



Antimatter and Positron Emission Tomography

What do Star Trek and Positron Emission Tomography (PET) have in common?
..... ANTIMATTER!

PET is a non-invasive diagnostic technique that takes 3-dimensional images of the body. Measurements and observations are done in vivo via an injection of radioactive isotopes into a patient and subsequent detection of the isotope's decay. So where does antimatter come into this? It's in the decay of the isotope.

The radioisotopes that are most often used are carbon-11, nitrogen-13, oxygen-15 and fluorine-18. These isotopes are neutron deficient and decay when a proton spontaneously converts to a neutron causing a positron to be emitted. These isotopes are mainly used because they decay only by positron emission. A positron, one type of antimatter, is a positively charged electron. When a positron is emitted it collides with an electron and undergoes an antimatter-matter annihilation process. In this process the two equivalent masses of the positron and electron are converted into electromagnetic radiation in the form of two equal ray photons (511 keV) that are emitted at 180 to each other. The emission of the rays is what is detected.

The reason these isotopes are used is that carbon, nitrogen, and oxygen are already present in molecules in our body. Thus, the addition of these isotopes would not significantly alter the chemical properties associated with these molecules. Although fluorine is not present in biological molecules, it can still be used because it is considered to be "isosteric" with the hydrogen atom which is present in the body. The half-lives of the isotopes are less than two hours, minimizing the exposure to radiation but still long enough to make observations. The isotopes are readily produced in their pure form in a cyclotron which adds protons to stable isotopes by high-energy bombardment of the stable nuclei with protons or deuterons. Since the half-lives are so short (oxygen-15: 2.03 minutes, carbon-11: 20.4 minutes, nitrogen-13: 9.96 minutes, and fluorine-18: 109.8 minutes) the isotopes must be made immediately prior to use. Thus, a cyclotron must be nearby.

In 1980, TRIUMF (Tri-University Meson Facility) started western Canada's only PET project in conjunction with the teaching hospital of The University of British Columbia. TRIUMF makes carbon-11, oxygen-15, fluorine-18, and bromine-75 which has a half-life of 98.0 minutes, and radiopharmaceuticals that are used in the imaging process. Once the radiopharmaceuticals are made by chemists they are sent underground in a 2.4 km pneumatic pipeline to the hospital. Travelling time is only 2 minutes! The radiopharmaceuticals are used by the Neurodegenerative Disorders Clinic where movement disorders such as Parkinson's Disease and Amyotrophic Lateral Sclerosis (ALS) are studied.

In a similar joint venture the Faculty of Pharmacy at the University of Toronto and the Regional Radiopharmacy at Chedoke-McMaster Hospitals are working together to synthesize new radiopharmaceuticals. The radiopharmaceuticals will be used for research and clinical purposes such as radioisotope synovectomy in rheumatoid arthritis, myocardial imaging, and neurophysiological measurements. Research is also being done to try and develop a tumour specific therapeutic and diagnostic radiopharmaceutical.