Towards a pragmatic view of theories in ecology

By Bruno Travassos-Britto, PhD
bruno.travassos@usp.br

University of São Paulo

Is ecology an immature science?

Ecology doesn’t have any laws!

Why are laws important to define theoretical maturity?

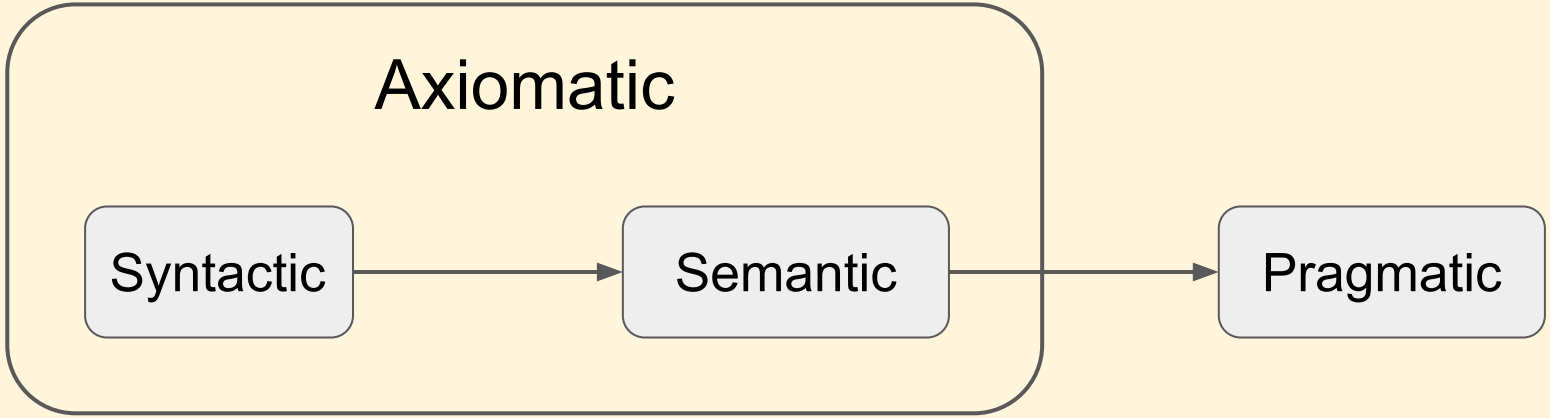
It depends on the view of **theory structure** one adopts.

Definition

Theory structure is defined by the components of a theory and how they interact in the knowledge generation process.

Axiomatic views of theory

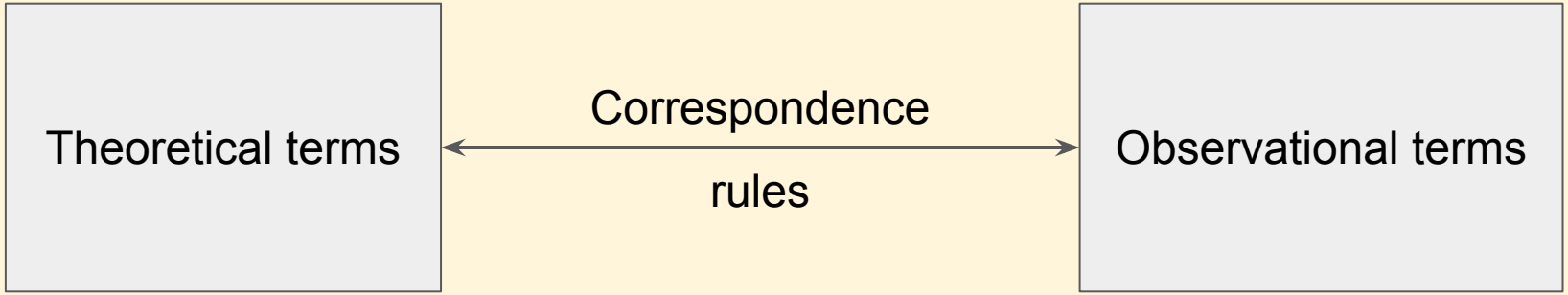
Different views of theory structure



Definition

An **axiom** is a self-evident assertion.

Syntactic view (received view)



Syntactic view

An ecological example with constant population growth

Axiom

$$\forall t \in N, N(t) = R^t \times N(0) \rightarrow \left(R := F(N)\right)$$

For any positive integer value of time, the size of the population equals the product of the finite rate of population increase powered by the time and the population size at time zero if R is not a function of N.

time

finite rate of population increase

population size

Syntactic view

Axiom

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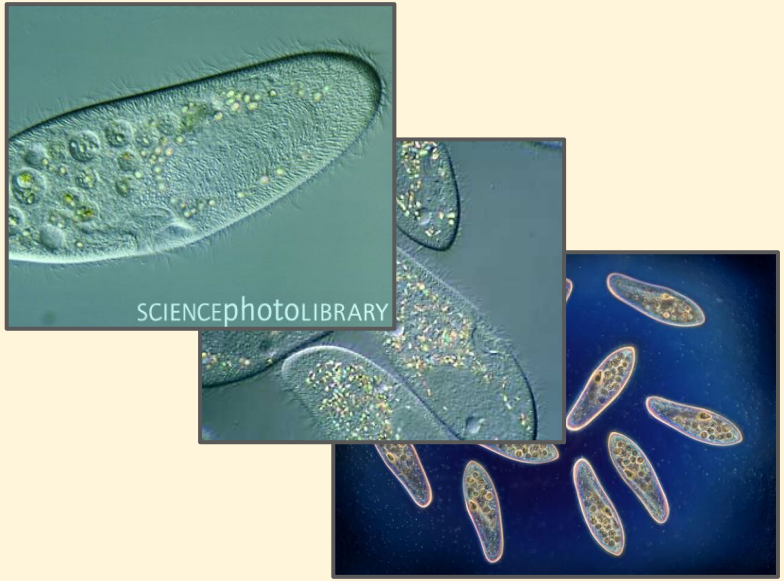


The Syntax of a scientific theory

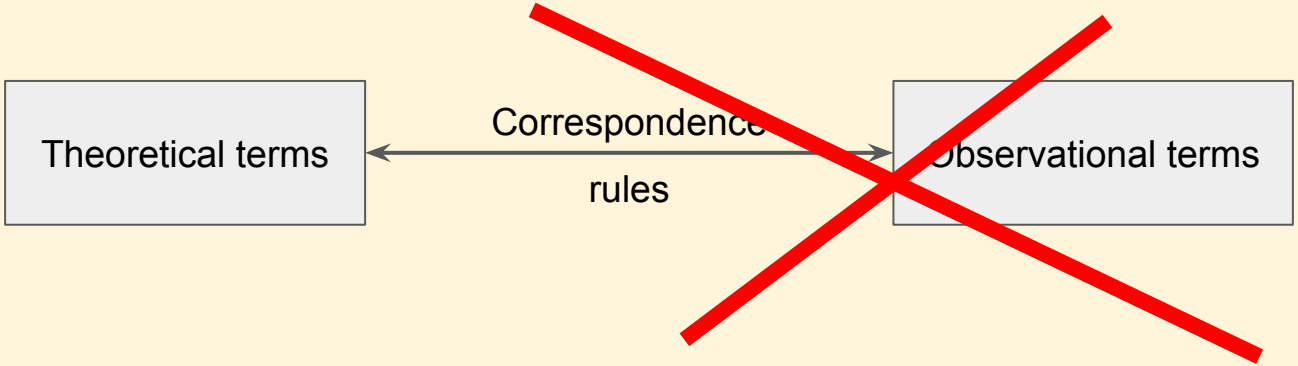
Axiom

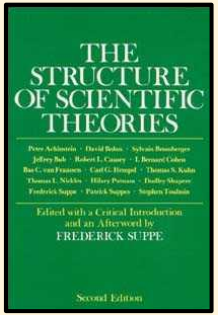
$$\forall t \in N, N(t) = R^t \times N(0) \rightarrow \big(R := F(N)\big)$$

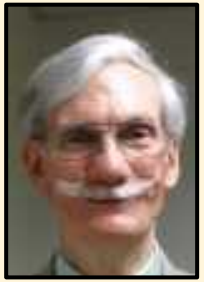
For any positive integer value of time, the size of the population equals the product of the finite rate of population increase powered by the time and the population size at time zero if R is not a function of N.

Theoretical terms ⟷ Correspondence rules → Observational terms

Semantic view



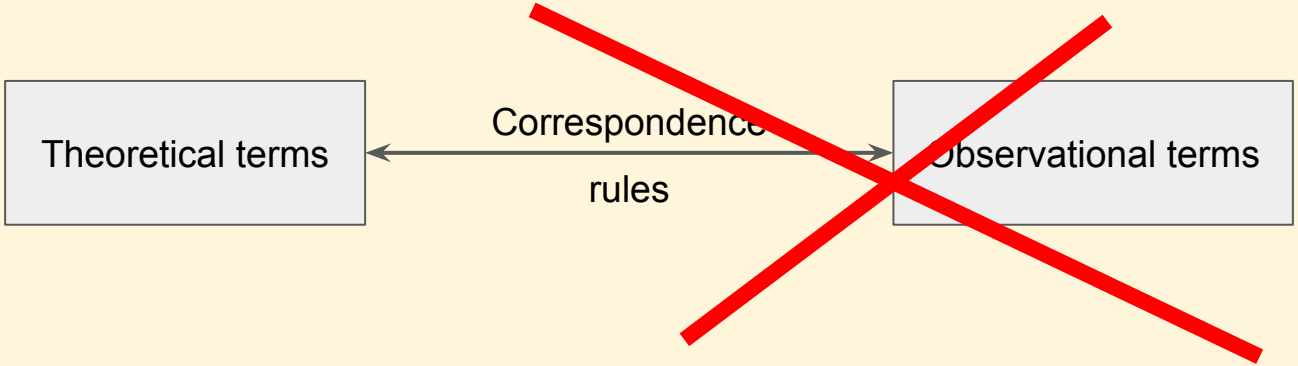


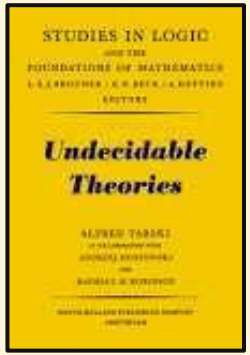


Frederick Suppes

"The formulation of a theory is a collection of axioms that are true in the theory." (Suppes 1989)

Semantic view





Adam
Tarski

Every construct in which the axioms of a theory can be assumed as true is a model of this theory. (Tarski, 1959).

Semantic view

An ecological example with constant population growth

Again!

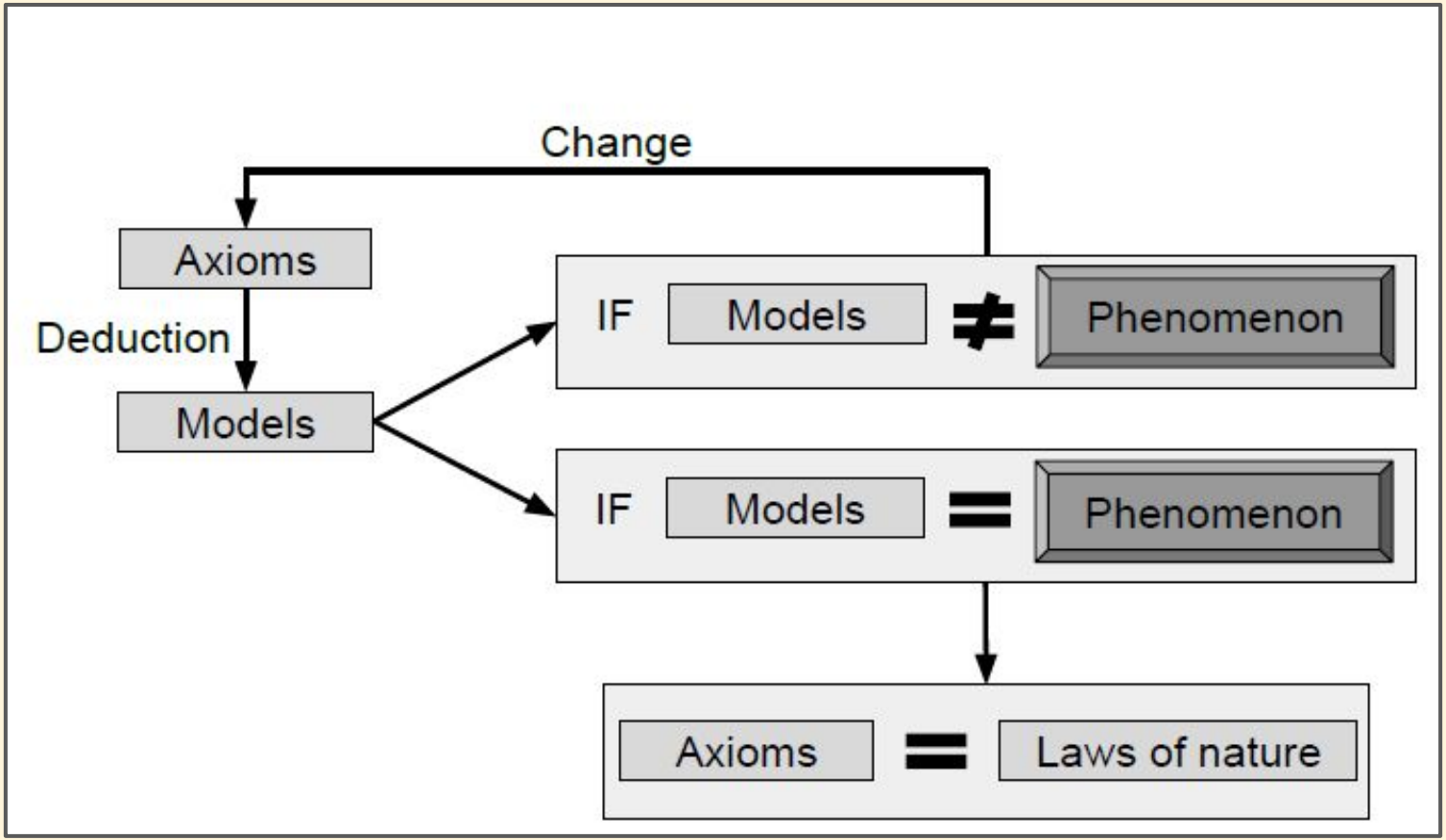
Axiom 1:
‘All life comes from life’ (‘omne vivum ex vivo’, as stated by Pasteur in 1864, Hutchinson 1978)

$$\frac{dN}{dt} = rN$$

Axiom 2:
Populations are limited to a maximum population size by a density-dependent process

$$\frac{dN}{dt} = rN - \frac{r}{kN^2}$$

Knowledge generation in an Axiomatic view



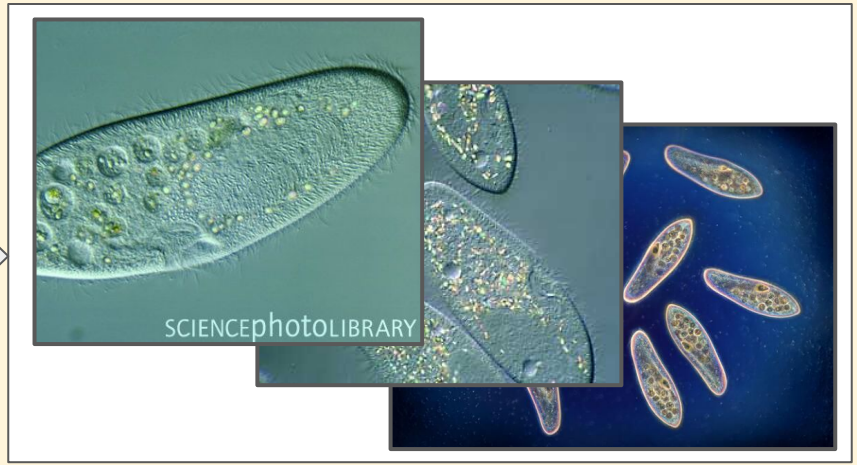
Axiom 1:
‘All life comes from life’

Deduction

$$\frac{d\bar{N}}{dt} = -rN + \frac{(a+k)r}{ak}N^2 - \frac{r}{ak}N^3$$

Model

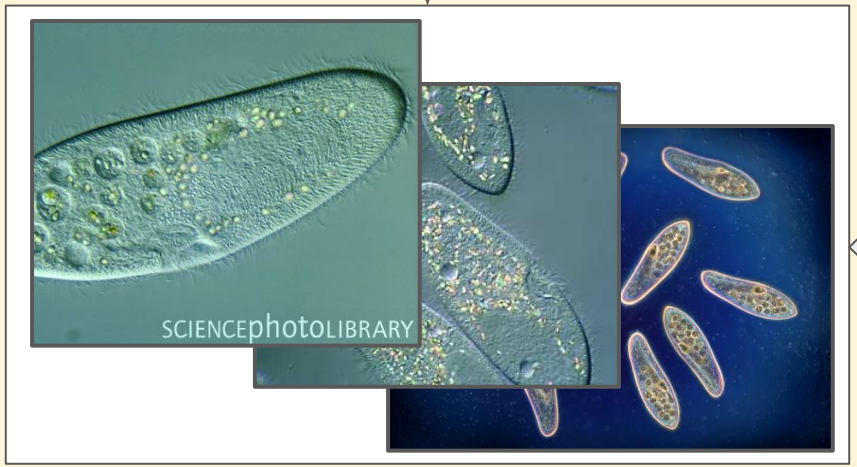
Isomorphy



Phenomenon

Axiom 1:
‘All life comes from life’

Deduction



Model

Isomorphy

Phenomenon

Axiom 1:
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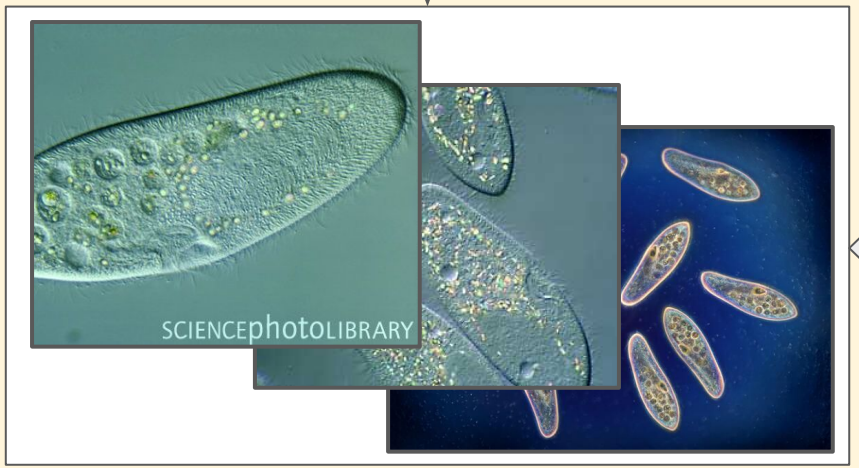
Deduction

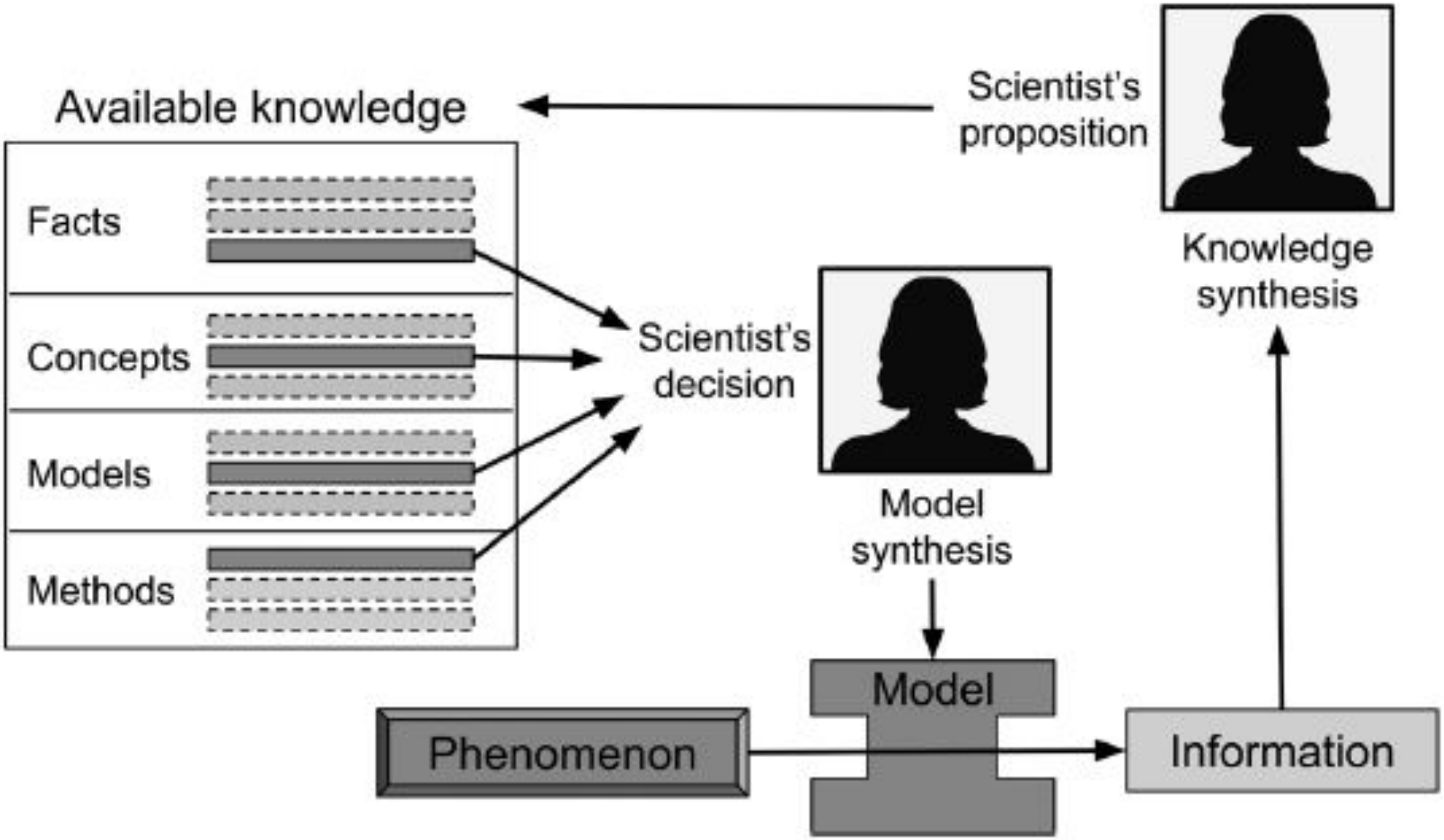


Model

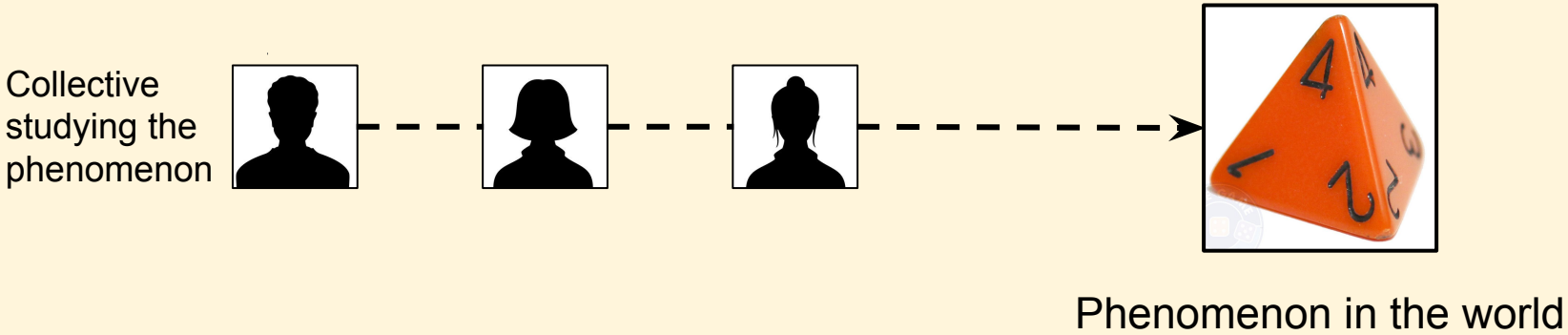
Similarity

Phenomenon

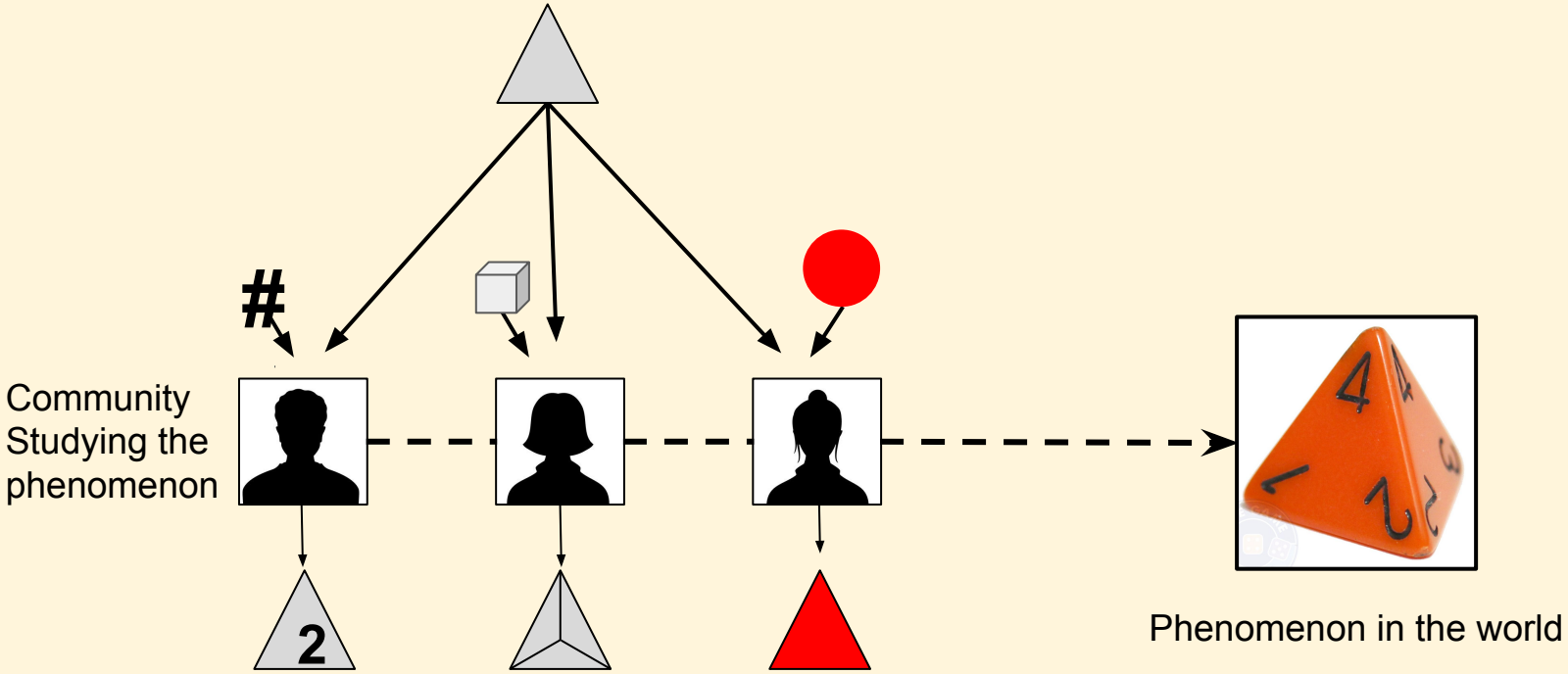
The pragmatic view of theories


Available knowledge
Facts
Concepts
Models
Methods
Scientist's proposition
Knowledge synthesis
Scientist's decision
Model synthesis
Model
Phenomenon
Information

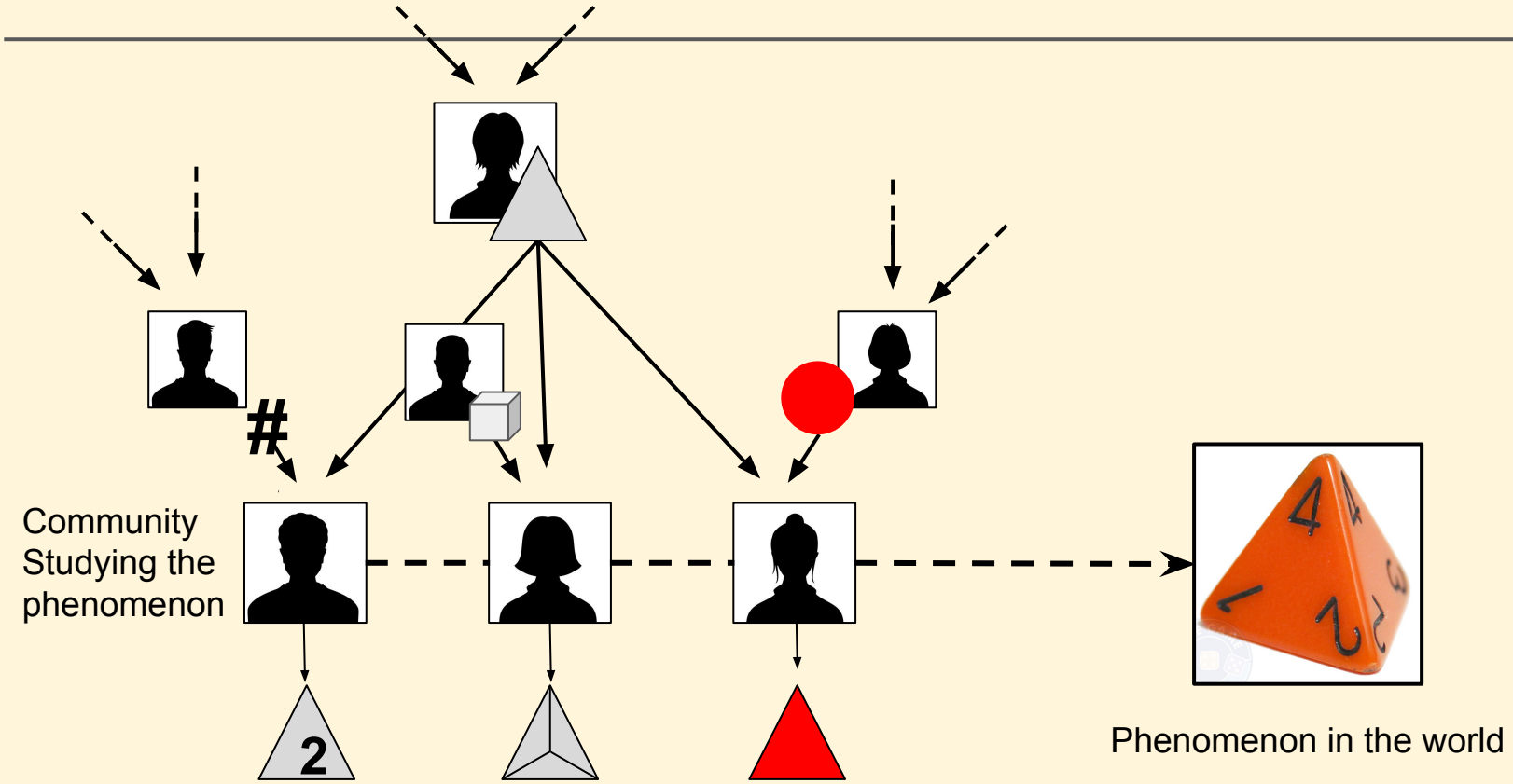
The PATh


Collective studying the phenomenon
Phenomenon in the world

The PATh


#
Community
Studying the
phenomenon
2
Phenomenon in the world

The PATh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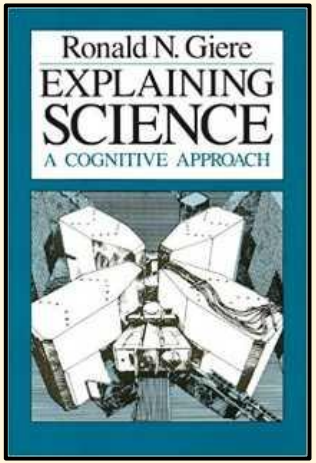
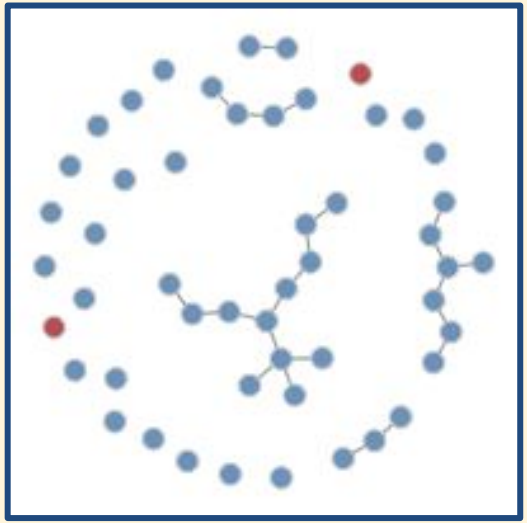
Phenomenon in the world

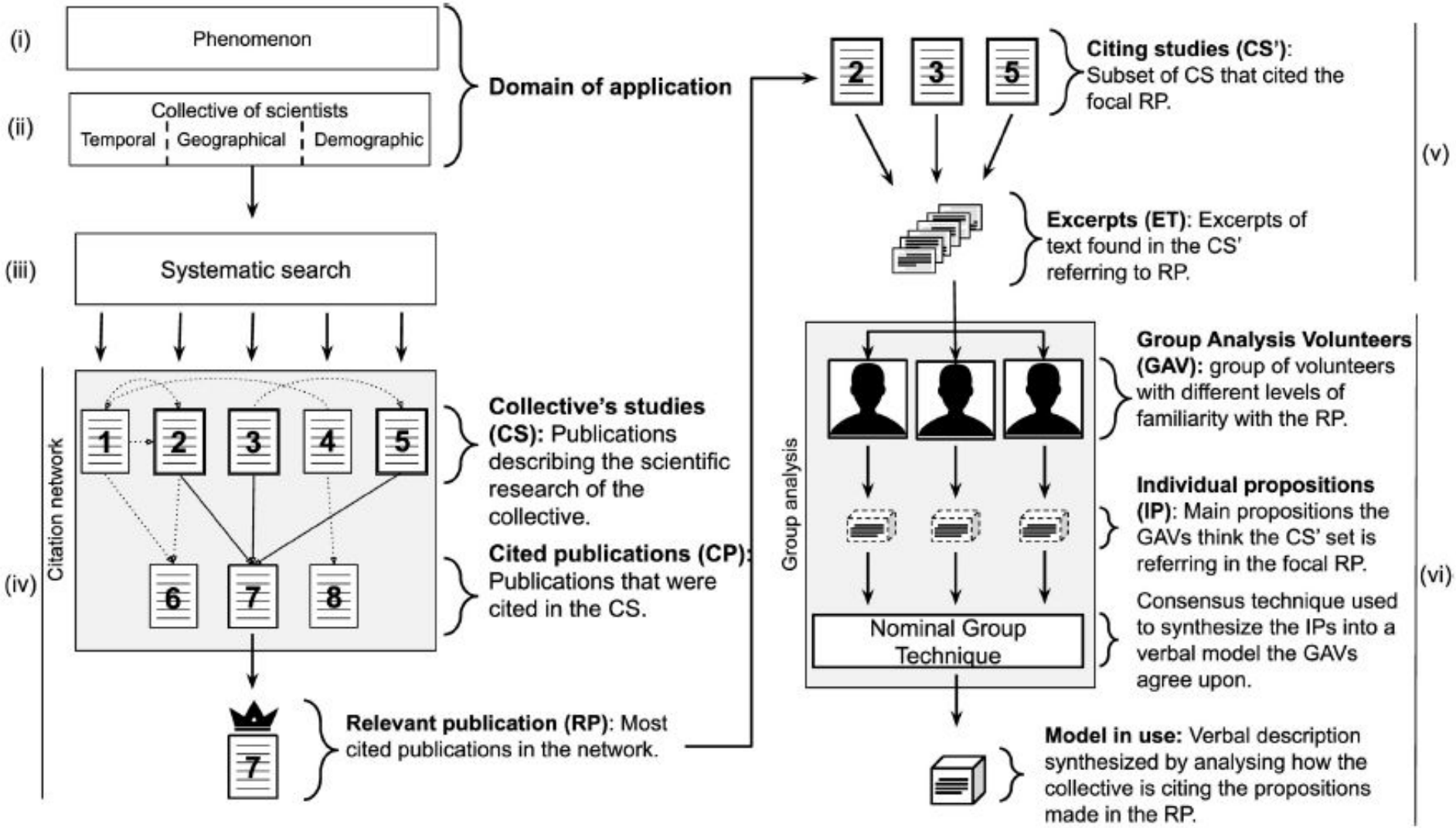
Theories are dynamic entities



Ronald Giere



The theory of a phenomenon is a elusive context-dependent ever-changing entity.


(i)
Phenomenon
(ii)
Collective of scientists
Temporal
Geographical
Demographic
Domain of application
(iii)
Systematic search
(iv)
Citation network
1
2
3
4
5
6
7
8
Collective's studies (CS): Publications describing the scientific research of the collective.
Cited publications (CP): Publications that were cited in the CS.
7
Relevant publication (RP): Most cited publications in the network.
2
3
5
Citing studies (CS'): Subset of CS that cited the focal RP.
Excerpts (ET): Excerpts of text found in the CS' referring to RP.
(v)
Group analysis
Group Analysis Volunteers (GAV): group of volunteers with different levels of familiarity with the RP.
Individual propositions (IP): Main propositions the GAVs think the CS' set is referring in the focal RP.
Nominal Group Technique
Consensus technique used to synthesize the IPs into a verbal model the GAVs agree upon.
Model in use: Verbal description synthesized by analysing how the collective is citing the propositions made in the RP.
(vi)

The pragmatic theory of succession

Vol. 111, No. 982 The American Naturalist November–December 1977

MECHANISMS OF SUCCESSION IN NATURAL COMMUNITIES AND THEIR ROLE IN COMMUNITY STABILITY AND ORGANIZATION

JOSEPH H. CONNELL AND RALPH O. SLATYER

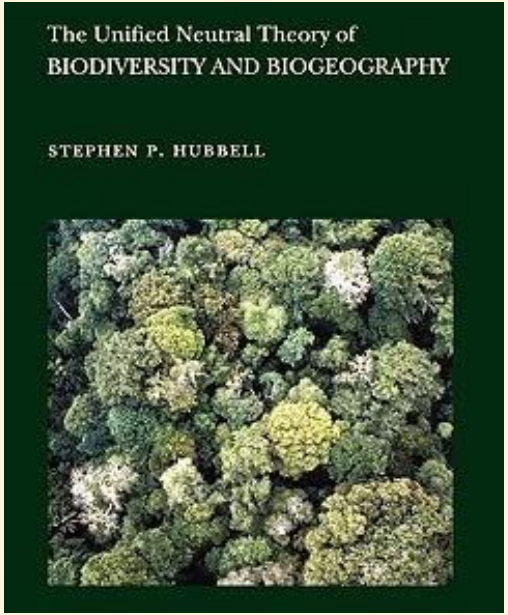
Department of Biological Sciences, University of California, Santa Barbara, California 93106; and Department of Environmental Biology, Research School of Biological Sciences, Australian National University, Canberra, Australia

It is in changing that things find repose. [HERACLITUS]

Succession refers to the changes observed in an ecological community following a perturbation that opens up a relatively large space. The earliest studies described the sequence of species that successively invade a site (Cowles 1899; Cooper 1913; Clements 1916); more recent studies have described changes in other characteristics such as biomass, productivity, diversity, niche breadth, and others (see review in Odum 1969). In this paper we will discuss only changes in species composition.

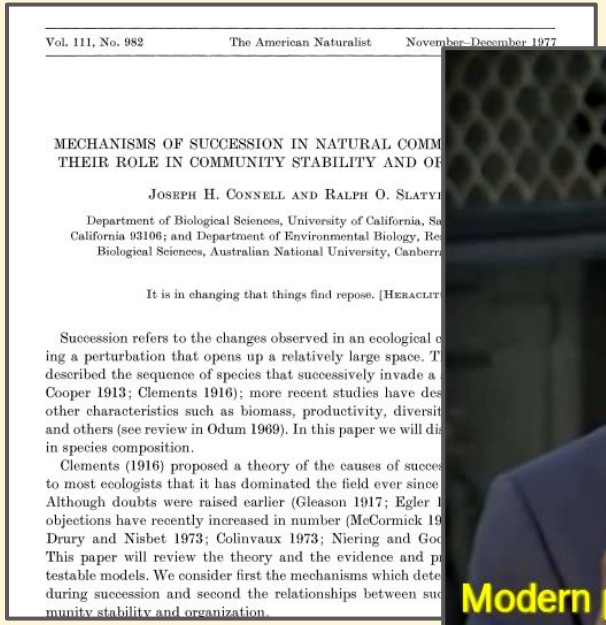
Clements (1916) proposed a theory of the causes of succession so satisfying to most ecologists that it has dominated the field ever since (see Odum 1969). Although doubts were raised earlier (Gleason 1917; Egler 1954), queries and objections have recently increased in number (McCormick 1968; Connell 1972; Drury and Nisbet 1973; Colinvaux 1973; Niering and Goodwin 1974, etc.). This paper will review the theory and the evidence and propose alternative testable models. We consider first the mechanisms which determine the changes during succession and second the relationships between succession and community stability and organization.

Connell and Slatyer 1977



Hubbell 2001

The pragmatic theory of succession



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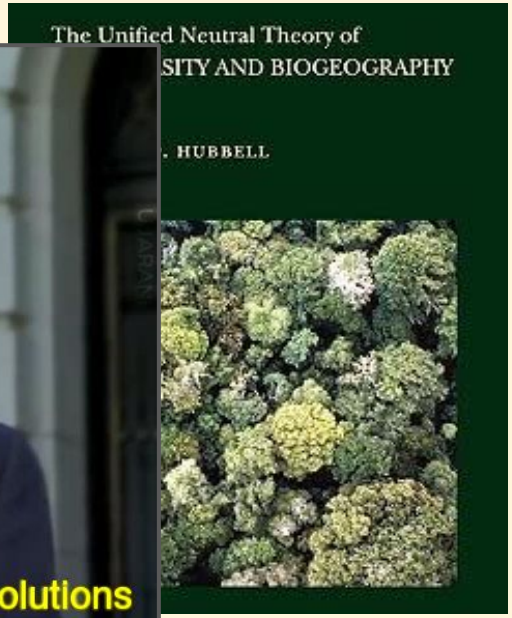

Connell and Slatyer 1977

Hubbell 2001

Propositions that unify succession theory?

Proposition 1: At any moment in time, there is the possibility that resources will be available for use.

Proposition 2: Organisms from different species or at different ontogenetic stages have different probabilities of taking a fraction of the total available resource units. This difference can be due to (a) differential probabilities of site colonization, or (b) different probabilities that the individuals at the site or their propagules will take resource units.

Proposition 3: The dynamics of the resource and the probabilities of the species taking resource units are contingent on the abundance of species in the community and other environmental settings where the communities are changing.

Maybe but… so what?

Charbel El-Hani
Ecological generalizations (2006)

GENERALIZAÇÕES ECOLÓGICAS

Charbel Niño El-Hani
Grupo de Pesquisa em História, Filosofia e Ensino de Ciências Biológicas – Dep. de Biologia Geral, Instituto de Biologia, Universidade Federal da Bahia (UFBA).
Programa de Pós-Graduação em Ecologia e Biomonitoramento/UFBA.
Programa de Pós-Graduação em Ensino, Filosofia e História das Ciências, UFBA/UEFS.
Universidade Federal da Bahia, Instituto de Biologia, Departamento de Biologia Geral. Rua Barão do Geremoabo, 147, Campus Universitário de Ondina, Ondina. CEP: 40170290 - Salvador, BA – Brasil
E-mail: charbel@ufba.br

RESUMO

Nos últimos anos, foram publicados vários trabalhos sobre a questão da existência e do estatuto das leis na ecologia. O presente artigo é uma revisão que pretende servir como um guia de estudo crítico dos debates sobre generalizações ecológicas. Uma série de trabalhos sobre generalizações na ecologia é discutida criticamente, bem como alguns desenvolvimentos da discussão epistemológica sobre o estatuto das leis biológicas dos últimos quinze anos. Minha posição é que a biologia apresenta generalizações com certo grau de necessidade nômica e poder explicativo e/ou preditivo. Sejam ou não chamadas de 'leis', elas cumprem importante papel na construção do conhecimento biológico e devem ser investigadas, de modo que possamos compreender melhor sua natureza e suas características. As generalizações biológicas têm domínio de aplicação restrito e uma compreensão teórica suficientemente desenvolvida é necessária para que se alcance um esquema geral abstrato para o estabelecimento destes domínios. Assim, a construção de teorias ecológicas (e, em termos gerais, biológicas) é o caminho para estabelecer generalizações testáveis, com poder explicativo e preditivo. Estas não são propriedades que uma proposição pode ter isoladamente, mas apenas como membro de um conjunto integrado de proposições ou uma rede teórica, na qual cada membro ajuda a delimitar o domínio de aplicação de qualquer outro membro. Esta concepção epistemológica sobre as relações e a natureza de proposições e teorias gerais na biologia, e, em particular, na ecologia, tem implicações metodológicas, destacadas ao longo do artigo.
Palavras-chave: Conhecimento biológico, Rede teórica, Epistemologia, Metodologia.

ABSTRACT

ECOLOGICAL GENERALIZATIONS. In recent years, several studies about the issue of the existence and status of laws in ecology have been published. This paper is a review which intends to play the role of a critical study guide to the debates about ecological generalizations. A series of studies about generalizations in ecology are critically discussed, as well as some developments of the epistemological discussion about the

"Ecology may not have laws, but it has widely accepted propositions that have been useful for designing models and learn about ecological phenomena."

The PATh project

The past

OIKOS

Forum

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Bruno Travassos-Britto, Renata Pardini, Charbel N. El-Hani and Paulo I. Prado

PLOS ONE

RESEARCH ARTICLE

A pragmatic approach for producing theoretical syntheses in ecology

Bruno Travassos-Britto[1,2]*, Renata Pardini[2,3], Charbel N. El-Hani[2,4,5], Paulo I. Prado[1,2]

The present

The pragmatic theory of coexistence

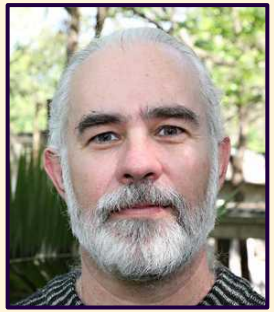
The PATh to higher education

The future

Analysing the science-practice gap in **ecological restoration**.

I am not alone in this

University of São Paulo



Paulo Inácio Prado

Renata Pardini

Daniela Scarpa

Charbel El-Hani

Federal University of Bahia

Tina Heger

Technische Universität München

Jonathan Jeschke

Freie Universität Berlin

Jim Harris

Cranfield University

Thank you