"L'illettrisme scientifique: quelle réalité/quels écueils"

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The roots of scientific illiteracy

How do we perceive?

- Cognition is the only interface between people and the world outside them
- Everything we know and think passes through the cognitive filter
- That filter is biased in various ways:
  - We only cognize a small number of dimensions
  - Our ideas are underdetermined by observations and over-determined by prior experience

What are the consequences?

- Our perception is partial
- About any complex system, many theories are possible
- Later experiences build self-referentially on earlier ones
- Science is but one among a range of alternative systems to 'make sense' of the world around us

What is scientific illiteracy?

- NOT: absence of scientific literacy
- BUT: having a different way to 'make sense' of one's experiences
  - Hugh Jones' experience in the Amazon
- That 'way to make sense' is acquired very young
  - Family, school, associations, social network are the context in which this happens
  - Nowadays the internet is a major agent in this domain

Is there a scientific literacy crisis in the USA?

- Prominent elite, immigration helped build scientific literacy
- Science literacy has been stable until recently
- De Tocqueville – Jeffersonian notion of science as part of the competencies of the citizen
- BUT
- Poor education system
- Elite immigration has been slowed down
- Proliferation of independent religious movements
- Possibility to self-educate children
- HENCE: many children not in contact with science or other 'universalizing' cultures
- Currently 1/3 of the US population is *deliberately deaf* to science

The potential consequences

Current crises

- Apparently many crises: environmental, financial, political, etc …
- 'Crisis is a temporary incapacity to process the information a society needs to process in order to deal with the dynamics of which it is part'
- In the end there is only one crisis: a crisis of information processing in society
- Why? Insufficient shared ways of thinking to align stakeholders in society
  - Politics in EU and USA as examples
- What happens when this process persists?

A lesson from archaeology

- Tainter (1988):
  - Roman empire spread as long as it could capture 'stored energy', in its case treasure (in ours: fossil fuel)
  - It used that to build infrastructure (including army and administration), spread culture (shared ideas)
  - When it was thrown back on annual solar energy, it could not maintain that dynamic
  - In the meantime the periphery had taken over many ideas
  - The interest of people to be part of the Empire waned; people began to look out for themselves
  - As a result, the Empire broke apart

STEM is the foundation of our society

- Our society holds together because of STEM culture:
  - Includes all sciences
  - Universalist
  - Produces material advantages for many
  - Projects a vision
- Faith in STEM culture is regressing in the West, spreading beyond it
- BRICS periphery is quickly learning all that we have to teach, and is taking off on their own.
- How much longer will material and consumption growth in the West (a) be possible, and (b) be desirable and desired?
- Innovation is needed to keep the system working, yet
- US patenting indicates the total economic contribution per patent is decreasing since a century.

What is science?

Is STEM 'truth' or social construct?

- Science is a structured process of questioning, observation and organization of knowledge
  - The process is undertaken and maintained by a social community of scientists
- Society constructs its context and values, and co-defines the questions and means to observe
  - Objectively observed facts answer subjectively, self-referentially negotiated questions
  - It's not about 'true' or 'false', but about defining the domain and degree of validity of observations
- The knowledge produced is generally reliable and used to construct society
  - Hence it has to be integrated in the societal dynamic
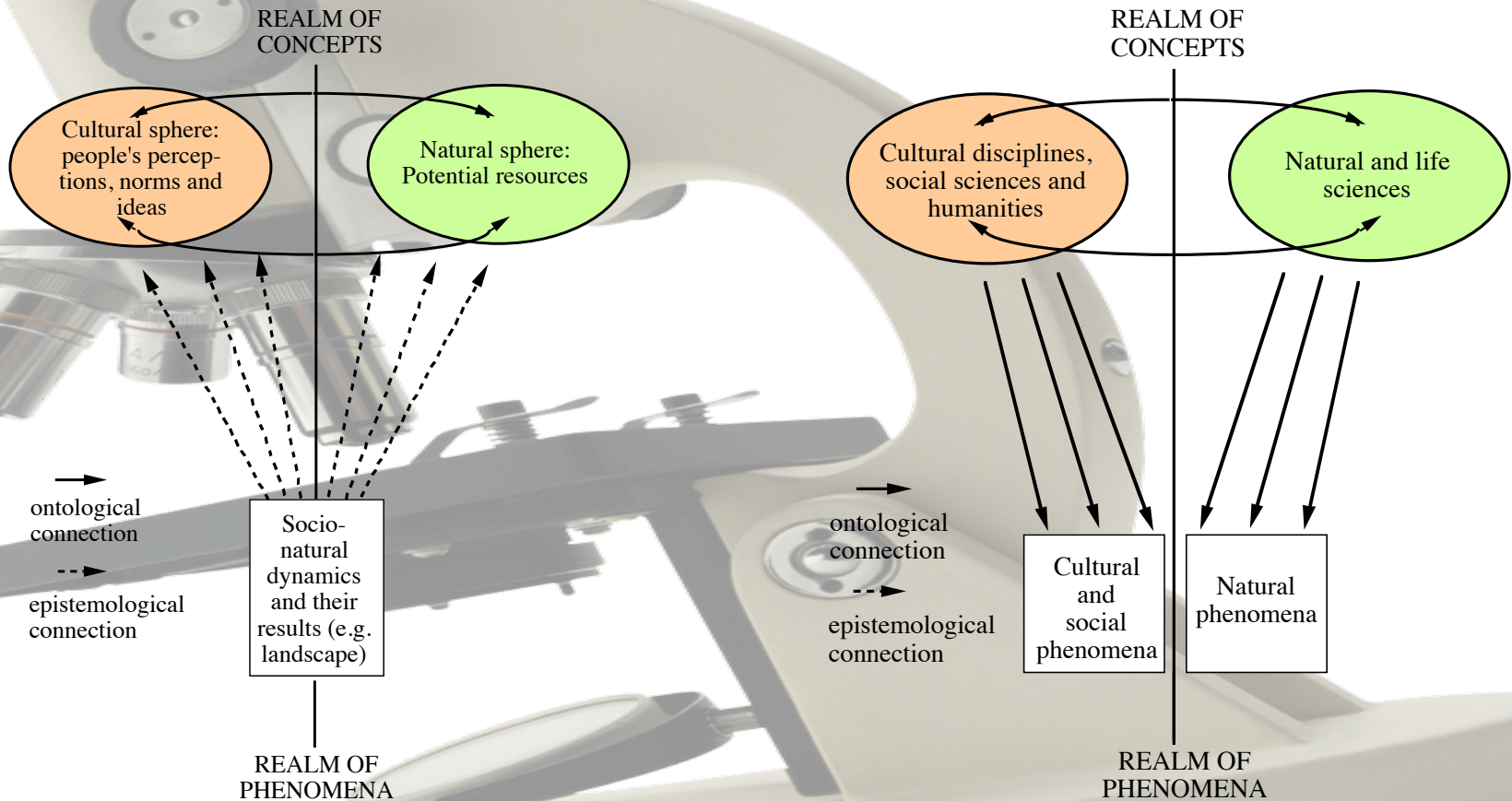
The changing role of STEM

- After 200+ years of symbiosis, science and society have grown apart
- STEM no longer responds effectively to society's expectations
  - Society's expectations of STEM are unrealistic
  - Unintended consequences are increasing
- Society is losing trust (interest?) in science
  - Reductions in R&D funding at all levels in all western countries
- Both society and the science community have become defensive
  - Science tries to impose its values, society to deny them
- Why?

Institutionalization of STEM

- STEM has been institutionalized (academia, GRO's, industrial R&D)

- Its role is institutionalized as provider of
  - innovation for industry
  - knowledge for decision-making

- This has changed the STEM process itself (fig 1)
  - from observation driven to discipline driven
  - Its world view has been fractured

- But it also changed its relation to society
  - It has politicized STEM, made it contentious

Transformation into disciplines

REALM OF CONCEPTS

Cultural sphere: people's perceptions, norms and ideas

Natural sphere: Potential resources

ontological connection

epistemological connection

Socio-natural dynamics and their results (e.g. landscape)

REALM OF PHENOMENA

REALM OF CONCEPTS

Cultural disciplines, social sciences and humanities

Natural and life sciences

ontological connection

epistemological connection

Cultural and social phenomena

Natural phenomena

REALM OF PHENOMENA

Barriers to scientific impact

Science and politics

- Politics: admittedly subjective
  - Challenges the irrational bases of society, mediates a non-rational but emotionally satisfying operational solution
  - Looks forward (emergence)
  - Deals head-on with complexity (brings dimensions out)
  - Topics relatively stable over time
- Science: many 'objectivities'
  - Investigates these irrational bases by raising questions and trying to find rational answers
  - Looks back (origins)
  - Simplifies (reduces dimensions)
  - Rapidly changing topics; different disciplinary perspectives
- Which drives which?
  - Simplified visions of each impact on one another

Science and the public

- Scientific illiteracy is not lack of understanding
  - Public reception of knowledge never purely intellectual
  - Experienced and judged as material social relationships, interactions and interests
- It's about the trust the public will invest in scientists and scientific institutions
  - Neither science nor trust should be reified
  - They are dynamic, contextual processes interacting with beliefs and occurring in social networks (Layton, Wynne)
- Understanding is a social construct, part of a process of identity construction

Sheep farming after Chernobyl

- Inconsistency and over-optimism of scientific advice undermines trust
  - Scientific idiom of certainty and control contrary to farmers' experience of change and uncertainty
  - Former based on ex-post, latter on ex-ante experience
    - Scientific advice based on wrong model of caesium behavior
    - Scientists ignore farmers' knowledge and advice
  - Farmers lose trust in science
    - Experience scientists as threat to their society
    - Refer to either arrogance or conspiracy of scientists
  - Farmers link their experience to Sellafield controversies and blame the latter, not Chernobyl

Legitimacy and identity

- A fundamental issue is one of identity and legitimation across community boundaries
  - *Farmer*: my idea is legitimate because I was born here, live here and know every inch of this field, and what it can and cannot do
  - *Scientist*: my idea is legitimate because I was not born here, don't live here and don't know every inch of the field, but know my science
  - *Neither:* my idea is legitimate because it responds best to the questions we ask (indeed, we cannot unite on the questions to ask!)

Uncertainty and doubt

- Farmers' ex-ante perspective is about doubt, expecting and dealing with deviations from judgments based on past experience
  - To live with it, they construct their own world view, linking events and observations in different ways

- Scientists' ex-ante perspective is about certainty and its absence, intellectually limiting predictive value of ex-post science
  - They accept uncertainty as a limitation to what they can say, but don't depend on their response to it.

Clarity and ambiguity

- As in the case of science and politics, we have to do with two world views
  - One that aims to remove contradiction and therefore builds an unrealistic view of life
    - To do so, it reduces the number of cognized dimensions of the complex system (doesn't consider questions it cannot answer)
  - One that reconciles itself with contradictions that cannot be dissolved, and 'muddles through'
    - It acknowledges the full complexity of the system and its incapacity to control it
  - Ambivalence and ambiguity play a major role

Expectations and institutions

- Each side expects the other to understand it
  - Absence of understanding breeds distrust
- Scientists at a disadvantage because they claim *knowledge* and *abstraction,* farmers *understanding* and *experience*
- Scientists' association with government etc. aggravates distrust because it associates them with external power
  - "The sense of being ensnared by an alien and unrecognizing combination of science and bureaucracy" that denies the *identity* of the farmers

Phenomena and ideas

- Phenomena have an infinite number of dimensions,
  - They are essentially poly–interpretable,
- By virtue of the limitations of our cognitive system, ideas have limited dimensionality,
  - They are less poly-interpretable
- Interactions between the realms of ideas and phenomena are asymmetrical
  - Hence the scientific concept of 'unintended consequences'
  - In the public realm, all consequences are unintended and unexpected – and the concept thus does not exist

Have we reached a 'tipping point'?

- Viewing public opinion as a complex system, we need to ask:
  - Whether the shift in trust in science is nearing a 'tipping point'?
  - What might be the cause of such a shift?
  - What we might do, if anything, to delay such a shift?
- I am choosing a resilience perspective on these questions

System boundaries tenuous; innovations possible -*"Egalitarian"* perspective in unstable, precarious circumstances of reorganization

Things change slowly; resources 'locked up' -*"Hierarchist"* **perspective:** limited resources, impose regulation and control
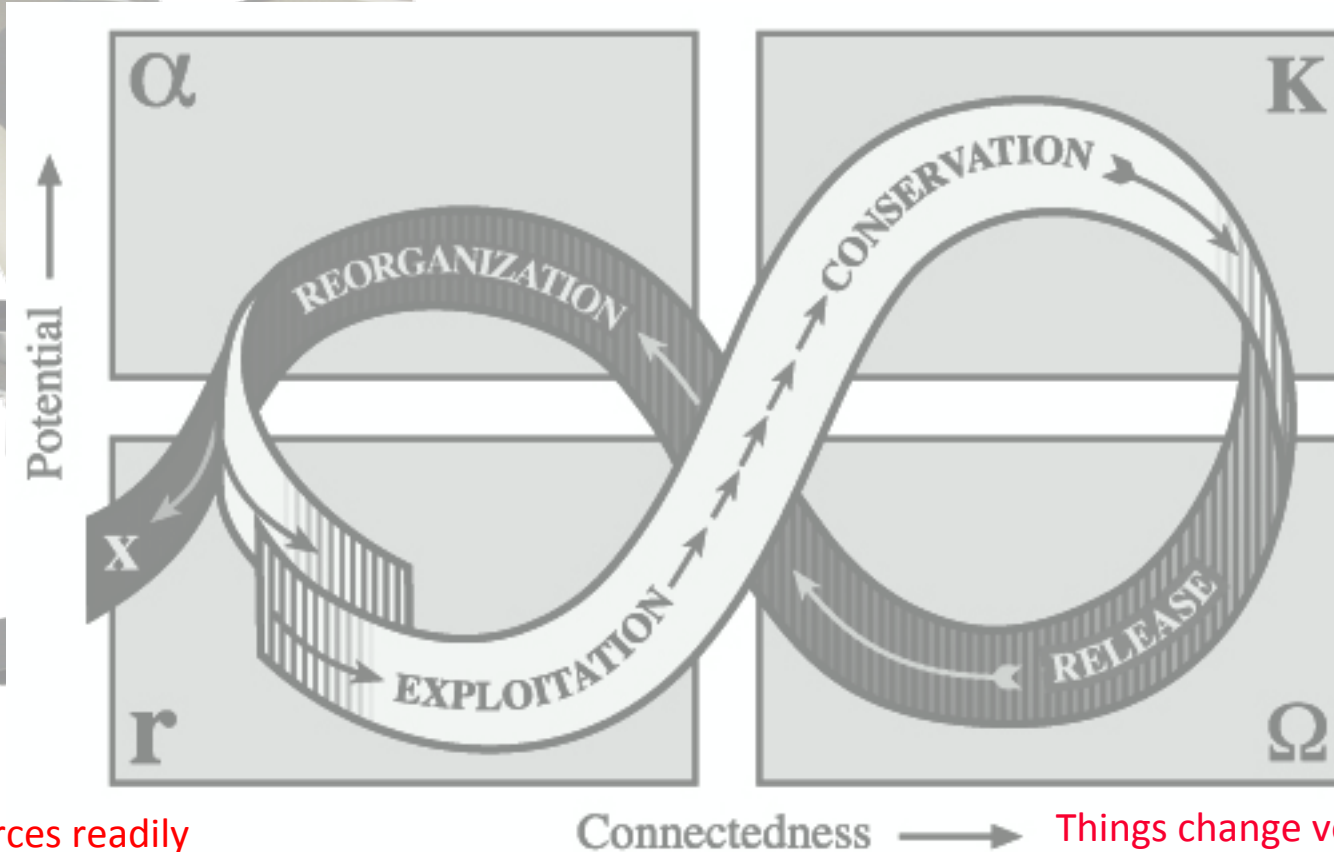
Resources readily available - *"Individualist"* perspective in a stable world, with ample resources.

Things change very rapidly; 'locked up' resources suddenly released-*"Fatalist"* perspective: the world is out of control, and life is a game of chance.

The role of hope and fear

- Near Sellafield, fear discredits science
  - Nuclear science only promotes fear
- In health issues, fear reinforces science
  - Health sciences give hope
- In the environmental debate, science has promoted fear, and discredited itself. Why?
  - Within the scientific world, fear raises money
  - In the public domain, hope raises money
  - Soften: scientists acting like politicians in using the environment, brought it in the political domain, could not extricate

What could we do about this?

Change science?

- If we don't want to be part of the problem, we have to become part of the solution, and identify our problem

- Science has helped create the current situation by being perceived as:
  - *Arrogant*: thinking the scientific world view is 'better' than others
  - *Insular*: operating in a closed system, talking mostly to ourselves
  - *Deaf:* preferring talking and preaching over listening

Institutional context

- Institutions of all kinds have adopted a rationalist perspective and identity
  - This gave rise to backlash – alienation and extra-institutional forms of politics ('Tea Party')
  - 'Crisis of Late Modernity'

- Science assumed (wrongly?) to be the epitome of the skeptical modern institution
  - Scientific institutions should take the lead in changing this perspective

The institutional structure counts

- In judging science, the public very often refers to an analysis of its institutional structure
  - Often more transparent than the science itself
  - People have experience with institutions' ways of working and defending their interests:
    - Accountability, pluralism or hegemony, patyronage, ownership and control

- Scientists would profit from taking this into account

Opening the kitchens of science

- Reflexive recognition of science's conditionality is essential
  - Critically examining the basic pre-analytic assumptions that frame knowledge commitments (paradigms)
  - Integrating the community dynamic in the evaluation of scientific constructs
- Institutional reform of its organization, control and social relations
  - Extended peer-groups to offer criticism from beyond the immediate community, including epistemology
  - Renegotiate boundaries of the scientific and the social to remove inappropriate power structures
- Resistance to this serves to maintain closure around socially achieved forms of interpretation

The social setting counts

- Reasoning and understanding are contextual and uncontrolled in science as elsewhere
  - Problem definitions and solutions are negotiated simultaneously
    - The linear model of science is unrealistic in both public and scientific contexts
  - Reasoning improves with positive stimulus, degrades with alienation and disempowerment
    - Social role of ignorance – to avoid direct threat to existing social arrangements
  - This is affected by the many networks individuals are part of
    - The network dynamics themselves create a very unstable situation with complex fields of tension
    - The role of power further complicates this
  - Science's often 'monovalent' approach does not work well in this context