Week 2 Slides

CSSE290 Artificial Life

First Time Goal:

2x4+1 minutes
4 minute Pres.
1 minute Q/Connection
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10 minutes for logistics, feedback

Will G. – Complexity Book Chapter 2

Quote To Lead Off:

"It makes me so happy. To be at the beginning again, knowing almost nothing... The ordinary-sized stuff which is our lives, the things people write poetry about -- clouds, daffodils -- waterfalls... These things are full of mystery, as mysterious to us as the heavens were to the Greeks... It's the best possible time to be alive, when almost everything you knew is wrong" - Tom Stoppard, Arcadia (via Melanie Mitchel, 2009)

Will G. – Complexity Book Chapter 2

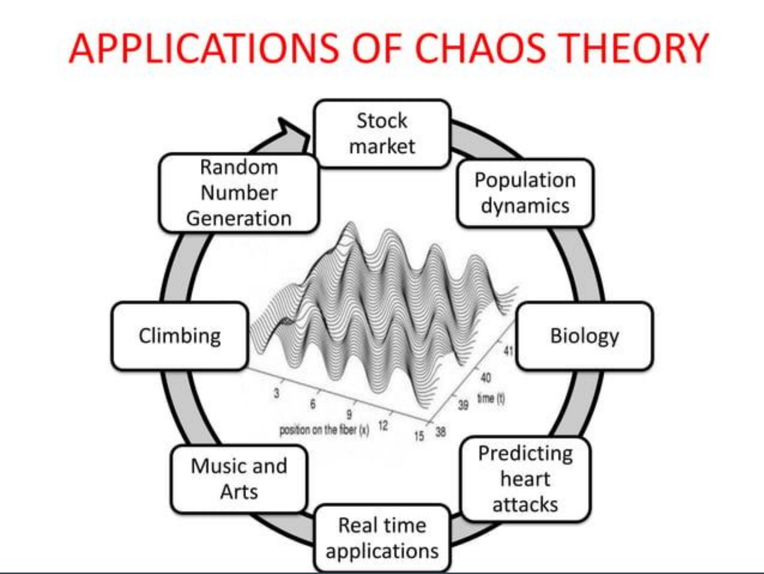
History of Dynamical Systems

- Aristotle
  - Teleology, believed systems could be modeled through logic alone, did not experiment.
- Galileo
  - Heliocentrism
  - Experimented with physical objects on Earth.
- Newton
  - "Invented, on his own, the science of dynamics" (Mitchell, p. 18, 2009)
  - Laws applied unilaterally across the universe (revolutionary idea)

Will G. – Complexity Book Chapter 2

Chaos

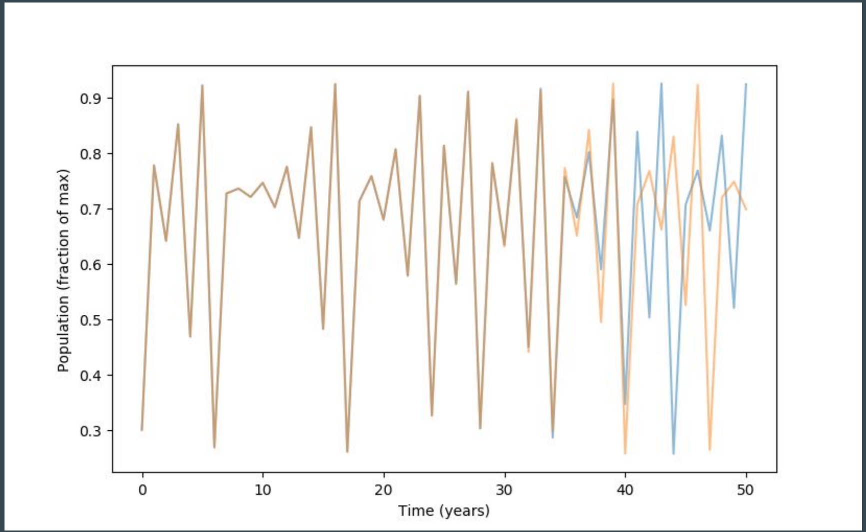
- "The defining idea of chaos is that there are some systems -- chaotic systems -- in which even minuscule uncertainties in measurements of initial [conditions] can result in huge errors in long term predictions." (Mitchell, p. 20, 2009)
- Three body problem



Will G. – Complexity Book Chapter 2

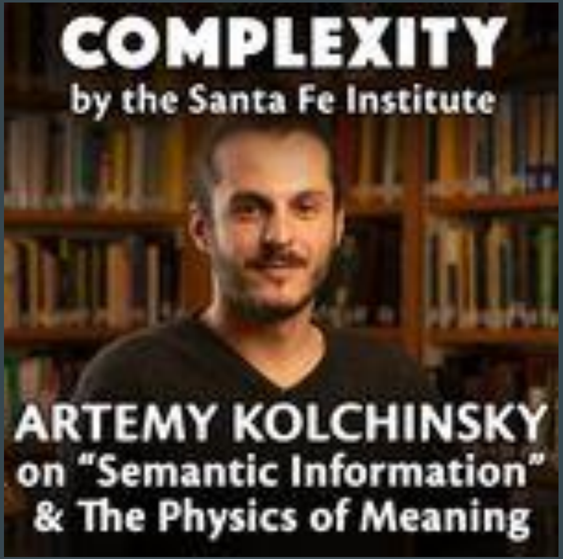
Linearity and Nonlinearity

- Doubling rabbits (linear system)
- Real rabbits (logistic model)
- Logistic Maps
  - x(t) = R * x(t-1) * (1-x(t-1))
  - Somewhere between 3-4, things get chaotic



Will/Steven – Artemy Kolchinsky "Semantic Information"

- Artemy Kolchinsky studied at IU Bloomington with a degree in cognitive science
- His interests:
  - Stochastic thermodynamics
    - Equilibrium of systems using information theory and statistics
    - Energy requirements of information processing systems
  - Semantic Information
    - "Information that has meaning" (Informal definition)
    - Relevant to a system if the system uses that information to maintain itself
    - Quantification of meaning through removal of information and observing the relevant effect on the system (kick out a gene and see what breaks, for example)



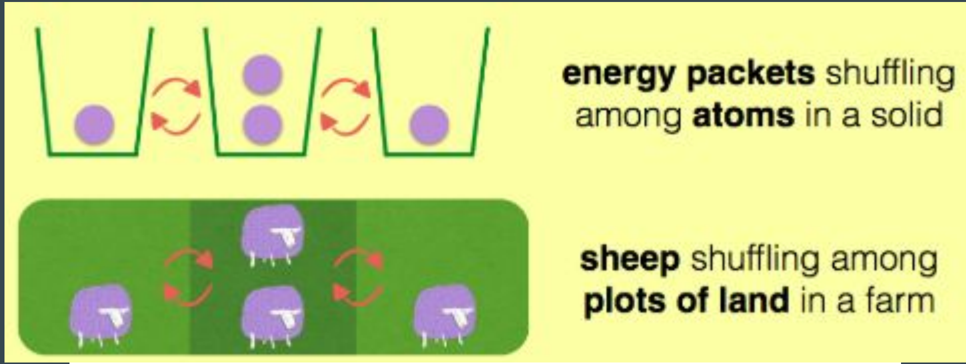
Steven J. - CORE Materials

- Physics (Entropy)
    - Sheep

"entropy is just a fancy word for 'number of possible arrangements'. Entropy is a count of how many ways you can rearrange the 'insides' of a thing (its microscopic internals), while keeping its 'outwardly' (macroscopic) state unchanged."

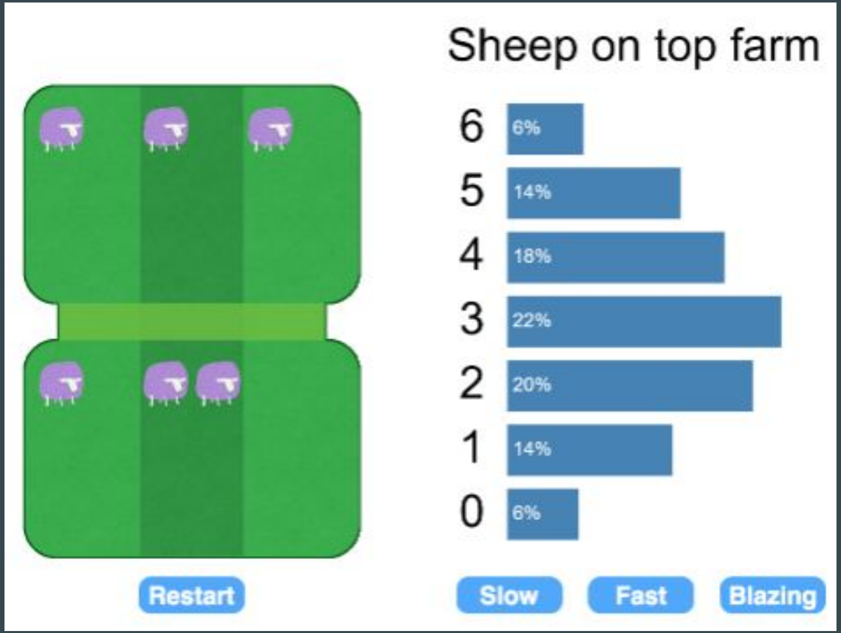
"So although the sheep are shuffled at random, over time, a pattern emerges. Some states are more likely than others."

"Higher entropy states are more probable than lower entropy ones."



Steven J. - CORE Materials - Sheep

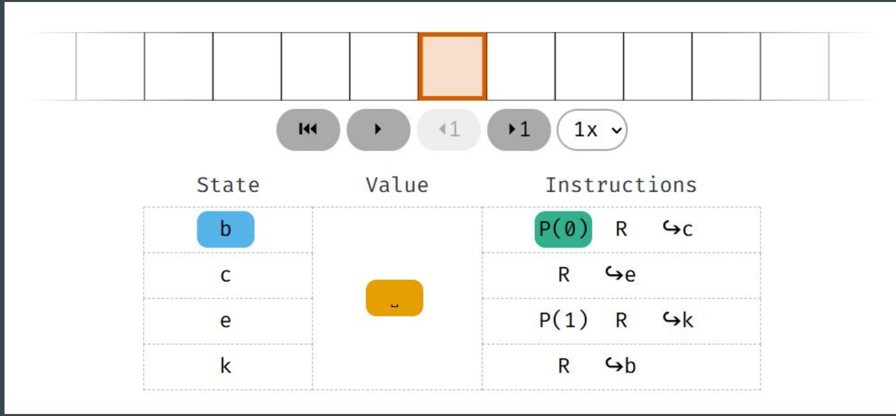
"So when we look at really tiny solids, energy doesn’t always flow from a hot object to a cold one. It can go the other way sometimes. And entropy doesn’t always increase. This isn't just a theoretical issue, entropy decreases have actually been seen in microscopic experiments (https://www.nature.com/articles/news020722-2)."



Steven J. - CORE Materials - Turing

"Everything you have ever seen a computer do can be done with a Turing machine."

Turing machine consists of 4 parts and 5 instructions:



Parts

1. a tape
2. a head
3. a program
4. a state

Instructions

1. P - prints a given symbol to the tap
2. R - moves the tape head right
3. -> - jumps to a given state
4. L - moves the tape head left
5. R - halts the machine

Steven J. - CORE Materials - Turing

What does it mean to compute?

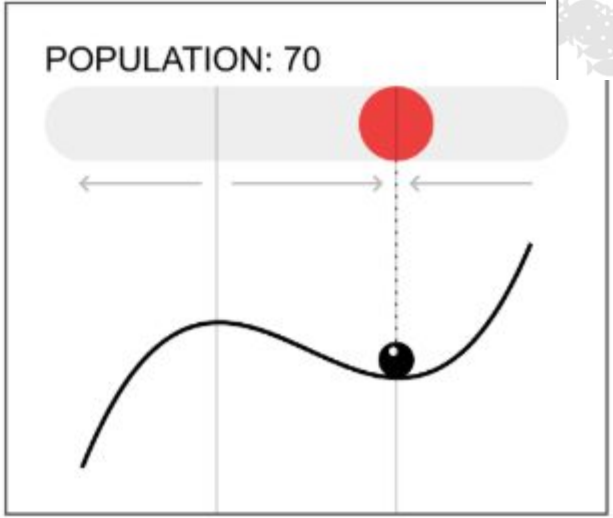
- Something is said to be "computable" if there exists an algorithm that can get from the given input to the expected output.

What does it mean to be Turing complete?

- "A system is Turing complete if it can be used to simulate a Turing machine."

Steven J. - CORE Materials - Attractor Landscapes

- "Population=0 and Population=70 are called attractors: because they "attract" the system to it"
- "Population=30 is called a repeller, because if the population is slightly below or above 30, it's "repelled" away from 30. Population=30 is also called a **tipping point** because that's where the ecosystem "tips" from the Population=70 attractor to the Population=0 attractor."



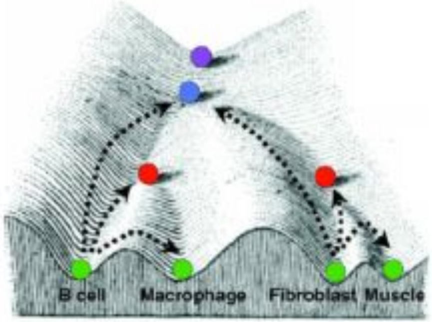
(note: the ball ● has no inertia. imagine the hills are covered with sticky molasses or something)

Steven J. - CORE Materials - Attractor Landscapes

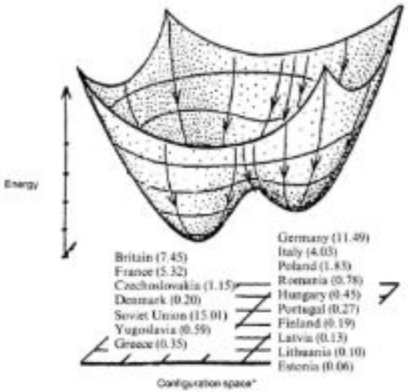
Now, when drawn as a landscape, seeing what the system does is easy! **Mountains ⋀ are repellers**; **Valleys ⋁ are attractors**.

The *depth* of a valley is how much **energy** it takes to escape the attractor. (e.g: Population=0 is deeper than Population=70; that's why it's easier to collapse an ecosystem than to restore it.)

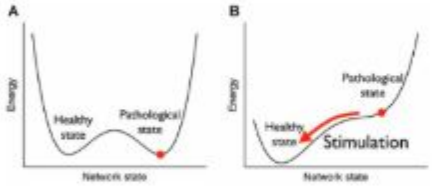
The *width* of a valley is called the **basin of attraction** – the range within which the attractor, well, attracts. (e.g: Population=70's basin of attraction is anything within 30<Population≤100)



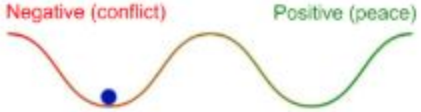
epigenetics: how stem cells become specialized cells (source)



political science: "predicting" likely political alignments during World War II (source)



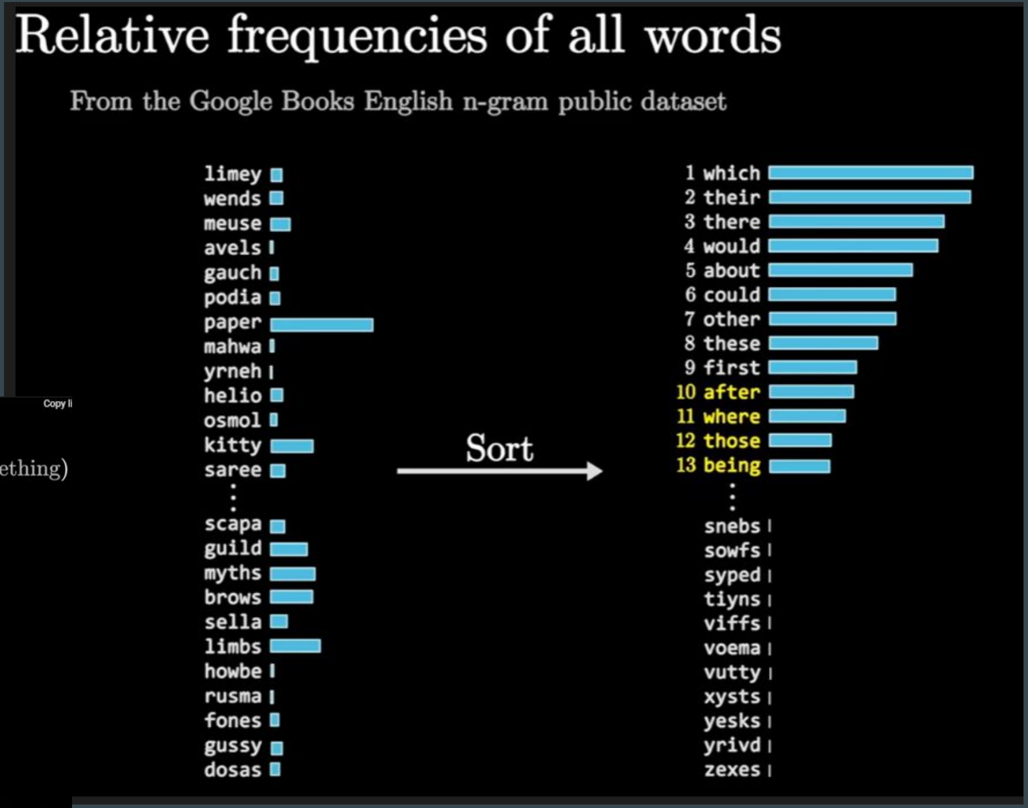
neuroscience: neurological stimulation gets your brain from a stable unhealthy state to a stable healthy state. (source)

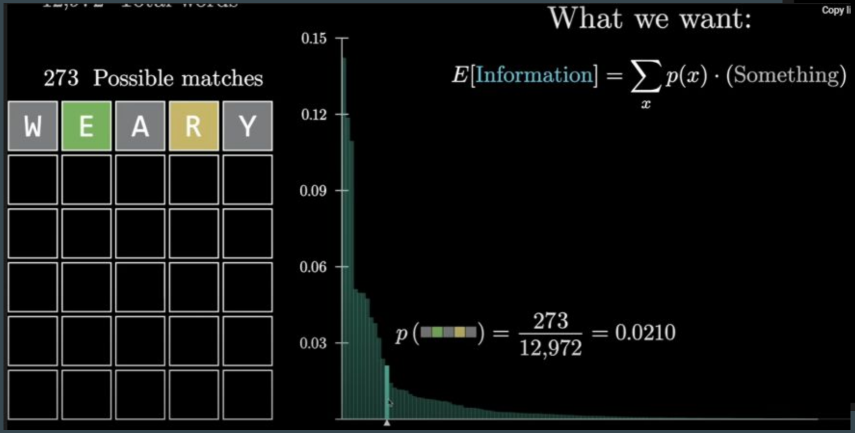


peace studies: peace is not the mere absence of war – they're different attractors! (source)

Steven J. - CORE Materials - Information Theory

- Sanderson used information theory to do Wordle
- “The higher the probability, the lower the information we get”





Unveiling Synchronization in Dynamical Systems

Explore the evolution of systems over time. Learn about the rules that govern their behavior.

This presentation sets the stage for understanding synchronization within these dynamic systems.

Defining Dynamical Systems

Mathematical Framework

A dynamical system is a framework describing how states change over time.

Broad Applicability

This applies to natural phenomena, engineered systems, and even abstract models.

Dynamical systems can be described using differential equations and maps.

Linear Systems: Predictable Behavior

1. **Predictable Behavior**

   Linear systems exhibit predictable behavior.

2. **Steady State**

   They often converge to a steady state.

3. **Ideal Pendulum**

   Outcomes scale linearly with inputs.

Simple oscillators are great examples of systems that follow linear rules.

Weakly Nonlinear Systems: Bifurcation

1. **Multiple End States**

   May allow multiple valid end states.

2. **Predictable**

   Still somewhat predictable.

3. **Sensitive**

   Sensitive to small initial nudges.

These systems exhibit bifurcation phenomena, where the outcome is sensitive to small changes.

Chaotic Systems: The Butterfly Effect

Deterministic

Deterministic yet highly sensitive to initial conditions.

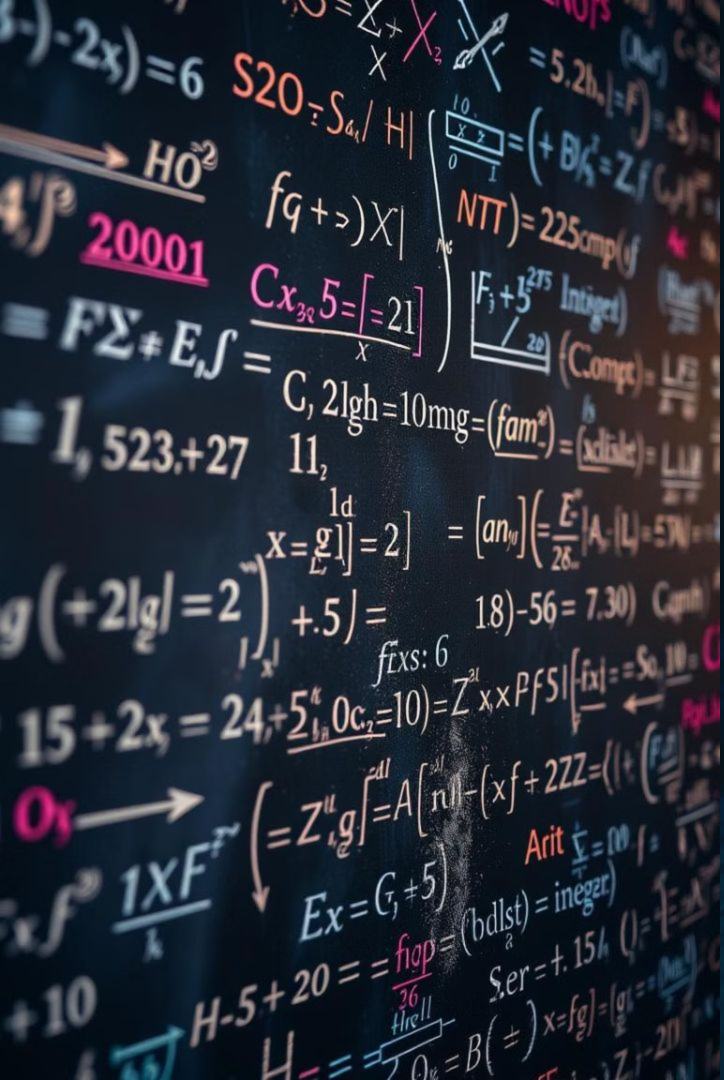
Butterfly Effect

Small changes can lead to large differences.

Complex Behavior

Yield unpredictable, complex behavior.

Even simple rules can yield unpredictable complex behavior.



Mathematical Framework & Tools

1. Differential Equations
2. Matrices and Eigenvalues
3. Maps

These tools are used to model iterative processes such as population growth.

Synchronization in Dynamical Systems

Emergence of Order

Independent oscillators align.

Mathematical Models

Local interactions lead to global sync.

Real-World Impact

Underpins technologies and phenomena.

This shows how local interactions yield global synchronization.

Applications & Real-World Examples

1

Physical

Pendulums, power grids.

2

Biological

Cardiac rhythms.

3

Complex

Weather, networks.

These systems reveal underlying order in complex behaviors.

Conclusion: Order from Complexity

1

Underlying Order

Dynamical systems reveal order.

2

Synchronization

Simple rules yield organized patterns.

3

Unified Approach

Insights into models and applications.

The study of these systems helps in understanding both theoretical models and real-world applications.

Peer Feedback on Deliverables

Moodle

Weekly Deliverables

Feedback Week 2 Deliverables

Shared Slides for Week 2

1 Complete the items below using the provided scale.

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Presentation #1 clearly explained the topic/resources.						
Presentation #1 allowed me to learn something new.						
Presentation #1 included an engaging activity.						
Presentation #2 clearly explained the topic/resources.						
Presentation #2 allowed me to learn something new.						
Presentation #2 included an engaging activity.						
Presentation #3 clearly explained the topic/resources.						
Presentation #3 allowed me to learn something new.						
Presentation #3 included an engaging activity.						
Presentation #4 clearly explained the topic/resources.						
Presentation #4 allowed me to learn something new.						
Presentation #4 included an engaging activity.						

2 Please paste in the follow template and answer the questions:

------------------------- Presentation #1-------------------------

What was something positive about presentation #1?

[answer]

What was something that could have been better in presentation #1?

[answer]

------------------------- Presentation #2-------------------------

Dr. Yoder - Weekly Reflection for Portfolio

alife simulator
- Brainstorming Ideas
- Sketch

code
- Title-of-Coding-Project

deliverable files

papers

personal

themes

videos

weekly deliverable planning

weekly reflection
- Week 1 Reflections - The Science ...
- Week 2 Reflections - The Physics ...
- Week 3 Reflections
- Week 4 Reflections
- Week 5 Reflections

weekly reflection / Week 1 Reflections - The Science of ALIFE

Week 1 Reflections - The Science of ALIFE

Note: This would be in reference the Tuesday of Week 2's class

What did you learn from the other student presentations on the Week 1 topic?

How does it connect to what you learned from your own work?

What would you like to learn more about?

Time Management Plan

How do you plan to manage your time with the expectation of spending ~3.5 or more hours of time outside of class between Thursday and Tuesday class sessions?

Dr. Yoder - Feedback

How did this work for you this week:

- What went well?
- What could be better?

What can I (Dr. Yoder) do to help facilitate more? (my default goals below)

- Provide a more Well-Organized list of resources by category and in one place
- Provide a scope/size of resources (small/medium/large)