Radiation

What is radiation?
In physics, radiation is a process in which energetic particles or energetic waves travel through vacuum, or through matter-containing media that are not required for their propagation. Waves of a massive medium itself, such as water waves or sound waves, are usually not considered to be forms of "radiation" in this sense.

Electromagnetic spectrum – different kinds of rays (all invisible, except for light).
Different wave lengths - > shorter the wave the more dangerous the rays.
3 kinds of radiation:

\( \alpha \) - radiation: alpha particles.
- Consists of helium nuclei.
- Very limited penetrating power.
- Contamination by food or injection.

\( \beta \) - radiation: beta particles.
- Electron sent (mass 0, charge -1)
- 1 neutron changes into proton
- Larger penetrating power.

\( \gamma \) - radiation: gamma rays.
- No particles (alpha, beta), just rays
- Very large penetrating power.

Half-life – the time it takes for half or the radioactive substance to decay.
During radioactivity the atomic nucleus changes: nuclear reactions take place.

Radiation therapy
Radiation therapy is a type of cancer treatment that uses beams of intense energy to kill cancer cells.
Radiation therapy most often gets its power from X-rays, but the power can also come from protons or other types of energy.

The term "radiation therapy" most often refers to external beam radiation therapy. During this type of radiation, the high-energy beams come from a machine outside of your body that aims the beams at a precise point on your body. During a different type of radiation treatment called brachytherapy, radiation is placed inside your body.

Radiation therapy damages cells by destroying the genetic material that controls how cells grow and divide. While both healthy and cancerous cells are damaged by radiation therapy, the goal of radiation therapy is to destroy as few normal, healthy cells as possible.

The history of radiation
The earth has been radioactive ever since its formation into a solid mass over 4½ billion years ago. However, we have only known about radiation and radioactivity for just over one hundred years.

Radiation was discovered by Wilhelm Conrad Rontgen on the 8th of November, 1895.
- Rontgen discovered radiation because he had been experimenting in his laboratory with the discharge of electricity in 'vacuum tubes'.
- The glass tubes were evacuated and had metal plates sealed at the ends.
- Metal plates were connected to a battery or an induction coil.
- This flow of electricity was necessary in order for the tube to glow.
- The glow emerged from the negative plate (the cathode) and disappeared into the positive plate (the anode).
- The glass tubes were given various names, e.g. Crookes tubes (named after William Crookes) or Hittorf tubes (Johann Hittorf) based on the individual able to design a tube better able to generate or hold vacuum.
- In a darkened room, Roentgen noticed the screen fluorescing, emitting light.
• However, since the Hittorf tube was covered in cardboard, no cathode rays or light could have come from Hittorf tube.

Roentgen experimented with these “new rays”, alone in his laboratory, for many weeks. He found that objects were transparent to these rays in different degrees. Photographic plates were sensitive to x-rays.

• 1896, July  Antoine Henri Becquerel discovered radioactivity in Paris. Only one month after the discovery of x rays, a severe case of x-ray-induced dermatitis was published.
• 1897  J.J. Thomson discovered the electron.
• 1898  Marie and Pierre Curie discovered the first radioactive elements: radium and polonium. Ernest Rutherford concluded that radiation can divided into 2 types, alpha and beta rays.
• 1900  Pierre Curie discovered that there is another type of radiation; the gamma rays.
• 1902  The first dose limit of about 10 rad per day (or 3000 rad per year), was recommended.
• 1913  Hans Geiger invented the Geiger counter form measuring radioactivity.
• 1915  The first people with cancer were cured with radiation.
• 1927  Radioactive tracers were first used to diagnose heart disease.
• 1934  Irene and Frederic Joliot-Curie discovered artificial radioactivity.

Side effects
Acute side effects:
- damage to the epithelial surfaces
- mouth and throat sores
- intestinal discomfort
- swelling
- infertility

- fibrosis (irradiated tissues become less flexible)
- dryness
- cancer
- heart disease
- cognitive decline

Late side effects:

When is it appropriate?
After lumpectomy (lumpectomy plus radiation is sometimes called breast-preservation surgery). Radiation attempts to destroy any cancer cells that may have been left in the breast after the tumor was removed.

Typically a doctor will recommend lumpectomy followed by whole breast radiation if the cancer is:
- early stage
- 4 centimeters or smaller
- located in one site
- removed with clear margins

After mastectomy
These factors are associated with a high risk of recurrence after mastectomy. Radiation may be recommended if any of these factors are present:
- The cancer is 5 centimeters or larger (the cancer can be 1 lump, a series of lumps, or even microscopic lumps that together are 5 centimeters or larger).
- The cancer had invaded the lymph channels and blood vessels in the breast.
- The removed tissue has a positive margin of resection.
- Four or more lymph nodes were involved OR, for premenopausal women, at least 1 lymph node was involved.
- The cancer has invaded the skin (with locally advanced or inflammatory breast cancer).

Radiation is not an option for you if:
- you have already had radiation to that area of the body
you have a connective tissue disease, such as scleroderma or vasculitis, which makes you extra-sensitive to the side effects of radiation
- you are pregnant
- you are not willing to commit to the daily schedule of radiation therapy, or distance makes it impossible

**Pros and cons**
Radiation also kills healthy body cells = bad.

New York Times:
“For some, radiation may enhance their prospects of preventing a recurrence of their breast cancer. But whether that translates into increases in the chances for long-term survival is not clear.

*Some doctors are simply prescribing radiation; others want to wait for more data.*"

The goal of radiotherapy is to deliver as much dose to the tumour whilst sparing normal tissue. Technological advances incorporating new imaging modalities, more powerful computers and software, and new delivery systems such as advanced linear accelerators have helped achieve this.

**Conclusion**
Radiation remains an important modality for cancer treatment with ongoing efforts towards designing new radiation treatment modalities and techniques which continue to improve the survival and quality of life of cancer patients. With the improved clinical outcomes of cancer treatment, minimizing radiation therapy related toxicities has also become a priority. The emergence of mechanistic biological studies together with improvements in radiation technology has improved the sparing of normal cells/tissues through dose fractionation and conformal radiation techniques. Radiation is also being delivered in combination with molecular targeted therapy with the aim of further improving the therapeutic ratio of the radiation treatment [10, 57, 58].

Though ionizing radiation remains one of the most effective tools in the therapy of cancer cure, answers to a number of questions remain: 1. What criteria drive the cancer cells in the selection of a particular type of cell death pathway? 2. How does a cancer cell switch from a recovery (repair) program to destructive cell death? 3. Ways to optimize the effectiveness of radiation therapy in combination with other modalities of treatment? 4. Would it be possible to lower radiation therapy effects to normal tissues? Answers to these and other questions together with ongoing advancements in radiation therapy technology and techniques will ultimately lead to continued improvement in cancer treatment.