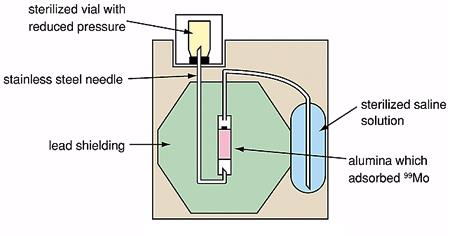
**TAQ-1**

**2. Describe the production of two different radioisotopes for medical imaging purposes.**

Technetium(**90mTc**) is the most commonly used radionuclide. Molybdenum(99Mo) is its parent nuclide, which spontaneously undergoes beta decay and produces the technetium in excited state. Technetium production can be represented by the following equation,

**9942Mo → 0-1𝛃 + 9943Tc**

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As shown in the diagram, an Mo adsorbed alumina container is placed in the Tc generator. The 99Mo undergoes beta decay and produces technetium which gets dissolved into the saline solution being passed through the alumina. Due to the pressure difference this solution is continually sucked up by the sterilized vial. The filled vial now contains a saline solution with only technetium dissolved in it.

Two radioisotopes of Iodine, namely 123I and 131I are used as tracers in medical imaging. I-131 is a reactor-produced radionuclide of Tellurium target. The production of 131I can be shown by the following equations,

**13052Te → 10n + 13152Te**

13152Te then undergoes beta decay to produce 131I.

**13152Te → 0-1𝛃 + 13153I**

The produced 13153I is then washed away and separated by passing an alkaline solution through the beta decaying Te. The alkaline solution absorbs only the 131I particles.

References:

**World-nuclear.org. (2017). Radioisotopes in Medicine | Nuclear Medicine - World Nuclear Association. [online] Available at: http://www.world-nuclear.org/information-library/non-power-nuclear-applications/radioisotopes-research/radioisotopes-in-medicine.aspx [Accessed 21 Aug. 2017]**

**En.wikipedia.org. (2017). Technetium-99m. [online] Available at: https://en.wikipedia.org/wiki/Technetium-99m#Production [Accessed 21 Aug. 2017]**

**Dr Tomislav Me&#353;trovi&#263;, P. (2017). Radioiodine Production. [online] News-Medical.net. Available at: https://www.news-medical.net/health/Radioiodine-Production.aspx [Accessed 21 Aug. 2017]**

**3. State and explain the key biological and radiological properties of radioisotopes used in medical imaging by comparing the two isotopes that you described in 2) above. 200**

99-Tc has a half life of approximately 6 hours and I-131 has half life of about 192 hours(8 days). These time intervals are long enough to monitor and diagnose human body's biological processes. There is no radiation overdose and its harmful effects because these half lives are short enough. They both undergo low energy gamma decay which is detectable by a gamma camera. They are both quickly eliminated from the body. Both Tc-99 and I-131 emit gamma rays and electrons of low energy and because of the same reason the radiation dosage level, the patient is exposed to, is within the safety limits. They emit gamma rays of low energy, which facilitates them to easily pass through the human body and are precisely detected by a gamma camera. I-131 however, converts only 10% of its energy to gamma radiation and the rest 90% is beta radiation which can cause serious damages to internal organs. Due to this, only very low doses of I-131 are used in imaging techniques when compared to Tc-99. Tc-99 has the added advantage that it emits energy only as gamma radiation, there is no beta or alpha emission in the process, and that results in more accurate images.

References:

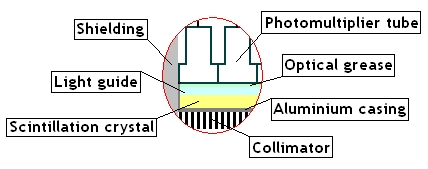
**Khan Academy. (2017). Khan Academy. [online] Available at: https://www.khanacademy.org/test-prep/mcat/physical-sciences-practice/physical-sciences-practice-tut/e/the-radioactivity-of-iodine-131 [Accessed 22 Aug. 2017]**

**Drugs.com. (2017). Sodium Iodide I 131 - FDA prescribing information, side effects and uses. [online] Available at: https://www.drugs.com/pro/sodium-iodide-i-131.html [Accessed 22 Aug. 2017]**

**TAQ-2**

**1. Describe the process of producing a gamma camera image including the preparation of the patient and how the gamma camera works. You will need to include a fully labelled diagram of the gamma camera and refer to it in your answer.**

A radionuclide is administered into the patient's body in the form of a radiopharmaceutical (also called as tracer). It can be in any state of solid, liquid or gas depending on the tracer used. This is then followed by a wait interval which allows the tracer to accumulate in some part of the body for a short period of time. The substance emits gamma radiation while it is in the desired part of the patient’s body. A gamma camera captures these emitted gamma rays and forms an image using a computer.



A gamma camera has a detector plane(crystals) which is optically coupled with an array of photo-multiplier tubes(PMT). The collimator is a lead plate with drilled holes in it. It makes sure that only the gamma rays travelling vertically upwards reach the detector plane(scintillator). As the gamma ray falls on the scintillator, it produces a tiny flash which is too low in energy to be detected by a film. These tiny flashes of photons is then guided via a light guide and the fall on the PMT. The bottom layer of PMT is of photocathodes. When the photon falls on it, an electron is emits an electron which is then accelerated to higher levels of energy by step voltages in the second part of the PMT. This high energy electron collides with other atoms and starts the Avalanche effect which eventually generates enough electrons to produce a small current which is detected by an amplifier. The amplifiers pass on the signal to a computer system which uses this data to generate a diagnostic image.

References

**En.wikibooks.org. (2017). Basic Physics of Nuclear Medicine/Nuclear Medicine Imaging Systems - Wikibooks, open books for an open world. [online] Available at: https://en.wikibooks.org/wiki/Basic\_Physics\_of\_Nuclear\_Medicine/Nuclear\_Medicine\_Imaging\_Systems [Accessed 21 Aug. 2017]**

**(ACR), R. (2017). Nuclear Medicine, General. [online] Radiologyinfo.org. Available at: https://www.radiologyinfo.org/en/info.cfm?pg=gennuclear [Accessed 21 Aug. 2017]**

**En.wikipedia.org. (2017). Gamma camera. [online] Available at: https://en.wikipedia.org/wiki/Gamma\_camera [Accessed 21 Aug. 2017]**

**2. Give an example of a typical imaging process for a particular condition and state what radioisotope would be used.**

In clinical oncology, PET (Position Emission Tomography) imaging technique is heavily used. It is also an effective and important research tool to image the normal metabolisms of human brain and heart, and support in drug research and development. PET is capable of detecting areas of molecular biology detail (even prior to anatomic change).

In clinical oncology, PET scanning is widely used with the tracer fluorine-18 (F-18) fluorodeoxyglucose (FDG), called FDG-PET. Fluorine-18 is a glucose chemical analog (or structural analog) that is taken up by glucose-using cells and phosphorylated by hexokinase. As F-18 enters the patient's body system, it replaces oxygen atoms which may have entered instead. As a result of this lack of oxygen atoms no further reactions happen after the FDG has been generated. Furthermore, most of the human body parts and tissues (except the kidneys and the liver) cannot discard the phosphate introduced in the body by hexokinase. This implies that any cell that takes up FDG, will retain it until it decays out by itself. This leads to dense radiolabeling of body parts which have high glucose uptake, for example the brain and the liver. As a result, FDG-PET can be used for the diagnosing/imaging and curing of cancers with added advantage of monitoring the effectiveness of the treatment.

References:

**En.wikipedia.org. (2017). Medical imaging. [online] Available at: https://en.wikipedia.org/wiki/Medical\_imaging#Nuclear\_medicine [Accessed 22 Aug. 2017]**

**Understanding Medical Radiation. (2017). Types of Medical Imaging. [online] Available at: https://www.medicalradiation.com/types-of-medical-imaging/ [Accessed 22 Aug. 2017]**

**En.wikipedia.org. (2017). Fluorine-18. [online] Available at: https://en.wikipedia.org/wiki/Fluorine-18 [Accessed 22 Aug. 2017]**

**TAQ-3**

**1. Explain the advantages in the use of radiopharmaceuticals for treatment, as opposed to irradiation using external sources of Radiation.**

Radiopharmaceutical is a special class of radio chemical formulation having high purity, sterility and apyrogenicity. It is suitable for administration to human body either orally or intravenously, either for diagnosis or therapy.

Nuclear medicine has a huge advantage that it can detect the radiation coming out of a patient's body with very little or no effect on the biological processes in the body. Other diagnosis procedures expose the body from external source of radiation from a radiation source, which can cause tissue damage and other radiation related problems if the radiation dosage is not monitored strictly.For thorough purposes, radiopharmaceuticals have been used as tracers of physiological processes. Radiopharmaceuticals have a clean safety record and the cases of their negative effects are extremely low.

Nuclear medicine determines the cause of a medical problem based on an organ function whereas other diagnostic procedures determine the presence of a problem based on anatomy or structural appearances of body parts and organs.

As it is a systematic treatment, it can treat multiple disease sites in the body, even those which were not known to be existing to the doctor. It directly treats tumors and especially useful for bone metastasis and usually only one dosage; oral or injection; is needed for the treatment. In short, using unsealed radioactive elements has the advantages of both systemic administration into the patient’s body and treatment using selective irradiation.

As it is a non-invasive treatment technology, the patient can leave the hospital directly after finishing the procedure. Also, radiopharmaceuticals can be used, in metastasis, to ease the bone pain at multiple sites without actually curing the cause of the problem to help the patient. Doing this using conventional analgesic medicines is very difficult.

References

**Pharma Mirror. (2017). Radiopharmaceuticals - Pharma Mirror. [online] Available at: http://www.pharmamirror.com/knowledge-base/pharmaceutical-dictionary/radiopharmaceuticals/ [Accessed 22 Aug. 2017]**

**valenciatoni\_12 (2017). Radiopharmaceuticals. [online] Slideshare.net. Available at: https://www.slideshare.net/valenciatoni\_12/radiopharmaceuticals-11987915 [Accessed 22 Aug. 2017]**

**authorSTREAM. (2017). Radiopharmaceuticals. [online] Available at: http://www.authorstream.com/Presentation/REDDY9441701016-2261224-radiopharmaceuticals/ [Accessed 22 Aug. 2017]**

**Medical News Today. (2017). MRI Scans: All You Need To Know. [online] Available at: http://www.medicalnewstoday.com/articles/146309.php [Accessed 22 Aug. 2017]**

**Chop.edu. (2017). General Radiography: X-ray | Children's Hospital of Philadelphia. [online] Available at: http://www.chop.edu/treatments/general-radiography-x-ray [Accessed 8 Aug. 2017].**

**TAQ-4**

**1. Describe the effects of alpha, beta and gamma radiation on living Cells.**

Alpha particles are very low energy particles, hence they are not able to penetrate the skin. But they can enter the body via oral ingestion, inhalation or adsorption into the bloodstream. Inhaled alpha particles mostly stay in the lungs and can damage the tissue cells and develop cancer. It can also damage the kidneys if it enters the body through blood or liquid ingestion. Prolonged presence of alpha particles in the body can lead to DNA damage too.

Beta radiation is high energy particle and hence it has more penetrative power. It can damage tissue when exposed and even increases the risk of cancer. Inhalation or ingestion of beta particle can cause cell mutation and changes in cell functioning. It is also capable of inducing hair loss, skin burn and weakness.

Gamma radiation is energetic enough to break bonds in genetic material and DNA molecules. It is also capable of altering cell component structures. Prolonged exposure to gamma radiation can lead to diarrhea, headache, hair loss and skin burns along with higher risks of cancer and cataract.

References:

**Sites.google.com. (2017). Biological Effects - Gamma Radiation. [online] Available at: https://sites.google.com/site/smrichardsgammaradiation/biological-effects [Accessed 21 Aug. 2017]**

**Orfano, F. (2017). Learn about the Effects of Alpha Radiation on Humans. [online] Bright Hub. Available at: http://www.brighthub.com/environment/science-environmental/articles/85643.aspx [Accessed 21 Aug. 2017].**

**Rerf.jp. (2017). How radiation affects cells - Radiation Effects Research Foundation. [online] Available at: http://www.rerf.jp/radefx/basickno\_e/radcell.htm [Accessed 21 Aug. 2017].**

**TAQ-5**

**1. Distinguish between the effects that radiation can have on an adult and those which can result as a consequence of a foetus being exposed to a significant dose of radiation. 180**

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Effects of radiation exposure on adults includes, hair loss because the radiation damages the hair roots and renders them unable to grow more hair. Skin reddening (like sunburn) because of high energy transfered to the skin tissue from radiation particles. Breakdown of the intestinal lining due to tissue damage and impairment of functioning of vital organs. It can also cause cataract, sterility and radiation sickness, which involves nausea, vomiting and diarrhea. All of the above mentioned effects of radiation exposure on adults depends on the dose and the duration of exposure.

An embryo is most susceptible to the harmful effects of the radiation in the early fetal period. Exposure to radiation can lead to several effects including carcinogenic, mutagenic or teratogenic effects. Effects of radiation on foetuses are, great tissue damage which leads to miscarriage, DNA damage which results in birth defects and mental retardation. Leukemia is also caused by radiation poisoning. It can also cause mental retardation and growth restriction. The effects of radiation exposure on foetuses depends upon the gestational age and the dose of radiation.

References:

**Imagewisely.org. (2017). Ionizing Radiation Effects and Their Risk to Humans - Image Wisely - Image Wisely. [online] Available at: http://www.imagewisely.org/Imaging-Modalities/Computed-Tomography/Imaging-Physicians/Articles/Ionizing-Radiation-Effects-and-Their-Risk-to-Humans [Accessed 22 Aug. 2017]  
  
ARPANSA. (2017). Health effects of ionising radiation. [online] Available at: https://www.arpansa.gov.au/understanding-radiation/what-is-radiation/ionising-radiation/health-effects [Accessed 22 Aug. 2017]  
  
Williams, P. and Fletcher, S. (2017). Health Effects of Prenatal Radiation Exposure. [online] Aafp.org. Available at: http://www.aafp.org/afp/2010/0901/p488.html [Accessed 22 Aug. 2017]**