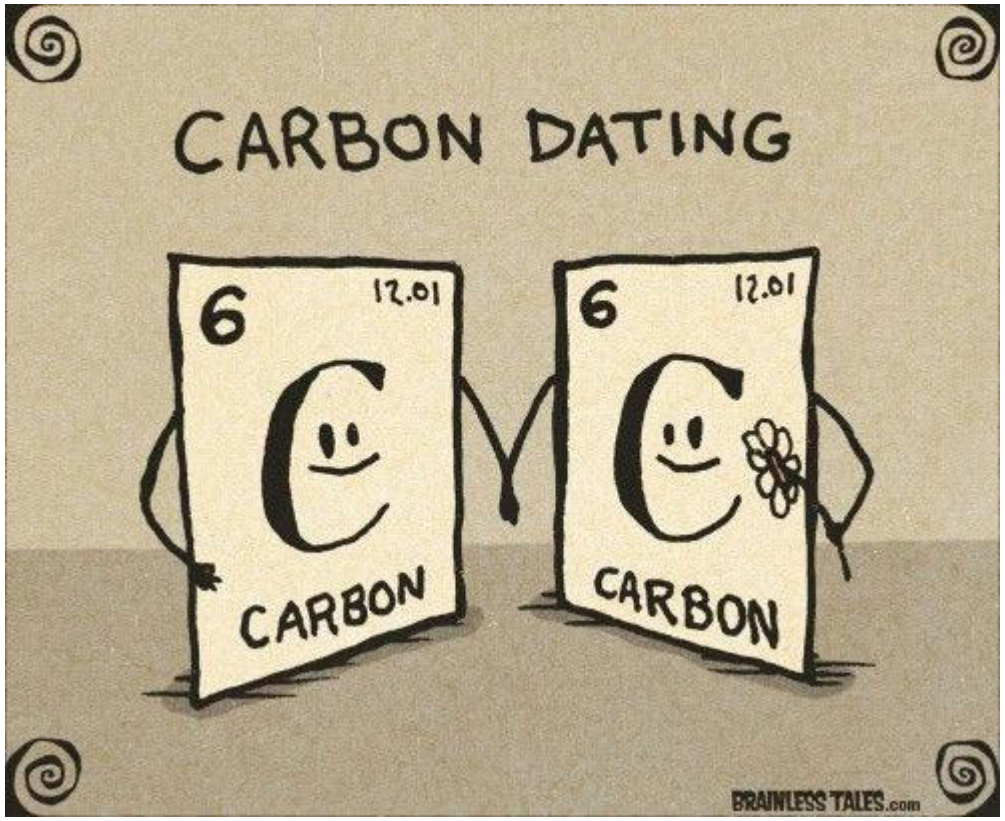
# Radiocarbon Dating

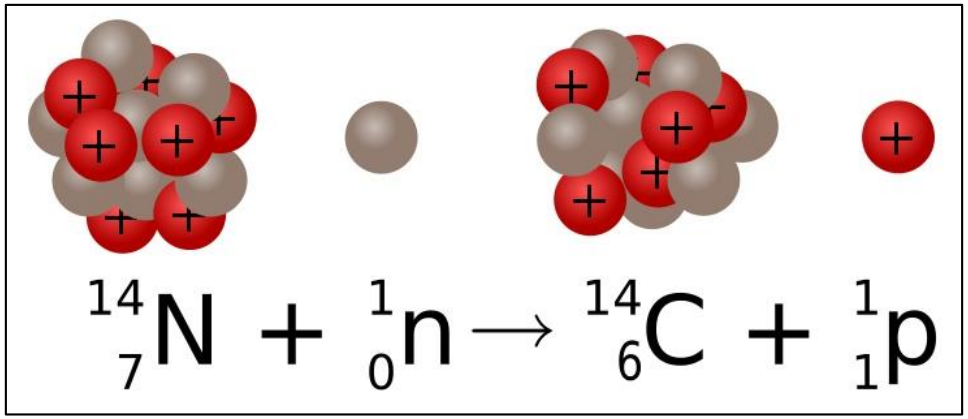



30TH OCTOBER 2019

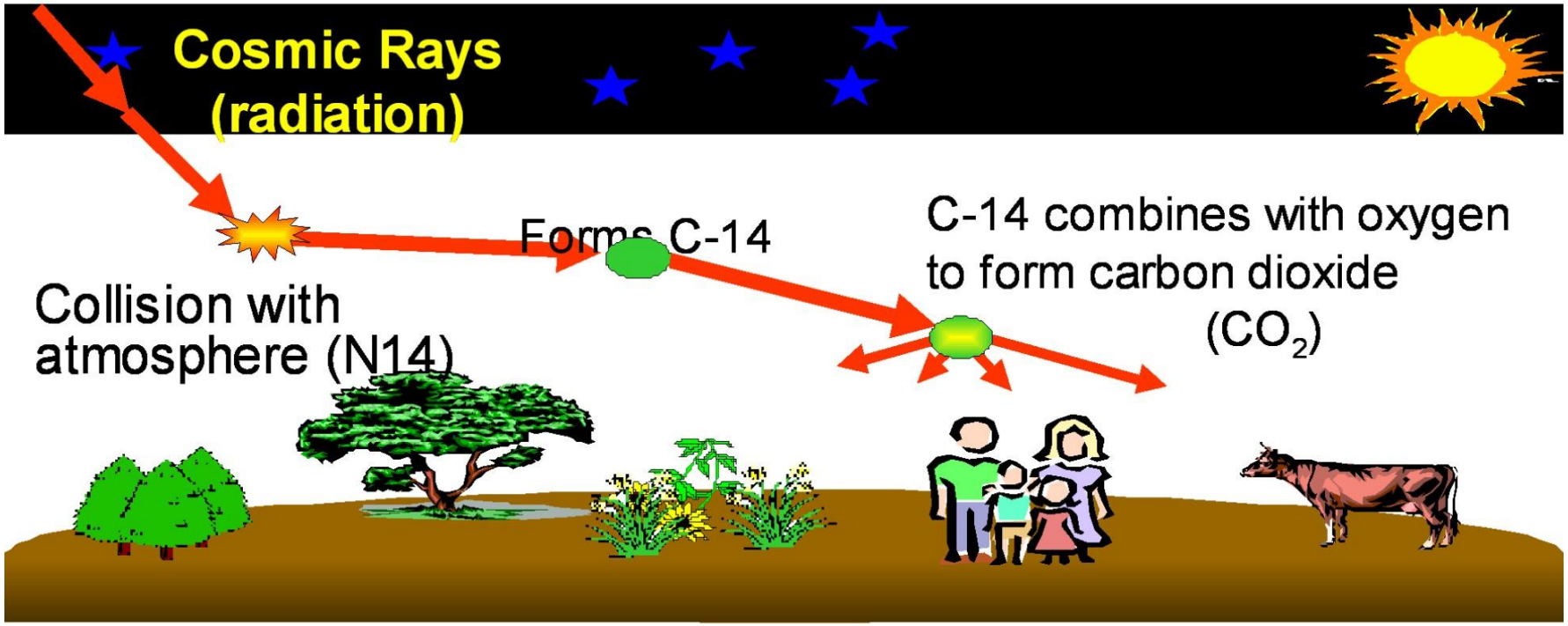
https://www.chemistryjokes.com/jokes/carbon-dating/

# Carbon dating

- Carbon dating is the use of decaying nitrogen of radiocarbon, or C-14
- The C-14 is produced at a constant rate via the interaction of cosmic rays with atmospheric nitrogen in the upper atmosphere.
- The ratio of the number of C-14 atoms to the number of C-12 atoms is constant in time, at a value of approximately **$1.20 \times 10^{-12}$**.
- The ratio C-14/C-12 decreases in time as C-14 decays at the death of the living things.
- Measuring this ratio in a tissue sample can determine how long the living thing has been dead.

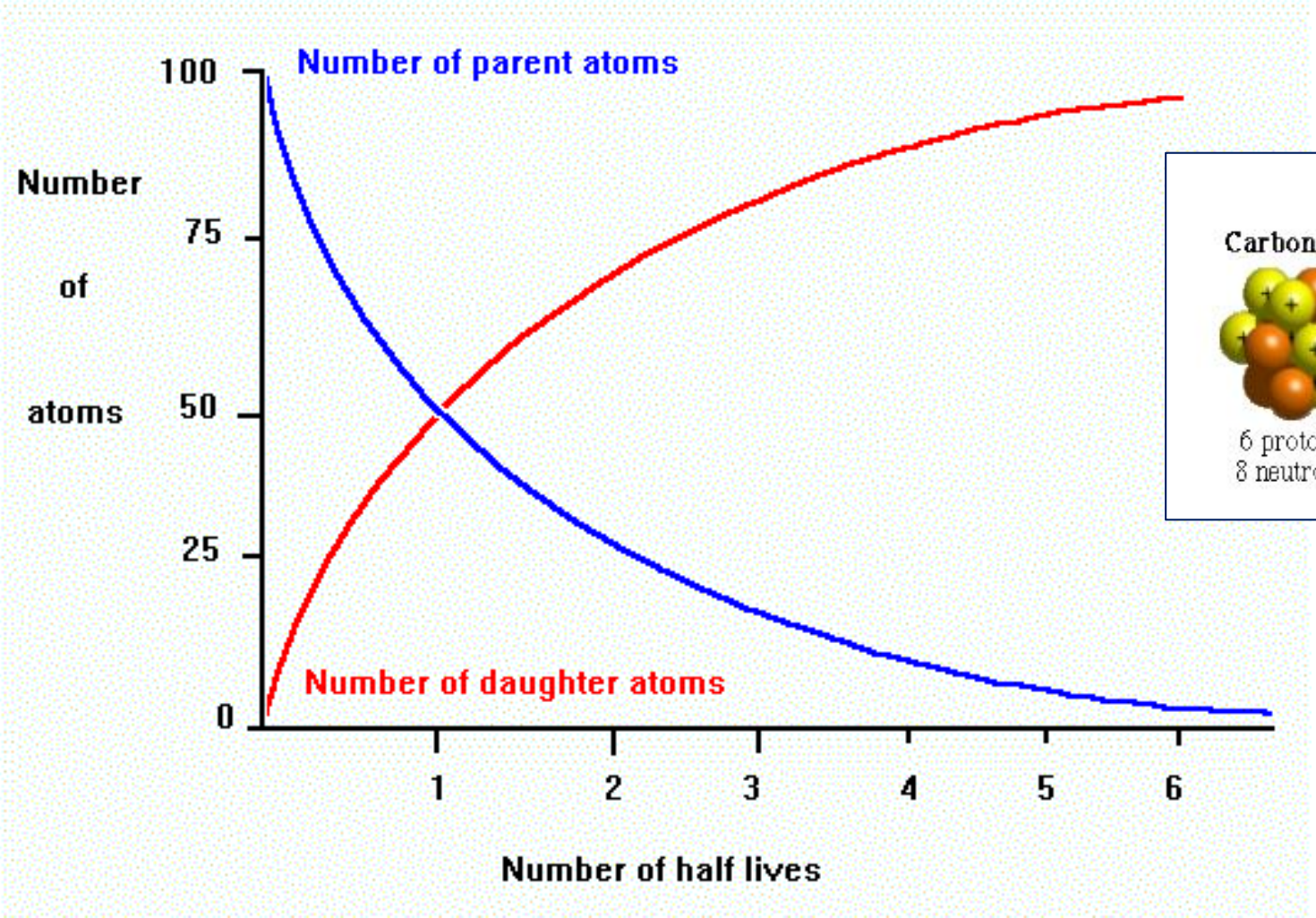


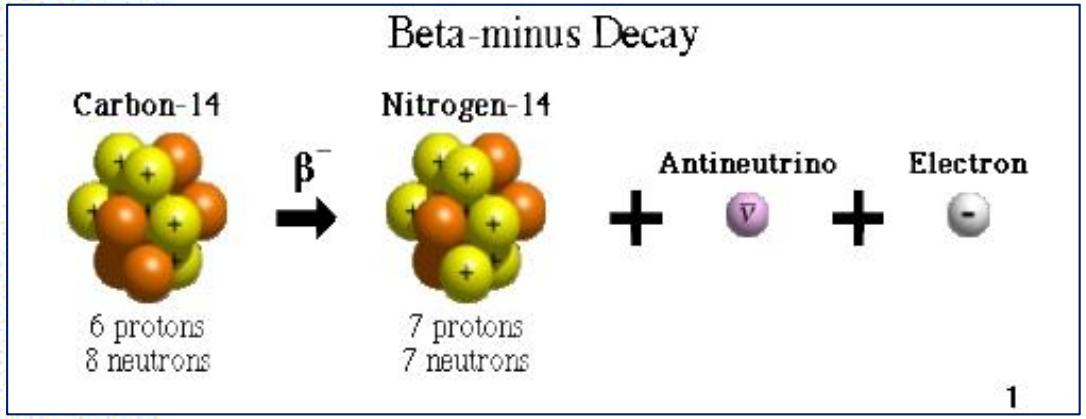

# How Carbon-14 Is Produced




http://seethethingis.wordpress.com/2012/04/12/carbon-14-decaying-into-carbon-12-its-not-exactly-science-is-it/

# The rate of decay is proportional to the number of parent atoms present.

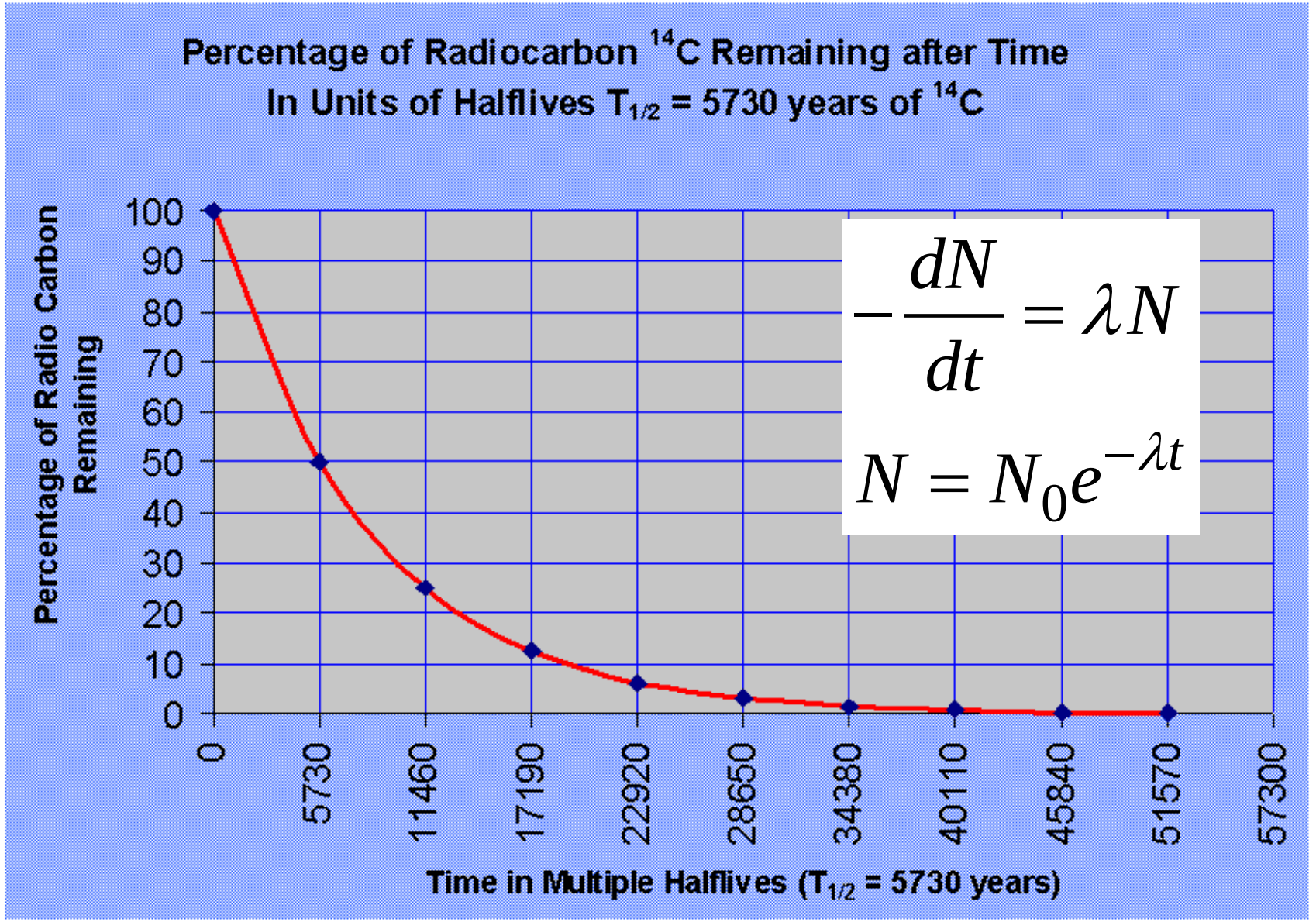



If there is three times as much daughter as parent, the …….half lives have passed.

http://www.das.uchile.cl/~mhamuy/radio.html

# C-14 half life




http://extinctionshift.com/KNOWLEDGE_BIBLE/Firmament_Gen2C.htm

The Nobel Prize in Chemistry 1960
Willard F. Libby

*Share this:* 14

# The Nobel Prize in Chemistry 1960

Willard Frank Libby
Prize share: 1/1

The Nobel Prize in Chemistry 1960 was awarded to Willard F. Libby *"for his method to use carbon-14 for age determination in archaeology, geology, geophysics, and other branches of science".*

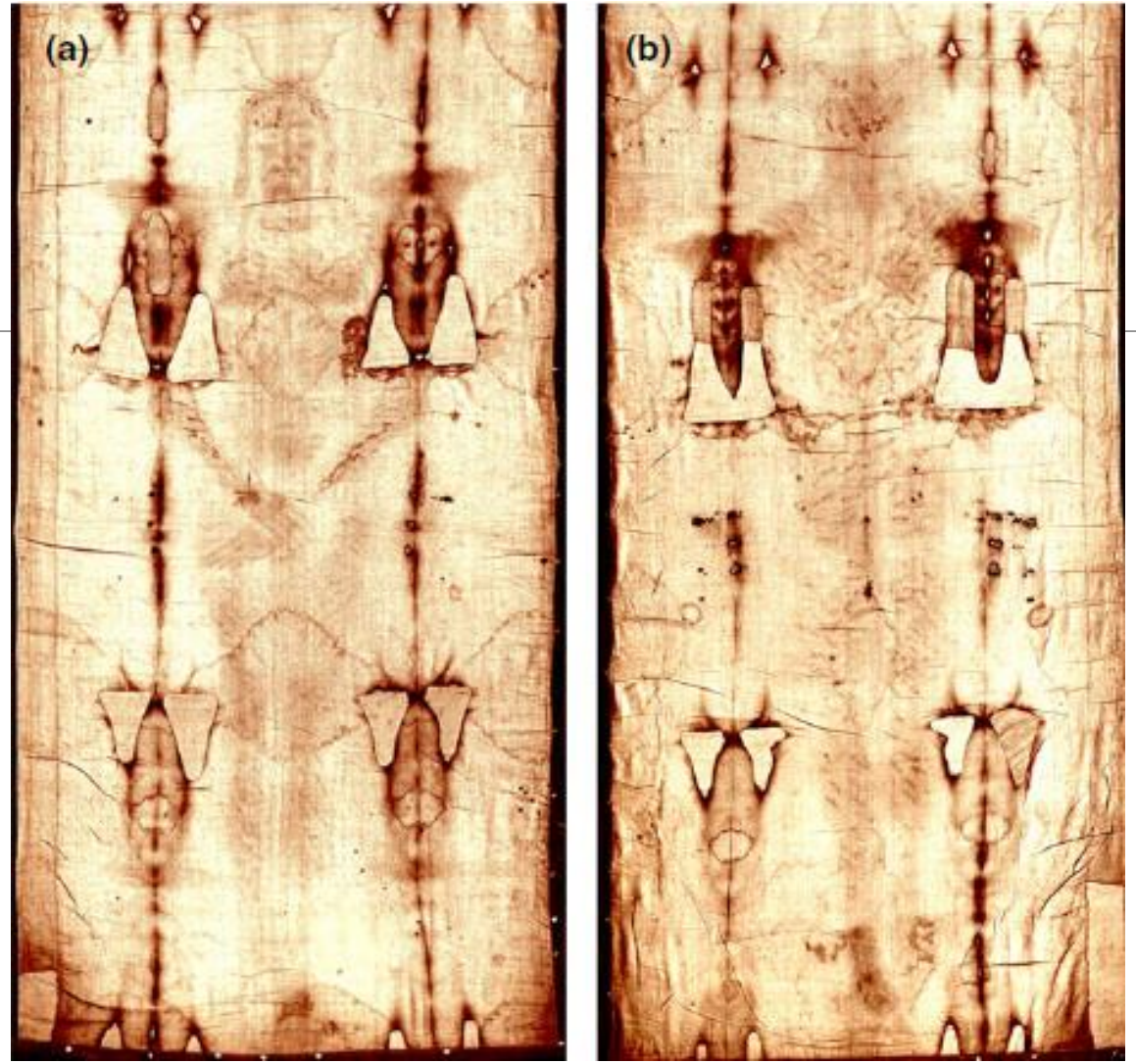
The American physical chemist Willard Frank Libby (1908-1980) discovered the method of carbon dating in 1949 and was awarded the 1960 Nobel Prize in Chemistry for this achievement.

https://www.nobelprize.org/nobel_prizes/chemistry/laureates/1960/

# Solved Problem : Carbon dating

- The Shroud of Turin is large piece of linen cloth that some people claim is the burial shroud of Jesus of Nazareth.
- It is kept in the Cathedral of Saint John the Beptist in Turin, Italy.
- In 1988, the Vatican allowed radiocarbon dating of the shroud.

http://apatheticagnostic.com/articles/meds2/med42/med830.html



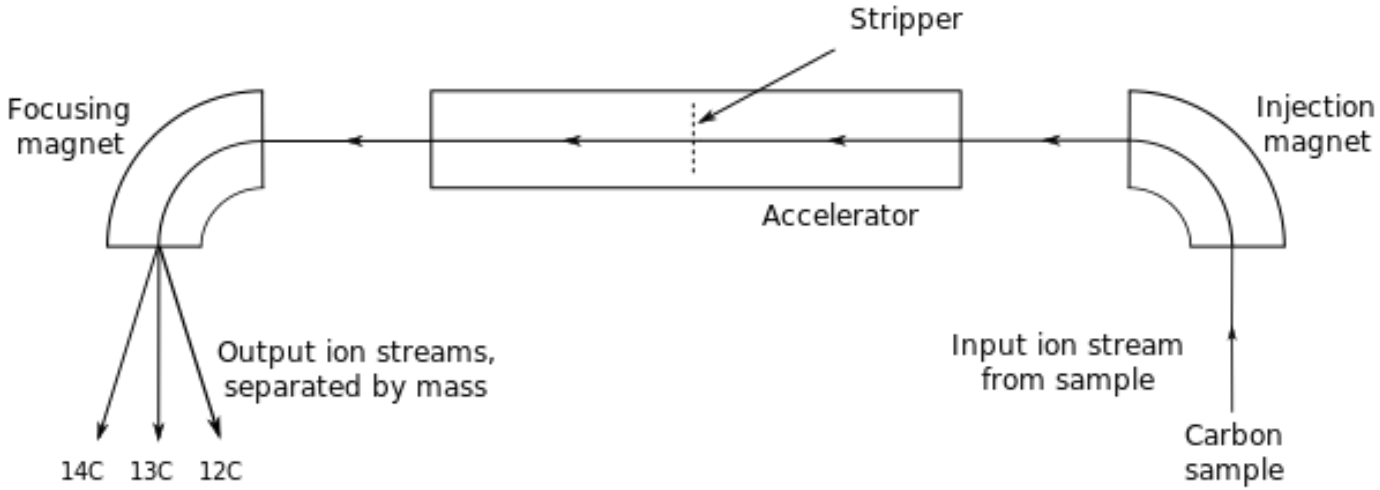

Shroud of Turin before 2002 restoration (a) Frontal and (b) Dorsal images

*J Forensic Sci*, 2018
doi: 10.1111/1556-4029.13867

Many people believe that the Shroud was used to wrap Christ's body, bearing detailed front and back images of a man who appears to have suffered whipping and crucifixion.

# Accelerator Mass Spectrometry (AMS)

- In order to measure radiocarbon ages it is necessary to find the amount of radiocarbon in a sample. This measurement can be made either by measuring the radioactivity of the sample (the conventional *beta*-counting method) or by directly counting the radiocarbon atoms using a method called **Accelerator Mass Spectrometry (AMS)**.



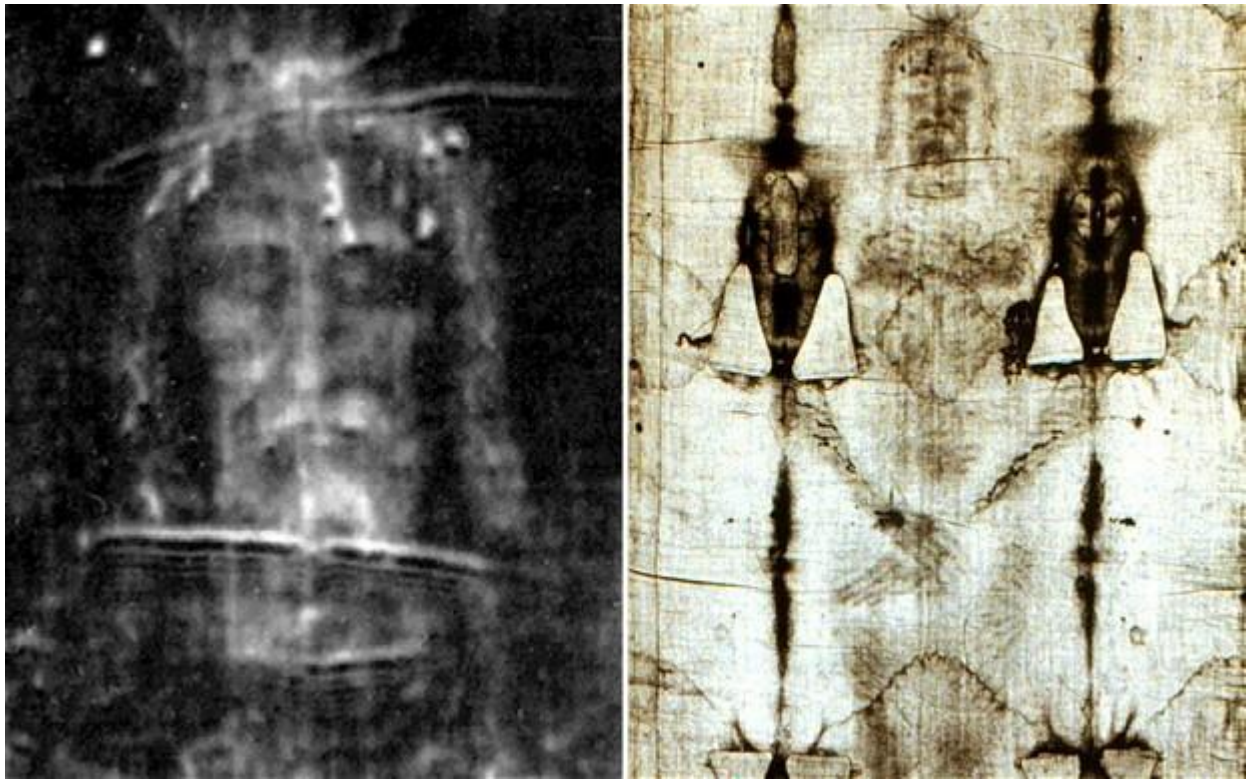

Simplified schematic layout of an accelerator mass spectrometer used for counting carbon isotopes for carbon dating

https://c14.arch.ox.ac.uk/ams.html

https://commons.wikimedia.org/wiki/File:Accelerator_mass_spectrometer_schematic_for_radiocarbon.svg

# Problem

**If the textile sample contain $1.08 \times 10^{-12}$ atoms of the carbon-14 isotope for each carbon-12 isotope, what its age?**



Many Catholics believe that the 14ft-long linen cloth was used to cover Christ's body when he was lifted down from the cross after being crucified.

http://www.telegraph.co.uk/science/science-news/10631973/Turin-Shroud-may-date-from-time-of-Jesus.html

# Calculation

# Radiocarbon dating of the Shroud of Turin

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§ Institut für Mittelenergiephysik, ETH-Hönggerberg, CH-8093 Zürich, Switzerland
‖ Lamont–Doherty Geological Observatory, Columbia University, Palisades, New York 10964, USA
¶ Research Laboratory, British Museum, London, WC1B 3DG, UK

*Very small samples from the Shroud of Turin have been dated by accelerator mass spectrometry in laboratories at Arizona, Oxford and Zurich. As controls, three samples whose ages had been determined independently were also dated. The results provide conclusive evidence that the linen of the Shroud of Turin is mediaeval.*

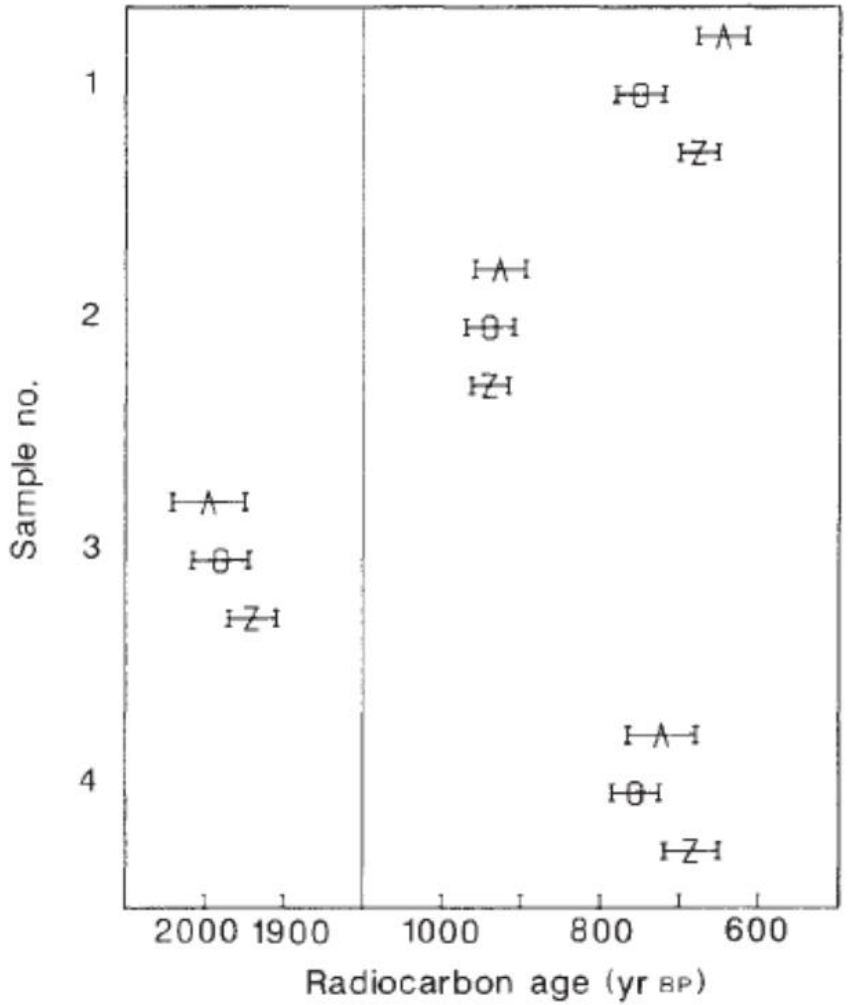


**Fig. 1** Mean radiocarbon dates, with $\pm 1\sigma$ errors, of the Shroud of Turin and control samples, as supplied by the three laboratories (A, Arizona; O, Oxford; Z, Zurich) (See also Table 2.) The shroud is sample 1, and the three controls are samples 2–4. Note the break in age scale. Ages are given in yr BP (years before 1950). The age of the shroud is obtained as AD 1260–1390, with at least 95% confidence.

The results of radiocarbon measurements at Arizona, Oxford and Zurich yield a calibrated calendar age range for the linen of the Shroud of Turin of AD 1260-1390. These results therefore provide conclusive evidence that the linen of the Shroud of Turin is mediaeval.

***controls are known age textile samples.**

# Conclusions

- **The final answer is $t \approx 870$ years**.
- The textile sample would have to be produced in around 12th century.
- The radiocarbon dating allows us to date samples up to 10 half life time of carbon 14.
- The assumption that the concentration of carbon -14 has always constant is not quite true since 1950s, the atmospheric concentration of carbon-14 and other isotopes have be changed by atmospheric tests of nuclear weapons.

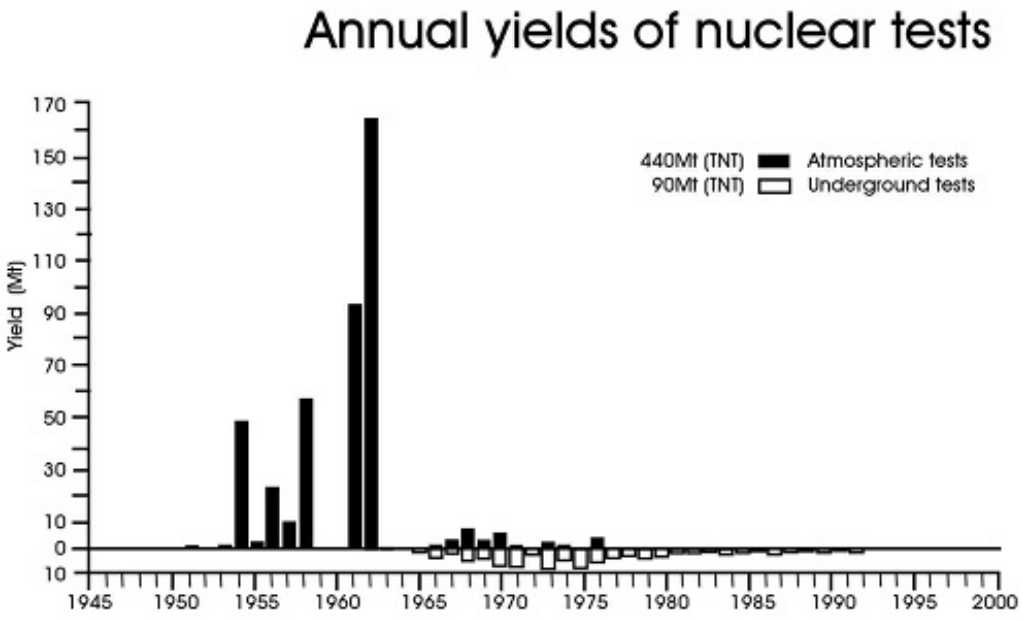

Figure 2. Annual yields of tests of nuclear weapons in the atmosphere and underground

https://skepticalscience.com/nuclear.html

# Dinosaur bone dating

- Carbon-14 dating won't work on dinosaur bones due to its short half life.
- Dinosaur bones are millions of years old. To determine the ages of these specimens, scientists need an isotope with a very long half-life such as **uranium-238, uranium-235** and **potassium-40.**
- **The dating is made from the rock where the fossils were found.**

http://science.howstuffworks.com/environmental/earth/geology/dinosaur-bone-age1.htm

## Half Lives for Radioactive Elements

| Radioactive Parent | Stable Daughter | Half life |
|---|---|---|
| Potassium 40 | Argon 40 | 1.25 billion yrs |
| Rubidium 87 | Strontium 87 | 48.8 billion yrs |
| Thorium 232 | Lead 208 | 14 billion years |
| Uranium 235 | Lead 207 | 704 million years |
| Uranium 238 | Lead 206 | 4.47 billion years |
| Carbon 14 | Nitrogen 14 | 5730 years |

http://www.das.uchile.cl/~mhamuy/radio.html