Source: http://www.viaradiology.com/news/articles/4-radiation-myths-and-facts

Myth: There is no safe dose of radiation.

Fact: We are continuously exposed to different forms of radiation every day, including when we breathe air or eat food. Small amounts of radiation in medication, electricity generation and many other applications has extended and saved many lives. According to studies done by the United Nations Scientific Committee, the risk associated with low-dose radiation from natural and man-made sources is extremely small.

Myth: X-Rays can cause radiation side effects

Fact: The small level of radiation that a patient is exposed to during X-Rays, MRIs and other radiology scans is not dangerous to their long-term health and will not cause side effects such as headaches. When imaging equipment is used properly by highly trained radiologists, the radiation levels are low and targeted to only one area of the body.

Myth: Radiation from nuclear plants makes you sick and causes cancer.

Fact: Nuclear power plants emit extremely small amounts of radiation and pose no threat to the public or the environment. After more than 50 years of radiological monitoring and medical research, there has been no evidence suggesting that radiation from nuclear plants has negative health effects on the public.

Source: http://www.hiroshimasyndrome.com/the-nuclear-isn-t-natural-myth.html

The Nuclear-Isn't-Natural Myth

A subtle but significant misconception is that **solar energy** is not **nuclear energy**. The reality is quite different. All stars, including our Sun, produce their energy from fusing the nuclei of smaller atoms together to make the nuclei of larger atoms. Our Sun is a middle-aged star, so nearly all of the energy produced comes from the fusing of Hydrogen nuclei together and making Helium nuclei. Some Helium-Hydrogen fusion occurs, as well as Helium-Helium fusion, but both are but a very tiny fraction of the total fusions in our Sun.

When fusion occurs, a minute fraction of the atomic masses of the two nuclei being fused is annihilated into pure energy, as demonstrated by Einstein's famous formula $E=MC^2$. It actually takes some thousands of years for this energy to migrate out from the core of our sun to the surface and be released into space. More than 99% of the released energy from the Sun is a weak form of gamma radiation, or what we more commonly call sunlight. This makes all sunlight nothing less than nuclear by-product material. Solar energy is actually nuclear by-product energy.

Wind energy is formed by the uneven heating of our atmosphere by solar radiation. Thus, wind energy may be correctly understood to be an indirect result of solar nuclear by-product material. In fact, all weather on our planet owes it's existence to solar nuclear by-product material. Even fossil fuels can be understood as solar nuclear by-product material which has been stored for millions of years in decay-transformed plant chemistry (coal and oil). Literally, all forms of energy we have at our disposal are the result of the energy made in the natural **nuclear reaction**s of our Sun.

One other common misunderstanding concerns the existence of radioactive elements we find everywhere in our world, breathe into our bodies with every breath, and eat in our foods with every meal. Stars do not only make gamma radiation, but also a number of radioactive elements releasing two other types of radiation. In total, there are no less than 29 naturally-occurring radioactive elements, containing more than 40 radioactive isotopes, to be found in our world. Most of these radioactive elements come from ancient super-novae and have been spread throughout our galaxy, including Uranium, Thorium, Radium, Bismuth, Polonium, Protactinium, Radon, Lead and Plutonium. In theory, all of these radioactive heavy elements were originally Uranium isotope 238 (U-238) spawned by the ancient supernovae. U-238 is radioactive and its decay chains, over billions of years, have produced the rest of these very heavy elements.

Naturally occurring Plutonium has an interesting place in all of this. The incomprehensible force produced by supernovae releases a high concentration of free neutrons as well. About half of the freshly made U-238 in a supernova absorbs some of these neutrons and through two relatively rapid radioactive (Beta) decays becomes Plutonium isotope 239 (Pu-239). Plutonium has a relatively short radioactive half-life (compared to the age of a star) of 24,000 years. After no more than 10 half lives after it has been produced, a radioactive material has literally decayed itself into oblivion. It's gone. All the primordial Pu-239 that was originally part of our planet was gone after about 250,000 years.

As it turns out, Pu-239 decays to U-235, with a 700 million year half life. 4.5 billion years ago, there was about 60 times more U-235 than we have today The initial U-235 has decayed for a little less than 7 half lives, leaving but a small fraction of the original concentration. This is why we have a tiny fraction of all existing Uranium in the isotopic form of U-235, with no remaining Plutonium. Plutonium has too short of a half-life to be around anymore, and the natural radioactive decay of its "daughter" isotope, U-235, has contributed to all the current levels of the rest of above-listed naturally occurring radioactive isotopes we find today. They all literally owe their existence to primordial Plutonium. Because supernovae happen regularly, throughout our roughly 200-billion-galaxy universe, Plutonium can now be understood as a naturally occurring element in our universe, contrary to traditional belief.

But the heavy, Uranium-spawned elements we find in our environment are not the only naturally-occurring radioactive elements we encounter. One of the most common is an isotope of Potassium, a necessary mineral for human life and health. To be specific, Potassium isotope 40 (K-40), which is generated from collisions between cosmic rays and some of the molecules found in our upper atmosphere. This isotope comprises but one tenth of one percent of all the Potassium on our planet. Because of it's long half-life (1.3 billion years) K-40 has not decayed into oblivion, and won't for about another 9 billion years. Further due to its relatively high abundance in the soils of our planet, Potassium is literally found everywhere. K-40 is uniformly mixed in with the non-radioactive isotopes K-39 (which comprises 93%) and K-41 (at a bit less than 7% abundance). Mother Nature does not segregate them from each other. So, when we eat a potassium-rich food, such as bananas or broccoli, we are ingesting enough K-40 to potentially set off the ultra-sensitive radiation monitors in most nuclear power facilities. Two bananas will definitely do it. (It happened to me) Potassium is also found in milk, all dairy products, and just about every form of fresh green produce found in the grocery market. Ubiquitous and invisible, yes. Also, unavoidable.

One other commonly ingested naturally radioactive element is Tritium (Hydrogen isotope 3; H-3), found in trace amounts in all surface waters and almost all drinking waters. Once again, Mother Nature does not discriminate between the radioactive and non-radioactive water molecules on our planet. We drink tiny quantities of H-3 in every glass of water we consume. Add to this the small concentrations of radioactive radon gas mixed uniformly into the air that we breathe, and we reach one inescapable truth; everywhere we go, everything we do, and everyone we know (including ourselves) is naturally radioactive.

Source: http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-wastes-myths-and-realities.aspx

Radioactive Wastes - Myths and Realities

(Updated February 2016)

- **There are a number of pervasive myths regarding both radiation and radioactive wastes.**
- **Some lead to regulation and actions which are counterproductive to human health and safety.**

Over the years, many views and concerns have been expressed in the media, by the public and other interested groups in relation to the nuclear industry and in particular its waste. Questions have been raised about whether nuclear power should continue when the issue of how to deal with its waste has apparently not yet been resolved.

Some views and concerns include:

- 1. The nuclear industry still has no solution to the 'waste problem', so cannot expect support for construction of new plants until this is remedied.
- 2. The transportation of this waste poses an unacceptable risk to people and the environment.
- 3. Plutonium is the most dangerous material in the world.
- 5. Nuclear wastes are hazardous for tens of thousands of years. This clearly is unprecedented and poses a huge threat to our future generations.
- 6. Even if put into a geological repository, the waste might emerge and threaten future generations.
- 7. Man-made radiation differs from natural radiation.
- 8. Nobody knows the true costs of waste management. The costs are so high that nuclear power can never be economic.
- 9. The waste should be disposed of into space.
- 10. Nuclear waste should be transmuted into harmless materials.

1. The nuclear industry still has no solution to the 'waste problem'

Many people quite reasonably feel that the nuclear industry shouldn't continue operation without having a solution for the disposal of its radioactive waste. However, the industry has in fact developed the necessary technologies and implemented most of them - the remaining issue is to ensure that the proposed solutions are acceptable to the public.

Today, safe management practices are implemented or planned for all categories of radioactive waste. Low-level waste (LLW) and most intermediate-level waste (ILW), which make up most of the volume of waste produced (97%), are being disposed of securely in near-surface repositories in many countries so as to cause no harm or risk in the long-term. This practice has been carried out for many years in many countries as a matter of routine.

High-level waste (HLW) is currently safely contained and managed in interim storage facilities. The amount of HLW produced (including used fuel when this is considered a waste) is in fact small in relation to other industry sectors. HLW is currently increasing by about 12,000 tonnes worldwide every year, which is the equivalent of a two-storey structure built on a basketball court or about 100 double-decker buses and is modest compared with other industrial wastes. The use of interim storage facilities currently provides an appropriate environment in which to contain and manage this amount of waste. These facilities also allow for the heat and radioactivity of the waste to decay prior to long-term geological disposal. In fact, after 40 years there is only about one thousandth as much radioactivity as when the reactor is switched off to unload the used fuel. Interim storage provides an appropriate means of storing used fuel until a time when that country has sufficient fuel to make a repository development economic.

In the long-term however, appropriate disposal arrangements are required for HLW, due to its prolonged radioactivity. Disposal solutions are currently being developed for HLW that are safe, environmentally sound and publicly acceptable. The solution that is widely accepted as feasible is deep geological disposal, and repository projects are well advanced in some countries, such as Finland, Sweden, France and the USA. In fact, in the USA a deep geological waste repository (the Waste Isolation Pilot Plant) is already in operation in New Mexico for the disposal of transuranic waste (long-lived ILW contaminated with military materials such as plutonium), although Nevada is showing classic Nimby[a] resistance to the proposed Yucca Mountain repository. These countries have demonstrated that political and public acceptance issues at a community and national level can be met.

The nuclear industry therefore has clearly defined waste disposal methods for all waste produced and is making progress in many countries to achieve public acceptance of the approved programmes. It is important that other governments in nuclear energy-producing countries now follow the lead set by these countries on the issue of long-term disposal of high-level radioactive waste.

With the availability of technologies and the continued progress being made to develop publicly acceptable sites, it is logical that construction of new nuclear facilities can continue. Nuclear energy has distinct environmental advantages over fossil fuels. As well as containing and managing virtually all its wastes, nuclear power stations do not cause any pollution.

The fuel for nuclear power is virtually unlimited, considering both geological and technological aspects. There is plenty of uranium in the Earth's crust and furthermore, wellproven (but not yet fully economic) technology means that we can extract about 60 times as much energy from it as we do today.

The safety record of nuclear energy is better than for any major industrial technology. All these benefits should be taken into account when considering the construction of new facilities.

2. The transportation of this waste poses an unacceptable risk to people and the environment

Nuclear materials have been transported safely (virtually without incident and without harmful effect on anyone) since before the advent of nuclear power over 50 years ago. Transportations of nuclear materials cannot therefore be referred to as 'mobile Chernobyls'.

The primary assurance of safety in the transport of nuclear materials is the way in which they are packaged. Packages that store waste during transportation are designed to ensure shielding from radiation and containment of waste, even under the most extreme accident conditions. Since 1971, there have been some 7000 shipments of used fuel (over 80,000 tonnes) over many million kilometres with no property damage or personal injury, no breach of containment, and very low dose rate to the personnel involved, *e.g.* 0.33 mSv/yr per operator at France’s La Hague reprocessing facility.

Relative to petrol and chemical tankers routinely used on public roads or on railways, transport of any radioactive wastes as normally practised poses trivial hazards.

3. Plutonium is the most dangerous material in the world

Plutonium has been stated to be 'the most toxic substance on earth' and so hazardous that 'a speck can kill'. Plutonium is indeed toxic and therefore must be handled in a responsible manner. Its hazard is principally associated with the ionising radiation it emits. However, it is primarily hazardous if inhaled in small particles.

Comparisons between toxic substances are not straightforward since the effect of plutonium inhalation would be to increase the probability of a cancer in several years time, whilst most other toxins lead to immediate death. Best comparisons indicate that, gram for gram, toxins such as ricin and some snake venoms and cyanide are significantly more toxic. Consider also that all the cleaning products that we have in our kitchen are toxic if we absorb them, whilst some of the products that are spread onto crops are toxic as well.

5. Nuclear wastes are hazardous for tens of thousands of years. This clearly is unprecedented and poses a huge threat to our future generations in the long-term

Many industries produce hazardous waste. The nuclear industry has developed technology that will ensure its hazardous waste can be managed appropriately so as to cause no risk to future generations.

In fact, the radioactivity of nuclear wastes naturally decays progressively and has a finite radiotoxic lifetime. The radioactivity of high-level wastes decays to the level of an equivalent amount of original mined uranium ore in between 1,000 and 10,000 years. Its hazard then depends on how concentrated it is. Compare this to other industrial wastes (*e.g.* heavy metals such as cadmium and mercury), which remain hazardous indefinitely.

Most nuclear wastes produced are hazardous, due to their radioactivity, for only a few tens of years and are routinely disposed in near-surface disposal facilities. A small volume of nuclear waste (~3% volume of total waste produced) is long-lived and highly radioactive and requires isolation from the environment for many thousands of years.

International conventions define what is hazardous in terms of radiation dose, and national regulations limit allowable doses accordingly. Well-developed industry technology ensures that these regulations are met so that any hazardous wastes are handled in a way that poses no risk to human health or the environment. Waste is converted into a stable form that is suitable for disposal. In the case of high-level waste, a multi-barrier approach, combining containment and geological disposal, ensures isolation of the waste from people and the environment for thousands of years.

6. Even if put into a geological repository, the waste might emerge and threaten future generations

The reality is that with today's spent fuel or vitrified high-level waste (HLW), extra layers of protection come from the multi-barriers of stable ceramic material, encapsulation, and depth from the biosphere that are designed to prevent any movement of radioactivity for thousands of years. A stable geological formation, within which the waste will be disposed, also constitutes a highly reliable barrier.

Radiation scientists, geologists and engineers have produced detailed plans for safe underground storage of nuclear waste and some are now operating. Geological repositories for HLW are designed to ensure that harmful radiation would not reach the surface even with severe earthquakes or the passage of time.

Nature has also provided good examples of nuclear waste 'storage'. About two billion years ago, in what is now Gabon in Africa, a rich natural uranium deposit produced spontaneous, large nuclear reactions which ran for many years. Since then, despite thousands of centuries of tropical rain and subsurface water, the long-lived radioactive 'waste' from those 'reactors' has migrated less than 10 metres. Furthermore, deposits of uranium ore exist underground without any expression of this by release of radionuclides at the surface (*e.g.* at Cigar Lake in Canada and Olympic Dam in South Australia).

7. Manmade radiation differs from natural radiation

Radiation emitted from manmade radionuclides is exactly the same form as radiation emitted from naturally-occurring radioactive materials (namely alpha, beta or gamma radiation). As such, the radiation emitted by naturally-occurring materials can not be distinguished from radiation produced by materials in the nuclear fuel cycle.

Most elements have a radioactive form (radioisotope) and many of these occur naturally. We live our lives surrounded by naturally-radioactive materials, and are constantly bathed in radiation originating in the rocks and soil, building materials, the sky (space), food and one another. A typical background level of exposure is 2-3 milli Sieverts per year (mSv/y). Regulations limit extra exposure from man-made radiation due to human activities (other than medicine) to 1 mSv/y for members of the public and average 20 mSv/y for occupational exposure. These levels are very seldom exceeded, though no harm has been shown for levels up to 50 mSv/y. Some people are exposed to lifelong natural background levels which are higher than this.

8. Nobody knows the true costs of waste management. The costs are so high that nuclear power can never be economic

Because it is widely accepted that producers of radioactive wastes should bear the costs of disposal, most countries with nuclear power programmes make estimates of the costs of disposal and update these periodically. International organisations such as the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD) have also coordinated exercises to compare these estimates with one another. For low-level waste, the costs are well-known because numerous facilities have been built and have operated for many years around the world. For high level-waste (HLW), cost estimates are becoming increasingly reliable as projects get closer to implementation.

Based on the estimated total costs of managing nuclear wastes, many countries require that the operators of nuclear power plants set aside funding to cover all costs. Different mechanisms exist in different countries. Although the sum already deposited in dedicated funds are high, the costs of waste management do not drastically increase the price of electricity. Typically the spent fuel management and disposal costs represent about 10% of the total costs involved in producing electricity from a nuclear power plant. Thus, although the absolute costs of waste management are high, they do not render the nuclear fuel cycle uneconomic, because of the high ratio of revenue earned to waste volumes produced.

9. The waste should be disposed of into space

The option of disposal of waste into space has been examined repeatedly since the 1970s. This option has not been implemented and further studies have not been performed because of the high cost of this option and the safety aspects associated with the risk of launch failure.

10. Nuclear waste should be transmuted into harmless materials

Transmutation is the process of transforming one radionuclide into another via neutron bombardment in a nuclear reactor or accelerator-driven device. The objective is to change long-lived actinides and fission products into significantly shorter-lived nuclides. The goal is to have wastes that become radiologically harmless in only a few hundred years.

Transmutation is not feasible for all of the wastes produced in the past or to be produced. Transmutation may be able to reduce waste quantities but it will do it only to a certain extent and therefore not eliminate the need for disposal. One of the technical issues is to isolate each nuclide (partitioning) so that it can then be irradiated, otherwise the process is likely to create as much waste as it destroys. Even if the economics of partitioning and transmutation were favourable, it is likely that the benefits would not compensate for the burden of additional operations required for separating and transmuting only part of the nuclides.