Crises: the long term view

Colloque 'Changer Pour Durer'

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"It's the best possible time to be alive, when almost everything you thought you knew is wrong"

Tom Stoppard
Arcadia

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The importance of the long term

- Including the long-term dynamics
  - Tectonics over 10^5 years
  - Cultures over 10^3 years
- Observing complete cycles
  - Not only the last 100 or so years
  - Observing wider range of behaviors
  - Correcting for bias
- Observing the change of change
  - Risk shift towards unknown long-term risks (time bombs)
  - From long-term investment to short-term 'dealing'

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The role of archaeology

- Need to complement polar climate data
  - Evolution of terrestrial environment (soils, rivers, flora, fauna)
  - Evolution of human behavior
  - Downscaling from global to regional
    - Mitigation to adaptation
- Archaeological record the only one at the timescales involved
  - Omnipresent, integrates all sources
    - Modern archaeology is in part an environmental science
  - Sometimes difficult to interpret
  - Slow process, long correction cycle

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The main difficulty is in the timescales

- Socio-natural phenomena are multi-temporal
  - Natural and social dynamics operate at an infinite number of scales, from the millennium to the minute
  - Any conjunction can trigger changes … how do we find out what 'did it', and what the role of the social or the natural is ?
  - Climate studies must downscale from the global, archaeological studies must upscale from the local
  - Different disciplines, different ways to deal with time
  - Different degrees of precision
- Contingency is not always causality
  - Much archaeology operates on internal consistency, rather than external proof

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Multi-temporal oscillations

- Glaciation cycles of 100-, 43-, 24-, 19,000 years
  - Milankovitch (excentricity, inclination of earth's axis, precession) change distance of surface to sun …
- Cycles in N American Icebergs c. 7,000 years
  - Heinrich events, not yet adequately explained, cool N Atlantic climate for decades (-4^0)
- Cycles in ice cores ($\Delta_{18}O$) of c. 2,500 years
  - Dansgaard - Oeschger cycle 10^0 in n.10^3 years
  - Also found in $\Delta_{14}C$, Scandinavian glaciers, etc.
- Cycles in foraminifera $\Delta_{18}O$ of c. 1,400 years
  - Bond events: slower thermohaline circulation, colder climate (-10^0).
- Last major event c. 8,200 BP:
  - Emptying of Canadian lakes (100,000 km^2 of cold water) in N. Atlantic

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Society

- Humans are biological beings - they need to process energy, and in that sense they are like all the other organisms
- They are social beings - they structure themselves in societies, and that takes information processing
- Societies are energy and information flow structures

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The human adventure

- How did the species survive for 10^6 years?
- Why did it take so long to 'invent' and accelerate innovation?
- Why did it go so fast, once we reached that point?
- What are the lessons for the future?

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Survival

- Throughout human history, survival depended on the adequacy of the group's subsistence, survival and social techniques
- Robustness, resilience, vulnerability …
- Efficiency of adaptation …
- Innovation enabled society to harness sufficient energy surplus to expand group size and interaction

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The long term evolution of artifact production

- Humans and many primates can invert observed causal sequences.
  - A causes B, therefore if I want B to happen, I have to do A.
- They were therefore biologically able to manipulate (aspects of) the material world
- But they had to learn how to put that capacity to use

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Acquiring conceptual toolkits

- Separating the material from the ideational realms took most of the time
  - Example: cognition of 3 dimensions
- It enabled the domestication of matter and (much later) energy
- That enabled group growth
- Which in turn reduced loss of information

What ensured survival in the Pleistocene?

- Throughout the Pleistocene, humans survived through the (Ice) ages, by
  - Harvesting the environment's offerings
  - A multi-resource strategy
  - Adapting to change by moving
  - Staying below the environment's carrying capacity
    - Australian famines only in river valleys
- No fundamental change in behavior:
  - People lacked the know-how to inter-act with their environment: natural dynamics were independent
  - Change and risk were the order of the day
  - Yet people minimized change
    - Epirus caves inhabited where tectonics keep change limited

Sedentary societies and climate change

- Holocene is a period of Earth System stability
- Beginnings of the Neolithic contribute to climate change?
  - Both climate and man can change vegetation cover locally (deforestation, cultivation)
  - C. 8000 BP CO_2 peak – first relatively large increase in population and forest destruction
  - c. 5000 BP CH_4 peak – first rice fields in SE Asia
- Very small populations, very local changes
  - Resolution insufficient to determine causality, but relationship presumably inverted!

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Three major 'revolutions' in 10,000 years

- 'Neolithic' revolution: the first villages, the first agriculture, the first domesticated animal herding (10,000-8,000 BP)
- 'Urban' revolution: the first cities (6,000-5,000 BP
- 'Imperial' revolution: the first multi-community, large, political entities (3,000 BP)

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What happened in the Neolithic?

- A fundamentally different way of life…
  - Change in subsistence base: cultivation, herding
  - New technologies: ceramics, basketry, huts
  - Different mode of life: villages
  - Different social life: larger groups
  - Different perception of space & time
- From harvesting the environment to investing in it. Why?
  - Mobility no longer the way to meet challenges
  - Old system was adapted, could have continued
  - Change in conceptual toolkit evolved during Pleistocene

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Changed relation to environment

- Domestication of food chain (cereals, animals)
  - Storage - change in risk spectrum
  - Occasional energy surplus
- Cognizing motion and energy
  - People move less, matter more
  - Animals both mobile stored food and beasts of burden
  - Energy surplus enables village life
- Cognizing time-space
  - Settlements are fixed points in time-space
  - The creation of mental maps and routes

How did that change the dynamics?

- Reciprocal relationship to environment and climate
  - Climate can change society and vice versa!
- Growing interventionism in nature
  - 'Milieu' and 'environnement': two perceptions of the same relationship which mutually reinforce interventionism and perception of control
- Survival depends on the adequacy of subsistence and survival techniques
- Sedentary societies try to control environmental risk:
  - Simplify the environment
  - Optimize and narrow the range of natural dependencies
  - Spatial and technical diversification

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New relationship with environment

- Problem-solving essential to survival
  - The bigger the challenge, the more important the solution
- Positive feedback between solutions, problems and numbers of people
  - Diversification and specialization
  - Ever larger interactive groups
- Information-processing the dominant driver, energy supply and conflict the main constraints
  - Very energy-intensive (100 watts --> 10,000 watts)
- The cost is growing social complexity
  - Increasing investment in maintaining society
  - As groups grow, cohesion becomes a problem

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Sociality becomes the key to survival

- How to combine differentiation and group cohesion?
- Reduction of communication effort leads to sedentism
  - Villages expression of new way of subsistence
  - Towns can not be explained by energy dynamics
- More and more potential for misunderstanding, conflict
  - Need to make communication ever more precise
- Keeping people out as important as keeping them in
  - Language differentiation; identity issues
  - Administration, writing prepare way for state formation
  - Towns and long-distance trade

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Investment narrows range of survival strategies

- As the system integrates, it is more vulnerable to external and internal disturbances
- The risk spectrum shifts to unexpected 'time bombs'
  - Many of these are social or socio-environmental
- The only way out of 'crises' is through innovation
- Urbanization facilitates innovation
  - Invention is a local phenomenon, in few cognitive dimensions
  - Innovation requires many cognitive dimensions, thrives in towns, comes to drive urbanization

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From cities to states and empires

- Towns emerge as clusters of independent entities (Greece, Etruria, Near East, Maya …)
- As towns grow, energy/matter networks exceed information networks
  - Long distance trade
  - Cities federate
  - Control over the countryside
- Ultimately, this creates 'Empires', i.e. administrative entities incorporating many nations, cultures …

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Role of cities

- Cities are the backbone of the system, the nodes in the system where most information-processing occurs
- They are networked, and each has properties that depend on their position on the information-processing gradient and in the communications and exchange networks.
- The structure of the urban system is stable; the place of individual cities changes.

Why are cities so essential?

- They bring information from different sources together
- They stimulate transformation of inventions (individual ideas) into innovations (socially accepted ideas) by placing inventions in much larger possibility space, with higher number of dimensions
- That enables innovation cascades, and maintaining the information gradient
- They are ultimately responsible for the exponential increase in innovation we see

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Emergence of towns

- With time, many social (information processing) networks emerge, with different functionalities
- Towns are nodes that link different networks
- They cannot be explained by economies of energy
- People move together to solve more complex problems
- This requires advanced social organization
- When energy becomes external, it is no longer the limit to the size of the network

The expansion of Rome

- Here used as example for urban societies in general
- Expansion by conquest of societies that had accumulated surplus during prior acculturation around the Mediterranean:
  - Invention of cities, money, markets, roads, aqueducts, administrative institutions and wealth
- Romans further organized them to facilitate uninterrupted inward flow of matter (raw materials, food) and energy (slaves)
- Result is a 4-mode 'world system' with hunter-gatherers in outermost sphere

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Exchanging organization for wealth

- Density and diversity of people enables innovation
- Ensures control over the flows of people and goods
- Enables long-term maintenance of information-processing gradient with hinterland
- Positive feedback between incoming information, innovation, and export of structure enables definition/ creation of value
- Exchange of information-processing superiority against resource access (wealth)

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The limits of organization

- When armies reach limits of pre-organized sphere, expansion is replaced by investment in conquered territories, to harness more resources
- Cost of maintaining energy/matter flows into core of the Empire grows
- Export of innovations reduces dependency of territories on Rome: information gradient levels out.
- People focus on own regional interests, empire decays. New structures at edges create their own cores
- Alignment of the system breaks down.

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What is an 'environmental crisis'?

- Human survival depends on people finding solutions to problems
  - All solutions involving the environment ultimately degrade it
    - Humans are not the only species who degrade their environment (e.g. fir trees)
    - There is no sedentary human occupation without environmental degradation
- Environmental crises are crises in the relationship between society and environment
  - Periods in which a society can no longer deal effectively with its environment
  - The society has invested so much that it cannot innovate itself out of difficulty before time runs out
  - Information processing is the crux

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How does a crisis come about?

- System pushes itself into a trap
- Short-term solutions create long-term problems
- Reduction of flexibility
- Increasing overheads
- Risks and ‘time-bombs ’
- Initial structuring also structures the form of the demise?

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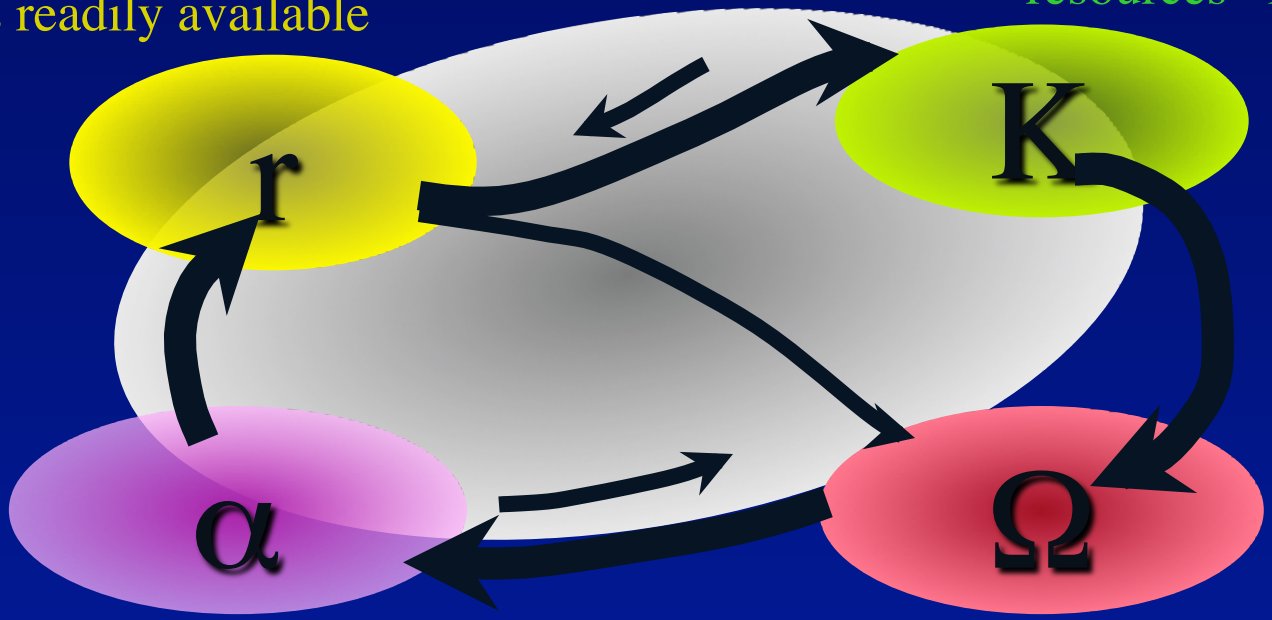
Resilience varies with the state of a system...

r: growth / exploitation
resources readily available

K: conservation
things change slowly; resources 'locked up'



α: re-organization/renewal
system boundaries tenuous; innovations are possible

Ω: release
things change very rapidly; 'locked up' resources suddenly released

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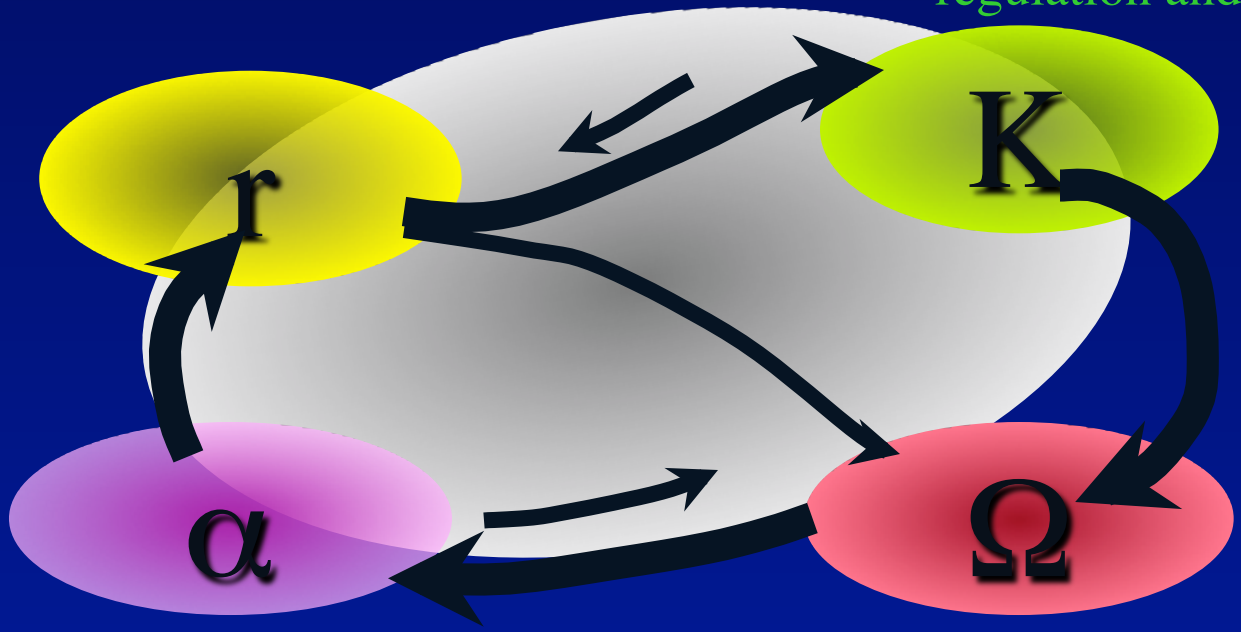
but people's attitudes are key!

"Individualist" perspective in a stable world, with ample resources.

"Hierarchist" **perspective:** Limited resources, impose regulation and control



"Egalitarian" perspective in unstable, precarious circumstances of reorganization,

"Fatalist" perspective: The world is out of control, and life as a game of chance.

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Can a crisis be avoided?

- There always comes a point where a system goes "nuts", because the dynamics are irreversible
  - The appropriation of nature point in this direction
  - So does the human perception of the relationship between people and their environment
  - So does human risk perception
  - And so does the relation between cognition and action

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The appropriation of Nature

- Over the long term, the landscape becomes disturbance-dependent
  - In the early Holocene, crises occur only when climate and human occupation weigh in together
  - If they are out of phase, delays build up
  - At the end of the period, the slightest oscillation in either climate or anthropogenic pressure creates an immediate crisis
- The system has become hyper-coherent (an accident waiting to happen)
- Society is what keeps it stable
- *This seems an irreversible process!*

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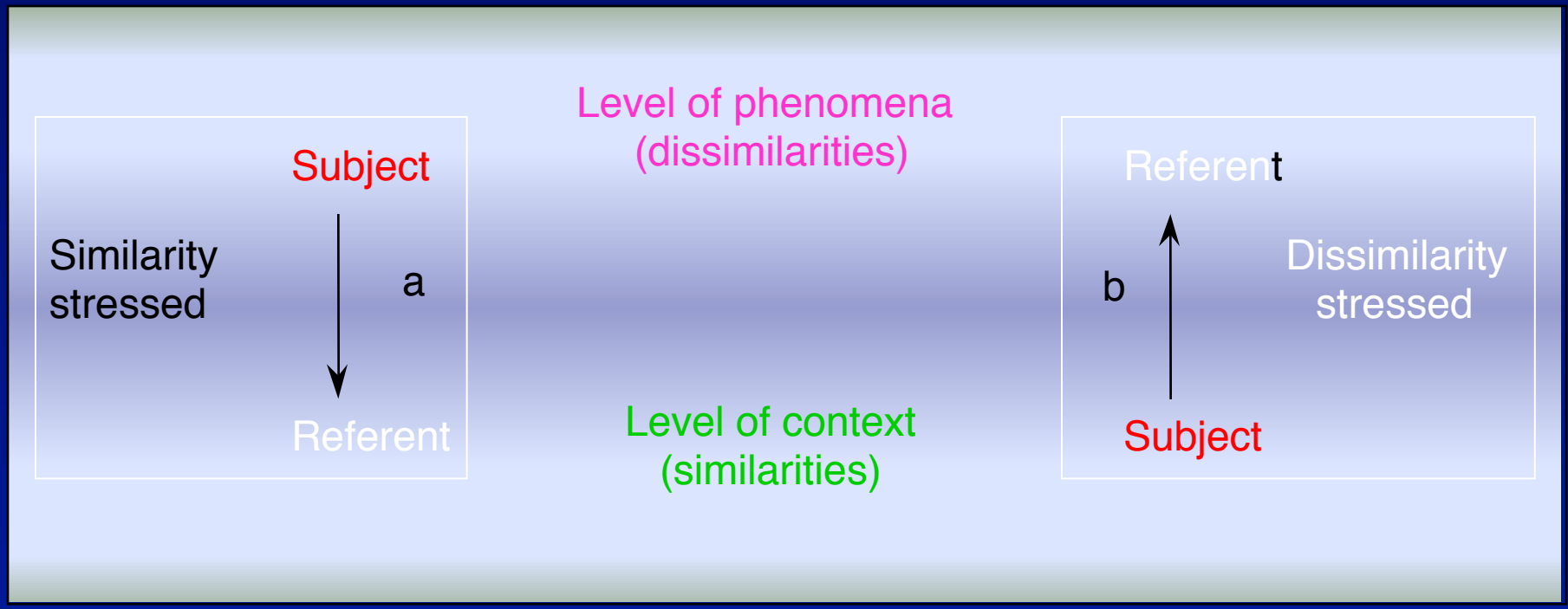
The perception cycle



Opening a category ...

... and closing it

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Two ways to perceive a relationship…

Milieu …

- Humanity is compared to nature
- The cohesion of nature, its unknown aspects, its strangeness and force are amplified,
- The confusion and the handicaps of humanity are accentuated;
- Humanity is *passive* in a natural environment which is *active* and agressive
- Change is attributed to nature, and people have no other choice but to adapt to nature;
- Natural changes tend to be viewed as dangerous, because they are beyond the control of humanity.

Environnement…

- Nature is compared to humanity
- The cohesion and strength of nature is diminished
- The same properties are accentuated in humanity
- The known aspects of nature seem to be more important
- Nature seems more controllable and loses its dangerous appearance
- Humanity tends to be viewed as the source of all change, people as creating their environment

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… and their interaction

- The "*milieu*" and "*environnement*" perspectives are complementary
- By their interaction, the natural dangers are exaggerated and those of human intervention systematically undervalued.
  - This encourages society to increasingly intervene in its natural environment
  - It gives the impression that society's actions reduce the risks it runs
  - In reality, society reduces by its actions the predictability of natural phenomena.
  - Society loses control: the more it transforms its surroundings, the less it understands them.
- *This seems to be another irreversible tendency!*

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Disturbance-dependency

- Complex ecological systems consist of hierarchies of dynamics on multiple spatio-temporal scales
- Faster dynamics easily take control of slower dynamics, *but not vice-versa*
- In the long term, "human" dynamics (rapid, but initially without much impact) take the upper hand, controlling the (slower) "natural" dynamics, that are more encompassing
- Landscapes become dependent on human activity to continue as they are ("*disturbance-dependent* ").
- *This seems to be a third irreversible tendency!*

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Risk spectrum shifts

- Any society's risk spectrum shifts over time with respect to its environment.
  - The perception of risk over-emphasizes frequent risks, and societies tend to do something about these
  - Human action involved introduces new risks, which include both short and long-term frequencies.
  - Long-term socio-environmental interaction tends to shift the risk spectrum towards the long-term.
  - Eventually, the society will meet what one could call a "risk barrier" by analogy to a "sound-barrier". That may just be a bit too much …
- *Another irreversibility!*

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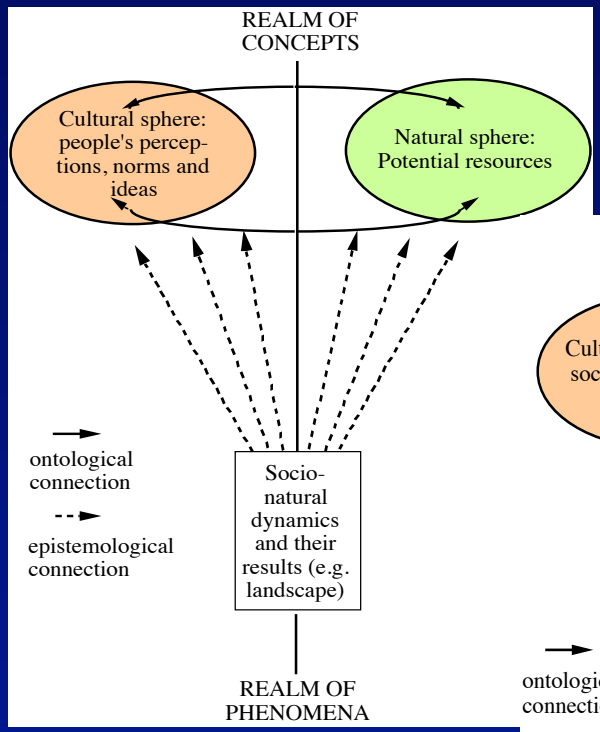
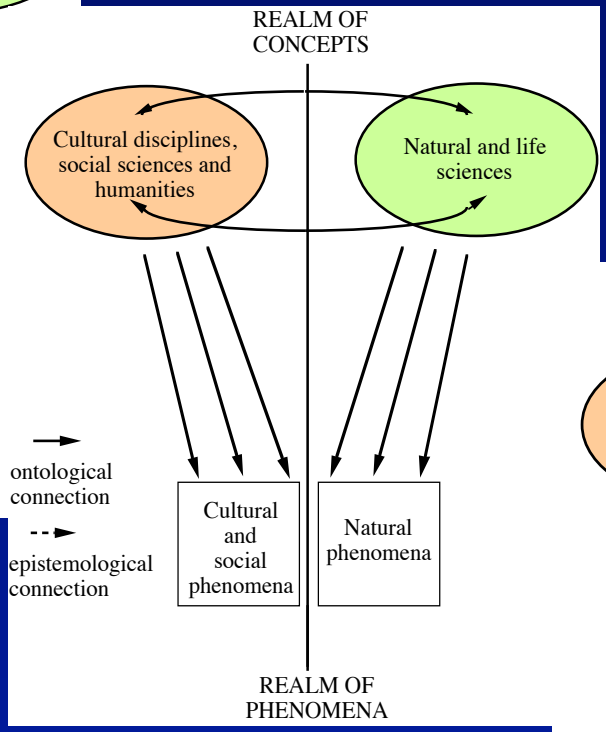
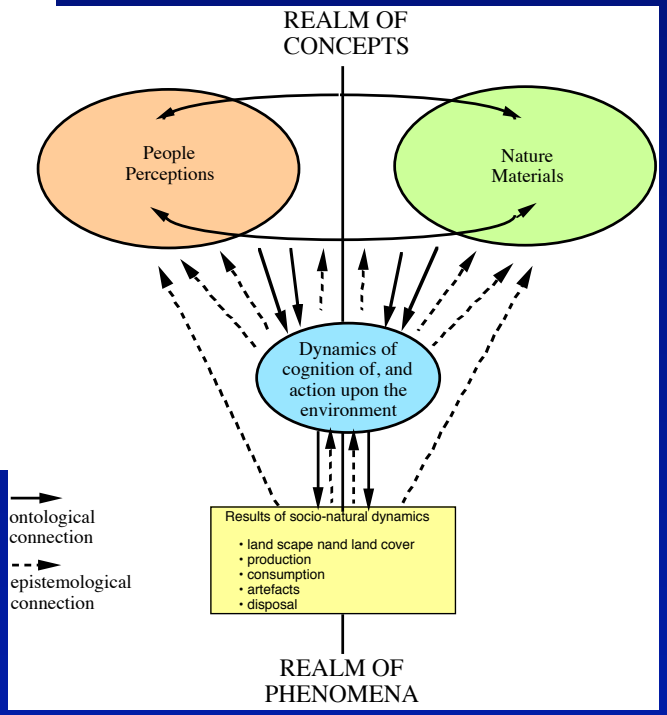
The epistemological shift







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Innovation and resources

- System growth required appropriation of more and more resources
- Remember: known problems beget solutions beget unknown problems
- As possibility space expands, problem space expands faster
  - Shift in risk spectrum, from short to longer
- That pushes towards ever more innovation, but also causes resource crises, and re-structurations
- Resources always limited the rate of innovation and system expansion.

The innovation acceleration

- Since 1800, we are in an exponential acceleration of innovation, urbanization and globalization
- For the first time we are capable of reflexive intervention in our own systems
- Our cognitive apparatus no longer has intuitive feel for the innovations concerned (NBIC)
- Our society is more and more dependent on innovation - we have aligned most of our economies on it; it has become internalized.
- It is the cause of the sustainability crisis, and some think it can be the way out

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We need control over innovation

- Innovation is feeding on innovation without any restraint, driving our system to collapse
  - Extreme concentration of information (power)
- Until now, this threat was always avoided by resource exhaustion or environmental degradation.
- Possibly, that is no longer true
- We should not allow innovation to overtake us
- How can we avoid it?

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How do we innovate?

- We don't know!
  - In reductionist science, it is a non-scientific topic
  - We have only used a posteriori indicators
  - We have looked for the key under the streetlamp
- Develop a generative ('a-priori') perspective
  - How does innovation happen?
  - How does one become innovative?
  - How does one create a culture of innovation?
- Evaluate role and consequences for innovation and sustainability of choices made against those not made
  - Simulation, fore- and back-casting as continuous process
  - High dimensionality of the system - to understand it we need to mobilize developing computational capability

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How does innovation affect society?

- Technological innovation requires social reorganization
  - Societal change is a slow, complex, process
  - General population lost touch with advanced technology: invisible; no intuitive grasp
  - Growing power disconnect between technocracy and society
- Awareness and research on this problem for NBIC
- What about the sustainability revolution?
  - It has to go fast, it has to be acceptable
  - It has to involve the community from the outset
- We must include both the societal and the environmental dynamics in our models of the future!
- We must educate scientists about society, society about science!

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Conclusions

- The long term is important, archaeology can help
- A multi-scalar approach is essential
- Crises are societal rather than environmental
- Striving for sustainability externalizes change, and enhances vulnerability
- Society's impact is strongest in domains where it is most dependent on environment
- *We need to get innovation under control!*

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