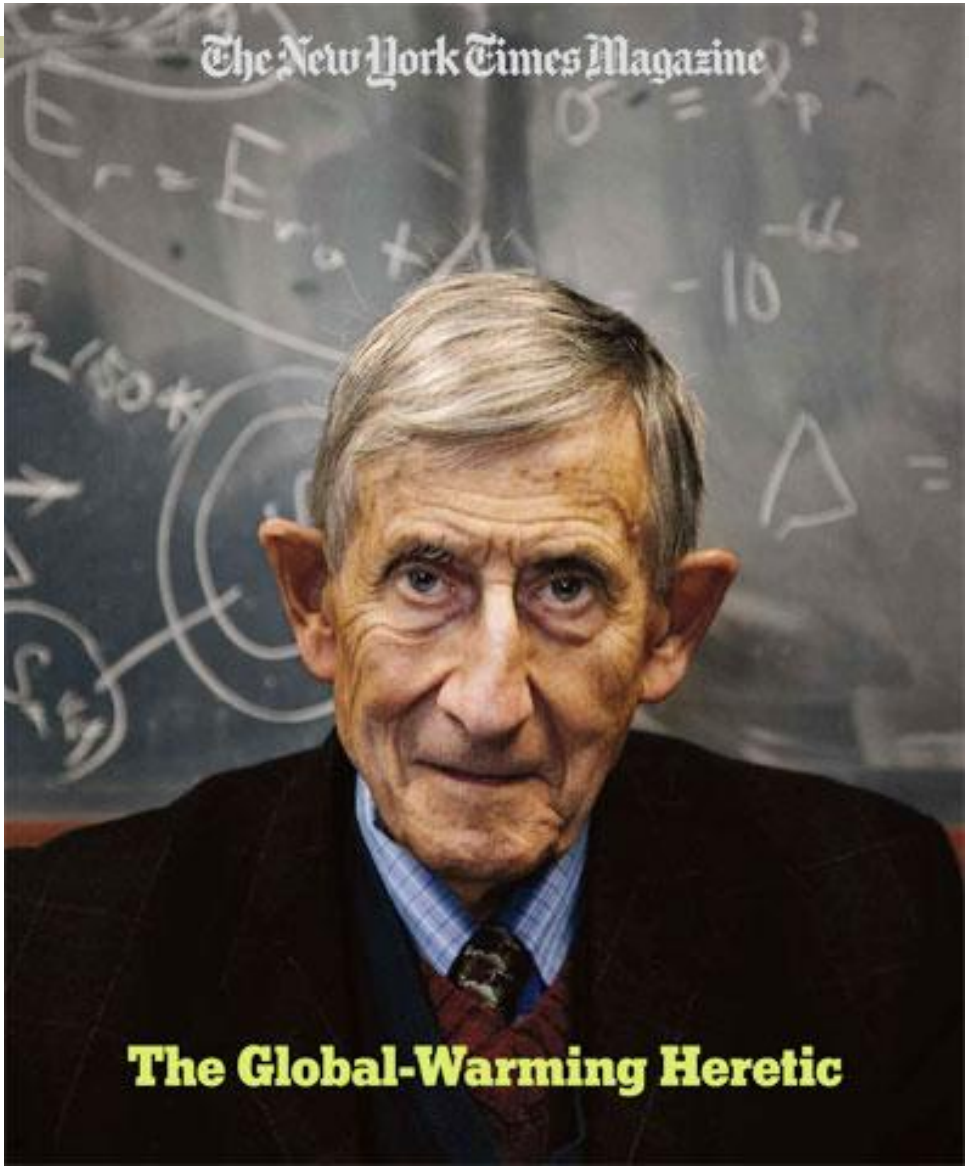
Spacetraveler's Manifesto:

The other-worldy career of Freeman Dyson

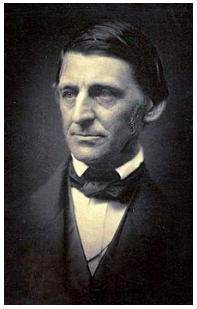
Phillip F. Schewe

KITP March 2016

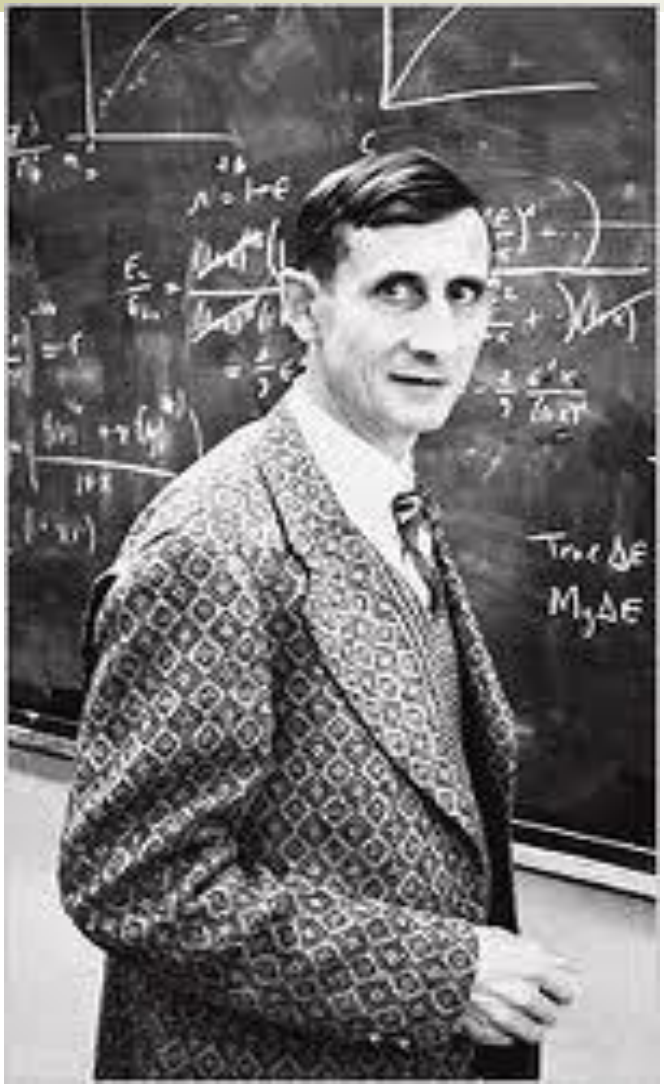
“I’m happy every time the Chinese and Indians make a strong statement about going ahead with burning coal.”



The emerson of our time



- Number theory
- QED
- Reactors
- Rocketships
- SETI
- Test ban treaty
- Vietnam nukes
- Adaptive optics
- Stable matter
- Late universe



- Origin of life
- No-first-use
- Meta-science
- Climate heresy
- Biotech
- Book reviewing
- Culture wars
- Colonize comets
- Persistence of life

Best schoolboy in Britain

Winchester as Hogwarts

Freeman as Harry Potter

All the math awards

Poetry in chemistry class

Science on your own

H G Wells, Jules Verne

Cambridge: again the best

Bomber Command

Dyson's moral education

1943-45

Operations research: closer formations

400,000 dead: Nuremberg

Anti-sub warfare would have been more effective

Postwar London: Physics or Math?

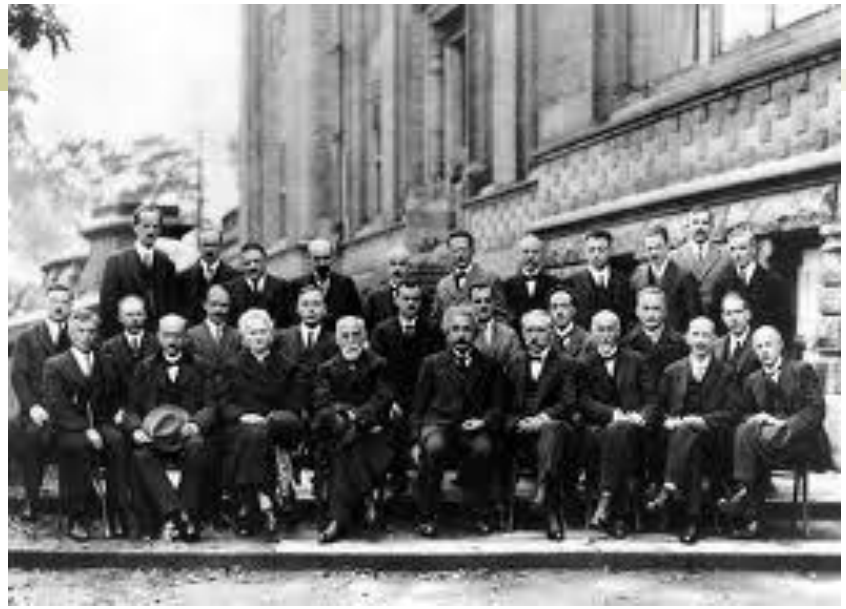
1945-47

Quantum textbooks: Gregor Wentzel, Walter Heitler

William James, William Blake, Olaf Stapledon

60-second chat: Cornell instead of Moscow

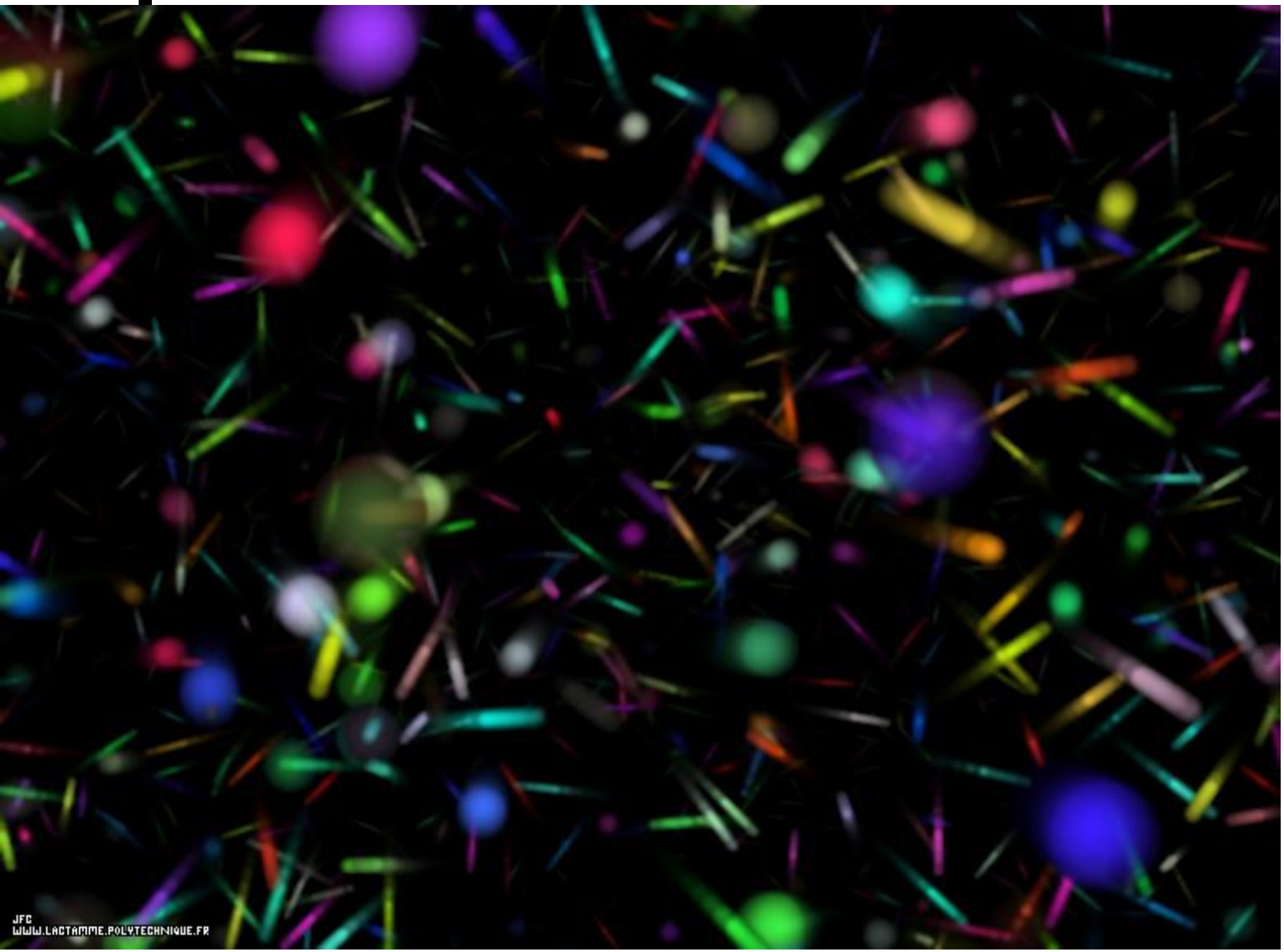
In the right place at the right time

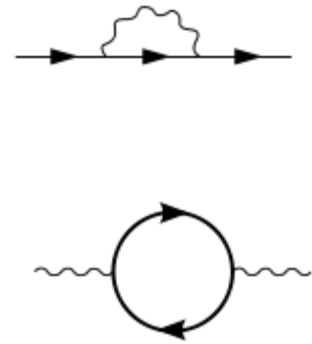


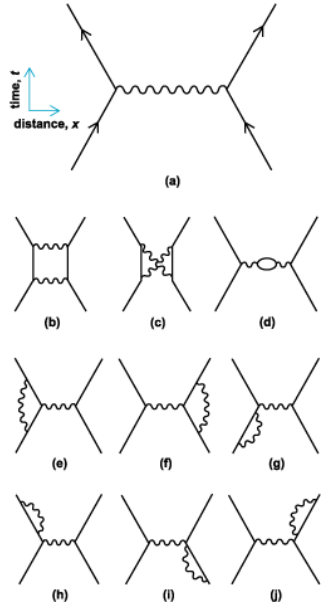
- 1927 SOLVAY
  - A. Piccard, E. Henriot, P. Ehrenfest, E. Herzen, Th. de Donder, E. Schrödinger, J.E. Verschaffelt, W. Pauli, W. Heisenberg, R.H. Fowler, L. Brillouin; P. Debye, M. Knudsen, W.L. Bragg, H.A. Kramers, P.A.M. Dirac, A.H. Compton, L. de Broglie, M. Born, N. Bohr; I. Langmuir, M. Planck, M. Skłodowska-Curie, H.A. Lorentz, A. Einstein, P. Langevin, Ch.-E. Guye, C.T.R. Wilson, O.W. Richardson

- 1947 Shelter Island
  - W. Lamb, K.K. Darrow, Victor Weisskopf, George E. Uhlenbeck, Robert E. Marshak, Julian Schwinger, and David Bohm. From left to right, seated are: J. Robert Oppenheimer (holding pipe), Abraham Pais, Richard P. Feynman (seated, with pen in hand), and Herman Feshbach

Vacuum isn’t nothing







Pocono Meeting

Spring 1948 (Nobel Prize 1965)

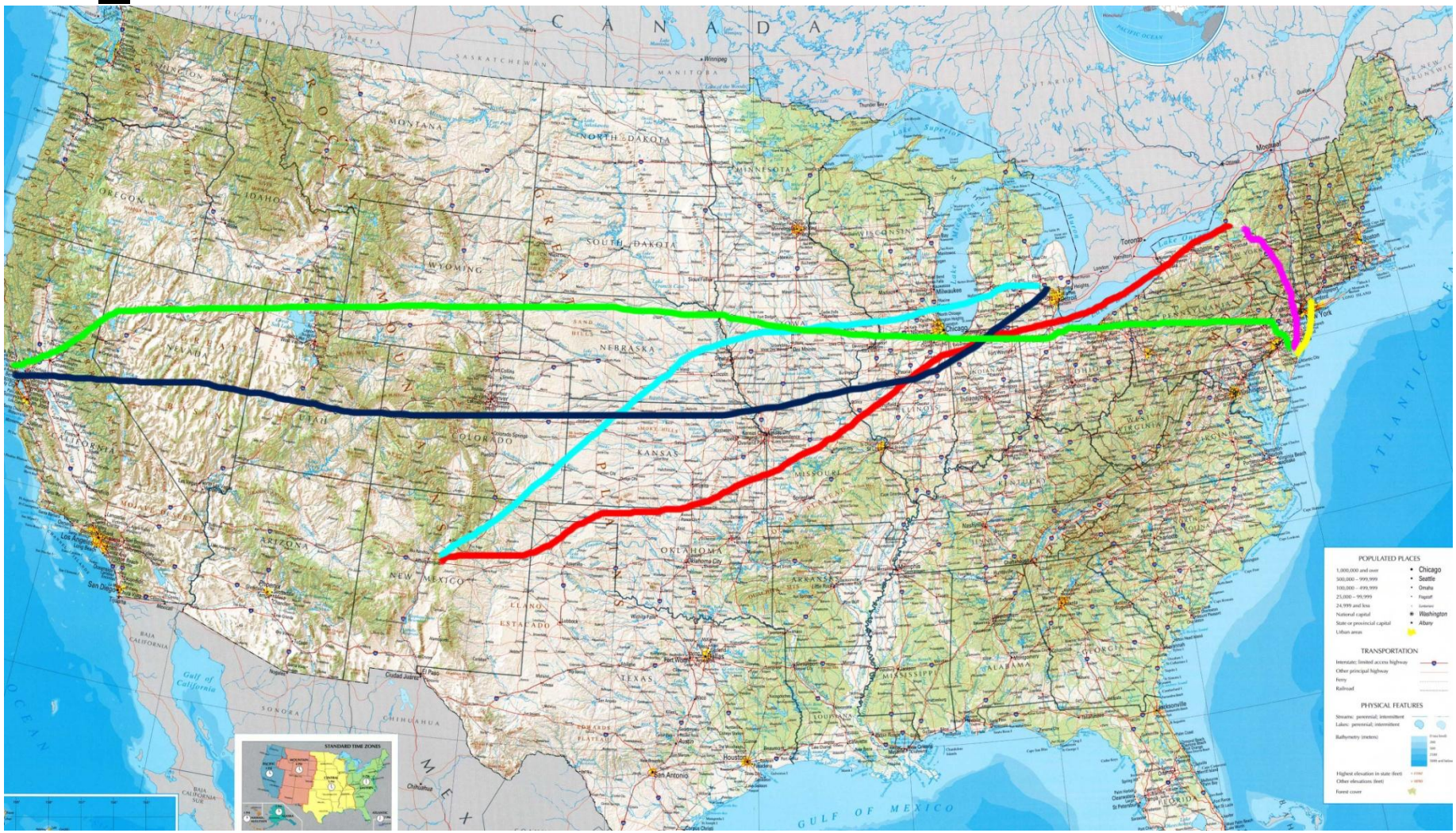
Richard Feynman

Julian Schwinger

Sin-Itiro Tomonaga

Summer 1948 *On the Road*

Red: with Feynman, June Turquoise: with Schwinger, summer Black: out to Calif
Green: trip east, Sept Magenta: visits Feynman, Oct Yellow: Bethe in NYC, Dec



Most-in-demand physics speaker

1949-1952

PHYSICAL REVIEW VOLUME 75, NUMBER 3 FEBRUARY 1, 1949

The Radiation Theories of Tomonaga, Schwinger, and Feynman

F. J. DYSON
Institute for Advanced Study, Princeton, New Jersey
(Received October 6, 1948)

A unified development of the subject of quantum electrodynamics is outlined, embodying the main features both of the Tomonaga-Schwinger and of the Feynman radiation theory. The theory is carried to a point further than that reached by these authors, in the discussion of higher order radiative reactions and vacuum polarization phenomena. However, the theory of these higher order processes is a program rather than a definitive theory, since no general proof of the convergence of these effects is attempted.

The chief results obtained are (a) a demonstration of the equivalence of the Feynman and Schwinger theories, and (b) a considerable simplification of the procedure involved in applying the Schwinger theory to particular problems, the simplification being the greater the more complicated the problem.

I. INTRODUCTION

As a result of the recent and independent discoveries of Tomonaga,[1] Schwinger,[2] and Feynman,[3] the subject of quantum electrodynamics has made two very notable advances. On the one hand, both the foundations and the applications of the theory have been simplified by being presented in a completely relativistic way; on the other, the divergence difficulties have been at least partially overcome. In the reports so far published, emphasis has naturally been placed on the second of these advances; the magnitude of the first has been somewhat obscured by the fact that the new methods have been applied to problems which were beyond the range of the older theories, so that the simplicity of the methods was hidden by the complexity of the problems. Furthermore, the theory of Feynman differs so profoundly in its formulation from that of Tomonaga and Schwinger, and so little of it has been published, that its particular advantages have not hitherto been available to users of the other formulations. The advantages of the Feynman theory are simplicity and ease of application, while those of Tomonaga-Schwinger are generality and theoretical completeness.

The present paper aims to show how the Schwinger theory can be applied to specific problems in such a way as to incorporate the ideas of Feynman. To make the paper reasonably self-contained it is necessary to outline the foundations of the theory, following the method of Tomonaga; but this paper is not intended as a substitute for the complete account of the theory shortly to be published by Schwinger. Here the emphasis will be on the application of the theory, and the major theoretical problems of gauge-invariance and of the divergencies will not be considered in detail. The main results of the paper will be general formulas from which the radiative reactions on the motions of electrons can be calculated, treating the radiation interaction as a small perturbation, to any desired order of approximation. These formulas will be expressed in Schwinger's notation, but are in substance identical with results given previously by Feynman. The contribution of the present paper is thus intended to be twofold: first, to simplify the Schwinger theory for the benefit of those using it for calculations, and second, to demonstrate the equivalence of the various theories within their common domain of applicability.*

[1] Sin-itiro Tomonaga, Prog. Theoret. Phys. **1**, 27 (1946); Koba, Tati, and Tomonaga, Prog. Theoret. Phys. **2**, 101 198 (1947); S. Kanesawa and S. Tomonaga, Prog. Theoret. Phys. **3**, 1, 101 (1948); S. Tomonaga, Phys. Rev. **74**, 224 (1948).

[2] Julian Schwinger, Phys. Rev. **73**, 416 (1948); Phys. Rev. **74**, 1439 (1948). Several papers, giving a complete exposition of the theory, are in course of publication.

[3] R. P. Feynman, Rev. Mod. Phys. **20**, 367 (1948); Phys. Rev. **74**, 939, 1430 (1948); J. A. Wheeler and R. P. Feynman, Rev. Mod. Phys. **17**, 157 (1945). These articles describe early stages in the development of Feynman's theory, little of which is yet published.

* After this paper was written, the author was shown a letter, published in Progress of Theoretical Physics **3**, 205 (1948) by Z. Koba and G. Takeda. The letter is dated May 22, 1948, and briefly describes a method of treatment of radiative problems, similar to the method of this paper.

- Job offers
- Feynman-Dyson graphs

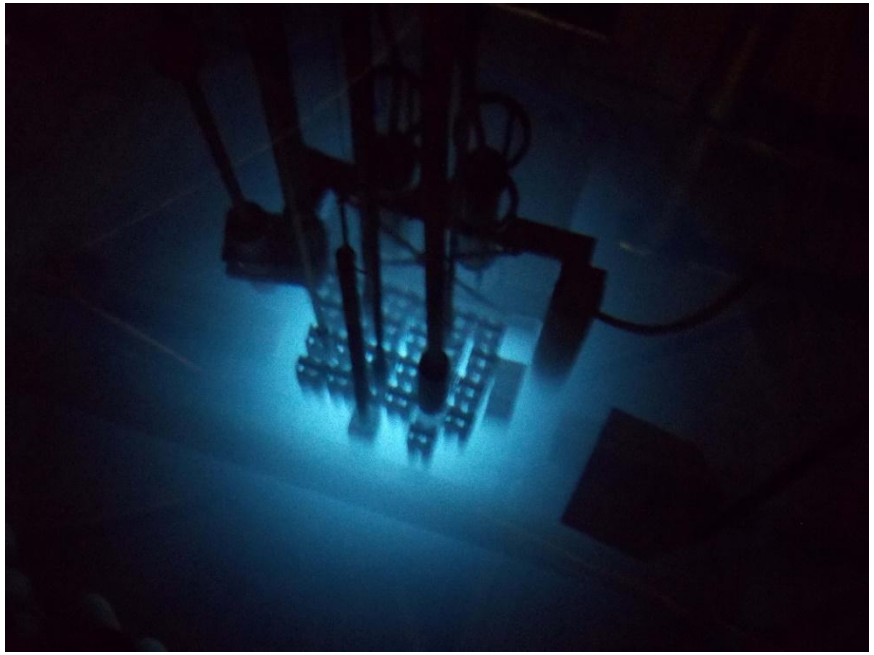
The story so far

- Cambridge 1941-1943
- Bomber Command, 1943-1945
- London: math vs physics 1945/46
- Cambridge 1946/47
- Cornell 1947/48
- Institute Adv Study 1948/49
- Birmingham 1949-51, no PhD
- Zurich with Pauli, summer 1951
- Fails to prove QED convergence

- Cornell 1951-1953
- Fails to apply QED to strong force
- Institute for Advanced Study 1953-
- Starts writing for magazines
- Summer 1953, Berkeley, solid state

Engineering

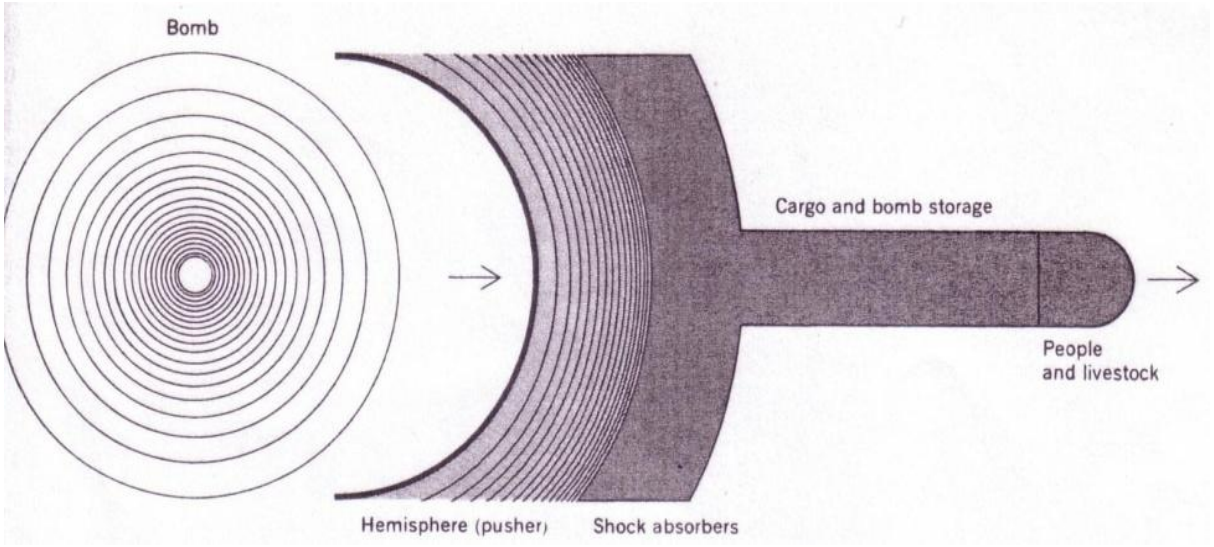
1956



- Dyson-Teller at General Atomic
- Intrinsically safe
- TRIGA: best-selling design; the first reactor in Africa;

Nuclear powered rocketship
PROJECT ORION 1958-59

Orion vs. NASA



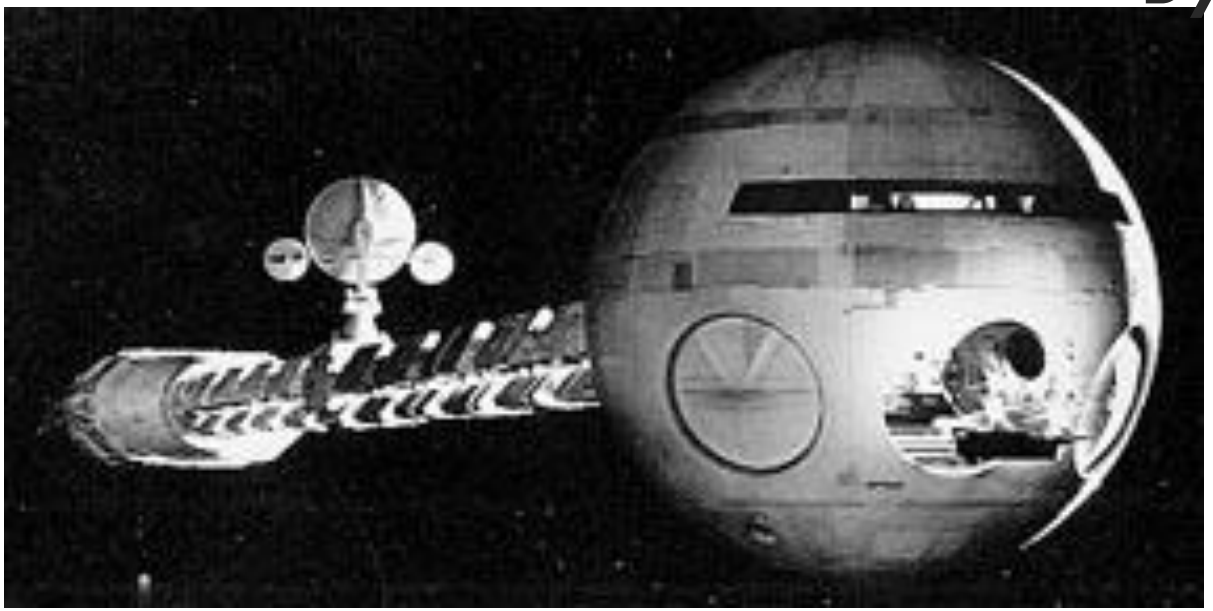
- "Our purpose, and our belief, is that the bombs which killed and maimed at Hiroshima and Nagasaki shall one day open the skies to men." *Spacetraveler's Manifesto*

“Saturn by 1970”

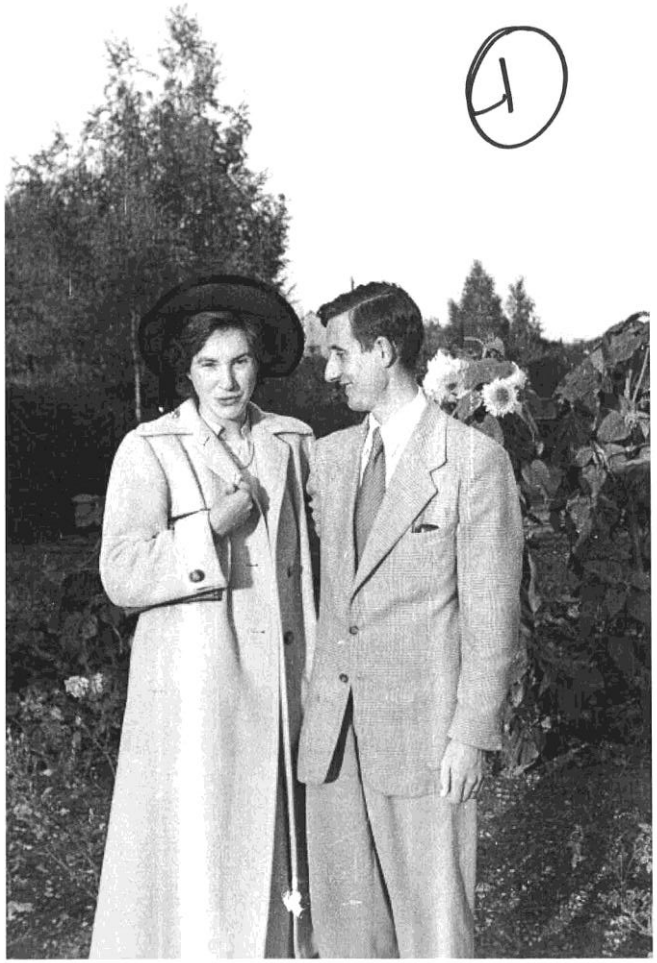
1966

- **Orion was the propulsion design for Stanley Kubrick’s *Space Odyssey* ship**

- **Dyson does screen test**



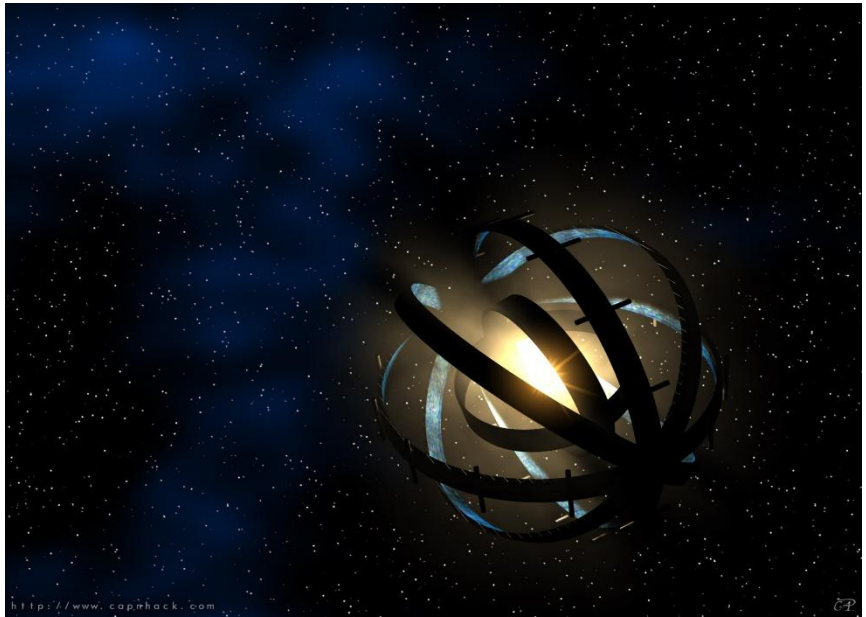
Family Man



Six Children, Sixteen Grandchildren

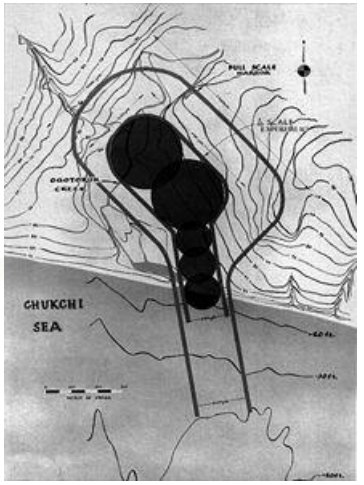
Search for extraterrestrial intelligence

1959: Dyson spheres



Limited Test Ban Treaty

Arms Control and Disarmament Agency, 1962-63



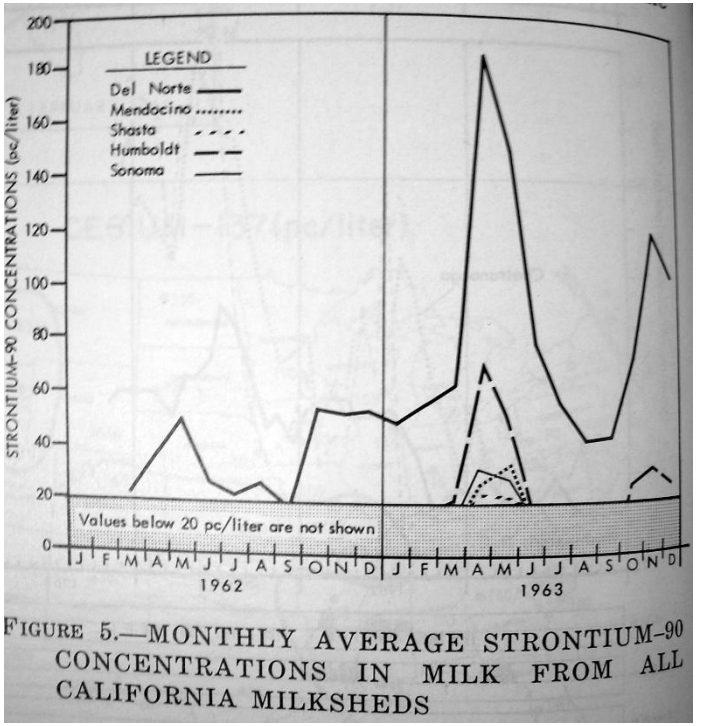
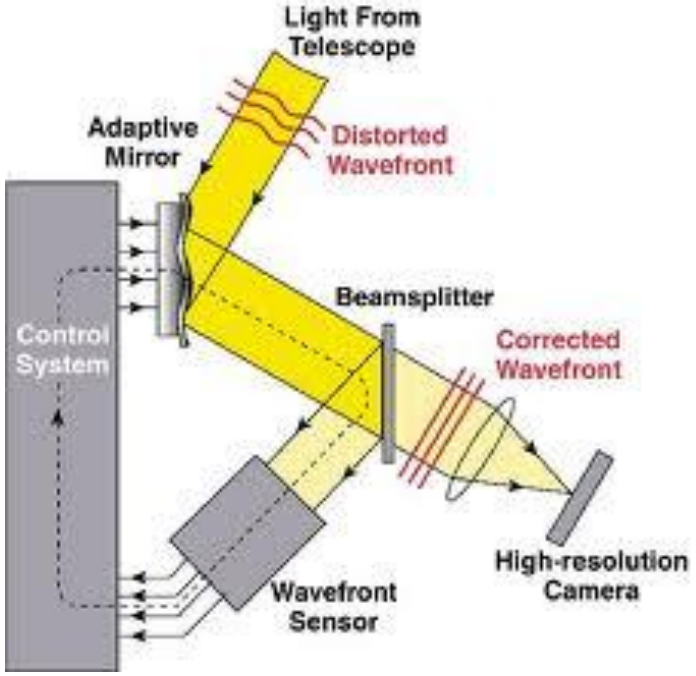


FIGURE 5.—MONTHLY AVERAGE STRONTIUM-90 CONCENTRATIONS IN MILK FROM ALL CALIFORNIA MILKSHEDS

Jason: “Throw in some Nukes”

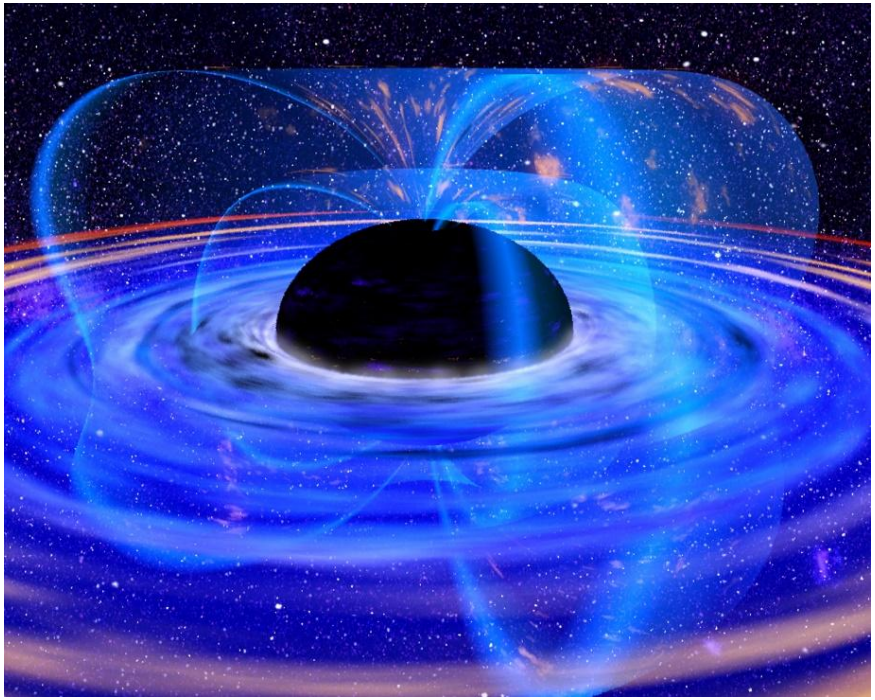
submarine noise; missile basing; stockpile stewardship; encryption, etc.

Nukes (1965) Adaptive Optics (c1972)



Never at rest

- Introduces field theory into condensed matter physics (mid 50’s)
- Random Matrices (1962)
- Proves stability of matter (1965/66)
- Fundamental constants (1967)
- Distant cosmological future (1979)



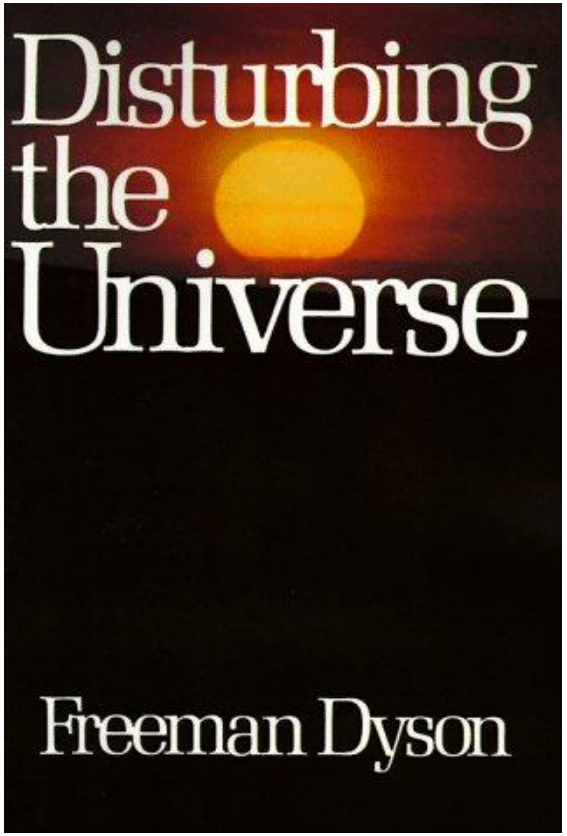
Life begins at 50

First book: 1975

THE NEW YORKER

SCIENTIFIC AMERICAN

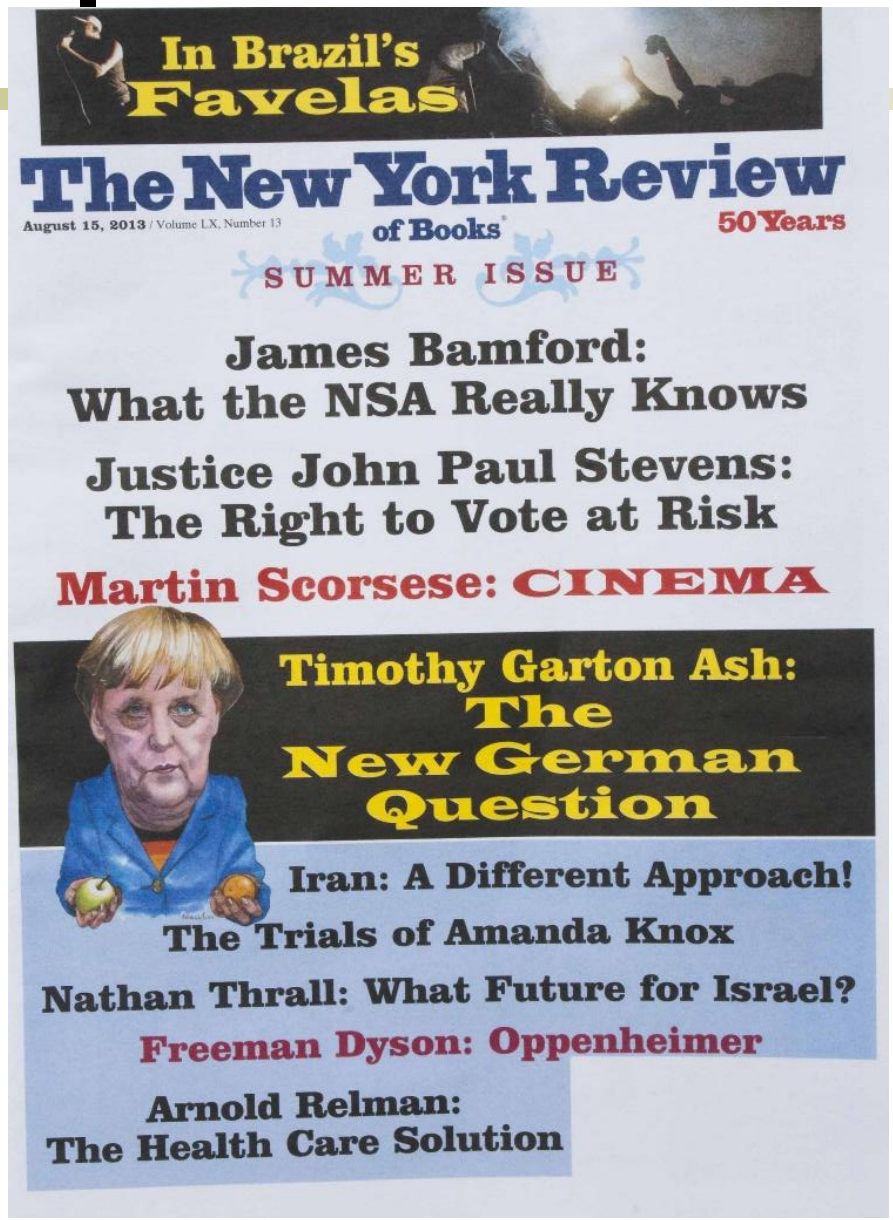
physics today



Dyson in Emerson mode:

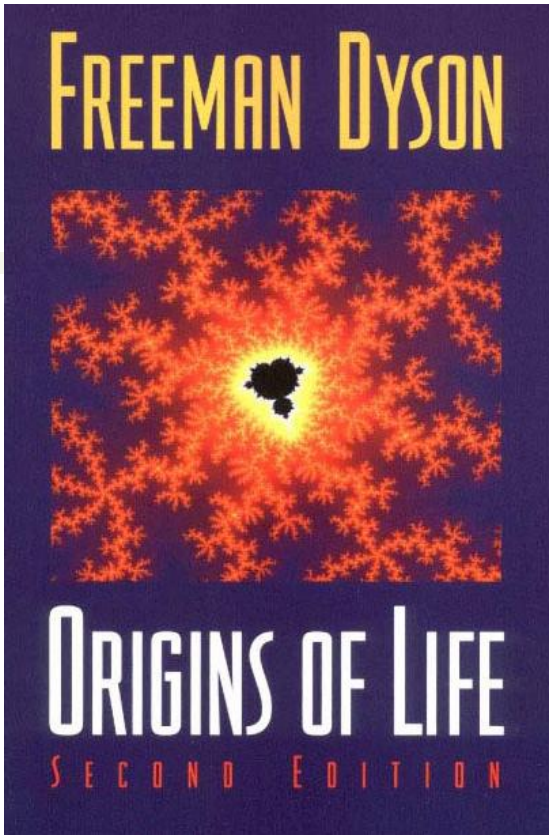
"My message is the unbounded prodigality of life and the consequent unboundedness of human destiny. As a working hypothesis to explain the riddle of our existence, I propose that our universe is the most interesting of all possible universes, and our fate as human beings is to make it so."

Freeman Dyson as Heretic



- Origin of life
- Nuclear weapons
- Science & religion
- Climate change
- Biotechnolgy
- Culture war
- Colonizing comets

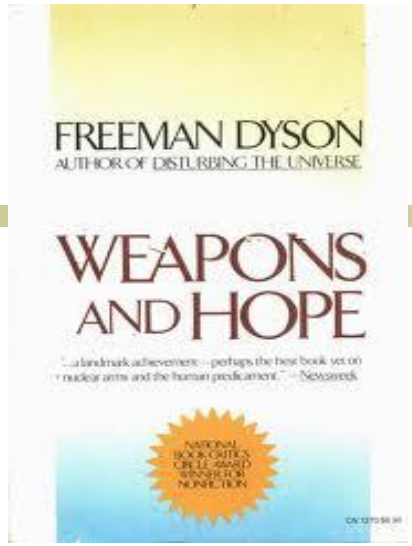
Dyson as Biologist

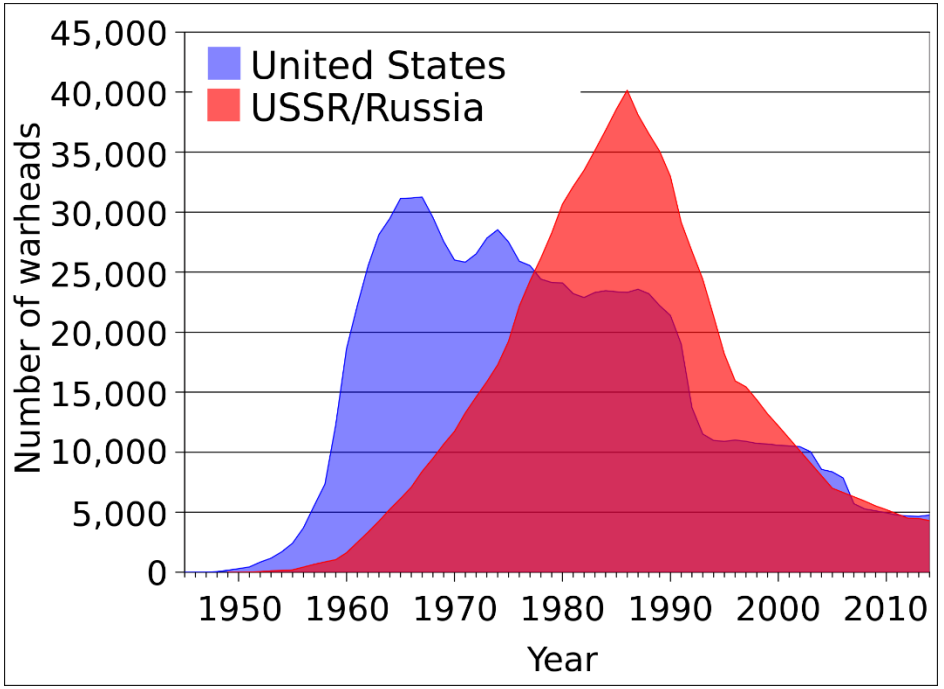


- **Pre-Darwin homeostasis: Early cells were mere bags of chemicals; reproduction was crude. Replicators (RNA) came later as invaders**
- **Post-Darwin age: culture trumps evolution**
- **Analog-vs-digital life: lengthy friendly argument with Lawrence Krauss over the indefinite survival of life in a cold universe**

Nuclear Slavery

No first use





Meta-science

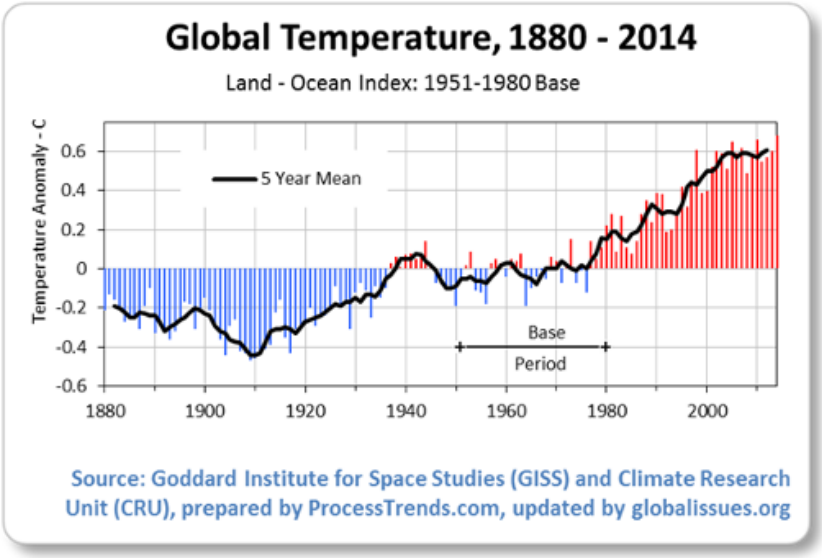
Scientific knowledge isn't the only knowledge

--View cosmos through many windows: science, art, religion

--"The central complexity of human nature lies in our emotions, not in our intelligence."

--Templeton Prize (2000)

terraforming the Earth



--Computer modeling isn't good enough (Dyson at Oak Ridge 1970s)

--Beneficial changes: wetter Sahara, warmer Siberia, greener England.

--Use the money to address hunger, pollution, poverty, war, illiteracy

"China and India getting rich is the most important thing that's going on in the world at present."

Culture War?

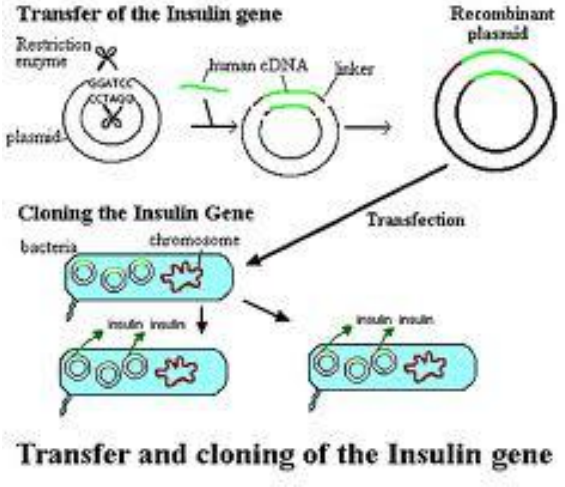
"Naturalists believe that nature knows best…anything we do to improve upon Nature will only bring trouble."

"The humanist ethic begins with the belief that humans are an essential part of nature… Through human minds the biosphere has acquired the capacity to steer its own evolution."

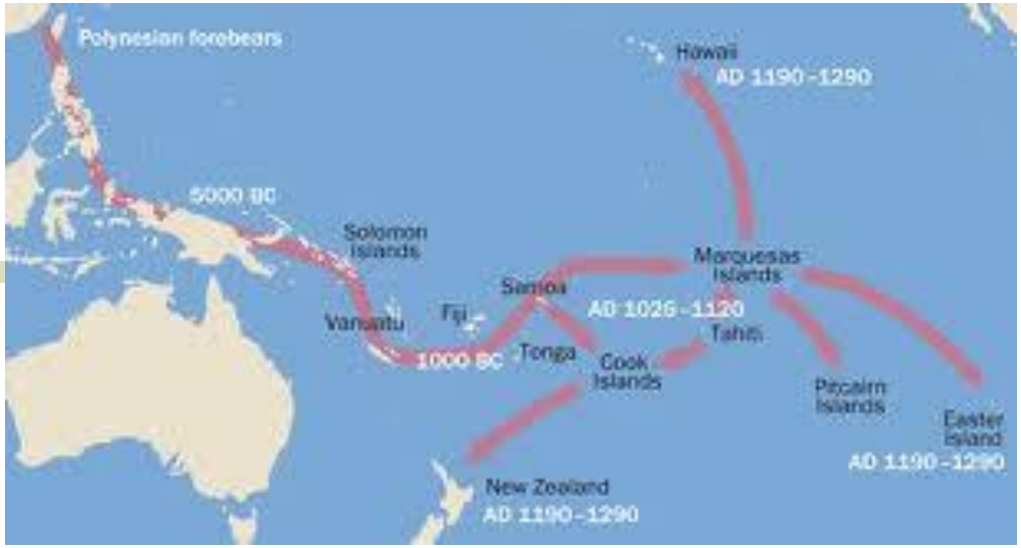
Genetically modify food?

humans?

Biotech games for children: "The winner could be the kid whose seed grows the prickliest cactus, or the kid whose egg hatches the cutest dinosaur. These games will be messy and possibly dangerous"

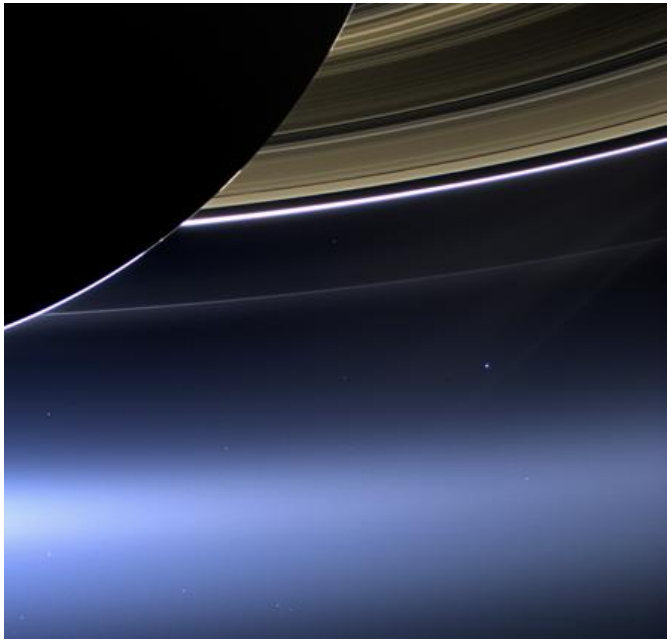


Transfer and cloning of the Insulin gene

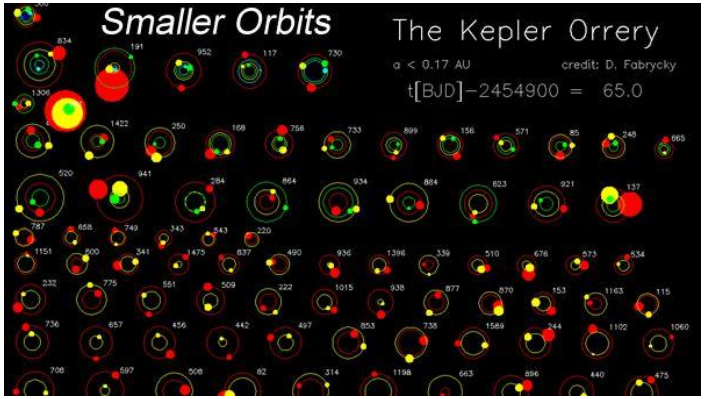


- **"In the end we must travel the high road into space, to find new worlds to match our new capabilities. To give us room to explore the varieties of mind and body which our genomes can evolve, one planet is not enough."**

- First adapt Earth to human needs. Then adapt humans to space conditions---low pressure, temp, gravity



Very-Long-Term thinking



- In the short run: space flight is a joke
- Medium run: Dispatch "Cosmic eggs," grow Dyson Trees (silicon leaves)
- Long run: an Orion craft can reach Alpha Centauri in 150 years. Venter: beam back genomes. (1%c speed: cross the galaxy in 10 million years.)

Return of the Neanderthals

- **“When desires for different ways of living can be translated into reality, the diversity of desires will be translated into a diversity of species.”**

To boldly go…

Key Dyson Writings

- **QED: first papers, PR 75, 486, 1736 (1949).**
- **QED non-convergence, PR 85, 631 (52).**
- **1st popular writing, Physics Today, Sep 52.**
- **Field theory in condensed matter physics, PR 102, 1217, 1230 (56).**
- **Statistical mechanics of energy levels, random matrices, J. Math Phys 3, 140, 157, 166 (62).**
- **Fundamental constants: proton charge, PRL 19, 1291 (67).**
- **Stability of matter, J. Math Physics 8, 423 (67); 9, 698 (68).**
- **SETI, "Dyson spheres," Sci 131, 1667 (60).**
- **Bomb shelters, Bulletin American Sci, Mar 62; Science editorial, 23 Mar 62.**
- **Test ban treaty. Against: Foreign Affairs, Apr 60. For: Senate testimony, Aug 63.**
- **TRIGA reactor patent #3,127,325 (Taylor and Dyson) 1956; *Disturbing the Universe*, 1979.**
- **Orion. General Atomic rep GA-848, 13 July 59; Sci 149, 141 (1965); Physics Today, Oct 1968.**
- **All top scientific papers reprinted in *Selected Papers of Freeman Dyson*, 1996.**
- **Adaptive optics, J Optical Soc Am, 65, 551 (75).**
- **Tactical nukes in Vietnam. Jason report 1966; title declassified 1971; Dyson responds, Physics Today, Apr 1973; report declassified 2002.**
- **Late-phase cosmology, RMP, 51, 447 (79).**
- **Non-proliferation, cold war, Bomber Command, *Weapons and Hope*, 1984.**
- **Origin of life, protein-first model, J. Molecular Evolution 18, 344 (82); *Origins of Life*, 1985.**
- **Climate. Madrid lecture 1974; Energy 2, 287 (77); Bull Atomic Sci, June 75; NYRB, 3 May 2003, 12 June 2008; *From Eros to Gaia*, 1992.**
- **Religion & science: Gifford Lectures,1985; *Infinite in All Directions*, 1988; NYRB 10 Apr 1997, 28 May 1998, 22 June 2006.**
- **Biotech. Congressional testimony, 5 May 1977; NYRB, 13 Feb 2003; 19 July 2007; *Scientist as Rebel*, 2006; *The Sun, the Genome, the Internet*, 1999.**
- **Humans and the cosmos. Bull Atomic Sci, Sep 69; Bernal lect, 1972 (*Rebel*); Atlantic, Nov 1977; Scientific Am, Sep 1977; *Imagined Worlds*, 1997; *A Many Colored Glass*, 2007.**