Frankenstein Turns 200 and Becomes Required Reading for Scientists

By Sidney Perkowitz

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EVERYTHING ABOUT Mary Shelley's *Frankenstein* (1818) is remarkable — not just the story about the laboratory creation of a living being, but its backstory. Mary started writing it in 1816 as an 18-year-old. The daughter of two eminent English intellectuals, she ran away to France at 16 with the married romantic poet Percy Bysshe Shelley. She lost their child soon after its birth, and then married Percy after his wife committed suicide. The story was written at the instigation of Percy's literary pal, the famously "mad, bad and dangerous to know" Lord Byron, who had his own romantic entanglement with Mary's stepsister. When the book emerged,

Frankenstein: Annotated for Scientists, Engineers, and Creators of All Kinds

By Mary Shelley, David H. Guston, Jason Scott Robert, Ed Finn

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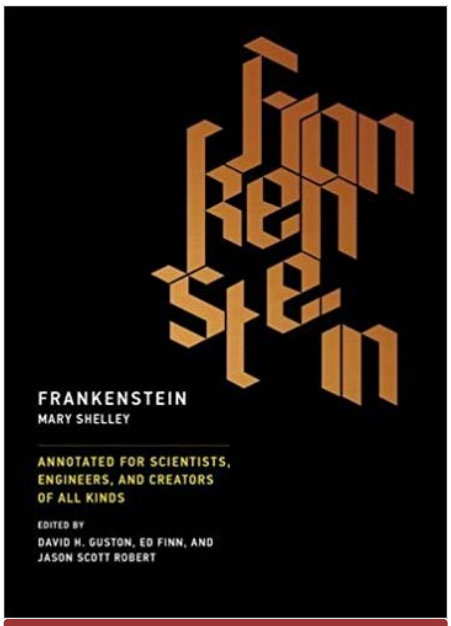
critics first ascribed it to Percy as a story that could not or should not have been written by a woman, until Mary corrected the record in her revised edition of 1831.

This rocky beginning turned into one of the greatest literary coups of all time. The tale Mary conjured up has never been out of print since it was published, and it is said to have appeared in more editions than any other novel. It has inspired scores of adaptations and related works in film, theater, and television. Now in its 200th anniversary year, it is the subject of a great many analytical and celebratory books — among them, *Frankenstein: Annotated for Scientists, Engineers and Creators of All Kinds*.

This effort was funded by the National Science Foundation as a "science and society" project. Its publication by MIT Press is important for what it says about the current scientific mood. It seems clear that the separation of what C. P. Snow in 1959 called "the two cultures" is no longer tenable if our species (and the planet) is to prosper, let alone survive. Humanists have long said that science needs the humanities. Now scientists themselves and the scientific establishment seem to be on board, acknowledging that we need to read and creatively imagine "what if" scenarios lest we wear blinders. A significant indicator of this new mood: the second issue this year of the internationally influential research journal *Science* featured a cover image, an editorial and a long article devoted to "the lasting legacy of Frankenstein." An 18-year-old girl's literary creation is now required reading, as it were, for scientists.

In the same spirit, the three editors of *Frankenstein: Annotated* — David H. Guston, Ed Finn, and Jason Scott Robert — describe their endeavor as nothing less than harnessing the "galvanizing power of *Frankenstein*" to "ignite new conversations about creativity and



responsibility among science and technology researchers, students and the public." The editors, who hold faculty positions at Arizona State University (ASU), hail from disciplines ranging from science and technology to science policy and the humanities and ethics. (Full disclosure: I attended a related *Frankenstein* workshop Guston and Finn ran at ASU in 2014, which motivated me to create, co-edit, and contribute to my own *Frankenstein* book this year. I myself am a scientist, not a humanist.)

Their expertise speaks to *Frankenstein*'s enduring message about existential stakes — and the potentially alarming societal consequences likely to devolve from the unfettered march of science and technology. Concerns about unintended consequences were urgent at the onset of the Industrial Revolution and the Nuclear Age, and they are, if anything, more urgent now. As the editors write in their introduction, we are now on the verge of hugely consequential technological endeavors:

> the creation and design of living organisms through techniques of synthetic biology [and] of planetary-scale systems through climate engineering, and the integration of computational power [into] global society […] each presents real and even existential risks […] Who gets to decide on the agenda for scientific research […] Who gets to say what problems or grand challenges we try to solve? Who gets to say how we solve them […] Who gets to partake in those benefits …

In the spirit of public education, they use different elements or strategies to enhance what they call "our collective understandings." These include, for instance, annotations to the text of the 1818 *Frankenstein*; Mary's introduction to the 1831 edition, which relates how the story came to be; short essays by contributors of various stripes; and appendices including "[d]iscussion questions" appropriate for students and others.

Biopower in the Era of Biotech
By Jim Kozubek

Future Frankensteins: The Ethics of Genetic Intervention
By Philip Kitcher

CRISPR, Patents, and Nobel Prizes
By Henry T. Greely

Beyond Designer Babies: Epigenetic Modification May Be the Next Game-Changer
By Michael Bess

On Writing a History of Crispr-Cas9
By Jim Kozubek

All this is introduced in a long piece about Mary and her work by the late literary scholar Charles E. Robinson of the University of Delaware, who had earlier extensively analyzed Mary's original manuscript. He describes how the scientific knowledge and attitudes of the time helped Mary imagine that a living being might be constructed. Mary was not a Luddite, he writes, and he surmises her parents encouraged her scientific interests. Both were writers and political philosophers, with Mary Wollstonecraft known for her book *A Vindication of the Rights of Woman* (1792) and William Godwin known for his radical political views.

Though Wollstonecraft died soon after Mary's birth, her feminist writings espoused equal education for boys and girls in "natural philosophy." Mary knew of the theories of Charles Darwin's grandfather Erasmus Darwin about the origins of life; she likely met her father's scientific friend William Nicholson, co-discoverer of electrolysis; and she read Humphry Davy's book about chemistry while writing *Frankenstein*. Percy, also interested in science, had carried out electrical experiments when he was at Oxford, and the couple attended lectures in London about chemistry and electricity. After Luigi Galvani's research in "animal electricity" in the 1770s, electricity was considered a possible "spark of life."

Robinson relates these experiences to characters and events in *Frankenstein,* then adds:

> *Frankenstein* and this introduction encourage STEM students to respect the humanities as offering a valid means of defining and even improving the world, much as science hopes to do. *Frankenstein* […] has become a metaphor for science that ignores human consequences and values.

In a nod to the students the book hopes to reach, Robinson ends by

showing how *Frankenstein* has been reimagined in more recent media presentations. In optimistic Hollywood versions, artificial beings are shown valuing humanity and saving lives — for instance, in James Cameron's film *Terminator 2: Judgment Day* (1991), when the T-800 android (Arnold Schwarzenegger) comes from the future to help avert the nuclear exchange programmed to destroy humanity. Of course, there are plenty of less optimistic spin-offs.

But Robinson does not dwell on these. His introduction is followed by the text of the 1818 *Frankenstein* with well over a hundred brief annotations crowd-sourced from nearly 50 contributors — academics in the humanities, natural and social sciences, and independent scholars, writers, and artists. This approach provides some fresh takes on *Frankenstein* — for instance, a note from an Earth scientist links the passion for scientific research in the early 19th century to the search for land and resources beyond the frontier. Many of the notes though, about literary and historical allusions, the motivations of the characters, the science of the time, and scientific ethics, will not surprise anyone familiar with *Frankenstein* and its milieu. But they are useful for students and first-time readers of the story.

Seven short formal essays follow the annotated text. In the first essay, Josephine Johnston, the director of research at the Hastings Center, a bioethics institute, defines "responsibility" as either "a *duty* to take care of something or someone or the *state* of being the cause of an outcome." The monster's creator, Victor Frankenstein, she writes, shirks both forms of responsibility. He does not think through the consequences of his work, and in the creation scene in the novel, he rejects the unnatural being he has made immediately after it stirs to life.

Frankenstein draws attention to this quasi-parental failure when the monster complains to Victor,

> But where were my friends and relations? No father had watched my infant days, no mother had blessed me with smiles and caresses […] I had never yet seen a being resembling me, or who claimed any intercourse with me. What was I?

and begs him to fashion a female companion. The monster's loneliness is palpable. Unlike climate engineers who "merely" create technological disruption, the creators of life are also responsible to the sentient, feeling beings they make. If their aim is to make beings that are not monstrous, but accepted and content within human society, then this adds another ethical layer to their endeavor.

In another essay, Jane Maienschein, director of the Center for Biology and Society, and Kate MacCord, a PhD candidate in the School of Life Sciences, both at ASU, emphasize the importance of human development. Titled "Changing Conceptions of Human Nature," their essay retraces Aristotle's thinking about deviations from the normal characteristics of a species, which the authors interpret as a path to the rise of a "monster." Aristotle argued that individuals must develop over time to become fully human, much as modern biology now confirms. In animating a physically complete being, then abandoning it, Victor

> made the fatal mistake of failing to understand that producing a life, in the sense of a fully and properly functioning living human, requires development […] It is not clear whether Victor or Mary learned the lesson that development matters or fell for the illusion that matter is enough.

Others agree that development matters in creating artificial life. In his seminal 1950 paper "Computing Machinery and Intelligence," Alan Turing, author of the eponymous test for artificial intelligence, asked "Can machines think?" The proper approach to building an AI, he believed, is to construct one at a child's level, then educate it

up to an adult level, which he thought would take as long as educating a human child.

In "*Frankenstein*, Gender, and Mother Nature," Anne K. Mellor, who works in English literature and women's studies at UCLA, takes a different tack. The novel, Mellor writes, "brilliantly explores what happens when a man attempts to have a baby without a woman [and why] an abandoned and unloved creature becomes a monster." As other critics have done, she relates these elements to Mary's feelings of "isolation and abandonment" after her mother's death and her father's remarriage to a stepmother who treats her badly, and to Mary's fears about her own pregnancy.

Calling *Frankenstein* a feminist novel, Mellor argues that Victor reveals his fears of female sexuality when he destroys the female counterpart he had started to build for his creature. He is creating a men-only society. The feminist elements in the story are clearly still meaningful — for instance, in the recently released biopic *Mary Shelley* by the pioneering female Saudi Arabian director Haifaa al-Mansour. She recognized the similarities between Mary's struggle to establish herself as a writer and her own background "as an aspiring artist in a conservative Muslim culture," and so directed a film described as "suffused with a righteous feminist fire."

Inevitably, with so much already written about *Frankenstein*, many of the essays echo themes that have been explored elsewhere. But "The Bitter Aftertaste of Technical Sweetness" by Heather Douglas stands out in a book devoted to helping scientists think about the implications of their work. Douglas, a philosopher of science at the University of Waterloo, Canada, relates a historical case study, the World War II Manhattan Project, to how scientists really feel about their research and how that can affect ethical considerations. She describes "technical sweetness" as the moment when "all the pieces [of a scientific puzzle] fit beautifully and functionally together." The

sweetness "is alluring, consuming and, as we can see in the story of Victor Frankenstein, potentially blinding to what might follow from the solution being sought."

The Manhattan Project scientists overcame huge obstacles to build an extremely powerful but controllable atomic bomb. They exulted when a first test at Alamogordo succeeded on July 16, 1945, but they were plagued by nagging doubts even before the destruction at Hiroshima and Nagasaki. "Now we are all sons-of-bitches," said one scientist. Another resigned from the project but was not allowed to share his reservations with his colleagues. Later, others recognized their responsibility in opposing ways. Some supported international control of nuclear weapons, whereas others advocated for the far more destructive hydrogen bomb to counter the Soviet Union. In other words: Even when we accept responsibility, what ought to come next is rarely clear.

Douglas notes that the Manhattan Project differed from Victor's solo effort in important ways: it employed thousands of scientists and was driven by real or perceived wartime needs and fears. But both projects functioned in isolation, separate from societal values. The Manhattan Project was kept secret, and as Douglas writes, Victor stopped "communicating with his friends and family and [disengaged] from the social connections that might give him a better perspective on his pursuit." And in both cases, the impetus toward technical sweetness — closely related to the "technological imperative," the desire to do it "because we can" — delayed recognizing consequences.

In these and other ways, *Frankenstein* offers lessons in how research today could go wrong, though to be sure much of the scientific community does indeed now recognize the need for ethical brakes — to control the modern equivalent of what Victor attempted, namely genetic manipulation using synthetic biology and the new

CRISPR gene-editing technique.

In 2015, Nobel Laureate David Baltimore and other scientists proposed placing a moratorium on research that would cause heritable changes to the human genome. In 2016, when the geneticist George Church at Harvard and a few colleagues announced their intention to construct the entire human genome from scratch, concerns about the lack of broader input forced the group to scale back its ambitious agenda. And in late 2017, the National Academy of Sciences and the National Academy of Medicine published *Human Genome Editing: Science, Ethics, and Governance*, a guideline for ethical genetic research that addresses the specific questions raised by the editors of this annotated *Frankenstein*.

But there are no guarantees that these standards will be followed. Moreover, though research in genetic manipulation is not driven by wartime considerations as was the case with the Manhattan Project, it is driven by commercial ones. At least a billion dollars in start-up funds has been funneled into companies that together form what has been called CRISPR Incorporated. These companies plan to apply genetic techniques to medicine and agriculture for profit — a powerful incentive to deliver the technology rapidly and perhaps with minimal forethought.

Frankenstein: Annotated for Scientists, Engineers, and Creators of All Kinds can remind scientists and engineers to proceed with caution. Though not everything in the book works equally well, it offers a valuable set of approaches to the ethical questions the original *Frankenstein* raises. By itself or in the hands of a teacher, *Frankenstein: Annotated* could encourage practicing or future scientists and technologists to consider the impact of their work, and it might remind ordinary citizens that science affects their lives when it leaves the lab.

Instilling these attitudes in young people could help change the world. We also need a gifted high school or college student of Mary's age to write his or her own *Frankenstein* for the 21st century. If this annotated edition inspires even a single young person to write such a book, then *Frankenstein: Annotated* will have been a success.

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Other books on *Frankenstein* published in 2017 and 2018:

Fiona Sampson, *In Search of Mary Shelley: The Girl Who Wrote Frankenstein* (Pegasus Books)

Kathryn Harkup, *Making the Monster: The Science Behind Mary Shelley's Frankenstein* (Bloomsbury Sigma)

Sidney Perkowitz and Eddy Von Mueller, eds., *Frankenstein: How a Monster Became an Icon: The Science and Enduring Allure of Mary Shelley's Creation* (Pegasus Books)

Christopher Frayling, *Frankenstein: The First Two Hundred Years* (Reel Art Press)

Joel Levy, *Frankenstein and the Birth of Science* (Andre Deutsch)

Mary Shelley, *The New Annotated Frankenstein* , ed. by Leslie S. Klinger (Liveright)

Mary Shelley, *Frankenstein, or "The Modern Prometheus": The 1818 Text*, ed. by Nick Groom (Oxford University Press)

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