# Medical Isotopes and Uses

# Student/Instructor Guide

January 22, 2017

# Table of Contents

### *Instructional Preparation Guidelines*

*Items contained in blue text are instructor notes and can be "hidden" for a cleaner look for the students.*

*Recommended – Instructor can coordinate a tour at a local nuclear medicine facility for a clearer understanding of the topics and hazards.*

### *Presentation Methods*

*Classroom*

### *Evaluation Methods*

*Pre-Course Assessment*

*Post-Course Assessment*

*Homework and Quizzes: Because of the short duration, homework may not be applicable to this course. Quizzes should be developed based on the break in the class.*

*Research project – Students should prepare a 1 to 2-page report regarding the history of nuclear medicine, including the early X-ray technology and the sources of radioisotopes used in the industry today.*

### *Training Aids*

*None identified*

### *Associated Training Materials*

*Whiteboard*

### *Notes to Instructor*

*Make copies of references available to students to use as additional materials for study.*

### *References*

*American Nuclear Society. Medical Use of Isotopes. La Grange Park, Il: Center for Nuclear Science and Technology Information, 2014. PDF.*

*Diagnostics: Medical Uses of Radioactive Materials. N.p., 2003. Web. 12 Jan. 2017. https://www.radiochemistry.org/nuclearmedicine/diagnostics/01_diagnostics.shtml*

*World Nuclear Association. Radioisotopes in Medicine | Nuclear Medicine - World Nuclear Association. N.p., 28 Dec. 2016. Web. 12 Jan. 2017. http://www.world-nuclear.org/information-library/non-power-nuclear-applications/radioisotopes-research/radioisotopes-in-medicine.aspx*

*National Research Council (US) Committee on Medical Isotope Production Without Highly Enriched Uranium. "Molybdenum-99/Technetium-99m Production and Use." Medical Isotope Production without Highly Enriched Uranium. U.S. National Library of Medicine, 01 Jan. 1970. Web. 16 Jan. 2017. https://www.ncbi.nlm.nih.gov/books/NBK215133/*

*Khan, Shoukat, AT Syed, Reyaz Ahmad, Tanveer A. Rather, M. Ajaz, and FA Jan. "Radioactive Waste Management in A Hospital." International Journal of Health Sciences. Qassim University, Kingdom of Saudi Arabia, Jan. 2010. Web. 16 Jan. 2017. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3068798/*

*Title - Slide 1*

## Introduction

1. **Introduce Self**

   Introduce self and Break Ice

2. **Learning Objectives**

   Hand out and review Learning Objectives

3. **Overview**

   Describe to the students how the course is to be taught and evaluated.

4. **Motivator** – What's In It for Me? The need for trained radiochemistry technicians is increasing in the medical field, this course combined with other radiochemistry and hands-on training, prepares the student to work in a nuclear medicine lab.

5. **Questions**

   Student Background

   Inquire to find out what kind of background the students may have to help tailor the discussions.

   Student Questions

   Convey to the students the ability to feel free to ask questions at any time.

## Course Objectives

*Objective Review – Slides 2 through 4*
*Discuss the course objectives*

EO 1 – State why radiation is used to sterilize medical equipment.

EO 2 – Describe how medical equipment is sterilized.

EO 3 – Explain how radioactivity is used in new drug research.

EO 4 – State why new drugs are tested with radioisotopes.

EO 5 – Describe how imaging improves medical treatment.

EO 6 – Explain how an X-ray image is produced.

EO 7 – Describe how a computerized tomography (CT) scan is produced.

EO 8 – State how magnetic resonance imaging differs from X-ray imaging.

EO 9 – Describe positive emission tomography (PET) scanning.

EO 10 – State common uses for the various medical imaging technologies

EO 11 – Discuss internal and external radiation therapy.

EO 12 – Explain the purpose of the most common radioisotopes.

EO 13 – Discuss the use of Tc-99m as a medical isotope.

EO 14 – State why Tc-99m is the most common radioisotope

EO 15 – Describe how Mo-99 is created.

EO 16 – Describe the process for obtaining Tc-99m.

EO 17 – Describe how Co-60 is used in medical treatment.

EO 18 – Explain how I-131 and Ir-192 are used as radioisotopes in medical treatments.

EO 19 – Discuss the regulations regarding shipping medical isotopes.

EO 20 – Describe the role of a source custodian.

# Medical Uses for Radiation

*Medical Isotopes – Slide 5*

*Fast Facts:*

- *For a U.S. population of over 300 million people, there are some 16 million nuclear medicine procedures per year.*
- *Over 10,000 hospitals worldwide use radioisotopes in medicine, and about 90 percent of the procedures are for diagnosis.*

The use of radiation and radioisotopes in the medical field is becoming increasingly popular. Each year millions of patients receive medical procedures that in some way were affected by radioisotopes. The uses include sterilization of equipment, new drug testing, medical imaging, and therapy. Proper use and handling of these radioisotopes is paramount to the success of the industry, the patient, and to ensure the public is safe from any detrimental effects.

## Sterilization of Equipment

*Sterilization by Radiation – Slide 6*

*Explain to students that radiation is also common in the beef market to effectively eliminate organisms that cause foodborne illness, such as Salmonella and Escherichia coli (E. coli).*

Sterilization is achieved on medical equipment by killing bacteria or other living organisms. Exposing equipment to a highly radioactive substance causes severe damage to the cell's components and to the cell's chromosomes, specifically the DNA. Radiation in the form of gamma rays, X-rays, or beta and alpha radiation have enough energy to ionize atoms and molecules. If enough damage is done to the cell's DNA, which acts as the cell's control mechanism, the cell cannot function properly or reproduce and the result is cell death (sterilization).

Radiation is used to sterilize medical instruments by first sealing a clean, but not bacteria-free, instrument in an air-tight bag. The bag and instrument are then placed in a very large field of radiation that can penetrate the bag—for example, gamma radiation, x rays, or high-energy electrons. These ionizing radiations kill the bacteria (cells); and the air-tight bag will keep the instrument sterile until the bag is opened in the medical facility.

## New Drug Testing

*Tagging New Drugs – Slide 7*

Pharmaceutical research companies add a radioactive isotope when developing and testing new drugs. The intent is to trace the distribution of the drug through the body to determine if any non-targeted areas receive the drug. The radioactive tag also allows the researchers to accurately determine the body's metabolism during use and the ability of the body to excrete a drug. By knowing these facts, drug manufactures can provide solid data to the Food and Drug Administration (FDA) and the medical community to obtain approval for sale and use. Adverse effects and other side-effect determinations are required before the drug can reach approval by the FDA.

## Medical Imaging and Diagnostics

*Imaging – Slide 8*

In efforts to rapidly asses, review, and treat injuries and ailments, medical imaging has become a fixed part of the medical community. Early history of this technology used X-ray imaging to give physicians the opportunity to view bone structure and density and a non-detailed look at internal organs. Because of the limitations, some diagnoses were incorrect. But eventually more advances in the technology and the addition of radioisotopes provided opportunities for improved diagnosis and eventual treatment and care.

### X-Ray

*X-Ray – Slide 9*

X-ray machines work by generating an electrical current or voltage, which is then projected through an X-ray tube to produce a series of X-ray waves, which either pass through objects or are absorbed by the surrounding material. X-ray machines essentially produce small amounts of radiation, which are transmitted to surfaces, such as tissue, bone and joints. While some beams pass through these objects, others are absorbed; this pattern of reflection and absorption produces an image on a special X-ray film

Bones contain much calcium, which due to its relatively high atomic number absorbs X-rays efficiently. This reduces the number of X-rays reaching the detector in the shadow of the bones, making them clearly visible on the radiograph. The lungs and trapped gas also show up clearly because of lower absorption compared to tissue, while differences between tissue types are harder to see.

## Computerized Tomography Scan

*CT Scan – Slide 10*

Computed tomography, more commonly known as a CT or CAT scan, is a diagnostic medical test that, like traditional X-rays, produces multiple images or pictures of the inside of the body. The cross-sectional images generated during a CT scan can be reformatted in multiple planes, and can even generate 3-D images. These images can be viewed on a computer monitor, printed on film, or transferred to a CD or DVD.

*CT Images – Slide 11*

CT images of internal organs, bones, soft tissue and blood vessels typically provide greater detail than traditional x-rays, particularly of soft tissues and blood vessels.

Using specialized equipment and expertise to create and interpret CT scans of the body, radiologists can more easily diagnose problems such as cancer, cardiovascular disease, infectious disease, appendicitis, trauma, and musculoskeletal disorders.

## Magnetic Resonance Imaging

*MRI - Slide 12*

*Stress to students that while MRIs do not use ionizing radiation.*

Magnetic resonance imaging (MRI) is one of the most widely used tools for diagnosis. An MRI can provide an image with far greater detail of the internal structures than an X-ray or even a CT scan. While no ionizing radiation is used during MRI studies, it is important to understand the uses and techniques for this diagnosis tool produce radiation of a different type. An MRI is produced by creating a magnetic field and pulses or radio waves to make images. Water in the body contains magnetic particles and when subjected to a magnetic field of appropriate strength, line up to provide an image.

*MRI Images – Slide 13*

The technique uses a very powerful magnet to align the nuclei of atoms inside the body, and a variable magnetic field that causes the atoms to resonate, a phenomenon called nuclear magnetic resonance. The nuclei produce their own rotating magnetic fields that a scanner detects and uses to create an image. Tissues with different densities and molecular structure show up in varying color shades to provide the detail necessary for the image. Injuries to tendons and ligaments and sensitive areas such as the brain can be imaged in detail.

*3D MRI Image – Slide 14*

MRI scans can also be created with 3D technology, further enhancing the tests abilities.

## Positive Emission and Single Photon Emission Computed Tomography

*PET and SPECT – Slide 15*

Other scans are used for diagnosis using radioactive tracers to assist in the imaging process.

*PET Basics – Slide 16*

*Video is basic introduction to PET.*

*PET Brain Scans – Slide 17*

*PET can detect active areas of the brain especially when color enhancement is added.*

A positive emission tomography (PET) scan is a medical imaging technique involving the introduction into the body of an isotope that decays via a positron (B+) particle. When this B+ particle encounters an electron (B-), they annihilate each other and produce two photons (light). The energy and path of these photons leaving the body can then be used to give an accurate picture of the area where the isotope was absorbed. Depending on the type of nuclear medicine exam, the radiotracer is either injected into the body, swallowed or inhaled as a gas and eventually accumulates in the organ or area of the body being examined. Radioactive emissions from the radiotracer are detected by a special camera or imaging device that produces pictures and provides molecular information.

PET scans are commonly performed to:

- detect cancer
- determine whether a cancer has spread in the body
- assess the effectiveness of a treatment plan, such as cancer therapy
- determine if a cancer has returned after treatment
- determine blood flow to the heart muscle
- determine the effects of a heart attack, or myocardial infarction, on areas of the heart
- identify areas of the heart muscle that would benefit from a procedure such as angioplasty or coronary artery bypass surgery (in combination with a myocardial perfusion scan)
- evaluate brain abnormalities, such as tumors, memory disorders, seizures and other central nervous system disorders
- map normal human brain and heart function

*PET Scan with CT – Slide 18*

When PET scans are combined with CT scans, a very detailed image can be produced. This is very common when determining if a cancer has spread throughout the body.

*SPECT Scan – Slide 19*

A single photon emission computed tomography (SPECT) scan is a nuclear imaging test that creates a 3-D picture. While imaging tests such as X-rays can show what the structures inside your body look like, a SPECT scan produces images that show how your organs work.

SPECT is like PET in its use of radioactive tracer and detection of gamma rays. In contrast with PET, however, the tracer used in SPECT emits gamma radiation that is measured directly. As previously stated, PET tracers emit positrons that create two gamma photons in opposite directions and detects these emissions coincident in time, which provides more local radiation event information and thus higher resolution images than SPECT. SPECT scans, however, are significantly less expensive than PET scans, in part because they can use longer lived, more easily obtainable radioisotopes than PET needs. SPECT is commonly used for blood flow studies, especially in the heart and brain. Like PET, when SPECT is combined with other tests (e.g. MRI), it can provide very detailed images of activity.

## Therapy

*Radiation Therapy – Slide 20*

Whereas radioisotopes are used for diagnosis, they are also use for treatment. Radiation and radioactive isotopes are used in the treatment of several diseases because of their ability to be targeted to a specific location and only cause damage of effect an intended area. External radiation and internal radionuclide therapies have been successfully used for diseases such as cancer and Grave’s Disease. According to the American Nuclear Society, approximately 10% of medical procedures use radiation.

### External Radiation Therapy

*External Radiation – Slide 21*

External radiation therapy allows physicians to direct a radioactive beam directly at a target to kill the cells. During the treatment, the beam penetrates from several different angles to prevent non-cancerous areas from receiving too much radiation, minimizing damage.

### Internal Radionuclide Therapy

*Internal Therapy – Slide 22*

Internal treatments from radionuclides include injections or deposits of a specific targeting radioactive substance. The radionuclide either targets the specific organ or area of the disease or is placed in very close proximity to the target in order to kill the unwanted cells. The dose is typically administered using a small catheter-like wire the leaves the radioactive source behind when the wire is removed or is injected directly into the targeted organ.

# Medical Isotopes

*List of Common Radioisotopes – Slide 23*

*Instructor can provide a much larger list in the form of a handout or web search if desired, but stress the importance that for this class, only the four mentioned are testable.*

There are dozens of radioisotopes used in medicine today. But specifically, there a few that are the most common. Each has a specific purpose and is used in special procedures to ensure the best affect and least illness and injury to patients. Technetium-99m (Tc-99m) is the most commonly used along with Cobalt-60 (Co-60), Iodine-131 (I-131), Iridium-192 (Ir-192).

## Technetium-99m

*Tc-99m – Slide 24*

*Tc-99m is used in 20 million diagnostic nuclear medical procedures every year. Approximately 85% of diagnostic imaging procedures in nuclear medicine use this isotope as radioactive tracer.*

One of the most common radioisotopes used in the medical community is Tc-99m. The World Nuclear Association states, "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." For this reason, Tc-99m is used in many instances, including scans of the bones, heart, kidneys, and lungs. The 'm' in the name of Tc-99m indicates that it is metastable. Tc-99m is radioactive because one or more of the protons and neutrons in its nucleus is in an excited state.

*Advantages of Tc-99m – Slide 25*

Tc-99m has several distinct advantages, which include:

- Short half-life of six hours
- Emits gamma rays and low energy electrons
- Gamma rays have sufficient energy to escape the human body and are accurately detected by a gamma camera.
- Chemistry of technetium is versatile

*Tc-99m SPECT/CT – Slide 26*

Tc-99m is used as a tracer and is injected into the body intravenously. After an uptake period, PET scans reveal the structure of the targeted location based on the Tc-99m gamma emitters. After only one day (approximately five half-lives), the Tc-99m decays to Tc-99 and is no longer radioactive.

## Molybdenum-99 Production

*Mo-99 Production – Slide 27*

*Stress to the students that the loss of just one or two of these reactors places the entire medical community on alert because of the high demand for Mo-99.*

To meet the demand for Tc-99m, industry is required to keep molybdenum-99 (Mo-99) in steady supply. About 75% of Mo-99 produced worldwide is made by irradiating targets of U-235 and a present, there are only five reactors in the world using this process.


*U-235 Target – Slide 28*

The most common method for producing Mo-99 is by irradiating highly enriched U-235 targets in a nuclear reactor. When U-235 fissions, one of the fission products is Mo-99. The fission yield of Mo-99 from U-235 is only around 6%. The U-235 targets are commonly clad with aluminum or other similar metals to assist in heat loss and securing the U-235. The targets are designed to be inserted into the reactor and will remain there for 5 to 7 days to ensure most of the U-235 is irradiated. When the targets are removed, they are cooled, typically in a water bath, for about a half of a day.

*Mo-99 Separation – Slide 29*

After irradiation and cooling, the targets are chemically processed to separate the Mo-99 from other fission products in work areas called hotcells. Hotcells are isolated work areas that use manipulators through thick glass and concrete to manipulate the samples. This is necessary because of the high radiation doses on the targets. The separated Mo-99 (in a purified solution) is then sent to a processing facility.

## Tc-99m Generator

*Tc-99m Generator Production – Slide 30*

The purified Mo-99 solution is received in processing facilities where Tc-99m generators are made. In those facilities, the Mo-99 is adsorbed on to columns and packed in the heavily-shielded Tc-99m generators. The generators are shipped all over the world where the Tc-99m is extracted in a hospital or clinic setting for use.

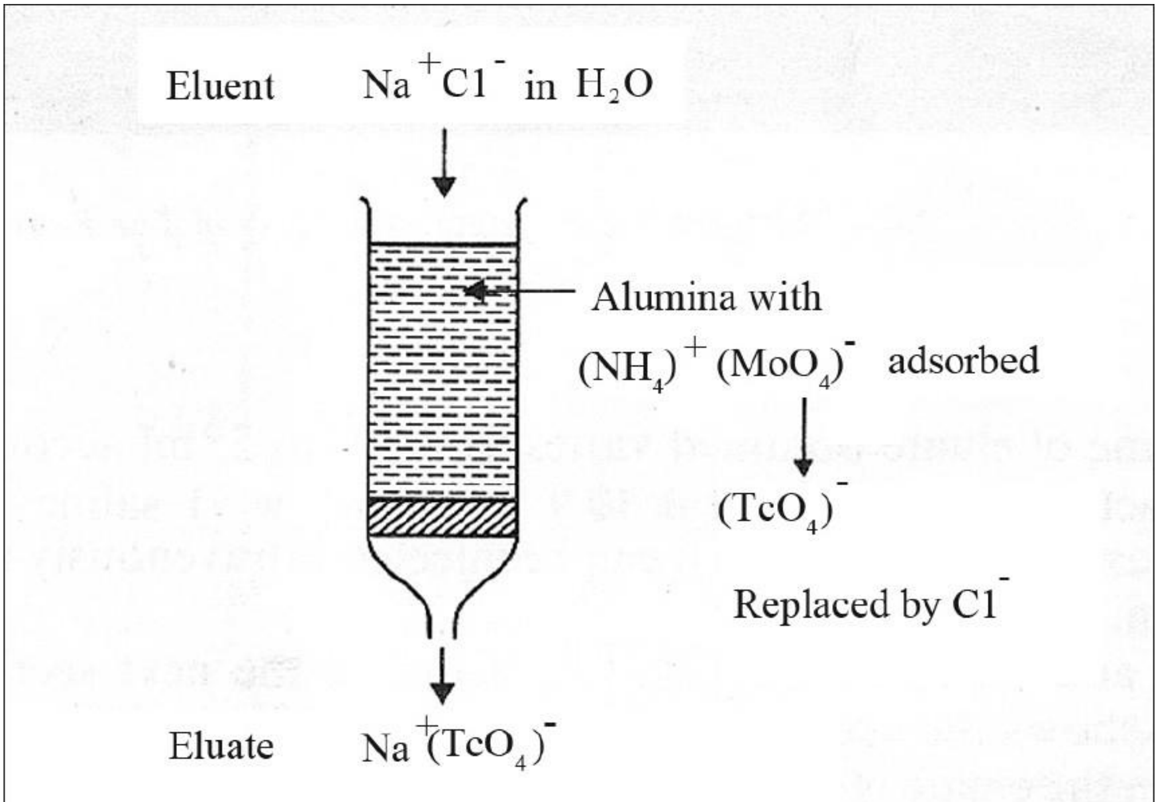
*Tc-99m Generator – Slide 31*

A nuclear medicine laboratory technician is responsible for extracting the Tc-99m from the generator for use by the hospital staff.

Tc-99m is a man-made radioisotope that is easily separated from its parent, Molybdenum-99 (Mo-99). A lab technician extracts Tc-99m from a column containing Mo-99 in only the amount necessary for use. Remaining Mo-99 and Tc-99m on the column is ready for additional uses. The half-life of Mo-99 (~66 hours) allows for transport to various locations and the very short half-life of Tc-99m (~6 hours) has the distinct advantages for medical use. A continuous supply of the Tc-99m generators is necessary for the medical field.

The generators make use of the fact that molybdenum likes to bond with aluminum oxide (alumina) but technetium does not. The generators are “milked” by drawing a saline solution across an inner molybdenum/alumina capsule; during this elution process any technetium that has formed will be drawn away with the saline and can then be used in tests. The eluate is clear with a pH of 4.5-7.5. Over the life of the generator, each elution will provide a yield of >80% of the theoretical amount of Tc-99m available from generator.

*Tc-99m Generator Chemistry – Slide 32*



Basic principles of a $^{99}$Mo-$^{99}$Tc$^m$ generator.

Each eluate of the generator should not contain more than 0.15 µCi of Mo-99 per 1 mCi of Tc-99m per administered dose at the time of administration, and not more than 10 µg of aluminum per mL of the generator eluate. These are determined by the technician before the medical procedure to ensure the proper radiation dose is given to the patient and that high concentrations of aluminum are not introduced to the blood stream.

Also, since the eluate does not contain an antimicrobial agent, it should not be used after twelve hours from the time of generator elution. Tc-99m has a half-life of 6 hours. The principal photon (gamma ray) is useful for detection and imaging studies.

Mo-99 decays to Tc-99m with half-life of 2.75 days. The physical decay characteristics of Mo-99 are such that only 86.8% of the Mo-99 nuclei form Tc99m. Generator elutions may be made at any time, but the amount of Tc-99m available on the column will depend on the time interval since the last elution. After six hours, only approximately 47% of maximum Tc-99m is available in the generator and at 24 hours, 96% is available.

The 2.75 day half-life limits the time the Tc-99m generator is available for Tc-99m extraction, as shown in the chart below. From this chart, it is easy to see why the production of Mo-99 is in constant demand and the generators are shipped so frequently.

*Decay of Mo-99, Tc-99m – Slide 33*

**Physical Decay of Mo-99**

| Days | % Remaining | Days | % Remaining | Days | % Remaining |
|---|---|---|---|---|---|
| 0 | 100 | 4 | 36.5 | 8 | 13.3 |
| 1 | 77.7 | 5 | 28.4 | 9 | 10.3 |
| 2 | 60.4 | 6 | 22.0 | 10 | 8 |
| 3 | 46.9 | 7 | 17.1 | 11 | 6.3 |

In addition, after elution from the generator, the Tc-99m must be used immediately to have its full effect. The chart below shows the rapid decline of Tc-99m activity based on its decay.

| Hours | % Remaining | Hours | % Remaining | Hours | % Remaining |
|---|---|---|---|---|---|
| 0 | 100 | 4 | 63.1 | 8 | 39.8 |
| 1 | 89.1 | 5 | 56.2 | 9 | 35.5 |
| 2 | 79.4 | 6 | 50.1 | 10 | 31.6 |
| 3 | 70.8 | 7 | 39.8 | 11 | 28.2 |

The extraction of Tc-99m is typically the most common procedure performed by a nuclear laboratory technician in the medical setting.

## Cobalt-60

*Gamma Knife Therapy – Slide 34*

*Review the following incidents involving Co-60 with students:*

*In 2000, a disused radiotherapy head containing a Co-60 source was stored at an unsecured location in Bangkok, Thailand and then accidentally sold to scrap collectors. Unaware of the dangers, a junkyard employee dismantled the head and extracted the source, which remained unprotected for a period of days at the junkyard. Ten people, including the scrap collectors and workers at the junkyard, were exposed to high levels of radiation and became ill. Three of the junkyard workers subsequently died as a result of their exposure. Afterward, the source was safely recovered by the Thai authorities.*

*In December 2013, a truck carrying a disused 111 TBq Co-60 teletherapy source from a hospital in Tijuana to a radioactive waste storage center was hijacked at a gas station near Mexico City. The truck was recovered shortly after, but it was discovered that the thieves had removed the source from its shielding. It was found abandoned and intact in a field close by. Despite early reports with lurid headlines asserting that the thieves were "likely doomed", the radiation sickness was mild enough that the suspects were quickly released to police custody, and no one is known to have died from the incident.*

Cobalt-60 (Co-60) is used as a high-energy gamma source for radiation therapy for tumors. Co-60 therapy is also known as Gamma Knife therapy. It is popular because it can be used anywhere on the body, but because of its accuracy, is very common for brain tumors.

Co-60 therapy allows the doctor to deliver higher doses of radiation to the tumor with limited damage to the surrounding healthy tissue and/or organs. For many cancers, Co-60 therapy is one of the most precise and advanced forms of radiation treatment available. Gamma knife therapy is the most precise treatment available.

Under local anesthesia, the patient is positioned on a table with a special rigid frame covering the head. Based on the results of an image study conducted just prior to treatment, the Co-60 therapy unit directs approximately 200 beams of gamma radiation at the patient’s tumor. Treatment takes anywhere from several minutes to a few hours to complete. Following treatment, the head frame is removed and the patient may return to normal activity.

## Iodine-131 and Iridium-192

*Brachytherapy – Slide 35*

Internal radionuclide therapy is performed by administering or planting a small radiation source, usually a gamma or beta emitter, in the target area. Large doses of radiation can be administered directly to a target in a short amount of time. Short-range radiotherapy is known as brachytherapy, and this is becoming the main means of treatment. Iodine-131 (I-131) is commonly used to treat thyroid cancer, probably the most successful kind of cancer treatment. It is also used to treat non-malignant thyroid disorders. Iridium-192 (I-192) implants are used especially in the head and breast. They are produced in wire form and are introduced through a catheter to the target area. After administering the correct dose, the implant wire is removed to shielded storage. Needles with Ir-192 are sometimes used to treat prostate cancer. Brachytherapy procedures give less overall radiation to the body, are more localized to the target tumor, and are cost-effective.

*Brachytherapy – Slide 36 (video)*

## Shipping and Handling Medical Isotopes

*Shipping – Slide 37*

Most medical isotopes are considered low in radioactivity and are shipped using normal methods such as UPS and FedEx. Personnel associated with the packaging, shipping preparations, and handling of the nuclear materials are required to obtain specific training associated with the hazards and regulations of these materials.

There are many groups involved in developing the rules for shipping radioactive materials, which include (but not limited to):

- Nuclear Regulatory Commission (NRC)
- Department of Transportation (DOT)
- United States Postal Service (USPS)
- Department of Energy (DOE)

*Training – Slide 38*

Of these agencies, the NRC and DOT are the primary regulators. The DOT requires that any person who prepares shipments, packages materials, or is responsible for handling the nuclear materials requires specific hazardous materials (haz-mat) training. According to the DOT, the training must cover the following topics:

- general awareness and familiarity with regulations
- safety
- security awareness
- function specific training for tasks performed

*Ask students: Why security of nuclear materials is important.*

*Answer: dirty bombs and terrorist attacks, especially since 2001*

The haz-mat training ensures the persons responsible understand the regulations and will properly prepare and mark materials for shipment to protect the workers and the public. It will also focus on the emergency response in the event of a spill or accident and the security of nuclear materials. Training will also include any contamination survey requirements that a shipper must adhere to.

*Laboratory Handling – Slide 39*

In the laboratory, technicians and technologists responsible for handing the materials will require specific training on the tasks they are to perform.  To assist the medical staff, training in radiation safety, dosimetry, and personal protective equipment requirements is required. In addition, training on the various instrumentation and equipment is necessary.

## Medical Isotope Source Custodian

*Source Custodian – Slide 40*

*The role of the source custodian is typically filled by a radiological control technician (RCT).*

*The instructor should review the job of an RCT and the training required.*

The source custodian is responsible for the tracking and control of the nuclear materials as they enter a medical facility. Under the direction of a radiological control officer (RCO), the source custodian will ensure that radioactive materials are properly received, logged, stored, and disposed of within the regulations for that facility.

Upon receipt, the packaging is inspected for damage and contamination. Newly arrived shipments are also monitored to ensure no leaks have occurred during shipping. Prior to sending the material to the proper location, the source custodian will enter them into the source log for tracking and inventory control.

The source custodian will also make that all labeling requirements for the material are met. Labels should include the contact radiation levels, removable contamination levels, dates monitored, and name of the individual performing the monitoring. The label should be sufficiently durable to remain legible for the useful life of the device or storage container and should be located in a readily visible place.

Regularly scheduled inventory reviews should be performed to ensure that all radioactive material is still present as well as labeled and stored properly. At any point during inventory procedure a source cannot be located, the RCO must be notified.

When a radioactive material is no longer useful, it must be disposed of according to local regulations. The source custodian is responsible to make sure that once it is disposed, it is removed from the inventory. Disposal may mean returning to a manufacturer as well as dilution or destruction to render it safe. Local regulations will determine when this is allowed.

*Course Review*

*Questions – Slide 41*

*Review - Slide 42*

The summary should provide a recap of what was covered.

A. Restate the Motivator
B. Restate the Terminal Objective
C. Review Enabling Objectives
D. Add Other Summary Items as Necessary

Include these elements in the order that best promotes learning:

**R**eview Objectives and Major Learning Points - Tell them what you told them. Don’t re-teach the lesson.

**E**licit Questions - Ask for all unanswered questions related to the topic.

**C**onnect to the Job - Explain how the transfer of the knowledge and skills back to the job supports performance.

**A**nswer All Questions - Always.

**P**unctuate the Finish! – Revisit the motivator, “What’s In It For Me?”