



## ECOLOGIE DES FORETS MEDITERRANEEENNES

# Models and theories in Ecology: revisiting Levins insights using the Gödel's notion of concept

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- 1. Genealogy of a question**
- 2. Around Levins paper (1966)**
- 3. Revisiting these epistemic questions  
with Gödel's thought**
- 4. The dialectical evolution of concepts of  
space and the real world**



# Genealogy of a question



1. Thesis on **modeling** carbon fluxes and water in forests
2. Making **generic** a model developed for Beech
3. Recruited at INRA to work on the dynamics of mixed forests
4. Two axes of research: tree mortality, physio-demo-genetic model
5. Current field of research: forest adaptation to climate change



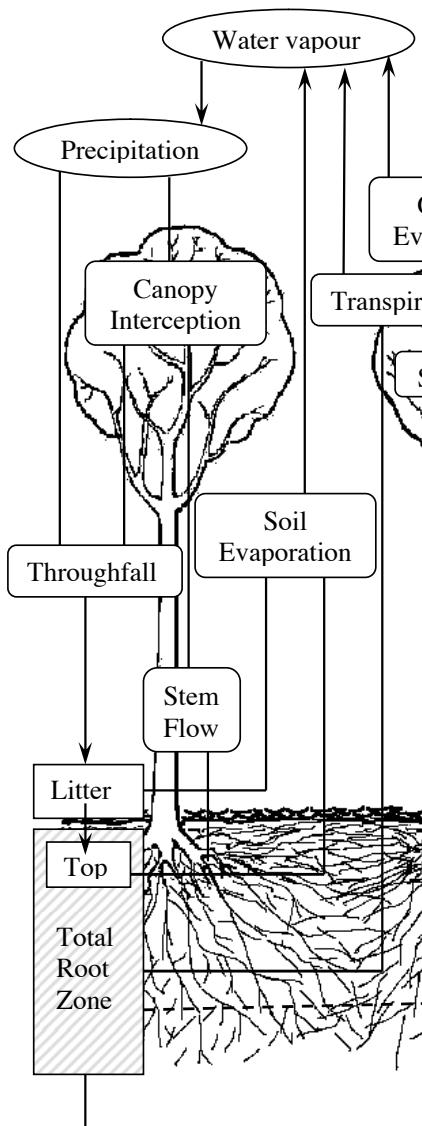
**Plurality of objects**

**Interdisciplinarity**

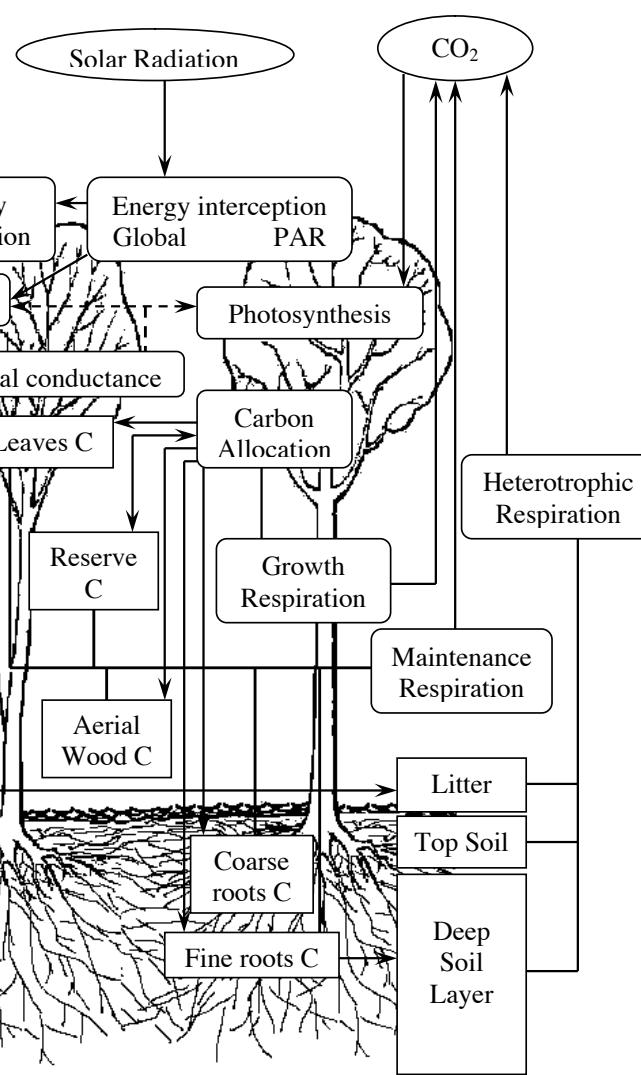


# Genealogy of a question

Water Balance Model



Carbon Balance Model



## Carbon budget

- Photosynthesis
- Tree respiration
- Soil respiration

## Energy budget

- Light interception
- Thermic budget

## Water budget

- Transpiration
- Soil evaporation
- Rain interception

## Growth

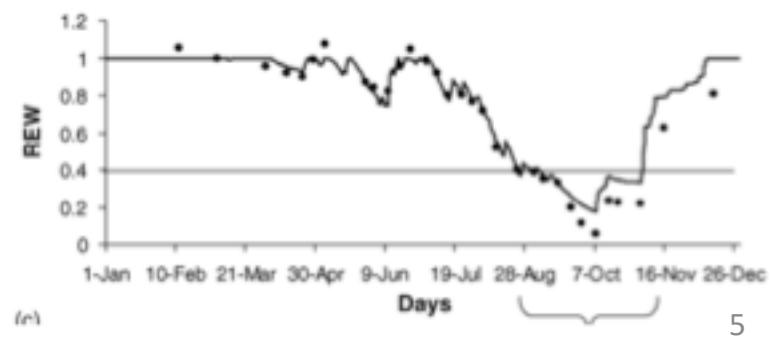
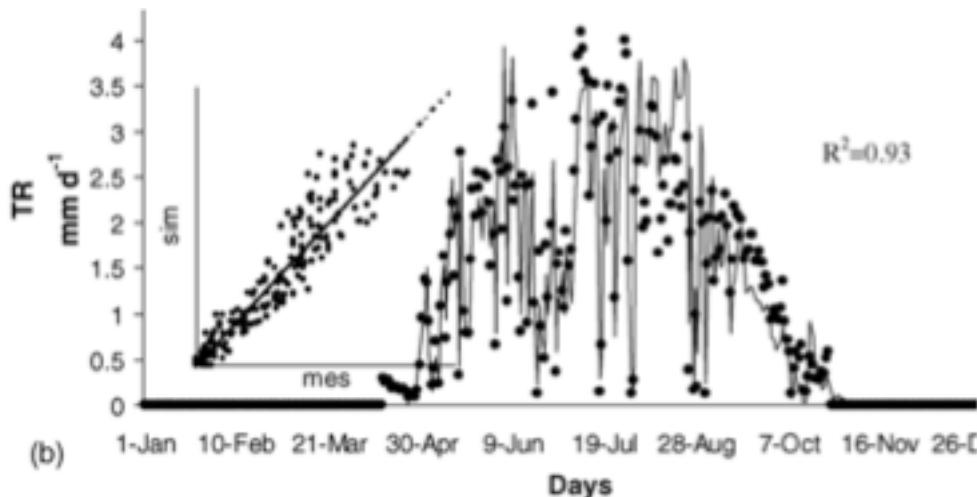
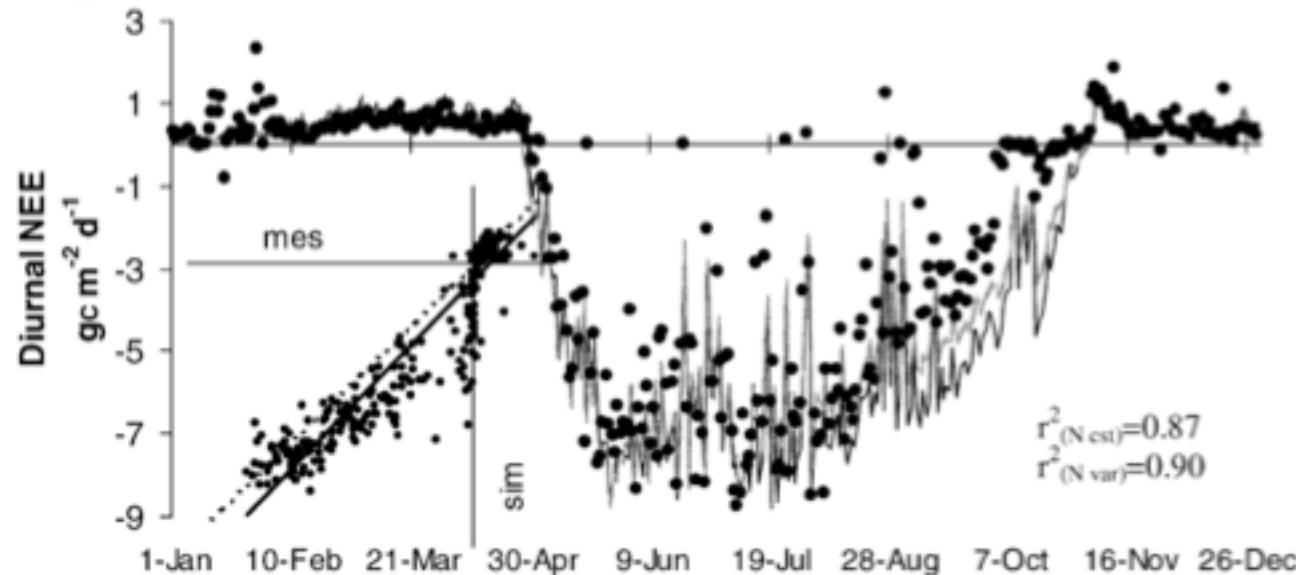
- Height
- Diameter
- Ring width
- Reproduction

Modelling

# Evaluation of CASTANEA model

## Validation

Model evaluation on several processes (Davi et al. 2005)

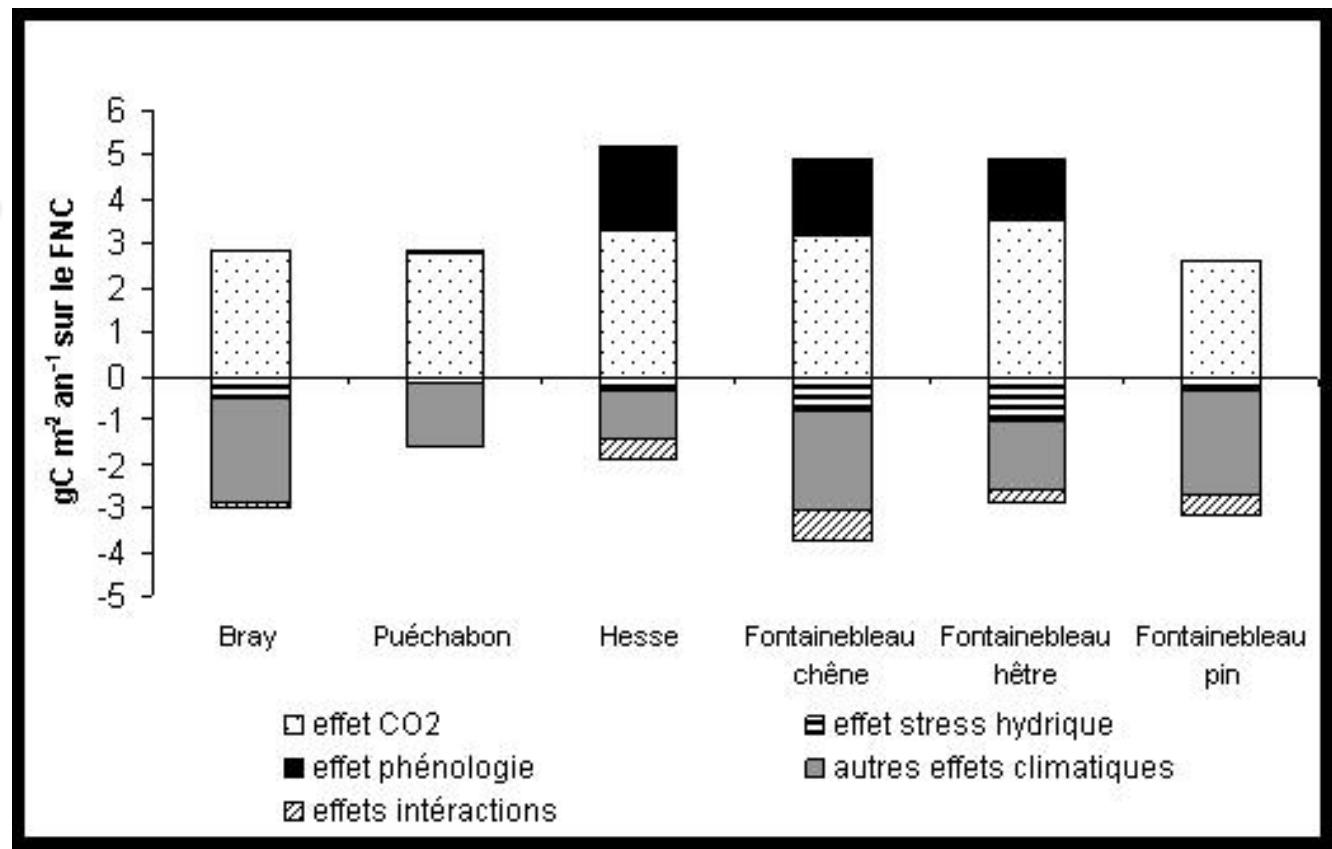


Increase in temperature, water stress and CO<sub>2</sub>

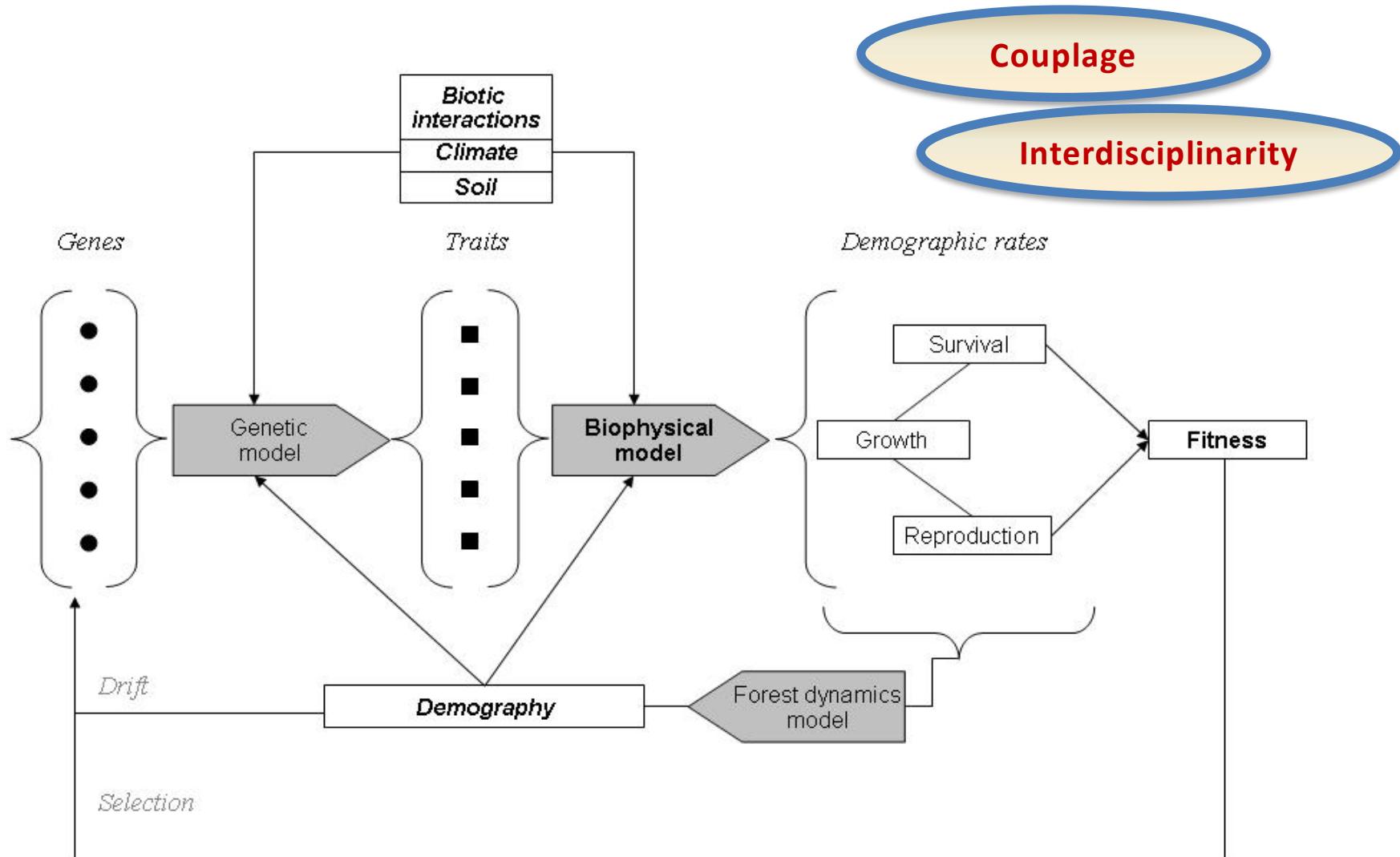


Effects modeling is complex (depend on the species)  
Statistical models are inoperative

« Prediction »



# Genealogy of a question



Oddou-Muratorio & Davi 2014

# PDG, a new hybrid model

CASIMMA

Dufrêne et al. 2005



*Fecundity = f(reserves)*



ADULTS

Ovules

Pollen

Mating system

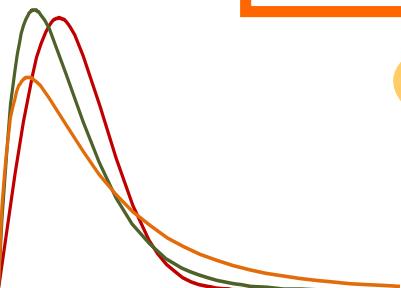
(2% selfing)

SEEDS



genes

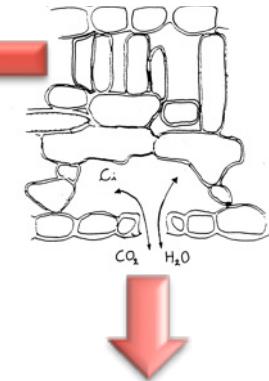
Rate of empty seed,  
germination, survival



Dispersal

Dispersal  
-pollen dispersal kernel

ADULTS



Growth/ mortality

ADULTS

Date of  
Budburst

Density-dependence  
mortality



SEEDLINGS



# Genealogy of a question

Recherche fondamentale  
dont les barrières  
disciplinaires sautent

Données « haut débit »



**Accroissement des capacités de calcul**

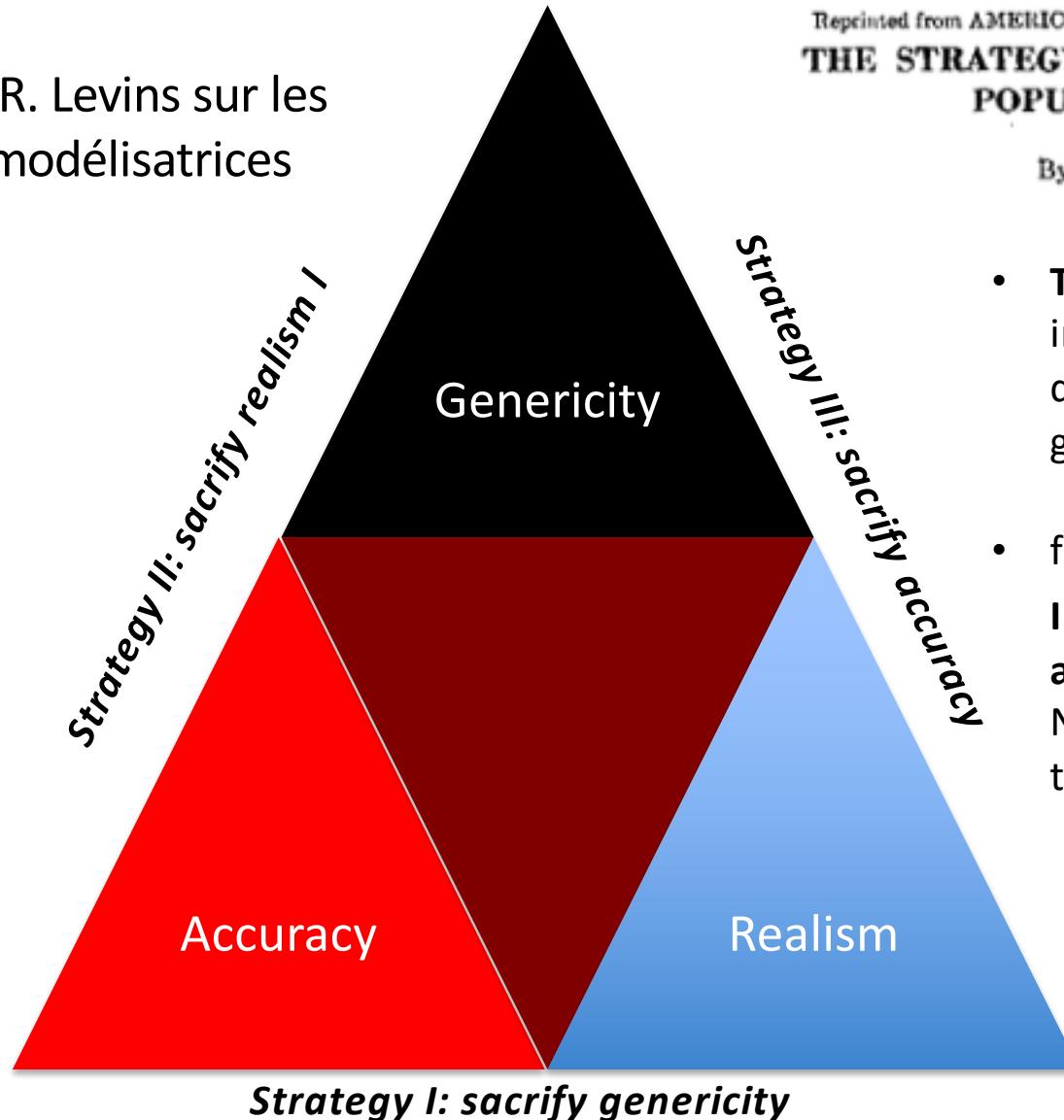


Pression sociétale: transfert entre recherche fondamentale et recherche appliquée:  
**comprendre pour prédire**



# Around Levins paper (1966)

Triangle de R. Levins sur les approches modélisatrices (1966)

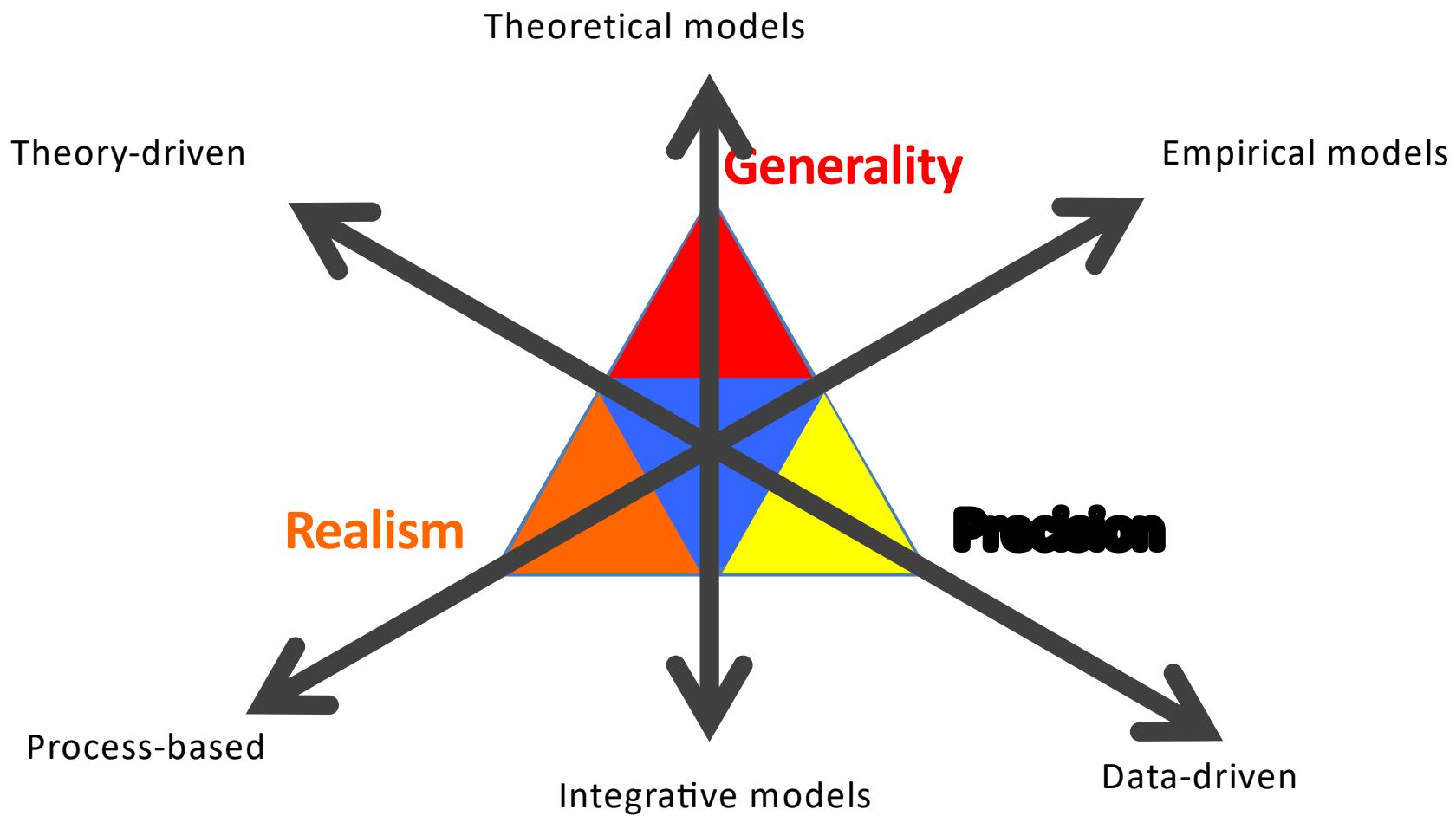


Reprinted from AMERICAN SCIENTIST, Vol. 54, No. 4, December 1966  
**THE STRATEGY OF MODEL BUILDING IN POPULATION BIOLOGY**

By RICHARD LEVINS

- **The question:** the importance of demography in population genetics
- for Levins  
**Illusion "brute force approach"**  
No model can reconcile the three properties

# Around Levins paper (1966)



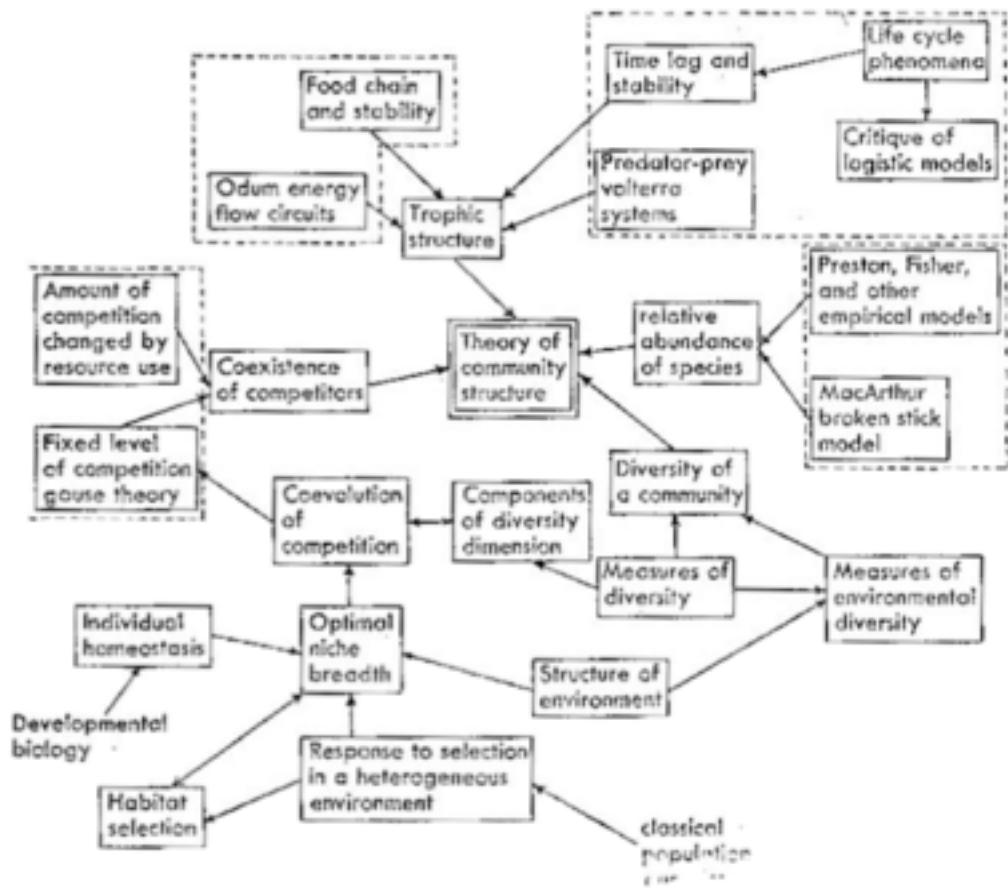
# Around Levins paper (1966)

## Other aspects of Levins paper

- What is modelling ?
  - Robustness of a modeling approach / sufficient parameters
  - Cluster of models depending the question

"A mathematical model is neither a hypothesis nor a theory. Unlike a scientific hypothesis model is not verifiable directly by experiment. All models are both true and false.

Almost any plausible proposed relation among aspects of nature is likely to be true in the sense that it occurs (although rarely or slightly) "



# Around Levins paper (1966)

## THE SCHISM BETWEEN THEORY AND ARDENT EMPIRICISM: A REPLY TO SHIPLEY AND PETERS

*Tilman 1991*

Ecological research, like all science, is most effective if it is based on the continual interplay of observation, hypothesis generation (theory), and experimentation. Empiricism is clearly a part of this process, as is theory.

Shipley and Peters suggest that the falsification of one prediction of a mechanistic model indicates that the model is “wrong” and thus not useful in explaining other patterns. This is an extreme, absolute interpretation that sees a model as the mathematical embodiment of ecological truth. In contrast, mathematical ecologists view models as abstractions (e.g., Schaffer 1981)—simplifications that, in the words of May (1973, p. 12), are “caricatures of reality, and thus have both the truth and falsity of caricatures.” All models are caricatures

# Around Levins paper (1966)

## The definitions d'Orzack & Sober (1993)

- « If one model applies to more real world word systems than another, it is more **general** »
- « If one model takes into account of more independant variables known to have an effect, than another, it is more **realistic** »
- « if a model generates points prediction for output parameters, it is **precise** »

## The critics of Orzack & Sober (1993)

- Taxonomy given by Levins rests on nothing:  
relative notions  
problem of instantiation
- No trade-off between genericity, realism,  
accuracy

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

$$\frac{dN}{dt} = rN + \alpha N^2$$

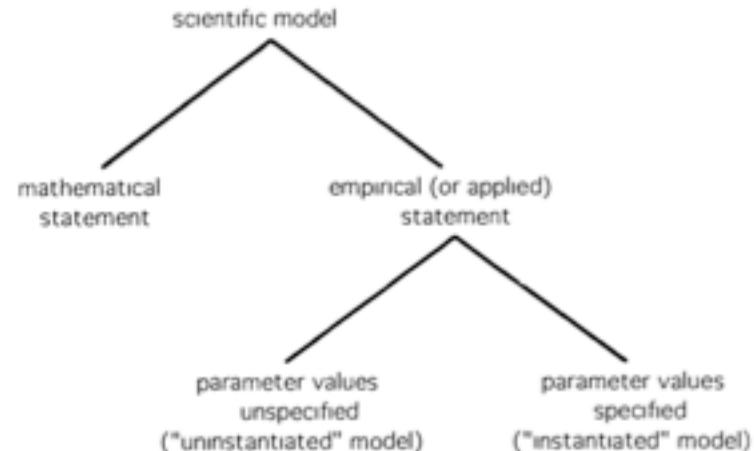
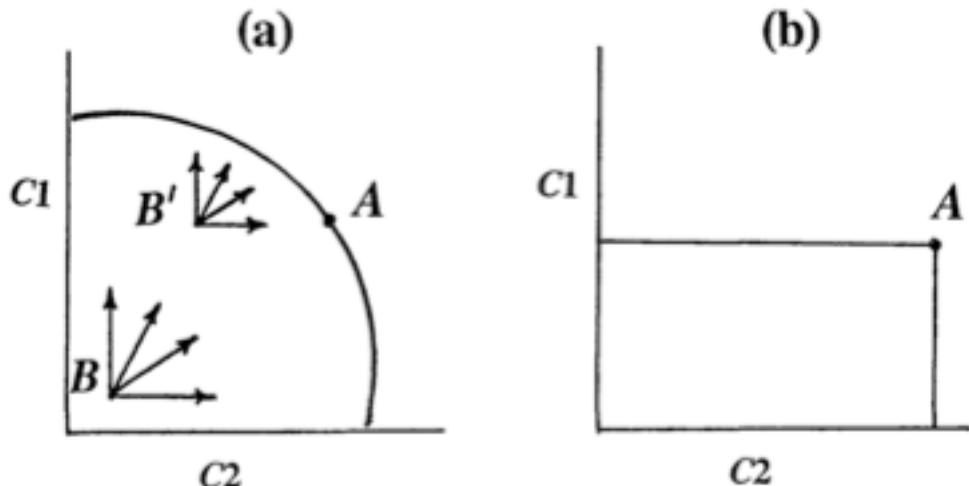


FIG. 1. THE RELATIONSHIP BETWEEN THE MATHEMATICAL STATEMENT OF A SCIENTIFIC MODEL AND TWO TYPES OF EMPIRICAL FORMULATION IT MIGHT RECEIVE

# Around Levins paper (1966)

## La réponse de Levins (1993)

- Dialectic point of view *versus* analytic
  - « *Orzarcz and Sober reify a discussion, on building model to a discussion of models* »
- The construction **depends on the issue** and is constrained by the state of scientific fields (computing capacity)
- Instantiation: point in a continuum specification



« *Formal analysis freezes moments of a process into things* »

« *Formal analysis prefers fixed definitions of objects free of their context* »

« *Formal analysis breaks the world and the scientific process that study the world into mutually exclusive categories, although the world is fluid and categories forms, dissolve, overlap and interpenetrate* »

→ Difference between maximisation and increasing

# Around Levins paper (1966)

1. The critics of Orzack & Sober is justify => force Levins to make it initial paper more accurate
2. The Levins answer and its critics of analytical point of view is convincing

**It eludes, in part, the problems:**

- No theoretical foundation of the proposed trade-off
- Origin of the trade-off in the nature of the world (ontological limit) or knowledge (epistemic limit)?
- No Foundation 'empirical' convincing

Raises epistemic issues

- What is the nature of the models used in ecology?
- Is there a "natural" typology models?
- The question of references of theoretical entities
- Relationship between model and truth



Dialectical view returns to a **instrumentalist view of modeling**  
But his notion of robustness tends to rehabilitate a **realistic vision**

# Revisiting these epistemic questions with Gödel's thought

1. Logician and mathematician

2. Important philosophical and epistemological reflections but often unpublished



1906-1978

The book of Hao Wang :

- Reflexion on Kurt Gödel MIT Press 1980
- A logic journey from Gödel to philosophy. 1996 MIT Press.
- Collected works of Kurt Gödel. Oxford University Press.
- Russell's Mathematical logic a paper that Gödel has published in 1944.
- The texts of Max Phil X, which are still unpublished, are reading notes that Gödel made.
- The philosophical significance of Gödel's slingshot argument. Article de S Neale dans mind

Gomperz

Hilbert

Turing

Kant

Leibnitz

Husserl

# Revisiting these epistemic questions with Gödel's thought

1. The world is rational
2. Human reason can in principle be even more developed  
(through certain techniques)
3. There are systematic methods for the solution of all problems
4. There are incomparably more a priori knowledge than is currently known.
5. The concepts have an objective existence

**9.4.17**

«A set is a special kind of everything.  
The sets are units that are just  
multitudes; but generally wholes are  
more than only multitudes, have also  
units »

**9.1.28**



- Realist
- Rationalist
- Positivist
- Holistic
- **Predominant role of conceptual thought**

# Revisiting these epistemic questions with Gödel's thought

## The no miracle argument and realist positions

« *The positive argument for realism is that it is the only philosophy that doesn't make the success of science a miracle* » Putnam 1975.

### Boyd définit le réalisme par 4 thèses

1. Theoretical terms of scientific theories (unobservable) should be thought of as actually referring expressions; scientific theories **must be interpreted realistically**
2. Scientific theories interpreted realistically can be confirmed and in fact often are approximately true as by the usual scientific evidence in accordance with the methodological standards used.
3. The historical progress in mature sciences are largely the product of approximation to the truth more and more precise both on the observed phenomena and those that remain unobservable. Typically the latest theories are built from knowledge (observational or theoretical) that were present in the earlier theories.
4. **The reality described by our scientific theories is largely independent of our thinking and our theoretical commitments.**

# Revisiting these epistemic questions with Gödel's thought

## L'instrumentalisme du Duhem

**Duhem** : « *Les propositions théoriques ne disent pas quelque chose du monde, ce sont des constructions syntaxiques pour aider l'expérience* ».

« *Une loi de sens commun est un simple jugement général ; ce jugement est vrai ou faux. (...). Il n'en est pas de même des lois que la science physique, parvenue à son plein développement, énonce sous forme de proposition mathématiques ; une telle loi est toujours symbolique ; or un symbole n'est à proprement parler, ni vrai, ni faux ; il est plus ou moins bien choisi pour signifier la réalité qu'il représente, il la figure d'une manière plus ou moins précise, plus ou moins détaillée, mais appliqués à un symbole, les mots vérité, erreur, n'ont plus de sens...*

 » 255 (237).

## Poincaré / Worrall : réalisme structurale

« *(...) mais ce qu'elle peut atteindre, ce ne sont pas les choses elles-mêmes, comme le pensent les dogmatistes naïfs, ce sont seulement les rapports entre les choses ; en dehors de ces rapports, il n'y a pas de réalité connaissable* »

« *Peu nous importe que l'éther existe réellement, c'est l'affaire des métaphysiciens ; l'essentiel pour nous c'est que tout se passe comme s'il existait et que cette hypothèse est commode pour l'explication des phénomènes* » p215.

# Revisiting these epistemic questions with Gödel's thought

## Realism and the question of the reference

Frege

Langage	Nom propre & DD	Prédicat	Enoncé
Sinn	Mode de donation de l'objet	Sens du prédicat	Pensé : Gedanke
Bedeutung	Objet	Concept	Valeur de vérité

« *Le sens d'un nom propre est donné à quiconque connaît suffisamment la langue ou l'ensemble des désignations dont il fait partie ; mais la dénotation d'un signe à supposer qu'elle existe, n'est jamais donné en pleine lumière* » p104. Frege 1892

« *George IV wished to know if Scott is the author of Waverley* »  
Ou “*L'actuel roi de France est chauve*”  
Russell

The realist posture Frege leads to logical paradoxes:

- every true statement is equivalent to any other true statement
- abandonment of realism => no noetic ray

# Revisiting these epistemic questions with Gödel's thought

Gödel refuses in his article on Russell abandoning realism

- Gives another interpretation of the slingshot argument
- The problem is the transition from a concept to a class

Class => Concept

Concept ≠> Class

8.6.14 : « Alors que c'est une hypothèse incorrecte de prendre comme propriété du concept de concept, le fait de dire que tout concept définit un ensemble. Il n'y a pas d'erreurs à dire que les ensembles ne peuvent seulement être définis par des concepts ou qu'un ensemble est une certaine façon de parler d'un concept »

For Frege denotation of concepts is also problematic because the propositional functions are unsaturated (Frege 1891):

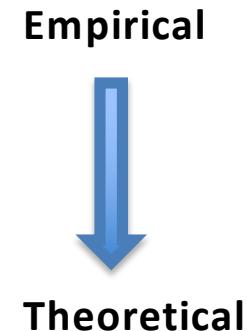
« Mon propos est de montrer que l'argument n'appartient pas à la fonction, mais que fonction et argument pris ensemble constituent un tout complet. De la fonction prise séparément on dira qu'elle est incomplète, ayant besoin d'une autre chose, ou encore insaturée. C'est par là que les fonctions se distinguent radicalement des nombres ». p84

# Revisiting these epistemic questions with Gödel's thought

## References of terms in models

### Typologie des références des termes idéels

- Objects
- Facts/ Relations between objects
- Finite class of objects, facts, relations
- *Infinite class* of objects, facts, relations
- *Concept: adaptation, resilience*



The problem of reference is especially for the last two types: the notion of sampling solving the problem to the finite classes!

When unified many processes under the concept of adaptation or biodiversity, what do we say about the real world?

# Revisiting these epistemic questions with Gödel's thought

## The notion of «logic space »

Espace logique	Réel	Champs	philosophe
Description (concept/symbole)	Choses	<i>Langue</i>	<i>Russell</i>
Phénomènes (ercheinung)	Chose en soi/ Dinge an sich	<i>Théorie de la connaissance</i>	<i>Kant</i>
Sinn	Bedeutung	<i>Sémantique</i>	<i>Frege</i>
Possibilité	Réalité	<i>Métaphysique</i>	<i>Leibnitz</i>
Multiple	Un		<i>Platon ou Leibnitz ?</i>
Lumière	Ce qui est éclairé	<i>Physique ?</i>	<i>Platon ?</i>
Ce que dans l'acte de connaissance est en nous	Ce que dans l'acte de connaissance est devant nous	<i>Epistémologie</i>	<i>Husserl</i>

*Ernst Gödel dans les Max Phils (Source G. Crocco)*

One part of reality, we pass by the concept to better return to the essence of the reality => save the realism of concepts by a dynamic (dialectical) between the two columns

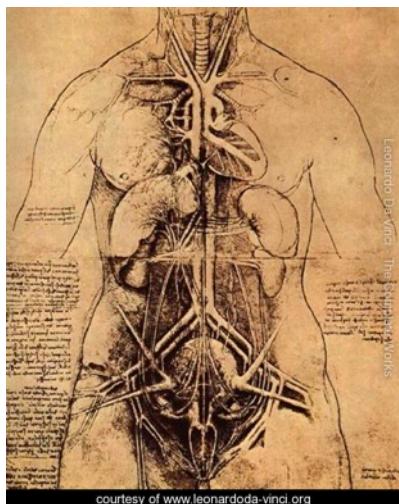
# Revisiting these epistemic questions with Gödel's thought

« La vérité (ou les vérités), sont une partie de la réalité, la réalité étant constitué de deux parties, à savoir les choses et les faits (ces derniers étant les liaisons entre les choses) » p20

« ...nous ne voyons rien de nouveau (dans le ciel des concepts) lorsqu'on regarde une chose à la lumière d'un concept, mais seulement lorsqu'on regarde une chose et un concept à la lumière de  $\varepsilon$  (ou de la vérité) » Max Phil X, p11



applying a predicate to a subject and looking into the facts if the product statement is true => In modeling we apply a theoretical relation to a specific case and we compare the results to observations



# The dialectical evolution of concepts of space and the real world

The view is determined by the question:



# The dialectical evolution of concepts of space and the real world

Science is iterative development, selection of some possible facts that have been invalidated by the observation. The probable and inferred facts are possible facts.



Which validates the realistic position is its evolutionary character

## Modelling and space of concepts



- Space of concepts is not an image of the real world but **an image of potential world**
- Space of concepts and model characterized by **intentionality**
- Objectivity and link to the real world **application** of a predicate to a subject ideational => Potential facts compared with actual facts
- Space of concepts and **third world** (Popper)

# The dialectical evolution of concepts of space and the real world

**Experimentation:** To better confront the space of concepts in the world, we distort the world by creating an experience that eliminates certain interactions to better test the expected major interactions in the analysis of the logical world of possible facts.

**Concept:** One consequence of the potential and intentional entities of space concepts is that they are **potentially empty** until finally they are applied to a phenomenon

« *Les intentions véritablement objectivantes, ce sont les intentions vides, celles qui visent par-delà l'apparition présente et subjective la totalité infinie de la série d'apparitions* » p28 *L'être et le néant* de Sartre

Empirical models

Proximity to facts

Induction

Theoretical models

Simulation model

Proximity to question/intention

Hypothetico-deduction

Mediators

IBE

# conclusion

The model is not a picture of reality

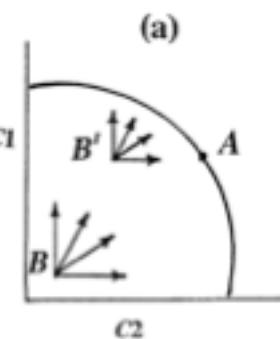
- ✓ it is a tool
- ✓ Representation conditioned potentials
- ✓ it "says" something real, including relationships

Place of intentionality is not a weakness but a strength, plurality of models is absolutely necessary

Plurality of models is not evidence of anti-realism

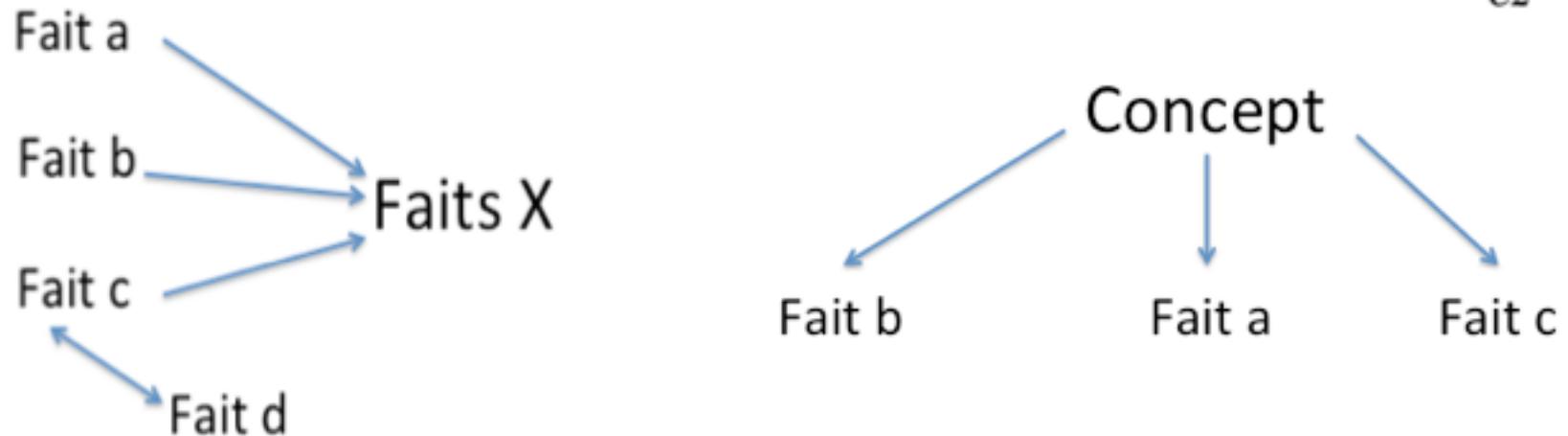
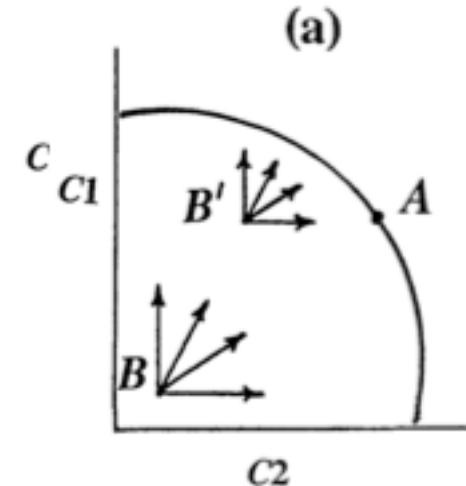
In the 3 poles of the triangle working in different but complementary objectives => but the surface changes with maximizing the growth of our knowledge

Epistemic trade-off between the three poles and ontologic trade-off between genericity and accuracy



# En guise de conclusion

4. Dans les 3 pôles du triangle on travaille à des objectifs différents mais complémentaires => mais la surface de maximisation change avec l'accroissement de nos connaissances



Analyse de faits = Unité phénoménologique  
Modèles empiriques/ précision

Synthèse de faits = Unité nomologique  
Modèles théoriques/ généricité

Merci



*Séminaire “Modélisation en Ecologie et Evolution”, édition 2015*

# Popper

« Nous pouvons donc dire que la science commence par des problèmes, et progresse à partir de là vers des théories concurrentes, qu'elle évalue de manière critique. L'évaluation de leur vérissimilitude a une portée particulière, car elle exige des tests critiques rigoureux et présuppose par conséquent, de hauts degrés de testabilité, qui dépendent du contenu de la théorie et que l'on peut évaluer *a priori*. Dans la plupart des cas, et dans les cas les plus intéressants, la théorie finira par s'effondrer et par donner naissance ainsi à de nouveaux problèmes. Et on pourra évaluer le progrès réalisé grâce à l'écart intellectuel entre le problème d'origine et le nouveau problème qui résulte de l'effondrement de la théorie »

p230

« Le monde est constitué d'au moins trois sous mondes ontologiquement distincts (...) : le premier est le monde physique ou le monde des états physiques ; le second est le monde mental ; ou le monde des états mentaux ; et le troisième monde est le monde des intelligibles, ou des idées au sens objectif ; c'est le monde des objets de pensée possibles ; le monde des théories en elles-mêmes et de leurs relations logiques ; des argumentations en elles-mêmes ; des situations de problèmes en elles-mêmes »