Systems

- a combination of parts that interact and produce some new quality of functions in their interactions
- characteristics of systems
  1. system are made of parts or elements
     ex. wheel in car
  2. these elements are in interaction
     ex. put all elements of car together (it won't be a car if we don't put it together)
  3. the interactions bet. elements result in new features of the whole
     ex. driving

* - elements of system differ from each other (not identical)
- elements have particular order / position

Interaction

- relationship bet. elements can be described as flows
- type of i-actions
  - positive feedback loops → ex. larger pop lead to more births (more new borns)

L negative feedback loops → ex. larger pop and limited food supply lead to less food per person

↘ system tries to stabilize itself

Complex system

- system that consist of many interconnected components where the behavior of system as a whole can't be predicted from the behavior of individual components
- 4 characteristics of complex system
  1. hierachy
  2. non-linearity
  3. connectivity
  4. emergence

hierachy

- ex. cells → organism → fish → school of fish → fish interact w/ vegetation (fish is part of ecosystem) ↘ or environments

non-linearity

① state transitions

pile of sands → At some points, the pile will be unstable (landslide occurs)

↓

stable sys to unstable sys

* irreversible *

② small change w/ large effect
ex. butterfly effect
└ when butterfly flap its wing at some part of the world, it can cause hurricane some where

③ scale-less behavior
- show the same patterns at different scale
ex. covid-19
└ locally spread to large city / large population
↳ still confuse a bit, how?

④ tipping points
- critical threshold → when we cross this threshold, it can cause the severe impacts
ex. climate change → increasing in earth temp. (2.5 °C)

connectivity
- form the network
- each elements has different degree of connectivity and position in network structure

A and B have diff degree of connectivity
(A has 2 connections, B has 1 connection)

Emergence
- connection bet. elements lead to emerging of new properties of system

new props (ex. pattern, structure, behavior)

ex. flocking of birds emerge due to adaption
└ pattern

Link bet. complex systems & agent-based model

- Components of ABM
  - agents, environments, and time

↓

ABM is like the complex system (hierachy properties)
- agents → can form group of agents
- interaction bet. individual agents, group of agents, agent and environment

↓

ABM can provide unexpected outcomes (depend on the type of model that we are