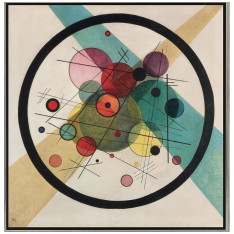
Discussion Group 3 Summary 2022-01-26



Ibon Santiago
Biophysics

Abdalrhman Mostafa
Medicine

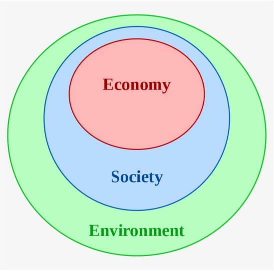
Andra Sonea
Financial Services/
Urban Science

Taiwo Ayinde
Agricultural Economics

Hanae EL GOUJ
Urban planning & Architecture

František Kalvas
Sociology

Asier Piñeiro
Quantum Physics



Yannick Oswald
Ecological Economics

Anastassia Vybornova
Transport Network Analysis

Marjorie Cantine
Earth sciences

Oriented toward sustainability and climate change:

How would a tax on meat impact the environment?
What does "fairness" in sustainability policy mean?
What technological innovations will prevent the collapse of the biosphere?
The world is ending. Why are we here studying complex systems?
Which area of complex systems is key for combating climate change? (Not only climatically but also public opinion and behavior)

General topics:

What is the direction the study of complex systems will take in the next decades?
What is the future of theories in relation to Big Data and AI?
Do you recognize important impacts on public policies from complex systems? (ie. "Has complex systems science done anything for policy?")
These last decades have been marked by social crises at global level. Has complex systems science contributed to the understanding of such crises? What is its direction?

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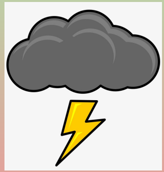

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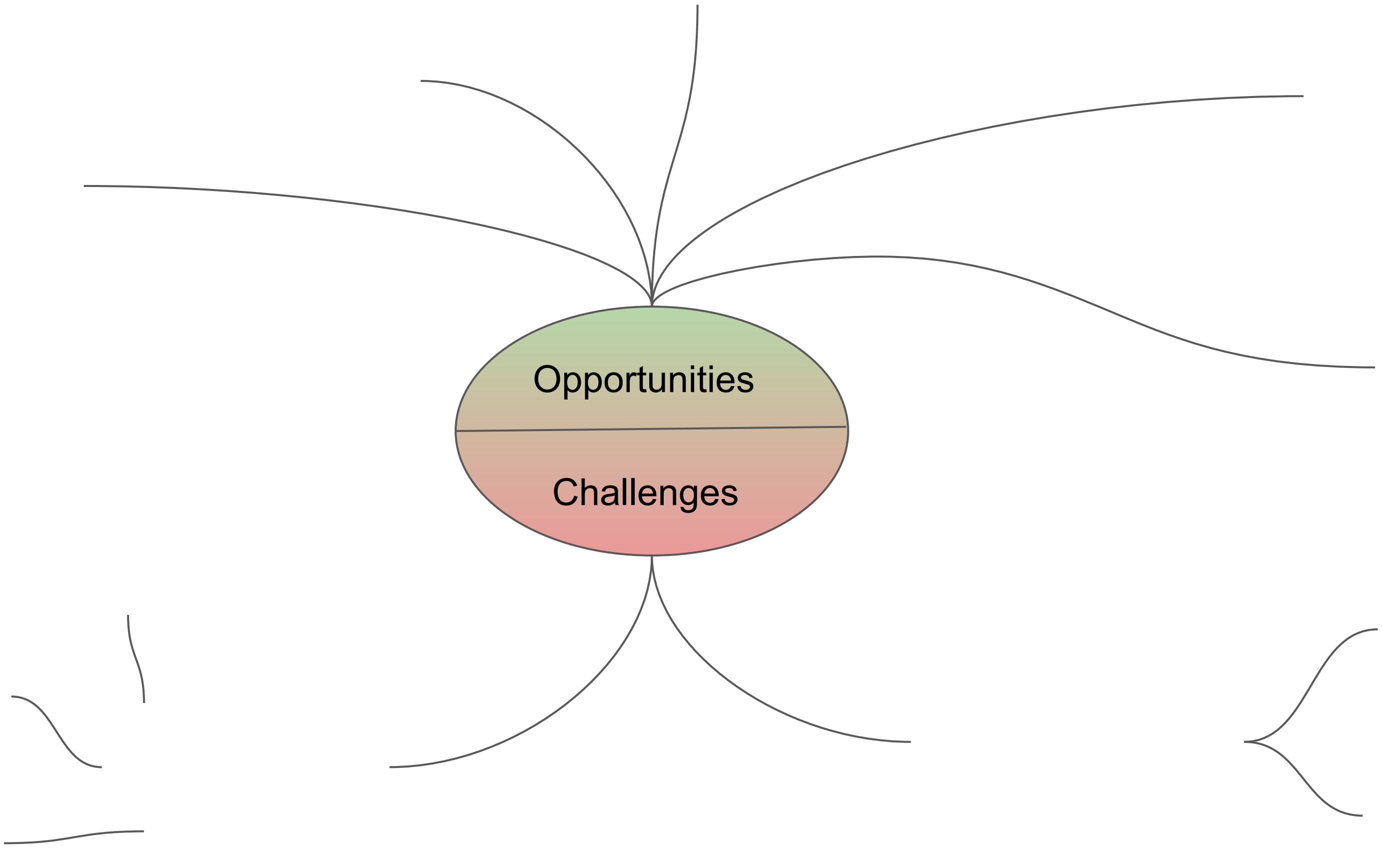
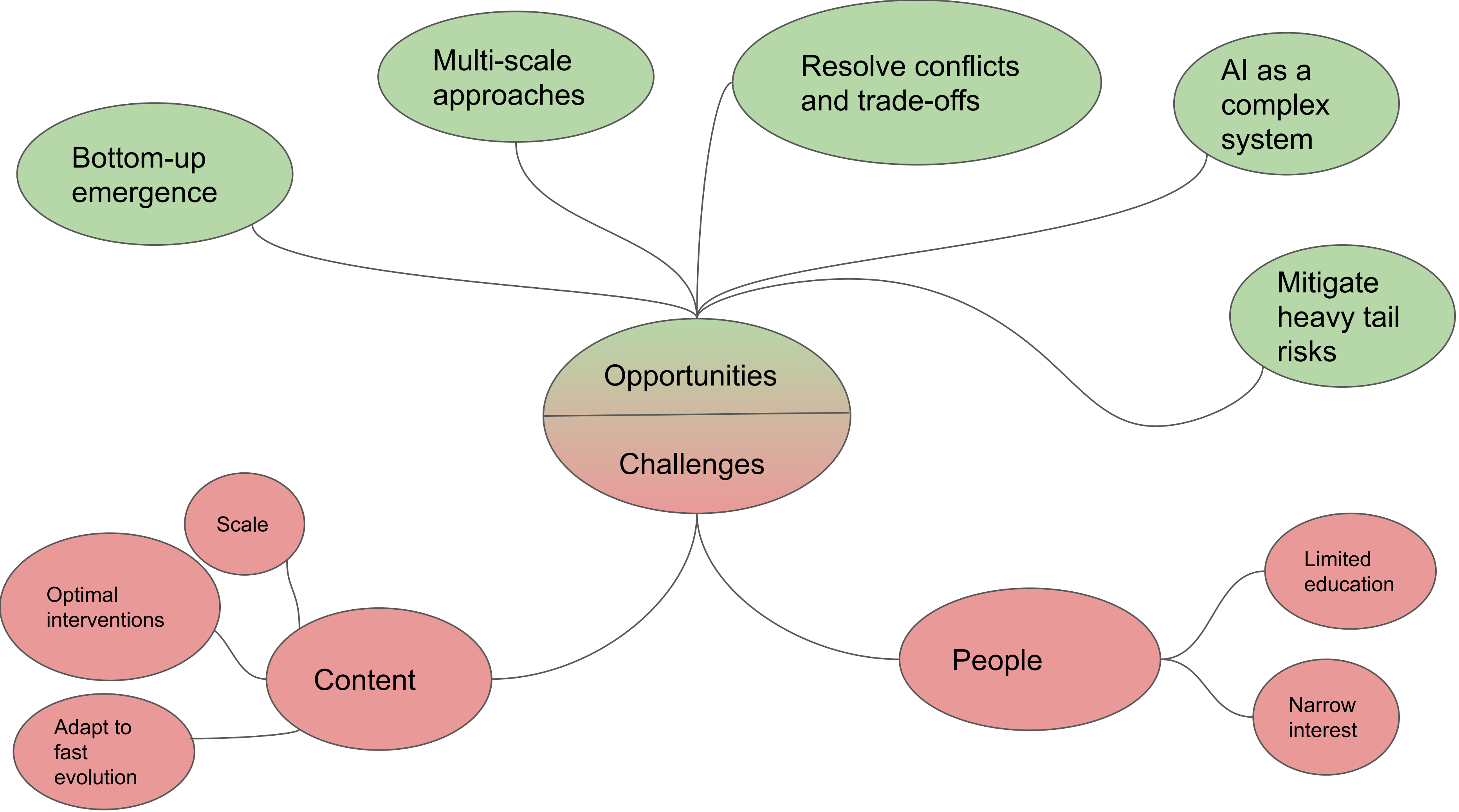

Opportunities
Challenges


Bottom-up emergence
Multi-scale approaches
Resolve conflicts and trade-offs
AI as a complex system
Mitigate heavy tail risks
Opportunities
Challenges
Scale
Optimal interventions
Content
Adapt to fast evolution
People
Limited education
Narrow interest

Ecological economics

Opportunity:

Model system dynamics of political forces and phase transitions.
Model, ABM based likely, the adaptation of different communities to climate change and new climate-friendly lifestyle.

Recognize universal patterns (e.g. distributions) across different systems.

Challenges:

Social scientists often work in ecological economics and many of them have limited interests or understanding of mathematical modelling.

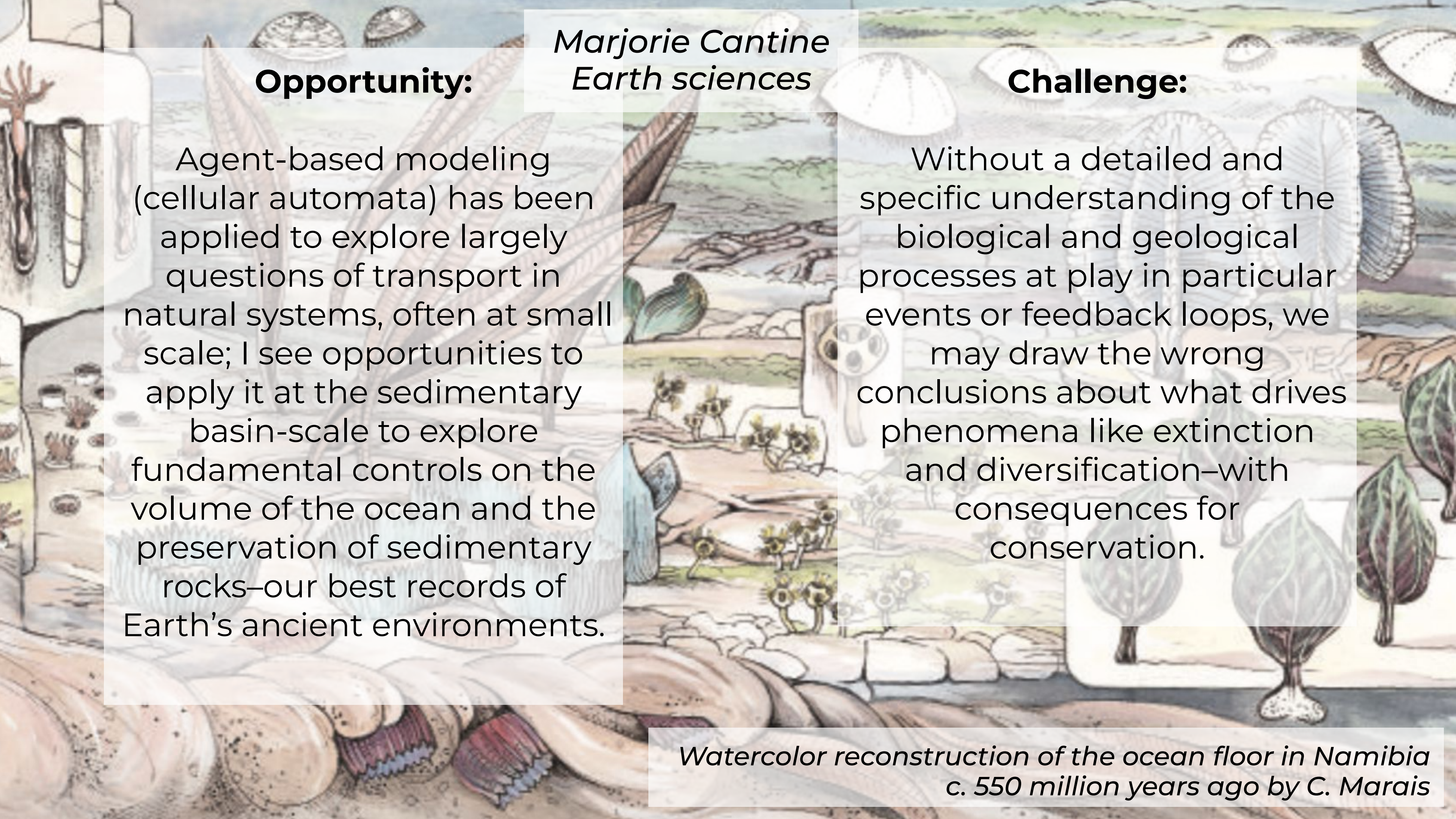
Marjorie Cantine
Earth sciences

Opportunity:

Agent-based modeling (cellular automata) has been applied to explore largely questions of transport in natural systems, often at small scale; I see opportunities to apply it at the sedimentary basin-scale to explore fundamental controls on the volume of the ocean and the preservation of sedimentary rocks–our best records of Earth's ancient environments.

Challenge:

Without a detailed and specific understanding of the biological and geological processes at play in particular events or feedback loops, we may draw the wrong conclusions about what drives phenomena like extinction and diversification–with consequences for conservation.



Watercolor reconstruction of the ocean floor in Namibia c. 550 million years ago by C. Marais

Sociology

Opportunity:

Getting inspiration from other fields via applying same complexity concepts. Possibility of results comparison across fields.

Concepts: Network analysis, ABM, scaling, fractality, entropy.

Possible applications: Public opinion dynamics, emergence of institutions.

Challenges:

‘Average sociologist’ avoids math and fascination by fancy graphs leading to using tools from complexity science as oracula without deep knowledge of their nature (what already has happened to statistics).

Hieronymus Bosch: Garden of Artistic Delights

Ibon Santiago

Molecular nanotechnology

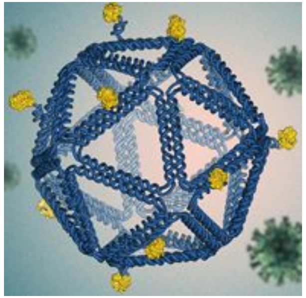
Opportunities:

The rational design of functional nanostructures is possible with the tools of nanosciences. DNA programmed assembly enables the bottom-up synthesis of nanostructures with ever increasing complexity. With the invention of the DNA origami, DNA self- assembly has reached a new level of sophistication. The interparticle interactions can be encoded in the sequence of DNA, thereby favoring specific 3D structures. These can in turn, react to environmental cues, compute and in the presence of chemical fuel, form chemical reaction networks that can give rise to out-of-equilibrium phenomena, like self-propulsion and replication. The ability to program matter opens the door to applying engineering principles at the nanoscale, creating soft molecular robots that mimic the complex machinery of life.

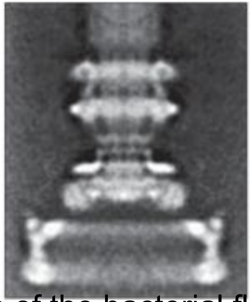
Challenges:

The engineering mindset, the systems theory thinking overlooks many of the challenges of the nanoscale, namely: wetness, thermal noise, Brownian motion, stickiness, low-Reynolds number etc. These elements make programming molecular complexity a difficult task.

But as the techniques to observe and manipulate matter become more advanced, we have the tools to create levels of complexity we see in nature. Creation brings better understanding.



DNA Origami with shape of capsid



Electron micrograph of the bacterial flagellar mot

Hanae EL GOUJ

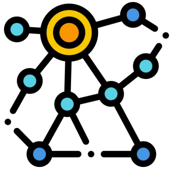
Urban planning

Opportunities:

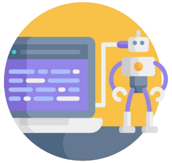
A city is a living structure and the territory in which it is embedded has a complex composition. Hence the need to deal simultaneously with both mechanism and shape: the city's functioning and its physical environment.

While cities are characterized by their organized complexity, their structure and development can be better understood by approaching their systems of networks and flows. Interactions within those networks can explain many aspects of city functions.

Theoretical framework *: e.g. Graph theory and network science*



Quantitative methods and metrics *: Modeling+ statistics ,...*



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Qualitative methods usually used in urban planning : Strategy proposition, survey

- ➔ Modelling to understand and to predict
- ➔ universality in patterns
- ➔ Adopting a multiscale approach

Challenges:

Urban planning or architecture are mainly practical fields so finding common ground between scientific studies and proposing some actual actions is one of the biggest challenges in applying complexity science to this field. While scientists are analyzing and trying to understand the city complexity, urban planner and decision maker are at the urge of deciding what is best to better manage the functioning and the evolution of the city.

- ➔ Defining "action oriented" studies
- ➔ Finding some common "vocabulary" by proposing practical interpretations of the empirical results.

Many-body quantum systems

Opportunities

Quantum systems are described by a so-called wave function, which is parametrized by exponentially many parameters (order 2^N, where N is the number of particles). This makes it difficult to even *store* a particular state of the system (memory problem), especially when a system is highly correlated. Hence, more efficient parameterizations are needed.

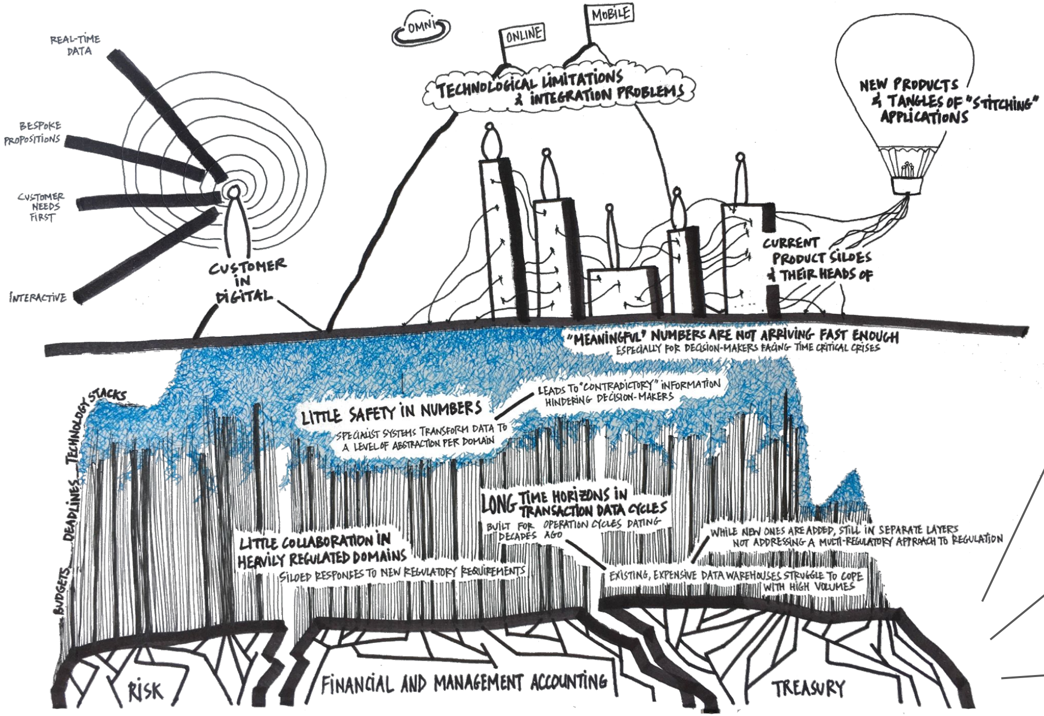
Representations commonly used in complexity science could offer new tools to efficiently capture the relevant correlations of a system. For example: machine learning, graphs, symplical complexes or hypergraphs. (Neural networks are quite hot in quantum physics right now)

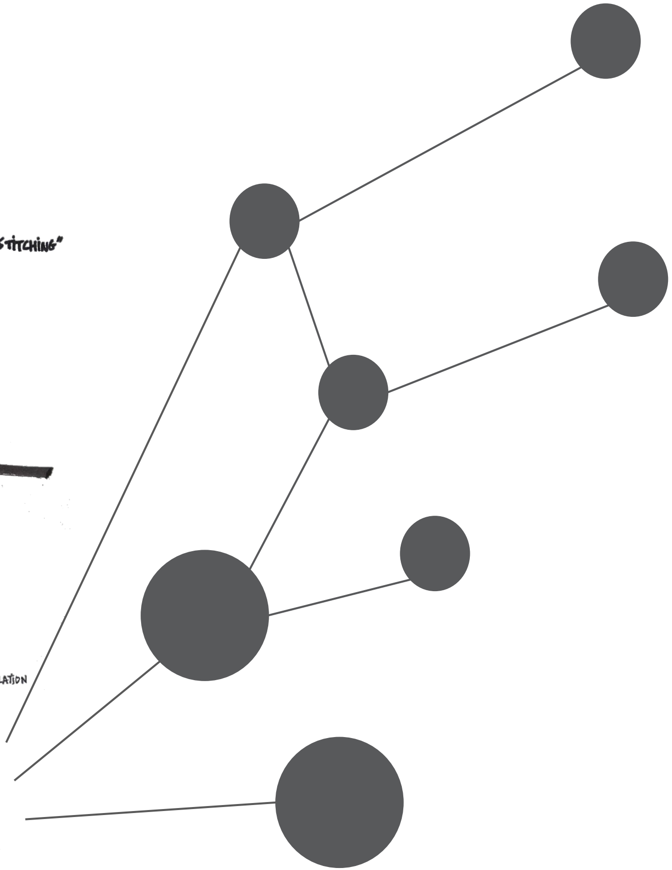
Challenges

1) Even when efficient representations are found it is often hard to *interpret* the results. What do the structures found mean physically?

2) It is sometimes hard to improve upon established methods or to genuinely find structures that other representations are totally blind to.

iStock/agsandrew





Andra Sonea
Financial Services

Taiwo Ayinde

Agricultural Economics

- Much climate-change research in lower-income countries has evaluated whether changes in smallholder farm-level production activities can reduce Greenhouse gas (GHG) emissions without negatively affecting household income, production pattern and resource use?
- Reductions in GHG are feasible while maintaining minimum household consumption, but cost in terms of foregone household income increases with larger GHG reductions
- There were no win-win opportunities of increased income and reduced GHG emissions using current production technologies

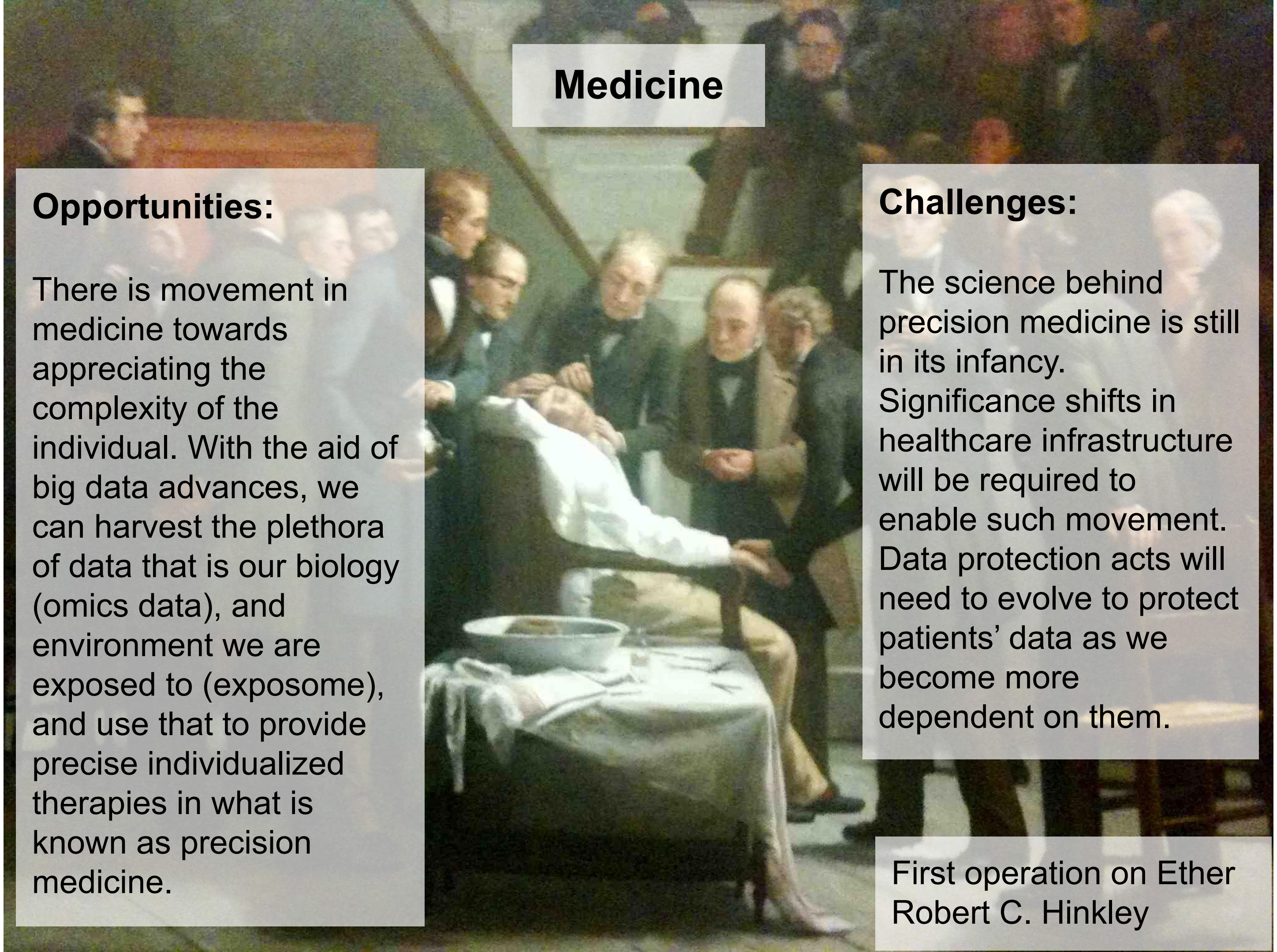
Opportunities

- Increased productivity that mitigate trade-offs and reduce GHG emissions without reducing farm household income may be possible with Regenerative Agriculture

Challenges

Future analyses that could account for multiple years and transition dynamics to assess variation in effects over time could be of great challenge

Medicine



Opportunities:

There is movement in medicine towards appreciating the complexity of the individual. With the aid of big data advances, we can harvest the plethora of data that is our biology (omics data), and environment we are exposed to (exposome), and use that to provide precise individualized therapies in what is known as precision medicine.

Challenges:

The science behind precision medicine is still in its infancy.
Significance shifts in healthcare infrastructure will be required to enable such movement.
Data protection acts will need to evolve to protect patients' data as we become more dependent on them.

First operation on Ether
Robert C. Hinkley

Common themes: (taken from Google Doc)

- Narrow interest of people / unawareness that there is a problem or that things could be better
- Timescales are important–**when is the optimum time to intervene?** What timescales are relevant for thinking about a problem, its causes and its damage? Understanding of **delayed effects**.
- Dynamical **co-evolution** of different complex adaptive systems. Where to intervene?
- Lack of competence or expertise with detailed techniques or **misuse of quantitative techniques** (eg p-hacking)
- Empirical data vs decision making
- Identification of **hidden (tail) risks** with big impacts (black swans?) and how to control/regulate them.
- Processes happening differently at different scales
- Communication; Part of the problem is the difficulty in communication with each other, reliant on discipline-specific names and frames of reference; complexity science can help with developing new language that bridges disciplines; goal to look forward to
- Need for specialist knowledge and to solve problem at another scale, complexity science skills/techniques come in; it's not just the method but also the different way of thinking
- New representations of known problems