Application of Radioisotopes

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Investigating Aspects of Metabolism

Metabolic Pathways:

- Radioisotopes are frequently used for tracing metabolic pathways. This usually involves adding a radioactive substrate, taking samples of the experimental material at various times, extracting and chromatographically or otherwise separating the products.
- Radioactivity detectors can be attached to gas liquid chromatography or high performance liquid chromatography columns to monitor radioactivity coming off the column during separation.
- Alternatively, radioactivity can be located on paper or thin-layer chromatography with either a Geiger-Muller chromatograph scanner or with autoradiography.

… Investigating Aspects of Metabolism

Studies of Absorption, Accumulation and Translocation:

- Radioisotopes have been very widely used in this study of the mechanisms and rates of absorption, accumulation and translocation of inorganic and organic compounds by both plants and animal.
- Such experiments are generally simple to perform and can also yield evidence on the route of translocation and sites of accumulation of molecules of biological interest.

Pharmacological Studies:

- Another field where radioisotopes are widely used is in the development of new drugs.
- The site of drug accumulation, the rate of accumulation, the rate of metabolism and the metabolic products must all be determined.
- In each of these areas of study, radiotracers are extremely useful.

Analytical Applications

- **Enzyme and Ligand Binding Studies:**
- Radioisotopes have also been used in the study of the mechanism of enzyme action and in the studies of ligand binding to membrane receptors.
- **Isotope Dilution Analysis:**
- There are many compounds present in living organisms that cannot be accurately assayed by conventional means because they are present in such low amounts and in mixtures of similar compounds. Isotope dilution analysis offers a convenient and accurate way of overcoming this problem and avoids the necessity of quantitative isolation.
- For instance, if the amount of iron in a protein preparation is to be determined, this may be difficult using normal methods, but it can also be done if a source of ^{59}Fe is available. This is mixed with the protein and a sample of iron is subsequently isolated, assayed for total iron and the radioactivity is determined.
- If the original specific activity was 10000 d.p.m. $(10\ mg)^{-1}$ and the specific activity of the isolated iron was 9000 d.p.m $(10\ mg)^{-1}$, then the difference is due to the iron in the protein.

... Analytical Applications

- **Radioimmunoassay:**
- One of the most significant advances in biochemical technique in recent years has been the develop-ment of the radioimmunoassay.
- **Radio Dating:**
- A quite different analytical use for radioisotopes is in the dating (i.e., determining the age) of rocks, fossils and sediments.
- In this technique it is assumed that the proportion of an element that is naturally radioactive has been the same throughout time.
- From the time of fossilization or deposition the radioactive isotope will decay.
- By determining the amount of radioisotope remaining (or by examining the amount of the decay product) and from the knowledge of the half-life, it is possible to date the sample.
- For instance, if the radioisotope normally comprises 1% of the element and it is found that the sample actually contains 0.25%, then two half-lives can be assumed to have elapsed since deposition.
- If the half-life is one million years then the sample can be dated as being two million years old.

Molecular Biology Techniques

- Recent advances in molecular biology that have led to advances in genetic manipulation have dependent heavily upon use of radioisotope in DNA and RNA sequencing, DNA replication, transcription, synthesis of complementary DNA, recombinant DNA technology and many similar studies.

Clinical Diagnosis

- Radioisotopes are very widely used in medicine, in particular for diagnostic tests.
- Lung function tests routinely made using xenon-133 (^{133}Xe).
- Kidney function tests using iodohippuric acid are used in diagnoses of kidney infection, kidney blockages or imbalance of function between the two kidneys.
- The most common radioactivity isotope used in radioactive tracer is technetium (^{99}Tc). Tumors in the brain are located by injecting intravenously ^{99}Tc and then scanning the head with suitable scanners.
- ^{131}I and most recently ^{132}I and ^{123}I are used to study malfunctioning thyroid glands.
- Tritium (^{3}H) is frequently used as a tracer in biochemical studies.
- ^{14}C has been used extensively to trace the progress of organic molecule through metabolic pathways.
- Various aspects of hematology are also studied by using radioisotopes.
- These include such aspects as blood cell lifetimes, blood volumes and blood circulation times, all of which may vary in particular clinical conditions.

…Clinical Diagnosis

- A most recent development is positron emission tomography (PET), which is a more precise and accurate technique for locating tumors in the body. A positron emitting radionuclide (e.g., ^{13}N, ^{15}O, ^{18}F, etc.) is injected to the patient, and it accumulates in the target tissue. As it emits positron which promptly combines with nearby electrons, it results in the simultaneous emission of two γ-rays in opposite directions. These γ-rays are detected by a PET camera and give precise indication of their origin, that is, depth also. This technique is also used in cardiac and brain imaging.
- Compound X-ray tomography or CT scans. The radioactive tracer produces gamma rays or single photons that a gamma camera detects. Emissions come from different angles, and a computer uses them to produce an image. CT scan targets specific area of the body, like the neck or chest, or a specific organ, like the thyroid

Therapeutic

- The most common therapeutic use of radioisotopes is ^{60}Co, used in treatment of cancer.
- Sometimes wires or sealed needles containing radioactive isotope such as ^{192}Ir or ^{125}I are directly placed into the cancerous tissue.
- The radiations from the radioisotopes attack the tumor as long as needle/wire is in place.
- When the treatment is complete, these are removed.
- This technique is frequently used to treat mouth, breast, lung, and uterine cancer.
- ^{131}I is used to treat thyroid for cancers and other abnormal conditions of thyroid.
- ^{32}P is used to treat excess of red blood cells produced in the bone marrow.

Ecological Studies

- In particular, migratory patterns and behaviour patterns of many animals can be monitored using radiotracers.
- Another ecological application is in the examination of food chains where the primary producers can be made radioactive and the path of radioactivity followed throughout the resulting food chain.

Sterilization of Food and Equipment

- Very strong y-emitters are now widely used in the food industry for sterilization of pre-packed foods such as milk and meats.
- Normally either ^{60}Co or ^{137}Ce is used, but care has to be taken in some cases to ensure that the food product itself is not affected in any way.
- Thus doses often have to be reduced to an extent where sterilization is not complete but nevertheless food spoilage can be greatly reduced.
- ^{60}Co and ^{137}Ce are also used in sterilization of plastic disposable equipment such as Petridishes and syringes, and in sterilization of drugs that are administered by injection.