



# Interdisciplinary Education: Challenging and Motivating both Students and Teachers.



**Machiel Kestra, Institute for Interdisciplinary Studies, University of Amsterdam  
Waterford Institute of Technology, Jan. 9, 2013**



UNIVERSITEIT VAN AMSTERDAM

# Philosophy & history of science, cognitive neuroscience, interdisciplinarity: some (on-line) pub's



'Darwin hat den Geist vergessen!  
Nietzsches worsteling met de evolutietheorie

door Machiel Keestra

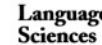
Beschikbaar sinds 12 oktober 2004 op de website van interdisciplinair e-zine Blind!, <http://www.ziedaar.nl/article.php?id=197>.



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)



Language Sciences 31 (2009) 531–552



[www.elsevier.com/locate/langsci](http://www.elsevier.com/locate/langsci)



Foundationalism and neuroscience; silence and language

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Received 12 July 2007; received in revised form 28 July 2007; accepted 19 September 2007

Concepts – not just yardsticks, but also heuristics: rebutting Hacker and Bennett

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Zonder kennis van de wiskunde geen toegang? Conceptuele kwesties in de geschiedenis van de wiskunde

Machiel Keestra

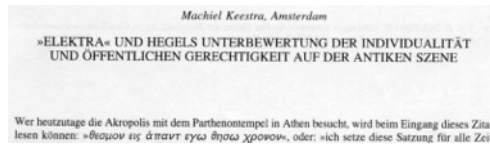


Review of General Psychology  
2008, Vol. 12, No. 2, 127–136

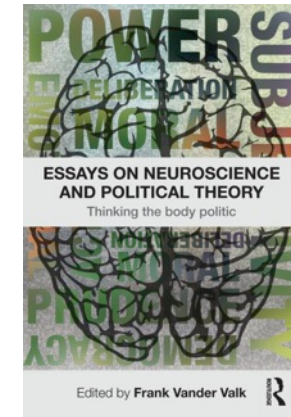
Copyright 2008 by the American Psychological Association  
1089-2689/08/\$12.00 DOI: 10.1037/1089-2680.12.2.127

The Diverging Force of Imitation: Integrating Cognitive Science and Hermeneutics

Machiel Keestra  
University of Amsterdam



Wer heutzutage die Akropolis mit dem Parthenontempel in Athen besucht, wird beim Eingang dieses Zitat lesen können: »θεσμον εις ἀπαντ εγω θεσω χρονος«, oder: »ich setze diese Satzung für alle Zeit



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BOUNDED MIRRORING

Joint action and group membership in political theory and cognitive neuroscience

Machiel Keestra

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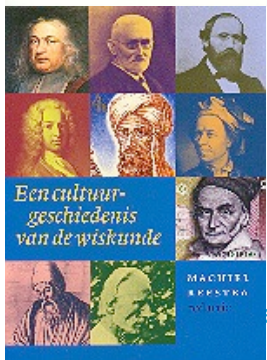
Understanding Human Action

Integrating Meanings, Mechanisms, Causes, and Contexts

Machiel Keestra



Integration in IDR and TDR  
Report from international td-net conference in Berne  
By Julie Thompson Klein, Machiel Keestra, and Rick Szostak





## Why inter-disciplinarity?

Karl Popper: *“We are not students of some subject matter, but students of problems. And problems may cut right across the boundaries of any subject matter or discipline.”*

(Conjectures and Refutations, Karl Popper, 1963, p. 67)



## ***How much help does a robot with or without a 'face' get? (1st year project)***





# Institute for Interdisciplinary Studies ([www.iis.uva.nl](http://www.iis.uva.nl))

- Bachelor degree Natural and Social Sciences ( $\pm$  400)
- Bachelor degree Future Planet Studies ( $\pm$  200)
- Research Master in Brain and Cognitive Sciences ( $\pm$ 100)
- Research Master in Forensic Science ( $\pm$ 60)
- Interdisciplinary electives ( $\pm$  1000)
- Honours classes ( $\pm$  150)
- Interdisciplinary minors (100)



# The I.I.S. Natural & Social Sciences (B.Sc.) bachelor: from interdisciplinarity to disciplinarity & back again

Year 3	S6	M	M	M	M	M	M
	S5	M	M	M	M	M	T3
Year 2	S4	M	M	M	M	M	T3
	S3	M	M	M	AC	T2	T2
Year 1	S2	AC	AC	AC	ID	ID	T1
	S1	AC	AC	AC	AC	AC	AC

Machiel Keestra - Waterford Inst. Techn. - Jan. 9, 2013

AC = Academic core, ID = Interdisciplinary Domain, T123 = Themes, M = Major/specialization



## **Stages of interdisciplinarity – corresponding to ID characteristics**

ID teaching & learning require of a person ever more:

- openness
- curiosity
- risk-taking
- being (self-)critical
- tolerance of ambiguity
- tolerance of uncertainty
- flexibility
- empathy



## ID courses which differ in:

- level of work
- width of ID
- didactics
- disciplinary depths
- original work

LEVEL 100 HUMAN ACTION:  
*4 SUB-DOMAINS – SMALL PROJECT*

LEVEL 200 OUR GENETIC IDENTITY:  
*PROBLEM BASED LEARNING*

LEVEL 300 INTERDISC. RESEARCH SEMINAR:  
*4 LARGE DOMAINS – LARGE PROJECT*







# ***1<sup>st</sup> year research project for a ‘Human Action’ course: “do animals have rituals, too?”***





# Encyclopedie (1750-1765): survey & cohesion of all available knowledge & expertise

*ENCYCLOPÉDIE,*  
OU  
DICTIONNAIRE RAISONNÉ  
DES SCIENCES,  
DES ARTS ET DES MÉTIERS,  
PAR UNE SOCIÉTÉ DE GENS DE LETTRES.

Mis en ordre & publié par M. DIDEROT, de l'Académie Royale des Sciences & des Belles-Lettres de Prusse; & quant à la PARTIE MATHÉMATIQUE, par M. D'ALEMBERT, de l'Académie Royale des Sciences de Paris, de celle de Prusse, & de la Société Royale de Londres.

*Tantum series juncturaque pollet,  
Tantum de medio sumptis accedit honoris! HORAT.*

TOME PREMIER.

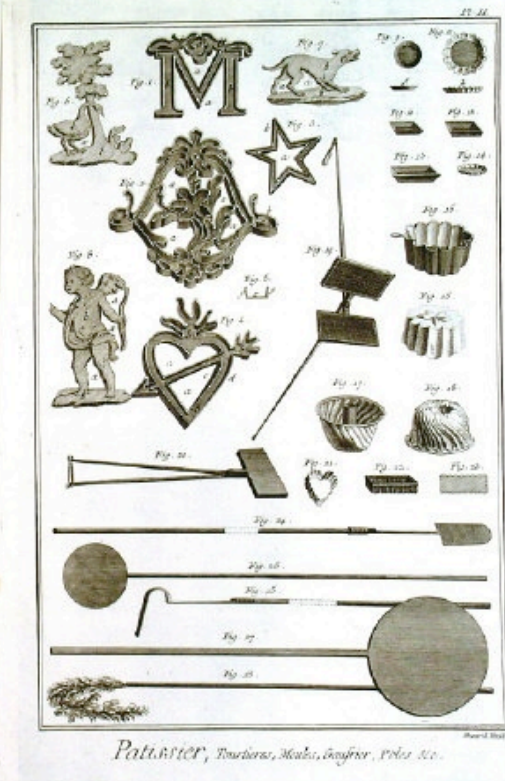


A PARIS,

Chez { BRIASSON, rue Saint Jacques, à la Sienne.  
DAVID l'aîné, rue Saint Jacques, à la Plume d'or.  
LE BRETON, Imprimeur ordinaire du Roy, rue de la Harpe.  
DURAND, rue Saint Jacques, à Saint Landry, le au Griffon.

M. DCC. LI.

AVEC APPROBATION ET PRIVILEGE DU ROY.





# Whewell's 1850 classification of domains of reality & corresponding sciences: still neat & surveyable

Fundamental Ideas or Conceptions	Sciences.	Classification
Space	Geometry	Pure Mathematical Sciences.
Time		
Number	Arithmetic	
Sign	Algebra	
Limit	Differentials	
Motion	Pure Mechanism Formal Astronomy	Pure Motional Sciences
Cause		Mechanical Sciences.
Force	Statics	
Matter	Dynamics	
Inertia	Hydrostatics	
Fluid Pressure	Hydrodynamics Physical Astronomy	
Outness		Secondary Mechanical Sciences. (Physics.)
Medium of Sensation	Acoustics	
Intensity of Qualities	Formal Optics	
Scales of Qualities	Physical Optics Thermotics	
	Atmology	
Polarity	Electricity Magnetism Galvanism	Analytico-Mechanical Sciences. (Physics.)
Element (Composition)		Analytical Science. Analytico-Classificatory Sciences.
Chemical Affinity	Chemistry	
Substance (Atoms)	Crystallography	
Symmetry	Systematic Mineralogy	
Likeness	Systematic Botany	
Degrees of Likeness	Systematic Zoology Comparative Anatomy	Classificatory Sciences.
Natural Affinity (Vital Powers)		Organical Sciences.
Assimilation		
Irritability (Organization)	Biology	
Final Cause		
Instinct		
Emotion	Psychology	Palaeontological Sciences.
Thought		
Historical Causation	Geology Distribution of Plants and Animals Glossology Ethnography	
First Cause	Natural Theology.	



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# **Classificatory Explosion of Sciences according to Dewey's Decimal System:**

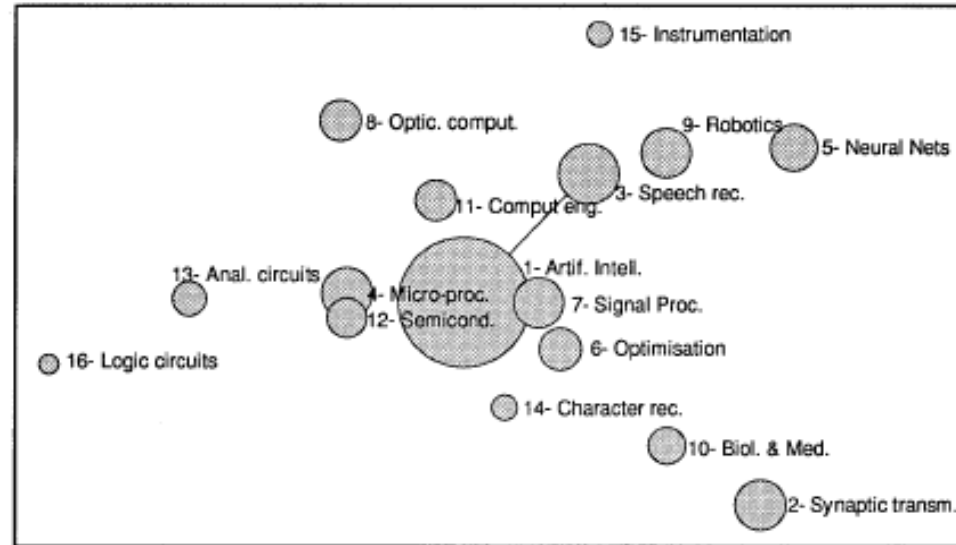
**1873 edition = 2000 entries**  
**recent edition = 27.000 entries + 13.000 additions**

- 000 – Computer science, information and general works
- 100 – Philosophy and psychology
- 200 – Religion
- 300 – Social sciences
- 400 – Language
- 500 – Science (including mathematics)
- 600 – Technology and applied Science
- 700 – Arts and recreation
- 800 – Literature
- 900 – History and geography

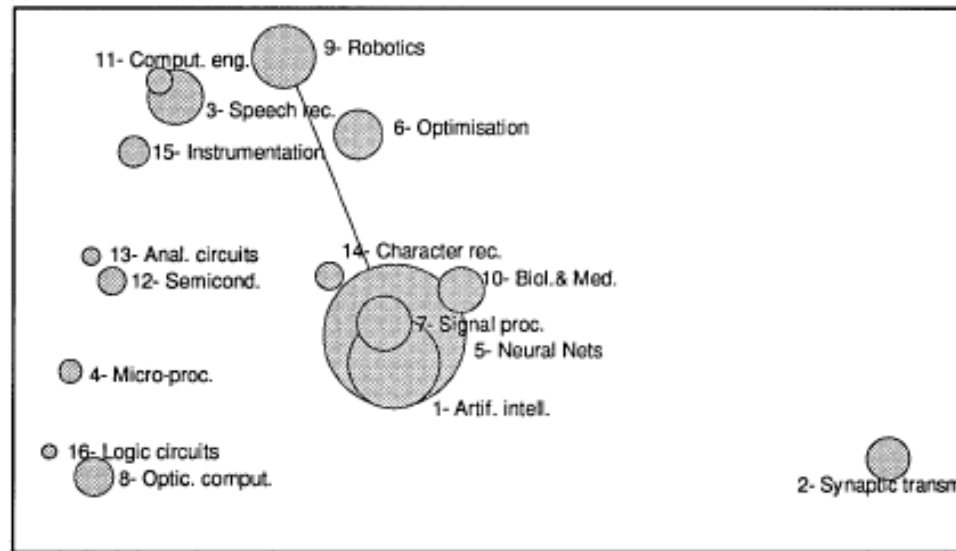


# Interdisciplinary science is always a dynamical phenomenon

(a) 1989/90 based on 1989/90 data



(b) 1992/93 based on 1989/90 data



Machiel Keestra, Interdisciplinair onderzoekspraktiku

FIG. 1. Neural network research maps (a: 1989/90 and b: 1992/93). Two-dimensional representation of sub-fields. Definition of sub-fields based on clusters of the most important classification codes in 1992/93. Cluster size (surface area) represents the proportion of publications included in each sub-field. Lines between sub-fields indicate relatively high number of 'common' publications.





## Interdisciplinarity's emergence

- 1920's ('26?): Social Science Research Council
- WW II and after: technological and social scientific demands for interdisciplinarity
- 1972: OECD report 'Interdisciplinarity: Problems of Teaching and Research in Universities
- 1979: Association for Integrative [Interdisciplinary] Studies
- 2011: International Network for Interdisciplinarity & Transdisciplinarity



## ***‘Meat the future: is artificial meat a sustainable alternative?’ (3rd yr.)***

- Management: niche-construction
- Technology: scaling up of production
- Biology: structure & quality of artificial meat







## Drivers towards IDR research:

- The Inherent Complexity of Nature and Society
- The Drive to Explore Basic Research Problems at the Interfaces of Disciplines
- The Need to Solve Societal Problems
- The Stimulus of Generative Technologies  
(Nat. Acad. Sciences report: Facilitating interdisciplinary research, 2004)





## Interdisciplinarity comes in different forms:

1. Borrowing of concepts, methods
2. Problem oriented collaboration
3. Bordering interdisciplinarity; increasing unification
4. Emergence of a new inter-discipline

(naar J. Thompson Klein, 'Interdisciplinarity', 1990 64-66)





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## European context and goals of education

- Eur. Comm. Bergen communique, 2005:
  - Goals of education are ‘preparing the student for the labour market, for further competence building and for active citizenship.’
- European Commission, 2006, ‘Modernisation Agenda’:
  - ‘Modernising Universities for Europe's competitiveness in a global knowledge economy ‘
  - ‘Enhance interdisciplinarity and transdisciplinarity.’
- Follow-up report from the Commission, 2008:
  - Mobility
  - New Skills for New Jobs
  - University-Business cooperation
  - Transparency in higher education performance



# New Curricula - Aiming for ‘Relevance’

THE EUROPEANIZATION OF HIGHER EDUCATION

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Table 1: Traditional and Emerging Curricula

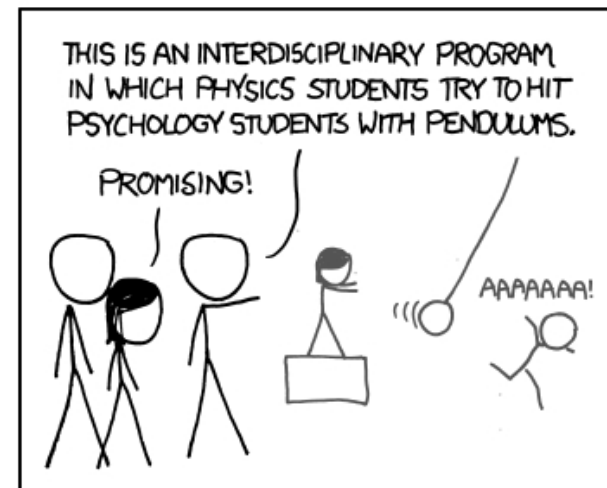
<i>Traditional Curricula</i>	<i>Emerging Curricula</i>
Knowing that	Knowing how
Written communication	Oral communication
Personal	Interpersonal
Internal	External
Disciplinary skills	Transferable skills
Intellectual orientation	Action orientation
Problem-making	Problem-solving
Knowledge as process	Knowledge as product
Understanding	Information
Concept-based	Issue-based
Knowledge-based	Talk-based
Pure	Applied
Proposition-based learning	Experiential learning

Source: Barnett *et al.* (2001, p. 437).



## Drivers against interdisciplinarity

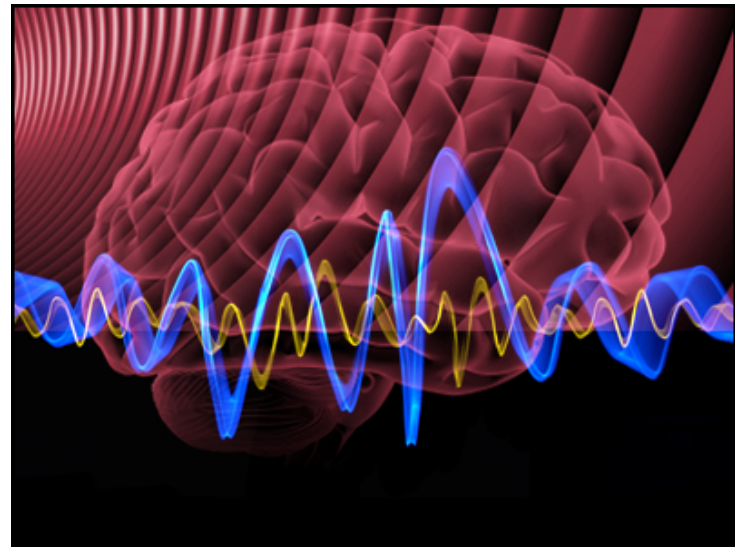
- disciplinary structure of the university
- disciplinary structure of academic education
- lack of emphasis on critical thinking, metacognition, higher order thinking
- organization and funding of research
- peer review process



MY PROFESSORS HAD AN ONGOING COMPETITION TO GET THE WEIRDEST THING TAKEN SERIOUSLY UNDER THE LABEL "INTERDISCIPLINARY PROGRAM."

# ***'Musical & rythmic stimulation in patients with Parkinson's disease' (3<sup>rd</sup> year)***

- Medicine – diagnosis & therapy
- Psychobiology - dopamine-circuits
- Musicology – (mathematical) analysis of musical elements

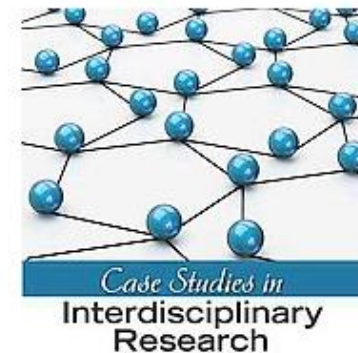




## An influential definition of interdisciplinarity:

[Interdisciplinary studies is] a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession . . . and draws on disciplinary perspectives and integrates their insights through construction of a more comprehensive perspective.”

(J. Klein & B. Newell: Advancing Interdisciplinary Studies, 1997.)



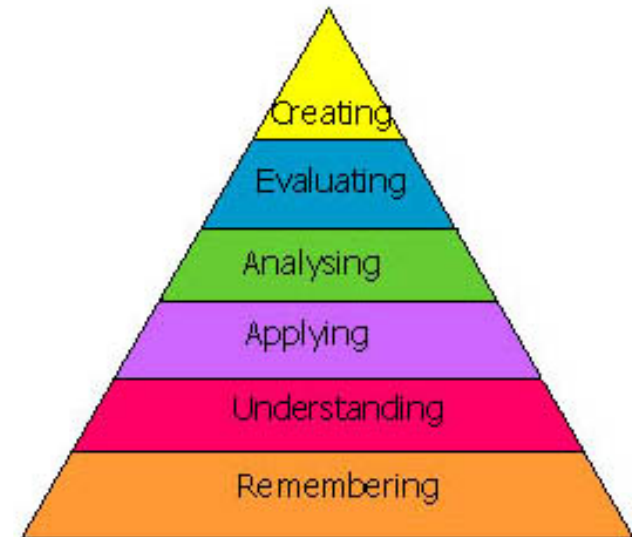
Allen F. Repko • William H. Newell • Rick Szostak



## An Integrated Model of the Interdisciplinary Research Process

### A. Drawing on disciplinary insights.

1. Define the problem or state the focus question
2. Justify using an interdisciplinary approach
3. Identify relevant disciplines
4. Conduct a literature search
5. Develop adequacy in each relevant discipline
6. Analyze the problem and evaluate each insight to it



### B. Integrating insights and producing an interdisciplinary understanding

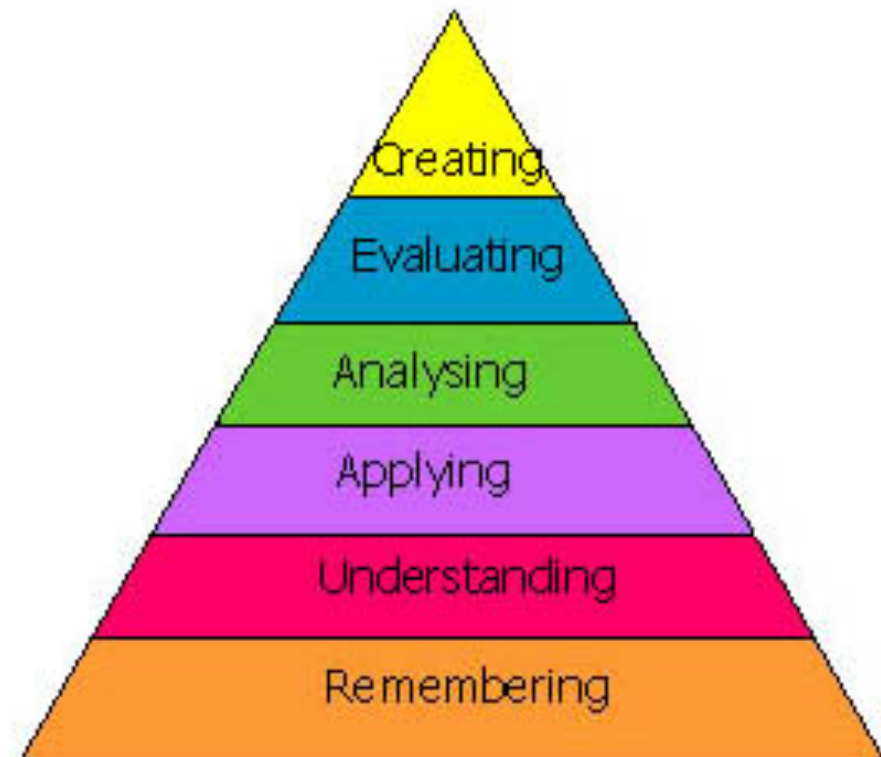
7. Identify conflicts between insights and their sources
8. Create or discover common ground
9. Integrate insights
10. Produce an interdisciplinary understanding of the problem and test it





# Requirements for *scientifically* and *societally* robust academic education.

- Scientific, cognitive skills
- Meta-cognitive skills
- Critical thinking skills
- Communicative skills





## **What results can come from interdisciplinary research?**

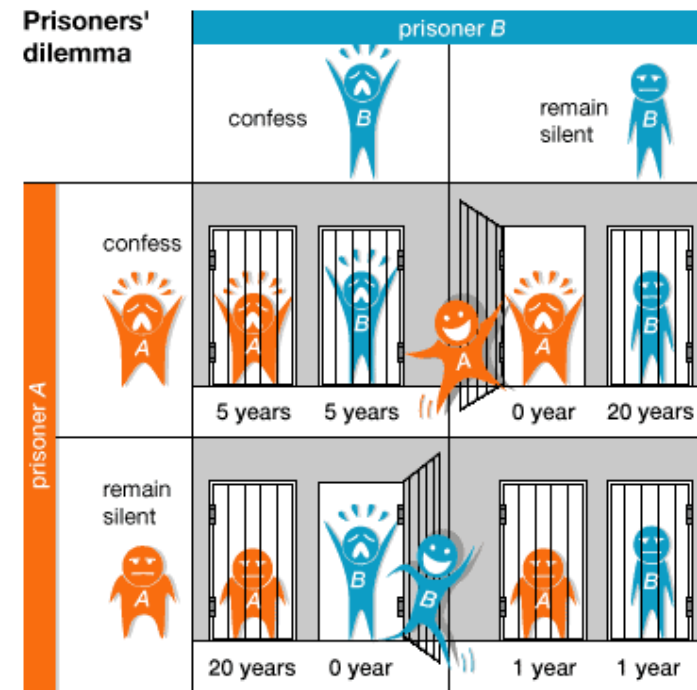
- knowledge of new empirical facts
  - conceptual & theoretical modifications
  - extended explanatory mechanism
  - optimization function
  - technological innovation
  - more robust intervention (medical, etc.)
  - more sustainable policy advice
- etcetera



# ***‘Why and how do tumor cells collaborate?’*** ***(3<sup>rd</sup> year)***

Three different majors:

- Biomedical science: tumor growth
- Psychobiology – evolutionary game theory
- Econometrics – mathematical model of collaboration

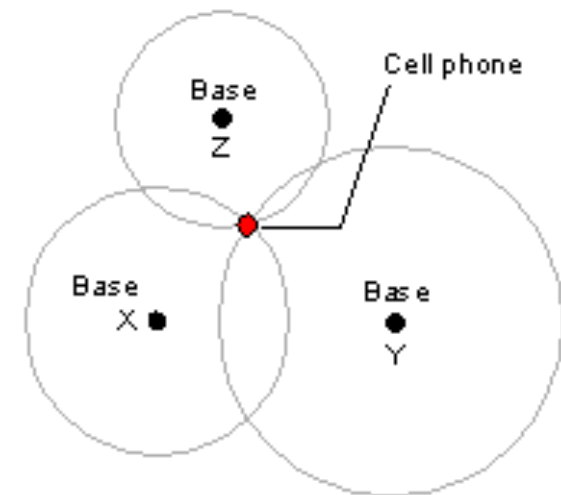


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## Triangulation exercise:

- Three different specializations
- Step 1: Subjects from your own discipline (taking others' into account)
- Step 2: Discover/formulate an overlapping subject
- Step 3: Formulate several questions/topics on that subject from your own discipline
- Step 4: Consider what type(s) of integration you would aim at.





## Thanks!

### INTERESTED?

- [www.units.muohio.edu/aisorg/index.shtml](http://www.units.muohio.edu/aisorg/index.shtml) (Association for Integrative Studies)
- [www.transdisciplinarity.ch](http://www.transdisciplinarity.ch) (Transdisciplinarity\_Net)
- [www.nchchonors.org](http://www.nchchonors.org) (Nat. Collegiate of Honors Colleges)
- [www.iis.uva.nl](http://www.iis.uva.nl) (Inst. Interdisciplinary Studies, A'dam)
- <http://home.medewerker.uva.nl/m.keestra>