“Prometheus stole fire and gave it to men. But when Zeus learned of it he ordered Hephaestus to nail his body to Mount Caucasus. On it Prometheus was nailed and kept bound for many years. Every day an eagle swooped on him and devoured the lobes of his liver, which grew by night.”

—- Apollodorus, The Library, 2nd Century BC

“When the stars threw down their spears,  
And watered heaven with their tears,  
Did he smile his work to see?  
Did he who made the Lamb make thee?”

—- William Blake

“Modern Prometheans have raided Mount Olympus again and have brought back for man the very thunderbolts of Zeus”

—- Scientific Monthly, September 1945

“It worked”

—- J. Robert Oppenheimer
“If there is intelligent extraterrestrial life watching us, they received an unambiguous ‘hand-wave’ from earth at 5:29 am (MST) on July 16, 1945.”
administrivia

• All slides will be available online; have Creative Commons license (i.e., can be freely shared) - dense slides since I’m not sure how well my audio stories come across on Zoom…

• Questions in Zoom chat (periodic breaks for Q&A) or via e-mail

• Happy to provide a reference list or bibliography

• Please give comments, content, and ideas!

• Please excuse name mispronunciations - also after awhile I tend to call characters by their first names - no disrespect intended
CAVEATS

• I am **not** a historian but have a long interest in the Manhattan Project

• My interest stems from:
  
  • Physics background - many of my scientific heroes and influences participated
  
  • Participation in underground nuclear testing at Nevada Test Site (in my early career)
  
  • Professional collaboration with Oak Ridge National Lab and Los Alamos National Lab
  
  • Political and ethical beliefs - social impacts, political decisions, “No Nukes”
COURSE GOALS

• To mix the history, the science, the personalities, the issues, the problems, the past and future impact into an interesting, compelling, and educational story

• To use the Manhattan Project as a way to describe scientific process

• To understand why the Manhattan Project team was so special and why so many of the participants did not need the project to assure their places in scientific history

• To explore the local (San Francisco Bay Area) connections/angles to the project

• To reflect on one of the most significant events of our generation and one that has proven to significantly impact the future of human civilization

• To have fun! (as much as Zoom allows)
THE PUBLIC IS STILL FASCINATED BY THE MANHATTAN PROJECT

PLUS MOVIES, TELEVISION, MUSIC, THEATER, OPERA, ETC.

WHY?
The Manhattan Project has become a trope for a massive, collaborative effort to accomplish a unified, unprecedented goal. (“Dream Team” and “Moonshot” have similar, more recent connotations)

Imagine an effort involving all American Nobel Prize in Medicine winners and leading medical researchers given unlimited resources to defeat Covid-19. Why not?
THE ROAD TO TRINITY - A PROLOGUE

Science, History, Politics, Intrigue, and Heartbreak
The 1930s were amazing times in nuclear physics

- Ernest Rutherford had already discovered the atomic nucleus which led to
  - Bohr model of the atom
  - Foundations of quantum mechanics
- Protons had been described - Henry Moseley and Antonius van den Broek had made the connection between atomic number, atomic weight, and the periodic table
- J.J. Thomson had already identified atomic isotopes
- The basic elements of natural radioactivity had been identified - alpha particles, beta particles, gamma rays
- It was understood how the radioactive decay of one element led to another element
- But no one was really certain about the building blocks of the nucleus…until…
PLEASE BEAR WITH ME FOR A SLIGHT DIGRESSION FOR
A BIT OF PHYSICS (AND CHEMISTRY) THAT WILL BE
HELPFUL
REMEMBER THIS ON THE WALL OF YOUR HIGH SCHOOL CHEMISTRY LAB?

<table>
<thead>
<tr>
<th>1</th>
<th>H</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>He</td>
<td>4.0</td>
</tr>
<tr>
<td>3</td>
<td>Li</td>
<td>3.0</td>
</tr>
<tr>
<td>4</td>
<td>Be</td>
<td>9.0</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>12.0</td>
</tr>
<tr>
<td>6</td>
<td>C</td>
<td>12.0</td>
</tr>
<tr>
<td>7</td>
<td>N</td>
<td>14.0</td>
</tr>
<tr>
<td>8</td>
<td>O</td>
<td>16.0</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>19.0</td>
</tr>
<tr>
<td>10</td>
<td>Ne</td>
<td>20.2</td>
</tr>
<tr>
<td>11</td>
<td>Na</td>
<td>23.0</td>
</tr>
<tr>
<td>12</td>
<td>Mg</td>
<td>24.3</td>
</tr>
<tr>
<td>13</td>
<td>Al</td>
<td>27.0</td>
</tr>
<tr>
<td>14</td>
<td>Si</td>
<td>28.1</td>
</tr>
<tr>
<td>15</td>
<td>P</td>
<td>31.0</td>
</tr>
<tr>
<td>16</td>
<td>S</td>
<td>32.1</td>
</tr>
<tr>
<td>17</td>
<td>Cl</td>
<td>35.5</td>
</tr>
<tr>
<td>18</td>
<td>Ar</td>
<td>39.9</td>
</tr>
<tr>
<td>19</td>
<td>K</td>
<td>39.1</td>
</tr>
<tr>
<td>20</td>
<td>Ca</td>
<td>40.1</td>
</tr>
<tr>
<td>21</td>
<td>Sc</td>
<td>45.0</td>
</tr>
<tr>
<td>22</td>
<td>Ti</td>
<td>47.9</td>
</tr>
<tr>
<td>23</td>
<td>V</td>
<td>50.9</td>
</tr>
<tr>
<td>24</td>
<td>Cr</td>
<td>52.0</td>
</tr>
<tr>
<td>25</td>
<td>Mn</td>
<td>55.0</td>
</tr>
<tr>
<td>26</td>
<td>Fe</td>
<td>56.0</td>
</tr>
<tr>
<td>27</td>
<td>Co</td>
<td>58.7</td>
</tr>
<tr>
<td>28</td>
<td>Ni</td>
<td>58.7</td>
</tr>
<tr>
<td>29</td>
<td>Cu</td>
<td>63.5</td>
</tr>
<tr>
<td>30</td>
<td>Zn</td>
<td>65.4</td>
</tr>
<tr>
<td>31</td>
<td>Ga</td>
<td>69.7</td>
</tr>
<tr>
<td>32</td>
<td>Ge</td>
<td>72.6</td>
</tr>
<tr>
<td>33</td>
<td>As</td>
<td>74.9</td>
</tr>
<tr>
<td>34</td>
<td>Se</td>
<td>78.9</td>
</tr>
<tr>
<td>35</td>
<td>Br</td>
<td>79.9</td>
</tr>
<tr>
<td>36</td>
<td>Kr</td>
<td>83.8</td>
</tr>
<tr>
<td>37</td>
<td>Rb</td>
<td>85.4</td>
</tr>
<tr>
<td>38</td>
<td>Sr</td>
<td>87.6</td>
</tr>
<tr>
<td>39</td>
<td>Y</td>
<td>88.9</td>
</tr>
<tr>
<td>40</td>
<td>Zr</td>
<td>91.2</td>
</tr>
<tr>
<td>41</td>
<td>Nb</td>
<td>92.9</td>
</tr>
<tr>
<td>42</td>
<td>Mo</td>
<td>95.9</td>
</tr>
<tr>
<td>43</td>
<td>Tc</td>
<td>98.0</td>
</tr>
<tr>
<td>44</td>
<td>Ru</td>
<td>101.1</td>
</tr>
<tr>
<td>45</td>
<td>Rh</td>
<td>102.9</td>
</tr>
<tr>
<td>46</td>
<td>Pd</td>
<td>106.4</td>
</tr>
<tr>
<td>47</td>
<td>Ag</td>
<td>107.9</td>
</tr>
<tr>
<td>48</td>
<td>Cd</td>
<td>112.4</td>
</tr>
<tr>
<td>49</td>
<td>In</td>
<td>114.8</td>
</tr>
<tr>
<td>50</td>
<td>Sn</td>
<td>118.7</td>
</tr>
<tr>
<td>51</td>
<td>Sb</td>
<td>121.8</td>
</tr>
<tr>
<td>52</td>
<td>Te</td>
<td>127.6</td>
</tr>
<tr>
<td>53</td>
<td>I</td>
<td>126.9</td>
</tr>
<tr>
<td>54</td>
<td>Xe</td>
<td>131.3</td>
</tr>
<tr>
<td>55</td>
<td>Cs</td>
<td>132.9</td>
</tr>
<tr>
<td>56</td>
<td>Ba</td>
<td>137.3</td>
</tr>
<tr>
<td>57</td>
<td>La*</td>
<td>138.9</td>
</tr>
<tr>
<td>58</td>
<td>Hf</td>
<td>178.5</td>
</tr>
<tr>
<td>59</td>
<td>Ta</td>
<td>181.0</td>
</tr>
<tr>
<td>60</td>
<td>W</td>
<td>183.9</td>
</tr>
<tr>
<td>61</td>
<td>Re</td>
<td>186.2</td>
</tr>
<tr>
<td>62</td>
<td>Os</td>
<td>190.2</td>
</tr>
<tr>
<td>63</td>
<td>Ir</td>
<td>192.2</td>
</tr>
<tr>
<td>64</td>
<td>Pt</td>
<td>195.1</td>
</tr>
<tr>
<td>65</td>
<td>Au</td>
<td>197.0</td>
</tr>
<tr>
<td>66</td>
<td>Hg</td>
<td>200.6</td>
</tr>
<tr>
<td>67</td>
<td>Tl</td>
<td>204.4</td>
</tr>
<tr>
<td>68</td>
<td>Pb</td>
<td>207.2</td>
</tr>
<tr>
<td>69</td>
<td>Bi</td>
<td>209.0</td>
</tr>
<tr>
<td>70</td>
<td>Po</td>
<td>209.0</td>
</tr>
<tr>
<td>71</td>
<td>At</td>
<td>210.0</td>
</tr>
<tr>
<td>72</td>
<td>Rn</td>
<td>222.0</td>
</tr>
<tr>
<td>73</td>
<td>Fr</td>
<td>223.0</td>
</tr>
<tr>
<td>74</td>
<td>Ra</td>
<td>226.0</td>
</tr>
<tr>
<td>75</td>
<td>Ac†</td>
<td>227.0</td>
</tr>
<tr>
<td>76</td>
<td>Th</td>
<td>232.0</td>
</tr>
<tr>
<td>77</td>
<td>Pa</td>
<td>231.0</td>
</tr>
<tr>
<td>78</td>
<td>U</td>
<td>238.0</td>
</tr>
<tr>
<td>79</td>
<td>Np</td>
<td>237.0</td>
</tr>
<tr>
<td>80</td>
<td>Pu</td>
<td>244.0</td>
</tr>
<tr>
<td>81</td>
<td>Am</td>
<td>243.0</td>
</tr>
<tr>
<td>82</td>
<td>Cm</td>
<td>247.0</td>
</tr>
<tr>
<td>83</td>
<td>Bk</td>
<td>247.0</td>
</tr>
<tr>
<td>84</td>
<td>Cf</td>
<td>247.0</td>
</tr>
<tr>
<td>85</td>
<td>Es</td>
<td>253.0</td>
</tr>
<tr>
<td>86</td>
<td>Fm</td>
<td>250.0</td>
</tr>
<tr>
<td>87</td>
<td>Md</td>
<td>249.0</td>
</tr>
<tr>
<td>88</td>
<td>No</td>
<td>250.0</td>
</tr>
<tr>
<td>89</td>
<td>Lr</td>
<td>253.0</td>
</tr>
</tbody>
</table>

* Periodic Table of the Elements

† Transuranium Elements
**Vocabulary and Symbolic Representations**

- **Atomic number**
  - An indicator of the strength of the positive electrical charge of a nucleus
  - Corresponds to the number of protons in the nucleus of an atom of an element
  - The order of the elements in the periodic table is based on atomic number (but wasn’t always)
  - So
    - Hydrogen = +1
    - Gold = +79
    - Uranium = +92
VOCABULARY AND SYMBOLIC REPRESENTATIONS

• Atomic weight
  • An indicator of the relative mass of the nucleus of an atom of an element
  • Relevant in chemistry - early version of the periodic table was based on atomic weight; remember chemistry is based on atomic interaction, the nuclear interactions are based on physics
  • Atomic weight >= Atomic number (that is only for one element)
  • Atoms of the same element can have different atomic weights but always the same atomic number - isotopes
  • Isotopes have the same chemical properties but can have other different properties (e.g., radioactivity/stability); various concentrations in nature

\[
\begin{align*}
\text{U}^{234} & \quad \text{U}^{235} & \quad \text{U}^{238}
\end{align*}
\]
NUCLEAR PROCESSES (1/3)

• There are two ways that a nucleus decays (becomes another type of nucleus) - alpha and beta

• In alpha decay

  • The atomic number is decreased by 2 and the atomic weight is decreased by ~4

  • So, the nucleus becomes an isotope of the element two places in periodic table before the element that is decaying

\[
\begin{align*}
    ^{218}_{84}\text{Po} & \quad \rightarrow \quad ^{214}_{82}\text{Pb} + \quad \text{alpha particle}
\end{align*}
\]
• In beta decay
  • The atomic number is increased by 1 and the atomic weight stays approximately the same
  • So, the nucleus becomes an isotope of the next element in the periodic table after the element that is decaying

\[ ^{14}\text{C} \rightarrow ^{14}\text{N} + \text{beta particle} \]
NUCLEAR PROCESSES (3/3)

• A nucleus can also emit a gamma ray
  • This happens when the nucleus is over-excited and needs to get rid of some energy to stabilize
  • Neither the atomic weight nor atomic number changes

Enough physics for now!

And a good time for questions/comments
UNTIL...JAMES CHADWICK
DISCOVERS THE NEUTRON (1932)

Be + alpha particle → C + ???
THE IMPORTANCE OF THE NEUTRON

• Not detected earlier due to
  • Its absence of electrical charge
  • If alone it exists briefly in nature (decays) unless traveling at relativistic speeds
• Completes an understanding of the atomic nucleus
  • How the nucleus stays together
  • The atomic weight and isotopes of elements - its mass is approximately that of the proton
• Since it is electrically neutral, it can be used to probe the nucleus
• It can be easily produced
• It can be used to destabilize the nucleus by changing atomic weight
Meanwhile, over in Berkeley...

• Ernest O. Lawrence wanted more control in bombarding atomic nuclei

• Irène Joliot-Curie and Frédéric Joliot (and later, Chadwick) had to “make do” with natural radioactive sources (e.g., alpha particles) [Irène and Frédéric did later create radio-isotopes]

• Lawrence wanted to be able to choose the type bombarding particles and control their energies (specifically protons since there are no natural proton emitters in radioactivity - at least not known at the time)

• He would get his protons from ionized hydrogen atoms

• Lawrence invented the cyclotron (aka “an atom smasher”) - 1931
“SPEED HYDROGEN IONS TO BREAK UP ATOMS!” - New York Times

- Lawrence succeeded in
  - Artificially creating nuclear isotopes
  - Element transmutation on a larger scale
  - Convincing UCB to finance the construction of bigger and bigger cyclotrons
  - Attracting the attention of the US Government

…..to be continued
Otto Hahn and Fritz Strassmann (1938)

• German chemists (not physicists) so were interested in chemical processes, not nuclear structure

• $\text{U}_{238}$ has the highest atomic number and atomic weight of all naturally occurring elements but has the highest concentration in nature (>99%) of all U isotopes - why?

• “So, let’s bombard it with neutrons and see what happens. Maybe we’ll get some new isotopes or maybe even a new element whose chemical properties we can explore?”
They were surprised

- They found barium - $^{137}_{56}$ Ba
- “Who ordered that? Our experiment must be contaminated”
- So they called in an old collaborator for a 2nd opinion - Lise Meitner
Lise Meitner

- Had been longtime collaborator of Hahn and Strassmann
- Was forced to leave Germany since she was Jewish
- Moved to Sweden to work at the Nobel Institute
- Her nephew, Otto Frisch (a physicist) worked with Niels Bohr in Copenhagen
- Lise and Otto said “What we have here is neutron-induced fission of the uranium atom.” Otto actually coined the term “nuclear fission.”
BACK TO SOME PHYSICS - NUCLEAR FISSION
MORE SPECIFICALLY

+ lots of gammas!
SO WHY DIDN’T THE HAHN-STRASSMAN EXPERIMENT BLOW UP?

• Otto Frisch had suspected fission from his work with Niels Bohr

• Bohr had actually theorized earlier that the $U_{235}$ nucleus could break apart if bombarded with neutrons and release more neutrons

• But not so much with $U_{238}$ nuclei

• Since $U_{238}$ nuclei were in far greater abundance (>99%) they would absorb all the excess neutrons with no immediate effect - that’s not to say that $U_{238}$ is not fissionable or is stable (more about this later)

• You’d also get $U_{239}$…more later
A SAD HISTORICAL FOOTNOTE

• Otto Hahn got the 1944 Nobel Prize in Chemistry for the “discovery of nuclear fission”

• The prize was not shared

• Lise Meitner, Fritz Strassmann, and Otto Frisch were ignored

• Others may have actually discovered nuclear fission earlier but just didn’t realize it - “By the will of God” - Emilio Segrè and Enrico Fermi
BELATED RECOGNITION: LISE MEITNER’S ROLE IN THE DISCOVERY OF FISSION

R.L. SIMIE

Department of Chemistry, Sacramento City College, Sacramento, California 95822 (USA)

(Received January 11, 1995)

Although physicist Lise Meitner is known for her first theoretical explanation of nuclear fission, the discovery itself is generally attributed only to her co-workers Otto Hahn and Fritz Strassmann. In fact, however, Meitner was essential to the discovery at every phase: she brought the uranium investigation to Berlin, led the Berlin group for four years, and, even after fleeing Germany, provided the critical direction which culminated in the identification of bismuth in December 1938. Recognition of Meitner’s contributions remains a significant historical omission, and places the discovery itself in its proper scientific context.

In 1963 Lise Meitner reminisced about the discovery of fission in an article for Naturwissenschaftliche Rundschau, a non-technical scientific monthly. With her title, “Wege und Irrwege zur Kernenergie,” she acknowledged that the road to nuclear energy had been, in her words, “surprisingly long, and in part an Irrweg” – a mistaken road. The road began in 1934 with Enrico Fermi and his group in Rome, whose neutron irradiation of uranium yielded several new beta activities which Fermi suspected might well be elements 93 and 94. “I found these experiments so fascinating,” Meitner recalled, “that as soon as they appeared in Nuovo Cimento and Nature, I persuaded Otto Hahn to collaborate directly with me once again ... in order to resolve these problems.” Physicist and radiochemist, Meitner and Hahn had long been colleagues in Berlin. They began work on their “uranium project” late in 1934; joined by Fritz Strassmann, they soon found more “transuranics” – elements beyond uranium – than they or anyone else could explain. All were beta emitters; all seemed to begin with the rather modest event of neutron capture by the uranium nucleus. Hahn and Strassmann worked on, confident of their chemistry; Meitner understood that the nuclear processes did not make sense: “I found it very disturbing that uranium should give rise to such a long chain of consecutive beta emitters.” The investigation continued. In context it was always a problem of nuclear physics; it was Lise Meitner who defined the problem and led the Berlin team.
“THE MARTIANS” (1/2)

• A fond reference to a group of prominent Hungarian scientists (mainly physicists and mathematicians) that emigrated to the United States in the early part of the 20th century.

• “Why is there no evidence of intelligent life beyond earth?” - “They are already here - they just call themselves Hungarians” (Leó Szilárd 🇭🇺)
## “THE MARTIANS” (2/2)

<table>
<thead>
<tr>
<th>Name</th>
<th>Field</th>
<th>Name</th>
<th>Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leó Szilárd</td>
<td>Physics</td>
<td>Paul Erdős</td>
<td>Math</td>
</tr>
<tr>
<td>Eugene Wigner</td>
<td>Physics</td>
<td>Theodore von Kármán</td>
<td>Math</td>
</tr>
<tr>
<td>Edward Teller</td>
<td>Physics</td>
<td>John G. Kameny</td>
<td>Math</td>
</tr>
<tr>
<td>John von Neumann</td>
<td>Math</td>
<td>George Pólya</td>
<td>Math</td>
</tr>
<tr>
<td>Elizabeth Róna</td>
<td>Chemistry</td>
<td>Paul Halmos</td>
<td>Math</td>
</tr>
</tbody>
</table>

**AND MORE**

*Images of the scientists are included in the table.*
SO, IF I AM ASKED
“WHO IS THE FATHER OF THE ATOMIC BOMB?”
I MIGHT SAY...
Leó Szilárd

- One of “The Martians” - born in Budapest in 1898
- Physicist, engineer, inventor, and social activist
  - Including patents with Albert Einstein - a home refrigerator with no moving parts (motivated by accidents due to toxic gases leaking from refrigerators)
  - German patent on the cyclotron (January 1929); Lawrence’s American patent (January 1932); Lawrence got the Nobel Prize, not Szilárd, for its invention
  - Other patents on linear accelerators (!), the electron microscope (another lost Nobel Prize), etc.
  - Known for doing his best thinking in the bathtub (9 am to noon everyday)
- Fled to London in 1933 since he was Jewish
Hungarians Think
The Darnedest Things

GENIUS IN THE SHADOWS
A Biography of Leo Szilard. The Man Behind the Bomb.
By William Lammert and Reta Shurz. Illustrated. 307 pp. New York:
A Robert Stewart Book.
Charles Scribner's Sons. $3.50

By Dick Teresi

FLYING saucers have long cherished the belief that extraterrestrials from an advanced civilization landed in South America centuries ago and left a contingent of scientists behind. Their job was to cultivate our species and vastly feed in their ideas to bring our earthbound civilization technologically up in par. Physicists scoff at such a notion as flying saucers ever landed in South America. This, segundo Hungarian colonists, have had an inordinate im

part on our culture. Think of just live Hungarian
refugees who came to America in this century: John von Neumann, Eugene Wigner, Dennis Gabor, Edward Teller and Leo Szilard. Von Neumann, a mathematician noted, invented computing, other champs. "The von
Neumann machine," known more vulgarly today as the computer. Eugene Wigner won the Nobel Prize for his work in theoretical physics. Dennis Gabor won the Nobel Prize in Physics for his invention of holography. Edward Teller scared us first with the H-bomb and
then with his Martian eyebrows.

But what of Leo Szilard? There is no "Szilard machine," no Nobel Prize for him. Yet he was associated with many noteworthy scientific and historical events of the century. It was Szilard who actually drafted Albert

Continued on page 23

Dick Teresi, a science writer in Amherst, Mass., is the co-author with the physicist Leon Lederman, of
"The God Particle."
szilárd was an enterprising guy

Szilard’s 1934 “reactor”:
- cathode rays shoot deuterium target, creating neutrons
- fuel (carbon/beryllium) reacts to neutrons, generating heat
- water (or mercury) absorbs heat, cooling reactor
- heated water drives boiler, generating power

deuterium target
fuel chamber (“transmutation space”)
water channels (cooling and heat exchange)
area that can be filled with neutron-absorbing substance to make radioactive by-products
The story goes...

• September 12, 1933 Szilárd
  • Attended a lecture by Ernest Rutherford about energy release from atoms
  • Lecture was a response to H.G. Wells’ book *The World Set Free* (1914) about unlimited energy from the atom and its impact on mankind
  • Rutherford described the book as “moonshine” which offended Szilárd
  • After the lecture while walking across the street (near the British Museum) in the rain, “time cracked open before him and he saw a way to the future, death into the world and all our woes, the shape of things to come” (Richard Rhodes)
• This was only slightly more than a year after Chadwick had discovered the neutron
SOUTHAMPTON ROAD & RUSSELL SQUARE

There should be a historical marker there!

(Thanks to Google Earth)
“If we found an element that when bombarded by one neutron would release two (or more) neutrons, it could lead to a chain reaction that could possibly release vast amounts of energy!”
• **Note**- “an element” - no mention of uranium - this was almost 6 years before Hahn and Strassmann’s experiment

• Perhaps true to form, Szilárd submitted a patent application for the *idea* of chain reaction applications (reactors and weapons) in 1934

  • this was not for personal gain but offered to the British War Office

• Upon hearing of the Hahn-Strassman experiment from Eugene Wigner (another “Martian”), he knew that he had “found his element”

• In 1938 he moved to the U.S. and started working on neutron moderation (essential for fission reactors) with Enrico Fermi and Walter Zinn
SO NOW WE HAVE
Szilárd was worried that if Germany invaded Belgium then they would have access to the world’s largest uranium mines in the Congo

With ample uranium supply and great German physicists there would be nothing to stop them from developing fission weapons

The “social activist” in him wanted to bring the potential threat of Nazi fission weapons to the U.S. government

He sent multiple letters to officials but was not taken seriously, so he decided to get some “celebrity help” - someone with enough international stature to be taken seriously
3 “Martians” and Albert Einstein

- Eugene Wigner was at Princeton with Albert Einstein
- Thus was instigated a series of meetings between Einstein, Szilárd, Wigner (then at Princeton), and later Edward Teller - July 1939, Peconic, Long Island
- The “Martians” would appeal to Einstein’s
  - Love of new physics and a “practical” application of $E=mc^2$
  - Freedom from scientific peer pressure
  - Feelings about the Nazi government after his flight in 1933
  - Known record of pacifism
  - Connections to the Belgian royal family
1 kg of U\textsubscript{235} (25) is the size of a golf ball!
Einstein was willing to write a personal letter to the Queen of Belgium but that seemed to be a “bit over the top” - “with the Nazis breathing down her neck, what could she do?”

The initial plan agreed upon was a letter to the Belgian ambassador with a cc: to the US State Department and see what happens.

Szilárd had some doubts.

- Was direct contact with the Belgians the best way to go?
- What would the State Department do? The US government had been non-responsive in the past…

Through a mutual friend (Gustav Stolper), Szilárd was introduced to Alexander Sachs.
ALEXANDER SACHS

• Well known and respected economist
• Worked at Lehman Brothers
• Close friend of and adviser to President Roosevelt - National Recovery Administration and National Policy Committee
• Would he fit with Einstein? - “always been of the view that the real warmongering, combined with defeatism, is done by the pacifists”
• Met with Szilárd and advised that they go straight to Roosevelt
• But who should be the messenger? Bernard Baruch? Karl Compton? Charles Lindbergh (!!)?
AE AND “THE MARTIANS,” ACT II

• Eugene Wigner was replaced by Edward Teller
• They drafted three letters which Einstein signed
  • A letter of introduction to Lindbergh
  • Two letters about “the threat” to Roosevelt - a short version and a long version
• Szilárd sent the letter to Lindbergh and the long letter to Sachs
“Dear Herr Lindbergh,

I would like to ask you to do me the favor of receiving my friend Dr. Szilárd and think very carefully about what he will tell you. To one who is outside of science, the matter he will bring up may seem fantastic. However, you will certainly become convinced that a possibility is presented here which has to be very carefully watched in the public interest, even though the results so far are not immediately impressive. With all respects and friendly wishes”

-A.E.
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,

[Signature]

(Albert Einstein)
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 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:
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.

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,

A. Einstein

(Albert Einstein)
EINSTEIN, Albert. Typed letter signed ("A. Einstein") TO PRESIDENT FRANKLIN DELANO ROOSEVELT, Peconic, Long Island, 2 August 1939, 1½ pages, 4to (10 7/8 by 8⅞ in.), on one side each of two sheets of typewriter bond paper, tiny punctures in upper right corners from stapling faint penciled note by Leo Szilard at top: "Original, not sent!"

Price realised
USD 2,096,000

Estimate
USD 800,000 - USD 1,200,000
THE WAITING GAME

• September 1, 1939 - Germany invades Poland, World War II begins

• No response from Lindbergh even after a reminder

• September 27, 1939 - Szilárd to Einstein: “Lindbergh is not our man”

• October 3, 1939 - Szilárd to Einstein: “Sachs confessed that he is sitting on the letter…possible that Sachs was useless”

• October 11, 1939 - Sachs reads the letter to President Roosevelt and schedules a breakfast for the next day
"All I want to do is to tell you a story. During the Napoleonic wars a young American inventor came to the French Emperor and offered to build a fleet of steamships with the help of which Napoleon could, in spite of the uncertain weather, land in England. Ships without sails? This seemed to the great Corsican so impossible that he sent [Robert] Fulton away. In the opinion of the English historian Lord Acton, this is an example of how England was saved by the shortsightedness of an adversary. Had Napoleon shown more imagination and humility at that time, the history of the nineteenth century would have taken a very different course."
ROOSEVELT’S REACTION

• He ordered a bottle of rare Napoleon brandy and poured drinks for Sachs and himself

**FDR**: “Alex, what you are after is to see that the Nazis don’t blow us up?”

**Sachs**: “Precisely”

**FDR** (to his attaché Brig. Gen. Edwin “Pa” Watson): “Pa, this requires action!”
BY EVENING

• The Advisory Committee on Uranium (Briggs Committee) was formed
  • Lyman Briggs (chair) - US Bureau of Standards
    • Alexander Sachs - advisor to the President
    • Leo Szilárd - physicist
    • Eugene Wigner - physicist
    • Edward Teller - physicist
    • Richard Roberts - physicist
    • Enrico Fermi - physicist
    • Merle Tuve - geophysicist
    • Keith Adamson - Lt. Col., U.S. Army
    • Gilbert Hoover - Comm., U.S. Navy
  • Given a budget of $6,000 (approximately $112,000 in 2020 $s)
THE WHITE HOUSE
WASHINGTON

October 19, 1939

My dear Professor:

I want to thank you for your recent letter and the most interesting and important enclosure.

I found this data of such import that I have convened a Board consisting of the head of the Bureau of Standards and a chosen representative of the Army and Navy to thoroughly investigate the possibilities of your suggestion regarding the element of uranium.

I am glad to say that Dr. Sachs will cooperate and work with this Committee and I feel this is the most practical and effective method of dealing with the subject.

Please accept my sincere thanks.

[Signature]

Dr. Albert Einstein,
Old Grove Road,
Nassau Point,
Poconic, Long Island,
New York.
The Advisory Committee on Uranium

October 21, 1939

AGENDA

1. Can nuclear power actually be harnessed?
2. Is building a bomb a realistic enough possibility to consider it seriously at this point?
3. Should research proceed on the assumption that one will be built, if feasible?
4. Should the international political scene be relevant to the pursuit of science?
5. What research on nuclear physics is now most important?
6. How much will it cost, and who will fund it?
7. Will research be kept secret?

From the 1st meeting of “the Martians” with Einstein to the 1st meeting of The Uranium Committee had taken 102 days
“THE URANIUM COMMITTEE” ISSUED ITS FIRST REPORT ON NOV. 1, 1939

• Recommendations:
  1. The U.S. should buy a supply of uranium dioxide for R&D
  2. The U.S. should fund research into uranium isotope separation (i.e., how to separate $U_{235}$ from $U_{238}$)
  3. The U.S. should fund Szilárd’s and Fermi’s work at Columbia University on neutrons and chain reactions

• Nothing about bombs, politics, or secrecy
• 1939 $s$ went a long way!
“I wish that the physicist who fished uranium in the first place had waited a few years before he sprung this particular thing on an unstable world. However, we have the matter in our laps and we have to do the best we can.”

-Vannevar Bush, Scientific Advisor to FDR
FOOTNOTE: “WHAT’S THE BIG DEAL ABOUT URANIUM?”
WHO ARE THESE GUYS AND WHY ARE THEY SO HAPPY?