Scientific Research Overview

1. The “world of the scientist”

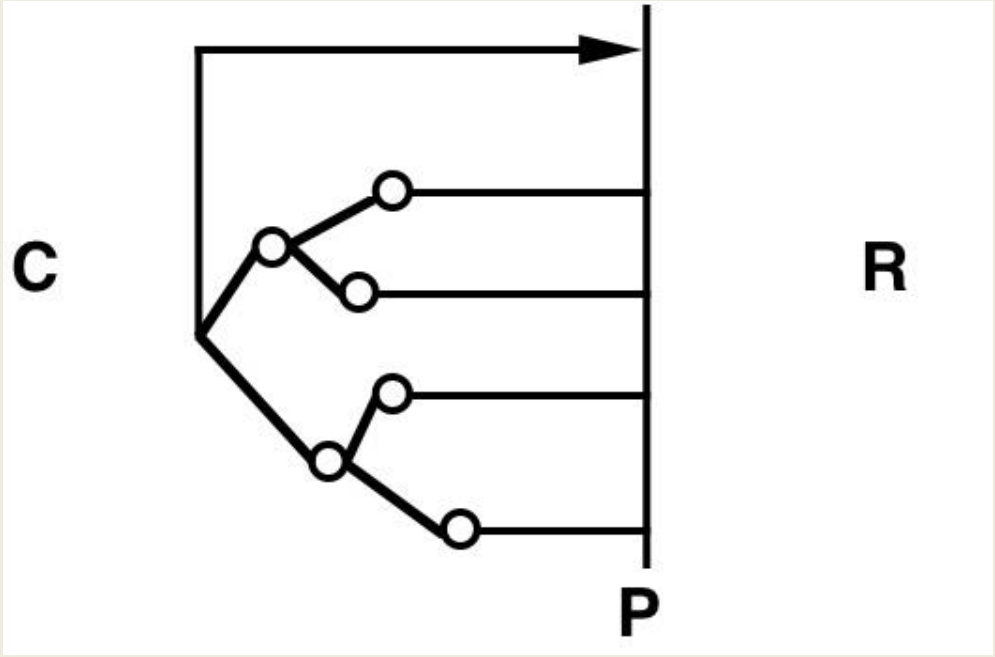
2. The scientific research cycle – i.e., general method of science

3. Kinds, goals, aims

4. Phases, tactics, modes of advance

1a. “World of the scientist”

Constructs

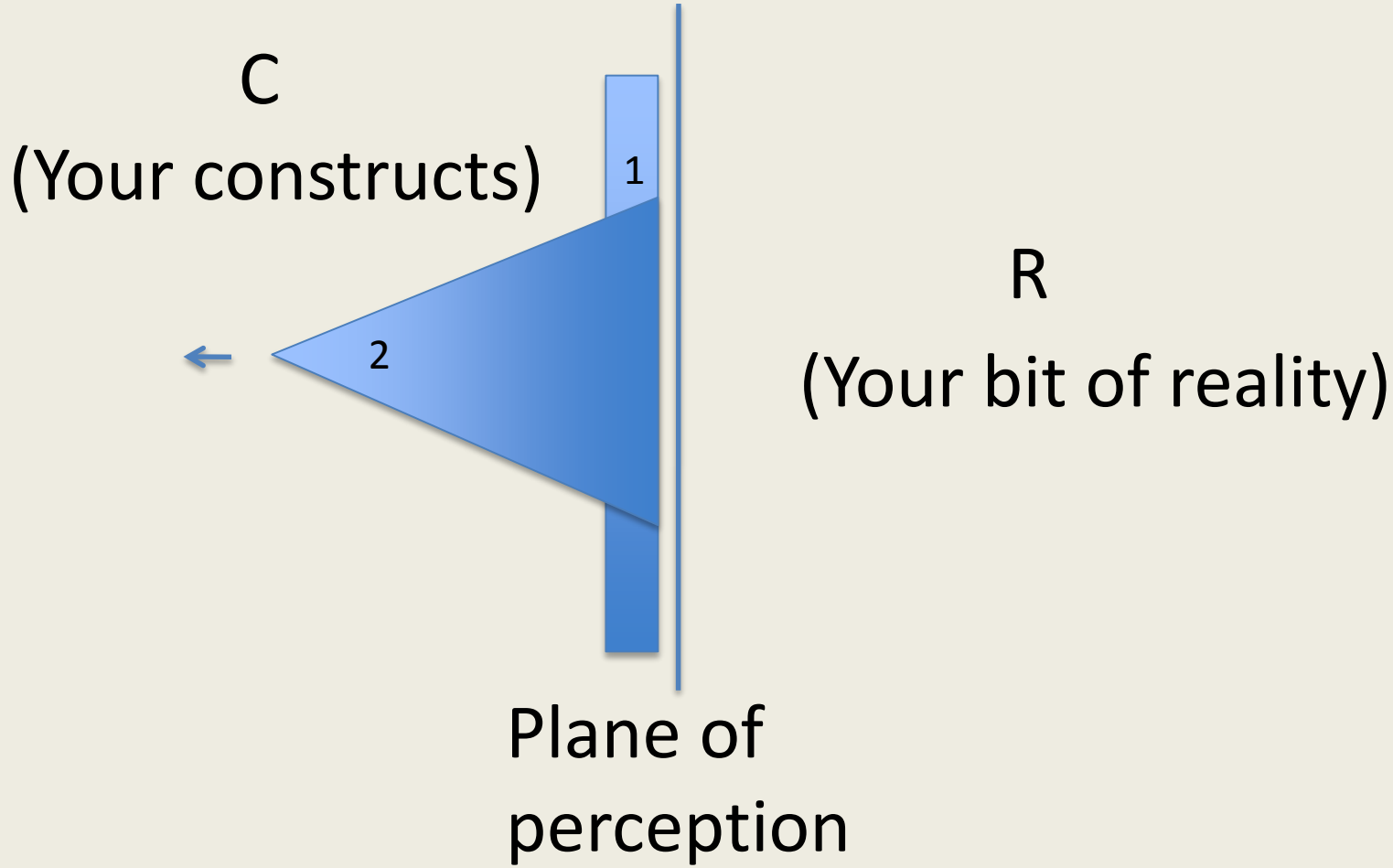


Reality

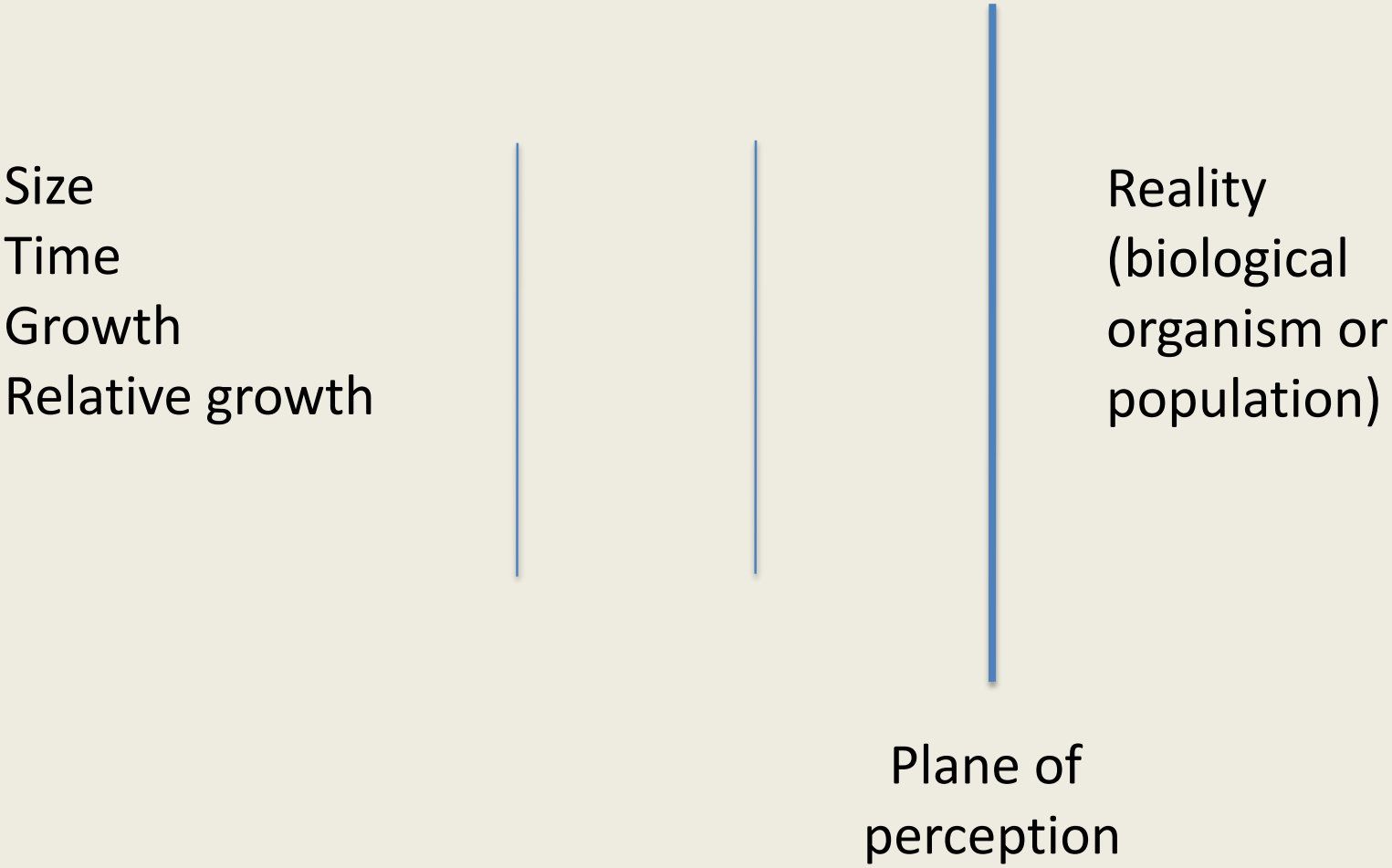
Plane of perception

[after Margenau 1950]

1b. As a research scientist:

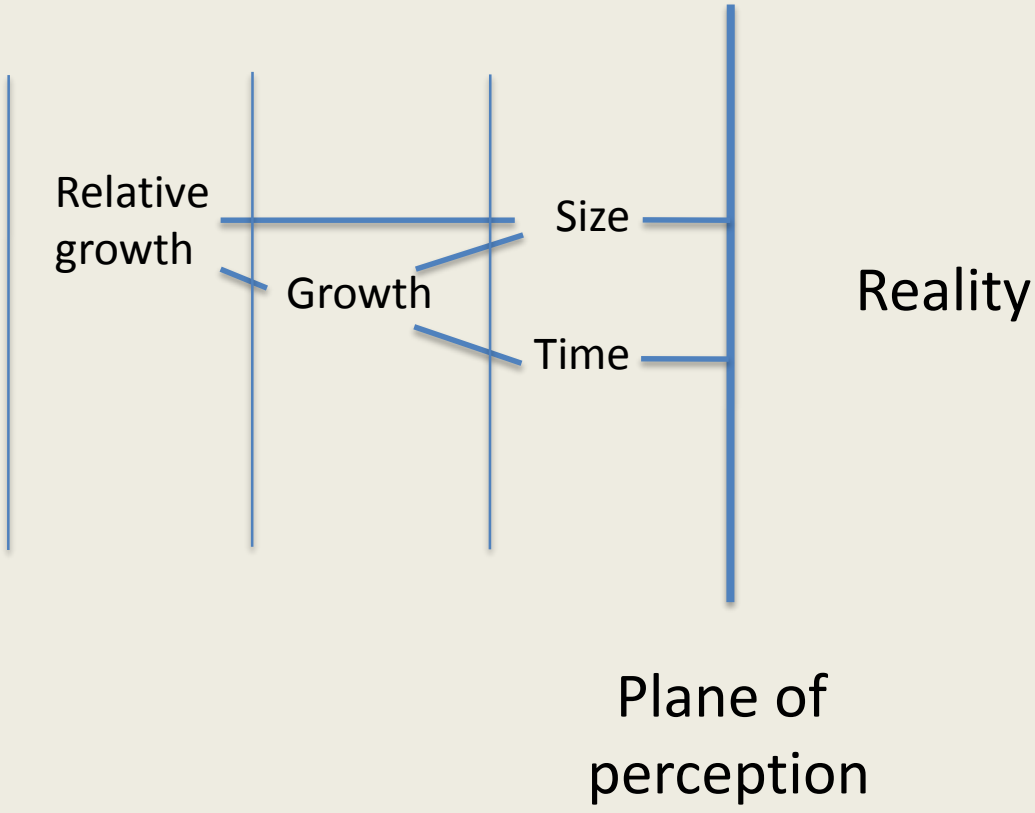


1c. Biological science example



1d. Biological science example:

Size
Time
Growth
Relative growth



2. The research cycle

This cycle is schematically represented in Fig. 1.1.

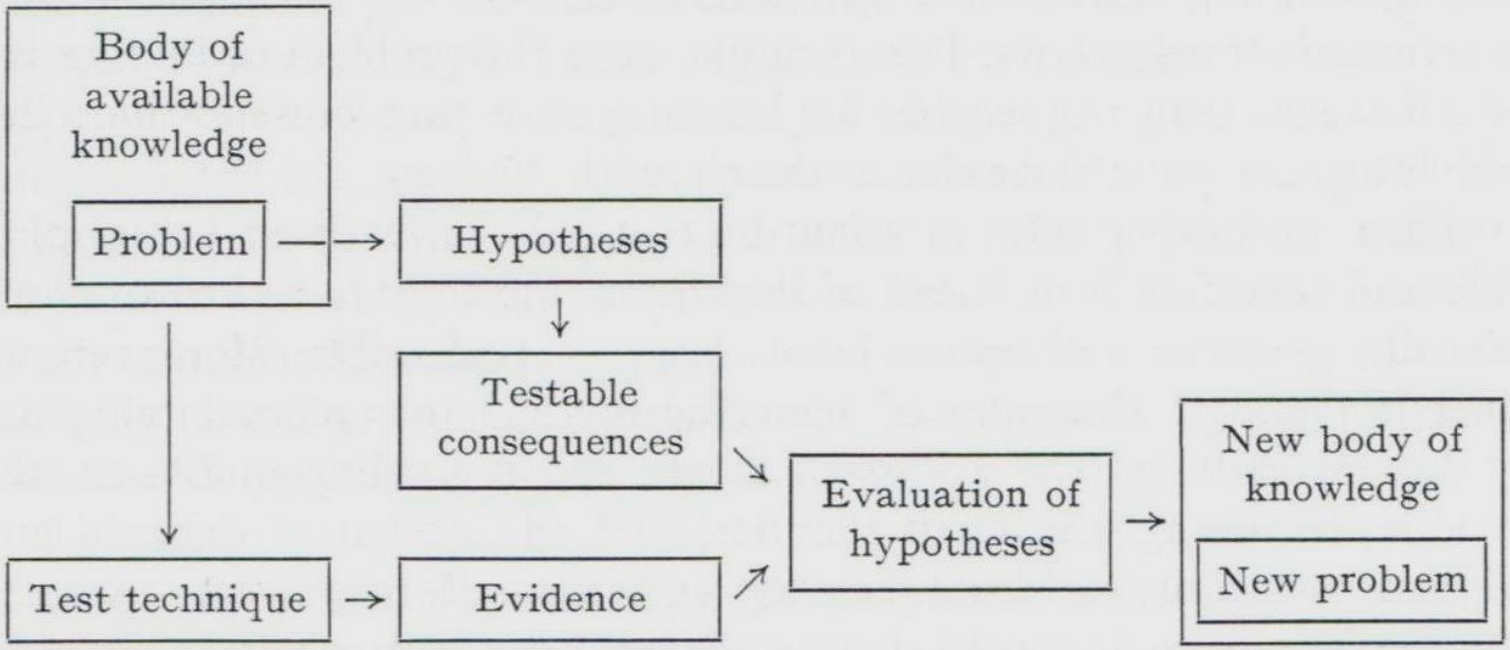


Fig. 1.1. A research cycle. The importance of a scientific investigation is gauged by the changes it induces in our body of knowledge and/or by the new problems it poses

Bunge, M. 1998. Philosophy of Science: From problem to theory. Transaction, pg 11.

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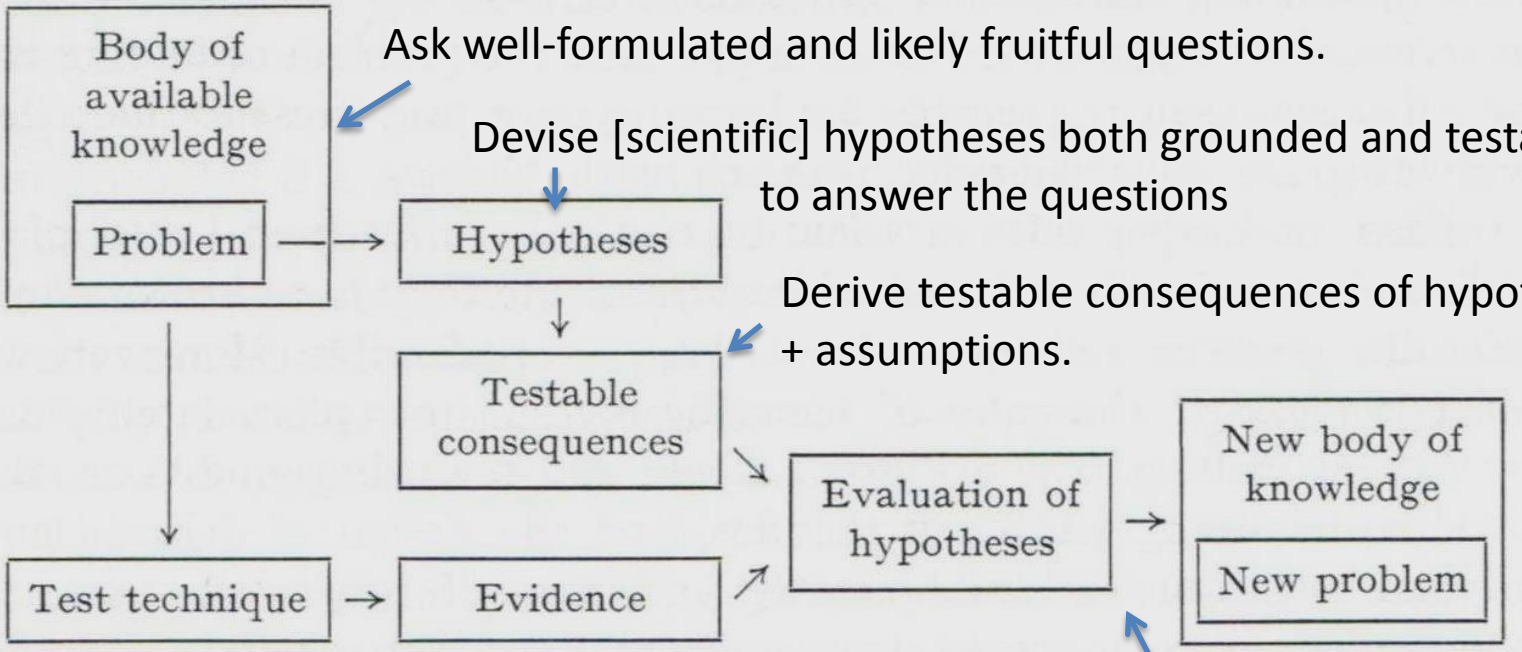

Fig. 1.1. A research cycle. The importance of a scientific investigation is gauged by the changes it induces in our body of knowledge and/or by the new problems it poses

Ask well-formulated and likely fruitful questions.

Devise [scientific] hypotheses both grounded and testable, to answer the questions

Derive testable consequences of hypotheses + assumptions.

Design techniques to test the [consequences].

Test the techniques for relevance and reliability.

Execute the tests and interpret their results.

Evaluate the truth claims of assumptions and fidelity of techniques.

1. The “world of the scientist”
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3. Scientific Research

a) kinds, b) goals, c) aims

3a. Kinds of research

arbiter	**value & type of research**
1. How soon can results be put to use?	a) Later – basic b) Sooner – applied
2. Who uses the results?	a) Other scientists – basic b) Technologists – applied
3. To what do the constructs refer?	a) Real things – factual b) Ideas – formal
4. How close are the constructs to the plane of perception?	a) Close – empirical b) Far – theoretical
5. What is the unknown?	a) What is the character of? What if? Why? – substantive b) How to? – procedural

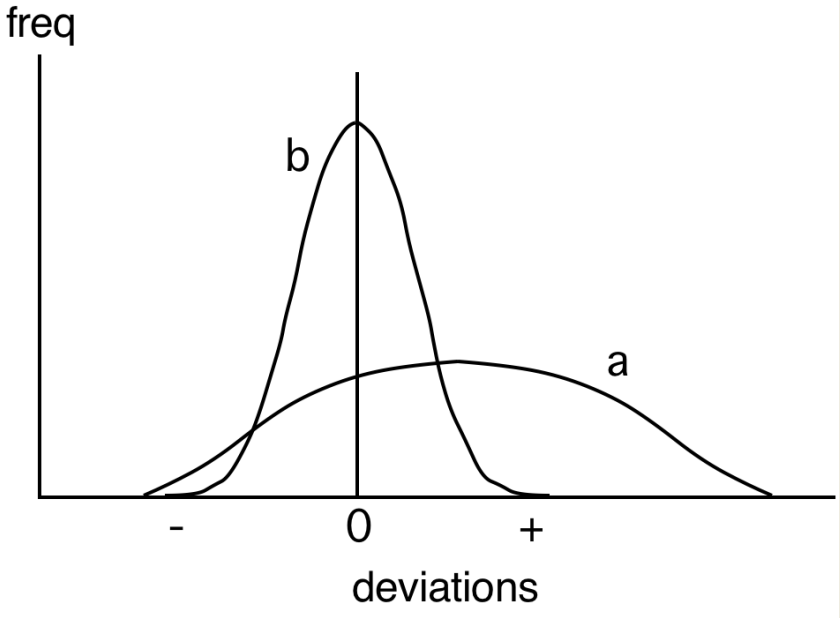
3b. Goals of Scientific Research

i) Substantive – statements about nature

1. What is the character of?	Description
2. What if?	Prediction
3. Why?	Explanation

ii) Procedural techniques or methods

- Improve an old method. Make it more <u>efficient and effective</u>
- Develop a new way of doing something



Ince, P. 1989. Risk analysis …. USDA Forest Service.

iii) Importance of pattern

- “Scientific research is,

  in short,

  the search for pattern”

  (M. Bunge 1998)

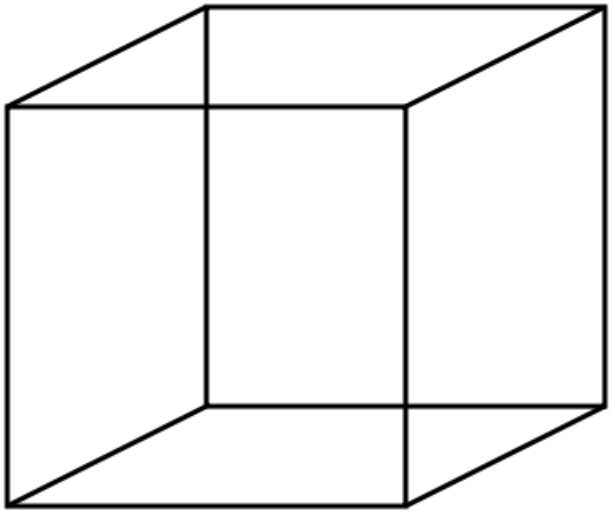
- But, what is pattern?
  - ….. repeated form?

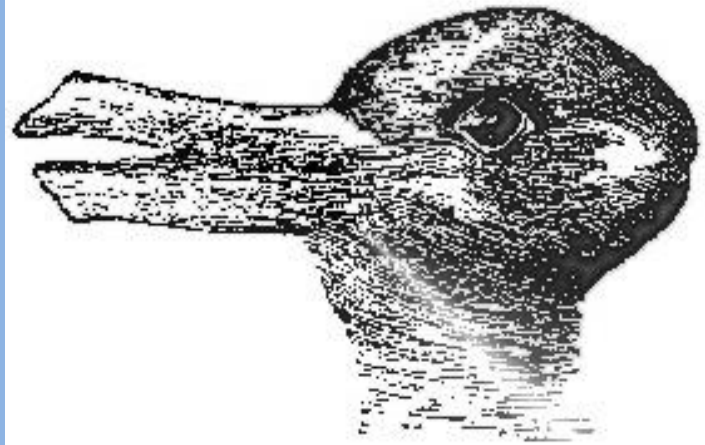
- What is pattern?

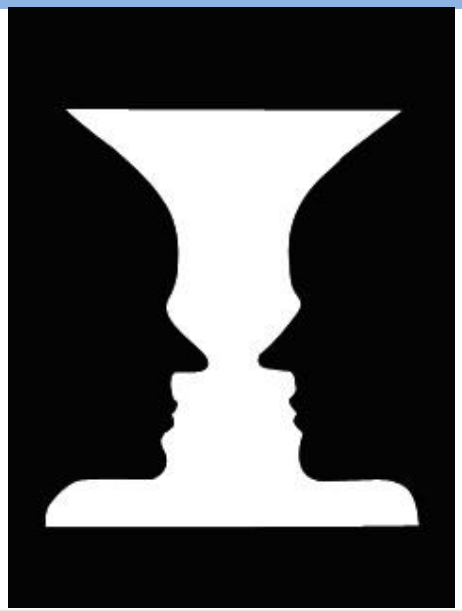
  …….Oops -- must be regularly repeated form…..

- One could argue:
  - "ALL the regularly repeated forms near the plane of perception have been observed by others" and reported on.

Classical … regularly repeated forms:







3c. Change vs. no change?

- … "most things and relationships change. (from place to place or time to time)

- Those things and relationships that don't change are either uninteresting or very interesting".

3d. Invariance vs. Symmetry

- Invariant -- An aspect of a relationship that does not change.

- Symmetry is a special kind of invariance

3e. Invariance vs. Sensitivity

- Fractal objects have scale invariance

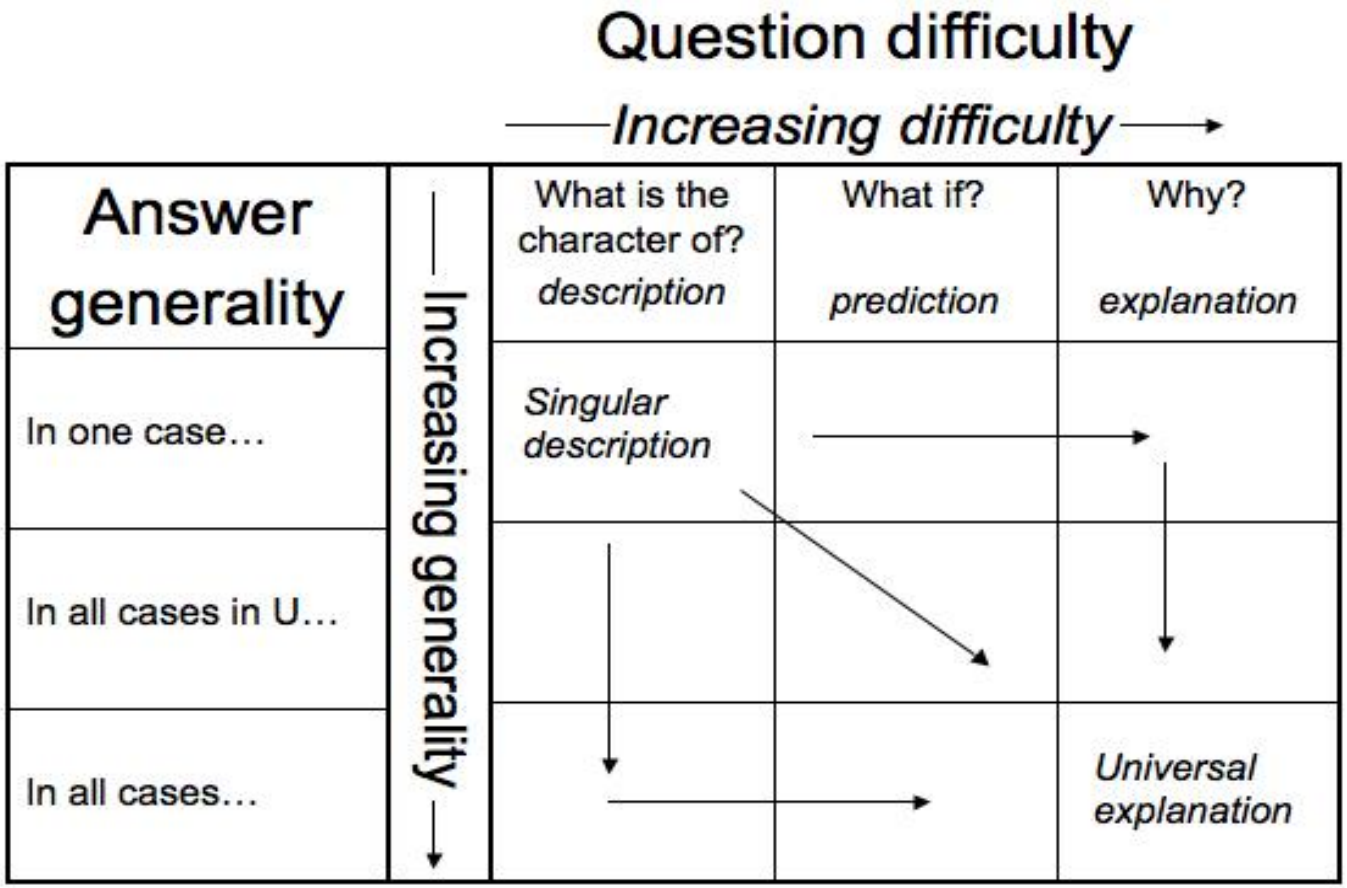
- Extreme sensitivity to initial conditions
  - Discovery by Edward Lorenz led to Chaos Theory -- almost the antithesis of 'invariance'.

3f. Goal of substantive research --

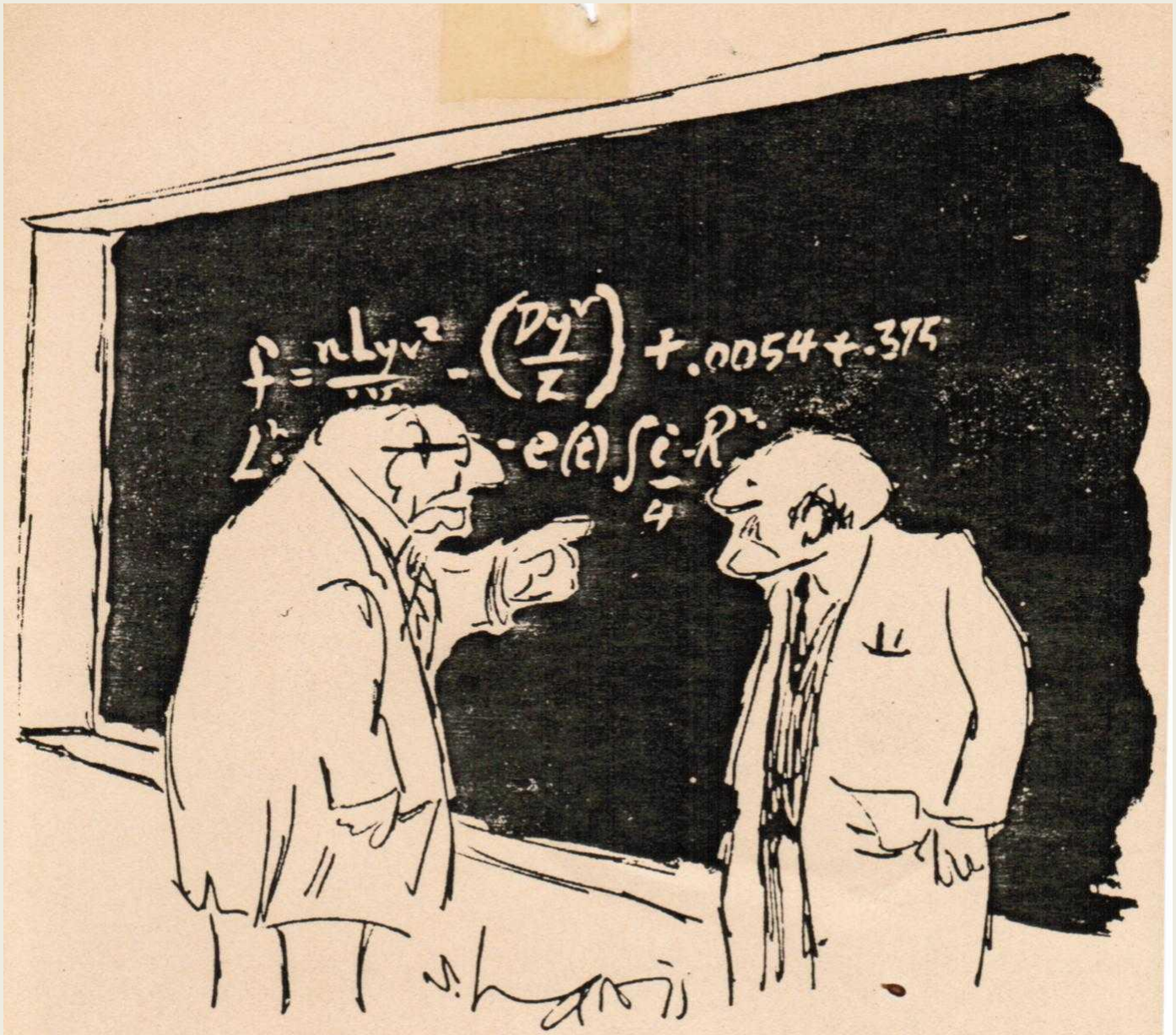
- Answer questions of increasing difficulty

with

- Statements of increasing generality

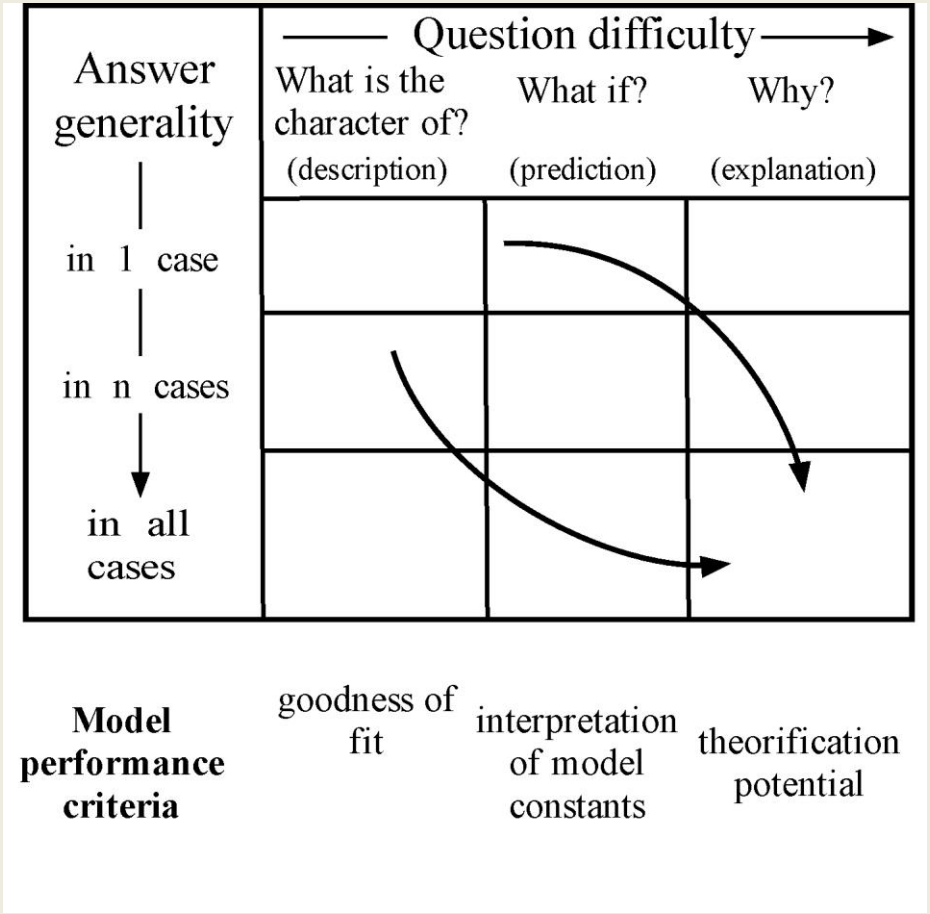

Question difficulty
Increasing difficulty
Answer generality
Increasing generality
What is the character of?
description
What if?
prediction
Why?
explanation
In one case…
In all cases in U…
In all cases…
Singular description
Universal explanation

ral, 1985



"Does this apply always, sometimes, or never?"

6


Answer generality
in 1 case
in n cases
in all cases
Question difficulty
What is the character of?
(description)
What if?
(prediction)
Why?
(explanation)
Model performance criteria
goodness of fit
interpretation of model constants
theorification potential

Scientific Research Overview

~~1. The "World of the scientist"~~

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~~2. Research cycle~~

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4. Tactics, phases, modes of advance

4. Tactics (1)

- Find the ground
  - The "ground" is the body of knowledge that surrounds the question of interest.
  - There must be ‘ground’ for your question to be well-founded. Otherwise it is stray, and probably unscientific.

One finds the ground from the literature:

1. No literature, no ground!

2. No ground, no science!

4. Tactics (2)

- Be ‘Pacmanish’

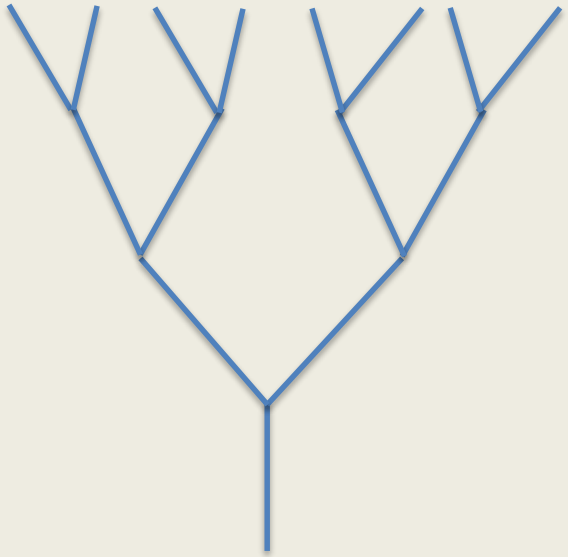
  - Begin by asking clear-cut and restricted questions

  - Adopt a piecemeal approach.

4. Tactics (3)

- Try to falsify rather than corroborate

- Use “exhaustive binary tree questioning” – also known as ‘strong inference’.



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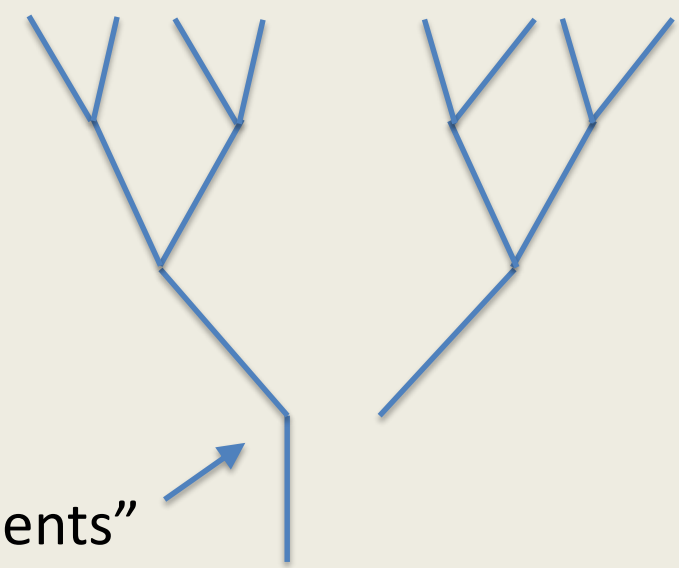
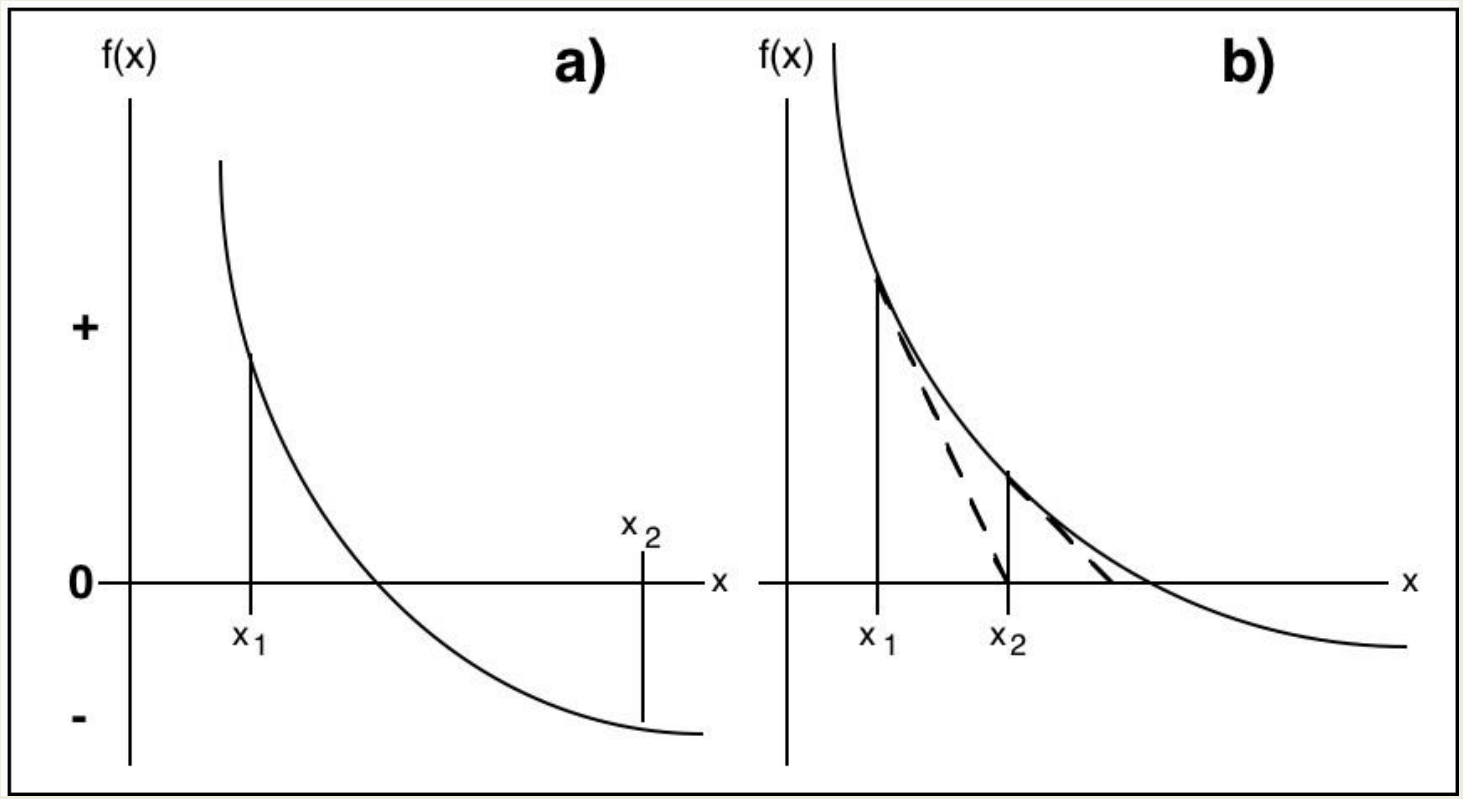


4. Tactics (4)

- Iterate toward the answer – as a root finding algorithm finds zeroes of a nonlinear equation

Interval halving

Newton Raphson



5. Phases of scientific research

- Richenbach (1938) is generally credited with articulating the two phases of research:
  - Discovery
  - Justification

5. Phases of scientific research

- Discovery
  - End point is a testable conjecture
  - Methods are not set

- Justification
  - End point is an objective judgment on the truth value of the propositional form of the hypothesis.
  - Methods are strict for valid justification

6. Modes of scientific advance

- What/who is the arbiter?: up☺ down☹
  - Authority
  - Reason
  - Nature through observation

6. Modes of scientific advance

- Controlling the pace
  - Incrementally
    - Discovery based on induction
    - Justification based on confirmation/corroboration
  - Speeded up
    - “conjectures and refutations”,
    - “guessing and testing”, e.g., Feynman’s -- gc^3

Takeaways:

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   Substantive -> Question difficulty + Answer generality

   Procedural -> Efficient & Effective.

Takeaways:

1. To be ‘in science’ you must become comfortable in the C field.

2. Scientific research has a ‘method’ that should/must be followed – more or less.

3. The two types of research – substantive & procedural – have different goals.
   Substantive -> Question difficulty + Answer generality.
   Procedural -> Efficient & Effective.

4. Some research strategies / tactics lead to more rapid advance than others. Learn what they are and how to apply them.

5. Understand the difference between Discovery research and Justification research, and which type you are doing.

Thank you!