# COMMISSION GUIDE

## UNCSTD

CCB MUN XVIII

**United Nations Commission on Science and Technology for Development**

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2020

# Contents

## 1. Presidents' Letter

Dear delegates,

We feel honoured to welcome you all to CCBMUNXVIII, and especially to the United Nations Commission on Science and Technology for Development. Our names are Santiago Castillo and Laura Duque from Colegio Berchmans and Colegio Freinet. This is our first time as presidents, and we are excited to lead this committee, which we believe is crucial for addressing the challenges humanity is facing nowadays. We will do our best to make this an exceptional, satisfying, and unforgettable model for both you as delegates and for us as presidents, and we hope this process will be a great learning experience for all of us.

For us, MUN has been a wonderful and enriching experience in every way, and we are glad to live it with you at UNCSTD. In this committee, delegates are called to debate about different issues or problems related to science and technology, and of course to find viable solutions aimed at development and evolution, taking into account ethics, social and environmental responsibility, and preservation of life above all.

This commission demands a debate that is not only political, but also theoretical. It is essential that delegates prepare themselves with the necessary knowledge, both in information about the country they represent and their position on the addressed topic, and in the theoretical aspects of the subject itself. We hope that each one of you will be the best delegate you can be, and that the debate is dynamic and purposeful, in accordance with the theoretical nature of this committee. Delegates must be well-enough prepared to accomplish propositional, controversial, pertinent, and concrete interventions in order to achieve a satisfactory debate.

Finally, we want to congratulate all of you for being leaders, and for accepting the challenge of caring about the future, because being here implies that not only are you becoming more critical citizens and more conscious people, but you are also acquiring academic skills to become more proficient and prepared students.

Do not hesitate to contact us by email if you have any questions. We are here to guide you.

Yours sincerely,

Your presidents,
Santiago and Laura

## 2. Commission Information

"Humankind has the science and technology to destroy itself or to provide prosperity for all. But while science offers us these opportunities, science will not make that choice for us. Only the moral power of a world acting as a community can" ~
Margaret Beckett

### i. History

The United Nations Commission on Science and Technology for Development is a subsidiary body of the Economic and Social Council (ECOSOC) established in 1992, to replace the Intergovernmental Committee on Science and Technology for Development and the UN Advisory Committee on Science and Technology for Development (both established in 1979). It provides the General Assembly and the Economic and Social Council with high-level advice through analysis and policy recommendations in order to: guide the future work of the United Nations; develop common policies; and agree on appropriate actions, regarding crucial scientific and technological issues.

The Commission met for the first time in April 1993, and since July of the same year, the United Nations Conference on Trade and Development (UNCTAD) secretariat has been responsible for the substantive servicing of the committee, and the commission was relocated from New York to Geneva. The UNCSTD has the following tasks: the examination of science and technology questions and their implications for development; the advancement of the understanding of science and technology policies, particularly in developing countries; and the formulation of recommendations and guidelines on science and technology matters within the United Nations system.

### ii. Structure

The United Nations Commission on Science and Technology for Development meets annually for a period of one week in Geneva, Switzerland. Its members are composed of national governments, specifically forty-three member states that are elected by the Economic and Social Council for a term of four years. It is composed of: eleven members from Africa; nine members from Asia; eight members from Latin American and the Caribbean; five members from Eastern Europe; and ten members from Western Europe and other States. Civil society also contributes to discussions which take place.

At each session, the Commission elects a new bureau (a chairperson and four vice-chairpersons) for the next session, and they assume responsibilities for the upcoming activities during the inter-sessional period. Strong links exist with other UN bodies, for example, the Commission on the Status of Women, International (UNCSW) Telecommunication Union (ITU), and the United Nations Educational, Scientific and Cultural Organization (UNESCO along with other regional commissions.

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# 3. Topic 1: *Implementation of nuclear energy as a predominant energy source*

## i. History/Context

Discovery of nuclear fission

The history of nuclear power begins with the discovery of uranium in 1789 by Martin Klaproth, a German chemist. After Wilhelm Rontgen and Ernest Rutherford's discoveries about radiation, in 1911 Frederick Soddy found radionuclides, which are unstable atoms due to an excess of nuclear energy. In 1932 James Chadwick discovered the neutron, also John Cockcroft and Ernest Walton produced the first nuclear transformations by bombarding atoms with accelerated protons, experiments which a year later were used by Enrico Fermi. He found that neutrons were capable of creating a prominent variety of artificial radionuclides than protons in nuclear transformation processes. In 1934 Fermi conducted experiments in which he bombarded uranium with neutrons, getting as result elements much lighter than uranium, discovering that neutrons could split many kinds of atoms.

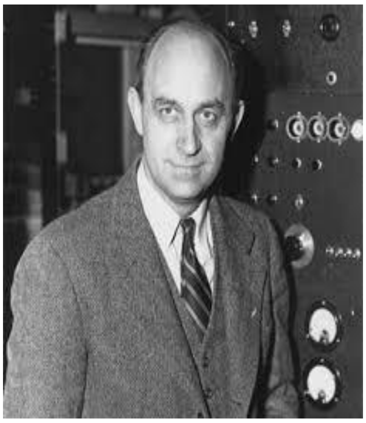

*Figure 1: Enrico Fermi*

German Scientists Otto Hahn and Fritz Strassman found that one of those resulting lighter elements was the barium in 1938. Accompanied by Lisa Meitner, an Australian colleague they added the atomic masses of the elements resulting from the fission of uranium, obtaining a total result less than its atomic mass, therefore, taking into account Einstein's theory of relativity, the lost mass was converted into energy.

In the following years, many more experiments and investigations were carried out by different scientists, including Niels Bohr and Francis Perrin, into nuclear fission chain reactions.

Development of the chain reaction and the atomic bomb

Knowing that a nuclear fission chain reaction was possible, Werner Heisenberg, a German physicist who presided over the German nuclear project, presented the possibility of the atomic bomb. Proposing that when the chain reaction was controlled and slowed down, a large amount of energy was produced, but when uncontrolled it could generate a powerful nuclear explosion. According to Heisenberg, to achieve this uncontrolled reaction, uranium 235 was required as an explosive. However, the necessary critical mass for this reaction was quite high and inconvenient.

It was Niels Bohr who argued that the suitable uranium isotope for the fission process was U-235, this isotope only represents 0.7% of natural uranium, while the other 99,3% is U-238 which led to the implementation of "enriched" uranium. Nevertheless, with Heisenberg's idea of using this element as an explosive, which required using a fairly high critical mass, the enriched uranium became a little insufficient. With the idea of taking advantage of the great availability of U-238, Carl Friedrich von Weizsäcker in 1940, proposed that U-238 could transmute to "element 94", also with great explosive potential, which would later be known as plutonium.

After the outbreak of World War II, Rudolf Peierls and Otto Robert Frisch produced the Frisch-Peierls Memorandum, a three-page document in which they predicted that an amount of about 5 kilograms of pure U-235 could make a very powerful atomic bomb equivalent to several thousand tonnes of dynamite, the document also stated the process of detonation; by thermal diffusion, the U-235 could be produced by separating it from the natural uranium. They also stated some radiation effects which might occur alongside the explosive effects of the bomb.

The MAUD committee, a British group of scientists from different universities formed during the Second World War, aimed to develop the atomic bomb. They made two important advances and as a final result, the MAUD committee delivered two reports in July 1940. The first was 'Use of Uranium for a Bomb', which stated that the atomic bomb was feasible, and that 12kg of active material was equivalent to 1800 tons of TNT (a powerful explosive). It stated that the bomb would leave a large amount of radioactive material in the environment; this material is dangerous for people and lasts for a long time. It also suggested continuing to work on the development of the bomb, as the Germans could also be working on it.

The second report ‘Use of Uranium as a Source of Power’ states that controlled fission of uranium could be used to provide energy in the form of heat for machines. It concluded that the ‘uranium boiler’ had the potential for future peaceful uses, but it was not worth the effort during the present war. Both of the reports led to a complete emphasis on the bomb and the ‘uranium boiler’, nevertheless Prime Minister Winston Churchill and the Chiefs of Staff decided that the bomb project would be pursued urgently.

Due to cooperation between the United Kingdom and the United States, in 1942, a group of scientists led by Fermi who were developing research at the University of Chicago, managed to generate the world's first self-sustainable chain reaction, and with this, the first nuclear reactor: Chicago Pile-1. Apart from uranium, this reactor was composed of graphite and the control rolls were made of cadmium, which is a metallic element that absorbs neutrons.

As a part of the Manhattan Project, on July 16, 1945 at Alamagordo in New Mexico, the first atomic device was successfully tested, mainly operated with plutonium. On 6 August 1945 the first atomic bomb, which used U-235 was dropped on Hiroshima, days after on 9 August a second bomb that contained Pu-239 was dropped on Nagasaki. The USSR declared war on Japan the same day. A day later, on August 10, the Japanese government surrendered.

The Soviet Union started their atomic bomb research program in 1942, but although advances were being made, it wasn't until the bombing of Hiroshima and Nagasaki that the program took relevance. In August 1949, the first Soviet atomic bomb (RSD-1, a plutonium device based closely on the Nagasaki bomb) was tested near Semipalatinsk in Kazakhstan.

<u>The nuclear reactor</u>

After the war, nuclear research and projects focused primarily on energy production. The first nuclear reactor to produce electricity started up in December of 1951, in Idaho, USA. The reactor was developed and operated by Argonne National Laboratory, and was an experimental Breeder reactor (EBR-1). However, this reactor was an experimental model, therefore it only produced a negligible amount of energy.

The AM-1 (Atom Mirny – peaceful atom) reactor was the first nuclear-powered electricity generator. It was water-cooled and graphite-moderated with a similar prototype to the previously used plutonium-producing reactors. It produced electricity until 1959, and was used as a research facility and for the production of isotopes until 2000.

In the United States, Westinghouse designed the first commercial Pressurised Water Reactor (PWR) of 250 MWe (megawatt electrical) that operated from 1960 until 1992, whilst General Electric designed the first Boiling Water Reactor (BWR) of 250 MWe. By the end of the 1960s orders were made for the designing of PWR and BWR with reactor units of more than 100 MWe.

In Canada, the first unit of reactors started in 1962, using natural uranium fuel and heavy water as a moderator and coolant. This type of reactor is called a CANDU reactor. In 1956, France started using Magnox reactors (they use natural uranium with graphite as a moderator and carbon dioxide as a coolant in order to produce atomic energy and plutonium) and then they started using standard Pressurised Water Reactors. In the Soviet Union, the first two nuclear power plants were built in 1964, a boiling water graphite channel reactor and a small pressurized water reactor. In 1972, Kazakhstan built the first commercial fast neutron reactor, it produced electricity and heat to desalinate seawater. Around the world, other countries decided to use light-water designs for their atomic energy projects.

## Nuclear Accidents

Serious nuclear accidents have happened throughout history, many of which have affected people's lives or the environment in which they occurred.

**United Kingdom:** On October 10, 1957, in the United Kingdom, two graphite-moderated reactors (Windscale Unit 1) caught fire in their cores, which led to an enormous amount of radioactivity to be released into the surrounding area. This reached mainland Europe, and more than 200 cancer deaths are attributed to the accident.

**USA:** On January 3, 1961, in the United States a power surge and steam explosion occurred at the SL-1 BWR. This was because of a mistake made in the control centre of the reactor, which caused its power to increase 6,000 times higher than the normal level in less than a second. This accident resulted in the demise of all workers on duty at the time.

**Ukraine:** On April 25, 1986, in Chernobyl, Ukraine (formerly part of the Soviet Union) a sudden surge in power during a reactor system test resulted in an explosion and fire that destroyed Unit 4. This was due to the lack of safety precautions during a routine test. Massive amounts of radiation escaped and spread across the western Soviet Union and Europe, and as a result approximately 220.000 people had to be relocated from their homes. The area is still out of bounds for people to enter due to its high levels of radioactivity.

**Japan:** On March 11, 2011, an earthquake and tsunami struck eastern Japan. This disaster caused a serious accident at the Dai-ichi nuclear power plant located in Fukushima. The earthquake cut off external power to the reactors, the tsunami reached levels more than twice as high as the plant was designed to resist, which resulted in hydrogen explosions, the melting of the fuel of three reactors, and radiation releases that contaminated a wide area surrounding the plant and forced the evacuation of nearly half a million residents.

## Nuclear reactions: Fusion and Fission

Nuclear reactions are the processes of interaction, combination, and transformation between particles or atomic nuclei. Energy can be obtained through two of them: fusion and fission. In nature, these reactions can be found in stars, for example, which generate large amounts of heat and light through nuclear fusion.

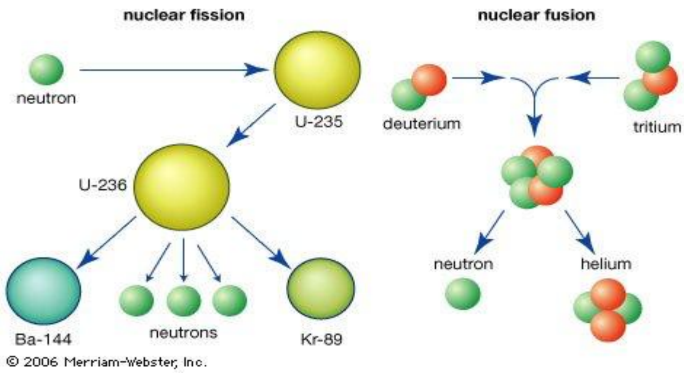


*Figure 2: Fission and Fusion*

In fusion, light elements with low atomic numbers form a heavier element, and like in fission, the difference in mass between the reactants and the products is represented in the release or absorption of energy. The elements considered most efficient for fusion are the isotopes of hydrogen, deuterium, and thyrite, to obtain helium and a neutron as a product. Although currently, a fusion reactor for electricity generation has not been perfected, this could be very beneficial since there are no radioactive residues in the fusion process. So far this technology has been used for hydrogen or thermonuclear bombs.

In nuclear fission, after the collision of a variety of particles such as neutrons, protons, deuterons, alpha particles, or electromagnetic radiation in the form of gamma rays, the atomic nucleus of a heavy element (U, Th y Pu) is divided into two lighter nuclei. In this reaction, the following are released: a large amount of energy since there is a difference in mass between the reactants and the products that are converted into energy; radioactive material, which is known as nuclear waste; and neutrons. One gram of U-235 in the fission process would produce a constant power of 1 MW (1,000 kW) during one day.

Radioactive Waste

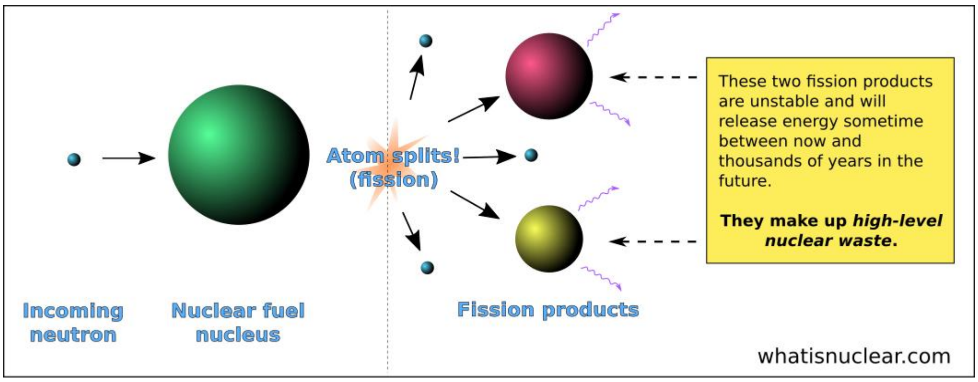


*Figure 3: Fission products*

Nuclear waste is one of the most debated issues regarding the implementation of nuclear energy, since this waste can have serious environmental and health impacts. Nuclear waste is a by-product, or a secondary product of the nuclear reaction, being the material that nuclear fuel becomes after use. Owing to the fact that it is composed of the smallest nuclei, a product of fission, it is a highly toxic and dangerous substance.

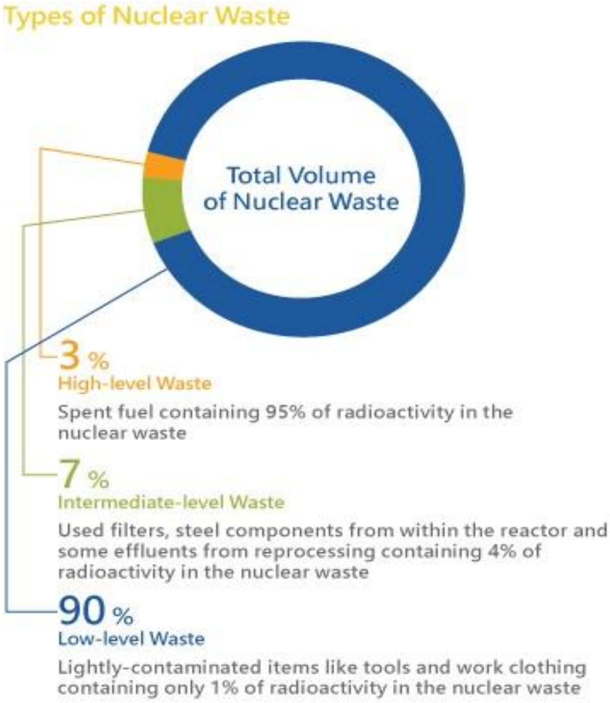


*Figure 4: Nuclear waste quantities*

It is classified into three types, according to its level of radioactivity - low, intermediate and high. 90% corresponds to the low level, with lightly contaminated objects containing only 1% of total radioactivity, such as tools or clothing. 3% of the waste is high-level and contains 95% of the total radioactivity; this is the waste that comes from nuclear fuel.

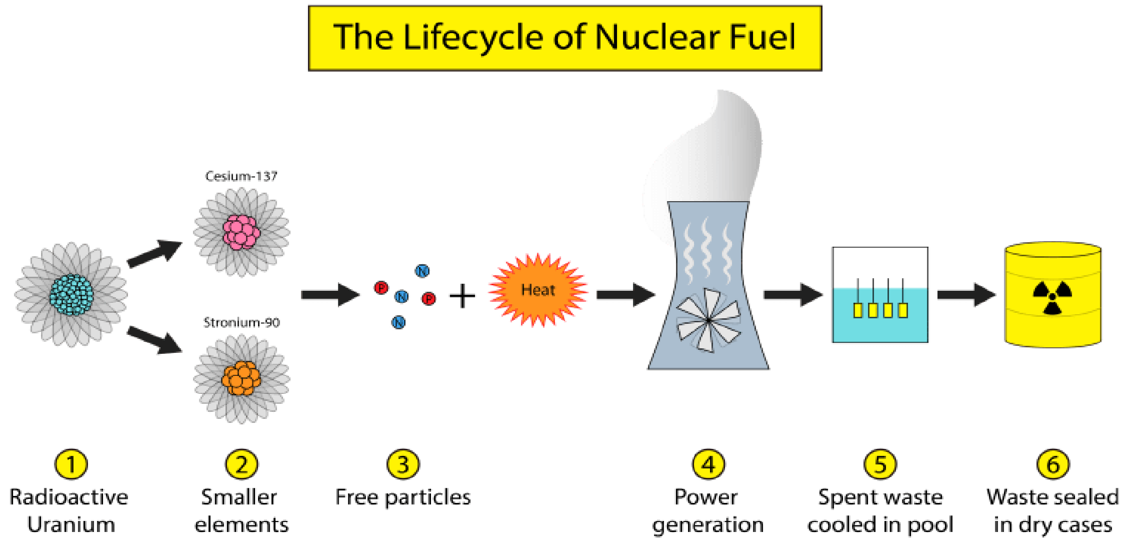


*Figure 5: Nuclear fuel's life cycle*

Some scientific communities affirm that nuclear waste is highly dangerous, since the toxicity and hazardousness of the radioisotopes remain for many years and continues to emit large amounts of radiation, causing permanent damage to health and the environment. Moreover, until now, the nuclear industry does not have an effective and long-term solution in the management of this waste, as the current storage pools are not safe enough, and as time goes by, the nuclear plants are left without space to store. What's more, reprocessing and recycling of nuclear fuel is not a solution, since it takes thousands of years for the levels of toxicity of the material to decrease. Security is also a concern, due to the possibility that some terrorist groups or simply malicious individuals may have access to these dangerous materials, which would undoubtedly pose a major threat. They say that a true long-term solution would require the safe management and final disposition of this waste for thousands of years.

On the other hand, the nuclear industry states that sufficient solutions for the management of nuclear waste already exist, therefore, it does not represent a danger to humanity or a problem for the implementation of nuclear energy. Firstly, they emphasize that the amount of waste produced is very small, and that it does not compare with the amount generated by other fossil energy sources, and that part of this amount is recycled over and over again. Secondly, it is argued that residual radioactive material does not represent such a threat to health due to the way it is used, and because radiation is already part of the planet and the environment.

Finally, within the solutions that the nuclear industry proposes, there is the recycling of nuclear fuel and direct disposal for the management of radioactive waste. Some countries use and recycle the same radioactive material for years, whereas others throw it away as waste in underground repositories; this second mechanism is used in Finland for instance.

### ii. Current Situation

Today, there are about 440 nuclear power reactors operating in more than thirty countries in the world, producing approximately 10% of the world's electricity. Also, many countries are currently building or have new atomic power plants in the planning stage, with 50 plants under construction. Additionally, there are other countries that depend partly on nuclear-generated power through regional transmission grids that supply their energy storage, as the nuclear industry is characterized by international commerce. A reactor under construction in any country may have components and supplies that have been provided by other countries.

In 2012 nuclear plants supplied 2346 TWh (Terawatt-hour) of electricity, then in 2017 it went up to 2503 TWh and in 2018 it was the sixth consecutive year that global nuclear generation increased - nuclear power plants supplied 2563 TWh of the world's electricity.

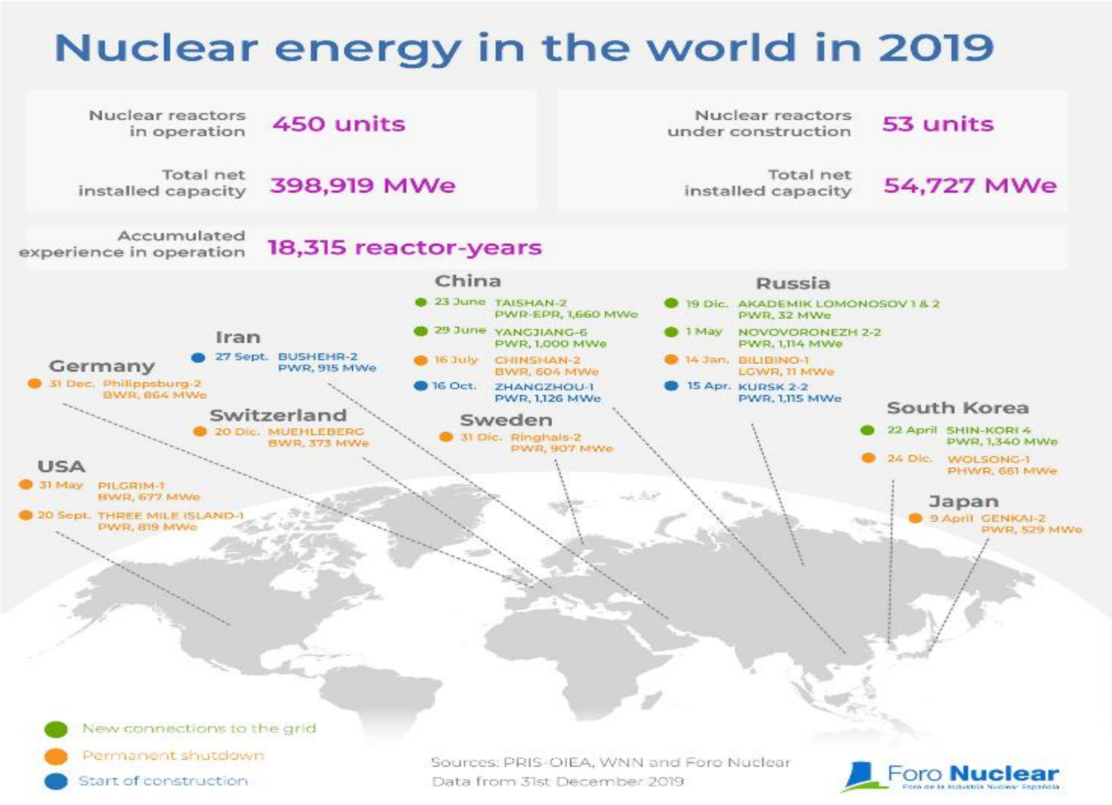


*Figure 6: Global view of nuclear energy 2019*

In 2018 twelve countries produced at least one-quarter of their electricity from atomic power. France gets approximately three-quarters of its electricity from nuclear energy. Hungary, Slovakia, and Ukraine get more than half of their energy from atomic power. Belgium, Sweden, Slovenia, Bulgaria, Switzerland, Finland, and the Czech Republic get one-third or more. South Korea gets more than 30% of its electrical supply from nuclear energy. The United States, United Kingdom, Romania, and Russia get one-fifth from atomic power. Japan used to get one-quarter of its energy supply from atomic power, they are expecting to return to that level again.

According to the report 'World Energy Outlook 2019' published by the OECD (Organization for Economic Co-operation and Development) International Energy Agency, by 2040 electricity generation from nuclear power plants will increase by almost 62%, representing 4409 TWh of electricity for the world's energy supply. However, the World Nuclear Association has proposed a more ambitious scenario in which nuclear power provides about 10.000 TWh of electricity. In this scenario, providing one-quarter of the world's electricity through atomic power will drastically reduce carbon dioxide emissions and will have positive effects on air quality.

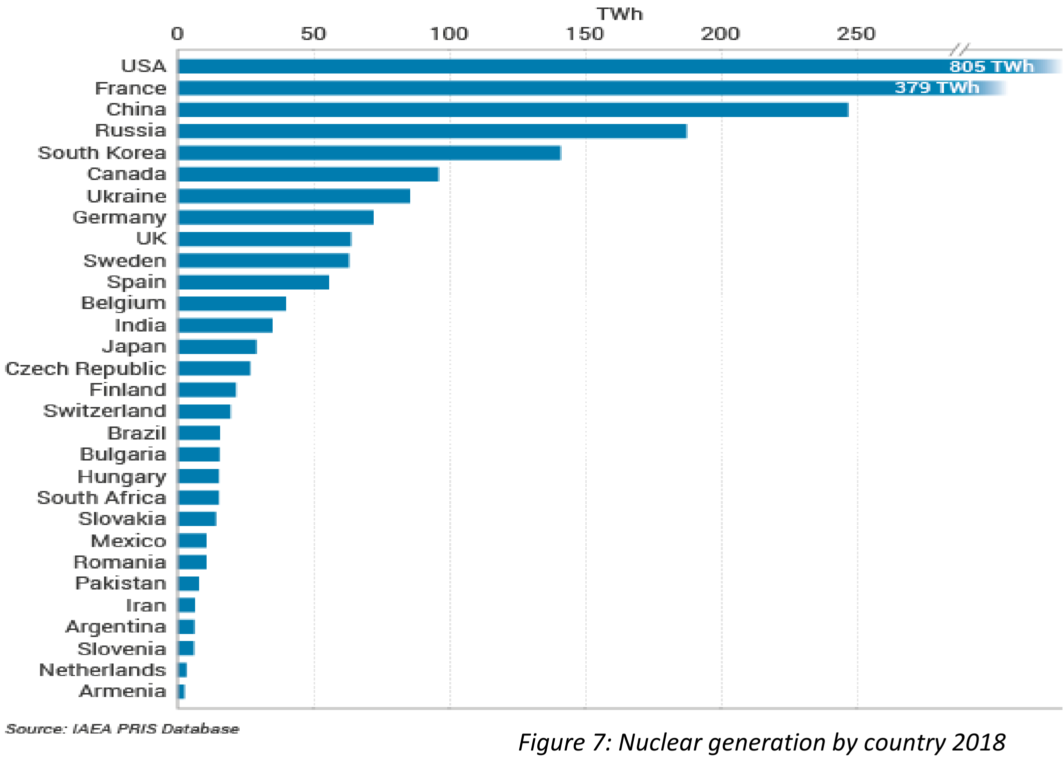


*Figure 7: Nuclear generation by country 2018*

## Anti-nuclear campaigns

Currently, most of the anti-nuclear movements in the world are from scientific communities and citizen campaigns. However, there are also some countries which maintain anti-nuclear policies whilst others, after suffering accidents in nuclear plants, have decided to either move towards the total elimination of all nuclear plants, to decrease the amount of plants, or to prohibit the construction of any more, only using those that are currently operating.

Countries like Australia, Austria, Denmark, Greece, Ireland, and Norway do not have nuclear plants; they have policies not to build them and atomic energy is not used to supply the country. Italy on the other hand, despite not having reactors, is one of the largest importers of nuclear energy in the world. While some countries continue to expand their nuclear capacity, others gradually decrease it such as Belgium, Germany, Spain, Netherlands, and Sweden, either by closing some of their plants or limiting the construction of new ones.

## The proliferation of nuclear weapons

As can be seen in the history of nuclear technologies, the origin of the atomic bomb and the generation of electricity from nuclear reactions are closely linked. In fact, the main motivation for atomic energy research was indeed military - to create the atomic bomb in the Second World War. Hence, one of the concerns about its implementation is that it may lead to an increase in the nuclear weapons capacity of some countries, since it facilitates access to raw materials and the technology and infrastructure necessary for their development.

Some countries have been accused of developing civilian nuclear energy for covert military purposes. This is due to various reasons. First, once plutonium is separated from fuel (for reuse, or any other use) it can be used as a highly suitable fissile material for atomic bombs; in 1962, a supplied atomic bomb was successfully detonated in the United States with plutonium originating from a civil-type reactor. Plutonium-producing reactors transmit electricity; in the 1990s, three Russian weapons-producing plutonium reactors were still being used to provide heat and energy to the population. In 1995, for instance, the Department of Energy (DOE) recommended the study of the use of civil reactors for the production of tritium (an isotope of Hydrogen that is very useful for hydrogen bombs).

Several countries such as India, Pakistan, Israel, South Africa, and North Korea are presumed to have increased their ability to develop nuclear weapons thanks to their nuclear power programme; the plutonium for the India nuclear bomb test in 1974 came from 40 MW civil thermal heavy water reactor (CIRUS).

The world's approximate production of plutonium from nuclear reactors is 70,000 kilograms, enough for making more than 10,000 nuclear warheads per year. At least 8 countries (Belgium, France, Germany, India, Japan, Russia, United Kingdom, and the United States) have separated around 200,000 kilograms of plutonium. Research and test reactors can also produce significant amounts of plutonium that, after chemical separation, can be used for making nuclear weapons.

Perhaps the main concern around this issue is that of materials. When nuclear facilities are available, it is much easier to have access to enriched uranium and plutonium, which are basically the main ingredients for atomic bombs. Furthermore, the democratization of knowledge and increase of expertise on nuclear reactions could lead to an increase in the proliferation of nuclear weapons, taking into account that the step between the latent development of this type of warfare to the active one can be very small.

Having said that, some scientific communities and representatives of the nuclear industry affirm that it is not possible to demonstrate that the increase in the production of electricity by nuclear energy contributes to the proliferation of dangerous nuclear weapons.

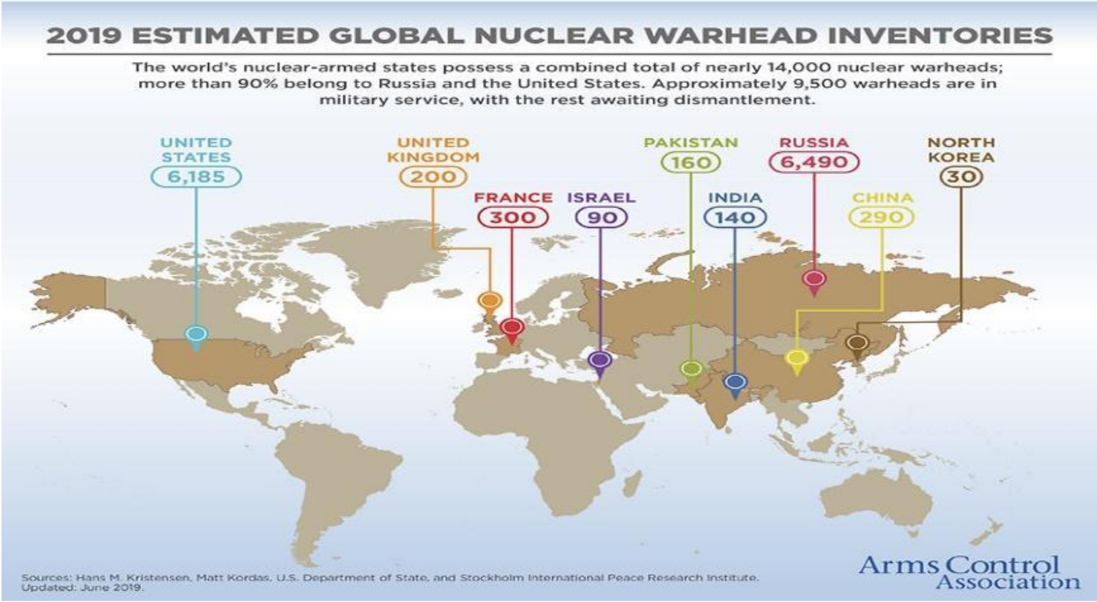


*Figure 8: Estimated global warhead inventories 2019*

<u>Advantages of nuclear energy</u>

Nuclear energy has a wide list of advantages, and it is considered to be 'sustainable'. It means that this type of energy is capable of fulfilling some requirements that permit correct development in an environmental, social, and economic way. In the environmental pillar, atomic power addresses issues that include climate change, land and water use, and ecosystem protection. In the social pillar, it contemplates issues regarding human health and employment. And in the economic pillar, it deals with resource adequacy, costs, and affordability.

The concentration of $CO_2$ emissions on a global scale increases climate change; three-quarters of carbon dioxide emissions result from the burning of fossil fuels for energy purposes. In order to reduce these levels, we must find technologies that emit small amounts of $CO_2$ per unit of energy. Nuclear energy emits about 12 grams of $CO_2$ equivalent per kWh (kilowatt-hour) of electricity produced, similar to that produced by wind energy. By reducing carbon emissions, nuclear power prevents natural phenomena such as eutrophication and acidification that affect the well-being of many ecosystems. The production of large amounts of low-carbon energy requires less land than other energy sources; a single two-unit nuclear power reactor provides energy for approximately 4 million people and has a generating two square kilometre footprint. Although atomic power requires a significant use of water, desalination processes for seawater, mineralized groundwater or urban water waste, can be used to solve this issue.

According to the World Health Organization, around 7 million people die prematurely each year due to air pollution exposure, much of which is produced by burning fossil fuels. Nuclear power plants don't emit any type of air pollutants during operation and, according to NASA's Goddard Institute for Space Studies and Columbia University's Earth Institute, the use of atomic energy prevented over 1.8 million deaths related to air pollution between 1971 and 2009. The operable life of nuclear power plants is about 60 years, which creates the opportunity of investing in human capital by offering long-lasting jobs for people in a wide range of fields and educational backgrounds. According to a study of the European Nuclear Industry, nuclear power provides more jobs per TWh of electricity generated than other renewable energies.

One concern is that uranium production and reserves is something only developed countries can afford. However, with all the uranium sources available in the world (in countries like Kazakhstan, Canada, Australia, Namibia, Niger, Russia, Uzbekistan, China, Ukraine, United States, India, South Africa, Iran, Pakistan, Czech Republic, Romania, Brazil, France, Germany, and Malawi) this should not be a problem.

Although nuclear energy is a fairly powerful and efficient source of energy, it has certain drawbacks and challenges that need to be addressed for its safe implementation. These challenges include the adequate management, transport, and disposal of nuclear waste. The production of nuclear energy should not imply a greater risk for health or the environment; this includes not only the process within the reactor, but the mining of uranium. Protection of material and technologies is also a fundamental aspect, to prevent access by terrorist groups, and the possible relationship between civilian nuclear power programs and the proliferation of nuclear weapons also needs to be taken into account.

The economic aspect could also represent a problem in the path of nuclear energy, firstly because it is a high-cost technology requiring high levels of investment, and secondly, because many oil economies in various countries of the world would be seriously affected.

### iii. Key points of the debate

- Positive and negative environmental implications of nuclear energy
- Economic consequences: the high cost of these technologies, oil-dependent economies and access for developing countries
- Radioactive material management
- Nuclear weapons proliferation
- Safety record of nuclear power plants

### iv. Participating Organisms

- United Nations Sustainable Development Group
- International Atomic Energy Agency (United Nations)

### v. Guiding Questions

1. To what extent does your country rely on nuclear energy, either as a provider, consumer or supplier of uranium for nuclear power plants?
2. In your country what environmental implications have there been, or could there be from the implementation of nuclear energy?
3. If your country has a nuclear energy programme, does it plan to continue investing in nuclear power plants?
4. If your country does not have nuclear power plants, is it considering implementing this technology? Why or why not?
5. Has your country used or plans for its nuclear energy resources and knowledge to develop atomic weapon research? If not, does your country consider that its implementation would contribute to the development of this weaponry?
6. What economic consequences would your country have to face if it sets nuclear power as its primary energy source?
7. What regulations need to be put into place with respect to the mining process of uranium, the acquiring of plutonium and the operation of an atomic power plant? Should any country be allowed to use this technology?

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# 4. Topic 2: *Stem cell research and its implications*

## i. History/Context

Types of stem cells

All living things are made up of cells which have different functions in the body.  Cells can reproduce and join together in multicellular blocks to form organisms such as the human body.

Stem cells are defined as undifferentiated cells in a multicellular organism that can differentiate into more specialized cell types. This means that they are cells which do not have specific functions, but can change (differentiate) into specialized cells, for example, into nerve cells.  They are classified into 5 types, some of which can differentiate into only one type of cell (unipotent) and others which can differentiate into any type of cell (totipotent).  In between there are pleuripotent, oligopotent and multipotent cells.

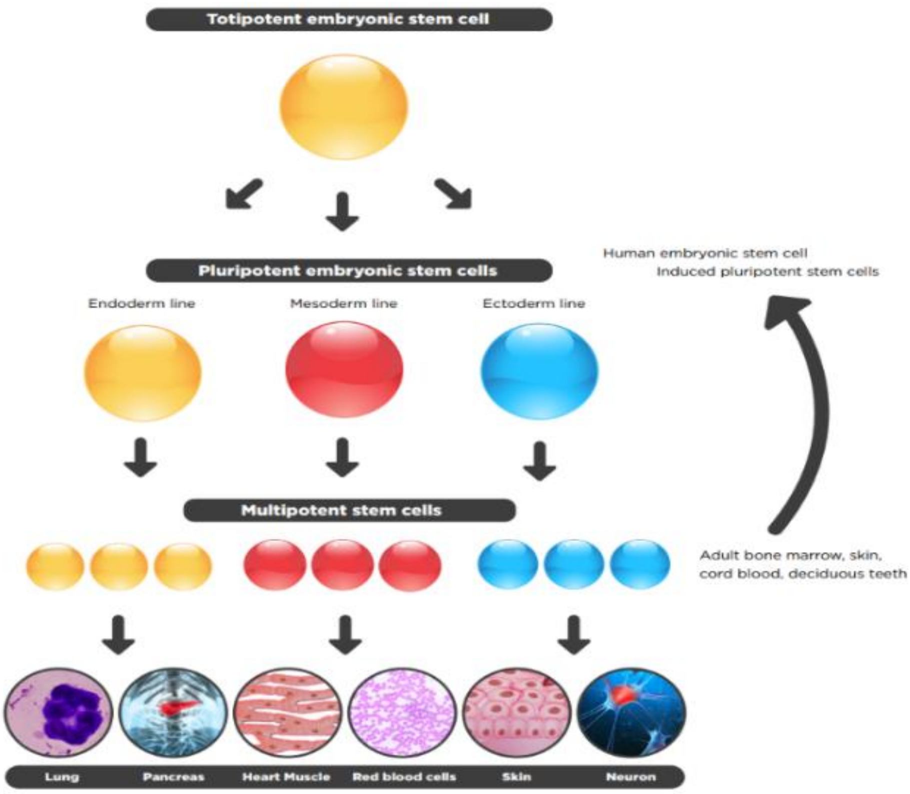


*Figure 9: Stem cell development process*

Stem cells also have a self-renewable capacity, meaning they can regenerate more cells of the same type indefinitely. There are stem cells in both embryos (ESC) and adults (ASC), and there are also adult stem cells that have been reprogrammed in the laboratory to act like embryo stem cells (iPSC).

## Discovery of stem cells

The concept of stem cells was first used by the German biologist Ernst Haeckel in 1868. He described the fertilized egg as the cell of origin of all the other cells of a human-animal or organism. Later scientists did further research into stem cells,

although the main focus was actually the chromosomes in DNA. Finally, the definition of stem cells was established as being cells with a self-renewal and differentiation capacity to turn into specific types of body cells.

In haematology, there was also great interest in stem cell research. In 1896 Artur Pappenheim called the common precursor cell of red and white blood cells "stem cells". He also discussed the phenomenon of cell differentiation, which is the process by which cells change from one cell type to a more specialized one. Later, different researchers concluded that all blood cells have a common stem cell. There was little agreement at first as to where and how stem cells were formed in the body.

The anatomist and biologist Ross Granville Harrison investigated for the first time the growth of nerve fibres from isolated neuroblasts (embryonic cells extracted from the embryo, that give rise to nervous tissue). This embryonic tissue stayed alive for about a week or more under those conditions, and Harrison observed that neuroblasts were capable of growing nerve fibres into their environment. In other experiments, he saw that with tissues of other parts of the embryo, embryonic cells started to differentiate in a specific way under the same experimental conditions (for example, into epidermis cells or muscle fibres). His research served as the beginning of the tissue culture method, which gave a wide list of possibilities for the study of tissue growth and differentiation.

## Stem cells and tumours

Julius Cohnheim explained that tumours come from displaced residual embryonic cells which, by receiving enough blood and owing to their embryonic capacity, can start to grow uncontrollably to form tumours and cancers. Cohnheim defined tumours as "atypical tissue neoplasms", neoplasms being abnormal masses of tissue. A lot of research was done into how tumours were formed, especially after World War II, when cases of tumours increased significantly. Mice were used to conduct experiments on cancer, and this eventually led to the theory that cancer was connected to stem cell reproduction.

In 1975, Beatrice Mintz and Karl Illmensee discovered that the malignancy of some tumour cells could be reversible. Then, in 1981 Martin Evans, Matthew H. Kaufman, and Gail Martin were able to isolate stem cells from mice embryos, producing the first pillars of modern embryonic stem cell research. In 1998, the groups of John Gearhart and James Thomson reported that they had been capable of isolating and culturing human embryonic stem cells, which they got from aborted embryos (Gearhart) and from supernumerary embryos which are left-over embryos resulting from in vitro fertilization (Thomson). In vitro fertilization is used when a person has fertility problems. It is the process of taking many eggs from the womb and fertilizing them in the laboratory. Some of the fertilized eggs are then put back into the womb; the rest may be frozen, donated to other people with fertility problems, or disposed of.

Stem cells as therapeutic agents

In 1956 in New York, the first bone marrow transplant was performed as a treatment for leukaemia by Dr. E Donnal Thomas, the donor was the twin brother of the patient, in 1968, it was performed again with a non-twin donor by Robert A. Good of the University of Minnesota and in 1973 with unrelated patients. This event gave way to the conception of stem cells as a regenerative medicine treatment. In 1978 the presence of stem cells in the human umbilical cord was discovered.

In 1981, two scientists, Martin Evans of the University of Cambridge and Gail Martin of the University of California, San Francisco, conducted research and successfully separated pluripotent stem cells from mouse embryos, thereby isolating the first embryonic stem cells. In 1986 Andrew Lassar and Harold Weintraub of Seattle, Washington conducted a fundamental experiment for regenerative medicine, in which they converted fibroblasts, which are a type of connective tissue, into myoblasts that generate muscle cells, managing to convert one type of cell to another. Dominique Bonnet and John Dick of Canada discovered in 1997 that leukaemia comes from the same stem cells that make our blood cells, supporting the idea of "cancer stem cells."

In 2006, Japanese scientists Shinya Yamanaka and Kazutoshi created the first induced pluripotent stem cells (iPSC), which are adult cells reprogrammed to behave like embryonic stem cells. In 2007, three independent teams in Japan, Wisconsin, and Boston, led by Shinya Yamanaka, James Thomson, and George Q. Daley created a human induced pluripotent stem cell. From there, regenerative medicine has been used as a means to treat different illnesses, although it is accompanied by strong controversy and great detractors.

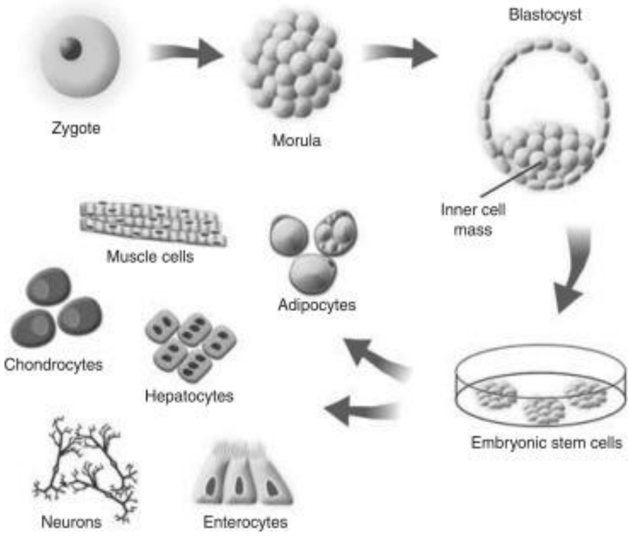


*Figure 10: Embryonic stem cell production*

Embryonic Stem Cells (ESC)

In human organisms an embryo is defined as the stage from the implantation in the uterus until the end of the second month of gestation. However Embryonic Stem Cells refers to a much stricter period of time, as they result from the isolation and cultivation of cells from the blastocyst, which is the structure formed in the early development of mammals, approximately 5 days after fertilization. Stem cell cultures are stem cells that have been grown in the laboratory.

Stem cell cultures are established in the process of development of the zygote, which is a cell resulting from the fertilization of an oocyte by a spermatozoon. The zygote is made up of totipotent stem cells, which can differentiate into any type of cell. Successive cell divisions of the zygote generate the morula, which has 32-64 totipotent cells. The morula develops into a blastocyst; its peripheral cells generate the embryonic membranes and placenta, and the inner cell mass develops into the foetus. However, these stem cell cultures are not totipotent, because they can't support the formation of another embryo, so they are considered to be pluripotent, due to their ability to produce all the cell types of the adult organism.

This type of procedure is complicated due to the strict conditions that undifferentiated cells need for their survival. This is an important factor for human ESCs; once they are established, they need to be maintained in permanent culture, frozen and transported between laboratories. It is important to mention that the process of establishing an ESC line requires the destruction of the blastocyst, although there is an alternative that involves the production of ESCs by collecting only one cell from the inner cell mass (which develops into the foetus) so that the remaining cells can be implanted in the womb.

Embryonic Stem Cells have defined characteristics: They are pluripotent, which means they have the capacity to differentiate into cells derived from the three germ layers (endoderm, ectoderm and mesoderm layers); in the culture, they are immortal (due to their high levels of telomerase) and can be easily maintained during the undifferentiated state, and they have a normal chromosomal composition (chromosomes contain the genetic material of a cell).

Adult Stem Cells ASCs

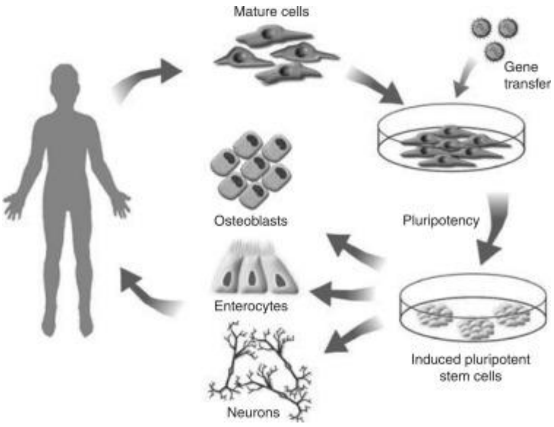


*Figure 11: ASCs extraction process*

Adult, or somatic, stem cells are the cells responsible for replacing the damaged cells of an organ, whether it is the product of physiological processes such as wear and tear or of any pathology. They have a limited capacity for self-regeneration and differentiation.

Due to the fact that all tissues have been shown to have their own compartment of adult stem cells, the following types are classified: Hematopoietic Stem Cells (Blood Stem Cells); Mesenchymal Stem Cells, which differentiate in skeletal tissue; Neural Stem Cells, that generate all types of cells of the nervous system; Epithelial Stem Cells, make up the surfaces and linings of the body; and the Skin Stem Cells.

Adult stem cells are renewed in the long term, generating specialized mature cells. From the stem cell, a first daughter cell is derived, which is known as a precursor or progenitor cell. This precursor cell can replicate and reproduce, giving rise to differentiated mature cells.

Induced pluripotent stem cells (iPS cells)

Induced pluripotent stem cells are created by putting embryonic genes into a somatic cell, which is any cell of the body except the sperm and egg cells. This causes the somatic cell to start a 'dedifferentiation' process, turning them back into a pluripotent stage, similar to an Embryonic Stem Cell. Induced pluripotent stem cells are identical to natural pluripotent ESCs in many ways.

Behaviour of Stem Cells

The behaviour of stem cells is directly related to the interaction between these cells and their microenvironment or "niche". Some cells can regenerate to form new tissue after loss or damage.  In order to optimally develop regenerative activity, a "regenerative niche" must be present at the site of injury. Adult stem cells are renewed in the long term, generating specialized mature cells.

The therapeutic property of stem cells is to restore or replace tissues that have been damaged by disease or injury; the use of ASCs avoids the ethical concerns associated with the use of ESCs, and also avoids other problems associated with their clinical use, such as spontaneous differentiation, which carries the risk of teratoma, or tumour, formation.

Therapeutic cloning

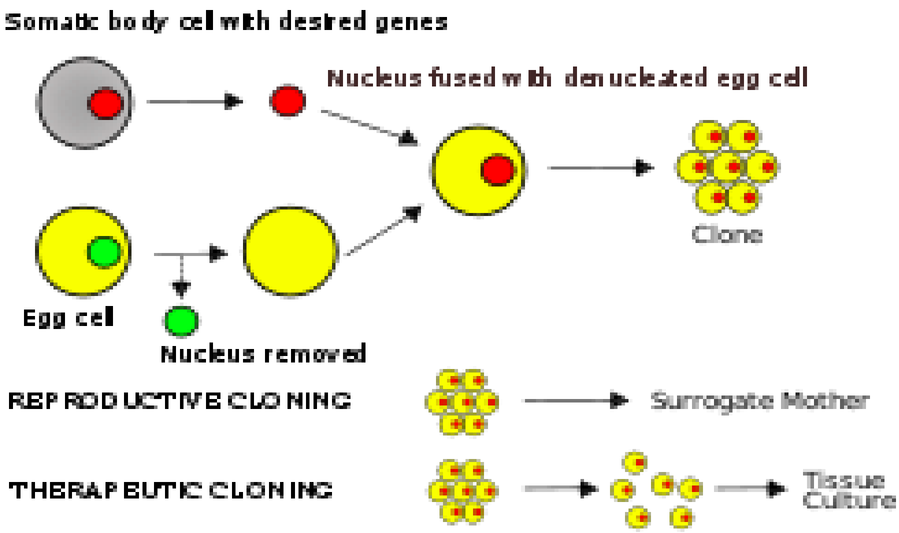


*Figure 12: Reproductive and therapeutic cloning processes*

Therapeutic cloning refers to a process called Somatic Cell Nuclear Transfer (SCNT) which produces identical cells to the somatic cells (clones). It consists of removing the nucleus of an egg cell, which has not been fertilized by sperm, to replace it with the material from the nucleus of a patient´s somatic cell. This causes the egg cell to become a stem cell, which needs to be stimulated in order for it to start dividing. Once the division process starts, about 5 to 6 days later, stem cells can be extracted, just as if they had been extracted from embryos through in vitro fertilization. The benefit of producing this type of stem cells is that they are an exact genetic match for the patient, which means the patient’s body does not reject these cells after transplantation.

Therapeutic cloning does not differ from reproductive cloning, which is the process of creating an organism genetically identical to its donor through SCNT, with the difference that the “cloned” cells do not become a living organism. Since both processes require the in vitro generation of a human embryo, legislation that prohibits reproductive cloning could directly affect scientific advances related to therapeutic cloning.

### ii. Current Situation

Stem cell research nowadays

Stem cells are crucial to an organism's creation and development. Some adult tissues (e.g. bone marrow, muscle, and brain) contain discrete populations of adult stem cells which produce replacements for cells that are lost due to conventional replacement, injury, or disease. These regenerative properties mean that stem cells could be used in therapy for diseases such as diabetes and heart disease. However, the way to use these cells for cell-based therapy to treat diseases (regenerative medicine) remains completely unsolved and requires more research and experimentation.

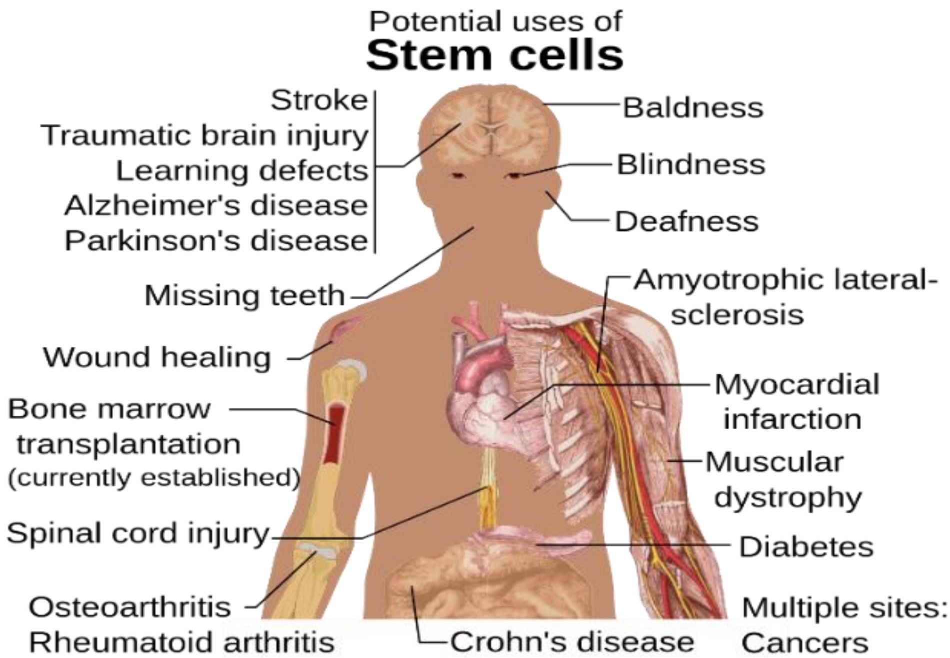


*Figure 13: Stem cells potential uses*

Laboratory studies in stem cells allow scientists and researchers to learn about their properties and to find out what makes them different from specialized cells. This knowledge is being used to develop new drugs, to study normal growth and to identify the causes of birth defects.

Adult bone marrow or peripheral blood stem cells have been used for clinical therapies in blood disorders such as leukaemia and lymphoma for many years. Adult stem cells, harvested from hair follicles and grown in culture, are used in skin replacement therapies by producing skin grafts, where skin is removed from one part of the body to another. Neural stem cells have been used for treatment of neuronal damage and diseases.

There is potential for a wide list of diseases to be treated with stem cell therapy including diabetes, spinal cord injury, muscular dystrophy, heart disease, and vision/hearing loss. Scientific researchers are investigating how stem cells work, and how they can be programmed to differentiate into certain types of cells for therapy.

Advantages

Stem cell research and regenerative medicine hold great promise in treating different diseases that science has been unable to find a cure or treatment for. They help to repair or restore tissue damaged by wounds, such as burns and damage to the spinal cord. They are also used in: the treatment of diseases such as Parkinson's and Alzheimer's and other neuronal injuries; different types of cancer treatments; cardiovascular diseases; replacing or repairing damaged organs and decreasing the risk of transplant rejection.

Apart from all the benefits as a clinical treatment, stem cell research offers numerous opportunities at a scientific and research level. First of all, knowing more about cell development, and how stem cells differentiate into other cell types, could lead scientists to learn more about how to treat, prevent, or cure certain ailments. Similarly, further development of stem cell research allows areas of embryonic treatment and genetic defects to be explored. The stage of pregnancy is when many birth defects or other potential issues begin and, thus, could be treated and identified. In addition, another potential use of stem cell research is pharmaceutical, since drug testing can be performed, thus avoiding drug testing on humans and animals.

There are different benefits to be gained from the three types of stem cells - adult, embryonic, and induced pluripotent. The benefits of ASC are evident and have already been demonstrated, with procedures such as bone marrow transplantation, among others. Furthermore, they significantly reduce the risk of rejection and incompatibility and eliminate the ethical and social dilemma that accompanies embryonic stem cells. For their part, ESTs offer other advantages, the most important being that they are pluripotent, that is, they can differentiate into almost all cell types, (unlike ASTs which are multipotent), allowing them to contribute to the treatment of many more diseases. They also have important scientific benefits as their research contributes to our knowledge of development processes. The IPSCs eliminate the incompatibility problem, contribute to pharmaceutical development and drug testing, and allow us to acquire knowledge in cell reprogramming to repair cells or tissue.

Disadvantages

As any conventional investigation, stem cell research has a series of economic, social, ethical, and scientific implications. Economic implications refer to the technology's cost and affordability; normally, medical treatments, when first made available to people, are very expensive, but as these technologies start to be used on bigger scales, the costs go down. For example, when bone marrow transplantation was done for the first time, it was extremely expensive, but a few decades later bone marrow transplantation became something conventional and affordable to everyone for the treatment of numerous diseases. However, the main concern regarding the costs of new stem cell technologies is their administration, due to the fact that in many cases the major advances of clinical research are focused on controlling diseases and not curing them, which makes health-care services extremely high in certain countries.

There is a social and ethical controversy regarding stem cell research because of the way in which stem cells are obtained. When isolating human embryonic stem cells, the embryo in its blastocyst stage is destroyed, raising an ethical issue, as scientific investigation and arguments alone do not determine if blastocysts should be considered as human beings. Religious and moral considerations have been the centre of many countries' positions regarding stem cell research, as in many cases it requires the creation of embryos in order to destroy them to isolate stem cells.

The scientific disadvantages of stem cell research are the complications in reproducing stem cells in a laboratory and triggering the differentiation mechanism for them to become the desired type of cell. There is a possibility they could overgrow, as happens with cancer tumours, and the combination of stem cells in the patient's body may cause an immune rejection. In some cases, the use of stem cells for therapeutic purposes in cancer treatment is difficult, as the stem cells themselves could actually raise cancer cells.

Moreover, each type of stem cell (ASC, ESC, and iPSC) has disadvantages for its use. ASC's negative aspects include: their limitations to differentiate are unknown, they are presumed to be multipotent or unipotent; growth time in culture is very short; very difficult to find them in the organism for their extraction; and, there isn't any technology to mass-produce them in culture. ESC disadvantages are: generation of ESC lines is inefficient; lack of enough research to know if they can be rejected in transplants; and, if used directly from the ESC culture for tissue transplants, they may cause tumours or cancer development. iPSC drawbacks are: methods for maintenance of iPSC are uncertain, their potential is presumed to be not as high as ESC, and some viruses used to introduce embryonic genes may cause cancer (as seen in mouse studies).

## Global overview

The rise in interest in developing stem cell research, along with all the controversy that comes with it, has caused governments to make their own regulations and policies. The International Society for Stem Cell Research has produced guidelines regarding stem cell research which governments may follow, keeping in mind all cultural, political, legal, and ethical perspectives related to the topic, and also the recommendations made by the United Nations in 2005 to ban stem cell research for reproductive cloning purposes.

Countries such as Japan, Singapore, China, South Korea, India, South Africa, United Kingdom, Switzerland, Brazil, Belgium, France, Germany, Italy, Sweden, Israel, Canada, United States, and Mexico, permit stem cell research for therapeutic purposes. However, many of them need to import stem cells, as they prohibit the creation of their own embryos for research. They also ban the use of stem cells for reproductive cloning processes.

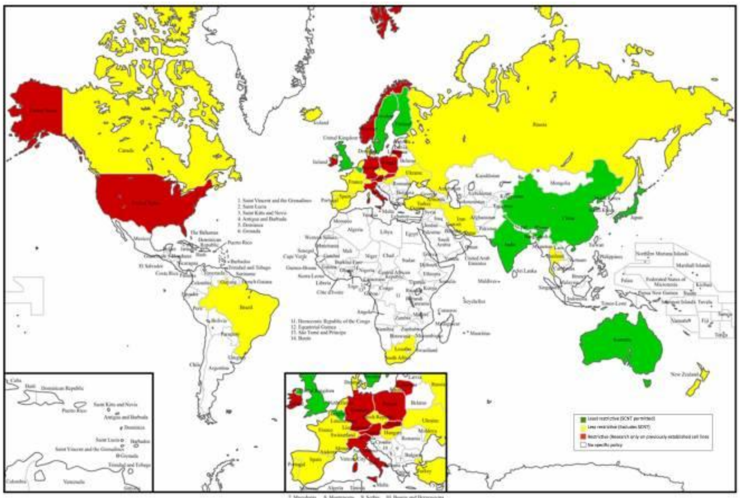

*Figure 14: World map based on the level of restrictions for each country*

In 2005, the UN declared human cloning to be "incompatible with human dignity and protection of life" after the signing of the United Nations Declaration on Human Cloning, which stipulated that all types of cloning (reproductive and therapeutic) were prohibited. The Assembly adopted the text by a vote of 84 in favour of 34 against, with 37 abstentions. Although this document is considered as a recommendation to member countries, it is not legally binding.

The document established that "Member States were also called on to protect adequately human life in the application of life sciences; to prohibit the application of genetic engineering techniques that may be contrary to human dignity; to prevent the exploitation of women in the application of life sciences, and to adopt and implement national legislation in that connection. " Several delegations affirmed that they voted against the recommendations because the document called for the prohibition of all kinds of cloning, including therapeutic ones.

### iii. Key points of the debate

- Scientific, therapeutic, and social implications of stem cell research
- Cost and effectiveness of stem cell therapy compared with traditional treatments
- Ethical and cultural concerns
- Biological consequences of stem cell therapy due to a lack of scientific knowledge with respect to cancer-causing gene mutations
- Reproductive cloning as a consequence of stem cell research for therapeutic purposes
- International policy frameworks to regulate stem cell research
- Economical access to stem cell research for developing countries

### iv. Participating Organisms

- United Nations Sustainable Development Group
- International Society for Stem Cell Research

### v. Guiding Questions

1. Does your country have stem cell research programmes? If so, what ethical and cultural implications are there?
2. If your country does stem cell research, what type of stem cells are used in experimentation? Are they produced in the country, or are they imported?
3. If your country doesn't have a stem cell research programme, what are the reasons for this? (for example, cultural, ideological, economic considerations)
4. What are your nation’s policies, if any, regarding stem cell research for therapeutic purposes?
5. Is reproductive cloning banned in your country? If so, is cloning allowed for therapeutic purposes, and what policies are there to regulate therapeutic cloning?
6. Was your country in favour, against, or in abstention when voting the United Nations Declaration on Human Cloning? Why?

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