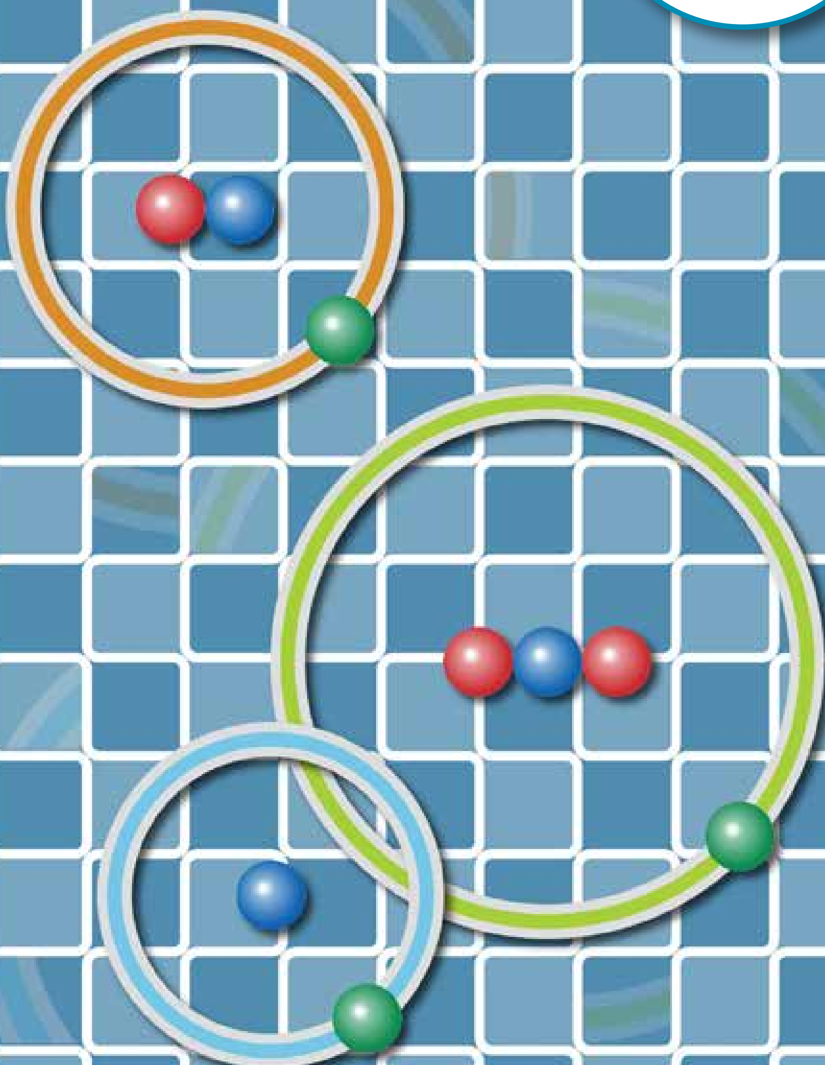
Special Bioassay

A GUIDE for Workers and Their Families



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Introduction

Los Alamos National Laboratory radiological workers are routinely monitored for both external and internal radiation doses. To detect exposure to radiation from external sources, workers wear dosimeters (for example, TLD badges). To detect intakes of radioactive materials (radionuclides), radiological workers are placed on a routine bioassay monitoring protocol: regular analysis of urine samples taken throughout the year.

If routine bioassay offers no indication of an intake, a worker will receive an annual report indicating that no intakes have occurred. If, however, a routine bioassay measurement indicates that an intake may have occurred (an "elevated" routine) or if there has been a workplace incident (for example, the failure of a fume hood or occurrence of a fire), a worker will be placed on a special bioassay protocol, which requires the worker to submit one or more urine samples to follow up on the possible intake. These samples help the Laboratory's Internal Dosimetry team answer the following questions:

- Has an intake actually happened?
- If there has been an intake, what is the dose?

If there has been an intake and the dose is significant, the worker would probably already know because the circumstances leading to large doses tend to be immediately obvious. So, while a worker might be alarmed when asked to submit a large number of urine samples, it is actually a sign that the intake, if it happened, is very small. This is because large intakes are much easier to detect than smaller intakes, so they can usually be detected with fewer samples.

This booklet, prepared by the Internal Dosimetry team, is for workers who have been placed on a special bioassay protocol. If you are one of those workers, the booklet will help you and your family understand the special bioassay process, and it will provide information about radiation and radiation exposure.

Please call if you have questions.

Internal Dosimetry Team Members

Tom Waters, program lead
665-2940 (uranium)

John Klumpp
667-0325 (plutonium and americium)

Deepesh Poudel
665-1798 (tritium)

Luiz Bertelli
664-0292 (backup)

For Workers Who've Been Placed on Special Bioassay

Why am I being asked to submit additional urine samples?

If a radionuclide intake ("intake" for short) may have occurred, we place the affected worker on a special bioassay protocol, which requires the submission of more urine samples than are usually submitted during the year (routine bioassay monitoring). We call for these additional urine samples if a routine bioassay measurement has an elevated result—an elevated routine—or if a worker was in the vicinity of an incident that might have caused an intake. In either case, we will ask for a series of urine samples over several months because that is the only way we can know if the worker has had an intake.

What is an "elevated" routine?

A routine bioassay that comes back higher than expected is called an elevated routine bioassay, or just an elevated routine. Most elevated routines are false alarms, meaning that there has not been a radionuclide intake, but we need to collect more bioassays to be sure.

What kinds of incidents might cause you to place a worker on special bioassay?

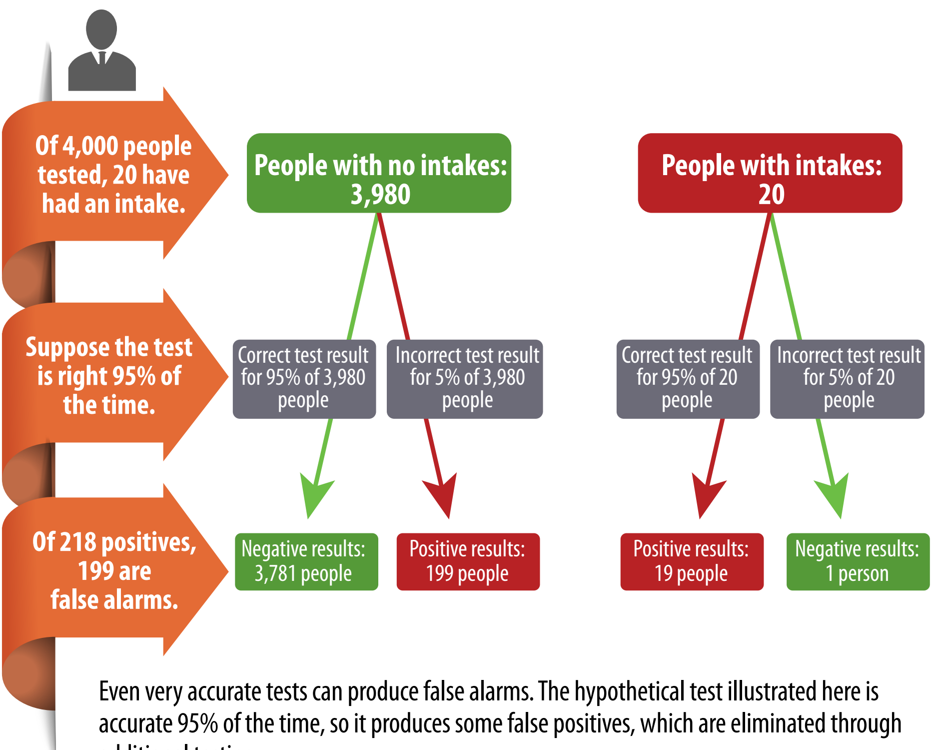
Some incidents that would cause us to ask for special bioassay are dramatic—for example, a fire—but thankfully, such incidents are very rare. Most situations that require special bioassay are such things as failure of a fume hood or the discovery of small amounts of material on a worker's skin. As with routine bioassay, special bioassay often shows that little or no radionuclide intake has happened.

What do I do now that I've been asked to submit another sample?

Your special bioassay kit will usually be identical to the one you used for your routine bioassay, and it will be provided, filled, and returned in exactly the same way. Rarely, some incident-related kits will need you to provide a larger sample. If that is the case, someone will call you to explain exactly what you need to do. Collect your new urine sample following the instructions in the kit. Please return the sample as soon as possible to help speed the process of determining whether you had an intake.

How do you determine if an intake has happened?

We look for intakes by measuring the radionuclides in urine samples submitted for bioassay. To determine if an intake has happened, we ask for a series of urine samples so we won't be fooled by a single elevated sample (i.e., a false positive). The additional measurements will tell us if there really has been an intake.



Even very accurate tests can produce false alarms. The hypothetical test illustrated here is accurate 95% of the time, so it produces some false positives, which are eliminated through additional testing.

The vast majority of workers who are placed on special bioassay have not had intakes. We place about 50 people a year on special bioassay, and fewer than 5 of them turn out to have had intakes.

There are several reasons why an elevated routine might be a false alarm. All bio-assay measurements detect background radiation from naturally occurring radionuclides, cosmic rays, and the sun. We always take such natural radiation into account when analyzing a urine sample, but sometimes there are random spikes in the background radiation, and an elevated routine may simply reflect one of those spikes. Also, the amount of a radionuclide being excreted by a given person varies randomly from day to day. Finally, urine samples may become contaminated during the measurement process.

Be prepared to wait. Testing a urine sample takes several weeks from the time you submit it, and we often need multiple samples to decide if an intake has happened. You will receive progress reports every month with information about the status of our analysis.

If there has been an intake, how do you determine the dose?

The committed effective dose (CED), which is the total radiation dose an intake will cause over 50 years, depends on the amount of radioactive material in the body and the material's chemical form. We can determine both the CED and the chemical form by analyzing multiple urine samples collected over several months.

Decades of research have taught us how different radionuclides move between different tissues and organs, including the bladder (from which radionuclides are excreted through urine). Because we have this knowledge, a single urine sample, which tells us how much material moved from the rest of the body into the bladder during the sample-collection time, allows us to estimate how much material is cur-

rently in the body. Additional samples tell us how the amount of material moving into the bladder is changing, which lets us estimate when the intake happened and where the materials were deposited in the body. This ultimately leads to an estimate of the CED. Because there are so many unknown quantities, many samples are often needed for a reasonably precise estimate.

Knowing when the intake occurred can also help us to determine the dose, so for larger intakes, we sometimes conduct interviews with the affected worker. The interviews help us determine when an intake, if it occurred at all, might possibly have happened. The interviews are not to figure out what might have gone wrong or to assign blame.

Why do you need so many samples to determine if there's been an intake?

Every urine measurement will detect some radiation that has nothing to do with an intake. For example, the amount of natural radiation detected in a urine measurement might be high enough to look like an intake. The only way we can know for sure if an intake has happened is by collecting more samples and seeing if we continue to detect more radiation than average in each sample.

We also need to collect a lot of samples because detecting an intake is not enough: we also have to determine the dose. To do that, we need to know when the intake happened, how big the intake was, how soluble the material was (how quickly it is being absorbed), and other factors. We estimate all of these things using multiple urine bioassay samples.

It is worth remembering that large intakes are much easier to detect than smaller intakes and can be detected with fewer samples. So, while being asked to submit multiple samples is often alarming, it is usually a sign that the intake, if it happened, must be very small.

How do you report your findings?

All workers being monitored for radionuclide intakes receive annual dose reports documenting their exposure status. Workers who have been placed on special bioassay because of an elevated routine or an incident receive monthly progress reports and an official dose report when we reach a conclusion about the intake and dose.

Following the dose assessment. At the end of the dose-assessment process, if the results show that an intake has happened, we call the worker. Calling the worker gives us the opportunity to explain the process, the results, and the health implications (if any) of our findings. The worker also receives an official dose report. Depending on the size of the dose, reports may be delivered by email or in person.

When we have determined whether or not a worker has had an intake, we also contact the worker's managers and the radiation protection team responsible for the worker's safety. A radionuclide intake may indicate that the job risk needs to be re-evaluated and/or controlled more effectively. In those cases, the Radiation Protection team determines what went wrong and how we can do better.

All workers participating in routine bioassay monitoring receive an annual dose report, which documents their total radiation dose from the past year. This dose includes the external dose (determined by dosimetry badges) and the internal dose, as expressed by the 50-year CED (see Glossary) that would be caused by any radionuclide intakes. For workers whose routine bioassay comes back negative for an intake, the annual dose report will show that the CED is zero. However, intakes detected through routine bioassay are often not confirmed during the same calendar year in which they happened. If that is the case, the dose won't appear on the annual dose report.

New bioassay samples sometimes allow us to update our dose estimates from intakes that happened many years ago. When this happens, the dose estimates for past years change on the annual dose report.

You can find up-to-date dose estimates for past years on the Dosimetry Reporting Project (DRP) website: drp.lanl.gov.

If I need more information, what should I do?

Worrying about radionuclide intakes can be stressful, not only for workers but also for families. We understand that a possible intake can be a hard thing to talk about and that you may be worried about frightening your loved ones.

While waiting to receive your special bioassay kit, we recommend that you take some time to learn about radionuclide intakes and the process we follow to determine if they have happened.

Talk to someone. Many options are available if you want to talk to someone about what you're going through.

For information about your case or about radionuclide intakes in general, you can call us, the Internal Dosimetry team, and we will answer all your questions. (See contact numbers on pp. 1 and 17.)

For information about the medical implications of radionuclide intakes, you can speak to your personal physician or a physician at LANL Occupational Health.

Friends and family are usually the best place to turn for emotional support, but we understand that this can be a hard thing to talk about. If you want to talk to your family but aren't sure how, Occupational Health can provide you with specific techniques for how to broach the subject and can tell you what to expect when you do. If you feel that you need more support than you can get from friends and family, remember that Occupational Health provides counseling free of charge.

OccHealth

For Those Who Have Had an Intake

If I've had an intake, what does that mean?

This means that we have reviewed your urine measurements and found strong evidence that a radionuclide intake has happened. Your dose report includes our best estimate of the committed effective dose (CED): the radiation dose your intake will cause over the next 50 years.

If your dose report says that you have a CED of 500 mrem, this really means your intake will give you an average dose of 10 mrem per year for the next 50 years. By comparison, the dose from natural background radiation in Los Alamos (not including medical procedures) is about 520 mrem per year (26,000 mrem over 50 years).

No Immediate Health Effects and No Observable Increase in Cancer Risk

Chest x-ray: 2 mrem
Mammogram: 300 mrem
Chest CT scan: 600 mrem
Flight, NY to Los Angeles: 2.5 mrem
Los Alamos background (over 1 year): 520 mrem
LANL dose limit (over 1 year): 2,000 mrem
Regulatory dose limit (over 1 year): 5,000 mrem
Los Alamos background (over 50 years): 26,000 mrem

Increased Cancer Risk, No Radiation Sickness

10,000 mrem: cancer risk up ~0.55%
25,000 mrem: drop in blood cells, no symptoms
66,000 mrem: Mars round trip (8 months)
1,000,000 mrem: largest estimated LANL plutonium dose (over 50 years)

Likely Tissue Damage and/or Radiation (rad.) Sickness

100,000 mrem: mild rad. sickness, cancer risk up ~5%

Up to 600,000 mrem: moderate rad. sickness

12,500,000 mrem: prostate brachytherapy (over many weeks)

1,100,000 mrem: bone marrow transplant (over 48 hours)

5,000,000 mrem: to organ targeted by cancer therapy (over ~10 weeks)

Lethal Doses

600,000 mrem: fatal (30 days)—*largest dose from "one of world's worst radiological incidents" (IAEA): Goiania, Brazil, 1987*
Up to 1,000,000 mrem: severe rad. sickness (1 week)
Above 1,000,000 mrem: fatal (in days)

Shown here are chronic (delivered over time) and acute (delivered all at once) radiation exposures, along with their sources and effects.

The CED in your dose report is only an estimate and will probably change when we collect more bioassay kits from you.

What is a radionuclide intake?

A radionuclide intake (intake, for short) occurs when radionuclides enter a person's body through breathing, swallowing, skin contact, a wound, or an injection (for example, iodine-131 for treating thyroid cancer). Radiation doses caused by radionuclides inside the body are called internal doses to distinguish them from doses caused by sources outside the body, which are called external doses.

Intakes are responsible for most of the radiation dose we all receive from natural background radiation—about 520 mrem annually in Los Alamos. Only about 15% of that is caused by external sources: radioactive materials in the ground and radiation from the sun and cosmic rays. The other 85% (roughly 440 mrem) is an internal dose caused by intakes of natural radionuclides in food, water, and air. Because internal doses tend to be delivered very gradually over the course of weeks, months, or even years, they are much less harmful than external doses in terms of causing deterministic effects such as radiation sickness. External doses can be more harmful because they tend be delivered all at once. Whether internal or external, doses smaller than 10,000 mrem do not measurably increase an adult's chances of getting cancer.

How do intakes happen?

Most intakes at LANL happen when radionuclides are inhaled. Sometimes, intakes are detected through routine bioassay. When that happens, it can be impossible to say exactly when the intake happened, so we cannot always determine what caused the intake. Other times, intakes happen because of an incident, in which case we can usually say exactly what happened.

It is worth remembering that while some of the radionuclides we work with do not exist in nature, the radiation that comes from them is the same as the radiation that comes out of naturally occurring radionuclides. For example, plutonium is a man-made element—it does not occur in nature. However, the kind of radiation released by plutonium—alpha particles—is the same kind of radiation that is released by radon, which accounts for at least three-quarters of the natural background radiation dose.

If I've had an intake, what should I do?

Our first concern is for your well-being. Although the vast majority of intakes are much too small to pose a major health risk, even very small intakes can cause significant anxiety in workers and their families. Here are some of the things you can do if you've had an intake.

Talk to the internal dosimetrist. All workers who have had intakes can talk with specialists about how their intake was detected, what the intake means for their health, and how they can take care of themselves and their families. For information about how the intake was detected and what the dose report means, you should contact the internal dosimetrist who was responsible for calculating your dose. That person's contact information is included with your dose report.

Talk to a doctor or counselor at Occupational Health. To discuss the possible health effects of your intake, let Occupational Health arrange for you to speak with a physician. If you feel the need, Occupational Health also has counselors, who can provide emotional support for you and your family free of charge.

Occupational Health can be reached at 667-0660.

Will I get sick because of an intake?

The health effects of concern in relation to radiation exposure are cancer and radiation sickness.

Cancer. Radiation doses greater than about 10,000 mrem may increase the risk of developing cancer. Specifically, each 10,000 mrem increases your chances of dying from cancer by about 0.55%. Intakes this large have happened, but they are very rare.

The majority of intakes we detect result in committed doses of 10s or 100s of mrem. In spite of a huge number of studies spanning more than half a century, no one knows whether doses that small increase the risk of cancer. The risk due to low doses, if it exists, is so small that research studies involving hundreds of thousands of people have been unable to detect it. The official position of the Health Physics Society, America's leading organization of radiation safety professionals, is that no increase in cancer risk will ever be observed for doses less than 10,000 mrem.

Suppose you got a radiation dose of 1,000 mrem. We don't know if doses that small increase the risk of cancer, but to be conservative, let's assume they do. We know that the risk of fatal cancer increases by 0.55% for every 10,000 mrem, so the 1,000 mrem dose would increase your risk of cancer by 0.055%. Every American has a 20% chance of dying from cancer, so a radiation dose of 1,000 mrem would raise your chance of dying from cancer to 20.055%.

Radiation sickness. Radiation sickness refers to the illness that happens within a few days or weeks of getting a very large radiation dose. No one at Los Alamos National Laboratory (or any other U.S. national laboratory) has ever developed any symptoms of radiation sickness because of an intake. This is because the doses from intakes of plutonium and americium are delivered gradually over many years, which is much less dangerous than doses that happen all at once.

If you need to see a doctor. In very rare cases, intakes are large enough to warrant medical treatment. The circumstances causing very large intakes are extreme enough that they are noticed right away, long before they would be discovered by routine testing. For example, a large release of radioactive materials to the air would be detected by on-the-job detectors, which set off alarms. The most common type of medical treatment for large intakes is chelation therapy.

What is chelation therapy, and when is it recommended?

Chelation therapy is the use of chelating drugs, administered via an IV injection or inhaler. Chelating drugs are drugs that combine with heavy metals inside the body and cause them to be removed rapidly from the body through urine. Chelation therapy is commonly used in hospitals to treat people who have been poisoned by materials such as lead, arsenic, or mercury, and it can also be used to treat people who have received a large intake of radioactive materials, such as plutonium or americium.

When administered immediately after a very large intake, chelation therapy can significantly reduce the committed dose because it removes the radioactive materials from the body before they can attach themselves to tissues in the bones and liver. However, the therapy is effective only if administered soon after an intake occurs.

Chelation therapy carries a risk of side effects, so it should be given only if the benefit outweighs the risk.

If I've had an intake, is it safe for me to be around my family, friends, and pets?

The radiation from uranium, plutonium, tritium, and americium cannot penetrate your skin or leave your body: it is not contagious. So, it is safe to shake hands with friends, cuddle with your children and pets, and sleep next to your spouse. Also, you cannot pass the radioactive materials inside of you to another person through kissing or sex.

If you have an intake, **you will not be a danger to anyone around you.**

After an intake, some people are afraid to cuddle or share a bed with a loved one.

But being close is perfectly safe. If the radiation could escape your body, we wouldn't need bioassay to detect it in the first place!

So, don't be afraid to get as close as you like. And remember, kissing is safe too!

Helpful Resources

Resources for Los Alamos Employees and Their Families

Employee Assistance Program

The Laboratory's Employee Assistance Program provides free counseling to employees and their families. It can help employees talk to their families and friends about intakes without causing fear or misunderstanding.

Los Alamos Radiation Protection Website

This website, available on the Yellow network, provides information about the Laboratory's radiation protection philosophy and practices, and it provides links where you can access your dose history.

In Vitro Bioassay Services Website

This website, available on the Yellow network, provides information about the *in vitro* (urine) bioassay program, including how employees are enrolled in bioassay monitoring and how they should fill their kits. It also provides phone numbers where you can ask questions about your bioassay kit.

Information about Radiation Safety and Internal Dosimetry

Environmental Protection Agency

The Environmental Protection Agency's website offers information about radiation protection and natural background radiation. Use the site's Search feature.

Health Physics Society

The society maintains a great website with information about radiation exposure.

Google Scholar

This website is an excellent resource for finding free peer-reviewed literature about ionizing radiation (and many other subjects).

Los Alamos Science, Number 23, 1995, Radiation Protection and the Human Radiation Experiments

The journal *Los Alamos Science* was published by the Laboratory from 1980 to 2006. This issue is devoted to the history of radiation safety. It is full of useful information, informative interviews, and interesting (sometimes alarming) history. Google "Los Alamos Science" to access the journal's archives.

Radiation Effects Research Foundation

This cooperative U.S.-Japan foundation is a scientific organization that studies the health effects of atomic bomb radiation—the longest-running study of this type. Google the foundation to reach its information-packed website.

U.S. Nuclear Regulatory Commission

The U.S. Nuclear Regulatory Commission (NRC) website gives information about the health effects of radiation (search for "radiation protection"), along with links to relevant NRC brochures and fact sheets.

World Health Organization, "Ionizing Radiation, Health Effects and Protective Measures"

The website for the World Health Organization (WHO) offers information on ionizing radiation. "Ionizing Radiation, Health Effects and Protective Measures" can be found on the WHO website by clicking on Fact Sheets under Health Topics, Resources.

Glossary

ALARA

ALARA is an acronym for the fundamental goal of radiation safety, which is to keep radiation doses "As Low As Reasonably Achievable."

Annual Occupational Radiation Dosimetry Report

Every March each employee who is being monitored for radiation doses receives a report documenting the total radiation dose from the previous calendar year.

Background Radiation

Background radiation is the radiation that exists naturally on Earth. It comes from sources such as cosmic rays and radionuclides in the soil. The dose from background radiation in Los Alamos is about 520 mrem per year. Background radiation is separate from the radiation a worker may be exposed to in the workplace, which is occupational radiation.

Bioassay Measurement

Bioassay measurement is a type of measurement in which radioactive materials are measured to determine their behavior inside a person. Measurements performed directly on a person are *in vivo* measurements, while those performed in a test tube are *in vitro* measurements. At the Laboratory, we use either urine (*in vitro*) or whole-body radiation counter (*in vivo*) bioassay measurement to determine how much radioactive material is present in the body and how quickly it is moving amongst the various organs and tissues.

Bioassay Office

The Bioassay Office is responsible for distributing and picking up bioassay kits. It tracks the status of kits until the final measurement results are reported by the Laboratory's Nuclear and Radiochemistry group. You can call the Bioassay Office (667-6275) at any time to ask about the status of your kit.

Chelation Therapy

Chelation therapy involves administering a drug that binds itself to heavy metals, such as plutonium and americium, and causes them to be removed from the body (typically through urine). This can dramatically reduce the radiation dose that a person is likely to receive as the result of an intake. Chelation therapy is effective only if given shortly after the intake occurs and should be administered only when the benefit outweighs the risk.

Committed Effective Dose (CED)

The committed effective dose (CED) is the total effective dose an individual receives over the course of 50 years as the result of a radionuclide intake.

Deterministic Effect

A deterministic effect of radiation exposure, sometimes called a threshold effect or non-stochastic effect, is an effect that always occurs beyond a certain dose threshold but does not occur below that threshold. Examples include sunburns, hair loss, and radiation sickness. Most deterministic effects are the result of cells being killed by radiation exposure. The effects usually appear within hours or days of exposure.

Dose

Dose is the amount of radiation absorbed by the body. External doses are doses from radiation sources outside the body, for example, x-ray machines. Internal doses are doses from radiation sources inside the body, for example, radionuclide intakes. The health risk from a dose depends on the type of radiation involved and the particular tissue that receives the dose. See Equivalent Dose and Effective Dose for more information.

Dosimeter

A dosimeter is a device that measures radiation dose. One type of dosimeter is a thermoluminescent dosimeter, known as a TLD, which is generally worn as a badge. Dosimeters are used to monitor the amount of external radiation dose workers receive and to let them know if radiation levels around them have increased.

Dosimetry Reporting Project

On the Dosimetry Reporting Project website (DRP.lanl.gov), an employee can find his or her up-to-date dose estimates for past years.

Elevated Routine Bioassay

An elevated routine bioassay (or elevated routine) is a routine urine sample measurement that yields a radionuclide count exceeding what is expected. Although most elevated routines turn out to be false alarms, they are a warning that an intake may have occurred. For that reason, an elevated routine triggers special bioassay.

Intake

An intake is an event in which radioactive materials are taken into the body. Radioactive materials can enter the body through the lungs, digestive tract, skin (in the case of tritium), or wounds (such as cuts or abrasions).

Internal Dosimetry

Internal dosimetry is the science of detecting intakes of radionuclides and determining the committed dose that is likely to result from them.

Internal Dosimetry Team

The Internal Dosimetry team is responsible for monitoring Laboratory employees for intakes of radionuclides and reporting the findings from the employees' bioassay measurements. This booklet was developed by the Internal Dosimetry team.

Radiation

Radiation is photons and particles that carry enough energy to ionize an atom, that is, remove electrons from around the atom's nucleus. When atoms are ionized, they try to regain their lost electron(s) through chemical reactions. In living creatures, those reactions sometimes lead to chemicals that can damage cells. Technically, whenever we use the word "radiation" in this book, we are talking about ionizing radiation.

Radionuclide

A radionuclide is any atom that emits radiation when its nucleus "decays" to a lower energy state, often transforming itself into a new kind of atom.

Routine Bioassay

Routine bioassay involves regularly scheduled measurements of *in vitro* samples (urine samples) submitted by workers whose jobs require monitoring for intakes of radioactive materials.

Special Bioassay

Special bioassay involves one or more measurements of urine samples (usually submitted once a month) to determine if a worker who has had an elevated routine bioassay has really had an intake. Investigating a possible intake requires several special bioassays and may take several months.

Stochastic Effect

A stochastic effect, or random effect, increases the probability that something will happen. The most important stochastic effect of large radiation doses is an increase in the probability that a person will develop cancer. Radiation-induced cancers, if they happen, can take many years to occur.

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Tom Waters, program lead
665-2940 (uranium)

John Klumpp
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