

Bringing Biology to Urban Design

All Aboard the Poop Train!

By: Sara Garnett, Jakob Nalley



Science Standards

- **E.ES.E.4 Natural Resources-** The supply of many natural resources is limited. Humans have devised methods for extending their use of natural resources through recycling, reuse, and renewal.
- E.ES.03.41
- Identify natural resources (metals, fuels, fresh water, fertile soil, and forests). *
- E.ES.03.42
- Classify renewable (fresh water, fertile soil, forests) and non-renewable (fuels, metals) resources. *
- E.ES.03.43
- Describe ways humans are protecting, extending, and restoring resources (recycle, reuse, reduce, renewal).
- E.ES.03.44
- Recognize that paper, metal, glass, and some plastics can be recycled.
-
- **E.ES.E.5 Human Impact-** Humans depend on their natural and constructed environment. Humans change environments in ways that are helpful or harmful for themselves and other organisms.
- E.ES.03.51
- Describe ways humans are dependent on the natural environment (forests, water, clean air, Earth materials) and constructed environments (homes, neighborhoods, shopping malls, factories, and industry).
- E.ES.03.52
- Describe helpful or harmful effects of humans on the environment (garbage, habitat destruction, land management, renewable, and non-renewable resources).
-

L.EC.M.3 Biotic and Abiotic Factors- The number of organisms and populations an ecosystem can support depends on the biotic (living) resources available and abiotic (nonliving) factors, such as quality of light and water, range of temperatures, and soil composition.

L.EC.06.31

Identify the living (biotic) and nonliving (abiotic) components of an ecosystem.

L.EC.06.32

Identify the factors in an ecosystem that influence changes in population size.

L.EC.M.4 Environmental Impact of Organisms- All organisms (including humans) cause change in the environment where they live. Some of the changes are harmful to the organism or other organisms, whereas others are helpful.

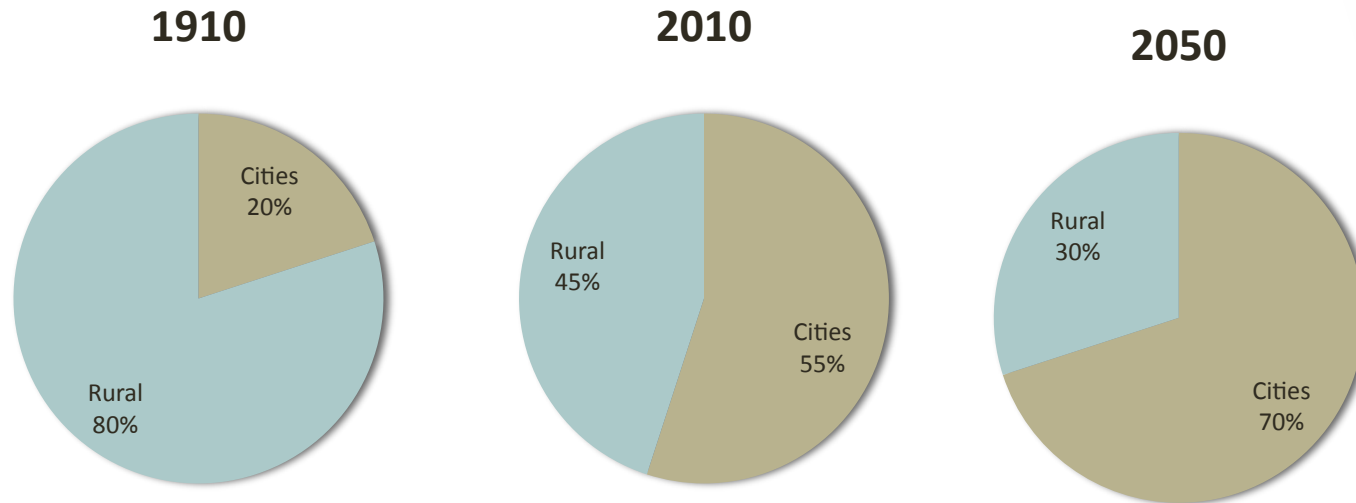
L.EC.06.41

Describe how human beings are part of the ecosystem of the Earth and that human activity can purposefully, or accidentally, alter the balance in ecosystems.

L.EC.06.42

Predict possible consequences of overpopulation of organisms, including humans, (for example: species extinction, resource depletion, climate change, pollution)

Moving to the City



- In 1910, 2 in every 10 humans lived in an urban environment
- By 2010, over half of the world's population was living in cities
- It is projected that by 2050, 70% of all humans will live in an urban area
- Also, human population size has been increasing throughout this time as well, resulting in higher human density within cities, and larger strain on resources.

Thought Experiment

What things do we need to survive?

Food, water, shelter

If you are living in a city, where does your food come from?

Not the supermarket

What are some potential issues with how far away these food items come from?

Can you think of a way to make this process more sustainable?

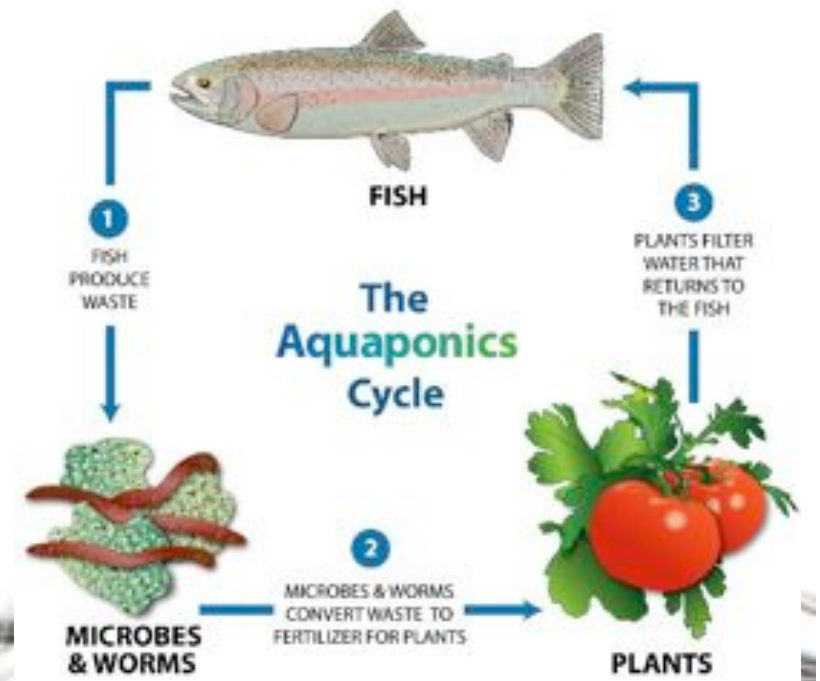


Urban Agriculture



Ecosystem Approach

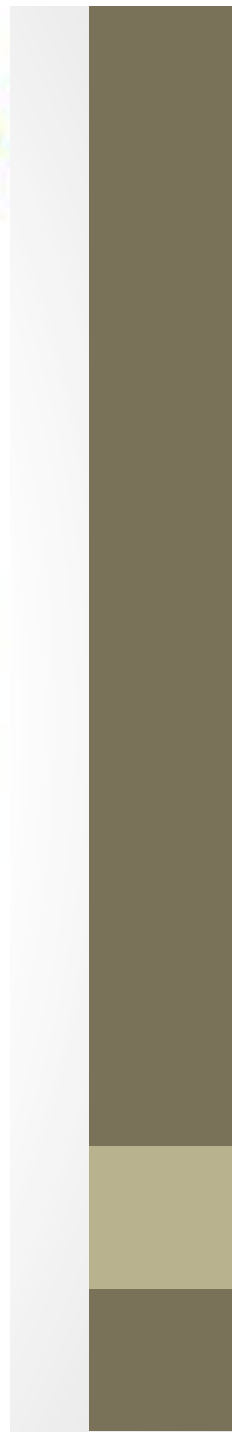
- An ecosystem is both the living and non-living things within an environment (biotic, abiotic)
- Plants are grown above small ponds of tilapia (or yellow perch)
- Water and fish waste is pumped up to the top plants and gravity pushes it to the other side and drains to the next level of plants
- The water has now been purified and what is left returns to the tilapia ponds



Vertical Urban Farming

- “Skyscraper greenhouse”
- Remember, over 70% of all people will be living in a city in 2050. Cities today grow very little of their own food.
- How sustainable is an urban area that ships all its food in from hundreds to thousands of miles away?
- “Food Deserts” – heart disease, diabetes, obesity
- Vertical urban farms would be farms built up (like a skyscraper) rather than out like corn fields in Michigan
- Could growth vegetables, fruits, livestock, fish





Some Design Ideas



Energy within the city

- Where do we get the energy we use to power our homes?
 - Non-renewable sources (fossil fuels)
 - Renewable sources
- More and more people in cities → more energy consumed
 - How do we meet this demand sustainably?
- Renewable energy (e.g., wind, solar energy)
- Conservation vs. efficiency
 - Can we reduce demand or increase efficiency by using what we know about nature when designing buildings?

Green roofs



Functional layers of a typical extensive Green Roof



- ① Roof deck, Insulation, Waterproofing
- ② Protection- and Storage Layer
- ③ Drainage- and Capilarity Layer
- ④ Root permeable Filter Layer
- ⑤ Extensive Growing Media
- ⑥ Plants, Vegetation



Metal roofing



Algae building





Experimenting with design

- Build replica buildings and monitor changes in temperature over time
- Experiment with different biologically-inspired innovations
- How do we keep temperature from fluctuating too much



Lighting urban areas

- Keeping urban areas well-lit at night requires lots of energy
- Buenos Aires (13 million people) switched to LED lights
- What other biologically-inspired strategies could reduce energy use (and potentially maintenance costs)?



Photo-luminescent road lines



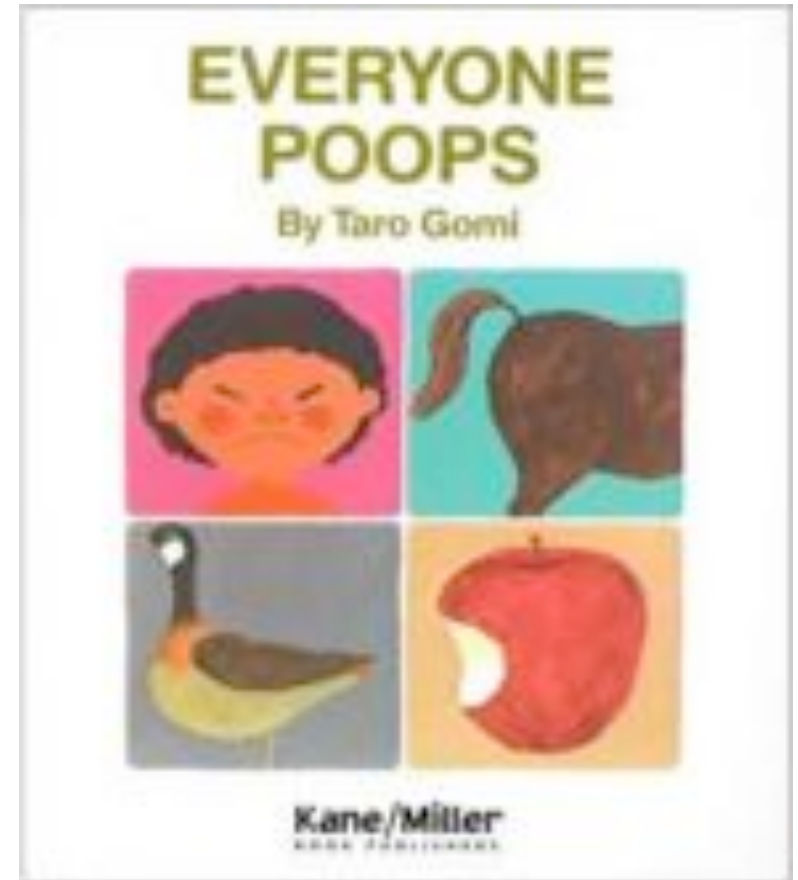
Photosynthetic Street Lamps

- Algae (and plants) collect the energy from the sun, and this process excites electrons
- Engineers are attempting to tap into the energy producing process of algae to charge batteries
- Also, algae take up large amounts of CO₂
- Can you think of any benefits of CO₂ sequestration within densely populated urban settings?



Human Waste

- North River Wastewater Treatment Plant – Manhattan, NYC
 - 125-340 million gallons of wastewater A DAY!
 - 7 billion pounds of solid waste
 - Before 1986, all waste went right into the Hudson River/Atlantic Ocean
 - Combust methane gas produced from digesters in the plant for electricity



Radiolab Episode

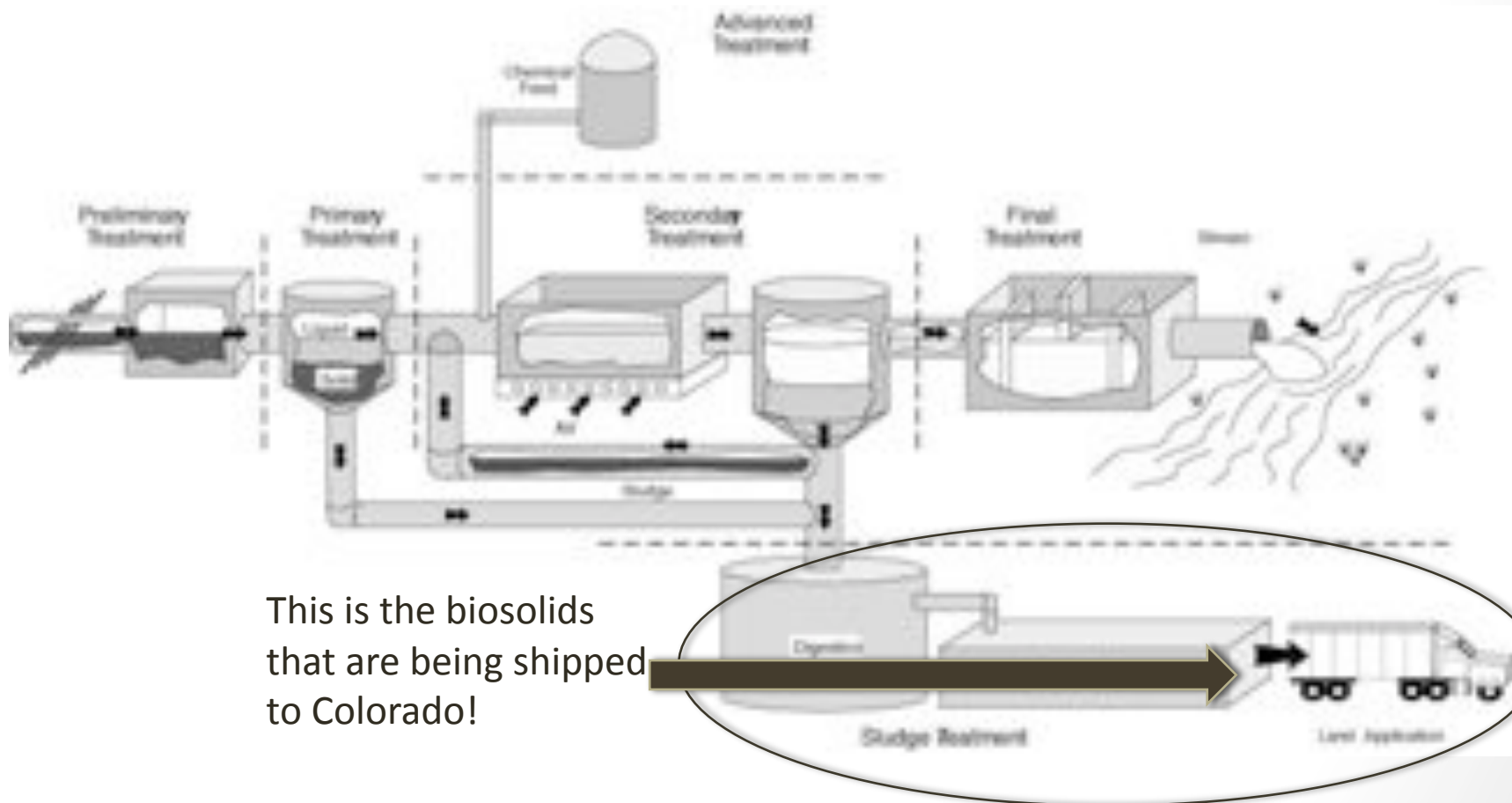
- <http://www.radiolab.org/story/poop-train/>
- Total of 21 minutes, start lesson at 2:30.
- Covers issues of how our water is treated (shower to toilet water), how biosolids are a part of our lives and we don't know it, and then raises some sustainability issues as well.
- A template for worksheet is on KBS GK12 website under "Lessons"



North River Wastewater Treatment Plant



Wastewater Treatment Process



This is the biosolids that are being shipped to Colorado!

Application of Biosolids

