

“Late Lessons from Early Warnings: Science, Precaution, Innovation”

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Europe in Bloom: a living façade at the EEA



BIODIVERSITY

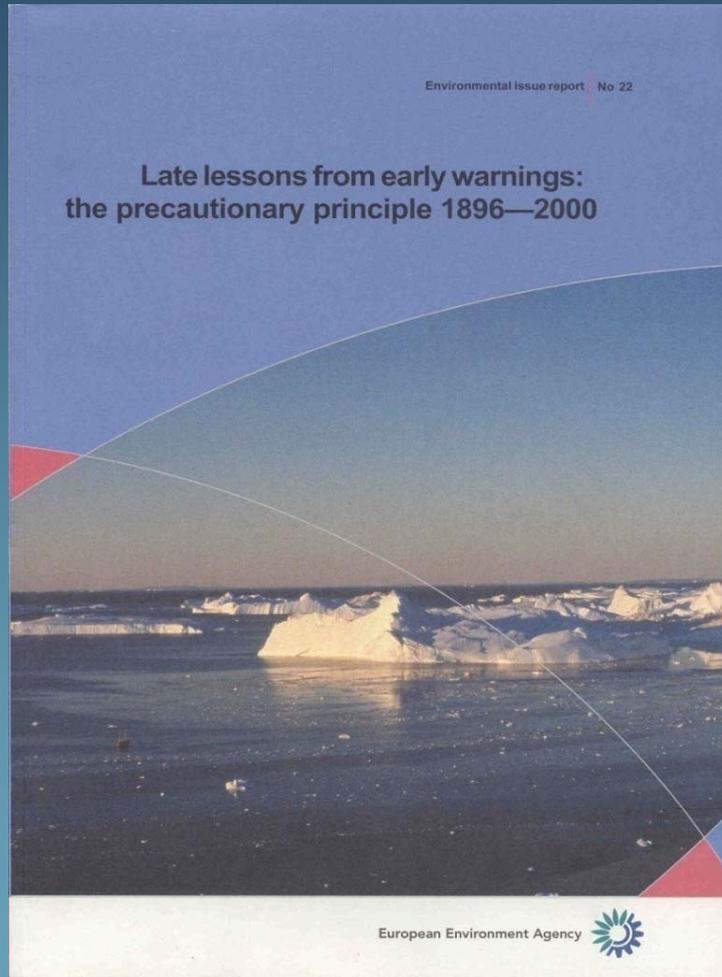
Summary

- What's in the Late Lessons reports?
- Some Early Warnings
- Some costs of Inaction
- The precautionary principle
- Barriers to precautionary action
- Need for greater public engagement

Homo Sapiens (tragicus?) as slow learners

Two volumes

2001



2013



European Environment Agency



History and Insight

***“History can offer something altogether different from scientific rules, namely insight....
..we study history in order to see more clearly into the situation in which we are called upon to act”.***

Collingwood R.G. Autobiography, 1939, cited in Preface, “Late Lessons from Early Warnings”, EEA, 2013

“New ways of thinking”?

“The important thing in science is not so much to obtain new facts as to discover new ways of thinking about them”.

William Lawrence Bragg

“Environmental protection in the 21st century requires a new way of thinking about pollution and its drivers, scale, effects, and solutions”.

“Science for environmental protection: the road ahead”

National Academies Press, USA 2012

http://www.nap.edu/catalog.php?record_id=13510

Vi tar strid i EU om förbud mot bisfenol

“We take the battle in the EU to ban bisphenol”

Environment Minister Lena Ek and Roger Tiefensee, environmental spokesperson, urges a total phase-out of the endocrine-disrupting substance bisphenol A.

Endocrine disruptors are a factor that contributes to the increase in worldwide problems with fertility. **EEA's report "Late lessons from early warning"** explains how important it is to apply the precautionary principle when it comes to chemicals....(and) highlights how important it is to act in time before irreparable damage harms the ecosystem.

<http://www.taz.de/!110440/>

34 case studies

'Environmental chemicals'

- Beryllium
- PCBs
- CFCs
- TBT antifoulants
- Mercury
- Environmental Tobacco
- Perchloroethylene
- Booster biocides
- DBCP
- DDT
- Vinyl chloride
- Bisphenol A

Ecosystems

- Ecosystems resilience
- Great Lakes pollution
- Fish stock collapse
- Acid rain
- Bee decline, France
- Invasive alien species
- Floods
- Climate change

Transport fuel additives

- Benzene
- MBTE
- Lead

'Micro technologies'

- Nano
- GMOs

Animal feed additives

- BSE, 'mad cow disease'
- Beef hormones
- Antibiotics

- Asbestos

Pharmaceuticals

- Contraceptive pill
- DES

Radiations

- X-rays
- Mobile phones
- Nuclear accidents



and 8 “horizontal “ chapters..

- the “12 late lessons” from vol 1...
..and in vol 2:
- **the precautionary principle;**
- **false positives;**
- **precautionary science;**
- **costs of inaction;**
- **protection of early warning scientists;**
- **why businesses ignore early warnings;**
- **Conclusions.**

From “data to”structured knowledge”

- “**data**” = “facts”
- **Information**= facts + analysis
- “**Structured knowledge**” = frameworks of understanding(**paradigms**; and **approaches** to environmental problems eg **demand side** management or **supply side** for energy,water, transport for focus *access* or *mobility*)?

Climate Change: Demand side management is critical.

Low energy demand scenarios would ensure a higher likelihood of staying below 2 °C for the same carbon price (from 66% probability to more than 80% at US\$40 tCO₂e⁻¹).

High energy demand would need much higher carbon prices (>US\$150 tCO₂e⁻¹) and make it much more difficult to reach the 2 °C objective with a probability of more than 66%.

“Probabilistic cost estimates for climate change mitigation”

[Joeri Rogelj](#), [David L. McCollum](#), [Andy Reisinger](#), Malte Meinshausen, Keywan Riahi, Nature, Vol. 493, Pages:79–83, 3 January 2013

When was first plausible early warning?

1896 radiation; climate change;

1897 benzene;

1898 asbestos;

1925 leaded petrol;

1965 antibiotics in animal feed;

1992/3 Goucho pesticide and bee decline;

1999 mobile phones



Climate Change: Lord Nick Stern, Davos, 2013

"Looking back (to 2006) I underestimated the risks. The planet and the atmosphere seem to be absorbing less carbon than we expected, and emissions are rising pretty strongly. Some of the effects are coming through more quickly than we thought then."

"Climate change is the biggest market failure ever. (Late Lessons chapter)"

Climate Change: "Political choices & **uncertainties** more important than scientific or technological uncertainties.

*"We find that **political choices that delay mitigation** have the largest effect on the cost–risk distribution, followed by geophysical uncertainties, social factors influencing future energy demand, and technological uncertainties surrounding the availability of greenhouse gas mitigation options"*

"Probabilistic cost estimates for climate change mitigation" [Joeri Rogelj](#), [David L. McCollum](#), [Andy Reisinger](#), Malte Meinshausen, Keywan Riahi, Nature, Vol. 493, Pages: 79–83, 3 January 2013

Chapter structuring questions

- **Where did that knowledge come from and what argumentation was used to accept/dismiss the Early Warning?**
- **What did societies do with that knowledge?**
- **What were the pros and cons of action or inaction?**
- **What can we learn?**

An Early Warning about leaded petrol, 1925.

“it seems likely that the development of lead poisoning will come on so insidiously that leaded gasoline will be in nearly universal use...before the public and the government awaken to the situation”

Yandell Henderson, chair Medical Research Board, US Aviation Service, 1925

(“Lead makes the Mind give way” , EEA, Late Lessons ,2013)

Early Warning scientists harassed for their “inconveneent truths”

- Selikoff on asbestos
- Hendersen, Byers, Patterson, Needleman on leaded petrol
- Henty Lai, Hardell on EMF radiation
- Putzei, Chapella on GMOs
- Dr Hosakawa on Minamata
- & others....inc.DR Stockman in Ibsen’s “An Enemy of the People”

Early Warnings from “Citizen Scientists”

- Workers: Asbestos, BSE, VCM,
- Local experts: fishermen (fisheries & feminised fish), beekeepers
- Victims: Minamata, DES. DBCP

“Useful truths” take years to be
“generally received”.

*“You will see that the Opinion of this **mischievous effect from Lead** is at least 60 years old; and you will observe with concern **how long a useful truth may be known and exist, before it is generally received and practiced on**”.*

*Benjamin Franklin, 1818, quoted in “**Lead makes the Mind Give Way**”, the leaded petrol story, in *Late Lessons from Early Warnings*, EEA, 2013.*

Exposures expand: to producers, users, bystanders, families, the public..

- Asbestos **users** (eg insulators) were more at risk than asbestos **producers**.....
- Many mesothelioma deaths are **domestic** (washing overalls, children of asbestos workers, Newhouse ,1965) and **environmental** (living near mines and factories; teachers etc)
- Lessons for nano, BPA, other chemicals in products ?

Nature of Harm expands with time ..

- **Asbestos:** 1929 asbestosis; 1954 lung cancer; 1959 mesothelioma, 2012 throat & other cancers
- **Tobacco:** 1951 lung cancer; 2012 many cancers, foetal harm; heart disease
- **PCBs:** 1960s bird reproduction; 2012s neurological harm in children; soil contamination
- **Lead:** 1979 brain damage in children; 2012 heart disease in adults

And all caused by lower, then lower, levels of exposure usually with no known threshold...eg Lead ,2012.

Costs of Inaction-PCBs-and relevance to costs of REACH

- **15b euros over 1971-2018** for costs of PCB soil/site remediation only ; excludes health/ecosystem damage.(Swedish estimate)
- **Costs of REACH-2-4b euro over 10 years**
- If REACH prevents 1 “PCB” disaster over the next decades will have paid for itself..
- this is likely because there are > 30k untested *existing* substances; and
- 75% of c 2k *new* substances are classified as “hazardous”

Costs of Leaded petrol

- Multi biological impacts in children and adults with no safe level (EFSA 2010)
- Mainly from lost lifetime productivity from reduced IQ in children- a “Catastrophe” (Prof Landrigan 2002).
- Current (2010) estimate is 1.5 Euro per gram of lead/litre in urban areas from petrol (EU prohibition ,2000)
- Giving annual costs of 4-6% GDP over the leaded years. (Discount rate critical)

Some Costs of inaction: Asbestos

- 2000-2035: **400b euro** in costs to society-EU **cancers only**
- Asbestos Removal..? Billions...
- Near collapse of Lloyds Insurance via US asbestos compensation cases

Earlier Action on Asbestos would have cost less..Holland...

A ban on Asbestos in The Netherlands in 1965 instead of in 1993 would have saved 34k deaths and 41 billion gldrs; from the total of 56k deaths and 61 b gldrs between 1969-2030.

(Heerings ,1999, cited in Late Lessons vol 1, EEA, 2001).

Benefits of “early” action on CFCs

- Benefits of action from 1987 come mainly from 20 million skin cancers & 130 million cataract cases avoided (UNEP, 2009)
- And from “secondary benefits” of GHG reduction over 2 decades $10 \text{ E /tonCO}_2\text{Eq} = 0.5 \%$ OECD GDP.

(Skou Andersen & Owain Club, “Costs of Inaction” chapter in “Late Lessons from Early Warnings”, EEA, 2013).

The PP: Two roles?

- As a **trigger for debates on future innovation pathways** in a water, energy and resource-constrained world (eg France , GMOs ,1997-2005
- As a **legal and moral justification for more timely actions** on early warnings about potential hazards.

Common definitions of the PP

- See PP chapter in Late Lessons for 13 definitions.
- Common elements of justifying action to **reduce harm in face of scientific uncertainty**
- But: no **explicit clarification of the standard of evidence needed to justify action...**
- And couched in **triple negatives** eg Rio definition..and
- The **context ,case specificity and proportionality** are implicit..

EEA working definition of the Precautionary Principle

“The PP provides justification for public policy actions in situations of *scientific complexity, uncertainty and ignorance*, where there may be a need to act in order to avoid, or reduce, potentially serious or irreversible *threats* to health or the environment, using *appropriate strengths of scientific evidence*, and taking into account the likely *pros and cons* of proportionate actions and inactions”.

Some Strengths of Scientific Evidence....

- **Beyond all reasonable doubt** (scientific causality & criminal law)
- **Reasonable certainty** (Int.Panel Climate Change , 2007)
- **Balance of probabilities/evidence** (IPCC,2001; civil law)
- **Strong possibility** (IARC on ELF ,2002; on RF 2011)
- **Reasonable grounds for concern**(EU Communication on PP)
- **Scientific suspicion of risk** (Swedish Chemicals Law,1975)
- **“Pertinent information”** (WTO SPS justifying member state actions to protect health
.....which are appropriate for different purposes, depending mainly on the costs of being wrong in acting/not acting

The “appropriate “ strength of evidence for precautionary action is an Ethical choice, not a Scientific issue

*Who benefits, and who gains, from **being wrong** in acting, or not acting, early enough to prevent harm?*

**Short term, specific, economic interests?
Or the longer term health & wellbeing
of people and their environments?**

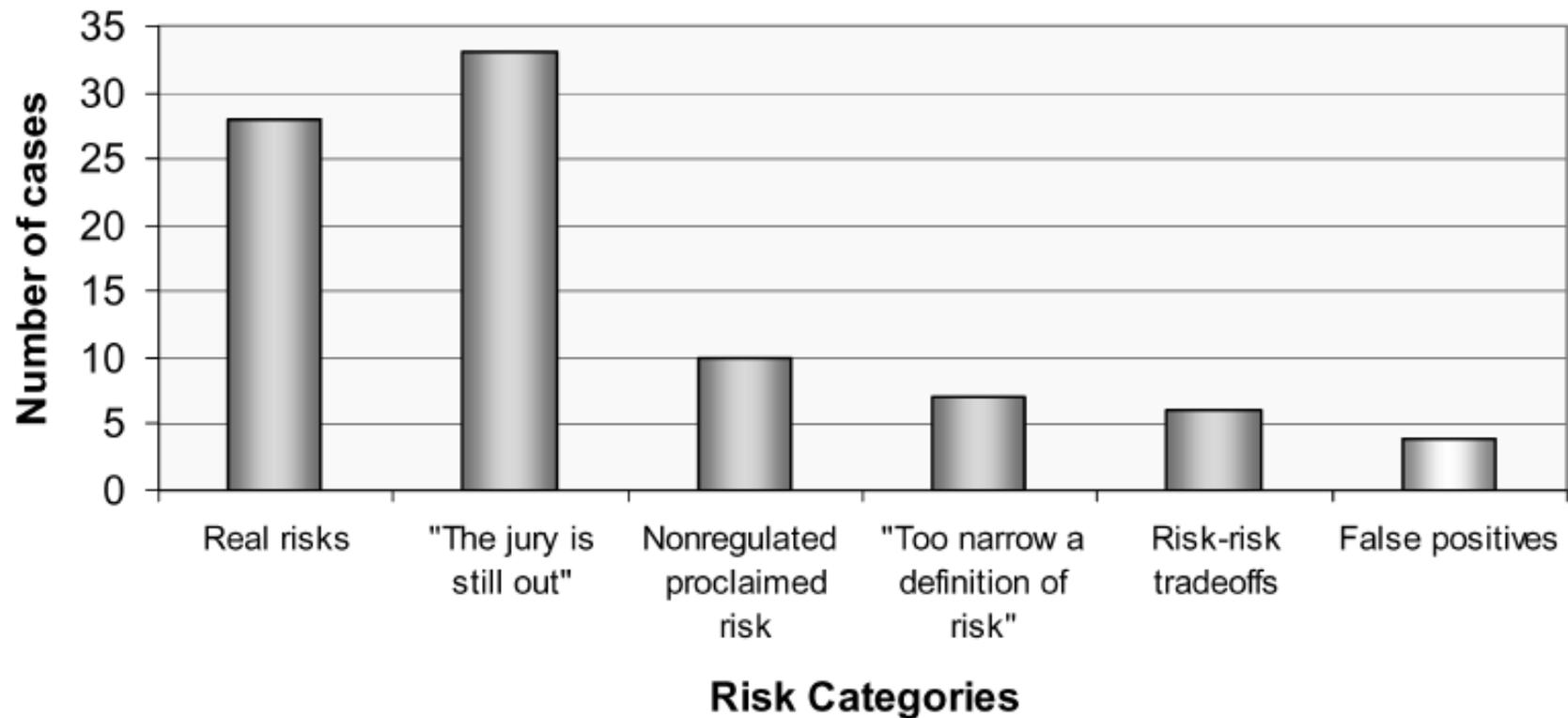
False Positives

- *“...Where action was taken on the basis of a precautionary approach that turned out to be unnecessary...” [EEA 2001:12]*
- What should be defined as “action”
 - We defined it as “regulatory action”, not public concern, not additional research
 - How to determine “unnecessary”?

Table II. Scale for Assessing State of Knowledge Used by IPCC
(Moss & Schneider, 2000)

95–100%	Very high confidence	
67–95%	High confidence	 Level used in this study
33–67%	Medium confidence	
5–33%	Low confidence	
0–5%	Very low confidence	

Proclaimed False Positives



Hansen et al. 2007. Risk Analysis 27(1): 255-269.

Identified False Positives

- **The Southern Corn Leaf Blight** - the decision in the U.S. in 1971 to plant more corn in anticipation that the Southern Corn Leaf Blight would return and destroy a large part of the harvest;
- **The Swine Flu of 1976** - the decision in the U.S. in 1976 to mass immunize the entire American population in anticipation of a return of the Swine Flu, which never reappeared;
- **Saccharin** - the decision to require saccharin to be labelled in the U.S. in 1977 because of it was believed to be a human carcinogen;
- **Food irradiation in relation to consumer health** - the reluctance to allow a seemingly safe and wholesome technology that could help reduce the large number for food pathogens and increase shelf life.

Cost & benefits of false positives

Costs :

- Mainly economic,
- Swine Flu did have more serious health effects and a wasted of resources due to bad planning

Benefits

- Sparked innovation within industry, government and scientific research
- Swine flu lead to a nation-wide disease surveiallnce program and a lot was learned about whole and split vaccines
- Labelling of saccharin lead to the development of several new artificial non/caloric sweeteners

More Precaution needed because of ..

- Complexity & multi-cauality,
- fast technological change,
- Slow increase in scientific knowledge
- Plausible evidence of delayed impacts
- lessons from past,
- Some public pressure,
- innovations needed for greener economies
- Some Progressive businesses

Less Precaution possible because of :

- Corporate stakes in status quo
- Technological “lock in”
- Wilfull blindness
- Conservative science with methodological, intellectual, funding and reporting biases that can generate false negatives

Barriers to Precautionary Action: Science

- Unrealistic **assumptions** about “safety”
- Authoritative but unsupported **assertions** of safety
- **Inadequate research** (“inertia”, low hazard/products ratio)
- Failure to acknowledge **scientific uncertainties & ignorance**
- **Conservative science**: methodological, intellectual, funding, reporting biases towards “safety”

The “Authoritative but unsupported
Assertion”: on Asbestos, 1906.

“One hears, generally speaking, that considerable trouble is now taken to prevent the inhalation of the asbestos dust so that the disease is not so likely to occur....”.

Dr Murray, evidence to UK Government Inquiry into Industrial Diseases.

Asbestos: 1967

“It would be ludicrous to outlaw this valuable and often irreplaceable material...

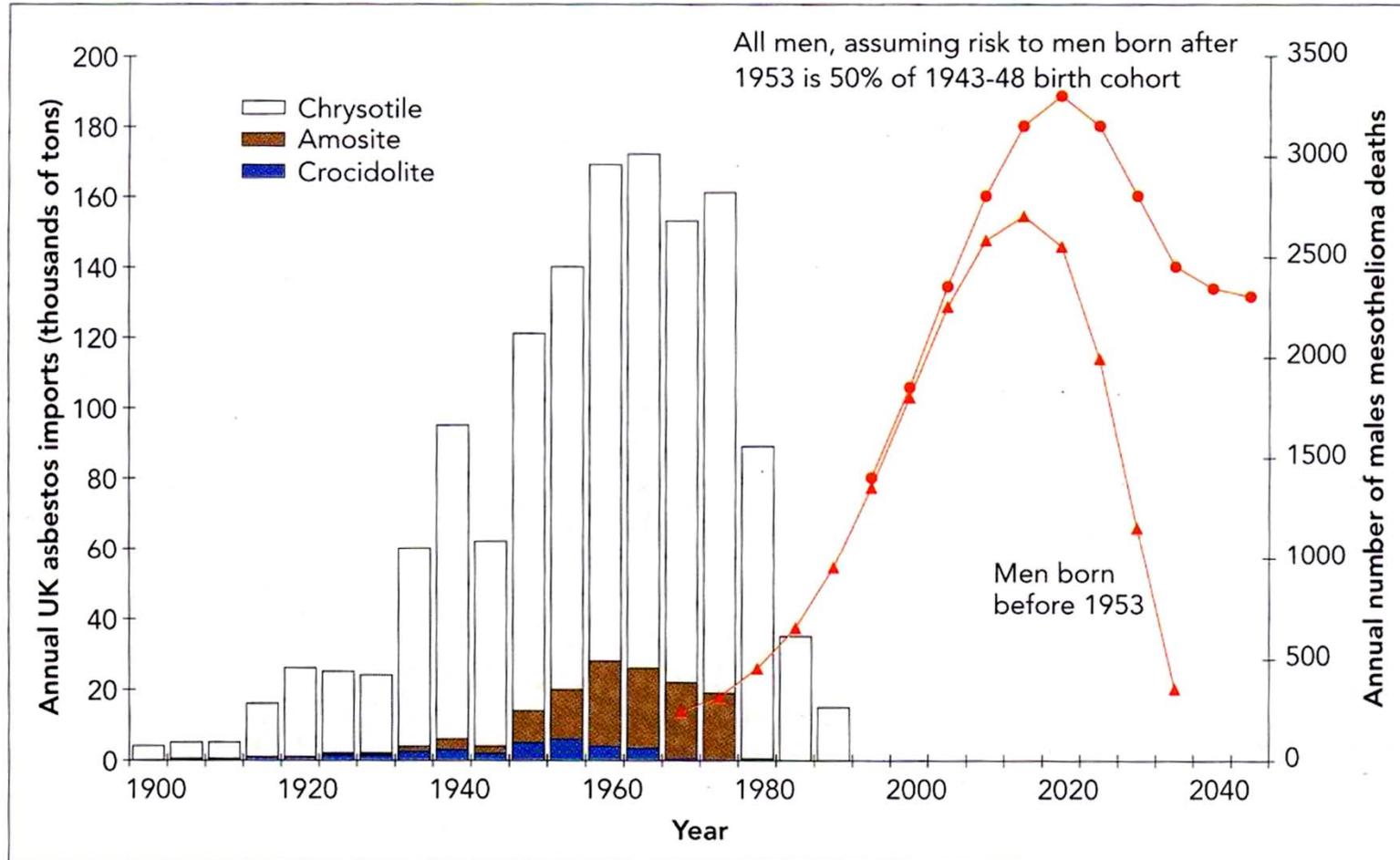
..asbestos can save more lives than it could possibly endanger”.

“The Lancet”, 1967, 17 June, p 1311/2.

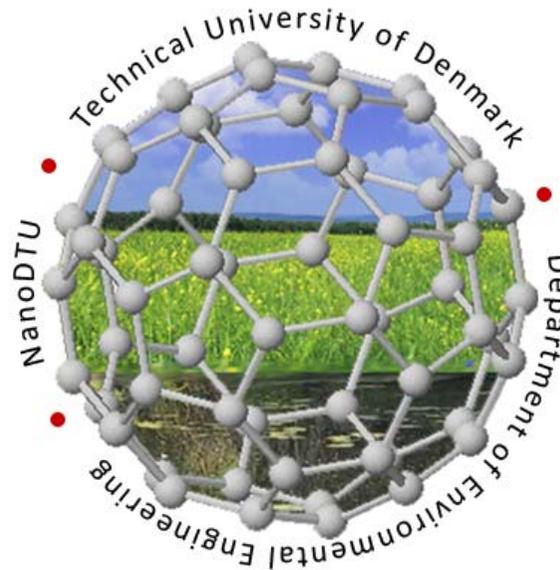
Use multi disciplinary scientific advisers on Risk Assessment Committees.

Predicted Asbestos Deaths

UK asbestos imports and predicted mesothelioma deaths



Nanotech: Early Lessons from Early Warnings



**Steffen Foss Hansen, Andrew Maynard, Anders Baun,
Joel Tickner, Diana Bowman**

“Carbon nanotubes in mice show
asbestos-like pathogenicity”, Nature,
May, 2008

“Our data demonstrate that asbestos-like pathogenic behaviour associated with nanotubes conforms to a structure/activity relationship based on length to which asbestos and other pathogenic fibres belong”.....

*...Our results suggest the need for **further research and great caution before introducing such products into the market** if long term harm is to be avoided”.*

Poland C., Donaldson K., et al, MRC ,Edinburgh

Where are we now with Nanofibres compared to the History of Asbestos?

- We are at about “1918”
- Because, like then with asbestos, we have a few suggestive pathological nano cases; some animal evidence of mesothelioma –like effects of nanofibres; and insurance company concern;
- But we also have today’s knowledge from cellular biology, and from the history of asbestos..
- And, unlike in 1918, we have an EU Code of Practice on Nano with 7 principles, including the **precautionary principle**.

Nano-Have We Learned the Lessons from Asbestos?

- Good start, now seems that we have become distracted
 - **Nanotechnology is being overseen by the very government organisations that promote it;**
 - Research strategies are not leading to clear answers to critical questions;
 - Collaboration continues to be hampered by **disciplinary and institutional barriers;** and
 - **Stakeholders are not being fully engaged,** or not being engaged early enough.
- Lots of bureaucratic inertia, claims that “risk research jeopardises innovation and “regulation is bad for business”

The “authoritative but unsupported assertion of safety” on CFCs..

the ***“only thing that has accumulated so far is a number of theories”***,

(Prof Scorer, atmospheric scientist, Imperial College, New Scientist, 19 June , 1975)...

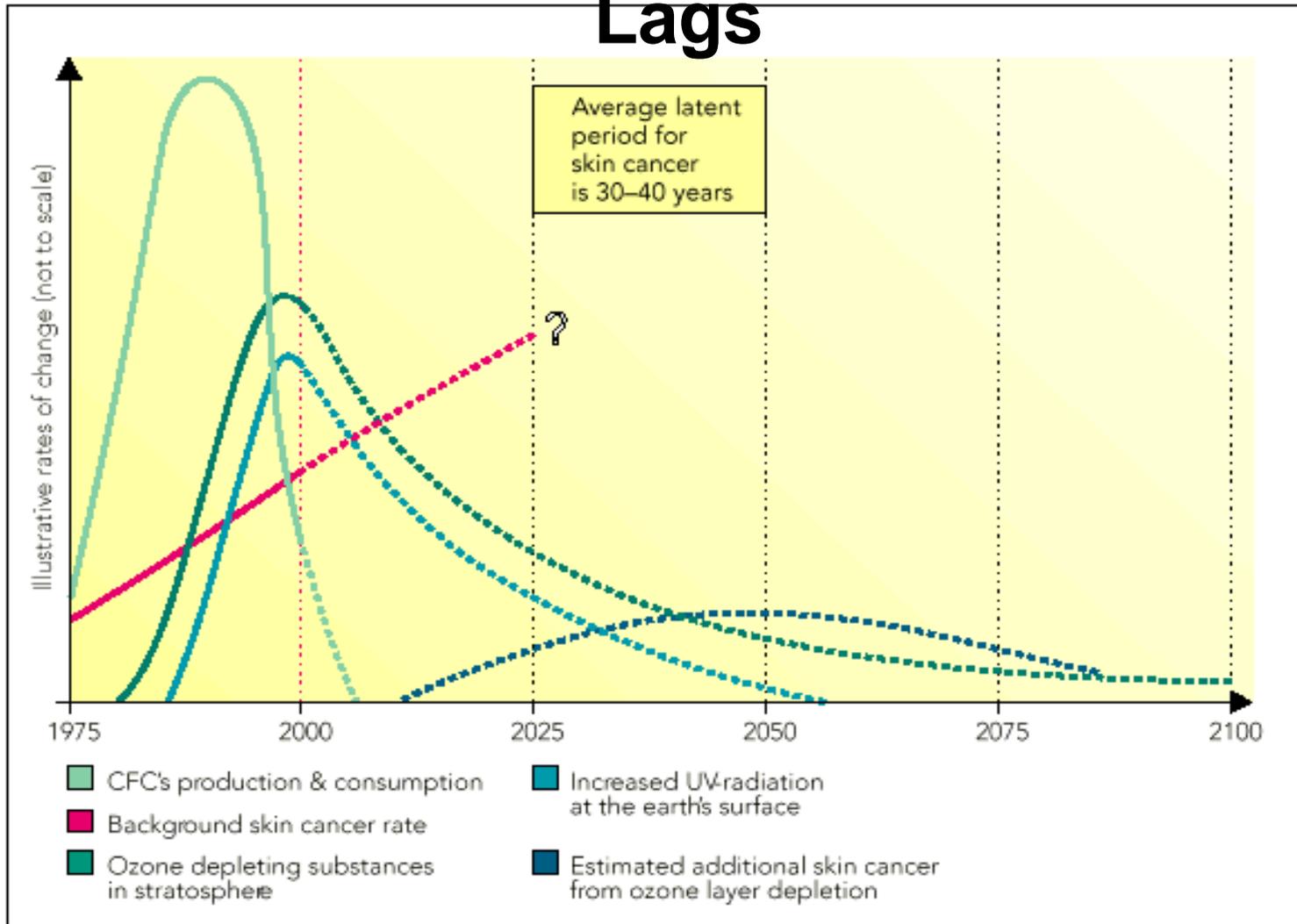
..responding to the 1974 “early warning” of Rowland & Molina about the accumulations of CFCs probably causing an ozone hole in 1974---

... for which they later got a Nobel prize...

Global Action on CFCs on;y in 1987 after

- “hole” was discovered by Jo Farman.

CFCs Chapter: Skin Cancer and Time Lags



Authoritative, unsupported assertion on mobile phones, 2011

..”the whole brouhaha over mobile phones causing brain cancer is monumentally irrelevant compared with all the other things there are to worry about”.

(Economist editorial, 2011)

Mobile phones and Head Cancer: evidence, 2011/13)

- International Agency for Research On Cancer (IARC) , 2011 : radiation from mobile phones is a **2B “possible” carcinogen risk for head cancer**
- **Italian Supreme Court, Oct, 2012, awards occupational disease benefit to man with relevant head cancer** after 12 years of c. 5 hours a day of mobile phone use.
- Evidence still only tentative & disputed, but stronger than **2007 (EEA early Warning)** and enough to justify precautionary exposure reductions.
- See **mobile phones chapter** in Late Lessons vol 2, and **IARC Monograph on RF, 2013.**

Radiofrequency Electromagnetic Fields

(Overall evaluation by IARC,2011)

Cancer in Humans

There is *limited evidence* in humans for the carcinogenicity of RF-EMF, based on positive associations between [glioma](#) and [acoustic neuroma](#) and exposure to RF-EMF from wireless phones.

Cancer in Experimental Animals

There is *limited evidence* in experimental animals for the carcinogenicity of RF-EMF.

Overall Evaluation

Radiofrequency electromagnetic fields are ***possibly carcinogenic to humans (Group 2B)***.

The limitations of simplistic models....

- The CFCs/ozone layer models predicted that only a **small fraction** of the chlorine is present in reactive forms such as Cl or ClO.
- However, these early model calculations were based on the assumption that only gas-phase reactions occur; they did not include the possibility of *reactions* on the surfaces of particles.....

Simplistic models ,early warnings and systemic risks in global finance.

*“In a global market the signs of Super-Systemic risk are multiplied. However..inadequate risk assessments relied on **overly simplistic linear models..that did not take into account..the non – linear nature of the hazards involved in international financial markets..causing these multiplied signals to be overlooked”***

Jacopo Torriti, London School of Economics, 2012.

**“No evidence of Harm” is not the same as
“evidence of no harm”.....**

...because no *relevant or reliable* research is available,

... or because of the limitations on what *could* be known with existing scientific methods, under **complexity and multi-causality**; and

.... long term ecological/biological effects

What is the “Knowledge/Ignorance Ratio” & Research Focus?

- The K/I ratio is **high** (much Knowledge, little Ignorance) for **Asbestos**, after 111 years of research since first “Early Warning” in 1898...
- But the K/I is **low** (little Knowledge, much Ignorance) for most **Chemicals, Nanotech, GMOs, EMF/RF,**
- Partly because there has been much more Research Expenditure into **Technological Applications** than on **Hazards**

See Nano, GMOs, EMF chapters in “Late Lessons”, vol 2, EEA, Jan 2013.

EU Research on Technologies (“Products”) and on Health & Environment (“Protection”)

	“Products”	“Protection”
EU Public Research 1994-2013	97 Billion euros	625 million Euros (0.6%)

Research: how much to develop products and protect People/Environments?

EU Public Research 1994-2013	“Products”	“Protection”
Nanotechnology (2002-2013)	5 billion	112 million (2%)
Biotechnology(1994-2013)	3.5billion	203 million (8%)
Information Communications Technology/EMF(2007-2013)	20 billion	9 million (0.005%)

“Acknowledge complexity, variability, uncertainty”

- “the causal links between stressors and harm are more **complex** than was previously thought”
- “much harm from cancers and climate change to decline in bees and in children’s IQ decline is caused by **co-causal factors acting independently or together**”
- “**Timing of exposure** can determine “the poison”
- “**Low dose effects** can be greater than high doses” (radiations, BPA)
- “**Varying susceptibilities** from age, sex, immune state, stress, genes, epigenetics...”
- “**there are Continuums from “effects” to “adverse” effects..**”
- “**But sometimes Thresholds & tipping points...**”
- “**Systems level effects** are not predictable from individual cells/organisms eg bee colonies;
- More **transparency about uncertainties** in risk assessments.

Barriers to Precautionary Action:Policy

- Inadequate/conflicting risk assessments
- Market failures ie costs of harm externalised onto society
- Corporate incentives & power; “manufactured doubt”; control of research (leaded petrol, GMOs)
- Regulatory capture
- Short termism & “Wilfull Blindness”

Seed-dressing neonicotinoid pesticides and honeybees: flawed risk assessments



Laura Maxim

**National Center for Scientific
Research (CNRS), France**

Jeroen van der Sluijs,

**Copernicus Institute of
Sustainable Development**

Utrecht University, The Netherlands



Nicotinoid pesticides: from citizen science to French then EU ban 1992=2013

“Early Warning from French “citizen scientist”
beekeepers, 1992

French ban using the PP on Gaucho® in sunflower seed-dressing in 1999..

..and on maize seed-dressing in 2004

EU ban 2013



Some deficiencies with Risk Assessments for Gaucho

- Wrong **exposure** estimates
- Only **Acute** effects, not **chronic**
- Old **spray** risk approach used for new **systemic** pesticide
- No/little **representation** of beekeepers & academic researchers in risk assessments
- Over reliance on Good Laboratory Practice studies (relevant to procedural quality not scientific quality)
- Independent critiques of RAs need **data access & transparent evaluations** but these were not available

Assumption driven Risk Assessments for GMO?

*“Each regulator found reasons not to ask the product developers to specifically test for effects from dsRNA, and **thus relied on assumptions** rather than testing to determine safety”.*

A comparative evaluation of the regulation of GM crops or products containing dsRNA and suggested improvements to risk assessments.

Jack A. Heinemann, Sarah Zanon Agapito-Tenfen, Judy A. Carman
Environ Int *in press*).

<http://www.sciencedirect.com/science/journal/01604120>

Risk Assessment and Management: an integrated activity.

“The iterative process starts with effective problem formulation, in which **policy goals and an orientation toward solutions** help to determine scientific needs and the most appropriate methods”.

“Systems thinking **to assess implications of decisions**”

“Applying science that anticipates, innovates, takes the long view, and is collaborative”

“Science for environmental protection” ,National Academy of Sciences, USA
2012,

The social costs of hazardous agents were mainly paid by victims, insurance co's, and taxpayers...

- The “external” or social costs of asbestos, PCBs, Leaded petrol, CFCs, benzene, mercury etc were **never internalised into their market prices of asbestos.....**
- which meant that **innovation on substitutes was stifled by “cheap”, monopolistic asbestos etc.....**
- taxpayers & victims paid most of these costs: a breach of the **“polluter pays” principle**

Need for greater public engagement

- In hazard/risk/options/alternative assessments
- In applying the PP via “acceptable” protection and choosing strengths of evidence for action
- In **choosing strategic innovation pathways** to 2050 on energy, agriculture etc.

A Resource use revolution?

“The era of plentiful and cheap resources is coming to an end. Raw materials, water, air, biodiversity and terrestrial, aquatic and marine ecosystems are all under pressure.

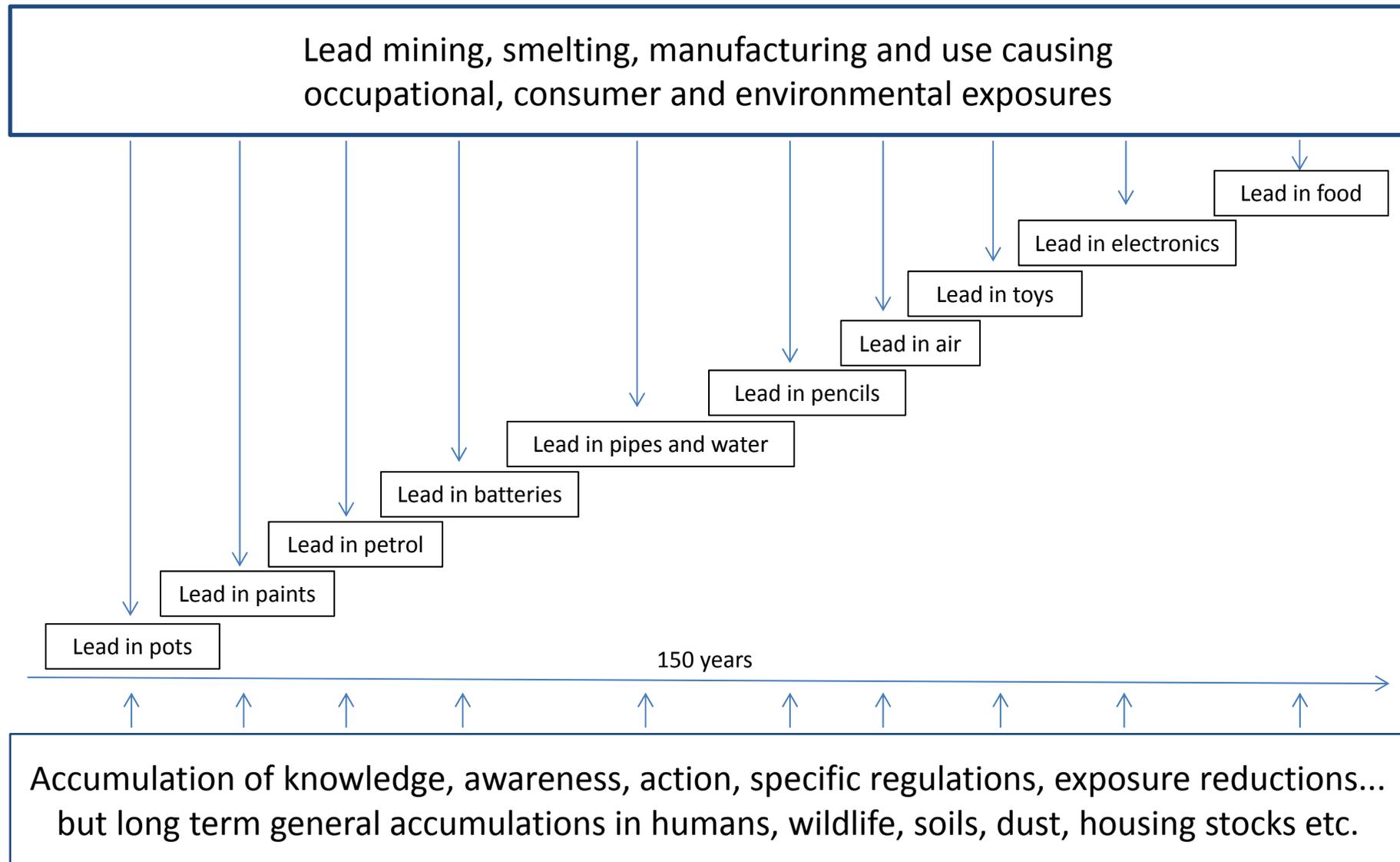
*By 2050 demand for food, feed and fibre is forecast to increase by 70%. **And yet** 60% of our ecosystems underpinning these resources are already degraded.*

*We need **radical change** in the way we produce and consume..*

..Its all about innovation.

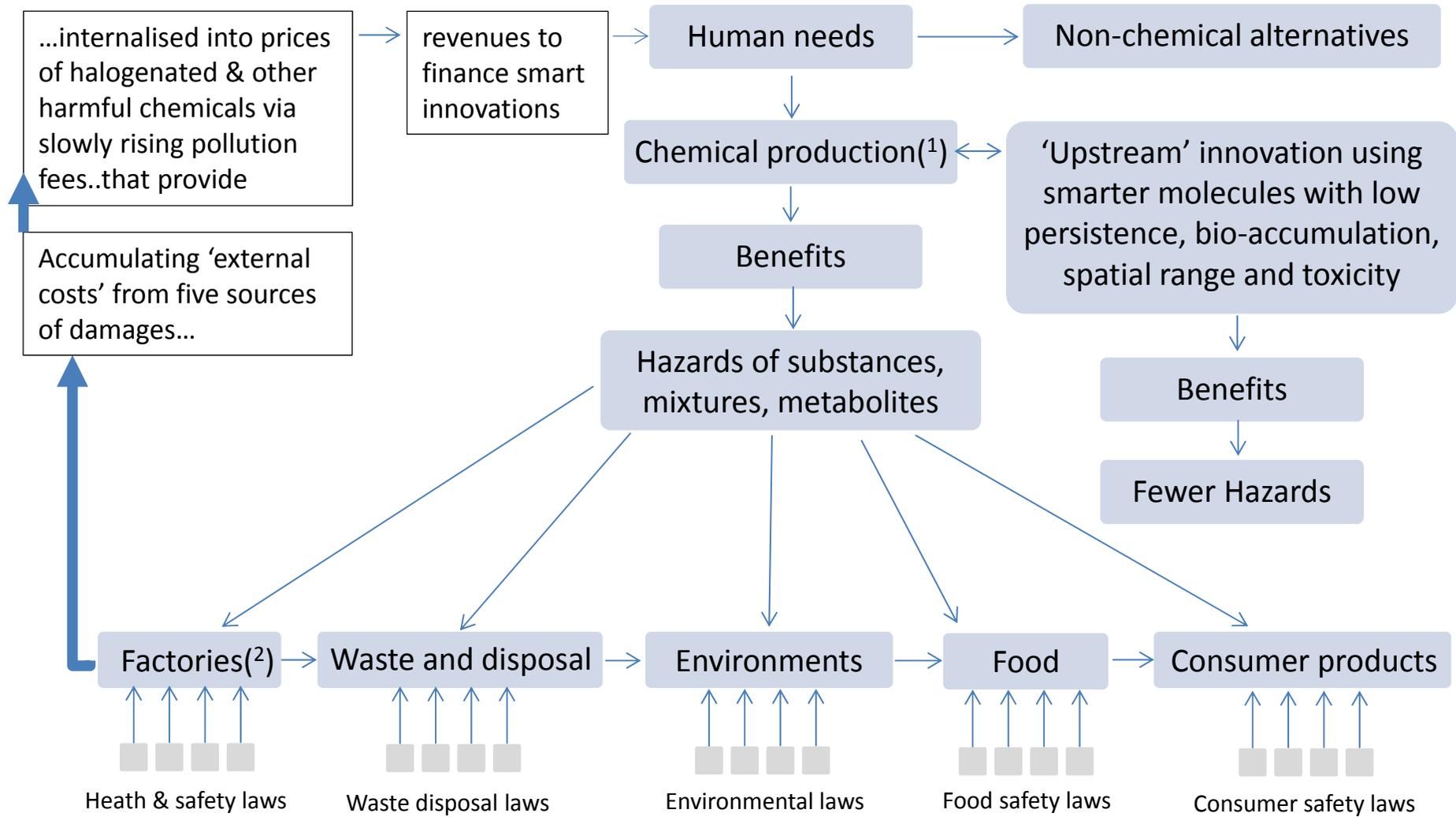
Janez Potočnik European Commissioner for Environment
Resource challenges for Europe Davos 2011

Lead production, flows, impacts, regulations, and accumulations



Would an upstream approach of limiting flows of lead through the economy be more effective and timely than regulations after specific harms occur? Is this a lesson for consumer chemicals now?

Approaches to hazardous chemicals: upstream innovations? or downstream 'fingers in the dyke'?



(1) Many industrial chemicals originate as by-products (and 'wastes') of other industrial activities, especially oil production
 (2) Plus harm to worker's families e.g. from asbestos, lead, beryllium, radiation etc

Knowledge into Action.

“Knowing is not enough : we must apply .

Willing is not enough : we must do”

Goethe