Radiation is used every day, for diagnosing and treating animals, and it can have harmful effects on people who work in and around facilities that have radiation. The goal of this handout is to familiarize you with general principles of radiation safety and preventive measures that should be used to help minimize the risk of these effects for you and your employees.

Why should you care about Radiation Safety?

First, it’s the law to make sure that your employees are protected from excess radiation exposure. All states have laws determining the amount of radiation exposure your employees can get. Second radiation is a silent threat. Since you can not see, taste or smell it, the only way to protect you and yourself from exposure is to understand where radiation exposure comes from and how it can hurt you and your staff. Finally, exposure to radiation can cause severe problems, if we don’t act to prevent it.

Radiation Effects on The Body

The effect that radiation has on the body depends on the following:

- **Dose** - most RT side effects are dose dependent to some degree whether their severity or incidence increases with dose
- **Dose rate** – acute exposures can have different effects than chronic exposures
- **Tissues involved** – radiation to the hands, for example, is less likely to cause cancer than radiation to the thyroid. Also it is less likely to cause acute effects than radiation to the abdomen.

The effects of radiation on the body can be divided into Stochastic (random) effects and deterministic or Non-stochastic effects.

**Stochastic (Random) effects** can occur at any dose (no threshold). Cancer is an example. It can be caused by a single photon causing a point mutation, but the risk of developing cancer increases with more radiation. However the severity of the side effect does not depend on the dose.

**Non-stochastic (Deterministic) effects** also increase in incidence with dose but there is a threshold. For example 3 Gy to the leg of an animal will have no clinical effects. However they increase rapidly with increased dose. For example changing from 15 to 19 treatments can result in dermatitis in more patients. Also the severity is
dose dependent. Most acute responding tissues, like your bone marrow or intestines and many late responding tissues act this way.

**Chronic exposure to small amounts of radiation is what people working in a hospital should be concerned with.**

Radiation exposure can cause **cancer, hereditary effects and damage to the fetus** in pregnant women.

**Cancer** typically occurs years after radiation exposure and is difficult to detect in a population of people because it is so infrequent. Leukemias can occur within a few to 15 years. Most solid tumors occur from 10 – 50 years after exposure to a **large** dose.

**Hereditary effects** can include malformations – these are usually the same mutations that occur in nature but they occur at a higher rate.

**Fetal effects** can include an increased risk of cancer or hereditary effects (the next generation) but also can include mental retardation or fetal loss.

**Some Units of Radiation Exposure:**

If you have an X-ray machine, or any other type of radiation in your practice, you should be monitoring the exposure of your employees. This is usually done through radiation badges.

Your exposure to radiation is measured in roentgens (R) or rem. The radiation dose reports that you get once a year give you your exposure in **rem** or **millirem**. This is a measure of the amount of radiation that your badge was exposed to and not a true indicator of the dose of radiation you received (the absorbed dose which is measured in Gray Gy or centi-Gray cGy).

Radiation safety takes into account the tissue that is irradiated by using a tissue weighting factor. For example 1 Gy to the finger is not the same as 1 Gy to the thyroid gland if we look at cancer risk. The measure for this is the **Effective dose**

**Sources of Radiation**

Radiation can come from radioactive materials like iodine-131 (I-131) which is commonly used to treat cats for hyperthyroidism. These sources constantly give off radiation.

Radiation also comes from machines that produce radiation, like a diagnostic x-ray tube or a CT scanner. These only give off radiation when they are turned on and active.
Most private practices have a diagnostic x-ray machine as the only source of radiation in their hospital. However, if you work anywhere where there are other types of radiation sources you should familiarize yourself with these, so you know how to avoid exposure.

**Types of Radiation**
It is important to understand the types of radiation and how they act to be able to avoid or limit exposure. In veterinary facilities mostly photons or electrons are used.

**Photons** include Gamma and x-rays. These can penetrate through patients, skin, walls etc. but the degree of penetration depends greatly on the energy. The **half value layer** is the thickness of a given material needed to decrease the radiation to half the original amount. For I 131 this is 2.4 mm lead. For Co-60 this is 11 mm lead. You can easily see that a lead apron (standard 0.5mm lead) doesn’t help much with these types of radiation. On the other hand diagnostic x-ray beams have a HVL of 0.12 mm lead. This is why lead aprons, gloves etc. are helpful in this situation. A lead apron with a thickness of 0.5mm lead can prevent a great deal of scatter radiation from getting to your body.

**Electrons** include electron beams from a Linac or Strontium probe. Many isotopes (e.g. I 131 and Strontium-90) give off electrons. The difference with electrons is that they do not penetrate far. For example a Strontium probe has a small lucite shield on the handle which helps dramatically reduce exposure to the hand of the person using it.

**Radiation machines**
There are lots of different sources of radiation that are used in veterinary medicine. These include CT scanners, Linear accelerators, Radioisotopes (I131, Tc99M), Cobalt machines, and Strontium probes. Most private practices only deal with diagnostic x-ray machines so we will focus on some key points for these:

**Diagnostic x-ray machines**
Diagnostic x-ray units use low energy x-rays. Think about the settings that you use for kVp..this is the energy that we are talking about. A linear accelerator uses radiation that is about 600 times more powerful. Still, the diagnostic x-rays that you use in practice can penetrate right through the patient, the walls, the door etc. so it is still very important to understand how to stay safe.

This starts with designing the room properly. If you are installing an x-ray unit in your practice consult with a medical physicist so that they can make sure that your room will be safe. If your room has glass, it needs to be a specific leaded glass. If at all possible there should be a barrier in the room that your personnel can stand behind when taking images.
Once your machine is installed and ready for use, it is important that all of your staff knows the safest way to take radiographs. X-ray machines only give off radiation when the machine is running – so it is important to only use it when hands fingers etc are as far away as possible. The majority of risk of being exposed to radiation is from the primary beam. Outside the primary beam the exposure drops dramatically. However, if you are in the room when an x-ray machine is on, you are getting exposed to scatter radiation. Therefore, it is important to be outside the room when taking radiographs, whenever possible. If you have to be in the room, keep your hands out of the beam. Also lead aprons, gloves, thyroid protectors and/or a shield should be used to decrease your exposure.

Another way to minimize exposure is to not have the same person taking radiographs all the time. If you set up an alternating schedule this will decrease the exposure that any one person gets. However, make sure that each person is fully trained in radiation safety.

**Ways to limit exposure to radiation**
The only way to decrease risk of radiation effects is to minimize your exposure to radiation. In the occupational setting most people follow the ALARA principle.

**ALARA stands for “As Low As Reasonably Achievable.”** It means that people who work with radiation can have some exposure but steps should be taken to minimize exposure without causing undue problems (e.g. loss of someone’s job, inability to treat patients)

**Monitoring Radiation Exposure**
Anyone who works with radiation should wear a radiation monitoring device. It is very important, for your health to wear the badge at all times when you are in the hospital. It should be worn close to your neck, near your thyroid glands. This way, if you are getting too much radiation exposure you can figure out why and correct the problem. Someone at your facility should be designated to review these reports to look for people who might be getting more radiation then they need.

**Avoiding Radiation Exposure**
This can be done by remembering three principles

- **Time**
  - E.g. minimizing the time that a single individual is taking radiographs will decrease the amount of radiation they are exposed to

- **Distance**
  - Inverse square law – doubling your distance from the source of radiation results in ¼ the radiation. Moving away from a source can greatly decrease the exposure. This is why it is important to stand back (or out of the room) when an x-ray machine is in use.
- **Shielding**
  - A lead apron, thyroid protector, and lead gloves can significantly decrease the exposure to scatter radiation from an x-ray machine.
  - The walls around the machine should be shielded to protect you from the radiation given off inside.

Any of the radiation sources in the hospital should be clearly marked with warning signs.

If you are unsure whether you might be unnecessarily exposing yourself to radiation, ask!

**Pregnant workers**

Special care should be taken if there are pregnant women working in your clinic, or if you are pregnant. The amount of radiation exposure to the fetus should be minimized as much as possible. Once a worker informs you that they are pregnant, steps should be taken to minimize their exposure. These include, but are not limited to, having them stop taking radiographs, using a second badge to monitor the dose to the fetus.