



Binghamton University

EngiNet™

State University of New York



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Media Production Operator: **TBA**

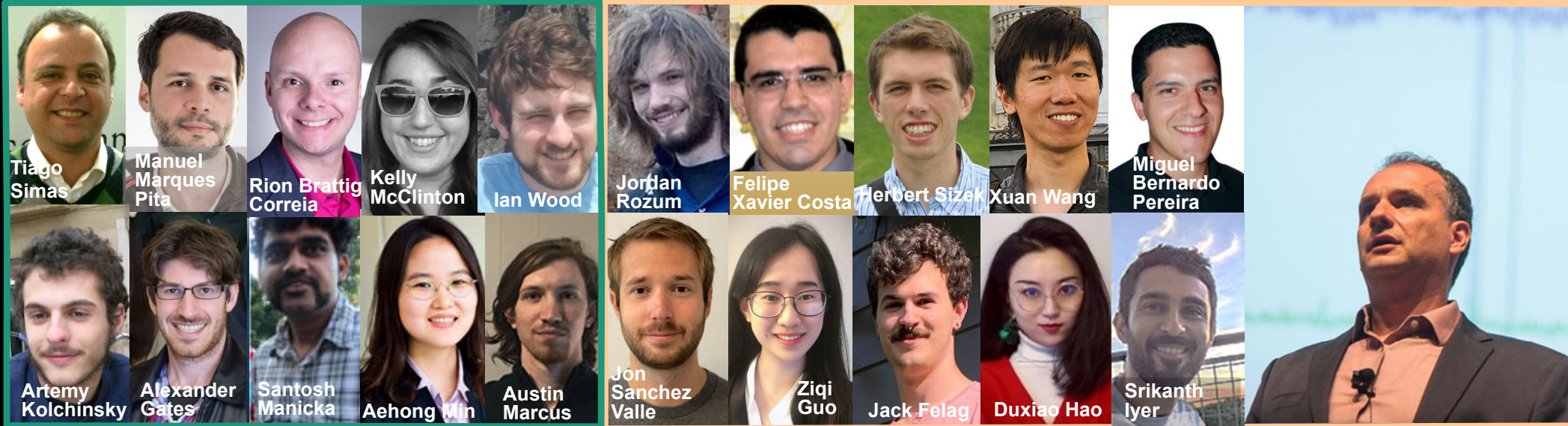
Instructor: Prof. **Luis M. Rocha**

Email: rocha@binghamton.edu

Phone: 607-777-5934

TA: **TBA**

evolutionary systems and bio-inspired computing



luis m. rocha

what I do



PERSISTENT



Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR



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CATOLICA
BIOMEDICAL RESEARCH CENTRE



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Complex adaptive systems and computational intelligence (casci lab)

Resources

- web page
 - casci.binghamton.edu/academics/i-bic/
- online class
 - [Link on Brightspace](#)
- blog: life inspired
 - life-inspired.blogspot.com
- Brightspace
 - <https://brightspace.binghamton.edu/d2l/home/412760>

SSIE-501/ISE-440 - Fall 2024

luis m. rocha



Teaching Assistant



bit.ly/atBIC

office hours:
TBA????

office hours:

thursdays 9:00- 11:30am, EB S04
[binghamton.zoom.us/my/luismrocha](https://binghamton.zoom.us/j/7105123456)



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CATOLICA
BIOMEDICAL RESEARCH CENTRE

BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK



integrating and analyzing multiomics data

social media data pipelines for biomedicine



a

b

X likes

anonymous_user Finally allowed 7 days of meds as opposed to 3 days! Woof! That makes things a bit easier. I'm feeling poorly today (I start of a **suprapubic cath** injection. I hate this! Silly body. #surpatent #recovery #medication #estrone? #quetiapine #pc #flowers #catheter #injection

1 DAY AGO

Y likes

anonymous_user Toothaches suck!!! I love my Simons cat hot water bottles! I have been truly struggling today. I woke up this morning not wanting to move or be alive. But now I'm ok! Bloody head. #bpd #borderline #low #depressed #depression #suicide #suicidal #moodswings

1-2 DAYS AGO

Add a comment...

c

X likes

anonymous_user Classic I know but I look at it everytime I feel extra lonely in this **addiction** snit hole. #addiction #addictorsreal #anxiety #anxiety

1 DAY AGO

Add a comment...

anonymous_user All that #painmeds just for a wisdom tooth extraction #dental surgery #ibuprofen #oxycodone #amoxicillin #painmeds #nochoice

1 DAY AGO

Add a comment...

anonymous_user A few months ago I did the self-assessment and got 70/100 for both **anxiety** and **depression**, labeled as "cause for concern" because it was so high (30 is what's considered a "normal" level). Took it again today and am so proud of how far I've come :) #doodogram #anxiety #depression #calaisorain #therapy #selfimprovement #happiness #success #inspiring :)

1 DAY AGO

Y likes

anonymous_user **Grasparit**, anyone? My **mood stabilizers** have a warning on label that says DO NOT EAT **PINK GRAPEFRUIT**. Here they sit, tempting me on the counter.

1 DAY AGO

Add a comment...

d

Anonymous User @Twitter

To all my followers. If I start making NO sense at all remember I've taken 2 painpills (**Oxycodone 15**) and my 2 sleeping pills (**Ambien 10**)

12:00 pm · 01 Jan 20XX · Twitter Web Client

Anonymous User @Twitter

that **percocet** knocked me out...feeling kind of **woozy** but I'll wait to eat until I take more

12:00 pm · 01 Jan 20XX · Twitter Web Client

Anonymous User @Twitter

I had **valium** for the first time last week: that was nice. It didn't help with **pain** but it made me not care.

12:00 pm · 01 Jan 20XX · Twitter Web Client

Anonymous User @Twitter

maybe **diazepam** can solve my problem though can't cure my illness **backpain**

12:00 pm · 01 Jan 20XX · Twitter Web Client

Anonymous User @Twitter

Ambien is hysterical. [...] Let your Dr know if you're driving while sleeping to go to [...]. #zoinks!

12:00 pm · 01 Jan 20XX · Twitter Web Client

Anonymous User @Twitter

diazepam...valium...tarnazepam...lithiumect...hrt...how long must I stay on this stuff?please don't give me more.

12:00 pm · 01 Jan 20XX · Twitter Web Client

e

4,000mg Keppra

Topic: Medication Issues

I am 23 and have **partial complex seizures** about 4-5 days a week and am currently controlling them with **Zonisamide**, **Vimpat**, **Phenobarbital** and **Keppra**. While I'm reading these forums, I see very low doses of these medications. I would obviously not like to stay on these medications forever and like to think a wean schedule is possible eventually, but I am currently on 2,000mg of **Keppra** twice a day. I just wanted to know if anyone else was on this high of a dose had any issues.

4 Comments

Subscriber · FDS

Joe Community Power User

While I do not know how long you have been taking and dosing with **Keppra**, I do know about taking several medications. My questions is: have you asked your neurologist about this issue? I took 3-750 mg **Keppra** along with 2-200 mg **Viagra** in morning and at night [...]. I haven't had any issues and your assumption or worrying needs to be looked at realistically. Can as people take the same amount of any medication? [...] Each person is different and their needs are different. Which means that their medications dosages can and do vary. At one time I was taking **Prozac**, **Citalopram** and **Sertraline**. The new neurologist I had to get asked me how I woke up in the mornings. His statement was followed by "since you take enough **Keppra** to put the average man to sleep for 24 hours, do so discuss this issue with your neurologist and ask about other medication or procedures that can help control your seizures.

Like · Reply · Share · 2 replies · 1 day ago

Mary

I'm on 1500mg **Viagra**, 200mg **Zonisamide**, 40-80mg **Viagra** and 2,000mg **Keppra** - all of these twice a day. I've been taking these medications for 4 years. I understand everyone's different, I've just been seeing very low doses on here and didn't know how normal it was for me to be on this much **Keppra**. Let alone this many medications.

Like · Reply · Share · 1 reply · 1 day ago

Joe Community Power User

each person is different therefore the amount a medication they take can vary. On and I have always needed higher dosages than most people take. If your doses are 2 times a day please make sure the doses are as close to 12 hours apart. That way it keeps the therapeutic levels where they need to be in order to stop break thru **seizures**. Also if your dosage hasn't changed in some time then discuss your issue with your neurologist. They may want to change your meds to newer meds with fewer side effects. Also understand that too much medication is just as bad as too little medication.

Like · Reply · Share · 1 day ago

Aona

I was placed on 1 believe 2000 mg of **Keppra** 2x a day a few years ago but didn't take any other meds along with that amount of **Keppra**. I don't remember trying any other the other meds that you mentioned other and I didn't get relief from thousands of **seizures** until a major surgery in May of 2012.

Like · Reply · Share · 1 day ago

Min et al [2023]. *CHI* 2023. 32.

Wood, Correia, Miller, & Rocha [2022]. *Epilepsy & Behavior*. 128: 108580.

Correia, Li & Rocha [2016]. *PSB*: 21:492-503.

Ciampaglia, et al [2015]. *PloS ONE*. 10(6): e0128193.

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Correia, Wood, Bollen, & Rocha [2020]. *Annual Review of Biomedical Data Science*, 3:1.

Wood, Varela, Bollen, Rocha & Sá [2017]. *Scientific Reports*. 7: 17973.

social media data pipelines for biomedicine



1 Social Media for Public Health Monitoring a scientific app.

The knowledge network represents how the terms in the dictionaries co-occur in the timelines. Terms that always occur together will be linked and closer to each other in the network.

project: **Opioids (Fentanyl & Oxycodone)**

network: **7 days**

Node & Edge Information:

Node: Warfarin
Type: drug

Source: Phytonadione
Type: drug

Target: Warfarin
Type: drug

Proximity: 0.11764705882352941

DDI ✓ ADR ✗ DI ✗

Timelines contributing to this edge: [View](#)

Visualization:

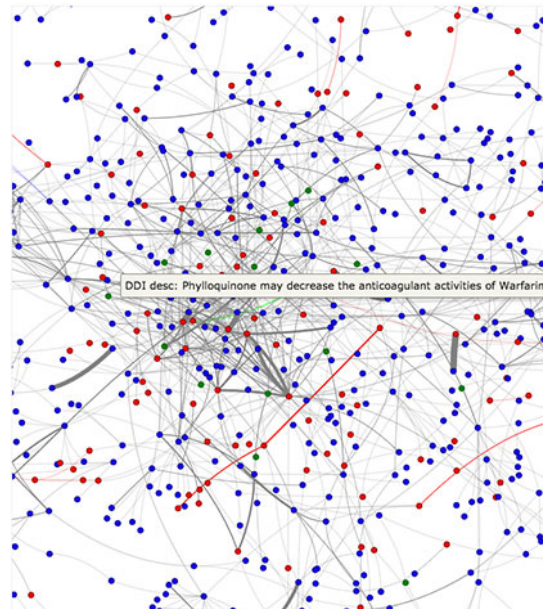
Search: Abasia [Locate](#)

☒ Drugs ☒ Symptoms
☒ Nat. Prod. [Remove orphans](#)

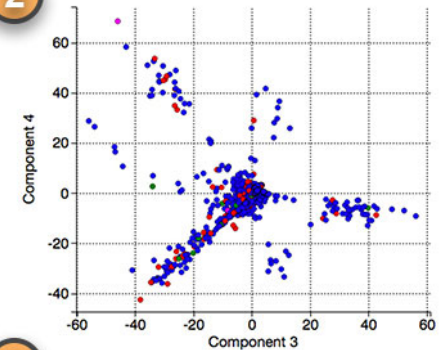
☒ Drug→Drug ☒ Nat. Prod.→Nat. Prod.
☒ Symptom→Symptom
☒ Drug→Symptom ☒ Drug→Nat. Prod.
☒ Nat. Prod.→Symp

☒ Network Layout (simulation) [Run!](#)

Selected nodes: 0

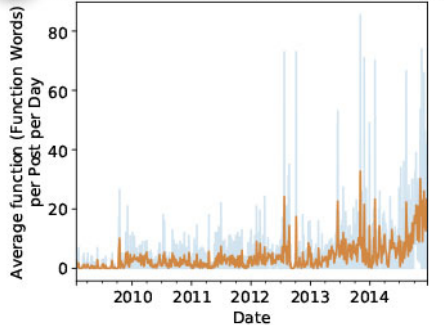


2



3

function (Function Words) for User: subject2



Min et al [2023]. *CHI 2023*. 32.

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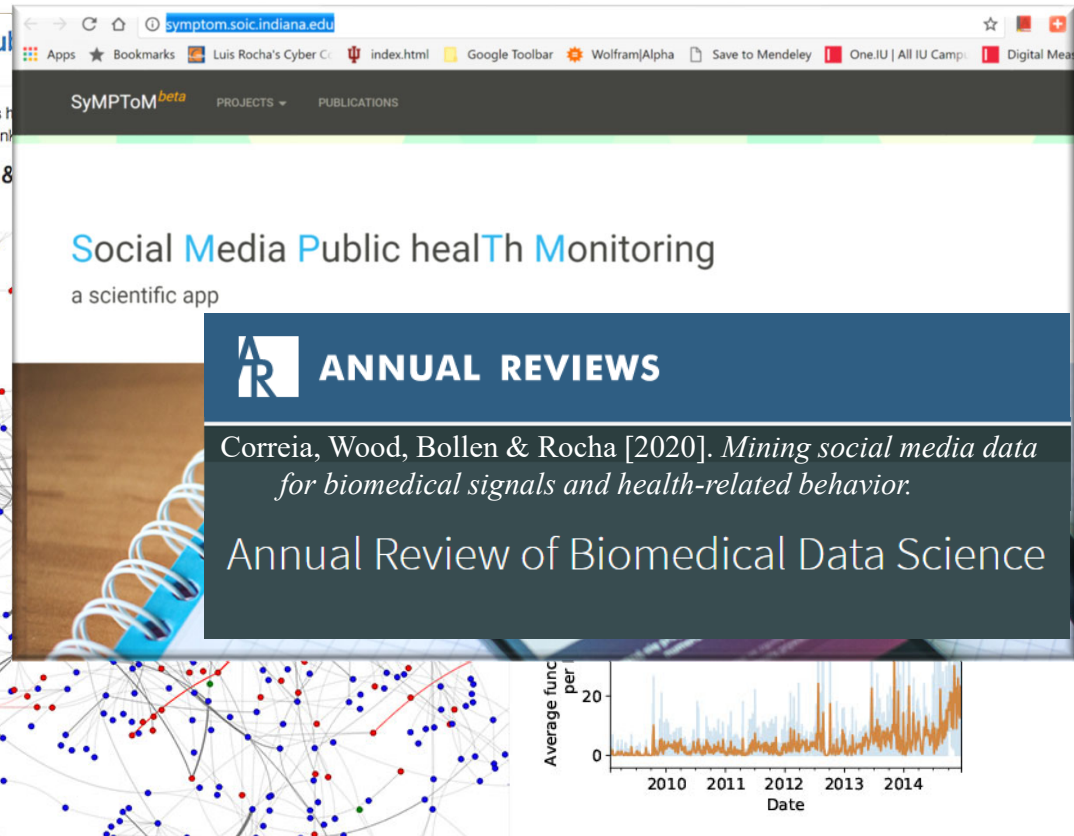
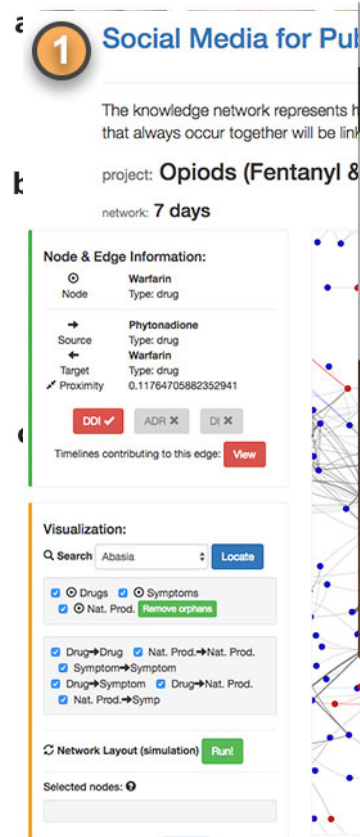
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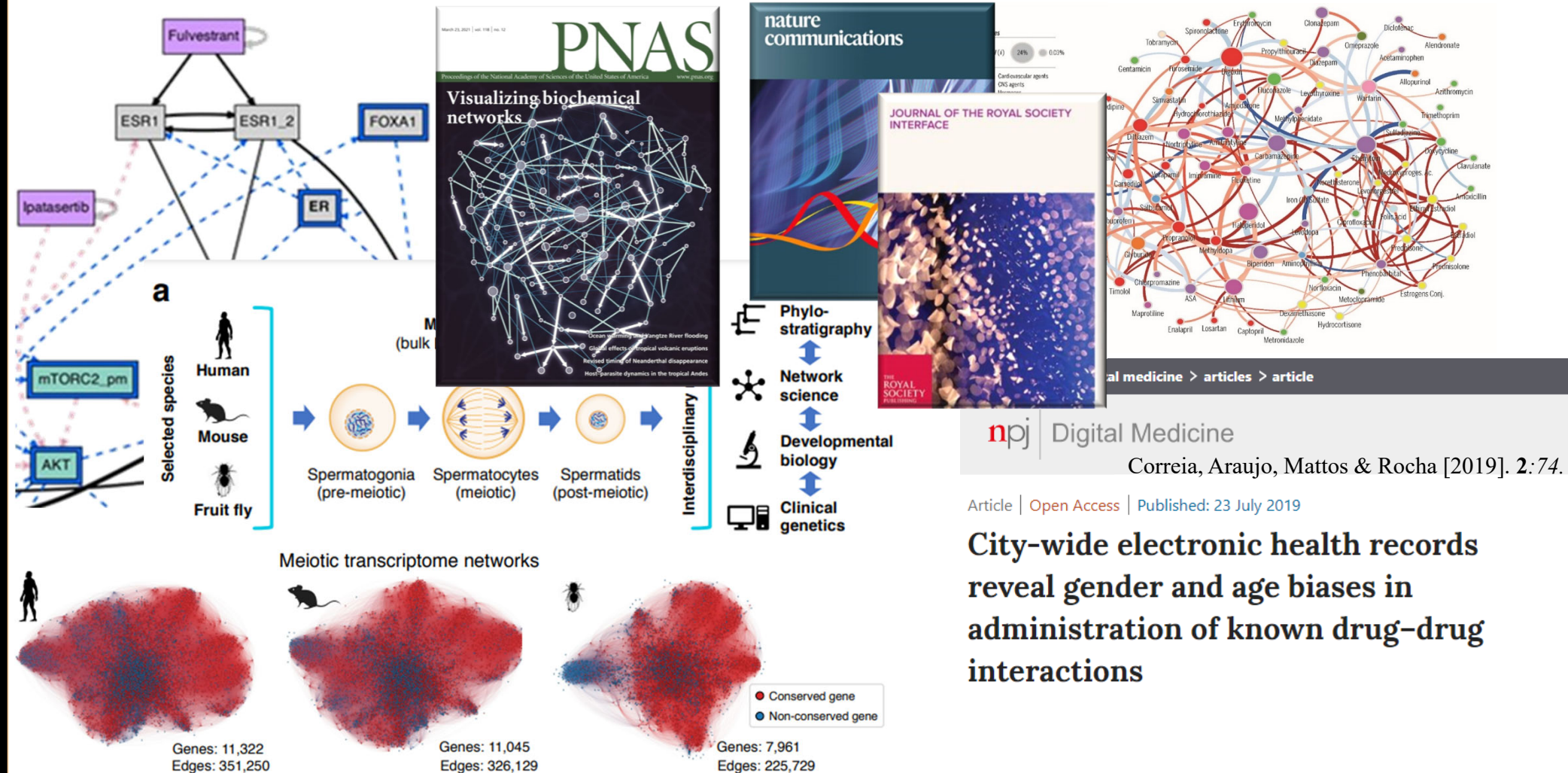
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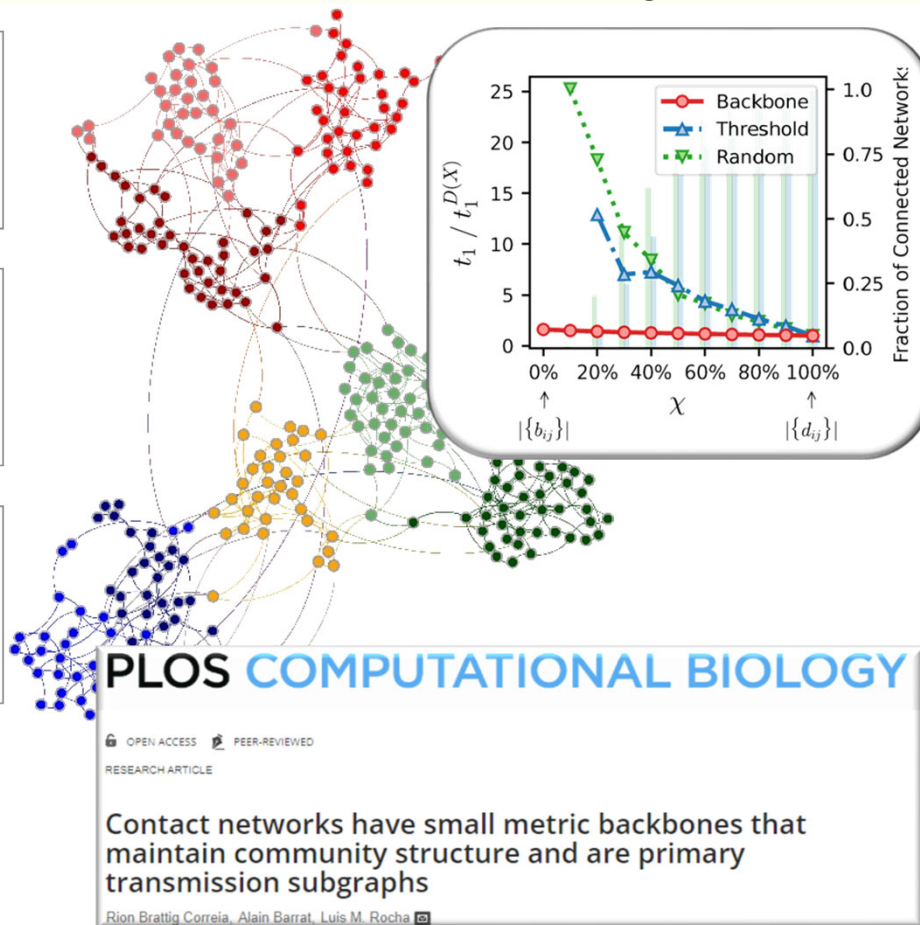
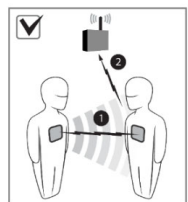
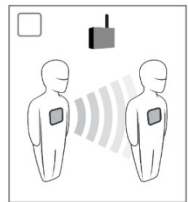
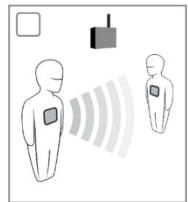
Wood, Varela, Bollen, Rocha & Sá [2017]. *Scientific Reports*. 7: 17973.

to predict comorbidity & drug interaction networks, disease factors & interventions



integrating and analyzing multilevel data sources with network science

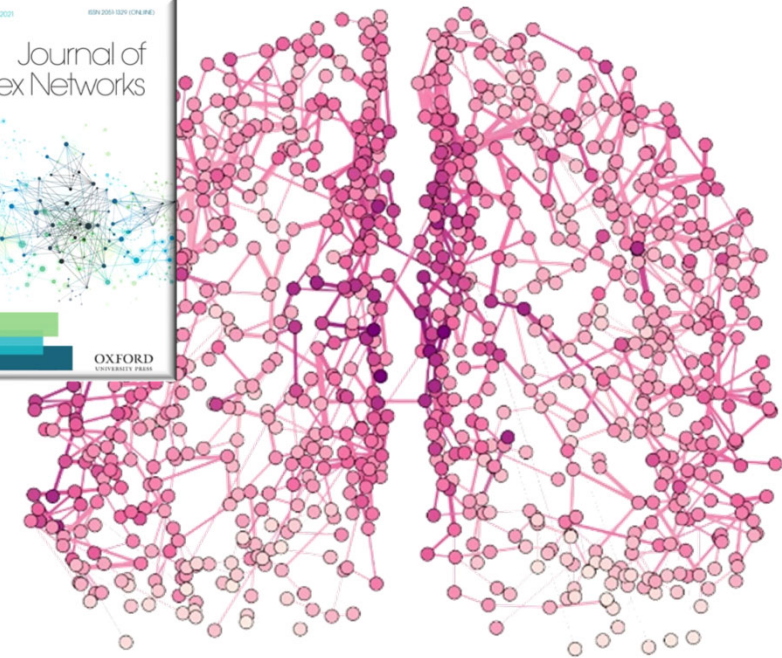
to predict disease spread, information integration



frontiers in
NEUROINFORMATICS

ORIGINAL RESEARCH ARTICLE
published: 24 July 2014
doi: 10.3389/fninf.2014.00066

Multi-scale integration and predictability in resting state brain activity



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Simas & Rocha [2015]. *Network Science*. doi:10.1017/nws.2015.11

Simas, Correia & Rocha [2021]. *J Complex Networks*. 9 (6), cnab021.

E-TRASH

LIVE IN LISBON

RIOT BOOTIQUE
DJ ANGST E-TRASH

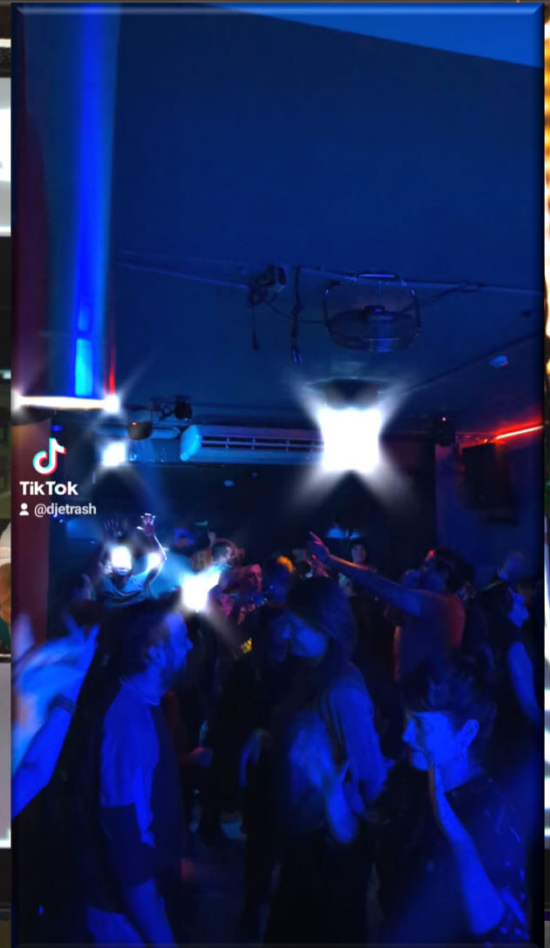
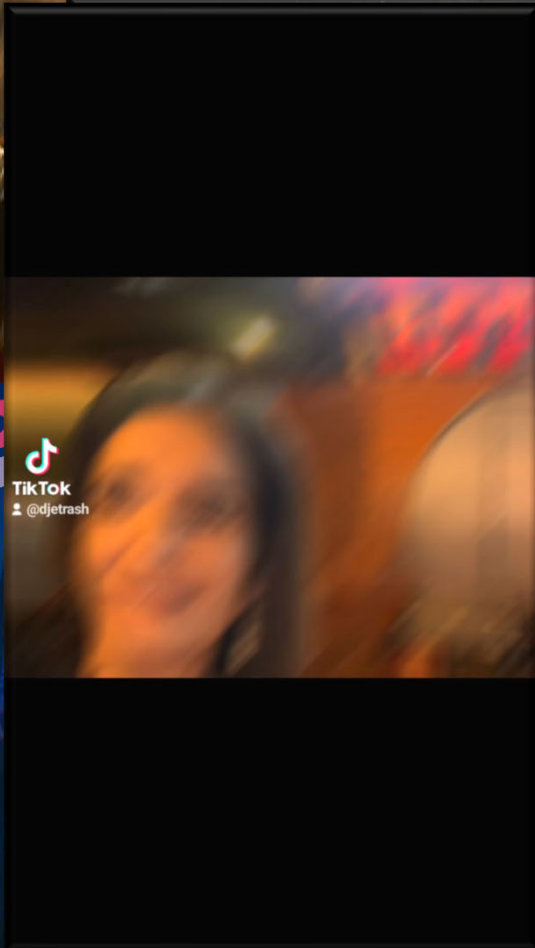


FEB 21 - 10 PM - NO COVER

FRIDAY, AUGUST 19: 1AM (BASEMENT)

E-TRASH

LIVE IN LISBON




FRIDAY, AUGUST 19: 1AM (BASEMENT)

what about you?

- Background
- Interests
- Course expectations



General Issues ▾

Topic	Threads	Posts	Last Post
Introductions ▾ For those online and anyone onsite who prefers this means. Please introduce yourself and why you are interested in this class	3	6	 Luis Rocha 1 minute ago

evolutionary systems and biologically-inspired computing

course materials

■ Lecture notes

- See course web page and blog

■ Class Handouts

- Web page and brightspace

■ Class Book

- Floreano, D. and C. Mattiussi [2008]. *Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies*. MIT Press.

■ Recommended or alternative books

- Flake, G. W. [1998]. *The Computational Beauty of Nature: Computer Explorations of Fractals, Complex Systems, and Adaptation*. MIT Press.
- Forbes, N. [2004]. *Imitation of Life: How Biology is Inspiring Computing*. MIT Press.
- Gleick, J. [2011]. *The Information: A History, a Theory, a Flood*. Random House.
- De Jong, K. [2016] A. *Evolutionary Computation: A Unified Approach*. MIT Press.
- Mitchell, M. [2019]. *Artificial intelligence : a guide for thinking humans*. Farrar, Straus and Giroux.
- Mitchell, M. [2009]. *Complexity: A Guided Tour*. Oxford University Press.
- Mitchell, M. [1999]. *An Introduction to Genetic Algorithms*. MIT Press.
- Nunes de Castro, Leandro [2006]. *Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications*. Chapman & Hall.
- Nunes de Castro, Leandro and Fernando J. Von Zuben [2005]. *Recent Developments in Biologically Inspired Computing*. MIT Press.
- Prusinkiewicz and Lindenmeyer [1996] *The algorithmic beauty of plants*.

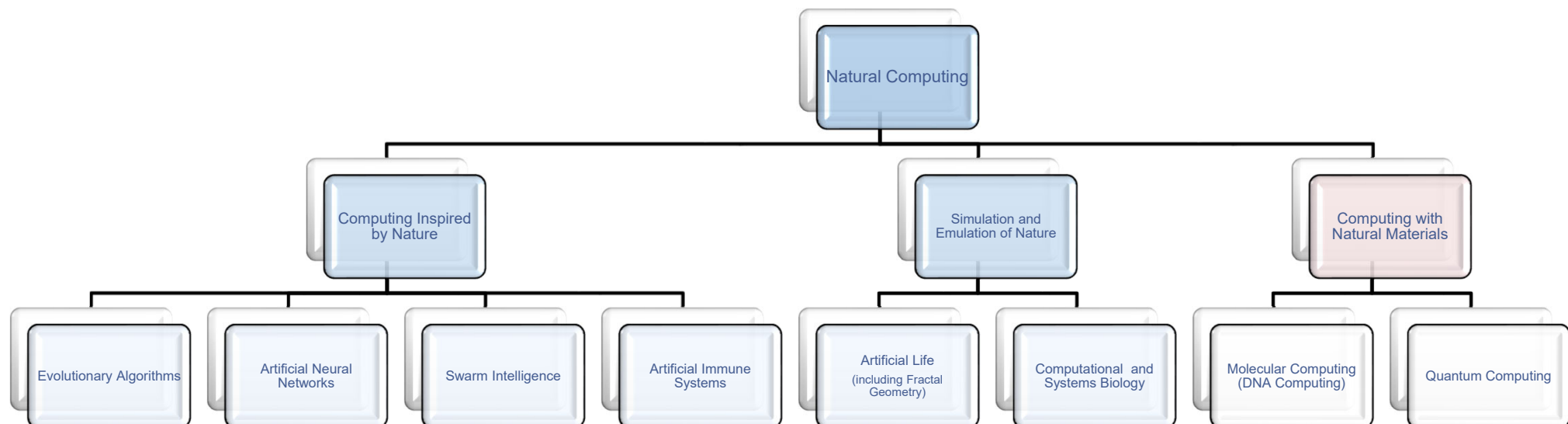
- ***Bio-inspired computing*** is a field devoted to tackling complex problems using computational methods modeled after **design principles encountered in nature.**

- Strongly grounded on the foundations of *complex systems* and *theoretical biology*.
- The goal is a deep *understanding* of the **distributed architectures of natural complex systems**, and how those can be used to produce **informatics tools** with enhanced robustness, scalability, flexibility and which can interface more effectively with humans.
- It is a **multi-disciplinary** field strongly based on biology, complexity, computer science, informatics, cognitive science, robotics, and cybernetics.

■ **Aims**

- Students will be introduced to fundamental topics in bio-inspired computing, and build up their proficiency in the application of various algorithms to real-world problems.
 - computational intelligence, modeling and simulation, machine learning, evolutionary systems, artificial life, and biology itself.

adapted from Nunes de Castro



Complex Systems Science Approach

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evolutionary systems and biologically-inspired computing

syllabus

■ What is Life?

- Life and information, logical mechanisms of life

■ Complex Systems and Artificial Life

- Life as self-organization: cellular automata, Boolean nets, neural nets

■ What is Computation?

- Universal computation, Life as computation

■ Life as Evolution of Turing Machines

- Open-ended evolution, natural selection, genetic and evolutionary algorithms

■ Collective Behavior and Swarm Intelligence

- stigmergy, swarm intelligence, multi-agent simulation

■ Immunocomputing

- Multi-level complexity

■ Imitation of Life

- L-Systems, fractals, chaos

■ Discussion Topics

evolutionary systems and biologically-inspired computing

evaluation

- **Participation: 15%.**
 - Based upon attendance and participation.
- **Labs**
 - **ISE-483 Assignments: 35%**
 - Students complete 5 (4 best) assignments on algorithms presented in class
 - **SSIE-583 Lab Delivery: 25%**
 - Develop, deliver, and assist grading one ISE-484 lab assignment
- **SSIE-583 - Presentation and Discussion: 25%**
 - Present and lead the discussion of an article related to the class materials. This includes presenting concepts necessary to understand the article.
 - SSIE-687 students present 2-3 papers
- **Project Paper: 50% (ISE-483), 35% (SSIE-583, SSIE-687)**
 - Students can choose to tackle a real problem using bio-inspired algorithms, or write a term paper (in Conference Style).
 - Students are expected to continuously consult with the instructor regarding the scope and depth of the project paper. Reusing and expanding labs is highly encouraged.
 - Project ideas available.

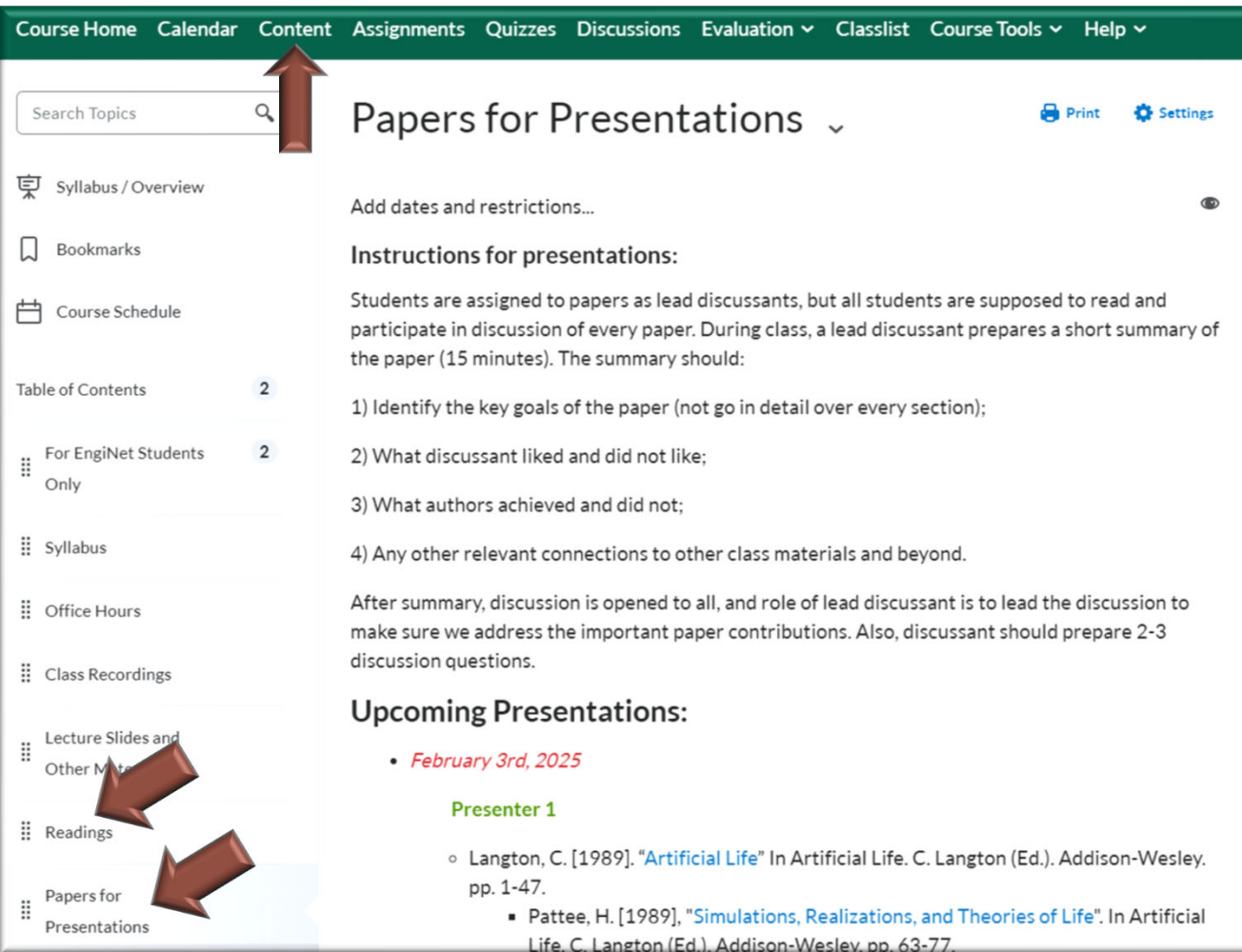


Some classics

- Adami, C. [2006]. "Digital Genetics: Unraveling the Genetic Basis of Evolution". *Nature Reviews Genetics*. **7**:109-118.
- Conrad, M. [1990]. "The geometry of evolution." *Biosystems* **24**: 61-81
- Crutchfield, J.P. and M. Mitchell [1995]. "The evolution of emergent computation." *Proc. National Academy of Sciences, USA*, **92**: 10742-10746.
- Hinton, G.E. and S.J. Nowlan [1987]. "How learning can guide evolution." *Complex Systems*. **1**, pp.495-502.
- Kauffman, S.A. [1969]. "Metabolic stability and epigenesis in randomly constructed genetic nets". *Journal of Theoretical Biology* **22**(3):437-467.
- Langton, C. [1989]. "Artificial Life" In *Artificial Life*. C. Langton (Ed.). Addison-Wesley. pp. 1-47.
 - Pattee, H. [1989], "Simulations, Realizations, and Theories of Life". In *Artificial Life*. C. Langton (Ed.). Addison-Wesley. pp. 63-77.
- Lindgren, K. [1991]. "Evolutionary Phenomena in Simple Dynamics." In: *Artificial Life II*. Langton et al (Eds). Addison-wesley, pp. 295-312.
- Ray, T. S. 1992. "Evolution, ecology and optimization of digital organisms". *Santa Fe Institute* working paper 92-08-042.
- Pattee, Howard H. [1969] "How does a molecule become a message?." *Communication in development* **3**: 1-16.
- Schmidt, M. and H. Lipson [2009]. "Distilling Free-Form Natural Laws from Experimental Data. *Science*, **324**: 81-85.
- Sims, K. [1994]. "Evolving Virtual Creatures". *Proceedings of the 21st annual conference on Computer graphics and interactive techniques*, pp. 15 – 22.
 - H. Lipson and J. B. Pollack (2000), "Automatic design and Manufacture of Robotic Lifeforms", *Nature* **406**: 974-978.
 - Lipson H. (2005) "Evolutionary Design and Evolutionary Robotics", *Biomimetics*, CRC Press (Bar Cohen, Ed.) pp. 129-155
- Varela, Francisco J.; Maturana, Humberto R.; & Uribe, R. [1974]. "Autopoiesis: the organization of living systems, its characterization and a model". *Biosystems*. **5** 187–196.

SSIE-583 - possible presentations

Some classics



Course Home Calendar **Content** Assignments Quizzes Discussions Evaluation ▾ Classlist Course Tools ▾ Help ▾

Search Topics 🔍

Syllabus / Overview

Bookmarks

Course Schedule

Table of Contents 2

For EngiNet Students Only 2

Syllabus

Office Hours

Class Recordings

Lecture Slides and Other Materials

Readings

Papers for Presentations

Papers for Presentations ▾

Add dates and restrictions...

Instructions for presentations:

Students are assigned to papers as lead discussants, but all students are supposed to read and participate in discussion of every paper. During class, a lead discussant prepares a short summary of the paper (15 minutes). The summary should:

- 1) Identify the key goals of the paper (not go in detail over every section);
- 2) What discussant liked and did not like;
- 3) What authors achieved and did not;
- 4) Any other relevant connections to other class materials and beyond.

After summary, discussion is opened to all, and role of lead discussant is to lead the discussion to make sure we address the important paper contributions. Also, discussant should prepare 2-3 discussion questions.

Upcoming Presentations:

- **February 3rd, 2025**

Presenter 1

- Langton, C. [1989]. "Artificial Life" In Artificial Life. C. Langton (Ed.). Addison-Wesley. pp. 1-47.
 - Pattee, H. [1989], "Simulations, Realizations, and Theories of Life". In Artificial Life. C. Langton (Ed.). Addison-Wesley. pp. 63-77.

Evolution". *Nature Reviews Genetics*.

1
computation." *Proc. National Academy of*

on." *Complex Systems*. 1, pp.495-502.
y constructed genetic nets". *Journal of*

Addison-Wesley. pp. 1-47.
Artificial Life. C. Langton (Ed.). Addison-Wesley.

n: *Artificial Life II*. Langton et al (Eds).

sms". *Santa Fe Institute* working paper

?" *Communication in development* 3:

from Experimental Data. *Science*, 324:

annual conference on Computer

Robotic Lifeforms", *Nature* 406: 974-978.
netics, CRC Press (Bar Cohen, Ed.) pp. 129-

topoiesis: the organization of living

for course

A+	98%	<i>Excellent Work.</i> Student performance demonstrates thorough knowledge of the course materials and exceeds course expectations by completing all requirements in a superior manner.
A	94	
A-	90	
B+	85	<i>Very Good Work.</i> Student performance demonstrates above-average comprehension of the course materials and exceeds course expectations on all tasks as defined in the course syllabus.
B	80	
B-	75	
C+	70	<i>Good Work.</i> Student performance meets designated course expectations and demonstrates understanding of the course materials at an acceptable level.
C	65	
C-	60	
D+	55	<i>Marginal Work.</i> Student performance demonstrates incomplete understanding of course materials.
D	50	
D-	45	
F	Less than 45	<i>Fail.</i>

but collegiality above all

■ Attendance

- We expect that students will approach the course as they should a professional job – attend every class. Applies to ENGINET students.
- No mobile phones and laptops only for class materials
 - All materials available online

■ Academic Integrity

- As with other aspects of professionalism in this course, you are expected to abide by the proper standards of professional ethics and personal conduct. This includes the usual standards on acknowledgment of joint work and other aspects of the **Binghamton University Code of Student Conduct**. Cases of academic dishonesty will be reported to the Office of Student Conduct.

■ Incomplete Grade

- An incomplete (‘I’) final grade will be given only by prior arrangement in exceptional circumstances conforming to university and departmental policy which requires, among other things, that the student must have completed the bulk of the work required for the course with a passing grade, and that the remaining work can be made up within 30 days after the end of the semester.

key events coming up

■ Labs: 35% (ISE-483)

- Complete 5 (best 4 graded) assignments based on algorithms presented in class

■ Lab 0 : February 3rd

- *Introduction to Python* (No Assignment)

- Delivered by TBA

■ Lab 1 : February 10th

- *Measuring Information* (Assignment 1)

- Delivered by Shayan Esfarayeni

■ SSIE – 583 -Presentation and Discussion: 25%

- Present and lead the discussion of an article related to the class materials

- Enginet students post/send video or join by Zoom

- First presentation February 3rd

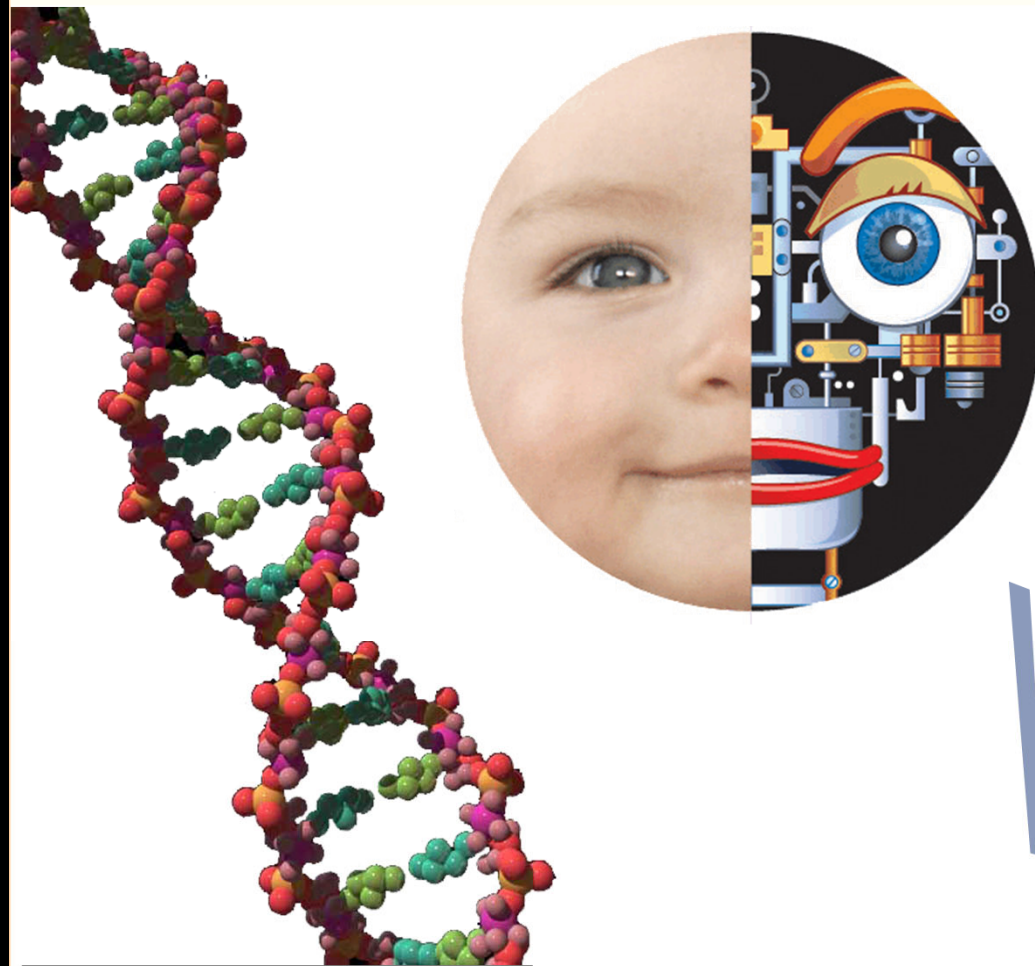
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- Presented by?

- Discussion by all

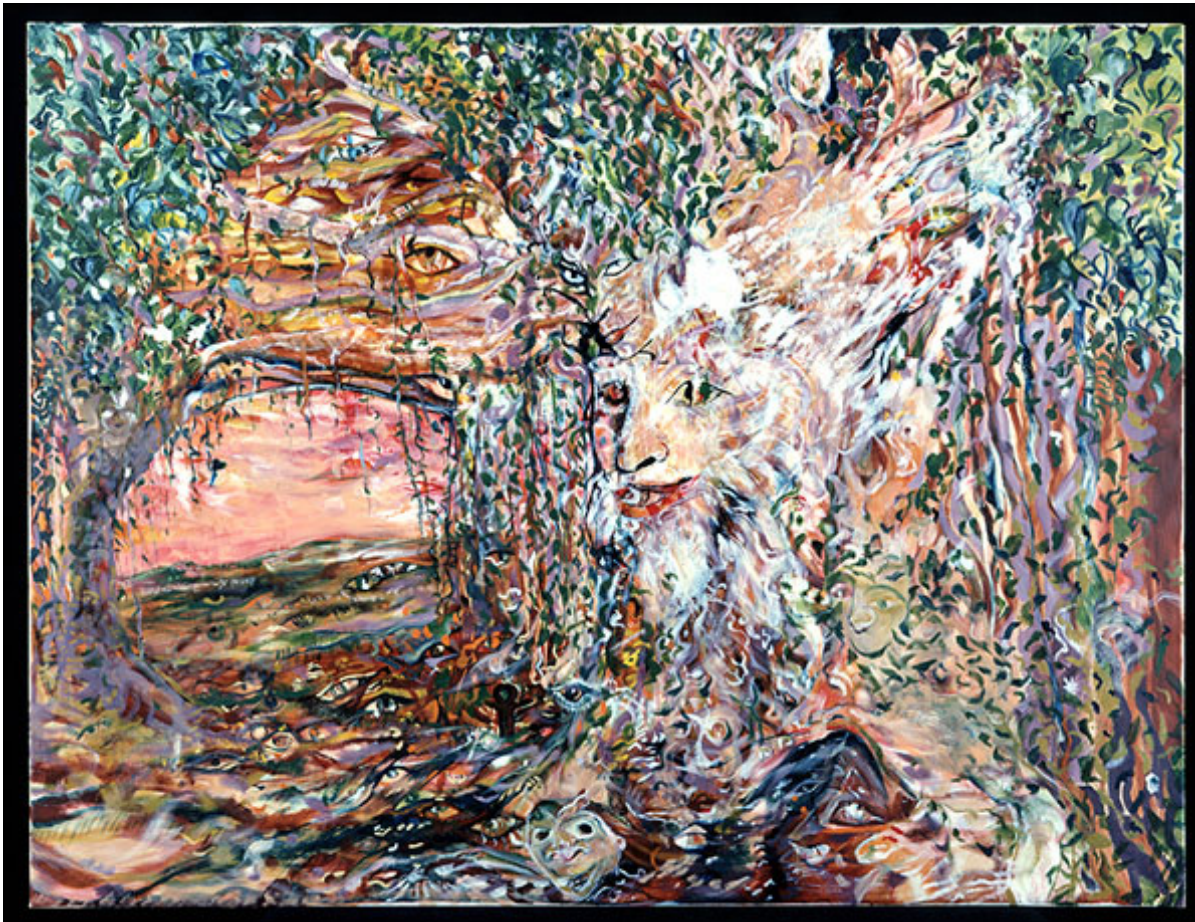
lecture 1



What is life?

What is life?

historically, not a relevant question

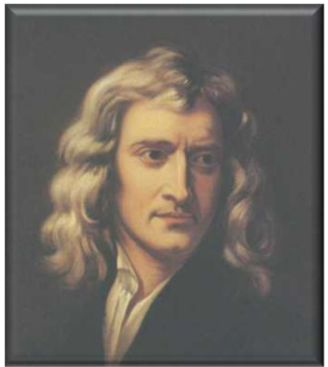
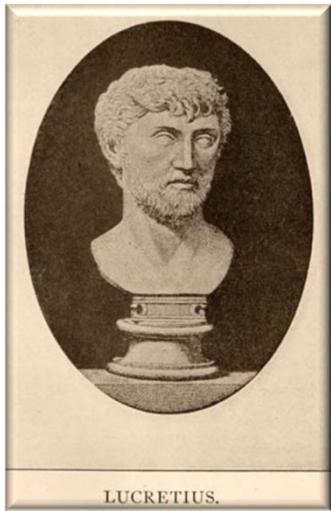


Animism by Georgeanne

rocha@binghamton.edu
casci.binghamton.edu/academics/i-bic

is life different from mechanistic matter?

how?

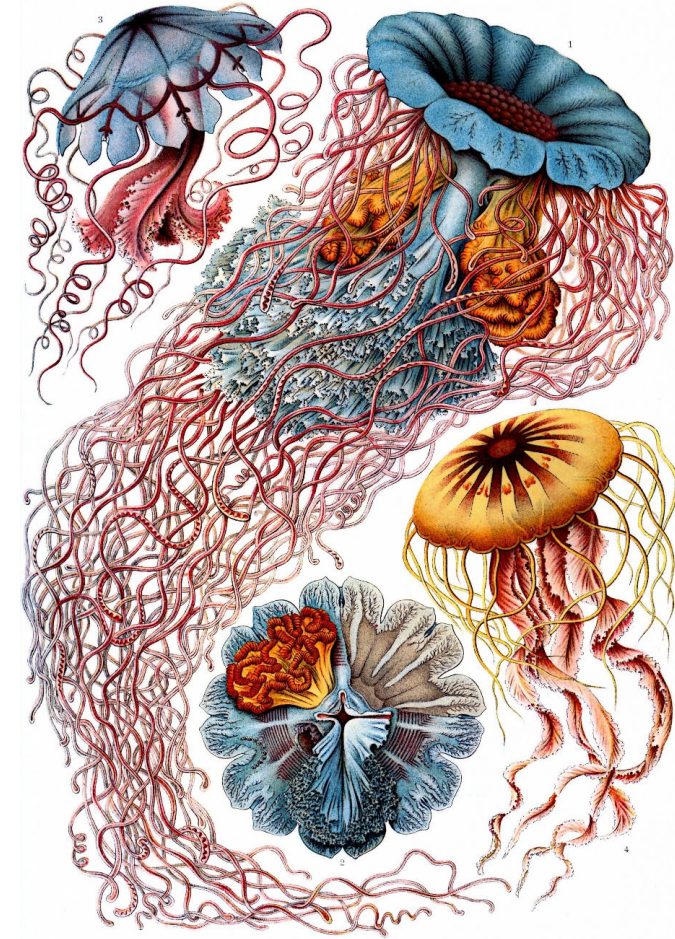


- **Lucretius (ca 66 B.C)**
 - How can choice arise if all atoms follow inexorable mechanical courses?
 - Titus Lucretius Carus
 - Epicurean Roman poet
 - Free Will vs. determinism
 - Also Aquinas...
- **Universal Mechanism**
 - The universe is best understood as a completely mechanical system
 - A system composed entirely of matter in motion under a complete and regular system of *laws of nature*.
 - Materialism, determinism
 - Laplace, Hobbes,....
- **Newton**
 - everything explained according to the operation of a single mechanical principle

Webster's dictionary

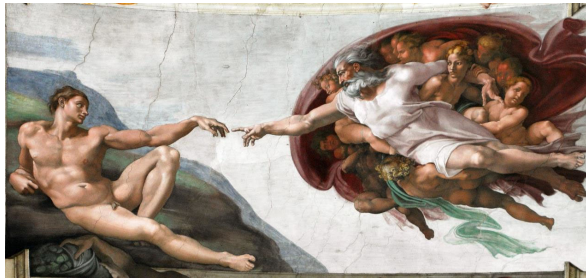
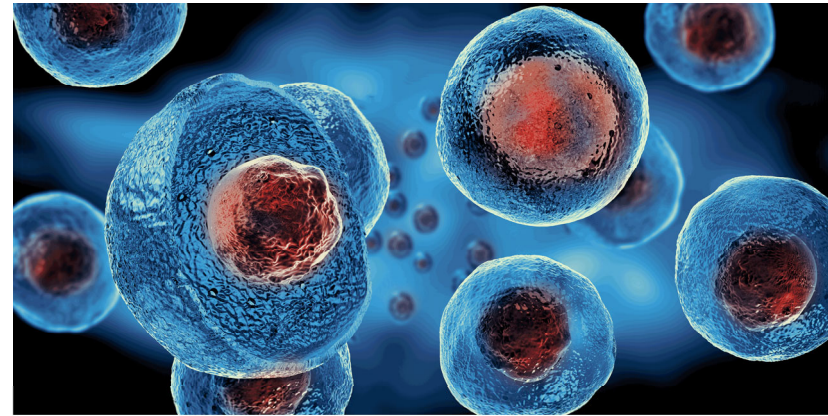
■ life adj.

- the general **condition that distinguishes organisms from inorganic objects and dead organisms**, being manifested by **growth** through **metabolism**, a means of **reproduction**, and internal **regulation in response** to the environment.
- the **animate existence** or period of animate existence of an individual.
- a corresponding state, existence, or principle of existence conceived of as belonging to the **soul**.
- the period of existence, activity, or effectiveness of something inanimate, as a machine, lease, or play.
- **animation**; liveliness; **spirit**: the force that makes or keeps something alive; the **vivifying or quickening principle**.



for life

- **Organization** distinct from inorganic matter
 - with an associated list of properties
 - matter controlled by genomic information
- **Animated behavior**
- **Vitalism**
 - life as a special, incommensurable, quality
 - Not a viable scientific explanation, because for science nothing is in principle incommensurable.
 - Pertains to metaphysics.
 - If the agent of design cannot be observed with physical means, then it is by definition beyond the scope of science as it cannot be tested.
 - See Dennett's and Polt's pieces



the living organization?

how to identify it?

■ List of properties

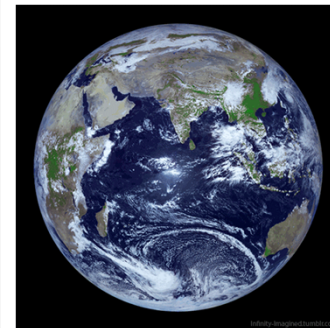
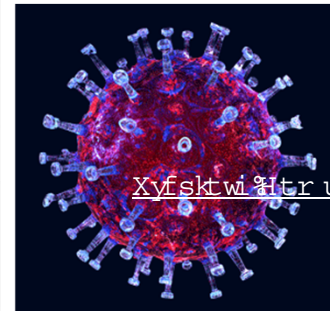
- Growth
- Metabolism
- Reproduction
- Adaptability
- Self-maintenance (autonomy)
- Self-repair
- Self-assembly
- Reaction
- Evolution
- Choice

■ Threshold of complexity

- Closure (metabolic, functional)
 - Categorization and Control
 - Function (self-reference)
- Open-ended evolution
- (genomic) Information

Is life
Fuzzy?

Is there a synthetic
criteria? How
general can it be?



viruses
candle flames
the Earth
hurricanes
robots
self-assembling wires?

the living organization?

how to identify it?

■ List of properties

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complexity threshold

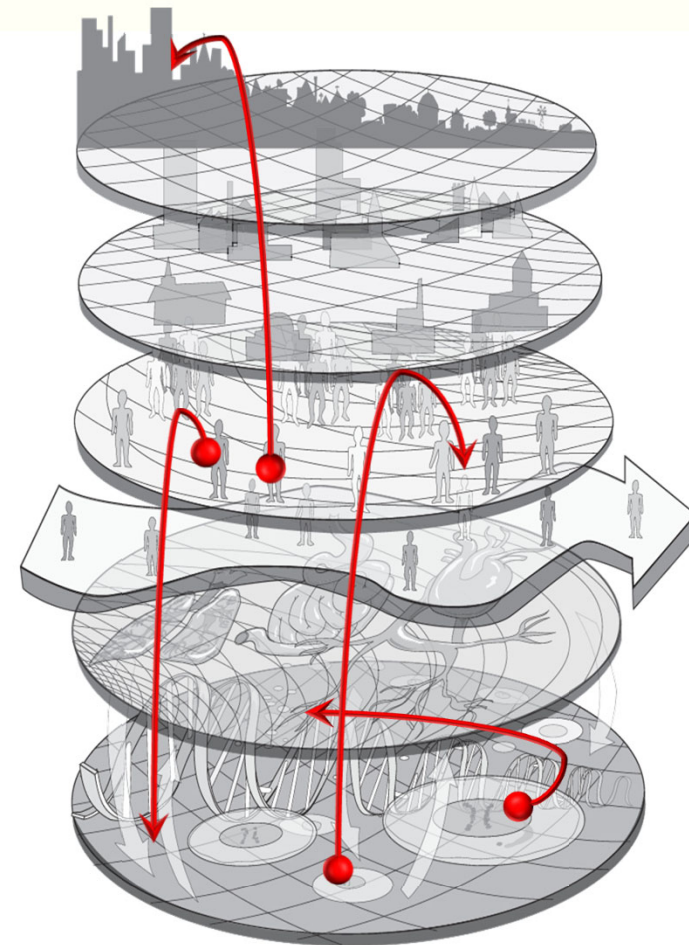
- Science often sees life as the complicated physics of a collection of moving bodies
 - Reductionist search for answers in the nitty-gritty of biochemistry
 - Separable variables or near-decomposable modules (Simon)
 - When do we reach a threshold of complexity after which matter is said to be living?
 - Which variables, networks, components, relations must be included?
- Life as (emergent) organization
 - Systems Thinking
 - Ludwig von Bertalanffy (1980)
 - What is important are not the actual physical components but the relations amongst them



But what about evolution and history?

- Conflict between (general) organization and specific components with their history
- What organization explains evolution?

“Seeking a connecting link, they had condescended to the preposterous assumption of structureless living matter, unorganized organisms, which darted together of themselves in the albumen solution, like crystals in their mother-liquor; yet organic differentiation still remained at once condition and expression of all life. **One could point to no form of life that did not owe its existence to procreation by parents**”. Thomas Mann [1924].



Pescosolido, B.A. 2006. Journal of Health and Social Behavior 47: 189-208.