How specific arguments defeat general dogmas: lack of parsimony in molecular biology

Vlasta Sikimić

University of Belgrade

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Motivation

How do you scratch your head?

Motivation

- Maximizing scientific knowledge as a whole.
- Optimal distribution of resources.
- Bigger picture – How do breakthrough results occur?

Law of parsimony – Ockham's Razor

- *Lex parsimoniae*: other things being equal, we should prefer simpler theories to less simple ones.
- Kant: "Rudiments or principles must not be unnecessarily multiplied" (Critique of Pure Reason).
- Newton: "Nature is pleased with simplicity, and affects not the pomp of superfluous causes" (Principia Mathematica).

Ockham's Razor in philosophy of science

Possible definition:

Efficient method for finding the true theory, even if the truth is complex (K. Kelly 2004, 2007).

Connections with induction: only hypothetical outcomes can be justifiably considered in the inductive analysis.

Key questions

- What is Ockham's Razor in argumentation theory?
- How to optimize scientific argumentation?

Choices

- A case study approach;
- Molecular biology (a field-specific approach);
- Significant non-parsimonious results.

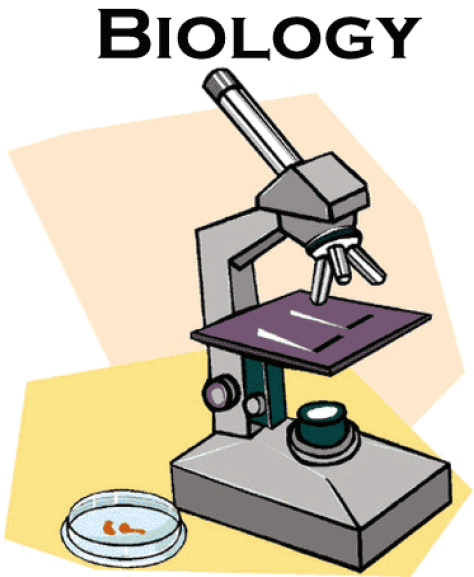
Data-dirven and field-specific approach

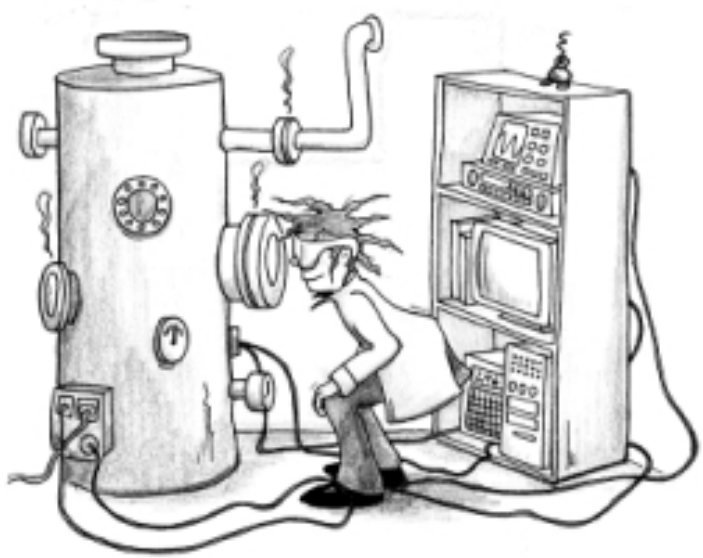
Benefits of a case study approach:

- it is context dependent;
- it has a clear reach;
- and a straightforward application.

Choices: Molecular biology

- Dynamic argumentative flow in the field of molecular biology (versus e.g. contemporary experimental physics).





Choices: Specific cases

- Modern dilemmas;
- Nobel Prize winning research:

Stanley B. Prusiner

Thomas R. Cech

Dogmas

D_1: All infectious diseases are caused by an organism. (Koch's postulate)

D_2: DNA encodes genetic material,
RNA transmits it,
proteins have a catalytic function.

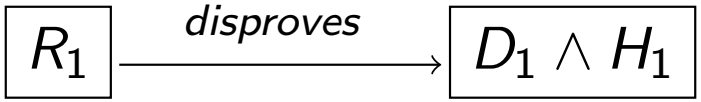
Summary: These are simple and universal explanations of the phenomena.

Argumentation in molecular biology

Assumptions:

- Experimental results are considered to be truthful (unless they are deliberately faked) $\rightsquigarrow$ they defeat a hypothesis in the strong sense –they disprove it.
- Only hypotheses can contradict each other, i.e. attack each other.
- We only consider correct inferences.

Argumentation example



R_1: Scrapie agent does not need to have intact nucleic acid.
D_1: All infectious diseases are caused by an organism.
H_1: All organisms need to have intact nucleic acid.

Argumentation comparison

Cases in which a disease is caused by an organism e.g. anthrax.

H: Disease is caused by a specific organism, e.g. bacillus.

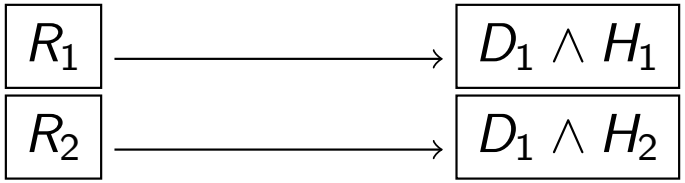
R_1: Organism found! $\rightsquigarrow$ **correlation**

$R_2 \wedge R_3$: Organism has to be grown in a pure culture and able to infect subjects. $\rightsquigarrow$ **causation**

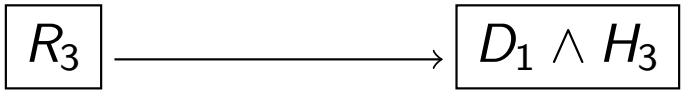
$$\frac{R_2 \wedge R_3}{H}$$

Koch's postulates.

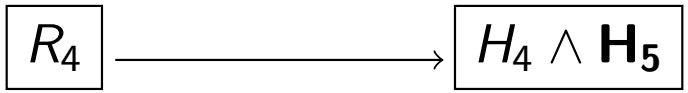
Argumentation comparison



R_2: Scrapie agent can be killed by protein destroying treatment X.
D_1: All infectious diseases are caused by an organism.
H_2: Treatment X destroys proteins.



R_3: Scrapie agent is as small as a protein.
H_3: No organism is as small as a protein.



R_4: PrP protein is also in healthy organisms.
H_4: Protein has only one fold (no special features).
H_5: PrP protein causes the disease.

Simple correlation!

$R_5 \wedge R_6$: Expressed protein causes the disease. $\rightsquigarrow$ **causation**
Convincing argument for the biological community.

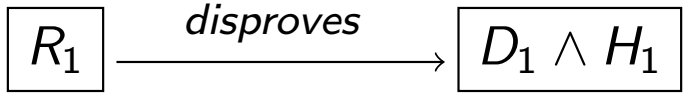
$$\frac{R_5 \wedge R_6}{\mathbf{H_5}}$$

Finally, since D_1 logically contradicts H_5:

$$\boxed{R_5 \wedge R_6} \longrightarrow \boxed{D_1}$$

Note

R_7: At least one organism is very resistant against DNA destructive treatment.

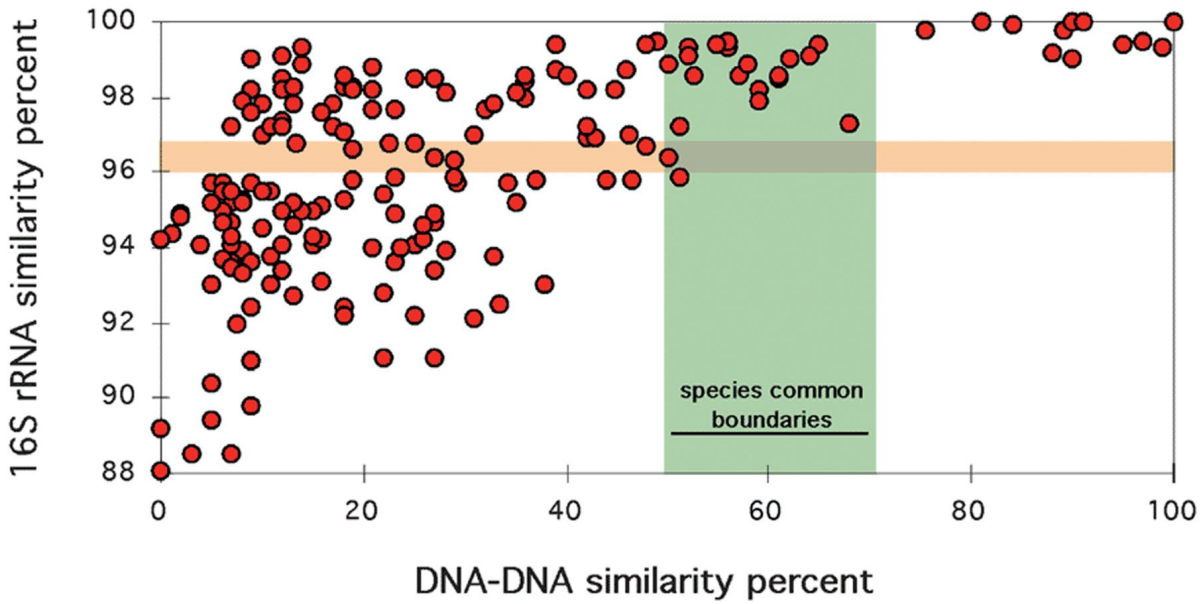


Second analysis: RNA has a catalytic function

- Experimental results were showing that there is no protein involved. $\rightsquigarrow$ correlation
- The lack of energy requirement in the reaction. $\rightsquigarrow$ correlation
- Purified RNA had the same behaviour. $\rightsquigarrow$ correlation
- Elimination of different factors in reactions. $\rightsquigarrow$ correlation
- Exact findings. $\rightsquigarrow$ **causation**

Level of inspection and frequences

- Mutation scenarios are typical examples of non-parsimonious behaviour in biology.
- Phylogenetics (subfield of evolutionary theory) uses maximum parsimony as an optimality criterion. Yet, there are exceptions.



(Rosselló-Mora and Amann, 2001)

Conclusions and further research

Conclusions:

- It is necessary to invest also in non-parsimonious ideas.
- Even if non-parsimonious behaviours are more prominent in molecular biology then in other disciplines, such behaviours are exceptions.
- Argumentation analysis helps us to understand important scenarios in which the principle of Ockham's Razor is violated.

Questions:

- When is it reasonable to consider non-parsimonious explanations?
- How many argumentative steps is reasonable to require?

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