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|  | **Introduction**  The idea of doing this project did not come quickly. I was originally flipping through books that only had projects which were already done to death. As I looked through these books consisting mainly of medicinal plants, my good friend suggested that I do something that I planned on doing later as a career. I, of course, have always dreamed of getting into Archaeology. I know there are aspects of archaeology which include Biology so I did not have to think hard to come up with a subject. Carbon dating immediately sprang to mind. This is a rather complex procedure to determine the date of a sample obtained by archaeological digs.  And so the search for information began. The first stop made was the Pleasanton Library. There was limited information at this library due to the complexity of the subject. I found a total of two chapters that included any information about 14C dating. So more drastic measures were needed. We gathered a small group who all needed to get information about research projects and headed out to the libraries at the UC Berkeley campus. This was a great success as there were separate libraries for each particular subject. One library was for Anthropology alone. Anthropology encompasses the subject of Archaeology and the library held an abundance of information on Carbon Dating. Here I found many different books containing every thing I wanted to know. It included a book with procedures both before and during the tests. There were several other books that included explanations of the procedures and a way to interpret results to find accurate dates.  There are many basic concepts in understanding how Carbon dating works. As described in Archaeological Techniques for Amateurs, " Carbon 14 or "heavy carbon" is a radioactive isotope of ordinary Carbon formed in the atmosphere through the bombardment of Nitrogen by cosmic rays.". 14C is absorbed by plant life and all animal forms in a stable rate and ratio. This means that all living things contain a certain amount of 14C. The diagram below was based on a diagram found in The Fabulous Isotopes  and shows how the radioactive Carbon 14 is formed.  diagram  "At the time of death the absorption of 14C ceases and the residual 14C within starts to disintegrate at a fixed rate". Archaeological Techniques for Amateurs. This is known as the half life of Carbon. The Carbon within the sample will last for about 50,000 years. It is logical to suppose that by determining the percentage of 14C present in sample one can then come up with an estimated date. About 0.1% of 14C decays a year.  Willard F. Libby developed the Carbon 14 dating technique after WW2 and consequently won a Noble Prize for his work in 1960. According to the very useful Waikato radiocarbon website which I will refer to many times throughout this report,[c14.sci.waikato.ac.nz](http://docs.google.com/www.c14.sci.waikato.ac.nz), Libby along with the help of Anderson and Arnold discovered that 14C decayed at a constant rate. "They found that after 5568 years, half of the C14 in the original sample will have decayed and after another 5568 years, half of the remaining material will have decayed, and so on (see figure 1 from web site)"  " The half life (*t*1/2) is the name given to this value which Libby measured at 5568+/-30 years. This became known as the Libby Half Life." Waikato University Radiocarbon Lab Website  Libby used modified Geiger counters to measure radioactivity. "These are devices to detect and measure ionizing radiation, as emitted from radioactive sources." [www.mathematik.uni-marburg.de](http://docs.google.com/www.mathematik.uni-marburg.de) .  But after the discovery the development of the dating method lead to two other techniques for dating. The conversion of carbon in the sample into CO2 gas which can then be measured was the next step in the development of Carbon dating. This method developed after Libby's findings is called Liquid Scintillation Counting. Broser and Kallman were the scientists who discovered the technique in the 1940s. They found that organic compounds or scintillators become florescent when exposed to ionizing radiation. The Waikato website again explains this process. " Each fluorescence event is proportional to a radioactive decay event, and the frequency of these events is directly proportional to the number of 14C atoms present in the sample." In this method Benzene is used as the scintillation solvent. In the website of the Radiocarbon Laboratory of the University of Zurich, Switzerland , [www.geo.unizh.ch/c14/](http://docs.google.com/www.geo.unizh.ch/c14/), the process is also summed up well.  "The benzene is produced as follows: Carbon dioxide, obtained by burning the sample, reacts with metallic lithium to form lithium carbide. The lithium carbide is hydrolyzed to acetylene which is subsequently converted to benzene by catalytic trimerisation. A small amount of Carbon dioxide is taken during the above process to enable the measurement of the stable isotope ratio 13C/12C. Scintillation counting results are statistically analyzed and reported as conventional radiocarbon ages corrected with 13C values."  The picture below is the synthesis line used for converting carbon dioxide into benzene which is located at the University of Zurich.  The second technique developed after LSC is more widely used. This is called Accelerator Mass Spectrometry. This involves directly measuring the radioactivity of a sample. The Zurich University website again gives a good description.  " The radiocarbon age is calculated from the measured ratio of carbon isotopes. Samples are chemically pre-treated and burned in sealed quartz glass ampoules. The resulting carbon dioxide gas from the ampoule is converted to graphite by one of the machines shown below."  "Mark II" Prototype"  The next step is explained in this quote from the Waikato website:  "The Graphite is ionized by bombarding it with caesium ions and then focused into fast-moving beam (energy typically 25keV). The ions produced are negative which prevents the confusion of 14C with 14N since nitrogen does not form a negative ion. The ions enter the accelerator. As they travel to the terminal (which is at about 2MV), they are accelerated so much that when they collide with the gas molecules in the central "stripper canal", all of the molecular ions (such as 12CH2 and 13CH) are broken up and most of the carbon ions have four electrons removed making them into C3+ ions. These are then accelerated down the second half of the tandem accelerator reaching energies of about 8MeV. The second magnet selects ions with the momentum expected of 14C ions and a Wien filter checks their velocity is also correct. Finally the filtered 14C ions enter the detector where their velocity and energy are checked so that the number of 14C ions in the sample can be counted."  This next image from the Waikato website shows the structure and process of Accelerator Mass Spectrometry involving the counting of the radioactive atoms in a sample.  Very important, however, are the pre-treatments which the samples must undergo to remove contaminants before testing can take place. The relevance of these tests are what I decided to base my research around. It is important to take into account the fact that many of the samples you work with will have been exposed to the elements which can alter the amount of 14C they contain. In the Pedological Perspectives in Archaeological Research it is said one must take into account the biological influences when trying to date a sample. Some of these biological influences are O2, moisture, temperature, C concentration and soil reactivity. Some of these variables can be measured by soil texture and depth below the soil surface at which the sample was found. Also the specific mean annual temperature and rainfall at the site and soil pH should be taken into account when determining what kind of contaminates to look for. For example: "rainfall and temperature affect soil development. Soil pH decreases with increased rainfall. Low pH directly affects extent of leaching and the rate of organic decomposition."  There are several different treatments that can be used to remove different contaminants or can be used depending on different types of samples. For example some samples are more sensitive than others and require a much more gentle treatment. Wood is a sample that is fairly durable and can stand up to harsher pre-treatments. Treatments range from chemical washes to careful work with tweezers and a microscope.  At the Beta Analytic, INC website, a Professional radiocarbon dating service, they offer numerous pre-treatments and explain what kind of samples the treatment is used on.  An "acid/ alkali/ acid" wash is used to remove carbonates and secondary organic acids. This is a method typically applied to charcoal, wood, some peats, some sediments and textiles. An "acid wash" is used to again get rid of carbonates. The alkali wash is not used due to the fact that the primary carbon is soluble in the alkali. This is applied to organic sediments, some peats, small wood or charcoal, and special cases. In "collagen extraction", used primarily for bone, acid washes are used to eliminate the mineral. A alkali wash is used to again get rid of organic acids in the sample. An "acid etch" is applied to shell, calcite and calcareous nodules. This involves the removal of secondary carbonate components. Some samples can be "neutralized" using de-ionized water. Usually this is applied to carbonate that have precipitated from ground water ( strontium carbonate and barium carbonate) and have had hardly any exposure to the atmosphere. An "acid/ alkali/ acid/ cellulose extraction" is used in treating wood that is highly contaminated or very old. All is extracted save the wood cellulose.  All of these pre-treatments are Chemical pre-treatments. There are also physical pre-treatments. These involve anything that does not include a chemical treatment. This is mainly work done by hand in removing obvious contamination of rootlets etc. Samples can be scraped clean with a scalpel, dentist drill or carborundum paper.  Now comes the part of the introduction that you have patiently waited for. I will explain how I have used all of the above information to formulate a question for research. I mentioned earlier that I would be using the pretreatment methods in my research. My aim in this Research project is to find out how much of a difference the pretreatment methods made in the final estimation of a sample's age.  " Is there a significant difference between the results of a pretreated sample and the results of the same sample with no pretreatment?"  In carrying out this idea I first had to find a way to test or collect data. I looked up a number of labs to see which ones did radiocarbon dating. Lawrence Livermore Lab was close by and it was a thought to find someone who could advise me. But I later found out that testing is a rather long and fairly expensive operation. The equipment used in testing cost around $2-3 billion a year in upkeep. So I thought of another way to attack my question. I would send out letters to different scientists around the globe and ask for results of tests that had already taken place. I inquired for possible results from a sample of wood and also asked for the method of pretreatment it was subjected to. I also asked if it was tested as a control without the pretreatment and also with the pretreatment.  These letters I sent to professors at Waikato University in New Zealand, to Professors at the University of Zurich, Switzerland, and to Professors at Purdue University where the PRIME Lab operates. I got wonderful replies back from all three areas giving information and web addresses at which there is a great deal of information.  The following report will thank all three and give the results of the information I collected. | |
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