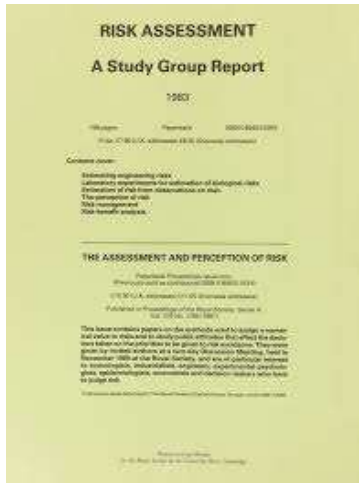
Educating about radiation risks in high schools: towards improved public understanding of the complexity of low dose radiation health effects

What is risk?



1983. Risk assessment / report of a Royal Society Study Group. Royal Society (Great Britain)

The report states:
We must distinguish between ***objective risk*** – the sort of thing that experts know about, and ***perceived risk*** – the lay person´s often very different anticipation of future events.

How is risk defined:
Risk is the probability that a particular adverse event occurs during a stated period of time. As a probability in the sense of statistical theory, risk obeys all the formal laws of combining probabilities.

What is detriment:
A numerical measure of the expected harm or loss associated with an adverse event. It is generally the integrated product of risk and harm and is often expressed in terms such as €, loss in expected years of life or loss of productivity. Detriment is needed for numerical exercises such as cost-benefit analysis or risk-benefit analysis.

The risk matrix

LIKELIHOOD	IMPACT			
Very High (4)	4	8	12	16
High (3)	3	6	9	12
Medium (2)	2	4	6	8
Low (1)	1	2	3	4
	Low (1)	Medium (2)	High (3)	Very High (4)

Risk = probablity x consequence

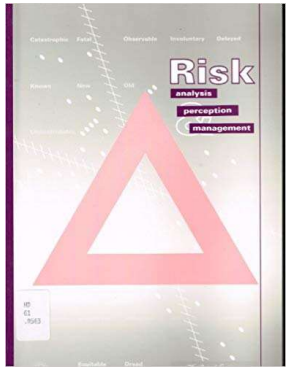
What is risk?

According to cultural theories of risk:

Culture, as a set of values and meanings, impacts on how humans perceive risk. The values shape our perception of what constitute the biggest potential dangers and form the basis for our reasoning about the solution.

Ackowledgement: Jack Valentin

What is risk?



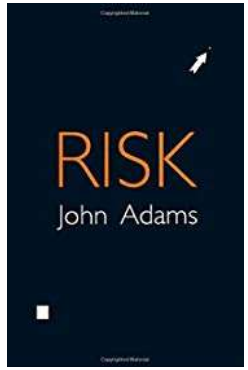
1992. Risk: Analysis, Perception and Management - Report of a Royal Society Study Group (not of the Society!)
Disclaimer: the views expressed are those of the authors alone

What happened?

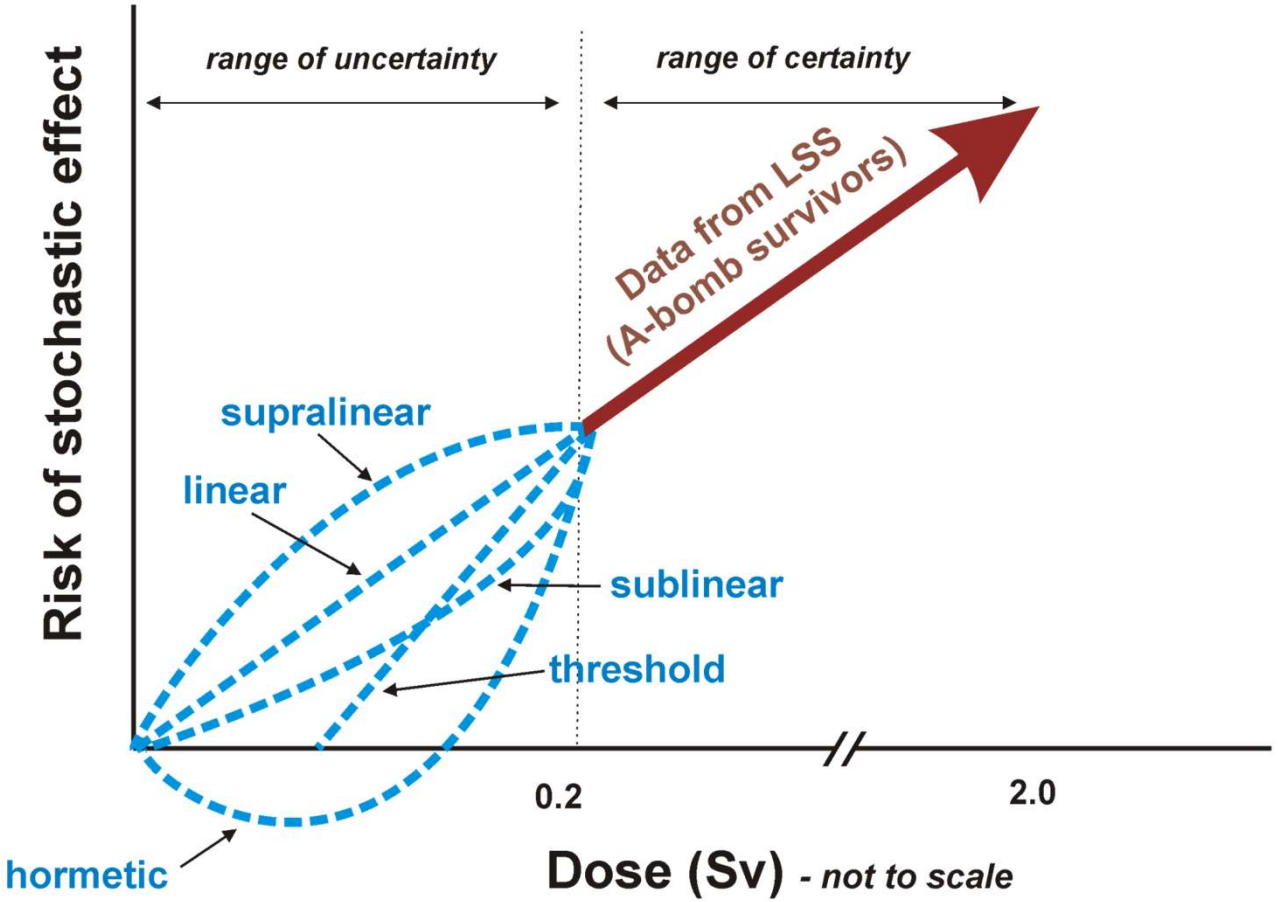
For their 1992 report the Society invited a group of **social scientists** – psychologists, anthropologists, sociologists, economists and geographers. The social scientists, with the exception of the economists, could not agree with the physical scientists of the Royal Society about the meaning of risk.

The 1992 report states that:
The view that a separation can be maintained between objective risk and subjective or perceived risk has come under increasing attack, to the extent that it is no longer a mainstream position.

More information:

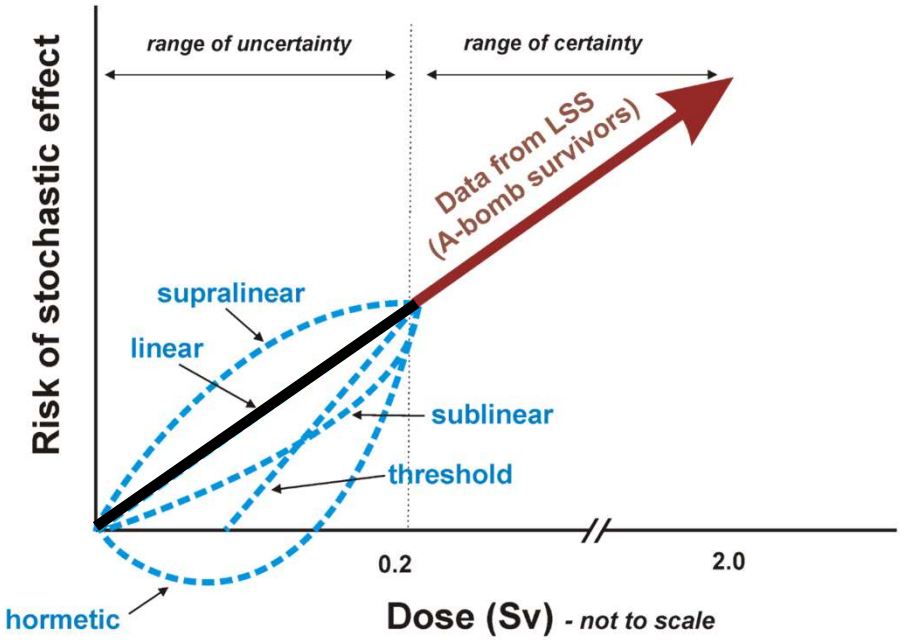


The radiological protection dilemma: what are the health effects of low dose exposure?

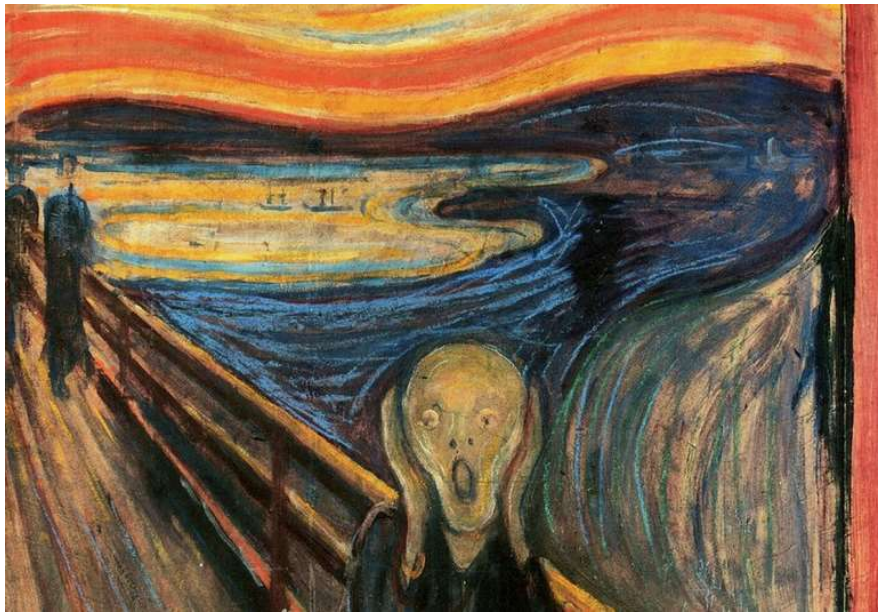


The LNT approach as used in radiological protecton

The LNT approach is based on the prudent assumption that there does not exist a “safe” dose of ionizing radiation and that this approach does not underestimate the level of risk (ICRP 9, 1965)



But if there is no safe dose of radiation…



Fear of radiation can have serious societal effects such as pregnancy terminations after the Chernobyl accident or phasing out of NPP in Europe following the Fukushima Daiichi accident in 2011.

What solutions are suggested to reduce of even eliminate the fear of radiation?

Introduce a dose threshold

Epidemiology Without Biology: False Paradigms, Unfounded Assumptions, and Specious Statistics in Radiation Science.
Bill Sack et al.
Biol Theory (2016) 11:69–101

Belief in LNT leads to **mass radiophobia** and harmful outcomes, including forced relocations of populations near nuclear power plant accidents, reluctance to avail oneself of needed medical imaging studies, and aversion to nuclear energy — all unwarranted and all harmful to millions of people.

Improve scientific knowledge of low dose risks

Multidisciplinary European low dose initiative: an update of the MELODI Program.
Sisko Salomaa et al.
IJRB 10, 1035–1039, 2017

Judgements on radiation protection standards are highly dependent upon scientific knowledge. Although current radiation protection standards are generally judged to be acceptably robust there remains considerable scientific uncertainty particularly with regard to health risks at low doses and/or low-dose rates. Consequent upon these uncertainties, the issue of low-dose risk is controversial in both scientific and political circles.

Educate experts in radiation protection research

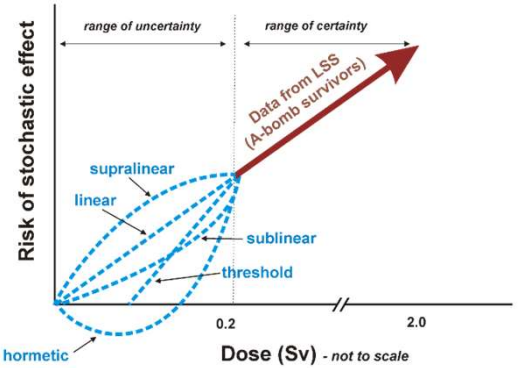
Education and training to support radiation protection research in Europe: the DoReMi experience.
Andrea Ottolenghi et al.
IJRB, 2018

To obtain reliable radiation risk estimates requires studies over many years, even decades, employing a wide range of scientific disciplines. This long-term broadscope process requires resources of knowledge, skills, and expertise that calls for a strategic program of education and training specifically designed to ensure a continuing influx of new top-level students into the needed scientific areas.

All three suggested strategies are based on the assumption that the public will rely on expert judgement of scientists, who "know the truth"

But: scientists make mistakes in their judgments. This is not surprising because uncertainty is inherent to scientific knowledge. It is unlikely that radiation researchers will ever agree on the shape of the dose response curve and on the precise level of risk at low radiation doses.

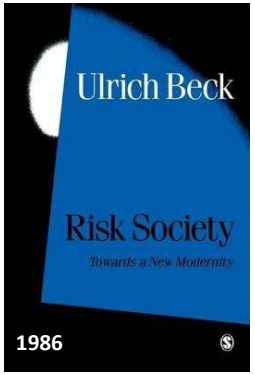
Wrong predictions lead to loss of confidence in expert judgments.



An example from the radiation research field

Wrong prediction regarding behaviour of ^{137}Cs in Wales and Cumbria following the Chernobyl accident in 1986. Based on results of previous experiments, scientists predicted that the impact on livestock of ^{137}Cs, which rained down following the accident, would be negligible because the radionuclide would be bound by the soil. This prediction was wrong, as the isotope was taken up by grass and subsequently eaten by the grazing sheep leading to contamination levels above the permissible limits.

Radiation risks are part of risks inherent to modern, technologically advanced society



A major problem of the modern, technologically advanced society is exposure of its members to global risks which are produced by the society itself. The advanced degree and complexity of technologies, as well as the often invisible nature of threats make them difficult to perceive, understand and predict. Also, “risk” has many aspects including psychological and cultural elements. A facette of risk society is the changing role of experts (scientists) and laymen (public).

Traditional way

The expert acts as an authoritative figure giving orders to the submissive layman who does not question the decision.

Modern way

The expert involves the layman in decision making by explaining the options and asking „what do you think“. Laymen must be educated to cope with this situation.

RiskEdu

How can teachers support the development of scientific literacy through teaching about risk and risk-assessment?

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What is RISKEDU?

RISKEDU is a three year project with the aim to generate knowledge about how science teaching can support the development of high-school students' competency in making decisions based on informed risk assessment in societal issues involving exposure to threats associated with modern technologies, such as ionizing radiation from nuclear power plants, electromagnetic fields from wireless telecommunication or the rapidly growing field of biotechnology.

RISKEDU is a collaborative project involving the following institutions from the Stockholm area:

Stockholm University

Royal Institute of Technology (KTH)

Blackeberg Gymnasium

Tumba Gymnasium

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4: Department of Mathematics and Science Education, Stockholm University, Sweden

5: Tumba Gymnasium, Botkyrka kommun, Sweden

6: Blackeberg Gymnasium, Stockholm, Sweden

***: Karim Hamza is the coordinator of RISKEDU**

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01.07.2015 - 30.06.2018

SKOL FORSKNINGS INSTITUTET

01.01.2018 - 31.12.2020

The aim of RISKEDU is not to educate high-school students about radiation risk facts.

It is to support the development their competency in making decisions based on informed risk assessment in societal issues involving exposure to threats associated with modern technologies. For example to ionising radiation.

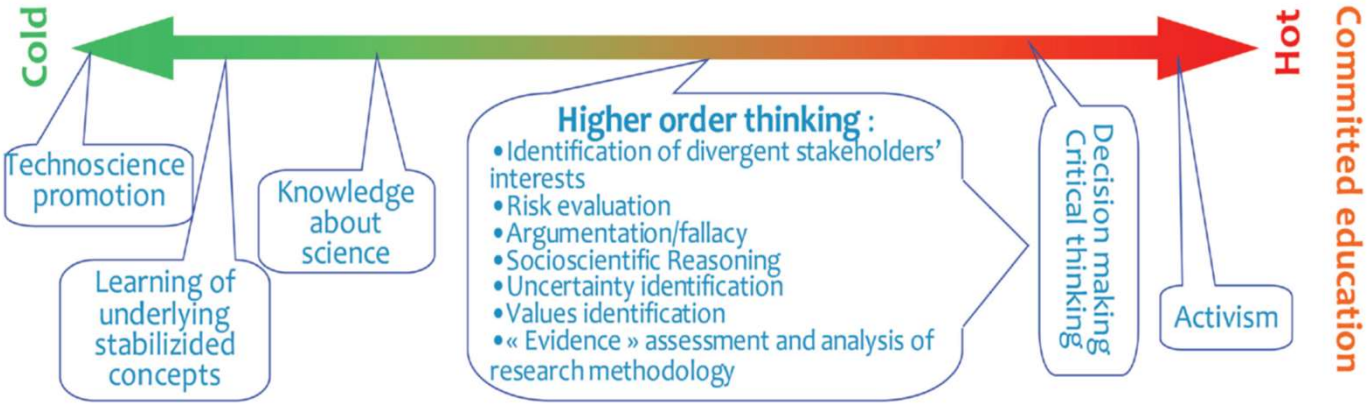
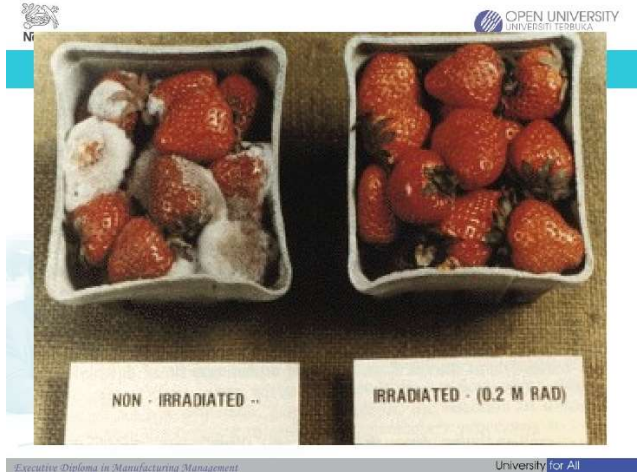


Figure 1. Variety of stakes in the teaching of SSIs

Simonneaux, L., Panissal, N., & Brossais, E. (2011) Students' Perception of Risk About Nanotechnology after an SAQ teaching strategy, IJSE, 35:14, 2376-2406

Example 1. Should strawberries be irradiated?



Irradiation of fresh food products (like strawberries) for the purpose of preserving their shelf life is prohibited in Sweden. So is the import of irradiated food, with the exception of spices.

Find answers to the following questions:

- Is this decision based on scientific evidence demonstrating a devastating effect of radiation on food quality?
- Do the food products become radioactive and is their consumption dangerous?
- Why is irradiation of food allowed in Belgium but not in Sweden?
- What alternative methods exist to preserve shelf life and how do they impact food quality?
- Is it better not to preserve products and take the risk of bacterial poisoning?

The unit ended with a consensus agreement that radiation is an optimal method of preserving the shelf life of food products and, consequently, that it should be permitted in Sweden.

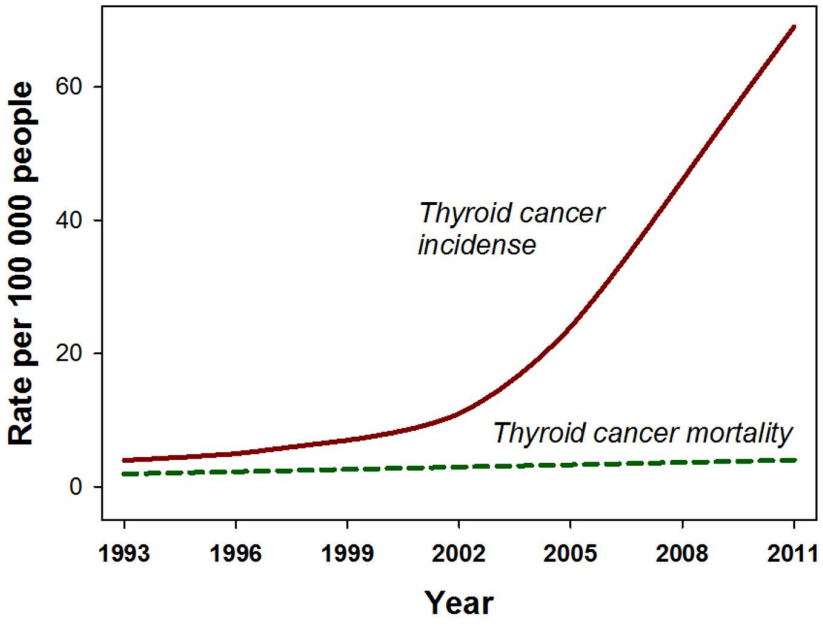
Example 2. To screen or not to screen?

Following the Fukushima Daiichi NPP, the government of the Fukushima prefecture decided to introduce a prefecture-wide screening action to detect early stages of thyroid cancer. The outcome was dramatic in that it revealed a strong increase in cancer incidence which was interpreted by some experts as evidence for stronger than hitherto assumed carcinogenic potential of radiation, while others claimed that it is due to screening. Who is right?

The action left the parents with the burning question of what they should do with a positive diagnosis.

What is more harmful: uncertaintly about whether I will develop radiation-induced thyroid cancer (low risk) or overdiagnosis (high risk)?

Incidence and mortality due to thyroid cancer in South Korea after introducing the program of general screening in 1991



The RISKEDU team preparing education material…