NOTES: The Fossil Record and Geologic Time

Vocabulary:

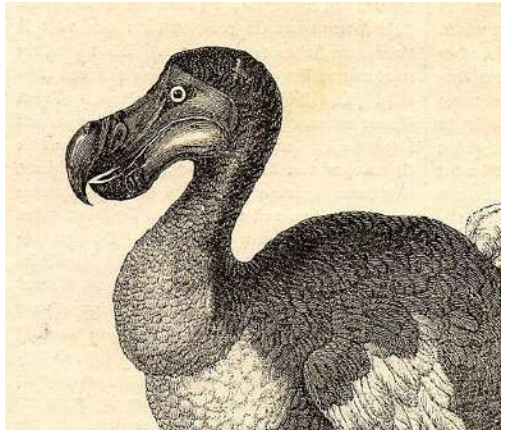
- Paleontologist
- Fossil record extinct
- Relative dating
- Absolute dating
- Geologic time scale

Objectives:

- What are fossils?
- How are they made?
- How do scientists know how old things are?
- What is the difference between relative and absolute dating?

GEOLOGIC TIME & AGE OF THE EARTH

► Our planet is home to a huge variety of organisms!! (Scientists estimate 5 - 20 million species of organisms alive today)



► Even more amazing is evidence of organisms that once lived on earth, but are now extinct.

► Several hundred million species have come and gone during the 4.6 billion years the Earth has existed.

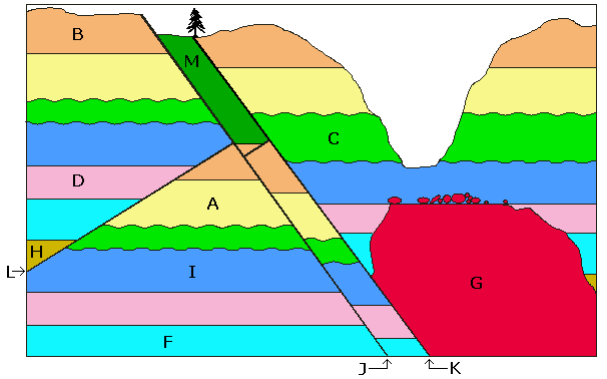
Geologic Time- The History of the Earth

2 ways of determining age:

1) Relative Dating:

- order of events based on the position of rocks in a sequence

- older layers of rock are on the bottom; newer rock lays down on top of the older rock



2) Absolute Dating/ Radioactive Dating:

► some isotopes undergo radioactive decay where an alpha or beta particle of radiation leaves the nucleus thereby changing the original element into a new one

► each radioactive material has a specific and measurable rate of this decay (**half-life**)

► comparing the ratio of the original amount of radioactive material to how much is left can determine the **age of the object**

FOSSILS

1. What is a fossil record?
2. What is extinction?
3. What is a paleontologist?

FOSSILS

1. What is a **fossil record**?

   Information about past life showing change over time; evidence in form of fossils

2. What is **extinction**?

   Disappearance of a species from its geographical range

3. What is a **paleontologist**?

   Scientist who studies fossils (classifies fossils).

FOSSILS

clues to the past

FOSSILS

- A **FOSSIL** is **the remains or evidence of a living thing**
  - bone of an organism or the print of a shell in a rock
  - burrow or tunnel left by an ancient worm
  - most common fossils: **bones, shells, pollen grains, seeds.**

Examples of different kinds of fossils

PETRIFICATION is the process by which plant or animal remains are turned into stone over time. The remains are buried, partially dissolved, and filled in with stone or other mineral deposits.

A **MOLD** is an empty space that has the shape of the organism that was once there. A **CAST** can be thought of as a filled in mold. Mineral deposits can often form casts.

Thin objects, such as leaves and feathers, leave **IMPRINTS**, or impressions, in soft sediments such as mud. When the sediments harden into rock, the imprints are preserved as fossils.

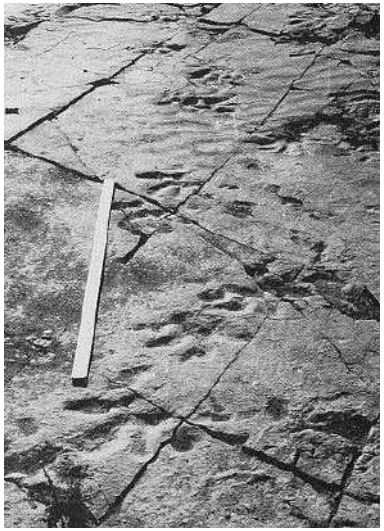
PRESERVATION OF ENTIRE ORGANISMS:
It is quite rare for an entire organism to be preserved because the soft parts decay easily. However, there are a few special situations that allow organisms to be preserved whole.

FREEZING: This prevents substances from decaying. On rare occasions, extinct species have been found frozen in ice.

AMBER: When the resin (sap) from certain evergreen trees hardens, it forms a hard substance called amber. Flies and other insects are sometimes trapped in the sticky resin that flows from trees. When the resin hardens, the insects are preserved perfectly.

TAR PITS: These are large pools of tar. Animals could get trapped in the sticky tar when they went to drink the water that often covered the pits. Other animals came to feed on these animals and then also became trapped.

TRACE FOSSILS: These fossils reveal much about an animal's appearance without showing any part of the animal. They are marks or evidence of animal activities, such as tracks, burrows, wormholes, etc.



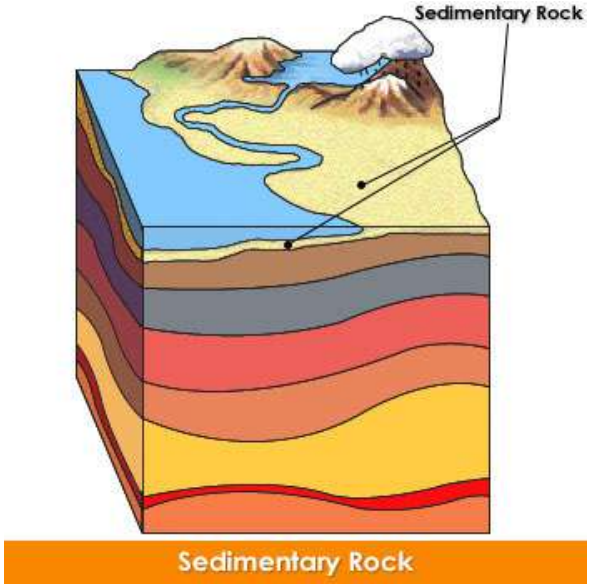
Where would you expect to find older fossils and where are the younger fossils?

Why?

Fossil Formation

- Buried remains of organisms settle on the **bottom**
- ***How is sedimentary rock formed?***
- New layers of sediment are constantly being deposited
  - The weight of overlying rock compresses the lower layers
  - Eventually the sediments

  ➔ **ROCK**



FOSSILS

The Fossil Record:

- Provides evidence about the history of life on earth
- It also shows how different groups have **changed over time**

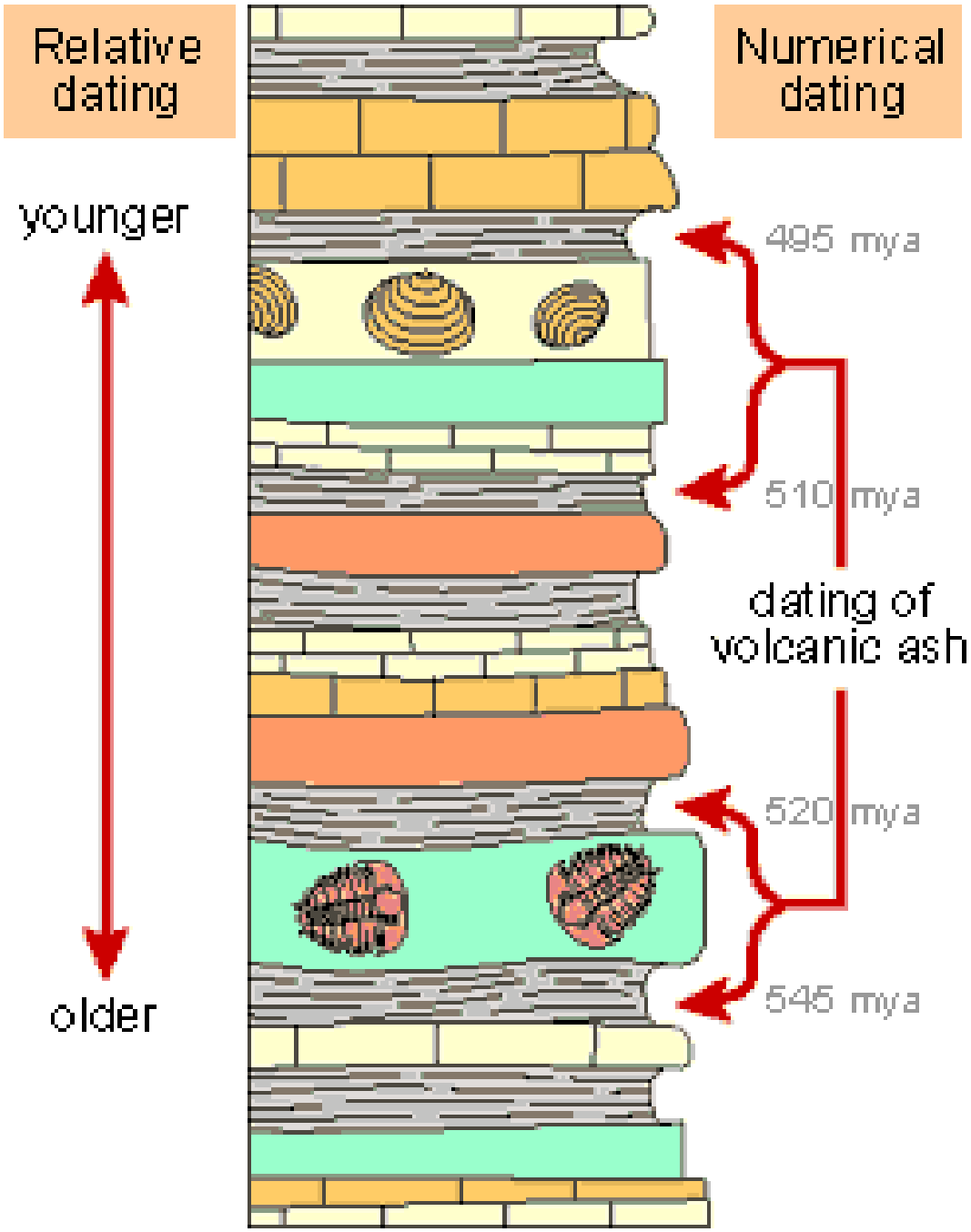
REVIEW: What are the 2 ways paleontologists date fossils?

- Which gives an **estimate** age?
- Which gives an **absolute** age ?

- What is an index fossil?
- Why are they important?

What are the 2 ways paleontologists date fossils?

- Which gives an estimate age?
  - **Relative Dating**
- Which gives an absolute age ?
  - **Radioactive Dating**
- What is an *index fossil*?
  - **fossil used to help determine the relative age of the fossils around it**
  - **must be easily recognized and must have existed for a short period BUT over wide geographical area.**

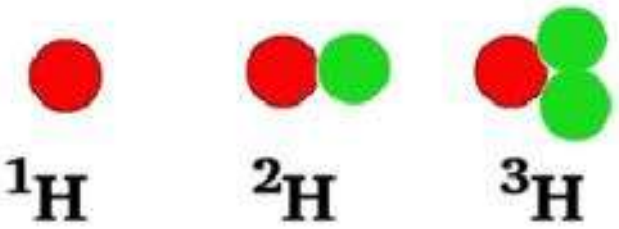

Relative dating
Numerical dating
younger
older
495 mya
510 mya
dating of volcanic ash
520 mya
545 mya

Radioactive Dating =

Calculating the ABSOLUTE age of fossils based on the amount of remaining radioactive isotopes it contains.

Isotope = atom of an element that has a number of neutrons different from that of other atoms of the same element

Hydrogen
1 proton



^{1}H ^{2}H ^{3}H

Helium
2 protons

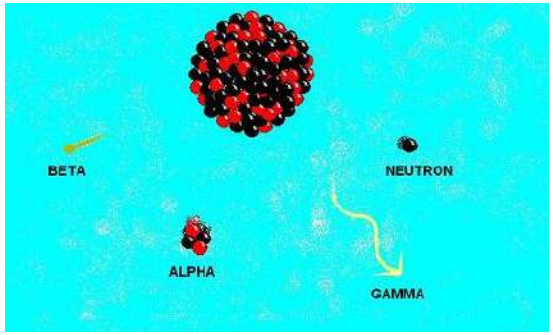
^{3}He ^{4}He

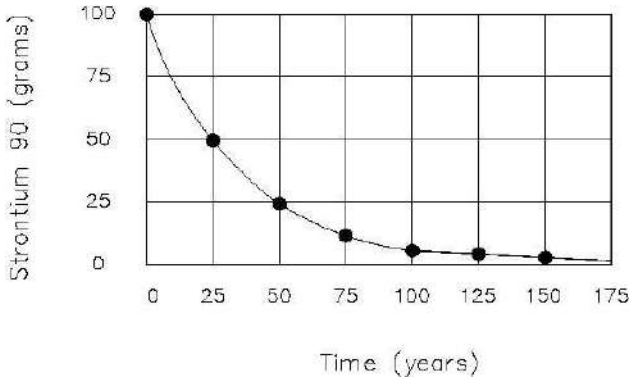
Lithium
3 protons

^{6}Li ^{7}Li

Radioactive Dating

- Certain naturally occurring elements are radioactive, and they decay (break down) at predictable rates
- An isotope (the “parent”) loses particles from its nucleus to form an isotope of the new element (the “daughter”)
- The rate of decay is expressed in a “half-life”





HALF LIFE = the amount of time it takes for ½ of a radioactive element to decay.

How to figure out the age of the object:

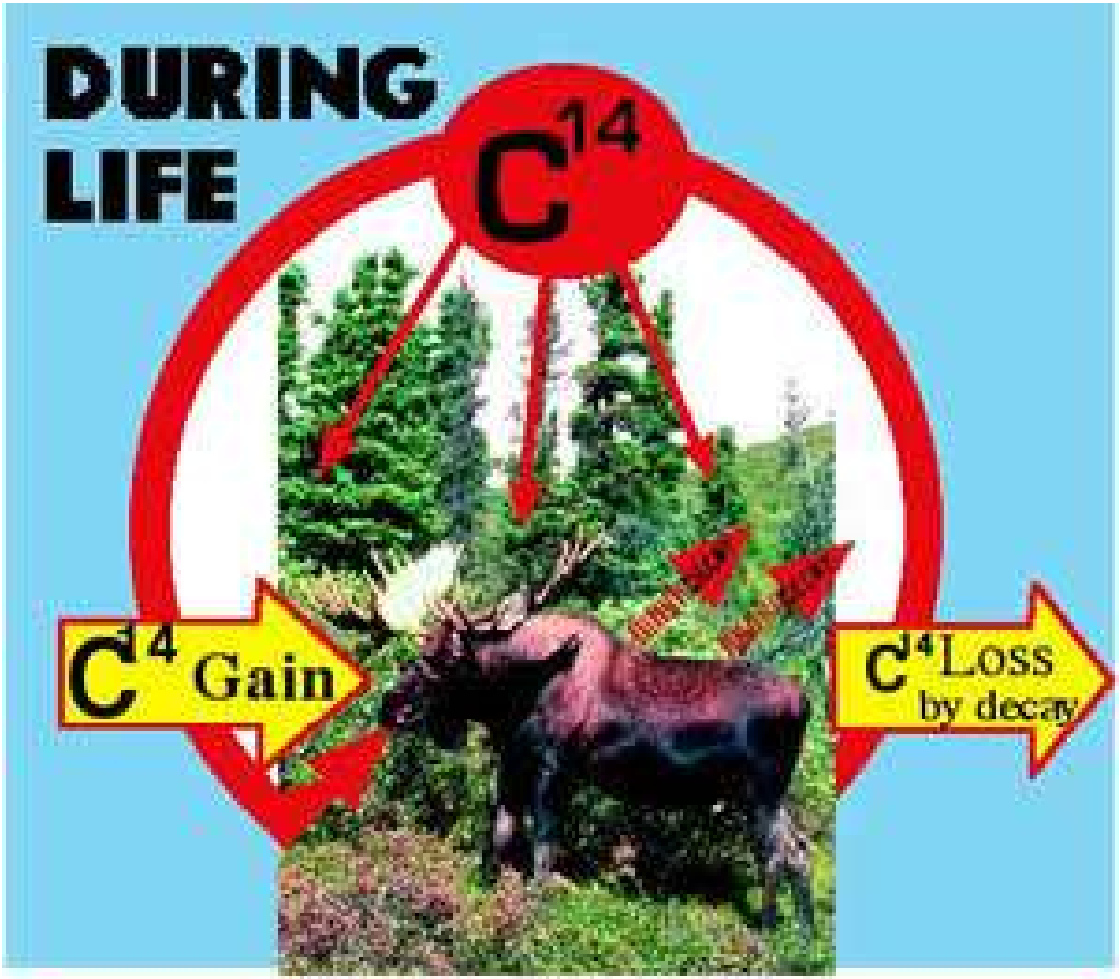
1. comparing the amount of the “parent” (original sample) to the amount of the “daughter” (remaining sample)
2. knowing the half-life, then do the math to calculate the age!

Parent Isotope	Daughter	Half-Life
Uranium-238	Lead-206	4.5 billion years
Uranium-235	Lead-207	704 million years
Thorium-232	Lead-208	14.0 billion years
Rubidium-87	Strontium-87	48.8 billion years
Potassium-40	Argon-40	1.25 billion years
Samarium-147	Neodymium-143	106 billion years

Radioactive Dating

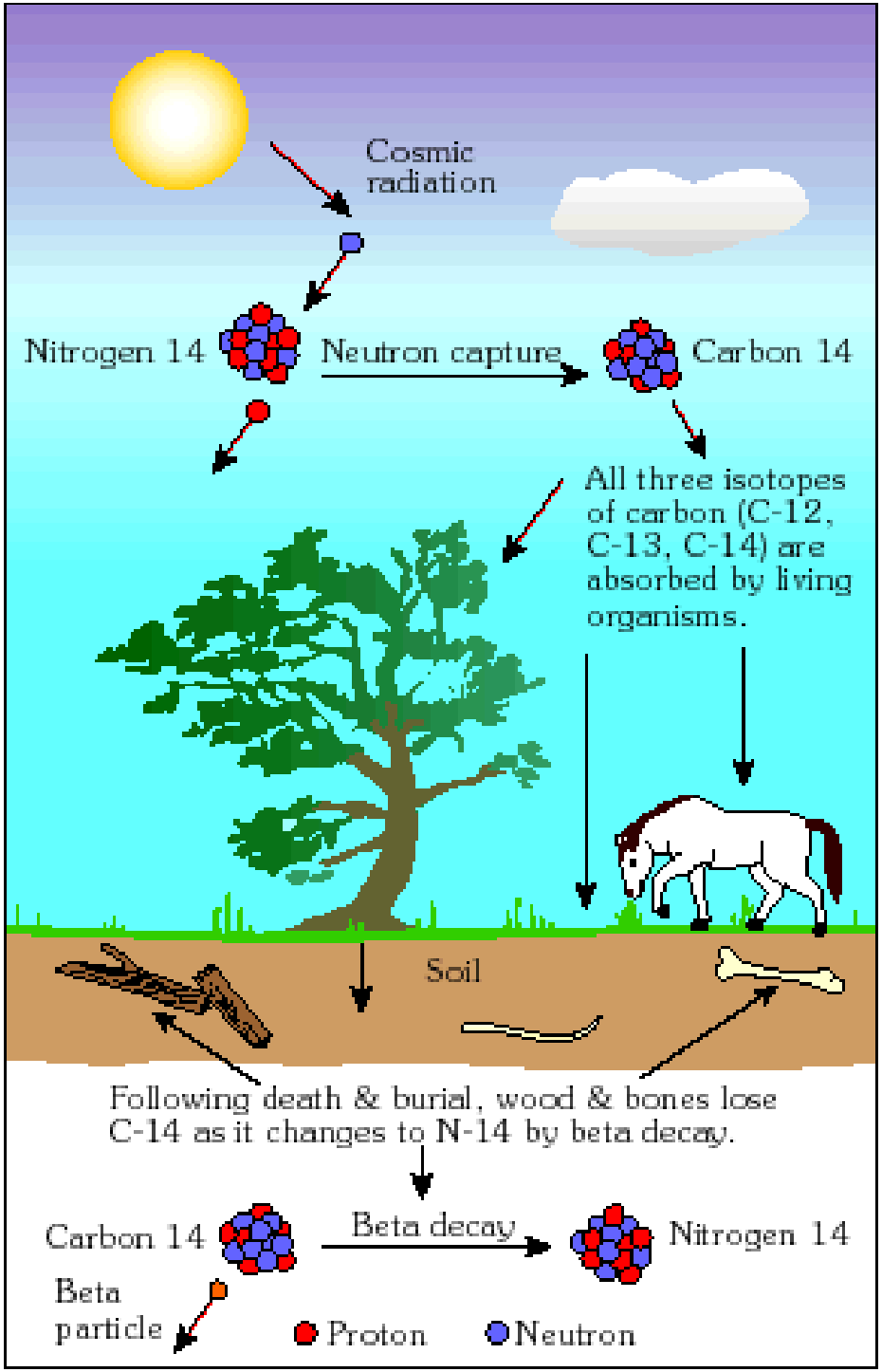
Example: Carbon 14

- Used to date material that was **once alive**
- C-14 is in all plants and animals
  - C-12 is too, but it does NOT decay!
- When an organism dies, the amount of C-14 decreases because it is being converted back to N-14 by radioactive decay


DURING LIFE
C^{14}
C^{14} Gain
C^{14} Loss by decay


DEATH
C^{14} NO GAIN
C^{14} Loss by decay

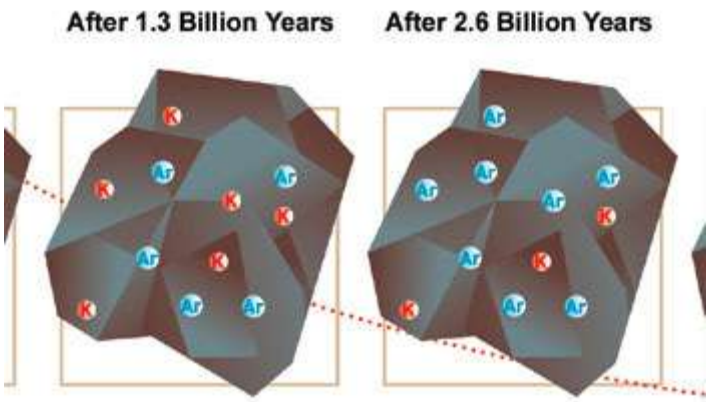
- By measuring the amount of C-14 compared to N-14, the time of death can be calculated
- C-14 has a half life of 5,730 years
- Since the half life is considered short, it can only date organisms that have died within the past 50,000-60,000 years


Cosmic radiation
Nitrogen 14
Neutron capture
Carbon 14
All three isotopes of carbon (C-12, C-13, C-14) are absorbed by living organisms.
Soil
Following death & burial, wood & bones lose C-14 as it changes to N-14 by beta decay.
Carbon 14
Beta decay
Nitrogen 14
Beta particle
Proton
Neutron

Review:
Radioactive dating vs. Relative dating

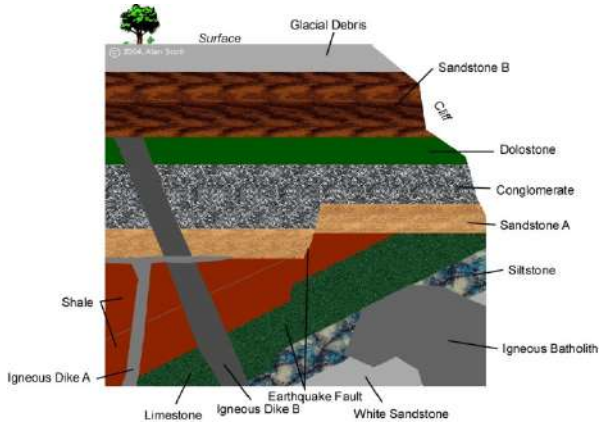
Radioactive dating:

"actual" age using radioactive isotopes and half lives

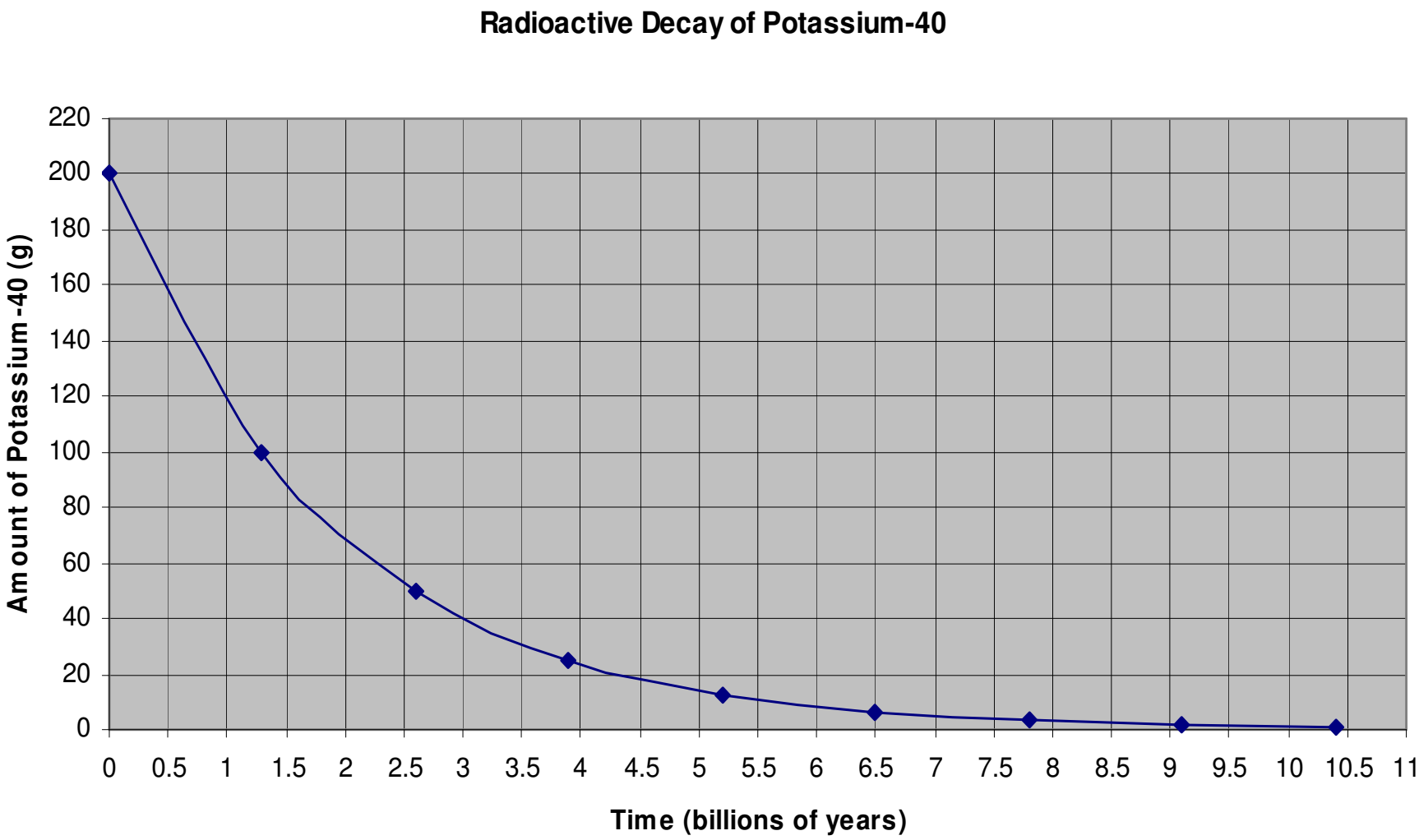


Relative dating:

age of the fossil compared to others in layers of sedimentary rock (uses index fossils)



Radioactive Decay of Potassium-40



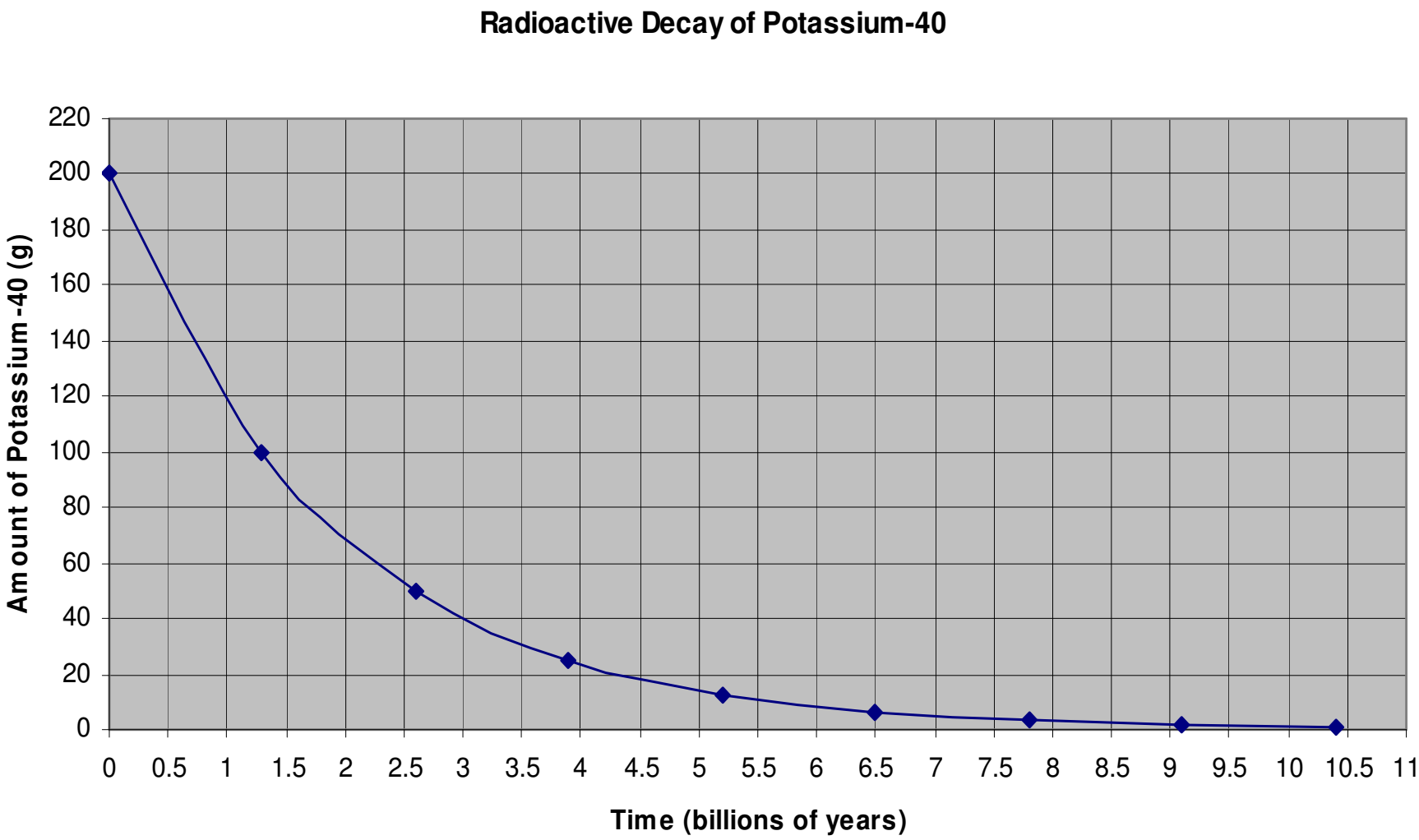
Use graph of potassium-40 decay:

1. **What fraction of potassium-40 remains after two half-lives?**

2. **What fraction of potassium-40 will remain after five half-lives?**

3. **How many years does it take for one half-life to occur?**

Radioactive Decay of Potassium-40

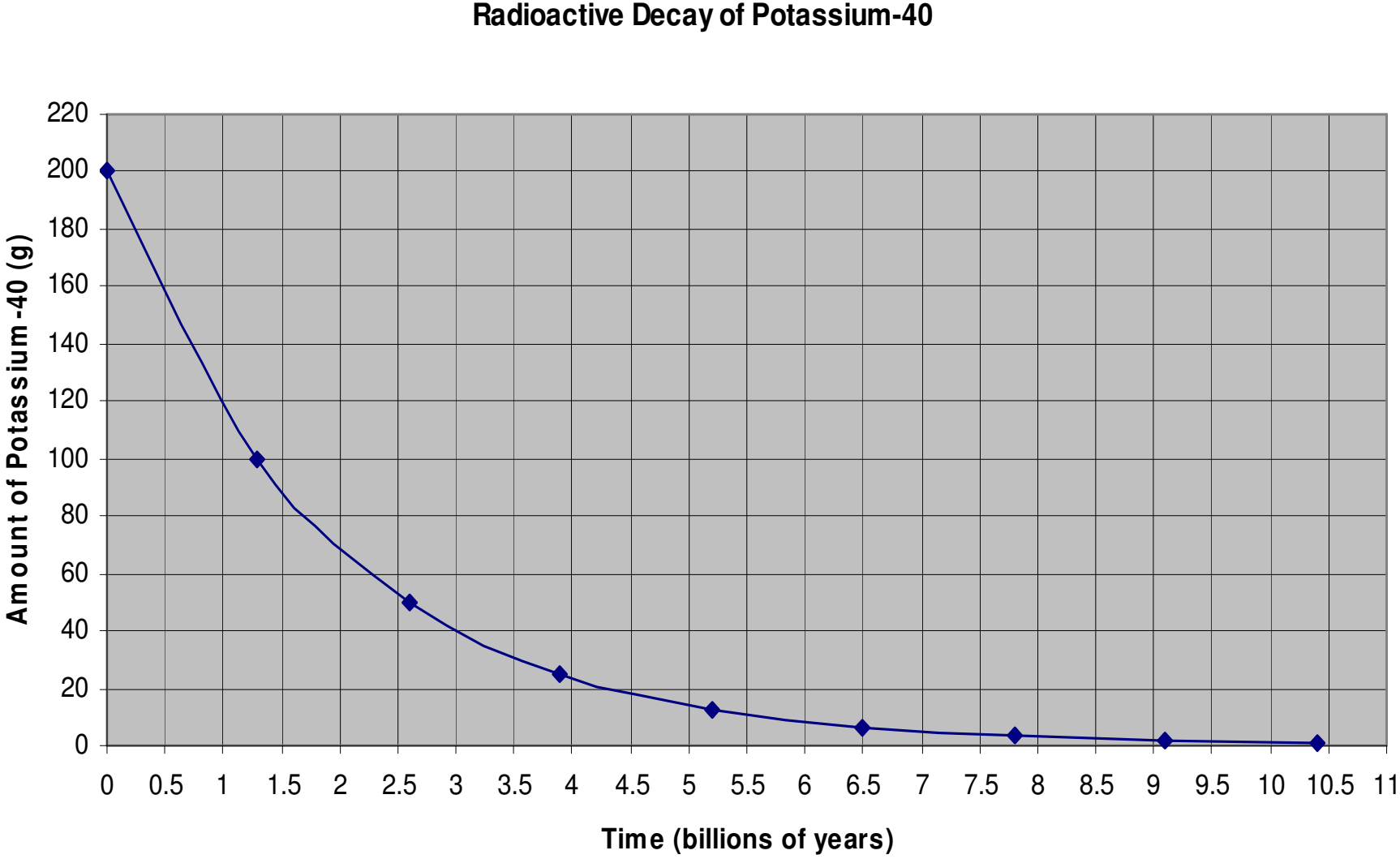


Answers

1. What fraction of potassium-40 remains after two half-lives? 1/4

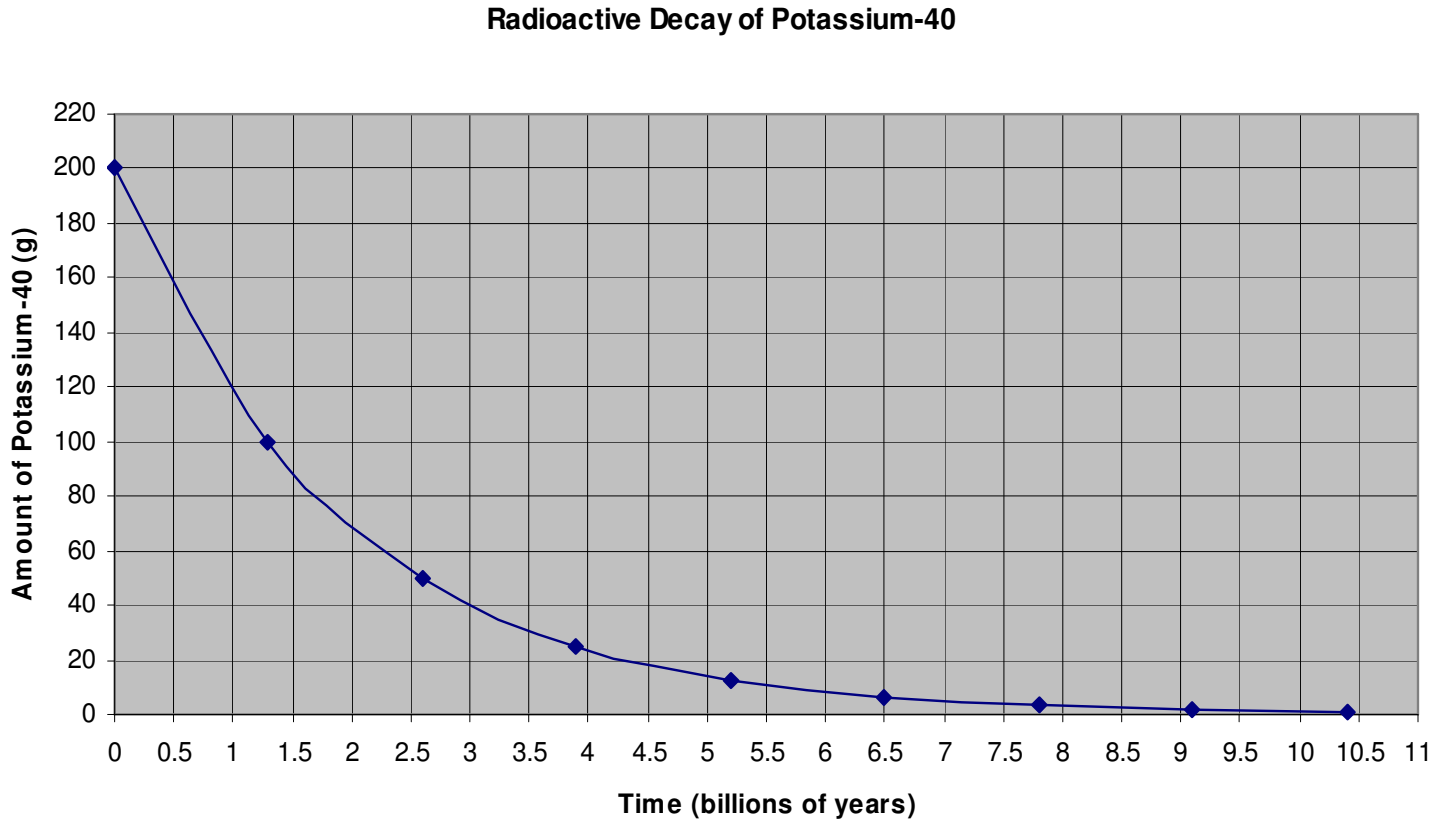
2. What fraction of potassium-40 will remain after five half-lives? 1/32

3. How many years does it take for one half-life to occur? 1.2 billion years



4) How <u>many half-lives</u> will it take for potassium-40 to decay to 50g?

5) How <u>long</u> will it take for 200 g of potassium-40 to decay to 50g?



4) How <u>many half-lives</u> will it take for 200 g of potassium-40 to decay to 50g?

<u>2 half - lives</u>

5) How <u>long</u> will it take for 200 g of potassium-40 to decay to 50g?

<u>2.6 billion yrs.</u>