DSPMU UNIVERSITY, RANCHI.
DEPARTMENT OF GEOLOGY

B.Sc. SEMESTER-II **DATE-11/05/2020**

CARBON-14 DATING

Radiocarbon dating (also referred to as carbon dating or carbon-14 dating) is a method for determining the age of carbon based organic material (eg. trees, plants, and animal remains; as well as human artifacts made from wood, bones and leather etc.) by using the property of radioactivity of isotope of carbon.

Most isotopes found on Earth are generally stable and do not change. However some isotopes, like ^{87}Rb, ^{40}K, ^{14}C have an unstable nucleus and are radioactive. This means that occasionally the unstable isotope will change its number of protons, neutrons, or both. This change is called radioactive decay. The atomic nucleus that decays is called the **parent isotope**. The product of the decay is called the **daughter isotope**.

For example, unstable ^{14}C transforms to stable nitrogen (^{14}N).In this example, ^{14}C is the parent and ^{14}N is the daughter.

Concept

Carbon is found in different forms in the environment. Mainly in the stable form, carbon has two isotopes: carbon-12 (^{12}C), carbon-13 (^{13}C), and in the unstable form is the radioactive carbon-14 (^{14}C). Over time, carbon-14 decays radioactively and turns into nitrogen.

Carbon-14 is continually being formed in the upper atmosphere by the effect of cosmic ray neutrons on nitrogen-14 atoms. It is rapidly oxidized in air to form carbon dioxide and enters the global carbon cycle.

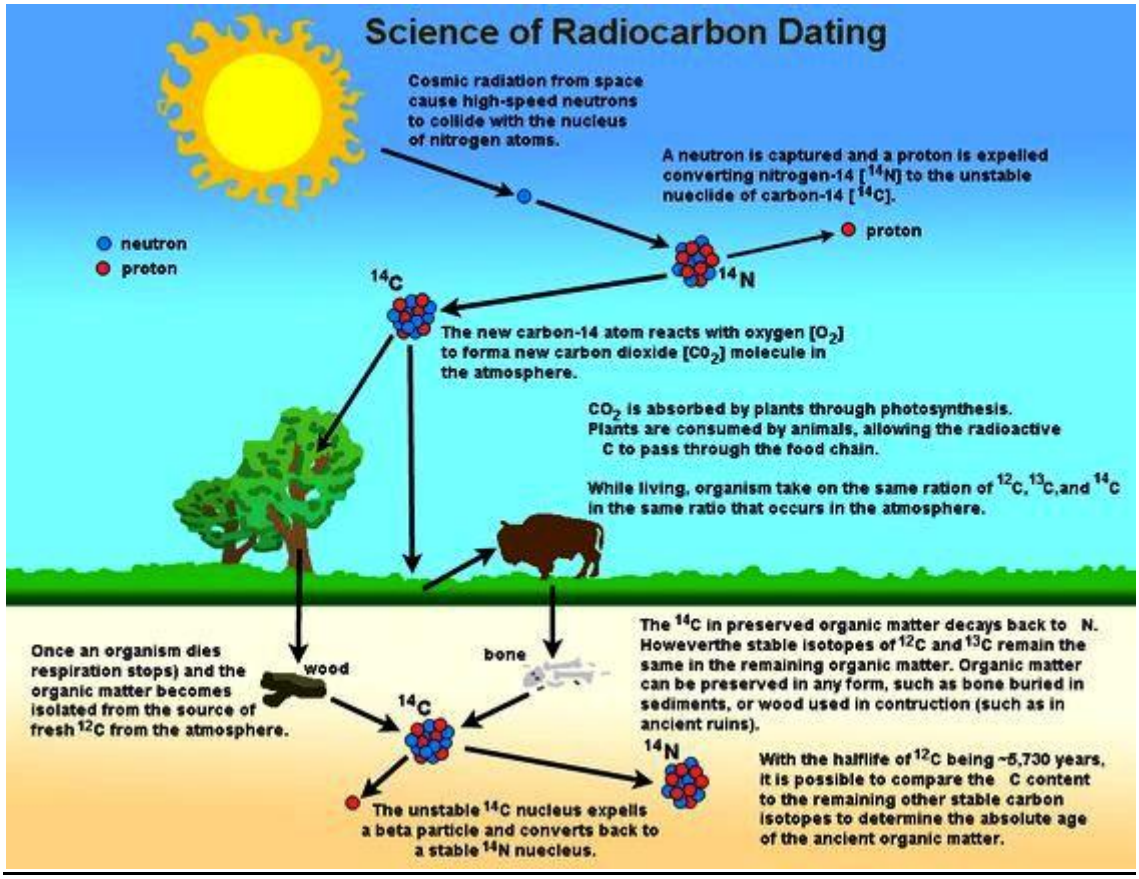
A living organism continuously takes in both carbon-12 and carbon-14 from the environment (by process of respiration, eating etc.) in the same relative proportion that they existed naturally. Once the organism dies, it stops replenishing its carbon supply, and the total carbon-14 content in the organism slowly disappears. Scientists can determine how long ago an organism died by measuring how much carbon-14 is left relative to the carbon-12.

Carbon-14 has a half life of 5730 years, meaning that 5730 years after an organism dies, half of its carbon-14 atoms have decayed to nitrogen atoms. Similarly, 11460 years after an organism dies, only one quarter of its original carbon-14 atoms are still around.

Limitations

Because of the short length of the carbon-14 half-life, carbon dating is only accurate for items that are thousands to tens of thousands of years old (~70,000 yrs). Most rocks of interest are much older than this. Geologists must therefore use elements with longer half-lives.

For instance, potassium-40 decaying to argon has a half-life of 1.26 billion years and beryllium-10 decaying to boron has a half-life of 1.52 million years. Thus, geologists measure the abundance of these radioisotopes instead to date rocks.


Science of Radiocarbon Dating
Cosmic radiation from space cause high-speed neutrons to collide with the nucleus of nitrogen atoms.
A neutron is captured and a proton is expelled converting nitrogen-14 [^{14}N] to the unstable nuecilde of carbon-14 [^{14}C].
neutron
proton
proton
^{14}C
^{14}N
The new carbon-14 atom reacts with oxygen [O_2] to forma new carbon dioxide [CO_2] molecule in the atmosphere.
CO_2 is absorbed by plants through photosynthesis. Plants are consumed by animals, allowing the radioactive C to pass through the food chain.
While living, organism take on the same ration of ^{12}C, ^{13}C,and ^{14}C in the same ratio that occurs in the atmosphere.
Once an organism dies respiration stops) and the organic matter becomes isolated from the source of fresh ^{12}C from the atmosphere.
wood
bone
^{14}C
The ^{14}C in preserved organic matter decays back to N. Howeverthe stable isotopes of ^{12}C and ^{13}C remain the same in the remaining organic matter. Organic matter can be preserved in any form, such as bone buried in sediments, or wood used in contruction (such as in ancient ruins).
^{14}N
With the halflife of ^{12}C being ~5,730 years, it is possible to compare the C content to the remaining other stable carbon isotopes to determine the absolute age of the ancient organic matter.
The unstable ^{14}C nucleus expells a beta particle and converts back to a stable ^{14}N nuecleus.