Submission No 35

INQUIRY INTO URANIUM MINING AND NUCLEAR FACILITIES (PROHIBITIONS) REPEAL BILL 2019

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Submission regarding the Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019

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Introduction

Just weeks after the 2011 Japanese earthquake and tsunami, when Australia's media had largely moved on from the distressing images of the thousands of dead and injured and was firmly focused on the Fukushima power plant, with its refreshing lack of dead bodies or gore of any kind, radical UK environmental activist and journalist George Monbiot began a column in the *Guardian* with the words[1]:

> *Over the past fortnight I've made a deeply troubling discovery. The anti-nuclear movement to which I once belonged has misled the world about the impacts of radiation on human health. The claims we have made are ungrounded in science, unsupportable when challenged and wildly wrong.*

Monbiot had realised that his views on radiation were half a century behind the science. DNA biology, radio-biology, epidemiology and oncology are all vastly different now than in the 1950s and 60s when the anti-nuclear movement began. Claims that once represented the best available science are now just plain wrong, but continue to be recycled in activist groups and the general community.

There will be no community consensus on nuclear power while understanding of the risks associated with radiation remain stuck in the past.

[1] https://www.monbiot.com/2011/04/04/evidence-meltdown/

Once the modern science on DNA, radiation, radiotherapy and cancer is understood, even at a fairly superficial level. Public worry will drop to a realistic level and risks associated with nuclear power will be seen for what they are; lower, for example, than those of air travel or bacon. The cry of "But what about the waste!" will be seen for what it is; an expression of a simple lack of knowledge about one of life's less complex and risky waste problems.

This submission will describe the relevant science in lay language as simply and accurately as possible.

Background

The *anti-nuclear* movement grew out of the *ban-the-bomb* opposition to nuclear weapons during the 1950s. Both movements are premised on beliefs about radiation and DNA biology that are now known to be false.

The Nuclear Facilities Prohibition Bill is similarly based on beliefs that were sincerely believed at the time, but are now known to be false.

Back in the *ban the bomb* days of the 1950s, genes were thought to be essentially unchanging, with natural mutations occurring perhaps *"once in a hundred thousand generations"*. That phrase comes from an article on the *Genetic Effects of Radiation* by one of the leading geneticists of the day, James F Crow (see Jan 1958 edition, p.19)[2]. These wrong assumptions[3] were behind Linus Pauling's famous predictions[4] of thousands of birth defects and cancers from the fallout due to atmospheric testing of atomic bombs. These predictions got Pauling a Nobel Prize for Peace and the banning of atmospheric testing. The ban was wonderful, but the predictions about birth defects and cancers were simply false; they were based on wrong assumptions.

At the time Pauling, like every other scientist, believed that:

1. *any* DNA damage was dangerous,
2. cumulative and
3. permanent;

all three beliefs are now known to be false. You can check this in any DNA biology text book (e.g., *Essential Cell Biology (4th Edition)*[5]).

I'll outline the modern science on DNA damage and radiation later; but first a little aside on the latest TV docu-drama.

[2] http://books.google.com.au/books?id=dQkAAAAAMBAJ
[3] http://scarc.library.oregonstate.edu/coll/pauling/peace/notes/1960a.4-ts-07-large.html
[4] http://www.sciencemag.org/content/128/3333/1183.abstract
[5] http://www.amazon.com/gp/product/0815344546

Over 30 years ago, in a land far away ...

Anyone watching the recent HBO series on Chernobyl may have wondered *why* the people sent on what were said, with great gravitas, to be suicide missions, didn't die.

They may also wonder why, despite radioactive contamination over vast areas of Ukraine, Belarus and Russia (and beyond), there hasn't been a tsunami of cancers.

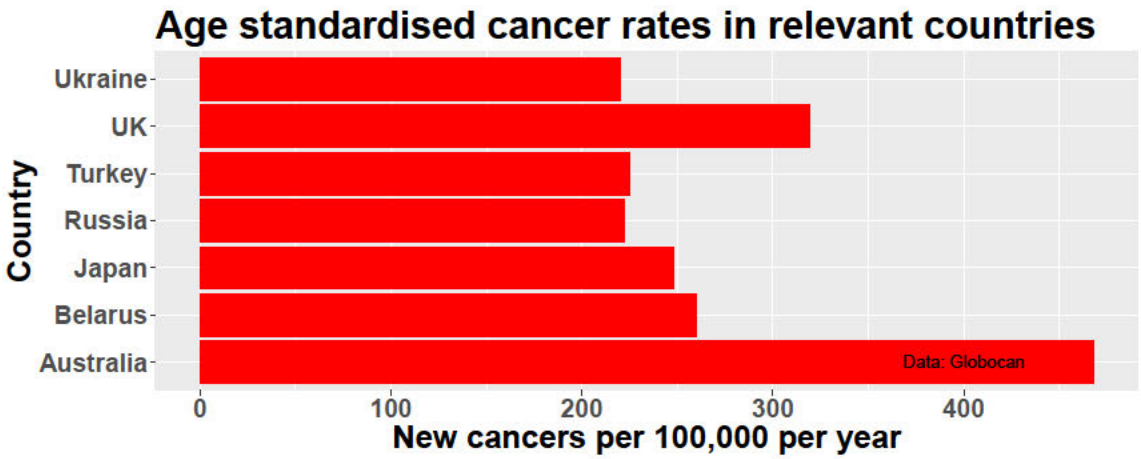
Why is the human exclusion zone around Chernobyl teeming with wildlife? HBO put physicists and the heart of their TV docu-drama; and ignored doctors. Nor did it cover the actual aftermath of the tragedy. It didn't, for example, tell people that the cancer rate in Ukraine today is less than half that of Australia (220 compared to 468[6] new cancers per 100,000 people per year). Good TV isn't always good science.

There was, as it happens, a US doctor on the front lines at Chernobyl ... looking after the firefighters; Robert Gale. Unlike anti-nuclear myth-maker, Helen Caldicott, who has never published any peer reviewed science on anything, Professor Gale has over 1,100 peer reviewed scientific papers. Caldicott graduated in 1961, and pretty much everything she learned during her medical degree about DNA, genes and radiation was wrong. You can read Gale's 4-part series on the TV series here[7], here[8], here[9], and here[10].

The anti-nuclear movement has no explanation for the absence of an explosion of cancers in Ukraine and beyond. So it has invented a conspiracy theory[11] about the World Health Organisation covering up a million deaths to explain what is obvious to anybody with an up to date understanding of DNA biology, radiation and cancer. Monbiot exposed this conspiracy for what it is; delusional ignorance.

Helen Caldicott, for example, warns against Turkish apricots[12] or any other Turkish food because it is "extremely radioactive". The following chart shows cancer incident rates for a few relevant countries; radioactively polluted Russia, Belarus and Ukraine plus Turkey, compared with the UK and Australia. I've included Japan also, because it will be relevant when I discuss the cancers due to the atomic bombing of Japan in the Second World War; and also the Fukushima meltdowns.

[6] http://gco.iarc.fr/today/fact-sheets-populations
[7] https://cancerletter.com/articles/20190517_4/
[8] https://cancerletter.com/articles/20190524_3/
[9] https://cancerletter.com/articles/20190614_3/
[10] https://cancerletter.com/articles/20190621_4/
[11] https://www.monbiot.com/2011/04/04/evidence-meltdown/
[12] https://www.youtube.com/watch?v=pb5HItRpDY8



Modern DNA biology

What's the modern estimate of gene mutations? Those things that were thought to happen once in a hundred thousand generations when Caldicott was a student.

The current best estimate is that *every one* of your 20,000 genes is mutated in about a billion cells of your body[13] during your lifetime. This is considerably different from "once in a hundred thousand generations"!

The apparent genetic stability theorised by scientists in the 1950s and 60s was the result of both crude measurement technology and mistaking very efficient repair for no damage. It's rather like looking at clean city streets and concluding that the city generates no garbage.

In the 1950s and 60s, DNA repair was, at most, the stuff of speculation. Now there are big thick text books about it. Repair is ubiquitous and involves many mechanisms because multiple types of damage are an unrelenting consequence of normal metabolic processes.

The public exposure to radiation after events like Chernobyl or Fukushima is doses in the order of a few milli Sieverts; a milli Sievert is a thousandth of a Sievert. A Sievert is a very large radiation dose; 5 is life threatening. At Fukushima a grand total of 7 reactor workers got doses of radiation above 200 milli Sieverts.

The firefighters who died at Chernobyl received 5-10 Sieverts over a very short period. But most died not just from radiation, but radiation in combination with 3rd degree burns to large areas of their bodies. Some 13 of the *least* burned firefighters were chosen for bone marrow transplants; the following table is a simplified version[14] showing the burn scores and radiation doses. Most people know how serious a 3rd degree burn is. Chernobyl was certainly a radiological emergency, but mostly it was just a big hot horrible fire; just like a gas or fertiliser explosion.

[13] http://www.amazon.com/gp/product/0815344546
[14] https://www.nejm.org/doi/full/10.1056/NEJM198907273

ID	Dose	Burn Score	Percent of body
1	6.6	2-3	50
2	9.2	2-3	95
3	12.1	2-3	60
4	11.9	2-3	100
5	4.4	0	-
6	5.2	1-3	40
9	9.6	2-3	50
11	5.6	1-2	20
16	10.2	2	25
17	13.4	2-3	50
27	8.3	3	20
28	6.4	1-2	40
29	8.7	1-2	30

When a person gets radiotherapy, they typically receive 1-1.5 Sieverts to the tumour and some surrounding tissues in a 10 minute dose ... and the same again the next day, and again and again and again; for weeks. Why so often? Because our DNA repair mechanisms kick in and fix the damage. Even these large doses can't reliably overwhelm our DNA repair mechanisms and kill tumour cells. Radiotherapy works because tumour cells are dividing more rapidly, so a little more susceptible to damage, and also less efficient at handling that damage than normal cells and thus die at a higher rate. Tumour cells often have damage to the genes that drive DNA repair ... it's part of what makes them tumour cells.

Some DNA damage is trivial for our cells to repair; it might be just a break in a single strand of the double stranded DNA molecule. But sometimes the damage is a break in both strands, and that's much harder to fix. *You get about 50 or so double strand breaks in every cell in your body every day*. Nobody knew that in 1961 either! To cause the same level of these double strand breaks with radiation as occur naturally (from normal metabolic processes), you'd need about 1.5 Sieverts per day[15].

In 2012, MIT researchers exposed[16] mice to continuous radiation for 5 weeks at about 400 times background levels; background radiation depends very much on local geology, but is typically a few milli-Sieverts per year, so a radiation level of 400 times the background rate would be about one full Sievert per year. The researchers found no uncorrected DNA damage in the mice. As long lived animals, humans need, and have, much better DNA repair mechanisms than those of mice; with elephants being better again. Mostly, it seems, elephants are better at inducing cell suicide in cells with DNA damage[17]; dead cells don't cause cancer.

The MIT researchers estimate that normal cellular processes cause about 10,000 pieces of damage *per cell per day* and that the extra damage from this large radiation exposure would add about 12 pieces of damage per cell per day.

[15] https://www.ncbi.nlm.nih.gov/pubmed/14566050
[16] http://news.mit.edu/2012/prolonged-radiation-exposure-0515
[17] https://www.sciencedirect.com/science/article/pii/S2211124718311458?via%3Dihub

Figure 1: Guarapari Beach

A Sievert per year is about 114 micro Sieverts per hour. Figure 1 shows a person with their legs buried in the mineral sands of Guarapari Beach in Brazil, where tourists and locals alike sunbathe amid radiation levels in the vicinity of 30-50 micro Sieverts per hour. If the Japanese Government was in charge, large companies would be lining up to make money packing up all those beaches into big black plastic bags. Journalists would be writing stories about the cost.

Radiation Vs lifestyle as a cause of cancer

Remember the graph showing the cancer rates in various countries? Recall Japan's low rate?

The survivors of the Hiroshima and Nagasaki atomic bombings suffered a cancer rate increase[18] of about 11 percent. If instead of surviving an atomic blast, they'd migrated to Australia, we know that their cancer rate would also have changed as they adopted our life style. We'd expect the children of those Japanese to have an Australian cancer rate ... about 50 percent *higher* than that of their parents in Japan. i.e., moving to Australia and adopting our lifestyle will raise your risk of cancer about 5 times more than surviving an atomic blast.

Identity politics and rationality

This submission has presented, in lay terms, a considerable amount of science that was not known when the anti-nuclear movement began. The leaders of the anti-nuclear movement

[18] https://www.rerf.or.jp/en/programs/roadmap_e/health_effects-en/late-en/cancrisk/

have a tendency to avoid reading anything that might contradict their views ... or alternatively dismissing any science they don't like as being industry propaganda; they have much in common with climate change deniers and anti-vaxxers.

But, of course, in Australia, as elsewhere, the vast bulk of people who are anti-nuclear, have just inherited those beliefs and simply never bothered to question them. I was exactly the same until late in 2008! Few people have the time I've devoted to reading cancer and radio-biology text books and journals.

Stepping outside your comfort zone and reading things that contradict your current views is never easy. The modern world of identity politics makes change even harder again. But tribalism on energy and other policies is an insidious anti-rational disease that has to be opposed at every opportunity.

Conclusion

Science is a job-lot. If you accept the science behind climate change predictions, for example, then you should equally accept any science on which there is strong consensus, like modern DNA biology, oncology and radiotherapy. That science is used in radiotherapy units of hospitals all over the planet as well as by the International Atomic Energy Agency in formulating its emergency guidelines. If those IAEA guidelines had been followed there would have been no evacuation at Fukushima and the environmental "clean up" would have been over years ago and tiny by comparison to the on-going circus of contractors milking the fear driven cash cow and doing things that range from useless to ecologically damaging.

Reading ABC journalist Mark Willacy's book on Fukushima[19] (reviewed here[20]) throws light on Prime Minister Nato Kan's handling of the situation. Kan seriously thought that Chernobyl was an atomic explosion (as did Willacy!), and was frightened of an atomic explosion at Fukushima. The irrational fear that drove Kan's panic isn't surprising given such ignorance. What's the difference between steam and hydrogen explosions and an atomic explosion? It's the difference between 1 damaged building and about 700 hectares of totally flattened buildings.

A sensible country re-evaluates legislation in the face of the best available science. The best available science says that even the worst possible reactor accident is far less dangerous than the ongoing carnage on our roads, or sunshine, or the cancers caused from red and processed meat[21].

The best available science says that even old nuclear reactors have been extraordinarily safe; and, in displacing coal, they have saved almost 2 million lives[22] globally over the past 40 years. The best available science says that we can build nuclear reactors quickly and cheaply if we get the regulatory regimes right. These regimes also need to catch up with the radiation science.

The best available science also says nuclear waste is easily handled. Consider, for example, the proposed, but currently moth balled, US Yucca Mountain waste repository. Have a look at

[19] https://www.amazon.com/Fukushima-Mark-Willacy-ebook/dp/B00DGLB18A
[20] https://bravenewclimate.com/2013/09/06/willacys-fukushima/
[21] http://www.abc.net.au/news/2015-10-27/processed-meats
[22] https://pubs.acs.org/doi/abs/10.1021/es3051197

the Environmental Impact Statement[23]. It describes the risks in excruciating detail. Suppose for example, somebody in 30,000 years time drilled into the repository, this would effectively breach the seal and allow a slow release of radioactive material. Sound like a big deal? The scenario was studied in detail and guess what kind of radiation dose people in an 80 kilometre radius would eventually get? About 0.02 micro Sieverts per year ... that's 1/50th of a chest x-ray (~1 micro Sieverts)[24]. When people suggest that radioactive material must be isolated for thousands of years, they never ask the obvious question: *"Or what?"* The Yucca EIS showed that the worst case consequences of failure are trivial.

During the recent debate in the Victorian Parliament, various MPs mislead the Parliament about nuclear power. They either claimed that their was an unsolved waste problem or that nuclear power stations posed *"significant community health and environmental risks"*. Over the past 33 years, thyroid cancers from Chernobyl radiation have killed a total of some 10 people[25]. This is similar to the number of children who drown in back yard swimming pools[26] in Australia *every year*. Why don't we have a Swimming Pool Technologies Prohibition Act? In any event, such cancers would be unlikely in any future accident in a developed country because the children of Ukraine at the time were iodine deficient and particularly susceptible.

Why are so many in Australia seemingly more worried about nuclear accidents and possible health impacts than children drowning in swimming pools? The latter don't just cause risk, but children actually die. Yet I've never seen throngs of people holding *"No Pools"* placards. But even the hint of nuclear waste disposal, let alone a nuclear reactor, has them frothing at the mouth with rage.

Nor has the anti-nuclear movement been consistently concerned about cancer in general, but only selectively concerned about those from a Soviet era accident decades ago. We have a few thousand new bowel cancers[27] annually caused by red and processed meat. Nobody knew about that in the 1950s either! A sensible science based response for people *sincerely* concerned about cancer's tragic toll would be to make a legislative swap; legalise nuclear reactors and phaseout beef, pork and bacon.

It's time for science based legislation in NSW; time to accept the modern science of radiation, DNA biology and cancer along with that on climate change. And we can start by repealing legislative relics banning nuclear power based on obsolete science.

[23] http://energy.gov/sites/prod/files/EIS-0250-FEIS_Summary-2002.pdf
[24] http://www.radiologyinfo.org/en/pdf/safety-xray.pdf
[25] https://cancerletter.com/articles/20190614_3/
[26] https://www.royallifesaving.com.au/___data/assets/pdf_file/0005/16448/RLSNSW_ChildDrowningReportLR.pdf
[27] http://www.abc.net.au/news/2015-10-27/processed-meats

Appendix: Understanding Chernobyl cancer predictions

Anti-nuclear advocates make much of predicted cancers. A predicted cancer is very different from an actual death.

During World War II, the allied forces firebombed Japanese cities toward the end of the war in raids that killed 2-3 times more people than the atomic bombings of Hiroshima and Nagasaki. But they didn't just kill, they left people with horrific injuries; full thickness burns to large areas of their body, among other things. The atomic bombings left similar horrific injuries ... to far fewer people. Survivors also got a dose of radiation. You don't feel a radiation dose. It doesn't hurt, it doesn't cripple or maim but it may predispose you to a cancer later in life at a rate similar to having a daily bacon habit. For some strange reason, radiation victims have received massive compensation while the firebombing victims, people with real injuries causing lasting problems, have not[28].

Three years after Chernobyl at a place called Ufa, also in the Soviet Union of the time, and a couple of thousand kilometres to the East of Chernobyl. A natural gas explosion caught a couple of passing trains and killed over 500 people[29]. As well as the dead, there were some 800 serious burns victims. It's physically painful to even contemplate such horror.

Actual deaths and injuries like these are very different from predicted cancers based on theoretical models where those concerned suffer no associated injury and disability.

The anti-nuclear movement has very effectively terrorised the public over a theoretical risk while ignoring real risks ... like coal dust illnesses. The price of this terror has been high not only on the workers involved, but in terms of our contribution to damaging the climate.

Robert Gale's articles (see links above) cover the actual cancers from Chernobyl, the thyroid cancers, but what about the predicted cancers? Gale estimates the number of *possible* cancers from Chernobyl radioactive material over an 80 year period as between 11,000 to 25,000 in the vast sea of some 200 million cancers in the region over which Chernobyl's radiation spread, including Europe and Scandinavia. How are such possible cancers estimated and what do such estimates mean? What does it mean to say of a 90 year old with cancer that he or she got it as a consequence of Chernobyl?

Imagine throwing a rock into a still pond. You can use physics to estimate the size of the ripple that this will cause. Now throw the rock into a stormy ocean. You can still use the same physics to get the same answer but you won't see the ripple among the waves crashing on the beach. The big causes of cancer are the ones causing those waves. Most are lifestyle related and have nothing to do with radiation or chemicals in hair spray or any of the other things that cause public fear from time to time. There are certainly potent occupational causes of cancer that need stringent protective measures for workers and radiation is certainly among these.

But the big causes of cancer[30] that effect us at a population level are from being too inactive, too overweight, drinking too much alcohol, eating red and processed meat or smoking cigarettes;

[28] http://bit.ly/2KTk58z
[29] https://en.wikipedia.org/wiki/List_of_accidents_and_disasters_by_death_toll
[30] https://www.wcrf.org/dietandcancer

and in some parts of the world, from spending too much time in the sun. There may be some other big ones still to be discovered, but radiation won't be among them.

There are models, like the one Gale used, that enable predictions just like that used to predict the size of the ripple in the pond. It may never even be possible to know if these models are correct; we can't, as it were, statistically detect the ripple among the waves. But the models still attempt to predict cancers from tiny doses. This is similar to debates about the cancer impacts of tiny amounts of alcohol or red meat. If 200 grams of meat a day increases your chance of cancer by 20 percent, then what about 1 gram a day? or 1 piece of meat a month? A bowel cancer probably starts with a mutation caused by some meat cells in a mouthful of meat on a particular day. It began as some particular piece of damage that escaped repair. Some would therefore argue that there is no safe amount of meat. Similarly with alcohol. This may or may not be true. But arguments like this are of little practical utility, however fascinating they may be to experts. Nevertheless, they've been very effective in frightening people.

The atomic bomb survivors got a 10 percent increased risk of cancer from a much bigger radiation dose than any of the public would get from a nuclear accident or from something even more benign like the failure of a radioactive waste repository. Instead of asking how may people died as a result of that radiation exposure, its much more sensible to ask by how much was their life-span reduced? The answer is that the median loss or life-span for atomic bomb survivors getting up to 1 Sievert, was about two months[31].

[31] http://www.ncbi.nlm.nih.gov/pubmed/21402804