Risk, Uncertainty, Hormesis and Legislation

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What is Risk?

- The possibility of something bad happening

So

“Radiation risk”

Presupposes something bad will happen

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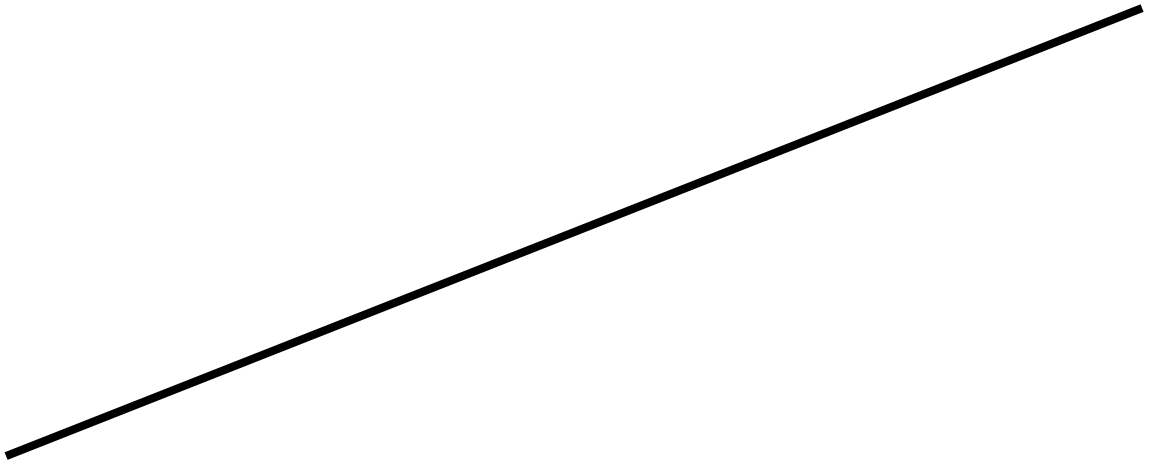
Collective dose

- The sum of the individual doses received in a given period by a population from exposure to a specified source of radiation

Fictional science



To low dose risk + multiply numbers = people dying from an X-ray

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So

- Risk as a concept cannot be good
- But risk ≠ harm
- As radiation may have beneficial effects a new concept is needed [interaction probability???]

Uncertainty

- Uncertain means “not known or fixed” or “not completely certain”

Danger of psychological certainty

"It's not what we don't know that gets us into trouble but what we know that ain't so"

Mark Twain

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What we don’t know is a lot!

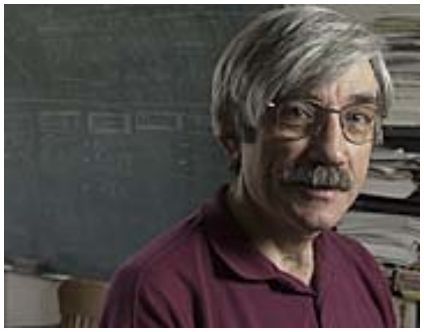
The universe is made up mostly of dark matter and dark energy and we don’t know what either of them is

We don’t know a lot about the mechanisms of low level radiation effects

And we know even less about the combination effects of radiation and chemicals

Within cells

The shear complexity of cells makes chaos theory attractive



Chaos

The sensitivity of the system is dependent on initial conditions

Some order can emerge through bifurcation points

As an example Ed acts as a strange attractor for hormesis and imposes some order on the field

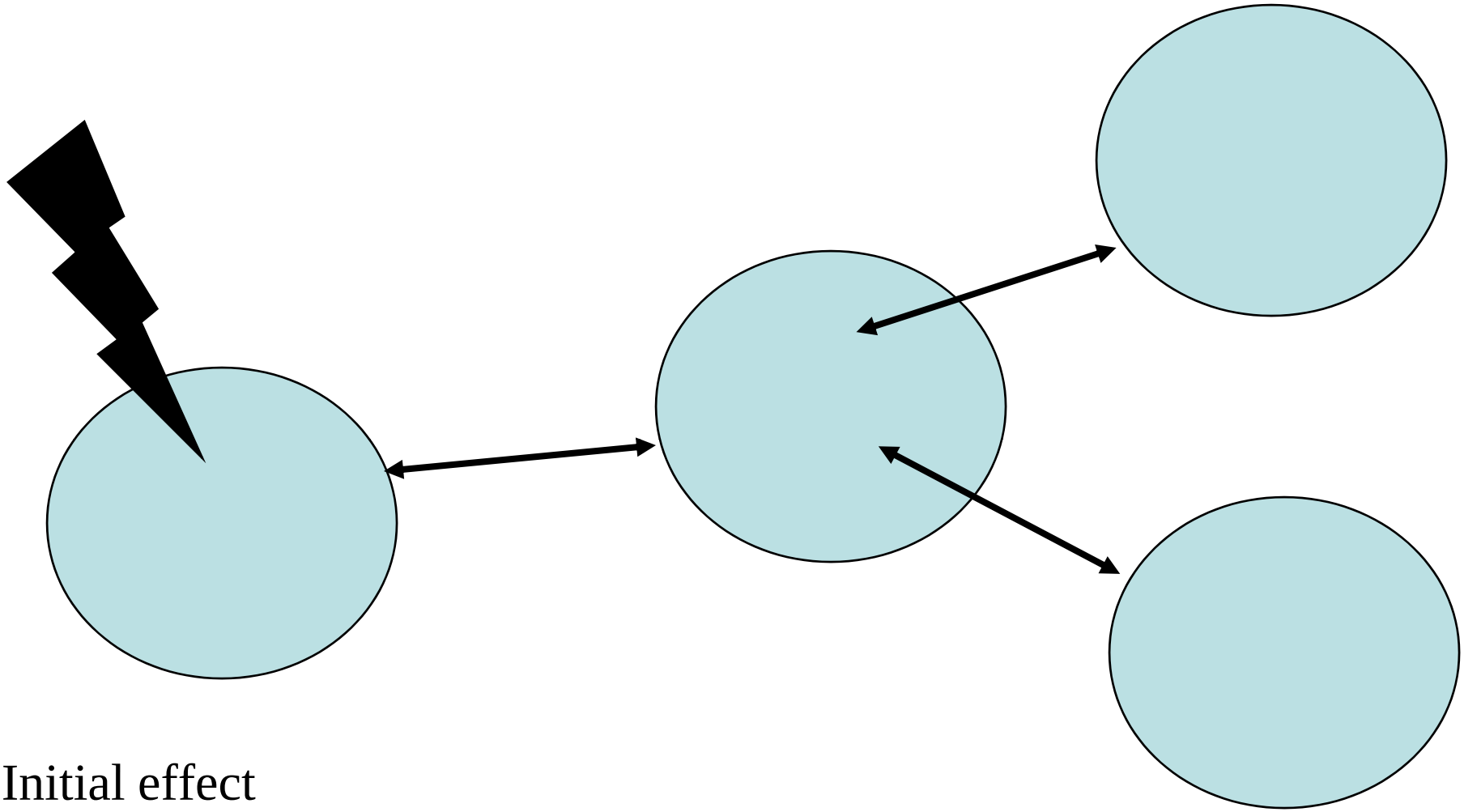
At low doses - what determines the radiation response?

- If initial system sensitivity is important, then the chemical reactions in the free radical field occur in femtoseconds. During a 1second irradiation $1X10^{14}$ [an awfully big number] reactions could occur, and each reaction would change the state of the cell and theoretically allow a different response.

But!

- Suppose surrounding cells determine the response……?

- And then there are feed-back loops……..



Initial effect

Quorum sensing and
Population response

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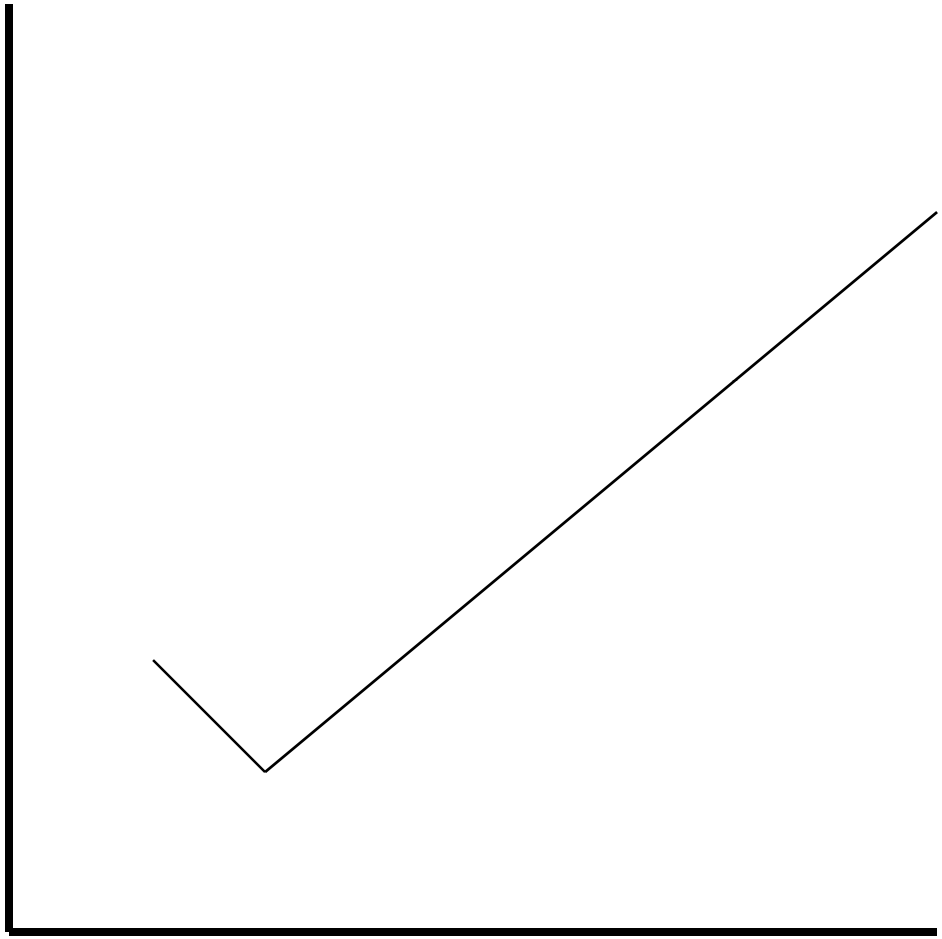
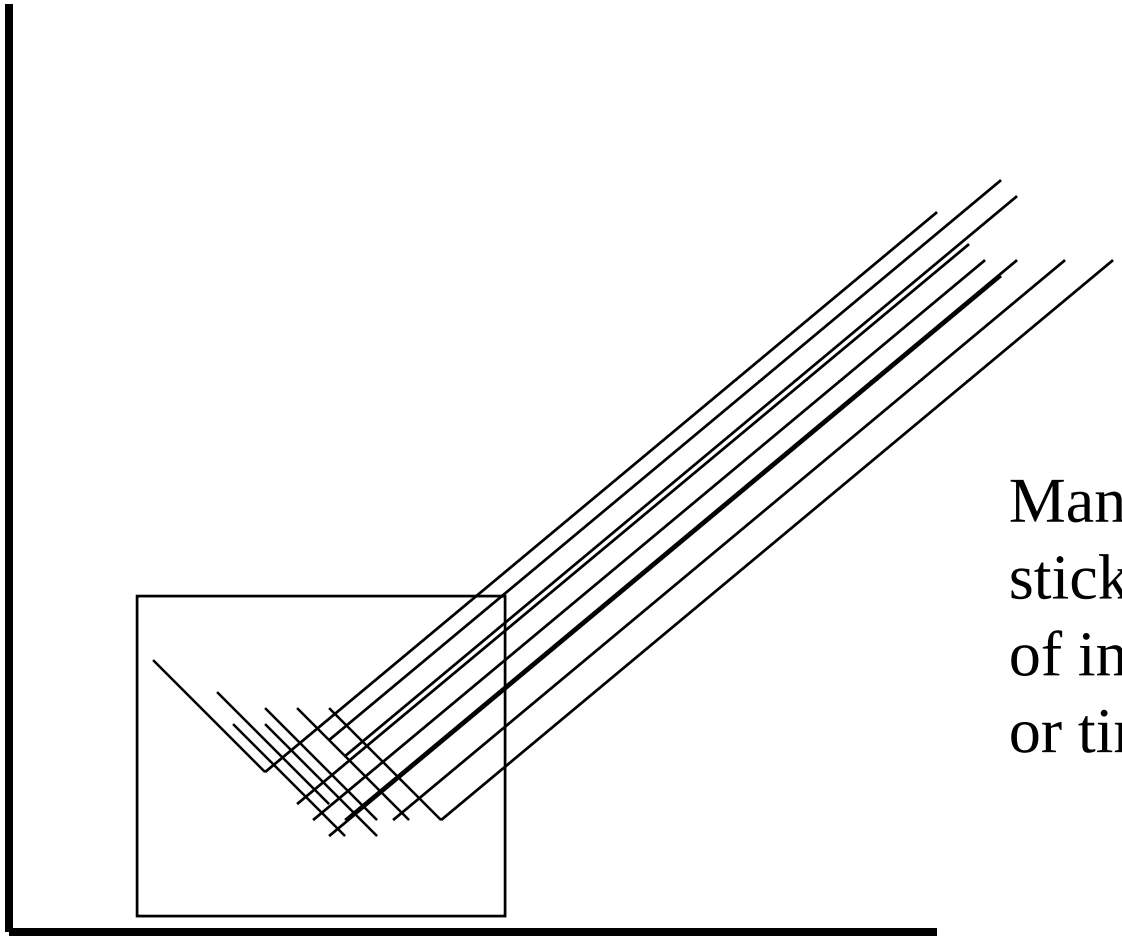
The uncertainty of a hormetic response



One hockey stick

The uncertainty of a hormetic response



Many hockey sticks- uncertainty of initial conditions or time

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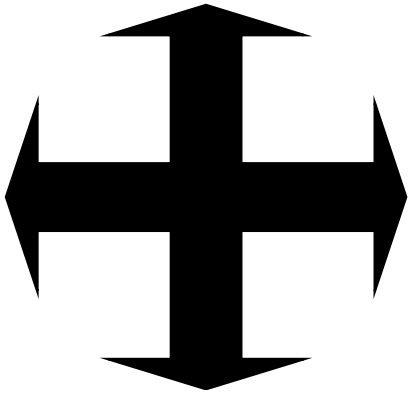
Uncertainty

Can only occur when the outcome is variable

At high doses of anything, death is certain



Legislation

- Society is built upon laws, either written [civil code] or through usage [common law]

The key issue is certainty

Laws have an ethical component

BUT

Which ethical system should predominate

Individual rights?

Societal rights?

For certainty, law needs

- Sine qua non

- Causa causans

Both are issues of causation but at low doses ±environmental carcinogens, the issue is blurred

The law needs proof of causation of damage

BUT

If for example, the role of insects in the ecosystem is unknown and the effect of low level carcinogens is not predictable, how can proof of damage be shown?

Res Ipsa Loquitur

If there is a clear and compelling link between the damage and neighbourhood activities, the law may presume the link

Law likes to be simplistic

- An activity is wrong -
- or right

The law should be easy to apply

- The LNT model is easy to apply

- A hormetic model would be difficult

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Chernobyl example

- LNT model: All suffered harm, harm measured according to dose
- Hormetic model: More people benefited than were harmed [more people exposed to very low dose than high dose]
- So LNT - Chernobyl bad
- Hormetic - Chernobyl good

Can people believe a hormetic model?

Difficulties in legislation-

Murder good if the right people are murdered

Need a legislative framework

Is the best hope a threshold model that discards beneficial effects?

Mechanistic problems

- Legally you must link cause to effect
- The law likes certainty!
- Therefore one issue is to enable the law to deal with biological uncertainty
- In legal terms you need the smoking gun, in biological terms the bullet may have been fired by your grandfather.

The way forward?

- Can we change from a legal system based on certainty and precedent to one reflecting the reality of biological complexity and uncertainty?