

RCR Forum

The Environmental Implications of Biotechnology

Daniel A. Vallerio, Ph.D.

Duke University, Pratt School of Engineering

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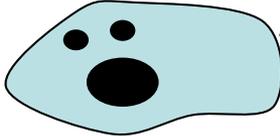
No matter your research, likely to encounter biotechnology....

Red	Medical
Yellow	Food Biotechnology
Green	Agriculture
Blue	Aquatic
White	Gene-based industry
Grey	Fermentation
Brown	Arid
Gold	Nanotechnology/Bioinformatics
Purple	Intellectual
Dark	Bioterrorism/Warfare

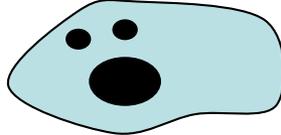
We need carbon and energy.....



Bob manipulated my DNA. Now, I turn dintrochickenwire into harmless CO₂ and water....



Bob got a nice grant and has written some great journal articles bragging about me



I wonder why Bob hasn't noticed that I have no natural competition and that I have an affinity for mammalian tissue....



I'll bet Bob tastes really good!

L'Acide Case Study

1. Read first 2 pages.
2. Skim the attachment... (Select salient material, depending on your area of expertise).
3. Break into groups (by color of your handout).
4. Discuss the facts first.
5. Share opinions on responsible actions.
6. Find way to reach consensus (not necessarily unanimity).
7. “Hire” a spokesperson.
8. Be ready to share details with the whole group (particularly the ones you brought up in the breakout).

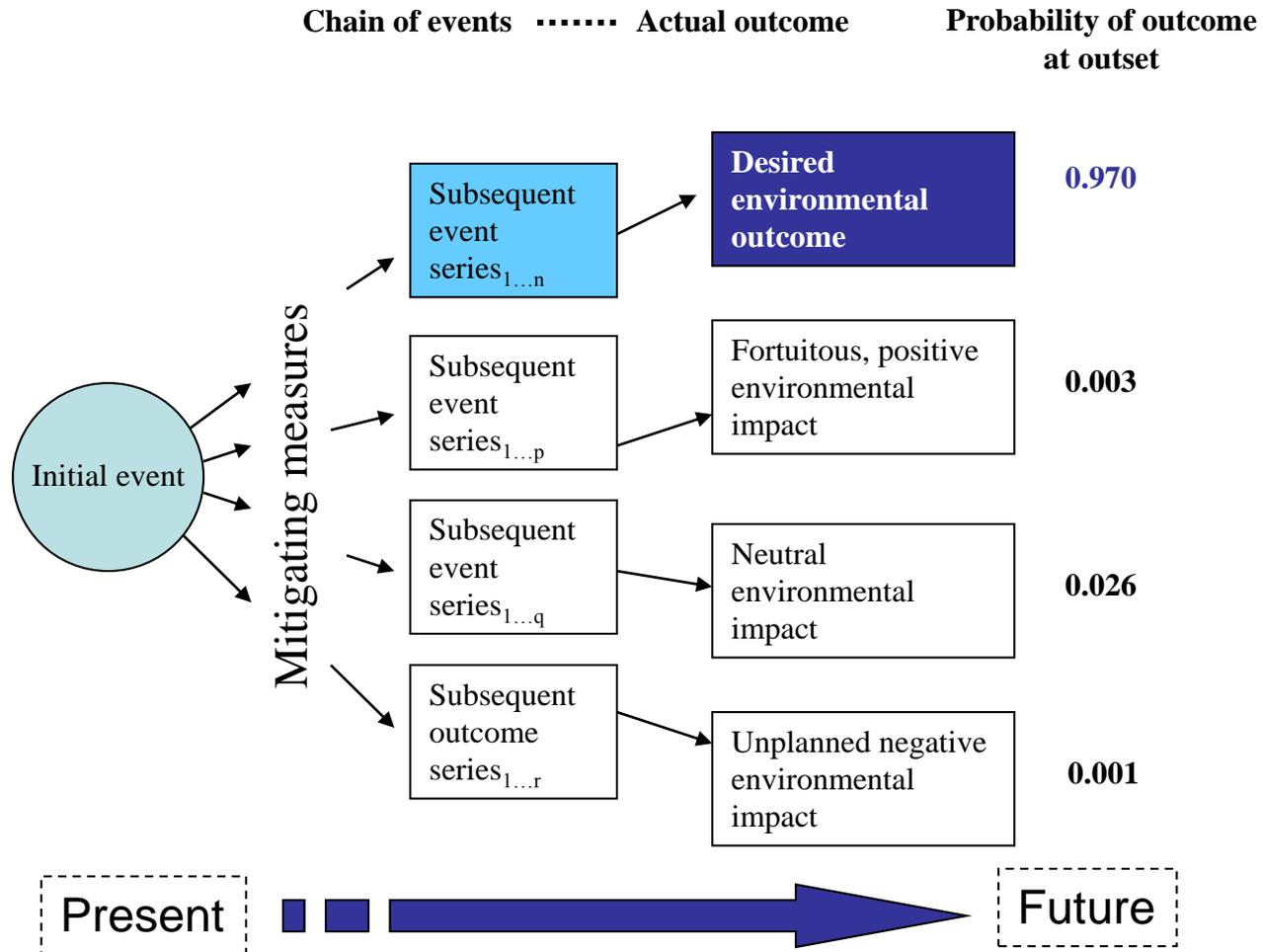
“Hold paramount...”

- Engineers must “hold paramount the safety, health and welfare of the public.”
- Characterizes the need for not only protecting public health and the environment, but to be guardians for sustaining these protections.
- But, **how** do we do this....?

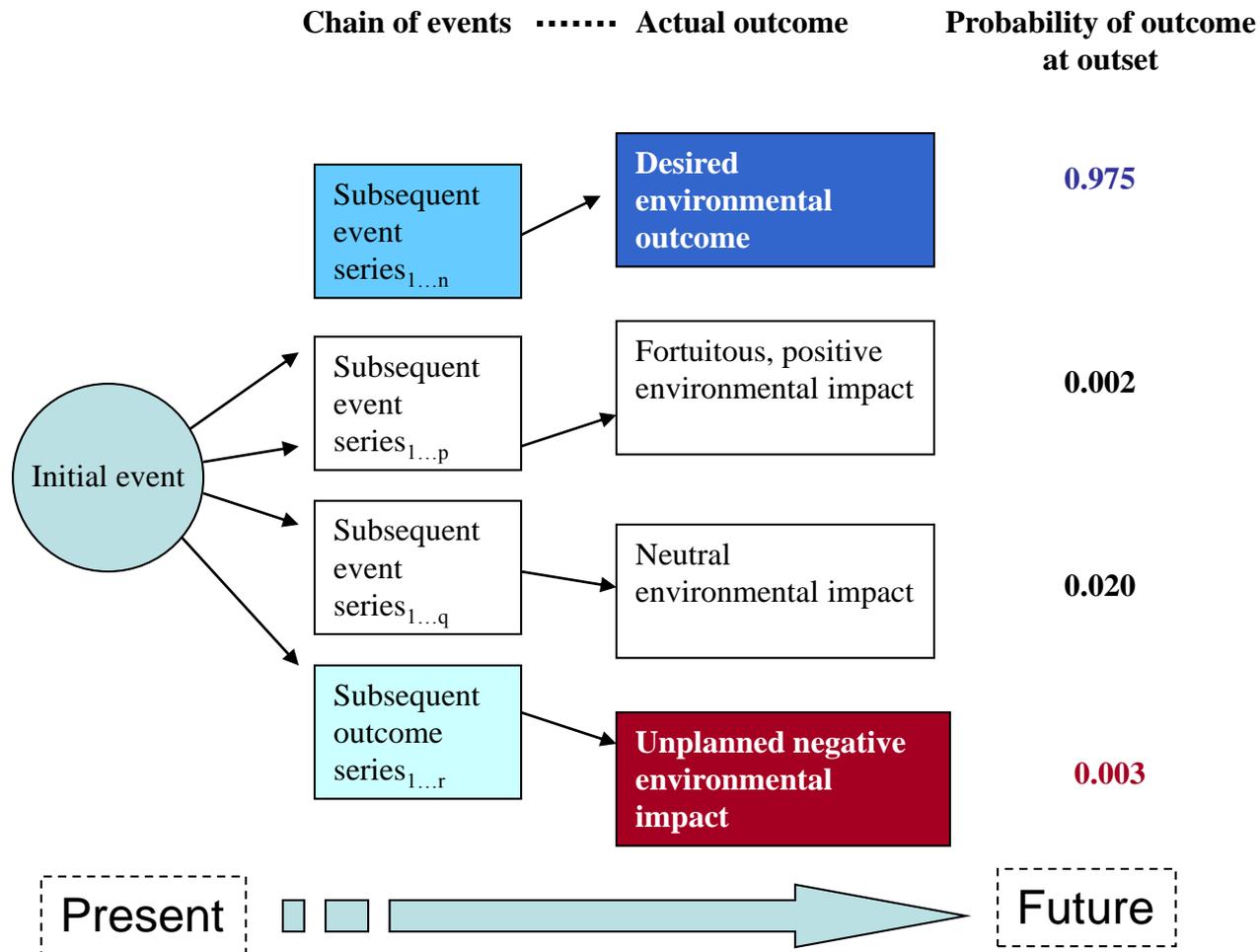
Contaminant Cleanup Feasibility

1. Protect human health and environment
2. Comply with applicable regs
3. Provide long-term effectiveness & permanence
4. Reduce toxicity, mobility or volume (treatment)
5. Provide short-term effectiveness
6. Consider ease of implementation
7. Consider cost
8. Gain State's acceptance
9. Gain community's acceptance

Chaos



Improve desired outcome, but at what cost?



Decision Tree (hypothetical)

	First Order Outcome	Second Order Outcome	Likelihood	Importance		
				Environment	Public Health	Food Production
Spores and crystalline insecticidal proteins	Efficacious with no impacts		0.810	1	1	1
	Efficacious with no human health impacts, but with ecological impacts	Non-target effects	0.005	5	2	3
		Biodiversity effects	0.001	5	3	2
	Efficacious with agricultural effects	Pest resistance	0.010	3	2	4
		Crop damage	0.020	3	3	5
	Efficacious with human health impacts, but without ecological impacts	Direct poisoning*	0.002	3	5	4
		Indirect contamination (e.g. track-in)	0.030	3	5	4
		Cross-resistant bacteria	0.002	5	5	5
		Transgenic food problems	0.020	3	3	5
	Nonefficacious		0.100	NA	NA	5

1 = Best; 5 = Worst

*This has its own decision tree according to vulnerability index, i.e. percentile exposure (high to no exposure) and sensitive subpopulations (children, elderly, asthmatic, etc.)

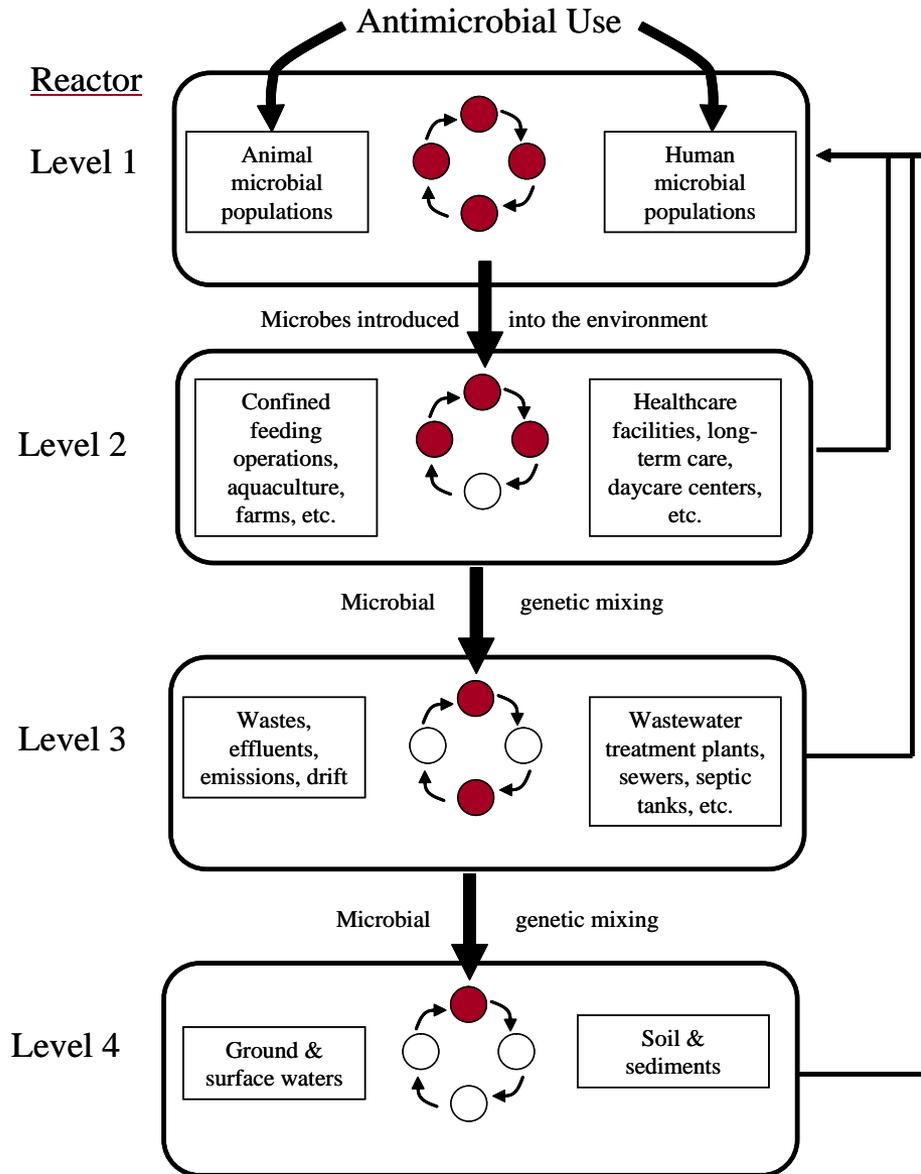
European classes of risks posed genetically modified microorganisms

Hazard Level	Description of Microbial Hazard
Least	Never identified as causative agents of disease in humans and that offer any threat to the environment.
Hazardous when contained, low human risk	May cause disease in human and which might, therefore, offer a hazard to laboratory workers. They are unlikely to spread in the environment. Prophylactics are available and treatment is effective.
Severe when contained, moderate human risk	Severe threat to the health of laboratory workers, but a comparatively small risk to the population at large. Prophylactics are available and treatment is effective.
High human population risk	Severe illness in humans and serious hazard to laboratory workers and to people at large. In general, effective prophylactics are not available and no effective treatment is known.
Greatest ecological and human population risk	Most severe threat to the environment, beyond humans. May lead to heavy economic losses. Includes several classes, Ep1, Ep2, Ep3 (see Table 1.2 for descriptions) to accommodate plant pathogens.

European classes of microbes causing diseases in plants.

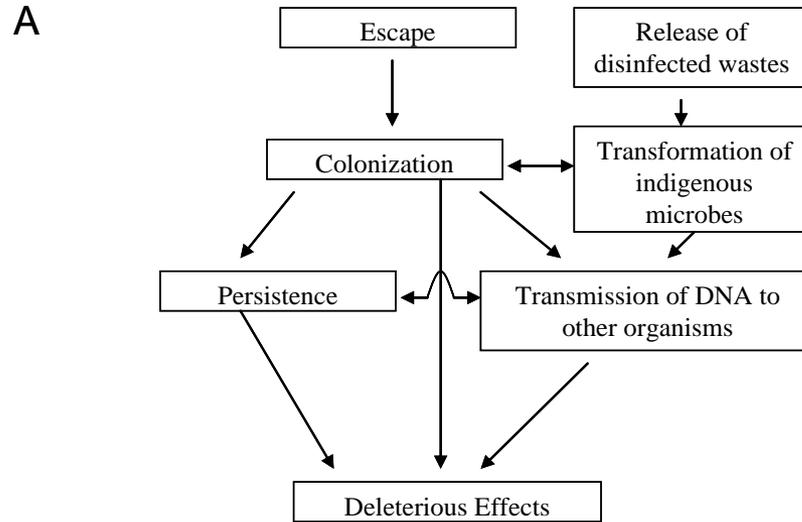
Biotechnology Class	Description of Microbes in Class
Ep 1.	May cause diseases in plants but have only local significance. They may be mentioned in a list of pathogens for the individual countries concerned. Very often they are endemic plant pathogens and do not require any special physical containment. However, it may be advisable to employ good microbiological techniques
Ep 2.	Known to cause outbreaks of disease in crops as well as in ornamental plants. These pathogens are subject to regulations for species listed by authorities in the country concerned
Ep 3.	Mentioned in quarantine lists. Importation and handling are generally forbidden. The regulatory authorities must be consulted by prospective users

The environment can be seen as series of **reactors**....

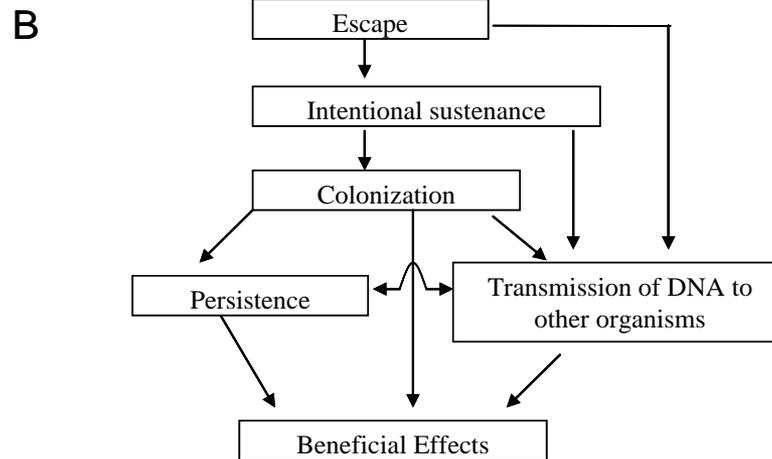


Adapted from: F. Baquero, J.L. Martínez and R. Cantón (2008). Antibiotics and antibiotic resistance in water environments. *Biotechnology*. 19:2 60–265.

Disaster



Project



Hmmmm.....

Perception is crucial

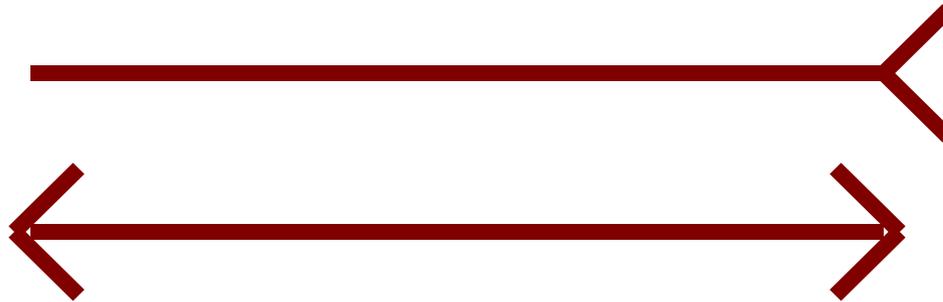
- Which line is longer?



The Müller-Lyer Illusion.

Perception is crucial

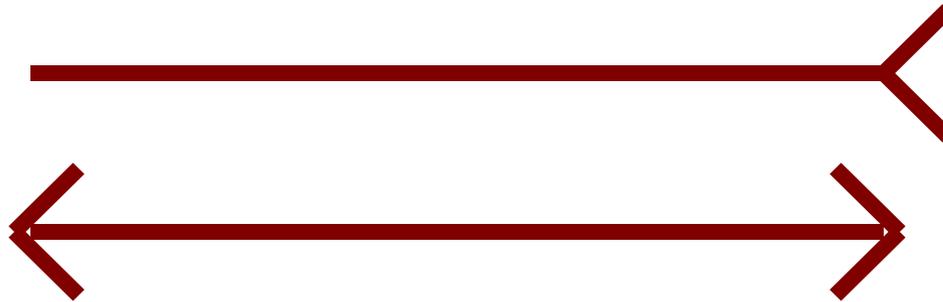
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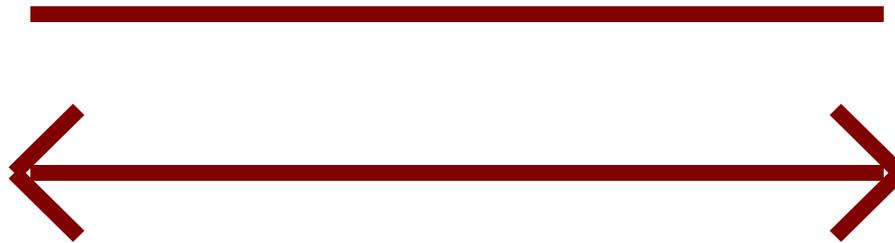
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The Müller-Lyer Illusion.

Perception is crucial

- Which line is longer?



The Müller-Lyer Illusion.

Perception is crucial

- Which line is longer?



The Müller-Lyer Illusion.

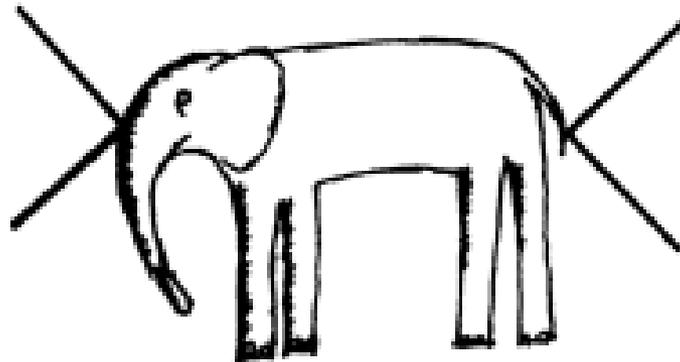
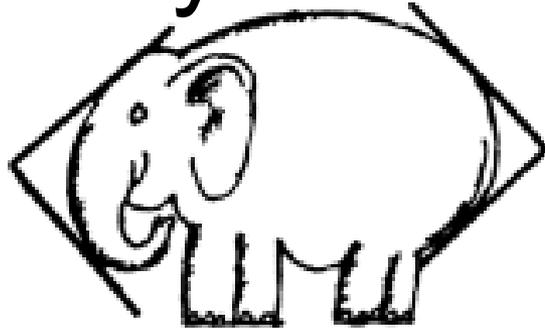
Perception is crucial

- Which line is longer?



The Müller-Lyer Illusion.

But sometimes, perception is
pretty accurate....



Source: *Pardon*, ca. 1970.

Problem of valuation of environmental resource

- Always a problem with non-monetized valuation
- E.g. what is the value of a life?
- Dilemma of gross domestic product for eco-resources
- Rethinking value (**beyond willingness to pay**)

Environmental Ethics

What is valued?

Humans exclusively



All cognitive entities



All sentient entities



All biotic entities



All material entities



**All entities and
ecological
phenomenon (abiotic
and biotic, plus other
values, richness,
abundance, diversity
sustainability)**

Environmental Ethics

What is valued?

Ethical View

Humans exclusively

Anthropocentric

All cognitive entities

All sentient entities

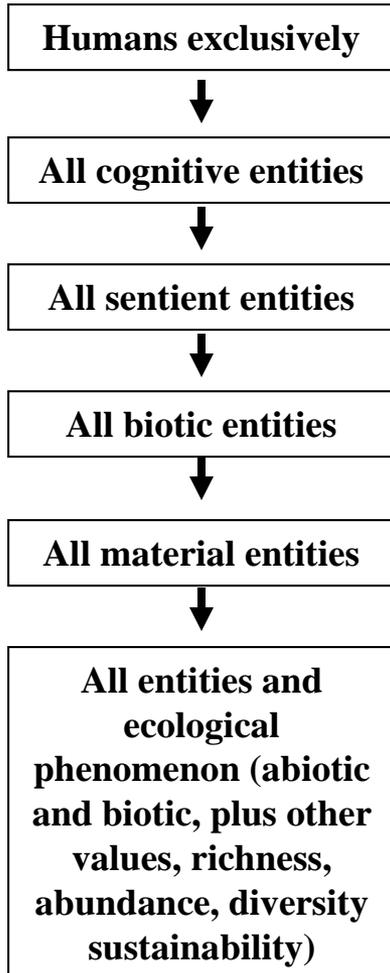
All biotic entities

All material entities

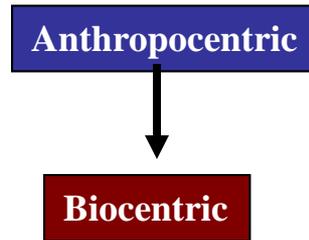
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Environmental Ethics

What is valued?

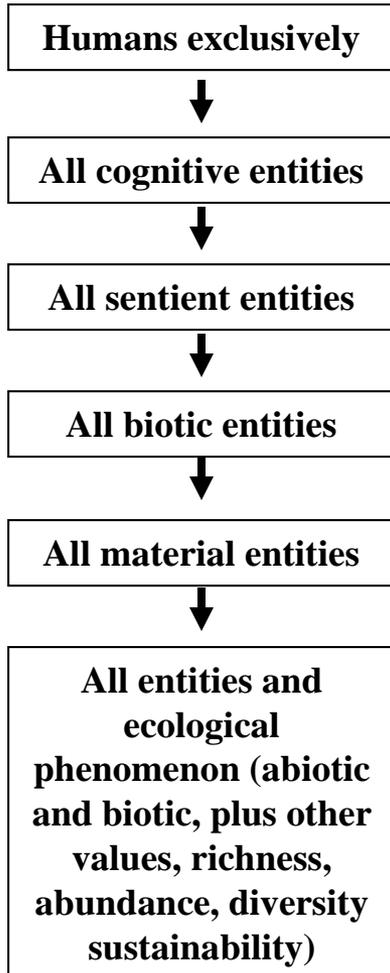


Ethical View

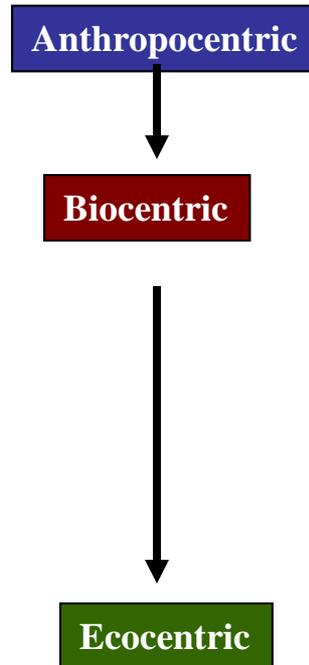


Environmental Ethics

What is valued?

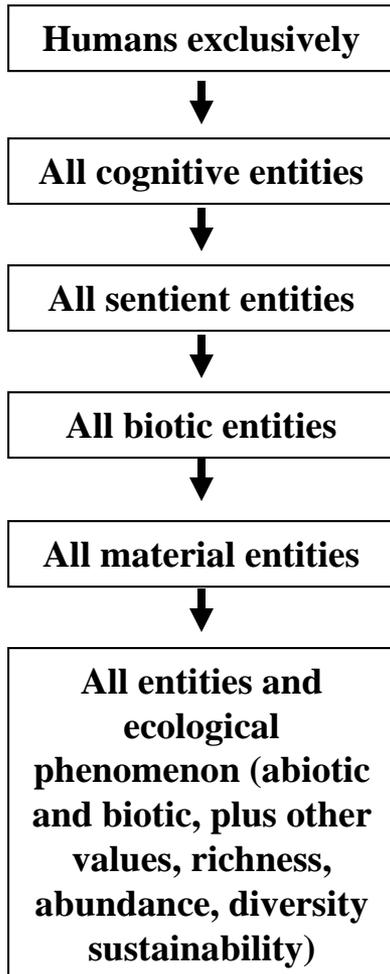


Ethical View

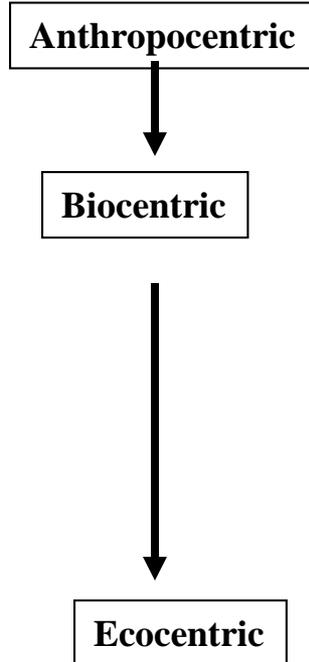


Environmental Ethics

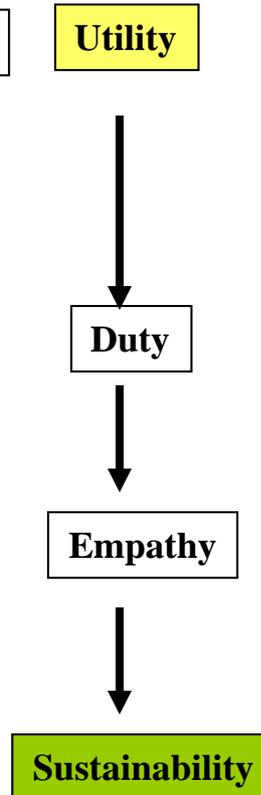
What is valued?



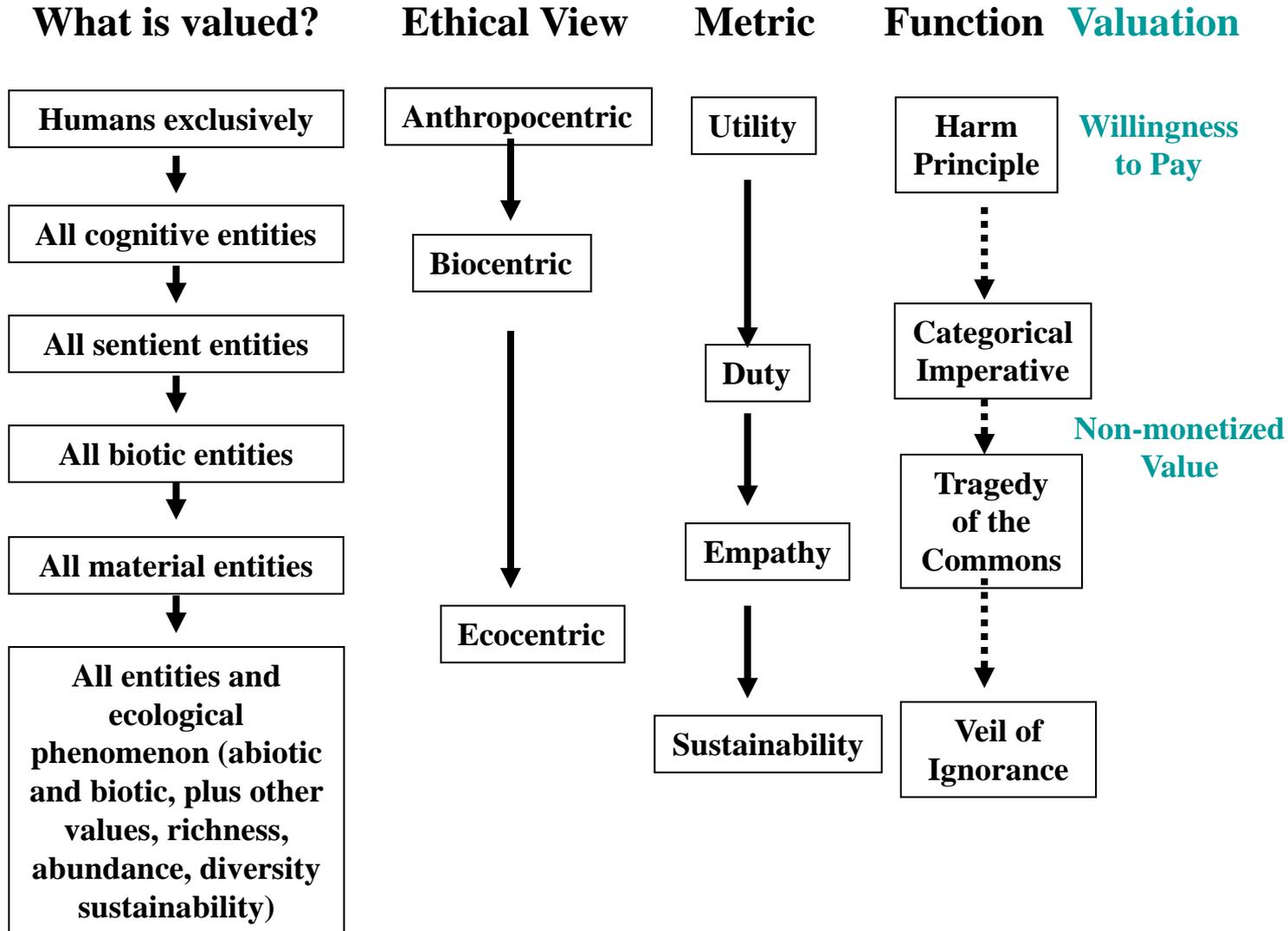
Ethical View



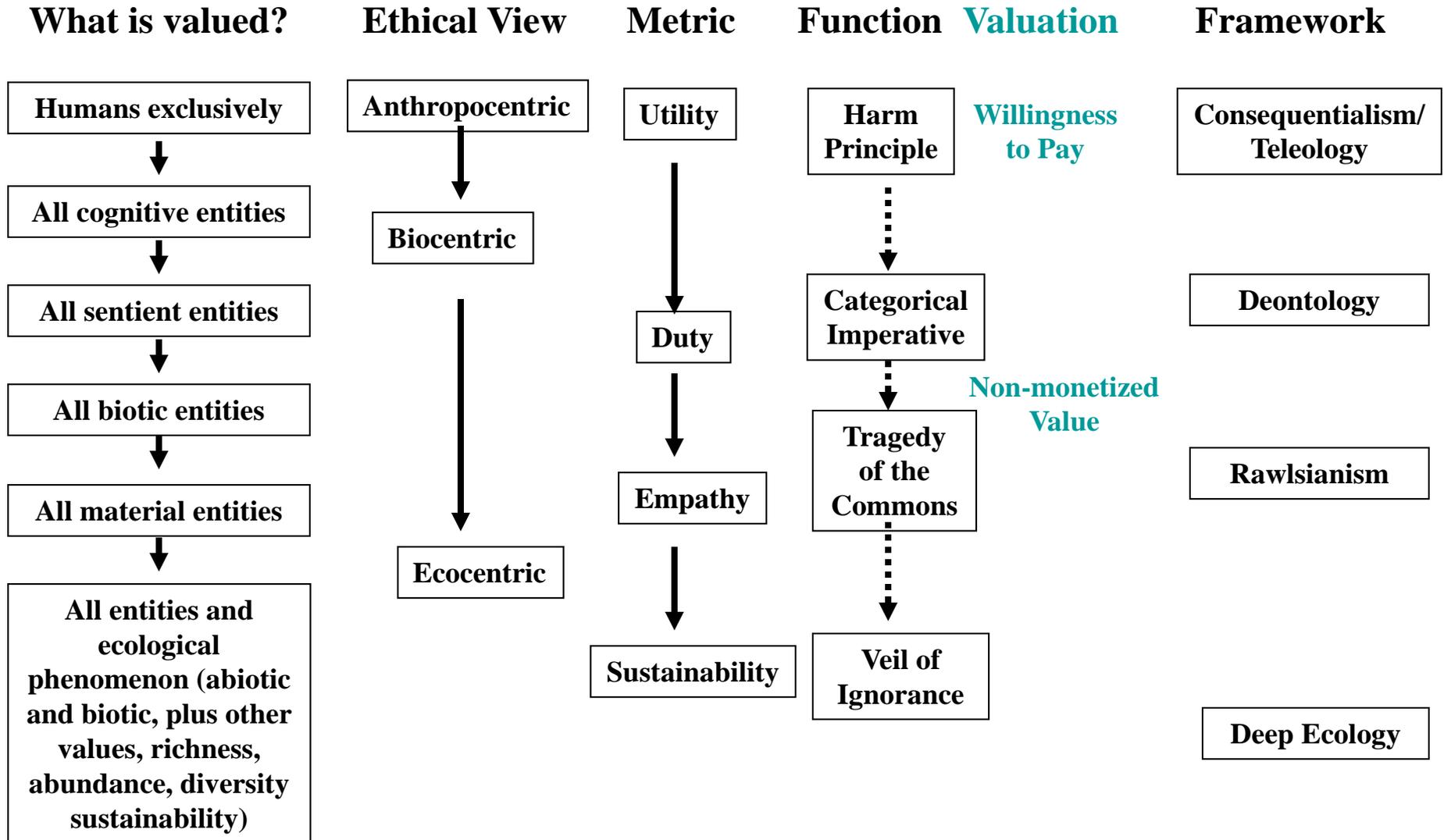
Metric



Environmental Ethics



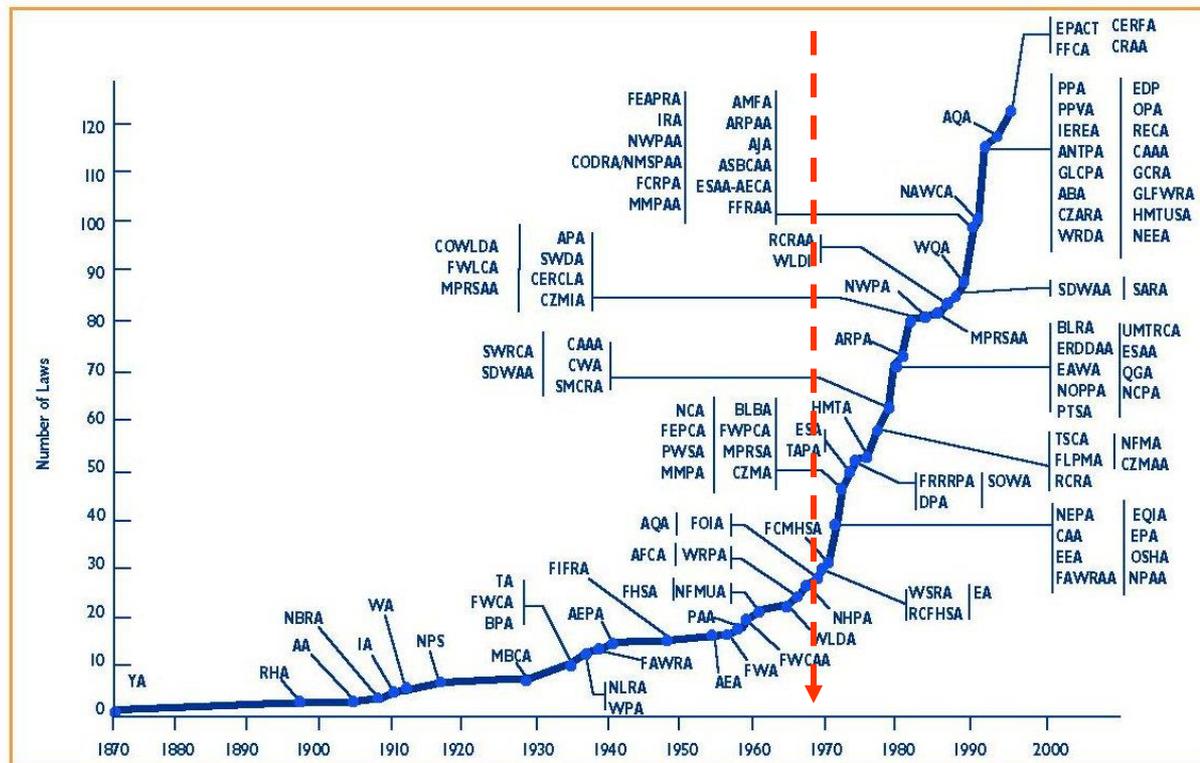
Environmental Ethics



Environmental Legislation

Sea change

- Sources
- Ambient



(From D. Allen & D. Shonnard, *Green Engineering*, Prentice-Hall, 2002)

Factors increasing perceived risk:

(after Covello, 1992)

1. Possible Severely Negative or Catastrophic Outcome
2. Unfamiliarity with Situation and Potential Risks
3. Inability to Explain Processes and Mechanism
4. Little Certainty in the Science and Engineering
5. Perception of Personal Control
6. Involuntary Exposures to Risks
7. Risk to Children and Sensitive Groups
8. Long-term Exposures, Latency Periods, Chronic Risk
9. Possible Transgenerational Exposures and Risks
10. Uncertainty about Potential Victims

... and the risk is perceived to increase even more when ...

- Greater “dread”
 - Major problem for nuclear power industry
- Mistrust of corporate or governmental partners
 - Guilt by association
- Negative media attention
- A history of accidents and failures at this site or in similar situations
- Benefits are not clear
- Mistakes are irreversible
 - Global climate change, for example

So, then what is risk, really?

- **Definition: Probability of harm or loss**
- **Part of our everyday lives**
 - Different for each of us
 - Basis for decision-making
- **But is it *quantifiable*?**

... depends on how you ask
but,...

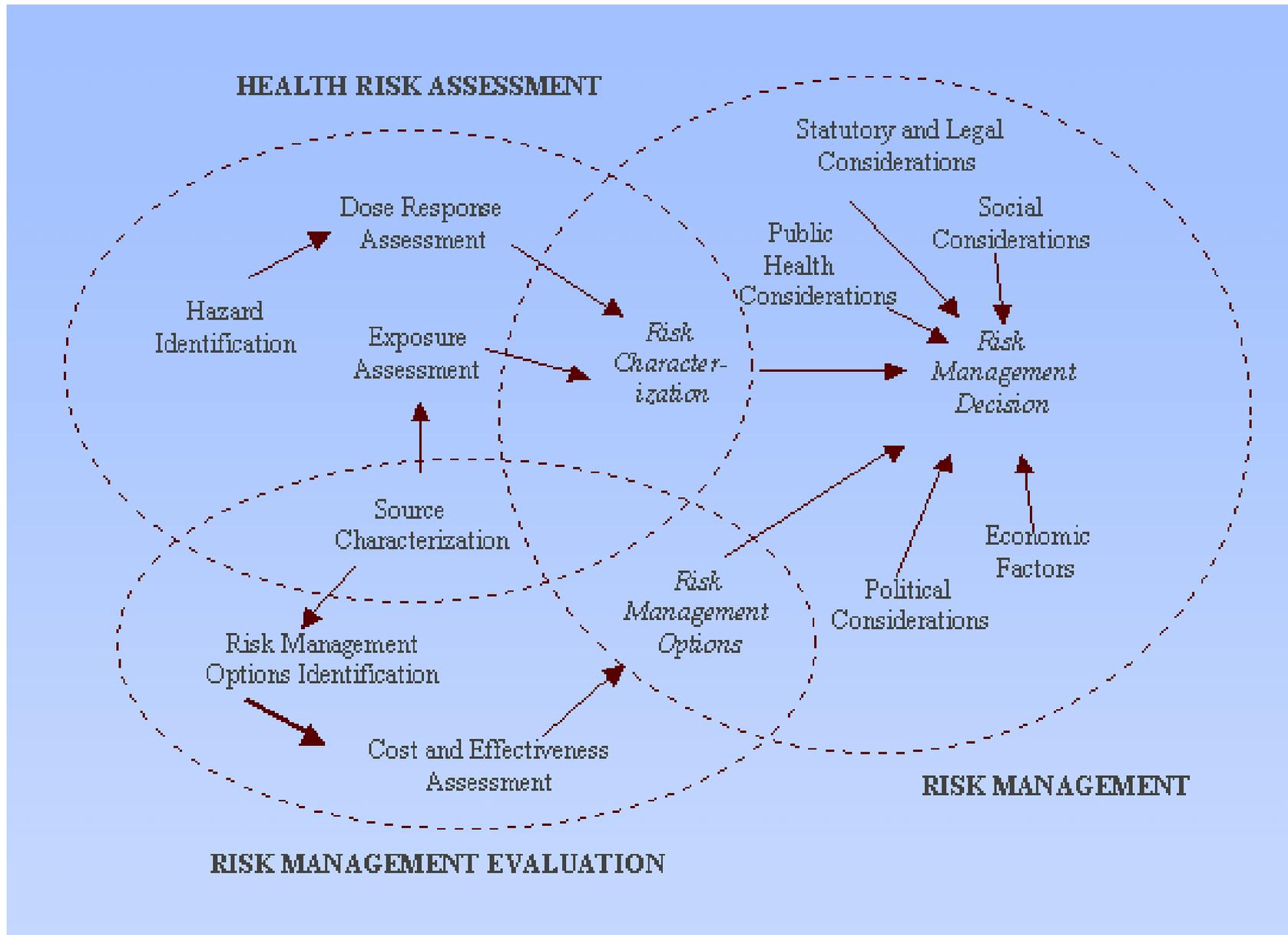
- **Yes it is quantifiable:**
 - ✓ **Risk = $f(\text{Hazard} \times \text{Exposure})$**
- **A probability, a fraction**
- **Part of our everyday lives**
 - **Different for each of us**
 - **Basis for decision-making**

Risk Assessment Defined:

Risk assessment is a process where information is analyzed to determine if an environmental hazard might cause harm to exposed persons and ecosystems.

Paraphrased from the “**Risk Assessment in the Federal Government**” (National Research Council, 1983)

Risk assessment...

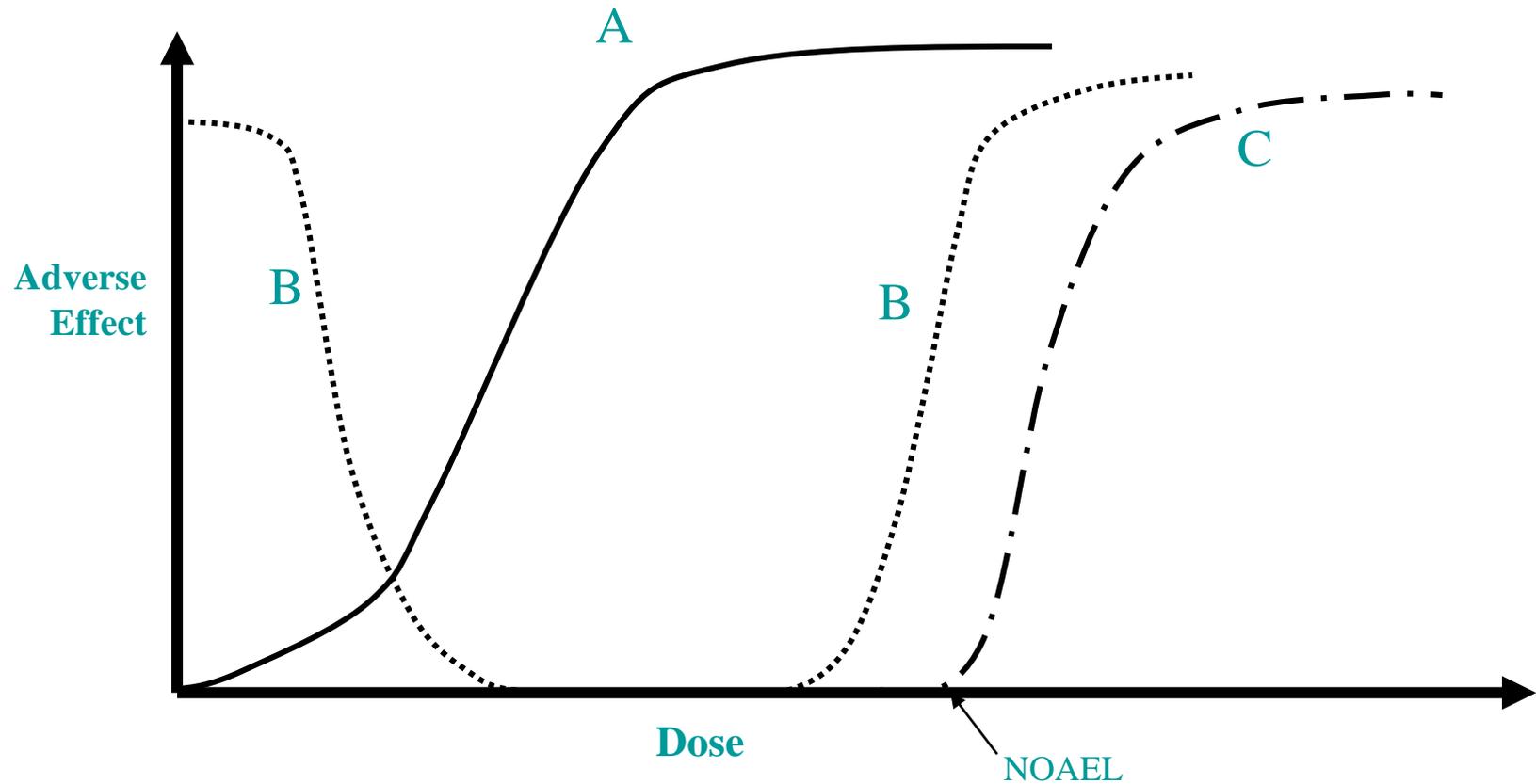


Different Processes at Work: Not everyone thinks like you do....*

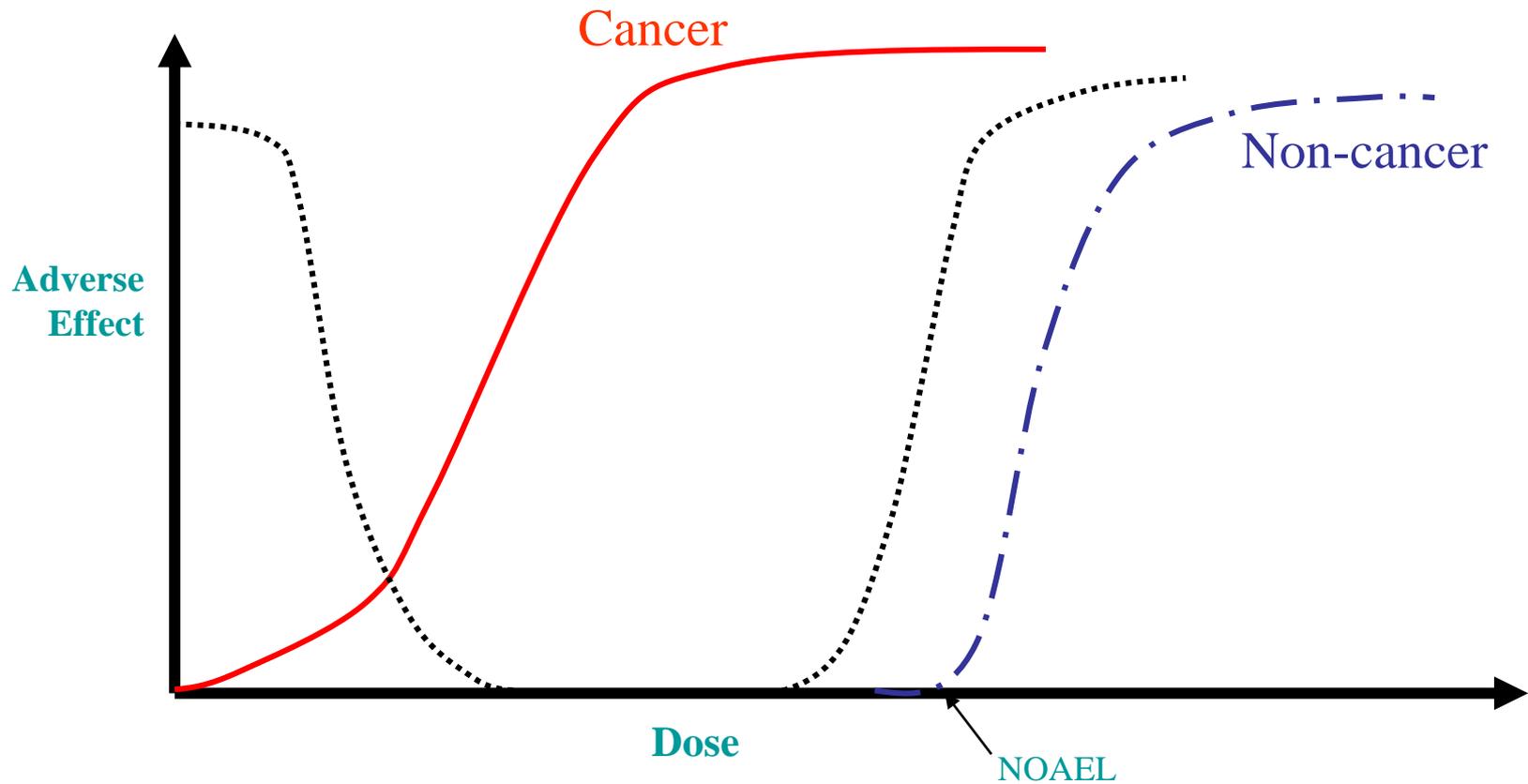
Analytical Phase	Risk Assessment Processes	Risk Perception Processes
Identifying risk	Physical, chemical, and biological monitoring and measuring of the event	Personal awareness
	Deductive reasoning	Intuition
	Statistical inference	
Estimating risk	Magnitude, frequency and duration calculations	Personal experience
	Cost estimation and damage assessment	Intangible losses and non-monetized valuation
	Economic costs	
Evaluating risk	Cost/benefit analysis	Personality factors
	Community policy analysis	Individual action

*Adapted from K. Smith, 1992

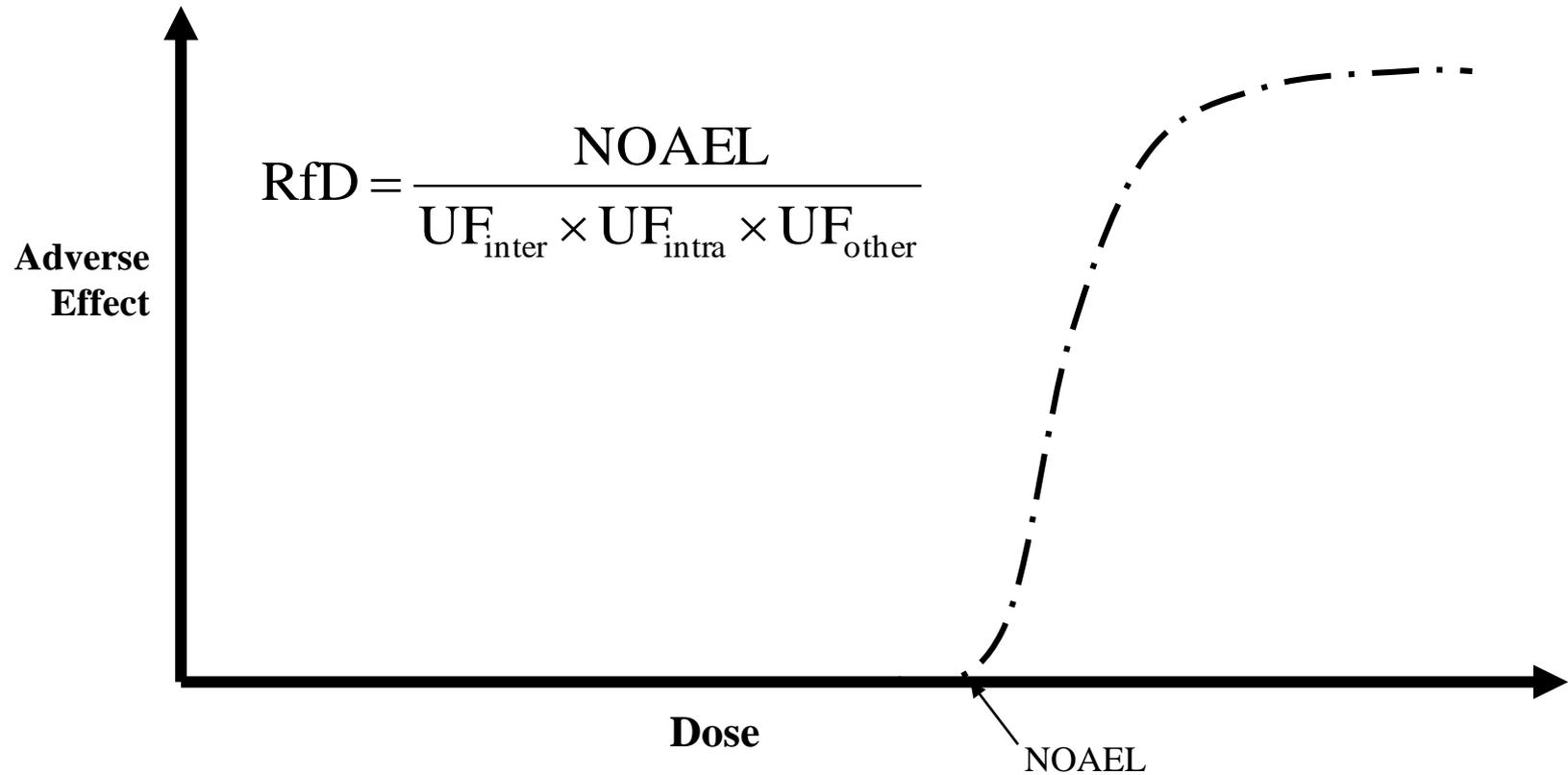
Dose-Response: A Way to Define a Hazard



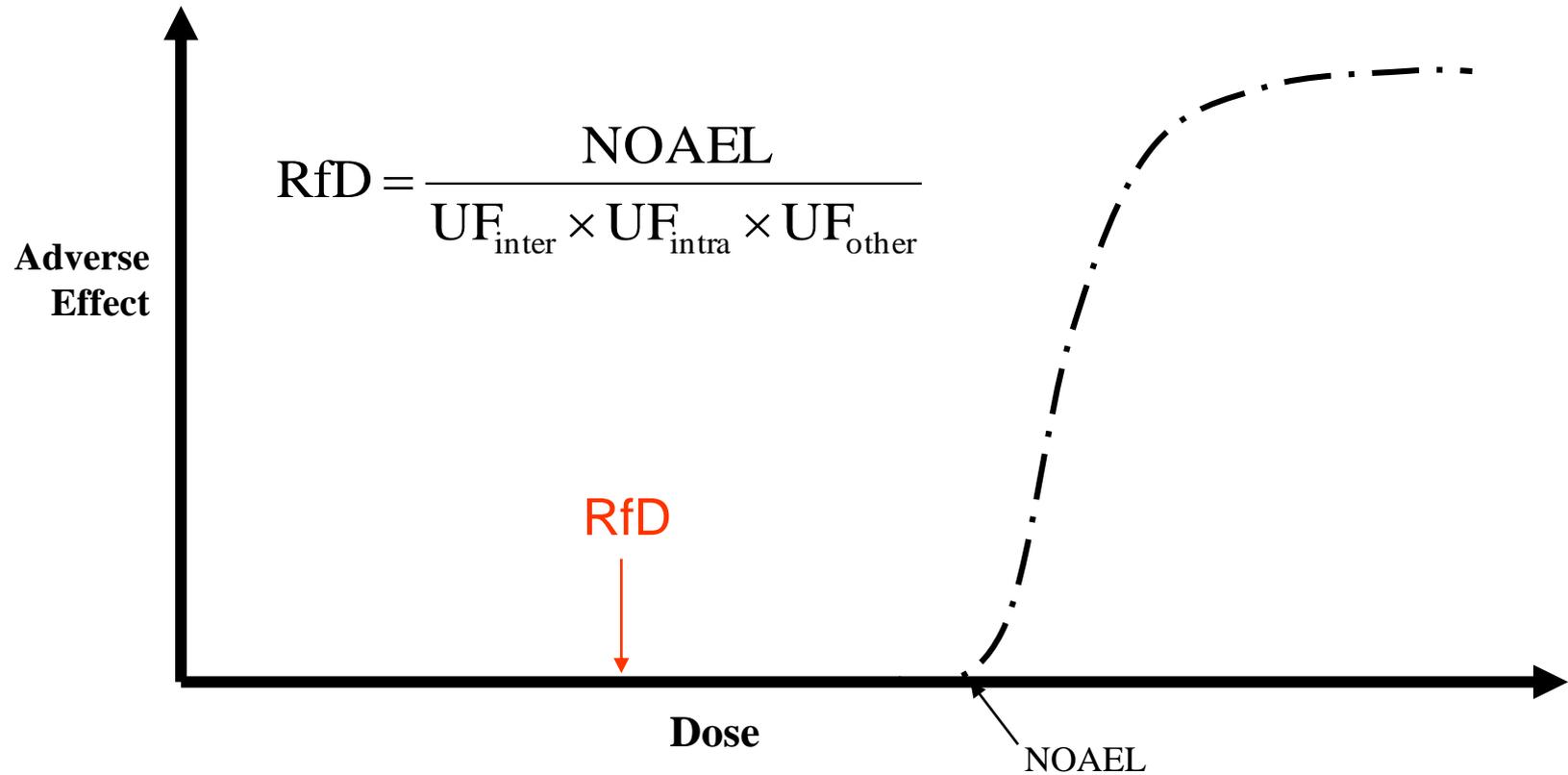
Dose-Response: No threshold for cancer



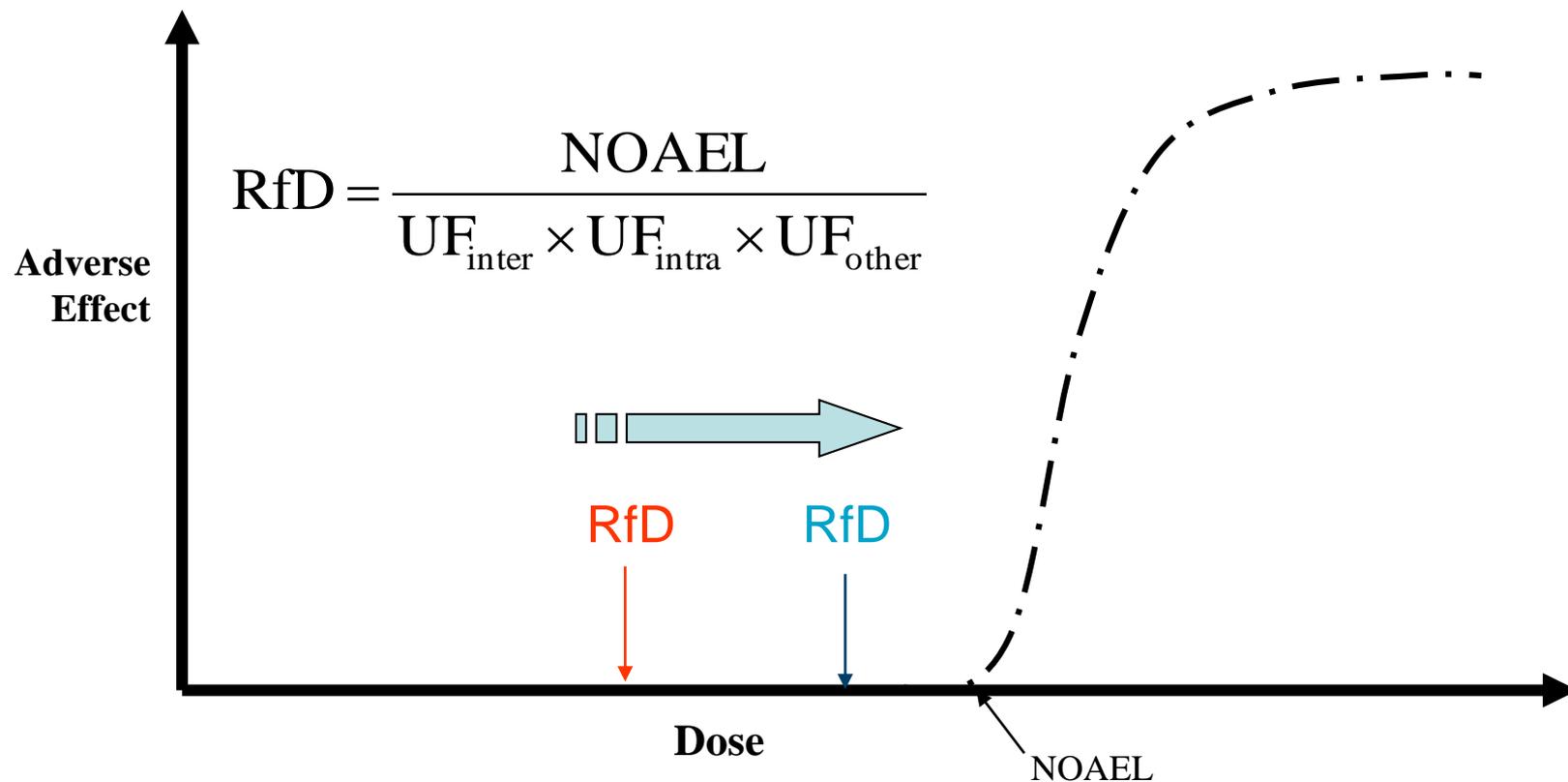
Dose-Response: Safety in Reference Dose



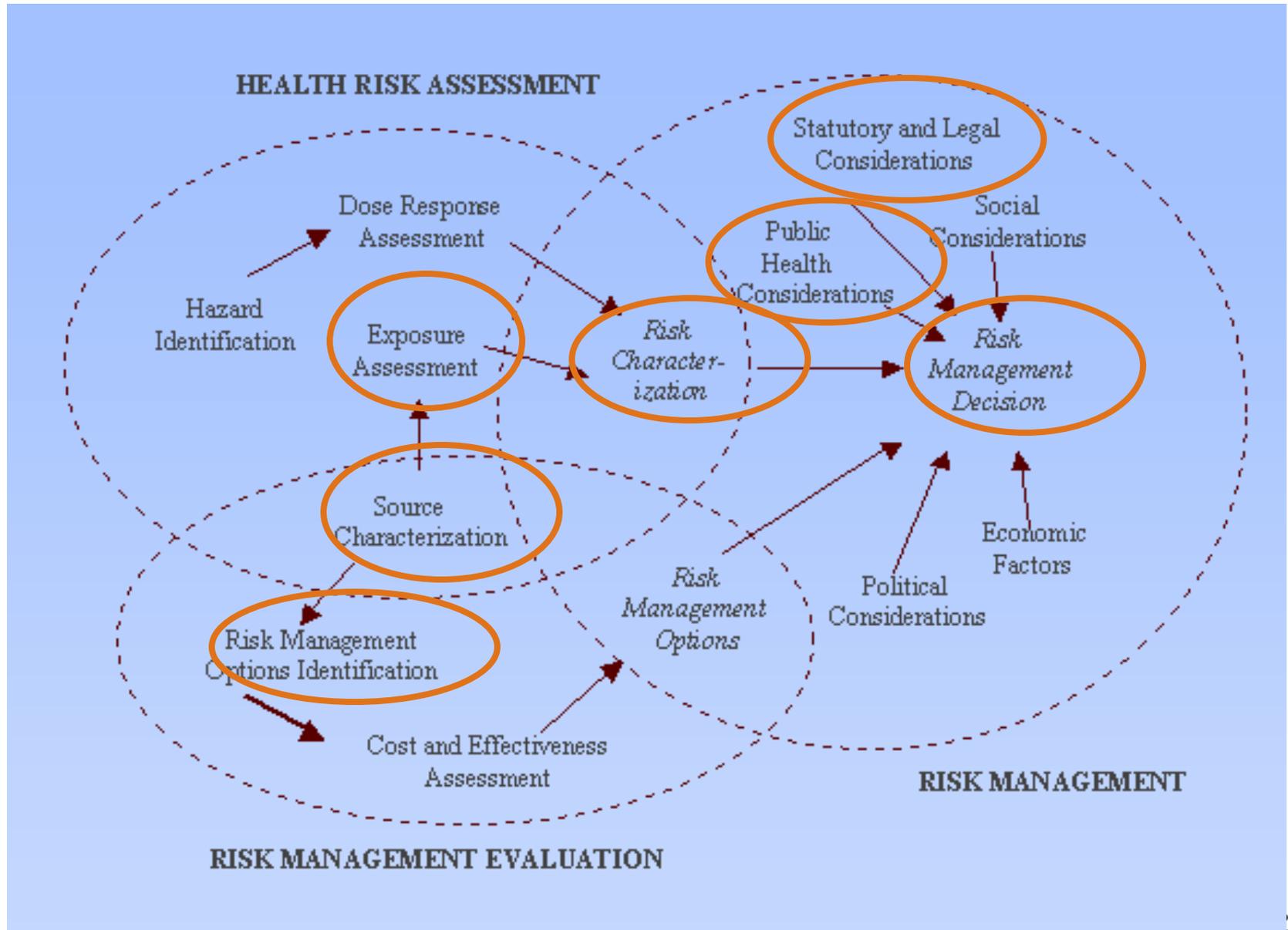
Dose-Response: Safety in Reference Dose



Improved Certainty from Better Measurements



Exposure ...



Calculating Exposures: Amount of Hazard Reaching Us

$$E = \int_{t=t_1}^{t=t_2} C(t) dt$$

Where,

E = personal exposure during time period from t_1 to t_2

$C(t)$ = concentration at interface, at t .

Exposure bridges the physical and social sciences

Chemistry & Physics

$$E = \int_{t=t_1}^{t=t_2} C(t) dt$$


Psychology & Sociology

Where,

E = personal exposure during time period from t_1 to t_2

$C(t)$ = concentration at interface, at t .

Discussion Questions

- What principles of research ethics are conflicting in this example?
- Is there more information you need to help you resolve this conflict?
- How should this conflict be resolved?

It's a matter of trust....

- This is a commodity that can be lost easily but regained with much difficulty....
- Numerous examples of loss of trust in sciences....

An 6-step approach to ethical decision making (from Resnik)

1. State or define the problem/issue
2. Gather information
3. Delineate options.
4. Apply different values, rules, principles, regulations to the different options.
5. Resolve conflicts among values, rules, etc.
6. Make a decision and act

A few final words...

- Do you agree with the risk paradigm?
- Should it be evidence based?
- How about the precautionary principle?

Trust is what it's about....

- *Ethike aretai*
 - *Engineering needs character*
 - *Engineering needs skill*
- *Credat emptor!*
- Resolve today to keep building competence and character.

If you have questions, contact me....

- dav1@duke.edu
- 919-541-3306

