PROGRESS UNDER UNCERTAINTY

How Collaboration Improves
Risk Assessment for Complex
Scientific Problems

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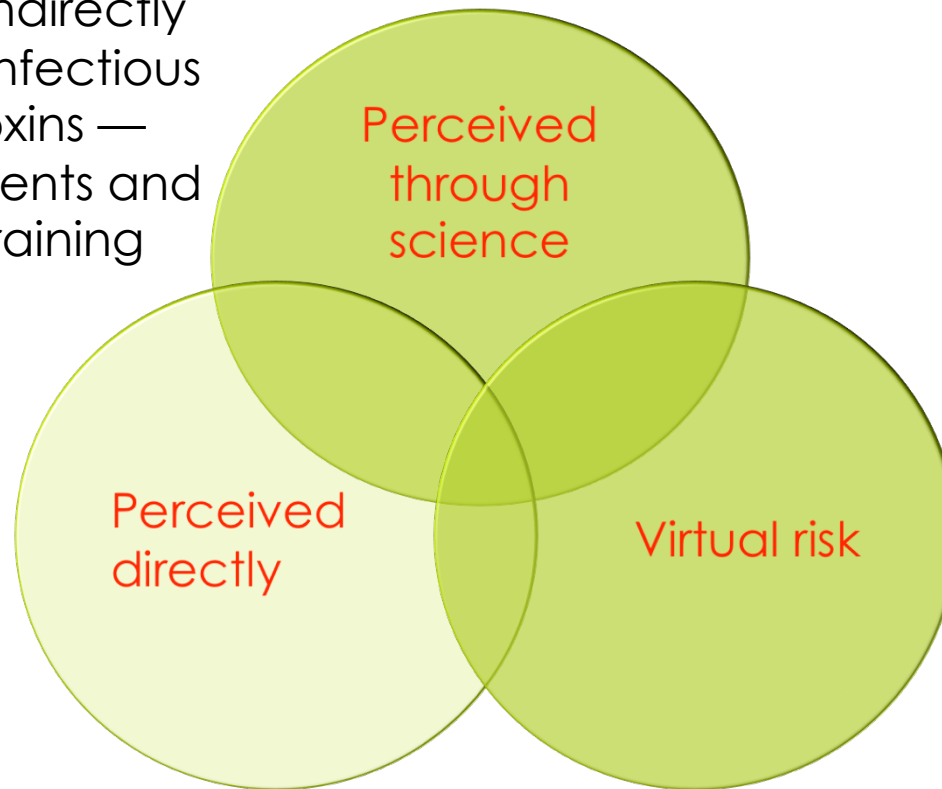Department of Engineering and Public Policy
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'RISK' MEANING WHAT?

Known but indirectly perceived: infectious disease, toxins — need instruments and scientific training

Perceived through science

Perceived directly

Virtual risk

Biking, driving, operating heavy machinery, texting while crossing a street

Unprecedented events, technological innovations — scientists don't have data, or can't agree

(Source: John Adams)

PERCEIVED THROUGH SCIENCE

Radiation

Traditional pesticides

Asbestos

Mercury

Antibiotic resistance

DISCIPLINARY BY NATURE

- Cause-and-effect well understood
- Plenty of unambiguous data to calculate probabilities
- Unintended consequences are minimal, controllable
- 'Engineering' is possible
- **DECISIONS UNDER RISK**

DECISIONS UNDER RISK

Predicated on ability to quantify

- Cost-benefit analysis
- Mathematical modeling
- 'Acceptable levels' of toxicity, morbidity, mortality

'VIRTUAL' RISK

Genetic engineering

Synthetic biology

Nanotechnology

Geo-engineering
(involves interactions
with some or all of the
above)

INTERDISCIPLINARY BY NATURE

- Not the purview of a single discipline
- Data on interventions is ambiguous, sensitive to disciplinary assumptions
- Systems are too complex to model the effects of interventions
- Great uncertainty; discoveries often break previous understanding
- Consequences cannot be predicted
- Guided perturbation, not 'engineering'
- **DECISIONS UNDER UNCERTAINTY**

INDUSTRIAL ERA HAS SHIFTED TO INFORMATION AGE ...

DECISIONS UNDER RISK

DECISIONS UNDER UNCERTAINTY
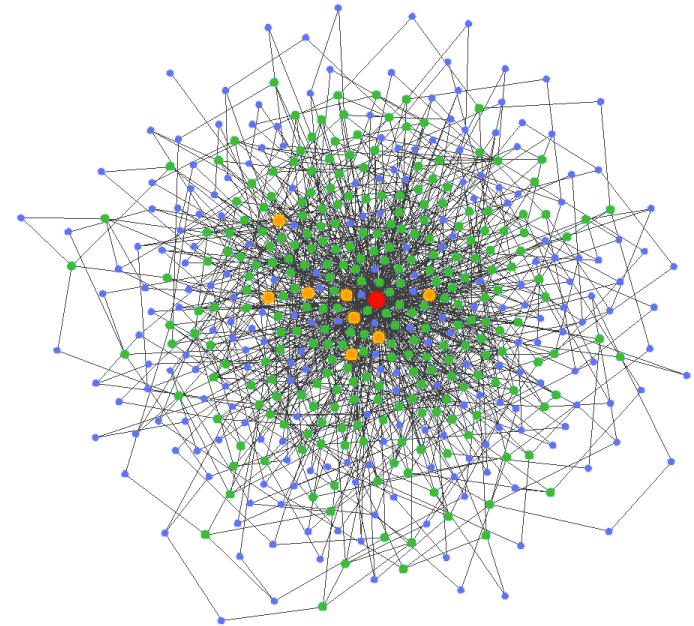
Analogy courtesy of David Rejeski

… BUT SOMEONE FORGOT TO TELL THE RISK ANALYSTS

Cost-benefit doesn't work when data are sparse or assumptions are incorrect

Virtual risks 'perceived by science' (i.e., toxicity, morbidity, mortality) often neglect indirect effects

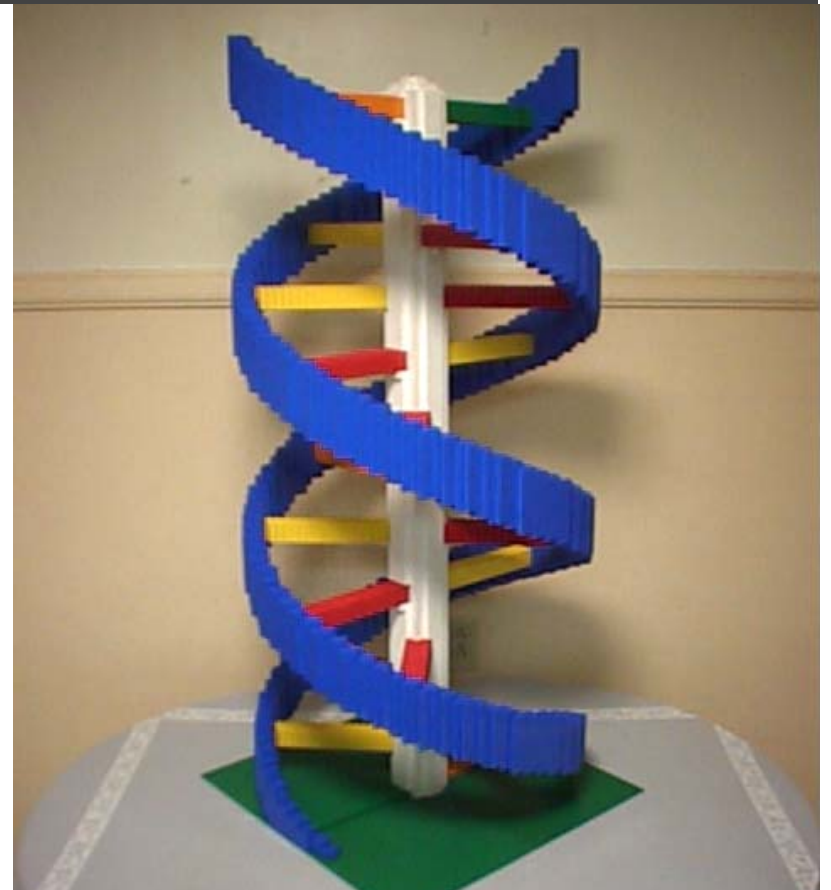Prediction is unfeasible under uncertainty — complexity breaks the models

ENCODE Study, 2003-2007

'Parts list of all biologically functional elements' in 1% of the human genome

Genes operate in 'complex, interwoven networks'

'Reshaped our understanding' and ...

'Poses some interesting mechanistic questions'

Howard F. Schwartz, Colorado State University

'ROUNDUP READY' SUPERWEEDS: 1M+ INFESTED ACRES IN ARKANSAS

Herbicide-resistant soy and cotton crops transferred their HR genes to the giant pigweed.

GM COTTON

Pink bollworm has developed resistance to the pesticide protein produced by Monsanto's GM cotton.

GM MAIZE

New health effects 'mostly associated with the kidney and liver, the dietary detoxifying organs' (IJBS 2010)

Crop runoff has introduced insecticidal proteins to water supplies (PNAS 2010)

NILE PERCH v. GM SALMON

Invasive Nile perch

Transgenic and unmodified salmon
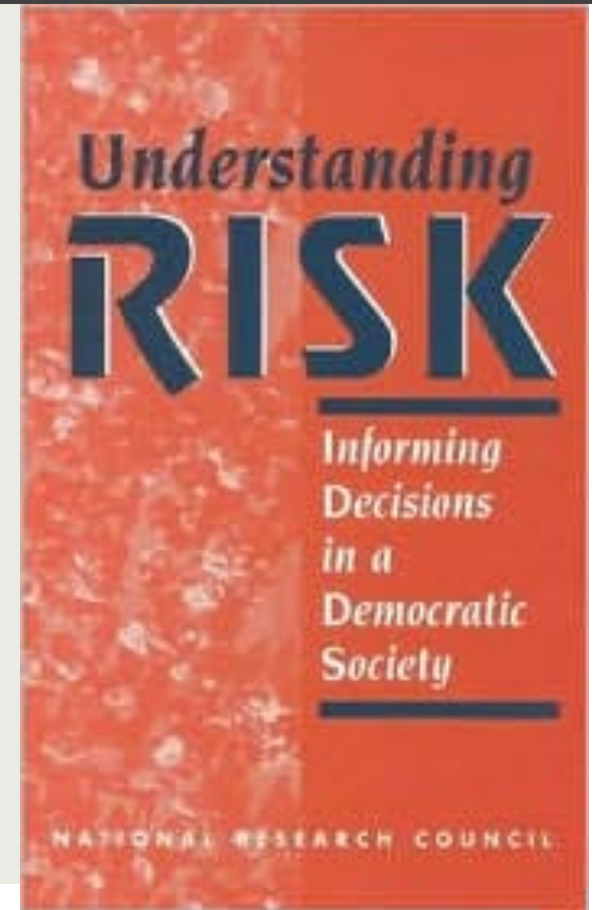
PROGRESS UNDER UNCERTAINTY

Requires methods as *interdisciplinary* and *challenging* to the status quo as innovations they assess

THE BEST PLACE TO START

Understanding Risk, NRC 1996

Chaired by Harvey Fineberg, now president of Institute of Medicine

Landmark study

THE ANALYTIC-DELIBERATIVE PROCESS

Problem/decision-driven, not product driven

Interdisciplinary, cross-sector

All interested and affected parties at the table

Combines analysis where data is available with collective consideration of issues — including uncertainty — when it is not

WHEN TO DEPLOY?

1. When **lots of different dimensions** can be affected by the outcome

2. Where there's **scientific uncertainty** — where there's not enough science to know how things will turn out

3. When **people disagree about benefits** or outcomes, and they may change if they're given new information.

4. **No single authority can be trusted** to know all the answers.

5. Where **a decision must be made** before "getting certain"

# CHEMICAL WEAPONS DISPOSAL: WHAT ARE THE ALTERNATIVES?

INCINERATION would produce and release dioxin, vaporize and release toxic heavy metals.

Concerned citizens petitioned Congress to consider alternatives.

DOD started an A-D process that included scientists, government officials, and relevant stakeholders.

Four scientifically sound alternatives were developed; NEUTRALIZATION was deployed .

(Sources: Mary O'Brien, Heather Douglas)
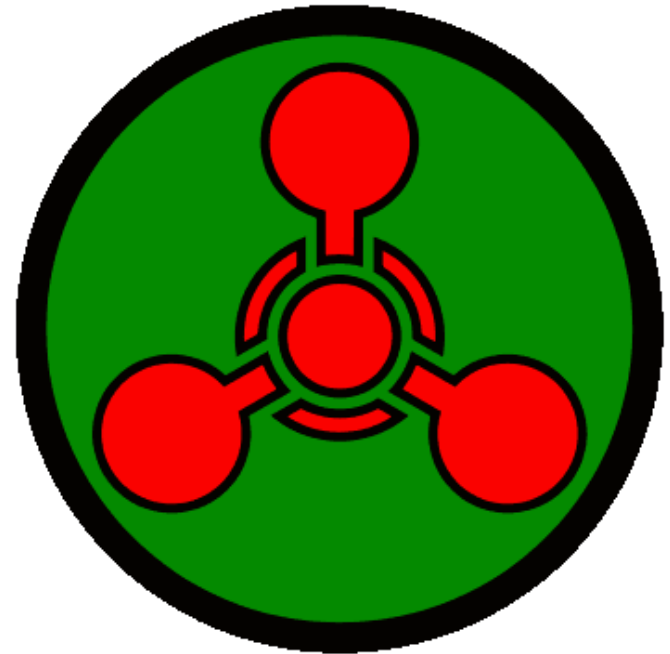
TUGBOATS IN VALDEZ, ALASKA

PARTICIPANTS: Citizen's Advisory Council, oil industry and all agencies involved in the decision

RESEARCH TEAM: Industry and advisory council experts, with oversight from all three groups

EXPERT: A-D 'Increased our understanding of the problem domain, and enabled us to get lots of data we didn't think was available.'

New vessel was deployed in 1997.

(Source: Heather Douglas)

EPA'S DISINFECTANT BYPRODUCT RULE: WHAT IF THERE ARE NO DATA?

Chlorination + organic compounds = "disinfectant by-products," some of which are carcinogens.

EPA compelled by Congress/lawsuit to make a rule despite lack of data on health effects

Because of uncertainty and controversy, EPA convened AD process,

Result: Not enough data to BAN or APPROVE

Information Collection Rule for ongoing monitoring and testing, and specific actions based on results

Breakthrough: the rule could be modified over time based on new data

WHAT'S THE DOWNSIDE?

SINGLE POINTS OF CONTROL ARE GONE
(this makes some people very cranky)

POTENTIAL ISSUES OF SCALE

DOCUMENTED BENEFITS

- Data/evidence directly informs the deliberation

- Transparency challenges assumptions about evidence and uncertainties, ensures diversity and agreement on the problem

- Fewer, better conflicts – focuses the assessment on real issues, not factual misunderstanding

- Acknowledging uncertainty provides practical directions for research, thus can help drive scientific discovery

- Problem-driven, so the solution is the goal, not justifying one particular product or approach.

WHERE TO BEGIN?

'The problem is so vast there is no point in getting hysterical.'

Augusto Leggio, Italian government official, about Y2K's impact on transportation

START MAKING LISTS

- Start a book clubs amongst yourselves so you can learn this field *(I will make a reading list, if you want)*

- What are the most imminent interventions, in remediation and climate intervention?

- Who are the experts and affected parties for each?

- Where can you find a pool of independent experts in dialog and deliberation? *(I can help with this, too)*

DISCOMFORT YIELDS CHANGE. AMBIGUITY IS UNAVOIDABLE. TOLERANCE IS KEY.

Thank you for your attention!
If I can help, please call on me.