Institute and Faculty of Actuaries

The IFoA Conference 2022

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Emerging risk, complex systems and lessons from Covid

Nick Silver

Contents

- Ontology of risk
- Covid
- The Infocene
- Complexity and information

Ontology of risk

Risk paradigm

Example - Efficient Market hypothesis

- Asset prices reflect all available information.

Random Walk

- Prices react to new information

Stock price: $$P_t = E_t[M_{t+1}(P_{t+1} + D_{t+1})]$$

Random walk:

$$\log P_t = \log M + E_t[\log P_{t+1}]$$

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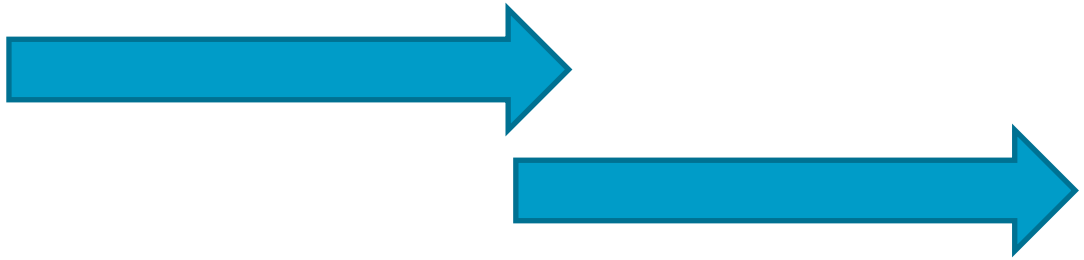
Risk paradigm - axioms

1) There is new information from outside system
2) Prices have a risk distribution

Types of “risk” relative to human system

Extraneous	Mixed	Endogenous
Alien invasion	Pandemic	Financial crisis
Comet	Extreme weather	War
Super volcano		Terrorism
Solar flare		AI/cyber



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Risk, certainty and uncertainty

Certainty	Risk	Uncertainty	Radical uncertainty
Will definitely happen	Probability distribution	an occurrence probability distribution not knowable	Unknown unknown
“I will die”	probability I will die if I play Russian roulette	I will die as a result of nuclear war	A new technology emerges enable people to live indefinitely

Risk, certainty and uncertainty

Category depends upon:

- Information available
- Processing power
- Completeness of model
- Time frame
- Perspective
- Agency

To Laplace's Demon everything is a certainty

(or is there a physical limit on computability?)

Certainty	Risk	Uncertainty	Radical uncertainty
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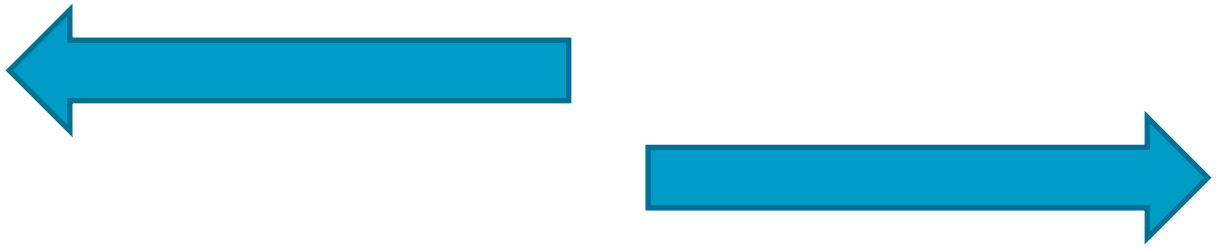

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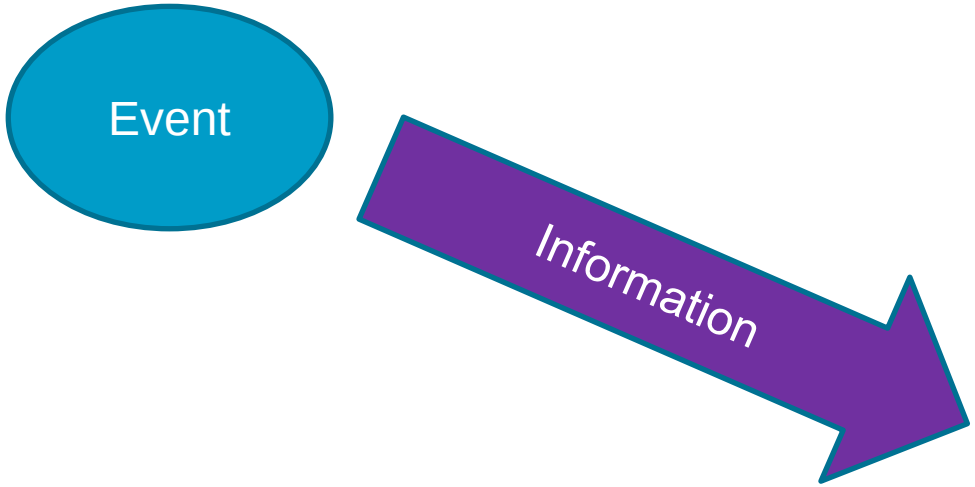
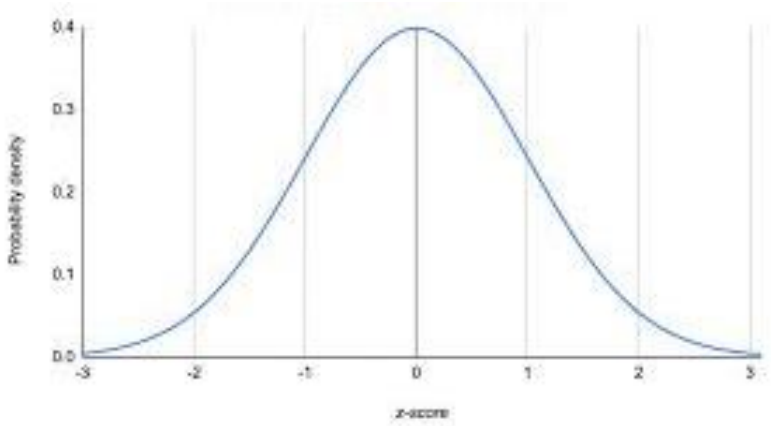
EMH type model



Impact of information



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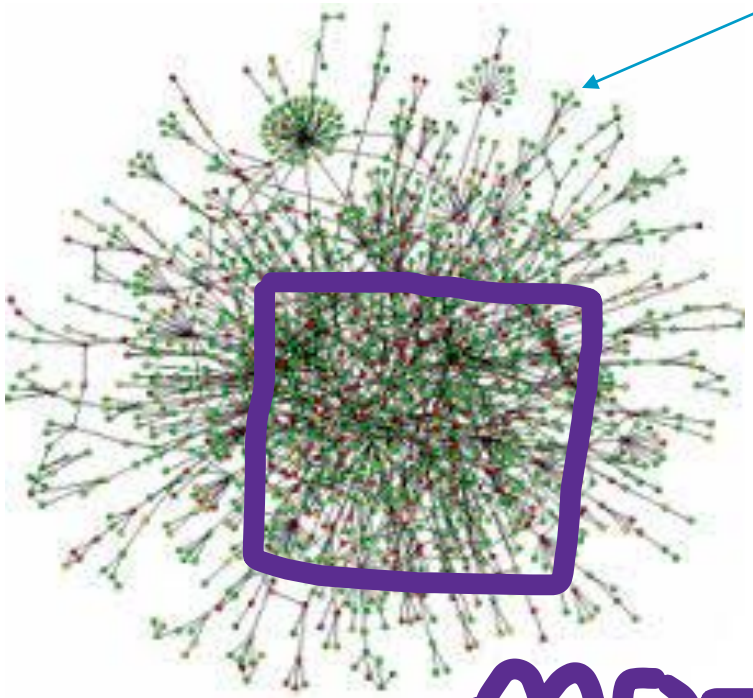
Assumptions/theory/historic data

Apparent uncertainty



Predictive output

Argument of talk

Risks are becoming certainties because of

- Increase information/data
- Increased processing power
- Complexity science

Risks are becoming uncertainties because of

- The context: infocene
- Rapid change driven by exponentials

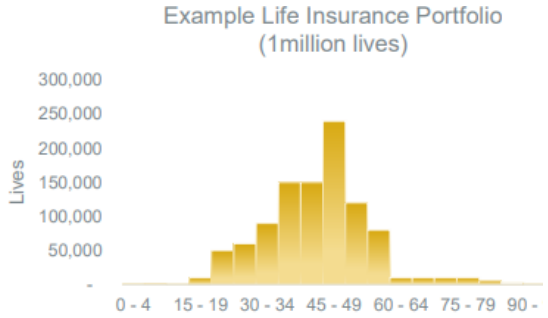
Learning from Covid

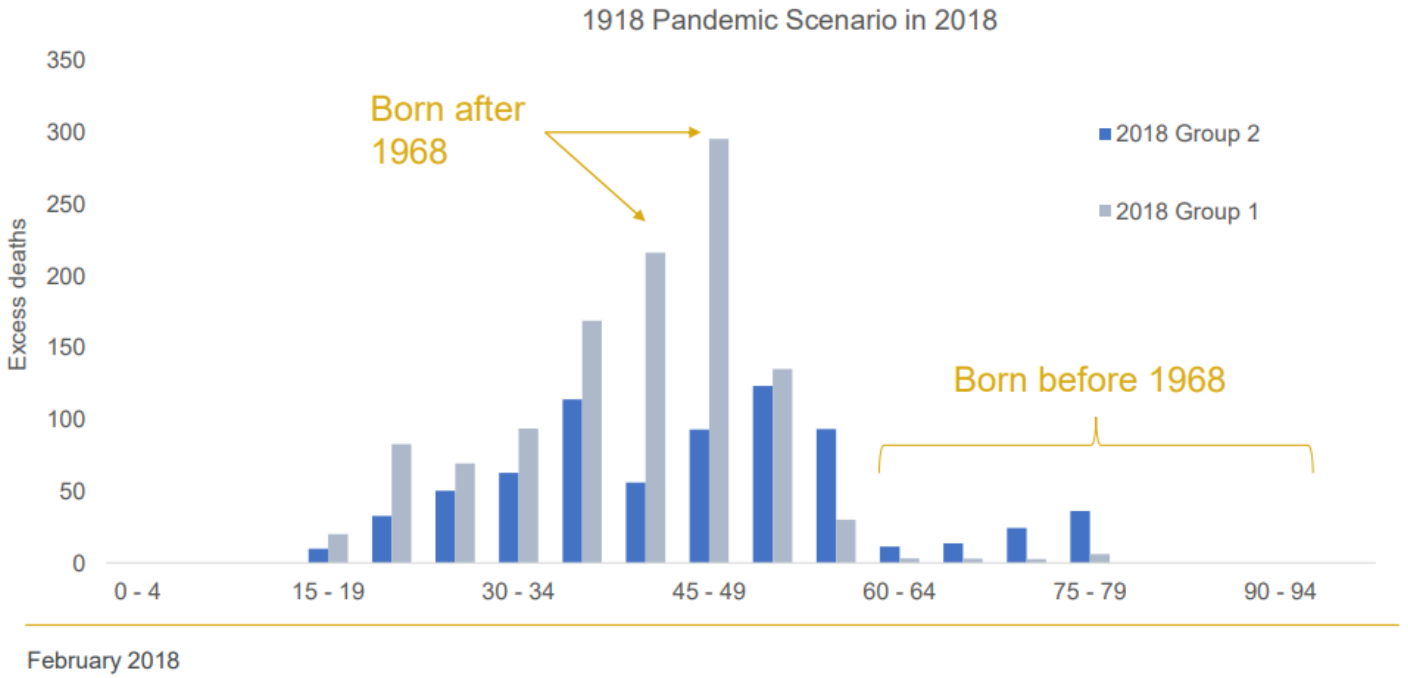
Actuarial conferences

- “Reimaganing the 1918 Pandemic” by Ashley Campbell at Highlights of the IFoA Life Conference 2018
- Gordon Woo. IFoA International Mortality and Longevity Symposium 2016

Looked at impact on a life portfolio “like Spanish Flu” type pandemic

Results





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A (parody) of a standard risk management technique

On early news from China (eg insurance/pension fund)

- Increased incidence of health insurance claims
- Increased mortality older workers: one-off boost pension annuity funding

Risk mitigation:

- Adjust pricing
- Increase (decrease) reserves
- Adjust policy wording
- Re-insurance

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What actually happened

Actual impact on insurance company

Product Lines

- Life, health, travel, business interruption, etc

Investment

Staff/operations/supply chain

Reputation

Social context of operation

Government/regulations

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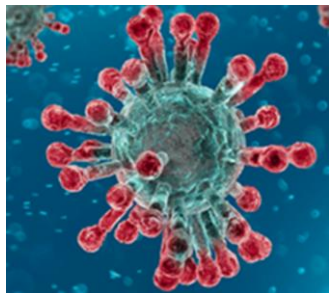
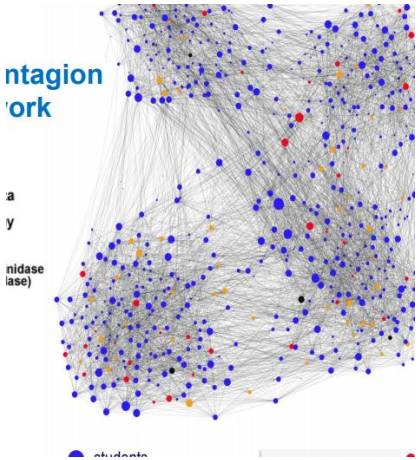
Woo/Ashley model

Virus: characteristics



Physical human contact:

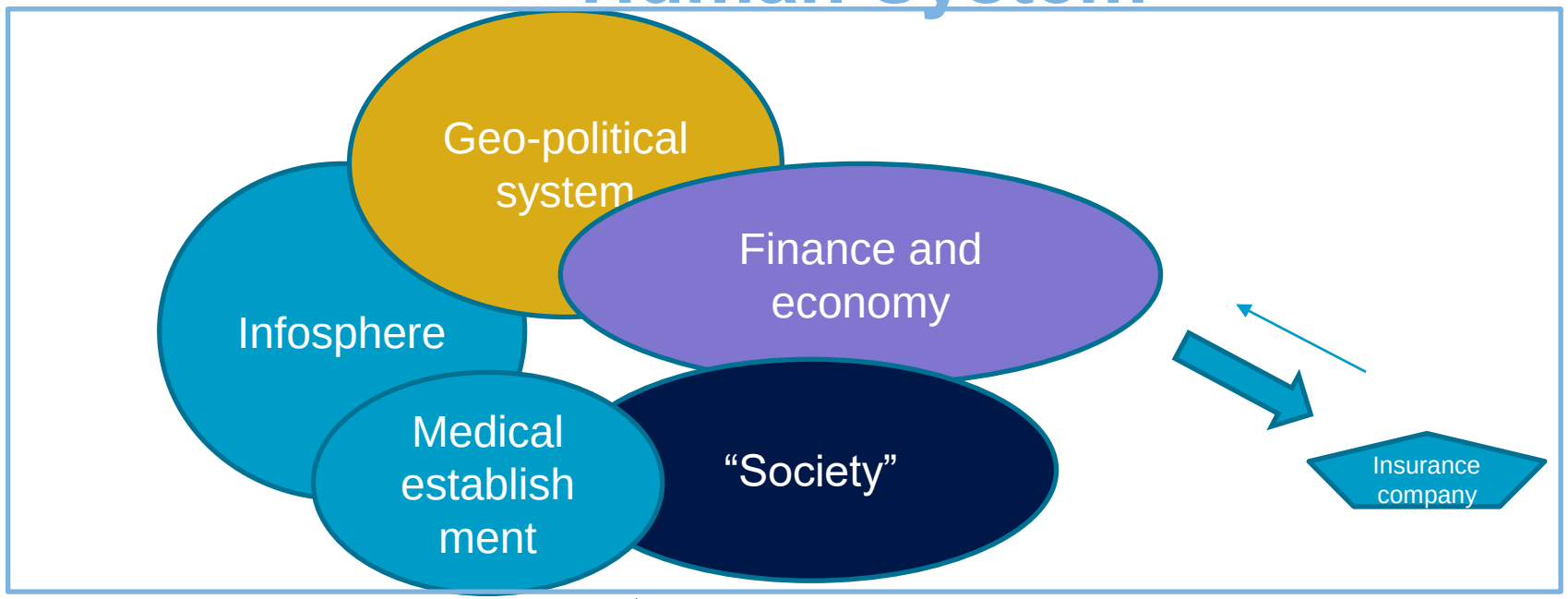
Network model

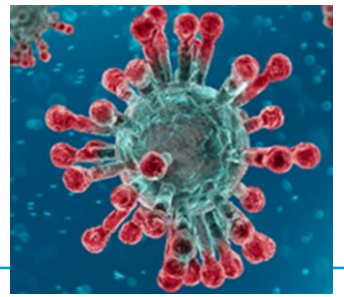


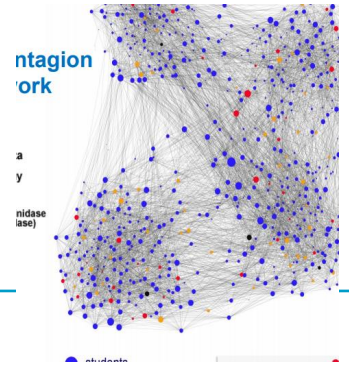
Insurance company

Life portfolio

“Human System”







Action/Reaction of Human systems

Disease characteristics	Social impacts
Risk of novel diseases (climate, interaction with animals, (laboratory accidents?), globalisation	Social/political reaction - infodemic
Speed of transmission	Financial background: tax, furlough + interest rates
Virulence	Manifestation of investment
Transmission rate - R number	Change in resource allocation – eg investment
Longevity of pandemic	Vulnerable social groups

Learning from Covid

The Infocene

Anthropocene - physical

Infosphere - information

The Anthropocene
What is it?

The **Anthropocene** is a proposed geological epoch dating from the commencement of significant human impact on Earth's geology and ecosystems, including, but not limited to, anthropogenic climate change

an **epoch** is a subdivision of the geologic timescale that is longer than an age but shorter than a period. The current epoch is the Holocene Epoch of the Quaternary Period. Rock layers deposited during an epoch are called a series. Series are subdivisions of the stratigraphic column that, like epochs, are subdivisions of the geologic timescale. Like other geochronological divisions, epochs are normally separated by significant changes in the rock layers to which they correspond.

Geologist agreed that Anthropocene started mid 20th century – when human marker would first be detected in rocks by future geologists (because of nuclear explosions)

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Background Anthropocene

The biosphere is a complex adaptive system formed of living and non living elements/systems

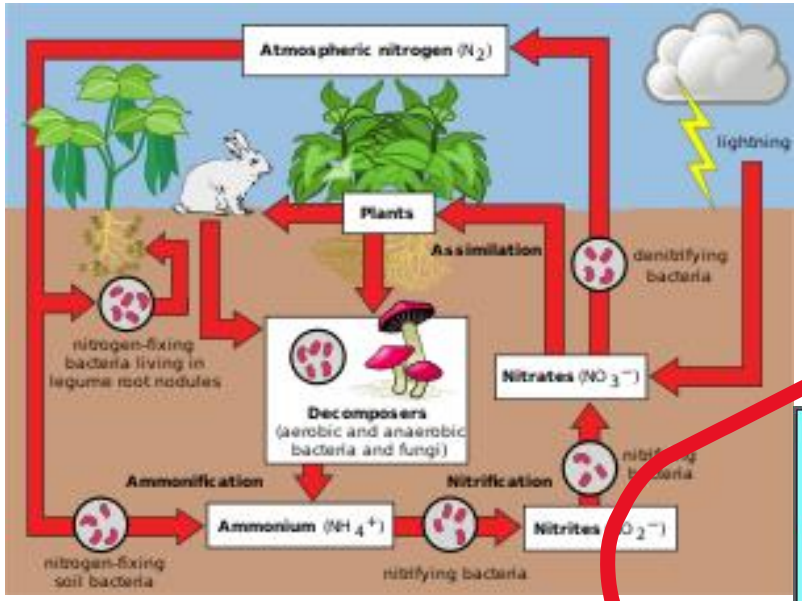
It is formed of integrated systems; including weather, geology, water, living systems, minerals, etc.

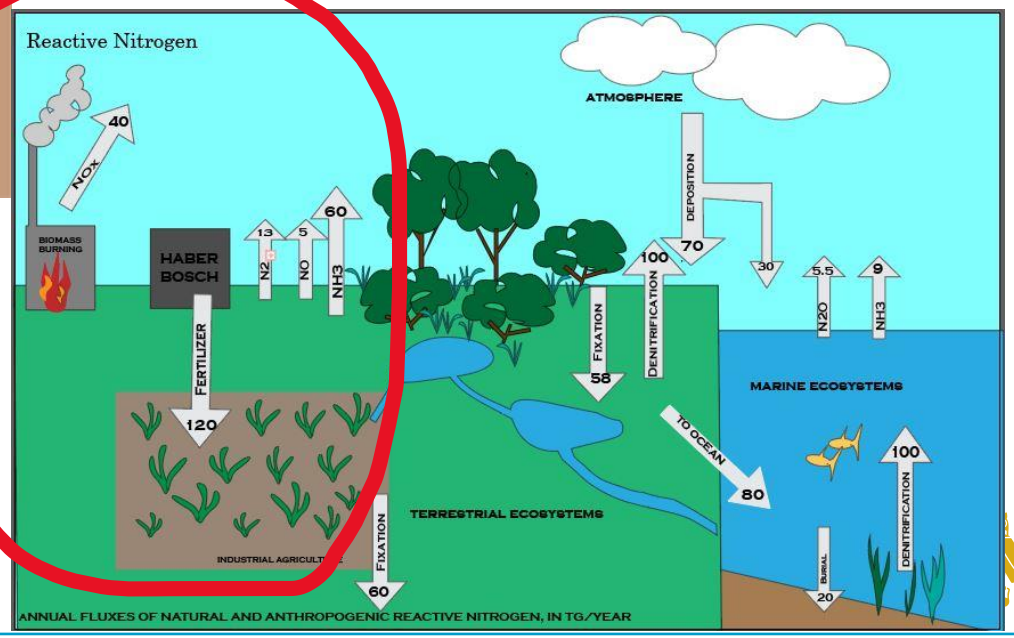
Life is incorporated into these systems, but they also perform crucial life support functions for most living organisms, to support ecosystems and human life

These functions include stabilising climate, providing minerals/nutrients for life, recycling waste, providing clean water, etc

An extreme form of this is the ***Gaia Hypothesis*** – that the earth is a living entity

Example: nitrogen cycle





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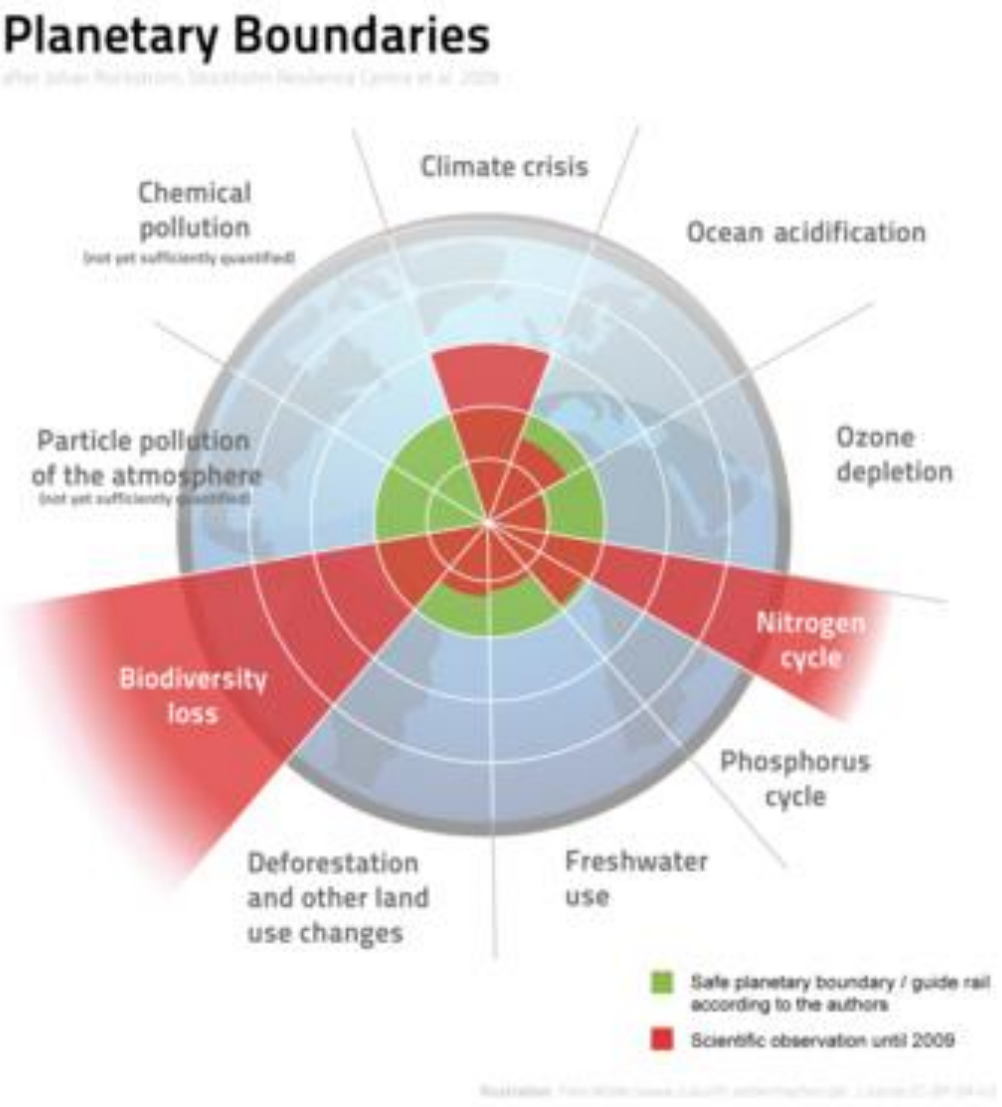
Planetary boundaries



Environmental boundaries: safe operating space for humanity

"transgressing one or more planetary boundaries may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental-scale to planetary-scale systems."

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The infosphere

Infosphere is a metaphysical realm of information, data, knowledge, and communication, populated by informational entities called inforgs (or, informational organisms).

Information

Information is required to maintain the human system at sufficient level of complexity to use energy to maintain/increase the level of complexity

What is information? See Shannon/Information theory

Information requires energy/resources to maintain

Information is **additive** – normally doesn't get destroyed

To maintain exponential growth requires technological innovation/revolution

Higher complexity of the system, the more information is required

The more complex system generates more information

Information generates more information (**positive feedback**)

Information - revolutions

Abstract speech – 100,000 years ago??

Writing – 6,000 years ago

Printing - China 1500 years ago
- Europe 500 years ago

Computer – 100 years ago

Internet – 30 years ago

Information

Eg DNA

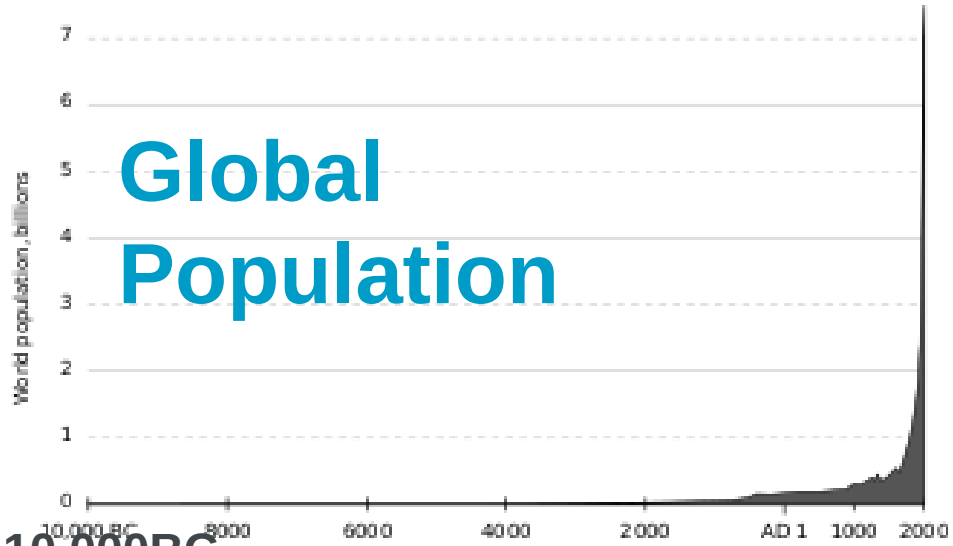
Infotsunami
Infoderms

Exponential world

“Anyone Who Believes Exponential Growth Can Go On Forever in a Finite World Is Either a Madman or an Economist” Kenneth Boulding

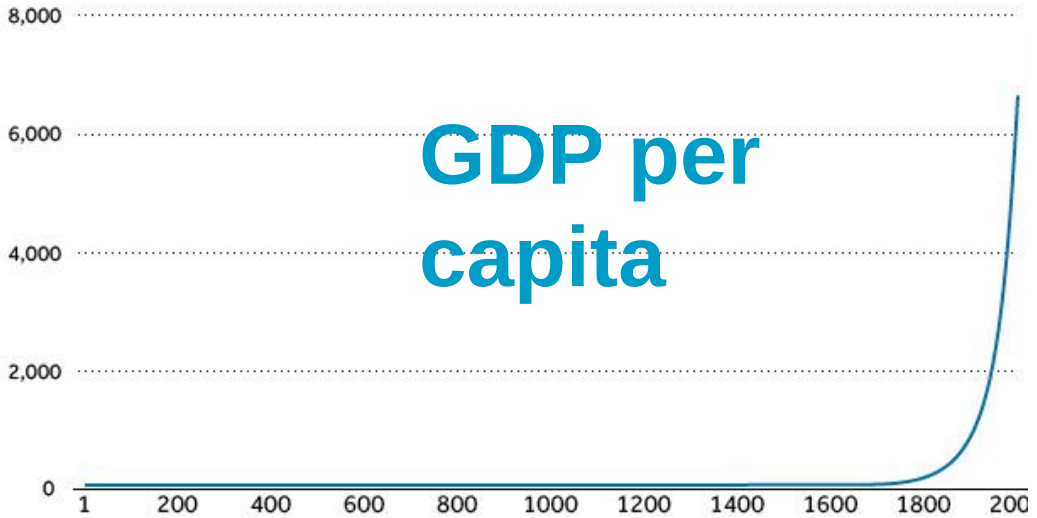
“The future is widely misunderstood. Our forebears expected it to be pretty much like their present, which had been pretty much like their past.”
Ray Kurzweil, The Singularity Is Near

Global Population



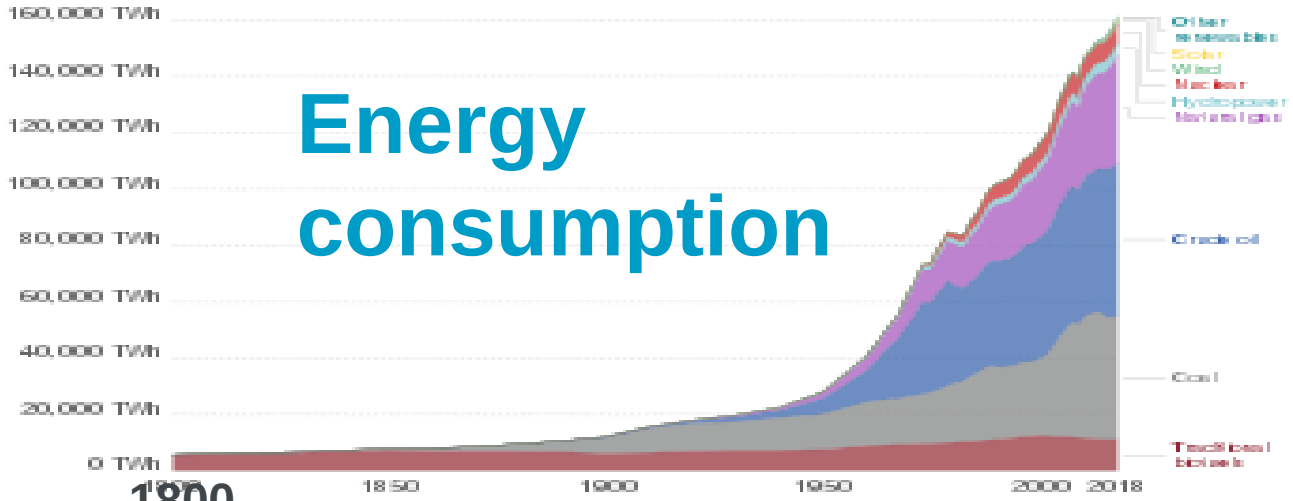
10,000BC

GDP per capita



1 AD

Energy consumption



1800

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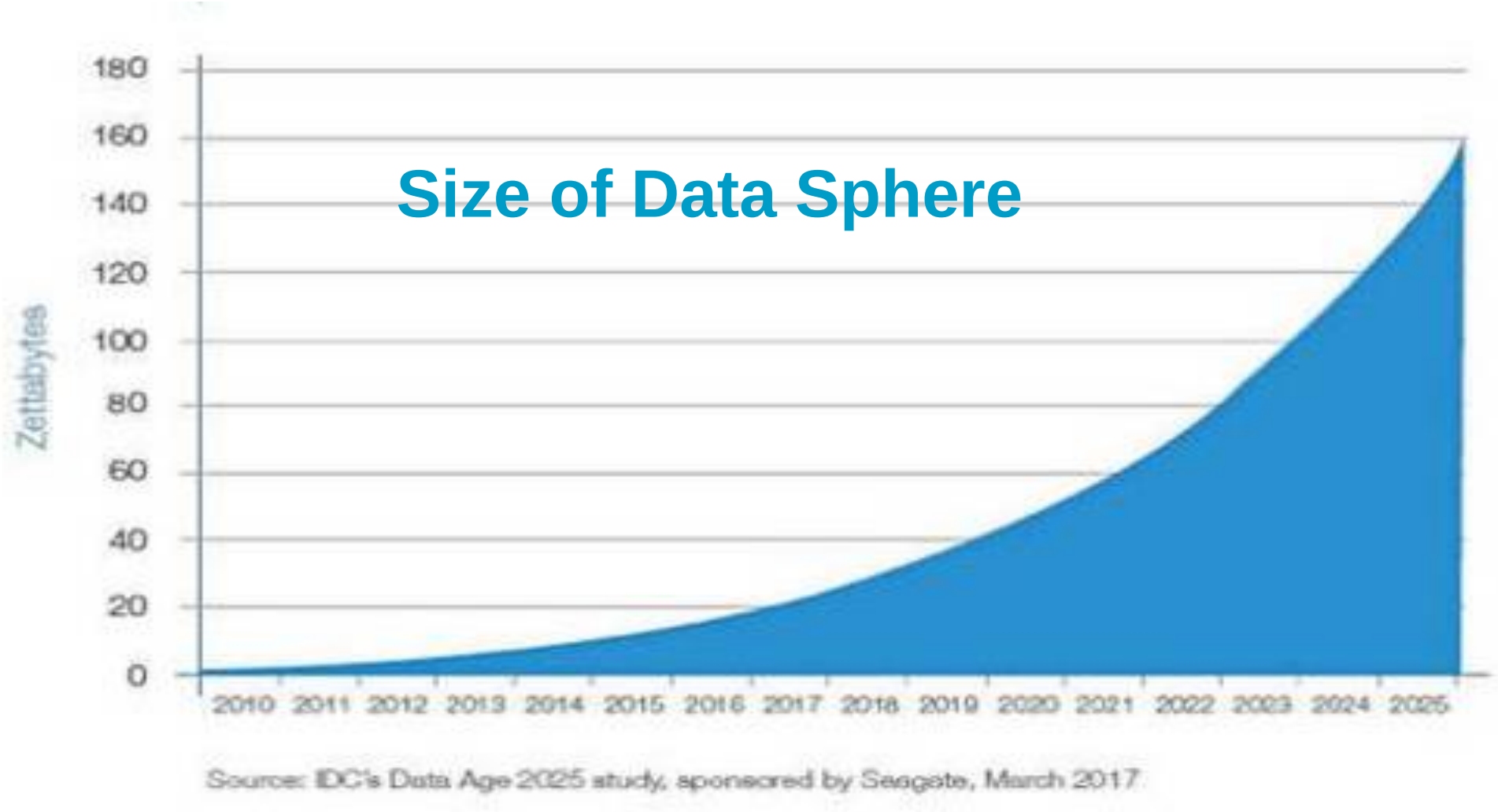
Size of Data Sphere



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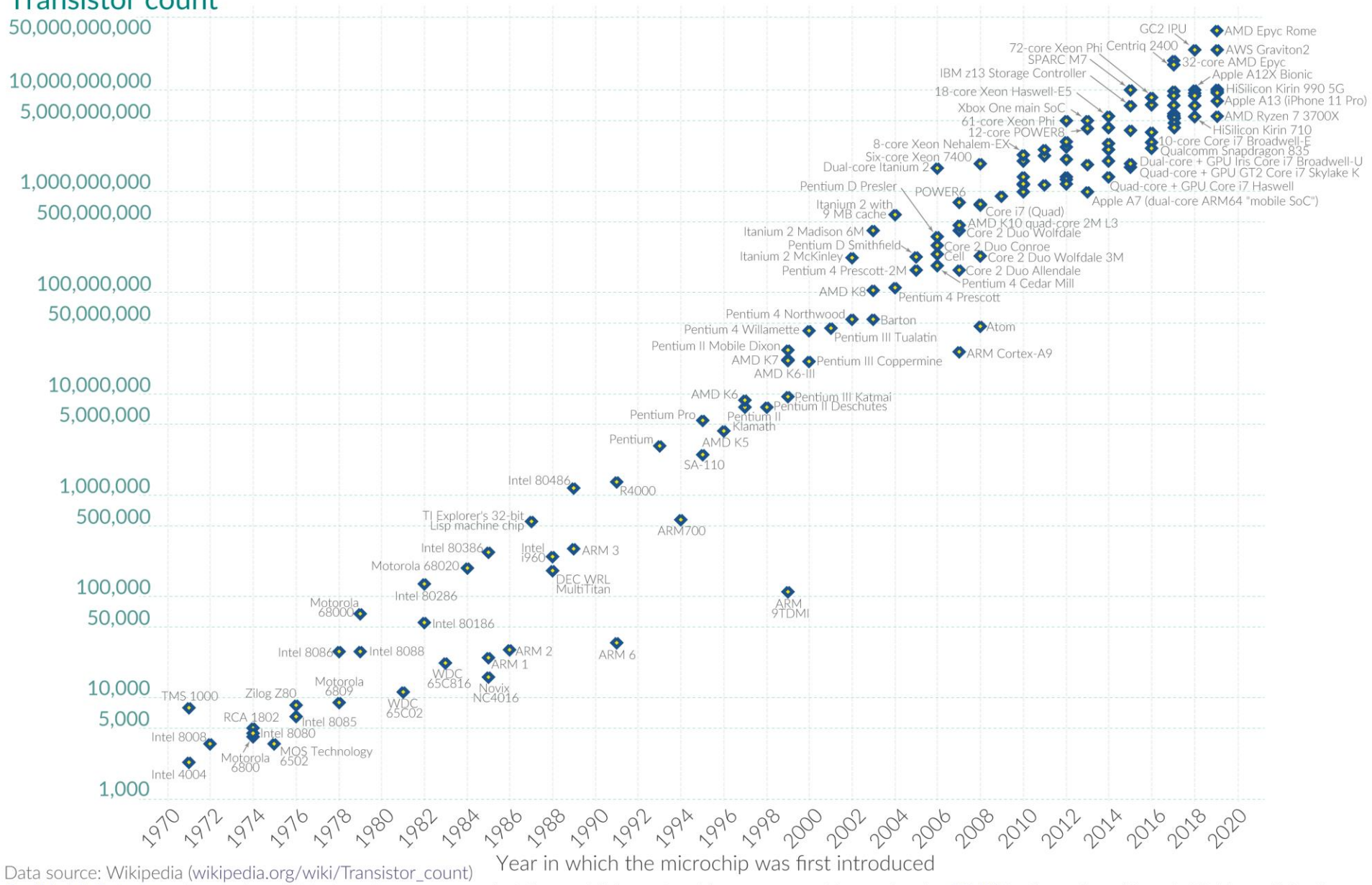
Moore's Law: The number of transistors on microchips doubles every two years

Our World in Data

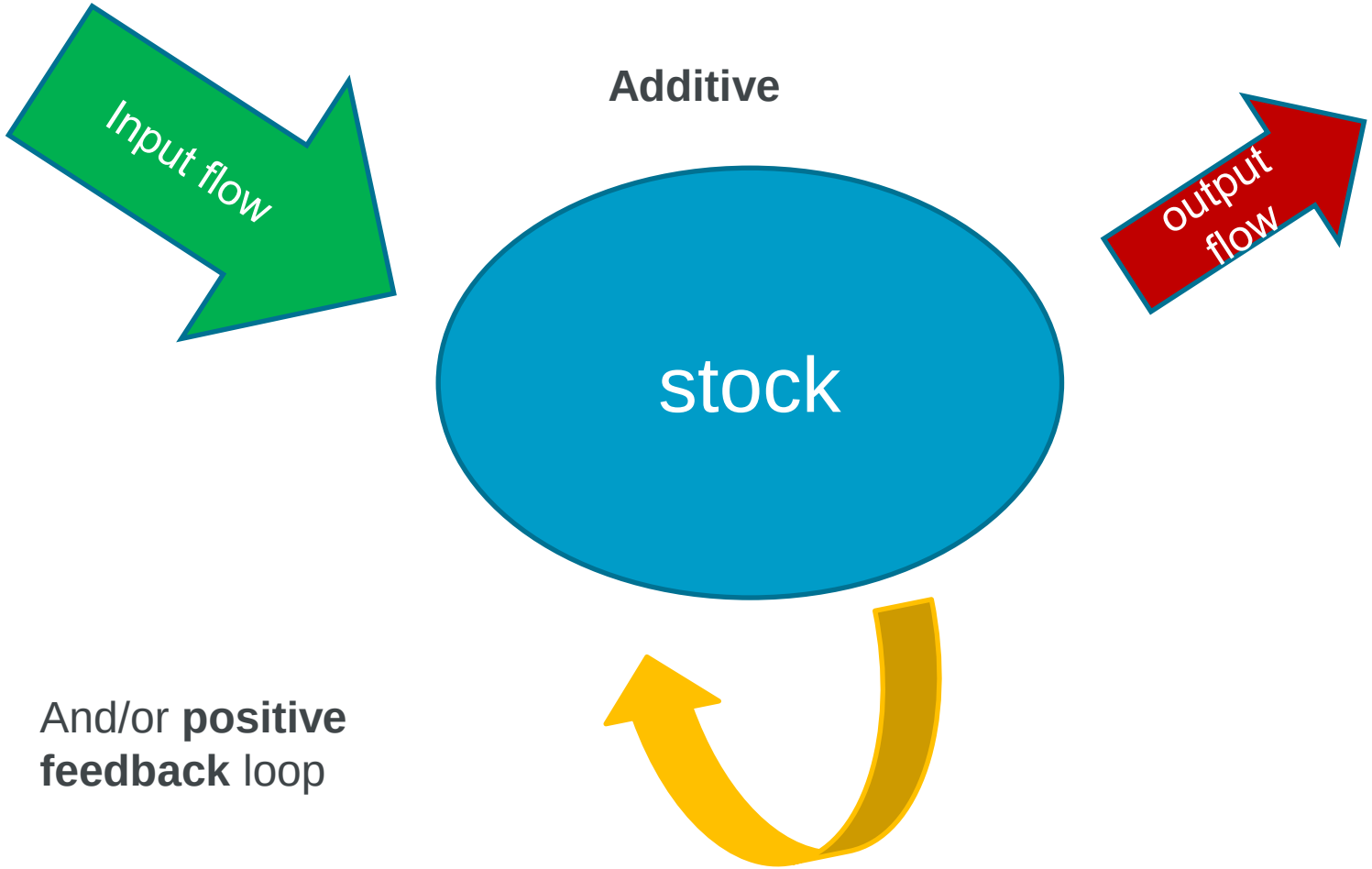
Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important for other aspects of technological progress in computing – such as processing speed or the price of computers.



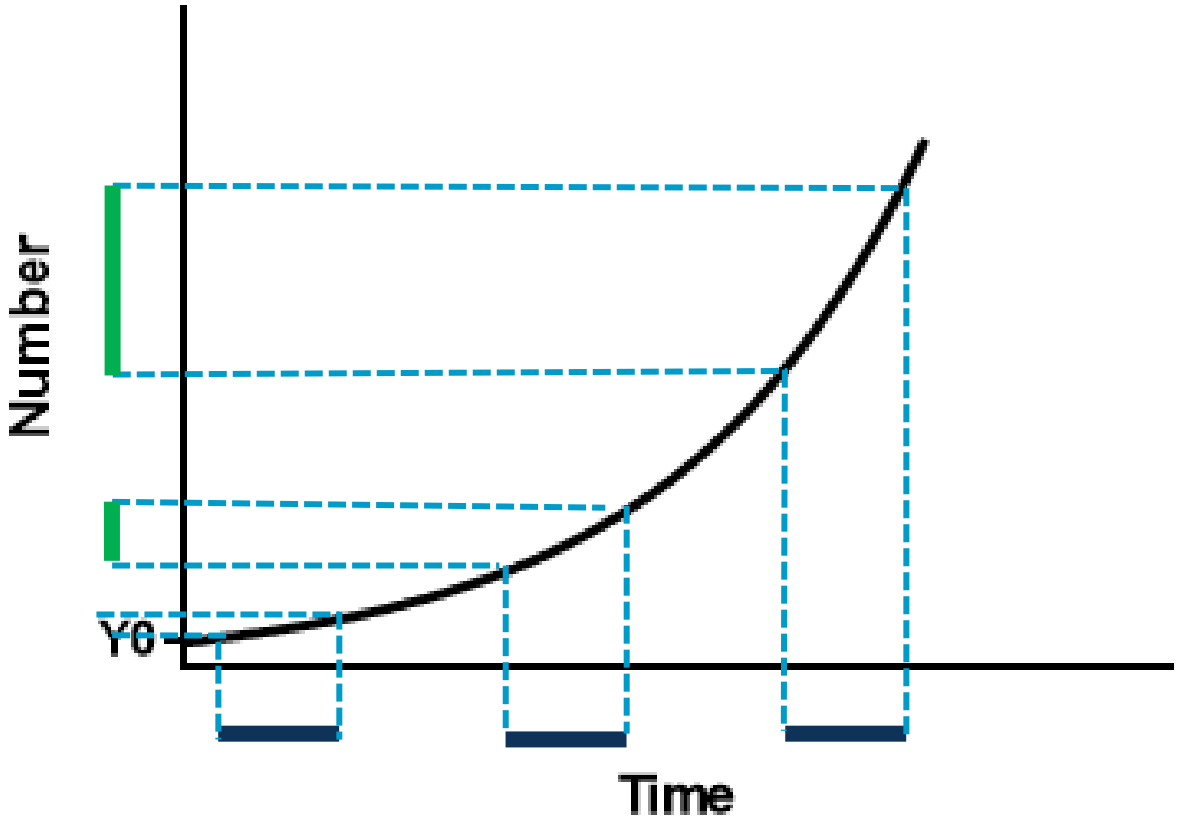
Data source: Wikipedia (wikipedia.org/wiki/Transistor_count)

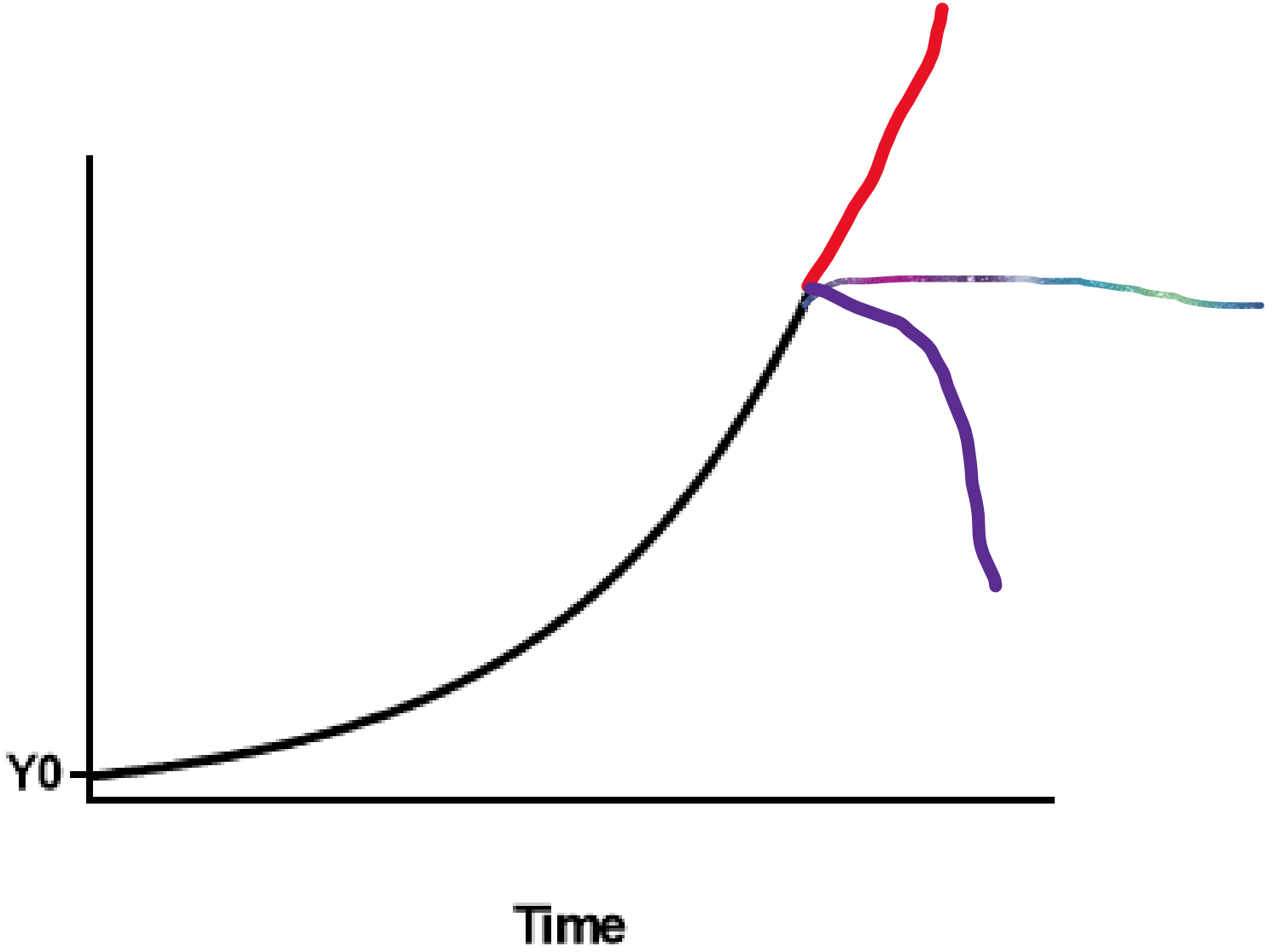
OurWorldinData.org – Research and data to make progress against the world's largest problems.

How does exponential come about?



And/or **positive feedback** loop


Number
Y0
Time


Number
Y0
Time

Exponentials: implications

- Accelerating absolute impact
- Unstable when past inflection point, either:

    Requires either phase change
    J curve
    collapse

- Physical boundary:
    Slow approach
    Rapid cross
- Risk magnifier
- Speed of change > adaptability:

    human psychology
    Institutions
    natural systems

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Infocene v anthropocene

Anthropocene:

humans main impact on planet

Infocene:

Natural world subsumed by human system

Human system actively “in charge” of planet

Determinant factor is information flows and interaction physical world

The Infocene as a complex system

Laws of Thermodynamics

1. The first law, also known as Law of Conservation of Energy, states that energy cannot be created or destroyed in an isolated system.

2. The second law of thermodynamics states that the entropy (disorder) of any isolated system always increases.

So how do these come about?

Complexity – what is it?

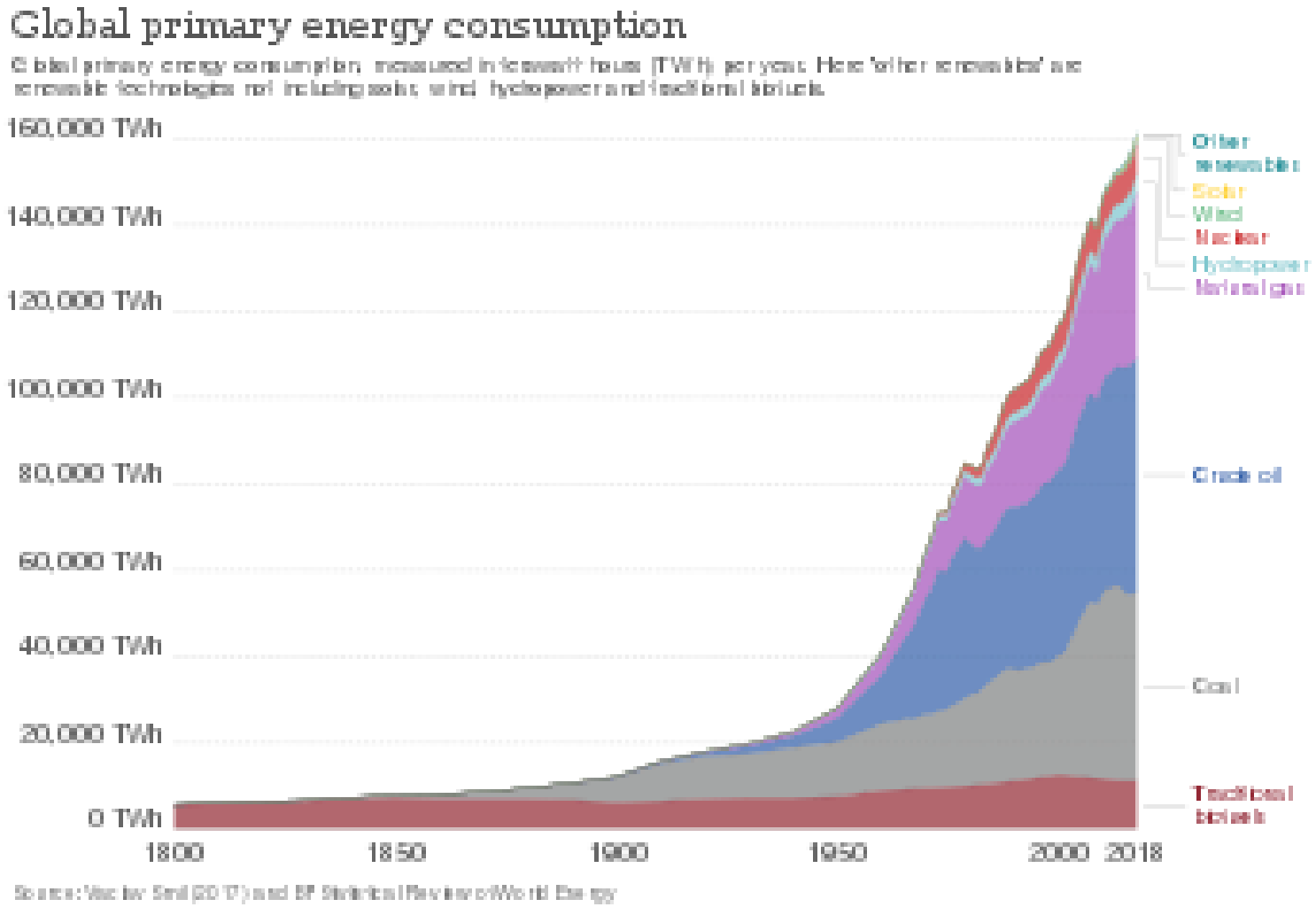
Complexity requires energy to maintain itself as it is not in thermodynamic equilibrium

Open system – takes energy from outside system (eg the sun)

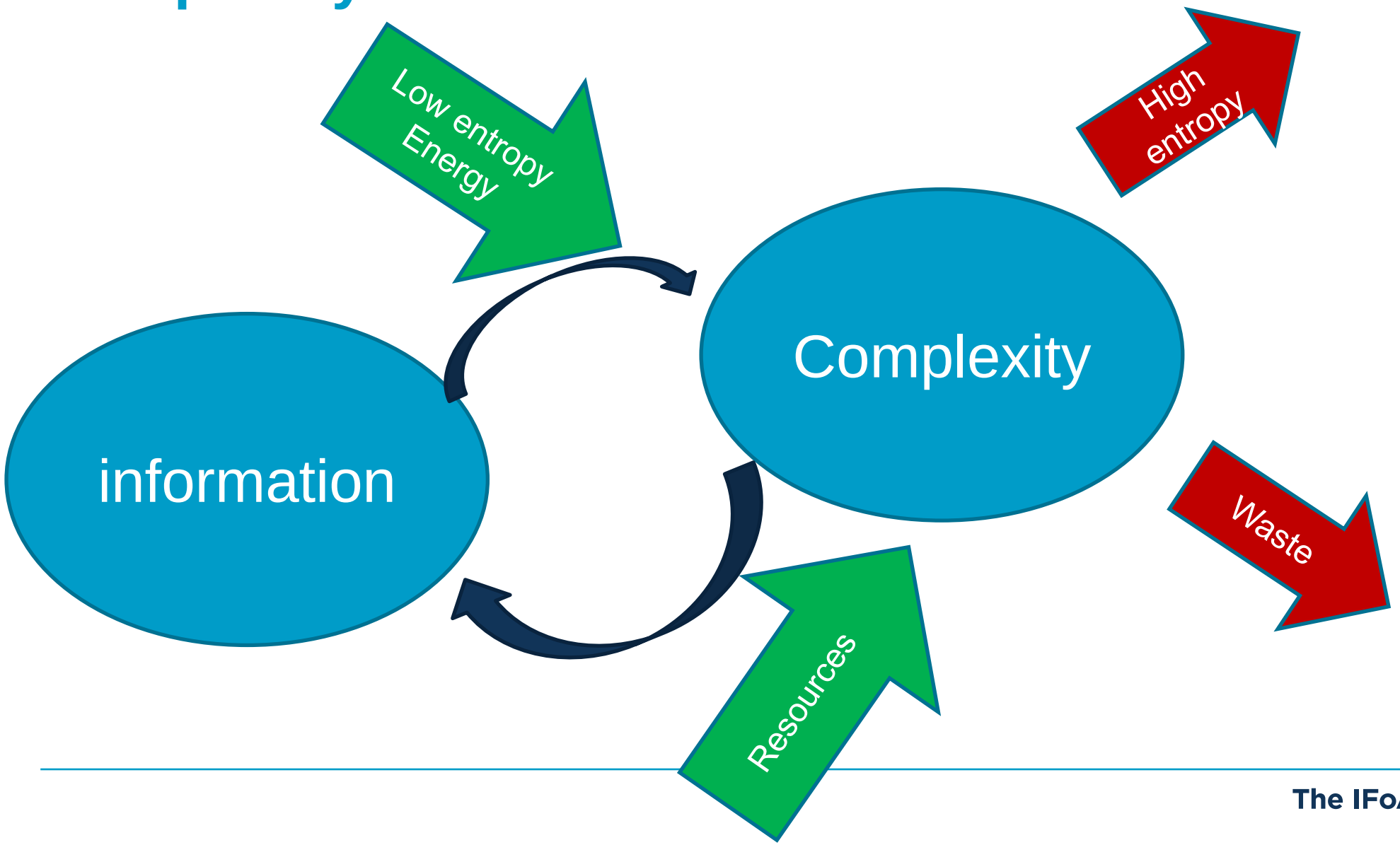
Dissipative structure: takes in low entropy energy and dissipates it as high entropy

Entropy in universe increases

Energy consumption



Complexity and information



The cause of the Anthropocene

- The human system has grown exponentially
- The size of global economy is a proxy for impact on planet
- The use of energy is approx measure of complexity
- Exponential growth in these physical factors are driven by additive properties of information and capital
- The exponential growth overwhelming the functions of biosphere
- Driven by 2nd law of thermodynamics

Complexity and information

Complexity

- many parts where those parts interact with each other in multiple ways, culminating in a higher order of emergence greater than the sum of its parts.
- Measure of a system's ability to dissipate energy (increase **entropy**)

Information

- Information measured in terms of **entropy** – level of uncertainty
- Complex systems higher entropy than simple systems but lower than chaos
- Information embodies history

Infocene – complexity and information

- Human system codifying information within biosphere (including human system itself and universe) and manipulate this information
- Speeds up generation of new information and hence complexity
- Ability to change and control human and natural systems

Infocene – implications

- The exponential growth overwhelming the functions of biosphere
- Acceleration in growth and change outpaces institutions ability to change
- Increasing “risks” without historical data
- Look to infosphere for risk generation and transmission
- Processing power:
  - Novel ability to model complex phenomena
  - Unprecedented power to solve problems generated by infoscene
  - Models themselves impact reality

Implications

- Global risks are endogenous to the human sphere
- Stocks, flows and feedback loops
- Exponential function
- Era of rapid acceleration – natural and human systems
- Phase transition or collapse to become norm
- Complexity generates risk
- Lack of exponential growth unbalance a system (eg economy)
- Humans have to take over natural functions – reformation human sphere

Certainty	Risk	Uncertainty	Radical uncertainty
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“I will die”	probability I will die if I play Russian roulette	I will die as a result of nuclear war	A new technology emerges enable people to live indefinitely

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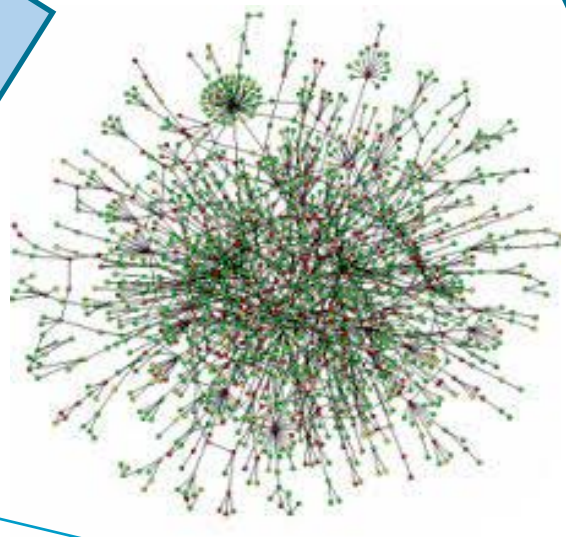
Core skills
Actuarial science
Economic – principles + insights
Risk management
Statistics
Information theory

Soft skills
Working in collaboration
Pluralistic leaning
Shaping policy + markets

Complexity science

Understandin g/insight



Exploration of risk space

Machine learning/AI

Physical sciences
Complexity science
Physics
Biology

Social sciences
Psychology
Anthropology/sociology
philosophy

Practical skills

How to integrate knowledge?

- Conceptual shift: in way we think about modelling
- Collaborative and multi-disciplinary
- Different layers of knowledge required:
  - develop thinking
  - develop tools
  - Practical modelling skills
  - Commercial interaction with clients
- Lots of new knowledge:
  - Currently not familiar with
  - Realistically never be familiar with
- How to decide on what we need
- How to shape change (inside and outside profession)

Back to covid

Anthropocene

- Pandemic is not novel
- Prediction
  1. climate change + biodersity: increased risk zootonic pandemic
  2. Complexity/networks: increase inter-human transmission

Infosphere

- Information tsunami
- Infodemic
- Interaction existing infosphere phenomena
- Transmission information – medical/public health
- Manipulate information – development vaccine/treatment

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Questions

Comments

Expressions of individual views by members of the Institute and Faculty of Actuaries and its staff are encouraged.

The views expressed in this presentation are those of the presenter.

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