Using the World Issue of Food Security to Teach Multiple NGSS

PROJECT FEED 1010

Institute for Systems Biology

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Institute for Systems Biology
Revolutionizing Science. Enhancing Life.

Fill out a notecard for a chance to win a free aquaponic system!

1. Your name
2. Your contact information
3. School and city, state
4. What intrigues you about this session topic?
5. What do you hope to learn today?

Place in box at front of the room when you're done

Institute for Systems Biology: Baliga Lab

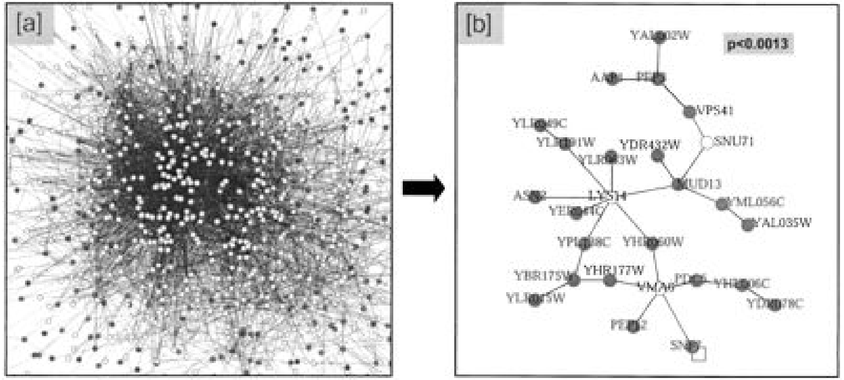
- 9 faculty
- 45 degree fields
- 25 senior research scientists & engineers
- 1000 K-12 science educators annually receive professional development & systems biology training

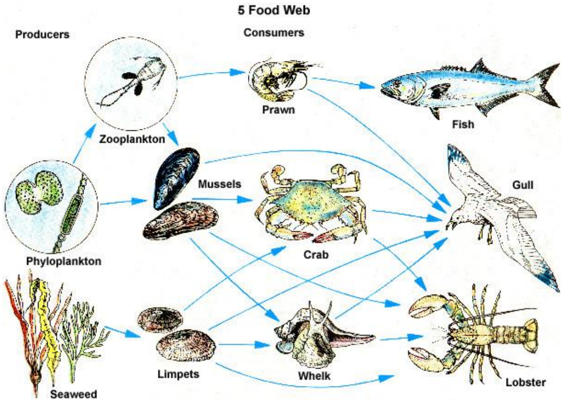
We will discuss…

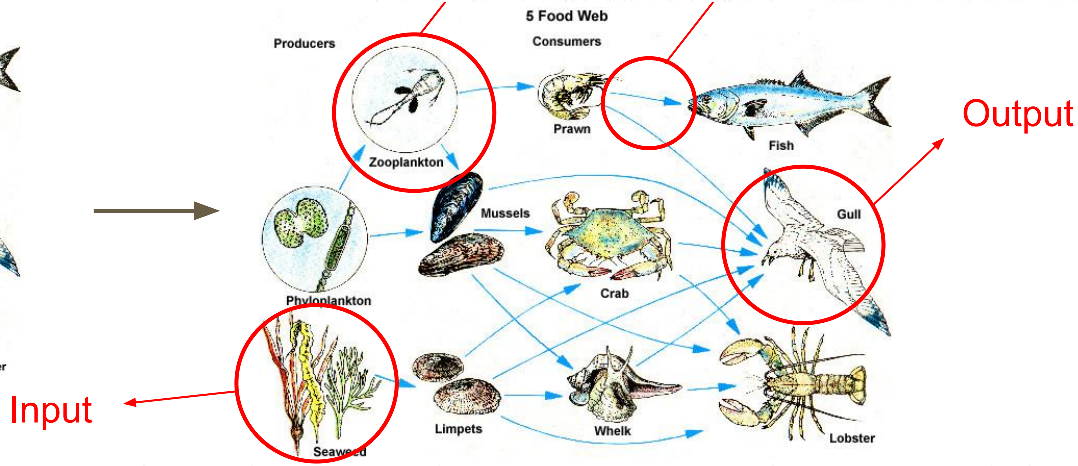
1. **Systems biology**
2. Project Feed 1010
3. NGSS
4. Aquaponics and citizen science
5. Resources

Systems Biology

Studying large, complex systems and the interactions between the components

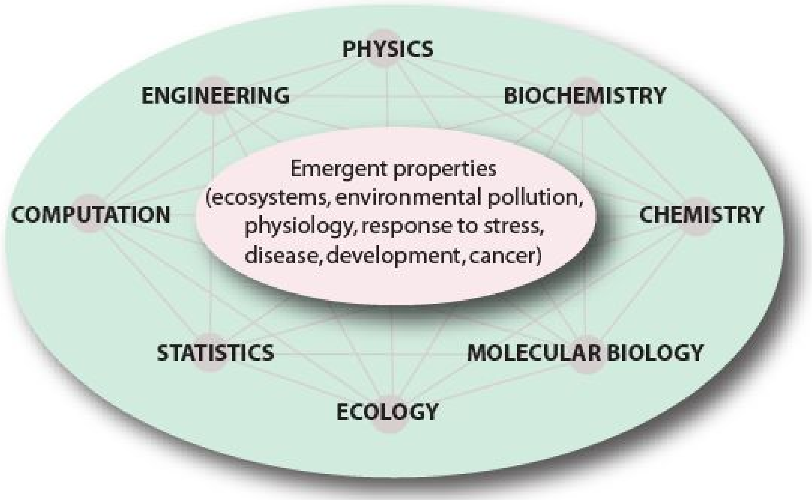






What do the arrows (edges) represent?	Relationships (energy transfer)
What do the circles (nodes) represent?	Components
What happens if we remove an animal?	Collapse

Translating Today's Science



Mission: Cultivate cross-disciplinary skills for solving complex problems

Goal: Foster development of the thinking and concepts of **systems biology** by using a **common problem** that brings together biology, chemistry, physics, mathematics, statistics and computer science (STEM)

The Global Food Crisis

Environmental issues

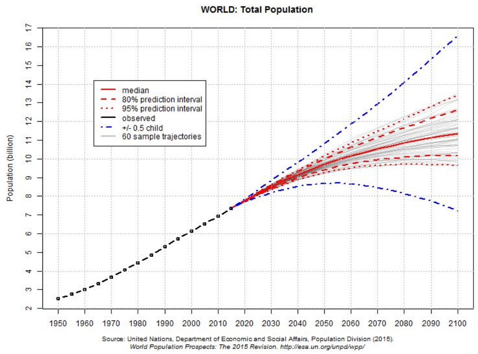
- Drought
- Soil loss
- Changing climate
- Pollution

Hunger

- 1 in 9 people in world are undernourished - mostly developing countries (where 12.9% of the population is undernourished)
- Food insecurity

Population Growth

- 10 billion by 2050



How will we feed 10 billion people by 2050 and also protect our environment??

We will discuss…

1. Systems biology
2. **Project Feed 1010**
3. NGSS
4. Aquaponics and citizen science
5. Resources

Project Feed 1010

Create a **paradigm shift** towards sustainable living and scale up sustainable agriculture

- Train and educate the future workforce in sustainable food production and human wellness
- Optimize food production systems through research and experimentation
- Develop infrastructure to support network

Systems Education Experiences

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CURRICULUM SUPPLEMENT SERIES:
MODELING SUSTAINABLE FOOD SYSTEMS

Students take an interdisciplinary approach to understand a global issue. The driving question: "*Is there a way to produce and consume food resources that will be environmentally sustainable and sufficient for future global needs*?" Students learn that systems thinking is helpful in identifying influences and interactions within the food security system. After critically examining the environmental tradeoffs involved with various food production techniques, students build an aquaponic system (optional) to evaluate the potential of scaling up aquaponics to fill the future food gap. Next, students examine the origins of food and resources required to produce it. Throughout this module, student groups investigate the various aspects of the food crisis in a specific country, which culminates in a UN council meeting to propose a solution.

COURSE INTEGRATION

Statistics, Human Geography, Biology, AP Biology, Environmental Systems, AP Environmental Science, Agriculture, Social Studies

LESSON 1: INTRODUCTION TO FOOD SECURITY

TIME

50 minutes - 1 class period

STANDARDS

- NGSS HS-LS2D Social interactions and group behavior
- NGSS HS-ESS3.C: Human impacts on earth systems
- CCSS MATH.CONTENT.7.RP.A.2 Recognize and represent proportional relationships between quantitites

OBJECTIVES

What students learn

Students understand the definition of food security and that it is influenced by many factors including poverty, geography, society, climate, and politics.This is a global problem that needs addressed in *their* lifetime.

What students do

Students formulate their own definition of food security using videos and class discussions to guide them. They also use global statistics to compare and contrast food security in countries around the world and research 1 country with high food insecurity.

LESSON 2: CRITICALLY EVALUATING FOOD PRODUCTION TECHNIQUES

TIME

90 minutes - 2 class periods

STANDARDS

- NGSS HS-LS2D Social interactions and group behavior
- NGSS HS-ESS3.C: Human impacts on earth systems
- CCSS MATH.CONTENT.7.RP.A.2 Recognize and represent proportional relationships between quantitites

OBJECTIVES

What students learn

Students revisit the 3 pillars of food security and recognize there are various strategies used to mitigate the food crisis. They learn that some methods are more sustainable than others. If time allows, an optional lab guides students through building an aqauponic system.

What students do

Students respond to *Food for Thought* video questions and work together to research various food production techniques to evaluate their environmental impact and efficiency. Students share their findings and assign sustainability scores to each method, then use a graphic organizer to determine what all methods have in common.

DO IT YOURSELF: CREATING AN EFFICIENT SYSTEM (OPTIONAL LAB)

TIME

90 minutes - 2 class periods, weekly monitoring

STANDARDS

- NGSS HS-LS2D Social interactions and group behavior
- NGSS HS-ESS3.C: Human impacts on earth systems
- CCSS MATH.CONTENT.7.RP.A.2 Recognize and represent proportional relationships between quantitites

OBJECTIVES

What students learn

Students learn the inputs, outputs, and components of an aquaponic system, and the importance of system stability. They learn that bacteria and the Nitrogen cycle are key to maintaining a stable system.

What students do

Students apply systems biology approaches to illustrate an aquaponic system network. Groups present their graphics and build an aquaponic system in groups or as a class.

LESSON 3: WHO CARES? STAKEHOLDERS!

TIME

50 minutes - 1 class period

STANDARDS

- NGSS HS-ESS3.C: Human impacts on earth systems
- NGSS HS-ESS3.D: Global climate change
- NGSS HS-ETS1B Engineering Design: developing solutions
- CCSS ELA-LITERACY.RI.11-12.1 Key ideas and details in text

OBJECTIVES

What students learn

Students recognize the influence of stakeholders in decision making, as well as learn more about the various stakeholders involved in the global food security crisis.

What students do

Students are assigned the role of a stakeholder. They critically examine their stakeholder's background information in order to present their case: *will an increase in food production alone solve the global food crisis?*

LESSON 4: FOOD SECURITY AS A SYSTEM

TIME

90 minutes - 2 class periods

STANDARDS

- NGSS HS-LS1A Negative and positive feedback loop models
- NGSS HS-LS2C Ecosystem dynamics functioning and resilience
- NGSS HS-LS2D Biodiversity and humans

OBJECTIVES

What students learn

Students learn the 13 habits of a systems thinker and the 6 steps used to anallyze systems, along with various strategies for illustrating systems. They also understand interactions and tipping points within systems.

What students do

Students relate systems thinking habits to everyday situations, make a food security systems diagram usina a new illustration approach, and work as a class to create a large, causal loop map of the food crisis.

LESSON 5: WHY DON'T WE JUST GROW MORE?

TIME

50 minutes - 1 class period

STANDARDS

- HS-LS1A System structure and function, HS-LS2C-Ecosystem dynamics, functioning, resilience, HS-LS2D-Biodiversity & humans, HS-LS4C Adaptation, HS-ESS2C Water & Earth's surface processes, HS-ESS2D Weather/climate, HS-ESS2E Biogeology, HS-ESS3A Natural resources, HS-ESS3C Human impacts on Earth's systems, HHS-ESS3D Global climate change, CCSS ELA-LITERACY.RI.11-12.1 Key ideas and details in text

OBJECTIVES

What students learn

Students recognize that solving the global food security crisis is complex and that most decisions will affect many stakeholders. Students learn some network nodes have more influence than others.

What students do

Students work in groups to analyze *The Great Balancing Act*, from the World Resources Institute. They discuss how their stakeholders would be affected by the scenarios and connect these concepts to Lesson 4's food security network.

LESSON 6: WHERE DOES OUR FOOD COME FROM?

TIME

50 minutes - 1 class period

STANDARDS

- NGSS HS-LS1: C: organization for Matter and Flow, D: Information processing, NGSS HS LS2: A: Interdependent relationships in ecosystems, B: cycling of matter and energy transfer in ecosystems, C: ecosystem dynamics, functioning and resilience, NGSS HS ETS 1: B developing possible solutions, NGSS: HS ETS 2: A interdependence of science, engineering and technology, B: Influence of engineering, technology and science on society and the natural world.

OBJECTIVES

What students learn

Students understand the environmental and economic costs associated with production and consumption of food products and how external variables can effect them.

What students do

Students become business people and are challenged to purchase ingredients and make sustainable food products in the face of rising food prices and changing environmental conditions while incorporating ethics and morals.

SUMMATIVE ASSESSMENT: UNITED NATIONS COUNCIL MEETING

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LESSON 1: INTRODUCTION TO FOOD SECURITY

THE BIGGER PICTURE

Food security is a foreign concept to many Americans. Most believe that chronic hunger and malnutrition happens only to people in developing nations or to the homeless. In reality, 1 in 6 people in America go hungry every day and are not food secure. To some students, food insecurity is a reality, therefore this is a subject that must be approached with great sensitivity and care. Throughout the lesson students will develop and refine their understanding of food security using online resources, videos and class discussion to help guide their thinking. This concept is the introduction to the unit and will be addressed in future lessons associated with the unit, so it is important that the students get a solid understanding of the concept. They are able to compare different countries and analyze what food security issues they have based on the three pillars using global statistics. The lesson ends by introducing students to the UN council meeting that will take place at the end of this unit, and answering questions to prepare for it in the *Building Your Case* worksheet.

OBJECTIVES

What students learn

Students understand the definition of food security and that it is influenced by many factors including poverty, geography, society, climate, and politics.This is a global problem that needs addressed in *their* lifetime.

What students do

Students formulate their own definition of food security using videos and class discussions to guide them. They also use global statistics to compare and contrast food security in countries around the world and research 1 country with high food insecurity.

STANDARDS

- NGSS HS-LS2D Social interactions and group behavior
- NGSS HS-ESS3.C: Human impacts on earth systems
- CCSS MATH.CONTENT.7.RP.A.2 Recognize and represent proportional relationships between quantitites

TIME

50 minutes - 1 class period

PREREQUISITES

Students should have a basic understanding of middle school mathematics - percentages, ratios, and proportional relationships.

BEFORE CLASS

Gather materiarls: Optional whiteboard for discussion; index cards numbered 1-10, map of the world; world hunger map (link provided in lesson); Food Security Vocabulary PowerPoint; 3 Pillars PowerPoint; Building your Case worksheet; Further Background section (below). All of the *Modeling Sustainable Food Systems* resources are on the SEE website: see.systemsbiology.net.

TEACHER INSTRUCTIONS

You will be using a few online, interactive maps to help students understand the overwhelming number of people who are undernourished and food insecure around the world. The following data comes from the UN's World Food Program using their most recent data from the Food and Agricultural Organization (FAO). Your challenge is to take global statistics and translate it to the number of students. It would be beneficial to read the Further Background section (below) before teaching this.

Hunger statistics that can be used for this activity

- Globally - 795 million hungry people of a population of 7,300 million = 11 %
- USA proportion of undernourished <5%
- North Korea (Democratic People's Republic of Korea) proportion of undernourished = 42%
- South Korea (Republic of Korea) proportion of undernourished <5%
- Dominican Republic proportion of undernourished = 12%
- Haiti proportion of undernourished = 53%

1. Warmup: Show Food Security Vocabulary PowerPoint. Have students hypothesize what they think "food security" means. There is no right or wrong answer at this point. They can write their thoughts in a notebook or share outloud. Do not give them the correct definition yet!
2. Before introducing the lesson, pass out an equal number of index cards labeled 1-10, one per student. Extra student(s) can be employed as counters during the activity. If you have more than 10 students, make additonal cards numbered 1-10.
3. Display a map of the world on your projector. Give the students the global hunger statistics and have them determine which combination of cards distributed equals 11%. This equates to about 1 in 10 students or 2 in 20 students that go hungry each day. Students with a "1" or "2" raise their hands depending on the number of students in your class.
4. Ask students to predict what the % of undernourished people is in the USA or Canada. Tell them 4% is a high estimate and have them determine which combination of cards distributed that equals 4% (less than 1 in 10 people, ~1 in 20 people).
5. It isn't always about geographic location; countries with certain policies/politics/geography all influence food security. The United States even has problems with hunger. Point out two sets of countries that share common borders such as Haiti and the Dominican Republic, or North and South Korea. You can use any combination of countries of your choosing off of the FAO's World Hunger Map: http://www.fao.org/hunger/en/.

TEACHER INSTRUCTIONS CONTINUED

6. Continue having students determine which combination of cards distributed equals the % undernourished in those countries.
7. Display the high resolution UN World Hunger Map (http://www.wfp.org/content/hunger-map-2015) and ask if students see any patterns. Hypothesize a few reasons these patterns may exist. At this point, many issues/ideas should begin to surface (political system, geography, state of the country's economy, infrastructure, climate, etc).
8. Discussion: there are a number of things that keep people from having enough food. What are some things that prevent them from getting enough food? When students start listing ideas, link them to the 3 pillars of food security and the correct vocabulary.
   - Food availability: sufficient quantities of food available on a consistent basis.
   - Food access: having sufficient resources to obtain appropriate foods for a nutritious diet.
   - Food use: appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation.
9. Show the 3 Pillars PowerPoint and discuss which of the 3 pillars of food security some countries are missing (availability, access, and/or use).
10. Start a discussion: of the countries we looked at, do you think these countries are missing all of these pillars? Can you be food secure and only have 2 pillars? What if they're missing one pillar? Students should recognize that, even if a country is only missing one pillar, it would still be considered food insecure. Ex: even if they have food available and accessible, they would need to know how to use it in order to be secure.
11. Lead a class discussion to come up with a class definition of food security, and then compare that to the definition given by the World Health Organization. See below: Lead the class into the idea that food security is not just an American issue, but worldwide, and is not just about growing more food or eliminating poverty.
12. Optional math extension (see Extension Activities below).
13. Formative assessment: Open the Food Security Vocabulary PowerPoint. Is the answer to food security simply growing more food? Justify your answer. Students will revisit their answers in Lesson 3.
14. Hand out the Building your Case student document and complete questions from Lesson 1. Split students up into up to 3 groups to represent 3 different countries - North Korea, Nambia, or Haiti. If you have less than 25 students, split up students into 2 groups and choose 2 countries. Within those country groups, students should split up into smaller groups of 3-4 to complete the Building Your Case questions each day.

BUILDING YOUR CASE ACTIVITY

Students now recognize that many countries around the world, including the United States, suffer from food insecurity. You and your students will be using the *Building your Case* student and teacher documents at the end of each lesson in this curriculum series. This activity will guide students through the process of investigating a food insecure country and creating a proposal to aid the UN in solving the crisis in that country. Each lesson will introduce more information to students pertaining to the global food crisis and sustainable food production. After learning new material in each lesson, students will apply it to questions in the *Building your Case* worksheet.

MATH EXTENSION ACTIVITY

This optional extension activity (~15 minutes) gives students the opportunity to practice calculating percentages and growth rates and recognize the implications of population growth on food security. This activity should follow step 11 in the teacher instructions.

1. Remind students that currently 11% of the global population is undernourished.
2. Open link to Figure 1 from Resources and select "world" from the dropdown menu. Either explain the graph or allow students to gather information from the key and figure summary.
3. Using the figure, have students determine the percent growth of the Earth's population from today to 2050.

Example Calculation:

- Current global population: 7300 million
- Projected global population in 2050: 9500 million
- What is the percent increase in population?
- (9500 – 7300)/7300 * 100 = 30% increase

4. Using this % increase and current hunger trends, how many hungry humans will there be in 2050?

Example Calculation

- Current global population: 7300 million
- Projected global population in 2050: 9500 million
- Number of hungry people: (95/73)*795 = 1030 million (approximately 3x USA population)

5. Is this an exaggerated or conservative value? Explain.

FURTHER BACKGROUND

Food security is a complex sustainable development issue, linked to health through malnutrition, but also to sustainable economic development, environment, and trade. There is a great deal of debate around food security with some arguing that:

- There is enough food in the world to feed everyone adequately; the problem is distribution.
- Future food needs can - or cannot - be met by current levels of production.
- National food security is paramount - or no longer necessary because of global trade.
- Economic Globalization may - or may not - lead to the persistence of food insecurity and poverty in rural communities.
- Increasing food production to meet future growing population demands may or may not lead to increased negative environmental impacts.
- Climate change may or may not make agricultural production more difficult
- Issues such as whether households get enough food, how it is distributed within the household and whether that food fulfils the nutrition needs of all members of the household show that food security is clearly linked to health.

Agriculture remains the largest employment sector in most developing countries and international agriculture agreements are crucial to a country's food security. Some critics argue that trade liberalization may reduce a country's food security by reducing agricultural employment levels. Concern about this has led a group of World Trade Organization (WTO) member states to recommend that current negotiations on agricultural agreements allow developing countries to re-evaluate and raise tariffs on key products to protect national food security and employment. They argue that WTO agreements, by pushing for the liberalization of crucial markets, are threatening the food security of whole communities.

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BUILDING YOUR CASE

Globally, one in nine people in the world today (795 million) are undernourished. The vast majority of the world's hungry people live in developing countries, where 12.9% of the population is undernourished. Throughout this lesson, you will be the voice for one of these countries, where they so desperately need a solution to the food crisis. You will be preparing a proposal for the United Nations (UN) that clearly describes your country's plan to eradicate food insecurity, and will present it to the UN council at the end of this unit. You will answer the following questions after learning more information in each lesson. This will help you build your case.

LESSON 1: INTRODUCTION TO FOOD SECURITY

1. You and your group are representatives of the following country ______
2. Fellow country representatives ______
3. With your smaller team of country representatives, collect background information about your country
4. Annual rainfall ______
5. Current population size ______
6. Land area ______
7. Population density (people per square kilometer) ______
8. Population growth rate ______
9. Exports (price and main materials) ______
10. Imports (price and main materials) ______
11. Per capita income ______
12. Political issues ______
13. Cultural and/or religious notes ______
14. Main transportation and any difficulties ______
15. Land use ______
16. Current environmental issues ______
17. Diet ______
18. Primary crop production ______
19. Primary type of farming ______
20. Biomes ______
21. Climate ______

LESSON 2: CRITICALLY EVALUATING FOOD PRODUCTION TECHNIQUES

1. You just investigated various strategies for growing food. Based on your country's demographics and needs, which growing technique would you choose? Justify your answer. Questions to consider: does the system rely on resources that are limited? How does the system deliver food to people?
2. Where and how will the system be used? Are their limited resources such as water or adequate healthy soils? Explain your answer.

LESSON 3: WHO CARES? STAKEHOLDERS!

1. Which stakeholder are you representing? ______
2. As a stakeholder, you care about the outcome of the decision to solve the food security crisis in your country as it will affect you in a number of ways. Do you believe we can simply grow more food to solve this issue in your country? Expalin.
3. After meeting with the other stakeholders in your country, were you able to come up to a consensus about whether or not simply growing more food would solve the crisis in your country? If so, how did you come to that conclusion? If not, what were some of the points of disagreement?

BUILDING YOUR CASE - STUDENT (CONTINUED)

LESSON 4: FOOD SECURITY AS A SYSTEM

1. Draw a food security network for your country that will help the UN better understand the very complex nature of your country's crisis.
2. Choose 2 nodes that could be changed in some way that would have an effect on the overall issue. Expalin.

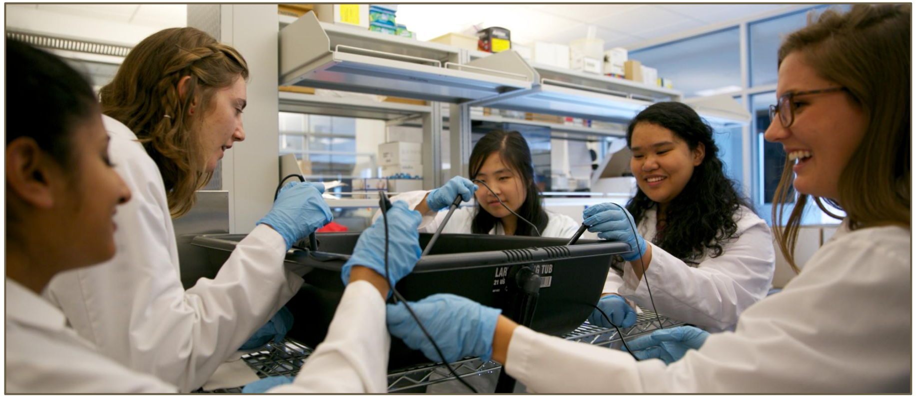
LESSON 5: WHY DON'T WE JUST GROW MORE?

1. Choose 2 menu items from The Great Balancing Act and describe how your stakeholder would be affected by the proposed change in your country. Would you benefit or not? Explain.
2. Which 2 menu items do you believe most other stakeholders in your country would agree would most benefit your country's crisis? Justify your choices.

LESSON 6: WHERE DOES OUR FOOD COME FROM?

1. Where does most of the food eaten in your country come from? What would happen if a drought diminished the supply of that food? How would that effect the price? Expalin.
2. How could your country become more resilient to the effects of environmental catastrophes on the food they depend on to survive? Provide 2 solutions and explain why they would help.
3. Do you believe your country has a relatively small or large environmental impact due to the primary food items they eat? Justify your answer.

Research & Experimentation



- How could we make the most food with the fewest resources (water, soil, etc)?
- How could we grow vegetables and protein (animals) at the same time?
- How do we reduce pollution?
- What types of plants grow the best in different climates?
- How do we increase access to food?

There are a lot of questions. We need everyone’s help to answer them!

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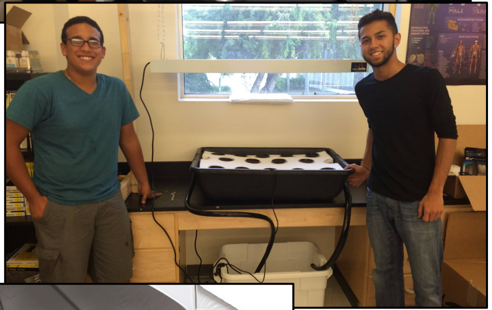
Citizen Science



What is it?

"A citizen scientist is an individual who voluntarily contributes his or her time, effort, and resources toward scientific research in collaboration with professional scientists or alone." - SciStarter

How is this helping us?

Data students collect from their system and upload online will help us understand how to grow food in the future. They are citizen scientists helping other scientists answer real-world questions!

We will discuss…

1. Systems biology
2. Project Feed 1010
3. **NGSS**
4. Aquaponics and citizen science
5. Resources

Teaching Systems Concepts

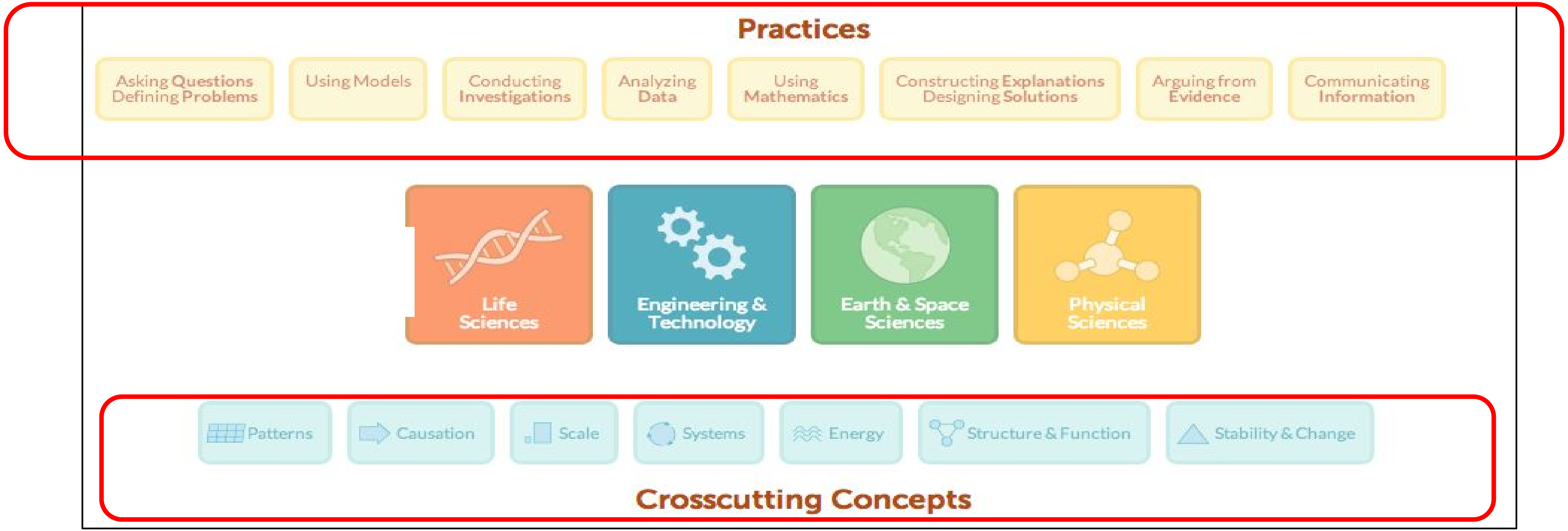
"…even our best schools don't teach the new survival skills our children need..."

-Tony Wagner in *The Global Achievement Gap (2008)*

7 survival skills

- Critical Thinking and Problem Solving
- Collaboration across Networks and Leading by Influence
- Agility and Adaptability
- Initiative and Entrepreneurialism
- Effective Oral and Written Communication
- Accessing and Analyzing Information
- Curiosity and Imagination

NGSS Big Picture Overview



https://see.systemsbiology.net/resources/standards-addressed

ETS1: Engineering Design

ETS2: Links Among Engineering, Tech, Science & Society

ESS3: Earth and Human Activity

PS1: Matter and Interactions

B: Chemical Reactions

LS1: From Molecules to Organisms: Structures and Processes

C: Organization for Matter and Energy Flow in Organisms

PS2: Motion and Stability: Forces and Interactions

PS2.C Stability and Instability in Physical Systems

PS3: Energy

PS3.B Conservation of Energy and Energy Transfer

PS3.D Energy in Chemical Processes and Everyday Life

PS4: Waves and Their Applications in Technologies for Information Transfer

PS4.C: Information Technologies and Instrumentation

LS2: Ecosystems: Interactions, Energy and Dynamics

LS4: Biological Evolution: Unity & Diversity

LS4.D: Social Interactions & Group Behavior

We will discuss...

1. Systems biology
2. Project Feed 1010
3. NGSS
4. **Aquaponics and citizen science**
5. Resources

Aquaponics

Fish meal

Waste

Aquaculture:

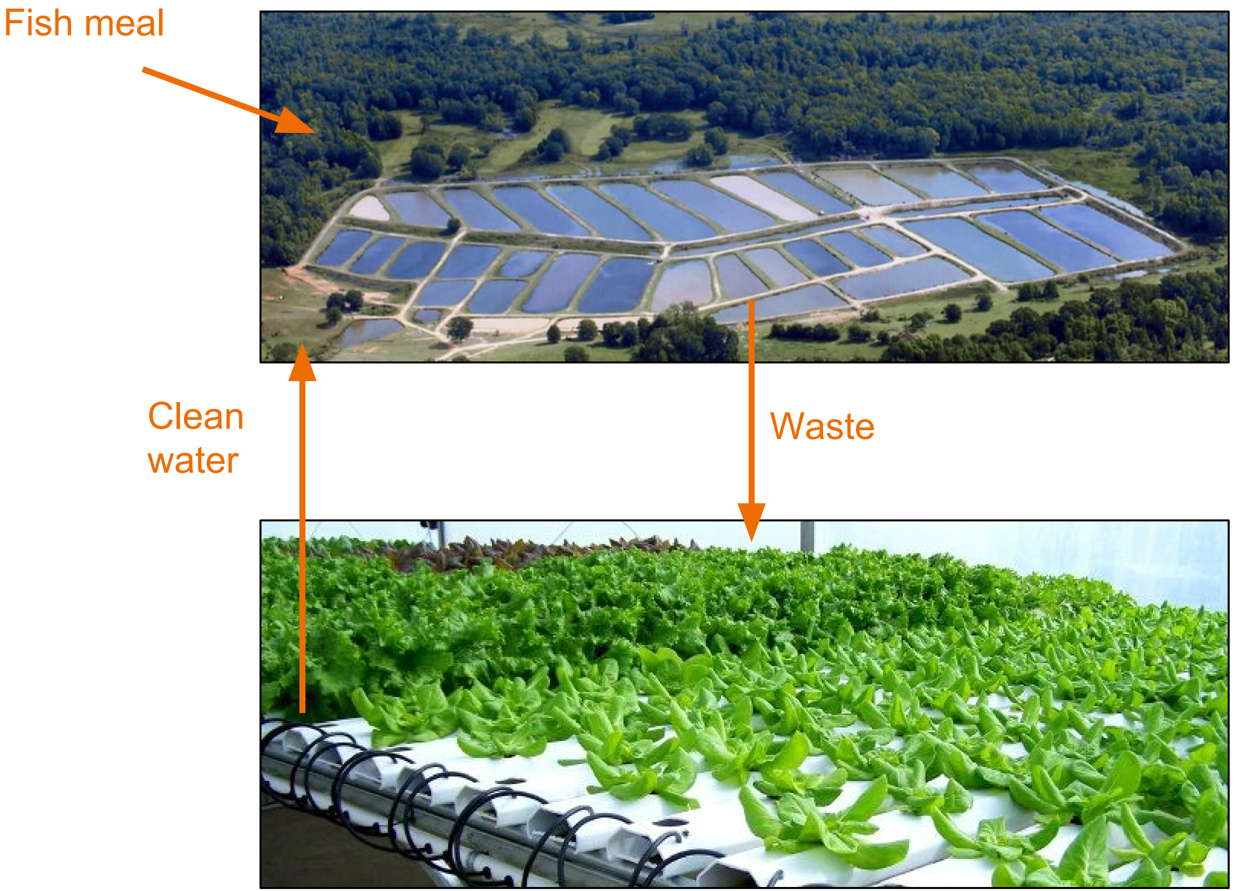
Raising aquatic organisms

✚

Nutrients

Hydroponics:

Growing plants without soil



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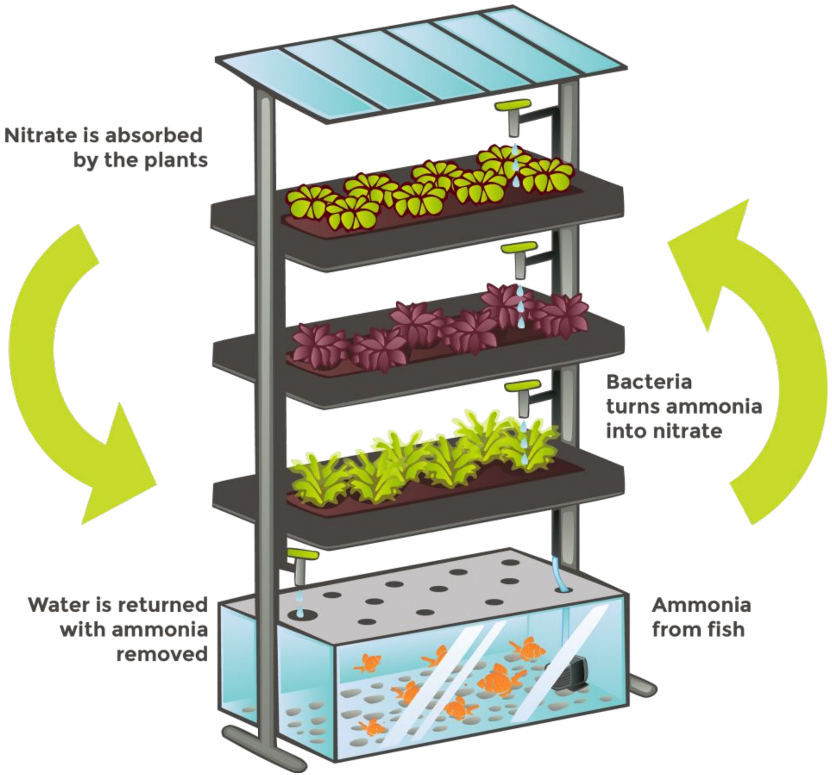
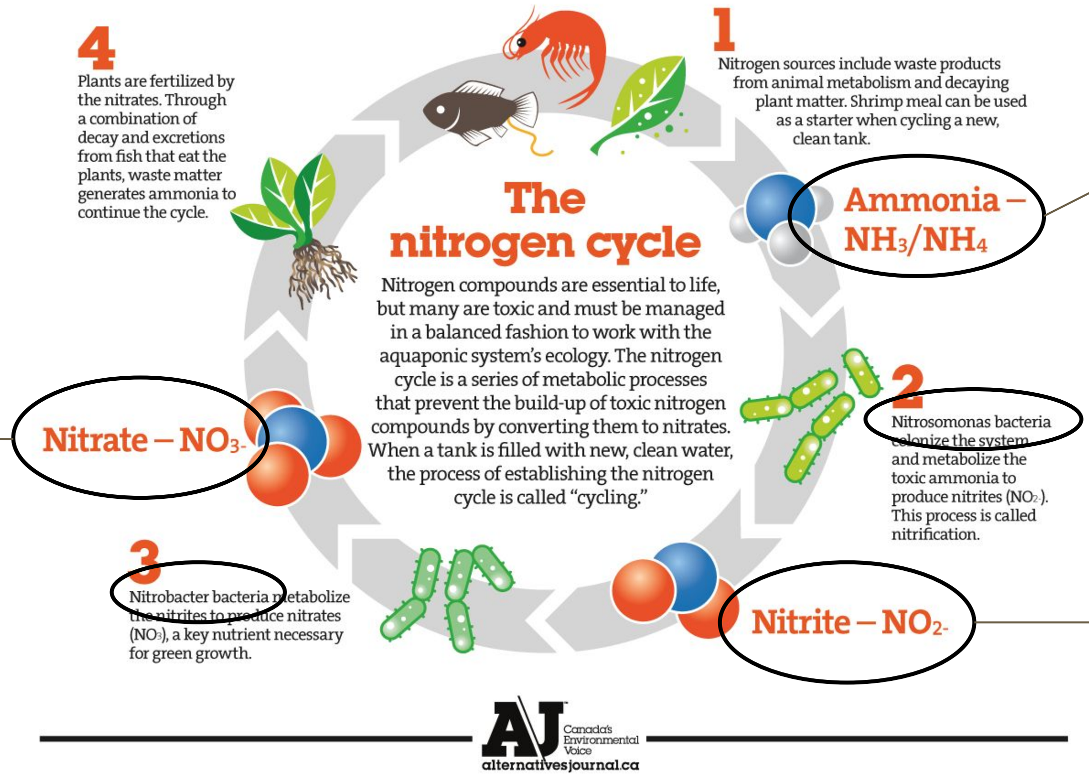
Requirements

1. Fish
2. Bacteria
3. Plants



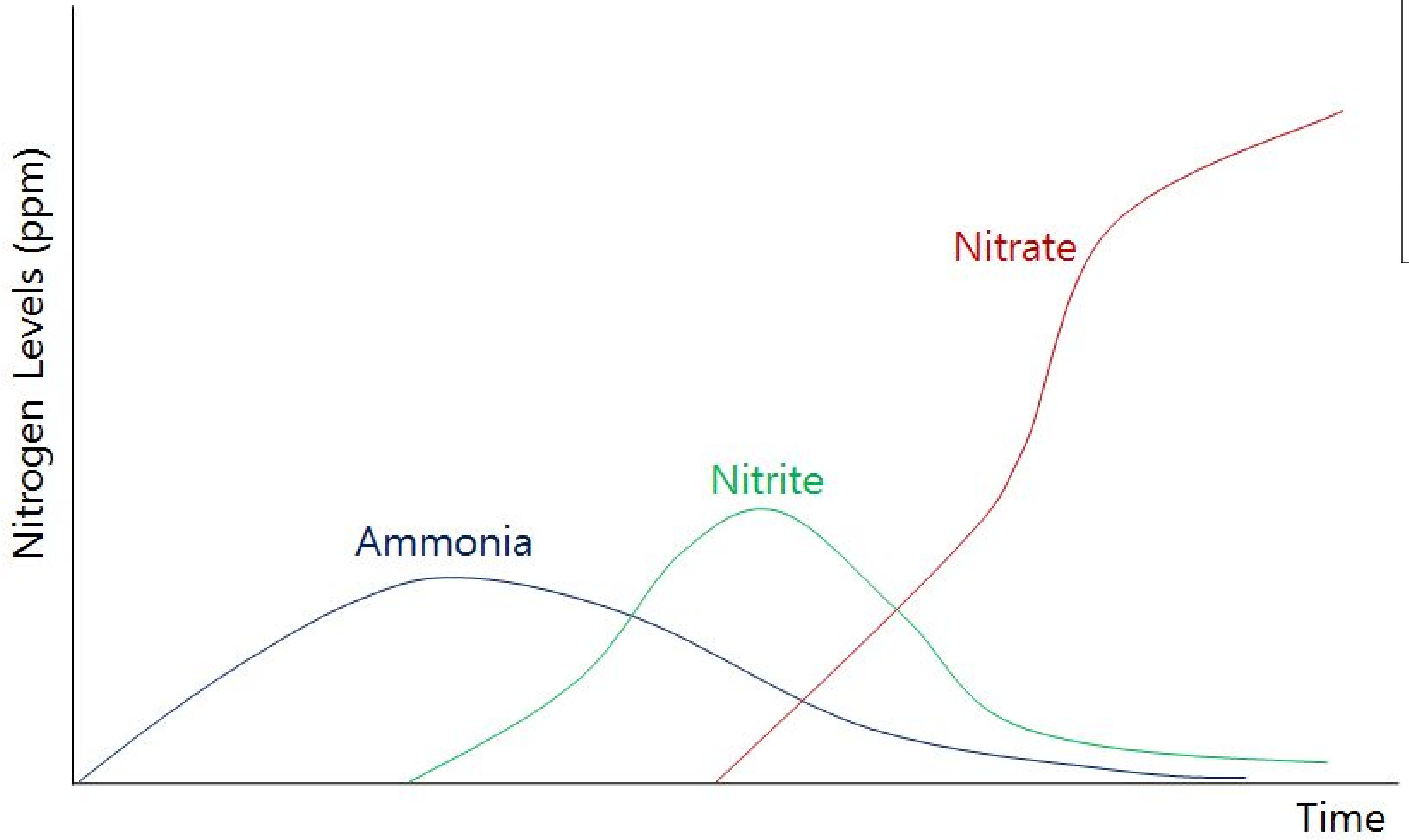
How does it work? The Nitrogen Cycle

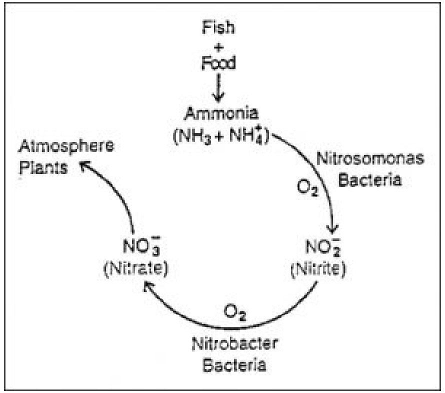


Bad for plants and fish

Good for plant growth

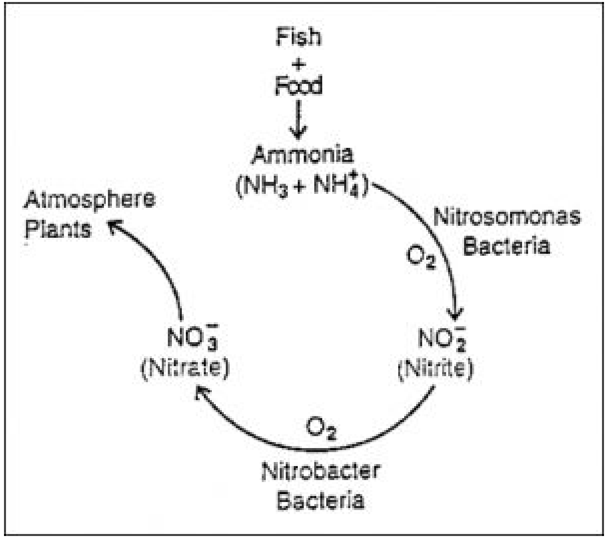
Bad for plants and fish


Nitrogen Levels (ppm)
Time
Ammonia
Nitrite
Nitrate


Fish
+
Food
Ammonia
($NH_3 + NH_4^+$)
Nitrosomonas
Bacteria
O_2
NO_2^-
(Nitrite)
O_2
Nitrobacter
Bacteria
NO_3^-
(Nitrate)
Atmosphere
Plants

Now you try! Collecting and analyzing data

1. Collect data for your sample using the instructions on the Water Chemistry Testing Guide
2. Record data on data collection form. Make sure you label which sample you're testing!
3. Describe what you think is happening in each system. Is it fully cycled, healthy, etc.?
4. What modifications would you make to this system based on the data you observed?



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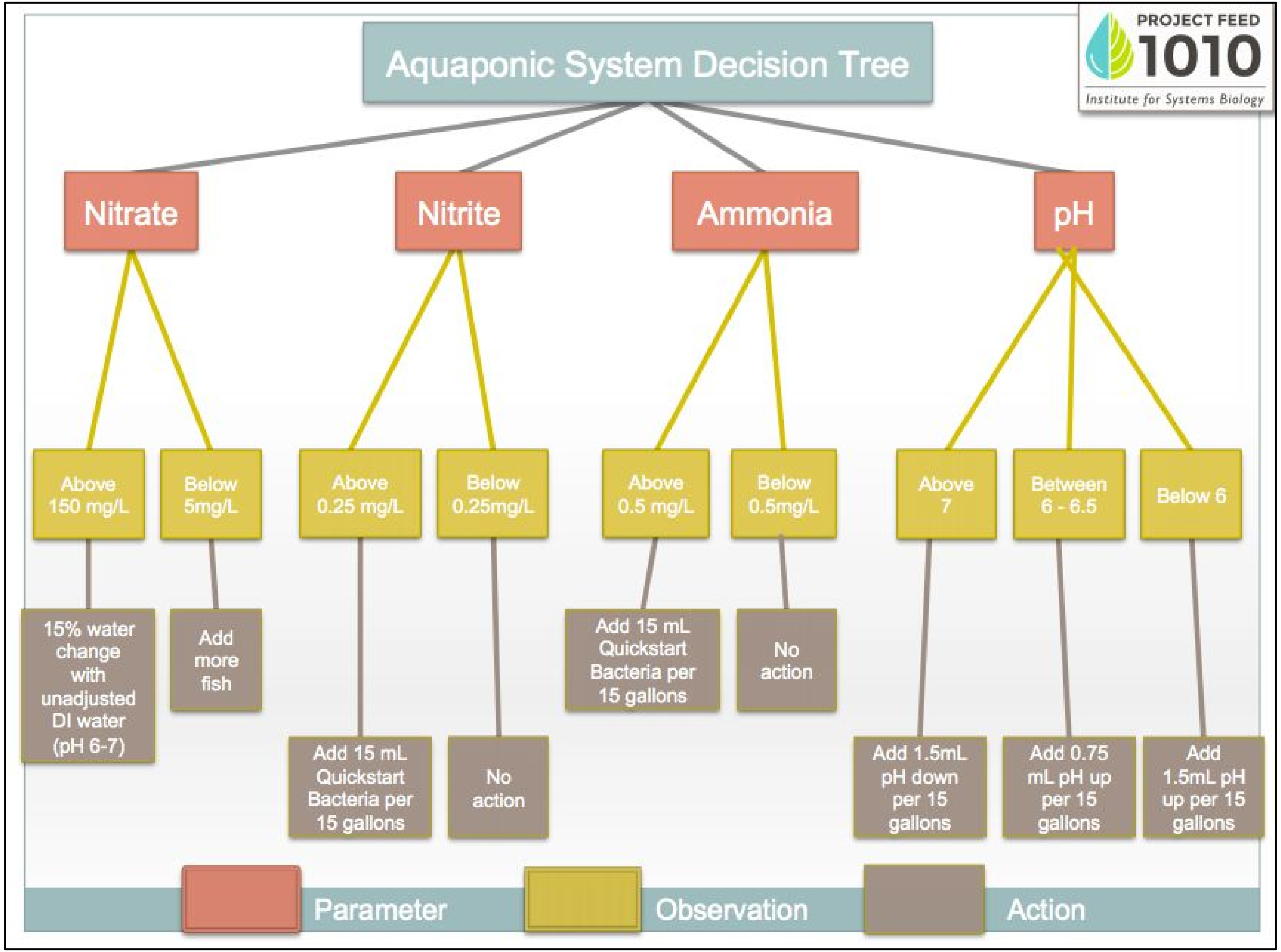
Aquaponic System Decision Tree
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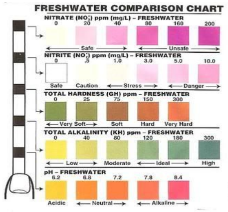
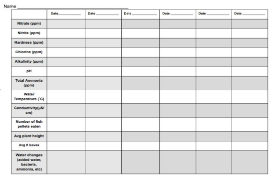
Nitrate
Nitrite
Ammonia
pH
Above 150 mg/L
Below 5mg/L
Above 0.25 mg/L
Below 0.25mg/L
Above 0.5 mg/L
Below 0.5mg/L
Above 7
Between 6 - 6.5
Below 6
15% water change with unadjusted DI water (pH 6-7)
Add more fish
Add 15 mL Quickstart Bacteria per 15 gallons
No action
Add 15 mL Quickstart Bacteria per 15 gallons
No action
Add 1.5mL pH down per 15 gallons
Add 0.75 mL pH up per 15 gallons
Add 1.5mL pH up per 15 gallons
Parameter
Observation
Action

Citizen Science and Aquaponics

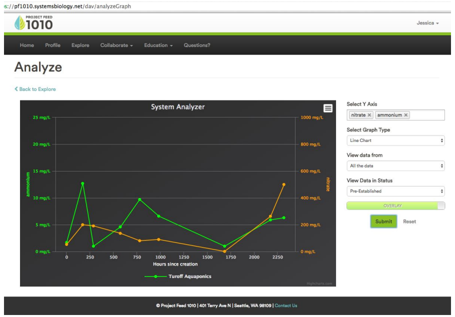
1. Put together water garden

2. Collect data





3. Upload data online



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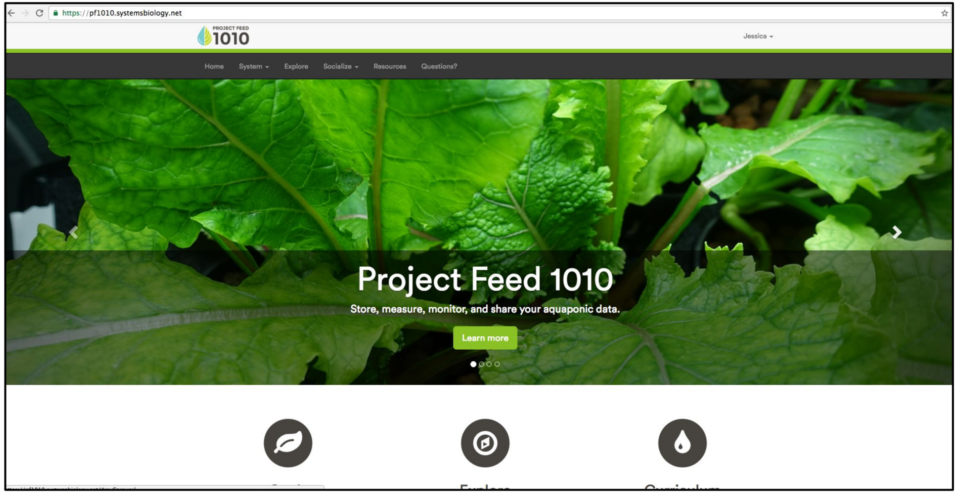
Uploading data to the website...

https://pf1010.systemsbiology.net/

1. Sign in using your Google+ account
2. Create a new system
3. Start inputting data
4. Observe patterns/trends



What you'll need

In the Back to the Roots kit

- Fish tank and gravel
- Seeds and grow stones
- Bacteria
- Coupon for Betta fish
- Water pump
- Fish food
- Water dechlorinator

In the PF1010 kit

- Adhesive thermometer
- 6-in-1 water test strips
- Ammonia water test strips

On NSTA and SEE websites (see.systemsbiology.net/categories/news)

- Data Collection Forms
- Water Chem Testing Guide
- Aquaponics Decision Tree

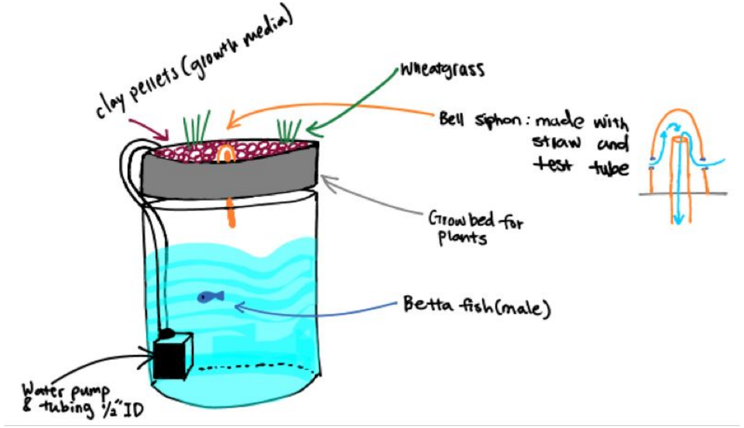
Other options

Engineering challenge

- Pump, filter, siphon design
- Lowest energy use/most efficient

Low-cost

- Tip box challenge - modeling aquaponics
- Substitute materials
    - Socks/twine for pump
    - Ecocolumn/bottle biology

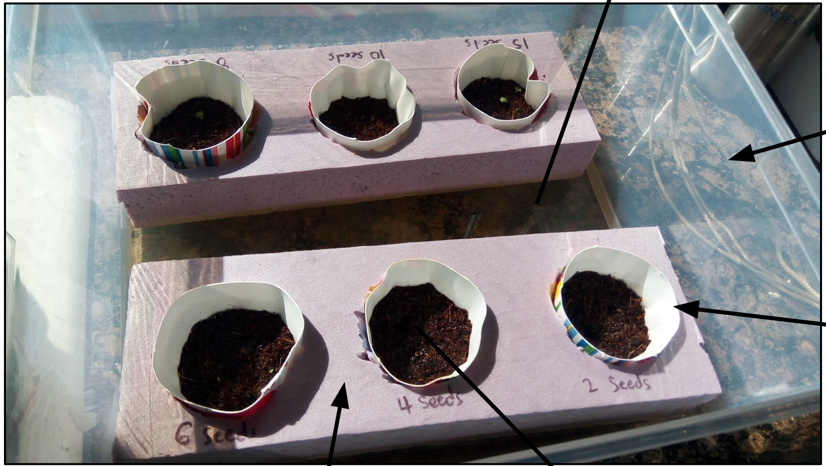


Goal

Use low-cost materials easily found in schools or homes

The Design

De-chlorinated tap Water

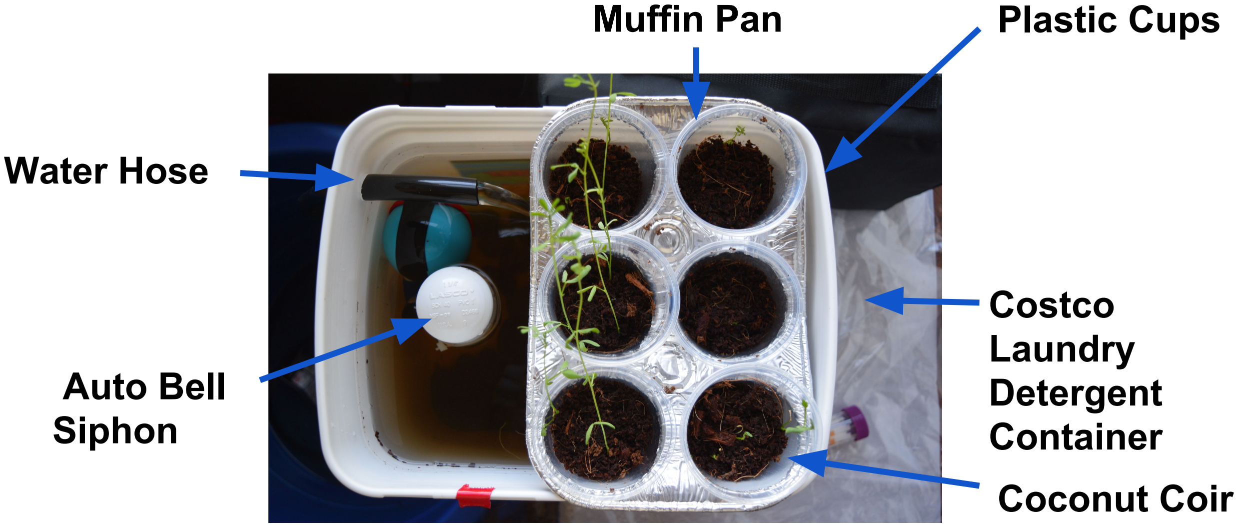


Large transparent plastic tub

Paper cups (with small holes in the bottom)

Floating foam blocks

Coconut husk potting mixture


Muffin Pan
Plastic Cups
Water Hose
Costco Laundry Detergent Container
Auto Bell Siphon
Coconut Coir

We will discuss...

1. Systems biology
2. Project Feed 1010
3. NGSS
4. Aquaponics and citizen science
5. **Resources**

Resources

- Project Feed 1010 website: http://www.projectfeed1010.com/
- Data management website: https://pf1010.systemsbiology.net
- PF1010 Facebook page: https://www.facebook.com/groups/ProjectFeed1010/
- Frequently asked questions: http://www.projectfeed1010.com/blog/2015/08/18/diy-aquaponics-faqs/
- Email: projectfeed1010@systemsbiology.org
- Water chemistry test strips (2): **6-in-1:**http://www.tetra-fish.com/products/aquarium-testing-kits/easystrips-6-in-1-aquarium-test-strips-kit.aspx or Petco **Ammonia:**http://www.petco.com/shop/en/petcostore/tetra-easystrips-ammonia-aquarium-test-strips or Petco
- Bacteria:http://www.drsfostersmith.com/product/prod_display.cfm?pcatid=24846&cmpid=03cseYY&gclid=CNPMo5mEkM8CFUhgfgodqSEFzg or Petco

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What questions do you have?

Feedback: https://goo.gl/forms/B7sesRmFccYeU5cJ3

Acknowledgements

- Baliga Lab
- Nitin Baliga
- Claudia Ludwig
- PF1010 Team
- Curriculum Team
- PF1010 Interns
- Crowdrise Donors
- NSF

Systems Education Experiences

Baliga Lab at Institute for Systems Biology

Institute for Systems Biology

Revolutionizing Science. Enhancing Life.

Extra: Build a system...

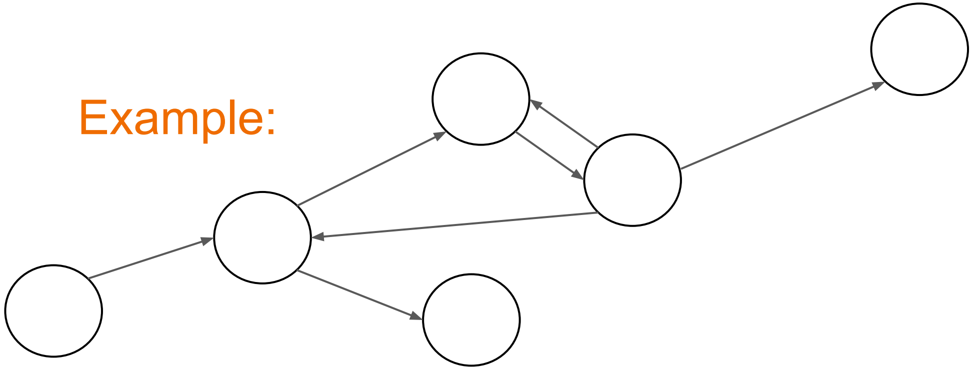
Nodes: Sun, plants, water, bacteria (2 types), fish, nitrogen sources

Edges: Nutrient and water flow

Inputs: Sun, water, fish food

Outputs: Plants, fish

Example:



Reminder:

Nitrosomonas: Input = Ammonia   Output = Nitrite

Nitrobacter: Input = Nitrite   Output = Nitrate