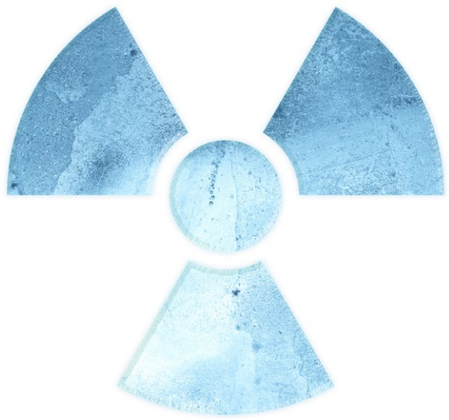
Rethinking a tenet of cancer risk assessment for low radiation doses

Science isn't perfect, but it does theoretically correct itself, and in the process even overturns keystones to fields of knowledge. However, such shifts don't occur without pushback, especially from individuals and organisations with something to protect. The Health Physics Society, which is dedicated to radiation safety, produced a documentary that exposes a history of scientific errors, profound bias, professional self-interest, and scientific misconduct that established the fundamental tenet of cancer risk assessment for low doses of radiation where most people live and work.



Scientific knowledge grows incrementally, and in the process, scientists develop a clearer understanding of the remarkable and beguiling intricacies of our natural world. In the gap between what we think we know and what we don't, scientists hypothesise – all the while remaining well aware that at any stage, even keystones of scientific knowledge can be overturned. However, even though such invalidation is vital to the scientific process, it doesn't occur without reluctance or pushback. This is especially true if influential individuals or groups have significant investments at stake, either academic, ideologic, or business. Leadership within the Health Physics Society (HPS) are challenging such a keystone in cancer risk assessment, and have discovered scientific errors, profound bias, professional self-interest, and scientific misconduct at the highest levels that challenges the existing radiation protection philosophy in low-dose environments.

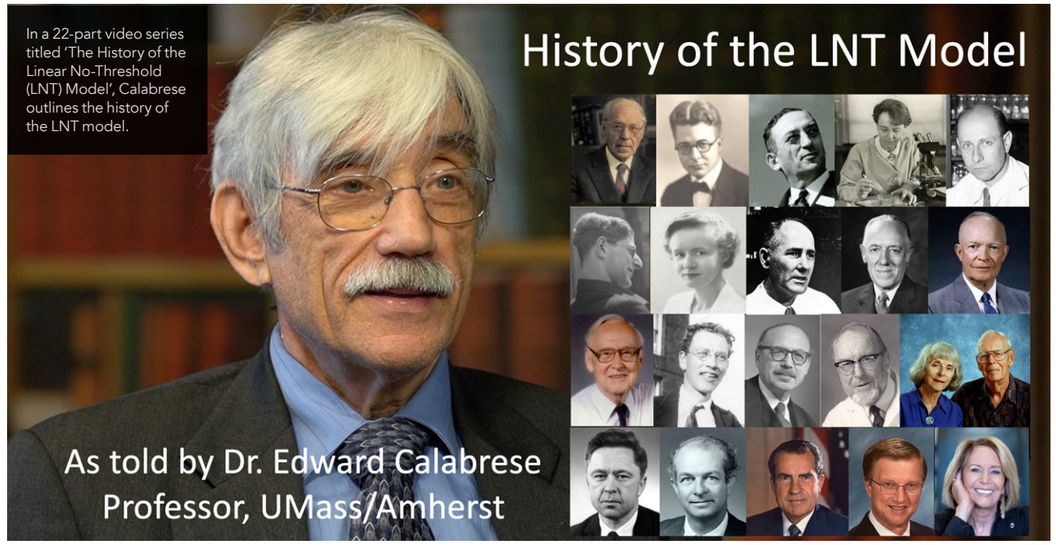
Scientific knowledge is evolutionary, but every now and then, it undergoes fundamental self-correction. Einstein unwound Newton's clockwork theory of the universe; Barry J Marshall and J Robin Warren received the Nobel Prize in Medicine for disproving the long-held belief that harmful bacteria couldn't exist in the human gut; Bennet Omalu upset an entire sport by proving a causal link between repeated head injuries in American football players and progressive degeneration of brain function; and Lynn Margulis' theory of symbiosis in cell evolution shocked our understanding of cell biology. Notably, such self-correcting significant advances weren't easy and invited considerable scorn and rebuke from academic circles. Influential companies and organisations with financial interests in retaining the status quo ensured extra inertia. Marshall and Warren found few friends in pharmaceutical companies selling chronic medication to people with stomach ulcers, and the powerful National Football League (NFL) almost destroyed Omalu's career.

Such fights for the soul of science continue. In the United States, food multinationals that influence federal dietary regulatory committees are pushing back against growing scientific evidence that the nutritional guidelines could be feeding the obesity epidemic. And leadership within the US-based HPS – a professional organisation dedicated to radiation safety – is strongly encouraging a re-examining of one of the fundamentals of radiation risk assessment they claim should never have seen the light of day.

THE LINEAR NO-THRESHOLD MODEL

Our understanding of ionising radiation exposures, such as X-rays or gamma rays, is framed by the Linear No-Threshold (LNT) model. It was derived from health effects associated with very high doses and high dose-rates. This theoretical model extrapolates to very low doses or low dose-rates (meaning the quantity of radiation absorbed or delivered over a period of time) to estimate the potential health risks associated with radiation environments in which most people live (eg, less than 10 mSv per year) and suggests that there is no threshold below which radiation exposure would be considered safe or without any risk.

It is an extremely cautious assertion that creates crippling fear leading to poor decision-making by authorities and the public.



The HPS leadership strongly encourages an urgent review of the LNT model after carefully examining how it came to be considered akin to scientific dogma.

Leadership within the HPS strongly encourages an urgent review of the LNT model after carefully examining how it came to be considered akin to scientific dogma. HPS leaders, led by health physicists John J Cardarelli II, Brett Burk, Barbara Hamrick, and Dan Sowers, worked closely with Edward J Calabrese, professor of toxicology at the School of Public Health and Health Sciences, University of Massachusetts Amherst. Calabrese has been undaunted and meticulous in following the LNT model's trail back to before the Second World War, and his methods are those of a combination of a seasoned investigative reporter and historian of science. He has secured access to original documents, including unpublished dissertations and theses, research proposals, letters, memos, and meeting transcripts between leading figures in the LNT model's development, and what he found was unquestioned acceptance.

Calabrese has published extensively on his discoveries, but leadership at the HPS felt the story needed a wider audience. They asked if he'd be willing to sit down for a video interview to tell the story, hoping they'd secure, at best, a couple of hours of his time. He agreed. When they finally switched off the video cameras, the group had on their hands a remarkable, at times unbelievable, even shocking story that spools over into a 22-part video series on the HPS website titled 'The History of the Linear No-Threshold (LNT) Model'. The story has many players, plots, and sub-plots, with several smoking-gun-like revelations that should cause most scientists to question the validity of LNT in low-dose environments for cancer risk assessment.

WHERE IT STARTED

If you're looking for a player at the LNT Model's genesis, it's Hermann J Muller. Muller was a leading American geneticist who, during the 1920s and 1930s, performed, at the time, groundbreaking research into radiation on fruit flies. He believed that his work proved a link between radiation exposure and genetic mutations. His work, published in the eminent journal *Science*, helped establish his reputation as a specialist in the nascent field of radiation genetics. However, as Calabrese points out, Muller did not include his data in the publication. There are a couple of other unfortunate facts: Muller received the Nobel Prize in Physiology or Medicine in 1946 for showing a link between radiation exposure and genetic mutations, but, according to Calabrese, Muller confused a mechanism (eg, gene mutation) with a transgenerational phenotype change, a mistake he admitted ten years after receiving his Nobel Prize. Also, his experiments focused primarily on the effects of massively high doses and high dose-rates of radiation, over 100-million-fold dose-rate more than background radiation, and he assumed that the concept of genetic repair mechanisms did not exist. The concept of genetic repair mechanisms in mice was first suggested in 1958 by

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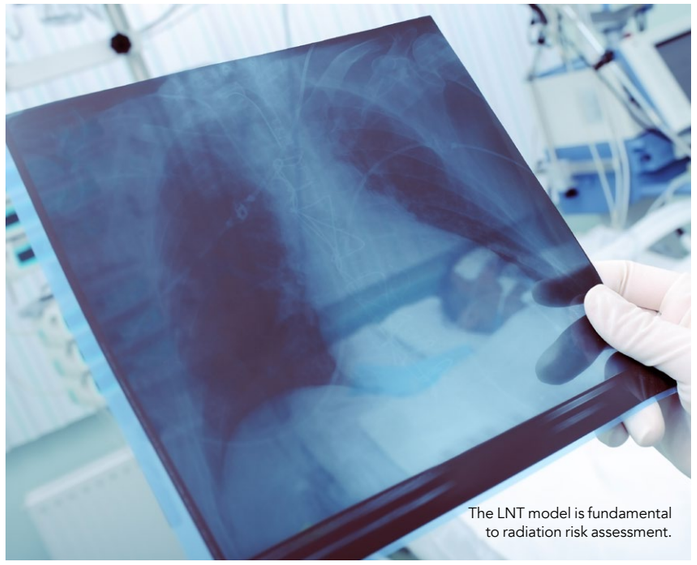


The LNT model is fundamental to radiation risk assessment.

Generations of radiation geneticists have been incorrectly brought up to believe all genetic damage is cumulative, irreparable, and irreversible.

radiation geneticist William Russell, a colleague of Muller.

There's more: the focus of Muller's research – fruit flies – may share many fundamental genetic and biological characteristics with other organisms, but they're certainly not humans. At the end of the Second World War, as America entered a protracted nuclear race with the Soviet Union, it needed a clearer picture of the possible genetic effects of radiation on humans. However, the American human-population geneticist, James V Neel, published research showing no significant increase in birth defects or other genetic damage in the offspring of Japanese survivors of the Hiroshima and Nagasaki bombs, effectively challenging Muller's risk assessment interpretations. Muller, nonetheless, used his influence to prevent Neel's study from being reviewed by the 1956 US National Academy of Sciences (NAS) genetics panel that was charged to assess potential human health effects from radiation exposures, especially at low doses. Instead, Muller used his positions on various panels guiding US government and international policies on the biological effects of nuclear radiation to promote his burgeoning LNT Model for cancer risk assessment.

THE RUSSELLS AND THE MICE

Other highly significant players in this scientific drama are William L Russell, a geneticist and radiation biologist who worked at Oak Ridge National Laboratory, part of the US Atomic Energy Commission, from the 1940s through 1990s, and his wife and fellow geneticist, Liane. The Russells attracted generous government funding to investigate the genetic effects of radiation exposure on mice, specifically focusing on the inheritance of mutations caused by massive doses and dose-rates of radiation. Their published research helped support Muller's LNT model and its adoption by central scientific and regulatory advisory committees. However, according to Calabrese, the Russells failed to report numerous control-group mutations which lead to a gross overestimate of hereditary risk. This failure ultimately influenced the US NAS to formally adopt the LNT model for hereditary risk in 1956 and cancer risks in 1972.

Another serious deception by William Russell has been recently revealed. In a major study ending in 1959, William Russell exposed male mice to a very high (near life-threatening) acute dose of radiation while observing health and longevity in the offspring. He concluded that the offspring of the mice exposed to this extremely high dose of radiation didn't experience any adverse effects. This outcome challenged the LNT model that predicts low-dose radiation would lead to negative findings in offspring. Despite the obvious importance of this finding, Russell did not publish his data for over thirty years until 1993, in order to help win a court case for the British nuclear industry, by which time Muller's LNT Model was considered untouchable. Russell's written reason for not publishing his findings was '*It was, therefore, something of a surprise not to obtain a positive result in the experiment described here, and it was feared that publication of a negative finding could mislead the public into a false feeling of safety.*'

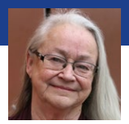
A FLAWED PERSPECTIVE

Hermann J Muller and William and Liane Russell are just a few of the players in the illuminating HPS interviews with Calabrese that come to light as having shaped our understanding of heredity and cancer risk assessment. There are many others, and in the interviews, drawing on the vast trove of correspondence between them and other original documentation, Calabrese untangles the web of decisions and consequences he believes hampered scientific progress and regulatory agency public health and cancer risk assessment policies.

As the HPS stresses, generations of radiation geneticists, health physicists, nuclear engineers, and others have been incorrectly brought up to accept the LNT Model as an unshiftable keystone of their discipline and to believe all genetic damage is cumulative, irreparable, and irreversible. The HPS says this flawed perspective transformed the field of radiation protection and, in their words, 'created a vehicle for an ideology that has influenced government policies, educational messages, research agendas, technologies, social programmes, individual lifestyle decision-making and, of course, cancer risk assessment'.

Behind the Research

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Health Physics Society

Research Objectives

Leadership within the Health Physics Society is encouraging an urgent review of the Linear No-Threshold (LNT) model since it adversely impacts society, from national policy to the individual.

Detail

Bio

CAPT (Ret.) **John J Cardarelli II**, PhD was the President of the Health Physics Society (2021–2023). He is certified in health physics and industrial hygiene and holds a Professional Engineering License (nuclear specialty). He authored several book chapters, publications, and technical reports and produced several video documentaries on radiation.

Dr Edward J Calabrese is a professor of toxicology within the Department of Environmental Health Sciences, School of Public Health and Health Sciences, University of Massachusetts Amherst. He is the author of over 1,000 peer-reviewed papers and numerous books on toxicology and risk assessment.

Brett Burk is the Executive Director for the Health Physics Society.

Barbara Hamrick is a certified health physicist and RSO at UCI Health in Orange, California. She is a past president of the HPS and spent 20 years working for regulatory agencies at the federal, state and local levels. She holds a BS and MS in physics and a law degree.

Dan Sowers is a certified health physicist and currently serves as the RSO for the Defence Threat Reduction Agency. He serves on a variety of committees and working groups within the diverse world of Health Physics, is a published author, and holds an MS from Purdue University.

Funding
The Health Physics Society

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Personal Response

Considering what you've uncovered, you wish to reframe the conversation around low-dose models; what would you like to see happen next?

"This history should be formally acknowledged by the international and national radiation protection communities. The radiation cancer risk assessment methods should be based on current understandings of how biological systems (including humans) respond to low doses of radiation (where most humans live) and not based on a public-health LNT-based precautionary principle."

HPS Specialists in Radiation Protection