

EINSTEIN

An Educator's Guide

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FOR FURTHER INFORMATION AND ACTIVITIES, VISIT OUR WEB SITE AT WWW.AMNH.ORG/RESOURCES/EXHIBITIONS/EINSTEIN

EINSTEIN

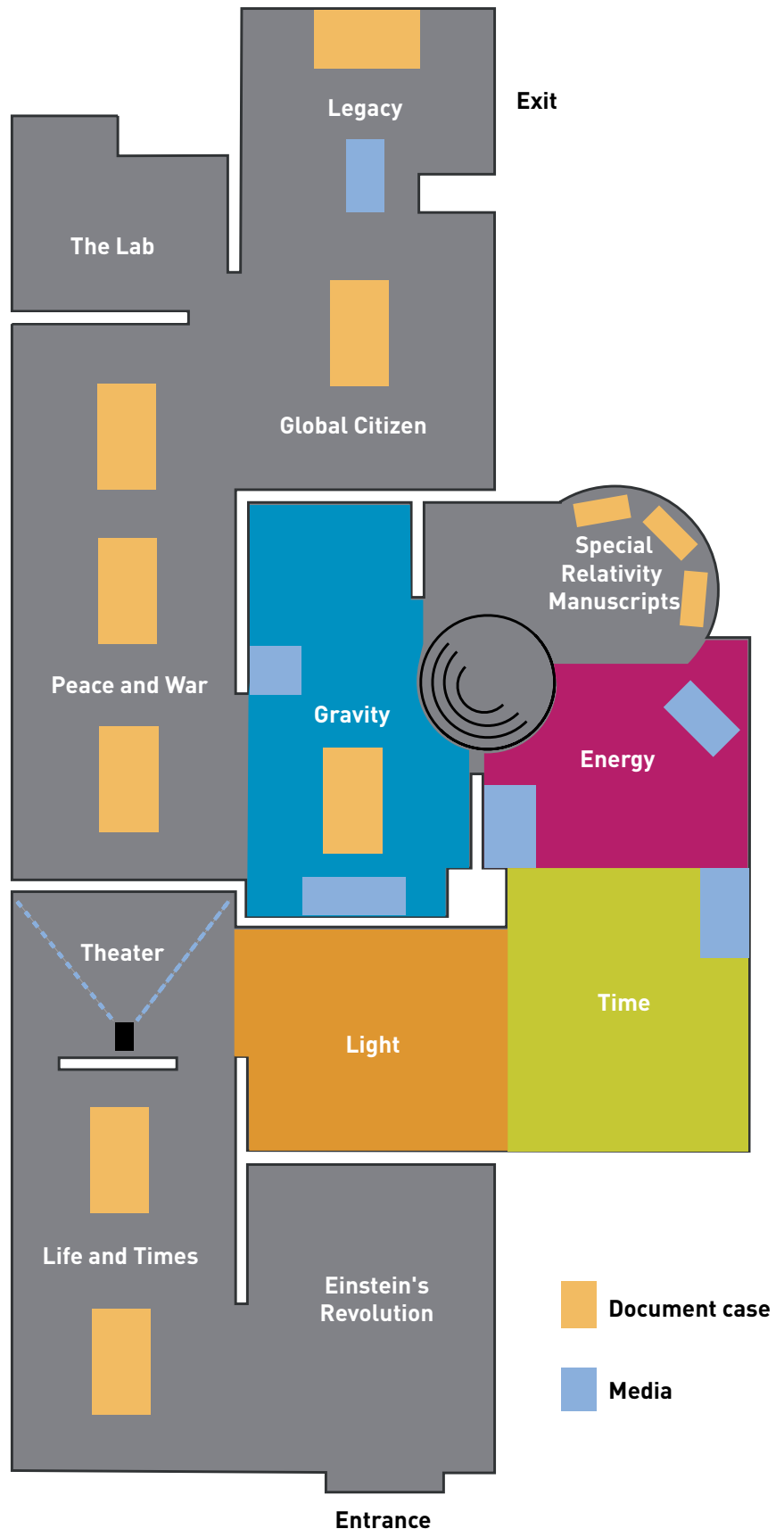
how to read the labels

Panel text in each **science section** of the exhibition provides:

- An introductory anecdote with Einstein's thinking on the subject.
- An "Einstein's Revolution" section that offers three pieces of information: how the world explained a subject before Einstein; flaws Einstein saw in this explanation; and finally Einstein's explanation.

Interactives, media, and exhibits further illuminate Einstein's theories throughout the exhibition.

In the **document sections**, wall text explores different themes in Einstein's life, and document cases address specific subjects.





KEY CONCEPTS and orientation

come prepared !

The Einstein Exhibition

The life of Albert Einstein represents a world full of imagination, science, history – and the limitless possibilities of the human mind. The exhibition captures the wonder of Einstein's world and the impact he had and continues to have on ours. Handwritten manuscripts, letters, personal effects, displays, interactives and videos bring to life Einstein's theories and concerns, giving students a window into the mind of a great thinker and humanitarian.

Teaching in the Museum

The Museum offers many opportunities for self-directed learning. Build flexibility into your planning to allow students to explore on their own.

The exhibition is full of revolutionary ideas that may seem counterintuitive. Remind students that this is an introduction, a way to get their feet wet—they are not expected to master Einstein's work.

Remember that your visit can be customized, and that the questions and activities in this guide can be adapted for different grades, class levels, and curriculum emphases. It may be helpful to review the questions in this guide's "Exhibition" section before your visit.

To help prepare students and to follow up after the visit, the complete exhibition text is available online at www.amnh.org/exhibitions

Explainers, trained specialists from the Education Department, will be stationed throughout the exhibition hall to provide information and answer questions. After 12:30 p.m., explainers will also be available in the Learning Lab, a physical-science hands-on laboratory set up in the Einstein exhibition. **Classes of up to 30 students can register for a free 45-minute program with activities based on their grade level.** Programs are at 10:30 a.m. and 11:30a.m. At all other times the Learning Lab is open for public visitation. Call (212) 769-5200 to register in advance.

The exhibition approaches Einstein in two main ways: through examination of his scientific work, and through his life and humanitarian endeavors. Multiple sub-themes run throughout the exhibition. These themes are provided in this guide under "Exhibition" and offer effective ways of presenting this wealth of information to students.

SCIENCE

A brilliant and imaginative thinker, Einstein revolutionized our ideas of space, time, light, and motion. He developed his ideas by investigating and applying the work of previous scientists. In a similar way, nearly all work in astrophysics in the last 50 years has built on Einstein's work.

- Albert Einstein was a theoretical physicist who used mathematics to formulate **models**, or representations, of his thought experiments. While some scientists work in labs or in the field, some scientists like Einstein use their minds and imagination to conduct experiments.
- Einstein conjectured that light travels at a constant speed; observers measure the same speed of light no matter how fast they are moving. In the **Special Theory of Relativity**, Einstein showed that mass and energy are related to each other—they are two forms of the same thing. He expressed it mathematically as $E = mc^2$, where E is the energy of mass (m) and c is the speed of light ("c" stands for *celeritas*, the Latin word for swiftness).
- Einstein showed in the Special Theory of Relativity that the rate at which time passes for each person depends on the speed at which that person is traveling.
- According to Einstein's **General Theory of Relativity**, **gravity** is not a force, but an effect of the warping of space-time produced by the presence of a mass. **Space-time**, in which all things live, is the union of three-dimensional space with the fourth dimension—time.

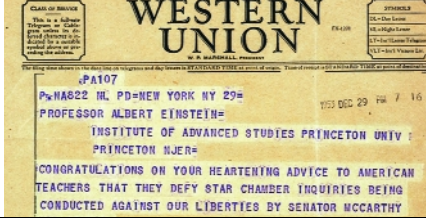
SOCIAL AND POLITICAL

Using his celebrity to influence social and political agendas, Einstein spoke out against anti-Semitism, segregation, McCarthyism and nuclear armament, and in favor of democracy and global government.

- Einstein believed in the **democratic system** of government. For this reason, he left Germany (and a teaching position there) in 1933 when the Nazis came to power. He emigrated to the United States and became a U.S. citizen in 1940.
- Einstein wrote to President Franklin D. Roosevelt to warn him that the Nazis might be developing a nuclear bomb. Einstein was a great **pacifist**; however, he did suggest that the U.S. should take steps to research atomic weapons. Later, he regretted sending this letter.
- Einstein's stand on civil rights and on **socialism** caused problems for him in the United States, but he held fast to his beliefs in spite of the pressures put on him. He spoke out against McCarthyism, encouraging the use of the First Amendment, and he defended individuals brought up before the House Un-American Activities Committee.
- Einstein was against **nationalism** and supported a single, unified world government.
- Einstein championed the creation of a Jewish homeland in the Middle East but stressed the need for cooperation between Jews and Arabs.



EXHIBITION



The seven themes below represent possible tours through the exhibition. Each has specific examples of questions to guide your students as they interact with the exhibition. In the following, exhibition sections are in color, displays are in bold.

LIGHT

Physicists before Einstein thought light traveled through a medium called ether. Setting himself apart, Einstein said the ether doesn't exist and that—with no medium to affect light waves—light travels at a constant speed.

- **Entire Exhibition: Einstein's Revolution** – Observation of the location of stars during a 1919 eclipse confirmed one of Einstein's predictions. Ask students:
 - How did Einstein's ideas about light make him a worldwide celebrity?
- **Light: Constant Speed** – A sculpture illustrating light's constant speed. Ask:
 - What is the message of the sculpture? What does it say about light?

TIME

One of the most startling concepts in Einstein's work is that time does not flow at a constant rate for all observers. If A is traveling much faster than B, then A's clock runs slower than B's—though neither will feel the difference.

- **Time: Frames of Reference** – The animation illustrates the impact of frame of reference on perspective. Ask:
 - Why do the observer and the basketball player see the ball behaving in different ways? Why are they both right?

before your visit

To help students more fully understand the science topics discussed in the exhibition and appreciate Albert Einstein's contributions to humanity, try the following discussion starters.

- Ask students what they already know about Einstein—his life, his contributions to science, the causes he pursued, etc. What would they like to learn about Einstein?
- Review vocabulary in bold.

Science

- Einstein's work touches many areas of science. Familiarize your students with some of the science subjects they will encounter at the exhibition, such as: **energy, light, gravity, mass, space,** and **eclipses**. Helpful Web sites include NASA's (http://lheawww.gsfc.nasa.gov/users/jacob/qa_gp.html) and the Moveable Museum Web site (<http://education.amnh.org/moveable/astronomy/>)
- Explain that Isaac Newton theorized that gravity was a force, and that time and space are absolutes. Building off these ideas, Einstein presented completely new views of the universe, such as his General Theory of Relativity, and expanded our three-dimensional understanding of space to include the

- **Time: A Matter of Time** – Watch the animation that explains Einstein's ideas about moving clocks. Ask:
 - Why is the time on the moving clock different than the time on the stationary clock?

ENERGY

Einstein is most famous for the equation $E = mc^2$. Before Einstein, energy and matter were considered two different things. Einstein said they are interrelated; mass is a form of energy, and energy is a form of mass. A small amount of mass can be converted into a large amount of energy.

- **Energy: $E=mc^2$ Interactive** – Exploration of Einstein's most famous equation. Ask:
 - What does each letter and symbol stand for? What does the equation mean?
- **Peace and War: A Call for Action, Einstein and the Bomb, The Nuclear Age** – This series of letters traces Einstein's role in the history of nuclear weapons. Ask:
 - What was Einstein's opinion about nuclear weapons? How did it change?

GRAVITY AND SPACE-TIME

According to Einstein, all objects with mass warp space-time, and this warping creates the effect of gravity. Mass and light travel along a straight path in space-time. However, if they encounter a warp, mass and light move along a bent path, following the shape of the warp.

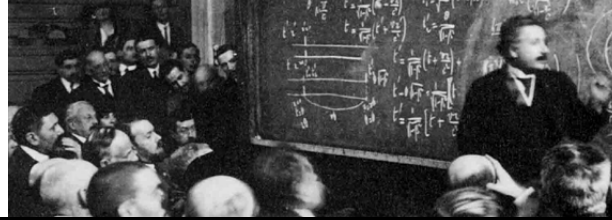
- **Gravity: You Bend Space-Time** – Einstein said any mass, even yours, warps space-time. Ask:
 - What happens to the grid as you approach the wall? How is this related to space-time?
- **Gravity: Black Holes** – The model shows one of the stranger things to come out of Einstein's General Relativity Theory—a black hole.
 - What is a black hole? Why do you think Einstein himself didn't believe they existed?

fourth dimension, time. To ease the exhibition's introduction of space-time (a description of the four-dimensional universe in which we live) and to reinforce students' understanding of space in three dimensions, discuss width, length, and height.

- Hold a class discussion on the nature of time. Ask students: What is time? How can it be measured? Does time flow in one direction only, or can it flow backward?

Social and Political

- Einstein's energy went beyond science. He helped shape and was shaped by world events taking place around him. Familiarize students with social studies topics they will encounter, such as: **World War I** and **World War II**, **Nazism, democracy, immigration, pacifism, civil rights, nationalism, McCarthyism**, and the **First and Fifth Amendments of the Constitution**.
- Admiring Jewish values, Einstein identified himself as a "cultural Jew," not a "religiously observant Jew." Ask students what they think he meant by this. Discuss their answers, guiding them to recognize the difference between ethnicity, religion, and nationality.
- Einstein used his fame to speak out for causes in which he believed. Ask students if they can name anyone who has used their fame to promote a cause.



THOUGHT EXPERIMENTS

Einstein used a pen, paper, mathematics, and—most importantly—his own imagination to explore the universe in his thought experiments.

- **Time: Time Machines** – This installation is a working thought experiment to help viewers understand the relativity of time. Ask:
 - Why do scientists sometimes use thought experiments like this one rather than conducting laboratory experiments?
- **Gravity: Introduction** – After reading the anecdote, ask:
 - What led Einstein to think about gravity and relativity?

EINSTEIN & THE WORLD

Einstein supported causes of peace, human rights, and international cooperation. An opponent of nationalism, a promoter of global government, and a Jew, he also considered himself a citizen of the world.

- **Peace & War: Introduction, The Making of a Pacifist** and **Global Citizen: Erasing National Boundaries** – Areas that show Einstein's first expressions of pacifism and anti-nationalism. Ask:
 - Why did Einstein favor world government over nationalism? Why was he a pacifist? What world events helped shape his beliefs?
- **Global Citizen: Einstein & Israel** – The letter that offers Einstein the presidency of Israel. Ask:
 - Why do you think Einstein declined?
- **Peace & War: The McCarthy Era** – A pacifist, Einstein admired Gandhi's use of peaceful methods in his struggle against Britain to gain India's independence.
 - Ask students to read the letter from Einstein to Katsu Hara on the insert. Have them locate the letter Einstein wrote to Rose Russell. What was Gandhi's goal and what method did he use to attain it?
- **Global Citizen: Communist Witch Hunts** – During the McCarthy era, U.S. citizens were tried for their political beliefs and asked to identify others who shared their beliefs. Ask:
 - Why did Einstein encourage people not to use the Fifth Amendment to defend themselves? Why did Einstein prefer the First Amendment?
- **Entire Exhibition: Einstein Quotes** – These quotes reveal his observations and opinions on many subjects. Einstein had a gift for presenting complex thoughts in simple, understandable language. Ask:
 - Which Einstein quotations do you find most interesting? Why? Does Einstein always talk or write with words you would expect a genius to use?

EINSTEIN'S REVOLUTION & EINSTEIN'S LEGACY

Einstein believed that all physical phenomena could be described in an all-encompassing Unified Theory. Today, Einstein's work still leads the way as scientists continue the search for a Unified Theory.

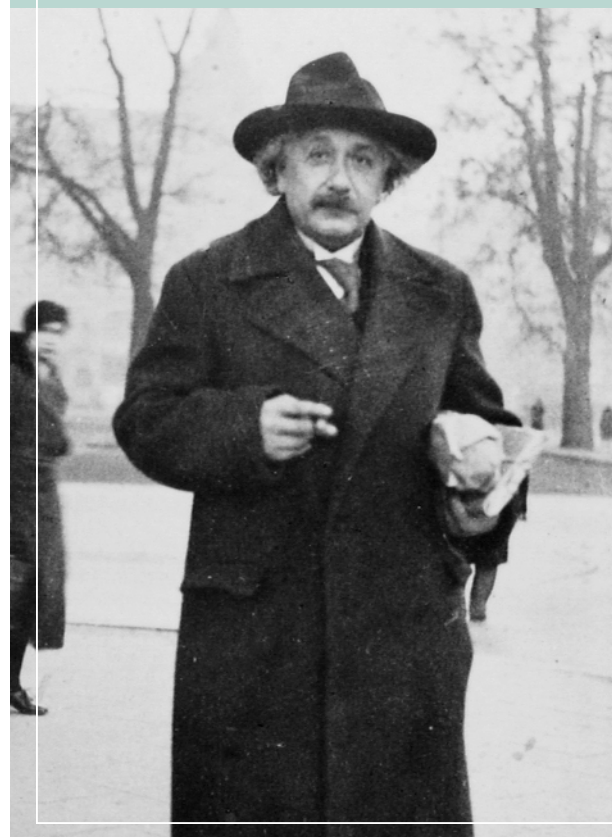
Other discoveries and applications influenced by his ideas include laser surgery, CDs, checkout scanners, X-rays, microwave ovens, global positioning satellites, and nuclear power plants.

- **Light, Time, Energy, and Gravity: Einstein's Revolution** – Introductory panel text found throughout the exhibition. Ask:
 - What effect did Einstein's ideas have on the scientific world?
- **Legacy: The Great Debate** – Physicists of today strive to make these two revolutions – Relativity and Quantum Theories – work together to describe the universe even more completely. Ask:
 - What was "The Great Debate?" How is it still a part of physics today?

while you're at the museum

Rose Center for Earth and Space

- **Lower Level:** A wonderful film, *Black Holes: Gravity's Ultimate Triumph*. Just outside this theater on the floor is an excellent visual presentation of black holes.
- **Planets Wall:** More about Isaac Newton's discoveries about gravity and our solar system's planets.
- **Universe Wall:** A presentation of Newton and Einstein's descriptions of gravity and gravitational lensing in the "Universality of Physical Laws."
- **Throughout the Rose Center:** Scales set in the floor measure your weight on different planets or celestial bodies, and allow you to observe the effect of differences in mass on gravity.
- **The end of the Cosmic Pathway:** Information that explores the gravity between Earth and the Moon. Investigate gravity and its relationship with ocean tides.





back in the classroom

Links to New York State Standards

The exhibition and the activities in this guide fulfill the following standards:

Math, Science, and Technology Standards

STANDARD 3: Mathematics Standard

STANDARD 4: Science Standard

STANDARD 6: Interconnectedness: Common Themes

STANDARD 7: Interdisciplinary Problem Solving

Social Studies Standards

STANDARD 1: History of the United States and New York

STANDARD 2: World History

STANDARD 3: Geography

STANDARD 5: Civics, Citizenship, and Government

References

A full list of recommended reading, including books for students ages seven and up, is available at:

www.amnh.org/resources/exhibitions/einstein

Breithaupt, Jim. *Einstein: A Beginner's Guide*. Hodder & Stoughton: London, 2000.

Calaprice, Alice, ed. *The Expanded Quotable Einstein*. Princeton University Press: Princeton, 2000.

Einstein, Albert. *Relativity: The Special and General Theory*. Wings Books: New York, 1961.

Hawking, Stephen. *The Universe in a Nutshell*. Bantam Doubleday Dell Pub.: New York, 2001.

Jerome, Fred. *The Einstein File: J. Edgar Hoover's Secret War Against the World-Famous Scientist*. St. Martin's Press: New York, 2002.

Strathern, Paul. *The Big Idea: Einstein and Relativity*. Anchor Books: New York, 1997.

For students ages seven and up:

Brallier, Jess M. *Who Was Albert Einstein?* Penguin Putnam, Inc., New York, 2002

John R. and Mary Gribbin. *Time and Space*. Dorling Kindersley Ltd.: London, 2000

Related Web sites

The *EINSTEIN* exhibition Web site:

<http://www.amnh.org/exhibitions>

The AMNH Moveable Museum site:

<http://education.amnh.org/moveable/astronomy/>

TIME.com person of the century profile on Einstein:

http://www.time.com/time/time100/poc/magazine/albert_einstein5a.html

An online exhibit chronicling the life of Albert Einstein:

<http://www.aip.org/history/einstein/>



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Planetary Pen Pals: Ask each student to pick a planet or a star and pretend to have a pen pal there. Have students write down a short back-and-forth conversation with their pen pals. Ask: How long would this conversation take if questions and responses traveled at the speed of light?

Elevator Antics: Ask students if they think they can quickly change their weight without leaving Earth (or going on a diet!). According to Einstein, they can. How? Have a student stand on a bathroom scale while in an elevator. Then ride up and down and watch the student's weight change as the elevator accelerates up and down. Why does this happen? Scales measure the gravity pulling on a mass. When the elevator goes up, your mass is working against gravity, and you appear heavier on the scale. When you go down, your mass is working with gravity, and you seem lighter.

Map It Out: To give students an appreciation of the global nature of Einstein's influence, display a world map and ask students to place a flag in the key countries covered in the exhibit. (Countries include Germany, Switzerland, Israel, Italy, Czech Republic, India, Japan, and the United States.) Students can go online, recall their visit to the exhibition, or do additional research.

Discussion Starters:

- Einstein supported the idea of global government. Discuss with students if they think this idea is feasible.
- Einstein was an immigrant to the United States. He left Germany in 1933 because he disagreed with the politics of the Nazi government and the dangers it presented for him as a Jew. Ask: How do you think Einstein felt toward his adopted country? Discuss what it means to be an immigrant. What are the challenges immigrants face entering a new country?
- Einstein was a Jew who held passports to Germany, Switzerland, and the United States. Ask: Why do we identify ourselves with different nationalities and ethnicities? Why do some of us identify with two or more nationalities? What does it mean to be American?

Activities on the Web:

- For additional activities on gravity, light, and space, visit NASA's Jet Propulsion Laboratory Web site, "The Space Place."
http://spaceplace.nasa.gov/teachers_page2.htm
- Visit the "A Walk Through Time" and create a history of timekeeping timeline.
<http://physics.nist.gov/GenInt/Time/time.html>
- Visit the NOVA Web site on Einstein, which includes a teacher's guide and activities.
<http://www.pbs.org/wgbh/nova/einstein/>



Credits

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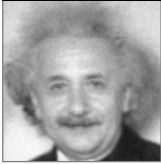
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Back cover – top: Courtesy of the Albert Einstein Archives; bottom: AMNH

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Einstein in Time

Albert Einstein has been called one of the freest people who ever lived. He didn't let anything hold back his imagination and it powered him to completely new places. As a great humanitarian, Einstein supported causes that helped people around the globe. Take a trip through his incredible life and see for yourself!

Year	Event	Quote
1879	Albert Einstein is born on March 14 to a Jewish family in Ulm, Germany.	
1884	Receives a compass from his dad, which sparks his curiosity about how things work. This curiosity leads to a lifelong love of physics, mathematics and philosophy.	<i>"I have no special talent, I am only passionately curious."</i>
1885	Starts playing the violin.	<i>"If I were not a physicist, I would probably be a musician...I get most joy in life out of music."</i>
1896	Enrolls in university in Switzerland and gives up German citizenship. Later he becomes a Swiss citizen.	
1902	After graduating from Zurich Polytechnic Institute, he takes a job in a Swiss patent office.	
1905	Publishes papers that deal with his Special Theory of Relativity, photoelectric effect, and the original version of the equation $E=mc^2$. It has been called his "year of miracles."	<i>"I am now working very eagerly on electrodynamics of moving bodies, which promises to become a capital paper."</i>
1918	While in Jerusalem, he delivers the first scientific lecture at Hebrew University.	
1919	Becomes a worldwide celebrity when Sir Arthur Eddington confirms his 1915 General Theory of Relativity. Begins to use his celebrity to champion causes he believes in, including the formation of a Jewish state.	<i>"The bond that has united the Jews for thousands of years and that unites them today is, above all, the democratic ideal of social justice, coupled with the idea of mutual aid and tolerance among people."</i>
1921	Wins the Nobel Prize in physics.	
1925	Signs a document with Gandhi against forcing men into military service.	<i>"Peace cannot be achieved through violence, it can only be attained through understanding."</i>
1932	Spends several months teaching at CalTech in Pasadena, California, where his fame leads to contact with movie stars and other celebrities.	
1933	Gives up his job at a school in Germany as the Nazi party comes to power. Joins the Institute for Advanced Study at Princeton, NJ.	<i>"I did not wish to live in a country where the individual does not enjoy equality before the law and freedom to say and teach what he likes."</i>
1939	Writes to President Franklin D. Roosevelt urging U.S. to develop atomic energy research. He is concerned that Nazi Germany's research will soon allow it to build an atomic bomb. Later, he regrets sending the letter.	<i>"I made one mistake in my life—when I signed that letter to President Roosevelt advocating that the bomb should be built..."</i>
1940	Becomes a U.S. citizen.	<i>"America is today the hope of all honorable men who respect the rights of their fellow men and who believe in the principles of freedom."</i>
1952	Turns down an offer from the State of Israel, which is 4 years old, to be its president.	
1953	Speaks out against the mistreatment of those unjustly accused of being communists during the era of McCarthyism.	<i>"In the last analysis, everybody is a human being."</i>
1955	Dies on April 18 at Princeton Hospital.	
2000	Time Magazine names Einstein "Person of the Century."	



Einstein letter to Katsu Hara, editor of Japanese magazine, *Kaizo*, 1952.

courtesy J. Jehle

On My Participation In The Atom Bomb Project

by A. Einstein

My participation in the production of the atom bomb consisted in a single act: I signed a letter to President Roosevelt. This letter stressed the necessity of large scale experimentation to ascertain the possibility of producing an atom bomb.

I was well aware of the dreadful danger for all mankind, if these experiments would succeed. But the probability that the Germans might work on that very problem with good chance of success prompted me to take that step. I did not see any other way out, although I always was a convinced pacifist. To kill in war time, it seems to me, is in no way better than common murder.

As long however, as nations are not ready to abolish war by common action and to solve their conflicts in a peaceful way on a legal basis, they feel compelled to prepare for war. They feel moreover compelled to prepare the most abominable means, in order not to be left behind in the general armaments race. Such procedure leads inevitable to war, which, in turn, under today's conditions, spells universal destruction.

Under such circumstances there is no hope in combating the production of specific weapons or means of destruction. Only radical abolition of war and of danger of war can help. Towards this goal one should strive; in fact nobody should allow himself to be forced into actions contrary to this goal. This is a harsh demand for anyone who is aware of his social inter-relatedness; but it can be followed.

Gandhi, the greatest political genius of our time has shown the way, and has demonstrated ~~the~~ sacrifices man is willing to bring if only he has found the right way. His work for the liberation of India is a living example that man's will, sustained by an indomitable conviction is stronger than apparently invincible material power.

Albert Einstein
A. Einstein

"Science has brought forth this danger [atomic weaponry], but the real problem is in the minds and hearts of men. We will change the hearts of other men [only] by changing our own hearts and speaking bravely."

- Albert Einstein at the fifth Nobel Anniversary Dinner in New York, 1945.

INVESTIGATE

- Based on this document do you think Einstein regretted his letter to President Franklin D. Roosevelt?
- Einstein says he engaged in a "single act." Do you think that a single act by an individual can have global repercussions? Explain why or why not.
- After writing his letter to Roosevelt, how can Einstein still maintain his pacifist ideas? Refer directly to this letter. According to the letter, what circumstances led to the production of certain weapons or means of destruction?
- When you get to the exhibition, read the letter by Katsu Hara, editor of the Japanese magazine, *Kaizo*, that prompted this letter from Einstein (in *Peace & War: Einstein & the Bomb* document case, or read the letter online). Do you think that Einstein sufficiently answers the questions posed by the editor? Why or why not?



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