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**MATRIC NO: 17/MHS06/022**

**MLS 314 Medical Physics**

**1. What are radioactive tracers?**

A radioactive tracer or radioactive label, is a chemical compound in which one or more atoms have been replaced by a radionuclide so by virtue of its radioactive decay it can be used to explore the mechanism of chemical reactions by tracing the path that the radioisotope follows from reactants to products. Radiolabeling or radio tracing is thus the radioactive form of isotopic labeling.

Radioisotopes of hydrogen, carbon, phosphorus, sulfur, and iodine have been used extensively to trace the path of biochemical reactions. A radioactive tracer can also be used to track the distribution of a substance within a natural system such as a cell or tissue, or as a flow tracer to track fluid flow. Radioactive tracers are also used to determine the location of fractures created by hydraulic fracturing in natural gas production.Radioactive tracers form the basis of a variety of imaging systems, such as PET scans, SPECT scans and technetium scans. Radiocarbon dating uses the naturally occurring carbon-14 isotope as an isotopic label.

There are two main ways in which radioactive tracers are used

1. When a labeled chemical compound undergoes chemical reactions one or more of the products will contain the radioactive label. Analysis of what happens to the radioactive isotope provides detailed information on the mechanism of the chemical reaction.

2. A radioactive compound is introduced into a living organism and the radio-isotope provides a means to construct an image showing the way in which that compound and its reaction products are distributed around the organism.

**2. Discuss explicitly one application of tracer in medicine**

In medicine, tracers are applied in a number of tests, such as technetium-99m(99mTc) in autoradiography and nuclear medicine.

**Application of tracers in autoradiography**

**Receptor autoradiography**

The use of radiolabeled ligands to determine the tissue distributions of receptors is termed either in vivo or in vitro receptor autoradiography if the ligand is administered into the circulation (with subsequent tissue removal and sectioning) or applied to the tissue sections, respectively. The ligands are generally labeled with 3H (tritium) or 125I (radioiodine). The distribution of RNA transcripts in tissue sections by the use of radiolabeled, complementary oligonucleotides or ribonucleic acids ("riboprobes") is called in situ hybridization histochemistry. Radioactive precursors of DNA and RNA, [3H]-thymidine and [3H]-uridine respectively, may be introduced to living cells to determine the timing of several phases of the cell cycle. RNA or DNA viral sequences can also be located in this fashion. These probes are usually labeled with 32P, 33P, or 35S. In the realm of behavioral endocrinology, autoradiography can be used to determine hormonal uptake and indicate receptor location; an animal can be injected with a radiolabeled hormone, or the study can be conducted in vitro.

**Detection of protein phosphorylation**

Phosphorylation means the posttranslational addition of a phosphate group to specific amino acids of proteins, and such modification can lead to a drastic change in the stability or the function of a protein in the cell. Protein phosphorylation can be detected on an autoradiograph, after incubating the protein in vitro with the appropriate kinase and γ-32P-ATP. The radiolabeled phosphate of the latter is incorporated into the protein which is isolated via SDS-PAGE and visualized on an autoradiograph of the gel.

**General Principle Of Autoradiography**

The principle of autoradiographic imaging is the precipitation of silver (Ag) atoms, resulting from the ionization of a silver halide (AgX – silver bromide, chloride, iodide or fluoride – AgBr, AgCl, AgI or AgF, respectively) by radiolabeled samples. AgX are light sensitive compounds commonly used in photography. They are generally suspended in a gelatin photographic emulsion. Each AgX molecule is individually encapsulated in the gelatin, and functions as an independent detector of radioactive decay from the radiolabeled sample. Once radioactive particles hit the gelatin emulsion, AgX is reduced resulting in the production of insoluble silver crystals.

Gelatin photographic emulsions are used to coat photographic and X-ray films, which are made of a flexible base (usually cellulose acetate). When a radiolabeled sample is in contact with a coated X-ray film (exposure), it generates a latent (hidden) image corresponding to the radioactivity distribution within the sample. To make the image visible, the exposed photographic / X-ray film must be submerged in a developing reagent, a chemical mixture that converts the silver crystals into metallic silver, darkening the gelatin emulsion. Silver nitrate (AgNO3) is highly efficient in the reduction of AgX molecules and is usually a component of developer solutions. The reaction is then stopped by a fixative reagent, which removes the excess AgX from the photographic / X-ray film. Highly radioactive areas (e.g. areas with higher concentration of a radiolabeled drug, or with higher metabolic activity) reduce more AgX molecules, resulting in higher optical density in the film (darker areas).