From the Editor

W

e have several news items in this issue, related to the March and April meetings. The March meeting sessions sponsored by the Forum were very interesting (I attended all of them since the meeting was in my home city). I expect the April meeting will be equally successful. At the March meeting we had also a joint reception with the Forum on International Physics, at which some of our new Fellows were introduced.

Expect to see in forthcoming issues articles by our recent prize winners and also by several of the people that have been invited talks at Forum-sponsored sessions at recent meetings.

In fact, Curtis Asplund, one of our April speakers, already has an article in this very issue. We have two more articles, one on introducing undergraduates to the Manhattan project, by Cameron Reed, and another by Daniel Jassby on the continuing controversy on laser fusion.

We have also our usual complement of book reviews as organized by Quinn, our Reviews Editor.

We are still looking for a Media Editor. 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.

This newsletter and its contents are mostly reader driven. Please consider sending your contribution or persuading somebody to do it. All topics related to Physics and Society are acceptable, excluding pure politics and anything containing *ad hominem* invective. 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@gc.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 Content is *not peer reviewed and opinions given are the author’s only, not necessarily mine, nor the Forum’s nor, a fortiori, the APS’s either*. But subject to the mild restrictions mentioned above no *pertinent subject needs to be avoided on the grounds that it might be controversial. Controversy is welcome.*

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Wed. April 3, 1:30 p.m. – 3:18 p.m. PDT
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Building High Energy Density Science Capacity at an Emerging Research Institution
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Collaborations Between Emerging Research and R1 Institutions: A Success Story!
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Advances in Earth Observation Capabilities and their Impact on Nuclear Stability
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International efforts to reduce the increasing danger of nuclear weapons
Curtis T Asplund (San Jose State University)

G01: Nuclear Energy: Small Modular Reactors and Climate Change
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Ballroom A1, Floor 2

TBA
Steven Chu (Lawrence Berkeley National Laboratory)

TBA
Raluca Scarlat (UC Berkeley)

Can Small Modular Reactors really help mitigate climate change?
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Burton Award Talk - Challenges to foster science in developing countries. Learning from lost opportunities
Galileo Violini (Centro Internacional de Física)

Szilard Award Lecture - Why we have confidence that the design of nuclear power plants against earthquakes is adequate
Robert J Budnitz (Lawrence Berkeley National Laboratory)

Reflections on Advancing Science through Inclusion
Kartik Sheth (NASA)

L04: Panel Discussion: Physicists and Arms Control - The Role of Science in Global Security
Fri. April 5, 10:45 a.m. – 12:33 p.m. PDT
Ballroom A5-6, Floor 2

Dylan K Spaulding (Union of Concerned Scientists)

Other Panelists: Stephen I Schwartz (Bulletin the Atomic Scientists), Lisbeth D Gronlund (Massachusetts Institute of Technology MIT), Raymond Jeanloz (University of California, Berkeley)
Forum Activities at the 2024 March meeting

The March Meeting took place in Minneapolis and is now past. The FPS sponsored a number of sessions. The titles and speakers are given below. Some of the presentations may be available online. Expect to see articles by some of the speakers in future issues of this newsletter.

B02: The NSF Mathematical Sciences Institutes: Physicists Collaborating with Mathematicians on Major Societal Challenges

Opportunities for Interdisciplinary Collaborations at the Mathematical Science Institutes
Mon. March 4, 11:30 a.m. – 12:06 p.m. CST
L100B
PRESENTED BY
Christian Ratsch (University of California, Los Angeles)

Automated data-driven upscaling of transport properties in materials: the results of a multidisciplinary collaboration between physics and mathematics
Mon. March 4, 12:06 p.m. – 12:42 p.m. CST
L100B
PRESENTED BY
Danny Perez (Los Alamos National Laboratory)

Methods for simulating quantum hardware
Mon. March 4, 12:42 p.m. – 1:18 p.m. CST
L100B
Kyungjoo Noh (AWS Center for Quantum Computing)

Physics and Number Theory
Mon. March 4, 1:18 p.m. – 1:54 p.m. CST
L100B
Miranda Cheng (University of Amsterdam)

Multi-Disciplinary Collaborations Enabling Uncertainty Quantification for Climate Science
Mon. March 4, 1:54 p.m. – 2:30 p.m. CST
L100B
Jonathan Hobbs ()

W24: Equity Considerations in Energy System Decarbonization

Decarbonizing the Built Environment through Equitable Thermal and Building Science
Thu. March 7, 3:00 p.m. – 3:36 p.m. CST
101DE
Roderick Jackson (National Renewable Energy Laboratory)

Phasing Out Natural Gas in the Residential Sector: Climate and Equity Considerations
Thu. March 7, 3:36 p.m. – 4:12 p.m. CST
101DE
Elena Krieger (PSE Healthy Energy)

Developing Metrics to Assess Justice and Equity Impacts of Early-Stage Research
Thu. March 7, 4:12 p.m. – 4:48 p.m. CST
101DE
Nikita S Dutta (National Renewable Energy Laboratory)

Equity Considerations in Modeling Decarbonized Energy Systems
Thu. March 7, 4:48 p.m. – 5:24 p.m. CST
101DE
Michael Wang (Argonne National Laboratory)

Equity Aspects of the Infrastructure Act and the Inflation Reduction Act
Thu. March 7, 5:24 p.m. – 6:00 p.m. CST
101DE
Deborah Behles (Independent Consultant)


The quantum computing industry and protecting national security: what tools will work?
Fri. March 8, 8:00 a.m. – 8:36 a.m. CST
Auditorium 1
Kate Weber (Google)

The Missing Middle: The Role of the DOE National Laboratories in Connecting Academia to Industry, Maturing Technology, and Promoting National Security
Fri. March 8, 9:12 a.m. – 9:48 a.m. CST
Auditorium 1
Benn Tannenbaum (Sandia National Laboratories)

AI and Data Innovation: Innovating in Constrained Environments
Fri. March 8, 9:48 a.m. – 10:24 a.m. CST
Auditorium 1
Meghan S Anzelc (Three Arc Advisory)
International efforts to reduce the increasing danger of nuclear weapons

Curtis T. Asplund, San Jose State University, curtis.asplund@sjsu.edu

Physicists have been concerned about nuclear weapons since the earliest days, when many prominent members of our field were involved in inventing, constructing, and developing them. Some of those early struggles and debates were depicted in the phenomenally successful film Oppenheimer. The film left out the stories of many though. For example, Lise Meitner, co-discoverer of nuclear fission, who scrupulously refused to work on weapons research [1], and Joseph Rotblat, who left the Manhattan Project on moral grounds when it became clear that Nazi Germany would not develop an atomic bomb [2]. In the following decades, Meitner called for promoting the best ethical traditions of physics as an antidote to war fighting, and Rotblat went on to become an outspoken critic of nuclear weapons and was active in organizing fellow scientists to advocate for international peace and nuclear disarmament.

Though the 1980’s and 90’s saw major nuclear arsenal reductions and significant arms control treaties, recent years have seen increasing nuclear weapons development, deployment and saber rattling, to the point where many believe we are in a new nuclear arms race [3]. The United States, in particular, which already has over 1,700 deployed nuclear weapons [4], is undergoing a major revamping of its nuclear arsenal, at great cost and risk, with justifications that have been called into question [5]. In response, a renewed grassroots effort has emerged, to organize members of our field from around the world to educate the public and policy makers about the increasing dangers of these weapons and to advocate for policies that reduce them. In particular, a group of physicists, including myself, convened a workshop in October 2023 at the International Centre for Theoretical Physics, which drew approximately 45 physicists from 15 nations, entitled “The Increasing Danger of Nuclear Weapons: How Physicists Can Help Reduce the Threat” [6]. At the workshop, participants presented their work on nuclear threat reduction and participated in discussions about how to move forward.

The main themes of the workshop were:

- new technical developments related to nuclear weapons
- the state of physicists’ engagement and advocacy in various nations
- ethical questions about weapons related work
- how to communicate with the public and students
- how we can organize local, national and international efforts of physicists as advocates for policy change

Physicists work on a wide variety of technical aspects of nuclear weapons, from the warheads to the delivery vehicles to non-proliferation measures. We heard from speakers on many of these topics, but I will leave more detailed discussions to other participants who are also writing articles for this newsletter, specifically Dr. Lindsay Rand’s article about the implications of emerging technologies on nuclear weapons policies, and Dr. Igor Moric’s “Advances in Earth Observation Capabilities and their Impact on Nuclear Deterrence” in the January 2024 edition.

New studies modeling the impacts of nuclear wars have made it clear that they have the capacity to cause catastrophic climactic changes and to decimate critical societal systems such as food production and distribution. These studies expand and deepen our understanding of what is sometimes called “nuclear winter.” Specifically, Dr. Alan Robock presented his and his collaborators’ study that concluded that a nuclear war between India and Pakistan could cause the deaths of more than 2 billion people, and that a war between the US and Russia could cause over 5 billion people to die [7]. Workshop participants discussed the need for continued research on these impacts and what the policy implications of this work are or should be. The National Academies’ “Independent Study on Potential Environmental Effects of Nuclear War” should ultimately be a useful resource on this topic (report has not been released at the time of writing) [8].

The international nature of the meeting allowed for us to hear directly from physicists engaged with nuclear weapons policy issues in various nations. We heard about the state of policy and advocacy in China, Russia, India, Pakistan, the United Arab Emirates, France, the United Kingdom, Japan, Italy, Germany, Argentina, and Brazil. Each has challenges as well as opportunities. I won’t try to paraphrase my colleagues’ assessments of these national and regional situations, but will instead focus more on the implications for those of us working in the US, with an eye towards how we can coordinate and work in concert with those abroad.

The situation in other countries makes it clear that as physicists in the United States, we have unique privileges, responsibilities and opportunities for engaging with these issues. We have relatively few bounds on our freedom of expressions, a constitutional right to petition our government, and one of the largest nuclear arsenals in the world. The US is also home to a relatively new grassroots organization, the Physicists Coalition for Nuclear Threat Reduction, that pro-
vides some resources, expertise, and networking opportunities for those interested [9]. These factors all support the idea that, as a recent article put it, "Physicists need to be talking about nuclear weapons" [10]. It must be stressed, though, that even in alliance with the broader US arms control community, such grassroots efforts are small in comparison to the large amounts of money, personnel, and lobbying efforts available to the nuclear arms industrial and governmental complex. Nonetheless, those gathered at this workshop agreed that efforts to convey the reality of nuclear weapons threats to the public and policy makers must be made.

We brainstormed and discussed many ways that physicists can engage and inform the public on nuclear arms issues. These included collaborating with those in the media and in the arts, reaching out to schools and universities, producing online content and courses, and creating curriculums for either complete courses or course modules. Another idea was to work within our professional societies, and this article and the associated session at the 2024 April Meeting are examples of that. All such methods have their own challenges and complexities and are variably suited to different individuals, issues, and organizations. The workshop offered the chance for sharing lessons learned as well as generating new ideas.

One outcome of this workshop was the intention to form an international working group of physicists who share an interest in advocating for nuclear arms control and reduction. Participants emphasized that this group should be diverse in nationality, career stage, gender, and ethnicity. As of this writing, the specific mission, composition, and operation of this working group are still under active discussion, but several planning meetings are scheduled in the coming month. Many participants at the workshop expressed a sense of urgency for physicists to work together and speak out about the growing dangers of the weapons that were, after all, invented by our field. Readers interested in learning more about these issues or joining in some of these efforts should consider joining the Physicists Coalition [9] or may contact the author at the email address above.

It’s Premature to Endorse Direct Drive Laser Fusion

Daniel L. Jassby, Retired from Princeton Plasma Physics Lab., djjenterp@aol.com

To accomplish nuclear fusion by “indirect drive,” a suitable energy source is first converted to X-rays in a hohlraum, and those X-rays implode a fusion fuel capsule by ablation of the capsule surface. Radiative implosion of the fusion fuel is the only terrestrial technique that to date has proved capable of igniting thermonuclear burn, whether the energy source is a multi-terajoule fission explosion [1] or megajoule laser beams [2]. By contrast, in the process of “direct drive” the laser beams themselves are focused upon a spherical fusion fuel capsule to implode it [3].

In the January 2024 Newsletter of this Forum, an article by Bodner [4] declared that indirect drive laser fusion is irrelevant to planned fusion power reactors and should be abandoned in favor of direct drive, while an article by Manheimer [5] urged that the US DOE transform the mission of a magnetic confinement laboratory to research and perfection of direct drive laser fusion, including development of the optimal laser. The authors identified the alleged fatal flaws that will eventually doom the application of indirect drive to IFE (Inertial Fusion Energy) as the inefficiency of converting laser energy to X-rays of which only a small fraction is absorbed by the fuel capsule, and the extra cost of fuel targets that employ a hohlraum.

In favoring direct drive, both Bodner and Manheimer propose programs to develop a reactor-grade excimer laser (ArF or KrF) followed by a research program to achieve thermonuclear ignition. But their proposals employ coupled speculations, as Bodner has shown elsewhere [6] that only the ArF laser has the potential to effect ignition with direct drive, principally because of its short wavelength (193 nm), broad bandwidth (10 THz), and ability to zoom. If an ArF laser of the required energy (e.g., 30 kJ per module) and pulse length (~ 3 ns) cannot be developed, then ignition with direct drive is likely impossible.

NIF Experiments With Direct Drive

The NIF (National Ignition Facility) near Livermore, California is the world’s most powerful laser-driven fusion facility, featuring a frequency-tripled Nd-glass laser that produces up to 2.2 MJ at 351 nm. While the NIF fusion program is concerned mainly with indirect drive, the project uses direct drive when it wants a “quick and dirty” neutron source for some application, because it’s cheaper and faster than setting up indirect drive.

However, the NIF laser beam configuration is far from ideal for optimizing the performance of direct drive. For indirect drive the NIF laser beam array is oriented so that beams enter the two opposite ends of a hohlraum, called the “polar” configuration. In the absence of a hohlraum there is asymmetric laser illumination of the spherical D-T fuel capsule, so the beams must be defocused to increase uniformity on the target. With direct drive NIF has produced up to 35 kJ of fusion yield with 1.2 MJ of laser energy, giving target gain Q = 0.03 [7]. This value is about 1/60th of the highest target Q reached with indirect drive on the NIF.

OMEGA Experiments with Direct Drive

The OMEGA facility at the Univ. of Rochester (URLLE) houses the second largest laser for fusion research in the US, which is also a frequency-tripled Nd-glass laser that delivers up to 35 kJ at 351 nm.

Very recently the URLLE published an extensive account of the best direct drive results with their OMEGA laser imploding a spherical D-T fuel capsule [8]. The facility produced 900 J of fusion energy with a 28 kJ laser pulse, giving Q = 0.03, which by coincidence is the same as the highest Q obtained by direct drive on the NIF with 40 times as much laser energy.

The URLLE “hydro-equivalently” scaled OMEGA results to the NIF with 2.1 MJ laser pulses and with the model using spherically symmetric laser illumination of the fuel capsule (unlike NIF’s actual polar direct drive). This extrapolation gave a fusion yield up to 1.6 MJ but did not quite ignite [9]. Nevertheless, this yield scaled from the OMEGA results was 45 times larger than the amount achieved experimentally with a 1.2 MJ laser pulse and polar direct drive.

By contrast, with indirect drive the NIF has actually ignited fuel capsules numerous times with just 250 to 300 kJ of X-rays absorbed by the capsule [10]. The fact that ignition can be achieved by X-rays with just 1/7 of the laser energy is a testimony to the greater penetrating power of the short wavelength X-rays and resistance to instability growth offered by their incoherent nature.

Laser Development

For the next decade, laser development for IFE is likely to be pursued mainly by private companies in the US with modest support from the DOE and by government labs abroad. The half-dozen private companies in this field claim that they will develop a reactor-grade laser system based on either the DPSSL (diode-pumped solid-state laser), or KrF, or ArF. This R&D may result in a superior MJ-level, nanosecond-pulse, high-rep-rate laser for direct drive. If not, then the only route to IFE is indirect drive, which can tolerate relaxed driver specifications. If the laser development is successful, an experimental test of the ability of direct drive to attain thermonuclear ignition is still 10 to 12 years away and the outcome is uncertain.
As for Manheimer’s proposal [5] to change the mission of a US DOE lab, one notes that reaching ignition or very high Q in the tokamak or stellarator is indeed as speculative as ignition with direct drive. However, the DOE and the magnetic confinement labs are convinced that the tokamak is a sure thing and in any case would not give up one speculation for another.

Increasing the Efficiency of Indirect Drive

The drawback with discarding or ignoring indirect drive is that after 75 years of controlled fusion R&D it is the only technique of a hundred fusion concepts that has demonstrated “scientific feasibility,” i.e., the ability to reach thermonuclear ignition, or for magnetic confinement systems to demonstrate fusion energy gains of 10 or more.

A different approach to overcoming the objections to indirect drive is to attempt to mitigate its relative inefficiency and the extra cost associated with hohlraum targets.

There are 5 components in the NIF chain of efficiencies:

1. the laser itself (0.5% electrical efficiency)
2. wavelength conversion (50%)
3. conversion to X-rays, including loss of laser light from the hohlraum (80%)
4. fraction of X-rays lost from the hohlraum (20%)
5. fraction of X-rays absorbed by the fuel capsule (15%)

Laser inefficiency is the “low-hanging fruit” and the electrical efficiency can be increased to at least 10% with either the DPSSL or a gaseous excimer laser. Developing the ArF laser system to generate repetitive MJ-level, nanosecond pulses, as proposed by Bodner and Manheimer, would be invaluable for indirect drive as well as direct drive. For indirect drive it obviates the need for frequency tripling (item #2), and will produce an electrical efficiency 40 times greater than the NIF laser system.

In present-day hohlraums, only about 15% of the laser energy is absorbed by the fuel capsule. However, the efficiency advantage of direct drive is no more than a factor of four because of reduced ablation effectiveness relative to that of X-rays, loss of laser light by backscatter exacerbated by cross-beam energy transfer, and deleterious laser-plasma instabilities [11]. Furthermore, the fraction of X-rays absorbed by the fuel capsule can be increased significantly with newly optimized hohlraum designs (item #5). For example, both rugby-shaped [12] and fustum-shaped [13] hohlraums have been shown experimentally to increase the X-ray absorption efficiency from 15% to 30%, which reduces the advantage of direct drive to a factor of two. The indicated failure to reach ignition when the OMEGA direct drive results are “hydro-equivalently scaled” to NIF’s 2.1 MJ raises the possibility that indirect drive may eventually have the efficiency advantage if only longer wavelength lasers are available. Excimer laser drivers would presumably give better results with direct drive than the glass lasers currently used at OMEGA and NIF [11].

Particle Beam Drivers

The residual factor of two advantage of direct drive indicated above will be erased if particle beams are the energy source for indirect drive because the electrical efficiency of those beams is tens of percent, and because the hohlraum will be closed, eliminating X-ray loss (item #4). Ion beams can penetrate the thin outer surface of the hohlraum into the material that converts their energy to X-rays.

Recent advances in accelerator development suggest that affordable compact fusion drivers will become available in the foreseeable future [14]. In the case of heavy-ion beams, the first experiments using existing ion-beam facilities would not need any fuel capsule, but must show that an adequate X-ray field can be established inside a hohlraum by an ion beam impinging on the exterior. While a working hohlraum will be closed, an experimental hohlraum must have holes for diagnostic access. The intensity and spectrum of X-ray production can be monitored by time-resolved X-ray spectrometers such as deployed on the NIF.

There have not yet been experiments with particle beams and fusion-relevant targets, and no private company is proposing to pursue this route. If the DOE (other than NNSA) is to fund anything substantial in inertial fusion research, given the success of indirect drive it ought to fund particle beam experiments with hohlraum targets using existing ion accelerators or those nearing completion.

Multi-megajoule pulses are inherent to heavy-ion drivers as well as some schemes using laser drivers [15]. The extra cost of a hohlraum target can be accommodated when driver pulses are tens of MJ instead of the more commonly cited 1 or 2 MJ, so that each pulse produces at least ten times as much fusion energy. For a given averaged power output, “oversized” pulses also allow a much reduced repetition rate and correspondingly longer time to clear target debris from the reaction chamber and for the FLIBE or molten metal first wall to recover from the impulse loading.

Summary

Radiatively driven implosion via soft X-rays is uniquely successful in the fusion game and should be exploited in all its potentially useful variations. There exist practical avenues for decisively increasing its overall electrical efficiency and for reducing the relative cost of target hohlraums. Its competitor, direct drive laser fusion, shows great promise but attaining ignition is far from assured. Indirect drive should not be set aside as an energy source until it has been shown to compete unfavorably with a direct drive system that actually produces ignition in the laboratory.
References

[1] First demonstrated in the Ivy Mike shot of November 1952. See Wikipedia entry on “Ivy Mike”.


A Memorandum Concerning Uranium Power and Bombs

Cameron Reed, Department of Physics (Emeritus), Alma College, Alma, MI, reed@alma.edu

In the Fall of 2023, I had the great pleasure of being asked by a local seniors organization to offer a short course on the Manhattan Project in response to interest generated by the Oppenheimer movie. My class was one of several into which seniors could enroll at very modest cost; no prior knowledge was assumed. The menu of courses varied from biblical history to current world events.

I had a very enthusiastic group of about 20 participants. Courses ran over six weeks, with one two-hour session per week. A course like this is always a bit of a balancing act: one wants to delve into enough of the scientific background to give a credible sense of what the scientists and engineers of the Manhattan Project were up against, but at the same time not overwhelm the audience. My group contained many retirees who had been professionals such as engineers and teachers; they were not going to let me get away with loose or shallow explanations. I followed a semi-quantitative approach supported with numerous slides, graphs, and photos.

The first couple weeks of the class offered a whirlwind tour of the scientific background: Atomic structure, radioactivity, isotopes, and on up to the discovery of fission. This brought us to the well-known story of how the Szilard-Einstein letter warning of the potentialities of nuclear energy made its way to President Roosevelt in the Fall of 1939. In discussing this, I saw an opportunity to prepare a convenient summary of the preceding background material: I imagined myself being asked to prepare a two-page, single-spaced memorandum giving a qualitative summary of the possibility of nuclear power and weapons. I imagined my reader to be a busy government official who did not have time for a seminar on nuclear physics, but I wanted to touch on all of the relevant essentials: The difference is that since nuclei of U-235 and U-238 are forms of the same element, their nuclei possess identical atomic numbers but different masses. The difference is that since U-235 could absorb neutrons and fission, while U-238 could not, U-235 could be used for nuclear fuel, while U-238 could not.

The text of the memorandum is reproduced below in the hope that it might be of use to instructors seeking a compact overall description of the nuclear situation as it was understood in late 1939/early 1940. I would be grateful for any feedback from interested readers.

Executive Summary

Recent research indicates that the element uranium might serve as a source of energy or as the active explosive in extremely powerful bombs. A uranium “reactor” engine could be used to power large naval vessels and submarines, while uranium bombs could release millions of times as much energy as conventional bombs on a pound-for-pound basis. We recommend that all uranium ores and uranium-bearing products be prohibited from export, that the Administration appoint an official to maintain contact with researchers, and that funding be authorized to support continued research. The following points summarize the situation.

(1) Neutron-induced fission

“Nuclear fission” is a process whereby the nucleus of a uranium atom breaks apart and releases “atomic energy” upon being struck by an incoming neutron. The probability that a nucleus will fission depends on the speed of the striking neutron. In essence, a “fissile” nucleus will potentially suffer fission if struck by any neutron, no matter how little energy it has; a “fissionable” nucleus needs to be struck by a neutron of a certain minimum energy to undergo fission.

Uranium ore comes in two forms: U-235 and U-238. U-238 comprises about 99.3% of natural uranium, with the remaining 0.7% being U-235. U-235 nuclei are fissile, while those of U-238 are fissionable. U-238 does, however, capture incoming neutrons and subsequently decay to a new element, plutonium. This is of potentially great value in the context of bombs as described in (4) below.

(2) Chain reactions via neutrons released in fissions

Each fission of a uranium nucleus releases 2 or 3 very energetic “fast” neutrons which can go on to precipitate a chain reaction in other U-235 nuclei. But since U-238 captures neutrons and constitutes the vast majority of natural uranium, it is impossible to create a fast-neutron chain reaction with natural-abundance uranium. This rules out a high-energy uranium bomb with natural uranium. But see point (3) below regarding the possibility of powerful U-235 bombs.

(3) Possibility of “fast-neutron” bombs

In contrast to point (2), it is predicted that an immensely destructive “fast-neutron bomb” could be possible if tens of kilograms of U-235 (or plutonium) could be isolated. The difficulty is that since nuclei of U-235 and U-238 are forms of the
same element, no ordinary chemical process can be used to separate them. To achieve any separation it will be necessary to utilize a technique that takes advantage of the slight difference in the masses between the two types of nuclei. Three such techniques are currently in the nanogram-level research stage, but tens of kilograms will be required to make a bomb.

(4) Possibility of low-energy neutron power sources; plutonium “breeding”

A subtlety in the physics of fission is that the probability that a bombarding neutron will induce a fission in U-235 rises dramatically as the speed of the neutron decreases; in effect, slow-moving, low-energy neutrons have more time to cause a fission. For slow neutrons, the U-235 fission probability is over 200 times greater than the capture probability for U-238; this is just enough to compensate for the small natural abundance of U-235 to the extent that a controllable, energy-producing chain-reaction becomes possible. In actuality, both neutron-induced fission of U-235 and neutron capture by U-238 would proceed in parallel in a slow-neutron environment; this is an important point.

To slow neutrons after they are emitted in a fission but before they strike another uranium nucleus, it will be necessary to disperse the uranium as small lumps throughout a medium which slows neutrons without capturing them. The entire assemblage is called a pile or reactor. Graphite is the most practical slowing medium now known. The neutrons’ energies from slowing and energy liberated in the fission reactions will be released as heat, which can be used to drive an engine. Such a power plant would require no fuel or oxygen, and would be ideal for use in a naval vessel such as an aircraft carrier or submarine; the range of such a vessel would be effectively unlimited.

After nuclei of U-238 capture incoming neutrons, they decay to a new element called plutonium. Laboratory tests have verified that plutonium behaves like U-235 and is in fact more fissile than U-235. An operating reactor would both provide power and “breed” a new fissile material which can be chemically extracted from the parent uranium fuel and used to power a bomb as in (3) above. It is estimated that a large-scale land-based reactor would supply enough plutonium for about a dozen bombs per year while also supplying power.

(5) Conclusions

The prospect of realizing nuclear power and weapons seems more probable than not. Competent authorities estimate that separation techniques and reactors could be developed within two to three years, but will require industrial-scale infrastructures costing hundreds of millions of dollars.

The ideas outlined here have also likely occurred to scientists in adversary countries. Any country which possesses such a tkksource of power would have a crushing advantage over one that does not. In view of this, we recommend that both nuclear pile and fissile materials research and development be given the highest possible priority.
The Deadly Rise of Anti-Science: A Scientist’s Warning


Peter Hotez is the co-director of the Texas Children’s Hospital Center for Vaccine Development, He is also the father of an autistic child. Mindful that opponents of vaccinations claimed that vaccines caused autism, he wrote a book titled Vaccines Did Not Cause Rachel’s Autism in 2018 and writes here of the retribution he experienced from doing so.

Hotez describes this book as a “dark and tragic story of how a significant segment of the population of the United States suddenly, defiantly, and without precedent turned against biomedical science and scientists.” With autism established as not resulting from vaccines, Hotez observes that anti-vaxxers have shifted from “medical/health freedom” to justify their cause, even foregoing protection from COVID-19 and aligning with far-right political groups. He sees “anti-science aggression,” fostered by the “triumvirate” of conservative news media, far-right political leaders, and pseudointellectuals, responsible for not only 200,000 avoidable COVID-19 deaths but also jeopardizing childhood vaccinations and threatening the return of childhood diseases. These avoidable deaths resulted, Hotez says, largely from unvaccinated Americans succumbing to the delta variant in summer-fall 2021 and the omicron-variant in winter 2022. Several of Hotez’s analyses of the COVID-19 death data all lead to approximately the figure of 200,000 unnecessary COVID-19 deaths which he claims. Moreover, the data for COVID-19 deaths or lack of vaccination show a correlation with the percentage of the vote Donald Trump received in the 2020 presidential election by county.

While government agencies and non-governmental organizations are credited with disseminating reliable information to counter the disinformation disseminated by the “triumvirate” and hate mail sent to bioscientists (Hotez reprints two he has received), they are no match for their opposition, Hotez writes. Nor are organizations of professional scientists, which have been reluctant to appear to be too political.

In his quest to oppose the “anti-science aggression” of the “triumvirate,” Hotez writes that he has reached out to two groups of like-minded scientists. He has also looked at the similar plight of another group of scientists – those studying climate change – and observes that the Climate Science Legal Defense Fund has been set up to provide legal assistance to climate scientists facing lawsuits, as the Southern Poverty Law Center provides assistance to victims of racism (and also tracks the activities of hate groups). Hotez notes that both examples could serve as models for an organization to protect against hate directed toward biomedical scientists. And because government health agencies have been ineffective in opposing hate from the “triumvirate,” he also argues that more is needed to protect biomedical scientists. Likening the hate directed toward biomedical scientists to terrorism, Hotez advocates that the US government mobilize its anti-terrorist resources against haters of biomedical scientists.

How to Argue With A Racist


Dr. Adam Rutherford is a geneticist based in Britain and has his PhD from University College London in 2002. In addition to his work as a geneticist, he is also an author, podcaster, and public speaker, focusing on the topic of genetic theory gone awry. He has written several books on genetics and its pseudoscientific misuse. The book reviewed here is entitled How to Argue With A Racist, published in 2020 by The Experiment. In the preface the author states the motivation for the book as written in response to some “race” based events that sparked a need to address his inner frustration at people who were not able to get things right, resulting in needless death. These events included the COVID 19 pandemic and the death of George Floyd by police murder. The book was written to show how science has been used incorrectly to support and institutionalize racism.

How to Argue With A Racist is a perfect read for this election cycle. With scientific theories and facts being widely ignored by a large segment of the population, being able to rationally debunk pseudoscience is an important read. This small book is packed with facts and figures and is segmented into four big ideas – Skin in the Game, Your Ancestors Are My Ancestors, Black Power, and White Matter.

The introduction take us back to Africa, where the earliest Homo Sapiens evolved and migrated into Asia and Europe. We all share these early origins in our DNA and yet there is widespread stereotypes and myths about race and structural racism. As an example of how genetics is used to promote a race-based myth, the author tells the story of Neo-Nazi members on social media “chugging milk”, which is an attempt to show their European ancestry and superiority with a gene mutation that came about 8,000 years ago in some populations.
of the world to process lactose. However, the Nazi’s forgot to look up the science – this same gene mutation evolved also in people like Kazaks, Ethiopians and Tutsi peoples who Neo-Nazi’s consider “non-white”.

_Skin In The Game_ acknowledges the easiest method of sorting humans is by skin color, and skin color is determined by genes. Dr. Rutherford also debunks the notion of eye color inheritance most of us learned in high school biology, stating the genes responsible for eye color are complex and it is possible for a child to have eye color much different than the parents. Rutherford lays out how the classification or taxonomy used in early times may have led to a racist structure being embedded within science itself and also within nation-states including ancient Greeks and extending to the middle-east. Taxonomy itself has been fraught with issues based on the Linnaean binomial nomenclature structure which encoded European notions of race and sexism as biological facts rather than social constructs. Linnaeus, like many men of his time, followed “Christian” norms of the time where humans were viewed as ascendent to animals and that natural scientific order should follow these same hierarchical rules, where organisms were ranked according to perceived intelligence, as viewed by church. When the first edition was published, Linnaeus had humans split into four categories based on colors and classes with “Europaeus albus (Europeans), Americanus rubescens (Americans), Asiaticus fuscus (Asians) and Africanus niger (Africans). Within European natural philosophy at the time, scientists liked to divide things into groups of four like the elements – earth, air, fire and water. For Linnaeus this connection of geography and skin color seemed like a valid way to group humans.

_Your Ancestors Are My Ancestors_ discusses the role genealogy and ancestors play in our limited understanding of our genetic history. The author discusses this in terms of people complaining about people (not like them) who move into their environs and the ensuing misrepresentation of who actually could or should lay claim to land. Dr. Rutherford points out we all ultimately have two parents, based on our ancient lineage which shows no more than 3 branches back in time. The author points out that after the initial branches, history gets blurred, and the last common ancestor of all Europeans was a woman who lived in 1400 CE. The author uses this notion to dismiss the idea of “tribal” violence towards those who we think are different than us – turns out people are not so different from each other. He states that these DNA kits which proclaim you are 40% British, 60% German, may be misleading since you do not know the time period or history of those ancestors, the results just show the number of people who have recent geographic associations, and can serve to reinforce stereotypes and myths about nation states.

In _Black Power_ the author debunks the myths of racial superiority in sports and how the success of black athletes has served to reinforce racist stereotypes in some people. Dr. Rutherford also discusses some of the genetics based performance attributes that have been seen in some long distance runners and sprinters and uses the term “necessary, but not sufficient”, meaning it is not enough to be an elite athlete to have the gene, you also have to do the hard work.

Finally, in _White Matter_ Dr. Rutherford talks about the position of many whites to feel genetically intellectually superior to other people not like them. He points out that while 144 people who are Jewish have won the Nobel prize, not one black person has won. Is that owing to genetic disparity or a lack of opportunity? Rutherford speaks to the limitations of the IQ test, and why it may not matter for success. He speaks to new methods in genetics for Genome Wide Association Studies (GWAS) and Polygenic Risk Score (PRS), that allows a scientist to understand the total genomic contribution to a trait. This technique has pointed to intelligence being inherited, but it does not compare between populations in terms of intelligence. Using this method, researchers have found relationships between traits and gene association, but there are no studies linking intelligence and genes.

Dr. Rutherford concludes by going back over his main points expressed in the chapters – evolution is real and there are genetic adaptations in humans over time creating differences between people, skin color as a classifier is pseudoscience, physical characteristics are not representative of differences between people, concepts of racial purity are historically inaccurate, and genetic difference between populations do not account for sports ability or intelligence.

There is much to read in this short book, and I look forward to reading his new book where Rutherford delves more deeply into the dark history of eugenics and the impact on our institutional and scientific systems.

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