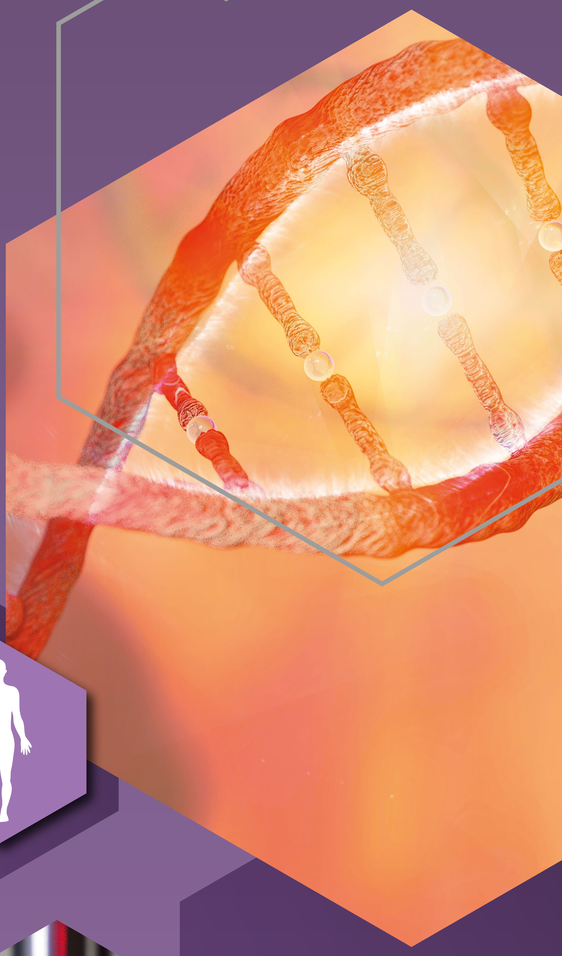
THE EFFECTS OF RADIOACTIVITY ON THE BODY



4.1 Design: ASN and IRSN Communications Departments - October 2021
Graphic design and production: www.kazoar.fr - Pictograms: Freepik, Kazoar – Photos: CIPhotos/iStock, Francesco Acerbis/Médiathèque IRSN (media library)

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THE EFFECTS OF RADIOACTIVITY ON THE BODY

BIOLOGICAL EFFECTS OF RADIATION

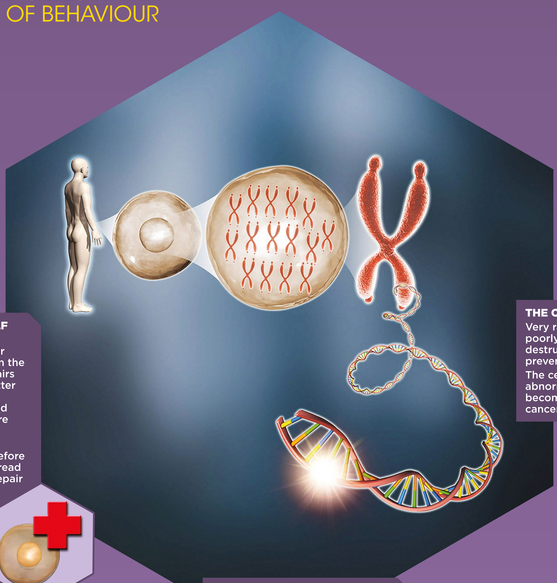
Radiation damages the DNA of our cells. Fortunately, cells have effective repair mechanisms. Nevertheless, damage can remain and cause all sorts of malfunctions, including cancer.

IRRADIATED CELL

Exposure to radiation can damage DNA:

- **directly:** an alpha or beta particle breaks the DNA molecule;
- **indirectly:** X-rays or gamma rays cause chemical reactions that lead to DNA damage.

DAMAGED CELLS HAVE 3 MODES OF BEHAVIOUR



THE CELL REPAIRS ITSELF

Our immune and enzyme systems are powerful repair mechanisms. Depending on the extent of the damage, repairs can be carried out in a matter of minutes or several days. Cells can be poorly repaired if the repair mechanisms are weak or overloaded.

A high dose of radiation received all at once is therefore much riskier than if it is spread out over time, giving the repair mechanisms time to play their part.

THE CELL MUTATES

Very rarely, cells may be poorly repaired or the self-destruct order may be prevented.

The cell will then multiply abnormally and, over time, become a tumour or cancer.

THE CELL DESTROYS ITSELF

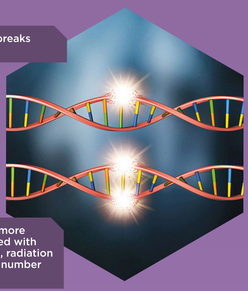
Cells have a natural self-destruction mechanism that they activate when they are damaged or too old.

In the event of extensive irradiation, a large number of cells can be eliminated. In the event of a very high dose, this can lead to organ dysfunction, serious illness or even death.

SINGLE OR DOUBLE DAMAGE?

Every day, every cell in our body undergoes multiple attacks that break the DNA.

Cells repair single-strand breaks quite easily.



Double-strand breaks are more difficult to repair. Compared with naturally occurring lesions, radiation significantly increases the number of double-strand breaks.

Radiation can break **a single strand** of the DNA chain **or both strands** in the same place.

4.2 Design: ASN and IRSN Communications Departments - October 2021
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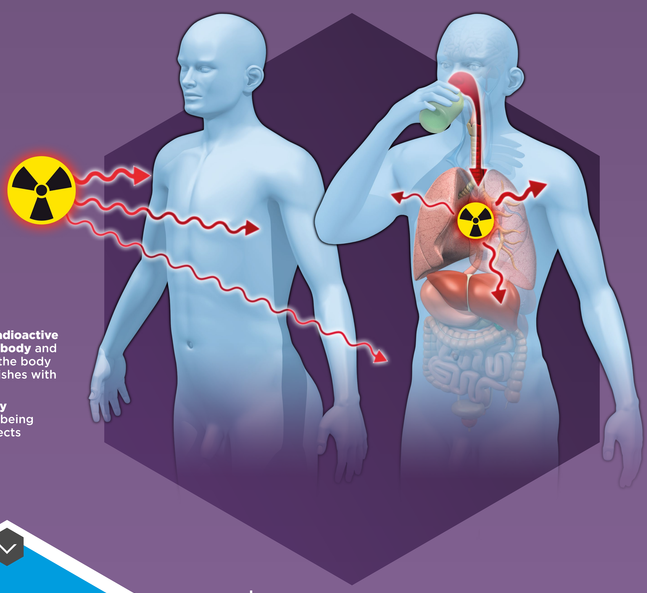
IRRADIATION OR CONTAMINATION?

A human being can be irradiated or contaminated by a radioactive source.

The person is **irradiated** if they are externally exposed to radiation from the source.

They are **contaminated** if radioactive particles are deposited on them or are ingested or inhaled.



IRRADIATION

Irradiation occurs when **the radioactive source is located outside the body** and the radiation passes through the body or part of it. Irradiation diminishes with distance from the source.

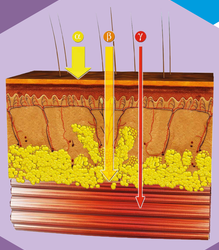
The person does not carry any radioactivity with them after being irradiated, but suffers any effects produced by the radiation.

RADIATION PENETRATION

Alpha radiation (α) does not penetrate deeper than the first cells of the upper layer of the skin.

Beta radiation (β) is more penetrating and can reach the inner layers and cause burns.

Gamma rays (γ) penetrate beyond the layers of the skin, inside the body.



CONTAMINATION

EXTERNAL

When radioactive particles are deposited on the skin or clothing without penetrating the body, this is known as external contamination.

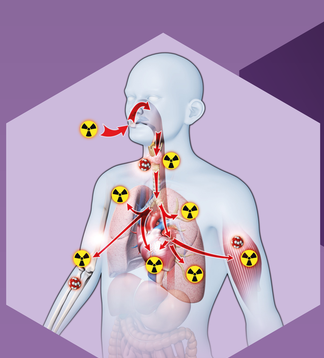
This can be eliminated by the person undressing and washing.

INTERNAL

Internal contamination occurs when radioactive elements enter the body through inhalation, ingestion or injury by contaminated objects.

The body does not permanently fix most radioactive particles. Depending on their nature, the time they spend in the body varies.

Just because a person has been contaminated internally or irradiated does not mean that they pose a risk to those close to them.



INTERNAL CONTAMINATION
Depending on their chemical nature, radioactive elements bind to different organs.

4.3 Design: ASN and IRSN Communications Departments - October 2021
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THE EFFECTS OF RADIOACTIVITY ON THE BODY

DANGER THRESHOLDS

Radioactivity can be dangerous, but it all depends on the dose received. In some cases, it is even used to treat illnesses.

SYSTEMATIC EFFECTS

Following intense irradiation, cells can be destroyed in large numbers. Tissues or organs are damaged.

These effects can be felt immediately or after a few days, and are certain to affect anyone exposed. **Their severity increases as the absorbed dose increases.**

RANDOM EFFECTS

Irradiation can damage DNA and may or may not cause subsequent effects. Radiation can increase the likelihood of cancer and, at high doses, can have immediate effects such as nausea.

After a certain time, consequences may appear, and only for certain people: a few years for leukaemia and thyroid cancer in children, 20 to 40 years for other cancers.

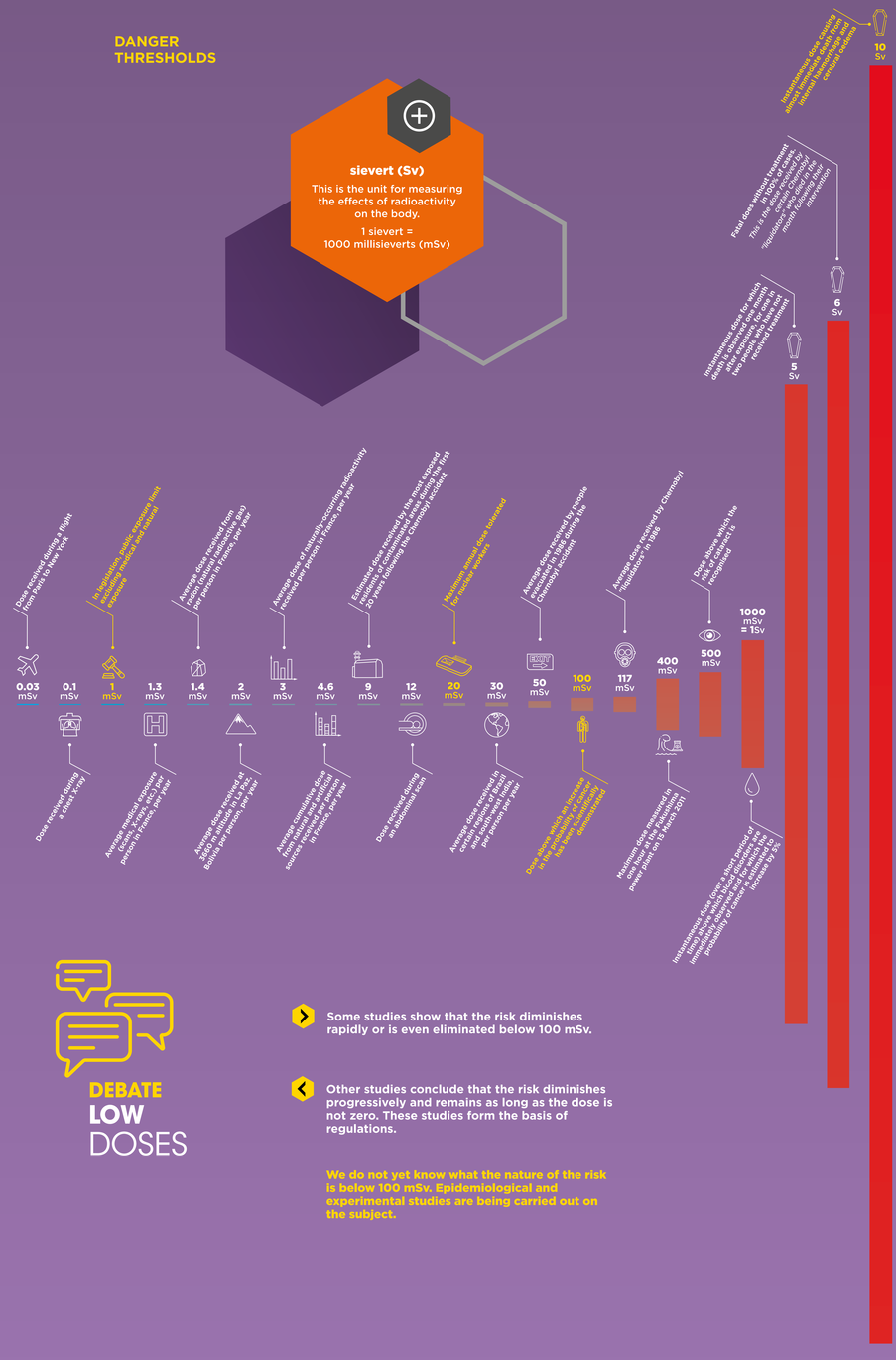
Since cancers can have a variety of causes, sometimes associated with one another, it is very difficult to attribute a cancer to irradiation with any certainty.

DANGER THRESHOLDS

sievert (Sv)

This is the unit for measuring the effects of radioactivity on the body.

1 sievert = 1000 millisieverts (mSv)



DEBATE LOW DOSES

Some studies show that the risk diminishes rapidly or is even eliminated below 100 mSv.

Other studies conclude that the risk diminishes progressively and remains as long as the dose is not zero. These studies form the basis of regulations.

We do not yet know what the nature of the risk is below 100 mSv. Epidemiological and experimental studies are being carried out on the subject.

4.4 Design: ASN and IRSN Communications Departments - October 2021
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THE EFFECTS OF RADIOACTIVITY ON THE BODY

ARE WE ALL EQUAL IN THE FACE OF RADIOACTIVITY?

We are **not all equal** when it comes to radioactivity, yet we are regularly exposed to it, particularly in the medical sector. Differences in our genes, age or sex explain these variations. In certain circumstances, such as pregnancy, special precautions may need to be taken.

VARYING LEVELS OF SENSITIVITY

Our genes are different and our bodies react differently to the aggressions of radiation. It is estimated that 5 to 15% of the population is radiosensitive, i.e. more vulnerable to radiation. This is an important factor when it comes to undergoing radiotherapy for cancer, for example.

ASN, which is responsible for monitoring personal radiation protection, is keeping a close eye on developments in this area.

PREGNANT WOMEN

Pregnant women may be exposed to radiation for a variety of reasons: occupational for workers, medical in the case of imaging examinations (particularly scans).

Precautions must therefore be taken to protect both the mother and the unborn child.

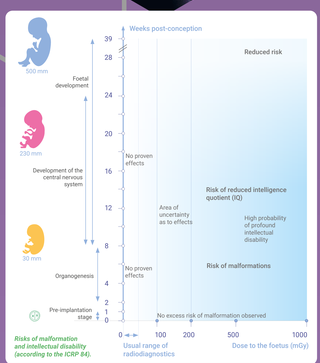
In the case of cancer, doctors and families are faced with a dilemma, as radiotherapy treatments can pose a risk to the unborn child.

From 0 to 2 months

The development of the embryo is such that radiation has an "all or nothing" effect: the embryo may or may not survive, but there is no risk of malformation.

During the foetal period (from 2 to 9 months)

The risk of malformation or physical or mental disability may materialize depending on the dose received.



Radiotherapists use this chart to decide, with families, what choices to make when a pregnant woman has to undergo radiotherapy.

SEX AND AGE

The bodies of men, women, children and the elderly react differently to ionising radiation.

IF A MAN IS CONTAMINATED,

he eliminates a radioactive substance more slowly than a woman or a child.

Cell renewal is very uneven, depending on the age of the individual and the tissues concerned: it is particularly rapid in the foetus and in children, but slower in adults and even slower in the elderly. This means that a mutation caused by irradiation will multiply more rapidly in younger people.

In addition, certain organs are particularly active in children, such as the thyroid, which supplies growth hormones.

THE ORGANS

Some organs are much more sensitive than others (gonads, liver, thyroid, etc.).

4.5 Design: ASN and IRSN Communications Departments - October 2021
Graphic design and production: www.kazoar.fr - Pictograms: Freepik, Kazoar - Illustration: R. Grimaldi/IRSN - Photos: JackF/Adobe Stock, Sergejs Rahunoks/Adobe Stock

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THE EFFECTS OF RADIOACTIVITY ON THE BODY

WHAT DOSES DO WORKERS RECEIVE?

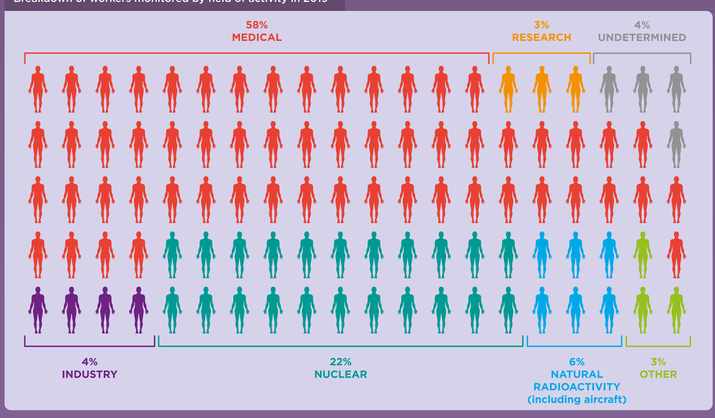
The doses received by workers in civil and military activities and those exposed to natural radioactivity are monitored and reported to IRSN, which establishes an annual report. ASN controls the radiation protection of workers.

NUMBER OF WORKERS MONITORED

395,040 workers underwent dosimetric monitoring in 2019, compared with 278,150 in 2006. 58% work in the medical field.

To this figure must be added more than 25,000 workers exposed to natural radioactivity, mainly flight crews exposed to cosmic radiation.

Breakdown of workers monitored by field of activity in 2019

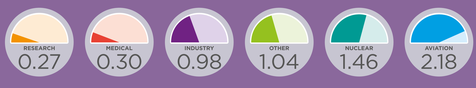


MEASURING EXTERNAL IRRADIATION

In all circumstances, the person wears a passive dosimeter for individual reference monitoring and, in work areas where the risk is greater, an operational dosimeter that can be read immediately, which indicates the dose received in real time and can trigger an alarm if a predefined threshold is exceeded.

AVERAGE INDIVIDUAL DOSE BY AREA OF ACTIVITY IN 2019 (mSv)

There are major disparities between the different areas of activity. Flight crews have the highest average individual doses, followed by workers in the non-nuclear and nuclear industries. 76% of monitored workers received no dose. Few workers receive more than 20 mSv: 9 in 2014, 5 in 2019.



MEASURING INTERNAL CONTAMINATION

For workers likely to absorb radioactive substances (through inhalation, ingestion, skin penetration or even injury), monitoring is based on anthroporadiometric examinations (*in vivo* measurements) and radiotoxicological analyses of urine or faeces (*in vitro* measurements).

ROUTINE MONITORING

The main purpose of routine monitoring is to check that workers are not contaminated under normal working conditions.

In 2019, out of almost 230,000 examinations, 0.5% revealed contamination.

SPECIAL MONITORING

Routine monitoring is supplemented by special monitoring when a particular event involving a suspicion of contamination is suspected or detected.

In 2019, out of approximately 10,000 examinations, 15% revealed contamination.

CALCULATE THE DOSE RECEIVED

Calculate the dose received during a flight by scanning the following QR Code or visiting http://www.sievert-system.org/

FIND OUT MORE ABOUT WORKER EXPOSURE

Find out more about worker exposure to ionising radiation in France (2019) at http://www.irsn.fr/travailleurs-2019

4.6 Design: ASN and IRSN Communications Departments - October 2021
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