



Western Washington University
Western CEDAR

Salish Sea Ecosystem Conference

2014 Salish Sea Ecosystem Conference
(Seattle, Wash.)

May 1st, 1:30 PM - 3:00 PM

Bringing critical systems thinking to high school students through ocean acidification research

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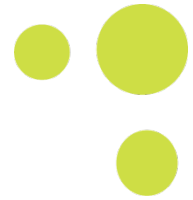
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Systems 
Education Experiences

Baliga Lab at Institute for Systems Biology



Bringing critical systems thinking to high school students through ocean acidification research

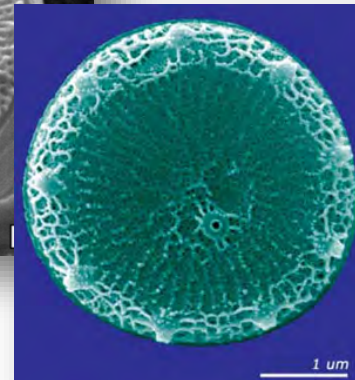
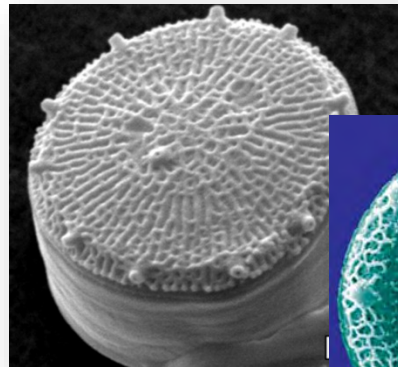
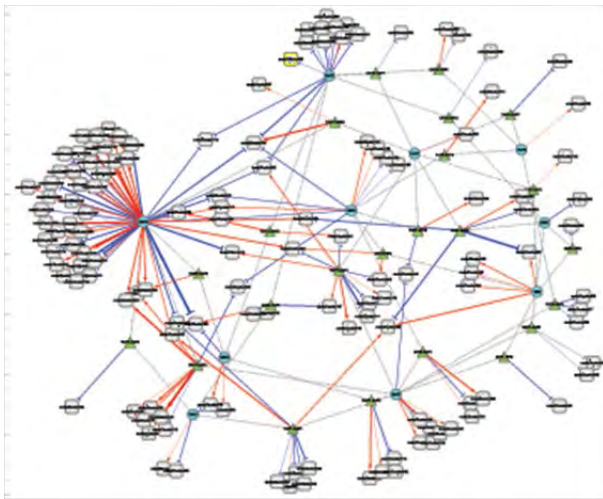
Claudia Ludwig, Mónica Orellana, Mari Knutson Herbert, Michael Walker, Jennifer Duncan-Taylor, JoAnn Chrisman, Eric Muhs, Allison Lee, Alexis Valauri-Orton, Alexis Bodela, Holly Keustner, Dina Kovarik, William Harvey, Dexter Chapin, Christine Lauer, Jake Valenzuela, Justin Ashworth, Helen Ippolito, Kedus Getanah, Eric Grewal, Donald Chao, Suzanne Reeve, Lisa George, Bill Palmer, Kim Kaufmann, Steven Do, Donald Cho, Raisah Vesteinsdottir, Meredith Carlson, Olachi Oleru, Kevin Baker, Jocelyn Lee, Jia Hao Xu, Danny Thomson, Aisha McKee, Nitin Baliga

5/1/2014 Salish Sea Conference – Novel Actions to Address
OA in the Salish Sea

Our 4th module – Ocean Acidification: A Systems Approach to a Global Problem

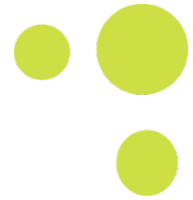


- Model current interdisciplinary research and connect to the work of others.
- Teach the process of thinking.
- Students as scientists and delegates.
- 3-5 weeks of class time.



Photos: genome.jgi-psf.org/Thaps3,
www.pnas.org/content/105/5/1391/F1.expansion.html

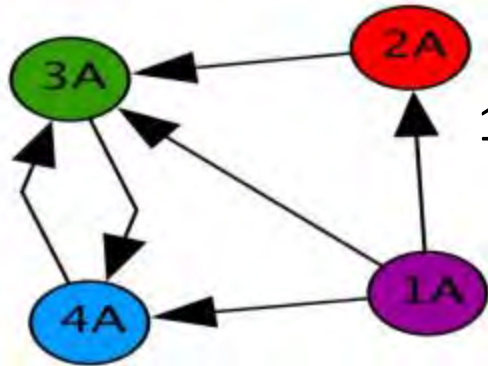
Main Goal



Analyze the effect CO₂ has on ocean chemistry, ecosystems and human societies

Prior Knowledge Needed: Understand basics of networks.

Classroom exercise: analyzing a social network

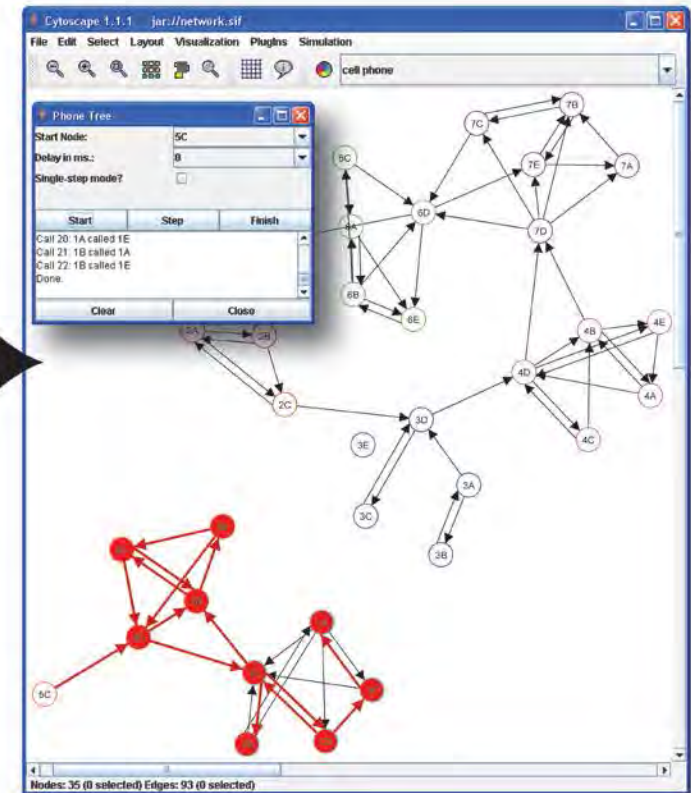
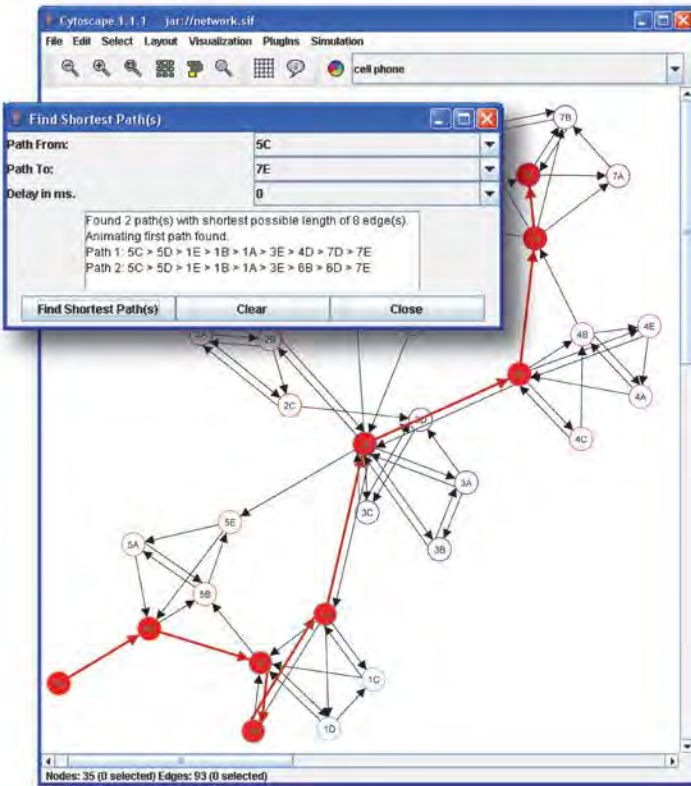


1. In an interactive group activity, students use **familiar** cell phone networks to learn about how information can be easily depicted.




2. Students pull together the class information to quickly learn that even when working in a team of five, it is still difficult to organize and **analyze** all of the information.

Motivation to use tools to solve problems




Systems thinking enables behavioral changes

Seeks to understand the big picture



Observes how elements within systems change over time, generating patterns and trends




Recognizes that a system's structure generates its behavior




Identifies the circular nature of complex cause and effect relationships




Habits of a Systems Thinker




Changes perspectives to increase understanding




Surfaces and tests assumptions




Considers an issue fully and resists the urge to come to a quick conclusion



Considers how mental models affect current reality and the future




Uses understanding of system structure to identify possible leverage actions




Considers both short and long-term consequences of actions



Finds where unintended consequences emerge



Recognizes the impact of time delays when exploring cause and effect relationships

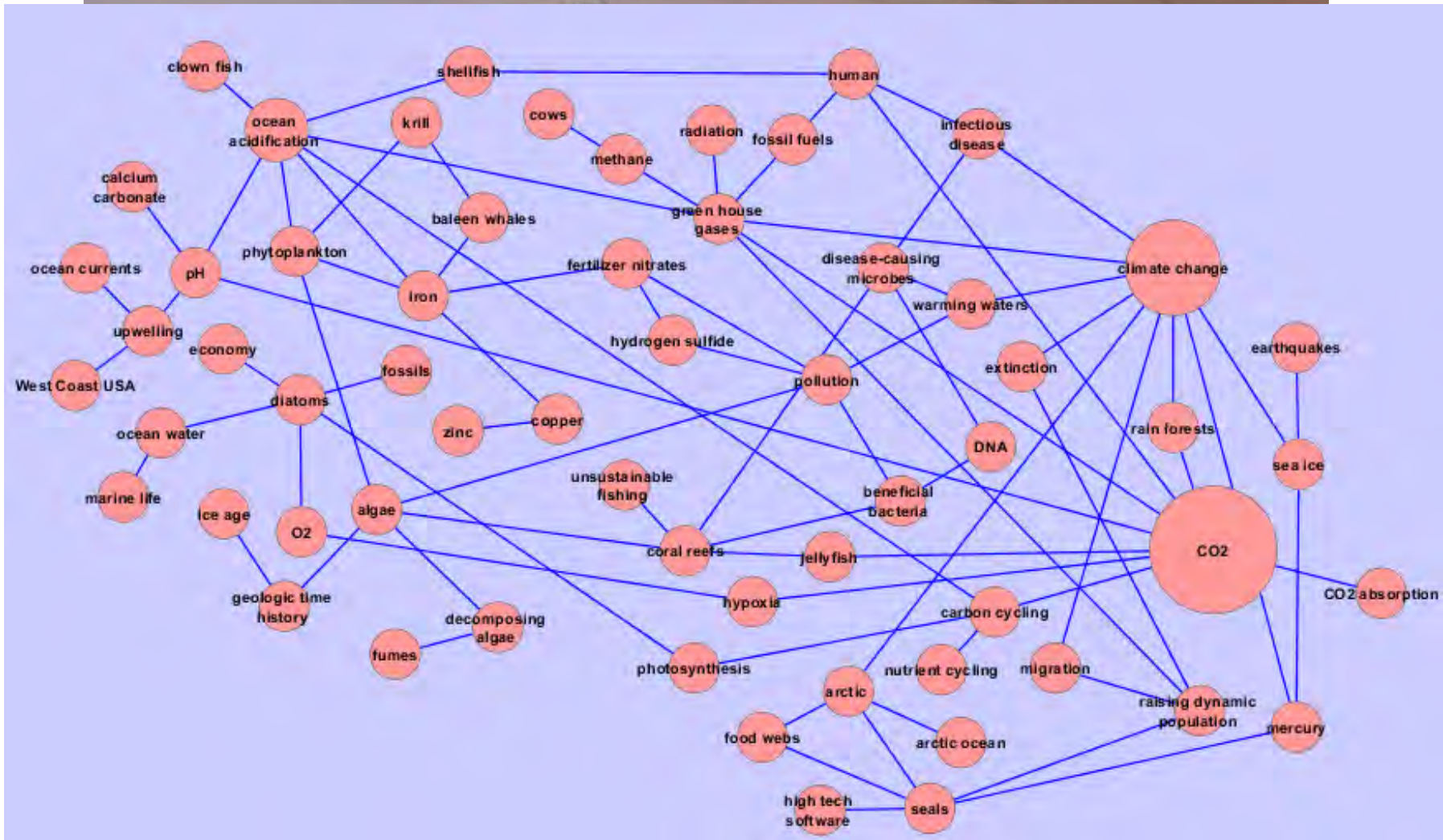
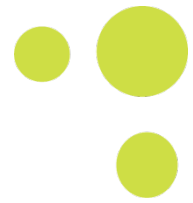


Checks results and changes actions if needed: "successive approximation"

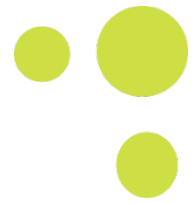


Lesson 1 (Introduction through case studies):

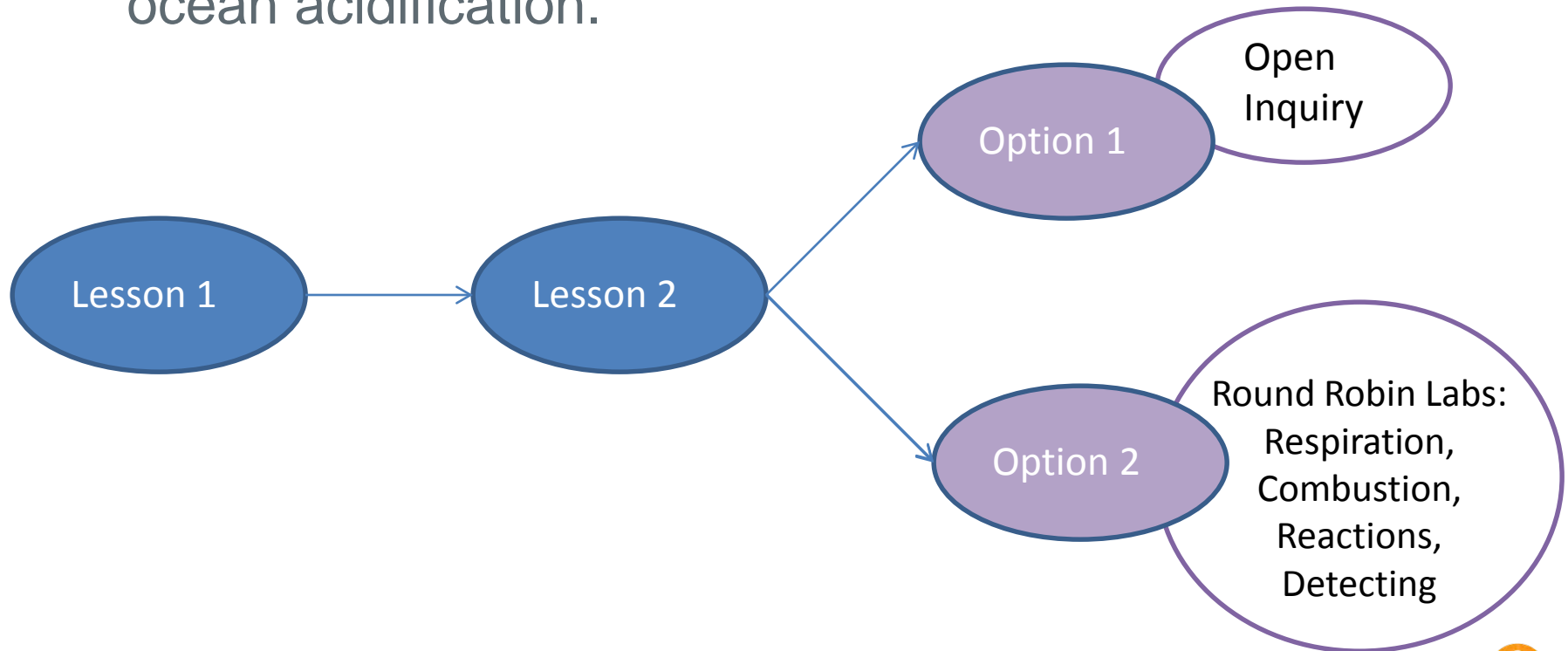
Understand the broad reach and accessibility of ocean studies and gain the critical thinking skills to properly evaluate news media.



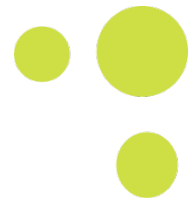
Lesson 2: Exploring CO₂ in the lab



- A. Use inquiry to understand CO₂.
- B. Learn the basics of the changing carbon cycle and ocean acidification.

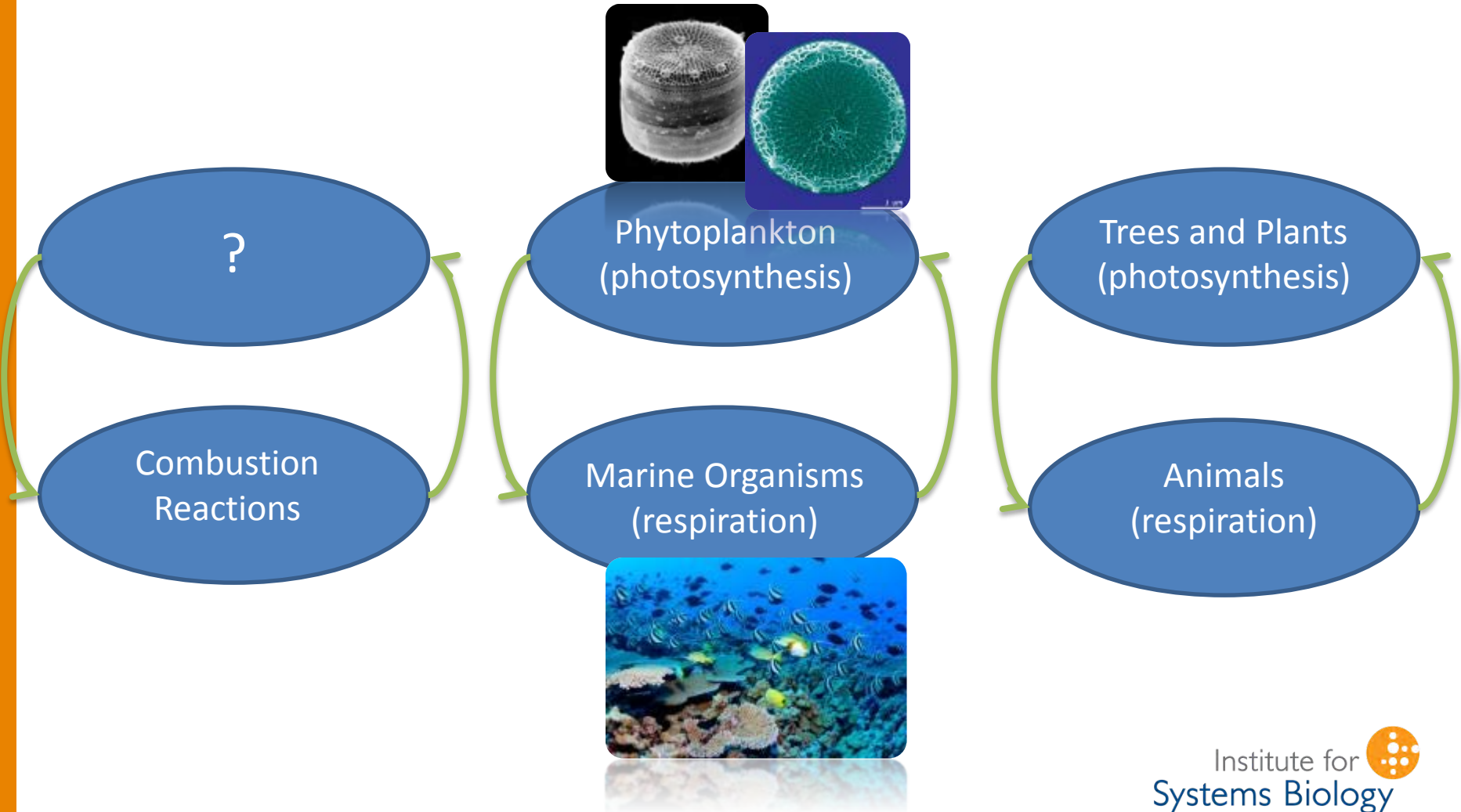


Lesson 3

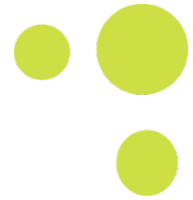


- Watch Acid Test video – realize this is a global problem with many stakeholders
- Setting the stage to model a collaborative lab group
- Is this a situation that requires a **systems study**?
 - Many parts with interactions, emergent properties, reverberating effects?

Does this require a systems study?



Lesson 4-5: Exploration of the effects of changing nutrient and carbon cycles



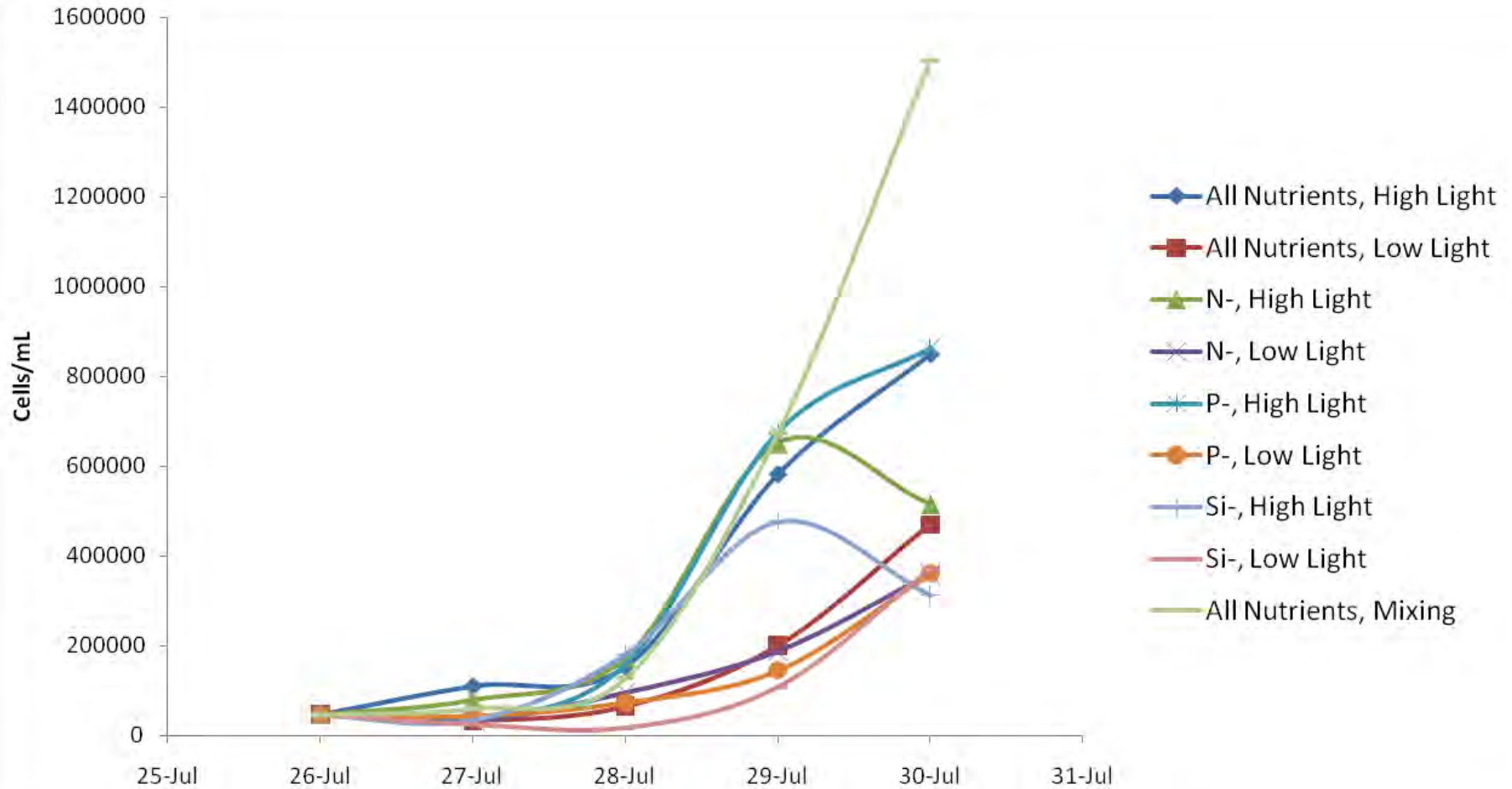
- In **interest groups**, experiment, analyze public (online) data, and prepare for a mock summit to address concerns.
- **Main question:** What effect does the increasing atmospheric CO₂ have on the ocean and its subsystems?
 - Model collaborative research by completing a cohesive set of experiments in order to determine the correct interactions within their sub-networks
 - Emphasis on need for multiple and diverse data
 - Need for multiple stressors

Options

- A. Student interest groups each design their own experiment
- B. ~ 8 protocols available for student groups to complete – slight variations
 - Diatoms – various nutrient, CO₂ entry, water, temperature, salinity types
 - Shell and bone dissolution with sea urchin online lab
 - Physical chemistry experiments

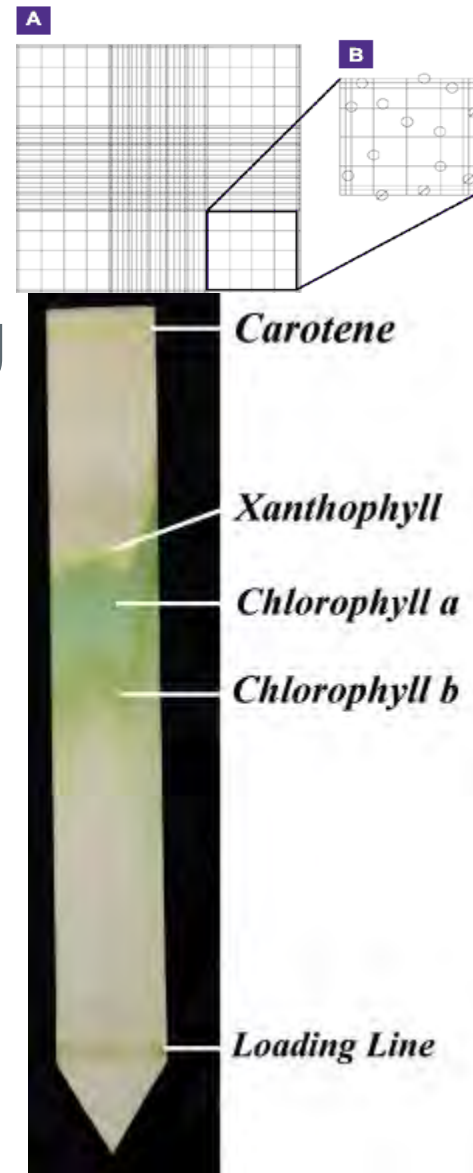


Growth curves as determined from hemocytometer counts performed by ISB high school interns



Need for multiple & diverse data

- Daily culture measurements:
 - Cell count using a hemocytometer
 - OD 600 reading/Fluorometer reading (depending on what technology is available)
 - Pigment description
 - Pigment extraction experiment
 - Chromatography



Example of experiment design



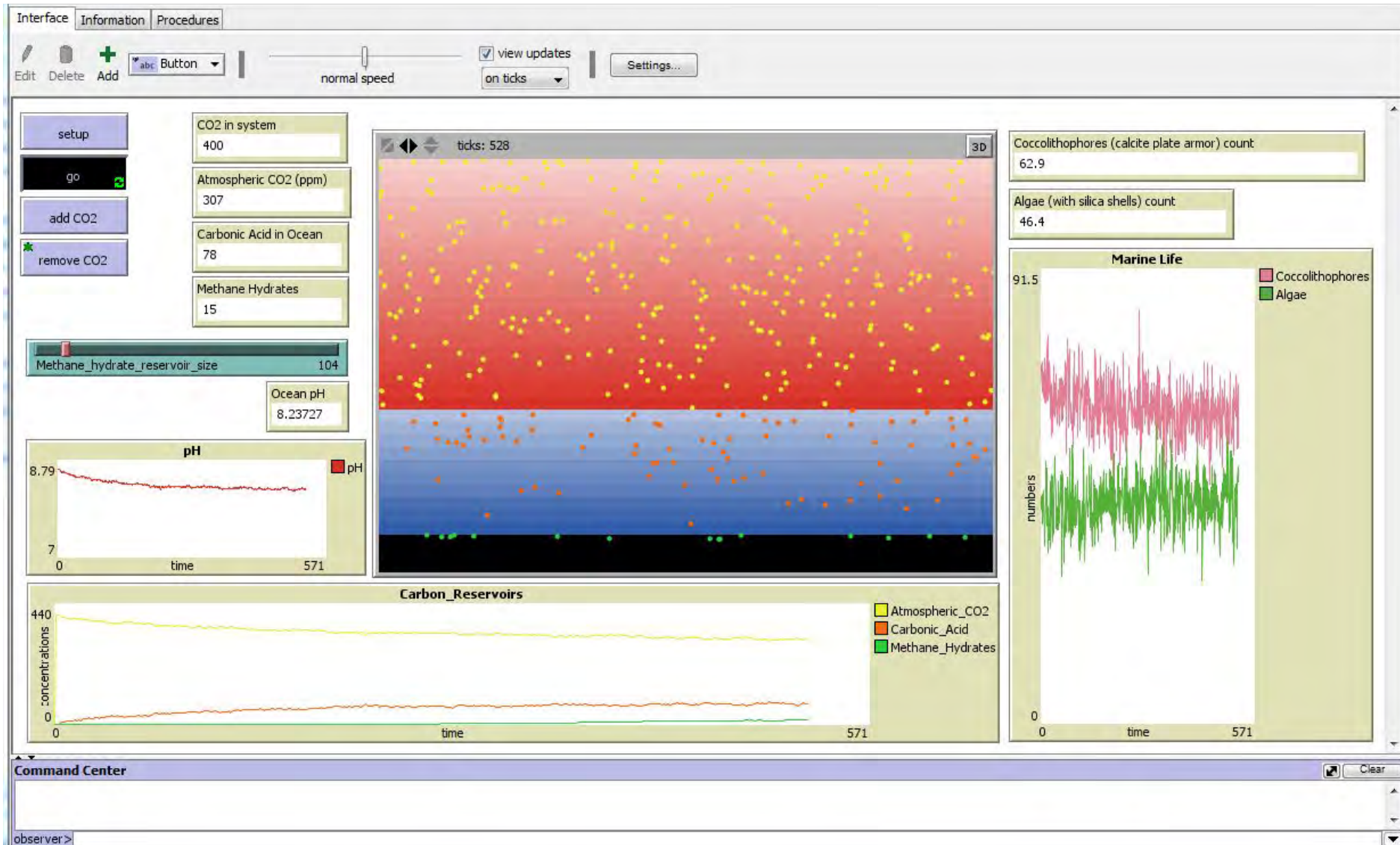
5g of dry ice were used to stabilize CO₂ levels at approximately 2000 ppm. pH of seawater dropped from 8.0 to 6.5 overnight. Shells left in seawater lost 2% of their mass over 3 days.

Supplement their experiment with online data component.

- Bad Acid: Sea Urchin Simulation
- C-MORE
- WA State Department of Ecology (Eyes over Puget Sound)
- Multiple in situ sensors
- Ice Core studies
- Mesocosm studies
- Many NOAA resources
- Carbon footprint calculators

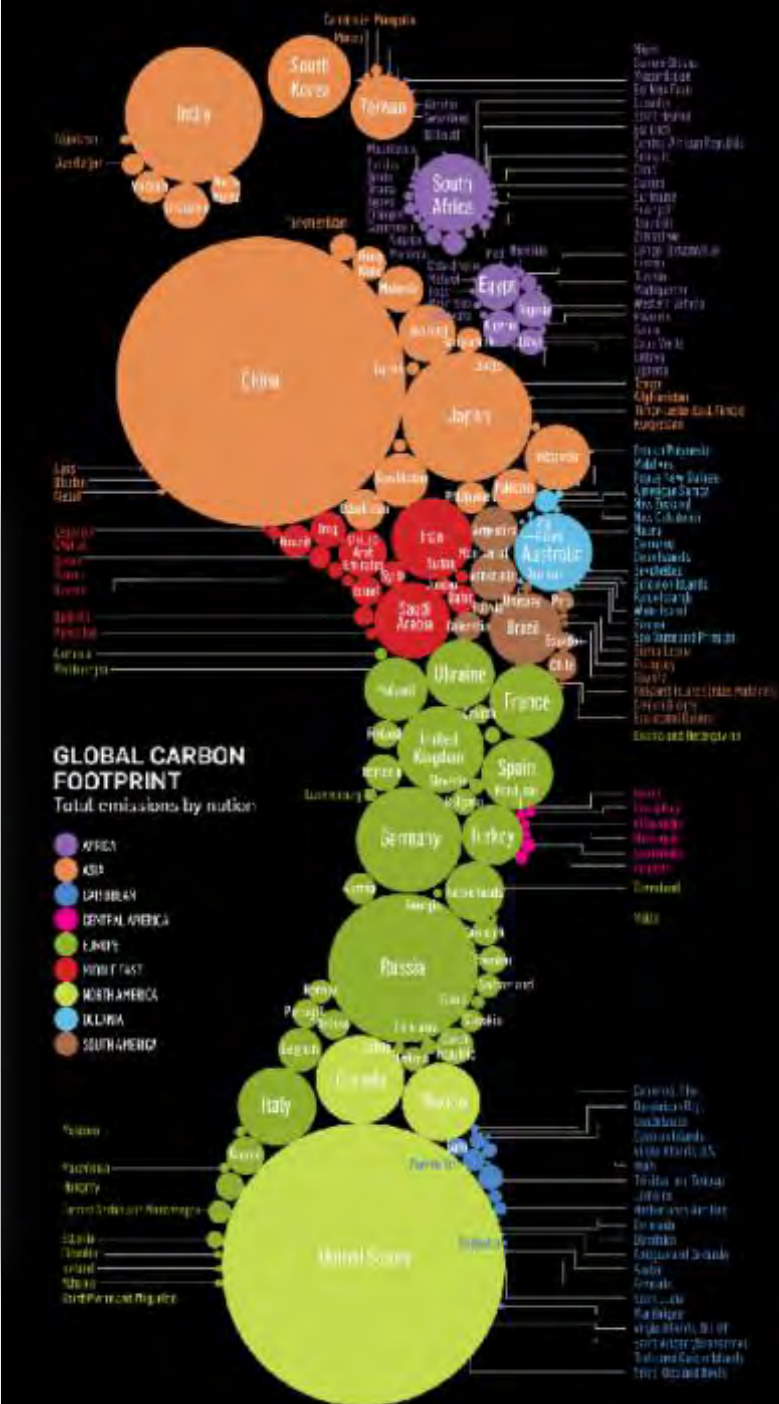


NetLogo / Java simulation for generating hypotheses.



Lesson 6: Mock Summit

Students as scientists and delegates

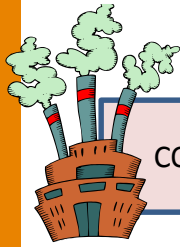
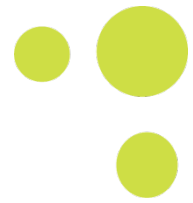


Discuss findings and next steps for all parts of the system

- Emphasis placed on the impact on the subsystem and system.
- Students reflect on unanswered questions, next steps and on what their roles
 - How they might change their actions in order to impact the network?
 - What does their final, class experimental network look like?



Atmospheric CO₂ Level



CO₂ Polluting Nations

Developing Island Nation Economies

Oxygen

CO₂ Absorbed by Ocean

Reef Tourism

Diatoms

Carbonic Acid

Ecosystem Services

Fisheries



Calcium Carbonate

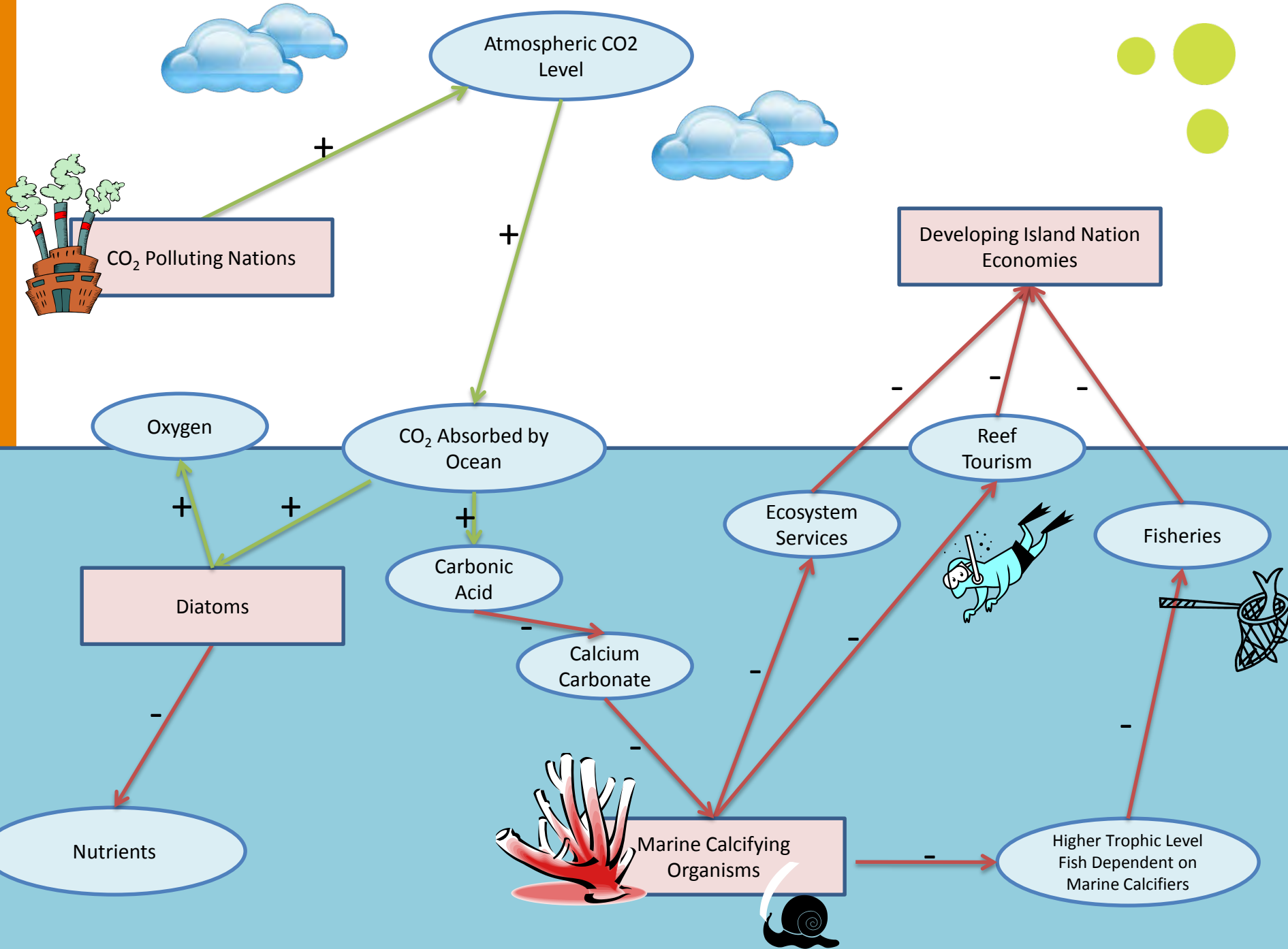
Nutrients



Marine Calcifying Organisms



Higher Trophic Level Fish Dependent on Marine Calcifiers



Is it working?

- Yes! They're learning, engaged, and thinking - systemically and locally.

Where are we going next?

- Genetic component, with predictions of future responses, acclimation and adaptation

Thank you for listening – please visit me for more information.



http://staff.wvu.edu/stefan/salish_sea.shtml

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- **Our curriculum team...**



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Please see <http://baliga.systemsbiology.net/> for more information.

