

# **Radiation and Reason**

## **The Road to Public Confidence in Nuclear Energy**

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Accessible article posted by World Nuclear Association  
<http://www.world-nuclear.org/publications/personalperspectives.html>

Books & other downloads <http://www.radiationandreason.com>

World Nuclear Power Briefing, Warsaw  
11 Dec 2012

# What is needed, simply

Public confidence in nuclear technology is very poor.

All those responsible need to ensure that they themselves understand the broad interdisciplinary picture that should inform the public. Appeals to experts should be minimised.

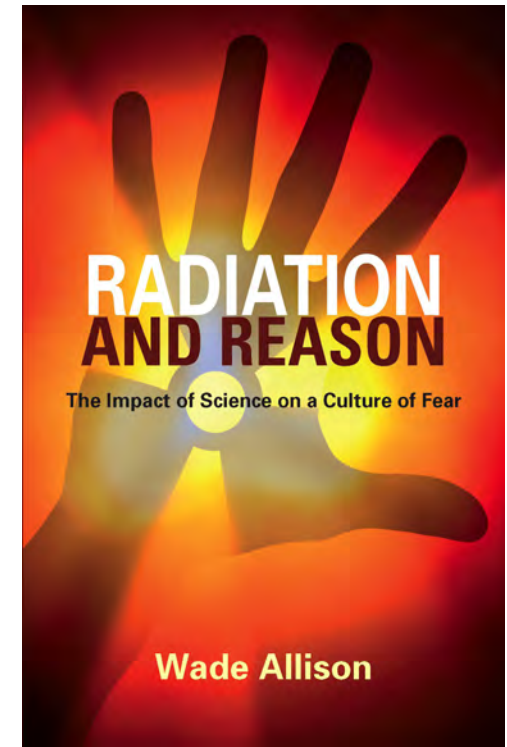
Communication with the public needs to be frank and honest, making explanations simple and abandoning the paternalistic and exaggerated attitude to safety inherited from the Cold War, a time when fear was intended

Education needs to come through figures of authority to re-establish trust in the use of science – symbolically Marie Curie, Charles Darwin, Florence Nightingale, Adam Smith – in practice the medical profession, school teachers and academics who can educate and explain simply, and whose impartiality is least in doubt

**Marie  
Sklodowska  
Curie,  
physicist,  
chemist,  
radiologist**



*“Nothing in life is to be feared. It is to be understood.”*



## **1. What happened at Fukushima?**

2. Why have there been so few casualties?

3. How dangerous is radiation?

4. Why are many frightened of nuclear power?

**Fukushima** (2011): reactors destroyed  
but no known radiation casualties, none likely

**Windscale** (1957): same

**Three Mile Island** (1979): same

**Chernobyl** (1986) 28 ARS deaths + 15 thyroid cancers,  
only

**Goiania** (1987) Children playing with redundant medical  
source 50.9 TBq Cs-137.

[1 million million glasses of “radioactive” water!]

250 people exposed, 7 with whole body > 4 Sv.

BUT only 4 ARS deaths, 28 burns treated.

No reported cancer.

**Problem 1: Why is life so unexpectedly resilient to radiation.**

# Food Regulation after Fukushima

July 2011. Regulation set at less than 500 Bq/kg

Eating 1 kg of such food gives 0.008 mSv dose over 3 months. [simple calculation agrees with Government]

Eating 1000 kg (1 tonne) gives 8 mSv dose over 3 months.

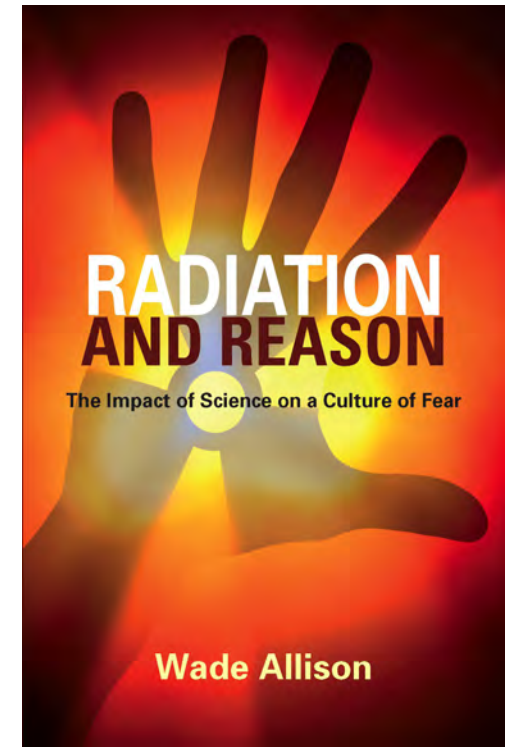
8 mSv is 1 CT scan, harmless. Regulation unrealistic!

[Note the 50 million million Bq Goiania source, also Cs-137]

**BUT** April 2012 regulation tightened to 100 Bq/kg,  
Then eating 5 tonnes equivalent to 1 CT scan!

**Problem 2: “Safety” is being applied at quite absurd levels to appease public fears, but it is not effective at that**

Charles Darwin,  
naturalist



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**Biology** its only business is protecting and stabilising life against attack a) from other biological agents and b) from physical/chemical agents.

Other biological agents, incl. disease, change with time and protection often fails (to the benefit of the agent) .

Physical/chemical agents do not change their form.

In 400 million years of evolution,  
first of plants, then of animals, latterly of man,  
Biology has established many stabilising features that protect life (DNA/cells/individuals) against chemical and radiation attack.

These fail infrequently, and many are well understood today.  
Their existence contradicts the simplistic Linear-No-Threshold safety model currently in use.

# Natural stabilisation of life, examples

## By design

- A complete DNA copy kept in every cell
- Scheduled cell cycle to replace cells
- Scheduled birth-life-death cycle to replace individuals

## By active response

- Anti oxidants remove active chemical radicals from cells
- Enzymes repair DNA breaks
- Planned death of foreign cells, and more.....

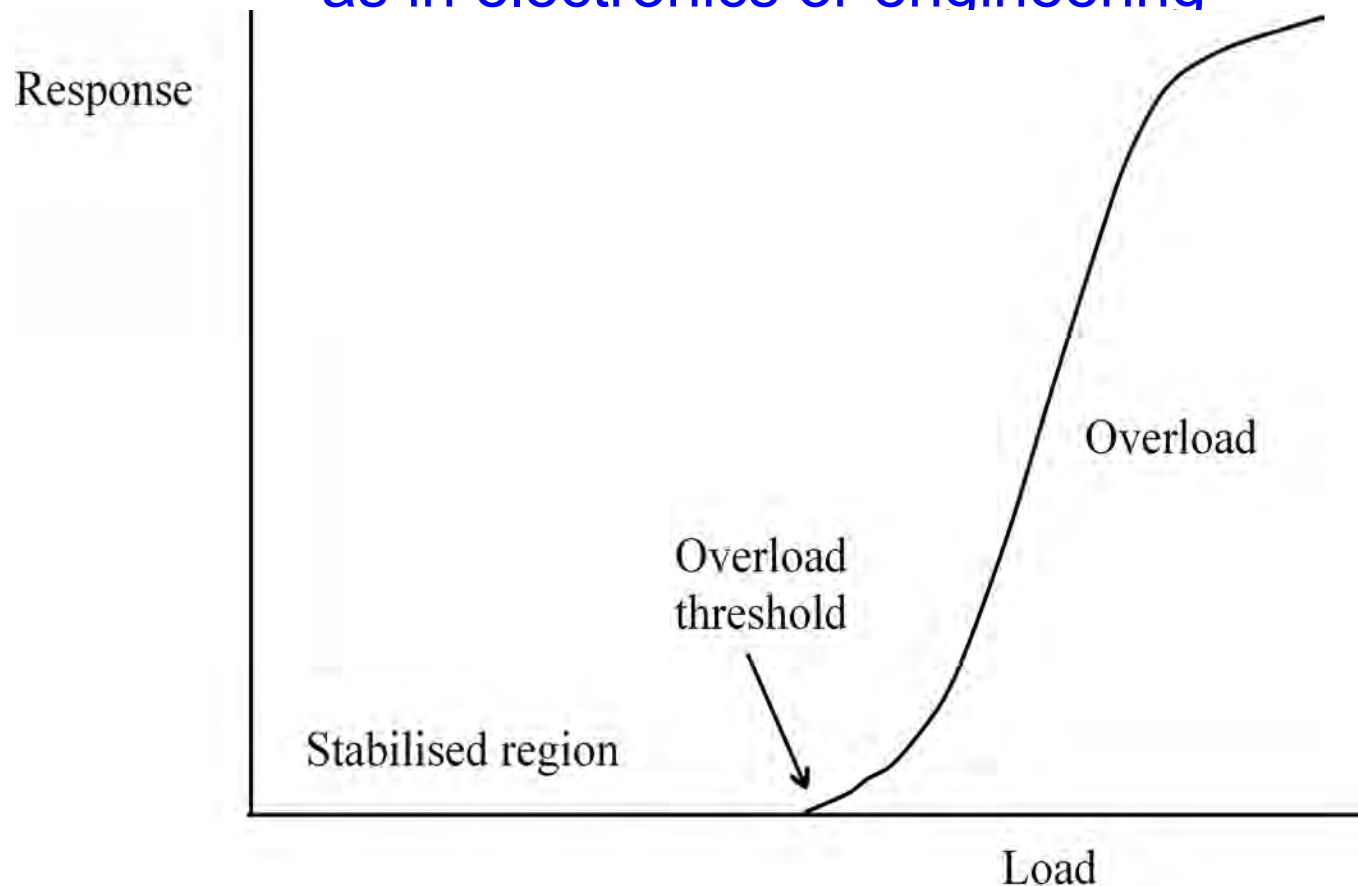
## By adaption (“hormesis”)

- Supplies of anti oxidants, enzymes, etc stimulated by history of attacks.



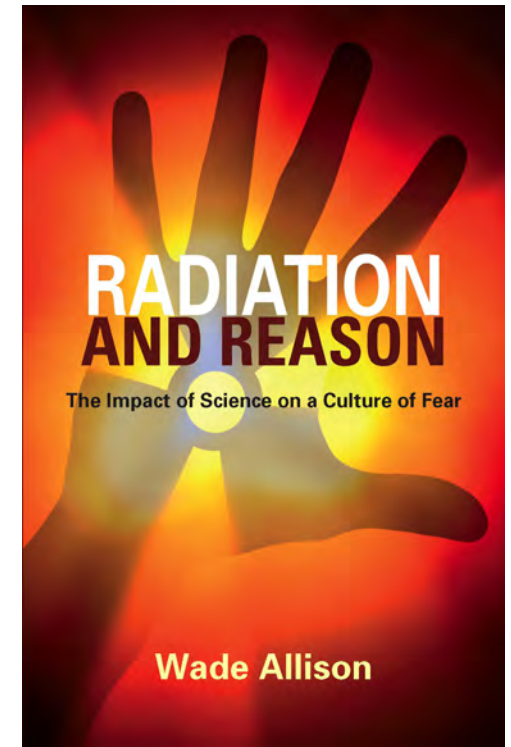
# An ideal stabilised system...

as in electronics or engineering



1. below a certain **failure threshold** stabilisation is successful
2. stabilisation takes a certain **repair time** or feedback time
3. any load/attack within that time builds and can reach overload
4. at longer times there is no memory of past effects, ideally
5. practical protection is achieved with many such systems

Florence  
Nightingale,  
pioneer  
nurse and  
statistician



*“How very little can be done under the spirit of fear”*

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# Failure modes and thresholds

**Data sources** - statistically unambiguous and uncontroversial

<b>Failure mode</b>	<b>Cell cycle failure, ARS</b>	<b>DNA errors, cancer</b>
<b>Acute</b> dose, mSv	Chernobyl firefighters	Hiroshima/Nagasaki
<b>Chronic</b> dose, mSv/month	Radiotherapy	Dial painters & radiotherapy

**Thresholds** found (Not precise, just getting factors of 10 correct)

<b>Failure mode</b>	<b>Cell death, ARS</b>	<b>Measurable cancer</b>
Acute dose, mSv	2000 mSv	100 mSv
Chronic dose, mSv/month	20,000 mSv per month	100 mSv per month

# Public trust in ionising radiation

Good reason to trust use of radiation in **medicine**  
modest **single** dose (5-10 mSv) in a scan.

## A recent public poster

# PET/CT がんどック

### PET/CT検査とは、

「がん細胞が正常な細胞に比べて多くのブドウ糖を取り込む」という性質に着目した検査です。

この検査では、一度の撮影でほぼ全身をみることができ、PET単独検査に比べて診断精度が格段に向上した「がん画像診断法」です。



### 料金

94,500円

※出雲市では、2万円を補助する制度があります。

対象者：40歳以上の出雲市民

実施期間：平成23年4月1日～24年3月31日

詳細は健康増進課までお問い合わせください。

### 実施日

毎週月曜日～金曜日

(但し祝日・年末年始は除く)

### 診療の流れ

#### 絶食



検査の6時間以上前から絶食にしてください。ただし、糖分を含まない飲み物（お茶、お水）は飲んでもかまいません。

#### FDGの注射



FDGを注射します。

#### 安静



薬剤が全身にいきわたるまで、約1時間安静にします。

#### 撮影



排尿後、PET/CTカメラの下で約30分安静にし、撮影します。

#### 診断



専門の医師がPET/CT画像を読影し、総合的に診断します。

### PET/CT検査に関するQ&A

**Q** 糖尿病でも、検査を受けられますか？

**A** 糖尿病など血糖値が高い方の場合、FDGが筋肉や脂肪へ集積しやすい傾向にあるため、がんへのFDGの集積が低下します。そのため診断精度が下がる場合があります。PET/CT検査が実施できるかどうかについては、かかりつけの医師にご相談ください。

**Q** 妊娠中や妊娠の可能性のある場合は検査を受けられないのですか？

**A** FDGは、微量の放射性物質を含んでいますので、妊娠中や、妊娠の可能性のある方は必ずかかりつけの医師にご相談ください。

**Q** PET/CT検査なら、どんな種類のがんも見つけられるのでしょうか？

**A** 臓器や部位によっては、発見しにくいがんがあることもご了承ください。FDGは尿中へ排泄されるため、腎臓や膀胱などががんも発見しにくい場合があります。

#### 発見しにくいがん

膀胱・尿管の癌  
腎臓癌  
肝細胞癌  
胃癌  
前立腺癌  
(すべての臓器の)微小ながんなど

**Q** PET/CT検査は入院が必要なのでしょうか？

**A** FDGを注射してから撮影終了まで、5時間程度ですので、入院の必要はありません。

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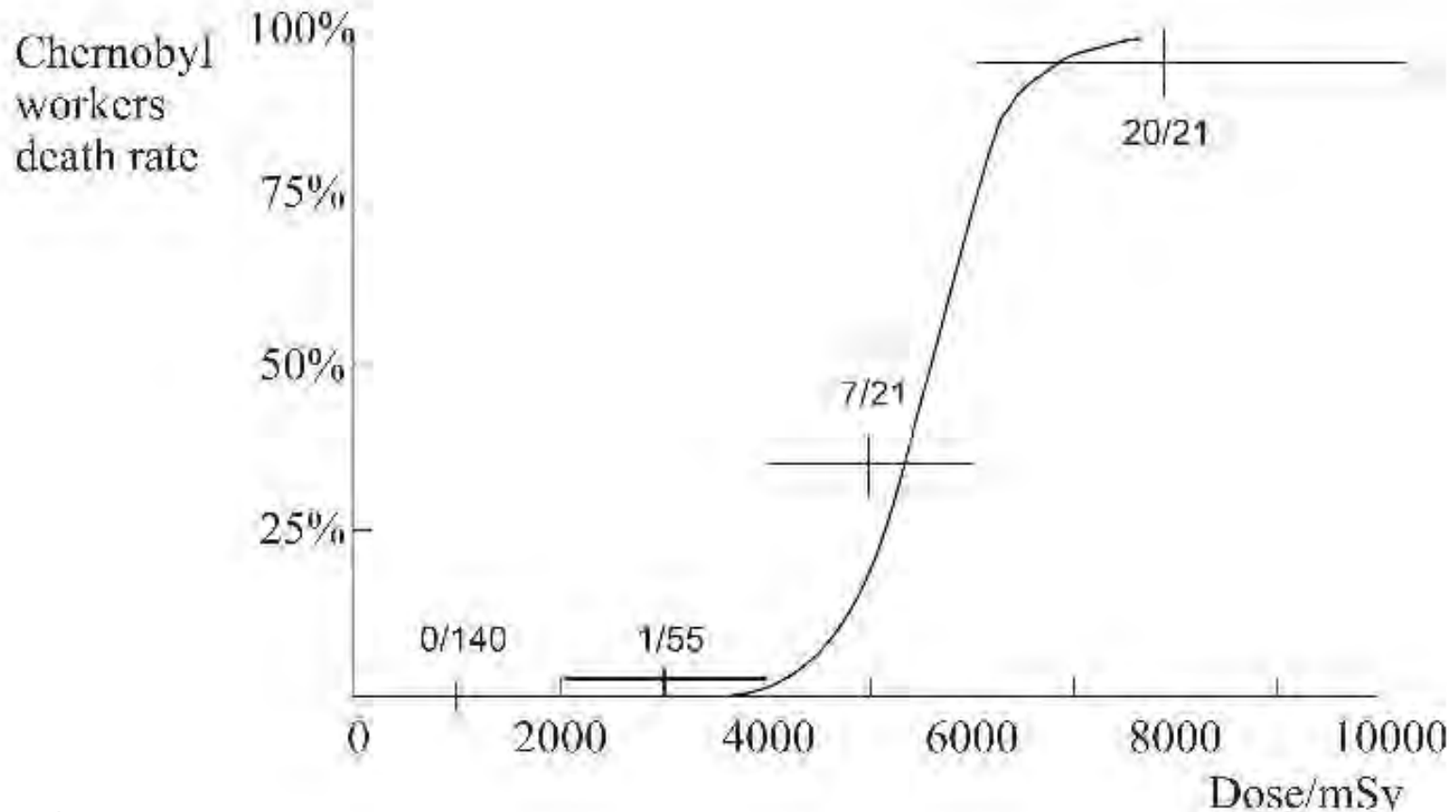
Multiple high doses (2000 mSv **daily**) to kill tumour cells,  
radiotherapy

Mortality threshold at Chernobyl, **single** 4000 mSv whole-body

# Chernobyl early firefighters

Crosses show mortality (curve is for rats).

Numbers show the number who died/total in each dose range.



4,000 mSv threshold

Above 27/42 died of ARS in 2/3 weeks, not cancer.

Below 1/195 died.

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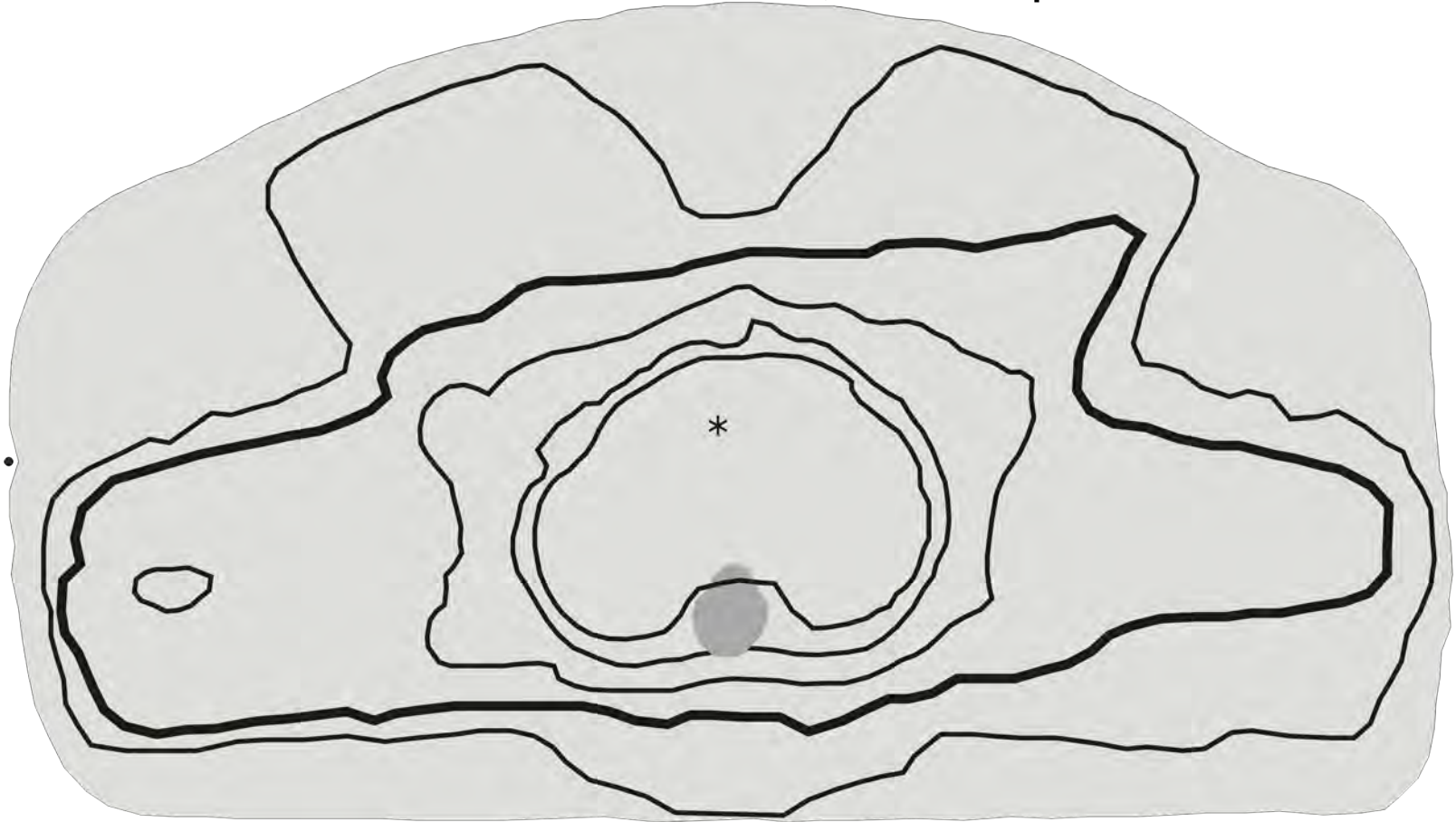
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In radiotherapy healthy tissue receives 1000 mSv **daily**, total  
more than 20,000 mSv in a **month** (about 5% risk of cancer).  
The public are thankful for this. It saves life, usually.  
At 100 mSv per **month** cancer risk would be 1/4000 or less.



**Radiotherapy dose contours** of a prostate cancer treatment. Section of lower abdomen perpendicular to the spine. Rectum shown shaded. Contours at 97, 90, 70, **50**, 30% of peak dose



[From an image by kind permission of Medical Physics and Clinical Engineering, Oxford Radcliffe NHS Trust.]

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A **single** flash dose at Hiroshima and Nagasaki, threshold of  
extra cancers in 50 years is 100 mSv

# Solid cancer deaths by dose range

Hiroshima and Nagasaki survivors, 1950-2000 (Preston et al., 2004)

Dose range mSv	survivor number	solid cancer actual	survivor deaths 1950-2000 expected	extra risk per 1000
less than 5	38507	4270	4282	-2.0 to 1.4
5 to 100	29960	3387	3313	0.0 to 3.5
100 to 200	5949	732	691	3.5 to 12.5
200 to 500	6380	815	736	9 to 18
500 to 1000	3426	483	378	25 to 37
1000 to 2000	1764	326	191	63 to 83
above 2000	625	114	56	72 to 108
all	86611	10127	9647	5.0 to 5.2

“expected” means the number of deaths predicted from those in other cities.

- Doses highlighted have risk compatible with zero, final column.

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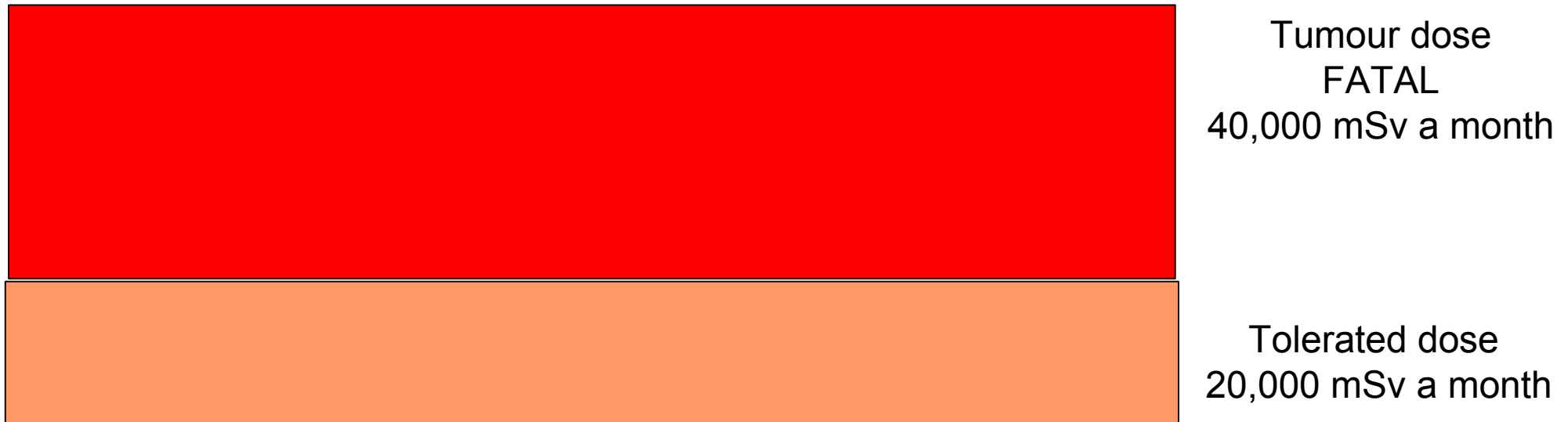
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\*\* Separate study shows a threshold for cancer at 100 mSv per  
**month, lifelong** dose rate. The Dial Painters...

# Monthly doses depicted as areas



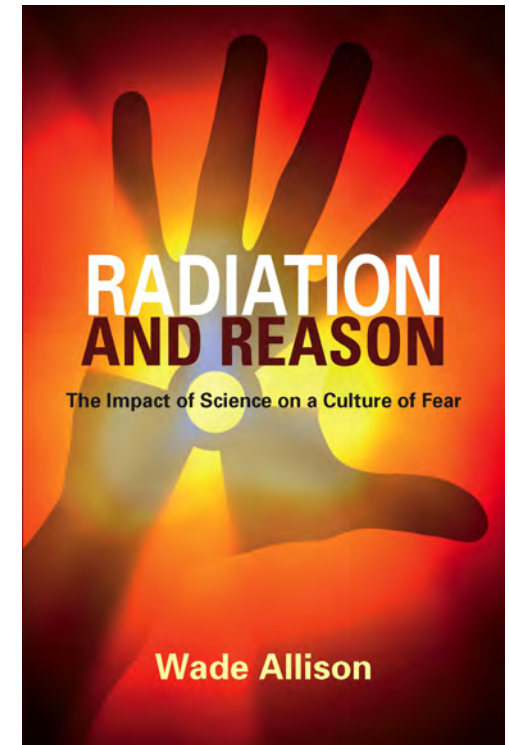
■ A conservative safe dose (AHARS). Less than Dial Painter threshold.  
100 mSv per month. [Also max 5000 mSv per lifetime, for the present]

→ Current public “safe” dose (ALARA), as considered at Fukushima  
0.1 mSv per month that is 1 mSv per year  
A small addition to natural background, average 0.2 mSv per month

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Safety levels As High As Relatively Safe (AHARS)  
would be a relaxation by *about* 1000 times compared to current  
As Low As Reasonably Achievable (ALARA) .

**Adam  
Smith,  
Economist**



*“Science is the great antidote to the poison  
of enthusiasm and superstition”*

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# Fear of radiation

## Superficial reasons

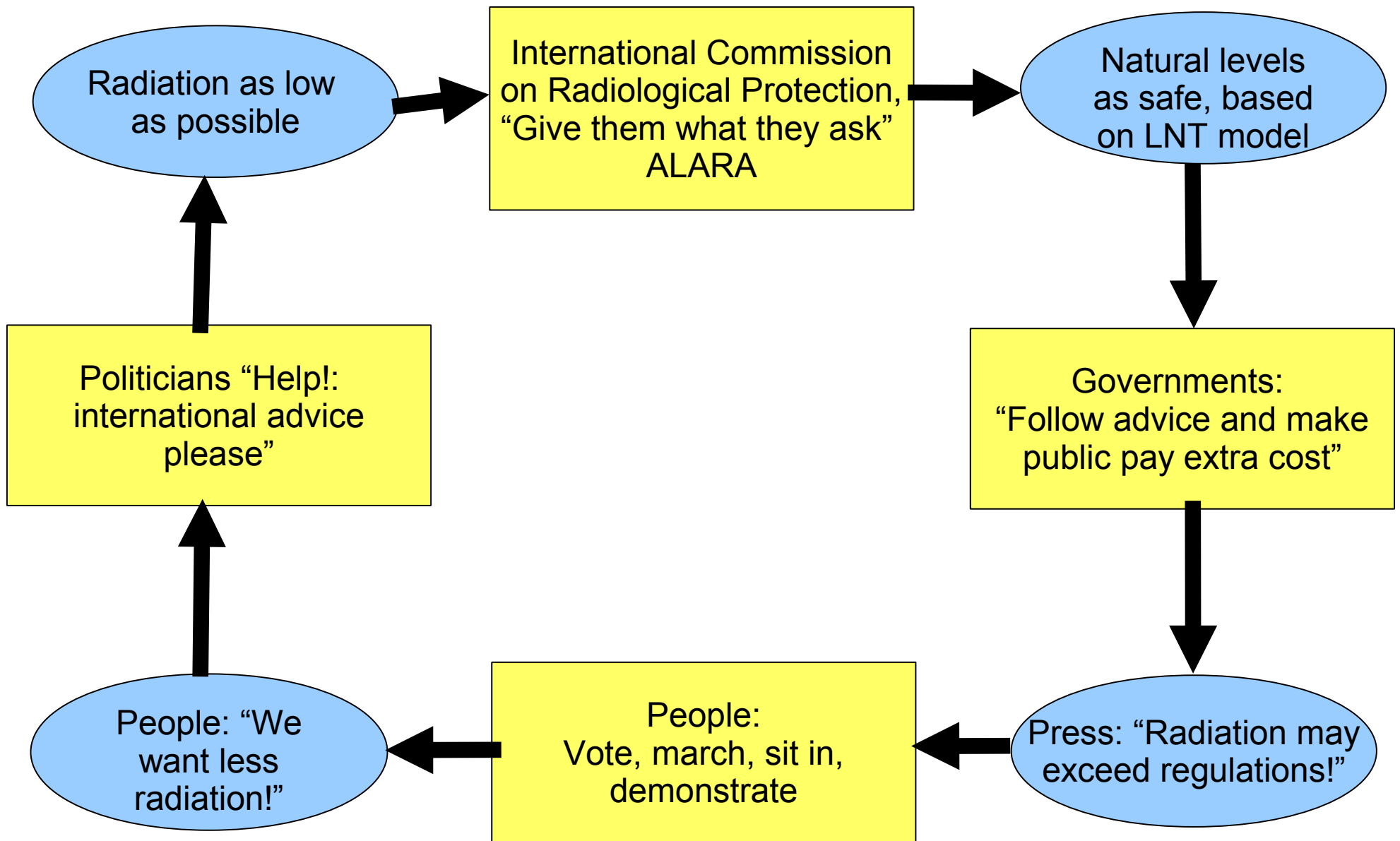
- a. Radiation fear symbol?
  - discard it
- b. INES scale, maximum 7 for Fukushima with no casualties?
  - discard it

## More substantial reasons

1. Fear of the aftermath of a nuclear holocaust.  
Effective Cold War message that frightened everybody at the time.
2. Cannot feel nuclear radiation! No problem
  - get a detector, like a smoke detector
  - better, the cells of your body can feel - repair the damage, too.
3. International regulations (ICRP) designed to appease public opinion, promising background levels, 1 mSv per year. Not a safety level!  
As Low As Reasonably Achievable (ALARA) Change the regulations



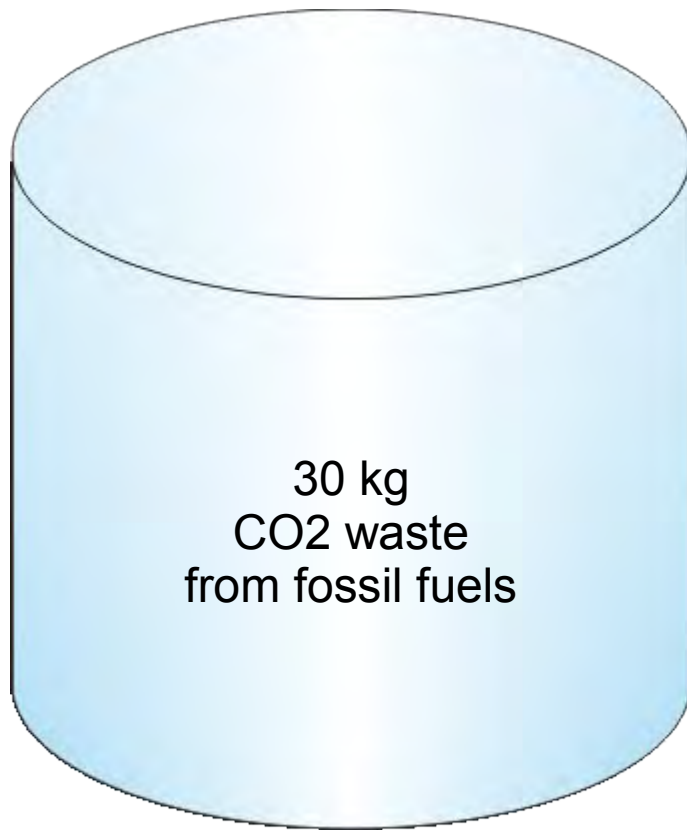
# Hysterical cycle of fear and ignorance, unrelated to safety





# Waste, including nuclear

*Canister volumes showing weight of waste per person per day (UK figures)*



1/4000 kg  
high level nuclear waste

Nuclear waste: solid, contained, recyclable, safe burial.  
No contagion without neutrons (in a working reactor).  
In 50 years 50 deaths

CO2 and burning:  
direct into the air driving climate change.  
Fire spread by contagion,  
a thermal chain reaction.  
Many thousands of deaths a year

Faeces and disease:  
direct into the environment (water).  
Disease spread by contagion/infection,  
a biological chain reaction. Millions of deaths a year

## **Solar UV radiation**

like nuclear gives cell death (sun burn).

And skin cancer is serious,  
3000 deaths a year in USA.

*A free plastic carrier bag from a high street pharmacy.*

Simple accessible advice to Mum and

Dad for the family. What a breath of fresh air!

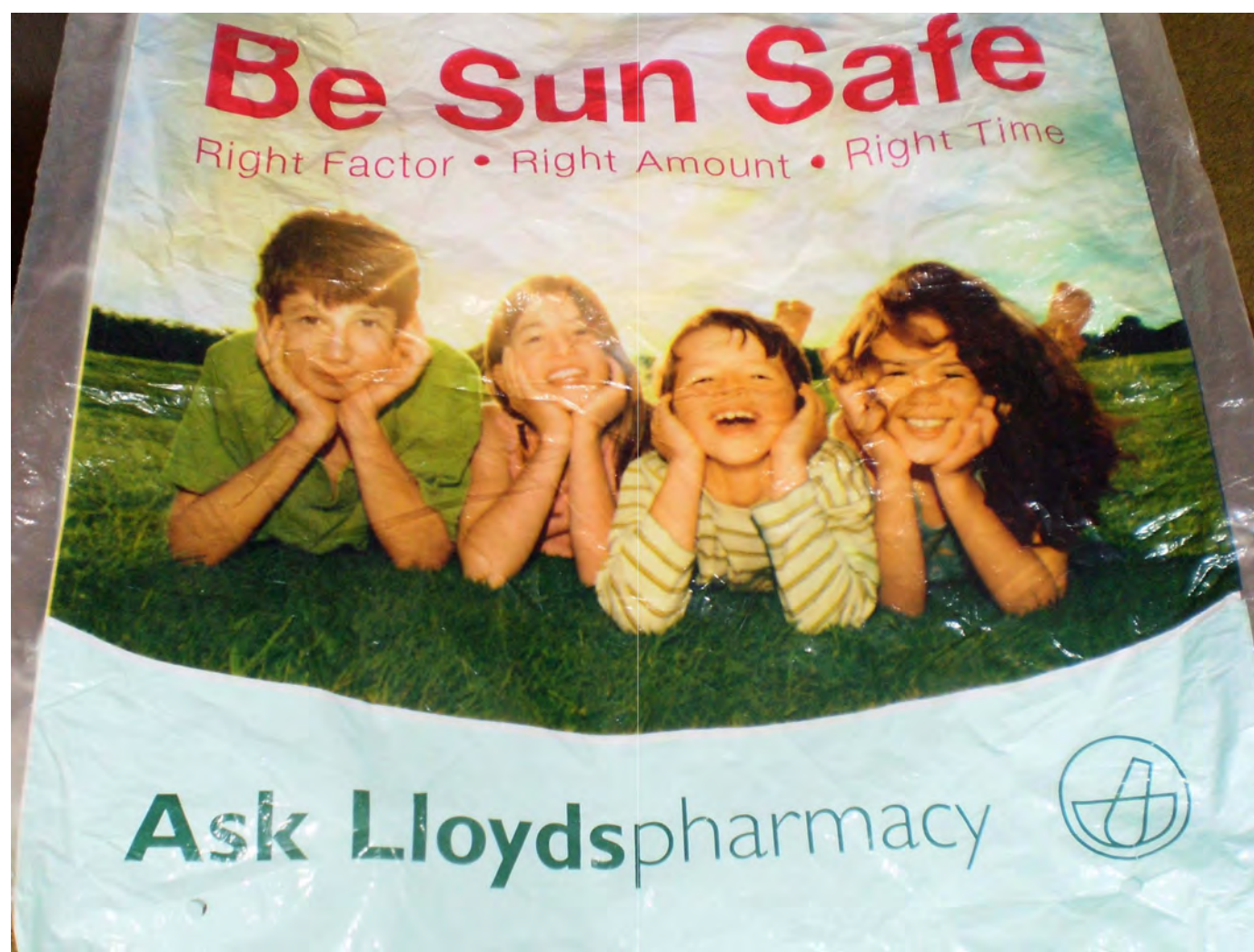
Engages with the joy of life and common sense, not unexplained safety regulations from an international committee.

**Nuclear confidence needs such simple education and personal responsibility too**

11 Dec 2012

World Nuclear Power Briefing, Warsaw

slide 26



# Take home messages

1. The world has completely misunderstood the dangers of “nuclear” and “radiation”, and world opinion is still paralysed by the **fear** of radiation inherited from the Cold War era
2. The problem is **trust**, both in nuclear and in society itself. This has been eroded by the demands of 24hr news and nuclear symbols and indices whose **only** effect is to excite fear.
3. The public already accepts radiation in medicine and trusts doctors. We should build on that with new **education**, separated from government interest in the nuclear industry
4. The safety of life (radiological safety) has been confused with control of reactors (reactor safety). A fresh **radiological safety** regime is urgently needed, based in modern science and with **substantially reduced nuclear costs**. Safety levels may be As High As Relatively Safe – these are quite different from present standards based on appeasing public concerns. They would open up **prosperity** and expansion, just as acceptance of motor vehicles did at the end of the 19th Century.
5. The new picture is rather **simple** to understand, as was the Copernican model of the heavens (see WNA article)

# Some reviews

*"If Professor Allison's well-documented arguments are right his book gives us a little more hope of confronting the problems posed by both dwindling fossil fuel reserves and the release of their waste products."* - **Michael Frayn, playwright and author**

**"Sensational" - Simon Jenkins, Guardian**

*"Why I'm becoming a pro-nuke nut.... The other scholar challenging my nuclear views is Wade Allison....(We must consider) nuclear energy, which just a few months ago I fervently opposed."*- **John Horgan, Scientific American**

*"The most comprehensible book for those who are really interested in learning, without prejudice, the truth about ionizing radiation and human health"* - **Otto on Amazon.com**

"Thank you for your excellent book. I studied a little physics in college many years ago and have sufficient knowledge to know when I am being conned. Your book strikes me as accurate and informative... clearly a seminal work.... Again thank you for a tremendous contribution to a very difficult topic." **Stephen Duval, a reader (from this Sunday's post bag)**