Analytical Technologies in Biotechnology
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Module - 2
Radioisotopes Techniques
Lecture - 6
Safety aspects and applications

In previous lectures, we have discussed about the methods for detection and quantification of radioactivity. We have discussed three methods, one based on ionization of gases, where GM counters are utilized. Second one on the based on the excitation of the solutions and solids, where we have discussed about solid and liquid syndication counters. And third one that is based upon the exposure to photographic emulsion, that is autoradiography. All three methods have particular applications and they could be utilized, as per the requirement of in particular application. Now, in this lecture we are going to extend our discussion on radioactivity, and we are going to discuss about, different applications of radio isotope technique and the safety aspects involved here.

Now, before we go into that let us first discuss there is one more technique, which is very important and it is the very sensitive and versatile technique, that is radio immuno acid. And this technique is quite widely used in both research and diagnostics. Now, this technique as it utilizes radio isotopes, this will certainly require to follow certain precautions, as well as you have to take license to use the radio isotopes. Another technique, which has kind of replaced radioimmunoassay Elisa, which will be discussed in some other section.

So, radioimmunoassay is a very sensitive used to measure concentration of antigens by the use of antibodies. Now, this could be like say, you would like to determine hormone labels in the blood or certain other analyte in the blood then if you have the suitable antibodies for that you can use it for as saying that particular substance. Now, this technique has revolutionized research and clinical practices in many areas. For example, blood banking in diagnosis of allergies say in the field of endocrinology and so on. So, it has revolutionized lot of different areas, it is a very simple technique, a very simple methodology is followed here to perform the assay.

So, what is done is I will show you the figure also, but just we will discuss little bit before that. What is done is, a known quantity of antigen is made radioactive by labeling it with mostly gamma radioactive isotope of iodine, which is attached to thyroxin. Now, the radio labeled antigen is mixed with known amount of first antibody for that antigen so that, they bind to one another. So, what you have is a radio label bound to antigen to first antibody, then a sample of serum of patient from a particular patient containing unknown quantity of the same antigen will be taken, and it will be added. And this is unlabeled antigen, so we can call it cold antigen or unlabelled antigen.

Now, what will happen is the unlabelled antigen will compete with the radio labeled or we call hot antigen, for antibody binding site. And this will certainly lead to, at increasing concentration of unlabelled antigens, what will happen is that increasing amount of radioactive antigens, will be displaced from the antibody molecules, and thereby, reducing the ratio of antibody bound radio labeled antigen to free radio labeled antigen. So, what you will are going to see in the solution, that you have a lot of free anti labeled antigen because it has been replaced by the cold antigen.

Now, antibody bound antigen is separated from the free antigen, the superannuated and radioactivity of each is measured, using a gamma counter. So, you can like first thing to do be done is, you have to have known the standards and the binding curve can be generated, which allows the antigen amount in the patients serum to be derived. As we do it for many other assays, so this is a very simple methodology, which is utilized in radioimmunoassay.

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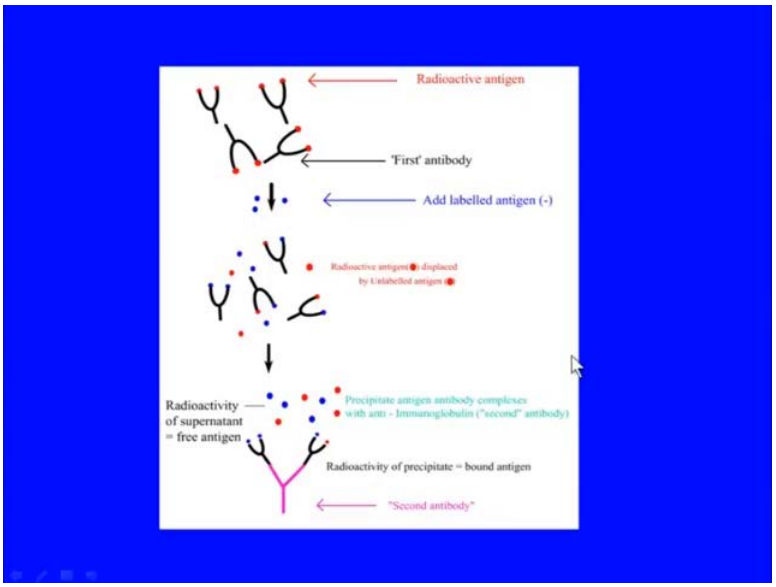

Now to explain that through a figure if you see on your screen, if you can see here, there is antibody here and there is a red colored antigen bound to that. That is the radio labeled antigen now, after radiolabel antigen you have bounded then that is the first we call it, first antibody and this is hot antigen, in terms of it is radio label antigen. Now, what you do is, you add unlabeled or cold antigen which is, we have negative as we have shown. Now this one, as the concentration is higher or increasing they will compete for the same site actually, because they are same antigen.

And some of the antigens the radio labeled antigens would be replaced in here. And then what will happen that the free labeled antigen then could be. So, the radioactivity of supernatant will be equivalent to free antigen and radio activity of precipitate will be bound to antigen. So, you can measure the radioactivity in free or free antigen and then ratio can be taken, and finally and this one here, which is shown here is the second antibody, which binds to the first antibody, so this way you can calculate the ratio and a standard curve can be drawn.

And through which, you can from the standard curve, you can determine the concentration of the unknown antigen. So that, that could be done without any problem so that is the very simple method of radioimmunoassay. Now, this is like I said it is very sensitive technique, quite used quite a lot in research, as well as clinical practices, but Elisa has kind of replaced it. Now, when you have done radioimmunoassay the one thing

which has to be done is, separating the bound antigen from free antigen. And there are several ways to do that, you can precipitate the antigen, antibody complex by adding the second body, directed against the first like, rabbit antibody can be used by adding an anti rabbit anti serum.

Then, antigen specific antibody can be coupled to particles like sephadex and by centrifugation, it can be separated. Radioimmunoassay is widely used, because of its great sensitivity, but it will certainly have certain disadvantages. For example, both iodine 125 or 131 emit radiation, that require special counting equipment. Now, many times body can concentrate iodine atoms, which can be radioactive or not in thyroid gland, where they are incorporated in, where thyroxin actually. But aside, beside these disadvantages, despite these disadvantages there are various applications which have been like for say, like hormone label in the blood.

It can be, it could be very useful for the presence of say hepatitis b surface antigen, in donating blood. That could be in blood banking, it could be analyzed DNA anti DNA bodies, could be utilized in systemic lupus erythematosus like, SLE. So, lot of different applications could be there for radioimmunoassay. So, this is like very sensitive and specific technique and which could be used with radio isotopes. Now, we will move on to the applications of the radio isotopes.

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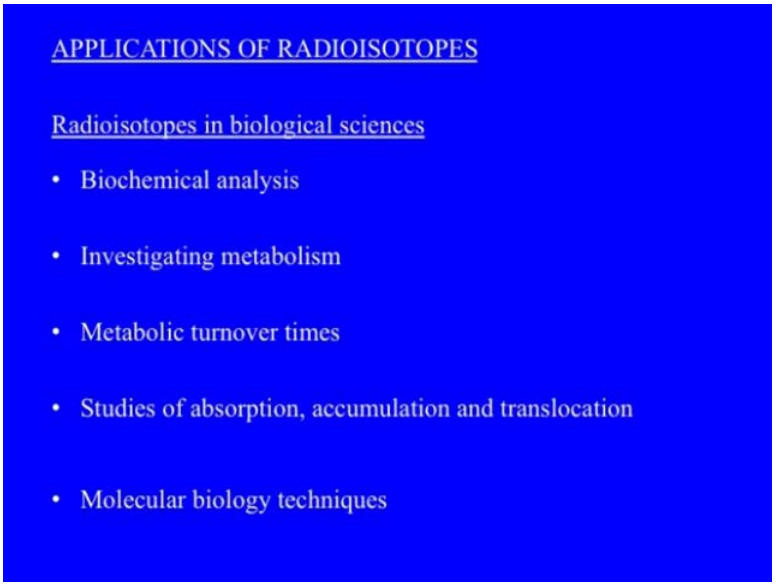

There are many applications of radio isotope techniques and radio isotopes are used in many different fields, which includes biological sciences, as well as other fields, which even include like, humanities and arts like, we will see how that is applied in there. So, let us start with radioisotopes, in biological sciences, what are different applications of these biological sciences. Now, one is biochemical analysis see, in bio chemical analysis you can detect presence or absence of some radioactive material, when they exist in low concentration. So, radioisotopes can be used to label molecules of biological samples, in vitro, that is out of the body.

And thus could be determine, the constituents of blood, serum, urine, hormones, antigens and many drugs, by use of associated radio isotopes. So, you can have like radioimmunoassay could be utilized to determine these like, we have discussed earlier. So, bio chemical analysis requires or can be, can use different kinds of radioisotopes. Then lot of different aspects of metabolism, where research is going on in metabolism, radioisotopes could be utilized. For example, radioisotopes are frequently used, for tracing metabolic pathways, it involves adding a radioactive substrate now then extracting and separating products from samples taken at, various times.

One example could be, to predict the fate of individual carbon atom say, 14c in acetate through the TCA or Krebs cycle. Now, this method have been developed, to isolate the intermediates and know the distribution of carbon, within each intermediate. Another example could be, evaluating pathways of say glucose catabolism. Now, to know the relative contribution of glycolysis, followed by Krebs cycle together with the pentose phosphate pathway, both path ways involves complete oxidation of glucose to CO_2, but the origin of the CO_2, in terms of 6 carbon atom of glucose is different. So that could be, asserted so lot of like in different investigative aspects of metabolism, this could be utilized.

Then, you can determine metabolic turn over number or how many times this takes place actually. So, radioisotopes provide a convenient method of ascertaining turn over times for particular compound example, turnover of proteins can be followed by injecting a radioactive amino acid of choice. And the radio activity in the organ or tissue of the interest is determined, at different time intervals. Then you can study absorption, accumulation and translocation of particular analyte. So, radio isotopes are frequently

used, to study the mechanism and the rates of absorption, accumulation and translocation of inorganic and organic compounds.

In both plants and animals, so this is another important application of radioisotope. In research, in molecular biological techniques radio isotopes are used quite a lot. The use of radio isotopes, has been critical I would say in advancement of molecular biology, leading to genetic manipulation. The radio isotopes have been used, in many procedures including DNA and RNA sequencing, linear application, transcription studies, synthesis of c DNA, recommend DNA technology and several other studies. So, in molecular biology this has really helped, in understanding lot of different mechanisms and procedures.

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In ecological studies, radio isotopes could be used. For example, radio stressors can be used for migratory pattern and behavior pattern of many animals. Then examination of food chains where the primary producers can be made radioactive and the path of the radio activity, followed throughout the resulting food chain. So, this is another important application of radio isotopes. Radio isotopes could be utilized, for sterilization of food and equipment. Now, very strong gamma emitters are widely used for, sterilization of pre packed foods such as milk and meats, by radiation. Normally, it could be cobalt 60 or 137 ccm is used for radiation. Care needs to be taken to ensure that, food product is not affected and so the doses are reduced or has to be standardized.

Now, food spoilage can be reduced to a great extent by this and it makes it more safer and fresh for a longer time. Then also, these things could be, these isotopes could be, radio isotopes could be utilized for sterilization of plastic disposal disposable equipment such as syringes and in the sterilization of drugs, that are administered by injection. So these, this is like quite good or quite important in sterilization of food and equipment. Another important application could be, generating mutagens.

Radio isotopes, may cause mutations particularly in microorganisms and in various micro biological studies, mutants are desired or desirable. Especially in industrial microbiology so radio isotopes could be used for mutagenesis and development of a new strain of a microorganism. That could produce give higher yields or desired product, which could be a microbial product. Radio isotopes are widely used in. lot of analytical applications.

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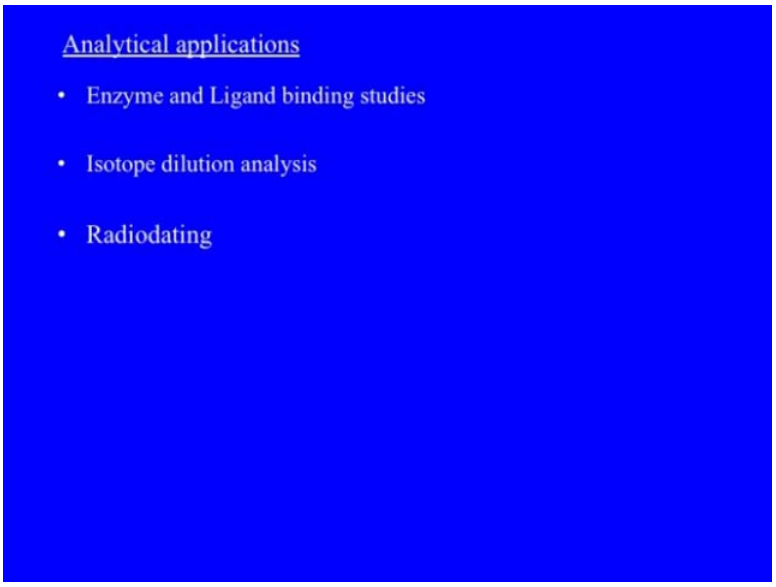

For example, in enzyme and ligand binding studies. To study mechanism of enzyme action ligand binding studies could be done, through radio tracer method. The method is more expensive, but provides a very high degree of sensitivity. Then isotope dilution analysis could be done like, many compounds in living organism, which cannot be because of presence of low amounts and in mixtures of several compounds, can be by this particular method. Only thing is that, you should have a radio form of compound, it

should be available. Now, in isotope dilution analysis what it provides is, convenient and accurate method, to solve this problem and avoid necessity quantitative isolation.

The technique is widely used say for, studies on trace element for example, to measure amount of iron in protein preparation, 59 Fe is mixed with the protein. And a sample of iron is sub sequentially isolated and I said for total iron and radioactivity is determined. So, this way you can determine very small amounts of different compounds. Then another very important and you must have heard about this it is radiodating. You must have heard about that, one fossil have been found which is so like a million years old or thousands of years old. So, radiodating or dating is the method of determining, the age of object which could be usually rocks, fossils, sediments etcetera.

On the basis of concern now this is done on the basis of concentration of a particular radio isotope, present in the sample. Here it is assumed that, the radio isotopes begin to decay at the time of fossilization or deposition, but by determining the rate of isotope remaining or amount of decay products. And from the knowledge of half life of radioisotopes, it is possible to date the sample. So, radio carbon dating is one such type of radio dating method.

Now, for say longer periods, uranium 238 or uranium 235 could be used, which has half life for around 4.5 billion years, and decays to let, 206 as we have discussed in earlier section. So, if this is present in a rock and by how many half-lives it has gone through, you can determine the age of the rock. For short term dating 14c is widely used, for long term dating uranium could be used actually. So, radio dating is very important part of radioisotope technique.

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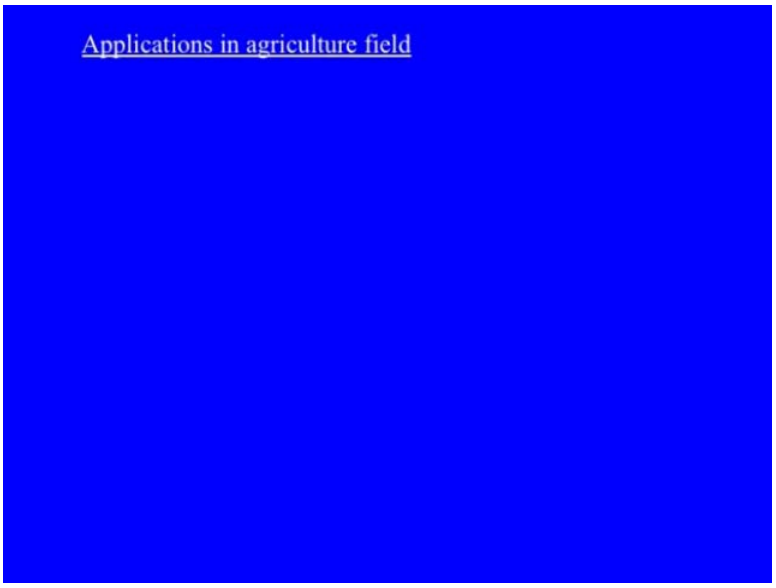

There could be, there are lots of applications of radio isotopes in agriculture field also, for producing high yielding crops seeds and speed of the process of developing superior agricultural products, radio isotopes could be used. Radiation palates are used in, green elevators to kill insects and rodents, insect control is very important application for, pest populations are drastically reduced and in some cases eliminated by, exposing the male insects to sterilization. So, they will have no off springs and thus will be reducing in population. Treasure technique is used to study the rate and direction of movement of an element in a plant isotope.

In plants, radio isotopes are used for determining the function of fertilizer, in different plants and also for reducing the consumption of fertilizers. So, you can see that, radio isotopes also have application in agriculture field. There are very like, radio isotopes are widely used in the field of medicine, there are whole lot of applications in the field of medicine, right from diagnostics to detection, to cure of diseases. One of the main field, which is nuclear medicine is a very prominent field in the medical sciences.

Now, nuclear medicine is a branch of medicine, that uses radiation to provide information, about the functioning of a person's specific organs or to treat a disease. Now, this information can be utilized by physician to make a quick and accurate diagnosis of patients illness. For example, thyroid warns, bones, heart, liver and many

other organs can be easily damaged and disorders in their functions can thus be, revealed through this technique.

Radiations can be used to treat diseased organs or tumors as well, nuclear medicines was developed in 1950's by the physicians with an endocrine emphasis. Initially using I131 to diagnose and then treat thyroid diseases. In recent years, lot of advancement has taken like for example, tomography like CT oblique, PET position emission tomography procedures have been established. So, lot of advancement has been taken in this place and now, this radio isotope technique could be used for diagnosis nuclear imaging and other applications.

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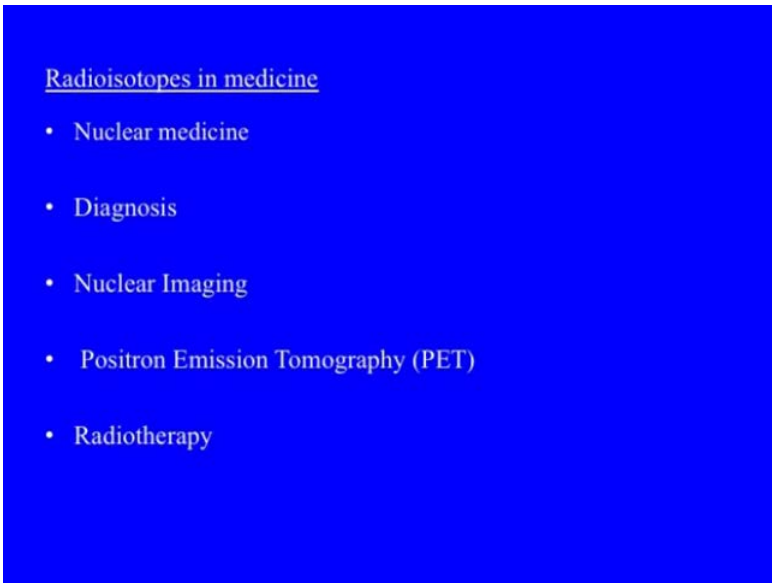

Like for example, radioactive tracers which emit radiations, from within the body could be used now, tracers should have short half lives to minimize the radiation dose to the patient. And can be given by injection, inhalation or inhalation orally or orally. So, they can be given by either injection, inhalation or they can be given orally. Nuclear imaging is another field in here, to evaluate like for example, brain functions or other organs. Organic radio chemicals are utilized for this purpose and gamma camera devices like, gamma camera can be utilized to detect radiation emitted from the organs.

And can view organs from many different angular sections, images can be enhanced by computer and viewed, can be viewed by physicians to detect blockages or other dysfunctional activity. It could be utilized to evaluate heart diseases like for example, a

radio isotope could be injected into the patient's blood stream, while he or she is exercising at 32 people could be injected say on a, he is working on a treadmill and the radio isotope travels towards the heart. And allows the doctors to follow, it on the screen so while looking at image doctors can check for reduced blood flow through arteries, a signal of heart disease.

Positron emission tomography, we were talking about is a very precise technique and it could be utilized for in different applications like, in oncology, in cardiac and brain. Combination of PET with city scan, computer tomography scans can be very useful and could give a better detection or diagnosis. Then there is a field of radio therapy so radio therapy could be utilized to cure many diseases like for say example, rapidly dividing cells are sensitive to damage, by radiation. Now, cancerous growth can be controlled or eliminating by, eradiating the areas concerning the growth precisely.

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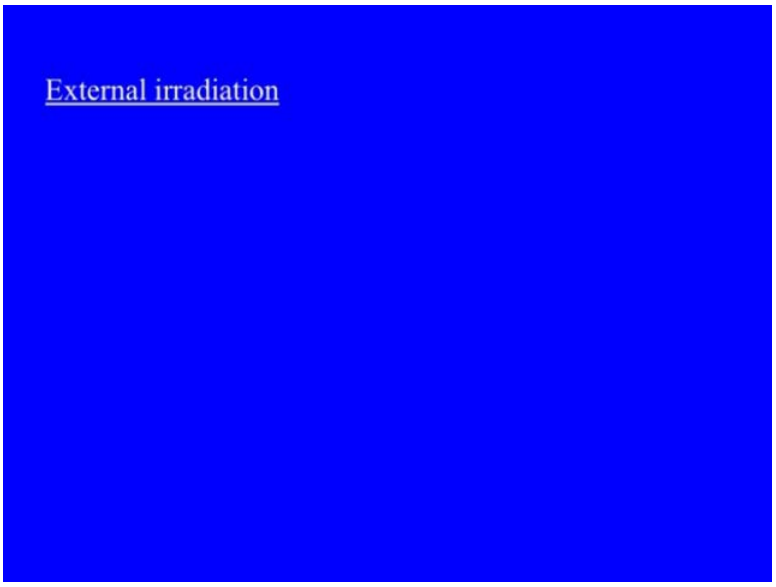

It could be external irradiation, where it is given externally or it could be internal radio therapy.

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Where you administer or plant a small radioactive radiation source, in the target area. So, this could be lot of different kinds of methods could be utilized here, there is boron neutron capture therapy. Boron 10, which concentrates in malignant brain tumors could be utilized, patients irradiated with thermal neutrons, which are strongly absorbed by the boron, and producing high energy particles, which can kill cancer. There are lot of different ways you can, one can or the medical people can utilize this radio isotopes. Radio isotopes can be utilized in another field, that is pharmacological studies.

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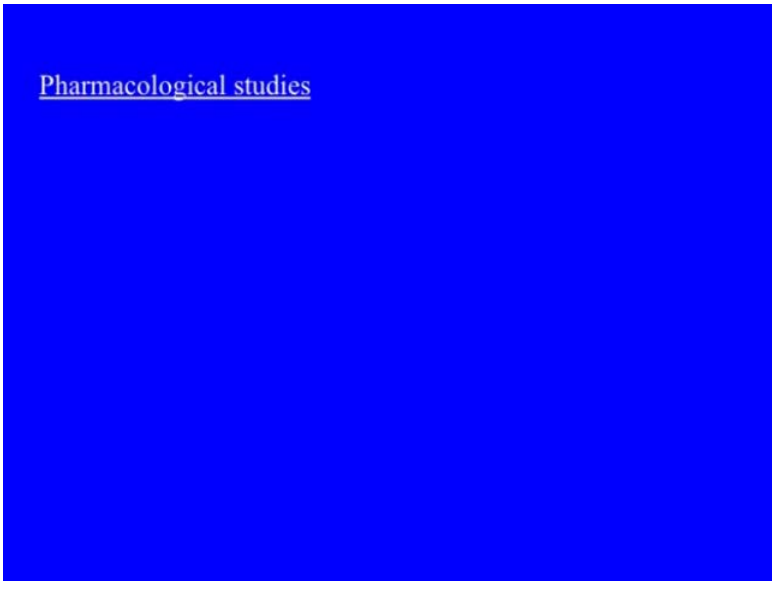

For development of new drugs, whether it has a desirable affect for clinical applications or say you want to locate the sight of accumulation. You want to know the rate of accumulation or the rate of metabolism and metabolic products can be determined using, radio isotopes. In each of these studies radio tracers would be utilized, say you can have auto radiography on whole section of experimental element. Yield information on sight and rate of accumulation so in pharmacological science studies say, accumulation of drugs could be seen or other analytes could be seen.

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So, diagnostics radiopharmaceuticals is used to examine blood flow to brain, functioning of the liver, lungs, heart or kidney to assess the bone growth, to predict the effect of surgery and lot of other things. A number of chemicals which would be identified, which are absorbed to specific organs for example, thyroid takes up iodine, brain consumes glucose. Likewise, which chemicals, which substances accumulate where it could be found out. So, with this knowledge radio pharmacists are able to attach, various radio isotopes to biologically active substances, which could be used for different applications. Radioactive form of these substances, after entering the body they are incorporated into biological processes and will be excreted in the usual way.

So, there are a lot of, lot of examples of these isotopes. Now like this, like you can use gamma ray emitting isotopes or you can use beta, like we have used 32P or I iodine 131, these could be used for lot of different applications. There is one called urea breath test,

it is used to detect the presence of the bacteria helicobacter pylori, in the stomach and this bacteria causes inflammation, ulcers and atrophy of the stomach. So, patient given with certain amount of urea, they will contain carbon that is 14c.

Now, if helicobacter is there in the stomach, urea will be broken down to carbon di oxide and is it is released and exhaled by the patient, which could be collected in a balloon and detected for the presence of the bacteria. Radio, therapeutic radiopharmaceuticals is another field where radio isotopes could be used, like for example, to destroy or malfunctioning cells, using radiation.

Radio isotopes generating the radiation, can be localized in the required organ through a radioactive element, following its usual biological path. For example I131, we have seen could be utilized for treatment of cancer of thyroid. And there are other examples like for example, boron 11 for metabolism and brain tumor treatment. So, these were applications for the, in the field of medical and pharmaceutical science.

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There are certainly the other applications like for example, radio isotopes could be utilized in industrial field also. Like for example, many types of thickness gauzes exploit the fact that, rays are attenuated when they pass through the material. So, while measuring the number of rays, the thickness can be determined and this process have several industrial application. For example, in automobile industry to test steel quality in the manufacture of cars and obtain the proper thickness of tin and aluminum. In air craft

industry to check for false in jet engines, construction industry, like for example, to increase the density of road side surfaces and substances.

And pipe line companies to test the strength of wells and other. So, there are radio isotopes can very well be used in industrial applications also, like there is another industrial application could be, cable manufactures to check cables and cracks other things. These are like a few applications of in industry now, not only in Indus industry like I said they could be used in art and humanity also. Neutron activation analysis, is useful in identifying the chemical elements present in say coins, pottery and other artifacts from the past. A tiny unnoticeable flack of paint from an art treasure or microscopic grain of pottery is sufficient to reveal its chemical makeup.

And this could be utilized say, work of famous painters that can be finger printed and could be detected. You can detect the work of forgers also, this so radio isotopes if as we have gone through has applications in many areas. Like from, right from biological sciences of biotechnology, to agricultural sciences, to medical sciences, pharmaceutical industry in normal other industries and even in art and humanity. So, radioactive isotopes have wide applications and it is like, it is being utilized for many different, it is being utilized in many different areas of size and otherwise. Now, all though it has lot of applications, but radio isotopes or radioactivity is a dangerous thing, it is not safe unless, it is properly utilized.

So, there are a lot of safety aspects related to this. So, when you have to utilize it, you have to permissions due care and precautions have to be taken and in this section, we are going to discuss those safety aspects involved, with the use of radio activity. Now, radio activity is a natural phenomenon and natural sources of the radiation are, the features of the environment, they are present all over in different forms actually. Now, radiation and radioactive substances have many beneficial applications like we have seen, ranging from power generation through nuclear plants to, use in biological sciences in field of medicine, in field of industry, agriculture and likewise.

Now, the radiation risk for to workers, to public and to the environment that may arise from these applications has to be, assessed and if necessary has to be controlled. So, that is a very important part of radio isotope technique. So therefore, some of the activities mentioned like, which I am mentioning here are subject to, standards of safety. For

example, medicinal use of radiation, one has to take care that, how much doses has to be given, whether they are safe or not. Then operation of nuclear installation, where they are localized like are they closed to community, what are the safety precautions being taken, to operate them.

And then production and transport and use of radioactive material then very important part is management of radioactive waste, which is generated after its use. So, it has to be properly disposed so that, it will not cause any harmful effects. Now, greatest disadvantage of using radio isotope is their toxicity and they are toxic because they produce ionizing radiations. So, when absorbed radiation causes ionization and free radicals, that will interact with the cells and different parts of the cells, macro molecules. And which could cause mutations, in DNA by affecting or altering the DNA and could hydrolyze proteins.

Now, these can damage any molecule by ionization and may be damaged to DNA for certain extend could be, repaired and not all the times. Many times DNA damage is not repaired and it could lead to mutations and which could be deleterious also. Like for example, mutation can lead to the formation of tumor and this has happened in many cases. So, for one example when we are utilizing these radioisotopes in labs in biotechnology labs.

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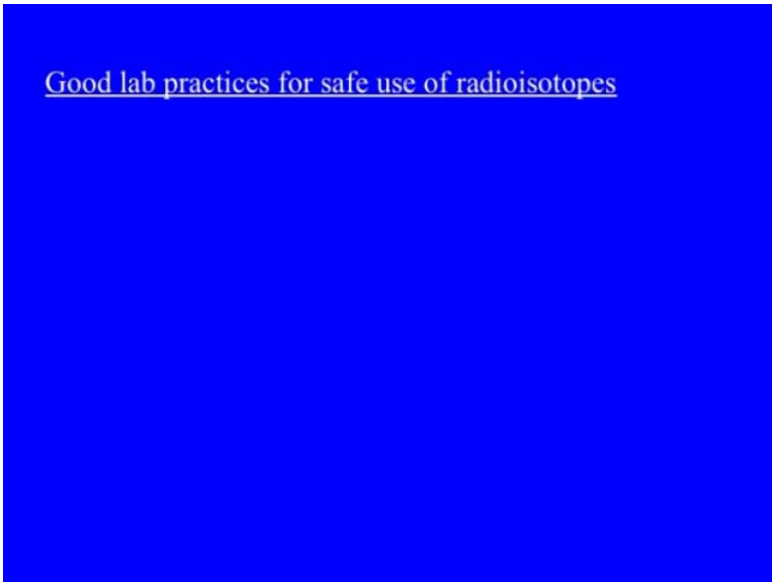

There are certain or any biological lab, there are certain good lab practices for, safe use of radio isotopes. And I would like to discuss some of them in here, now, good lab practices is a must for anybody, who is going to use these radio isotopes in any part or anywhere, of any application. And the first part is, one has to fully conversant with radiation protection by, reading lot of literature like reading regulations for the safe handling. And use of radio isotopes, there are lot of publications like code of practices to use radio isotopes and other publications, which are published by competent authorities.

So, those needs to be read thoroughly and understood thoroughly to, before going on to use the radio isotope, radio isotopes for your research or your other works. Second thing to be done is, one needs to obtain license from the department of energy or department of environment. Like for example, in India you have to obtain a license ah from bhabha atomic research center or BARC and other agencies. And so second part is that before you are utilizing radio isotope technique, you need to get the proper permissions, you need to obtain license. And they will be monitoring your area of research, where you are going to work and different aspects.

So that a safe utilization of radio isotopes could be performed then when you are using it, after you have done these first two things. Then there are certain norms to be followed like, proper training has to be taken and when you are utilizing the radio isotopes in the lab, first thing is protective clothing. That you have to protect yourself, protective clothing you have to wear gloves, which could be protective, protect so that you do not come in direct contact through your hands. There could be double gloves could be worn, there should be full length, lab coat should be used and closed toe shoes like, completely closed shoes has to be utilized.

And safety glasses for your protection of your eyes so you have to protect yourself, your sensitive areas like your skin, eyes and other like, you have to protect them through protective clothing. Second thing is mouth pipetting needs to be avoided completely, you will not mouth pipette a radio isotope solution. So, what you have to do, you have to use automated pipettes for this first. There should not be any food or drinks in vicinity, where you are utilizing radio isotopes or you are storing radio isotopes. Food and drinks has to be kept at a safer distance from, where your areas of, area is where you are utilizing radio isotopes or where you are storing.

Like for example, if you are storing at different place food and drinks has to be kept away from that place. Storage of radio isotopes is another important area, you will not leave radioactive material unsecured and unattended. Only when you are present there, you need, you will be utilizing those radio isotopes otherwise, you lock and secure those radio isotopes in safe place. So, this is very important part one has to really pay attention to these. Many times it might happen that, you might spill radio isotopes while using them and spillages are another important problem. So, all spillages like which are, may be on the floor or you are working area or on your skin, or clothing should be attended immediately.

And due care should be taken and it should be, problem should be solved here. So, spillages should be avoided, but if it spillages occur, spill the radio isotope you should clean it up and proper guidance's or directions needs to be followed here. All the labs which are utilizing radio isotopes, has to use proper signs and labels. So, any container, equipment, room, contaminated area with radioactivity should be labeled with proper signs, as radioactive like, it should show that, it is a dangerous thing. And one has to be careful, not to go near it unless somebody needs to use it and that too with protective clothing and all other precautions.

I will show you the signs, what we use like some of those then they should be like radio isotopes, where should be used in bio, safety cabinets or fumers. There is a term called alara, a l a r a which is like here, alara that is keeping radiation exposure to s low s reasonably, achievable, that is what it means. So, one has to take all the precautions, to follow all the guidelines to keep radiation as low as reasonably achievable. So, what one has to do, take all precautions to keep radiations exposure as low as possible.

We have radiation monitor badges and get them checked regularly, for radiation exposure. We will discuss it in a little while, check yourself, your clothing, area of work after radio isotope work is done. And this could be done like GM counters routinely, even if spills have taken place you can use, GM counters to detect that. And this is a very important part of safety in radioactivity use so these are some of the things.

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Now, if you can see these symbols here, this is like it shows ionizing radiation hazards symbol, which could be pasted on the areas where, work is going on. On the labs doors of the labs, which are utilizing radio isotope technique.

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There is another one, which is radioactivity danger logo, which could be also pasted in areas where radio isotope, are being used. So, these are two signs this one and another one and there other signs also, which needs to be pasted. And proper like, dangerous signs has to be, people has to be alerted for these, radioactivity is being used. Now, the if

like, little bit into what happens when, certain amount of somebody is exposed to radiation. And what are different parameters, which are important in here now, the toxicity of radiation will be dependent on, if somebody is really exposed or comes in close contact.

It will depend on the first is, the amount present that is the amount of radio isotope or radio activity present then amount absorbed by the body. And the energy of the absorbed radiation and its biological effect, all these things needs to be assessed. Therefore, a series of additional units and other ways have been devised, to assist this radiation hazard can be measured in terms of exposure. That is the quantity expressing the amounts of ionization in here, and there are lot of different ways, which could be done. We are not going into the details of that, one has to monitor and control exposure, radiation has always been present in environment and in our bodies.

The human body cannot sense ionization, ionizing radiation, but a range of instruments that are capable of detecting very low labels of radiation, from natural and main source adjust and they should be utilized. Like for example, there are dosimeters which are widely utilized now, dosimeters are available to measure the absolute dose over a period of time. If you know, we are talking about the badges, need to be put on your clothes or close vicinity, where it could be, the amount of exposure could be checked. So, dosimeters are available for that and they could measure the absolute dose over a period of time, they could be iron chamber dosimeters and they resemble like pens and they can clip to ones clothing.

And must be periodically recharged and the result should be locked, they could be film-badge dosimeters. And they enclose a piece of photographic film and this film becomes exposed, as the radiation pass through it. So, they must be developed in photographic emulsion, as photographic emulsion so the exposure can be counted and locked. So, once developed they will be, they are discarded.

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Now, there could be thermo luminescent dosimeters, which contains crystals, that emit visible light when heated. And they could be utilized again for logging and to record amount of exposure. There are lot of other like Geiger counters or scintillation counters, could be used for measure these things, radiation.

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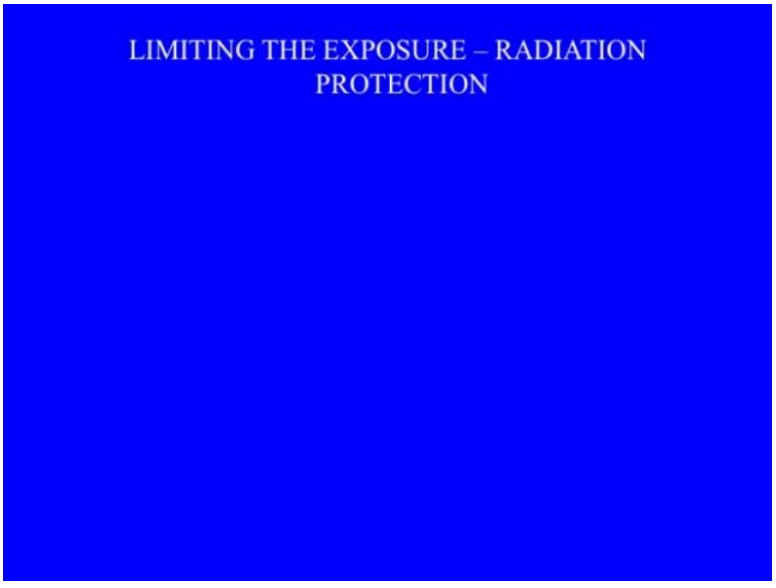

Now, another important part is how to limit the exposure, that is radiation protection. This is also known as radiological protection and it is the protection of the people and the environment, from the harmful effects of ionizing radiation, which include both particle

radiation at high energy electromagnetic radiation. Now, radiation protection can be divided into one occupational radiation protection like, protection of workers and then medical radiation protection, that is the protection of patients and the radiographer. Now, there is public radiation protection like for example, protection of the individual members of the public and the population as the whole.

For example, if there is a nuclear plant then that comes under public radiation protection radiation. Radiation exposure can be managed by combination of three factors, that control the amount of or of dose of radiation received from a source. For example, one is the first factor is time, the amount of radiation exposure increases and decreases with the time people spend near the source of radiation. Now, reducing the time of exposure will reduce the effective closed proportionality so if you are, if you are near the radiation source for lesser time, you will be exposed less, proportionately less.

And distance that is very important, the farther away people so one needs to be as away from radiation source, as possible. And that will also result in less exposure, also the energy of the radiation will determine whether, if you are at a particular distance so that, your exposure is less. For example, there are, we have discussed about beta particles with different energy levels, gamma rays which are highly energetic. And alpha rays which are not so they are energetic, but they are not so penetrating. Now, third factor is shielding which is very important to protect people now, greater the shielding around a radiation source, the smaller is the exposure.

So, biological shield refers to a mass of the absorbing material, placed around reactor or other radioactive source, to reduce the radiation label safer to humans. So, effective for if material as a shield is related to its cross section for scattering and absorption, proportional to the total mass of the material per unit area, inter proposed along the line of site. Between the radiation source and the reason to be protected, there could be different radiations like I said alpha radiation, a thin piece of light material could be utilized such as paper or even dead cells in the outer layer of the human skin are adequate, for shielding as these are not penetrating.

So if, but alpha source is present inside the body then there is no protection because the cells could be exposed to these particles. So, if these are inhaled or ingested then they could be dangerous, beta particles like I said they could be of different energy and they

could be ah covered or they could be avoided by heavy clothing. Like for example, materials of 5 millimeters of aluminum could be good enough to, attenuate these rays. Gamma rays are highly penetrative so you require thick dense shielding such as, lead it is necessary to protect against the gamma rays. And higher the energy of the gamma rays, thicker the lead must be likewise, x rays, exposure to x rays could be also, could be also shielding could be utilized, proper shielding could be utilized for that also.

So, when you are handling the radio isotopes, the rule is to minimize the distance between yourself and the source, minimize the time of exposure and maintain the shielding at all times. Management of radiation protection is similar, in many countries there are like I said that there are lot of regulations, there are lot of publications, which should be, one should be conversant with. And proper lab licensing and proper precautions need to be taken, to use these radio isotopes or the radioactivity. So, this is the little bit about safety aspects, which needs to be taken care of while using radio isotope technique.

So, this completes our section on radio isotope technique. And we have gone through, the basic concepts of radio isotope technique, where we have learnt about different types of radioactive decay the interaction of those particles, with matter, different types of detection and quantification method. In particular three methods then we have learnt about radioimmunoassay, very much used in research and clinical practices.

And we have learnt about, various applications of radio isotope technique. And particularly the safety aspects, which are very important for public at large, for researchers, medical science people to be protected from radio isotope, radio isotopes while using them for a lot of different applications. In coming lectures, we are going to start a new topic, that is chromatography and how macro molecules and other important constituents are purified. We are going to discuss that in coming lectures.

Thank you.