18th ICC
JULY 14 - 19, 2024
International Congress on Catalysis
LYON • FRANCE

Ethics committee "TENDING TO OUR ROOTS"
Professional development event

Lyon (France) - July 16th and July 18th, 2024.

An interdisciplinary dialogue for continuous grounding of our research

**How can we uncouple the development of catalysis,
the science of the acceleration of the transformation of matter, from the
worrisome aspects of the ecological and socio-environmental accelerating changes?**

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①– INTRO

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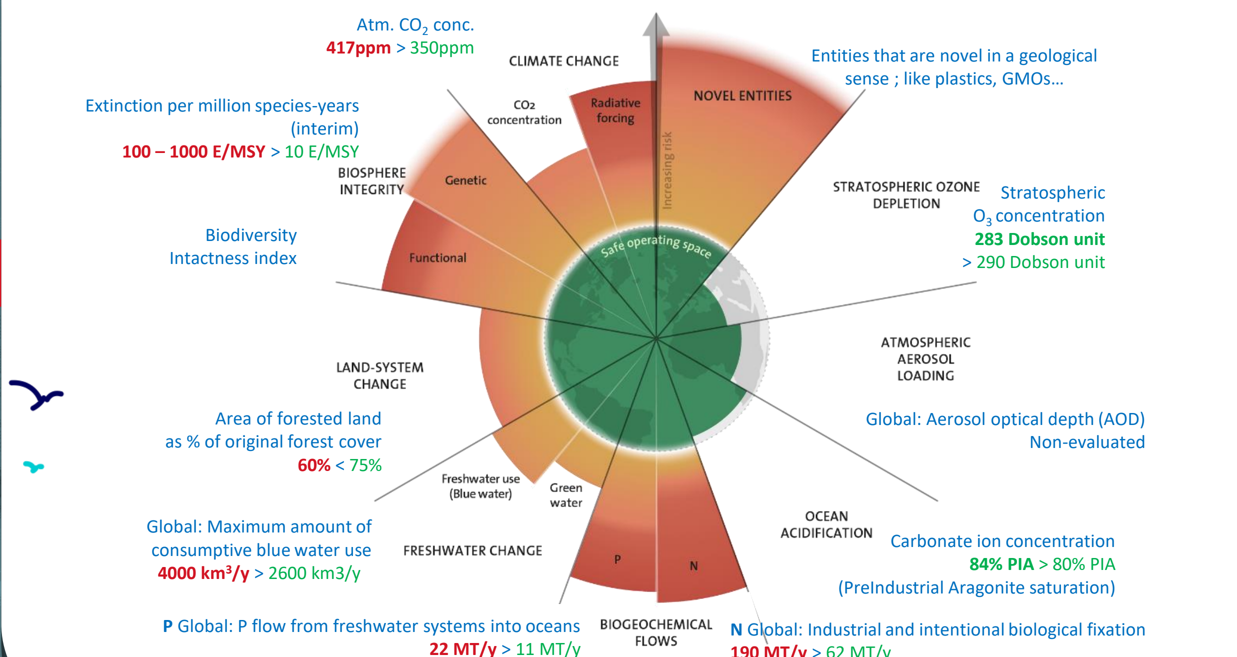
The planetary boundaries framework

The planetary boundaries concept proposes a set of nine planetary boundaries within which humanity can be expected to continue to develop and thrive for generations to come, the so-called "Safe operating space" in green in the picture below. Beyond these thresholds, the environment may not be able to self-regulate anymore.

J. Rockström, W. Steffen, K. Noone et al., **Nature**, 2009, *461*, 472–475



NAME OF THE PLANETARY BOUNDARY • Indicator used • Limit value for safe operating space • **2023 actual value** **In bold red if above safe limit** **In bold green if within safe limit**

More on https://www.stockholmresilience.org/research/planetary-boundaries.html

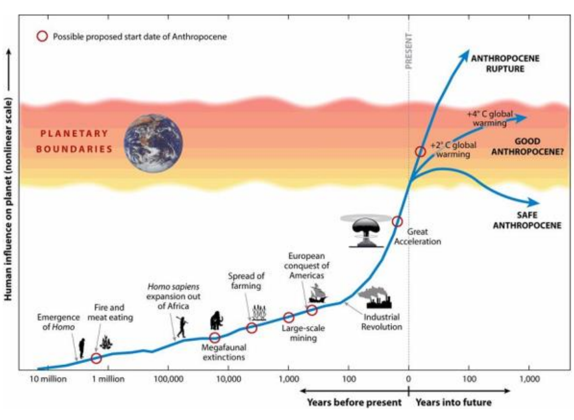
What is the Anthropocene?

A word designing the epoch during which the influence of human activities on the Earth system has become so large it has risen to a force of geological proportion.

P. Crutzen, "*Geology of mankind*" **Nature** *415*, 23 (2002).

In the Figure, several dates are proposed [1] for the process leading to the Anthropocene, the recent Great Acceleration [2], and the transgressing of planetary boundaries [3]. Researchers identify long-term causes and short-term causes of the overcoming of the planetary boundaries (see in red on figure), i.e., contributing to the cumulative advancements in technology [4].

- **Fire and meat eating**: certain scientists argue that the Anthropocene began as early as **the domestication of fire by Homo erectus**, enabling a meat-based diet of cooked food and the **modification of local ecosystems**.
- **Megafaunal extinctions**: The **expansion of Homo sapiens** out of Africa coincides with the **mass extinction of megafauna**.
- **Spread of farming**: The spread of farming, at the origin of urban civilizations, led to **deforestation** and modification of ecosystems, notably because of wet rice farming and the resulting **greenhouse gas emission**.
- **Large-scale mining**: Large well-organized societies cleared and **altered soils**, mining for heavy metals.



- **European conquest of Americas**: A symbol of the subsequent **European colonization of the world**, the spread of plantations and the Atlantic slave trade. These processes mark the beginning of a new form of **cultural and economic globalization**. World capitalism was fostered by the discovery of Americas and the transfer from resources to Europe, which facilitated the dominance of Europe and the **Industrial Revolution**.
- **Great Acceleration**: The Great Acceleration starting since the end of World War 2 is probably the **most dramatic break in human-Earth system history** on a world scale. It is the more consensual and precise date for the beginning of the Anthropocene.
- **In the Future**: Some scientist consider it will start **when the Earth system passes a critical transition** such as the climate system entering an alternative state.

[1] Y. Malhi. Annual Review of Environment and Resources. 2017, 42, 77-104. [2] K. Richardson et al. Science advances. 2023, 9.37.
[3] MJ. Head et al. Episodes Journal of International Geoscience. 2022, 45.4, 359-376. [4] B. Lahire. La Découverte. 2023.

This poster was made by: C. Collomb, A. Rigal, E. A. Quadrelli, V. L'Hospital, C. Grimaud, M. Perbet, Institut de Recherche sur la Catalyse et L'Environnement de Lyon IRCELYON – CNRS Université de Lyon1

②– INTRO

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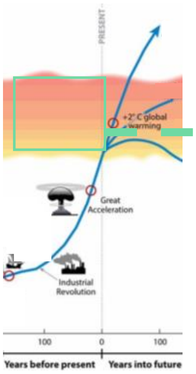
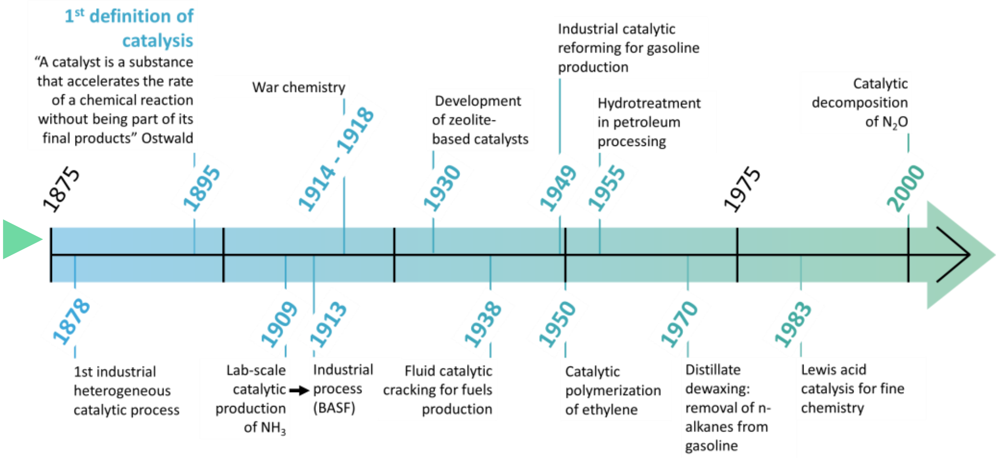
How does catalysis fit in the dynamics of anthropocene?

The extent of man-made changes becomes more evident since the industrial revolution and leaves the "safe operating space" at the Planet level



See poster INTRO #1

The timeframe of the industrial revolution overlaps with that of man-made catalysis: The history of catalysis starts within a period where human influence on the planet shows a great acceleration.



On history of modern catalysis see : Zecchina & Califano « The Development of catalysis » Wiley (2017)

Catalysis and planetary boundaries

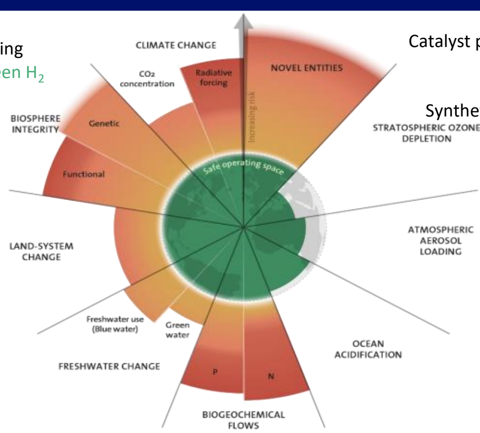
Catalysis is linked to key technological innovations that have affected both positively and negatively the current Earth system position at the 9 planetary boundaries.

Catalytic cracking in petroleum refining
Conversion technologies (fuel cells, green H_2 production)

Advanced oxidation processes (to degrade organic pollutants in wastewater)
Widespread use of synthetic fertilizers (biodiversity loss)

Biofuel production through catalytic processes
Catalytic soil remediation

Catalytic ozonation
Photocatalysis
Catalytic membranes
Electrocatalytic desalination



Haber-Bosch process (reactive N in fertilizers)

Catalyst production and use (e.g. containing rare or toxic metals)
Development of green catalysts
Synthetic polymers (e.g. plastics, microplastics)

Catalytic production of chlorofluorocarbons (CFCs)
Regulation and replacement of CFCs

Catalytic cracking in petrochemical industry
Emission control technologies (e.g. selective catalytic reduction for NO_x reduction)

Catalytic processes in fossil energy production (CO_2 emissions from fossil fuels combustion)
Carbon capture and utilization (capture and conversion of CO_2 into useful products)

Example of catalysis embedded in a humanity & Earth altering process:

The Green Revolution

the 20th century radical transformation of world agriculture from traditional to modern.

Modern agriculture includes the use of synthetic fertilizers, pesticides, mechanization of peasant work, and creation of new types of crops (wheat, rice, corn). This transformation of agriculture was led by technical inventions and a strong support of the USA and International Organizations. The increase of synthetic fertilizers (Haber-Bosch process) was embedded in a general transformation of the agricultural production leading to the strong increase of crop productivity: it tripled from the 1960s to the 2010s, even if the cultivated land area followed only a 30 % increase.

Yet, the Green Revolution had unintended negative effects: increase of energy use, excessive water use, soil degradation, impacts of chemical runoff and biodiversity loss, and finally the slowdown of crop productivity since mid-1980s based on the degradation caused by the above-mentioned factors. Moreover, the increase of crop productivity is higher in developed and emerging economies, than in poorer countries.

The Nitrogen Element – Sustainable food production?

Policy Workshop organized by the EuChems
https://www.euchems.eu/nitrogen-workshop/

PL. Pingali. *Proceedings of the national academy of sciences*. **2012**, 109, 31, 12302-12308.

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"An interdisciplinary dialogue for continuous grounding of our research"

We, the promoters of this exhibit, believe that

- given the state of the Earth system within the planetary boundaries framework (see poster intro #1)
- given the interdependencies between catalysis development and the ongoing Great Acceleration (see poster intro #2)

our collective and individual ethics responsibility of researchers in catalysis are engaged to question this link.

A possible question ensues:

How can we uncouple the development of catalysis, i.e. the science accelerating matter transformation, from the worrisome aspects of the ecological and socio-environmental accelerating changes?

How is this poster-session built?

We believe that the interdependencies between the future of catalysis and the overarching socio-environmental accelerating changes are so complex that **interdisciplinary conversations are necessary.**
We have thus invited scientists and scholars from other disciplines, and firstly those whose objects of study are society-based (ex. sociologist, historian) as well as philosophers into this conversation. This is our invitation statement to the discussion :

"Many ways to sustainability through catalysis have already been developed or are currently being investigated. Yet, there are still reasons to push harder (see acceleration of worrisome socio- environmental aspects; catalysis has a role in some of them). Questioning our roots is possibly a further way to look for new spaces of development for catalysis.

Within our roots, we have identified some **recurring aspects of our craft that echo aspects of accelerations or limitlessness** which we would like to explore with you:

- Recurrent Invitation to **Scale-up**
- Equating **optimization** with **efficiency maximization**
- Translating urgency for solutions into call for **fast-science**
- Growing demand for **resources**
- Reducing **systemic problems to disciplinary-based formulation** to enable finding solution within our chords."

After exemplifying some manifestations of these aspects in our field (see below), we have asked our guests to provide a disciplinary insight in the subjects proposed and engage in conversation with participant in a dedicated area of this poster-session

Data

Catalysis is accelerating its knowledge also through machine learning....

T. Mou *et al.* "… heterogeneous catalysis with machine learning." **Nat Catal** 6, 122–136 (2023)

Can we anticipate needs for *Fair Machine Learning*?

The Machine learning developers community provides examples

Machine Learning

Scale-Up

The scale-up that catalysis facilitates can become worrisome….

R. Milo et al. **Nature** 588, 442 (2020)

Can we afford to not demand scalability?

Economy provides examples where economy of scale is not the only golden rule. Relevant?

Economy

Efficiency

Since we rely also on efficiency maximization to guide optimization…

equation

$$\text{efficiency}\ (\%) = \frac{\text{energy output}}{\text{energy input}} \times 100$$

M. Qureshi & K. Takanabe* ***Chem. Mater.*** 2017, 29, 1, 158–167

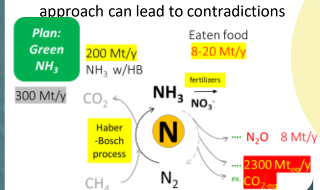
Can we afford to reduce efficiency?

Biology provides examples where sub-maximum efficiency is the optimum state. Relevant?

Biology

Disciplinary Approach

Since we can use discipline- framed considerations to address systemic issues and this discipline –framed approach can lead to contradictions



M. Prévot et al. **Chem. Sci.** (2024), 15, 9054.

Can we surpass disciplinary specialization?

Lets' see how philosophy conceptually frames the presence of disciplines and the approaches to overpass them

Philosophy

See **Case Studies** section

see **Philosophy** section

Example of Some current attemps to in(ter)disciplinary projects linked to catalysis research

"Post Fossil Societies" : a "sociology & engineering" proposal

Situated Green Chemistries : a "chemistry & social sciences" proposal

see **Projects** section

poster was made by: A. Rigal, E. A. Quadrelli, C. Grimaud, M. Perbet, Institut de Recherche sur la Ca… Université de Lyon1

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Philosophy

"on the disciplinary organization of Sciences and effects on research"

How can we uncouple the development of catalysis, the science of the acceleration of the transformation of matter, from the worrisome aspects of the ecological and socio-environmental accelerating changes?

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④ – PHILOSOPHY

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"An interdisciplinary dialogue for continuous grounding of our research"

What are scientific disciplines ?

Scientific disciplines are social institutions

Scientific disciplines are the product of a community of inquirers who are situated within particular social and cultural contexts.

Scientific disciplines are organized around paradigms that define the methods, standards, and goals of a scientific community. This organization influences how scientists communicate, collaborate, and train new members of their discipline.

Disciplines are embedded in and influenced by broader social, political, and cultural contexts. Scientific practices are entangled with values and responsibilities.


The Anatomy Lesson of Dr. Nicolaes Tulp by Rembrandt (1632)

"The subdivision of the sciences... occurs, not because of the subject matter, but because of the adherence to different paradigms, which define the scientific communities and their boundaries."

Thomas Kuhn *The structure of Scientific Revolutions* (1962)

"Scientific objectivity (…) cannot be complete without including the perspectives of those historically excluded from the scientific enterprise. (…) The knower's position within a particular social and historical context shapes the production and interpretation of knowledge."

Sandra Harding, *Reflections on Gender and Science* (1985)

"The values, interests, and power structures of society play a crucial role in shaping scientific research and its outcomes.."

Isabelle Stengers, *Power and Invention: Situating Science* (1997)

" Each society has its regime of truth, its 'general politics' of truth: that is, the types of discourse which it accepts and makes function as true; the mechanisms and instances which enable one to distinguish true and false statements, the means by which each is sanctioned; the techniques and procedures accorded value in the acquisition of truth; the status of those who are charged with saying what counts as true".

Michel Foucault, *Power/Knowledge: Selected Interviews and Other Writings, 1972-1977* (1980).

"A discipline is an organisational category within scientific knowledge; it institutes the division and specialisation of work and responds to the diversity of fields covered by the sciences.

Although it is part of a larger scientific whole, a discipline naturally tends towards autonomy, through the delimitation of its boundaries, the language it constitutes, the techniques it develops or uses, and possibly through its own theories.

Disciplinary organisation was established in the 19th century, in particular with the creation of modern Universities, and then developed in the 20th century with the growth of scientific research. In other words, the disciplines have a history: birth, institutionalisation, evolution, decline, etc.; this history is part of the history of the Academia, which is itself part of the history of society; as a result, the disciplines are part of the sociology of science and the sociology of knowledge (..).

So it is not enough to be inside a discipline to know all the problems associated with it."

Edgar Morin, *Sur l'interdisciplinarité, Bulletin Interactif du Centre International de Recherches et Études transdisciplinaires* (n° 2, juin 1994).

..and for more on the history of the word "discipline" check the Annex text by **Laurent Loty**, *Studies on Voltaire and the Eighteenth Century, 2005*

The Disciplinary paradox

Scientific specialisation encourages the accumulation of knowledge and the development of expertise but this very process is detrimental to a type of scientific discovery as well as to the capacity of scientists to take responsibility for the social, political or ecological consequences of their research.

- As specialization allows for deeper investigation into specific fields, it simultaneously creates barriers to comprehensive understanding leading to a fragmented and sometimes myopic view of the world.

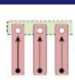
Laurent Loty, *Pour Sérendipité et indisciplinarité*, S Catellin, L Loty - Hermès, la revue, 2013

The integration of diverse perspectives and expertise is essential to address complex scientific questions and to produce robust knowledge.

Disciplinary
- Within one academic discipline
- Disciplinary goal setting
- Development of new disciplinary knowledge

⦿ Stakeholder Participants
● Discipline
○ Goal, Shared Knowledge
Academic Knowledge
Thematic Umbrella
Conventional Knowledge

Here and across Graphical representation of the concepts of disciplinary, multidisciplinary, participatory, interdisciplinary, and transdisciplinary research :



Multidisciplinary
- Multiple disciplines
- Multiple disciplinary goal setting under one thematic umbrella

Multidisciplinarity concerns itself with studying a research topic in not just one discipline only, but in several at the same time, incorporating the perspectives of several disciplines.

Participatory
- Academic and nonacademic participants
- Knowledge exchange without integration

Participatory Science includes diverse non-scientific voices and perspectives in the process of knowledge production. This requires a commitment to public engagement and accountability, recognizing that scientific decisions have far-reaching consequences for society.

Interdisciplinary
- Crosses disciplinary boundaries
- Development of integrated knowledge

Interdisciplinarity concerns the transfer of methods from one discipline to another. interdisciplinarity overflows the disciplines Interdisciplinarity has the capacity of generating new disciplines, like quantum cosmology and chaos theory.

See also Annex

Transdisciplinary
- Crosses disciplinary and sectorial boundaries
- Common goal setting
- Develops integrated knowledge for science and society

Transdisciplinarity concerns that which is at once between the disciplines, across the different disciplines, and beyond all discipline. Its goal is the understanding of the present world, of which one of the imperatives is the unity of knowledge.

L. Morton, S. D Eigenbrode, T. A. Martin *Architectures of adaptive integration in large collaborative projects* **Ecology and Society** 20(4):5, October 2015,

The emergence of new disciplines are part of broader epistemic shifts

According to Kuhn's *"Structure of Scientific Revolutions"*, after a paradigm shift the scientific community adjusts to new fundamentals, redefining research questions and methodologies to align with the new paradigm.

« Normal science, the activity in which most scientists inevitably spend almost all their time, is based on the assumption that the scientific community knows what the world is like. Much of the success of the enterprise derives from the community's willingness to defend that assumption, if necessary at considerable cost. Normal science, for example, often suppresses fundamental novelties because they are necessarily subversive of its basic commitments. (…) When paradigms change, there are usually significant shifts in the criteria determining the legitimacy both of problems and of proposed solutions. (…) The transition from a paradigm in crisis to a new one from which a new tradition of normal science can emerge is far from a cumulative process. It is better described as a reconstruction of the field from new fundamentals, a reconstruction that changes some of the field's most elementary theoretical generalizations as well as many of its paradigm methods and applications. When such a shift occurs, the community embracing the new paradigm is usually a scientific community within which a new, narrower, and more specialized discipline takes root. This new discipline, defined by a novel set of commitments and practices, allows scientists to pursue new avenues of inquiry that were previously invisible or deemed irrelevant."

Thomas Kuhn *The structure of Scientific Revolutions* (1962)

'At different times and in different societies, the forms of knowledge and their relations to one another change. These transformations can be described in terms of shifts in the epistemes that govern knowledge'

***Michel Foucault**, The Order of Things: An Archaeology of the Human Sciences (1966)*

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⑤– PHILOSOPHY

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The imperative to preserve the unity of human knowledge

Husserl : *"Progress came at the cost of [losing] sight of the unity of science [and neglecting] essential questions concerning the meaning and purpose of the whole of human life"* **(1936).**

The late 19th and early 20th centuries were periods of rapid scientific and technological progress. Advances in physics, chemistry, biology, and engineering significantly transformed society. On the eve of the Second World War, Edmund Husserl believed that this progress came at the cost of neglecting broader cultural and philosophical implications as the various scientific disciplines, in their specialization, have lost sight of the unity of science and the essential questions concerning the meaning and purpose of the whole of human life.

« Only through a return to the original sense of science as a unified, philosophical project can we overcome the crisis brought about by excessive specialization. The idea of a universal science, in which all particular sciences find their place and meaning, must be revived. »

Edmund Husserl, *The Crisis of European Sciences and Transcendental Phenomenology* (1936)

… yet the idea that scientific disciplines are interconnected into a coherent framework of knowledge is at the foundation of modern scientific inquiry.

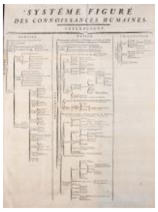
Three examples to show that unity of human knowledge is at the foundation of modern science

Francis Bacon (1561-1626) proposed a comprehensive system for the classification and organization of human knowledge based on the faculties of the human mind (memory, imagination, and reason) to facilitate the discovery and advancement of knowledge across all domains

" The divisions of the sciences are not like different lines that meet in one angle; but rather like branches of a tree that meet in one stem, which hath a dimension and quantity of entireness and continuance, before it break and part itself into arms and boughs."

Bacon, The Advancement of Learning,1605

Denis Diderot (1713-1784) in the "*Preliminary Discourse*," to the Encyclopédie (1751) describes the encyclopedia as bringing together all that is most essential in human knowledge in «*a body, forming a kind of circle, at the center of which lies man, and radiating out in all directions* ».



"The divisions between different kinds of knowledge are not like walls separating distinct territories, but more like roads running in parallel through a vast landscape, all leading to a deeper understanding of the world."

" We must regard all the branches of our knowledge as radiating from a common center and extending towards the periphery. It is this idea of the interconnection and interdependence of all fields of knowledge that distinguishes an encyclopedia from a mere dictionary."

Diderot, Discours préliminaire, Encyclopédie, 1751

Like Bacon or Diderot, **Auguste Comte** (1798-1857) believes in the "indivisible unity" of human knowledge, whose parts are only artificially separated for the convenience of study. The integration of all scientific knowledge into a coherent whole is essential for the advancement of human understanding and the progress of civilization.

..and for more on the unity of human knowledge check in the Annex text "The study of synthetic « generalities » as a remedy to « dispersive specialisation »"

Auguste Comte, *Cours of Positive Philosophy (1830-1842)*

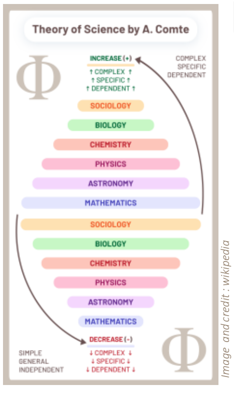
More information on Positivism

Positivism provides a unified epistemology and a common goal for all sciences

The aim of positivism is to bring about a state of society in which all knowledge is organized scientifically, leading to the improvement of the human condition.

Positivism provides a critical framework for examining the assumptions, methods, and implications of different scientific fields. By encouraging metadisciplinary research and education, it counter-balances the effects of "dispersive specialization" on scientific production.

The positivist mind gives up asking questions about the origin and end of the Universe, about the causes of the production of phenomena and about their intimate nature. The positivist no longer seeks to explain phenomena by their causes, but to discover their actual laws, establishing the invariable relationships of succession and similarity on the basis of observed facts. The laws appear as "general facts". Rational foresight is the main characteristic of the positive mind. Science consists above all in seeing in order to foresee, i.e. in "studying what is in order to conclude what will be". It thus provides "the true rational basis for man's action on nature".



"Science, hence foresight; foresight, hence action."

Auguste Comte, *Lessons in Positive Philosophy (1830-1842)*

The 6 fundamental sciences form a dynamic system moving from the simple to the complex, from the general to the particular; this is why mathematics precedes astronomy, physics and chemistry. Although mathematics is indispensable to astronomy, it cannot be used alone to find any laws of the heavens. Similarly, the physical and chemical sciences are necessary for biology, but they have no knowledge of life. ***The dependence of all living things on the inorganic world does not mean that the phenomena of life can in any way be reduced to an inert totality to which they would be homogeneous.*** *On the contrary, the very principles on which the sciences of matter are based (homogeneity, divisibility, intelligibility of the whole on the basis of its composition, exclusion of all spontaneity) become obstacles to the constitution of a science devoted to the living. Comte thinks of the living as a totality that is materially homogeneous to the physical totality but essentially different in its organisation. Similarly, Sociology understood as "the total study of human intelligence", has its laws, such as the law of the three stages.*

"The progress of the human mind is characterized by three distinct stages: the Theological, the Metaphysical, and the Positive. In the theological stage, phenomena are explained by supernatural beings. In the metaphysical stage, abstract forces replace supernatural beings. Finally, in the positive stage, human beings recognize that all phenomena are subject to natural laws discoverable by empirical observation and scientific reasoning."

Auguste Comte, *Lessons in Positive Philosophy (1830-1842)*

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Complex and systemic thinking are antidotes to reductionism

"**Reductionism** is the idea that you can understand something by breaking it into its parts and examining those parts in isolation. (...). **Systemic thinking** is a way of understanding reality that emphasizes the relationships among a system's parts, rather than the parts themselves. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static snapshots."

Meadows, D. H. (2008). Thinking in Systems: A Primer. Chelsea Green Publishing.

"What we need to teach is the ability to think that antagonisms can be complementary."

Image credit : *Wassily Kandinsky, Composition VII (1913)*

"Complexus, what is woven together. The components are different, but the overall picture must be seen as in a tapestry."

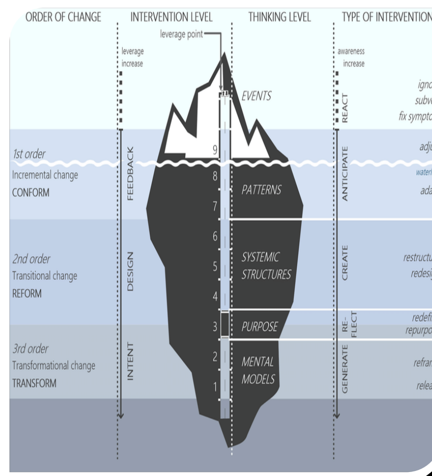
Edgar Morin, *La stratégie de reliance pour l'intelligence de la complexité*, **Revue Internationale de Systémique**, 9(2) 1995

"We can't control systems or figure them out. But we can dance with them!"

Meadows, D. H. (2008). Thinking in Systems: A Primer. Chelsea Green Publishing.

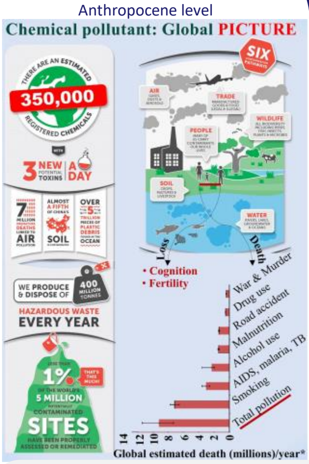
Integrated, system-oriented approaches to navigating social–ecological complexity transcend disciplinary boundaries by focusing on the dynamic interrelationships of different elements shaping complex issues. It follows these principles:

1. Get the beat.
2. Listen to the wisdom of the system.
3. Expose your mental models to the open air.
4. Stay humble. Stay a learner.
5. Honor and protect information.
6. Locate responsibility in the system.
7. Make feedback policies for feedback systems.
8. Pay attention to what is important, not just what is quantifiable
9. Go for the good of the whole.
10. Expand time horizons.
11. Expand thought horizons.
12. Expand the boundary of caring.
13. Celebrate complexity.
14. Hold fast to the goal of goodness.



The Anthropocene meltdown of disciplinary boundaries

Unintended Consenquences of Novel Chemicals at the Anthropocene level



"Humanity is unaware of how near or far it is from exceeding the Earth's capacity to 'absorb' or safely process our total chemical releases, which grows by many billions of tonnes with each passing year. This represents a potential catastrophic risk to the human future and merits global scientific scrutiny on the same scale and urgency as the effort devoted to climate change. "

Ravi Naidu *et al*. "Chemical pollution: A growing peril and potential catastrophic risk to humanity" **Environment International, 156**, 106616 (2021)

Post Normal Sciences

"When facts are uncertain, values in dispute, stakes high, and decisions urgent, the traditional distinction between hard, objective facts and soft, subjective values is blurred, and we enter the realm of post-normal science."

Silvio Funtowicz and Jerome Ravetz, Science for the Post-Normal Age

Post-normal science is defined by the inclusion of an extended peer community, where not only certified experts but all those with a stake in the issue are involved in the dialogue.

The performativity of scientific practices

The development of new technologies, driven by scientific research, has fundamentally reshaped the Earth's systems. These technologies are not neutral tools but active participants in the reconfiguration of our world. Theoretical frameworks are not just lenses through which we view the world but are themselves part of the world's fabric. They shape and are shaped by the knowledge they produce. Scientific practices are not merely ways of representing the world but are integral to the ongoing process of constituting the world itself. Science does not just describe reality but actively participates in its creation.

Karen Barad, Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning, 2007

"Science does not correspond to a world to be described. It corresponds to a world to be constructed."

Gaston Bachelard L'activité rationaliste de la physique contemporaine (1951)

"We are now able to join the natural and social sciences, not because we have discovered some new unified theory, but because we have learned to consider everything as an actor and not simply as a resource or a background for human action."

Bruno Latour, "The Politics of Nature: How to Bring the Sciences into Democracy" (2004)

This poster was made by: Patrick Degeorges Institute of Advanced Studies in the Practices and Arts of Transformation (IASPAT) https://ihepat.com/en and E. A. Quadrelli, Institut de Recherches sur la Catalyse et l'Environnement de Lyon IRCELYON – CNRS Université de Lyon 1 with the support of CPE LYON

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Ethics committee "TENDING TO OUR ROOTS"

" An interdisciplinary dialogue for continuous grounding of our research"

Case studies

"Examples of how interdisciplinary elements can nourish the question below"

How can we uncouple the development of catalysis, the science of the acceleration of the transformation of matter, from the worrisome aspects of the ecological and socio-environmental accelerating changes?

⑦ – CASE STUDIES

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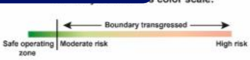
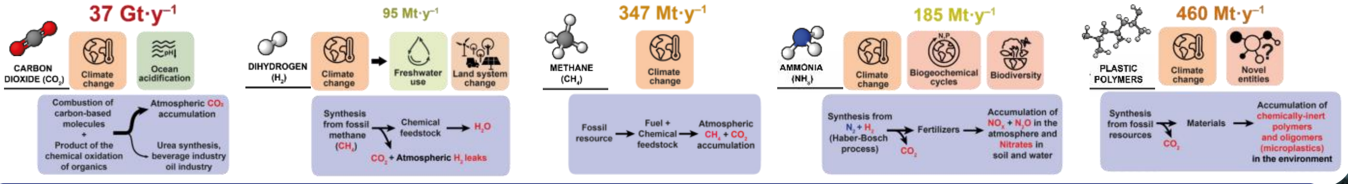
AN ANTHROPOCENE-FRAMED TRANSDISCIPLINARY DIALOG AT THE CHEMISTRY-ENERGY NEXUS

Prévot *et al.* ***Chem. Sci.*** (2024), 15, 9054

5 key molecular entities at the energy-chemistry-planetary boundaries nexus

This article examines the challenges related to energy transition and sustainable development through the lens of five key molecular substances: carbon dioxide (CO_2), hydrogen (H_2), methane (CH_4), ammonia (NH_3), and plastic polymers.





5 energy transition scenarios that help shape research avenues on the 5 chemical entities

Five European/UN/OECD scenarios reviewed : **IPCC, IEA, Shell, Dechema, Sunergy :**

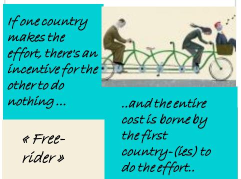
These scenarios share common points, including the recognition of climate change and the need to develop low-carbon energy systems. However, these scenarios often rely on optimistic assumptions about the development and deployment of new technologies.

Interdisciplinary approach to highlight some limitations and blind spots of these dominant scenarios

Economics – CO_2

Game theory can help suggest that efforts to industrialize CO_2 mitigation solutions might face significant economic obstacles, including the "free rider" problem in emission reduction efforts.

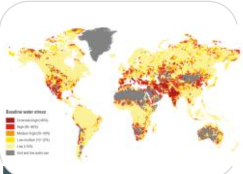
Game theory makes it possible to **model (non-)cooperation** between two (coalitions of) countries **aiming at emission reduction**



J.C. *"A game-theoretic interpretation of the climate change negotiations"*

Political Science – CH_4 and H_2

Potential conflicts over land and water use for deploying methane- or hydrogen-based solutions can be highlighted.



Annual baseline water stress. Source: WRI (2019). Licence Creative Commons Attribution 4.0 International (CC by 4.0).128

Ecology – NH_3

The relevance of ammonia as a major contributor to the energy transition is questioned, given its impacts on planetary boundaries

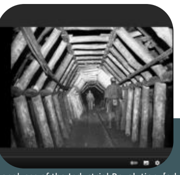
The 2024 EuChemS Periodic Table of Elements depicts element sustainability and causes of concern for future availability, including increased use and production from conflict resources, and impact on Earth system processes ("Serious global problems through overuse"). CC-BY-ND licence.

Decolonial Studies – Plastics

The dynamics of global plastic waste recycling highlight North-South inequalities.

History – "Energy Transition"

Historically, energy changes have more often been **additions** rather than substitutions. And **material symbioses** might contribute to this lack of substitutions. What about the current horizon of "energy transition"?



"[Some] analyses of the Industrial Revolution [advocate] that wood no longer played any role in the British energy mix in the mid-19th century (9). Yet British coal mines consumed huge quantities of wood: beams, props, poles and planks for timbering the galleries - a total of 4.5 million tonnes in 1913 (10). **This means that by 1913, Britain was using far more wood to extract its coal than it had burned in the mid-18th century.** "
Jean-Baptiste Fressoz « Sans transition. Une nouvelle histoire de 'énergie » Seuil, 2024

Discussion Elements

On the Scenarios

Several significant shortcomings:

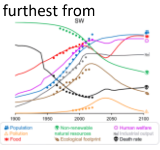
1. Focus primarily on climate change, often neglecting other Earth system processes.
2. North-South inequalities and potential conflicts related to extractivism and waste management not sufficiently addressed.
3. Maintain a hierarchy of values where economic profitability often takes precedence over environmental and social considerations.
4. Rely on optimistic assumptions about the development and deployment of new technologies.

On the scientific method

- Technical uncertainty is compounded by risks linked to environmental, geopolitical, and social effects, even when novel technologies were to be technically available at scale.
- Invariant between the present time and the projected transition(s): the hierarchy of values.
- To build up and justify our scientific choices, we rely on "cultural axioms", that we mostly do not question nor explicitly mention.

On the Time-frame

In the Club of Rome 30 year update the "Stabilize the World" scenario is statistically the furthest from empirical data (see fig)



The urgency is evident:
→ Urgent to avoid failure to change
→ Urgent to avoid the risks associated with implementation of some aspects of the dominant scenarios proposed.
→ Urgent to take time to redirect!

Conclusions

Urgent to change …differently!

1. **Accept and embrace our individual ethical responsibility as scientists on if/how outcome deriving from our research (even through misuse by others) aligns with (our personal or shared) values and societal needs.**

To do so:

1. Collaborate more closely with social sciences and humanities to better understand the systemic implications of our own research.
2. Understand the non-explicit assumptions, belief, and judgement systems currently overarching and shaping energy research and where/as deemed appropriate explore alternatives inspired by non-dominant scientific theories (examples given: ecological economics, post-growth theories, and decolonial studies).
3. Pay attention to knowledge production activities beyond academic circles.

This poster was made by: E. A. Quadrelli, E. Landrivon et M. PRévot, Institut de Recherche sur la Catalyse et L'Envieronnement de Lyon IRCELYON – CNRS Université de Lyon1
Initial summarized text of the article (Chem Science 2024, co-authored by two of us) by ChatGPT

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⑧– CASE STUDY

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Reflexivity : Term from knowledge theory about a practice especially used in social sciences : *“Reflexivity is the act of examining one's own assumption, belief, and judgement systems, and thinking carefully and critically about how these influence the research process.“*

Jamieson et al. *“Reflexivity in quantitative research: A rationale and beginner's guide”* ***Social and Personality Psychology Compas***. 2023;17:e12735

An case study in reflexivity inspired by :

“FAIRNESS IN MACHINE LEARNING FROM THE PERSPECTIVE OF SOCIOLOGY OF STATISTICS :

How machine learning is becoming scientific by turning its back on metrological realism”

- B. Benbouzid , *Proceedings of the 2023 ACM Conference on Fairness, Accountability, and Transparency* ***FAccT ’23,*** *June 12–15, 2023, Chicago, IL, USA*
- *B. Benbouzid,* ***Stat. Société*** *2022, No. 10 | 3, 69–84.*

What is, if any, the ethical equivalent of “integration of fairness” in AI-guided research in catalysis ?

Exploring the integration of fairness into machine learning (FairML)

Traditionally, statisticians aimed to eliminate politics from their measurement tools, striving for "mechanical objectivity." However, data scientists developing predictive machines for social applications face ethical issues. **Algorithmic fairness is a significant challenge in AI regulation.** While some studies suggest that machine evaluations are less biased than human judgments, others highlight the risks of systematic discrimination through algorithmic decisions. The rise of FairML aims to address these concerns by identifying discriminatory biases, defining fairness metrics, and exploring the relationship between algorithms and politics.

Summarized from Benbouzid *, op.cit.*

Are the biases found in Machine Learning relevant in AI-guided research in catalysis ?

Biases in software systems

Friedman and Nissenbaum, among the founders of the FairMachineLearning dynamics describe **three types of bias in software systems :**

(1) ***“preexisting bias”*** from previously involved stake-holders,

(2) ***“technical bias"***, which stems from "*the quantification of the qualitative, the discretization of the continuous and the formalization of the abstract, formalization of the informal*", all of which inevitably bias algorithmic decisions, and

(3) ***“emergent bias”*** when the software system interacts with a changing world.

B. Friedman and H. Nissenbaum *Bias in Computer Systems*. ACM Trans. Inf. Syst. 1996, 14 (3), 330–347.

What could be the non-neutral aspects of algorithm used in AI-guided research in catalysis?

No algorithm can be entirely neutral

FairML's development reflects the growing recognition that no algorithm can be entirely neutral, This Fair Machine Learning (*FairML*) community strives to come up with calculation procedures that must be simultaneously robust and reliable while also remaining aware of and managing the historically-, politically- and socially-constructed aspects of their craft.

Summarized from Benbouzid *, op.cit.*

What form of ethical-guided interdisciplinary dialogue could be relevant in AI-guided research in catalysis?

Need for continuous dialogue and interdisciplinary collaboration

The field of FairML is characterized by a specific form of objectivity that balances axiological pluralism and the expert's trained judgment. To be ethically acceptable, algorithms must be "reasonably" biased, reflecting situated knowledge rather than optimizing for fairness in a realist sense. This evolving controversy highlights the need for continuous dialogue and interdisciplinary collaboration to address the complex challenges of fairness in machine learning.

Summarized from Benbouzid *, op.cit.*

This poster was made by: A. Rigal and E. A. Quadrelli, Institut de Recherche sur la Catalyse et L’Environnement de Lyon IRCELYON – CNRS Université de Lyon1

Projects

“Attempts to intertwine research in sociology and research in chemical sciences”

How can we uncouple the development of catalysis, the science of the acceleration of the transformation of matter, from the worrisome aspects of the ecological and socio-environmental accelerating changes?

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⑨–PROJECTS

Ethics committee “TENDING TO OUR ROOTS”

“ An interdisciplinary dialogue for continuous grounding of our research”

Situated Green Chemistries : a “chemistry & social sciences” proposal

Exploring a transdisciplinary definition of sustainable chemistry through the concept of “Situated green chemistries” that combines chemistry, systems analysis and the situated knowledges framework [1] from social sciences.

[1] D. Haraway "*Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective* " **Feminist Studies**, 14, 575 (1988)

Why do we need to intertwine Green Chemistry and Social Sciences?

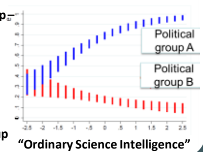
- Green Chemistry, the chemistry that announces as one of its primary drivers its intent to be(come) “benign by design”, needs critical inputs from other disciplines (ex. toxicology, ecology, …) to apprehend its effect : How else can we evaluate “benign” ?

- The current epoch, also called great acceleration, entails also acceleration of changes in the system under study. These fast changes might not allow some of the ambitions nor self-correcting methods that modern science has relied upon until now. For example, since the way we initially frame, collect and interpret experimental data is also culturally and historically based [1, 2, 3], these “biases” might not have time to resorb before the very system under analysis changes. So we need to change our practices to allow for this situated aspect of our research to be let in.

1 = 100% “yes” answers to question in polled sub-group

Question: *“Is climate change mostly of anthropic nature due to fossil fuel burning?”*

0 = 0 % “yes” answers to question in polled sub-group



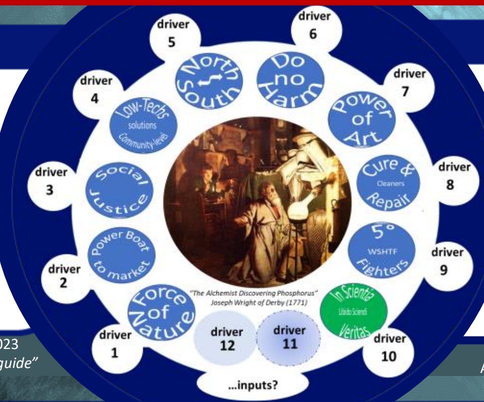
[2] D. M. Kahan, *Adv. Pol. Psych.* **36**, 1-43 (2015).

The situated Green Chemistries Framework

Goal

Achieve stronger objectivity in green chemistry by adopting a social science practice: learning how to explicit the assumption, belief, and judgement systems that influence the research process [1,2 and Figure above, 3]

[3] Jamieson *et al.* Social & Personality Psychology Compas. 2023 *“Reflexivity in quantitative research: A rationale & beginner's guide”*



Method

The goal stated is very ambitious. The starting proposal here is to just add **one** component of the social science practice. The chosen one: State as **primary driver** of our research the future toward which we gravitate and for which we would to contribute through green chemistry research (see 12 drivers, Fig).

The choice is inspired by historian who showed the importance of imaginary to bring major societal changes [4].

[4] *« La vie électrique. Histoire et imaginaire (XVIIIe-XXIe siècle)»* by Alain Beltran et Patrice Carré , 408 p., Ed. Belin (2016)

12 drivers of the Situated Green Chemistries Framework

Some explanations and examples on 12 drivers of Situated Green Chemistries

Driver 1: Planet-scale Force

The researcher’s conviction is that the best way forward for their research is to aim for the greatest possible "green effect" by interacting with the largest stakeholders of the moment (corporate, institutions).

- *Literature Inspirations :*

F. Jenck et al. “Products and processes for a sustainable chemical industry: a review of achievements and prospects”, Green Chem. (2004).

D.W. Keith et al., Stratospheric solar geoengineering without ozone loss, Proc. Nat. Ac. Sc. (2016).

Driver 2 : Start-Uppers

Entrepreneurial chemists set-up startups as alternatives to established companies to develop green chemistry innovations with strong commercial potential.

- *Literature Inspirations :*

H. Choi et al., Separation of Bio-Based Glucaric Acid via Antisolvent Crystallization and Azeotropic Drying. Green Chem. (2022).

Driver 3 : Social Justice

When research is primary motivated by the defense of social justice : the production of new scientific knowledge enriches a social or societal debate.

- *Literature Inspirations :*

J.E. Gallegos, et al., The Open Insulin Project: A Case Study for ‘Biohacked’ Medicines. Trends in Biotechnology (2018)
D. Booker et al., A Critical Air Quality Science Perspective on Citizen Science in Action. Local Environment (2023).

Driver 4 : Local low-tech

The chemist seeks to develop technologies that can be operated on a local scale by small communities with low-techs, with a low overall environmental burden.

- *Literature Inspirations :*

B. Roose et al., Local manufacturing of perovskite solar cells, a game-changer for low- and lower-middle income countries?, Energy Environ. Sci. (2022).
S. T Thomsen et al., Comparison of Different Pretreatment Strategies for Ethanol Production of West African Biomass, Appl. Biochem. Biotechnol. (2015).

Driver 5 : North-South

Remove injustices between North and South. For chemists who believe that the research is embedded also in colonial heritage to be deconstructed (extractivism, delocalization of pollution, etc.) and wish to develop a chemistry that would correct these injustices and propose new paths.

- *Literature Inspirations :*

Address Episte-micicde [4]: *W. Arndt, In Vitro Characterization of a 19th C. Therapy for Smallpox, PLoS One (2012).*

Contributing to establish right to access: *“Is Lithium Brine water?“ M. Ejeian, A. Grant, H.-K. Shon, A. Razmjou Desalination , 518, 115169 (2021).*

Diminish extractivism: *J. Septavaux, et al., “…metal purification from waste streams …”, Nat. Chem. (2020)*

[4] Bonaventura da Sousa “Epistemologies of the South”

Driver 6 : Do no harm

The "Do no harm" driver advocates the precautionary principle and prefers a "benign by design" approach to chemistry. The question is quite wide: who do we want not to do harm to? Humans, non-humans, non-living creatures?

- *Literature Inspirations :*

J. Xue et al., EISA-EXPOSOME: One Highly Sensitive and Autonomous Exposomic Platform with Enhanced in-Source Fragmentation/Annotation, Anal. Chem. (2023)
J. Kosta et A. Voutchkova-Kostal, Going All In: A Strategic Investment in In Silico Toxicology, Chem. Res. Toxicol. (2020)

Driver 7 : Power of art

These researchers see their profession with close analogies to artistic activity, because they create their own object: thei product of their research. Research thus unites beauty, imagination and understanding.

- *Literature Inspirations :*

M. Ivanova, What Is a Beautiful Experiment? Erkenntnis (2023)

V. Seifert, Can aesthetics contribute to chemistry?, Chemistry World (2023)

G. Parsons, The Epistemic Significance of Appreciating Experiments Aesthetically, The British Journal of Aesthetics (2000)

Driver 8 : Cure & repair

This driver is the desire to use chemistry to heal human beings and/or repair planet Earth.

- *Literature Inspirations :*

F. Lévesque et P. H. Seeberger. Continuous-Flow Synthesis of the Anti-Malaria Drug Artemisinin. Angewandte Chemie International Edition (2012).
B. Darling, et al. Filtration Membranes. US20190054426A1, 21 février 2019, https://patents.google.com/patent/US20190054426A1/en.

Driver 9: 5°C Fighters

New scientific knowledge that could become crucial if the future is severely disrupted by uncontrolled global warming or other natural catastrophes such as the collapse of biodiversity, profound social unrest or a drastic reduction in the world's habitable areas.

- *Literature Inspirations :*

J.E. Gallegos et al, The Open Insulin Project: A Case Study for ‘Biohacked’ Medicines. Trends in Biotechnology (2018).

Driver 10 : “Libido Sciendi”- The pleasure of learning

Researchers who feel the "libido sciendi", consider their faith in "science as the path to truth” and the pleasure they feel at this activity as the main driving force behind their research.

- *Literature Inspirations :*

D. Bourcier, P. van. Andel, La sérendipité : le hasard heureux : actes du Colloque de Cerisy-la-Salle [20-30 juillet 2009, Centre culturel international], Paris, Hermann (2011)

The 2024 InPACT’ students from Sorbonne University are kindly acknowledge for bringingforward the connection to serendipity

Other/different drivers?
This is just a starting proposal*…how can we collectively improve it –make it satisfactorily inclusive, satisfactorily impactful? At academic community level, first, and societal level after?

* These starting drivers are based on my experience of the field as an academic practitioner of green chemistry of 20 years, associate editor respected of peer reviewed journal of the field for 7 years, and my own sensibility and desire to see wider impacts and societal services being addressed by our collective work. Therefore, as a one-person –proposal for now it is unsatisfactory. Just a starter ✌

…And what are the changes in our practices (ex. evaluation criteria in peer reviewing) that we need to implement concurrently?

E. A. Quadrelli , *“Situated Green Chemistries: a starting proposal” manuscript in preparation.*

elsje.quadrelli@cnrs.fr @ElsjeQuadrelli

YouTube Ecole Urbaine de Lyon
Chimies situées #1/5 - Alessandra Quadrelli - Cours... Ecole Urbaine de Lyon EUL 697 views • 4 months ago

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The 2024 InPACT students and teachers from Sorbonne Université are gratefully acknowledged for artwork on each situated chemistry example

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"Post Fossil Societies" : a "sociology & engineering " proposal

Is it possible to develop a predictive framework connecting a research topic useful toward the energy transition with possible socio-political organizations?

A sociological perspective on energy: the focus on energy uses

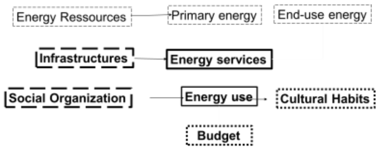
Energy as seen by an engineer: "Energy is the property that must be transferred to a body or system in order to produce a change." [1]

Energy as seen by a sociologist: "contemporary metrics reproduce understandings of energy as an all-purpose resource, rather than as something which is generated and consumed in ways that are highly contingent, variable and historically specific." [2]

[1] Jean-Marc Jancovici, The shift Project
[2] Shove. *Building Research & Information*, *46*(7):781. 2018

A starting point for a multidisciplinary analysis of energy

- In order to favor a transition to defossilized future, a research does not exist by itself.
- It is interwoven with infrastructure, economic, societal organization , cultural habit, ….
- To be understood, the energy system needs to be analyzed by multiple sciences.



Acknowledgements: Antoine Missemer, CNRS CIRED

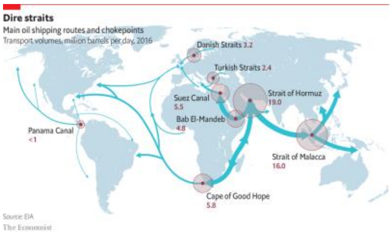
A precedent : The interconnected history of social movements, coal and oil

Timothy Mitchell has analyzed the relationship between coal & oil industries and social movements

Mitchell argues that the concentration of mines, the railway network that transported coal and connected them to factories favored the emergence of social movements aware of their power to disrupt these flows.

New Zealand Free Lance, 16 May 1908 Alexander Turnbull Library

Increased automation in oil production has reduced the number of workers needed, potentially affecting their bargaining power. Because most field oils are not located in Western democracies, blocking and sabotaging oil production is very difficult.

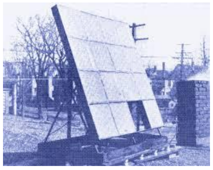


[1] T. Mitchell. Carbon Democracy. 2011.

Can we formalize the link between solar energy harvesting -oriented researches and compatible socio-political organizations?

An apparently similar technology can be linked to several -but not all?- contexts and create different -but not infinite?- effects on socio-political life.

Small-scale solar concentrator is compatible with low-tech developments for local use



Very large scale solar concentrator is compatible with industrial intensive development

https://solar.lowtechmagazine.com/2021/10/how-to-build-a-low-tech-solar-panel/

Is there a Sociological framework to be developed that can help infer connections between technology-oriented researches and the space of possible socio-political life ?

This poster was made by: A. Rigal and E. A. Quadrelli, Institut de Recherche sur la Catalyse et L'Environnement de Lyon IRCELYON – CNRS Université de Lyon1

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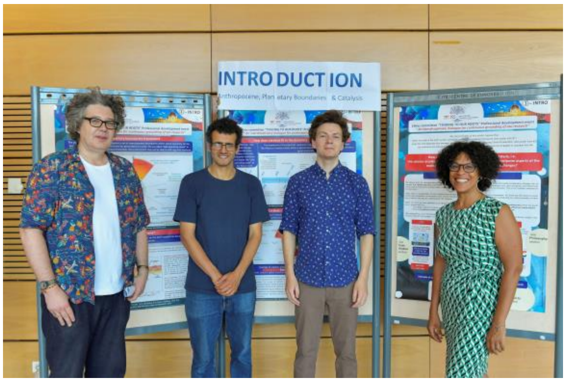
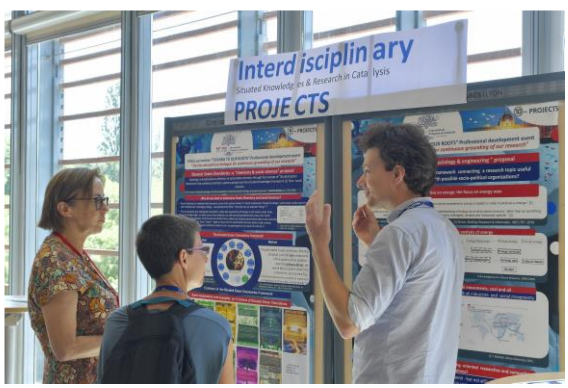
Pictures taken during event, Lyon, July 16th and 18th 2024





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Salon Pasteur, Lyon, July 16th and July 18th 2024

Poster List

Introduction

① The planetary boundaries framework and the definition of Anthropocene

② How does catalysis fit in the dynamics of Anthropocene?

③ How is this event structured ?

Philosophy

④ What are disciplines and the disciplinary paradox

⑤ The imperative to preserve the unity of human knowledge

⑥ Complex and systemic thinking are antidotes to reductionism

Case studies

⑦ An Anthropocene-framed transdisciplinary dialog at the chemistry-energy nexus

⑧ A case study in reflexivity inspired by fairness in machine learning

Projects

⑨ Situated Green Chemistries : a “chemistry & social sciences” proposal

⑩ “Post Fossil Societies” : a “sociology & engineering ” proposal

Co-animators

Alessandra QUADRELLI
CNRS
Chemist

Samir BOUMEDIENE
CNRS
Historian

Patrick DEGEORGES
Institute of Advanced Studies in the Practices and Arts of Transformation (IASPAT)
Philosopher

Alexandre RIGAL
CNRS
Sociologist