THE BRIDGE
FORUM DIALOGUE

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Scientific Advances by Women Researchers and Challenges They Faced

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Marie Skłodowska Curie: Discovery in the Service of Humanity
Nobel Laureate in Physics, 1903 and in Chemistry, 1911

^{209}Po:
half-life 125 years

^{210}Po:
half-life 138 days

^{226}Ra:
half-life 1600 years

Marie Curie realized that pitchblende ore might contain elements other than uranium and thorium. Working in a shed, Marie and Pierre Curie used chemical methods to refine pitchblende. They isolated polonium, 330 times more radioactive than uranium. From several tons of pitchblende waste, they isolated radium.

Media Library of France in the United States, https://media.franceintheus.org/11939/

Maria Skłodowska at age 16 in 1883

In her era, Polish universities were closed to women. So, Maria and her sister Bronisława took classes at the “Flying University,” an underground organization that moved from place to place to evade the czarist police.

In 1891, Marie came to Paris, to enroll at the University of Paris.

Image from https://rad.washington.edu/blog/featured-history-marie-sklodowska-curie/

Photo: https://kenyonlyceum.wordpress.com/2019/12/14/the-half-life-of-marie-curie/

Together, Marie and Irène Joliot-Curie carried out scientific research on radioactive materials.

Irène won the Nobel Prize in Chemistry jointly with her husband in 1935.

Photo: Wikimedia Commons, 1925, The Wellcome Collection

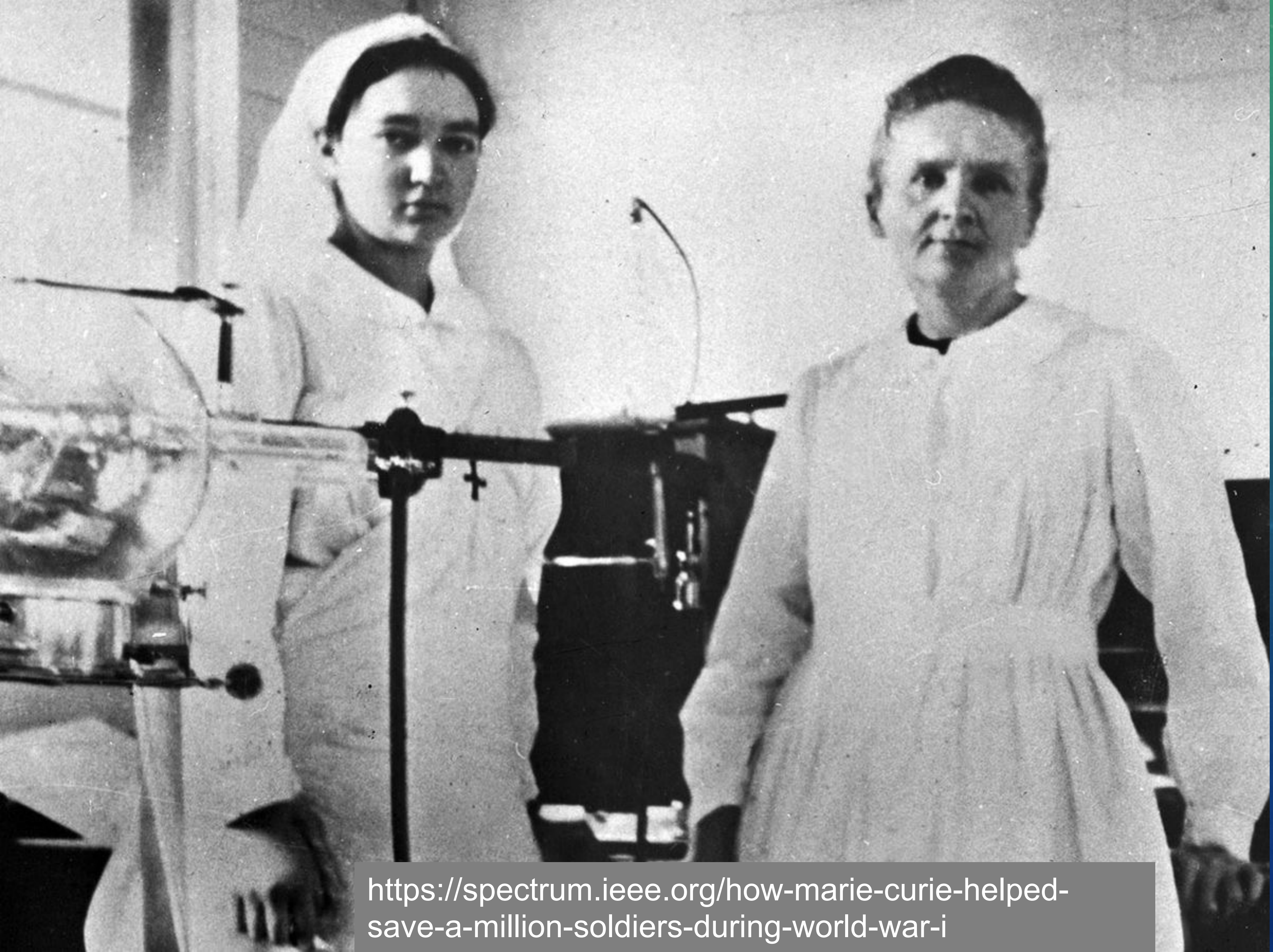
https://history.aip.org/exhibits/curie/war1.htm#:~:text=By%20late%20October%201914%2C%20the,petites%20Curies%20(little%20Curies).

Marie Curie: Director of the Red Cross Radiology Service in World War I,

“I resolved to put all my strength at the service of my adopted country, . . . “

Statement in a letter to Paul Langevin, 1915

https://www.themarginalian.org/2016/12/14/marie-curie-ambulance-little-curies/



https://spectrum.ieee.org/how-marie-curie-helped-save-a-million-soldiers-during-world-war-i

Marie Curie needed a collaborator to work in the field. Her daughter Irène started this work at the age of 17. The Curies wore Red Cross armbands on their sleeves. Irène X-rayed the soldiers' wounds, and then calculated the locations of bullets and shrapnel. The kind of bravery that Marie Curie showed has been called "the transformative moral courage of an example."

The mobile radiological units were called "Les Petites Curies." Marie learned to drive and learned automotive mechanics, to operate the units under field conditions. It is estimated that over *one million soldiers* were treated with her X-ray units. Additionally, Marie conducted the world's first studies using radiation to treat neoplasms.

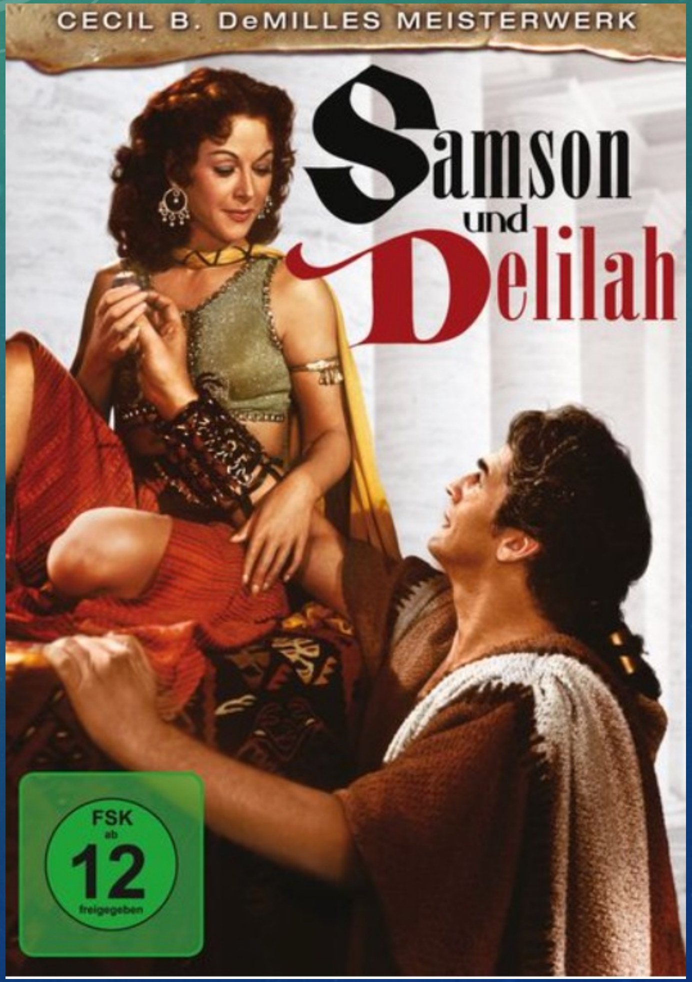
A woman who knew how to enter a room . . .

Hedwig Kiesler
Frau Fritz Mandl

A woman who knew how to enter a room . . .

Hedwig Kiesler
Frau Fritz Mandl
Better known as Hedy Lamarr

benchinternational.com



https://www.booklooker.de/Filme/Cecil-B-DeMille+Samson-und-Delilah-Bibel-Monumentalfilm-Hedy-Lamarr-Victor-Mature-George-Sanders/id/A02mVgfI11ZZK

Why is Hedy Lamarr included in this talk?

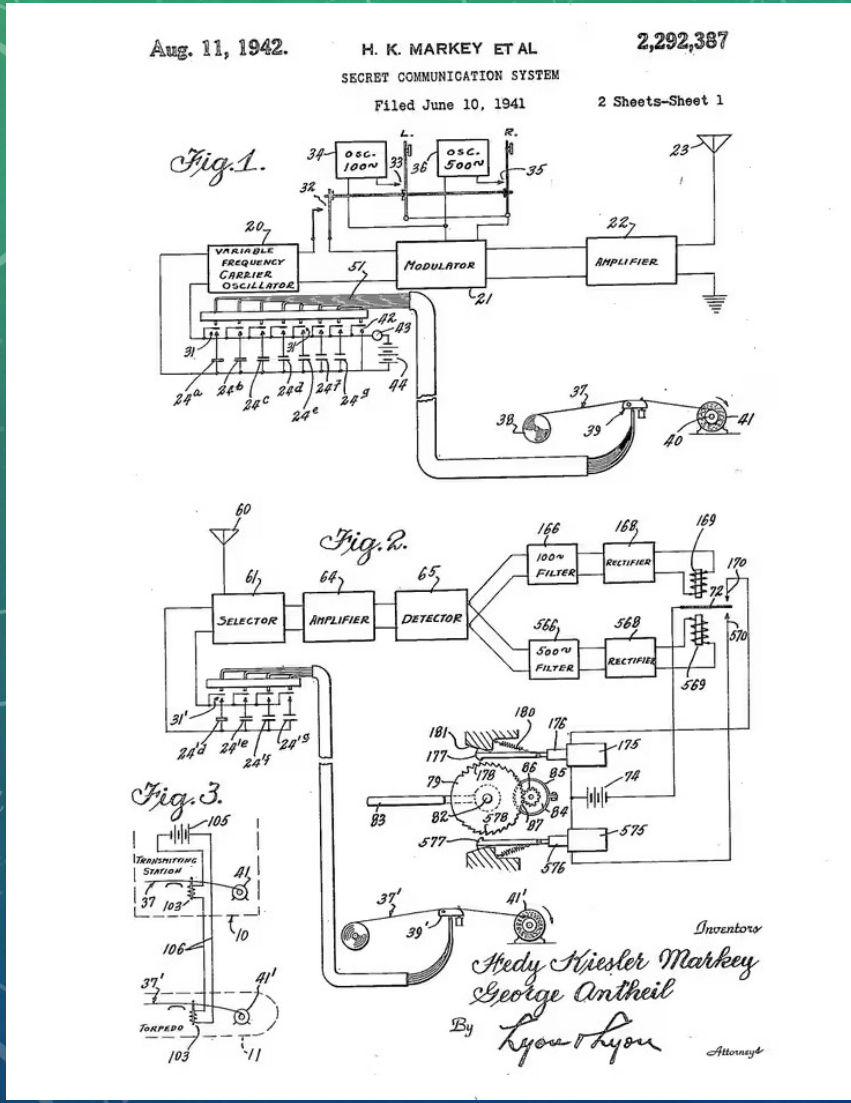
Hedy Lamarr – the 1940s 'bombshell' who helped invent wifi

The Guardian

Lamarr and George Antheil invented a radio guidance system based on frequency hopping, which was used to permit wireless guidance of torpedoes and to prevent the Germans from jamming Allied torpedoes. Their work did not become known until the late 1990s.

https://www.theguardian.com/film/2018/mar/08/hedy-lamarr-1940s-bombshell-helped-invent-wifi-missile

Here is the patent



United States Patent and Trademark Office

Lamarr (Hedy Kiesler Markey) worked with a musician, George Antheil to develop the idea. It is safe to say that Antheil was equally unconventional. At the Paris debut of his works, *Airplane Sonata*, *Sonata Sauvage*, and *Mechanism*, a riot broke out. Man Ray, Pablo Picasso, and Jean Cocteau were in the audience. Antheil's first "big work" was *Ballet Mechanique*, which was originally scored for sixteen synchronized player pianos, two grand pianos, electronic bells, xylophones, bass drums, a siren, and three airplane propellers. A riot also broke out at the first performance of this work in Paris.

What led to the invention?

In Vienna, Lamarr had married an Austrian munitions manufacturer, Fritz Mandl, when she was 18 and he was 33. Mandl often met with scientists and military technologists; he had a library containing physics and mathematics books. Although educated at a Swiss finishing school, Lamarr was largely self-educated in these subjects.

Wire guidance was employed for guided torpedoes at the time, because radio-controlled torpedoes could be jammed and sent off course. Lamarr had the idea of hopping between frequencies. She believed that the mechanism George Antheil had used to synchronizing player pianos could also be used for torpedoes.

https://en.wikipedia.org/wiki/Hedy_Lamarr

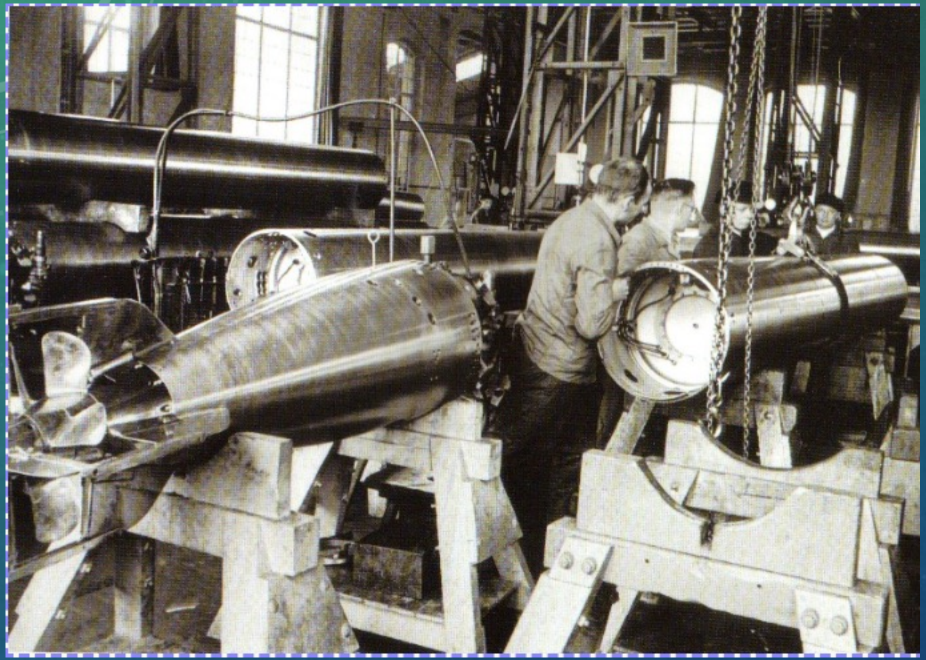


Photo: Établissement de Communication et de Production Audiovisuelle de la Défense.

Adaptive frequency hopping is used by Bluetooth. In 1903 Nikola Tesla had been granted US patent 725,605, for frequency hopping in another context.

The challenges were immense

Hedwig Kiesler had attracted the attention of Fritz Mandl when she performed as Empress Elisabeth of Austria in a play at the Theater an der Wien. Mandl wanted to keep German influence out of Austria, and he had allied with Mussolini in the attempt to do that. Hedwig's parents may have thought that the alliance would help to protect Hedwig, and secondarily her parents themselves. Mandl grew jealous of Hedwig. He would not allow her to leave their residence at Schloss Schwarzenau without his explicit permission.

How did she leave Austria?

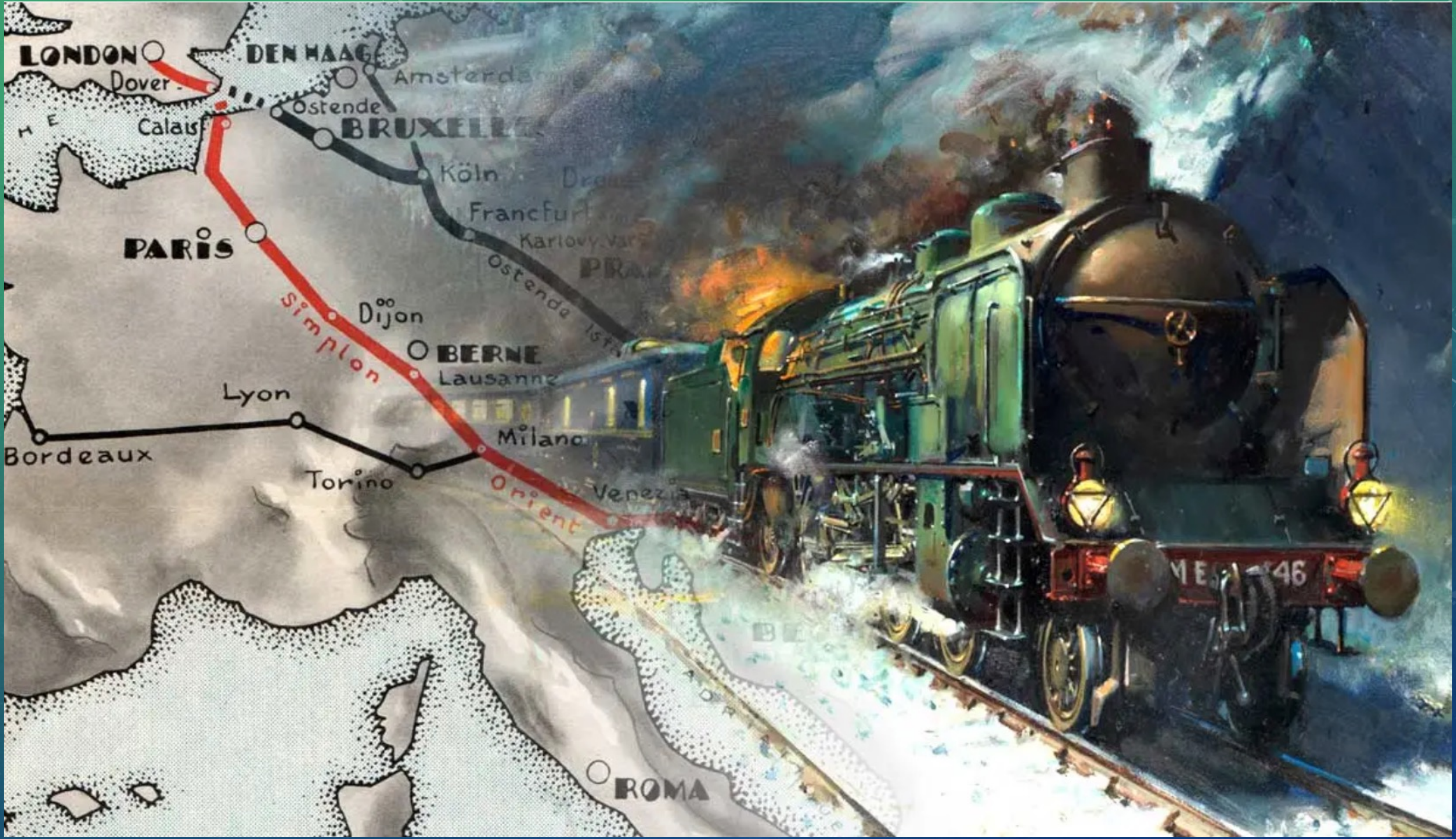


Illustration from an article in *The Collector* by Vedran Bileta,
perhaps based on a 1930 painting by Terence Cuneo

How did Hedwig Kiesler become Hedy Lamarr?

Quick Answer: On the *SS Normandie* in the Atlantic, traveling from London to the US in 1937

In London, she had met Louis B. Mayer, the founder and head of MGM Studios. He offered her a contract. She turned it down. Then she arranged to travel to the US on the same ship that Mayer and his wife were taking.

On the first evening at sea, she donned a dark green gown and headed for the ballroom. She reportedly stood at the top of the staircase, waited until all eyes were upon her, then stepped down to the dance floor. She accepted a contract for nearly four times Mayer's original offer.

Adolphe Cassandre's 1935 poster of the SS Normandie

The Current Version of the Full Periodic Table with 118 Elements

1 H																															2 He
3 Li	4 Be																									5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg																									13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca															21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr															39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

https://en.wikipedia.org/wiki/Periodic_table

Element names that honor individual scientists

96 Cm

99 Es

100 Fm

101 Md

102 No

103 Lr

104 Rf

106 Sg

107 Bh

109 Mt

111 Rg

112 Cn

118 Og

f

d

p

Element names that honor individual scientists

Number	Symbol	Name
96	Cm	Curium
99	Es	Einsteinium
100	Fm	Fermium
101	Md	Mendelevium
102	No	Nobelium
103	Lr	Lawrencium
104	Rf	Rutherfordium
106	Sg	Seaborgium
107	Bh	Bohrium
109	Mt	
111	Rg	Roentgenium
112	Cn	Copernicum
118	Og	Oganesson

f d p

Element names that honor individual scientists

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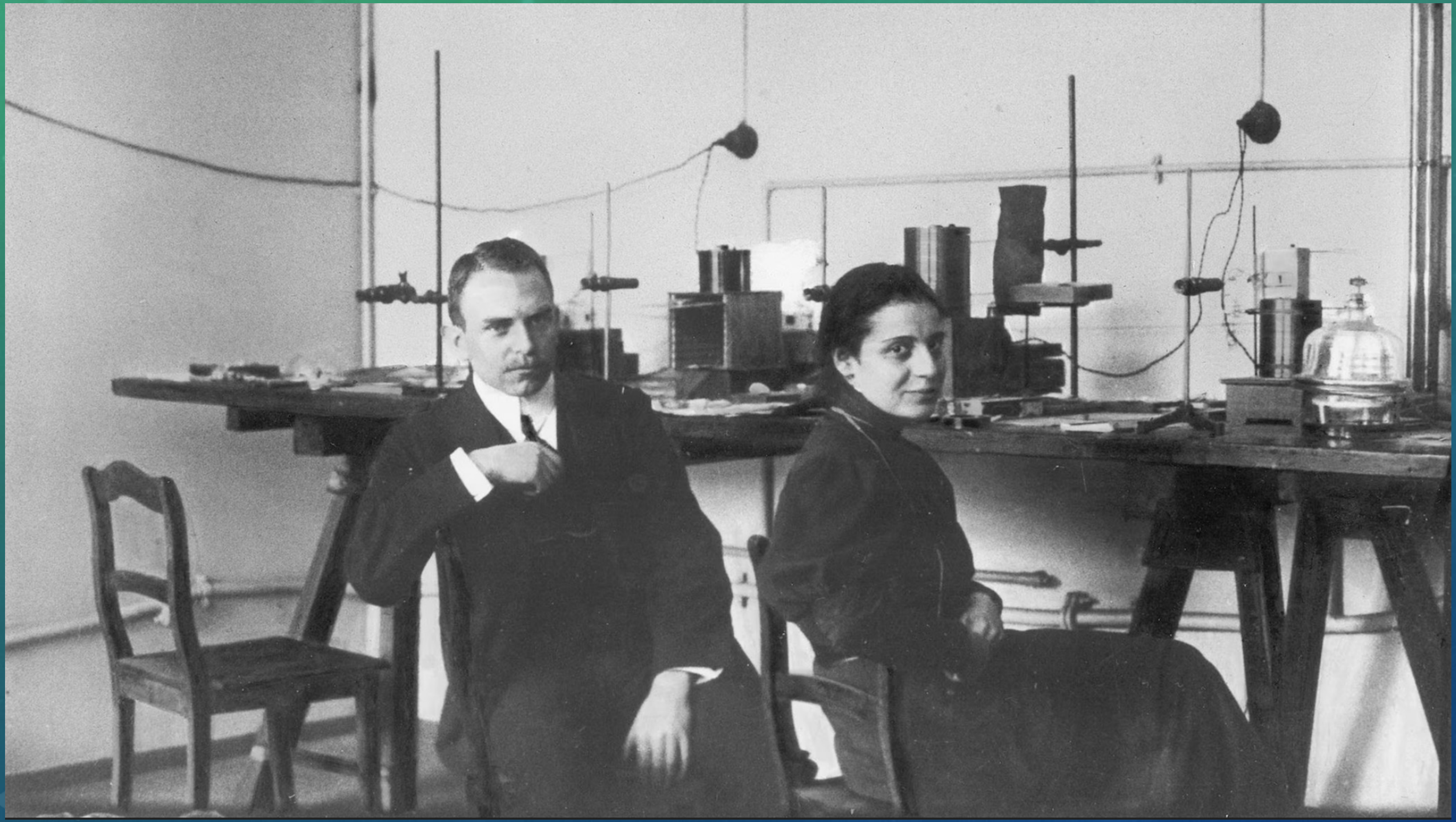
111	Rg	Roentgenium
112	Cn	Copercinum
118	Og	Oganesson

f d p

Lise Meitner, co-discoverer of nuclear fission



Nuclear chemist Otto Hahn and Nuclear Physicist Lise Meitner at the Kaiser Wilhelm Institute für Chemie in Berlin. The institute was directed by Emil Fischer. Fischer reluctantly agreed to allow Meitner to work with Hahn there, provided that she did not enter a chemistry laboratory; he was concerned that Meitner's hair might catch on fire.

Early challenges for Lise Meitner

Education for girls ended at age 14 in Austria when Lise was young. Lise attended the Mädchen Bürgerschule. She could not enroll in a private *höhere Töchterschule*, due to lack of financial resources.

1897: Austria first admitted women to its universities.

1899: Lise began to prepare for the Matura.

1901: Lise took and passed the Matura. She was 22.

1906: Lise became the second woman to receive a doctorate in physics from the University of Vienna

Curriculum of the Mädchen Bürgerschule

Arithmetic
History*
Geography*
Science*
Drawing
Singing
French*
Gymnastics
"Feminine Handiwork"

Preparation for the Matura

Greek
Latin
Mathematics
Physics
Botany
Zoology
Mineralogy
Psychology
Logic
Religion
German Literature
History

Lise studied with two other young women. Fourteen students took the Matura in July 1901 at the Akademisches Gymnasium. Four passed. Three were Lise and the two women who studied with her. The fourth was Henriette Boltzmann.

Career successes and career challenges

1907: Collaboration with Otto Hahn began at Friedrich Wilhelm University in Berlin; Meitner had to go in the back entrance of the building, and could not enter the lecture rooms nor laboratories.

1912: She moved to the Kaiser Wilhelm Institute for Chemistry.

1917: She and Hahn discovered the protactinium isotope ^{231}Pa.

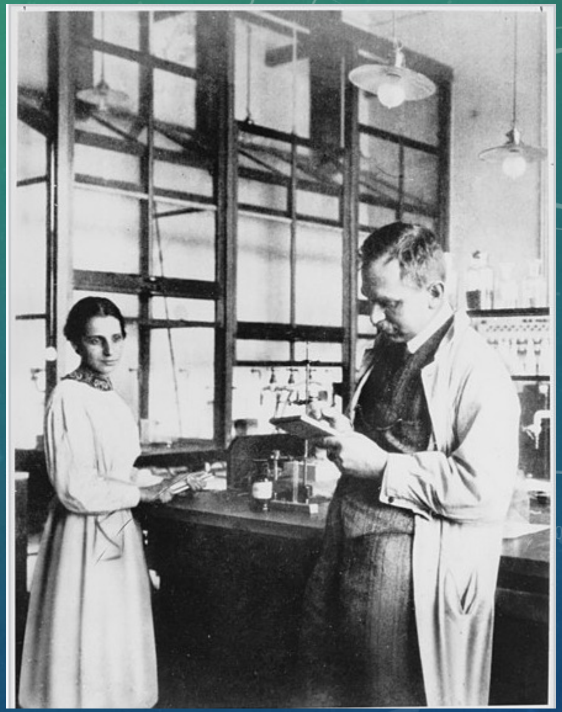
1926: She became the first female professor of physics in Germany.

1933: Her license to teach was revoked.

1938: She fled to Stockholm, where she worked at the Nobel Institute.

December 1938: Otto Hahn and Fritz Straßmann triggered nuclear fission; Meitner had collaborated with them for 4 years.

February 1939: Meitner and her nephew Otto Frisch published the first theoretical explanation of nuclear fission.



Lise Meitner and Otto Hahn at the Kaiser Wilhelm Institute for Chemistry, 1913. Meitner was nominated for the Nobel Prize 49 times! Hahn won it.

“Magic Numbers” of Electrons

Certain atomic numbers confer unusual stability on atoms, making them essentially inert. These numbers are 2, 10, 18, 36, 54, 86, and 118. The inert gases have a filled p shell. An added electron would have to go into the next-higher s shell.

Helium 2
Neon 10
Argon 18
Krypton 36
Xenon 54
Radon 86
Oganesson 118

“Magic Numbers” of Nucleons

Certain numbers of protons or neutrons confer unusual stability on atomic nuclei. These numbers are 2, 8, 20, 28, 50, 82, and 126 (Sequence A 018226 in the Online Encyclopedia of Integer Sequences). These numbers are somewhat similar to the “magic numbers” of electrons, but they are not identical. Nuclei with the magic numbers of protons are:

Helium 2
Oxygen 8
Calcium 20
Nickel 28
Tin 50
Lead 82

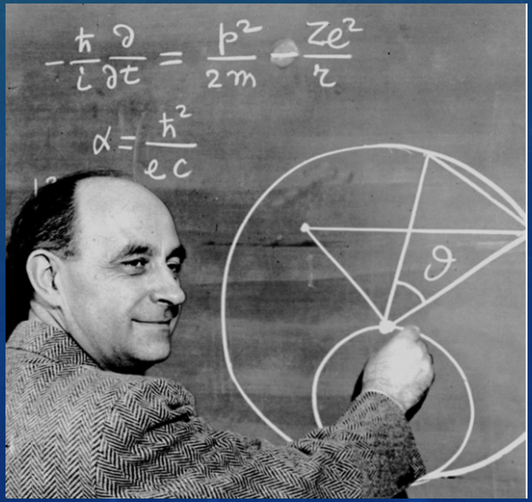
What explains the magic numbers of nucleons?

Maria Goeppert Mayer with her colleagues at Argonne National Laboratory, photo from Argonne

Goeppert Mayer worked at Argonne National Lab from 1946 to 1960

The photo caption on the Argonne National Laboratory web site reads “Maria Goeppert Mayer (fourth from right) poses with her colleagues . . . “

Explanation!



Eugene Wigner called the numbers of protons or neutrons that confer special stability “magic numbers.” They were considered baffling for many years. Goeppert Mayer was working on this problem in Chicago. A discussion with Enrico Fermi was interrupted by a telephone call, but as Fermi walked out the door, he asked about spin-orbit coupling. He returned shortly, and Goeppert Mayer had the full answer. She recalled, “When he said it, it all fell into place. In 10 minutes, I knew…I finished my computations that night. Fermi taught it to his class the next week.”

Portrait of Maria Goeppert Mayer from the Special Collections Research Center, University of Chicago Library; Portrait of Enrico Fermi from fnal.gov “Why are we called Fermilab?”

Maria Goeppert Mayer's description of nuclear spin-orbit coupling

"Think of a room full of waltzers. Suppose they go round the room in circles, each circle enclosed within another. Then imagine that in each circle, you can fit twice as many dancers by having one pair go clockwise and another pair go counterclockwise. Then add one more variation; all the dancers are spinning twirling round and round like tops as they circle the room, each pair both twirling and circling. But only some of those that go counterclockwise are twirling counterclockwise. The others are twirling clockwise while circling counterclockwise. The same is true of those that are dancing around clockwise: some twirl clockwise, others twirl counterclockwise."

From Joan Dash, *A Life of One's Own: Three Gifted Women and the Men They Married* (Harper's Row, New York, 1973).

Earlier work by Maria Goeppert Mayer

Photo from the Emilio Segrè Visual Archives, American Institute of Physics

In her Ph.D. thesis in 1930, Maria Goeppert worked out the theory of two-photon absorption. This could not be tested experimentally until lasers had been developed; but in 1961, two-photon fluorescence was detected in a europium-doped crystal, as reported by W. Kaiser and C. G. B. Garrett, in "Two-photon excitation in $CaF_2Eu_2^+$," *Physical Review Letters* **7**, 229 (1961). All three of her thesis examiners were or became Nobel Laureates: Max Born, James Franck, and A. O. R. Windaus. The unit of the two-photon absorption cross-section is the GM, in her honor.

Challenges for Maria Goeppert Mayer

- 1930: Maria Goeppert married Joseph Mayer (an American who had boarded with her family).
- 1930: Joseph was hired at Johns Hopkins University. Anti-nepotism rules precluded Maria from professorial positions for much of her life. At Johns Hopkins, she held a position officially working with German correspondence.
- 1939: Joseph took a position at Columbia University. Maria was offered an office, but no salary.
- 1941: Maria obtained a part-time professorship at Sarah Lawrence College, *after* her election as a Fellow of the American Physical Society.
- 1942: Maria began to work on the Manhattan Project.
- 1946: Joseph became a professor at the University of Chicago. Maria was appointed as a "voluntary associate professor."
- 1960: Maria was finally appointed as a Full Professor of Physics at the University of California, San Diego.
- 1963: Maria Goeppert Mayer won the Nobel Prize for Physics in 1963. She was the second woman to win this Prize.

WORLD RENOWNED—Dr. Maria Goeppert Mayer, 57, holds the slide rule she uses in the study of nuclear physics that won her a Nobel Prize today. She is a University of California professor here.

S.D. Mother Wins Nobel Physics Prize

Dr. Mayer 1st Woman in U.S., 2nd in History So Honored

By FRANK HOGAN

Dr. Maria Goeppert Mayer, 57, a research physicist at the University of California here, today was named a 1963 Nobel Prize winner in physics.

The red-haired college professor, mother of two, is the first woman residing in America to win a Nobel physics prize, the second woman in history.

She received the news in a phone call from Sweden at 4 this morning. The caller informed her she had been cited by the Swedish Royal Academy of Science for her work in determining the nature of the shell of the atom's nucleus.

Will Share Award

Mrs. Mayer will share the $51,158 prize with a West German scientist, J. Hans D. Jensen of Heidelberg, who made a similar but independent study, and Eugene Wigner of Princeton University, who helped lay the groundwork for the present advanced study in nuclear physics.

Wigner will get half the prize. Mrs. Mayer and Jensen will divide the rest.

Second on Campus Here

Mrs. Mayer is the second Nobel Prize winner on the university's San Diego campus. The other is Dr. Harold C. Urey of 7890 Torrey Lane, professor of chemistry at large, who won the Nobel chemistry award in 1934.

Mother of a married daughter and a grown son, Mrs. Mayer is the wife of Dr. Joseph E. Mayer, a chemistry professor at the University of California here. They joined the local faculty in 1960, and live at 2345 Via Sienna, La Jolla.

Caught by Surprise

Excited and insisting the award caught her by surprise, Mrs. Mayer said she would go with her husband to Stockholm for the formal award.

While there, she said, she

(Continued Next Page, Col. 1)

State Dept. Fires Officer Over 'Leak'

WASHINGTON (AP) — Otto F. Otepka was dismissed today from his job as a State Department security officer on charges of conduct "unbecoming an officer of the Department of State."

Otepka, 48, has been under suspension since Sept. 23, accused among other things of giving confidential information to the Senate Internal Security subcommittee.

A letter removing him from the ranks of department employes was delivered today.

Signed by John Ordway, chief of the department's personnel division, it replied to Otepka's 12-page-long letter of Oct. 14, requesting that charges against him be dismissed, and upheld the charges.

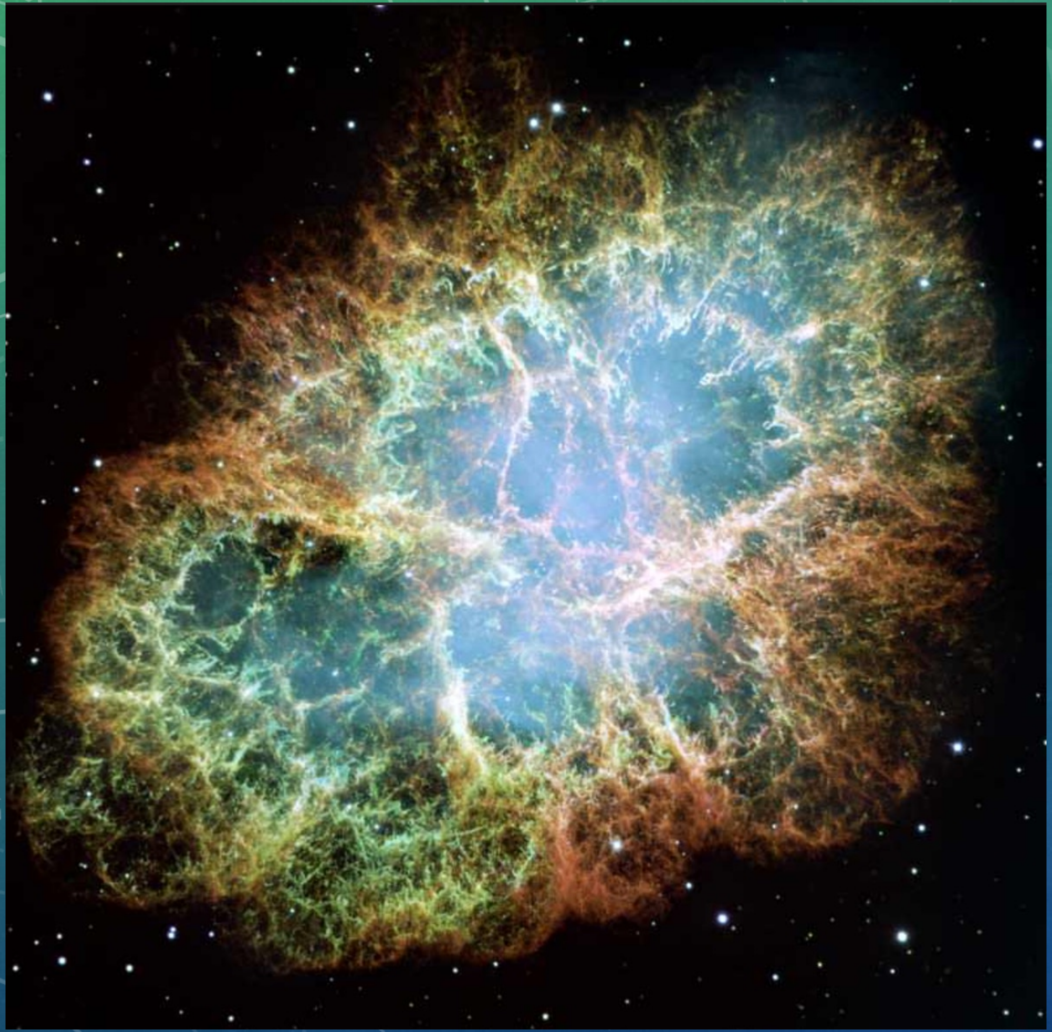
Otepka had been chief security risk evaluator for the department at a salary of $16,900-a-year.

A qualified source said that Otepka's case was thoroughly studied and the decision to dismiss him was made on a high level.

WEATHER

Forecast — Mostly sunny. Details, Page A-13.

We are starstuff!



Hubble image, Crab Nebula Supernova, credit NASA, ESA, J. Hester, and A. Loll

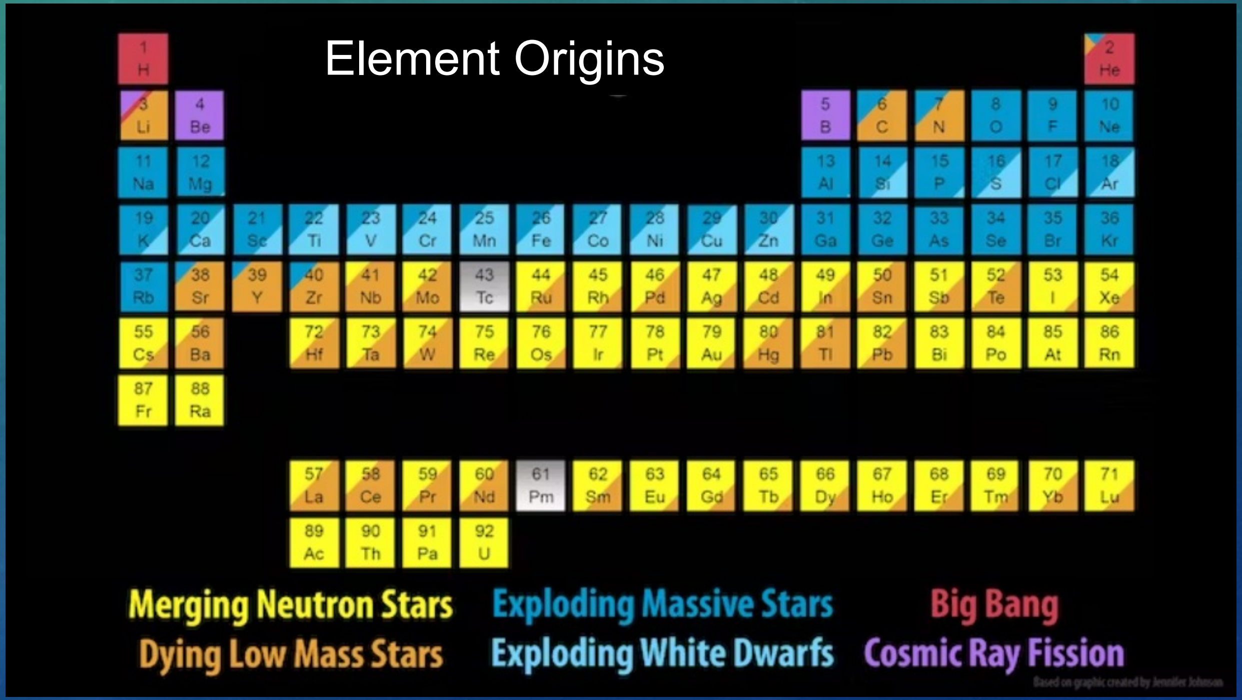
“The nitrogen in our DNA, the calcium in our teeth, the iron in our blood, the carbon in our apple pies were made in the interiors of collapsing stars.” As Carl Sagan famously said in his 1980 series Cosmos, “We are made of starstuff.” “The cosmos is within us.”

One catch: The process for producing gold and heavier nuclei was unknown until recently!

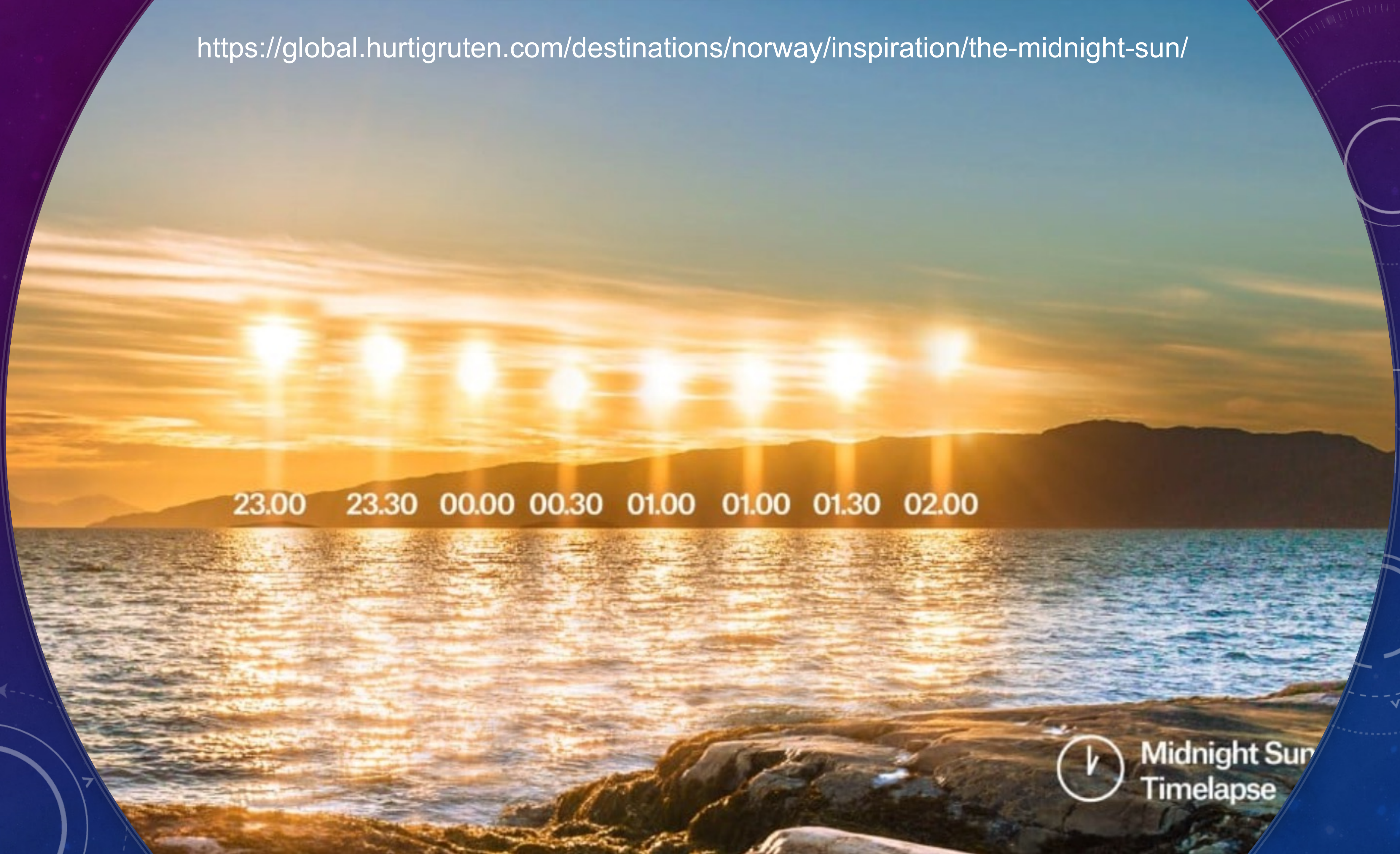
How did the heavier elements form?

Iridium, Platinum, Gold, Polonium and Radium: Exclusively or predominantly in colliding neutron stars! From element 41 (Niobium) onward, all the natural elements were formed at least in part in colliding neutron stars, with the exceptions of element 43 (Technitium) and element 61 (Promethium).

Artist's rendition of two neutron stars spiraling into a collision. Credit: Ron Miller. Illustration from "Cosmic Alchemy," *Scientific American* **328** (2023).



https://astronomy.fas.harvard.edu/news/cosmic-alchemy-colliding-neutron-stars-show-us-how-universe-creates-gold https://global.hurtigruten.com/destinations/norway/inspiration/the-midnight-sun/



What is the composition of the sun?

https://science.nasa.gov/sun/

Until the mid-1920s it was commonly thought that the elemental composition of the Earth and the Sun were very nearly identical.

In fact, silicon, carbon, and common metals are present in the Sun in about the same relative amounts as found on Earth.

However, hydrogen is more abundant in the Sun than on Earth by a factor of approximately one million.

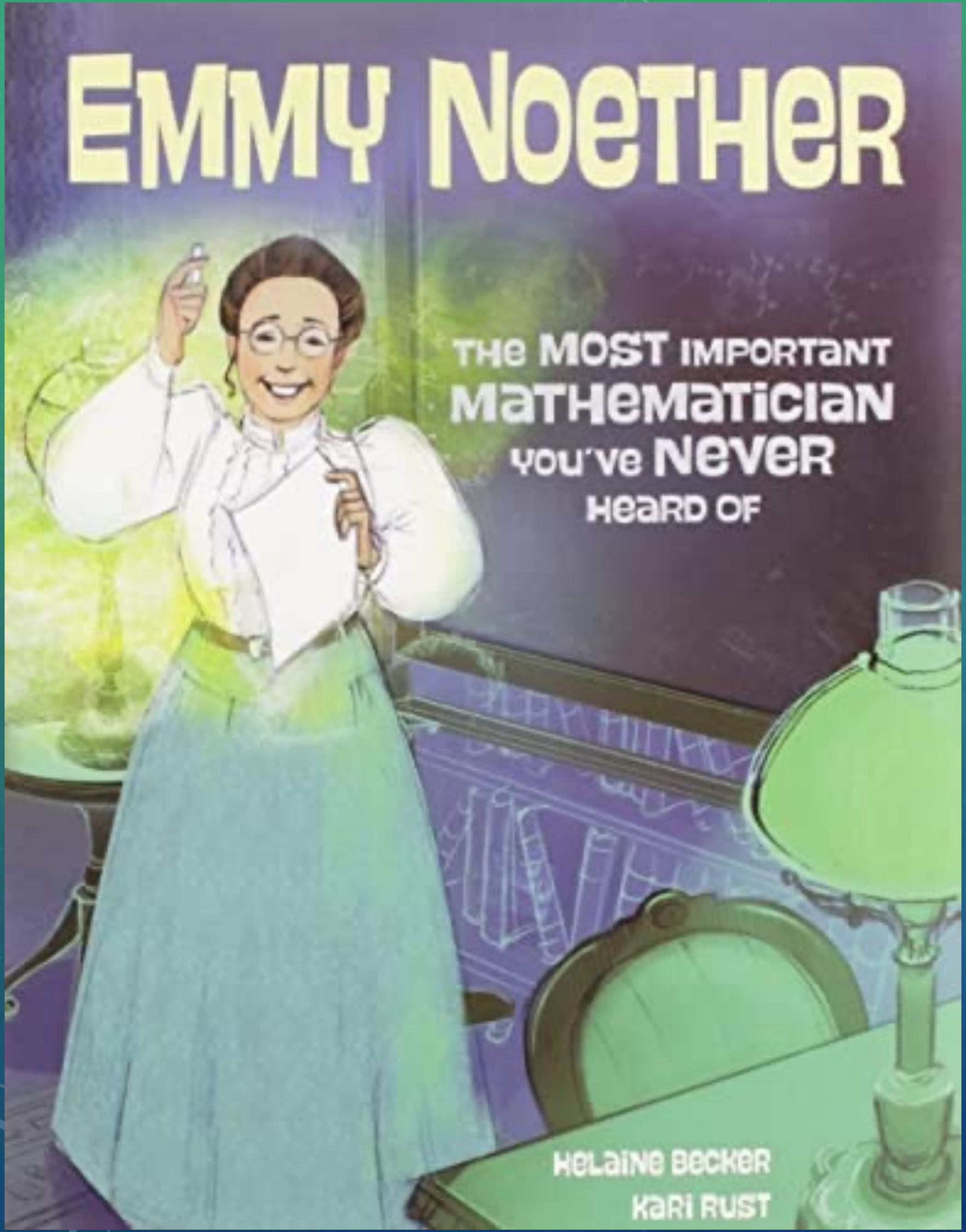
https://en.wikipedia.org/wiki/Cecilia_Payne-Gaposchkin

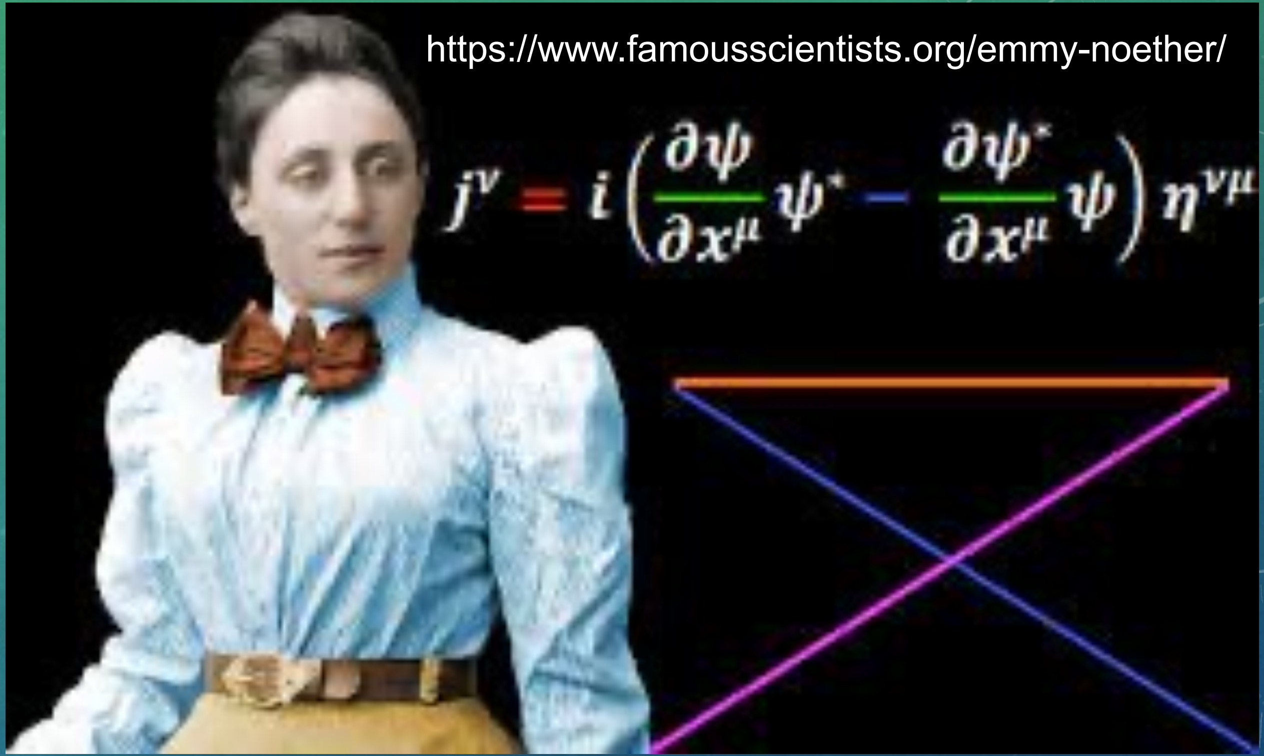
Cecilia Payne-Gaposchkin

https://www.famousscientists.org/cecilia-payne-gaposchkin/

Cecilia Payne-Gaposchkin proposed in her Harvard doctoral thesis that the Sun was composed primarily of hydrogen and helium. Her idea was initially rejected. Otto Struve described her thesis as "the most brilliant Ph.D. thesis ever written in astronomy," but not before she was forced to characterize her results as "spurious." Early on, Henry Norris Russell generally received the credit for her results.

When Payne-Gaposchkin completed her thesis in 1925, women were barred from becoming professors at Harvard. In 1958, Payne-Gaposchkin was named the Phillips Professor of Astronomy at Harvard University.





Einstein on Noether: “The most significant creative mathematical genius thus far produced since the higher education of women began.”

Noether’s theorem connects conservation laws to symmetries.

Noether's First and Second Theorems

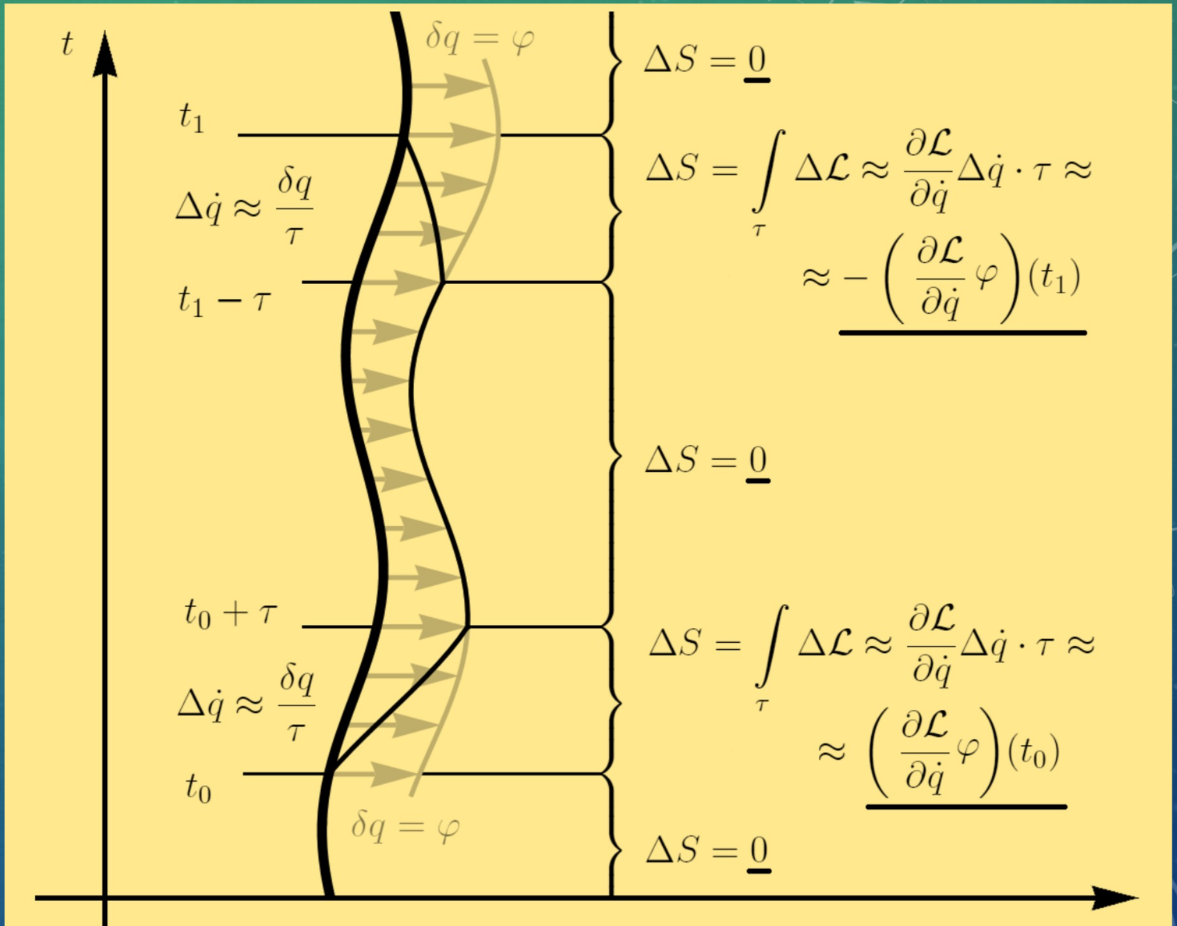
First theorem: "Every differentiable symmetry of the action of a physical system with conservative forces has a corresponding conservation law."

Symmetry with respect to motion in space $\rightarrow$ Conservation of momentum

Symmetry with respect to rotation $\rightarrow$ Conservation of angular momentum

Symmetry with respect to translation in time $\rightarrow$ Conservation of energy

Second theorem: "If the action has an infinite-dimensional Lie algebra of infinitesimal symmetries parameterized linearly by *k* arbitrary functions and their derivatives up to order *m*, then the functional derivatives of *L* satisfy a system of *k* differential equations."



L3erdnik, own work, 12 August 2019, Wikimedia Commons

Noetherian rings: These rings satisfy the condition that every increasing sequence of ideals has a largest element. The integers, the rational numbers, the real numbers and the complex numbers are all Noetherian rings.

Phillippa Fawcett

In 1890, Phillippa was the first woman to obtain the top score in the Mathematical Tripos at Cambridge University. Women could not receive degrees from Cambridge University at the time. However, Phillippa was among the "steamboat ladies" who travelled to Ireland between 1904 and 1907 to receive an *ad eundem* degree from Trinity College of the University of Dublin.

She taught at Newnham College, Cambridge. One of her students wrote, "My deepest debt to her is a sense of the unity of all truth, from the smallest detail to the highest that we know."

Phillippa died at age 80, just "a month after the Grace that allowed women to be awarded the Cambridge BA degree received royal assent."

Information from Wikipedia article on Phillippa Fawcett

From the Phillippa Fawcett Collection at the London Mathematical Society—History Collections

Baroness Ingrid Daubechies

Baroness Ingrid Daubechies was awarded the Wolf Prize in 2023, for her “creation and development of wavelet and harmonic analysis.”

One of her wavelets is used in the jpg 2000 standard.

Digital processing: compactly supported wavelets limit the required amount of information processing.

She and her team applied her methods to restoring the Ghent altarpiece from the fifteenth century, the work of Hubert and Jan Van Eyck.

https://en.wikipedia.org/wiki/Ingrid_Daubechies

https://www.ihes.fr/en/ingrid-daubechies-wolf-prize/

The Ghent Altarpiece, “het Lam Gods” (title in Dutch), 1432, by Jan Van Eyck and Hubert Van Eyck, in the collection of Saint Bavo Cathedral

Donna Strickland, 2018
Nobel Laureate in Physics

The Nobel Prize was awarded to Donna Strickland in 2018 for the practical implementation of chirped pulse amplification.

A chirped laser pulse has components of various frequencies that are spread in time.

After stretching a pulse by a factor of 1000 in time, the pulse can be amplified and then recompressed.

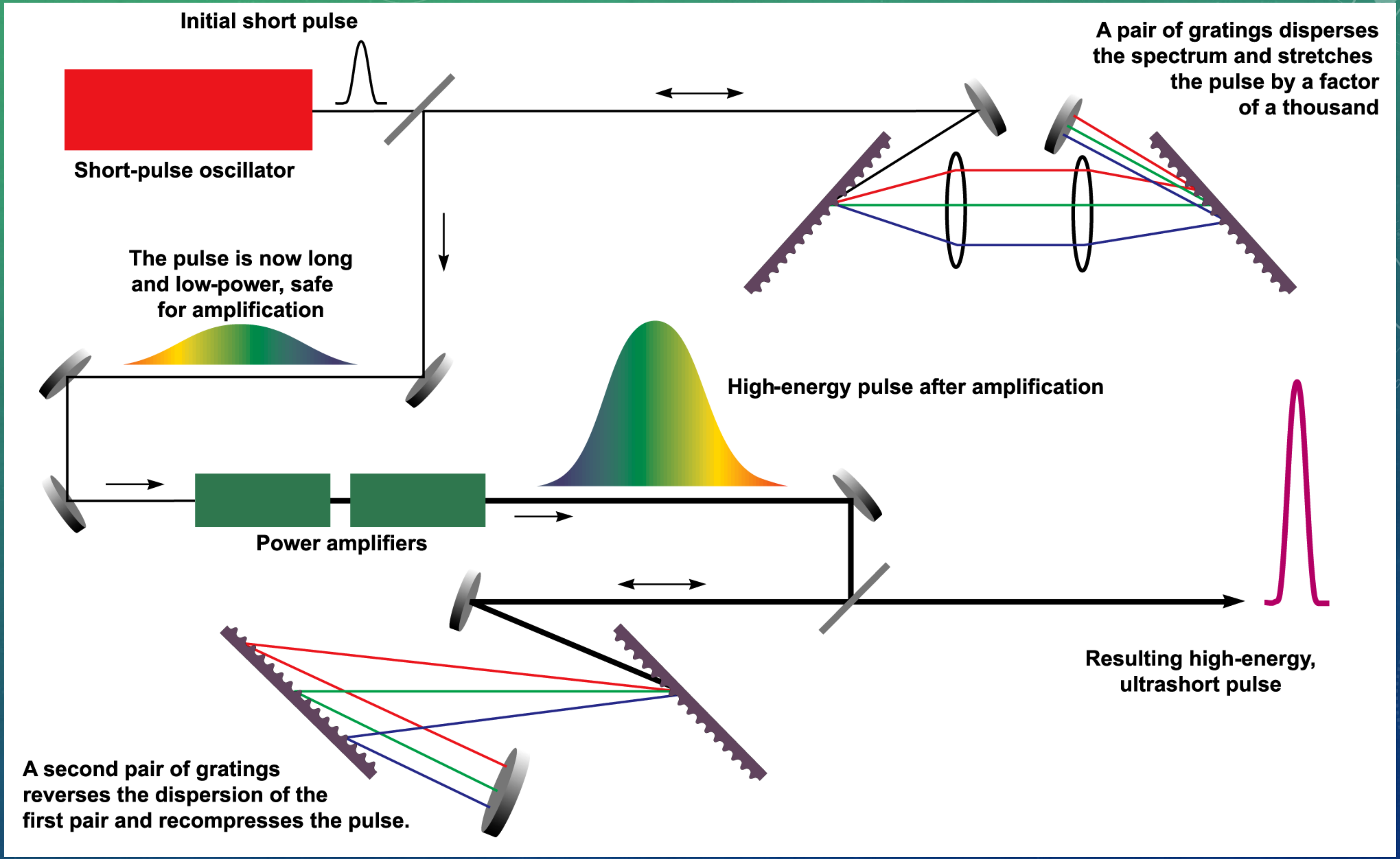
The result: *An ultrashort, high energy pulse*

https://en.wikipedia.org/wiki/Donna_Strickland#/media/File:Donna_Strickland_EM1B5760_(46183560632)_(cropped).jpg

Anne L′Huillier, Nobel Prize in Physics, 2023

https://www.lexpress.fr/sciences-sante/sciences/anne-l-huillier-laureate-du-prix-l-oreal-unesco_968083.html

The Nobel Prize recognized her work in producing laser pulses that can be used in attosecond chemistry, i.e, chemistry that occurs in 10^{-18} seconds. In 2003, she and her research group beat the world record for the shortest laser pulse, at 170 attoseconds. With such extremely short pulses, it is possible to follow the motion of electrons in real time, and thus to study electronic reorganization in chemical reactions.



Slightly modified from *Lawrence Livermore National Laboratory Science and Technology Review*, September 1995
https://commons.wikimedia.org/index.php?curid=12523319

German Chancellor Angela Merkel

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THE LOWEST BOUND STATES OF TRIPLET $(BH_2)^+$

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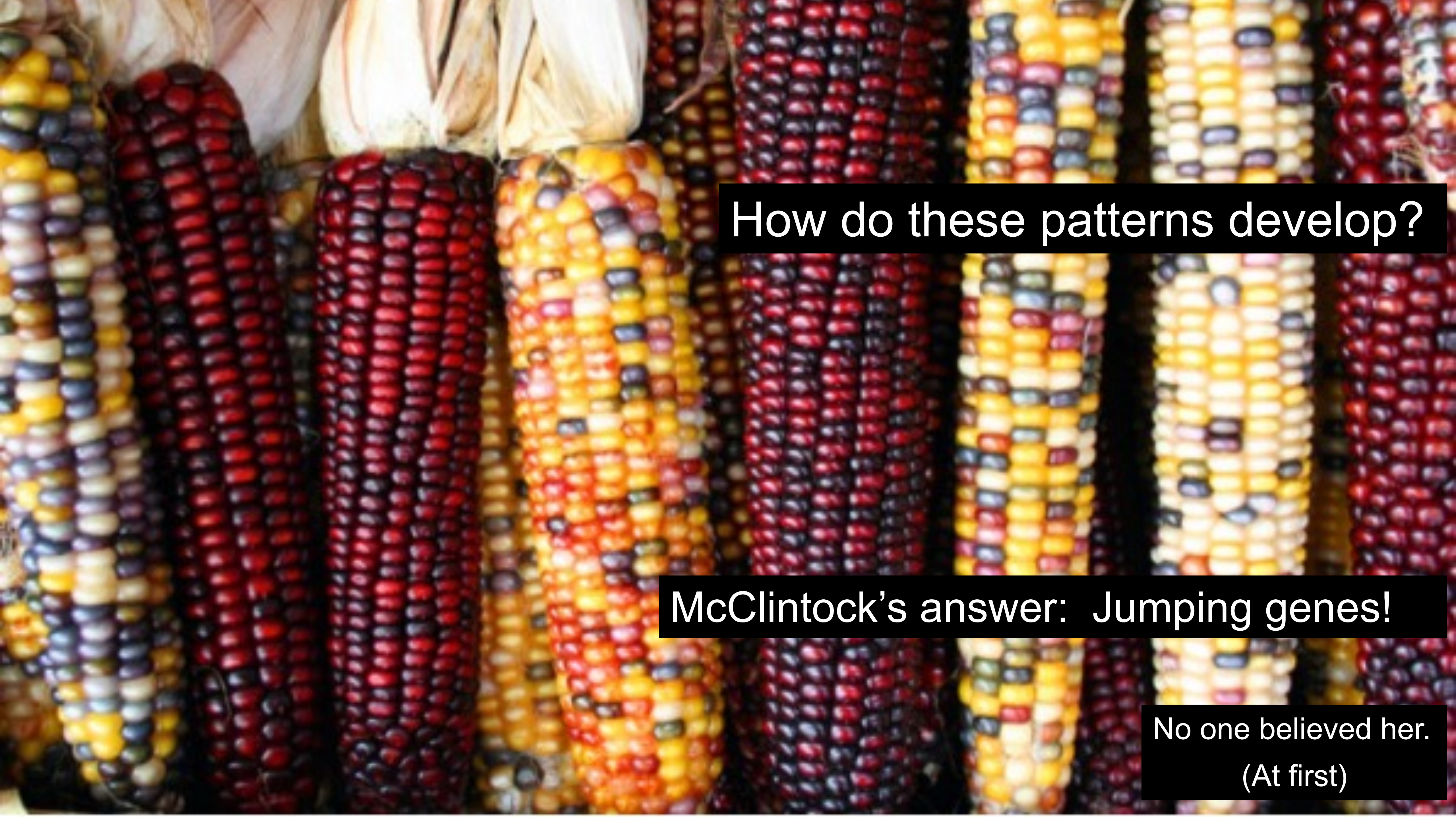
Ab initio SCF (self-consistent field) and CI (configuration interaction) calculations on the 1 $^3B_1$ and 1 $^3B_2$ states of $(BH_2)^+$ have been performed. The geometries, vibrational and rotational constants, as well as the dissociation energies for optimized equilibrium geometries, are compared with DIM (diatomics in molecules) model results.

In 1986, Merkel was awarded a doctorate (*Dr. rer. nat.*) for her thesis on quantum chemistry. Her paper "The Lowest Bound States of Triplet $(BH_2)^+$" was published the year the Berlin Wall came down. Merkel entered politics in 1990.

Barbara McClintock

1983 Nobel Prize in Physiology or Medicine, for work on the genetics of maize

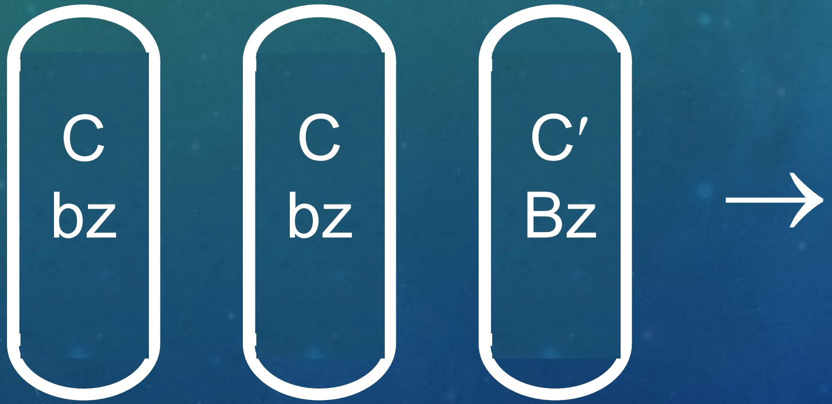
Photo from https://www.yourgenome.org/stories/unsung-heroes-in-science-barbara-mcclintock/

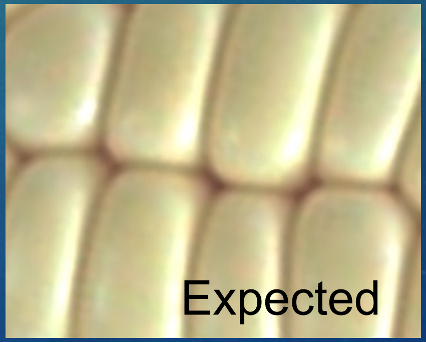

How do these patterns develop?
McClintock's answer: Jumping genes!
No one believed her.
(At first)

Corn cells have chromosomes in groups of three, rather than two. Several alleles control the color of the kernels:

C′	Dominant	Pale yellow kernels
C	Recessive	Permits color
Bz	Dominant over bz	Purple kernels
bz	Recessive	Brown kernels

Two female corn cell chromosomes, both C, bz
One male corn cell chromosome C′, Bz





???

Information from The Genetic Basis of Stuff and Things by Charlotte Scott, a review of McClintock’s 1951 paper.

How could this happen?

"La chance ne sourit qu′aux esprits bien préparés," Louis Pasteur

In 1930, Barbara McClintock was the first to describe the cross-shaped interaction of chromosomes during meiosis. In 1931, she and Harriet Creighton proved that chromosomes could cross over during meiosis.
In her experiments on the effects of X-rays on chromosomes, McClintock showed that chromosomes could break, and the broken segments could rejoin. Next, she discovered two dominant, interacting elements that she called Dissociation (Ds) and Activator (Ac). In the presence of Ac, Ds can move along the chromosome, resulting in chromosome breakage. The movement of Ds allowed C to be expressed, rather than C′. The kernels could gain color!

McClintock stopped publishing on this topic in 1953, due to opposition to her ideas. She won the Nobel Prize in Physiology or Medicine 30 years later.

https://en.wikipedia.org/wiki/Barbara_McClintock

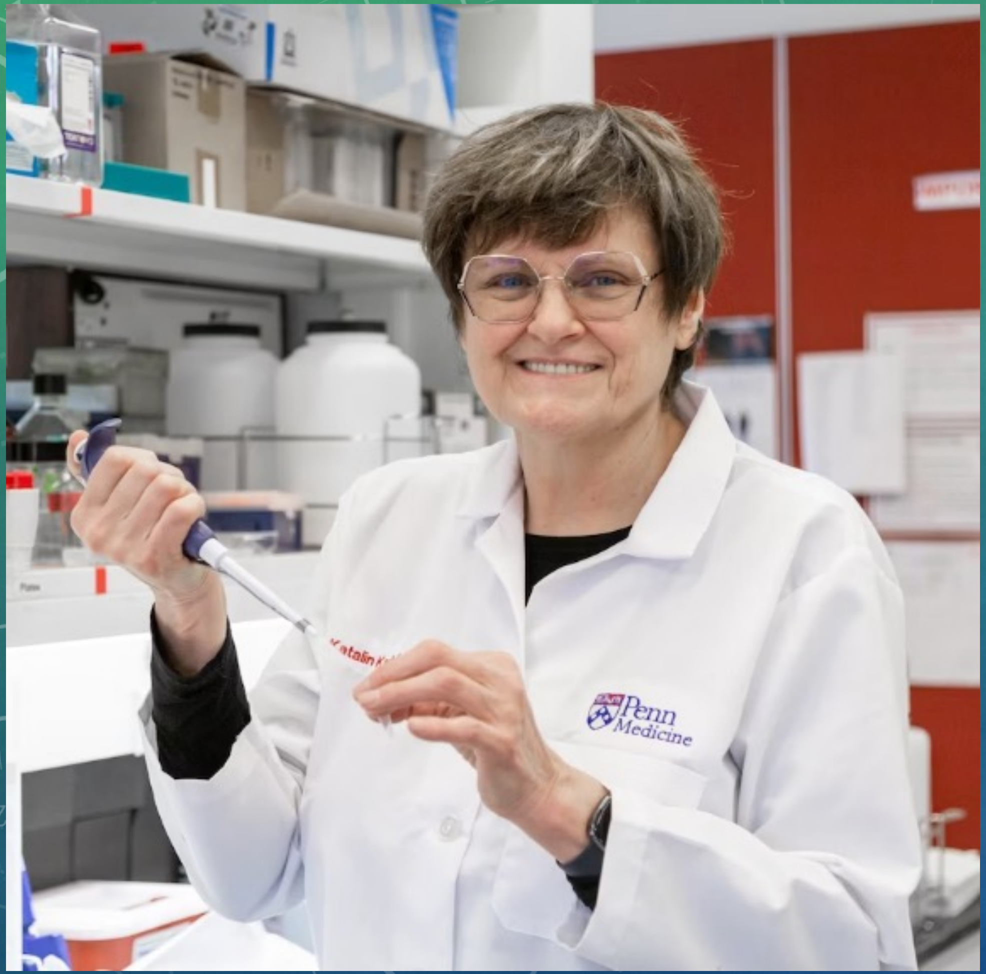
And many others!

Included today:
Curie
Lamarr
Meitner
Goeppert-Mayer
Payne-Gaposchkin
Noether
Fawcett
Daubechies
Strickland
L'Huillier
Merkel
McClintock

T shirt from goodteacherlife.com

More to know:
Carson
Hopper
Franklin
Goodall
Lovelace
Burnell
Hodgkin
Anning
Doudna
Cannon
Jackson
Jemison

One more: Katalin Karikó



Katalin Karikó and Drew Weissman received the 2023 Nobel Prize in Physiology or Medicine for their work to develop messenger RNA vaccines against Covid. Initially, mRNA always caused inflammatory reactions; but transfer RNA is not inflammatory. Karikó and Weissman discovered that replacing uridine in mRNA with pseudouridine prevented inflammation. They packaged the mRNA in small fat droplets, as a delivery mechanism.

Photo from https://www.diverseeducation.com/awards-honors/top-women/2023/article/15307306/dr-katalin-karik-university-of-pennsylvania

- 1985: Katalin Karikó left Hungary with her husband and their two-year-old daughter. They smuggled a total of £900 in their daughter’s teddy bear.
- 1985: Karikó became a postdoctoral fellow at Temple University.
- 1988: Karikó moved to the Uniformed Services University of the Health Sciences.
- 1989: Karikó was hired by the University of Pennsylvania as an adjunct professor, to work with Elliot Barnathan.
- 1990: Karikó submitted her first grant application to work on mRNA in gene therapy.
- 1995: After multiple grant rejections, Karikó accepted a demotion outside of the faculty ranks, in order to continue her research on mRNA.
- 1997: Drew Weissman was hired by the University of Pennsylvania as a Professor of Immunology. Karikó worked with him. Weissman said, “We had to fight the entire way.”
- 2013: Karikó left Penn to become a Vice President of BioNTech RNA Pharmaceuticals. As she left, she said, “In the future, this lab will be a museum.”
- 2023: Karikó and Weissman shared the Nobel Prize in Physiology or Medicine.

https://en.wikipedia.org/wiki/Katalin_Karikó
https://www.glamour.com/story/katalin-kariko-biontech-women-of-year-2021

I would like to express my very deep gratitude to the organizers of the Bridge Forum Dialogue for this evening's opportunity to describe the accomplishments of a remarkable set of women.
I am greatly honored by the invitation to speak!

At the University of Luxembourg, I am very grateful to the Institute for Advanced Studies for a DISTINGUISHED grant, which has made my visit possible.

I am also very grateful for the wonderful hospitality of the Department of Physics and Materials Science, and all the members of the Department. I have found a very exciting intellectual environment here, and I look forward to continuing collaborations after I have returned to my home university.