

# Nuclear Energy

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# What Is Nuclear Energy, and How is it Produced?

Nuclear energy is made from reactions within an atom's nucleus. The three reactions that are most common are:

- Fusion- when atoms are combined or "fused" together
- Fission- when nuclei are split apart
- Radioactive Decay- when particles decay at a known rate, depending upon the type of element

Uranium isotopes are the primary elements used to produce nuclear energy.

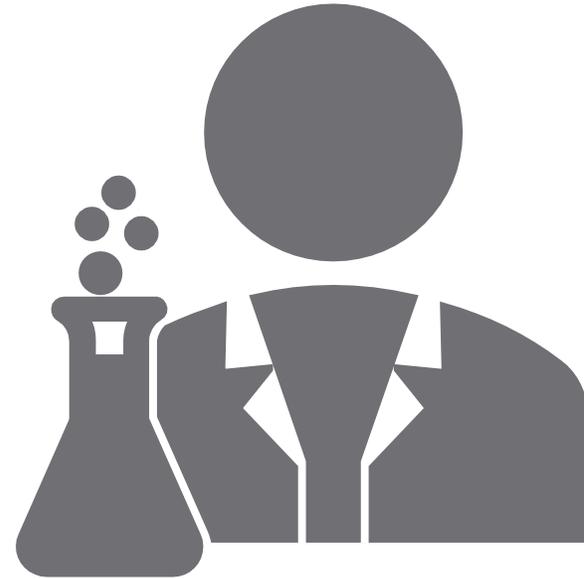
# Key Historical Events

**1932**

- James Chadwick discovers the neutron
- Cockcroft and Walton accomplish the first artificial splitting of a nucleus through bombarding the nucleus with accelerated protons

**1938**

- Picking up from previous experiments completed by Enrico Fermi, Otto Hahn and Fritz Strassman conclude that lighter elements such as barium produced from uranium shows that atomic fission had occurred, a process that was found to release a tremendous amount of energy (nuclear energy)



# Advantages of Nuclear Energy

- Nuclear energy has a variety of uses including:
  - Electricity
  - To power large, advanced vehicles such as submarines & space probes
  - Used for research in the scientific & medical fields
- Doesn't emit carbon dioxide or air pollutants so it is considered a "clean" energy source when it comes to air quality
- Reliable and cost effective
- Uranium is widely available, bringing more stable and predictable prices
- Higher electrical generation capacity and lower transmission costs than renewable energy

# Risks & Disadvantages of Nuclear Energy

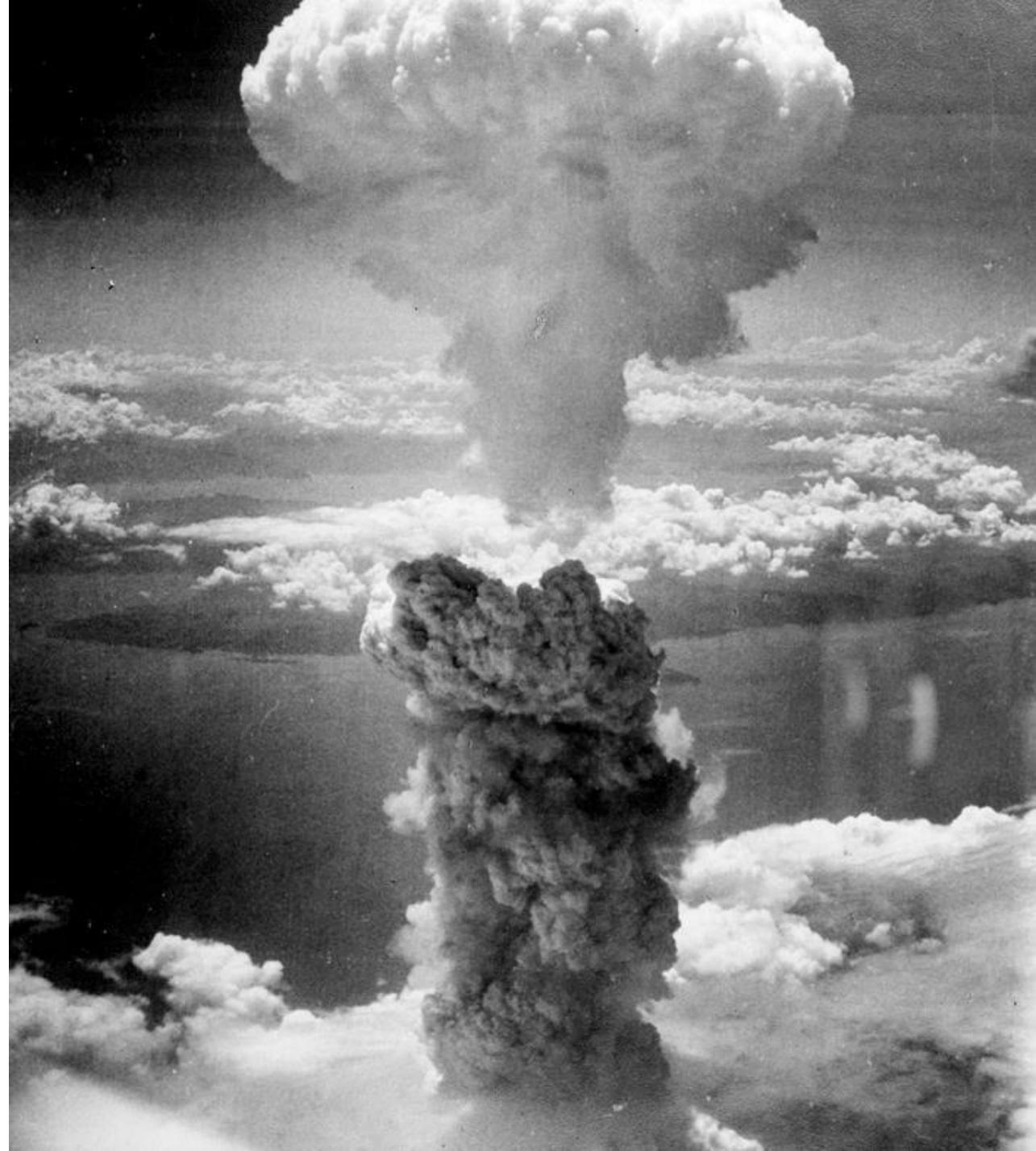
- Mistakes or errors (or intentional attacks using nuclear power) can cause catastrophic damage and lead to exposure of excessive and even fatal radiation
  - Three nuclear accidents that have occurred:
    - Three Mile Island (Pennsylvania, 1979)
    - Chernobyl (Ukraine, 1986)
    - Fukushima Daiichi (Japan, 2011)
- More costly than most renewable energy sources
- Creates radioactive waste that is difficult to store/dispose of and can contaminate soil, water, and crops
- Heat and radioactivity from used fuel takes several decades to decrease to safer levels through cooling in ponds/pools
- Nonrenewable
- Nuclear power plants can be expensive to build (construction delays, cost overruns)
- Plants are expensive to decommission also
- Plants are suspected targets for terrorism, sabotage, or cyberattacks
- Thermal pollution

A dark, grainy photograph of a tented structure, possibly a military or aid station, with the text 'Terrorism & Nuclear Weapons' overlaid in white. The background shows a large, dark tent with a white canopy on the right side. The text is centered and reads 'Terrorism & Nuclear Weapons' in a large, white, serif font.

# Terrorism & Nuclear Weapons

# The Manhattan Project

- The two atomic bombs created during the Manhattan Project in 1945 called “Little Boy” and “Fat Man” were released by the United States onto the two Japanese cities of Hiroshima and Nagasaki
- This caused nearly 80,000 deaths in both cities combined, the majority dying immediately after the bombing and another 60,000 people suffering severe injuries





Damage to  
Hiroshima



# Damage to Nagasaki



# Nuclear Disasters

# Three Mile Island



Three Mile Island Nuclear Generating Station in Pennsylvania on March 28, 1979



Caused by a partial meltdown & fire



A sequence of human errors, failures in the machinery, and flaws in the design ultimately lead to coolant being lost that was important for the reactor



Low-level radiation released among the citizens, prmildest nuclear accident



Three Mile Island

# Chernobyl

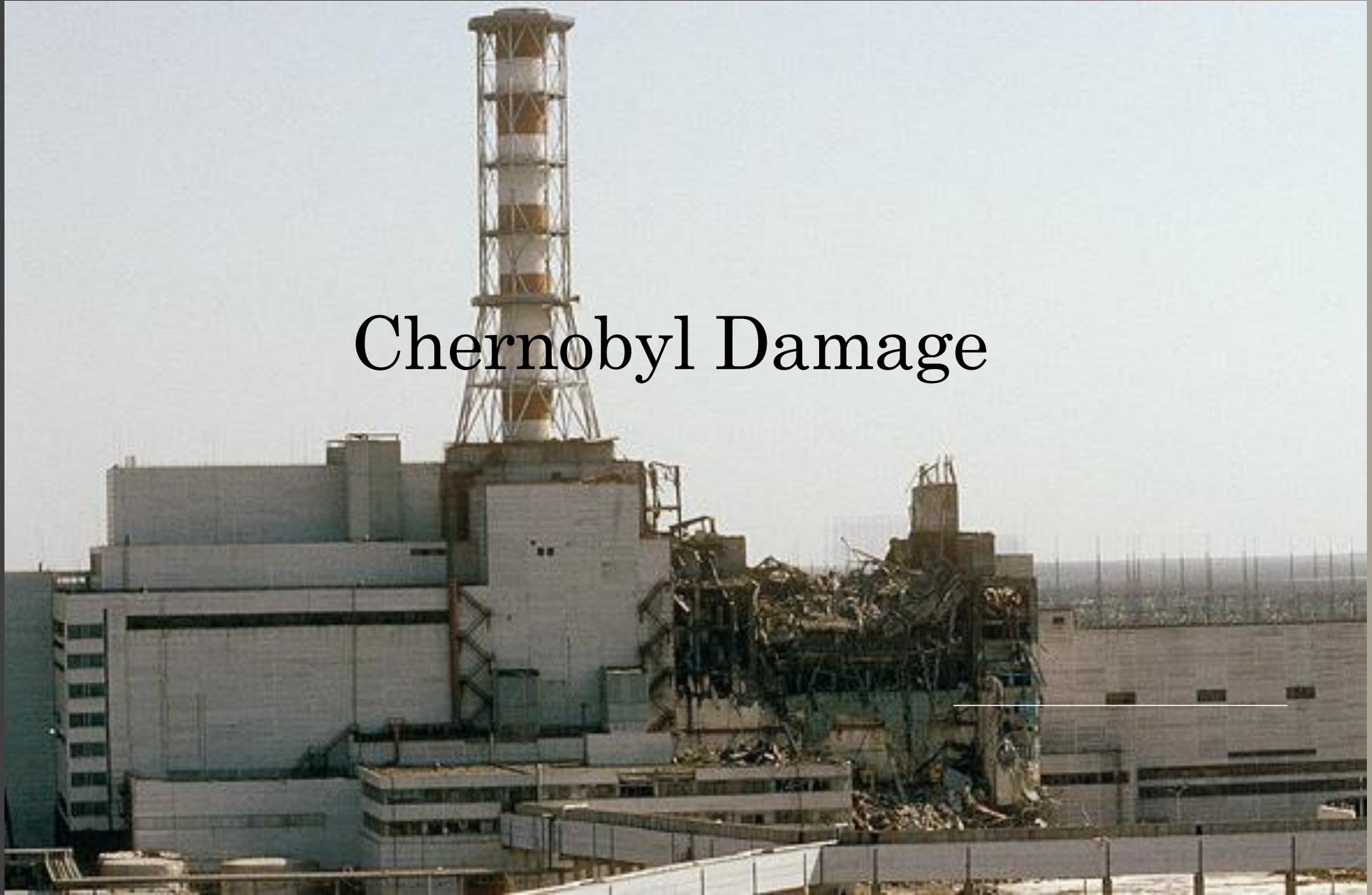
April 26, 1986 at the Chernobyl nuclear power plant in Chernobyl, Ukraine

Root cause was a part of the nuclear power plant design that made the fission reaction increase while the cooling water density decreased

Ultimately caused by human error, including an experiment that went awry and sent the Reactor 4 into meltdown, several violations of safety, and complicated design of the reactor which made it hard to control and operate

Within one day the entire town was evacuated, and a few days later those living within 30 kilometers of the nuclear power plant were also evacuated, totaling around 135,000 people, and after roughly four months 31 people had died from radiation sickness and burns; the worst nuclear disaster

# Chernobyl Damage



# Fukushima



Occurred at the Fukushima Daiichi Nuclear Power Plant in the city of Fukushima, Japan, on March 11, 2011



Caused by a severely destructive earthquake followed by a tsunami that led to a reactor core melt



Released massive amounts of radionuclides into the ocean as well as onto the surface of the water and land, making the conditions unlivable for both humans and wildlife



Over 120,000 people evacuated their homes and radiation caused a significantly higher proportion of HR-positive breast cancer than before the disaster

# Fukushima Damage





# Nuclear Waste

# Facts About Nuclear Waste



Nuclear power plants produce radioactive waste as a byproduct of power generation



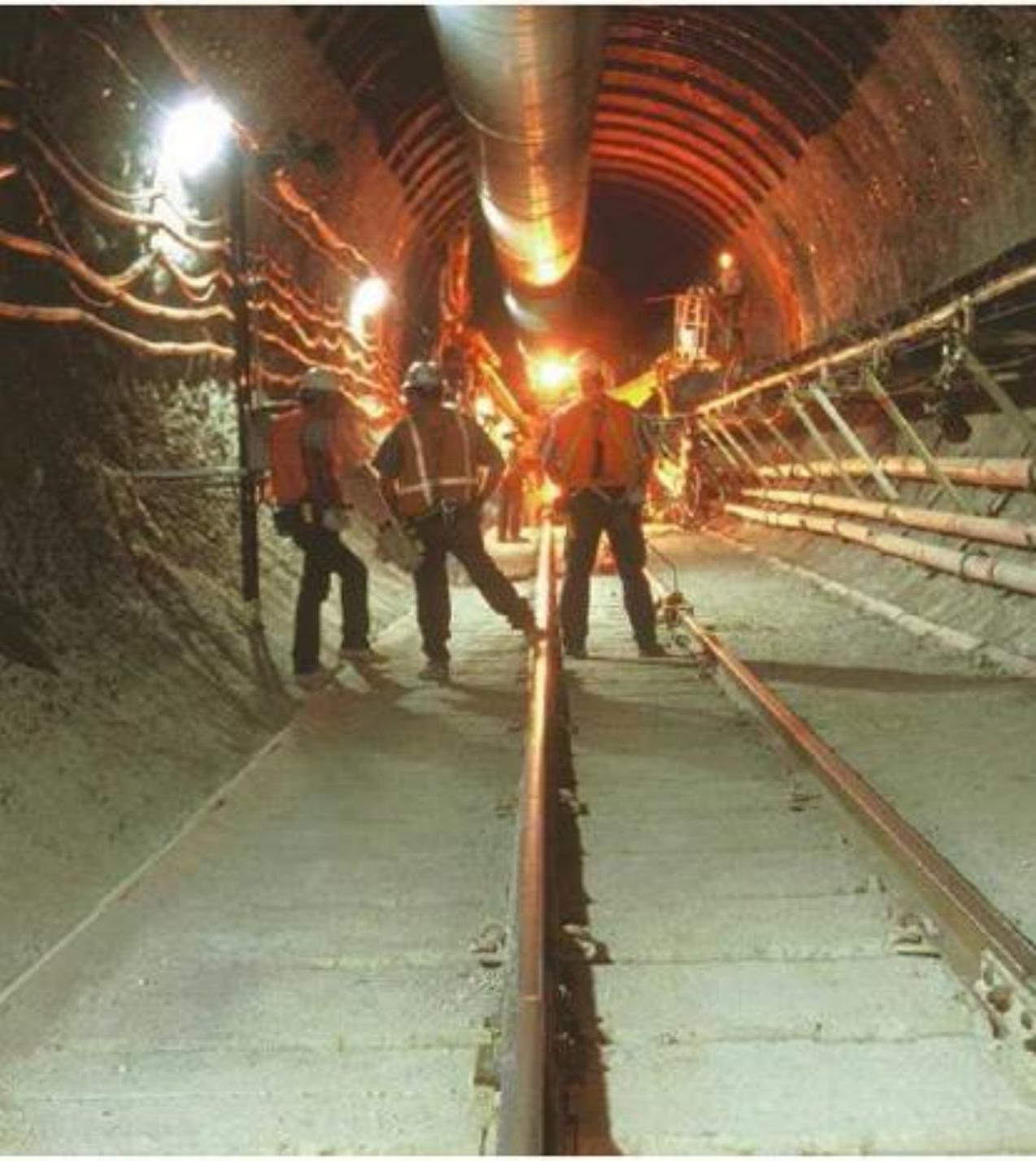
If radiation is released into the environment, it can contaminate soil, water, and food crops



Exposure to radiation through these can damage human cells, resulting in genetic changes that increase the risk of cancer, birth defects, and other health effects



Most nuclear power plants store the spent nuclear fuel rods in pools of water to cool them and prevent exposure to humans and the environment, but this leads to thermal pollution and contamination of water



# Yucca Mountain

- Potential facility for nuclear waste storage at a volcanic ridge in Nevada, has been debated for decades
- Supported because of its dry and desert-like geological features
- Contains two fault lines and the volcano is quite dormant, suggesting that no earthquakes or volcanic eruptions are expected to take place in this area for several thousand years
- May not be able to support the storage of some high-level nuclear waste, which may require 1-2 million years of storage

# Takeaway

- Risks of nuclear energy largely outweigh the benefits
- Has the potential to threaten any form of life in multiple different ways, including through:
  - Terrorism
  - Disasters
  - Dangerously radioactive waste
- Nuclear energy is only continuing to expand but it is important to keep ourselves informed as citizens to make sure our country is making the right decisions
- As science and technology advance, we can increase the potential to explore new sources of energy and improve the safety and usefulness of these sources
- Learning from historical mistakes will be key to shaping and creating a better future for ourselves and the planet

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