To know, or not to know: the nuclear question

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When humans learnt to use fire, their supremacy on the planet was assured, for a while at least. The advance was not barred by public fear and ignorance. Its adoption was welcomed and general instruction for its safe use was shared widely. However, today, with an increased population and larger economic horizons, we need a new source of energy, one that is more concentrated and has less impact on the environment.

Fortunately, nature offers such a source. While nuclear energy is a million times denser than fire, its effect on the environment is very small. Unfortunately, few in society have been ready to learn about it, or to appreciate its benign impact on life. They have preferred not to know. The reason for this failure is historical. Like other features of nature, nuclear energy can also be abused, and concern about its use in military conflict has coloured general perceptions of it ever since World War II. Although fear of radioactivity and its radiation is largely unjustified, it became a phobia in the days of the Cold War, when scientific truth was often obscured by official secrecy and public distrust. If humanity is to flourish in the future, we should examine these historical shadows and ensure that our children are not deceived by them. They should know; they should learn about nuclear energy, the part it plays in the natural world, and how it can help their future.

A simple description of the atoms, of which everything is made, is not difficult to follow. These LEGO bricks of matter are all very similar and governed by universal principles: each atom has a tiny nucleus, held at the centre of a cloud of electrons. This nucleus plays no active part in the usual technologies of electronics, lasers and chemistry, where energy is so much lower than nuclear. The biology of life takes place on a far larger scale with great variety and rules shaped locally by evolution.

Nuclear energy can affect life when a nucleus decays, releasing energy as radiation, and such a nucleus is called *radioactive*. Everything, even our own bodies, contains some natural radioactivity, and nuclear radiation shines on us from space too. If it had been really dangerous, life would have died out aeons ago, when the radiation flux was more intense than it is today. To survive the oxidative damage caused by radiation and oxygen, life has evolved a series of amazingly clever design features and strategies. These include: renewal by the cell cycle, the repair of broken DNA, apoptosis of errant cells, and even the birth-and-death cycle that replaces whole individuals. Each year more details are discovered about how these work and protect living tissue from low and moderate radiation fluxes.

Marie Curie showed that high radiation doses can be used to cure cancer, and everyone, directly or indirectly, is aware of these health benefits. However, in the 1950s twenty years after Marie Curie's death, draconian limits were introduced for acceptable exposures, in an attempt to appease fears expressed during the Cold War. Large public demonstrations and political confrontations ensured that leaders responded to the general fear of growing stockpiles of nuclear missiles. Limiting acceptable exposures to radiation by international regulation was such a response, although it was a sticking plaster solution that provided little reassurance. Nevertheless, those regulations, though not based on sound evidence, continue in use today. Varying from 1 to 20 milli-sievert per year, they are more cautious by a factor above 1000, compared to the 30,000 milli-sievert dose received by normal tissue in the course of a typical radiotherapy treatment.

The public appeal for radiation safety was answered by requiring that any radiation exposure should be As Low As Reasonably Achievable (ALARA). This was underwritten by the idea that any exposure is harmful, however small and received at whatever rate. This idea, called the LNT model, is not supported by scientific or mathematical evidence, is quite unlike the behaviour of other systems, evolved or designed for self protection, and is at odds with modern radiobiology. But what

story does the evidence tell?

At Fukushima the radiation doses were low, even to the workers, and there was no radiation casualty. But, without any knowledge of radiation, the public reaction to the imposed regulations was fear and distrust of the authorities. The result was great personal suffering in Japan, and near-panic and inept changes of energy policy, worldwide.

At Goiania, Brazil in 1987, a radioactive source, activity 50.9 TBq[1] Cs-137 from a disused radiotherapy unit, fell into the hands of the public, who liked the glow it emitted! They decorated themselves and ingested it with their food. In total 249 people were contaminated, over 70 of them internally. Within a few weeks four had died, 28 had surgery and many suffered from mental illness and alcoholism. However, no one died in the following 25 years as a direct result of the radiation. Two children were born normally, one who was already *in utero,* and another some four years later to a mother who had received 300 MBq, internally.

At Chernobyl, too, the fear and stigma of having been irradiated caused despair, family break-up, and mental illness. Hundreds of miles away mothers were frightened into aborting their unborn, and the expectation of many tens of thousands of deaths were raised in the media. However, the final count of deaths that can be linked to radiation, either identifiably or statistically, was 43, as reported by the UN and WHO.

In the public at large, ignorance about radiation and its effects on health is almost total. Few professional engineers or physical scientists are sufficiently informed on the medical side to challenge the entrenched opinion of ICRP, the safety committee sanctioned by the United Nations. The proper loyalty of most professional medics is to the health of their patients, and they are generally reluctant to pursue decades-old disagreements, even where the scientific and medical evidence is quite clear, as it is here. The nuclear industry, anxious for new business, has always stuck close to the regulators. Some safety professionals, who understand the radiobiology, admit that the regulations are quite inappropriate and against the general interest. However, they have jobs and careers that rely on the *status quo*, and so are reluctant to upset the apple cart, in spite of the large addition to healthcare costs involved. In some jurisdictions, Japan for example, large compensation payments have been made without requiring any evidence of harm from radiation to be shown. In this way the law has discouraged many from speaking about the real issue. These are the reasons that no one has stood up to say the truth – nuclear energy is much safer than fire.

The well rehearsed reaction to the 2011 tsunami in Japan was based on a civil defence policy of public education, but there was no similar provision for a nuclear incident, civil or military. Although the radiation from the reactor accident had no direct impact on health, it did show how a total lack of preparation can lead to near-panic. Fear of a nuclear holocaust was an important weapon during the Cold War. However, such an intense, but vague, apprehension makes actual reactions far worse. Today, panic and a breakdown of public order would be the dominant result of a "dirty bomb", or even a nuclear strike. Education and public health information could be provided relatively easily as a major improvement in social resilience.

We should look to such education to be broader, more open, and less fearful, not only for the young, but for the wider public too. At the level of public health, nuclear radiation is not difficult to understand: it is only the phobia (plus those who jealously guard its status) that makes it seem forbidding. If a wide spectrum of opinion makers had a better understanding of the range of future risks – radiation, environment, health, economic resources – the right balance between them would become clearer to everybody in society when decisions are made, and law and order would be preserved. A democracy based on ignorance is open to distrust and collapse.

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1 Tbq, a trillion, a million million, radioactive decays per second.