Systematically thinking about Systems

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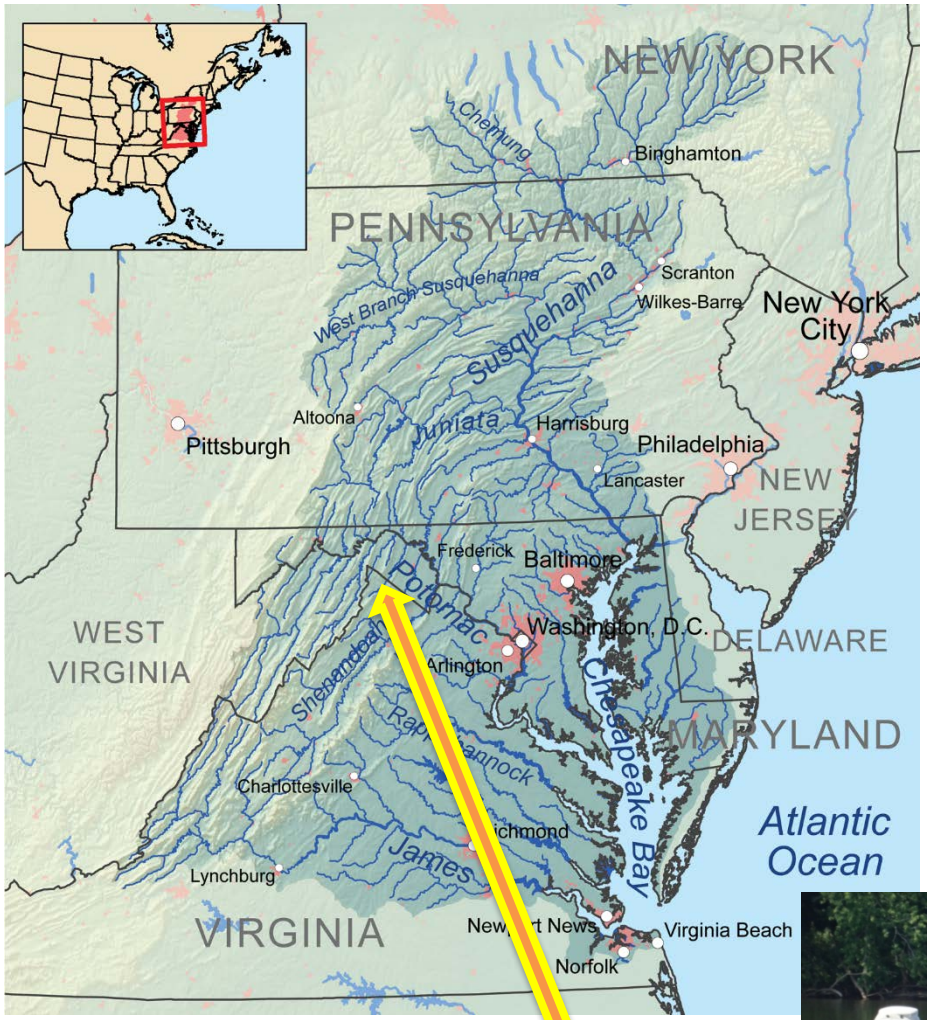
What we do:

- **Outdoor learning, preK-12**
- **Professional development**
- **Scientist outreach training**
- **Ecology research**
- **Public outreach**

Our Mission: *To increase understanding of the natural world through* ***research and education***



Our location

Analyze the objects at your table

- What are the PARTS?
- **What do you think each of these parts does? (What is their FUNCTION?)**
- What would happen to the object if you REMOVED one of the parts?
- **What is the INPUT to the object?**
- What is the object's OUTPUT?
- **Is this object a SYSTEM?**

System Analysis: Noise Maker

Parts	Function	Removal Impact

Input(s)	
Output(s)	

Is this object a system?

System Analysis: Noise Maker

Parts	Function	Removal Impact
Blow hole	Air entry point	No noise; no uncurling of paper tube
Whistle	Make noise	No noise
Tube	Air flow to flattened paper tube	No uncurling of paper tube
Curled paper tube (flattened)	Fills with air & uncurls	No obvious moving part
Wire (in paper tube)	Recurls paper tube	No recurling of paper tube

Input(s)	Air
Output(s)	Noise Flattened paper tube fills with air & uncurls

Yes!

Is this object a system?

System Analysis: Bag of Items

Parts	Function	Removal Impact

Input(s)	
Output(s)	

Is this object a system?

System Analysis: Bag of Items

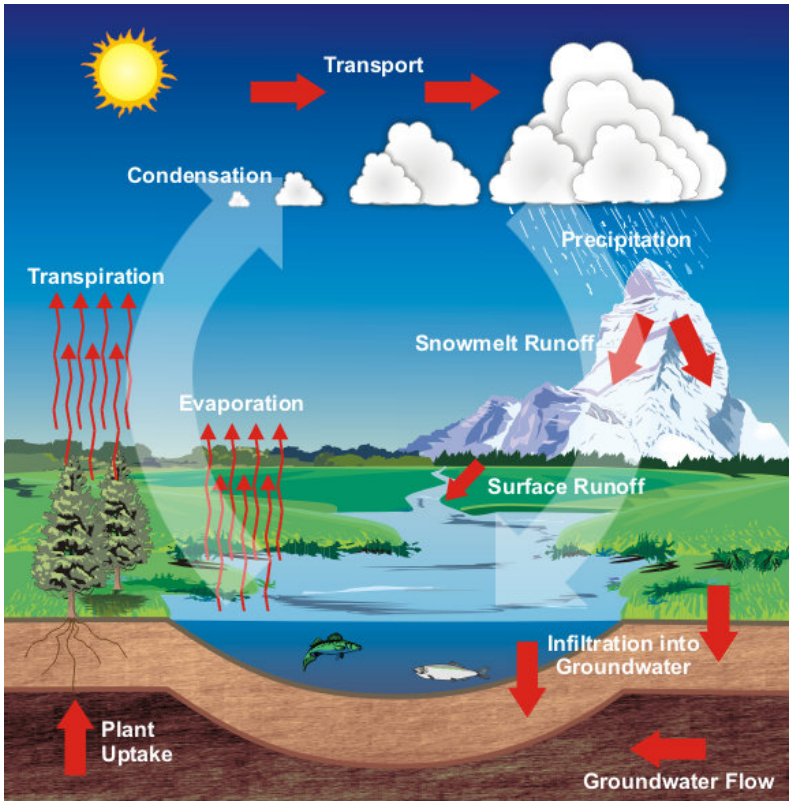
Parts	Function	Removal Impact
Items	?	None; still have a bag of individual items
Bag	Holds items in a group	Still have a group of individual items

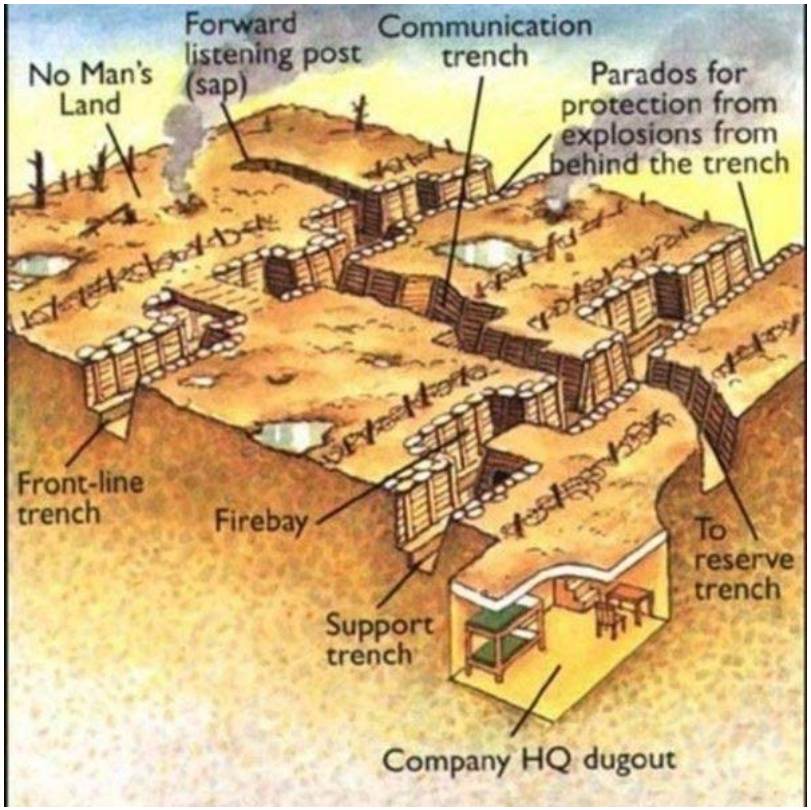
Input(s)	**None**
Output(s)	**None**

Is this object a system? **NO!**

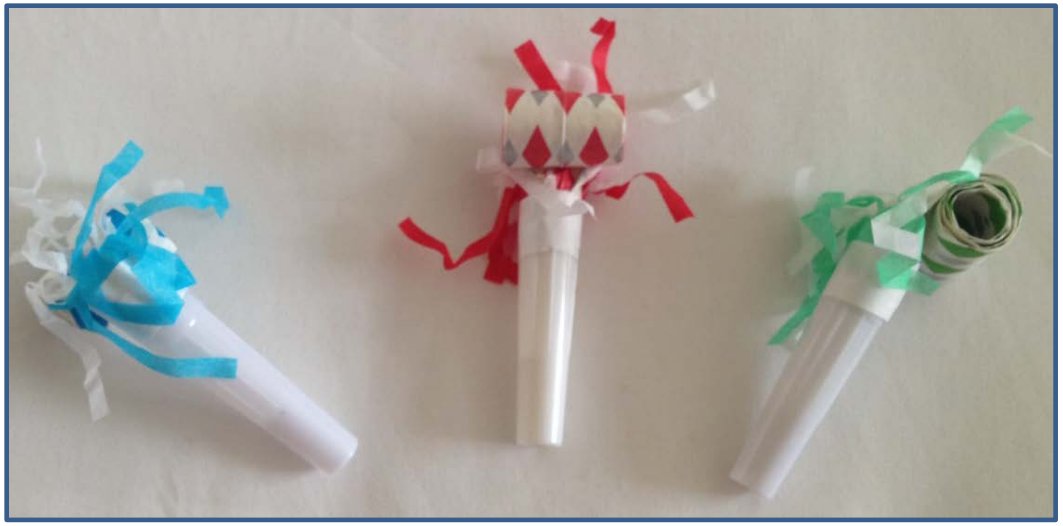
System Definition

A collection of interrelated parts that work together to achieve one or more common purposes or functions.

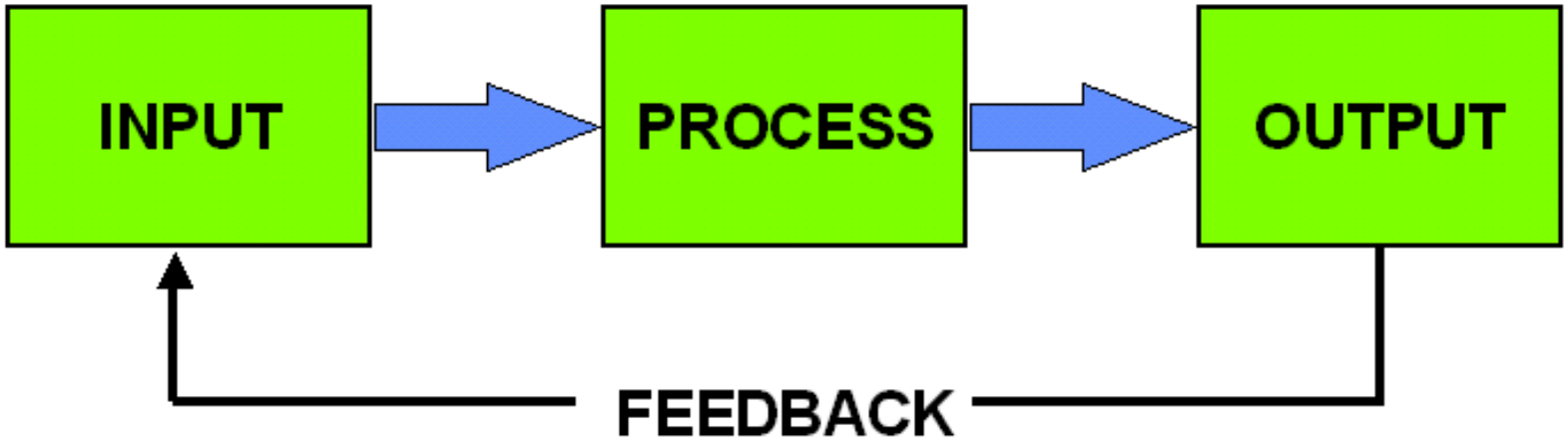




How do we begin to understand systems? **System Components**

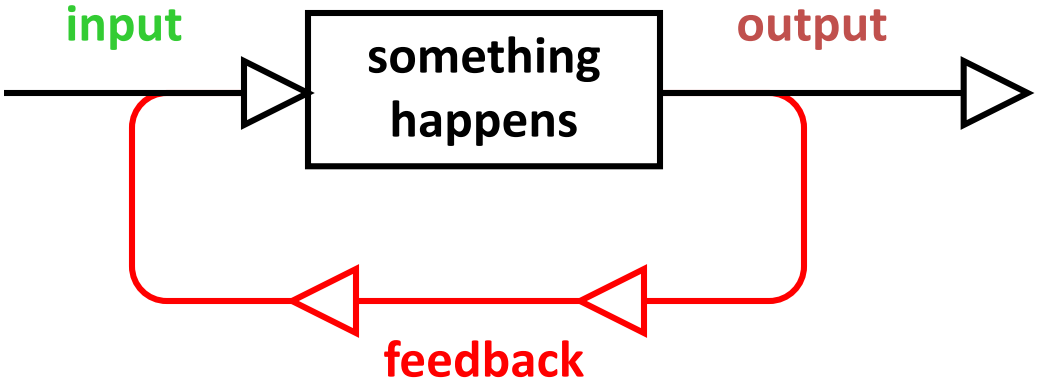


How do we begin to understand systems? **System Function**

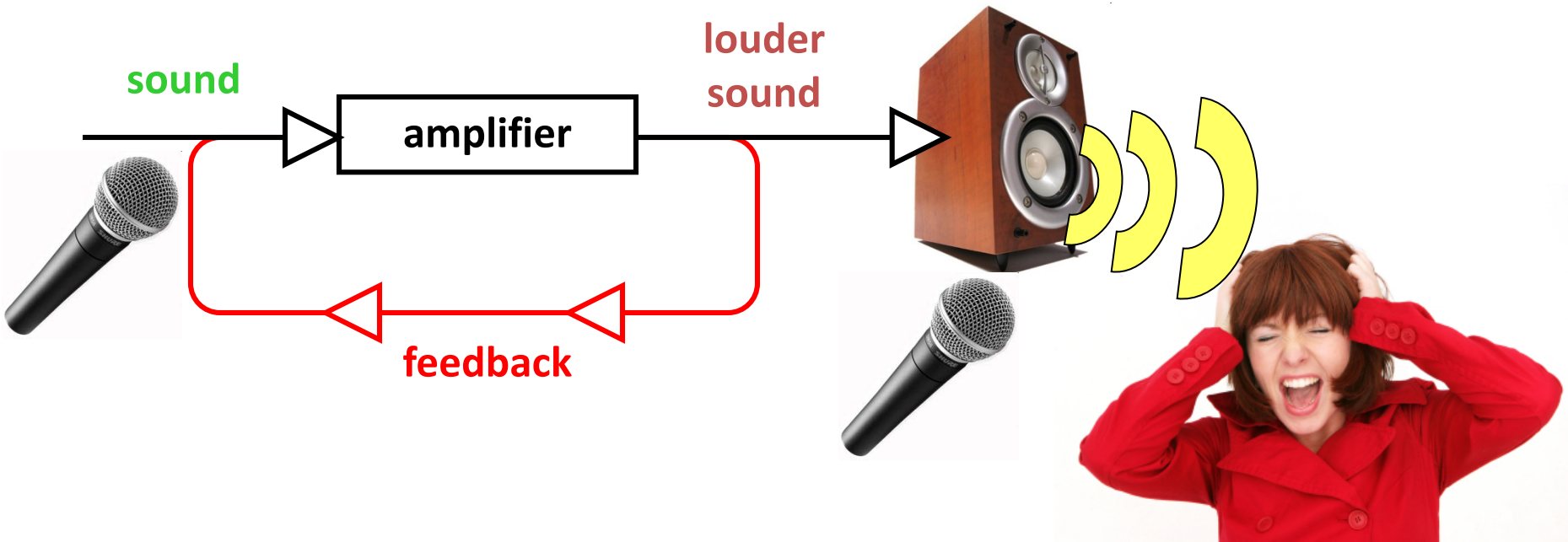


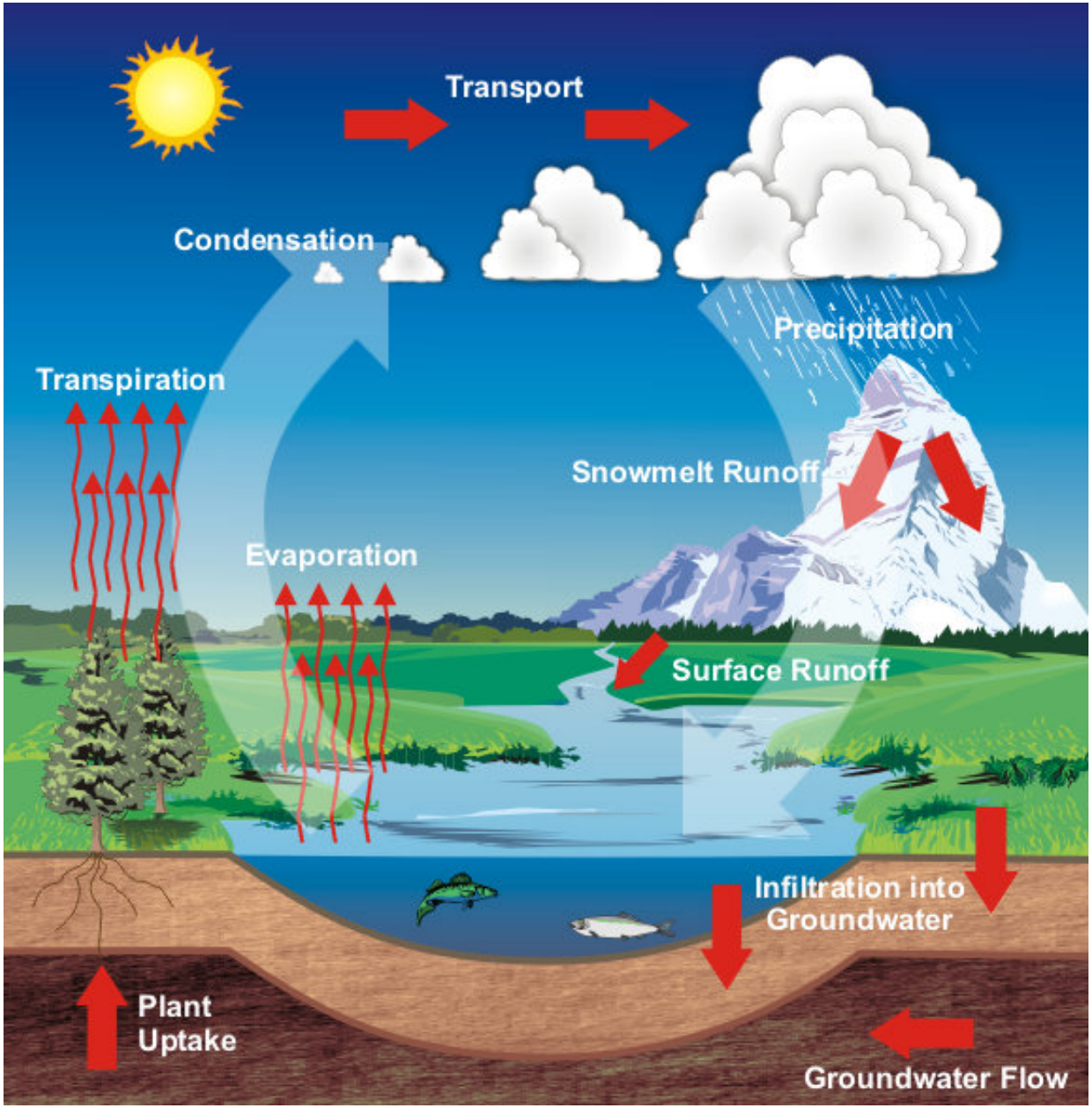
Components produce the activity (the system process) with a force or energy input

What is a Feedback?

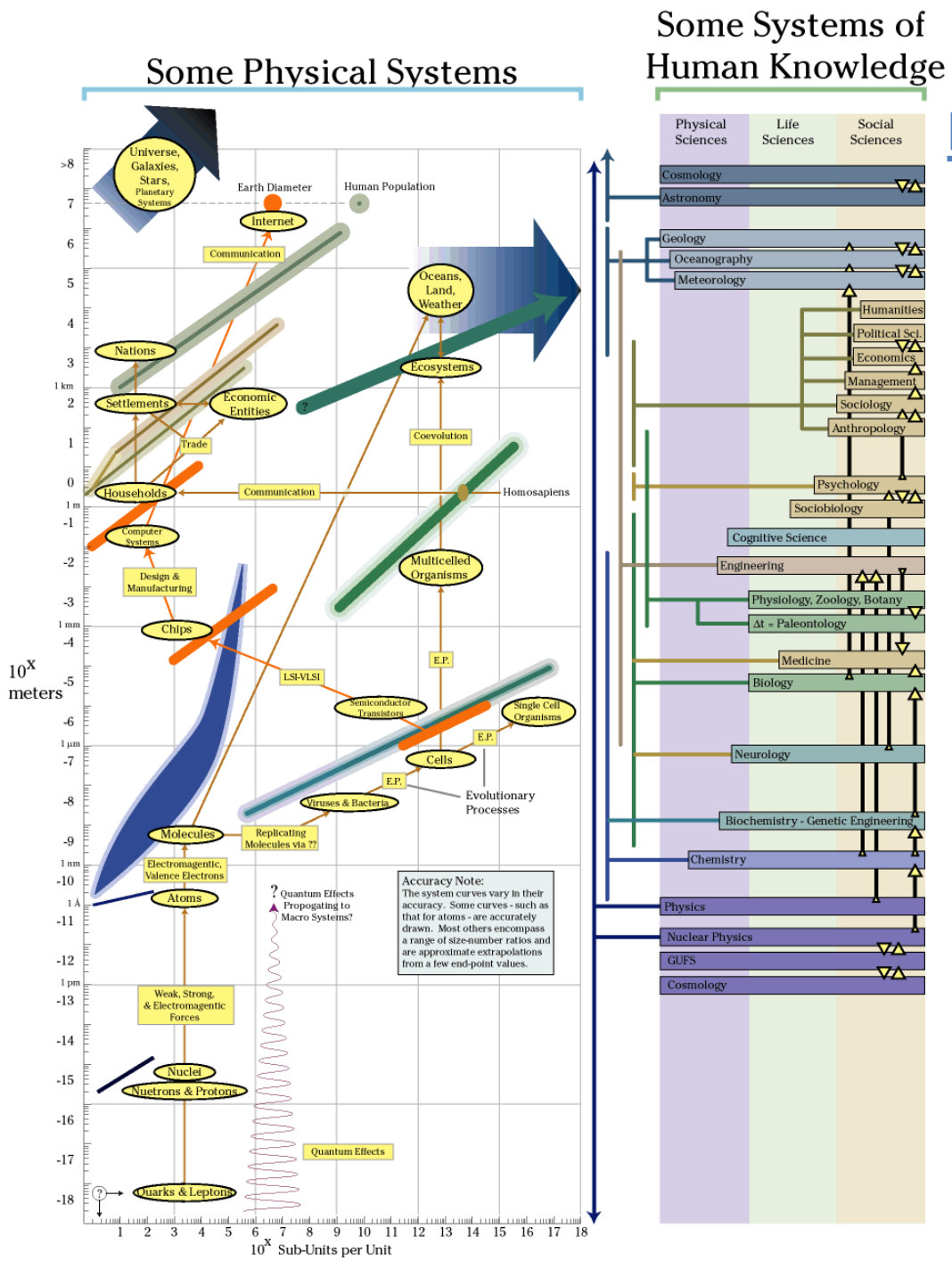


The output feeds back to the input





Feedback in a natural system



How do we define Systems?

By:

1. Type

- Simple or Complex
- Natural or Designed
- Physical or Informational

2. Scale

Minute to Infinite

3. Boundary

All the parts contained within a defined space

Natural & Human-Made Systems

System Analysis: Leaf

Parts	Function	Removal Impact

Input(s)	
Output(s)	

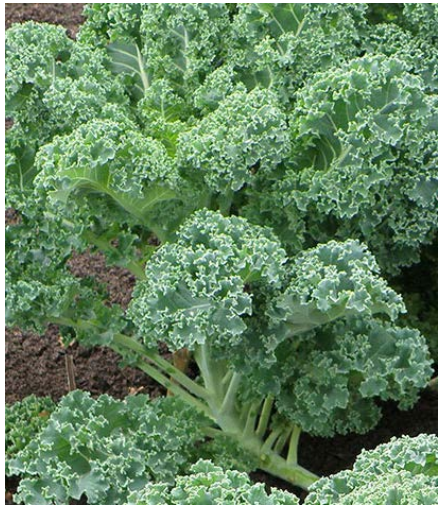
Is this object a system?

System Analysis: Leaf

Parts	Function	Remove
Blade	Oxygen exchange & absorbs energy from sunlight	No photosynthesis; plant will die
Leaf stem (petiole)	Attaches blade to plant stem	Leaf will not get water & necessary nutrients from other parts of the plant; Photosynthetic products will not be transferred to other parts of the plant; plant will die
Veins	Move water & nutrients around the blade & from the blade to the stem	Glucose produced during photosynthesis will stay in the leaf blade; plant will die

System Analysis: Leaf

Input(s)	**Water, Energy from sunlight, CO_2**
Output(s)	**Photosynthesis, Sugars, O_2**



Is this object a system?

Yes!

System Analysis: Jar of Rocks

Parts	Function	Removal Impact

Input(s)	
Output(s)	

Is this object a system?

System Analysis: Jar of Rocks

Parts	Function	Removal Impact
Rocks	?	None; still have a jar of rocks
Jar	Holds rocks in a group	Still have a group of rocks

Input(s)	**None**
Output(s)	**None**

Is this object a system? **NO!**

NGSS Cross-Cutting Concepts

- **Bridge disciplinary boundaries**
- **Unite core ideas throughout the fields of science and engineering**
- **Help students deepen their understanding of the disciplinary core ideas &**
- **Develop a coherent and scientifically based view of the world**

Structure and function. **The way in which an object or living thing is shaped & its substructure determine many of its properties & functions.**

Systems and system models. **Defining the system under study—specifying its boundaries & making explicit a model of that system—provides tools for understanding & testing ideas that are applicable throughout science & engineering.**

Systems Teaching in the NGSS

Grades	System Learning Focus	Disciplinary Examples
K-2	**What parts make up the whole?**	• Animal & plant characteristics • Sun, stars, planets • Weather
3-5	**What happens if we remove a part?**	• Interactions b/n organisms • Structure & function in organisms • Rock cycle • Simple & compound machines
6-8	**System inputs & outputs** **Subsystems**	• Earth's energy budget • Cells & cellular organization • Watersheds/Ecosystems/Solar Systems • Atomic structure
9-12	**Complex systems** **Balance/Homeostasis** **Feedback mechanisms (+/-)**	• Body systems • Earth system interconnections • Chemical properties & reactions • Transfer & storage of energy among systems • Global climate science

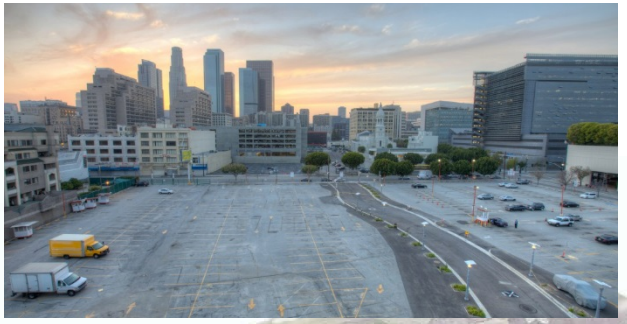
Atmosphere

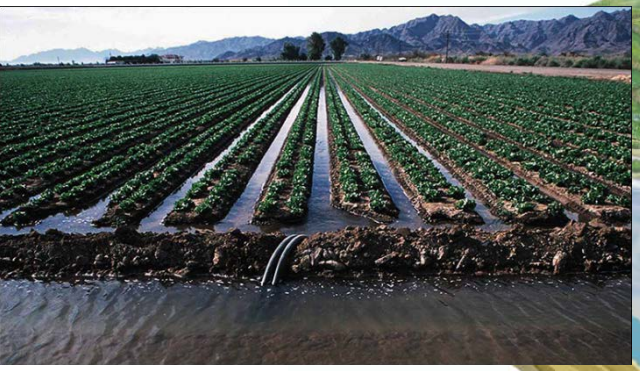
Hydrosphere

Geosphere

Biosphere

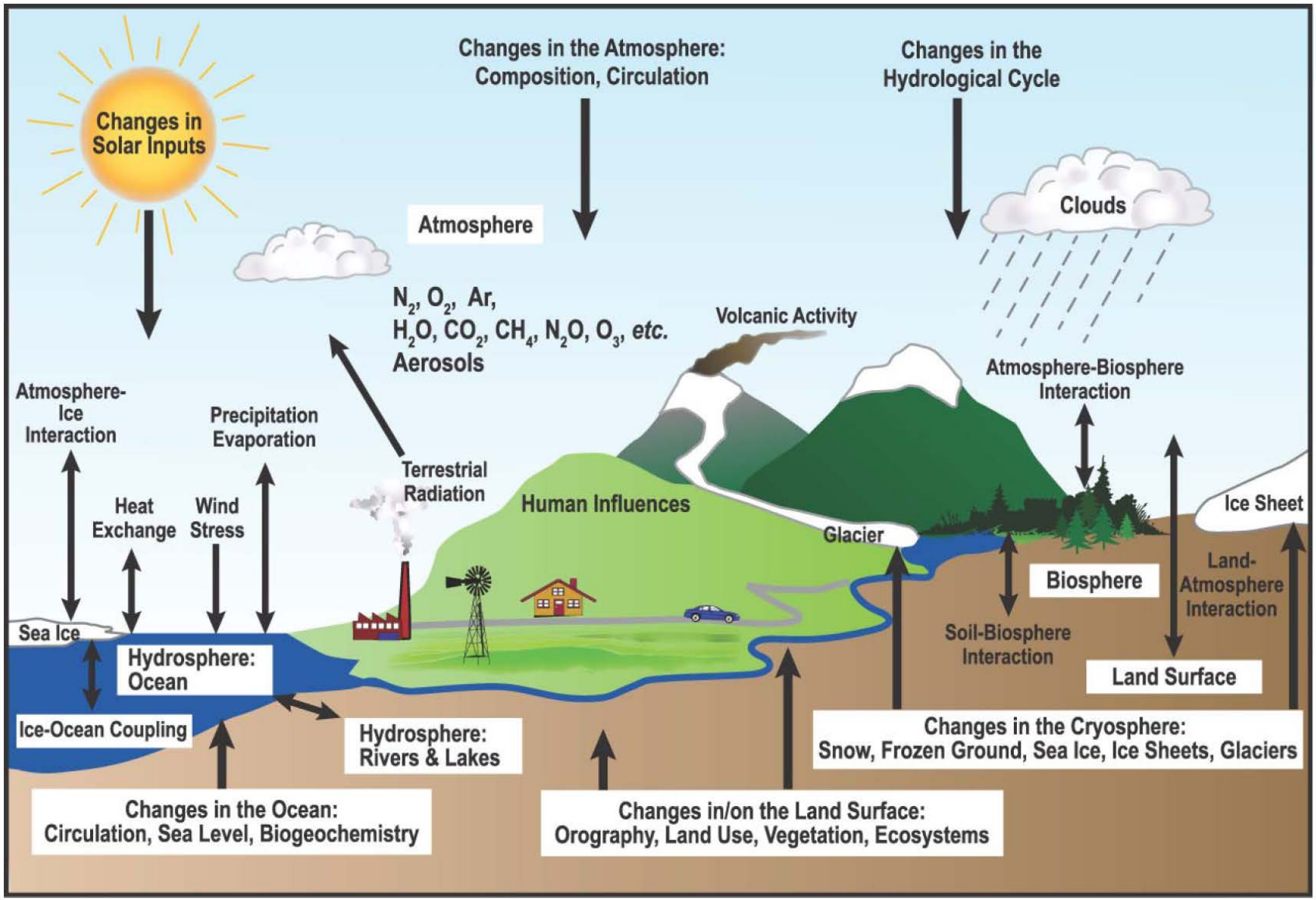
M. Ruzek, 1999





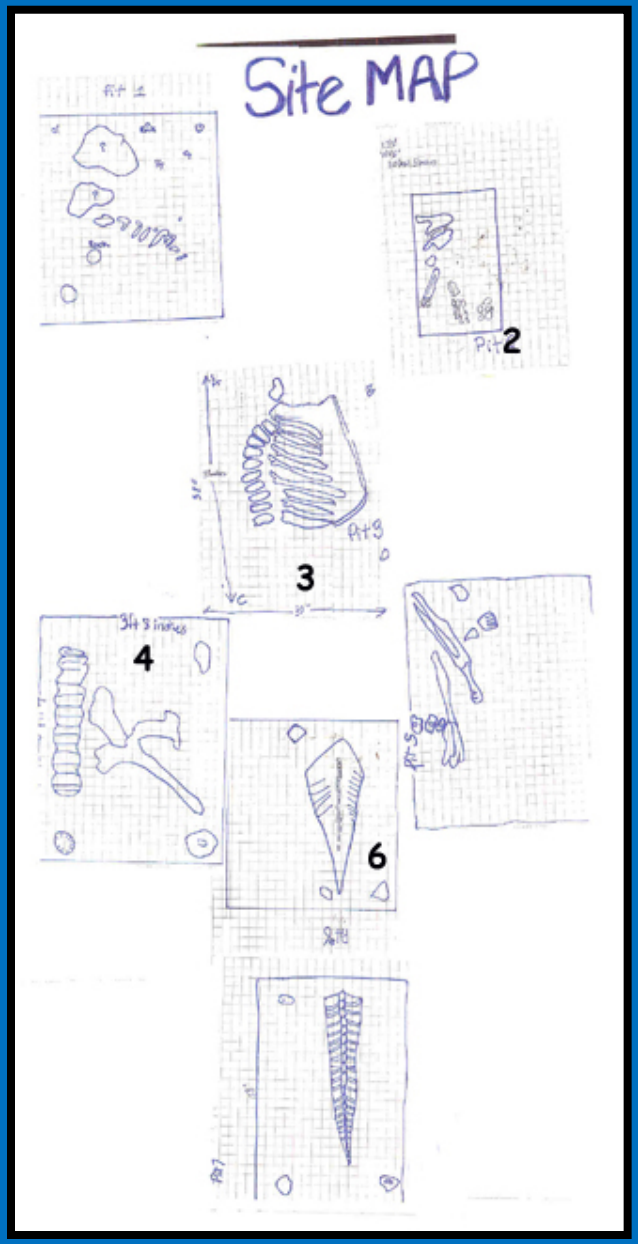
Watershed Studies

Global Climate Science



IPCC 2007

2nd Grade Students Excavating & Mapping a Paleontology Site

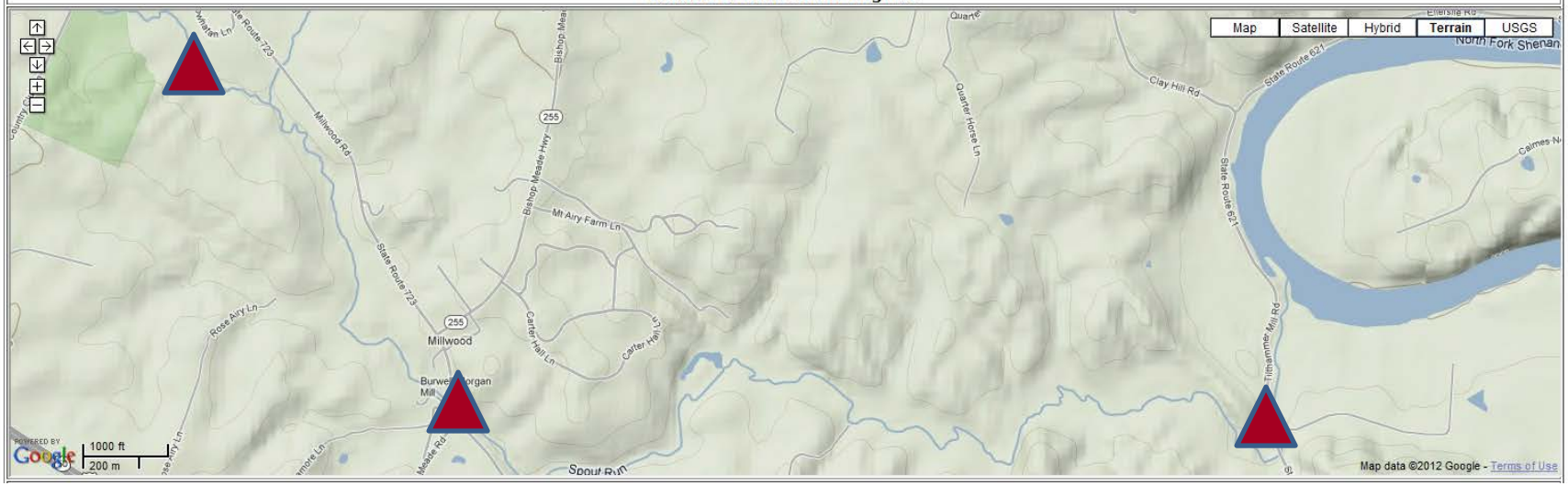


Watershed Analysis: 6th grade

Clarke County, Virginia
Hydrologic Unit Code 02070007
Latitude 39°04'01.29", Longitude 78°00'13.51" NAD83
Drainage area 21.4 square miles
Gage datum 440 feet above NGVD29

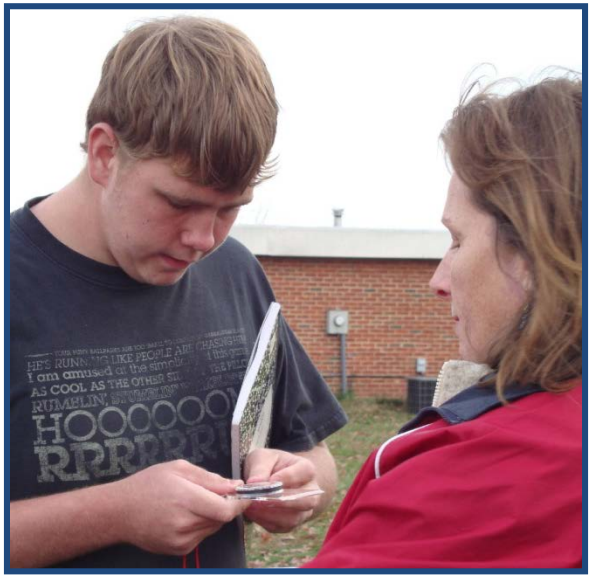
Watershed Analysis HS

Location of the site in Virginia.



Middle School Alternative Program

Is Lake Georgette functioning as a vernal pool?



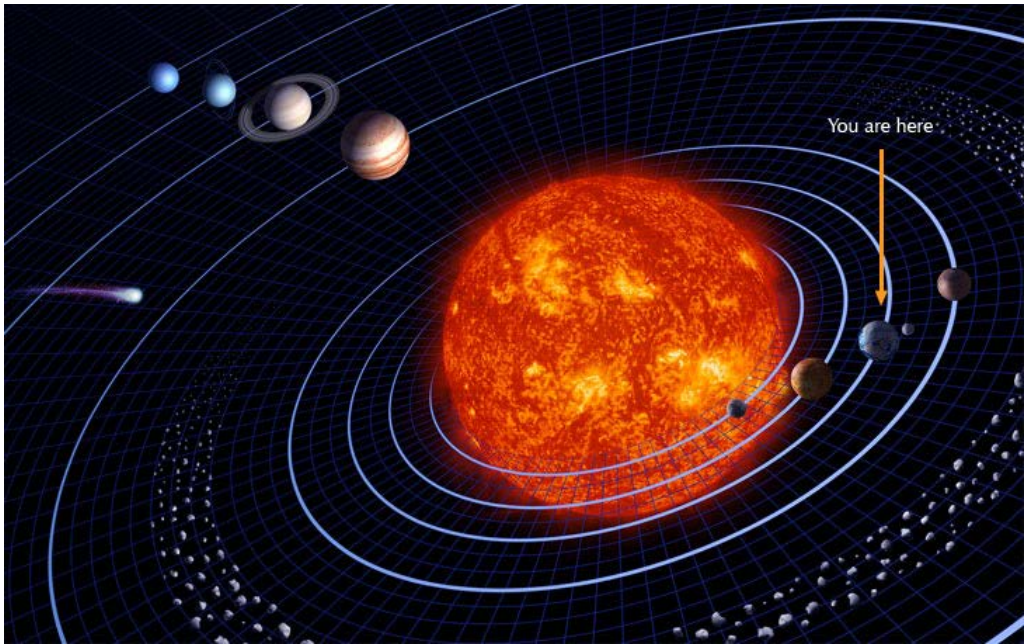
Organism identification & field site mapping

Name some disciplines that study systems

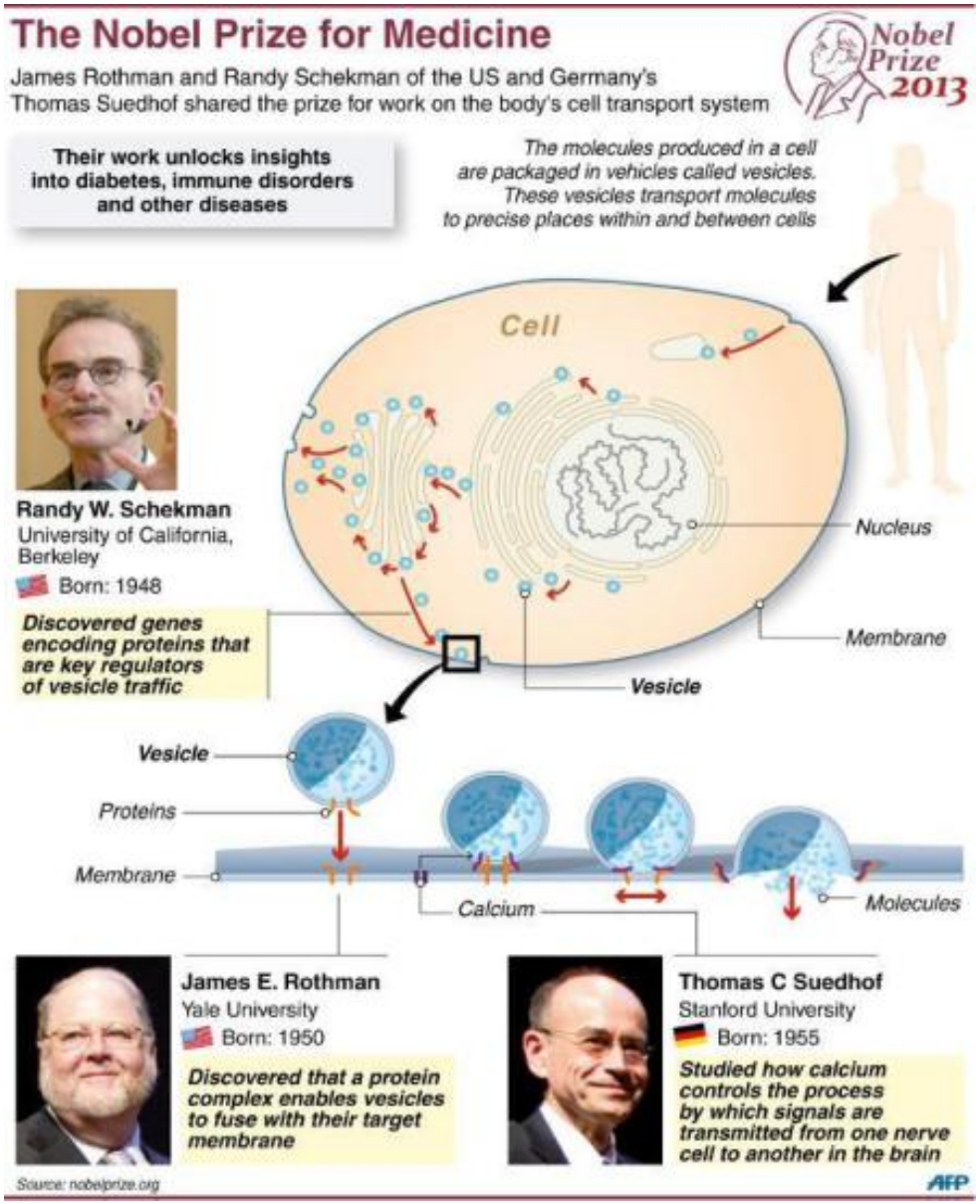
- **Economics:** production and consumption, market value, services
- **Ecology:** organisms, communities, ecosystems, energy flow, nutrient cycling
- **Linguistics:** phonetics, etymology, speech/writing analysis
- **Community Planning:** land development, mapping, cultural heritage
- **Mathematics:** numbers & equations, geometric models

Why is systems thinking important?

- Helps us to understand complex problems
- Helps us to communicate ideas
- Makes connections between seemingly unconnected ideas/disciplines
- Often at the realm of discovery



2013 Nobel Prize in Medicine

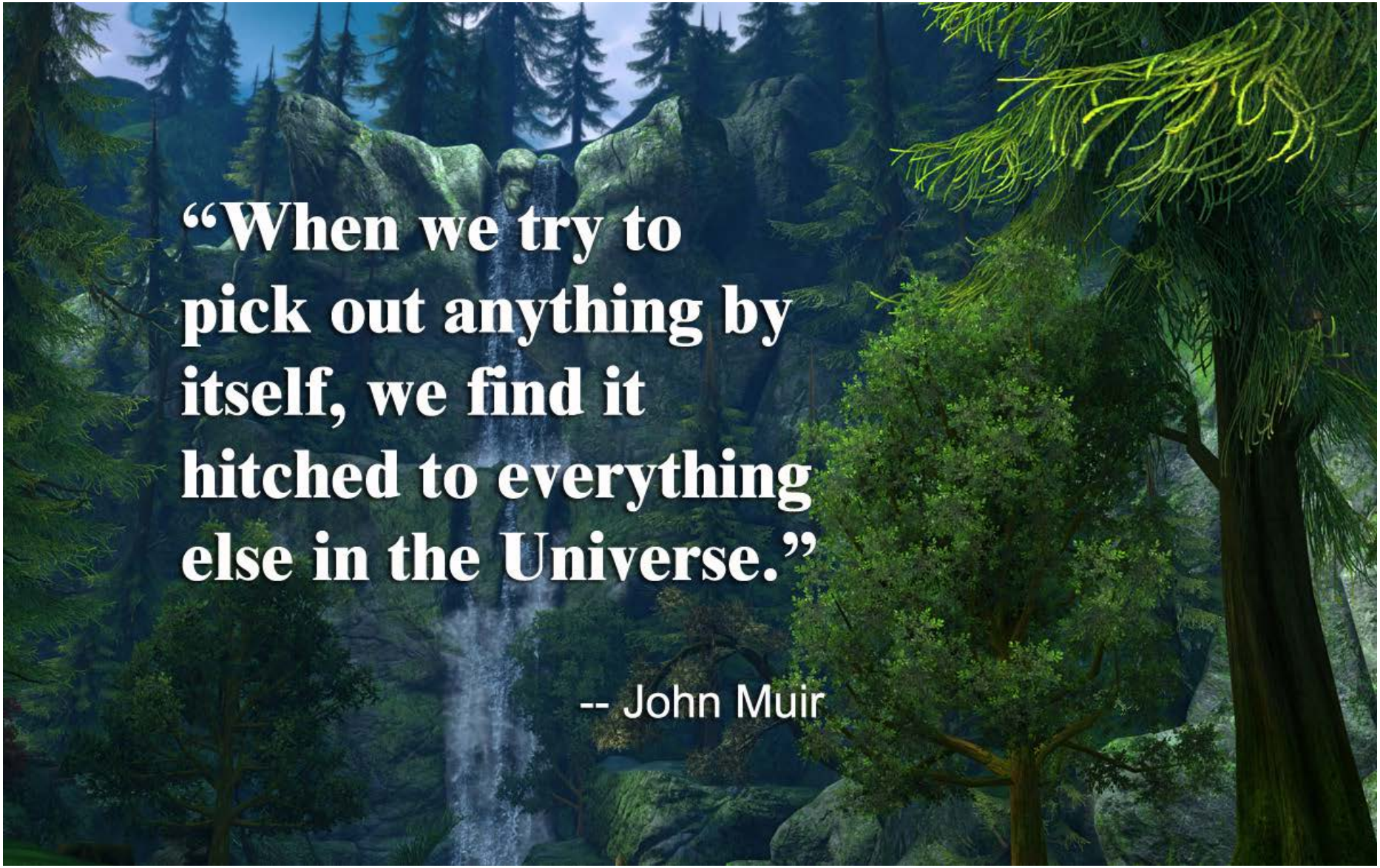


"…for their discoveries of machinery regulating vesicle traffic, a major transport system in cells"

- Protein structure & processes
- Celluar genetics
- Molecular signaling

Systems Thinking & Learning

- **What is a system?**
- **What is systems thinking?**
- **Why important to teach?**
  - ❖ Develop critical thinking, analytical, & problem-solving skills
  - ❖ Meaningful connections
  - ❖ Encourage discovery


“When we try to pick out anything by itself, we find it hitched to everything else in the Universe.”
-- John Muir

I welcome talking further with you!

Visit our website:

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Email:

lutzow-felling@ virginia.edu

Candace Lutzow-Felling
Director of Education

Call:

540-837-1758 x 230

Thank you !

EXTRA SLIDES

System: An assemblage of interrelated parts through which matter, energy, & information flow.

Subsystem: The subset of interrelated parts within the larger system.

Input: The addition of matter, energy, or information to a system.

Output: Matter, energy, or information that flows out of a system.

Open system: A system in which matter may flow in & out, as opposed to a closed system in which matter may not flow in or out.

Closed system: A system in which matter may circulate, but may not enter or leave. (energy, however, can flow in and out)

Why systems thinking?

In systems thinking, the individual parts are identified as well as an investigation of how the parts work together to make the whole.

- Develop reasoning skills that cut across the disciplines; cross-disciplinary reasoning
- Dissect problems & break them down into solvable components
- Spark innovation: create new models, new systems, new solutions