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*The Precautionary Principle
and Science for the 21st
Century
Epistemology in the Balance*

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Thesis

- 1) the world is complex. Uncertainty is the rule rather than the exception.
- □2) interventions can and do have surprising and often unintended consequences; the prec prin is one way of recognizing that;
- 3) the world has been damaged by humans and technology. The ecological infrastructure required to support humans has been undermined;
- □4) The prec prin is not a threat to science. It does challenge the old 17th century epistemology and recognizes the limits of science in the midst of complexity.
- 5) The contested space is deciding if we know enough to act and who gets the benefit of the doubt.



➤ **Definition of science**

- knowledge or a system of knowledge covering general truths or the operation of general laws especially as obtained and tested through scientific method

➤ **Definition of scientific method**

- the collection of data through observation and experiment, and the formulation and testing of hypotheses

➤ **Definition of epistemology**

- the theory of knowledge, esp. the critical study of its validity, methods, limits, and scope

Risk assessment

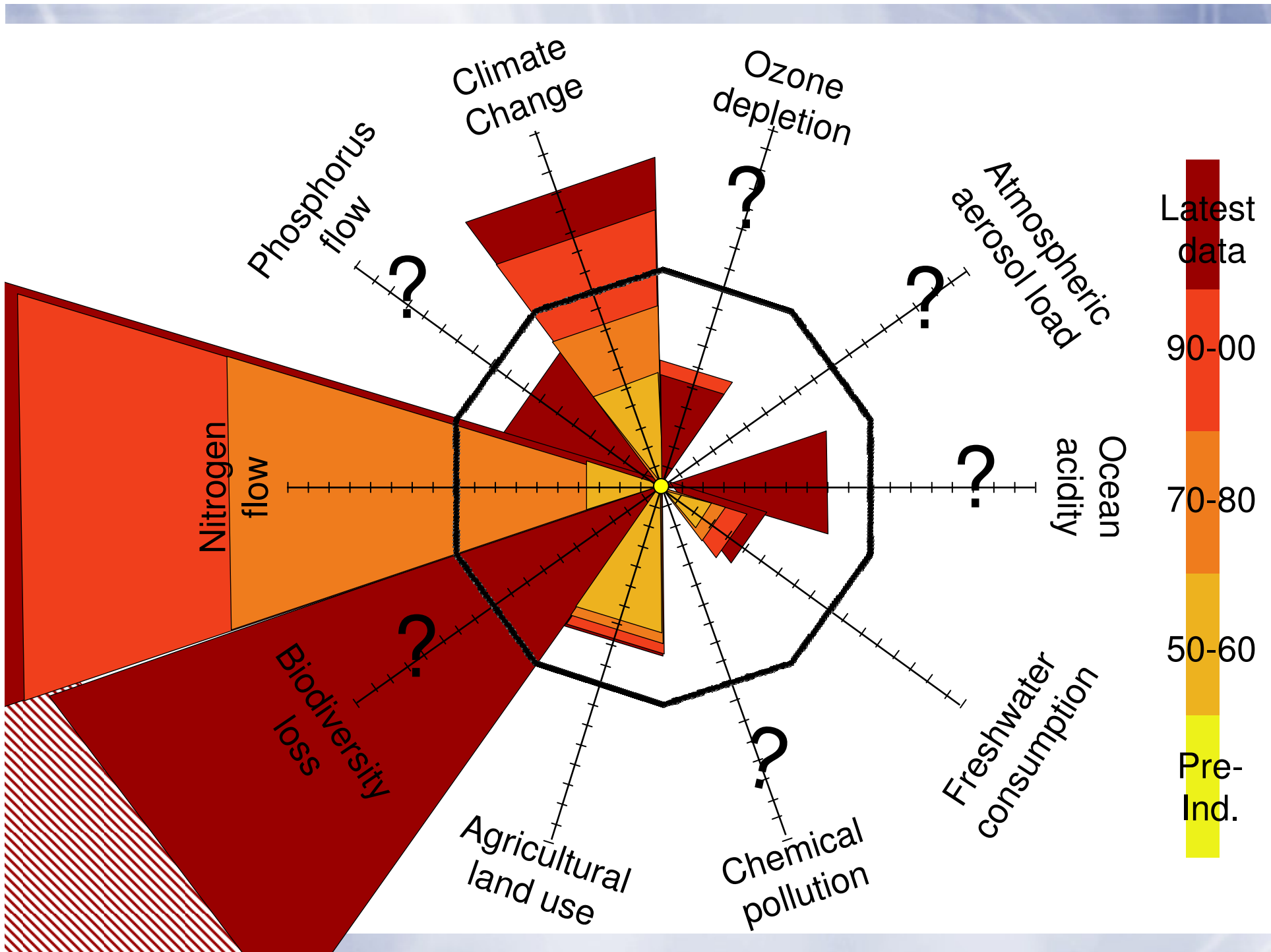
- 1) Reductionistic*
- 2) (usually) single discipline (toxicology)*
- 3) Narrow view of causation (simple and direct)*
- 4) Short term assessments (more accurately assesses acute rather than subtle, rare or chronic problems)*
- 5) Favors false negatives*
- 6) Does not account for uncertainty inherent in complex systems*
- 7) Does not account for cumulative impacts*
- 8) Doesn't build in feedback loops to test the RA*

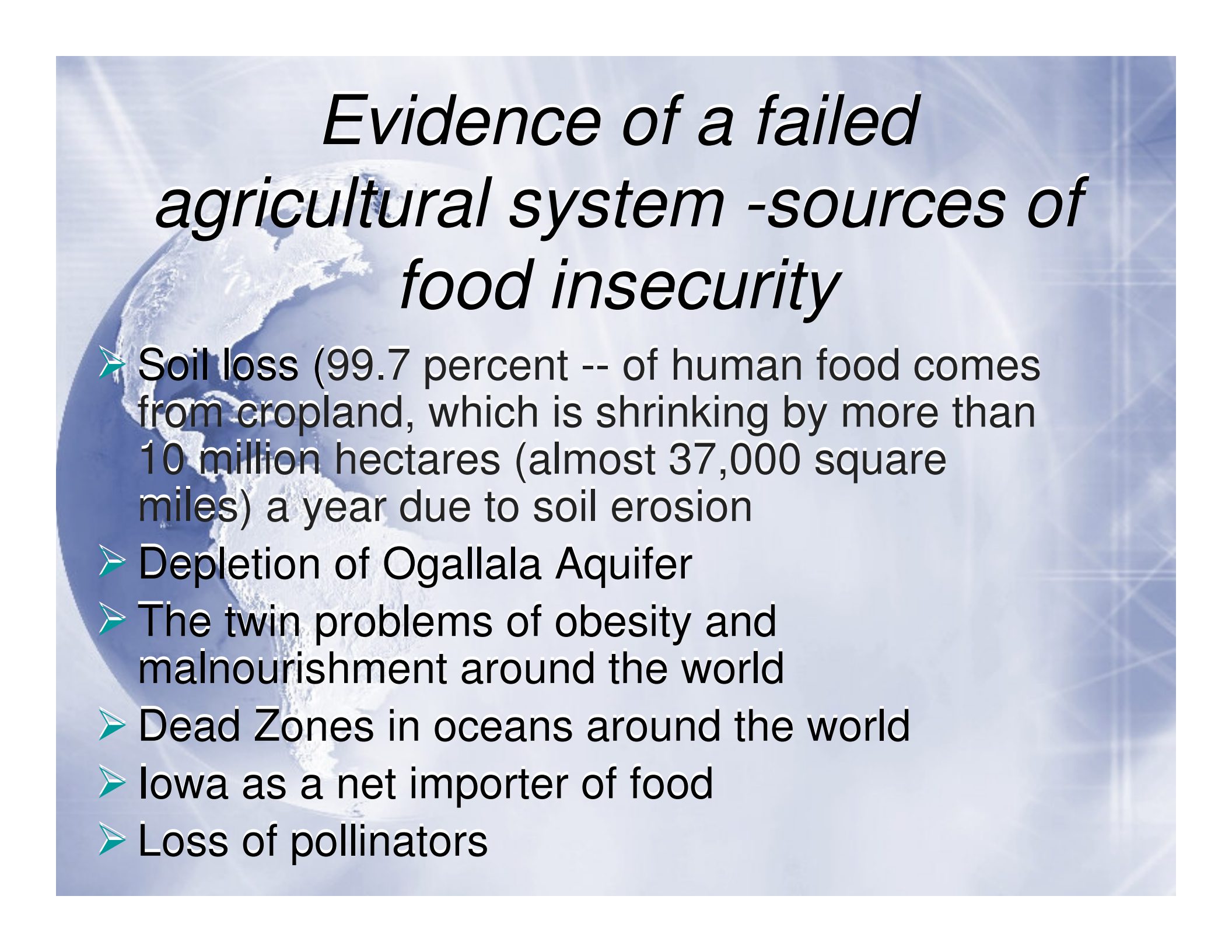


Planetary Boundaries: A Safe Operating Space for Humanity

- identified nine Earth-system processes and associated thresholds which, if crossed, could generate unacceptable environmental change.
 - climate change;
 - rate of biodiversity loss (terrestrial and marine);
 - interference with the nitrogen and phosphorus cycles;
 - stratospheric ozone depletion;
 - ocean acidification;
 - global freshwater use;
 - change in land use;
 - chemical pollution; and
 - atmospheric aerosol loading

- <http://www.nature.com/news/specials/planetaryboundaries/index.html#feature>





Evidence of a failed agricultural system -sources of food insecurity

- Soil loss (99.7 percent -- of human food comes from cropland, which is shrinking by more than 10 million hectares (almost 37,000 square miles) a year due to soil erosion
- Depletion of Ogallala Aquifer
- The twin problems of obesity and malnourishment around the world
- Dead Zones in oceans around the world
- Iowa as a net importer of food
- Loss of pollinators



*Industrial agriculture is
predicated on*

- Cheap energy from fossil fuels
- Stable climate
- Abundant fresh water



Precautionary principle

- Broad view of causation (complex causation = context dependent)
- Favors false positives (drives more information)
- Accounts for uncertainty in complex systems



Precautionary Principle

Rio Earth Summit 1992 Principle 15

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Wingspread Statement 1998

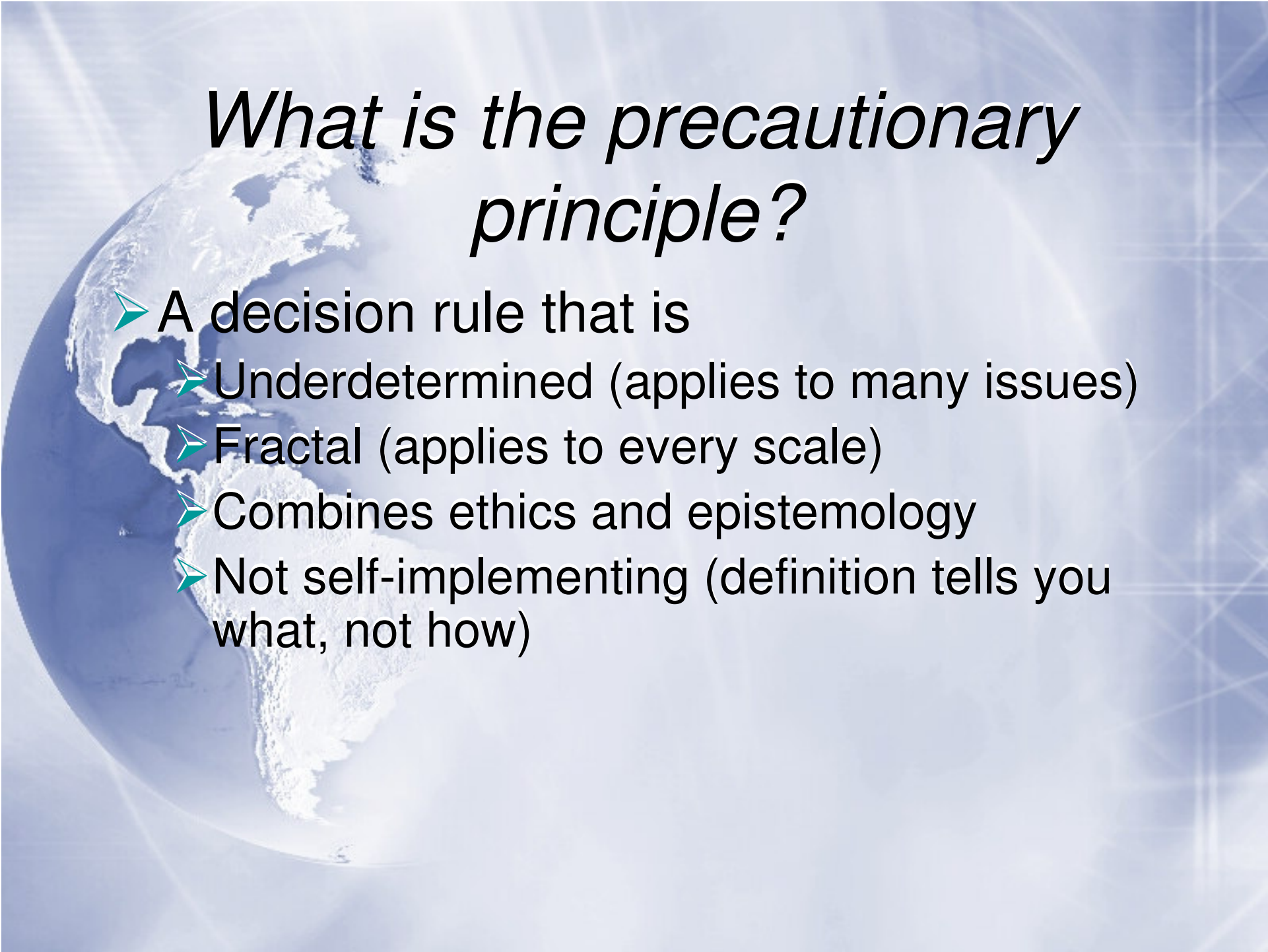
When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.



Elements of the precautionary principle

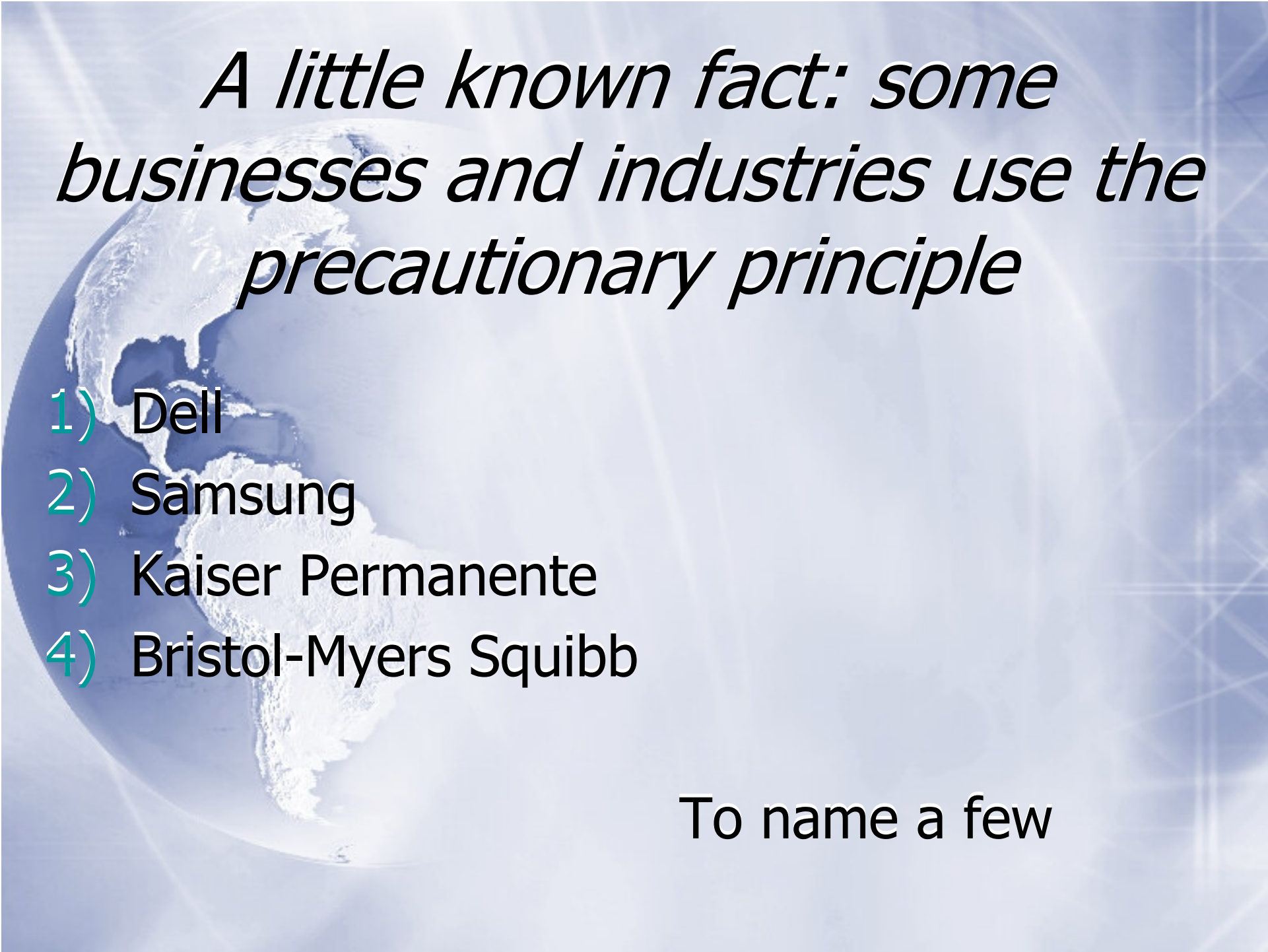
- Plausible threats of harm
- Lack of scientific certainty
- Precautionary action to prevent harm

Note: every formulation of the precautionary principle contains these three elements.



What is the precautionary principle?

- A decision rule that is
- Underdetermined (applies to many issues)
- Fractal (applies to every scale)
- Combines ethics and epistemology
- Not self-implementing (definition tells you what, not how)



A little known fact: some businesses and industries use the precautionary principle

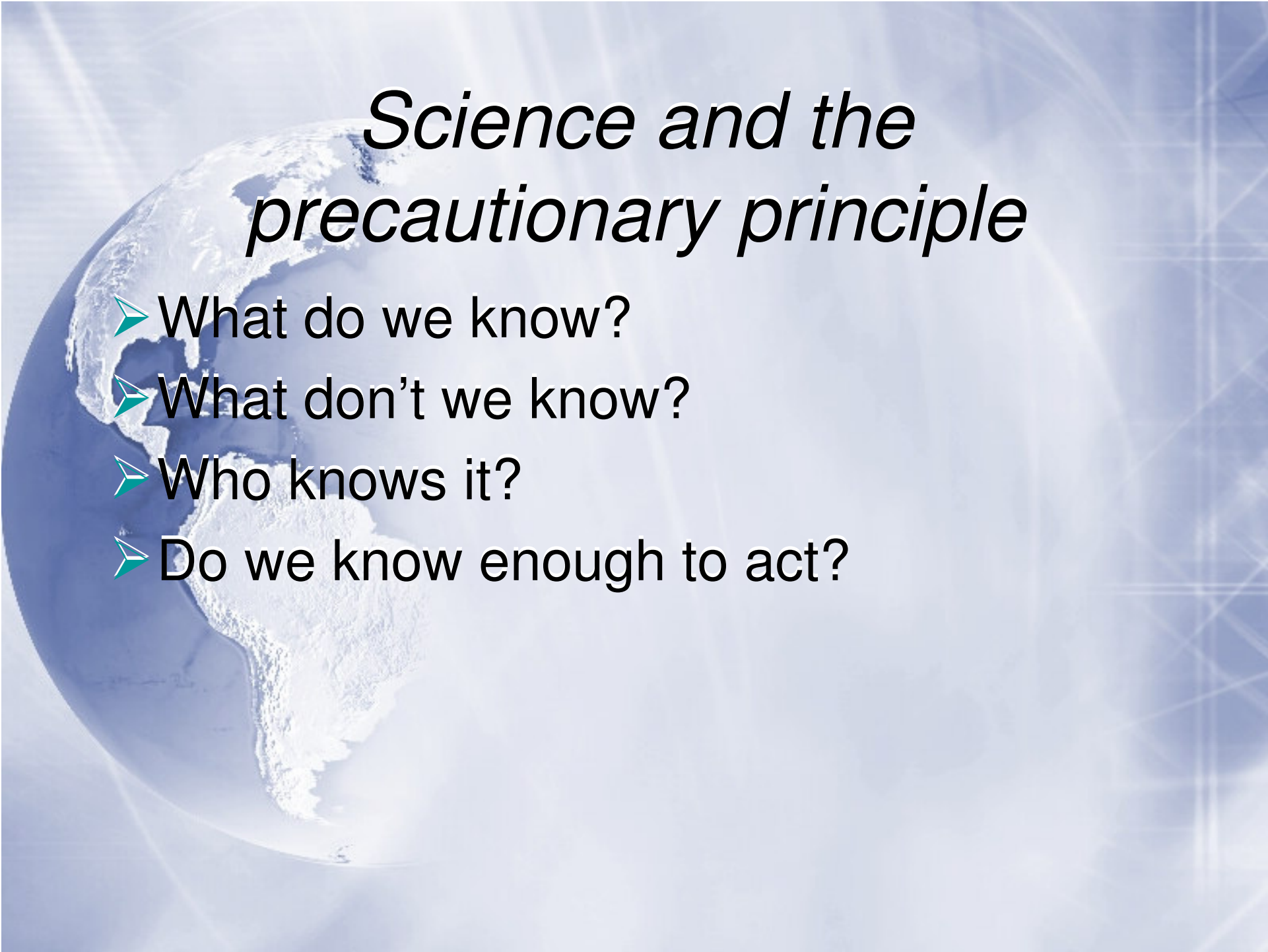
- 1) Dell
- 2) Samsung
- 3) Kaiser Permanente
- 4) Bristol-Myers Squibb

To name a few



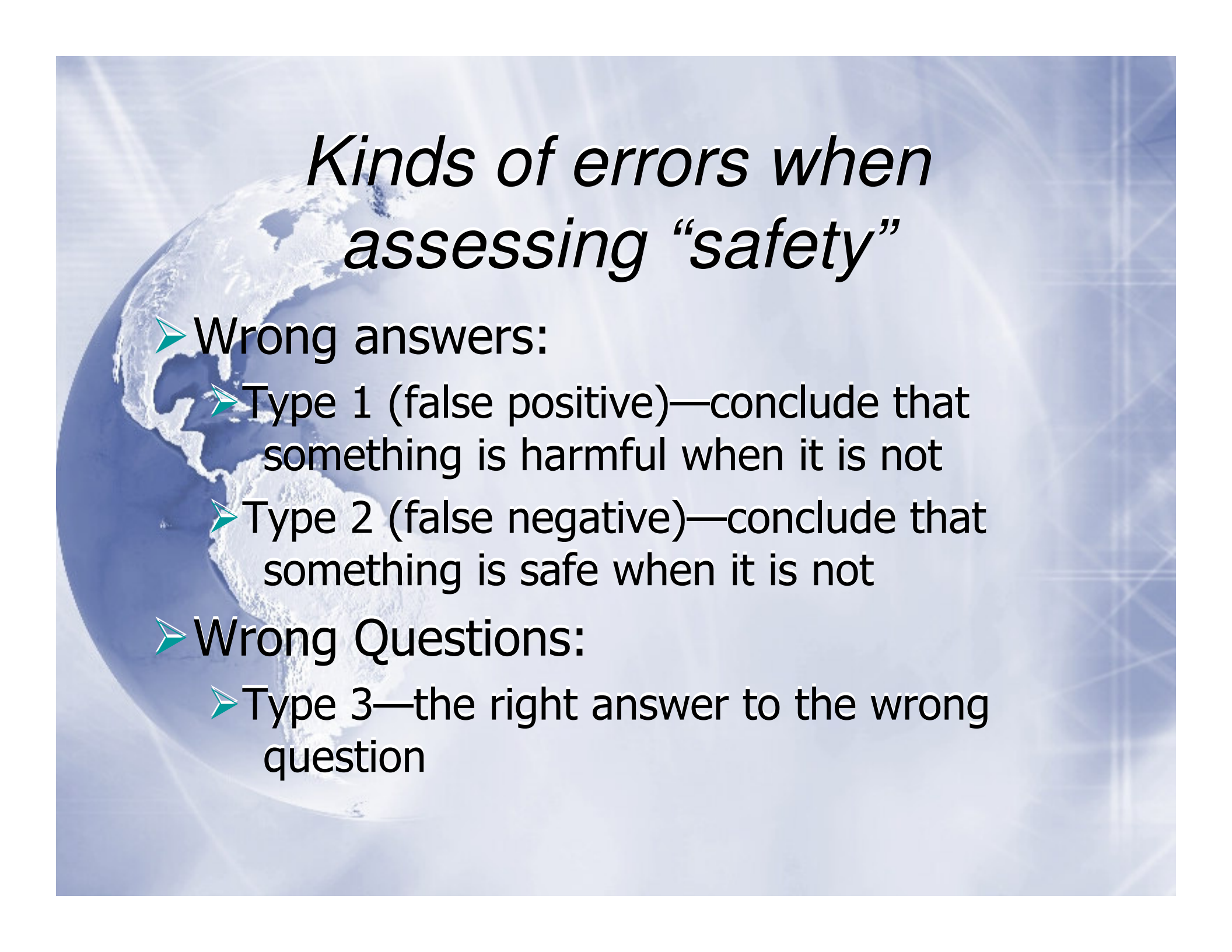
Implementing the precautionary principle

- 1) Heeding Early Warnings
- 2) Setting Goals
- 3) Identifying and Choosing the Best Alternatives
- 4) Reversing the Burden of Proof
- 5) Democracy: engaging all affected stakeholders



Science and the precautionary principle

- What do we know?
- What don't we know?
- Who knows it?
- Do we know enough to act?



Kinds of errors when assessing “safety”

- Wrong answers:

- Type 1 (false positive)—conclude that something is harmful when it is not

- Type 2 (false negative)—conclude that something is safe when it is not

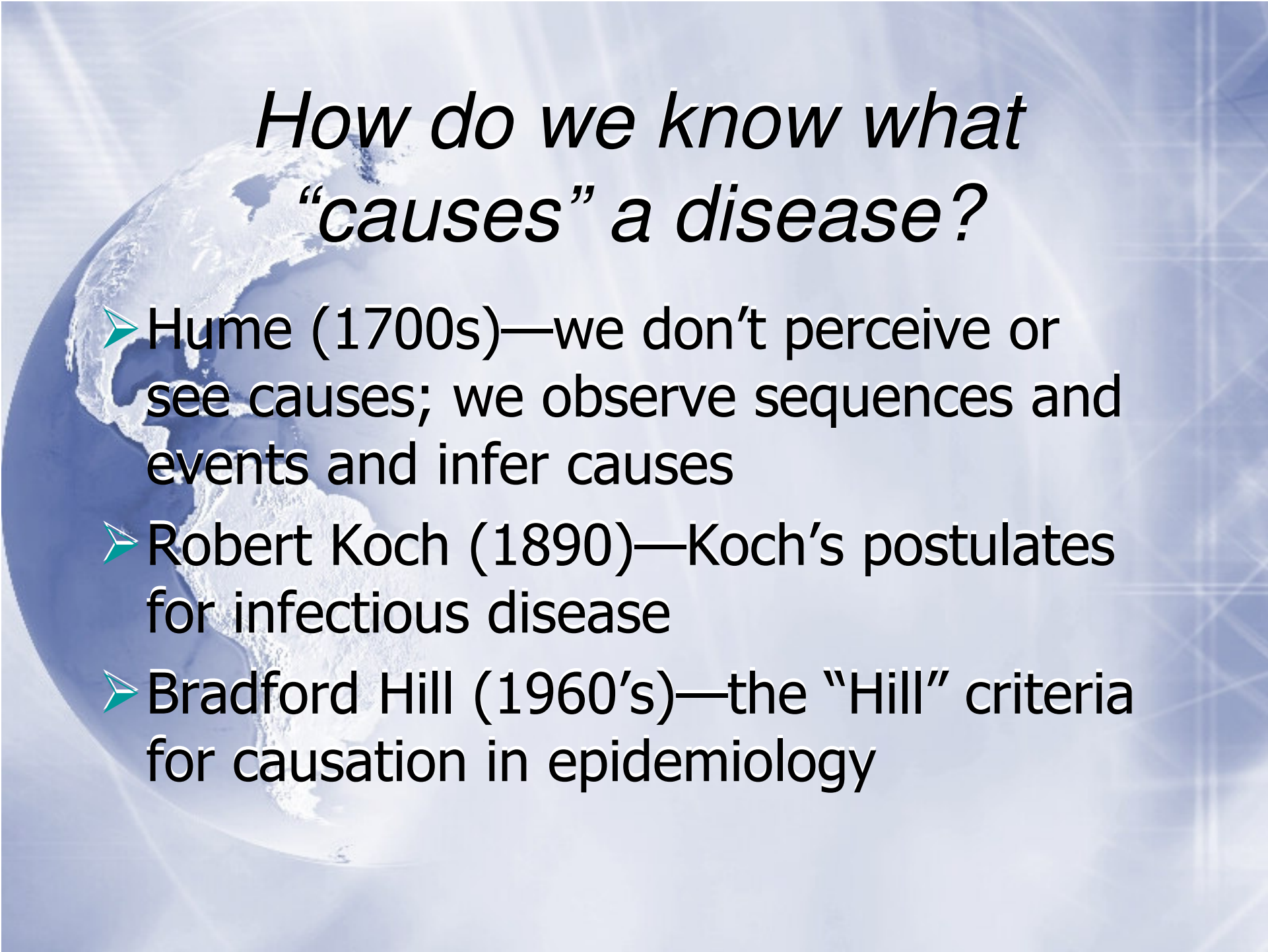
- Wrong Questions:

- Type 3—the right answer to the wrong question



Error bias

- Scientific studies are usually interpreted to favor type 2 over type 1 errors
- This is because we have chosen not to conclude that evidence is “significantly positive” without it being “strong”
- Should the interpretation of “science” for establishing policies to protect public environmental health favor Type 1 errors?
- Who should decide?



How do we know what “causes” a disease?

- Hume (1700s)—we don't perceive or see causes; we observe sequences and events and infer causes
- Robert Koch (1890)—Koch's postulates for infectious disease
- Bradford Hill (1960's)—the “Hill” criteria for causation in epidemiology



Hill criteria for causation in epidemiology

- Consistency of findings
- Strength of association
- Biological gradient (dose-response)
- Temporal sequence (“cause” before effect)
- Biologic plausibility (mechanism)
- Coherence with established facts
- Specificity of association



Comments from Bradford Hill

- “None of my criteria can bring indisputable evidence for or against a cause and effect hypothesis and none, except for time sequence, can be required as a *sine qua non*”
- “All scientific work is liable to be upset or modified by advancing knowledge. That does not confer upon us a freedom to ignore the knowledge that we already have, or to postpone the action that it appears to demand at a given time.”



Cigarettes and lung cancer— evidence for causation

- 1945—Ochsner—Incidence rises together
- 1950—Doll & Hill—case-control study
- 1953—Wynder—tar causes cancer in mice
- 1954—Follow up studies show association, and that greater exposure > greater risk
- 1990s—biological mechanism(s) described (genetic factors; mutations)

21st century science for agriculture

- Open source technology development
- New disciplines
 - Biomimicry
 - Green chemistry
 - Green engineering (only changes in farm equipment over 70 years = bigger and went from analog to digital)
- Additional kinds of evidence in regulation
 - Trends
 - Monitoring feedback loops
 - Systemic
 - Multi-factorial
 - Alternatives assessment



And last but not least

- Regulation will employ the precautionary principle and:
 - Will monitor and act on early warnings
 - Search and choose the best alternatives (driving innovation) and use risk assessment to compare them
 - Will give the benefit of the doubt to health and the environment
 - Recognize the ethic of preventing harm to present and future generations

*The Earth is one of the better
campsites in the universe*

