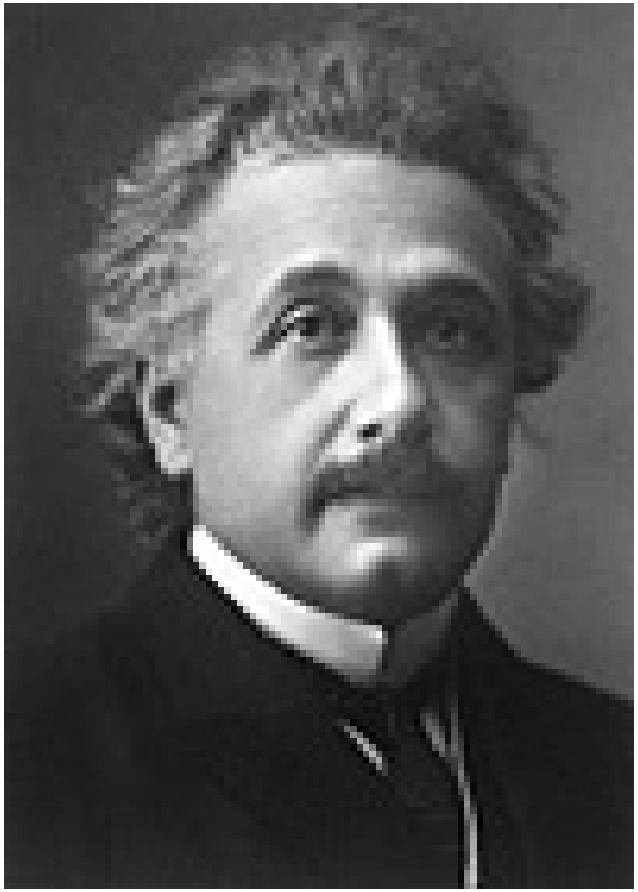


Hiroshima, Japan,
shortly after
August 6, 1945

ON THE ELECTRODYNAMICS OF
MOVING BODIES

BY

A. EINSTEIN

Translated from "Zur Elektrodynamik bewegter Körper," Annalen der Physik, 17, 1905.

Cracks in the Foundations of Science

Albert Michelson at Chicago University
Photo: University of Chicago

$$c = \frac{1}{\sqrt{\mu\varepsilon}} \quad \text{(speed of light)}$$

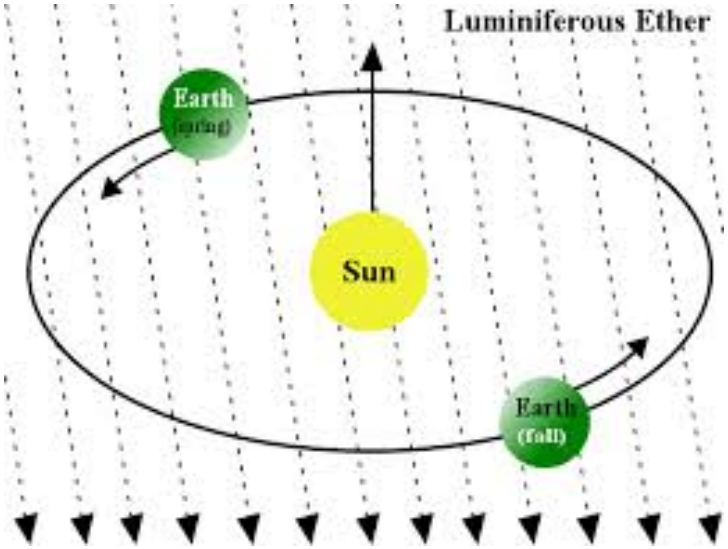
In Free Space (Vacuum):

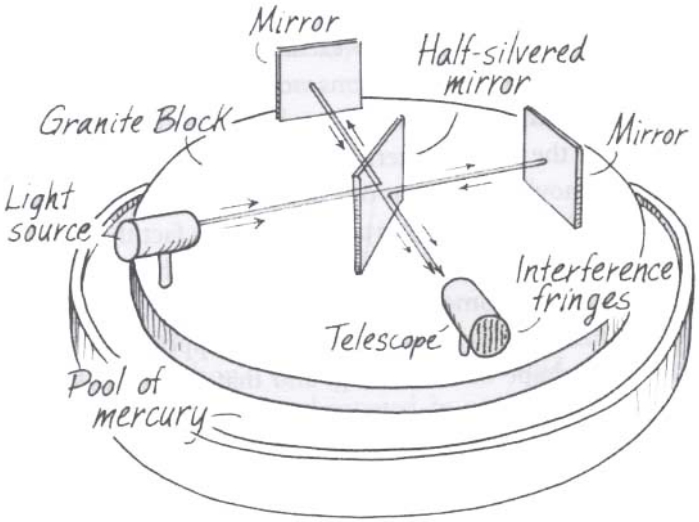
$\mu_0 = 4\pi \cdot 10^{-7}$ [H/m]

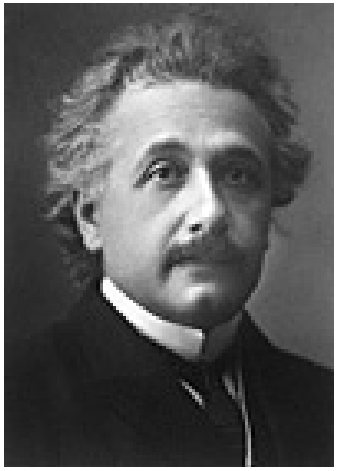
$\varepsilon_0 = 8.854 \cdot 10^{-12}$ [F/m]

$$c_0 = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = 299{,}795{,}638 \text{ [m/s]}$$

Edward Morley
Photo: Case Western Reserve Archives







ON THE ELECTRODYNAMICS OF MOVING BODIES

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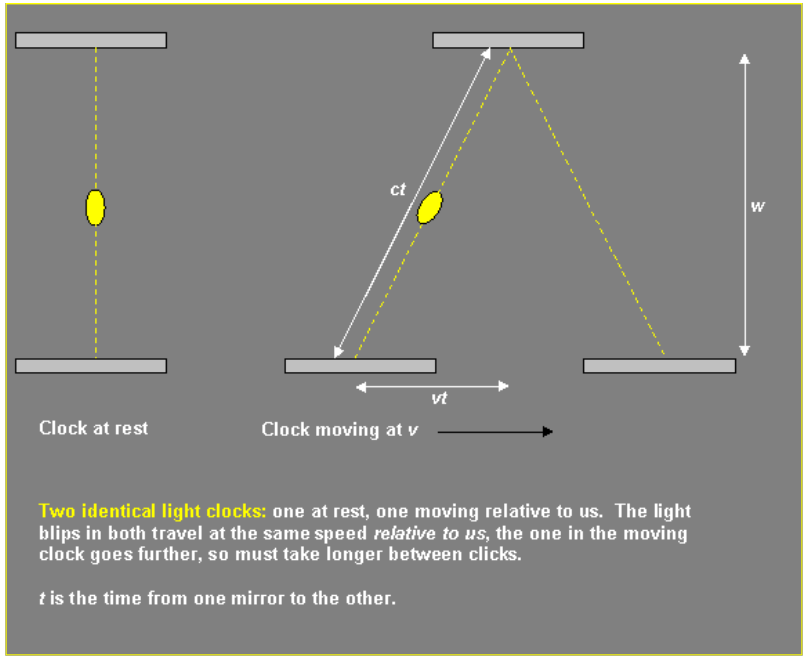
A. EINSTEIN

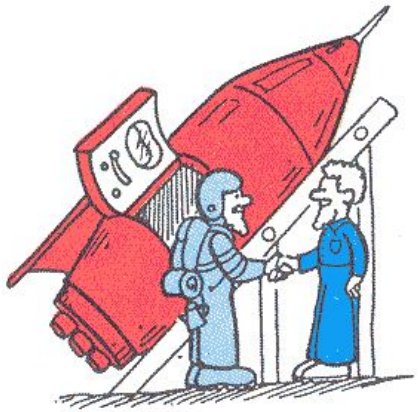
Translated from "Zur Elektrodynamik bewegter Körper," Annalen der Physik, 17, 1905.

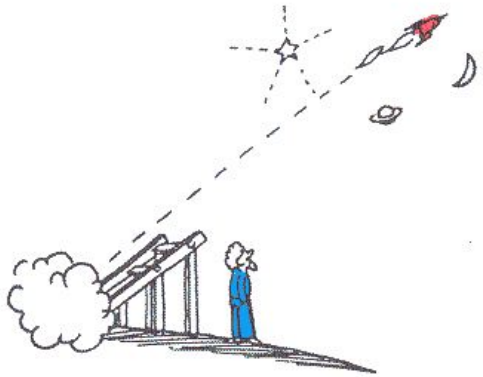
… the same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good. We will raise this conjecture (the purport of which will hereafter be called the "Principle of Relativity") to the status of a postulate, and also introduce another postulate, which is only apparently irreconcilable with the former, namely, that light is always propagated in empty space with a definite velocity **c** which is independent of the state of motion of the emitting body.

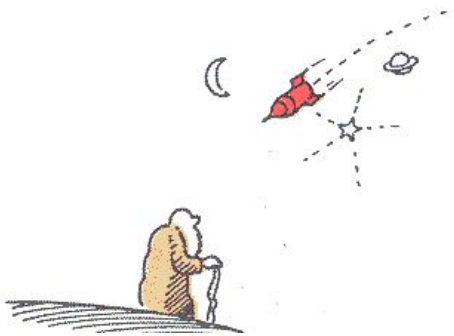
…… These two postulates suffice for the attainment of a simple and consistent theory of the electrodynamics of moving bodies based on Maxwell's theory for stationary bodies. The introduction of a "luminiferous ether" will prove to be superfluous

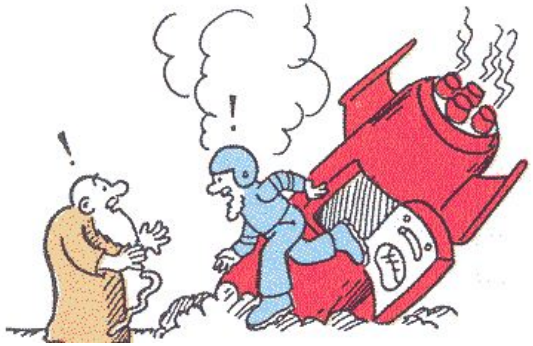
Time Dilation: Einstein's Light Clock

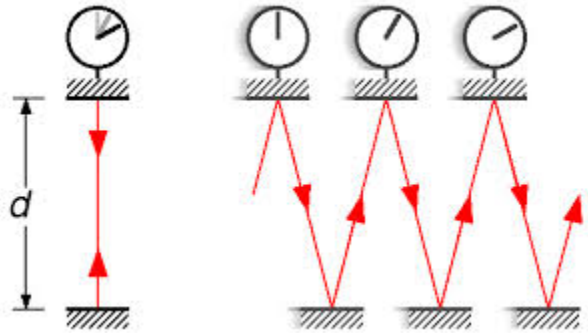




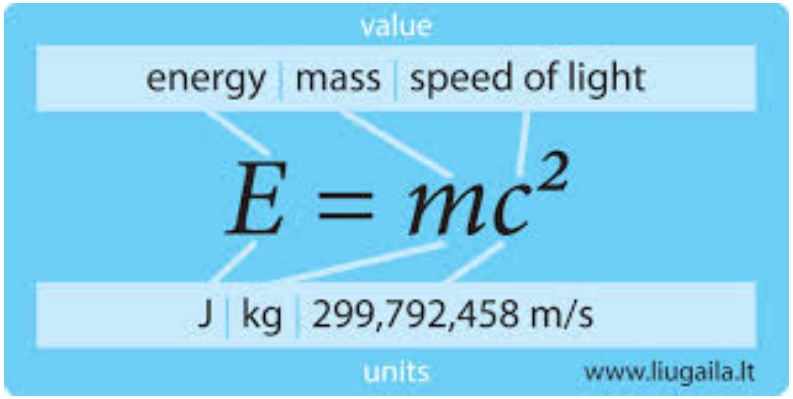








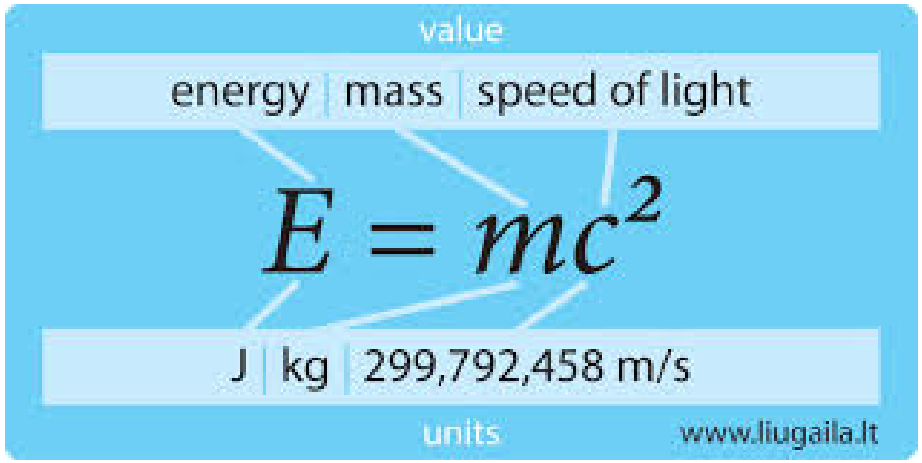
Mass Energy Equivalence

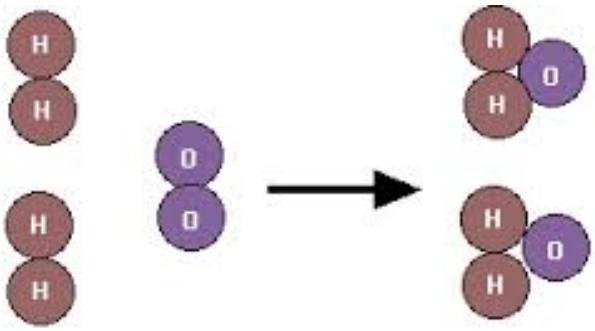


"Does the Inertia of a Body Depend Upon Its Energy Content?", A. E. Einstein, *Annalen der Physik* , November 21, 1905

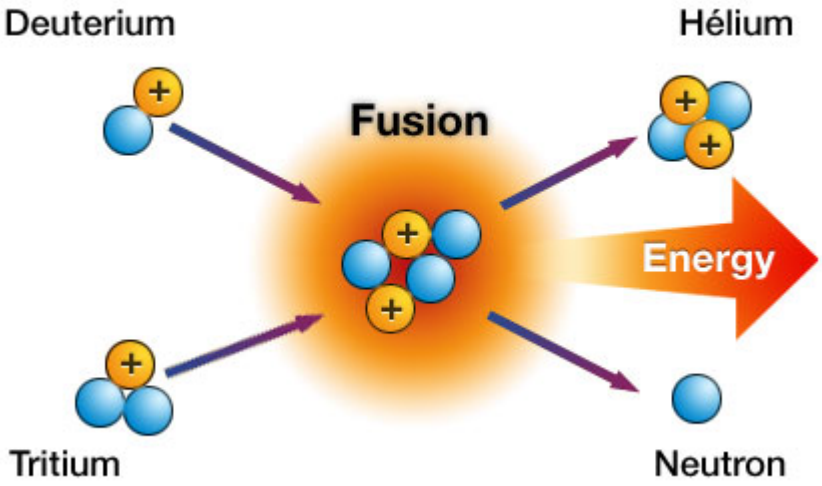
"…..The mass of a body is a measure of its energy-content; if the energy changes by L, the mass changes in the same sense by $[L/c^2]$ $L/9 \times 10^{20}$, the energy being measured in ergs, and the mass in grams."

$E=mc^2$ and Exo/Endothermic Reactions



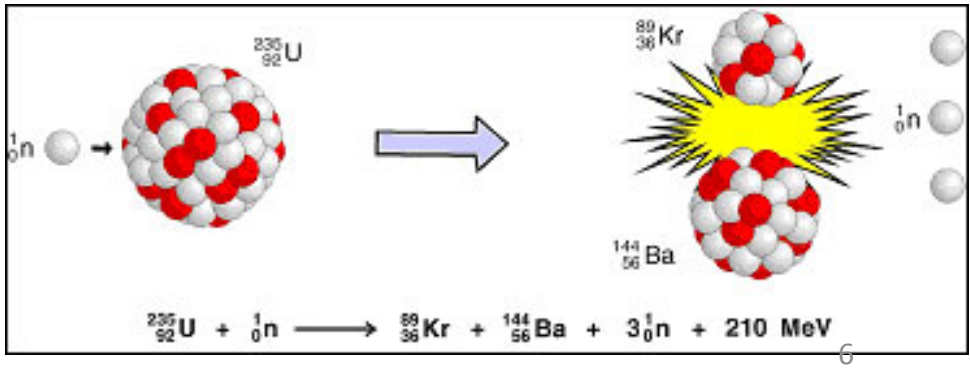


$2H_2 + O_2 \longrightarrow 2H_2O$ + energy



$2C_8H_{18} + 25O_2 \rightarrow 18H_20 + 16CO_2 +$ energy

(octane + oxygen → water + carbon dioxide + energy)



$E=mc^2$ is does not explain nuclear bonding or reactions that release the energy, anymore than it explains chemical bonds and reactions.

This brief paper of September 1905 ends with the remark that bodies 'whose energy content is variable to a high degree, for example, radium salts,' may perhaps be used to test this prediction. But Einstein was not quite sure. In the fall of 1905 he wrote to Habicht, 'The line of thought is amusing and fascinating, but

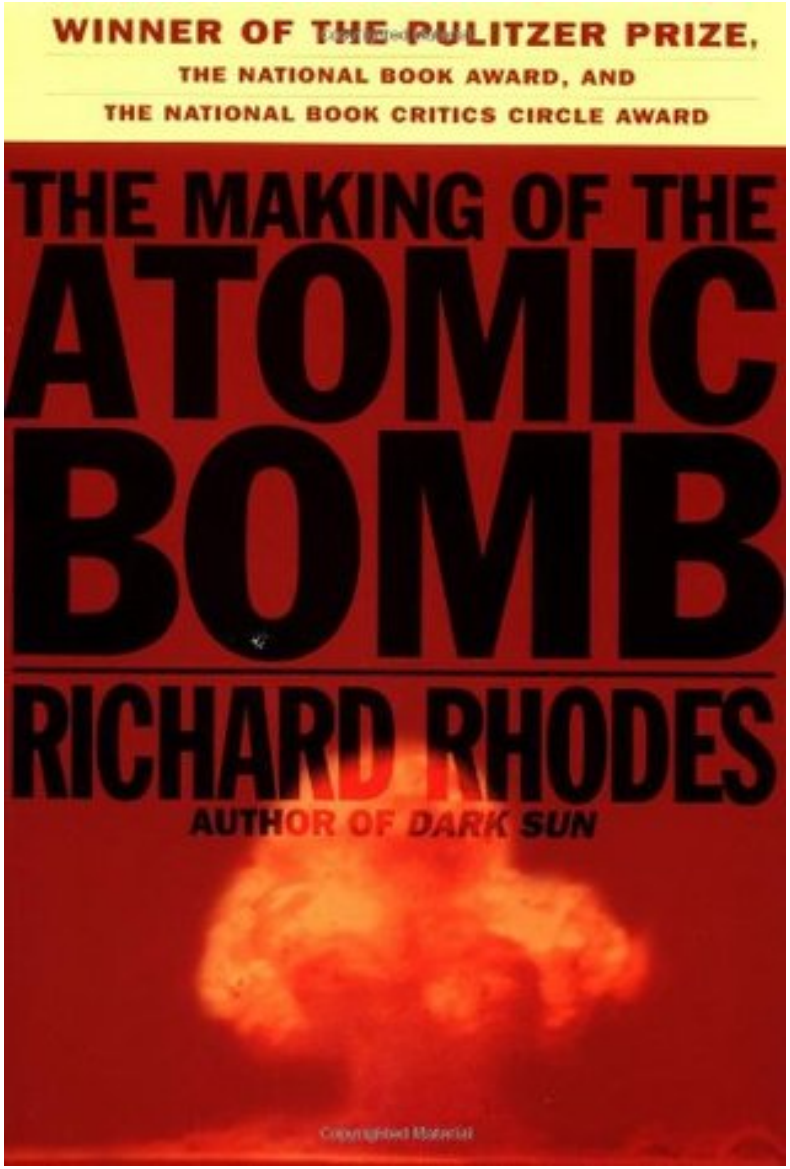
I cannot know whether the dear Lord doesn't laugh about this and has played a trick on me' (. . . mich an der Nase herumgeführt hat) [E14]. In his 1907 review he considered it 'of course out of the question' to reach the experimental precision necessary for using radium as a test [E15]. In another review, written in 1910, he remarked that 'for the moment there is no hope whatsoever' for the experimental verification of the mass–energy equivalence [E16].

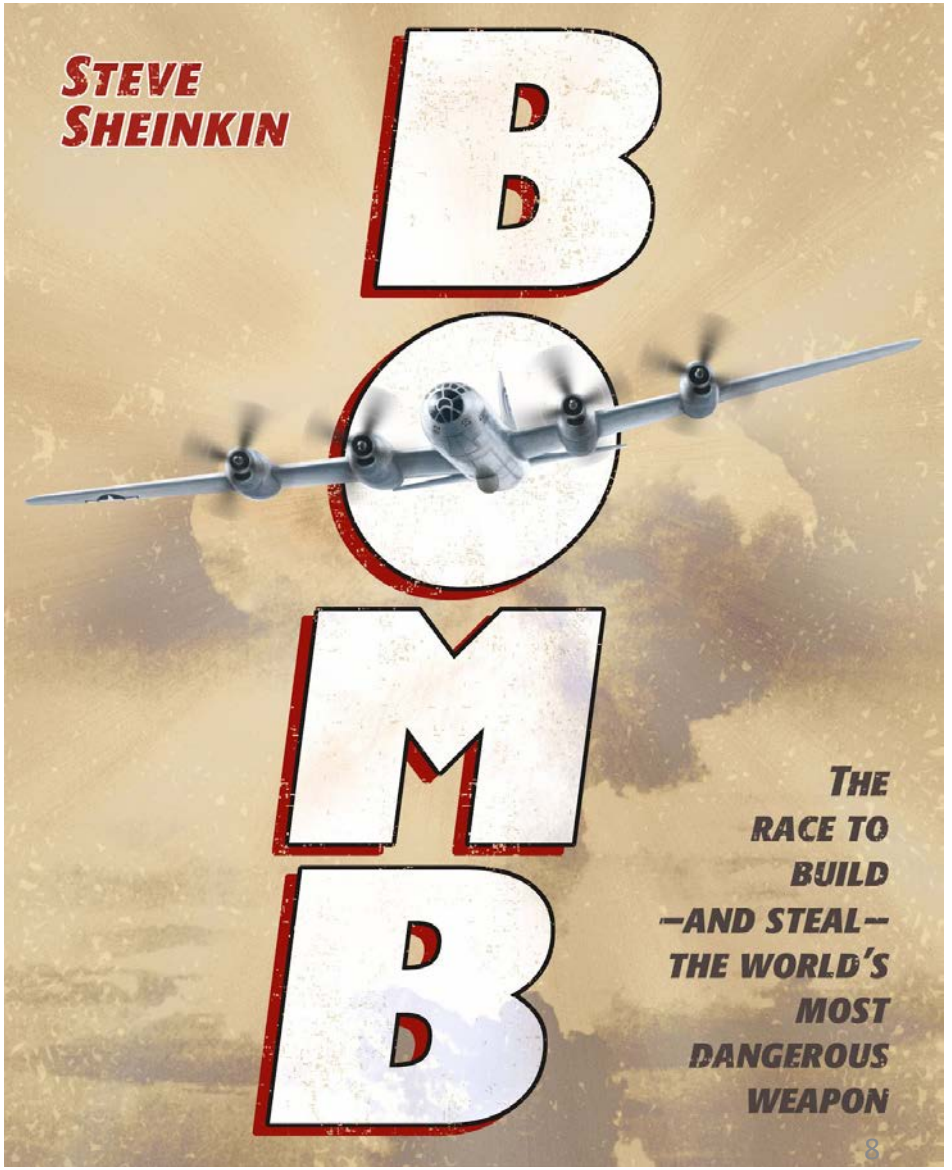
In all these instances, Einstein had in mind the loss of weight resulting from radioactive transformations. The first to remark that the energy–mass relation bears on binding energy was Planck. In 1907 he estimated the mass equivalent of the molecular binding energy for a mole of water [P6]. This amount (about 10^{-8} g) was of course too small to be observed—but at least it could be calculated. A quarter of a century had to pass before a similar estimate could be made for nuclear binding energy. Even that question did not exist until 1911, the year the nuclear model of the atom was published. Two years later, Paul Langevin had an idea: 'It seems to me that the inertial mass of the internal energy [of nuclei] is evidenced by the existence of certain deviations from the law of Prout' [L3]. That was also the year in which J. J. Thomson achieved the first isotope separation. Langevin's interesting thought did not take account of the influence of isotopic mixing and therefore overrated nuclear binding effects. Next came the confusion that the nucleus was supposed to consist of protons and electrons—no one had the right constituents yet. Still, Pauli was correct in surmising—we are now in 1921—that 'perhaps the law of the inertia of energy will be tested *at some future time* [my italics] by observations on the stability of nuclei' [P7]. In 1930 it was written in the bible of nuclear physics of the day that one can deduce from the binding energy of the alpha particle that a free proton weighs 6.7 MeV more than a proton bound in a helium nucleus [R2]. What else could one say in terms of a proton–electron model of the nucleus?

Nuclear binding energy and its relation to $E = mc^2$ came into its own in the 1930s. In 1937 it was possible to calculate the velocity of light from nuclear reactions in which the masses of the initial and final products and also the energy release in the reaction were known. The resulting value for c was accurate to within less than one half of one per cent [B4]. When in 1939 Einstein sent his well-known letter to President Roosevelt, it is just barely imaginable that he might have recalled what he wrote in 1907: 'It is possible that radioactive processes may become known in which a considerably larger percentage of the mass of the initial atom is converted into radiations of various kinds than is the case for radium' [E15].

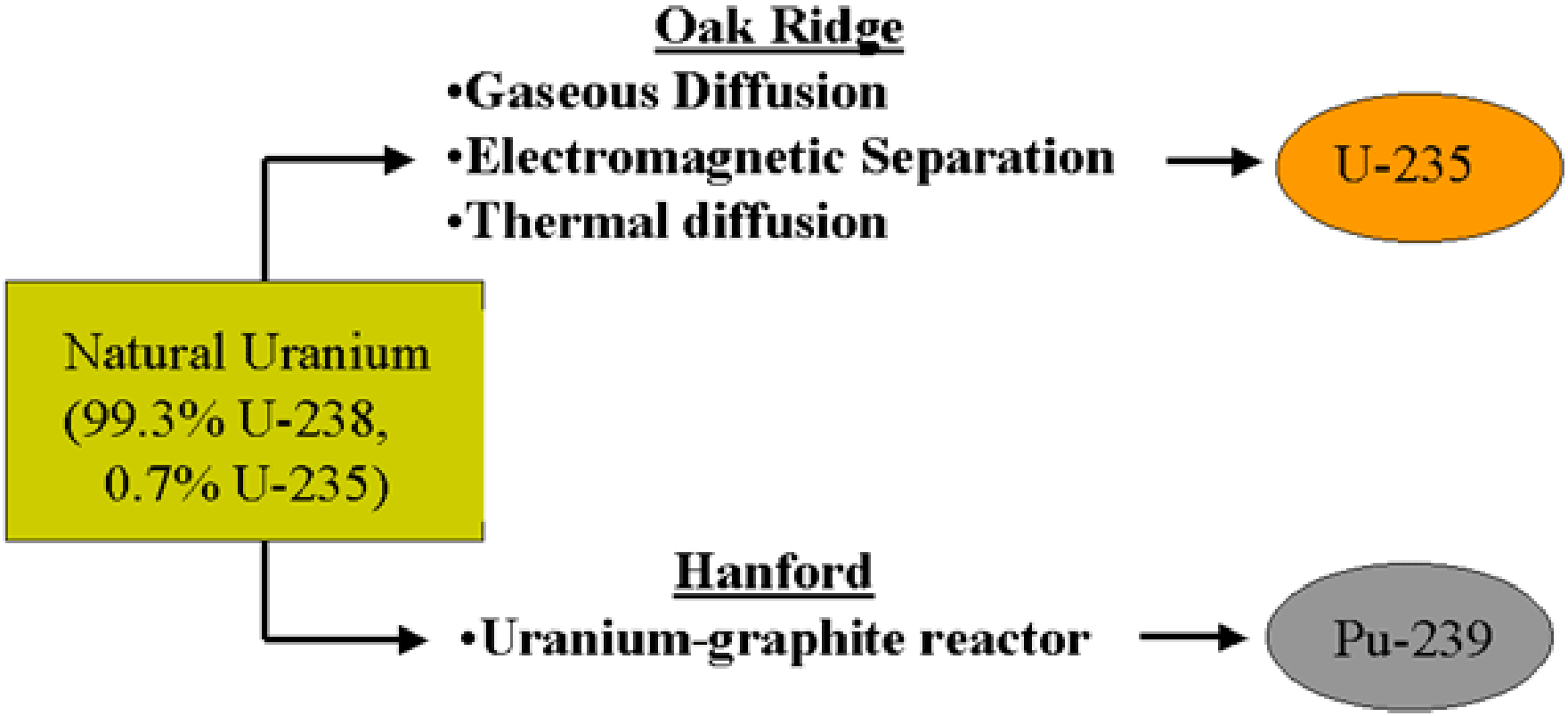
"Subtle is the Lord. The Science and Life of Albert Einstein," by Abraham Pais, p. 148.

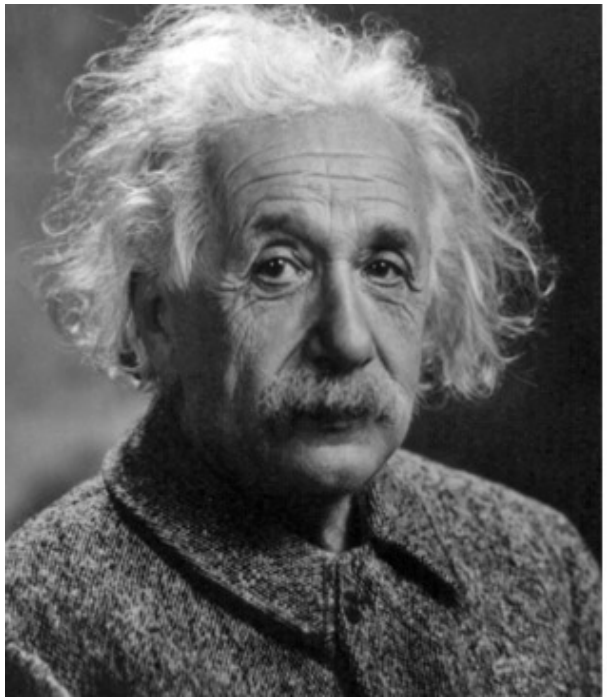
The Making of the Atomic Bomb

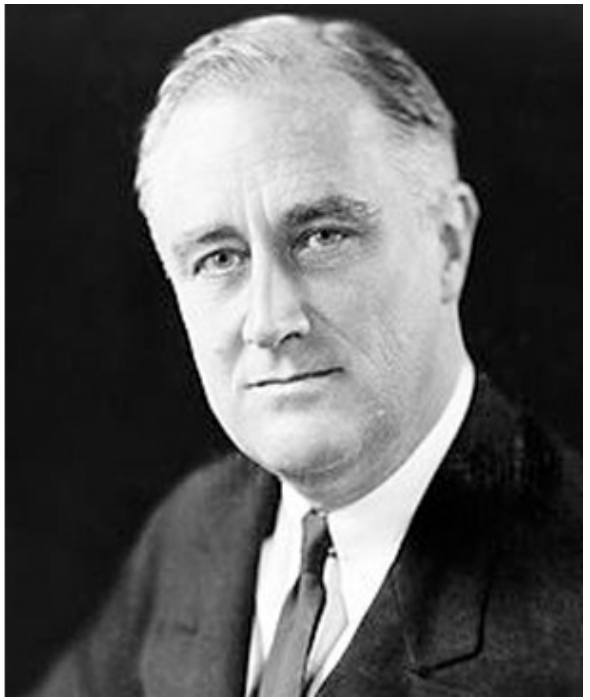




Routes to Fissionable Materials Used by U. S.







Albert Einstein
Old Grove Rd.
Nassau Point
Peconic, Long Island

August 2nd, 1939

F.D. Roosevelt,
President of the United States,
White House
Washington, D.C.

Sir:

Some recent work by E.Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem

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Sir:

Some recent work by E.Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendations:

In the course of the last four months it has been made probable - through the work of Joliot in France as well as Fermi and Szilard in America - that it may become possible to set up a nuclear chain reaction in a large mass of uranium,by which vast amounts of power and large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable - though much less certain - that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.

The United States has only very poor ores of uranium in moderate quantities. There is some good ore in Canada and the former Czechoslovakia, while the most important source of uranium is Belgian Congo.

In view of this situation you may think it desirable to have some permanent contact maintained between the Administration and the group of physicists working on chain reactions in America. One possible way of achieving this might be for you to entrust with this task a person who has your confidence and who could perhaps serve in an unofficial capacity. His task might comprise the following:

a) to approach Government Departments, keep them informed of the further development, and put forward recommendations for Government action, giving particular attention to the problem of securing a supply of uranium ore for the United States;

b) to speed up the experimental work, which is at present being carried on within the limits of the budgets of University laboratories, by providing funds, if such funds be required, through his contacts with private persons who are willing to make contributions for this cause, and perhaps also by obtaining the co-operation of industrial laboratories which have the necessary equipment.

I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German Under-Secretary of State, von Weizsäcker, is attached to the Kaiser-Wilhelm-Institut in Berlin where some of the American work on uranium is now being repeated.

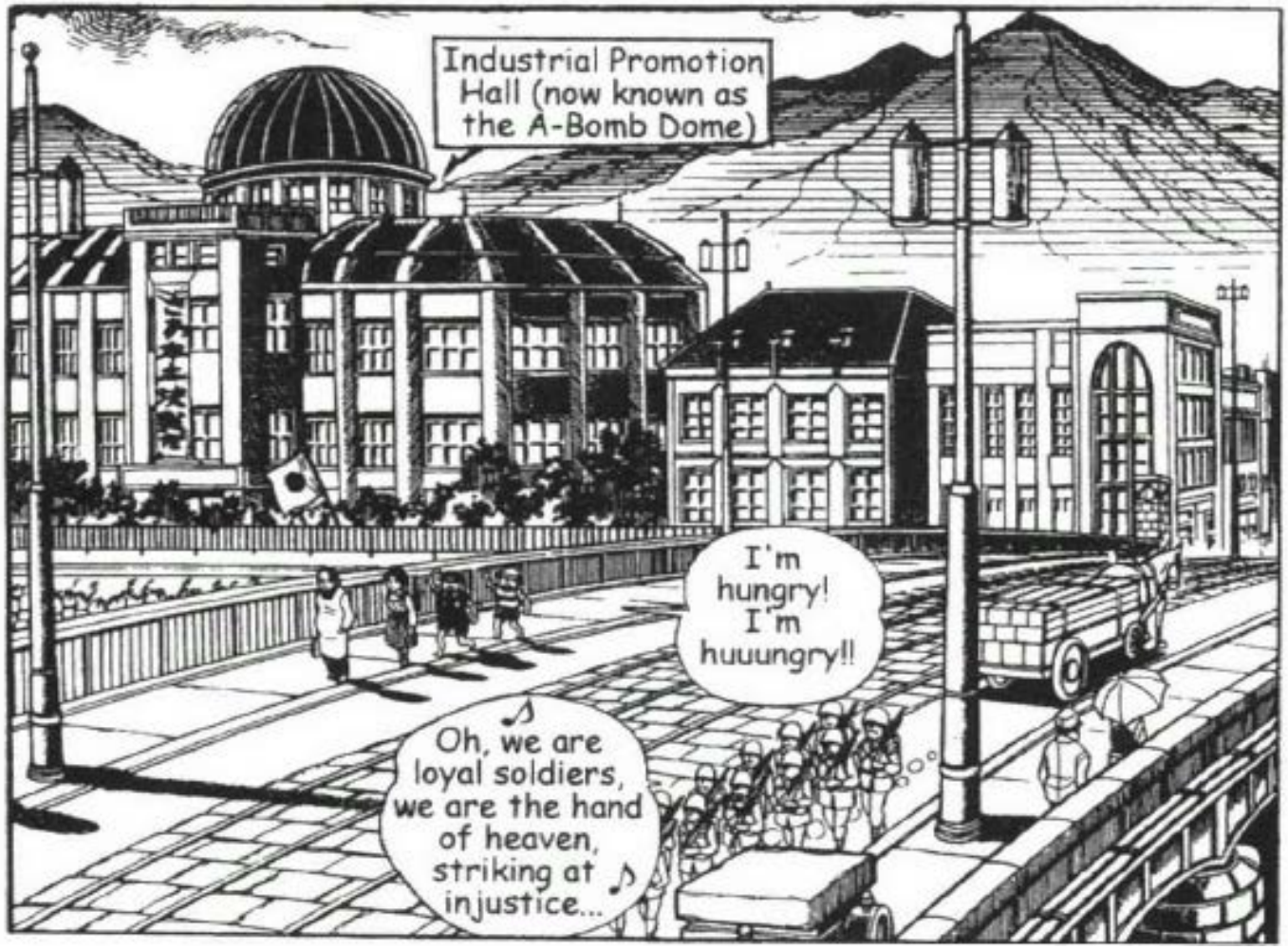
Yours very truly,

(Albert Einstein)

Barefoot Gen, Japan, and I: The Hiroshima Legacy: An Interview with Nakazawa Keiji

Asai Motofumi
Translated by Richard H. Minear

In August 2007 I asked Nakazawa Keiji, manga *artist and author of* Barefoot Gen, *for an interview. On August 6, 1945, Nakazawa experienced the atomic bombing as a first grader. In 1968, he published his first work on the atomic bombing* -- Hit by Black Rain -- *and since then, he has appealed to the public with many works on the atomic bombing. His masterpiece is* Barefoot Gen, *which can be said to present Nakazawa's alter ego. His works from* Barefoot Gen *on convey much bitter anger and sharp criticism toward a postwar Japanese politics that has never sought to affix responsibility on those who carried out the dropping of the atomic bomb and the aggressive war (the U.S. that dropped the atomic bomb, and the emperor and Japan's wartime leaders who prosecuted the reckless war that incurred the dropping of the atomic bomb).*


Industrial Promotion Hall (now known as the A-Bomb Dome)
I'm hungry! I'm huuungry!!
♪ Oh, we are loyal soldiers, we are the hand of heaven, striking at injustice... ♪


43 SECONDS LATER, 1800 FEET OVER HIROSHIMA, THE ATOMIC BOMB NAMED "THIN BOY" EXPLODED WITH A WHITE-HOT LIGHT—
IT WAS AS IF A MILLION FLASHBULBS HAD GONE OFF AT ONCE...
FLASH

Hibakusha

The surviving victims of the atomic bombings of Hiroshima and Nagasaki are called ***hibakusha*** (被爆者), a Japanese word that literally translates as "explosion-affected people" and is used to refer to people who were exposed to radiation from the bombings.

Hibakusha and their children were (and still are) victims of severe discrimination due to public ignorance about the consequences of radiation sickness, with much of the public believing it to be hereditary or even contagious. (Wikipedia)

“…if someone says, "I'm a hibakusha," Tokyo people won't touch the tea bowl from which he's been drinking, because they'll catch radioactivity. They'll no longer get close to you. There are many ignorant people of that sort. When they told me this, for the first time, it clicked. "Ah, that's how it is." And I thought, never speak of the atomic bomb again! “ Nakazwa Keiji