Let's have a date...

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Due to the pandemic outbreak, social distancing is one of the foremost recommended measures that each and every person must take into consideration. It has been advised to keep a distance of approximately 2 metres from each other. Under such a bizarre scenario, the warmth of sharing a sip of hazelnut coffee splashed with chocolate syrup with your loved one over a weekday matinee is quite an uncommon sight. Thus, no question of dating. Alas!
BUT, how about dating radioactive elements?! By the time your eyebrows are squeezed, eyeballs are zoomed to the maximum, let me tell you that you read it right.

Have you ever wondered how anthropologists and geologists calculate the absolute age of fossils, rocks, trees and glaciers that were there on earth since the time of its birth? As it is said that one leaves footsteps while walking on a path, nature too leaves a mark for each of its activity.

The technique used is known as Radiometric or Radioactive Dating. It is based on the inherent fundamental property of decay of radioactive elements. The spontaneous phenomenon of radioactivity was discovered by Henri Becquerel in 1896. The term 'Radioactivity' was introduced by Marie Curie and Pierre Curie as they concluded radiation emissions are an atomic phenomenon and have nothing to do with physical and chemical states.

Principle of Radioactive Decay
Radioactive decay is analogically similar to a parent- daughter relationship. The nucleus of the radioisotope which disintegrates by particle emission is termed as the parent nucleus and the resulting converted nucleus of a new atom is termed as the daughter nucleus.

The decay rate of a radioisotope is proportional to the number of atoms of that isotope present at that instant. Being a unique characteristic of each isotope, half-life of the parent nuclide is the duration of time required for half of it to decay to daughter products. It is denoted by $t_{1/2}$. Thus, during this time period N_o number of nuclei are reduced to $N_o/2$ number of nuclei which means since formation, the amount of parent isotope gradually decreases with time. The number of disintegrations per unit time is termed as radioactivity or activity .

Now, let's explore the most familiar Radiocarbon Dating.

Radiocarbon Dating

We know that the most common form of carbon has an atomic number (Z) of 6 and mass number (A) of 12 which implies carbon is composed of 6 protons (hence 6 electrons too) and 6 neutrons. But unlike Carbon-12, radiocarbon is unstable and has a mass number of 14. Thus it is often referred to as Carbon-14 (^{14}C). ^{14}C is composed of 6 protons and 8 neutrons. Hence, radiocarbon dating is also called Carbon-14 dating as this process depends on the decay of ^{14}C to ^{14}N (Nitrogen -14).

^{14}C, a cosmogenic nuclide, continually formed in nature as a result of neutron interaction with ^{14}N. It is mainly used for age determination of living beings. Radiocarbon (^{14}C) forms $^{14}CO_2$ through oxidation. As it penetrates the atmosphere to reach the Earth's surface, it enters the food chain of living beings because plants intake CO_2 during photosynthesis and animals exhale it through respiration and this process continues until they die. Hence the concentrations in them are in equilibrium with the ^{14}C content in the atmosphere. It also enters other earthly elements such as water bodies, soil, etc through atmospheric exchange. Once consumed, ^{14}C slowly decays within the living organism and the lost amount is continually replenished until the last breath. But post death, no amount of radiocarbon is absorbed and hence the deposited ^{14}C in tissues steadily decreases at a constant rate. The time required by ^{14}C to disintegrate to half of its amount since death is 5730 years, which is equal to the half-life of ^{14}C. By measuring the residual amount of ^{14}C, an estimated date of when the organism died can be calculated.

This versatile technique, useful in dating fossils, plant based artifacts, determine the age of mummies, prehistoric artifacts and dwellings was first proposed during the 1940s by American physicist Willard F. Libby. In 1960, he won the Nobel Prize in Chemistry for "his method to use carbon-14 for age determination in archaeology, geology, geophysics, and other branches of science". This technique is valid only for samples 30,000 to 40,000 years old.

Have you ever tried to estimate the age of Arizona’s Meteor Crater or rate of erosion of rocks or study the avalanche of glaciers or thinning of Antarctica's ice sheets ? Let’s find out how.

Surface Exposure Dating

Cosmogenic nuclide dating can be used to determine rates of ice-sheet thinning and recession, the ages of moraines, and the age of glacially eroded bedrock surfaces.We can calculate the exposure age of the earthly element such as rocks and glaciers.

Beryllium-10(^{10}Be), another cosmogenic nuclide, half life of 1.39 $\times 10^6$ yrs, produced in the atmosphere as a result of cosmic ray spallation of oxygen and nitrogen decays to Boron-10 (^{10}B). It gets accumulated on the earth surface. Hence, ^{10}Be dating is used to estimate the exposure age of rocks, rates of erosion and sedimentation. By dating the amount of Aluminium-26 (^{26}Al), which decays to stable Magnesium-26 (^{26}Mg), in the meteorite sample the age of meteorites that fell on Earth can be estimated.

So now you have an alternate dating option that can be done abiding the rules of social distancing and at the same time contribute towards age estimations of earthly samples to eventually help in forecasting atmospheric conditions.