Give two examples of the application of radioactive isotopes in the study of the structure determination and Medical diagnosis.

1.Radioactive materials are used to inspect metal parts and the integrity of welds across a range of industries. Industrial gamma radiography exploits the ability of various types of radiation to penetrate materials to different extents. Gamma radiography works in much the same way as X-rays screen luggage at airports. Instead of the bulky machine needed to produce X-rays, all that is needed to produce effective gamma rays is a small pellet of radioactive material in a sealed titanium capsule.The capsule is placed on one side of the object being screened, and some photographic film is placed on the other side. The gamma rays, like X-rays, pass through the object and create an image on the film. Just as X-rays show a break in a bone, gamma rays show flaws in metal castings or welded joints. The technique allows critical components to be inspected for internal defects without damage.X-ray sets can be used when electric power is available and the object to be scanned can be taken to the X-ray source and radiographed. Radioisotopes have the supreme advantage that they can be taken to the site when an examination is required – and no power is needed. However, they cannot be simply turned off, and so must be properly shielded both when in use and at other times.The process of gamma radiography, a type of non-destructive testing (NDT), is used to validate the integrity of poured concrete and welds on fluid vessels, pipelines, or critical structural elements. The unique characteristics of gamma radiography have resulted in the technique becoming a crucial tool throughout many industries. For example, to inspect new oil or gas pipelines, special film is taped over the weld around the outside of the pipe. A machine called a 'pipe crawler' carries a shielded radioactive source down the inside of the pipe to the position of the weld. There, the radioactive source is remotely exposed and a radiographic image of the weld is produced on the film. This film is later developed and examined for signs of flaws in the weld.

2.Radioisotopes are an essential part of medical diagnostic procedures. In combination with imaging devices which register the gamma rays emitted from within, they can study the dynamic processes taking place in various parts of the body.In using radiopharmaceuticals for diagnosis, a radioactive dose is given to the patient and the activity in the organ can then be studied either as a two dimensional picture or, using tomography, as a three dimensional picture. Diagnostic techniques in nuclear medicine use radioactive tracers which emit gamma rays from within the body. These tracers are generally short-lived isotopes linked to chemical compounds which permit specific physiological processes to be scrutinised. They can be given by injection, inhalation, or orally. The earliest technique developed uses single photons detected by a gamma camera which can view organs from many different angles. The camera builds up an image from the points from which radiation is emitted; this image is enhanced by a computer and viewed on a monitor for indications of abnormal conditions. Single photon emission computerised tomography (SPECT) is the current major scanning technology to diagnose and monitor a wide range of medical conditions.A more recent development is positron emission tomography (PET) which is a more precise and sophisticated technique using isotopes produced in a cyclotron. A positron-emitting radionuclide is introduced, usually by injection, and accumulates in the target tissue. As it decays it emits a positron, which promptly combines with a nearby electron resulting in the simultaneous emission of two identifiable gamma rays in opposite directions. These are detected by a PET camera and give very precise indications of their origin. PET's most important clinical role is in oncology, with fluorine-18 as the tracer, since it has proven to be the most accurate non-invasive method of detecting and evaluating most cancers. It is also well used in cardiac and brain imaging.New procedures combine PET with computed X-ray tomography (CT) scans to give co-registration of the two images (PET-CT), enabling 30% better diagnosis than with a traditional gamma camera alone. It is a very powerful and significant tool which provides unique information on a wide variety of diseases from dementia to cardiovascular disease and cancer.Positioning of the radiation source within (rather than external to) the body is the fundamental difference between nuclear medicine imaging and other imaging techniques such as X-rays. Gamma imaging by either method described provides a view of the position and concentration of the radioisotope within the body. Organ malfunction can be indicated if the isotope is either partially taken up in the organ (cold spot), or taken up in excess (hot spot). If a series of images is taken over a period of time, an unusual pattern or rate of isotope movement could indicate malfunction in the organ.A distinct advantage of nuclear imaging over X-ray techniques is that both bone and soft tissue can be imaged very successfully. This has led to its common use in developed countries where the probability of anyone having such a test is about one in two and rising.

Every organ in our bodies acts differently from a chemical point of view. Doctors and chemists have identified a number of chemicals which are absorbed by specific organs. The thyroid, for example, takes up iodine, whilst the brain consumes quantities of glucose. With this knowledge, radiopharmacists are able to attach various radioisotopes to biologically active substances. Once a radioactive form of one of these substances enters the body, it is incorporated into the normal biological processes and excreted in the usual ways.Diagnostic radiopharmaceuticals can be used to examine blood flow to the brain, functioning of the liver, lungs, heart, or kidneys, to assess bone growth, and to confirm other diagnostic procedures. Another important use is to predict the effects of surgery and assess changes since treatment.The amount of the radiopharmaceutical given to a patient is just sufficient to obtain the required information before its decay. The radiation dose received is medically insignificant. The patient experiences no discomfort during the test and after a short time there is no trace that the test was ever done. The non-invasive nature of this technology, together with the ability to observe an organ functioning from outside the body, makes this technique a powerful diagnostic tool.A radioisotope used for diagnosis must emit gamma rays of sufficient energy to escape from the body and it must have a half-life short enough for it to decay away soon after imaging is completed.The radioisotope most widely used in medicine is Tc-99, employed in some 80% of all nuclear medicine procedures. Myocardial perfusion imaging (MPI) uses thallium-201 chloride or Tc-99 and is important for detection and prognosis of coronary artery disease.For PET imaging, the main radiopharmaceutical is fluoro-deoxy glucose (FDG) incorporating F-18 – with a half-life of just under two hours – as a tracer. The FDG is readily incorporated into the cell without being broken down, and is a good indicator of cell metabolism.

Sources:

1. www.world-nuclear.org/information-library/non-power-nuclear-applications/radioisotopes-research/radioisotopes-in-industry.aspx

2. www.world-nuclear.org/information-library/non-power-nuclear-applications/radioisotopes-research/radioisotopes-in-medicine.aspx