We have three articles in this October issue: One of our last batch of Forum APS Fellows, Michael Dennin, has written on his experiences about outreach, the work that earned him the Fellowship nomination. And then we have Michael Ford updating us on the status of Fusion Energy and its relation to nonproliferation.

The third article is by historian of Science Michel Janssen, whose specialty is Physics of the 20th century, and it is on his analysis of the movie “Oppenheimer” as history.

And this is not all about this movie. Our Book Reviews Editor, Quinn Campagna, has taken up a new role: for the first time ever we have in this newsletter in addition to the usual Book reviews, a movie review of “Oppenheimer”.

As you know our Media Editor Tabitha is retiring from her job. I am very grateful to her for the job she has done these past five years. We are again advertising for a successor. This is a great opportunity for somebody up to date on everything related to social media, and who wants to get more involved in Forum activities. Please apply or get somebody to apply.

Once more, the contents of this newsletter are very largely reader driven. Please consider sending your contribution. Manuscripts should be sent to me, preferably in .docx format, except Book Reviews which should be sent directly to book reviews editor Quinn Campagna (qcampagn@go.olemiss.edu). Content is not peer reviewed and opinions given are the author’s only, not necessarily mine, nor the Forum’s nor, a fortiori, the APS’s either. No pertinent subject needs to be avoided on the grounds that it might be controversial. Controversy is good.

Oriol T. Valls, the current Physics and Society Newsletter Editor, is a Condensed Matter theorist at the University of Minnesota.

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FPS Newsletter Media Editor Wanted

The FPS newsletter is looking for a Media Editor to help increase the electronic and social media presence of the Forum and its quarterly newsletter. The Media Editor works with the Editor and the APS Media team. Responsibilities and duties are quite flexible, but might include developing outreach through the Engage community site and expanding the media presence of the newsletter. This is a great opportunity for a media savvy person who is interested in getting more involved with the Forum and with APS. Please contact the Newsletter Editor at otvalls@umn.edu or the current Media Editor tabithacolter@gmail.com if you think you might be interested in volunteering for this position.
How Science Really Works

Michael Dennin, mdennin@uci.edu

I am often asked why I appear on shows such as Ancient Aliens or why I talk about science and pop culture in podcasts such as Fascinating Gadgets, Gizmos, and Gear-Based Technology or in my own YouTube series The Physics of X: where X is everything except politics. Besides being great avenues for reaching large audiences, I have found that interacting with people through these avenues has provided important insights into why there is such a large disconnect between people's understanding of science and their willingness to engage in public policy from a scientific perspective. This has significant implications for the work of the Forum on Physics and Society and our ability to effectively engage the public on how physics and, more broadly, science are relevant to public policy.

A common occurrence throughout my career has been listening to colleagues lament that “the general public just does not understand science” and “if they only understood science better, they would realize what the problems are and how to approach policies that best address them.” These lamentations generally lead to conversations on how to improve science education in K-12 and how to get more students to take general education in college. I have even seen them produce changes to general education science courses in hopes of making them more interesting. However, I think that many of these conversations and subsequent changes rely on an underlying assumption that does not seem to hold up—the assumption that people are generally ignorant of or not interested in science.

Assuming that the issue is a lack of interest in or understanding of science drives our fundamental approach to science education—teaching people scientific “content.” I use the word “content” to refer to the broad spectrum of scientific facts, principles, and approaches to solving problems. I would argue that people understand these better than we believe: what is really lacking is a sense of how science really works, which is fundamentally different from understanding scientific content. And while it is worth noting that there is a growing focus on teaching how to think like a scientist, I also argue that this is different from teaching how science works in some important ways, as I hope to make clear below.

In addition to not understanding how science works, there is another challenge with leveraging science to impact policy. Most changes in policy require also changing people’s minds. There is significant evidence that facts do not change people’s views. And yet, this is often the approach when it comes to science outreach, especially when arguments are made around science-based public policy. Instead of emphasizing scientific facts and relying on hard data as a persuasion tactic, understanding people’s goals and frames of mind and connecting with them is more important. And I argue part of doing that is being explicit about the scientific mindset.

I opened this piece discussing my experiences communicating with the public in a range of alternative venues because my personal experience aligns with the growing research on how to change people’s minds. And my work has taught me how much most people are actually fascinated with science and want to know more. To illustrate what I mean, let’s discuss my work on Ancient Aliens. Thanks to my participation in the show, I’ve had the opportunity to attend and even speak at a number of UFO conferences. What fascinates me is the way in which many people at these events misunderstand how science works. The most common question I get is: “Given that scientists are supposed to be open-minded and question things, why don’t they consider that UFOs may be extraterrestrial in origin and spend more time studying these things?”

These questions have a number of features worth unpacking here. First, one of the common features of teaching people how to think like a scientist is the process of asking questions and being skeptical of statements made based on “authority.” It is this aspect of thinking like a scientist that people focus on and then wonder why scientists are not working on a whole range of questions that many people find interesting. What is missing from their understanding are some of the key elements of how science works: conducting repeatable experiments, generating falsifiable hypotheses, etc.

Their lack of understanding regarding how science works rather than a lack of scientific information is made even more obvious by their love of and reference to science facts. While many of the people I talk to may not have a deep understanding of the workings of relativity and quantum mechanics, I find that many of them are aware of the types of facts we teach in traditional general education science courses. Also, my most-requested talks at these meetings are straight “science talks” on aspects of relativity. However, without the context of how science works, these facts get misused and become effective tools for common errors, such as confirmation bias.

What have I done in the face of this disconnect? Leveraging the research that shows that empathy, rather than stating facts, is a better approach to convincing people of different positions, I have started by acknowledging that it is possible...
for some UFOs to be (or have been) of extraterrestrial origin. However, I explain that the type of phenomenon most UFO enthusiasts are interested in cannot be answered by scientific approaches. These are one-time events not amenable to replicable experiments. A better conceptual approach would be a criminal investigation, which requires a different framework and approach to gathering evidence and determining facts.

Having established some common ground and clarified the framework, I can then talk about fundamental principles, uncertainty and error, and skepticism within science. I can explain how some phenomena can be ruled out by science using these approaches and methods and discuss the likelihood of various explanations for behavior for which definitive answers are not possible. I believe an important outcome of this approach is that the general public no longer sees science and scientists as the enemy of something they believe is fascinating and worth pursuing. And when this approach works the best, people are able to accept a new way of thinking about occurrences they are fascinated by. Ultimately, a better understanding of how science works in a context like UFOs can then carry over to how science works in more policy-related situations.

This example offers a framework for thinking about how our approaches to teaching science cause unintended challenges when applying science to policy. Ironically, we tend to teach science as definitive and fixed. For example, we emphasize that the laws of physics cannot be violated, and we teach well-confirmed facts as definitive. We spend less time, if any, on the process of science. How does science deal with the unknown? How do we generate new understanding when faced with uncertainty? How do we formulate hypotheses that can be falsified and then design experiments to test them?

Unfortunately, when we focus on science as a set of things that are correct instead of science as a process for testing hypotheses, we set it up as just one of many belief systems. Couple this with what research tells us about changing minds, and we should not be surprised that our attempts to leverage science in policy approaches often fail short!

I want to close by highlighting the recent COVID pandemic as an example. When looking at scientific intervention and public policy during the COVID pandemic, a distinct timeline can be drawn: an early period where scientists warned of a problem and suggested actions (based on limited information), a period of resistance from the general public, a period where scientists were challenged to make their case because their early predictions and suggested actions had since changed, and eventually, a loss of faith in science in some sectors due to the perception that “scientists could not get it right.”

To briefly highlight a few key points (in which I fully acknowledge I am making generalizations), as the health community became aware of the nature of the COVID virus, a few interesting things happened early on. We already knew a reasonable amount about this general class of viruses, and we understood good general public health practices. We also knew the risk to public safety would be high if we did nothing. Therefore, a range of recommendations went out to the public. Most of the recommendations involved individual actions (wearing masks, social distancing, cleaning surfaces, etc.) but the purpose was collective protection. As the scientific community learned more, the recommendations changed, but to drive behavior, they were often framed as a means of protecting oneself.

This sequence of events created two challenges for communicating “the science” and supporting policies. First, people started to question the science because, if the first recommendations were wrong, how could they trust the new ones? Second, we did not clearly communicate the difference between collective and individual issues. Therefore, individuals who followed best practices sometimes still got sick, and individuals who “violated” best practices sometimes stayed healthy! This provided additional confirmation for some people that “scientists did not know what they were talking about.” Ultimately, introducing more facts did not help change people’s minds because they did not have a framework for understanding what the science was really doing.

I would argue that if people really understood the scientific process, it would have helped with both the changing recommendations and the individual vs. population issues. For the first issue, understanding how scientists refine knowledge based on available and emerging information would have set up the expectation that recommendations would change. For the second issue, understanding how science is sometimes statistical and studies populations rather than specific individuals would have established more realistic expectations regarding the difference in individual and collective COVID outcomes.

Both of these ideas fall into the general categories of how the process of science deals with uncertainty. As scientists and educators, we need to do a better job of explaining how science deals with and focuses on uncertainty. I believe that we fell into a common trap at the beginning of the pandemic. We communicated with authority about what we knew without any authority on what we would learn and how this could lead to changes!

As we move forward, there is much to take from the growing literature on how to motivate change in people. I am certainly seeing more scientists learning from this literature and modifying their traditional fact-centric approach to an approach focused on meeting people where they are and taking them on a journey. I would also love to see more research on how we teach science that looks at the effectiveness and impact of focusing on the scientific process. From such research, we can build a foundation of understanding and knowledge that would make policy discussion—if not easier—at least more focused on shared principles of approach.
Abstract. This article summarizes the findings and recommendations of a Department of Energy (DOE) National Nuclear Security Administration (NNSA) sponsored workshop hosted by the Princeton Plasma Physics Laboratory (PPPL) in January 2023. The workshop helped establish a community of interest to support the path to commercialization for fusion energy simultaneously with addressing nonproliferation concerns.

Introduction. Fusion energy systems, if developed and deployed broadly, could provide a nearly limitless source of clean energy. The potential benefits to our climate and worldwide energy security from accelerated development of these systems cannot be overstated. Importantly, fusion systems differ significantly from the fission systems (except for fusion/fission hybrid designs) in that they do not require the use, and therefore the presence of, special fissionable materials. However, these facilities do have the potential for use in the production of this material if constructed/modified in such a way that high energy neutrons produced in the fusion reaction are harnessed to convert fertile source material to fissile material. Fusion systems may also include significant inventories and flows of tritium, control over which is a potentially important element of ensuring no spread of materials that could be used for illicit weapons activity. The potential for illicit use of fusion systems leading to proliferation concerns is certainly much lower than for fission systems. However, the risk is not negligible. Additionally, concerns regarding proliferation risks may impact public acceptance and availability of this low carbon technology for broader deployment when available. Addressing these concerns in parallel with technical developments will be key in ensuring that fusion technologies can be deployed broadly and rapidly when technical readiness has been achieved.

To begin the examination of these issues, DOE NNSA Defense Nuclear Nonproliferation (DNN) sponsored a workshop at Princeton University and moderated by the Princeton Plasma Physics Laboratory (PPPL) to investigate five key areas related to fusion energy system commercial development. These areas included: 1) The potential for clandestine production/diversion of special fissionable material, 2) Tritium management in fusion systems, 3) Environmental justice/social acceptance as it relates to proliferation/security concerns, 4) Inertial fusion development and management of data and 5) Issues related to regulatory frameworks. The workshop was supported by senior leaders from the Office of Science and Technology Policy, the Department of Energy, the Nuclear Regulatory Commission (NRC), and the International Atomic Energy Agency (IAEA), along with experts from industry and academia. While final answers were not developed in these areas, a clear consensus was reached among attendees that the fusion community should solicit more voices and encourage debate on nonproliferation issues as we move into an era where new existential threats (i.e., climate change) and energy system transition needs (i.e., rapid decarbonization) are facing humanity. An entering argument was that the standard assumptions/perspectives developed from the cold-war era may not be the best way to approach a new “nuclear technology” like fusion. In examining these issues, workshop attendees identified future research needs spanning development of efficient regulatory approaches to focus areas for technical and social science research and development.

Nonproliferation Workshop Focus Area Summaries.

Potential for clandestine/covert production and diversion of special fissionable material. The most accessible and broadly pursued fusion reaction [FIA, 2023], deuterium + tritium (DT), produces highly energetic neutrons (14.1 MeV) that could be used to breed “special fissionable material” for use in weapons development. Fusion neutrons could be used to breed Plutonium-239 (or Uranium-233). In evaluating this risk, participants in the workshop were asked to consider two scenarios 1) covert production and 2) clandestine system development and production. In the first scenario a known fusion energy facility would be covertly modified to produce fissile material and in the second, a smaller fusion facility would be developed without awareness of the international community and would be used for fissile material production. Participants considered the potential risks embodied by these scenarios and debated the ability to mitigate these risks through either existing protocols or through implementation of some additional regulatory or technical means that would ensure this issue did not delay or derail deployment of fusion systems. Though many considered the technical challenges in modifying fusion systems for these illicit purposes to be high and certainly not something that would be done for any commercial purpose, security experts noted that the motivation that should be assumed when considering the proliferation aspects is that of a determined proliferator. Recommendations were then made as follows:

- Calculations of potential special fissionable material production from various fusion systems should be re-visited including analysis of a wider variety of blanket systems. These might have different degrees of difficulty of modification to produce special fissionable material and/or different potential production levels.
• Analysis of the proliferation risks of specific fusion device designs should be conducted by private enterprises working with the publicly funded entities, while being respectful of trade secrets and other business considerations.

• There should be more fully integrated engineering analyses to assess the difficulty of all system modification scenarios.

• Potential “light” methods for monitoring fusion energy systems for misuse should be evaluated.

• Acquisition Pathway Analysis that considers the full capabilities of potential state proliferators should be completed.

• Research and development (R&D) should be funded to understand the possible use of fusion for clandestine or covert production of special fissionable material, in light of smaller fusion systems currently under consideration:
  • Whether it would be possible to detect reliably the required purchases or the physical construction of such a facility.
  • Whether electrical grid connections and heat rejection would provide reliable signatures.
  • Whether wide-area sampling (e.g., for tritium) would be a viable detection technique.

Tritium and Lithium Management

In the commercial development of fusion systems, given that most developers plan to use a DT fuel cycle [FIA 2023], the worldwide quantities of Tritium could expand dramatically. Current stores of Tritium total less than 50kg worldwide. However, a single GW scale fusion energy system could burn more than this quantity in a single year and could have ten times this amount in plant flows annually. Additionally, to maintain the necessary inventory of fuel, systems will rely on Tritium breeding blankets that employ the isotope ⁴Lithium. Both Tritium and ⁴Lithium are materials of interest in nonproliferation regimes and are export controlled. They would have value for nations that have a desire to pursue a nuclear weapons program. Attendees discussed tritium and lithium in the context of nonproliferation and noted that these are not controlled substances maintained on any trigger list. Discussion centered on whether the existing export controls for these substances, as well as the controls that would be employed to monitor Tritium flows within an operating facility would be sufficient to ensure that small quantities of Tritium are not diverted for illicit use or sale. Experts from Savannah River National Laboratory described current accountancy practices at the Savannah River Site and attendees debated whether current methods of control were scalable and whether imposition of additional material control practices would be unduly burdensome for developers, slowing commercialization and perhaps limiting deployment to nations with lower institutional readiness. While more assessment is needed, all agreed on the value of further activities to strengthen nonproliferation in fusion energy development and deployment by improving the accountancy of tritium from a fusion power plant including:

• The Savannah River Site (SRS) experience base in accountancy (unclassified version) should be assembled to provide the fusion community the present best practices in use for a large-scale tritium facility.

• Development of new sensor and inventory methods for fusion devices should be considered to provide tritium inventory in a “dynamic” system with tritium in-process. Kalman Filters for such nested new, innovative sensors for tritium in-process should be developed.

• Experts should develop sub models and integrated models to account for in-process tritium inventories in the burn, generation, extraction, and gas handling phases in fusion fuel cycles. This analysis should include identification of existing and/or development and evaluation of technologies and methods to provide the best way to inventory tritium at those distinct points in the process flow diagrams where tritium is consumed, generated and/or packaged to provide a better level of confidence in the balance of tritium at a fusion facility.

Energy Justice, Social Licensing and DEIA (Diversity, Equity, Inclusion and Accessibility)

While energy justice is not a typical subject in nonproliferation discussions, organizers included this subject to ensure that at all stages of commercialization, social license and energy justice are considered. Discussion in this area was led by experts from academia and non-governmental organizations. In providing context, the experts emphasized that there were scenarios where nonproliferation concerns could impact equity and social licensing to include:

• A proliferator uses a fusion reactor to produce fissile material or diverts materials from the fusion supply chain for weapons purposes

• The fusion non-proliferation system is so restrictive that only nuclear weapon states and their chosen allies are allowed to have fusion

• The fusion non-proliferation system is perceived to be an instrument of nuclear weapon state control, limiting appetite for non-nuclear weapon states from deploying fusion

• Fusion loses stakeholder and public trust with regards to non-proliferation
Attendees indicated that several areas tied to nonproliferation require further investigation to determine the impact of nonproliferation concerns on energy justice and social license as fusion systems are prepared for commercial deployment. This included:

- Research should be conducted, including deliberative polling, to understand the public’s comparative perception of nonproliferation and of climate change. This would include examination of the nonproliferation concerns of the fusion fuel supply chain.

- In the US context, disadvantaged communities have been disproportionately impacted by energy deployment. How do we define energy justice in an international context when considering the nonproliferation context? To address this, a critical assessment of the historical impact of the nonproliferation regime in limiting access to nuclear energy to portions of the world should be conducted.

- A global comparative analysis should be conducted in the nonproliferation context of fission vs. fusion. Differences, similarities and future data needs should be identified.

- Members of the fusion ecosystem should work with disadvantaged communities in the Regional Development Dialogue (RDD) and Fusion Pilot Plant (FPP) development/siting to address the challenges of fusion (including nonproliferation) while supporting the communities.

- Conduct additional research to examine how we can implement energy justice and social licensing to aid in the public acceptance of fusion energy.

Inertial Confinement Fusion (ICF)

Discussion of ICF challenges tied to nonproliferation were tailored to primarily focus on model and data availability. The organizers and sponsors acknowledged that this area warrants a more detailed assessment, likely in a classified forum. Following detailed descriptions of ICF status and challenges in commercialization led by experts from LLNL, the following key questions were identified. These issues will need to be addressed and follow up actions planned to inform any approaches or mitigations that would enable a future in which inertial fusion energy (IFE) power plants may be distributed broadly across the globe, while managing proliferation risks.

With the benefit of a decade of research on the National Ignition Facility (NIF), DOE NNSA should revisit the conclusions of the 1995 report on “The National Ignition Facility and the Issue of Nonproliferation” assuming that the pursuit of IFE technology will open a path to high yield science facilities internationally.

An assessment should be made to evaluate the impact of high repetition rate, small scale, sub-ignition facilities that would be enabled by IFE technology development and would be far more accessible and may be valuable.

Once a national understanding is reached, international engagements should be considered, beginning with the permanent members of the UN Security Council (P5) with the goal of developing common understanding of sensitive areas and common principles for information sharing. Participation could be broadened as and when other nations attain a predetermined technology level on a case-by-case basis.

DOE NNSA should develop US IFE specific guidance including an unclassified version to articulate what information is unclassified and what information requires protection. As with other national security missions, such guidance defines boundaries for US experts regarding what information can be shared. Ideally other P5 nations would agree to a similar procedure, which would also be adopted by other nations.

It would be valuable to review the status of export control guidance to provide clarity for developers and policy makers of how it applies to fusion (all design types) and to identify potential choke points that may benefit from policy adjustment.

NNSA should develop a clear near-term guidance on the use of ICF codes, consistently applied across institutions, for accelerating domestic partners’ pursuit of IFE, including consideration of enabling private industry.

NNSA should evaluate future options that support increased demand for code access by a growing IFE industry. This should consider broad implications for national security and national competitiveness, including potential beneficial feedback into the NNSA of industry or co-developed software.

Regulatory Frameworks

The final area of review focused on potential regulatory structures for fusion, emphasizing nonproliferation and safeguards considerations. This segment was well supported by experts from industry, the US NRC and the IAEA and was moderated by experts from the legal community of practice in nuclear regulatory matters. US and international experts concurred that there were existing export controls for management of Tritium, Be, and 6Li and their presence in a facility does not trigger an inspection regime under the Nonproliferation Treaty. IAEA experts posited that the allowance for ‘Complementary Access’ under the IAEA Additional Protocol would provide an avenue to monitor facilities with large neutron fluxes and that this level of access already incorporates some level of local environmental sampling. They noted that the Additional Protocol covers 140 states of 188 Non-Proliferation Treaty Signatories. However, they also pointed out that there is no unattended monitoring, design information verification, or containment & surveillance available under the AP. Finally, experts agreed that there was a potential for a voluntary “Fu-
Reflections on Christopher Nolan’s *Oppenheimer*

Michel Janssen

In this article, at the invitation of my University of Minnesota colleague and editor of this newsletter, Oriol Valls, I want to share some thoughts about Christopher Nolan’s movie *Oppenheimer* based on the Pulitzer-prize-winning book *American Prometheus: The Triumph and Tragedy of J. Robert Oppenheimer* by Kai Bird and Martin Sherwin. I am by no means an expert on Oppenheimer or the Manhattan project. But as the resident historian in our School of Physics and Astronomy, I was called upon to give a talk preparing our students and faculty for the movie. A recording of my talk was put on a YouTube channel of the university and has gathered over 2,000 hits (the URL is www.youtube.com/watch?v=_TQJEMC6mkk). I gave this talk shortly before the movie was released and I tried to anticipate—on the basis of the book, the cast list, and the trailer—which parts of this complicated story would make it into the movie. That made preparing the talk fun, provided my audience with an insurance policy of sorts against spoilers, but also turned the movie’s release date into my talk’s expiration date (although several people have told me my talk helped them understand the plot better *after* they saw the movie). Rather than summarize my talk, I figured I would highlight some key elements of the movie that I missed in my talk and organize my article around those. Unlike my talk, this article thus calls for a *Spoiler Alert*: in what follows, I will assume that the reader has seen the movie, which I have meanwhile seen twice and thoroughly enjoyed both times. And it made me want to keep reading about the topic. One of the books I picked up is Gregg Herken’s *Brotherhood of the Bomb. The Tangled Lives and Loyalties of Robert Oppenheimer, Ernest Lawrence and Edward Teller* (New York: Henry Holt, 2002). I already thought it was excellent the first time I read it shortly after it came out—I found it much more manageable than Richard Rhodes’ classic *The Making of the Atomic Bomb* (New York: Simon & Schuster, 1986)—but feeling, thanks in no small measure to the movie, that I know many of the characters much better now, I liked it even more this time around. If the movie (and the book by Bird and Sherwin) also left you wanting more, you may want to check out Herken’s book.

Given that an actor as prominent as Robert Downey Jr. was cast as Lewis Strauss, Oppenheimer’s nemesis, it was obvious that the movie would deal as much with the 1954 security hearings as with the Manhattan project, Los Alamos...

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**References:**


and the Trinity test. However, I completely failed to anticipate the clever way in which the movie handles the conflict between Oppenheimer and Strauss. That was not for a lack of clues in the cast list. The most important one was that Rami Malek—Freddie Mercury in the Queen movie *Bohemian Rhapsody*—was listed as playing David Hill. Why was such a well-known actor playing a character I had never even heard of? Hill is not mentioned anywhere in Bird and Sherwin's book. He now has his own wikipedia page but I'm pretty sure that page did not exist before the movie was released. I was similarly puzzled by the names of several senators in the cast list: McGee, Bartlett, Pastore, Scott ... What was their connection to Oppenheimer? I would have expected Senator Brien McMahon, author of the 1946 Atomic Energy Act, which placed all nuclear matters under civilian rather than military control and led to the establishment of the Atomic Energy Commission (AEC). Why McMahon and not Oppenheimer?

The answer to these questions had actually been staring me in the face: on Strauss' wikipedia page I had read about his 1959 Senate confirmation hearings after he'd been nominated by President Eisenhower to be his secretary of commerce. The senators in the movie were the ones involved in these confirmation hearings. Strauss' wikipedia page even mentions that David Hill testified against him but I don't recall seeing that bit before and I suspect it was added after the movie came out. Yet, even if it had been there all along, I doubt I would have recognized the narrative potential of these confirmation hearings. Christopher Nolan did. It was a brilliant move on his part to turn these hearings into one of the movie's central storylines. It is deeply satisfying to see the bad guy—and Robert Downey Jr. deserves an Oscar for the number he does on "Tugboat Admiral" Lewis Strauss!—get his comeuppance in the end. What makes this especially sweet is that Strauss' downfall closely mirrors Oppenheimer's, which Strauss orchestrated with such evil care. It is the result not of a trial, covered by well-established rules of engagement, but of a hearing in which one makes up the rules as one goes along—a "kangaroo court" as Bird and Sherwin, echoing AEC counsel Joe Volpe, call it in Oppenheimer's case. Accordingly, my favorite line in the movie, applied to both hearings, is: "We don't convict, we just deny." It Oppenheimer's case. Accordingly, my favorite line in the movie, applied to both hearings, is: "We don't convict, we just deny." It Oppie's "vitamins"-punchline to the even punchier: "but more important than a sandwich". This hearing took place in June 1949, a week after Oppenheimer's appearance and a day before the Senate hearing about sharing radioisotopes with Norway, important than a sandwich). This hearing took place in June 1949, a week after Oppenheimer's appearance and a day before the Senate hearing about sharing radioisotopes with Norway, taking place in the Senate in the movie. The movie also covers the scene in which Oppenheimer knocks a clipboard out of his hands, presumably with the petition that the person standing next to him, Leo Szilárd (played by Máté Haumann), wanted to give to Oppenheimer. The signatories of this petition (known as the Franck report after German emigré and Chicago physicist Otto Franck) were asking for a demonstration rather than combat use of the atomic bomb.

The Strauss confirmation hearing is not the only scene taking place in the Senate in the movie. The movie also covers the Senate hearing about sharing radioisotopes with Norway, in which Oppenheimer ridicules Strauss (with Nolan changing Oppie's "vitamins"-punchline to the even punchier: "but more important than a sandwich"). This hearing took place in June 1949, a week after Oppenheimer's appearance and a day before his brother Frank's appearance before the House Un-American Activities Committee (HUAC), neither of which made it into the movie. That surprised me. This is where Robert threw some of his students under the bus. This scene would thus have helped Nolan underscore the somewhat slippery character of his main protagonist. Nolan leaves it largely to Oppenheimer's enemies, Strauss and Robb, to highlight some of the more dubious aspects of his character. The best example may be the bitter speech by Strauss/Downey Jr. after he is denied his cabinet post in which he argues that Oppenheimer should be thanking him because he, Strauss, helped Oppenheimer become the martyr he always wanted to be. I don't know whether Strauss actually said that, but the sentiment, I'm afraid, cannot be fully dismissed.
As I indicated above, the most important Senate action missing from the movie is the establishment of the McMahon atomic energy act in 1946. Leaving this out also affects the introduction of someone who does play an important role in the movie: William Borden (played by David Dastmalchian). Borden wrote the letter with derogatory information about Oppenheimer to the FBI that set the wheels in motion for the 1954 hearings, was an aide to Senator McMahon. A Democrat from Kentucky, McMahon chaired the congressional Joint Committee on Atomic Energy during the years of the Truman administration. He died a few months before the 1952 elections in which the Republicans took back both the presidency and the Senate. Staffer Borden thus lost his job. Given McMahon’s push in 1946 for civilian control of atomic matters, one naturally thinks that he was on Oppenheimer’s side (and this is certainly the impression I gave in my talk). Which raises the question why his aide had it in for Oppenheimer. Herken’s _Brotherhood of the Bomb_ answers that question in detail. In the late 1940s and early 1950s, McMahon and Borden were clearly on the side of Strauss and Edward “the real Dr. Strangelove” Teller (a stellar performance by Benny Safdie). Both McMahon and Borden were strongly in favor of the crash program to develop the H-bomb and were extremely annoyed with Oppenheimer’s lobby against it. From his hospital bed in 1952, not long before he died, McMahon warned Truman that he would initiate impeachment proceedings against him should Truman decide to postpone an upcoming test of an H-bomb (Herken, p. 256). In the early 1950s, McMahon and Borden were also vehemently opposed to the idea, favored by Oppenheimer, to explore the possibility of a test ban on nuclear weapons with the Soviets. In fact, an important trigger for Borden’s letter about Oppenheimer to the FBI is that, early in Eisenhower’s presidency, it looked as if Oppenheimer had the president’s ear whereas the Strauss camp clearly had gained the upper hand toward the end of the Truman administration. Recall that, in late August 1949, the Soviets exploded an exact copy of “fat man,” the plutonium bomb dropped on Nagasaki, and that, in early February 1950, Los Alamos spy Klaus Fuchs confessed that he had transmitted the relevant blueprints to them (some of the Russian scientists who worked on that program told my Minnesota colleague, Misha Shifman, that they made sure to include every screw shown in the drawings even if they had no idea what it was for).

Following Bird and Sherwin, Nolan recognizes these events as a critical turning point in the story. Despite the unanimous recommendation of Oppenheimer’s General Advisory Committee (GAC) to the AEC not to develop the H-bomb, Truman decided to do so anyway. Nolan took some liberty with the historical record by having the Fuchs bombshell and the news about the Soviet bomb break at the same time but that’s certainly defensible: Strauss already knew that the FBI was on to Fuchs when the discussions about how to respond to the Soviet bomb took place (Herken, p. 213). Nolan has a bunch of scientists, politicians and military men (I could not identify them all) sit around a big round table (with a big bouquet of flowers that keeps being moved around for no discernible purpose) to discuss how to respond to the Soviet bomb. Brigadier General Kenneth D. Nichols, played by Dane DeHaan, is one of those present. Colonel Nichols (he was promoted shortly after the war) had been General Groves’ right-hand man on the Manhattan project and continued to serve the military and the government in various capacities related to matters concerning atomic weapons. I overlooked the importance of Nichols in my talk (I flashed up the organizational chart of the Manhattan project where Nichols appears just below Groves but only mentioned Nichols toward the end of my talk). Nolan gives Nichols his due. We see him run security, for instance, at Los Alamos. Both Groves and Oppenheimer treat him with disdain (I recall Groves/Damon handing Nichols/DeHaan his coat and telling him to go hang it up somewhere and Nichols/DeHaan snapping at Oppenheimer/Murphy that it is not his fault that it takes so long to get his security clearance). The moviegoer understands that Nichols does not care for Oppenheimer. The revelation about Fuchs during the discussion about how to respond to the Soviet bomb gives Nichols/DeHaan an opportunity to complain about the lax security at Los Alamos. That nicely sets things up for Nichols’ role in the 1954 security hearings. That part, however, is not in the movie. In the movie, the hearings end with the 2:1 recommendation of the personnel security board chaired by Gordon Gray (played by Tony Goldwyn) to strip Oppenheimer of his security clearance. But that was just a recommendation. It still had to be voted on by the AEC. In 1953, Nichols had become the General Manager of the AEC. Worried that his fellow commissioners might not follow the Gray board’s recommendation, Strauss had Nichols add a letter putting their spin on the security board’s report. In this highly prejudicial letter, Nichols wrote that “the record showed” that Oppenheimer is “a communist in every respect except ... that he did not carry a party card.” Since the AEC upheld the “verdict” of the Gray board, I can understand why Nolan left out this part but, given Nichols’ prominent role in the rest of the movie, it would have been appropriate to have him twist the knife that Strauss stuck in Oppenheimer’s back.

There is another connection I missed in my talk and I’m grateful to Nolan for making it for me. This has to do with Boris Pash (played by Casey Affleck). Pash is the one to whom Oppenheimer first mentions the Chevalier incident (providing actors Jefferson Hall and Guy Burnet with rewarding parts as the Oppenheimers’ friend Haakon Chevalier and the commie busybody George Eltenton, respectively). Oppenheimer/Murphy is caught off guard, thinking that Pash/Affleck and a fellow officer (Colonel John Lansdale, not identified in the movie) want to ask him questions about his lefty student Rossi Lomanitz (played by Josh Zuckerman), a victim of the communist hysteria of the 40s and 50s, who ended up “living in a hovel on the edge of a swamp [working] as a day laborer” in the
early 1950s (Herken, p. 273). While he incriminated several of his associates in his HUAC testimony in 1949, Oppenheimer did not give Pash any names. But he badly underestimates the intelligence of the security officers questioning him and thought he could get away with concocting, on the spot, what he would later call a “cock-and-bull story” (a quaint phrase that I associate with movies like *The Maltese Falcon*). A tape of the interview would come back to haunt Oppenheimer in 1954, prompting his defeatist admission to Robb that he had been “an idiot.” Pash also testified in 1954. When asked about his interview a decade earlier, Pash tells Robb that he doesn’t know how the story ended because he was transferred to Europe. I knew he’d been transferred. It’s in my talk. He became the head of the Alsos mission to check up on the German bomb project. But I’d never stopped to ask myself why. Nolan gives the answer: Groves needed him out of his hair!

Groves got Oppenheimer to reveal Chevalier’s name to him but only after he promised he’d keep that information to himself (the movie doesn’t make that completely clear, I thought, but the scene with Damon and Murphy discussing this on the train is still one of my favorites). Groves probably agreed to that condition because he expected the name to be of someone he already knew was a communist, Oppenheimer’s brother Frank or one of his students. That the name was new to him put him in a difficult predicament. He didn’t want to break his promise to Oppenheimer but he also realized it was a serious security breach to keep this name to himself. On the eve of the Oppenheimer hearings, in an effort to limit the damage Groves could do to their case, Strauss and FBI director Hoover made it perfectly clear to Groves that he could get into trouble for withholding the name of a suspected spy (Herken, p. 271). Groves probably didn’t need the reminder. As Nolan made me realize and Herken (p. 112) confirms, Groves sent Pash (and Lansdale) to Europe because they knew he had compromised himself in the Chevalier affair. For years, I’ve been showing my students a picture of Pash and Lansdale in Strasbourg, where Heisenberg’s colleague von Weiszäcker had set up shop. I always presented it as a complete coincidence that both of them also played an important role in the Chevalier incident. Although I had read Herken’s book before, it only dawned on me watching Nolan’s movie that this was no coincidence at all.

A lot more can be said about this movie but I’ll limit myself to two final points, one about the storyline involving Einstein (which, as a former editor on the Einstein Papers Project, I feel I have to) and, related to that storyline, the final message with which Nolan decided to send his audience home.

I was surprised that Nolan left out the scene of Einstein and Szilárd writing to FDR. Maybe he thought that was a little too trite. The first time I saw the movie, I was puzzled and put off by one of the Einstein scenes Nolan did put into the movie. This is where Oppenheimer goes to see Einstein to ask him about calculations indicating that there is a small chance that an atomic bomb might ignite the atmosphere. No such visit ever took place. Einstein didn’t know anything about nuclear physics: scores of physicists at Los Alamos, even some of the most junior ones, would have been in a much better position to do those calculations. Furthermore, given Einstein’s perceived politics (he was enough a leftist to be on a watch-list of the FBI), this would have been security breach comparable to his visit to ex-girlfriend Jean Tatlock (a great performance by Florence Pugh). I warmed to the scene the second time I saw the movie, absorbing the full Einstein storyline (fictitious as it is). In between, I learned from Herken’s book (p. 66) that the scene of Oppenheimer’s wartime visit to Einstein not completely made out of whole cloth. There was a worry about igniting the atmosphere but it was about (Teller’s earliest ideas about) the H-bomb, not the A-bomb, it was in Berkeley well before they all went to Los Alamos, and a short calculation by the top theorist, Hans Bethe, quickly put the matter to rest. Yet, Oppenheimer was sufficiently worried about this possibility that he wanted to discuss it with one of the higher-ups. Since he felt it was too sensitive to discuss over the phone, he took a train to Michigan, where he visited Nobel laureate Arthur Holly Compton, vacationing in his summer house on a lake there. So we get a glimpse of how the sausage is made by Nolan: Berkeley becomes Los Alamos, H-bomb becomes A-bomb, lake in Michigan becomes pond in Princeton, Compton becomes Einstein.

When I saw the movie the second time, I also understood that the point of Oppenheimer’s visit is not so much to have Einstein do the calculation but what to do depending on the result. And Einstein’s advice (like Compton’s presumably) is very sensible: if there is a serious chance to ignite the atmosphere, stop and inform the Germans so that they stop too. The scene with Oppenheimer’s visit also sets up the scene with Oppenheimer and Einstein in Princeton after the war very nicely. This is when Strauss is offering Oppenheimer the job as Director of the Institute for Advanced Study and there is the first harbinger of the trouble ahead when Oppenheimer says he’ll consider the offer instead of immediately accepting it and thanking Strauss profusely. I like the way the movie returns to that scene at the end. It nicely resolves the issue Strauss has been obsessing about, namely what Oppenheimer said to Einstein to cause Einstein to snub him, Strauss. As Strauss’ aide suggests casually: maybe they weren’t talking about him, maybe they had more important things to talk about. We then finally get to see the actual conversation. The conversation has two parts. One is the bit about ignoring the atmosphere. The other parts gives a nice twist to the scene that follows shortly thereafter of Oppenheimer receiving the Fermi award out of the hands of Lyndon Johnson, barely a week after the assassination of John F. Kennedy, who made the decision to give Oppenheimer this award. In my talk, I used this rehabilitation of Oppenheimer to end on a positive note after the disgrace of the 1954 hearings. Nolan doesn’t need it for that: he uses the much better Strauss comeuppance story for that purpose. Instead he
can use the 1963 scene to show how Einstein’s prediction came true: if you stick around long enough, they’ll eventually pin a medal on your chest, at which point it’s not really a medal for you anymore but for the generation that came after you, following in your footsteps, but leaving you in the dirt. I thought that was a nice touch. Most viewers, however, will remember this scene primarily because of the “igniting the atmosphere” threat, which Nolan gives pride of place at the end of the movie.

The final scene, where Oppenheimer sees the planet about to be engulfed in flames echoes an earlier in which Borden, the former congressional aide doing Strauss’ dirty work who had been a pilot in the Air Force during World War II, sees German rockets heading towards Britain and worries about the future. At the beginning of the war, while still a student at Yale, Borden had already written a grim book about the possibility of a “nuclear Pearl Harbor” (Herken, p. 194). And shortly after the war, he and some friends had placed a newspaper ad demanding that the US issue a nuclear ultimatum to the Soviets (ibid.). This ad is what first drew Senator McMahon’s attention to Borden. Nolan somehow manages to pack that information into one short scene with Borden flying his plane and seeing those German rockets. And then he creates a similar scene with Oppenheimer.

Nolan clearly wanted to send the message that we should continue to be extremely concerned about nuclear weapons. He overdoes it a bit for my taste. Nobody should lose sleep over nuclear bombs igniting the atmosphere. Nuclear armageddon is not the biggest threat facing mankind. Climate change is. I can see this with my students. None of them are worried about nuclear weapons. All of them are worried about climate change. So I would have preferred Nolan to highlight a different message, which, while also part of the movie, doesn’t get pride of place. And that is the danger of demonizing scientists for telling politicians things they don’t want to hear. Fauci is a good example (and this remains true even if it should turn out that the hard lockdown he championed did more harm than good in the end). The more insidious example is the demonizing of climate scientists. As the movie makes clear, there are difficult questions about what role scientists should play in societal decisions about the use of their findings. But what should be non-controversial is that scientists are not going to be punished for giving politicians and thereby society advice based on their honest assessment of the science they are asked to evaluate. That to me is the main take-away from the Oppenheimer story.
Oppenheimer
A film written and directed by Christopher Nolan. Run time 3:00:00

In 1971 I taught a short course, called "A Humanistic Approach to Science," which focused on Galileo Galilei and J. Robert Oppenheimer, both chosen because they were known for their run-ins with the powers-that-be. I asked my students to read biographical works about both scientists and dramatic works about them (Bertolt Brecht’s *Galileo* and Heinar Kipphardt’s *In the Matter of J. Robert Oppenheimer*, based upon the transcript of Oppenheimer’s security hearing.) One of the options for students to show what they had learned was to present a scenario of an alternative dramatic presentation of the story of either scientist’s life.

Because Oppenheimer’s life was filled with so much drama, I was especially interested in what possibilities my students would come up with. Unfortunately, they chose other ways to show what they had learned, but I decided to give the Oppenheimer story a try. I started with a scene replicating what has been called the “Chevalier incident,” and 25 scenes later I stopped on the eve of the security hearing. When a former student told me in summer 2022 that the Oppenheimer story would be told in a movie, I really couldn’t wait to see it.

Armed with my reading about Oppenheimer from my 1971 course and more recently reading Kai Bird and Martin J. Sherwin’s 2005 biography, *American Prometheus*, on which the film is based, I attended a screening the first Monday morning after the film opened. I was quickly amazed by the sheer number of details, one of the first being Oppenheimer’s placing a poisoned apple on the desk of P. M. S. Blackett (recounted by Bird and Sherwin on page 46). I was also a bit nonplussed by the fact that the actors portraying Niels Bohr, Hans Bethe, Enrico Fermi, and I. I. Rabi bore no resemblance to the actual physicists; this required me to associate their faces with the physicists’ names. And I wondered how many in the audience would know that the guy with bongos was playing Richard Feynman but had no lines to speak that I can recall. On the other hand, Cillian Murphy presents an excellent likeness, both in appearance and manner, of Oppenheimer; and Matt Damon is a convincing General Groves.

Christopher Nolan couches the Oppenheimer story in the context of the security hearing, which is where the film begins, then flashes back to Oppenheimer’s earlier life. Both of these threads in the film are in color; but a third, in black and white, focuses on Oppenheimer’s interaction with Lewis Strauss, played by Robert Downey, Jr. Bird and Sherwin describe how Strauss clashed with Oppenheimer, both as a trustee of the Institute for Advanced Study and as Chair of the Atomic Energy Commission, in the latter case engineering the termination of Oppenheimer’s security clearance. But the film goes beyond this, culminating in the Senate’s rejection of President Eisenhower’s nomination of Strauss to be Secretary of Commerce.

I found the black and white sequence especially interesting, especially the part played by an actor who was with Strauss in an anteroom during the Senate hearings. At first I thought he was Strauss’s aide; but, as the action unfolds, he becomes accusatory toward Strauss, and I wonder whether he was employed as a dramatic device to explicate the story.

With so much to tell in the Oppenheimer story, I found my eyes glued to the screen and my sense of time not realizing that three hours had gone by. And when it was all over, all I could do was to reflect that I had just witnessed the recreation of a huge swath of history. To me it was a very powerful experience. Yet I also found myself wondering whether I’d have felt the same had I not known so many details of Oppenheimer’s life beforehand.

Not to detract from the film but rather enable it to be used for educational purposes, I would like to add my observation that the two scenes with Jean Tatlock which required an R-rating for this film could be worked around so that a PG-13 version could be produced for use with high school students.

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Life - A Journey through Science and Politics

I enjoy reading autobiographies because it gives you a snapshot of history through someone else’s eyes. With Paul in his 90s, it is a solid 100 years! Paul puts together a biography filled with his friends, colleagues and family and how specific events, big and small, affected his future. There is much history here and lots of people who influenced Paul’s future. Paul assures us that he was lucky in life. It is true that sometimes it takes luck, but as the saying goes you must be prepared and open to opportunities that come your way. Paul and his wife Anne both jumped at opportunities and embraced life, they both especially enjoyed spending time with a variety of people, which led to much of their success.

The book is chronologically ordered, with many details of their friends and colleagues. It is amazing that Paul continues to stay in touch with so many people in his life. I got the feeling Anne and Paul were on the ground floor of a friends and colleagues pyramid scheme. Each friend/colleague led to more friends/colleagues which lead to more adventures, research papers, and books. A busy yet fun life with plenty of wine is an overall theme in this autobiography.

Paul was very good at laying out the problems that face humanity, and I would have liked to hear more about what he felt the solutions are or where we may look for solutions to life’s problems. One specific case he brings up many times is the structure of our educational system, especially universities. With the world’s problems being so complicated, the solutions need to come from many different disciplines. However, our academic structure has disciplines in individual silos. He argues (correctly I believe) that we need to break out of this structure. Over the last few decades, we have seen the start of departments coming together, for example, biophysics. Paul would argue that scientists need to work with non-science fields to solve present and future problems. He does not say how this could be achieved; not everyone is as extraverted. My thought is that granting institutions could help accelerate collaboration between science and non-science professionals to solve societal problems. In the last few chapters Paul talks more about these issues, but I would have liked to read more about his detailed thoughts on solutions.

Much of his thinking about the world was formed in his early academic career with the writing of The Population Bomb, which came out of his course on evolution. Most of the course was spent on where human beings had come from and the final week was spent on where he thought humanity was going. The students really enjoyed this last week which led Paul to doing public outreach in this area which led to appearances on the Johnny Carson show. Paul’s thoughts on where humanity is heading has always leaned toward the worst part of the spectrum of possibilities. Paul has been around long enough to see many good and bad changes for humanity, such as racism, which he encountered as a Jewish person, environment disasters, nuclear weapons, etc. In the last few chapters Paul brings the hammer down on how bad things could get. In his mind we are headed toward these really bad times and even worse for our great grandchildren (grandchildren?). I agree many aspects of the world we live in are unpleasant, Paul would lean toward horrible. I am more optimistic about our future, but I think we should heed his warnings if we want our future to be a good life.

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A proverbial Martian visiting Earth notes that humans are under Darwinian edicts to reproduce. They are also socially organized, so their reproduction is greatly complicated by religion and politics. They have gestation periods of some 9 months, divided into first, second and third trimesters. Different trimesters require different abortion procedures. An anti-abortion US president tasked an anti-abortion medic (C.E. Koop) to show that abortion was bad for women. After 5 years Koop (whom I met and was the picture of a confident surgeon) reported that his group could find no evidence for this claim, and that more research was needed. Turnaway is such a modern study, which treats the pros and cons of abortion in depth. Why should a physics Forum review this book? Physics is the prime experimental science, where we have great control over the variables. Turnaway treats examples of “natural experiments”, where Nature provides the variables: This approach is common in the observational sciences such as astronomy, meteorology and geology. A common binary choice of variable is experiment/control. Here the natural divisor is between women who present themselves a few days before the gestational time limit set by an abortion provider, and those who present a few days after. In the study, over 1,000 pregnant women were interviewed, by ‘phone, for up to 5 years, in depth. The author “find[s] no evidence that abortion hurts women.” There is evidence that women are better after an abortion—including in physical health, in employment and finances, and in having a greater chance for a wanted pregnancy (p. 21). Women denied an abortion had bad outcomes, including the large physical health risks (with death) of continued pregnancy and childbirth, poorer self-rated overall health, increased anxiety, and economic hardship (p. 21). Abortion can be a normal part of planning a family, as is shown by the example of “Amy” (p. 24).

Politicians and anti-abortion activists have long stated, without conclusive data, that abortion causes some sort of mental health harm. This study found that there was no mental health harm following an abortion (p. 39). An interesting table (p. 50), on planning methods to have only two children, lists items, an estimate of the number of necessary items, and of the unwanted pregnancies expected with each item, per thousand women. The risk of conception per sex act ranges from zero to ten percent, depending on where one is in the menstrual cycle; overall it is about three percent. Withdrawal results in up to 7 unwanted pregnancies, compared with implants of 0.0 such pregnancies. Abortion can be good, better is contraception. Male contraception is otherwise not mentioned. Each of the chapters is followed by a woman’s first-person narrative in the chapter, of some 10 pages. The author’s own family story is charming (p. 259).

Turnaway comes from Advancing New Standards in Reproductive Health (ANSIRH); their website ansirh.org provides useful updates and a listserv. (Curiously, the abbreviation is missing from the book’s index). Contrary to public myth, in the US childbirth is 14 times more maternally lethal than abortion (p. 142). Birth is also associated with thrice as many days of limited activity, compared to abortion (p. 146). Mothers are sicker (pp. 147, 148), birth is associated with household poverty (p. 177). Credit scores are depressed for even 5 years after an unwanted pregnancy (p. 180). Moreover, US maternal mortality now is twice the value in 1987 (p. 151). One wonders about other countries. The book is mainly confined to the US; ANSIRH has commenced a similar study in Nepal, where the lifetime risk for maternal death is 150 times the US value. A constant refrain is that women do not know that they are pregnant. So would a rapid, reliable, convenient, cheap pregnancy test help—though these adjectives reflect ambitious aims?

Modern medicine uses “confidence intervals CI”, or error bars, to show how (un)certain are numerical results, e.g. between women who have had an abortion, and women who were turned away from an abortion. It is a pity that Turnaway does not show uncertainties well, although the original papers do give them. There is a report of 2 maternal deaths in the study (p. 150) which simplistically gives a rate of 100 times the national death rates. As the author intuits, this is probably an artefact of the 2; a confidence interval calculation should clarify.

It is quaint that the few graphs do not show uncertainties. The next edition of the book would profit from examples in Science, or from the more-accessible Economist, which has a unit devoted to displaying graphical information. In the meantime, colorful graphs (especially for Fig. 6 p. 169) could be given on the website ansirh.org.

Turnaway is well-referenced, although some references are given only as URL’s—which can be ephemeral. The writing is clear, I saw no typos. (Though I wonder if the last two entries in the p. 50 table, of 30 and 25, are misprints; they could be omitted for clarity.) The narratives from women in each chapter, which are worth reading, buttress the Take Home (p. 311) of Trust Women.

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The Turnaway Study: Ten Years, a Thousand Women, and the Consequences of Having—or Being Denied—an Abortion
by Diana Greene Foster, Simon and Schuster. 2020, 384 pgs,
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