



NUCLEAR science

Nuclear science is an exciting and dynamic field of study! In just 50 years, scientists around the world progressed from discovering X-rays and identifying the components of atoms, to testing and producing destructive atomic bombs.

In the next ten years they demonstrated the use of nuclear energy to generate electricity and even to propel a submarine, the USS Nautilus being the first.

With the power of nuclear becoming increasingly apparent, politicians and civilians became involved in the next four years in directing this energy towards peaceful means.

The foundation was laid for the nuclear agreements, regulations, safeguards and treaties which today govern all nuclear-related matters and ensure the safety of citizens throughout the world.

FEAR of the unknown

We are all afraid of things and situations which we do not understand! In fact, everyone is afraid of ionising radiation, except those who understand and work with it. Knowledge is the only thing that frees us from fear, allowing us to know what is safe, what is unsafe, and how to work safely.

IT ALL comes down to atoms.

Atoms (composed of protons and neutrons in the nucleus and electrons moving outside the nucleus) are the basic building blocks of everything we know. Both chemistry (the study of the interactions between atoms) and nuclear physics (the study of the interactions of sub-atomic particles) are therefore very important research fields. The application of the knowledge generated by this research flows into many fields of science, technology, engineering and medicine.

NUCLEAR APPLICATIONS in everyday life

The following are just some of the many applications resulting from nuclear research:

- Nuclear energy electricity and propulsion
- Nuclear medicine diagnostics and treatment
- Radiation sterilisation of medical instruments and supplies
- Insect eradication the release of insects sterilised by irradiation
- Industrial applications detection of leaks and defects in closed systems
- Domestic applications smoke detectors and self-luminous safety signs

BECOMING INVOLVED in the exciting nuclear science world

If you wish to follow a career in nuclear science you need to:

- Study maths and science at school level
- Obtain a science degree at tertiary level, or
- Obtain an engineering degree at tertiary level, or
- · Obtain a medical degree at tertiary level, or
- Obtain a technical diploma at an FET college









NUCLEAR MILESTONES at a glance

1895-1899 Ernest Rutherford discovers alpha and beta 1895 Wilhelm Roentgen discovers X-Rays 1905 Albert Einstein relates mass to energy in the famous formula E=mc² 1919 Rutherford discovers that alpha particles ionise hydrogen gas 1930 Sir Arthur Eddington's *The Internal Constitution of the* Stars is published, which systematically addresses the problem of where the energy, radiated from stars, originated, concluding that the only process that explains the high amounts of energy released and the long lives of stars is one in which lighter constituents build up heavier nuclei - fusion 1939 Albert Einstein writes a letter to US President Roosevelt which discusses German nuclear research and the possibility of building an atomic bomb 1942 The US Manhattan Project begins 1945 Los Alamos becomes the site for an atomic laboratory 1945 The first atomic bomb is tested by the US at Alamogordo, New Mexico 1945 An atomic bomb, Fat Man, is dropped on Nagasaki, Japan (9 August). The 10,000 pound plutonium bomb, dropped on the site of a Mitsubishi torpedo manufacturing plant, kills 40,000 people and injures 60,000. Japan surrenders on 14 August 1946 The US tests an atomic bomb underwater at Bikini Atoll 1946 The US Oak Ridge facility ships the first nuclear reactor-produced radioisotopes for civilian use to the Barnard Cancer Hospital in St. Louis 1949 The Soviet Union detonates its first atomic device 1951 First usable electricity from nuclear fission is produced at US Experimental Breeder Reactor 1 (EBR-I) 1952 US explodes first fusion device at Eniwetok 1954 USS Nautilus, the first nuclear submarine, is launched 1954 The US Atomic Energy Act of 1954 is passed to promote the peaceful use of nuclear energy through private enterprise and to implement President Eisenhower's 'Atoms for Peace' Programme 1957 An electron-beam is used for fabrication of safer nuclear fuel rods 1961 US, UK, and USSR observe an informal suspension on nuclear tests

1963 Limited Test Ban Treaty signed by US and Soviet Union,

prohibiting underwater, atmospheric, and outer space nuclear tests (More than 100 countries, including

South Africa, have subsequently ratified this treaty)

- $1897\,$ Becquerel and Marie Curie discover radioactivity
- 1898 Marie and Pierre Curie isolate the two new chemical elements polonium and radium
- 1908 Rutherford discovers that alpha particles are helium nuclei and beta particles are electrons
- 1929 Nuclear fusion is first investigated in a theoretical paper by Atkinson & Houtermans
- 1932 James Chadwick discovers the neutron as a product when beryllium is bombarded by alpha particles
- 1934 Fermi bombards heavier elements with neutrons in order to produce trans-uranium elements
- 1938 Otto Hahn and Fritz Strassman, two German scientists, and Lise Meitner, demonstrate nuclear fission. Meitner's name is not mentioned on their seminal paper, since she was a woman and a Jew fleeing Nazi persecution
- 1944 The first reactor begins operation in Richland, Washington, US
- 1945 Fermi demonstrates nuclear chain reaction at the University of Chicago; soon many top-secret nuclear research/production facilities are built for the Manhattan Project
- 1945 An atomic bomb, *Little Boy*, is dropped on Hiroshima, Japan, by the US B-29 bomber, Enola Gay. The 9,700 pound uranium bomb destroys everything within five square miles, kills 70,000 people and wounds another 70,000
- 1946 The Atomic Energy Act establishes the Atomic Energy Commission in the US, placing further development of nuclear technology under civilian control
- 1948 The US does atomic tests at Eniwetok Atoll
- 1948 South Africa establishes the Atomic Energy Board
- 1952 First British atomic detonation at Monte Bello Islands, Australia
- 1953 Eisenhower proposes "Atoms for Peace" programme to UN General Assembly, to develop peaceful applications for nuclear energy through international collaboration
- 1954 The first hydrogen bomb (H-bomb), Castle Bravo, is tested
- $1955\,$ Arco, Idaho becomes first US town to use electricity from a nuclear reactor
- 1957 The International Atomic Energy Agency (IAEA) is formed to promote the peaceful use of nuclear energy and provide international safeguards and an inspection system to ensure nuclear materials are not diverted for military purposes
- 1960 France conducts first nuclear test in the Sahara desert
- 1962 First surface ship sails on nuclear energy
- 1964 China (PRC) tests first nuclear bomb
- 1965 South Africa commissions its research reactor, SAFARI-1

1967 Outer Space Treaty bans nuclear weapons from being placed in orbit	1967 Treaty of Tlatelolco signed to keep Latin America and the Caribbean free of nuclear weapons
1968 Nuclear Non-proliferation Treaty (NPT) calls for a halt to the spread of nuclear weapons capabilities.	1972 The CAT scan is developed combining many high-definition, cross-sectional x-rays to produce a two dimensional image of a patient's anatomy
1972 Strategic Arms Limitation Treaty (SALT I) signed by Nixon and Brezhnev in Moscow	1974 India detonates a low-yield device under the Rajasthan desert
1978 South Africa commences with the production of Highly Enriched Uranium (HEU)	1978 The United States stops development of the neutron bomb
1980 The Low-Level Radioactive Waste Policy Act is passed in the US, making states responsible for the disposal of their own low-level nuclear waste from hospitals and	1979 Three Mile Island Nuclear Power plant near Harrisburg, Pennsylvania experiences a partial core meltdown (minimal radioactive material is released)
industry	1982 Strategic Arms Reduction Talks (START) begin in Geneva
1982 South Africa passes the Nuclear Energy Act of 1982 making the Atomic Energy Corporation (AEC) responsible for all nuclear matters including enrichment	1985 Lead-iron phosphate glass is invented creating a more durable containment medium for storing nuclear waste
1986 South Africa's low and intermediate level radioactive waste disposal facility at Vaalputs begins operations with operating licence from the National Nuclear Regulator	1986 Chernobyl Nuclear Reactor meltdown and fire occur in the Soviet Union releasing radioactive material
1987 The hot cell complex comes on line at Pelindaba	1986 Tests at EBR-II demonstrate the inherent safety of the Integral Fast Reactor concept
1989 One-hundred and eleven commercial reactors are operating in the US	1989 The US DOE shifts focus from nuclear materials production to one of environmental cleanup
1991 The US and Soviet Union agree to cut back on long-range nuclear weapons by 30% over next seven years	1991 The START treaty is signed, reducing the amount of nuclear arms
1991 South Africa signs a safeguards agreement with the IAEA	1991 South Africa signs the Nuclear Non-Proliferation Treaty, becoming the only country in the world to have developed
1995 178 nations renew the Non-Proliferation Treaty	nuclear weapons and then voluntarily dismantled them
1996 French President Chirac announces an end to French nuclear tests	1995 The US announces a total ban on all US nuclear weapon testing 1996 A multilateral agreement, the Pelindaba Treaty, is signed by
1996 United Nations approves the Comprehensive Test Ban Treaty (CTBT)	49 of the 53 members of the Organisation of African Unity, creating a Nuclear Free Zone throughout Africa
1998 France's National Assembly votes unanimously to ratify the CTBT	—
1998 Pakistan tests six nuclear devices	1998 India tests five more nuclear devices
2010 Necsa and its subsidiary NTP won a USD 25 million awar from the US Department of Energy's National Nuclear Security Administration (NNSA), having demonstrated South Africa's successful implemention of the world's first large scale production of the medical isotope moly denum-99 (Mo-99), using Low Enriched Uranium (LEU	country's international commitments. The South African Nuclear Energy Corporation (Necsa) is a state corporation established from the AEC under the Act.

NEED TO KNOW MORE?

1 +27 12 305 5761 F +27 12 305 5751 E communication@necsa.co.za

