1896- 1898

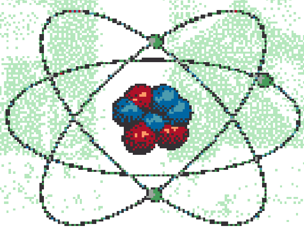
1996-1998

CENTENNIAL of the DISCOVERY of RADIOACTIVITY

"La radioactivité n'a pas été inventée par l'homme, c'est un phénomène naturel."

A discovery which changed everything

- Discovered a hundred years ago
- What is radioactivity
- As old as the world...
- Indispensable today
- Doses, effects and radiation protection
- Radioactivity is also...



Site's pictures

Events and publications of the Centennial

- ***Calendar***
- ***Organisms and committees***
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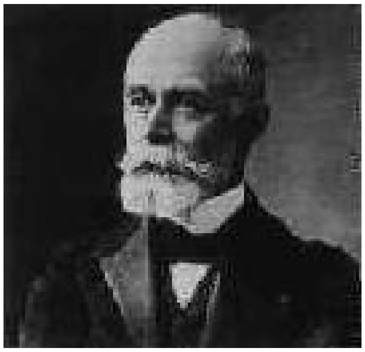
Discovered a hundred years ago...

The discovery of natural radioactivity caused a veritable revolution in scientific thought and an upheaval in the understanding of the Universe and in the evolution of knowledge. Owing to its many applications, this extraordinary discovery has also strongly influenced the history of human society and the life of mankind.

In March 1896, Henri Becquerel discovered an invisible, penetrating radiation emitted spontaneously by Uranium. He showed that these "**uranic rays**" made an imprint on photographic plates and made air conduct electricity.



Henri BECQUEREL (Paris 1852 - Le Croisic 1908)

Professor of Physics at the French Natural History Museum in Paris and at the *Ecole Polytechnique*, Henri Becquerel was a specialist in phenomena related to the polarisation of light and, like his father Edmond Becquerel - in processes involving the luminescence of materials. The year after completing his Doctoral thesis in 1888, he was elected to the Academy of Sciences.

Pierre and Marie Curie discovered two other elements that emitted similar radiations. They baptised the first **Polonium** in July 1898 and the second **Radium** in December of the same year. Pierre and Marie Curie characterised the phenomenon that produces these radiations and called it "**radioactivity**". They discovered that a given mass of radium, which is the most active of all the "radioelements", emits 1.4 million times more radiation than the same mass of uranium.

Pierre CURIE (Paris 1859 - Paris 1906)

Professor at the ESPCI, the School of Industrial Physics and Chemistry in Paris, Pierre Curie was already known for his work on piezoelectricity (with his brother Jacques), symmetry and magnetism when he married Maria Sklodowska in 1895. In 1898, he abandoned his research on crystals to join forces with his wife. In 1904, Pierre Curie was appointed Professor at the Science Faculty in Paris and he was admitted to the French Academy of Sciences in 1905. One year later, he met a tragic death in a Paris street, run over by a horse-drawn cart.

Marie CURIE-SKLODOWSKA (Warsaw 1867 - Sallanches 1934)

Since University admission was barred to women in Poland, Marie Sklodowska arrived in 1891 to study at the University of Paris. After her marriage, Marie Curie worked on a Doctorate in science on the "mysterious" radiation discovered by Henri Becquerel. After the death of her husband, she became the first woman to teach at the Sorbonne. Continuing her research by herself, she succeeded in bringing about the creation of the Institute of Radium and, during World War I, set up a radiology service on the Front. In 1934 she succumbed to leukemia, brought on by her work.

For their discoveries, **Henri Becquerel, Marie Curie** and **Pierre Curie** were jointly awarded the Nobel Prize for Physics in 1903.

In 1902, in Montreal, two British physicists, **Ernest Rutherford** and **Frederick Soddy**, showed that, in radioactivity, the emission of radiation is accompanied by a spontaneous transformation of one chemical element into another.

So the atom was neither unalterable nor indivisible!

It remained to be shown whether Radium was indeed a chemical element like another. This Marie Curie did, by isolating it from several tons of minerals, and determining its atomic " weight ". In 1911, following this extenuating work, she received a second Nobel Prize, in Chemistry this time.

The discovery of radioactivity was a determining factor for the development of all scientific disciplines in the twentieth century, from nuclear physics, which it initiated, as well as radiochemistry and, later on, particle physics, to biology, the Earth sciences, and astrophysics.

What is radioactivity?

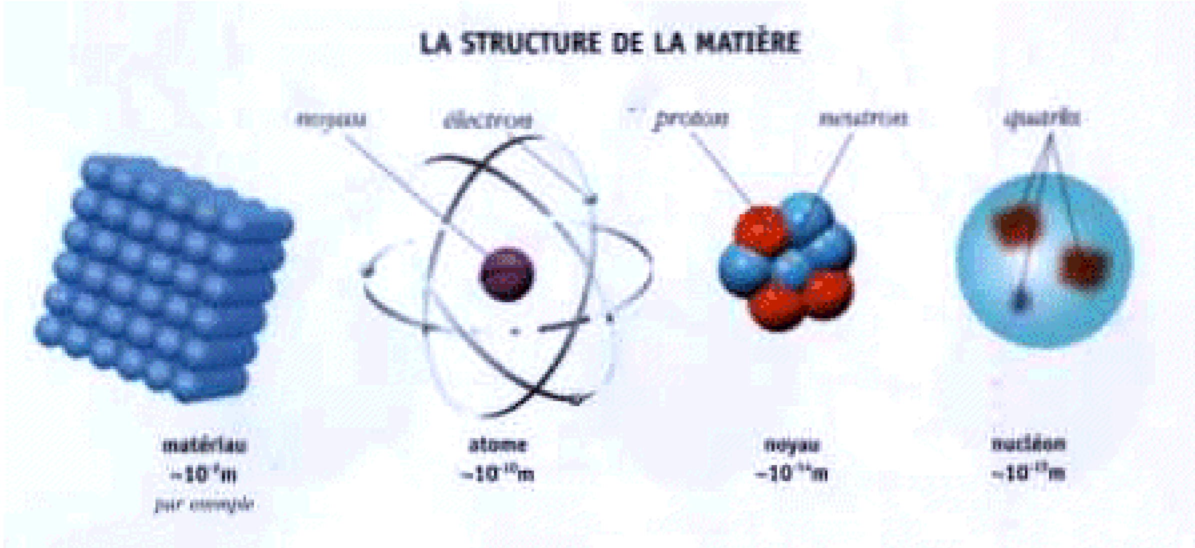
The atoms making up matter are generally stable, but some of them are spontaneously transformed by emitting radiations which release energy. This is called radioactivity.

Atoms

In nature, matter - whether water, gas, rocks, living beings - consists of molecules, which are combinations of atoms. Atoms include a positively charged **nucleus**, around which move negatively charged **electrons**. The atom is neutral.

The structure of matter

The nucleus of the atom includes positively charged protons as well as neutrons. It is this nucleus that is transformed when a radiation is emitted by radioactivity.



Protons and neutrons are, in turn, composed of quarks.

Isotopes

All atoms with nuclei having the same number of protons form a **chemical element**. Having the same number of protons, they have the same number of electrons, hence the same chemical properties. When they have different numbers of neutrons, they are called "**isotopes**". Each isotope of a given element is designated by the total number of its **nucleons,** i.e. protons plus neutrons.

For instance, Uranium-238 and Uranium-235 both have 92 electrons. Their nuclei have 92 protons. Isotope 238 has 146 neutrons, and Uranium-235 has 143 neutrons.

Radiations from radioactivity

There are three types of radiations corresponding to three types of radioactivity.

alpha radioactivity corresponds to the emission of a helium nucleus, a particularly stable structure consisting of two protons and two neutrons, called an a particle.

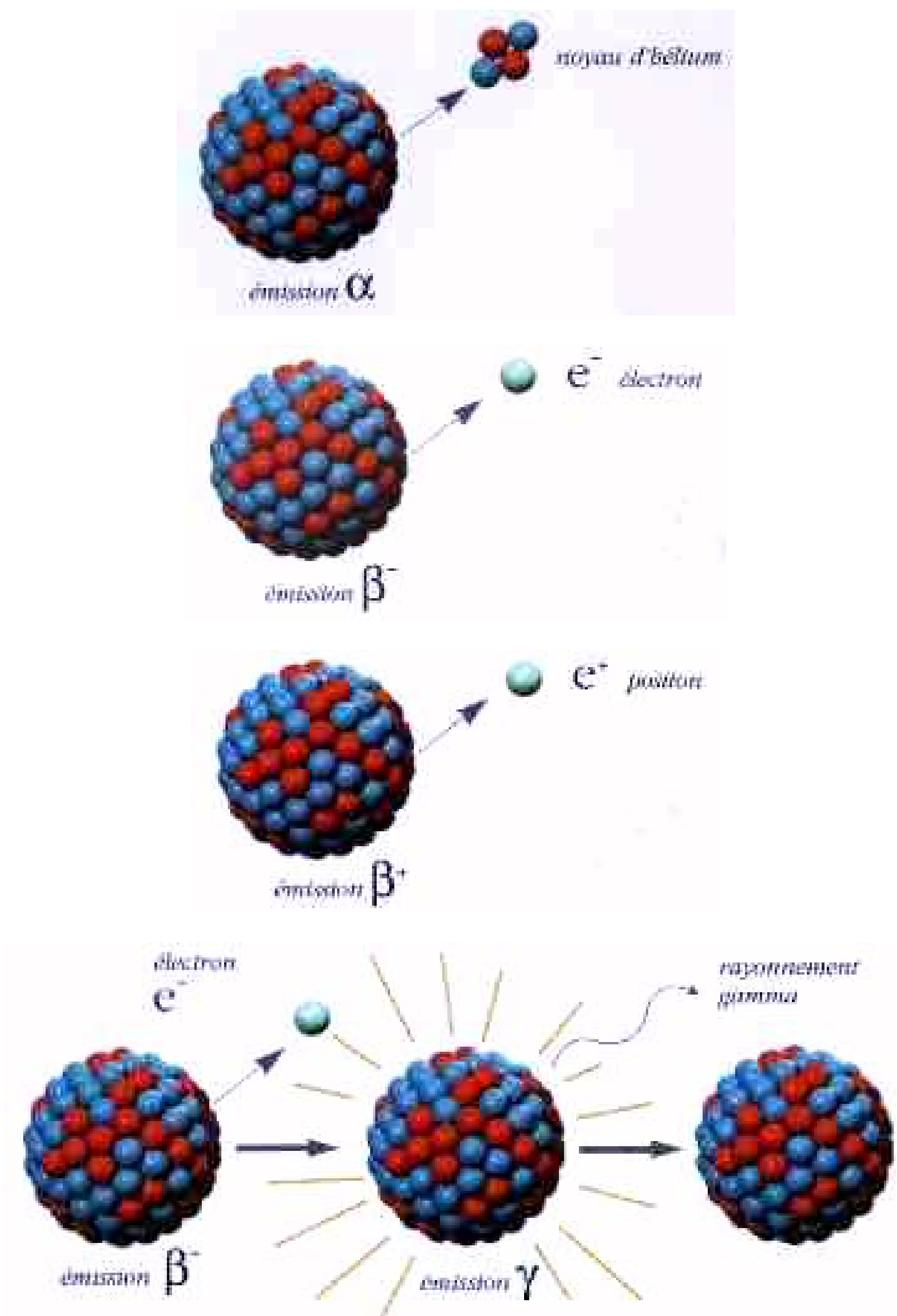
beta radioactivity corresponds to the transformation, in the nucleus:

- either of a neutron into a proton, beta^{-} radioactivity, characterised by the emission of an electron e-

- or of a proton into a neutron, beta^{+} radioactivity, characterised by the emission of an anti-electron or positron e+. It only appears in artificial radioactive nuclei produced by nuclear reactions.

gamma radioactivity, unlike the other two, is not related to a transmutation of the nucleus. It results in the emission, by the nucleus, of an electromagnetic radiation,

THE various types of radioactivity



like visible light or X-rays, but more energetic.

gamma radioactivity can occur by itself or together with alpha or beta radioactivity.

As old as the world...

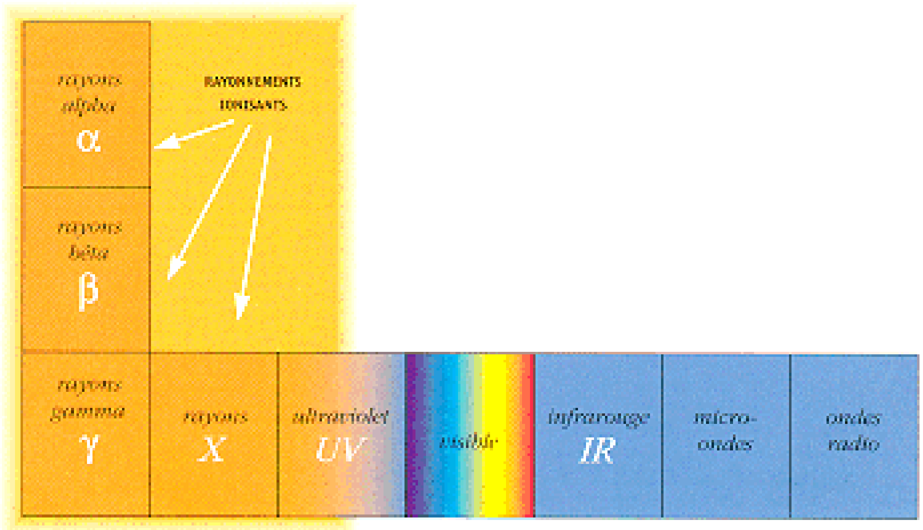
Natural radioactivity has been part of the Universe since its creation. It is found on Earth, within matter and even in living beings. The radiations emitted are invisible, but can be measured with high sensitivity and precision.

Invisible but perfectly measurable

Since the beginning of the Universe, probably some fifteen thousand million years ago, radioactive atoms have been disintegrating. Most of them have disappeared, yielding stable atoms. However, some of them are still radioactive, sometimes for thousands of millions of years to come, pursuing series of transformations which should bring them to final stability. Others are created daily. This is why, since the dawn of time, the Earth, all living beings and everything around them, are radioactive. Natural radioactivity is also present inside the human body, as the food and water we absorb, the air we breathe contain naturally radioactive atoms. This radioactivity all around us can be measured, by means of specific instruments (radiation counters), with great precision, high sensitivity and good spatial resolution.

Ionising radiations

A radiation is said to be **ionising** when it has enough energy to eject one or more electrons from the atoms or molecules in the irradiated medium. This is the case of a and b radiations, as well as of electromagnetic radiations such as g radiations, X-rays and some ultra-violet rays. Visible or infrared light are not, nor are microwaves or radio waves.



Activity

- one litre of milk: ~ 60 Bq
- a 5-year old child: ~ 600 Bq an adult weighing 70 kg: ~ 10,000 Bq
- one ton of granite: 7 to 8 million Bq one gram of radium: 37 thousand million Bq

When one nucleus is transformed into another nucleus by radioactive emission, it is said to disintegrate or decay. The **activity of a radioactive body** is the number of disintegrations of its atoms in one second. It is measured in becquerels. One becquerel corresponds to the disintegration of one atomic nucleus per second. This is a very small unit of measure.

Radioactive half-life

Activity, Time

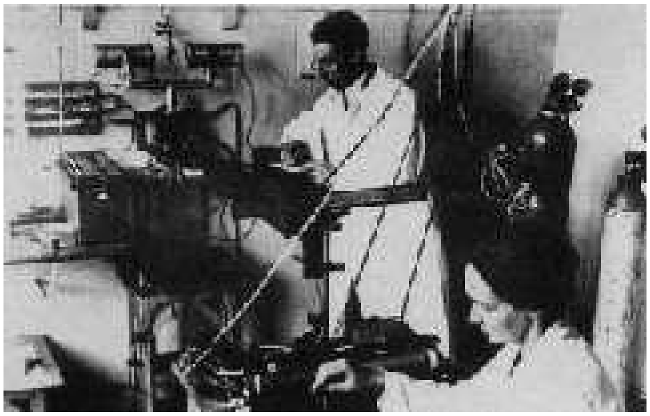
As unstable atoms are transformed, the radioactivity of a substance decreases. The time required for this activity to decrease by half is called **half-life**. This half-life is characteristic of each radioactive isotope. It may range from a few fractions of a second to several thousand million years, depending on the isotope. Nature thus provides several hundred radioactive isotopes which constitute as many calibrated clocks.

Examples: Polonium-214 (0.164 second), Oxygen-15 (2 minutes), Iodine-131 (8 days), Cobalt-60 (5.3 years), Carbon-14 (5730 years), Plutonium-239 (24110 years), Uranium-238 (4.5 thousand million years).

Natural or artificial

Artificial or man-made radioactivity is a phenomenon of the same type as **natural radioactivity**, but for which the emitting nuclei are produced in the laboratory or in reactors.

The discovery of artificial radioactivity



In January 1934, Irène Curie and Frédéric Joliot discovered artificial radioactivity. By bombarding a sheet of Aluminium-27 with a particles, they observed the creation of a new radioactive isotope, or radioisotope,

Phosphorus-30. They received the Nobel Prize in Chemistry for this discovery.

This experiment showed that, by bombarding stable nuclei, it is possible to fabricate radioisotopes that do not exist in nature. Today, it is known how to create hundreds of artificial radioisotopes for a broad range of uses.

Indispensable today...

Today, the applications of radioactivity are constantly growing in number, and especially in chemistry, biology, medicine, archeology, sciences of the Earth and the Universe, the food industry, etc. The energy contained in nuclei is used to produce electricity.

Going back in time: dating

Dating methods are based on the progressive decay, in well defined time periods, of the radioactivity of isotopes contained in the remains to be dated. Carbon-14 in particular is used to determine the age of objects less than 50,000 years old.

Other dating methods using combinations of different isotopes allow an age to be attributed to the events that describe the history of the Earth, its climate and the living beings that have

Principle of ^{14}C-dating.

The carbon dioxide present in the atmosphere contains stable Carbon-12 and a very small percentage of radioactive Carbon-14, with a half-life of 5730 years, continually being formed by cosmic rays. The carbon dioxide is continually exchanged between the atmosphere and the living world (breathing, photosynthesis).

Once a living organism dies, its Carbon-14 is no longer renewed. As this isotope decays, its percentage with respect to Carbon-12 decreases, thus constituting a time clock. The less Carbon-14 remaining, the older the sample to be dated is.

Painting in the Cosquer cave dated back 27,000 years.

inhabited it up to now.

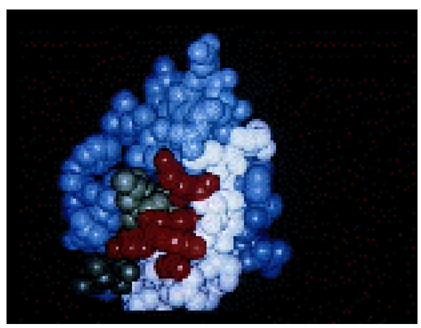
Isotopic labelling in biology and medicine

The different isotopes of an element have the same chemical properties. Replacing one by another in a molecule therefore does not change the molecule's function. However, the radiation emitted makes it possible to detect it, localise it, follow its movement and even to measure its concentration without intervention. Isotopic labelling has thus allowed the study of the functioning of the living body, from individual cells to the entire organism, without disturbing it.

Radioactive isotopes are used in nuclear medicine, especially in medical imaging, to study the way medication works, understand the working of the brain, detect a cardiac disorder, track down cancerous metastases, etc.

In biology,

A large number of breakthroughs during the second half of the twentieth century are linked to the use of radioactivity: functioning of the genome (the backbone of heredity), the metabolism of cells, photosynthesis, transmission of chemical messages (hormones, neuromediators) in the body.



Computer-generated image of a insulin molecule.

Radiations and radiotherapy

Ionising radiations may preferentially destroy tumour cells and provide an efficient treatment for cancer. This is radiotherapy. This was one of the first uses of radioactivity following its discovery.

In France, 40 to 50% of cancers are treated by radiotherapy, often associated with chemotherapy or surgery. Thus, radioactivity cures a large number of people every year.

The various forms of radiotherapy

- **Curietherapy** uses small radioactive sources (platinum - iridium wires, granules of caesium) placed next to the tumour.
- **Teleradiotherapy** consists in concentrating the radiation emitted by an external source onto the tumour cells.
- **Immunoradiotherapy** uses radiolabelled carriers whose antibodies specifically recognize the tumour cells onto which they attach themselves to destroy them.

Nuclear energy

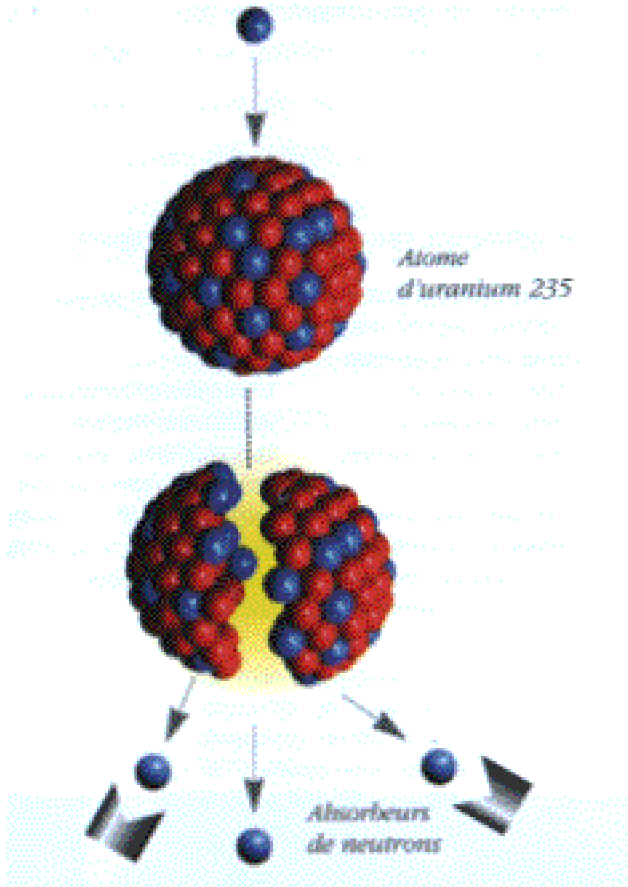
After having understood what natural radioactivity is and having observed the highly complex structures of nuclei, physicists endeavoured to understand where their high cohesion and density came from.

Fission

The study of the considerable forces

involved showed that a very large amount of energy could be drawn from them. Just as the bonding of atoms in molecules is the source of chemical energy, the bonding of protons and neutrons by nuclear forces is the source of nuclear energy, by far the most concentrated. It can effectively be released by **fission** or **fusion**.

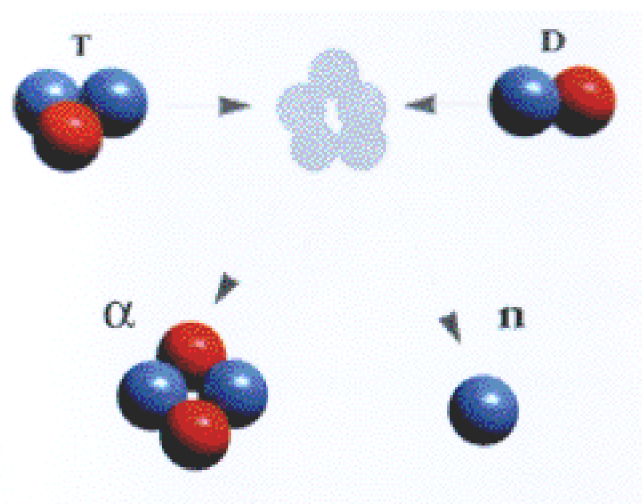
A heavy nucleus is said to undergo fission if it breaks up, either spontaneously or because provoked to do so, into two or more lighter nuclei and a few neutrons. These neutrons can, in turn, induce other fissions, and so forth in a chain reaction which releases a large amount of energy. In nuclear power stations, the chain reaction is controlled, i.e. it cannot get out of hand. In fission atomic bombs, or A bombs, on the contrary, the idea is to amplify this effect.



Fission energy

The total mass of the fission products and neutrons emitted is smaller than the mass of the initial nucleus. The mass difference or **mass defect** has been transformed into energy according to Einstein's famous equation **$E = mc^2$** . The fission of all the nuclei of one kilogram of Uranium-235 thus produces as much energy as the burning of 2,500 tons of coal!

Fusion



Two nuclei of light isotopes (isotopes of hydrogen for instance) can release a large amount of energy by fusing into a heavier nucleus such as helium,. The fusion reaction occurs at a very high temperature, around 200 million degrees Celsius. This is why fusion is said to be a thermonuclear reaction. Such reactions occur in the Sun and stars. They were used in the H bomb (hydrogen bomb).

Fusion energy

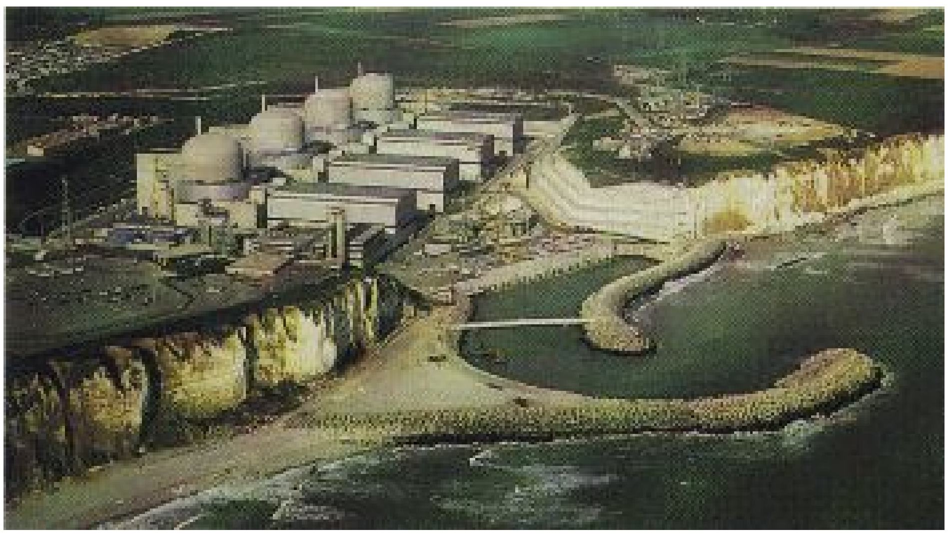
In a **fusion reaction**, the mass of the final nucleus is lower than the sum of the masses of the two initial nuclei. This mass defect, relative to the same number of nucleons, provides a release of energy still higher than that given by a fission reaction. The fusion of all the nuclei of one kilogram of a mixture of deuterium and tritium would produce as much energy as the burning of 10,000 tons of coal!

Controlled fusion

Physicists are endeavouring to control the fusion reaction which could provide a new source of energy in the future. Controlled thermonuclear fusion is so important for humanity that it is the subject of the only research programme bringing together all the countries that have achieved a high level of scientific and technical development: the ITER project (International Thermonuclear Experimental Reactor). The photograph represents the inside of the toroidal chamber of the superconductor system "Tore supra", built in Cadarache (CEA) in the framework of the EURATOM programme to study controlled fusion by magnetic confinement.

Production of electricity

Fission chain reactions of Uranium are used in nuclear power stations which produce more than 75% of the electricity in France.



Nuclear fuel cycle

Radioactive waste management

Radioactive wastes are classified according to two criteria:

- **their activity level**, i.e. the intensity of the emitted radiations which

In a reactor, the fission of Uranium-235 results in the formation of radioactive nuclei called **fission products**. The capture of neutrons by Uranium-238 produces a small amount of Plutonium-239, which can also supply energy by fission.

Only a small part of the fuel placed in a reactor is burnt by fission of nuclei. The unburnt fuel and the plutonium produced are recovered and then recycled to produce electricity again. The other elements, formed during the reaction, are sorted into three types of wastes according to their radioactivity, in

conditions the protections to be used,

- **their radioactive half-life**, which defines the duration of their potential toxicity.

Low and medium activity short-lived wastes represent 90% of the radioactive wastes produced in France, and they lose almost all radioactivity in less than 300 years. They are conditioned so as to reduce their volume as much as possible and placed in steel or concrete containers in which their radioactivity is well confined. Then they are stored on the surface.

Long-lived and/or high level wastes represent only 10% of the radioactive wastes, but their decay spans thousands of years. They are incorporated into glass. A law passed in 1991 fixed a time scale for the study of the future handling of long-lived and short-lived wastes in France. One of the options considered is disposal in deep geological formations, where their evolution will be monitored. Pending decision, they are conditioned and temporarily stored on the surface, in La Hague or Marcoule, in very safe conditions.

Fission reactors

In pressurised water reactors (PWR), the most widely used today, the energy originates from the fission reactions of Uranium-235. The pressurised water of the primary circuit serves both to slow down the neutrons and to evacuate the heat from the core. This heat generates water vapour in the secondary circuit. This water vapour, under pressure, activates a turbine which drives the shaft of an alternator, which in turn generates electricity.

In fast neutron reactors, Uranium-238, which represents 99.3% of natural Uranium, is also used as fuel.

order to be conditioned and then stored.

Nuclear safety

The use of the fantastic source of energy contained in the nucleus of atoms commands stringent compliance with a set of nuclear safety regulations to ensure the proper operation of nuclear power stations and the protection of the population.

Nuclear Wastes

All human activities produce wastes. The nuclear industry is no exception. On the average, France produces, per year and per inhabitant

5,000 kg of wastes, among which

- 100 kg of toxic wastes including
- 1 kg of nuclear wastes, and
- 5g of high level activity wastes.

We do not yet know how to destroy industrially radioactive wastes. They decay naturally with time, more or less rapidly depending on their half-life. Consequently, confinement and storage techniques are called upon.

Reduction in the volume and activity of radioactive wastes is a high priority research goal in France. The study of the long term behaviour of waste packages is

also a major line
of research.

Doses, effects and radiation protection

More than two-thirds of the dose of ionising radiations received in France on the average correspond to natural radioactivity and one quarter to medical irradiation (mainly X-rays).

Man is exposed to various types of ionising radiations which produce approximately the same effects, but are of different origins. Exposure to these radiations may be voluntary (sunbathing, medical examinations), or involuntary.

Ionising radiations

<table>
<tr><td>NATURAL ORIGIN</td><td>Ultraviolet rays (UV) from the sun
Cosmic rays:
• Accelerated particles in space</td><td></td></tr>
<tr><td></td><td>• Radioactivity from space
Natural radioactivity of the Earth and the atmosphere</td><td>NATURAL RADIOACTIVITY</td></tr>
<tr><td></td><td>Man-made radioactivity of an industrial origin
Radioactivity for medical usage :
scintigraphy, gamma-camera, positron camera, radiotherapy using radioactive sources</td><td>MAN-MADE RADIOACTIVITY</td></tr>
<tr><td>MAN-MADE ORIGIN</td><td>X-rays for medical usage:
X-rays and scanner, radiotherapy by X-rays
Particle beams for radiotherapy</td><td></td></tr>
</table>

To know the effects of ionising radiations, the type and intensity of the emitted radiation, on one hand, and the sensitivity of the irradiated medium, on the other, must be known.

The gray (Gy) and the milligray (mGy) are units of measure for the amount of energy transferred by the radiation to each kilogram of matter it goes through (units used particularly in radiotherapy).

The sievert (Sv) and the millisievert (mSv) are units of measure for the amount of radiation or dose to which a living medium is exposed, taking into account the type of radiation (alpha, beta, gamma) and the nature of the tissues concerned (unit used particularly in radiation protection).

Annual doses*

On the average, the dose of ionising radiations received in France is about **3.5 millisievert per inhabitant per year**.

- **Average annual natural exposure: 2.4 mSv per inhabitant:**

  in France, cosmic rays from space and especially the Sun represent received doses of about **0.4 millisievert (mSv)** per year at sea level, which doubles at 1,500 m in elevation (one round-trip Paris-New York corresponds to a received dose of **0.06 mSv**);

  the **radioactive elements contained in the ground**, and mainly Uranium, Thorium and Potassium, result on the average in France in irradiations of **0.4 mSv** per year, highly variable depending on the type of soil;

  the **radioactive elements absorbed by breathing or eating**, such as Radon-222, which is a natural gas from the decay of the uranium contained in the soil, and the main source of natural irradiation, or the potassium in food, a part of which becomes

* source : UNSCEAR

" United Nations Scientific Committee on the Effects of Atomic Radiations "

fixed in our body causing an average irradiation of about **1.6 mSv** per year.

- **Average annual artificial exposure: 1.1 mSv per inhabitant**

  exposures of a medical origin represent an average dose of about **1 mSv**, mainly due to X-ray examinations, very unevenly distributed over the population.

  industrial activities represent an average dose of about **0.1 mSv**, including **0.02 mSv** for nuclear energy.

Effects of radiations

Depending on the dose and the type of radiation received, the effects may be more or less harmful for the health. Two approaches are used to study their various biological effects: **epidemiology** and **experimentation on living cells**.

Effects of doses received by homogeneous irradiation of the whole body*

- **from 0 to 250 mGray**: no biological or medical effect, immediate or long-term, has been observed in children or adults. This is the domain of low doses.
- **from 250 to 1000 mGray**: some nausea may appear along with a slight decrease in the number of white blood cells.
- **from 1000 to 2500 mGray**: vomiting, change in the blood count, but satisfactory recovery or complete cure assured.
- **from 2500 to 5000 mGray**: consequences on health become serious; hospitalisation is mandatory; a dose of 5,000 mSv received all at once is lethal for one out of two people.
- **more than 5000 mGray**: death is almost certain.

Note that **for doses higher than 250 mGray**, long-term effects (risk of cancer increasing with the dose) have also been observed

* This table refers to doses absorbed at one time by homogeneous irradiation of the whole body. In this case, the Gray is equivalent to the Sievert for X, g and b radiations and to 25 Sv for a radiation. Cumulative doses much higher than 5 Gray are used on a part of the body in radiotherapy (60 to 80 Gray). They are administered locally by 2 to 3-Gray sessions four or five times a week.

Radiation Protection

The radiations from radioactivity are, at high doses, a danger for man. It is important to be protected from them. This is the purpose of radiation protection. Since the penetrating power of the various radiations is different, radiation protection techniques must be specifically adapted to each one.

- **alpha radiation** can be stopped by the air or by a sheet of paper. **a** emitters are most dangerous through inhalation or absorption. It is especially necessary to be protected from contamination by a radioactive product containing this type of emitter.
- **beta radiation** can be stopped by aluminium foil or a plate of glass.
- **gamma radiation** can be attenuated or stopped only by significant thicknesses of lead or concrete. This is why the radioactive spaces of nuclear facilities (particle accelerators and nuclear power stations) are enclosed in thick concrete walls.

Radiation protection includes all measures designed to protect the health of the population and those persons working in various areas where ionising radiations are handled: laboratories, hospitals, nuclear industry, etc.

Since 1928, the regulations set up in each country have been based on the recommendations of the International Commission for Radiological Protection (ICRP) which is an independent scientific authority recognized the world over.

Radioactivity is also...

· sterilisation

Irradiation is an excellent way to cold-destroy micro-organisms: fungus, bacteria, virus, etc., consequently there are many applications for the sterilisation of objects, particularly for medico-surgical equipment.

· protecting works of art

A gamma-ray treatment eliminates fungus, larvae, insects or bacteria present within objects thereby protecting them from further deterioration. This technique is used in conserving and restoring works of art as well as in ethnology and archaeology.

· production of materials

Under proper conditions, irradiation triggers chemical reactions which allow the development of lighter and more resistant materials, such as insulation, electric cables, heat shrinking sheaths, prostheses, etc.

· industrial X or g radiography

This consists in recording the image of the disturbance of an X or g ray beam caused by an object to be checked. It allows defects, in welds for instance, to be detected without destroying the material.

· leakage detectors and level gauges

Introducing a radionuclide into a circuit allows the displacements of a fluid to be followed, and leakage on dams or underground pipes to be detected.

The level of a liquid in a tank, the thickness of sheet metal or cardboard being fabricated, the density of a chemical compound in a tank... can be obtained using radioactive gauges.

· fire detectors

A small radioactive source ionises the atoms of oxygen and nitrogen contained in a small volume of air. The arrival of smoke particles changes this ionisation. Radioactive detectors sensitive to very small amounts of smoke are thus manufactured and are widely used in stores, plants, offices, etc.

· luminescent paints

Luminescent paints are the oldest applications of radioactivity, for reading clock dials and on-board instruments in night navigation.

· powering satellites

Power supplies working by means of small radioactive sources of Plutonium-239, Cobalt-60 or Strontium-90, are installed in satellites to supply them with electricity. They are very small in size and can operate for several years without maintenance.

historique
applications
atome & société
programme
organismes & comités
bibliographie
les images du serveur

Conférences, expositions, des dates à retenir

Durant trois années, la célébration du Centenaire de la découverte de la radioactivité est jalonnée de très nombreuses actions et manifestations organisées à l'échelle régionale, nationale et internationale.

Commémorations

17 nov. 1998 Paris - **Académie des sciences**	Cérémonie solennelle, sous la Coupole, commémorant le Centenaire de la découverte du radium , clôture officielle de la célébration.
30 sept. 1998 Paris - **Grand amphithéâtre de la Sorbonne**	Commémoration solennelle de la découverte de la radioactivité, du polonium et du radium, placée sous le haut-patronage et avec une allocution de Monsieur Jacques Chirac, Président de la République, en partenariat avec le Rectorat de l'Académie, Chancellerie des universités de Paris, en présence de Messieurs Georges Charpak (prix Nobel de physique), Claude Cohen-Tannoudji (prix Nobel de physique), Peter Armbruster (professeur à la Gesellschaft fur Schwerionenforschung), et Maurice Tubiana (membre de l'Académie des Sciences et de l'Académie de Médecine).
23 janvier 1996 Paris - **Académie nationale de médecine**	Séance commémorative « Le centenaire de la découverte des rayons X et de la radioactivité Roentgen et Becquerel»

Expositions

nov.1997 - avril 1998 Paris - Palais de la Découverte	Le Palais de la Découverte a choisi 1997 pour consacrer à la radioactivité une grande exposition . Cette exposition a reçu le soutien d'EDF, du CEA, de la COGEMA et de FRAMATOME.
exposition permanente Paris - Musée Curie	Le Musée Curie rénové pour son 75 ème anniversaire. Visites guidées, illustrations, anciens instruments de mesure, retracent les débuts de l'histoire de la radioactivité.
11 sept. 98 - 31 déc. 98 Galerie de minéralogie Muséum national d'histoire naturelle	L'Institut Curie propose une exposition sur les premières applications médicales de la radioactivité et des rayons X (1895- 1930) , intitulée «les rayons de la vie».
1996 à 1998 A travers la France	Exposition itinérante de la SFEN sur la radioactivité, de Becquerel, Pierre et Marie Curie jusqu'à nos jours . (Inaugurée au printemps 1996 à Paris : album photos)
juin 1996 à avril 1998 Paris - Muséum national d'histoire naturelle	Exposition « La Radioactivité, c'est naturel » *30 janvier 1997* : Réflexion centrée autour de trois films : Becquerel et la radioactivité
novembre 1996 à 1998 A travers la France	Exposition de 20 panneaux : "RADIOACTIVITE : QUAND LES ATOMES RAYONNENT"
exposition permanente Châtillon-Coligny	Exposition sur Becquerel au Musée de l'Ancien Hôtel Dieu de Châtillon-Coligny, 2 salles consacrées à la famille Becquerel
à partir de Septembre 1997 Marseille	Trois expositions à Marseille
16 sep.-16 nov1997 Nantes	Exposition « Radioactivité et nucléaire, Centenaire de la découverte de la radioactivité »au Muséum d'histoire naturelle

Colloques et conférences scientifiques

18-20 novembre 1998 La Villette, Paris	Colloque " **Risque et Société** ", à la Cité des Sciences et de l'Industrie de la Villette.
23-24 octobre 1998 Brest	Les Entretiens Scientifiques 98 - pour la deuxième année - Science et Ethique ou le devoir de parole : "**Risques biologiques et technologiques : éthique de la décision**".
31 août - 4 sept. 1998 Besançon	19e Conférence Internationale sur les traces nucléaires dans les solides. Laboratoire de Microanalyse Nucléaire de l'Université de Franche-Comté, à Besançon.
24-28 août 1998 UNESCO, Paris	Conférence Internationale de Physique Nucléaire (INPC 98), qui a lieu tous les trois ans, et chaque fois dans un pays différent. Organisée par le CEA, le CNRS et l'IUPAP
14-19 juin 1998 Caen	15e Conférence Internationale sur les Cyclotrons est ouverte à tous les ingénieurs, physiciens, médecins, biologistes et industriels de toutes les nationalités. (250 participants en provenance d'une trentaine de pays).
3-5 juin 1998 Dijon	37e Congrès de la Société Française des Physiciens d'Hôpital
14-16 mai 1998 Paris- Académie des Sciences	Colloque « Riques cancérogènes dus aux rayonnements ionisants. Mécanismes, relations dose-effet, progrès récents ».
13 mai 1998 Paris	4e rencontre «Physique et Interrogations fondamentales : symétries et brisures de symétrie », organisée par G. Cohen-Tannoudji pour la Société Française de Physique.
29 - 30 avril 1998 Université Pierre et Marie Curie - Paris	Journées franco-polonaises "Pierre et Marie Curie", comprenant le jumelage entre le Musée Curie de Paris et le Musée Sklodowska-Curie de Varsovie.

23- 24 avril 1998 Paris - UNESCO	L'UNESCO a inscrit le Centenaire de la découverte du polonium et du radium au nombre de ses célébrations officielles pour 1998. Rencontre internationale les 23 et 24 avril 1998 à l'UNESCO : « **Les scientifiques du futur : des femmes et des hommes** ». La médaille « Marie Curie » a été remise à la cosmonaute française Claudie André-Deshays, à Geneviève Fraisse, déléguée interministérielle aux droits des femmes et directeur de recherche au CNRS, et à René Bimbot, secrétaire général du Haut Comité national français pour le centenaire de la découverte de la radioactivité.
7-10 juillet 1997 Société Française de Physique Paris - Sorbonne	CONGRES de la Société Française de Physique Au programme : des conférences plénières, des colloques, des expositions, des visites de laboratoires.....
22 janvier 1997 **Sociéte Française de Physique** Paris	3ème RENCONTRE "Physique et Interrogations Fondamentales"
16-18 octobre 1996 Lille **Grand Palais**	XXVe colloque de médecine nucléaire de langue française
7-11 octobre 1996 Cherbourg Octeville	Symposium international sur les « Radionucléides dans les océans »
9-13 septembre 1996 Beaumont-Hague **Cogema**	Sixième conférence internationale sur les « Mesures à bas niveau des actinides et des radionucléides à vie longue dans les milieux biologiques et dans l'environnement »
8-13 septembre 1996 Saint-Malo	4e conférence internationale de chimie nucléaire et de radiochimie (NCR4)
2-4 septembre 1996 Montpellier	27e Congrès de la Société européenne de radiobiologie
8-12 juin 1996 Château de Blois	VIIIe Rencontres de Blois sur « Les neutrinos, la matière sombre et l'univers »
30-31 mai 1996 Paris- **Palais du Luxembourg**	Colloque « Atome et Société. Science, politique et opinion publique »
24-25 avril 1996 Grenoble- **Musée de peinture**	« les rayonnements ionisants en médecine et dans l'Industrie : réalisations et perspectives »

19-24 mai 1996 Orléans	Journées d'études de chimie sous rayonnement (JECR 96) sur « l'interaction des rayonnements ionisants avec la matière »
24-25 avril 1996 Grenoble- **Musée de peinture**	« les rayonnements ionisants en médecine et dans l'Industrie : réalisations et perspectives »
14-15 mars 1996 Paris- **Palais du Luxembourg**	«Les avancées de la radiologie médicale Paris et ses contraintes. Progrès en radioprotection et en dosimétrie »

Actions pédagogiques

1996 à 1998 A travers la France	**L'organisation des conférences :** Le Haut Comité National soutient l'organisation de conférences dans les lycées, collèges, universités, centres de culture scientifique et technique, mairies, hôpitaux, entreprises... Avec l'appui de la Société Française de Physique et l'Union des Physiciens, cette action a pour but de mieux faire connaître au public l'oeuvre de Henri Becquerel, Pierre et Marie Curie et l'impact de leurs découvertes sur l'approche conceptuelle de la physique, sur le développement des autres sciences, sur certaines technologies, et finalement sur notre vie quotidienne. 350 conférenciers (biologistes, chimistes, géologues, historiens, médecins, physiciens,...) donneront des conférences pendant ces trois années sur l'ensemble du territoire français. Ces conférences pourront faire l'objet de démonstrations relatives à la détection de la radioactivité, grâce au matériel contenu dans la valise pédagogique Becquerel-Curie.

juin 1997 à travers la France	**La brochure « Radioactivité » :** Éditée en juin 1997, la brochure « Radioactivité » est venue couronner l'ensemble de la production de matériel pédagogique du Centenaire. Cette plaquette de trente pages rassemble les informations essentielles concernant la radioactivité et l'ensemble de ses applications. Elle est agréablement illustrée dans un style rappelant celui de l'exposition de 20 posters dont elle constitue aussi le document d'accompagnement. Elle a été tirée à 100 000 exemplaires en français et mise à la disposition d'enseignants, de documentalistes et des Centres régionaux de documentation pédagogique. Des versions en anglais et en espagnol de ce document ont également pu être tirées à 25 000 exemplaires chacune, grâce au soutien du ministère des Affaires étrangères. Des encarts en arabe et en chinois sont prévus et une version japonaise est envisagée. La version française de la brochure sera diffusée à tous les enseignants de physique, chimie, biologie et géologie des lycées et collèges français.

Médias

28 avril 1998 sur **La Cinquième**	• Diffusion du film documentaire "***Surprises de la matière***" (52 minutes) *Auteurs : Jeanne Laberrigue-Frolow, François Christophe et Jean Druon.* *Réalisation : François Christoph,.* *Coproduction : Culture Production, La Cinquième, CNRS Audiovisuel.*
27 au 30 janvier 1997 19h30 - 20h00 sur **France-Culture**	• Le magazine ***Perspectives scientifiques*** donne l'actualité des Rencontres ***"Physique et interrogations fondamentales"*** *Par Michel Cazenave.*

25 sept. 1997 chaîne câblée **Paris Première**	• Le magazine ***Le canal du savoir*** traite de "Radioactivité : le rayonnement d'une découverte" *par René Bimbot*
Dossier hors-série Pour La Science **octobre 1996**	• Le magazine scientifique "***Pour La Science***" propose un dossier hors-série intitulé **"NOYAUX ATOMIQUES ET RADIOACTIVITE".**
19 mars 1997 à 18h30 Salle de cinéma du Palais de la Découverte	• Le Palais de la Découverte propose un film dans le cadre de son "***écran scientifique du mercredi***" consacré à **LA RADIOACTIVITE**, en collaboration avec le Centre National de la Recherche Scientifique et le Service du Film de la Recherche Scientifique *présentation : J.Laberrigue -Frolow et R.Bimbot*

Ils participent à l'organisation du centenaire

Les organismes

Académie des sciences/ Académie nationale de médecine/ Centre Antoine Béclère/ CEA/ CNRS/ EDF/ Institut Curie/ Muséum national d¹histoire naturelle/ Université Pierre et Marie Curie

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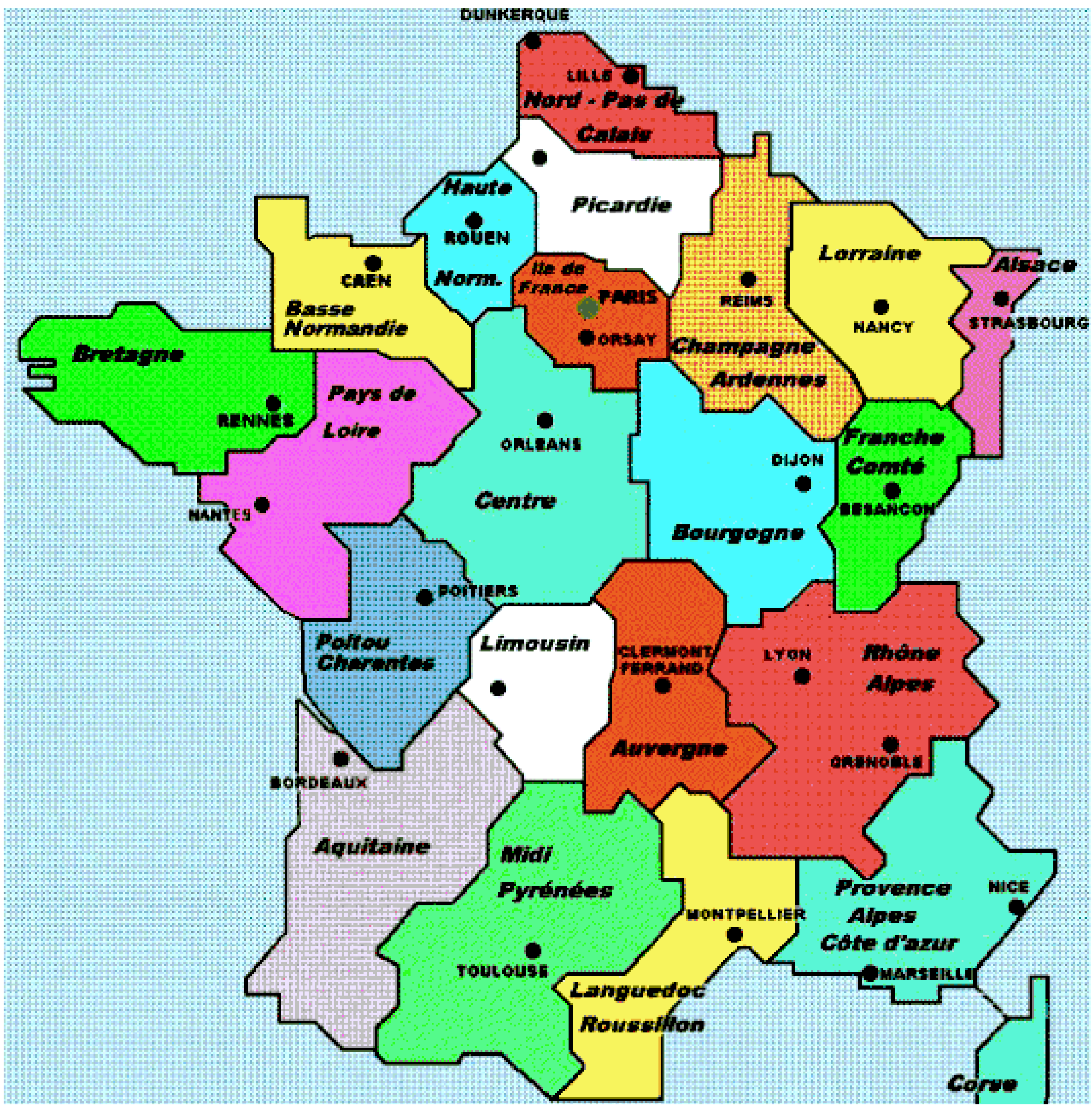

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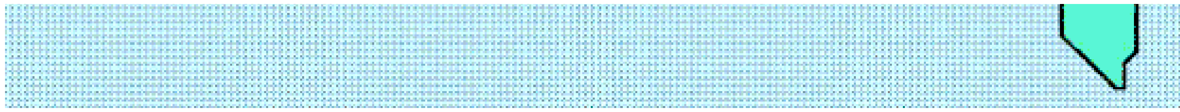

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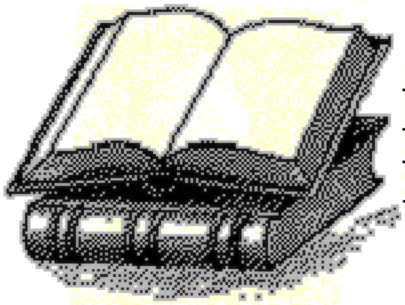

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L'ouvrage du Centenaire

Sommaire de l'ouvrage

Un siècle d'images et de réflexion sur la radioactivité.

Sélection de citations des plus grands auteurs et de photographies, documents, images anciennes et actuelles sur 100 ans de recherche et d'applications.

par René Bimbot[1], André Bonnin[2], Robert Deloche[3] et Claire Lapeyre[4]

avec la participation, pour l'iconographie,
de Lucile Arnaudet (CEA), Lenka Brochard (Archives Curie/CNRS), Marie-Odile Jacquot (CNRS) et Catherine Renon (CEA).

Introduction de l'ouvrage par *Georges Charpak et Maurice Tubiana*
Membres de l'Académie des Sciences,
Coprésidents du Haut Comité National pour le Centenaire de la Découverte de la Radioactivité

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[2)] Professeur de Radiologie et d'Imagerie Nucléaire à l'Hôpital Cochin
[3)] Docteur ès Sciences, Physicien au CEA.
[4)]Chargée de la Médiatisation des Sciences au Ministère des Affaires Etrangères.

Un ouvrage conçu par Robert Delpire et réalisé par Idéodis-Création.
144 pages illustrées en quadrichromie.
Format 220x280 mm à l'italienne.

Publication prévue pour novembre 1999.
Souscription ouverte jusqu'au 30 septembre 1999 auprès d'organismes et de particuliers.

Prix de souscription : 150 F TTC pour la version brochée
250 F TTC pour la version reliée.

Participation aux frais d'envoi :
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Extraits de citations

Le fantôme gris de ce squelette bagué indique du geste de sa main, notre nouveau monde, celui que nous fêtons et qui commence, en effet, entre 1896, année de la découverte de la radioactivité par Henri Becquerel et 1903, année de son PrixNobel.....*

Michel Serres, Colloque Atome et Société, 1996

**La main de Bertha Röntgen*

.... Si l'existence de ce nouveau métal se confirme, nous proposons de l'appeler polonium, du nom du pays d'origine de l'un d'entre nous.

Pierre Curie et Marie Curie, 18 juillet 1898

Vers 1903-1904, il devient certain que les rayonnements (rayons X ou Radium) peuvent guérir certains petits cancers, événement immense car jusque là on croyait que seule la chirurgie pouvait y parvenir...

Maurice Tubiana, Sorbonne, 1998

Avec la radioactivité, c'est l'instable, l'éphémère, et même le furtif qui ont trouvé place dans une physique jusque là rivée à la seule permanence.

Etienne Klein, La Recherche, 1997

Je suis de ceux qui pensent avec Nobel que l'humanité tirera plus de bien que de mal des découvertes nouvelles.

Pierre Curie, Discours Nobel, 1903

La radioactivité est à la matière ce que l'écume est à la vague.

Jean-Marc Cavedon, 1996

.....tournons nous un instant vers Marie Curie....Un mythe se crée à partir de l'épuisante chimie qui lui a permis d'extraire de quelques tonnes de pechblende une minuscule quantité de radium et de polonium....

Jacques Chirac, Sorbonne, 1998

... nous sommes en droit de penser que les chercheurs construisant ou brisant les éléments à volonté sauront réaliser des transmutations à caractère explosif, véritables réactions chimiques en chaînes.

Frédéric Joliot-Curie, Discours Nobel, 1935

.....Un progrès plus considérable encore, sans doute plus lointain, mais espérable cependant, sera de réaliser des conditions où les atomes légers d'hydrogène se condensent en atomes plus lourds, avec un dégagement de chaleur si grand qu'il explique le rayonnement du soleil et des étoiles.

Jean Perrin, 1923

En 1942, Fermi lance la première pile, en 1945 deux bombes éclatent dans le ciel du Japon... La suite, le devenir de cette capacité redoutable est notre problème. Notre problème.

Pierre-Gilles de Gennes, Panthéon, 1995

Le destin d'une civilisation,..., n'est pas de redouter la connaissance des choses, mais de la maîtriser. Le refus du savoir, la crainte de la pensée créatrice, sont, j'en suis sûr, le propre des sociétés perdues.

François Mitterrand, Panthéon, 1995

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Robert Dautray, Albert Einstein, Enrico Fermi, Bertrand Goldschmidt, Frédéric Joliot,
Irène Joliot-Curie, Françoise Giroud, Etienne Klein, Alexandre Kwiasniewski, Hélène Langevin-Joliot, Nicole Le Douarin,

François Mitterrand, Jean Perrin, Pierre Radvanyi, Ernest Rutherford, Glenn Seaborg, Emilio Segré, Michel Serres,
Gérard Toulouse, Maurice Tubiana, Lech Walesa, etc...

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Bulletin à renvoyer avant le 30 septembre 1999 à René Bimbot,
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