



FOUNDATIONS OF SYSTEMS THINKING

Francesco Gonella
Dept. of Molecular Sciences and Nanosystems
gonella@unive.it



| mathematics and computation



MATHEMATICS AND COMPUTATION | INTERVIEW

AI and particle physics: a powerful partnership

12 May 2021 [Tushna Commissariat](#)

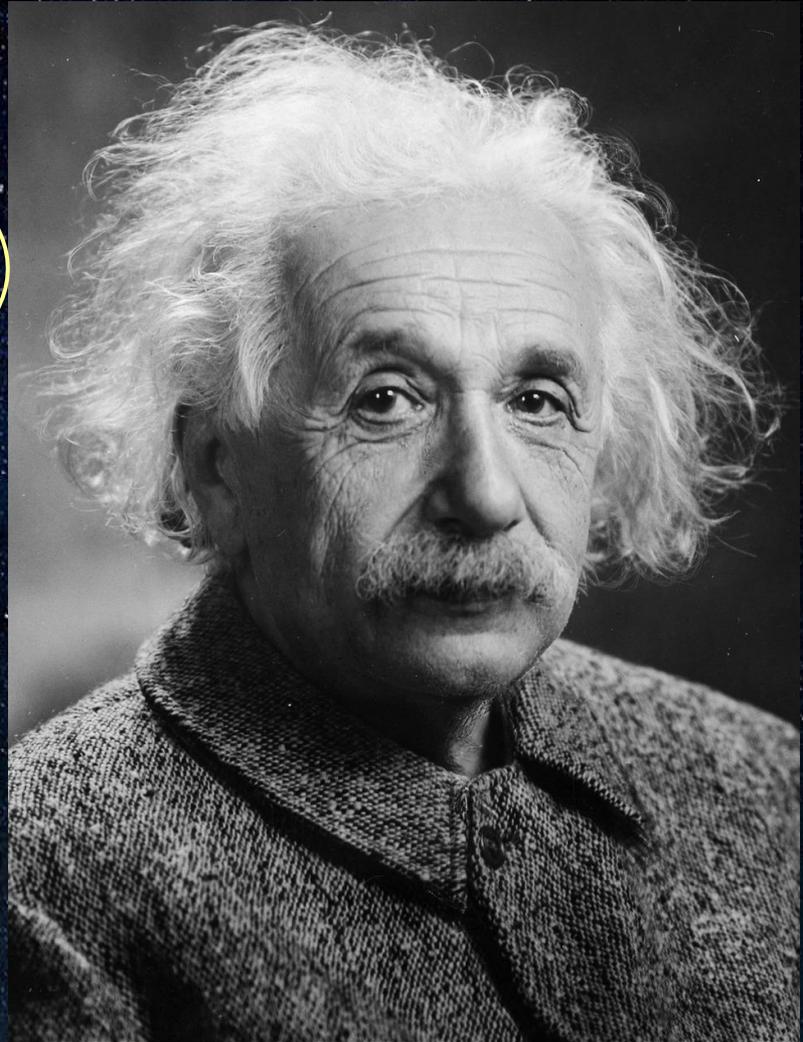
Taken from the May 2021 issue of *Physics World*. Members of the Institute of Physics can enjoy the full issue [via the *Physics World* app](#).

Experimental particle physicist [Jessica Esquivel](#) explores the beneficial collaboration between artificial intelligence and particle physics that is advancing both fields

What are the disadvantages of using AI?

Another disadvantage of particle physicists using AI, as Charles Brown and I wrote in an [online article for *Physics World* last year](#), is the lack of ethical discussions about the impact our work in AI may have on society. It's easy for the particle-physics community to believe the false narrative that the research we do and the tools we develop will only be used for particle-physics research, when historically we've seen time and time again – be it the Manhattan Project or the development of the World Wide Web – that the work we do translates to society as a whole. As US theoretical cosmologist Chanda Prescod-Weinstein says, “I’m talking about integrating into a scientific culture that has accepted the production of death as a tangential, necessary evil in order to gain funding. One that will march for science without asking what science does for or to the most marginalized people. One that still doesn’t teach ethics or critical history to its practitioners.”

The significant problems we face today cannot be solved at the same level of thinking at which they were created



“Significant” problems

**ALL OF THEM
ARE SYSTEMIC
PROBLEMS**



Courtesy by Tuca Vieira

INEQUALITY



POVERTY



CONFLICTS



CLIMATE CHANGE

Consensus of the scientific community worldwide

Warning to Humanity 1
2017 > 15.000 scientists

Warning to Humanity 2
2019 > 11.000 scientists

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World Scientists' Warning to Humanity: A Second Notice ^{PDF}
William J. Ripple, Christopher Wolf, Thomas M. Newsome, Mauro Galetti, Mohammed Alami, Eileen Crist, Mahmoud I. Mahmoud, William F. Laurance, **15,364 scientist signatories from 184 countries**
BioScience, Volume 67, Issue 12, December 2017, Pages 1026–1028,
<https://doi.org/10.1093/biosci/bix125>
Published: 13 November 2017

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Issue Section: Viewpoint

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Twenty-five years ago, the Union of Concerned Scientists and more than 1700 independent

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World Scientists' Warning of a Climate Emergency ^{PDF}
William J. Ripple, Christopher Wolf, Thomas M. Newsome, Phoebe Barnard, William R. Moomaw
Author Notes
BioScience, biz088, <https://doi.org/10.1093/biosci/biz088>
Published: 05 November 2019

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Issue Section: Viewpoint

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Scientists have a moral obligation to clearly warn humanity of any catastrophic threat and to “tell it like it is.” On the basis of this obligation and the graphical indicators presented below, we declare, with more than 11,000 scientist signatories from around the world, clearly and

“Scientists have a moral obligation to clearly warn humanity of any catastrophic threat and to “tell it like it is.” On the basis of this obligation and the graphical indicators presented below, we declare, with more than 11,000 scientist signatories from around the world, clearly and unequivocally that planet Earth is facing a climate emergency.”

MAMMALS BIOMASS IN THE WORLD IS MADE BY:



36% us



60%
animals in captivity
to be eaten



4%
all the rest

“Significant” problems ----->



The result of work by
people with BAs, BSs,
MBAs, and PhDs!



Something gone wrong
with their education

WHAT?

Since one century, huge effort to
solve these problems, by thousands
of intelligent, motivated and
powered decision-makers

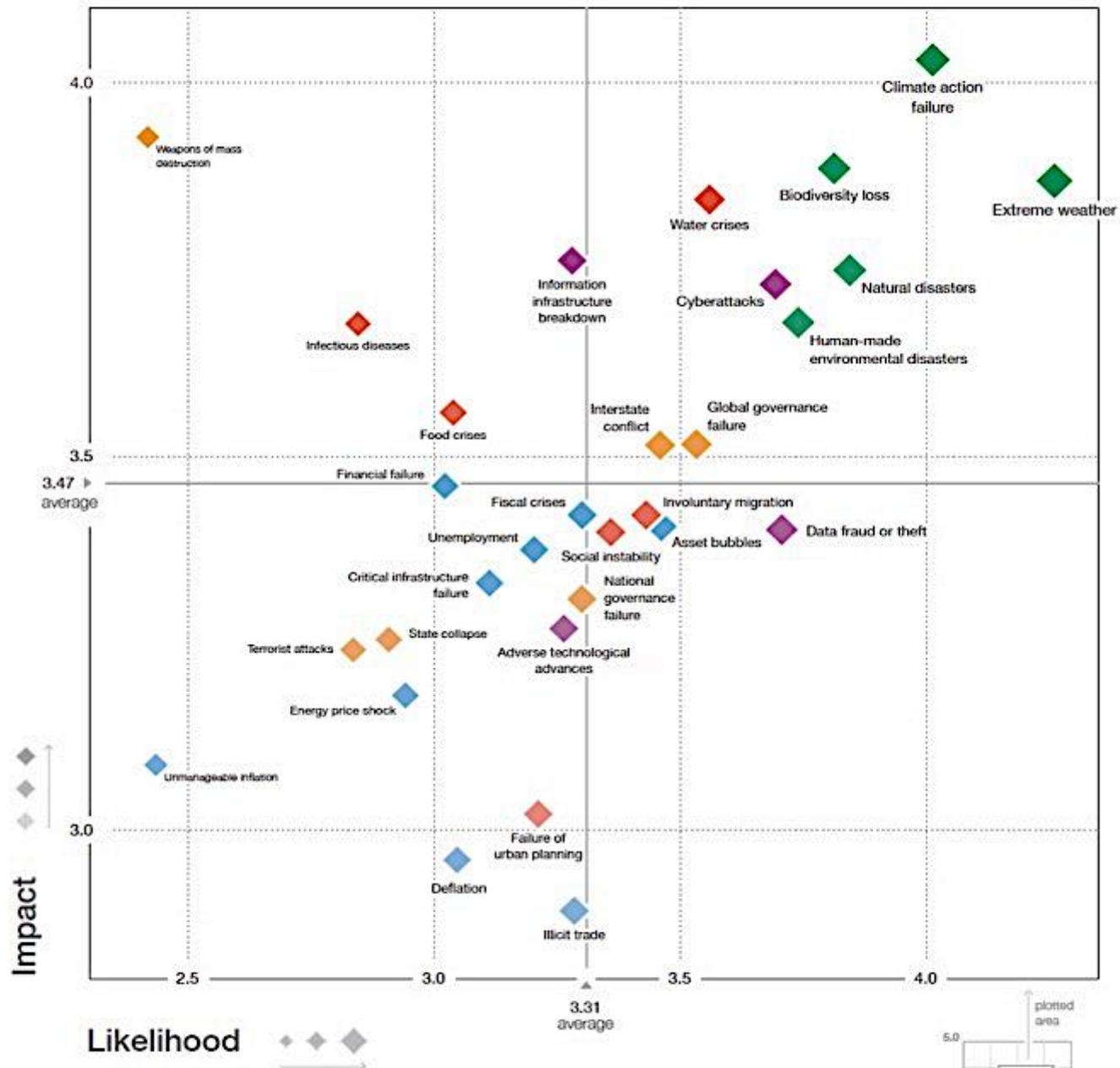


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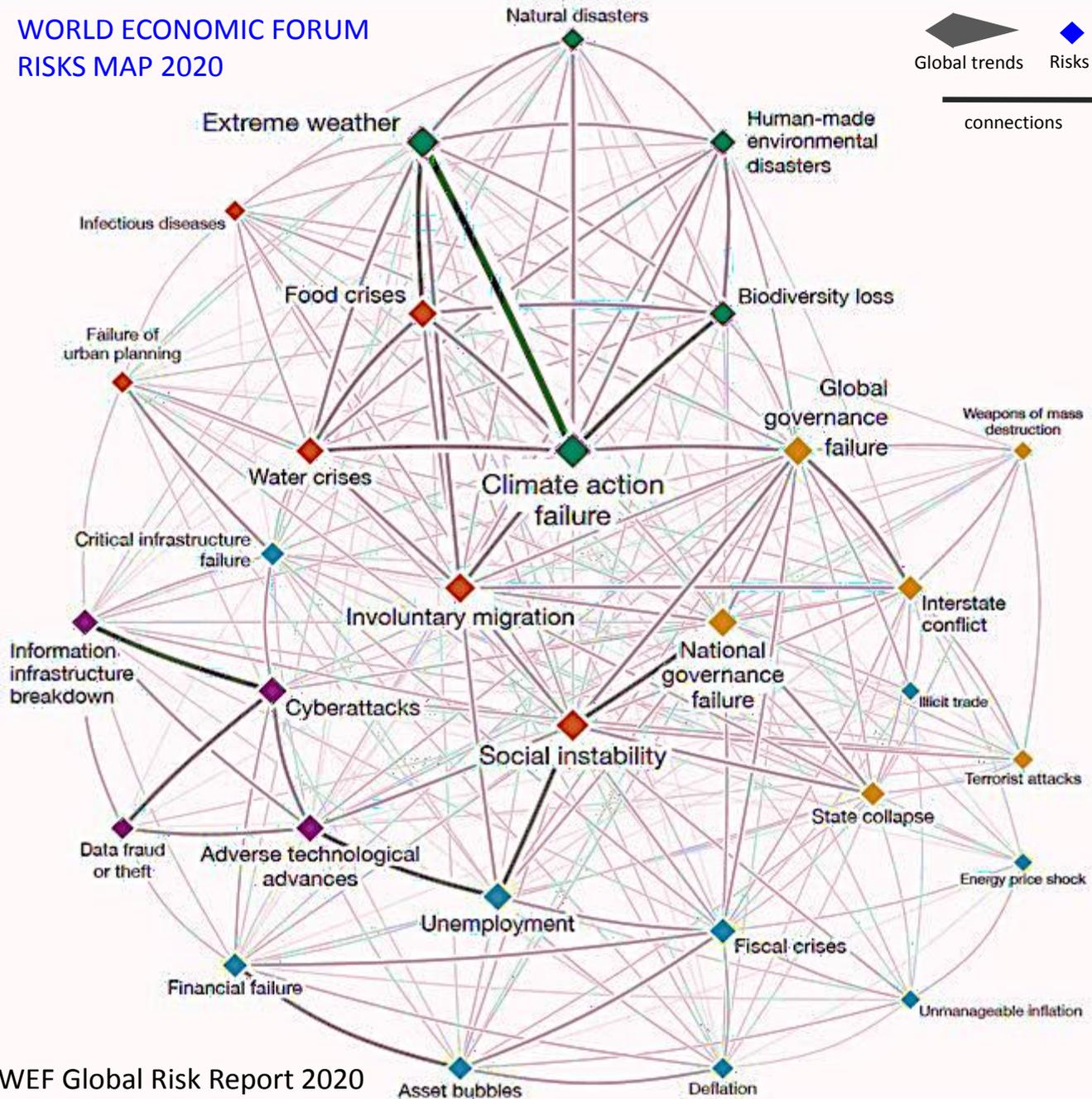
WHY?

*Here is where Systems
Thinking was born*

Figure II: The Global Risks Landscape 2020



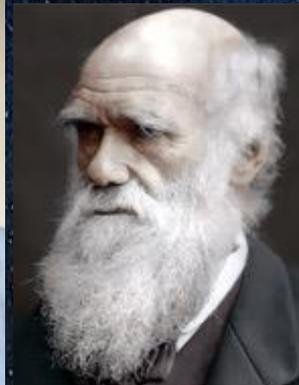
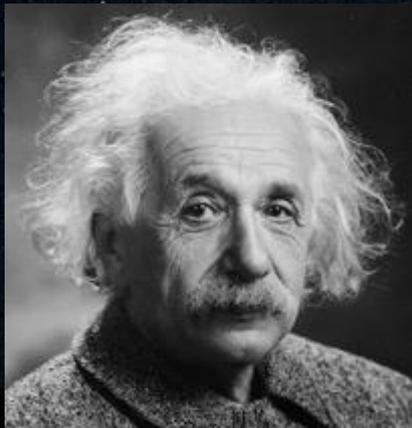
WORLD ECONOMIC FORUM RISKS MAP 2020





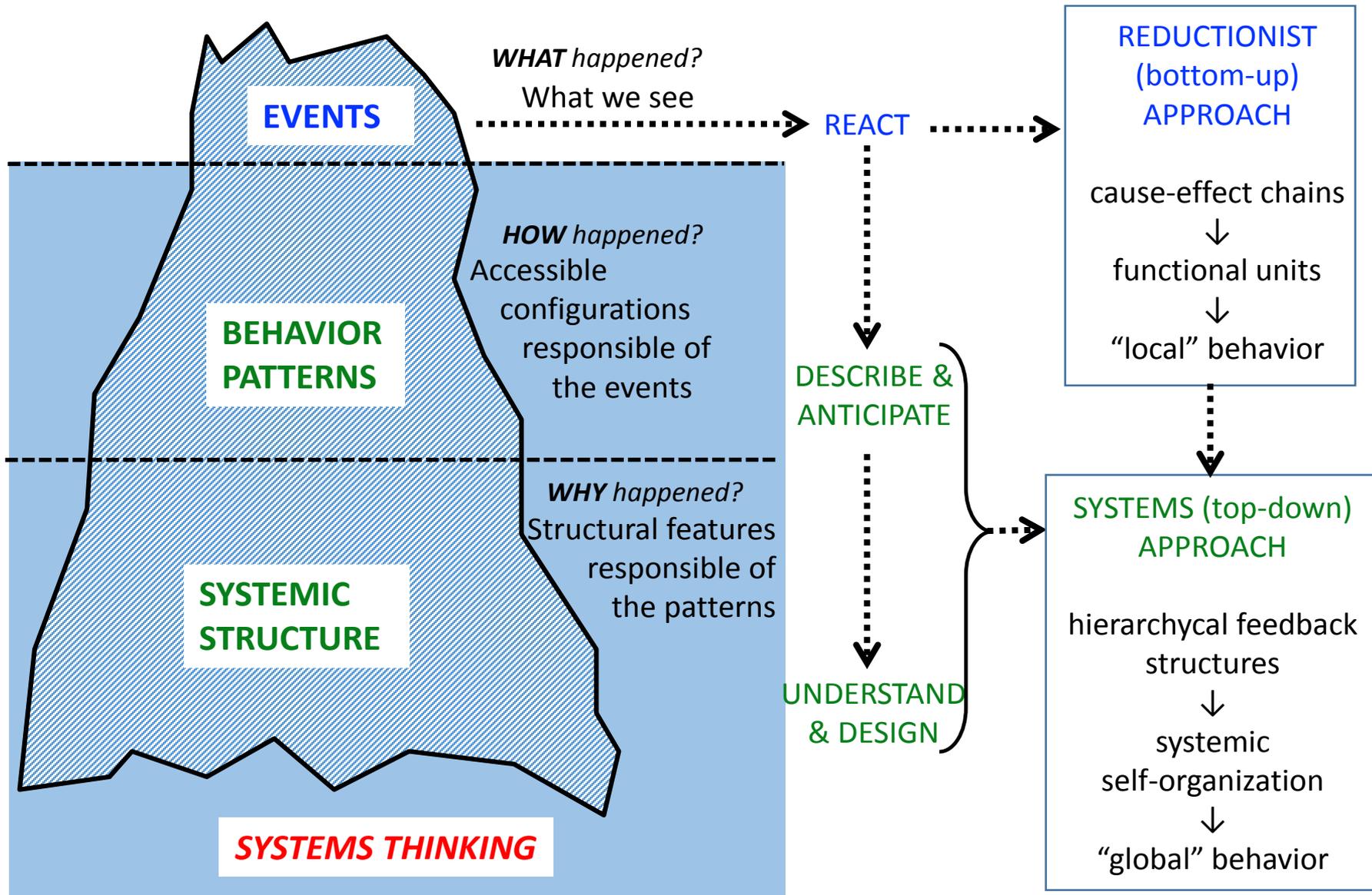
Undesired and unpredicted behaviors of many pieces of the reality around us persist in spite of the analytical ability and technical brilliance that have been directed toward studying and managing them. These pieces are complex systems.

The problems that affect them seem intractable because they are intrinsically systems problems, undesirable behaviors characteristic of the system structures that produce them. We should just stop casting blame, see the system as the source of its own problems, and find the way to restructure and redesign it

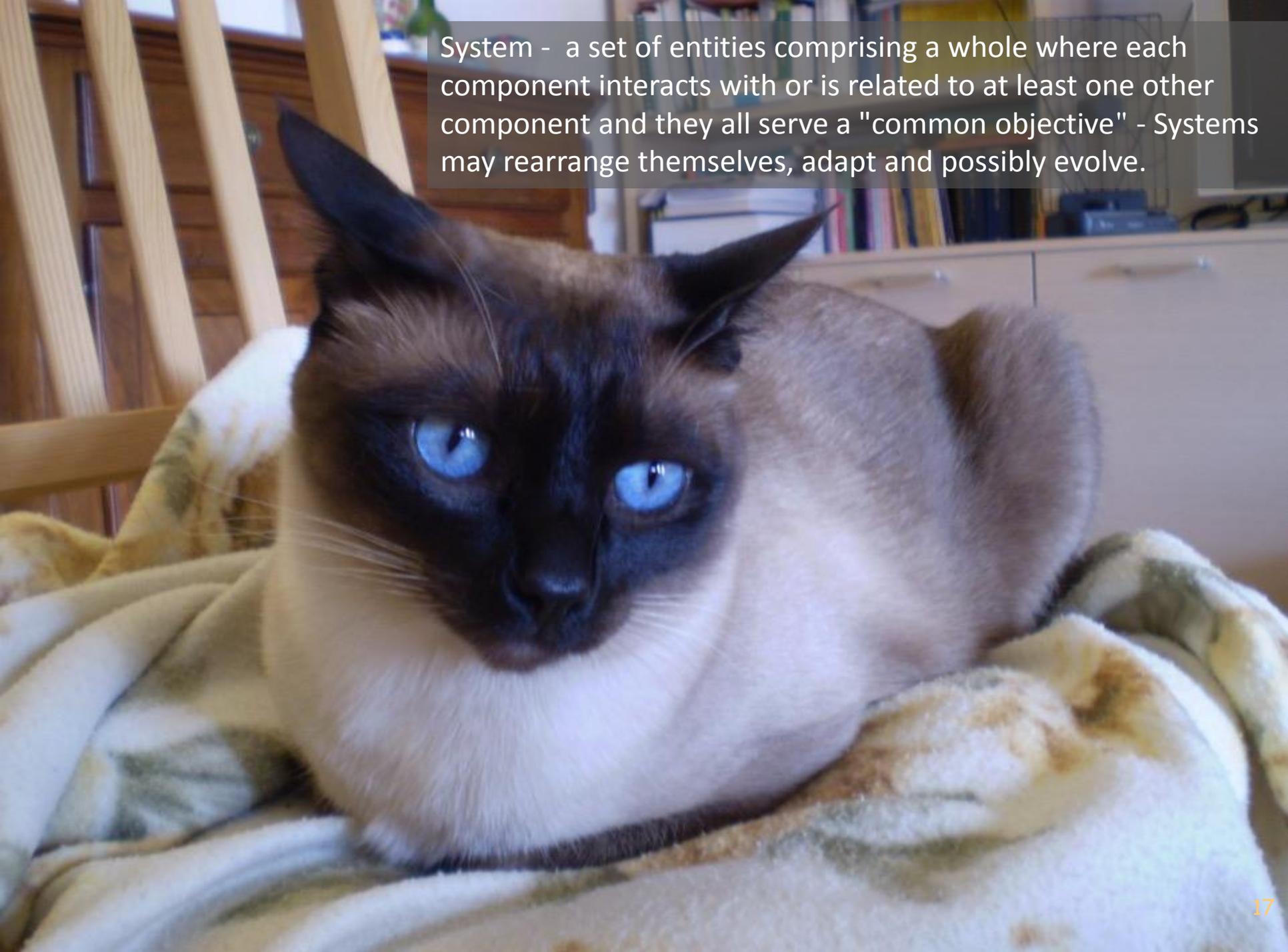


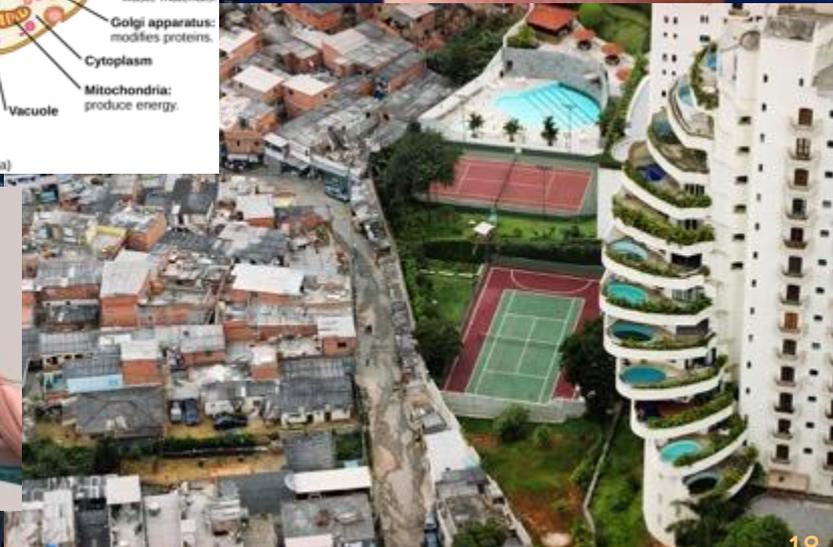
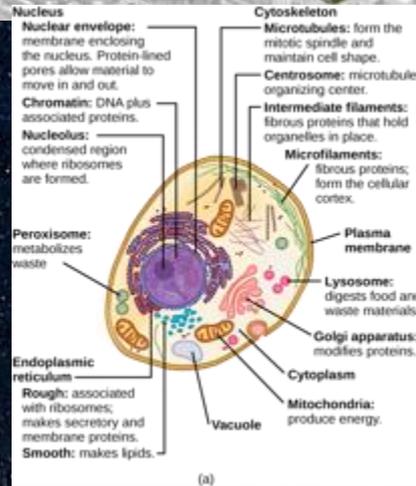
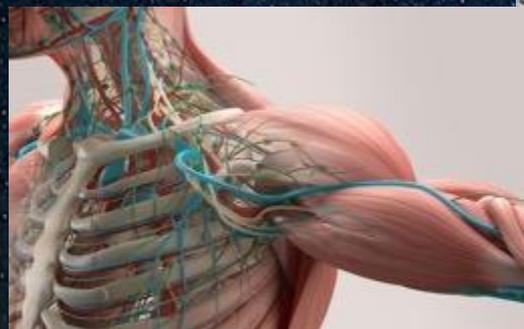


The more complex is the system we are observing
The more what we observe is made of systemic
features, not of isolated events



System - a set of entities comprising a whole where each component interacts with or is related to at least one other component and they all serve a "common objective" - Systems may rearrange themselves, adapt and possibly evolve.





SYSTEM	MAIN OUPUT	“CUSTOMER”	PURPOSE
Forest	Organic matter	Itself	Surviving
Theater company	Realize plays and performances	Spectators	Realizing profit
Public Hospital	Healed or dead people	Society	Providing a social service
Public University	Educated people, Research	Society	Providing a social service
Private University	Diplomas, Research	Students	Realizing profit
LHC	Data	Scientific community	Developing and testing theories
CERN	Knowledge	Society	Understanding, culture (technology)

SYSTEM

A system is a set of things interconnected in such a way that they produce their own pattern of behavior over time. It may be driven by external forces, but its response is characteristic of itself, and typically non-linear. The aggregate activity of its components typically exhibits self-organization under selective pressures

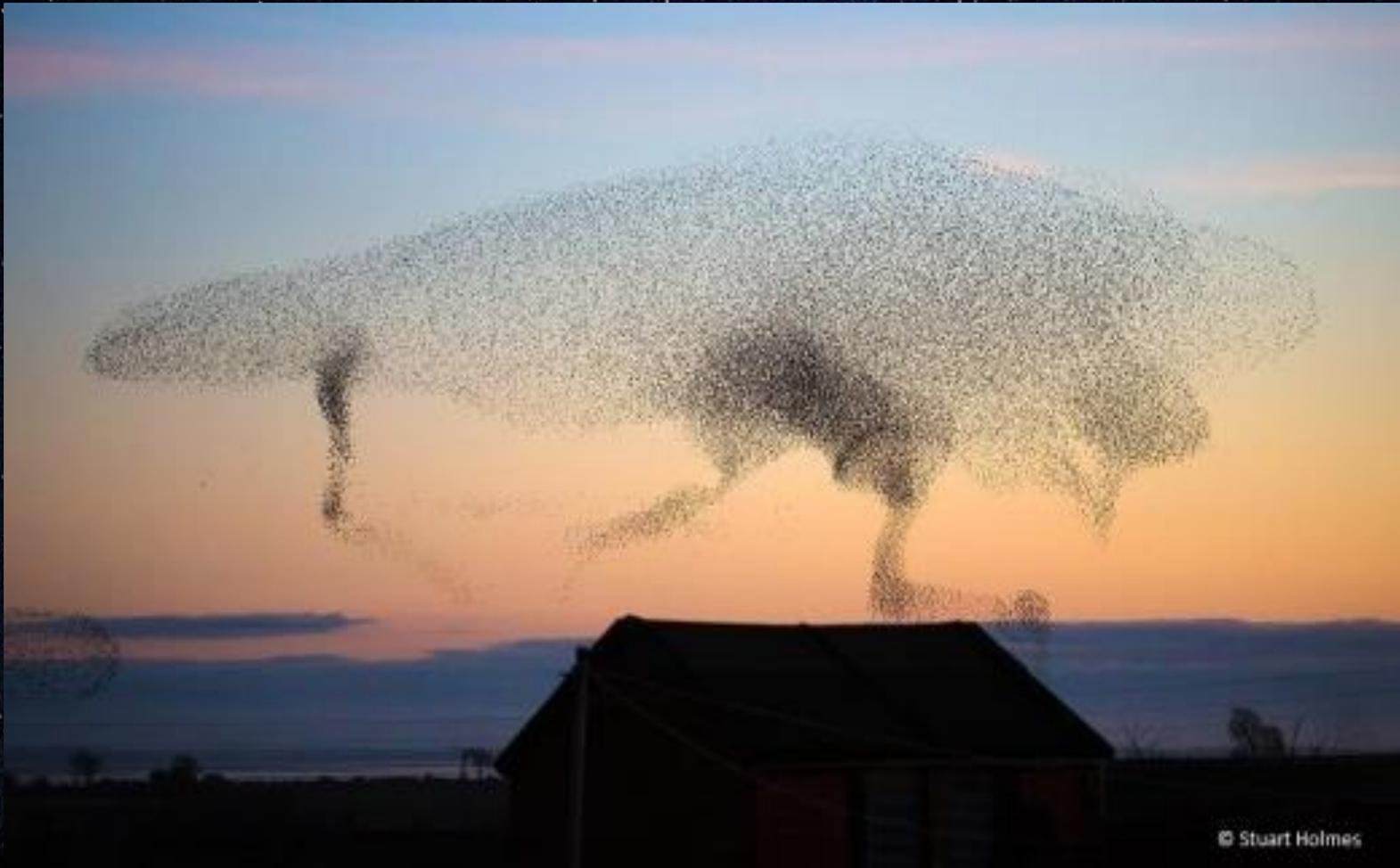
Two basic features

SELF-ORGANIZATION

FEEDBACKS NETWORK

SELF-ORGANIZATION

A property of **complex systems**. Interacting components creating a network of **feedbacks** exhibits **self-organization** under selective pressures



SELF-ORGANIZATION

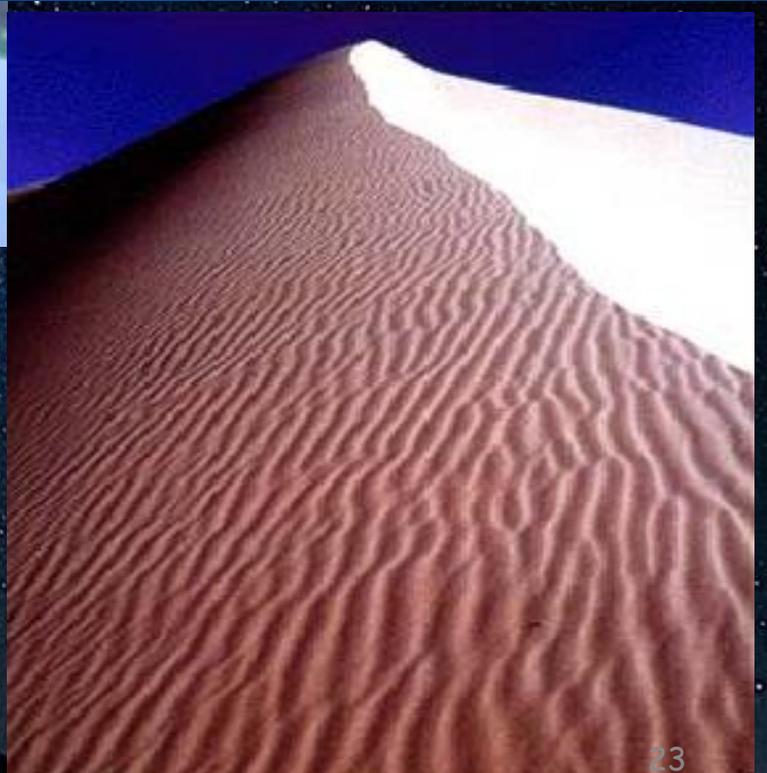
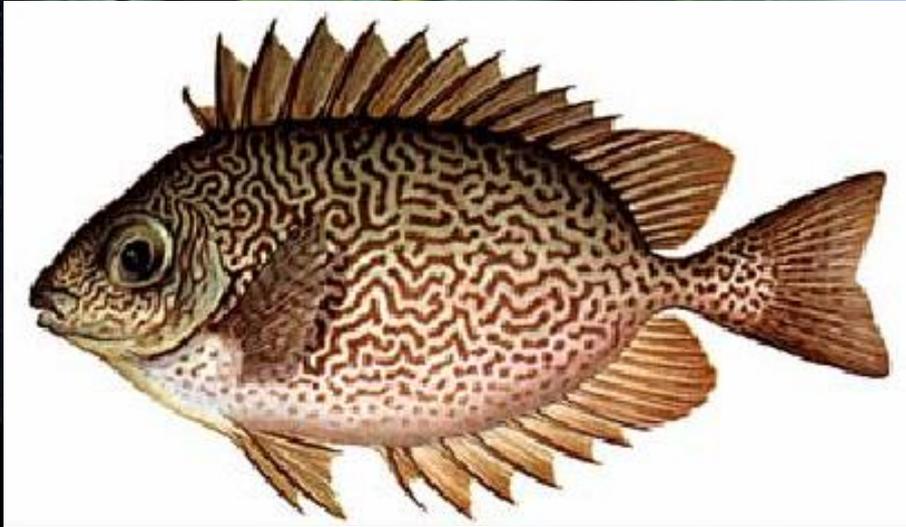
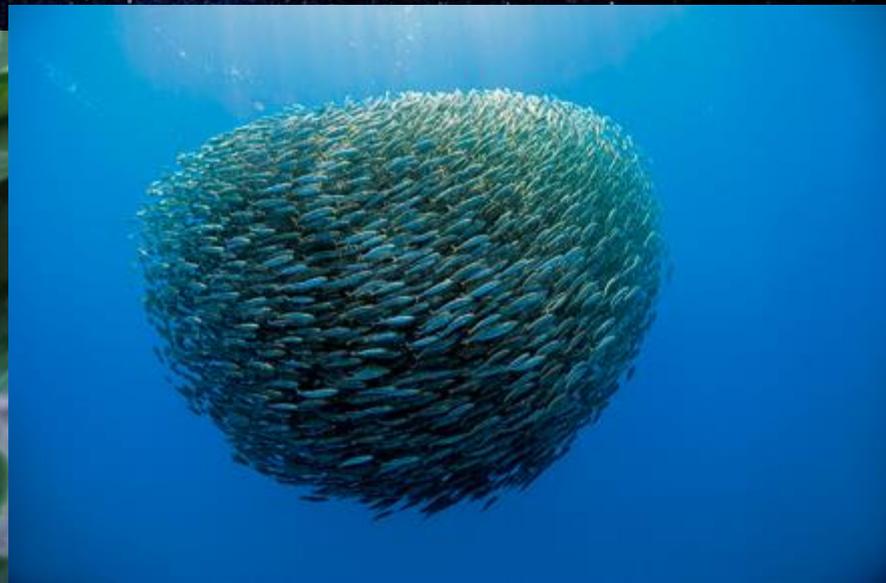


emergent phenomena



Interconnections and feedbacks allow the system to self-organize and develop collective behaviors

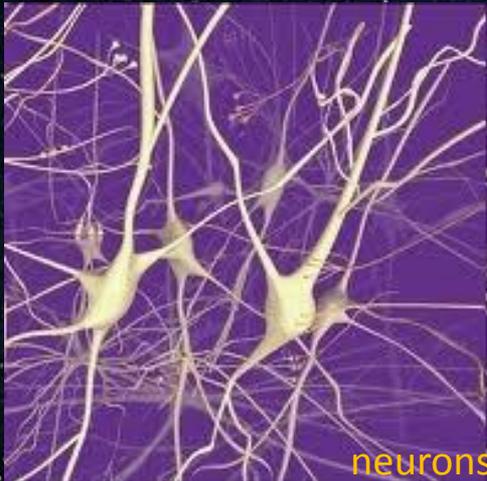
Even without a centralized hierarchical control, a self-organization pattern may emerge, through a selective mechanism



A complex system is one such that the **language** for describing its behavior cannot use the same lexical set used for describing its components



individuals → → society



neurons → → thinking brain



"What prevents us from overcoming policy resistance is not a lack of resources, technical knowledge, or a genuine commitment to change. What thwarts us is our lack of a meaningful Systems Thinking capability. (...) That is the real purpose of system dynamics: to create the future we truly desire - not just in the here and now, but globally and for the long term".

J.D. Sterman, director of the MIT System Dynamics Group