RadCommGB

RadComm Radiation Detection Systems

Introduction to the effects of radiation

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How does radiation harm us?

All radiation interacts with other atoms in the materials it meets.

Radiation that is *not* radioactive, **excites** the atoms it encounters and provides them with a *small* amount of energy. This is then released, and we observe this as light or sound, for example.

This type of radiation is all around us all the time.

How does radiation harm us?

Other types of radiation have larger amounts of energy. They have enough energy to *remove* the electrons from the atoms they encounter rather than just excite them.

This removal of the electrons is called **ionisation**. The radiation is called **ionising radiation**.

Ionisation radiation is harmful because it has the ability to make atoms more reactive.

How does ionising radiation affect us?

These ionised atoms are not only more reactive also behave differently. They no longer **bond** (join) with other atoms in the same way to form compounds.

Remember: all materials are made of atoms joined (bonded) together to make compounds (materials).

Why is radiation harmful?

Ultimately in a cell, where compounds make up the DNA, altering the atoms that make up compounds, through ionisation, causes the DNA to change.

- The cell may die…
- The DNA may *mutate* and change how it controls the cell so the cell not longer functions properly (different cells have different functions in the body, such as skin cells and blood cells)…
- The cell may grow uncontrollably… which we know as cancer.

How does ionising radiation affect us?

The harm that ionising radiation can do to the human body is determined by:

- The *amount* of radiation emitted by the source
- The *type* of radiation emitted by the source
- The *tissue* exposed that absorbs the radiation.
- The *distance* you are from the radioactive source
- The *time* you are exposed to the source
- The *shielding* between you and the source

How does radiation *amount* affect us?

Knowing the *amount* of radiation emitted from a source is only part of story in terms of the harm it can do to us.

The amount of radiation emitted is measured in **becquerel** (**Bq**).

1 Bq means that one atom is decaying, or emitting radiation, per second.

How does radiation *amount* affect us?

In addition each type of radiation has a certain amount of *energy*, which is measured in **electronvolts (eV)**.

Alpha particles typically have energies between 4,000,000eV (4Mega eV or 4MeV) to 8MeV. Beta particles have energies between 0.1 & 3MeV.

How does radiation *amount* affect us?

So the 'real' amount of radiation is a combination of the *amount* emitted (given out) from the source and the *energy* of the radiation emitted.

However, to do harm, the radiation has to be **absorbed**. This happens when the energy of the radiation is transferred to the atoms it interacts with (ionises).

This is the **absorbed dose** of radiation.

How does radiation *amount* affect us?

There are different ways of considering the dose:

- **Absorbed dose**
- **Equivalent dose**
- **Effective dose**

Absorbed dose is measured in **gray** (**Gy**).

It is the amount of energy in **joules (J)** absorbed per unit mass (**kg**) of material receiving the radiation.

How does *radiation type* affect us?

The extent of the *effects* of the radiation depend on the **equivalent dose** of radiation for each body part.
This is measured in **sieverts (Sv).**

This is based on the absorbed dose and, the energy and type of radiation absorbed.

Equivalent dose = absorbed dose * weighting factor
(for the radiation type and their energy accepted weighting figures are alpha particles = 20; beta & gamma = 1)

How does *body tissue* change the effect?

The **effective dose** considers the part of the body that has been affected by the radiation.

This is also measured in **sieverts (Sv).**

Effective dose = equivalent dose * weighting factor

(for the tissue or organ involved there are accepted weighting figures: lungs have a weighting factor of 0.12; skin a factor of 0.01)

How does *distance* affect us?

Each ionisation **transfers** energy from the radiation to the atom interacted with, until the radiation does not have enough energy to travel any further.

Alpha radiation *outside* the body rarely reaches the cells of the body to cause any ionising interactions. It ‘loses’ its energy quickly as it interacts with atoms close to it due to its large size.
Think of a large bus in a busy street, trying to get to through the traffic quickly: it will have many interactions when trying to travel through the traffic.

How does *distance* affect us?

However once *inside* the body alpha radiation will ionise concentrated areas of cells, damaging them.

Beta particles are much smaller and have less energy than alpha particles. Their interactions will be spready over a wider area. They travel or penetrate further because they do not ‘lose’ their energy so quickly.

Less harmful *inside* the body but could be harmful *outside* the body.

How does *distance* affect us?

Gamma radiation is much more **penetrating**.

It is harmful from *outside* the body. It can travel much further in air, so even a distance of several meters would not prevent it harming you.

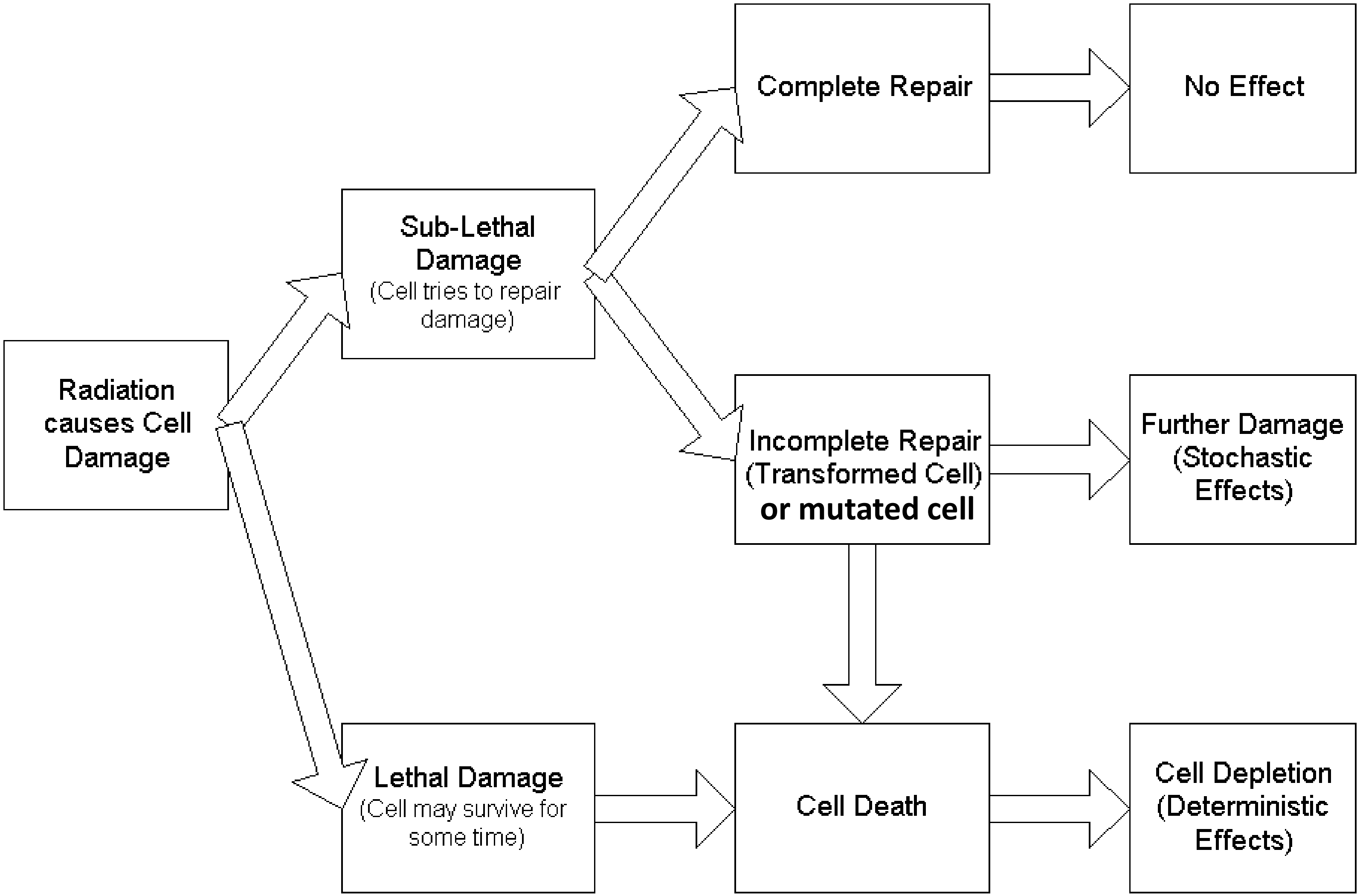
One of gamma radiation's effects, due to its penetration power, is deep internal burns even though it may only ionise a few atoms as it pass through your body.

How does exposure *time* affect us?

Some radiation effects only occur once a *threshold* of radiation exposure has been reached: increased exposure time increases the effect, such as skin reddening (radiation burns) and sterility. These are **deterministic** (tissue) **effects**.

Other effects are unrelated to amount of exposure. A single DNA mutation can lead to the effect, such as cancer. Increasing the amount of exposure only makes the event more likely to occur. These are **stochastic effects**.

Possible effects of exposure



Some deterministic effects of exposure

Injuries will start to show within a few hours of exposure:

Blistering of the palm of the right hand caused by an overexposure to radiation (IAEA).

Injuries suffered from radiation burns.

Stochastic effects of exposure

Injuries may not show for many years.

Cancer is a stochastic effect as are mutations that could be passed on to future offspring.

How does *shielding* affect us?

Linked to all of this is the **shielding** between us and the source of radiation.

A shield is something that will prevent the radiation from penetrating into our body.

Alpha particles do not penetrate very far before transferring all their energy. We are shielded by our skin even when close to a source.

How does *shielding* affect us?

Beta particles will penetrate a few cm of air, but can be stopped by a covering of clothing.

Gamma radiation however cannot be absolutely stopped even by lead or by many metres of concrete. The shielding of these materials reduces the exposure. Without it the radiation effect from gamma rays is very harmful.

What are the effects of radioactivity?

In summary:

- Effects should take into account *energy*, *type* and *amount* of radiation along with exposure *time* and *body tissue* exposed.
- Particulate radiation such as alpha and beta, are most harmful when inside the body: gamma radiation is harmful from many metres away.
- Some effects increase with exposure time, such as radiation burns (*deterministic* effect).
- Some effects will be chance events. Increased exposure may increase the likelihood but not the severity of the effect (*stochastic* effect).
- Radiation affects the bonds of atoms, and ultimately the DNA in our cells, which is made of many atoms bonded together.