high efficacy.").

[62] *See id., supra* notes 60-61.

[63] Zhang, D., Wang, G., Yu, X. *et al. Enhancing CRISPR/Cas gene editing through modulating cellular mechanical properties for cancer therapy*, 17 Nat. Nanotechnol. 777–787 (2022). https://doi.org/10.1038/s41565-022-01122-3 ("Genome editing holds great potential for cancer treatment due to the ability to precisely inactivate or repair cancer-related genes.").

[64] *See, e.g., Third International Summit on Human Genome Editing Symposia,* The Francis Crick Institute, Mar. 6 to 8, 2023, <https://www.crick.ac.uk/whats-on/third-international-summit-on-human-genome-editing> ("Building on previous events held in Washington, DC (2015) and Hong Kong (2018), this Summit will continue the important dialogue around human genome editing. It will facilitate a global discussion on somatic and germline genome editing, including developments in clinical trials and genome editing tools such as CRISPR/Cas9.").

[65] *See* Nature Portfolio, *DNA Nanotechnology* <https://www.nature.com/subjects/dna-nanotechnology>. *See also DNA nanotechnology 2.5,* 10 Nature Nanotech 729 (2015). https://doi.org/10.1038/nnano.2015.214 (discussing also some current challenges in animal application because "[c]rganisms have sophisticated mechanisms to detect and eliminate foreign DNA to protect their own DNA.").

[66] F. Ricci and H. Dietz, *The harmony of form and function in DNA nanotechnology*, 18 Nat. Nanotechnol. 541–542 (2023), https://doi.org/10.1038/s41565-023-01362-x.

through bottom-up self-assembly" and better study of "biology, protein assemblies for synthetic biology and green chemistry, targeted and adaptive drug delivery and diagnostic systems, multivalent."[67] DNA nanotechnology "in the past decades, including tissue regeneration, disease prevention, inflammation inhibition, bioimaging, biosensing, diagnosis, antitumor drug delivery, and therapeutics."[68]

DNA if it is not itself a living technology by some definitions, certainly when humans use DNA as a technology for other applications, it is becoming is a living technology.[69] Additionally, by many standards, humans and life or their constituents can be considered themselves "nanotechnology."[70] Humans and their DNA components are also inspirations for some of the highest expectations for nanotechnological achievement.[71] Utilizing DNA in nanotechnology intersects biology and engineering. Although DNA in general may not be considered itself a living technology because the DNA typically is not part of a living, self-replicating system, but used as building material that can be programmed to fold into specific shapes or to interact in specific ways with other molecules. While the DNA itself originates from living organisms, in nanotechnology it's usually acting in a way that is not inherently alive.

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[67] N. Seeman, *DNA nanotechnology*, *3* Nat Rev Mater 17068, 18-19 (2018)., https://doi.org/10.1038/natrevmats.2017.68. As of the final drafts of this book, continued work in bridging dry or wet nanotechnology, bottom-up or organic and non-organic nanotechnology continues. See *The intersection of bottom-up synthetic cell engineering and nanobiotechnology*, 19 Nat. Nanotechnol. 131 (Springer 2024), https://doi.org/10.1038/s41565-024-01627-z ("Nanotechnology is intimately intertwined with efforts to bring bottom-up synthetic cell research to the forefront, and only strengthening these bonds will expand the scope of what this might achieve.").

[68] W. Ma, Y. Zhan, Y. Zhang, *et al. The biological applications of DNA nanomaterials: current challenges and future directions*, 351 Sig Transduct Target Ther 1 (Nature 2021). https://doi.org/10.1038/s41392-021-00727-9

[69] *See id.* at 1 ("DNA, the carrier and transmitter of genetic information in all living systems, consists of four different deoxynucleotide monomers"). *See also* Mark A. Bedau, John S. McCaskill, Norman H. Packard, Emily C. Parke, Steen R. Rasmussen, *Introduction to Recent Developments in Living Technology*, 19 Artif Life 291–298 (MIT Press 2013), doi: https://doi.org/10.1162/ARTL_e_00121; and Søren Riis, *The Ultimate Technology: The End of Technology and the Task of Nature*, 19 Artif Life 471–485 (MIT Press 2013), doi: https://doi.org/10.1162/ARTL_a_00119 (discussing ambiguity of living technology and other technologies, including cybernetics and gene-altered bacteria).

[70] *See infra* § 8.3.2B Analogy to other Nanomachines.

[71] *See infra* § 8.3.1 Analogism of Humans as Nanomachines in Nanomedicine.

However, DNA in nanotechnology could be considered as bordering on living technology. DNA nanotechnology straddles the line between inanimate materials and biological systems, often borrowing mechanisms from life to achieve specific functions. While it may not possess all the characteristics of living systems—like metabolism, growth, or self-replication—it does use biological molecules to perform tasks in a way that's inspired by life. As of the writing a final draft of this book, case in point, this line has been crossed to where there is clearly living technology: By utilizing human tracheal cells, scientists have developed robots made out of cells, dubbed "anthrobots" which have been able to repair damaged neural tissue.[72] They can combine to form a "superbot" to repair tissues, heralding a new "tissue engineering 2.0."[73] Self-replication biobots from human lung tissue also have been developed that have advantages in tissue repair without manual sculpting or gene editing.[74]

Humans also could be viewed as a type of natural nanotechnology because cellular processes often occur at the nanoscale and involve molecular machines like ribosomes and enzymes. Many top scientists and Nobel laureates have refenced humans as such.[75] Then, when humans begin to be integrated into nanotechnology, such as through medical implants, drug delivery systems, or even theoretical concepts like "nanobots" for repairing cells—then that would be a form of merging biological life with engineered nanomaterials. This begins to become amalgamations of biological and nanotechnological components. It begins to blur the lines of natural and engineering nanotechnology, even leading to a new paradigm for understanding what it means to be human. This book's solution would include this new paradigm.

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[72] *See* Matthew Hutson, *Tiny robots made from human cells heal damaged tissue,* Nature News, https://doi.org/10.1038/d41586-023-03777-x.

[73] *See id.:*
Going forward, Levin, Gumuskaya and their colleagues think anthrobots made from a person's own tissue could be used to clear arteries, break up mucus or deliver drugs, with or without genetic engineering. By combining several cell types and exploring other stimuli, it might also be possible to develop biobots — robots made from biological material — with potential applications in sustainable construction and outer-space exploration

[74] *See* Gizem Gumuskaya, Pranjal Srivastava, Ben G. Cooper, Hannah Lesser, Ben Semegran, Simon Garnier, and Michael Levin, *Motile Living Biobots Self-Construct from Adult Human Somatic Progenitor Seed Cells,* Adv. Sci. 2303575 (2023 Wiley), https://doi.org/10.1002/advs.202303575.

[75] *See infra* § 3.1.4 Human Regulation as Nanolaw.

1.1.3 Janus's Treatment of Saturn as an Immigrant

Janus also taught Greeks to be civilized and he opened himself and welcomed the immigrant Saturn. He showed by doing so, one can perhaps achieve a golden age of sorts, or perhaps at least, a better world. This is important, because looking at nanotechnology in new ways reveals that human regularly regulate based on actual or perceived nanoscale attributes which are manipulated or projected onto other humans. Most often, this has been done to immigrants. This story also draws a parallel to nanotechnology as Janus can be a bridge between historical scientific practices and future technologies. Janus can be seen as a gateway of the parallel. This duality helps understand the dual nature of nanotechnology. This is the major ethical issue of nanotechnology. One of his faces to the left looks back to old methods, not only in science, but in law. The right side of his face is looking to the future with new methods in science, medicine, law, and industrial revolutions. One of his faces can be seen looking to the promise and innovation of nanotechnology and the other to its ethical and moral challenges.

1.1.4 Janus and Nanoethic Duality

A few years ago, *The Guardian* published an article[76] that set up the dichotomy of what confronts one of the major issues in Nanoethics today, as demonstrated with Janus's duality and its applications to nanoethics. On one side was the famous physicist and astronomer Stephen Hawking.[77] He helped bring science, especially cosmology, to the masses[78] and increased understanding of some of the most important aspects of our lives from black holes and reality[79] to personal survival and compassion.[80] The use of the word "genius" is rarely used with Hawking because the word is not

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[76] *See* Sarah Marsh, *Physicist said genetic editing may create species that could destroy rest of humanity: Essays reveal Stephen Hawking predicted race of "superhumans,"* The Guardian, Oct. 14, 2018.

[77] *See id.*

[78] *See* Stephen Hawking, A Brief History of Time (Bantam, 1998).

[79] *See, e.g.* Thomas Hertog, On the Origin of Time: Stephen Hawking's Final Theory (Bantam, 2023).

[80] The Theory of Everything (Working Title Films, 2014) [popular movie about life of Stephen Hawking, which was based on his wife: Jane Hawking, Travelling to Infinity: My Life with Stephen (Alma Books 2007)].

enough. His words, especially after his unfortunate passing, continue to carry great weight. Articles are written about newly discovered things he wrote or said. Newspapers from all over the world, from the U.K.[81] and the U.S.[82] to India[83] and China,[84] publish stories on newly discovered things he said, turn out to be true as he predicted, after his death, or the disabled all around the world Hawking inspired. Things he said evidence his thoughts. Issues he postulated still give society more to ponder from his great mind after its death. His thoughts on AI,[85] time, black holes, and potentially threatening alien life,[86] continue to illuminate. The name, word or phrase "Stephen Hawking" immediately conjures meaning in one's brain. His name and its meaning have passed throughout the human population like a meme[87] in not only its news, but movies and literature.

Hawking stated something very relevant to this book. He warned that "[l]aws will probably be passed against genetic engineering with humans. But some people won't be able to resist the temptation to improve human characteristics, such as memory, resistance to disease and length of life."[88]

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[81] *See supra* Marsh, *Physicist said genetic editing may create species that could destroy rest of humanity*, note 76.

[82] *See, e.g.* Dennis Overbye, *Did Death Cheat Stephen Hawking of the Nobel Prize,* New York Times, Oct. 4, 2021 (discussing recent study of blackholes that Hawking predicted decades ago).

[83] *See Here's Stephen Hawking's last scientific paper and all about it,* India Today ("Stephen Hawking's final scientific paper -- completed days before the British physicist's death -- has been written and posted online by his colleagues at Cambridge and Harvard universities.") (updated Oct 12, 2018), <https://www.indiatoday.in/education-today/gk-current-affairs/story/stephen-hawkings-final-paper-1366718-2018-10-12>.

[84] *See* Han Junhong, *Inspired by Hawking, Student with Disability Blazes Own Path,* China Daily, <https://www.chinadaily.com.cn/a/202108/05/WS610bc9e4a310efa1bd666f34.html > (updated Aug. 5, 2021).

[85] *See, e.g.,* Rory Cellan-Jones, *Stephen Hawking warns artificial intelligence could end mankind,* BBC News, Dec. 2, 2014 <https://www.bbc.com/news/technology-30290540> ("Prof Stephen Hawking, one of Britain's pre-eminent scientists, has said that efforts to create thinking machines pose a threat to our very existence. He told the BBC: 'The development of full artificial intelligence could spell the end of the human race.'").

[86] *See, e.g.,* Morgan McFall-Johnsen, *Congress's UFO hearing shows the hardest part of discovering alien life may be announcing it. Here's how NASA might break the news,* Business Insider, <https://www.msn.com/en-us/news/technology/congresss-ufo-hearing-shows-the-hardest-part-of-discovering-alien-life-may-be-announcing-it-heres-how-nasa-might-break-the-news/ar-AA17EeKP> ("Critics like Stephen Hawking have said that contacting any extraterrestrial intelligence could pose an existential risk for humanity.") (updated Feb. 18, 2023).

[87] *See* Dawkins, The Selfish Gene, *infra* note 138 and accompanying discussion.

[88] *See supra* Marsh, *Physicist said genetic editing may create species that could destroy rest of*

He based this on him being "sure that during this century, people will discover how to modify both intelligence and instincts such as aggression."[89] This is true and it has begun already into more realms as noted by the top science journals, including not only aggression, disease, and longevity, but also diagnosis, reproduction, personality, performance improvement, improved cognition, and performance enhancement.

The Guardian was keen to point out the juxtaposition of an even more important part of society that Hawking has so greatly contributed. They are a much more powerful and emotive side, perhaps of the whole of society: Children.[90] This particularly includes children of incurable diseases. Yet, there was no one name or concept akin to "Stephen Hawking," but something more complicated that took several words, phrases, and sentences to convey. The Guardian stated Hawking's "comments refer to techniques such as Crispr-Cas9, a DNA-editing system that was invented six years ago [2012], allowing scientists to modify harmful genes or add new ones. Great Ormond Street hospital for children in London has used gene editing to treat children with an otherwise incurable form of leukemia."[91] Crispr-Cas9 technology has continued to advance today: "Gene editing is a technology that precisely modifies the genome sequence to induce insertions, deletions, or base substitutions in the genome."[92]

This is but one of one example of biotechnology or nanotechnology;[93] their issues can overlap. Thus, there appears to be a balance of fearful concern of more predatory rich or powerful exploitation on one hand, and on the other, a compassionate need for such technological medical research development to protect the most vulnerable and sympathetic of society. It also

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humanity, note 76.

89 *See id.*

90 *Id.*

91 *Id.*

92 *See* Tianxiang Li, Yanyan Yang, Hongzhao Qi, Weigang Cui, Lin Zhang, Xiuxiu Fu, Xiangqin He, Meixin Liu, Pei-feng Li & Tao Yu, *CRISPR/Cas9 therapeutics: progress and prospects*, 8 Signal Transduction and Targeted Therapy Art. 36, at 1 (Springer Nature 2023), <https://doi.org/10.1038/s41392-023-01309-7>.

93 The terms "biotechnology" and "nanotechnology" are each their own distinct terms, but their issues overlap, and this is one of the important general considerations of this book, is that there is overlapping adding to the difficulty of ethical regulation. They share many common issues, as demonstrated in this article, and technologically, they could overlap.

demonstrates that even a decade ago, nanoscale science was already saving children against a well-known common disease that underlies its importance by editing genes.

However, it is not that neatly apportioned if one continues to unpack Hawking's observations. Hawking recognizes that with such powerful tools, including with improving human characteristics such as aggression, intelligence, and longevity, humans, even governments or corporations, will do it, breaking the law or violating ethics, if such exist and they may not in the case of nanotechnology. And it is not children necessarily on the other side. Children are often most exploited, such as in the case of human trafficking and modern-day slavery, not to mention the rich poor world dichotomy. Children also may need nanomedicine, but they are often unable to make their own legal decisions. Medicine requires test subjects and research. To reach medical achievement even for children, ethical hurdles are required to be jumped. Research includes test subjects on whom nanomedicine is tested and if the research, medicines, or diagnostics are not developed fast enough. Yet each day can mean a lost life. There are those who need the medicine and those who can obtain adequate health care. Millions of children need it and may never get it even if it is available. This can be individually or societally.[94]

Governments or parts of society can play the roles that Hawking has concern; they may want to improve soldier aggression and performance, or trafficking victims less calorie consumption, more work output and cognitive controllability. Marginalized minorities are also part of the vulnerabilities being already vulnerable. There is also a right to research, the right to be cured, the right to have one's health improved and the right to have a normal life. These can be human rights, which transverse many realms from a multitude of directions.

Technological advance is not just needed, society urgently needs nanotechnology for solutions to clean energy, medicine, food shortage and ecosystem balance. Nobel laureates have pleaded the case for nanotechnology for decades, since some solutions such as fusion, are still decades away.[95] Powerful corporate or governmental interests can also tilt the balance in

[94] This is such an important issue even with today in nanomedicine, a specific hypothetical on the subject is included at the end in hypothetical case studies at Ch. 15.

[95] *See* Smalley discussion associated with *infra* note 321.

promoting society need for power or economic gain without sufficient public stakeholder participation, yet they are the ones who can really make a difference and make it possible when public awareness is insufficient to properly develop nanotechnology. Nanotechnology is already raising these issues to the surface, and many stronger ones will break through. Thus, there is much that does not meet the eye in the dichotomy of Hawking's caution and the need for medical advance. Yet, in some respects, a mythical balance better serves humanity than an obscure realistic balance. There is a necessity to perpetually balance between caution and need. That is, to be cautious or regulate new technology, but only as minimally necessary to make sure the technology progresses for societal or individual needs.

As to the less apparent things in this story, not only Hawking's ideas but Stephen Hawking as a concept, or an abstract idea attached to words and language of this article. One can call it a "meme" or an attachment of a deep meaning and idea to not only the words "Stephen Hawking," but also "children," "leukemia" and "hospital." They are equally if not more powerful, but perhaps more common, becoming repetitive and mundane. They are not what catch attention to write the article, but perhaps a tool to catch attention and write about something important, such as curing diseases in children. There is language with words and phrases of "genes" and "Crispr-Cas9" and "DNA." They are more complicated and common concepts embedded in a small paragraph, compared to "Stephen Hawking," depending on the reader's perception and knowledge of Hawking or these other areas. These words may take more cognitive processing, especially "Crispr-Cas9." The receiver already knows what Stephen Hawking is and the concept of Stephen Hawking has much deep meaning and information associated with it relative to the reader's knowledge of Hawking and these issues; it may be easier to recall and understand than the sentences and technical words about gene editing for children.

Apart from these words, are larger phrases, sentences, and then overall primary ideas and then there is the more complex layers of processing broader related ideas from this article, what they trigger with the reader's thought processes, memories, current activities, education, and genetic predisposition, and so much depends on the reader's brain processing it. They may come from cultures where Hawking is little mentioned, nor English, a primary role. Yet, regardless of the language, the concept of

Hawking is likely to be stored similarly.

What does this language and the act of reading this article itself have to do with nanotechnology? It is this interface and mental processing the reader is having this article and its content, including written and internal language, relates to cognition and language. Cognition and language are nanoscale. Further, humans through evolution, have a specific gene, or series of genes, that allow them to attach abstract ideas to symbols in their thinking and language (internal and external), such as words. Genes are nanoscale. Not every animal can do this. In fact, no animal can do this. Only humans, not even the other four great apes.[96] Language also for humans is not just communication but primarily a cognitive tool. This understanding is underscored by top cognitive scientists, illustrated by a new book published by Cambridge University Press, who state that language is a biological endowment: "At a certain level of abstraction, then, there is just one human language faculty and thus one human capacity for language, which is, by definition, part of the innate biological endowment of Homo sapiens – your baby is born with it, your puppy is not."[97]

These ideas will resurface in this book and are important to an ethical solution, that could be potentially akin to a meme. It can be easier to learn and to analyze nanoethics and know what are "nanolaw" or human rights. Additionally, nanotechnology, nanoethics, nanomedicine or nanolaw, are all linguistic terms that carry deep meaning. Some of that meaning is developing with these new words. "Nanotechnology" represents new understanding and ability and so too does the "nano" language family. Although it is new science, it can also be used to look back in time on things not previously understood to be nanotechnology, to be nanotechnology. Then it can also peer into a future with better understanding. This is part of the Janus approach. Molding and developing the terminology is very important to develop the "thinking" of the nanotechnology family of words. Back to the broader issues.

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[96] For discussion on the distinguishment of language ability between humans and other animals, see *infra* notes 981-984.

[97] Noam Chomsky, T. Daniel Seely, Robert C. Berwick, Sandiway Fong, M.A.C. Huybregts, Hisatsugu Kitahara, Andrew McInnerney, and Yushi Sugimoto, Cambridge Elements in Generative Syntax, Merge and the Strong Minimalist Thesis 7 (Robert Freidin, ed., Camb. Univ. Press 2023).

1.2 Book Introduction

This book explores the ethical issues in nanotechnology, or nanoethics by looking at nanolaw.[98] It provides a present and future minimalist solution through a lens of looking at the past with new understanding. And just as important, it looks to future with new understanding.[99] This lens and new tools will not only help plan tomorrow but be better prepared for the already existent issues today.[100] Some of the tools are within our bodies and minds, but the insight into them is from new understanding and technology.[101] There are also some macro or legal tools that humans have already worked hard to create at the national level and internationally with other countries. They are ready to be applied globally in many types of relevant situations.[102]

However, this new understanding of the nanoscale will also open eyes to the past and present with new awareness and realization to find more ethical issues. It is akin to finding "skeletons" in human civilization's "closet," or "more dirt under the carpet" when one really looks at ethical issues through a nanoscale lens beyond more than what most scientists or legal specialists are either willing or unaware.[103] This raises more ethical concern, and raises the question whether it only adds to nanotechnology's ethical dilemmas.[104] Fortunately, the nanoscale lens in this ethical sweep can also provide new understanding for solutions with new tools even with the other issues found under the carpet; they were already there and paramount, but categorized differently.

There are many long standing ethical and legal issues in these areas like gene editing. The problems have existed for decades now, but this book finally has a solution. And the solution is not only in this practical realm that scientists think it should, rather than being esoteric that some lament about ethical jargon. Nanoscience creates a rethinking of law at the nanoscale.

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98 *See infra* Ch's 3, 9 & 10.

99 *See infra* Ch. 8.

100 *See id.*

101 *See id.*

102 *See* Ch. 4.

103 *See id.*

104 *See id.*

This rethinking of law at the nanoscale reveals even more nanoethical issues. They are longstanding ethical dilemmas still escaping science and rational thought. They are older than nanotechnology but also relate to the nanoscale. Literature and reality suggest that there is more benefit to nanotechnological advance and too much caution is based on fear. This is largely true, but as hinted above, there also is another reality in nanoethics not fully considered. This is in nanolaw.

In exploring these issues, this book promises to take you through a journey. It will take you through nanotechnology, law, nanomedicine, nanoethics, nanolaw, ethics and human rights. The journey includes not only the Roman god Janus, but also the ethicist Aristotle to help analyze modern issues. It invokes the famous astronomer Carl Sagan and King Charles, who had much to say the public understanding science and nanotechnology. This book will look at an English judge's decision in the late 1700s who provided a simple recipe for human dignity that evolved into great significance in legal scholarship. It was a precursor to modern day human rights documents and the Enlightenment. It explores these ideas from the Renaissance and the top scientific, legal, and ethical thought of today.

This book will explore the future including future nanotechnology, nanorobots and AI. It will talk about refugees, asylum seekers and laws regulating nationalities that many are not aware of. It will discuss immigration controversy, terrorists, the real threat of nuclear war. It will talk about hunger, exploitation, human trafficking and forced migration. It talks about national security, its problems and how to make it better. It will talk about people who need nanomedicine which can help them, but there are ethical dilemmas in how or if they can be given it. It talks about the major wars of yesterday, the wars of today and helps prepare for the wars of tomorrow.

This book includes science fiction, film, and popular culture. It will show that many of the issues we see in them are abstract clever ways of exploring the problems humans have now. This book will talk about language, linguistics, and cognition. It will make complicated or even intimidating subjects' everyday realization instead of science fiction. It hopes to make "nanotechnology," law and ethics, not to be so intricate, esoteric, or knotty, but something all of us as stakeholders in this important technological revolution should take by the helm.

This book will talk about some of the most important problems in society. This includes the main topic of the book, ethical and legal problems of nanotechnology. These and other problems are too well known, and some have dimensions that many are not aware because they relate to foreigners or enemy aliens.

This book also promises not to just be purely academic, but practical. After the journey and providing a solution to the problems discussed, it will provide case examples of the past, future and most importantly, the present with opportunities to apply the solution. What is explored in this book can be applied to real present-day life: It presents ethical legal solutions that are minimalist and can be universally applied no matter the reader's role or where they are in the world.

1.3 Science and Nanotechnology Education

Some argue that the lack of ethical development or clear ethical standards are due to the lack of public knowledge and discourse.[105] However, it is not just the "public," but also specialized occupations in and out of nanotechnology. One of the main issues in nanotechnology is that it moves forward without universal consensus because it is interpreted differently. Nanotechnology is broad, and analysis often compartmentalized or ethnocentric.[106]

The "law" is one answer because it applies to most everything. If one looks at the ethical standard for regulating the nanoscale, all nanotechnology can follow as it is or potentially can be regulated. Law is a big subject covering potentially everything. Where does one start? Perhaps, one can take another step back from this "nanotechnology" that permeates so many realms, away from the fuss, to clearly see the whole room—the elephant in the room: Humans. Humans also are nanotechnology. They are the pinnacle of technology, living technology. They are only one example. Not everyone believes this and there are some caveats to this concept, but that

[105] *See* Ch. 4.

[106] *See id.* Toumey, *Early voices for ethics in nanotechnology*, 14 Nature Nanotechnology, *supra* note 569 at 304–305.

will be discussed.[107] This will help provide a universal or global standard for emerging nanotechnology: The "humans" with their human rights law.

After humans, there are other analogies and standards for nanotechnology, but humans are a good starting point. This includes setting ethical standards. For example, as noted above, human DNA is one of the most important tools in nanotechnology, as are other biological materials of living creatures. New nanotechnology is already being applied to them, utilizing their bodies, diagnosing their bodies, altering their tissues, and using them as research subjects. This is just today; tomorrow's technology is another story which makes a legal ethical framework capable of regulating nanotechnology more important.

Some of this takes rethinking law with applied nanoscience. This creates a reciprocal ethical effect: Rethinking law in terms of nanoscience can also help law become more ethical. It helps law conform to a scientific standard of rationality but looking closer at how the law regulates the nanoscale and whether it does so in a rational manner. For this to be effective, it needs to be taken beyond nanoethics or esoteric legal discussions and into a more popular level of culture and discourse. One hindrance is that there is indeed insufficient public awareness about technology and human rights. The demand for ethical standards in runaway nanotechnology demands that the ethical standards must already be in existence and ready to use. History shows that law has always been too slow to respond to technological revolutions. Ethical analysis really needs to work beyond professional ethicists and other specialized professionals. It needs to be cross-disciplinary.

Top astronomer, author and science icon Carl Sagan warned during one of his last interviews in 1996, that humans live in a highly technical and scientific society, yet the public knows very little about it.[108] This is science and technology, then comes nanotechnology. King Charles raised the need

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[107] *See* Ch's 3 and 4.

[108] "We've arranged a society on science and technology in which nobody understands anything about science and technology, and this combustible mixture of ignorance and power sooner or later is going to blow up in our faces. I mean, who is running the science and technology in a democracy if the people don't know anything about it?" *Carl Sagan Interview,* Charlie Rose, Public Broadcasting System (PBS), broadcast May 27, 1996, <https://www.goodreads.com/videos/60991-carl-sagan-s-last-interview-with-charlie-rose-full-interview> (full interview, quote at 3:30) (visited Apr. 29, 2023).