Watershed Workshops

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TCU COLLEGE OF EDUCATION ANDREWS INSTITUTE

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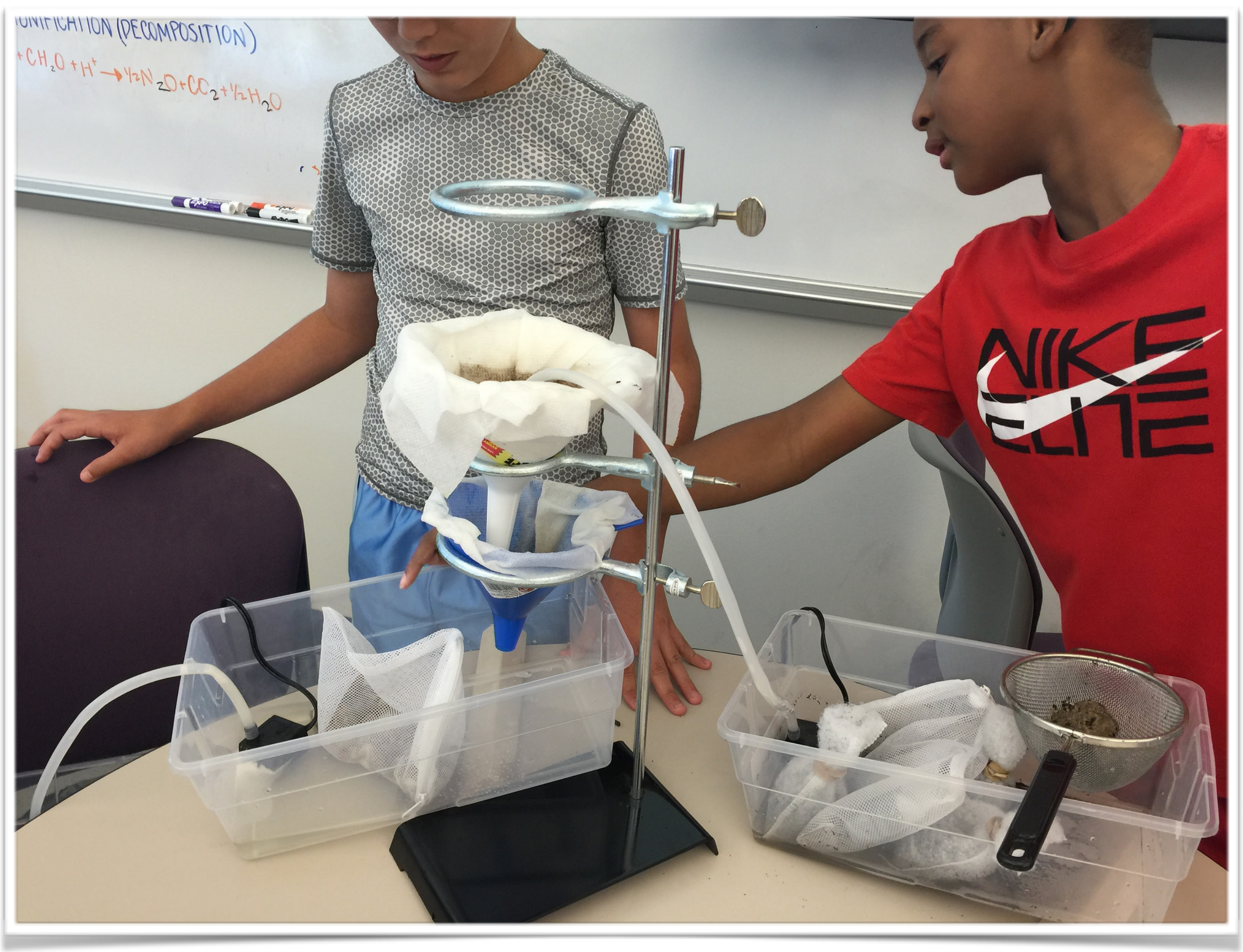
Diving Deeper

Grades 5-7

In this week-long workshop, alumni participants will build upon their past experiences in Watch Your Watershed and Watershed Rescue. They will take a closer look at the chemistry, geology, and ecology of the local watershed through inquiry-based investigations of participant-generated questions and research design. Prerequisite: Students will need to have completed Watch Your Watershed and/or Watershed Rescue.



Summary of Curriculum

Day	Suggested Timing	Topic	Activities
1	8:30	Check In	
	8:45	Introductions	
	9:15	Pre-data*	mATSI Pre-Concept map
	10:00	Journal set up	Set up journals for the week
	10:30	WYW letters	Distribute student responses to Mr Smith's email and the Area profiles. Students begin to evaluate student responses and come up with their own interpretations
	11:00	Station Lessons	Turbidity, Chemical filtration, and Biological filtration lessons at different stations that students rotate through.
	12:00	Dismiss	
2	8:30	Check In	TOC updates
	8:45	Doing Background Research	PPT of Wetlands and discuss biomimicry as solution for our area profile
	10:30	Begin to plan	Referring to materials, students work in teams to plan rapid prototypes.
	12:00	Dismiss	
3	8:30	Check In	TOC updates
	8:45	Complete and test rapid protypes	Build and test rapid prototypes. Adjust according to reports
	11:40	Concept Map*	Brainstorm with students 5 topics to include on their concept map
	12:00	Dismiss	
4	8:30	Test with dirty water	Use rapid prototypes to clean dirty water. Write up results in report
	9:30	Prototype technical drawing and report	Students create a technical drawing of their prototype with a report of their results.
	11:00	Gallery walk of technical drawings	Students evaluate technical drawings and make suggestions for improvement
	11:15	Adjust technical drawings	Respond to critiques to improve drawings

Day	Suggested Timing	Topic	Activities
	11:30	Real-life implementation	Students design a real-life implementation of their prototype (or an adjusted design of their prototype based on their findings).
	12:00	Dismiss	
5	**8:30**	Check In	TOC updates
	8:45	Post data*	mATSI Final Concept map
	9:15	Complete real-life design	Finalize design and create presentation of data/findings/field report
	11:00	Research presentation	Present designs and real-world plans to parents and faculty
	12:00	Dismiss	

*mATSI and Concept Map is used for data to investigate student perceptions of science and content understanding.

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Day 1: Nature of Science & Water Testing

Day	Suggested Timing	Topic	Activities
1	**8:30**	Check In	
	8:45	Introductions	
	9:15	Pre-data*	mATSI Pre-Concept map
	10:00	Journal set up	Set up journals for the week
	10:30	WYW letters	Distribute student responses to Mr Smith's email and the Area profiles. Students begin to evaluate student responses and come up with their own interpretations
	11:00	Station Lessons	Turbidity, Chemical filtration, and Biological filtration lessons at different stations that students rotate through.
	12:00	Dismiss	

*mATSI and Concept Map is used for data to investigate student perceptions of science and content understanding. Before beginning this lesson, you will need student-constructed Area Profiles of a creek or wetland area as described in the Watch Your Watershed workshop. In lieu of this, you could construct or define a distinct problem regarding water quality/access to clean water. It is important that the problem be relatable as well as solvable for the students.

Unless stated otherwise, students are always working in groups of 3-4. It is helpful to use thoughtful grouping techniques for this workshop. We suggest groups that are heterogeneous in interest and ability level. We refer to these as "Work Groups." In addition to work groups, we also suggest forming different groups that are more homogeneous in nature. These are helpful to move students into to discuss plans, give suggestions and ask questions, as well as conduct background research leveled by ability and interest. Throughout the workshop, we refer to these as "Oversight Committees."

Begin the workshop by helping students set up a journal (see slide 3). Journals may be set up to meet your particular style and the students' individual needs.

<u>Defining the Problem</u>: Distribute to students copies of Mr. Smith's email and student responses with Area Profiles (from Watch Your Watershed workshop). Give student work groups time to evaluate the data on their own and come up with interpretations. Guide students through questioning to identify or define a problem related to the water quality as described. It is advised to identify a problem as a class. For example, "The water at Frog Creek has a high turbidity and abnormal pH levels, how can we make the water more healthy for living organisms?" Depending on your data and resources, your problem may vary.

Activating prior knowledge: Student work groups rotate through four water testing stations where they investigate the turbidity, pH, nitrates, and phosphates. (See resource materials)

Turbidity Station: Students measure and record the turbidity of three water samples. It is suggested that the samples range from 0-20 JTU, 40-60 JTU, and 80-100 JTU so they experience the full range of turbidity options. Turbidity of water can be adjusted by adding in sand, soil, and leaf litter.

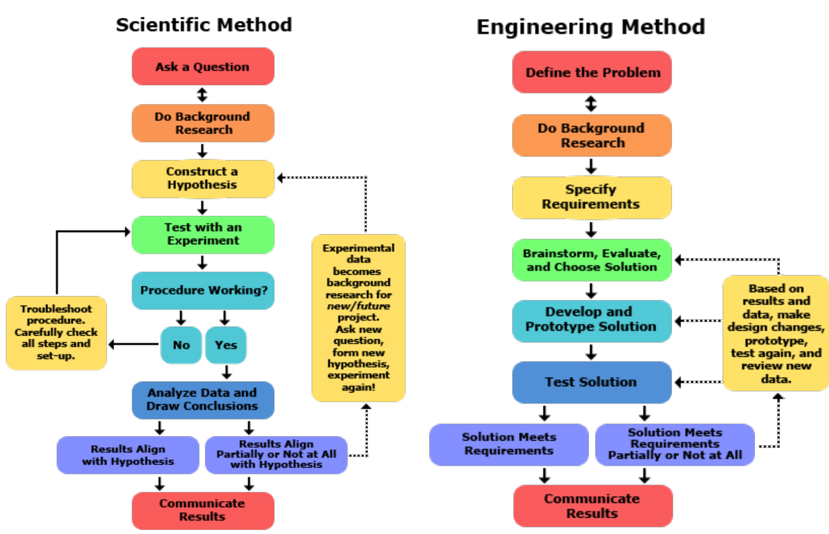
Chemical Filtration Station 1: Students measure and record the Nitrate and Phosphate levels of a "dirty" water sample (see resource materials) before and after being "cleaned" by activated carbon filter media.

Chemical Filtration Station 2: Students measure and record the Nitrate and Phosphate levels of a "dirty" water sample (see Recourses) before and after being "cleaned" by commercial filter media purchased from any fish or pet store.

Biological Filtration Station: Students note and record the beginning Nitrate and Phosphate levels of two water samples (one "clean" and one "dirty"). Each sample should include a living moss ball (purchased at any fish or pet store).

At the end of their rotations, move students into their oversight committees to share and compare data. Encourage students to note and discuss any differences.

End the day by discussing with students about the differences between Engineering Design and the Scientific Process (see slide 4). The Engineering Design Process will be used throughout the week to address the earlier determined challenge.



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Day 2: Introduction of Problem and Research

Day	Suggested Timing	Topic	Activities
2	8:30	Check In	TOC updates
	8:45	Doing Background Research	PPT of Wetlands and discuss biomimicry as solution for our area profile
	10:30	Begin to plan	Referring to materials, students work in teams to plan rapid prototypes.
	12:00	Dismiss	

Doing Background Research: Using slides 6-9, guide students through a mini-lecture that covers the Nitrogen cycle. This background knowledge should build onto what they understand about water quality and serve to help further understand the role of N in organic and inorganic systems. Use the Nitrogen Cycle Game (See materials and resources) to help solidify this for students.

Slide 10 reminds students of the benefits of a rain garden (review from Watershed Rescue) and slide 11 introduces the benefits of Wetlands. The linked video on slide 12 describes how a wetland system was engineered to solve a problem in North Texas.

Use slides 14-15 to remind students of the problem and the challenge.

In oversight committees, have students research the ways in which nature filters water. Assign readings by ability and interest level of each oversight committee. Use the readings found in materials and resources or others you may find. A variety of reading to learn strategies can be incorporated here. You may want to construct Anticipation Guides for each reading, break articles into smaller chunks to have groups jigsaw an article, or other strategies you may find beneficial to ensure students are able to digest the material.

Once each group has an understanding of their assigned article, have students return to their work groups to discuss each article. Allow them plenty of time to discuss what they learned from their reading.

Specifying the Requirements: Introduce students to the materials they have available to work with to engineer a solution to the problem (see Materials and Resources). Define the allotted time, amount and type of resources available for use, and the desired results. *You may choose to differentiate the desired results for each work group based on ability and/or interest. For example, you may require all groups to improve water turbidity, but only ask advanced groups* *to also improve pH or nitrate/phosphate levels*. Work groups should now begin to plan their prototypes using the provided materials.

Day 3: Prototype Design and Evaluation

Day	Suggested Timing	Topic	Activities
3	**8:30**	Check In	TOC updates
	8:45	Complete and test rapid protypes	Build and test rapid prototypes. Adjust according to reports
	11:40	Concept Map*	Brainstorm with students 5 topics to include on their concept map
	12:00	Dismiss	

*mATSI and Concept Map is used for data to investigate student perceptions of science and content understanding.

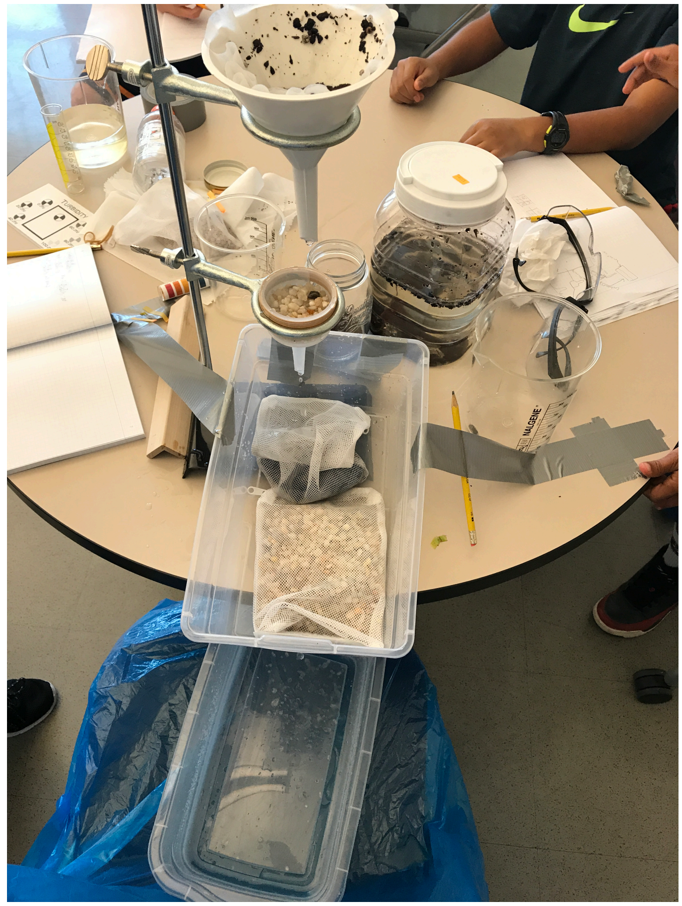
We advise that groups are not allowed to begin building until they can describe their plan. Each plan should be written and/or sketched in student journals before they begin. Now is also a good time to remind students that as engineers work they may make changes to their plan and designs, this is okay! But, it is important to record each change as well as the justification for the change in their engineering notebook/journal.

Do your best to allow students to fail during this step. Ask scaffolding questions, guide them to be able to justify their choices, but do not offer solutions. The purpose of this activity is to allow students to design, test, and make changes to their own prototypes.

At this point, you may want to move students into oversight committees to discuss their plans. During these conversations, they can ask questions, get ideas and suggestions from other work groups, and work to improve their plans. At any point during the prototype design, if groups are struggling you can call an oversight committee meeting to help move them forward.

Once students have a final plan, they should begin to build their prototypes. During this process groups may find that they need to alter their design and should feel free to make changes to the original plan, as long as they record and justify the changes in their journal.

A completed prototype is then tested for structural flaws by running clean (tap) water through the system. Groups should observe their prototype looking for impediment to flow; for example, leak, blockages, and overflow.



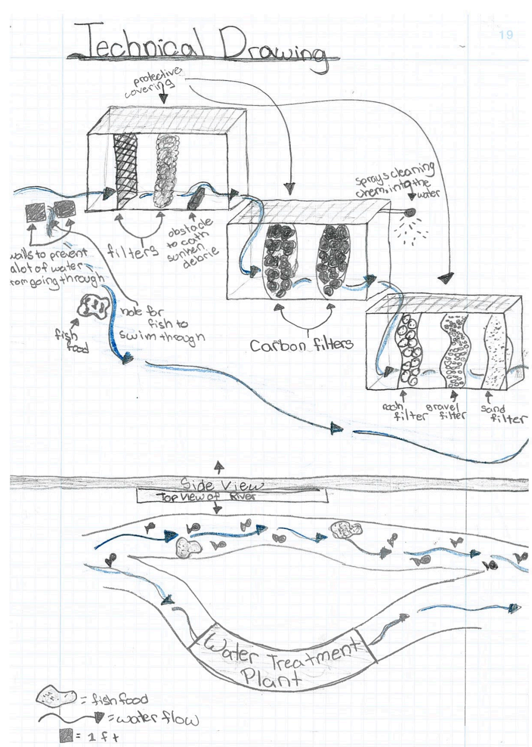
For a real-world application, you can introduce problems into the process. Examples include: <u>Power outage</u>: Turn out all the lights in the room. <u>Servers down</u>: Communication servers are down, groups have to work without talking or writing. <u>Supply shortage</u>: Take up all of one type of supply (duct tape, tubing, etc). These problems can challenge students to come up with creative solutions and/or slow down groups that may be moving at a faster pace than others.

After prototypes are tested and adjusted, students will need to write up a report with a rough diagram describing their prototype as well as any adjustments they made along the way.

Day 4: Technical Drawing

Day	Suggested Timing	Topic	Activities
4	**8:30**	Test with dirty water	Use rapid prototypes to clean dirty water. Write up results in report
	9:30	Prototype technical drawing and report	Students create a technical drawing of their prototype with a report of their results.
	11:00	Gallery walk of technical drawings	Students evaluate technical drawings and make suggestions for improvement
	11:15	Adjust technical drawings	Respond to critiques to improve drawings
	11:30	Real-life implementation	Students design a real-life implementation of their prototype (or an adjusted design of their prototype based on their findings).
	12:00	Dismiss	

After they have repeated their prototype initial report, they may begin testing their prototype using "dirty" water. Supply each group with 1.5-2L of dirty water to clean. *Students may decide to divide the water into three equal trials or may select to use all the water three times by capturing the outflow and recycling. They will need to add this data to their journal.*



After teams are done testing their water, they will need to complete a technical drawing of their prototype. The drawing should be detailed, labeled, and may need to be drawn to show multiple angles so that the design is clear. In addition, teams need to create a report that details the design of the prototype, changes made to design with justification, and the results of their water testing.

Allow teams to view each-other's technical drawings and reports to make suggestions for improvements for clarity. Remind students that their comments and critiques should be constructive and kind.

After technical drawings and reports have been adjusted and completed, discuss as a large group the differences in design, plan, and results. At the close of the discussion, move students into the real-world application phase. Ask students to work independently to design a real-world application of their prototype. How can they envision their plan working at full-scale? Have them create a scaled technical drawing of their real-world plan. Remind them that a key for scale is needed, as well as labels and multiple angles.

Day 5: Gathering Data & Communicating Results

Day	Suggested Timing	Topic	Activities
5	8:30	Check In	TOC updates
	8:45	Post data*	mATSI Final Concept map
	9:15	Complete real-life design	Finalize design and create presentation of data/findings/field report
	11:00	Research presentation	Present designs and real-world plans to parents and faculty
	12:00	Dismiss	

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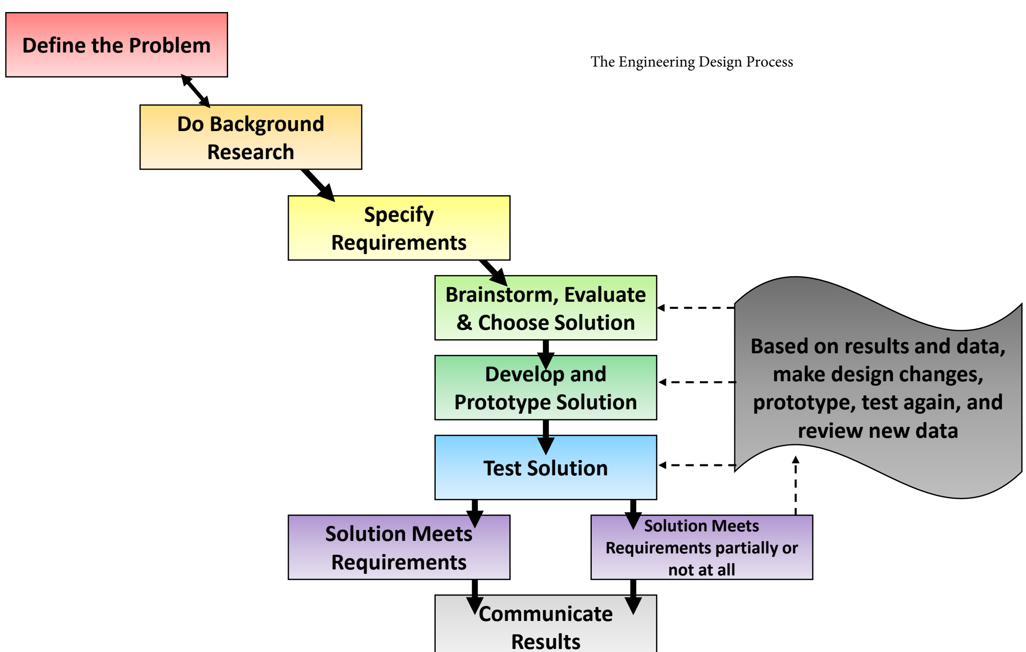
Work teams should work to create a research presentation that details their engineering design process. Use the graphic to remind students of each step of the process to help them focus their presentation. Encourage teams to share each real-world application designed by their team members. Final presentations are then shared with parents and guests to conclude the week.



Adapted from Science Buddies (2016).

Materials & Resources

Dirty Water Recipe:

- 1.5 L clean water (if possible, from a rain barrel or other rain catchment system)
- 0.5 L water from fish tank (can simulate tank water by letting clean water sit with a dirty fish tank filter for 1-2 days)
- 0.5-1 cup compost and organic litter
- Mix together in 2L bottle. Can sit for several days (but beware…it will get smelly!)

Nitrogen Cycle Game: https://scied.ucar.edu/activity/nitrogen-cycle-game#undefined

Materials

- LaMotte Low-Cost Water Monitoring Kit (1 per group)
- Ammonia test kit (1 per group)
- Plastic shoe boxes (2-3 per group)
- Plastic tubing
- Linen or similar cloth
- Zip ties, rubber bands, string, duct tape
- Mesh screen
- Aquarium gravel
- Sand
- 2-liter bottles
- Funnels
- Sponges or foam to cut to size
- Activated carbon
- Fish tank filter bags

Safety Rules

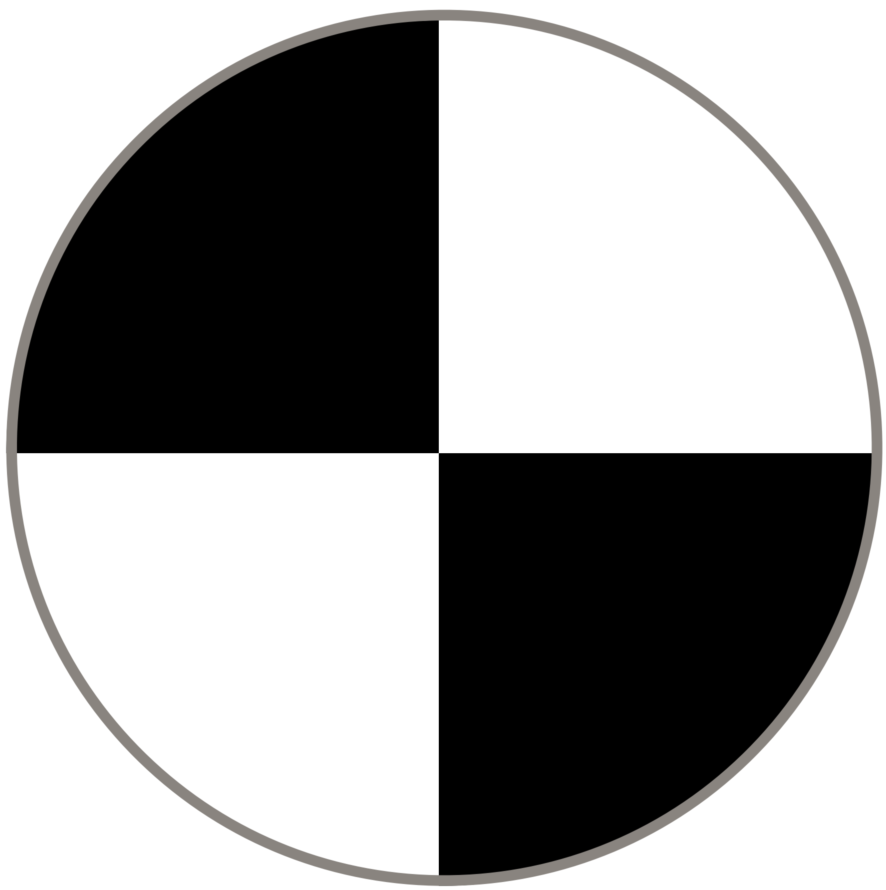
- Gloves and safety goggles should be worn at all times when handling water testing materials and/or "dirty water"
- Any spills should be cleaned up immediately
- Work areas should be kept organized to prevent spills
- Students should be aware of the areas as they move around their work space to avoid damaging prototypes and spills
- Use caution when cutting materials to size
- If holes are drilled in plastic shoe boxes, this should be done by the teacher

Turbidity Station Instructions

Turbidity: a measurement of the clarity of water. Measured in JTUs

Directions:

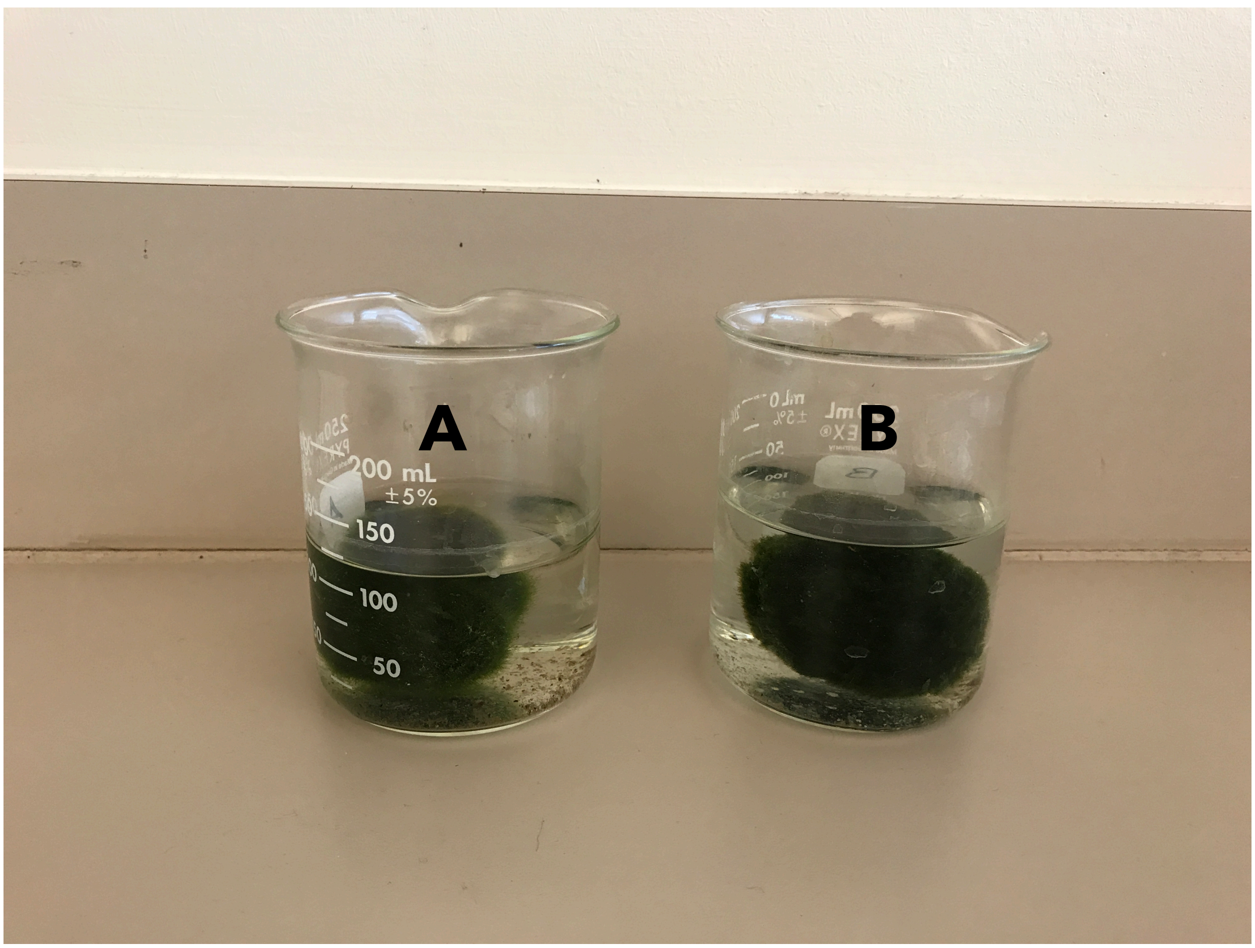
- Begin by recording your observations about the three water samples
- Next, record what you think may be affecting the turbidity of the water (Why is it cloudy or clear?)
- Test and record the turbidity of each water sample
  - For each sample:
    - Place the beaker on top of the large secchi disk
    - Compare the clarity of the secchi disk with the provided Turbidity card and record your result in JTUs
- Answer the reflection questions on your data sheet.



Biological Filtration Station Instructions

Directions:

1. Record your observations of each water sample in your data sheet.
2. Note and record the beginning Nitrate and Phosphate levels of each water sample
3. Answer the investigation questions on your data sheet.



Chemical Filtration Station #1 Instructions

Nitrate: A negatively charged ion made of Nitrogen and Oxygen. Occurs in animal waste, through decomposition, and industrial fertilizer. Acts as a plant fertilizer in aquatic environments. High levels can be toxic for living organisms.

Phosphorus (P) acts as a fertilizer for aquatic plants. High P levels cause water quality problems through excessive plant and algae growth. P Occurs naturally, but most comes from detergents (soaps).

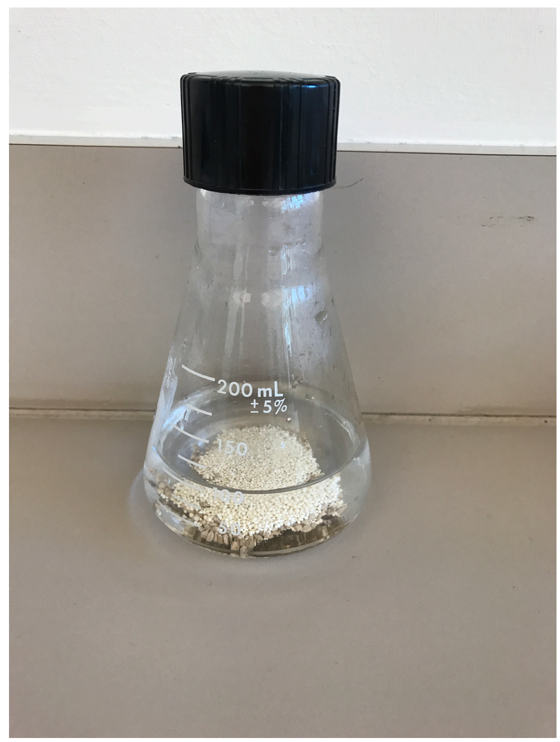
Directions:

1. First answer the two pre-investigation questions on your data sheet
2. Then, record your observations of the water samples in your data sheet.
3. Next, test and record the beginning pH, Nitrate and Phosphate levels of the water sample.
    a. Follow the directions given for each test carefully and record your results in your data sheet.
4. For the water sample, investigate how the activated carbon effects the Nitrate and Phosphate Levels.
    a. Fill an Erlenmeyer Flask with 50mL of the water sample.
    b. Add a scoop of activated carbon.
    c. Cap the flask.
    d. Swirl to mix for 1 minute.
    e. Record your observations in your data sheet.
    f. Re-test the “cleaned” water sample using the Nitrate and Phosphate tests from step 3 and record your results in your data sheet. (Pipette “cleaned” water out of the flask ensuring that you do not collect the filter media in your water sample to test)

Chemical Filtration Station #2 Instructions

Directions:

1. Record your observations of the water sample in your data sheet.
2. Test and record the beginning pH, Nitrate and Phosphate levels of the water sample.
    a. Follow the directions given for each test carefully and record your results in your data sheet.
3. For the water sample, investigate how the Filter Media effects the Nitrate and Phosphate Levels.
    a. Fill an Erlenmeyer Flask with 50mL of the water sample.
    b. Add One scoop of the filter media.
    c. Cap the flask
    d. Swirl to mix for 1 minute.
    e. Record your observations in your data sheet.
    f. Re-test the “cleaned” water sample using the pH, Nitrate and Phosphate tests from step 2 and record your results in your data sheet. (Pipette “cleaned” water out of the flask ensuring that you do not collect the filter media in your water sample to test)
4. Answer the post-investigation questions



How Biosand Water Filtration Systems Work

How Water is Filtered

http://thewaterproject.org/biosand_water_filtration

The concrete Biosand filter is an innovative version of the slow sand filter specifically designed for household use. These filters are built locally using available materials and labor. As with the other types of water projects we support, we are meeting the clean drinking water needs of the region and providing needed jobs. Each community is a full participant in the project.

The Biosand filter is comprised of a container - plastic or concrete - and is about the size of an office water cooler. It has an inset plastic pipe and is filled with layers of sand and gravel. Dirty water is poured into the top of the biosand filter, where a diffuser plate evenly distributes the water over the sand bed layer. The water travels down through the sand bed, passes through multiple layers of gravel, and collects in the plastic pipe at the bottom of the filter. The clean water then exits through the plastic piping for a family to collect in clean containers.

The removal of contaminants and disease causing agents is possible due to a combination of biological degradation and mechanical filtration processes. The organic material present in the dirty water is trapped at the surface of the sand bed, forming a biological layer, or schmutzdecke, which actively removes pathogens and contaminants. The drinking water produced with the Biosand process is tasteless, clear in color, odorless and safe for drinking.

Studies have shown the Biosand filter can remove more than 90% of bacteria and 100% of parasites, dramatically increasing the safety of the water.

http://www.hcn.org/issues/46.20/can-biomimicry-tackle-our-toughest-water-problems

Can biomimicry tackle our toughest water problems?

With floating islands and other inventions, eco-entrepreneur Bruce Kania thinks so.

Ben Goldfarb | **Nov. 24, 2014** | *From the print edition* /

"In the U.S., we've become masterful at growing food from the ground," Kania reflected as fish danced in the window. In his fierce focus, blue eyes narrowed, he resembled one of the raptors that hunt in his meadows. "But in the process, we've sacrificed our water."

Kania has spent the last decade trying to correct that imbalance through biomimicry, the concept of imitating natural processes to address environmental problems. Kania believes there are few ailments that copying nature can't heal. The dead zones that plague the world's oceans? Kania has a solution. The disappearance of wetland habitat? There's a fix. Insect-borne diseases? The common cure for all, he says, lies in Floating Island International's signature technology: buoyant artificial wetlands, nearly 6,000 of which are now deployed worldwide, from New Zealand to South Africa to China.

Building wetlands to capture pollution isn't new. Scientists have long understood that natural wetlands act as landscape sponges, filtering sediment, nutrients and waste from rainwater and snowmelt. Despite this, civilizations on every continent have drained swamps and marshes and converted them to farmland. Today, the United States has half as many wetland acres as when Europeans arrived.

As Kania researched cyanobacteria blooms, he realized the crisis transcended his land. The Yellowstone River is a branch of the Mississippi watershed, which deposits 1.7 million tons of nutrients into the Gulf of Mexico annually, generating blooms vast enough to see from space. The result is an oxygen-deprived swath, some years as large as New Jersey, devoid of marine life – a dead zone.

To Kania's puzzle-loving brain, the dead zone suggested another business. First, he needed a team. He called Frank Stewart, an engineer with expertise in biofilms, communities of bacteria that cohere everywhere from streambeds to human teeth. Biofilms are notorious for clogging pipes and contaminating hospital equipment, but Stewart realized they were exactly what Kania's smelly ponds needed. "If you have biofilm growing on rocks and plants, it will remove nutrients," Stewart explained. "Fish and other aquatic organisms move it up the food chain, and it keeps the water cleaner."

But biofilms can't grow without help: The bacteria need surfaces on which to adhere, structure that many ponds lack. Kania turned to nature for inspiration. Back in Wisconsin, where he'd once worked as a fishing guide, the biggest muskies and bass had congregated beneath floating peat-bog islands, whose vegetation provided refuge and clean water. He wondered now if there was some way to replicate those wetlands — to create platforms for biofilms and habitat for wildlife. What nature had made in Wisconsin, Kania resolved to re-create in Shepherd.

In a concrete-floored workshop near his house, Kania and a team of manufacturers built dozens of prototype platforms. They decided on a bristly mat, knitted from the fibers of recycled plastic bottles, whose crevices supported biofilms. They injected foam resin to make the plastic buoyant and drilled holes for wetland plants, like speedwell and monkey flower, whose roots absorb more nutrients. By 2005, they had their wetland –– a BioHaven, Kania called it — and a brand-new company, Floating Island International.

Word spread, aided by the evangelism of Kania and his wife, Anne, the company's vice president. Floating Island International constructed 1,600 BioHavens in its first two years: in lakes, in ornamental gardens, in wastewater ponds. At first, empirical evidence documenting their effectiveness was scant. Some agencies shied away; skeptics suggested that FII might be overhyping its product. "We've tried their technology, and it works," Steve Patterson, founder of a company called Bio x Design that makes its own wetlands, told me. "But they're not just something that you can use anywhere and everywhere and magically clear your water up."

Gradually, though, data rolled in. Floating wetlands, it appeared, had a major advantage over stationary ones: When water levels fluctuated, as they often did in stormwater ponds, Kania's creations rose and fell on the surface, their performance unfazed. A suite of islands installed behind a museum in Durham, North Carolina, improved total nitrogen removal by almost 30 percent. Another increased ammonia removal from a Billings wastewater lagoon by 38 percent. New Zealand reported similar results. When Jim Bays of CH2M Hill conducted tests in Florida, he found the islands increased nitrogen uptake by 32 percent. "At this point, there's definitely enough information to say that islands have an important place within the toolbox," Bays said.

LOOKING TO NATURE FOR SOLUTIONS ON WATER TREATMENT

http://www.ewisa.co.za/literature/files/ID174%20Paper325%20Dama-Fakir%20P.pdf

3.2 Filtration technologies

A wide range of organisms perform bulk filtration of water to filter out nutrients for feeding. The filtration is achieved through various principles. At the time of the study, the Baleen Filter was the only successful biomimetic filtration application identified, however it is envisaged that further investigations on the principles discussed in this section can lead to innovation filter designs in the future.

3.2.1 Filtration using keratinous filaments

Baleen whales which feed on krill have no teeth, instead they have developed a keratinous row of fibres known as a baleen to filter out organisms from the sea water. The keratin sheath of each baleen plate encapsulates hair-like strands that become evident as the sheath is worn down and splits open. Upon closing its mouth, the whale's lower jaw distends, creating pressure against the baleen. This forces water through the keratin fibres, but retains all organic material. Once all water is forced out the whale's tongue rises and sweeps the organic material off the baleen and swallows it (Attenborough, 1979). The principles of Baleen whale filtration have been emulated in existing biomimetic technology, called Baleen Filters. In the Baleen Filter, water runs through the filter, causing visible

solids and particles to remain behind in the filter. Hereafter, a second high-pressure, low-volume spray of water dislodges the solids and carries it away. As a result, there are two output streams; one which is filtered, and another which is a concentrated solids stream (Croll, 2008), (Brodie & Vikingsson, 2009).

The basking shark is the second largest living shark, after the whale shark and uses filtration to feed on Plankton < 1 mm. It is a slow moving and generally harmless filter feeder. It has anatomical adaptations to filter feeding, such as a greatly enlarged mouth and highly developed gill rakers (Sims, 1999).

Flamingos feed on crustaceans and algae > 0.5 mm. The bill of a Flamingo is lined with numerous complex rows of lamellae, which filter out the various small crustaceans, algae and unicellular organisms on which flamingos feed. The feeding process requires a series of tongue movements and opening and closing of the beak, which allows food items to be filtered by the lamellae and eventual ingestion. Unwanted items such as mud and saltwater are pushed out by the tongue. Swinging the head to and fro allows water to enter the beak and the tongue moves back and forth acting as a pump, sucking the water in and forcing it out up to four times a second (Erlich et al, 1988). The Lesser Flamingo has such a dense filter that it can sift out single cell plants (Biomimicry institute, 2010) (Jenkin, 1957).

3.2.2 Filtration using partial pressure

The Bladder Wort is a plant that uses a partial pressure method of feeding on water fleas and small fish, which are between 1μm – 1mm. The water plants are found in wetlands in many parts of the world. Their traps, the bladders from which they get their name, are tiny transparent capsules. Glands on the inner surface of the traps are able to absorb water and in doing so create a partial vacuum within. Each trap has a tiny door fringed with sensitive bristles. If a small water creature, such as a mosquito larva, touches one of these, the bristle acts as a lever, slightly distorting the edge of the door so that it no longer fits tightly on the rim. Water rushes in, sweeping the door inwards and with it, the little organism that touched the hair. The swirl of water within the capsule pushes the door closed again and the prey is imprisoned. The whole action is completed within a fraction of a second (Laakkonen, Jobson, & Albert, 2006).

3.2.3 Filtration using small cilia

The sea squirt has two openings, the inhalant and exhalant apertures. The water enters through the inhalant aperture and comes into contact with the basket-like interior of the sea squirt, which is covered with tiny gill slits with hair-like structures called cilia. This helps to propel the water, as well as to filter out food from the water current. The food then attaches to the mucus lining on the inside of the sea squirt and flows into the esophagus at

the lower end of the body. The remaining water exits through the exhalant aperture (Dales, 2008).

Daphnia are small, planktonic crustaceans, between 0.2 and 5 mm in length. Daphnia posses bristle-equipped appendages. These creatures swim with such appendages, using them as paddles - with semi-stagnant water around each bristle, an appendage can serve as a paddle. The creatures also use such appendages as rakes, filtering edible particles from the water around them. The principle behind the alternate paddling and filtering is based on the speed at which an appendage operates. The size of the appendage and speed of movement decide what function the movement will have. According to Vogel (2003), large and fast result in a rake or filter and small and slow allows for movement.

3.2.4 Filtration using mucus lined appendages

Salps, which feed on algae < 1 mm, are small free-swimming marine creatures with gelatinous, semitransparent bodies that move around by means of jet propulsion, drawing in water through an aperture at one end of the body and then forcing it out through another aperture at the opposite end. Small food particles are gathered by a mucous net of varying complexity (depending on species). It was found that organisms as small as 0.5 microns also get caught and eaten, since they stick directly to the mucus (Woods Hole Oceanographic Institution, 2012). The mucus net which captures the food particles rolls into a strand and goes into the gut, where it is digested. It is then released in the form of pellets, which sink to the bottom of the ocean. The net, or "house", is discarded when clogged, and a new one is quickly formed. An individual may produce up to 10 or more nets in a single day.

The Peacock worm feeds on detritus, bacteria and plankton between 0.2 and 100 μm and is a marine polychaete worm. Tiny hair-like structures or cilia on the mucus lined tentacles, filter suspended particles from the water. These particles are then sorted according to size; small ones are eaten, large ones are discarded and medium-sized particles are added to the top of the tube with mucus, in order to increase its length.

3.2.5 Sediment trapping in wetlands

While this is not a feeding mechanism, constructed wetlands also have an upfront screening/filtration step in the form of sediment trapping. Factors influencing sediment trapping include:

Vegetation – upright vegetation in the flow path tends to slow down the flow of water and trap suspended solids.

Hydrogeomorphology – topographic features resulting in the slowing down and spreading of water result in sediments settling to the floor of a wetland.

Geomorphology – The ratio of wetland size to drainage area, where a larger ratio results in improved sedimentation.

Presentation Slides

DIVING DEEPER

- Welcome! We are glad you are here.
- Please begin creating a Title Page on the first page of your journal.
  - The title of our workshop is "Diving Deeper"
  - You may design your title page any way you would like, but make sure it has:
    - A Title
    - Your Name

TCU COLLEGE OF EDUCATION
ANDREWS INSTITUTE

INTRODUCTIONS

INTRODUCTIONS

- On your notecard, write down:
  - TWO things about you that are TRUE
  - ONE thing about you that is a LIE
  - Do not tell anyone in your group!

INTRODUCTIONS

- On your notecard, write down:
  - TWO things about you that are TRUE
  - ONE thing about you that is a LIE
  - Do not tell anyone in your group!

- Go around your table, tell everyone your name and read the statements from your card. Let your table mates guess which of your statements is a LIE.

JOURNAL SET UP

JOURNAL SET UP

- TITLE PAGE

JOURNAL SET UP

- TITLE PAGE
- TABLE OF CONTENTS

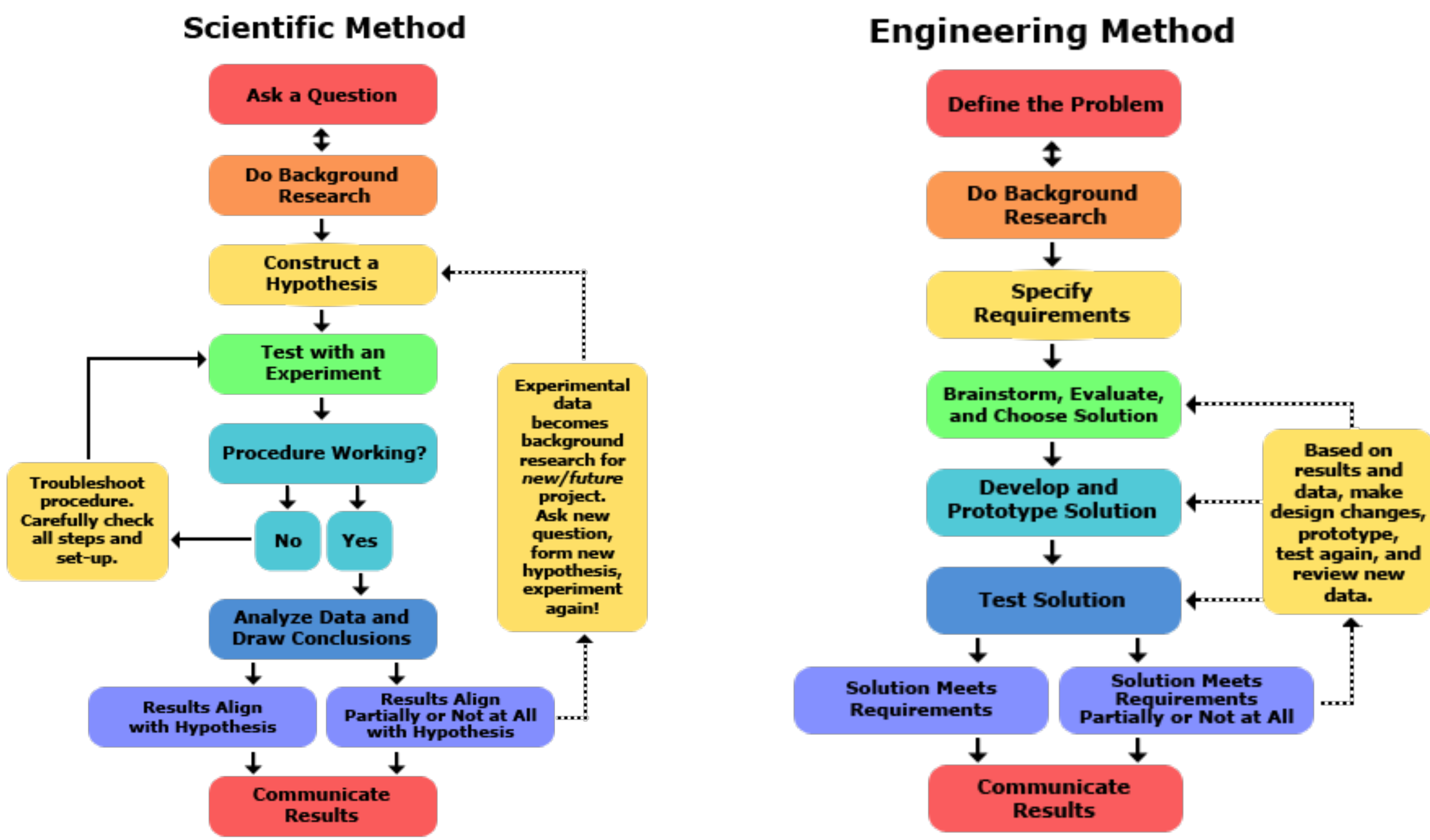
JOURNAL SET UP

- TITLE PAGE
- TABLE OF CONTENTS
- GLOSSARY

JOURNAL SET UP

- TITLE PAGE
- TABLE OF CONTENTS
- GLOSSARY
- NUMBER PAGES

NEXT PAGE: SCIENTIFIC PROCESS vs ENGINEERING DESIGN

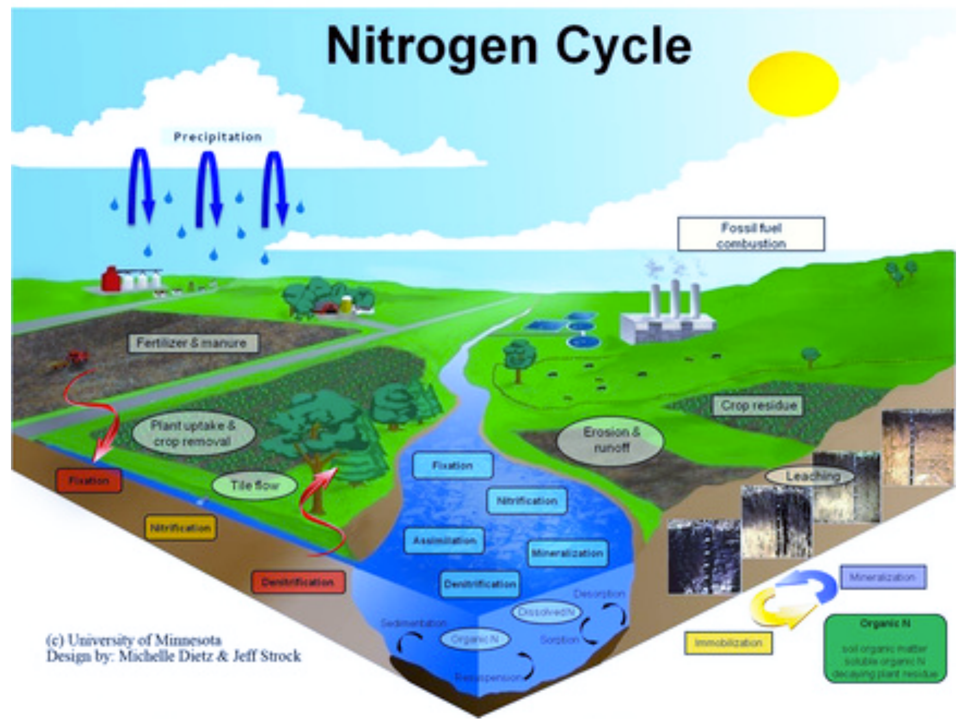


http://www.sciencebuddies.org/engineering-design-process/engineering-design-compare-scientific-method.shtml

DAY 2: WELCOME BACK

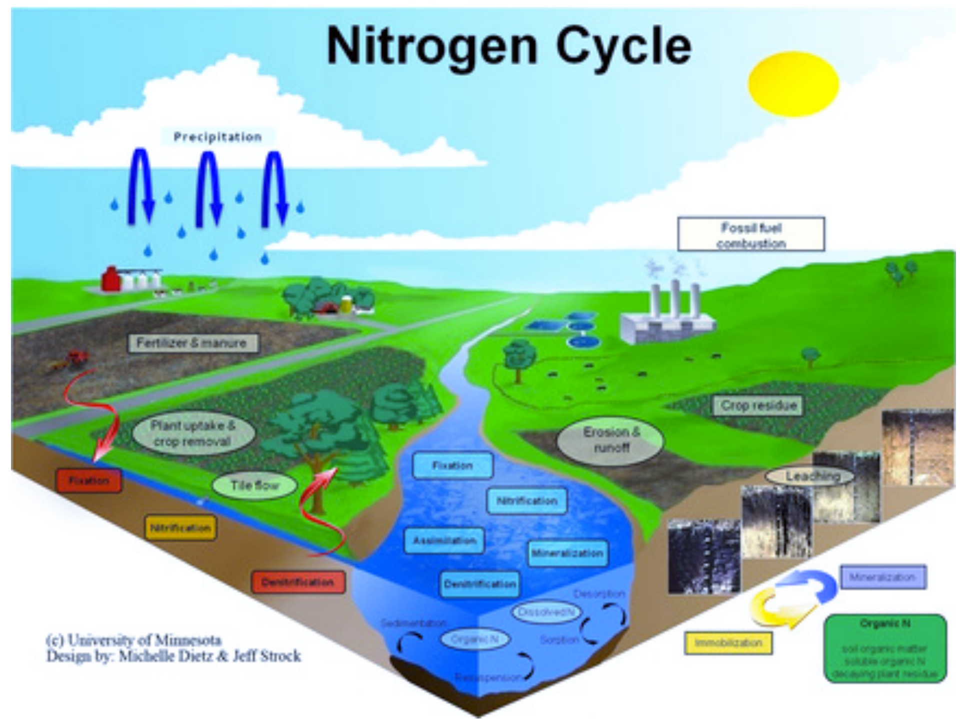
Date	Title	Page
	Area Profile Notes	
	Water Stations	

NEXT PAGE: THE NITROGEN CYCLE



NEXT PAGE: THE NITROGEN CYCLE

- Nitrogen is an element that is found in the organic and inorganic parts of the Earth's system.



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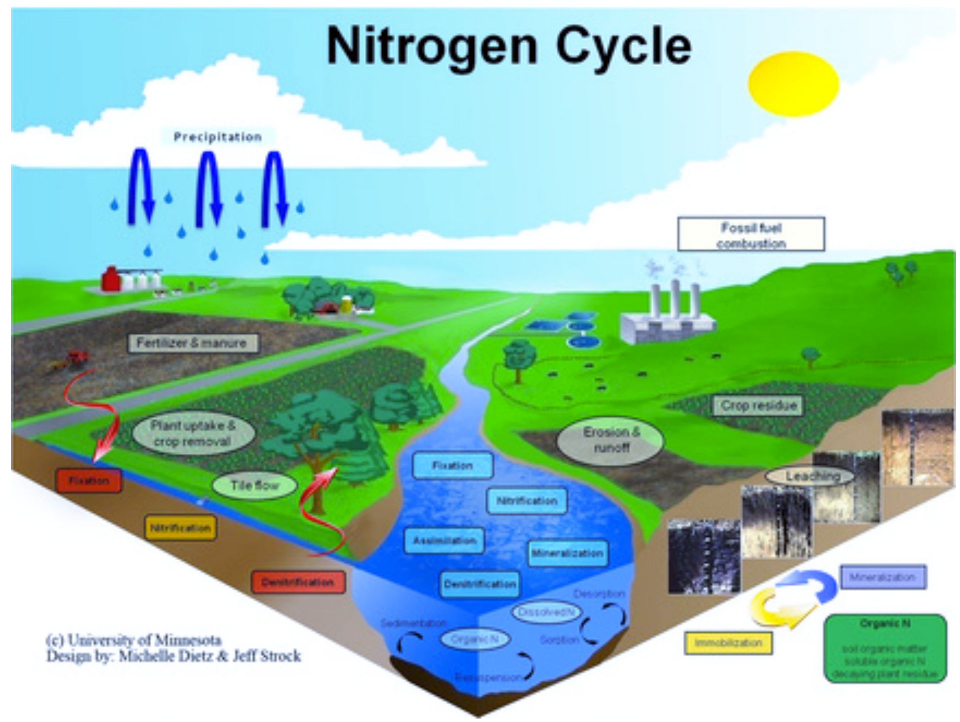
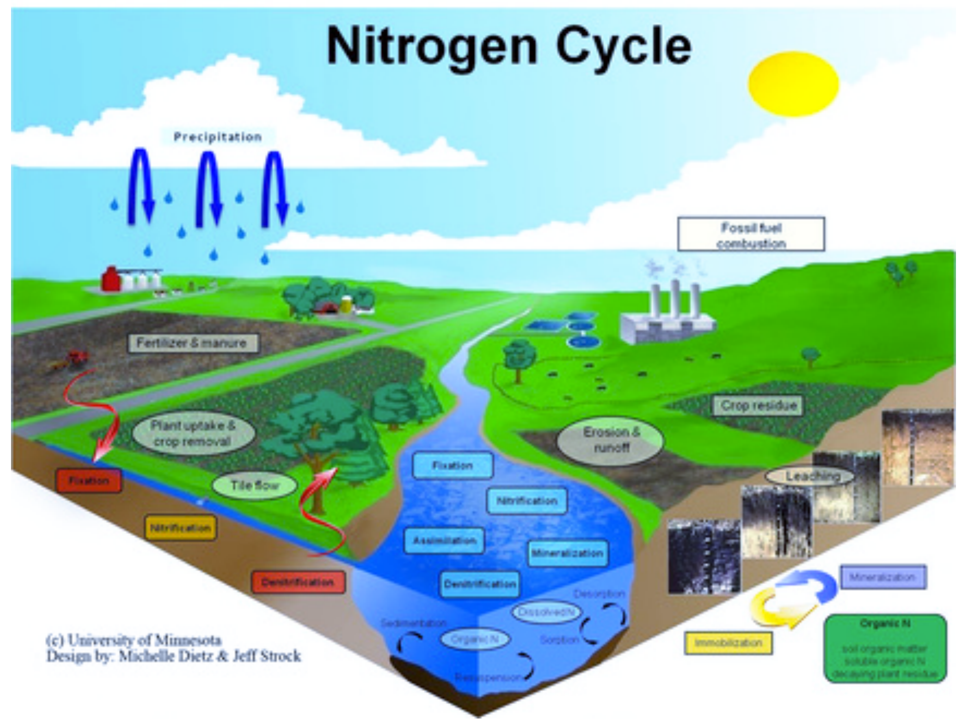
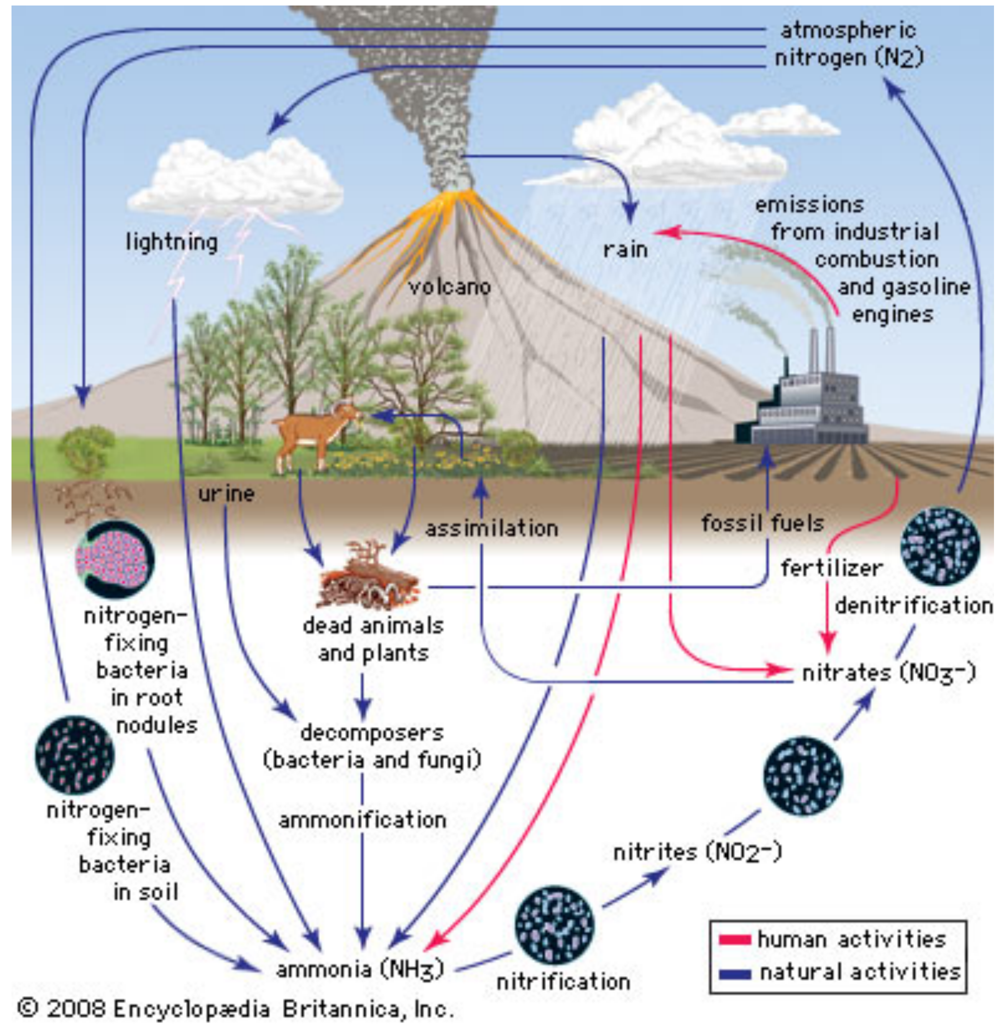
- Most of the nitrogen on Earth is in the atmosphere as N_2.



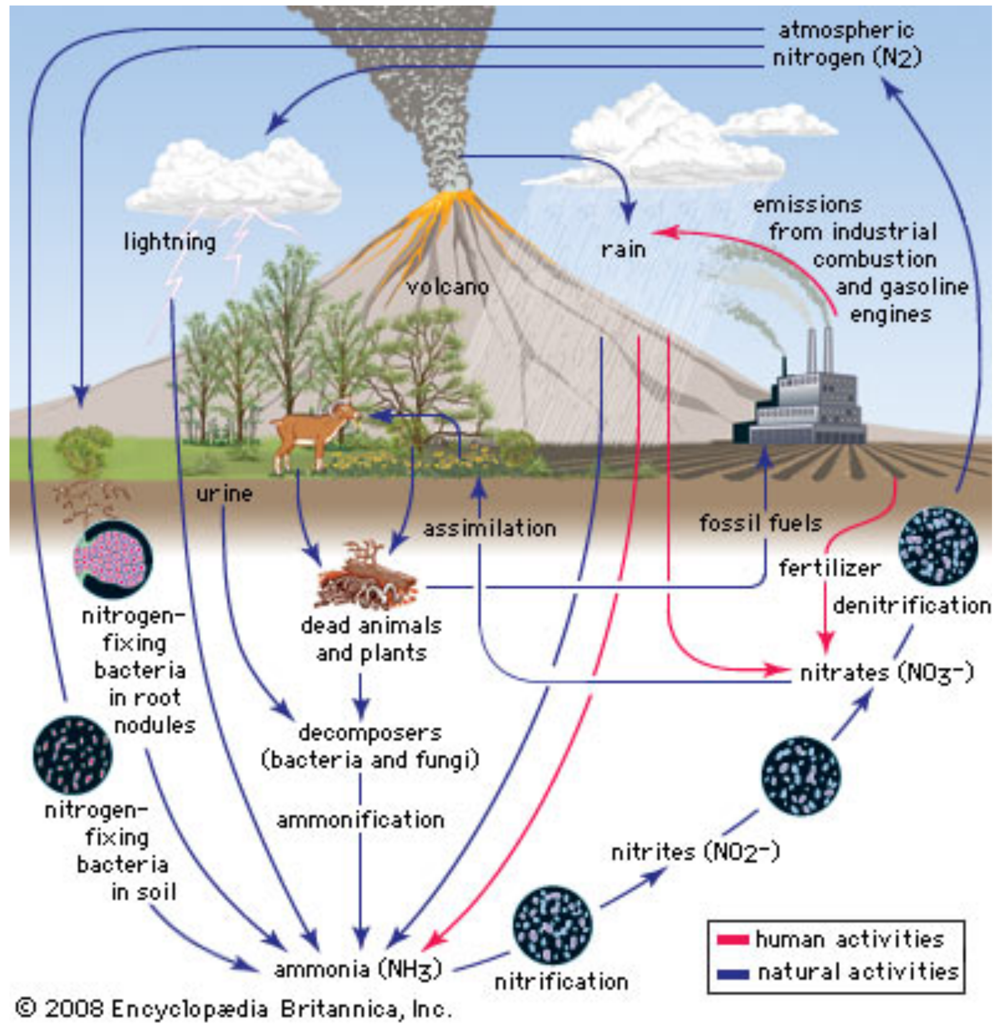
NEXT PAGE: THE NITROGEN CYCLE

- Nitrogen is an element that is found in the organic and inorganic parts of the Earth's system.
- Most of the nitrogen on Earth is in the atmosphere as N_2.
- All plants and animals need Nitrogen to make amino acids, proteins, and DNA, but the Nitrogen in the atmosphere is not in a form that they can use.




atmospheric nitrogen (N_2)
lightning
volcano
rain
emissions from industrial combustion and gasoline engines
urine
assimilation
fossil fuels
fertilizer
denitrification
nitrogen-fixing bacteria in root nodules
dead animals and plants
nitrates (NO_3^-)
decomposers (bacteria and fungi)
ammonification
nitrogen-fixing bacteria in soil
nitrites (NO_2^-)
human activities
natural activities
ammonia (NH_3)
nitrification
© 2008 Encyclopædia Britannica, Inc.

- N_2 can become usable by:
  - Lightening strikes or fires
  - Bacteria



- N_2 can become usable by:
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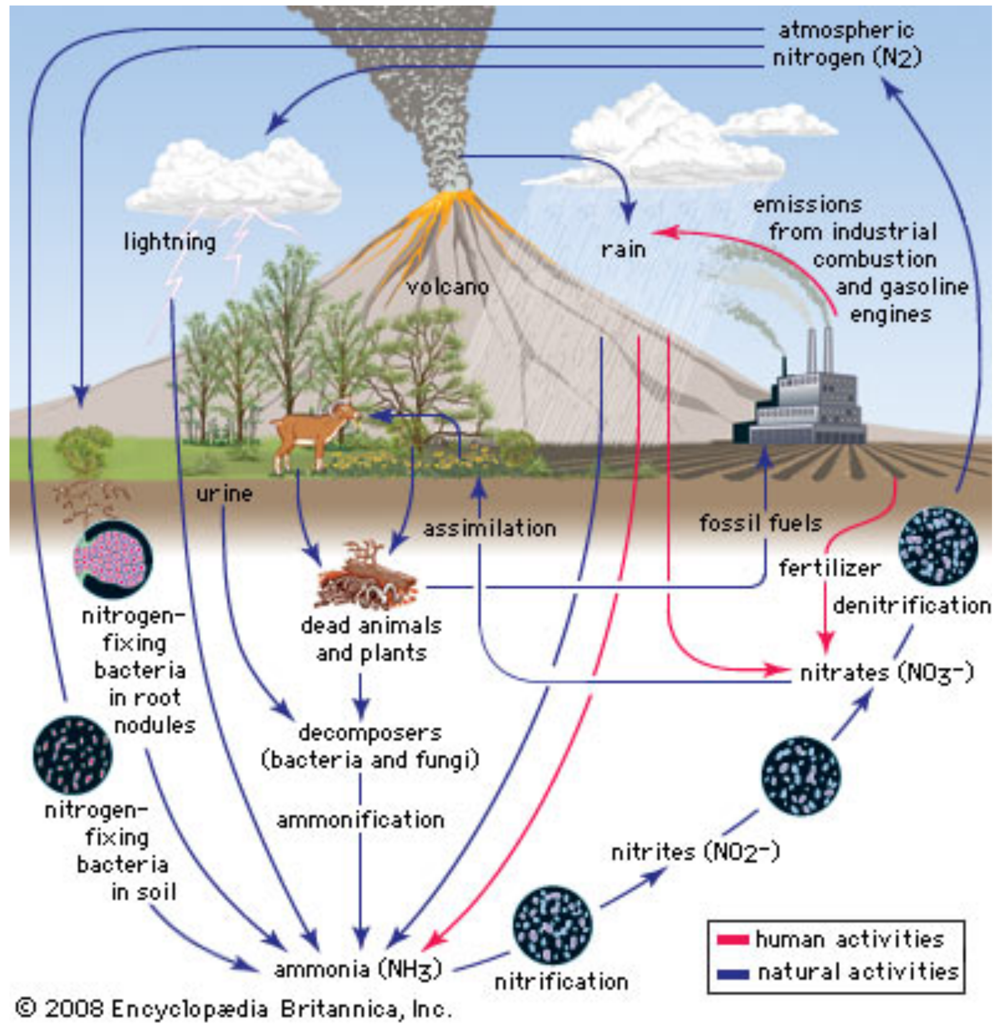
  - Bacteria
- As dead plants and animals decompose, nitrogen is converted into inorganic forms such as ammonia (NH_4^+) by mineralization.



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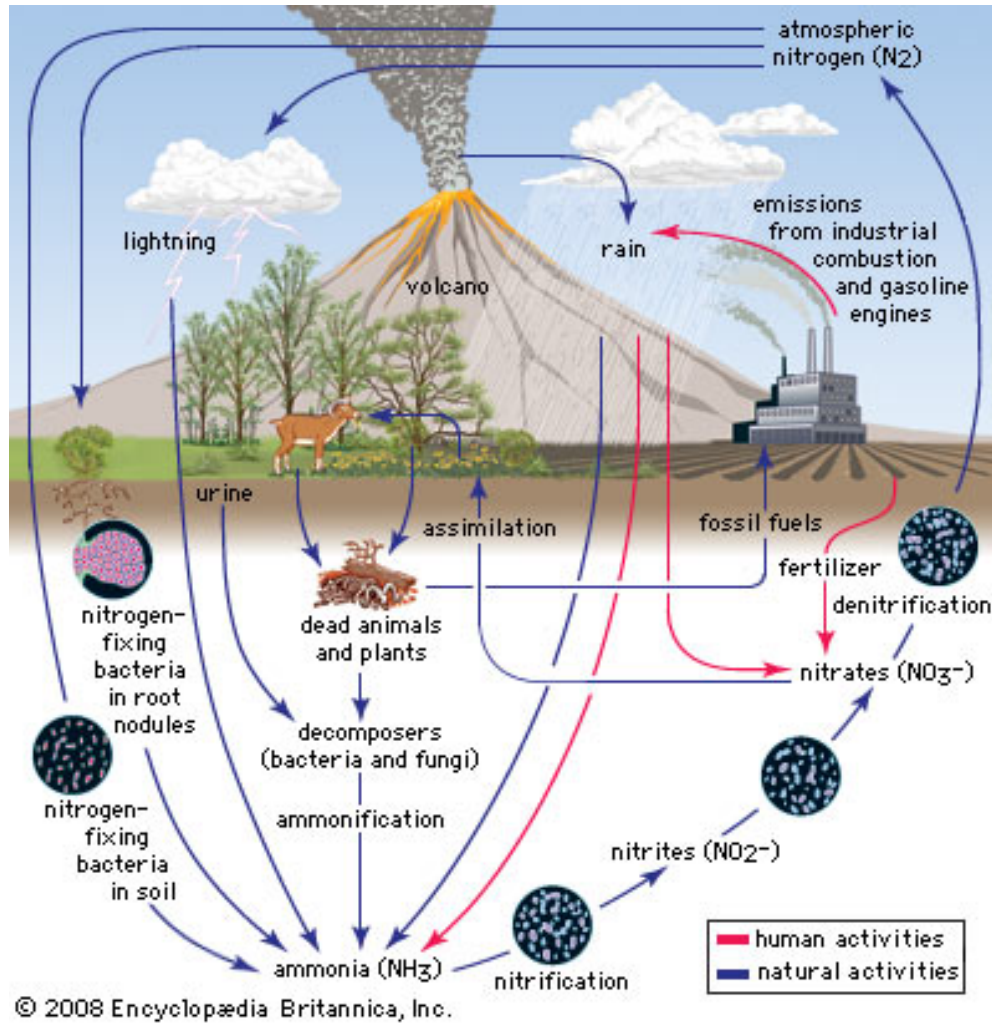
- Ammonia is then chemically altered by soil bacteria into Nitrite and then into Nitrate.



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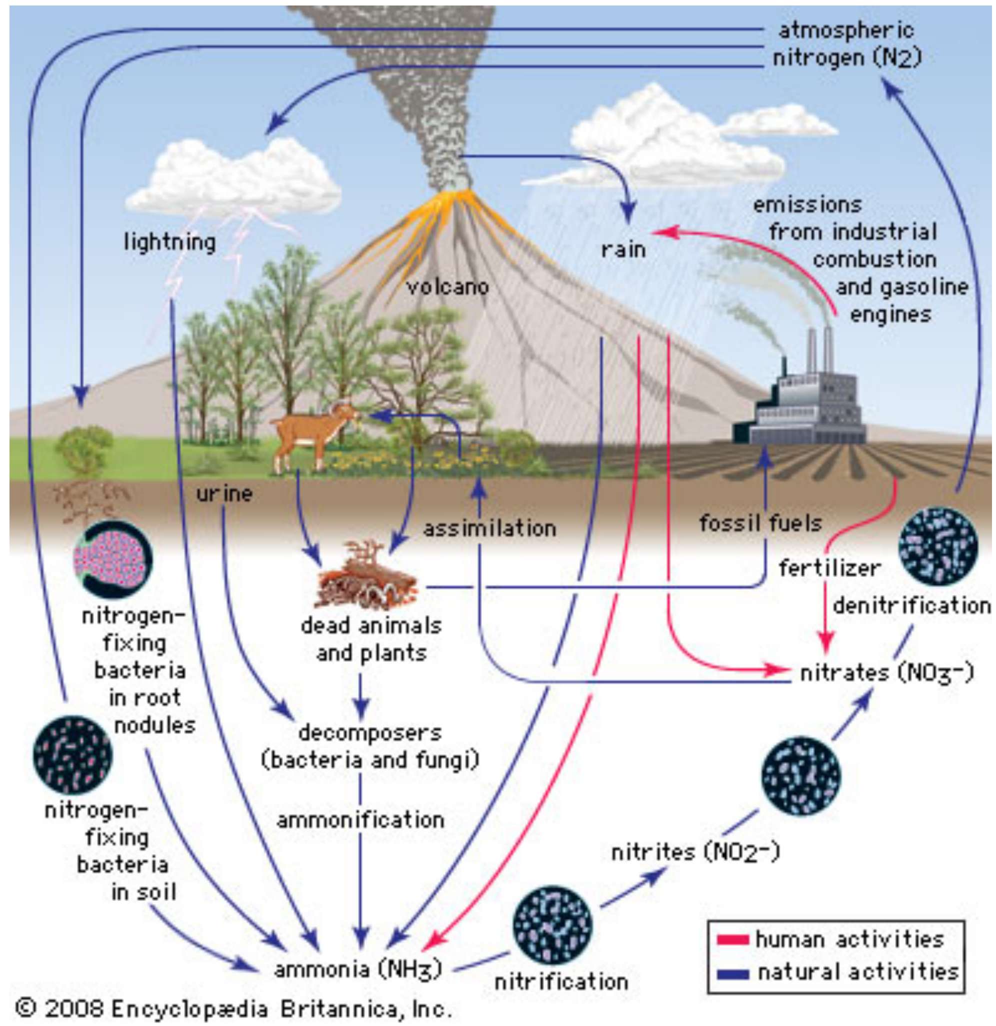
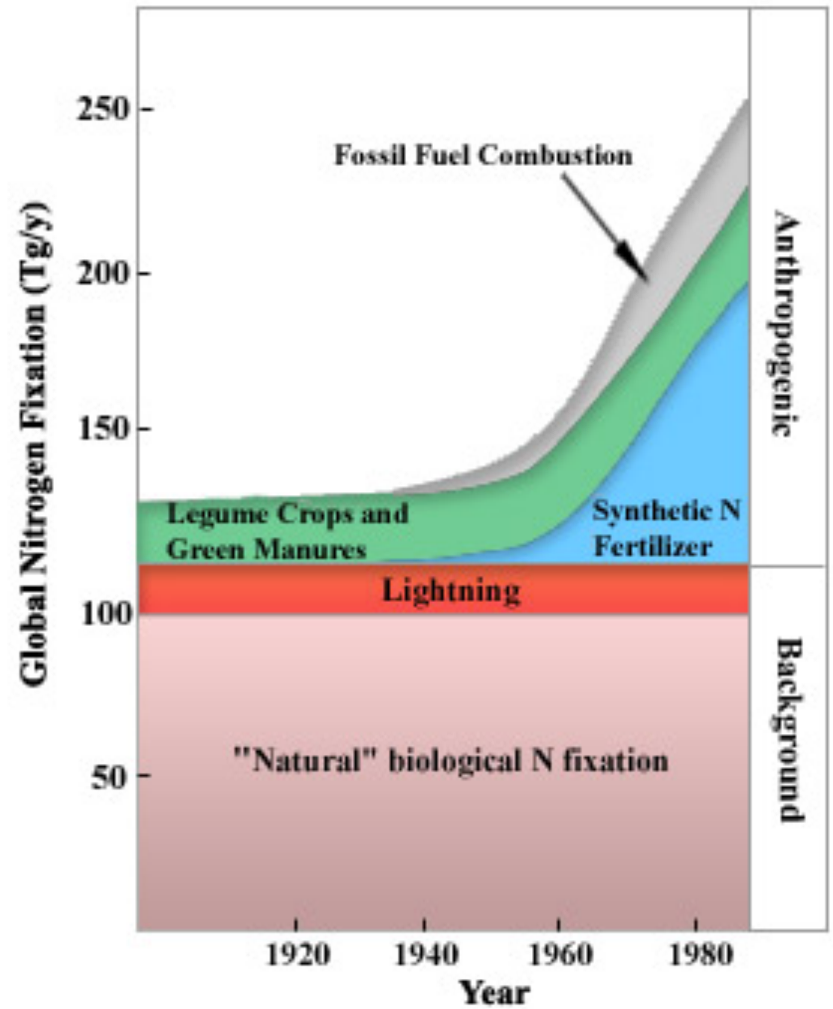
- Ammonia is then chemically altered by soil bacteria into Nitrite and then into Nitrate.
- Nitrate (NO_3^-) is the form used by plants. It is dissolved in water and leached from the soil.





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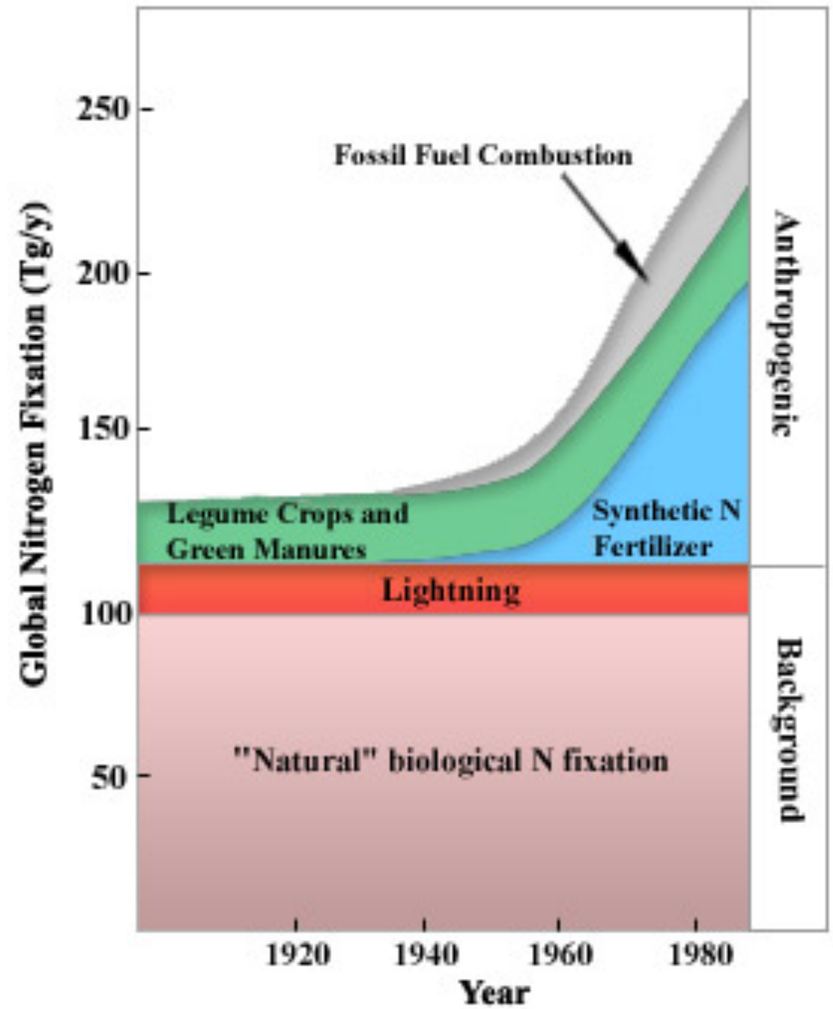
- Human activity causes changes to the Nitrogen cycle and the amount of nitrogen stores in water.



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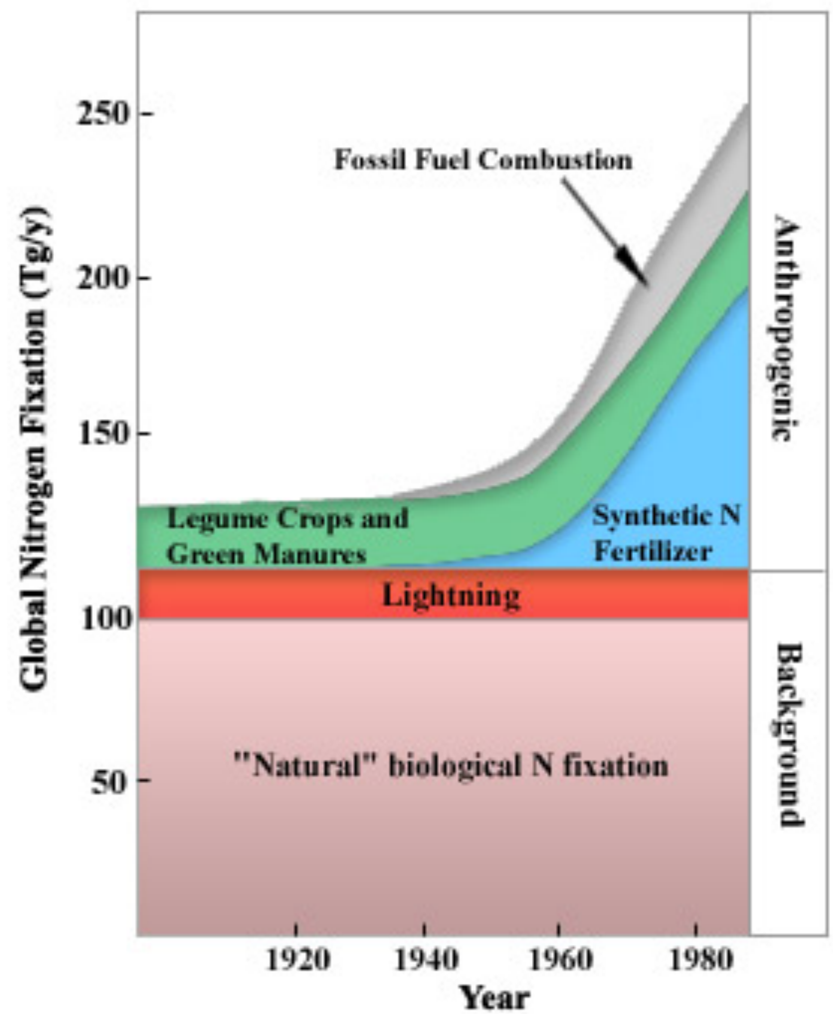
- Nitrogen-rich fertilizers can cause nutrient runoff
    - Causes increase plant growth



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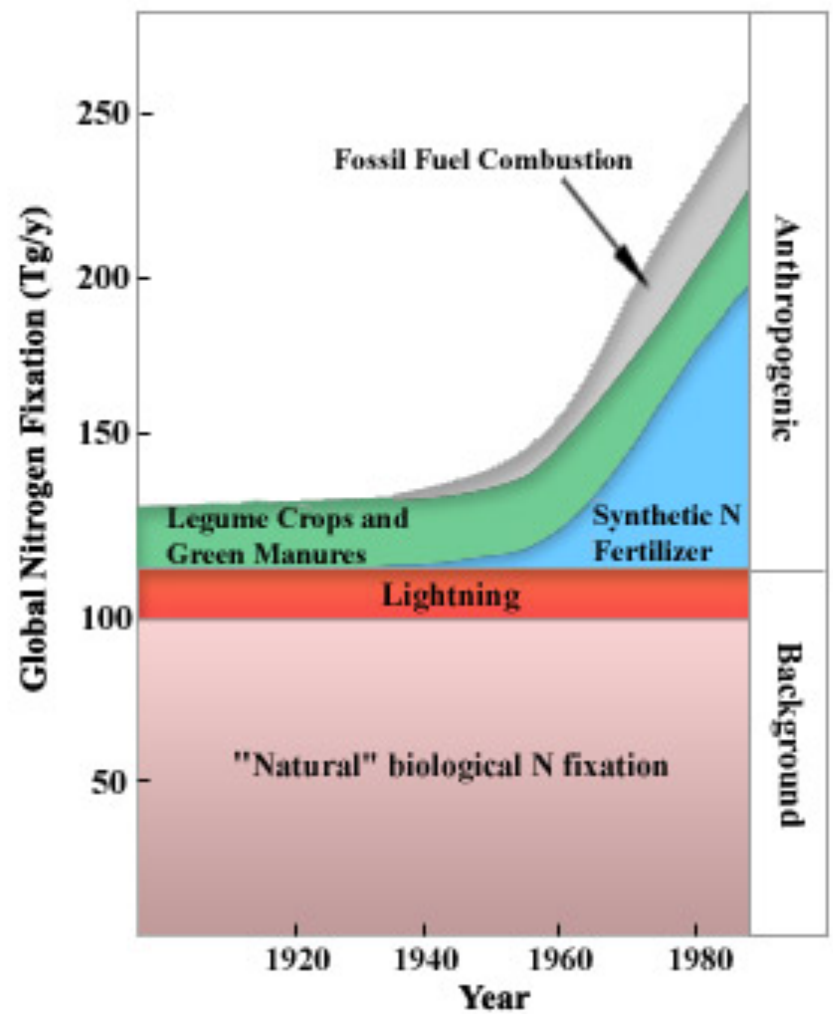

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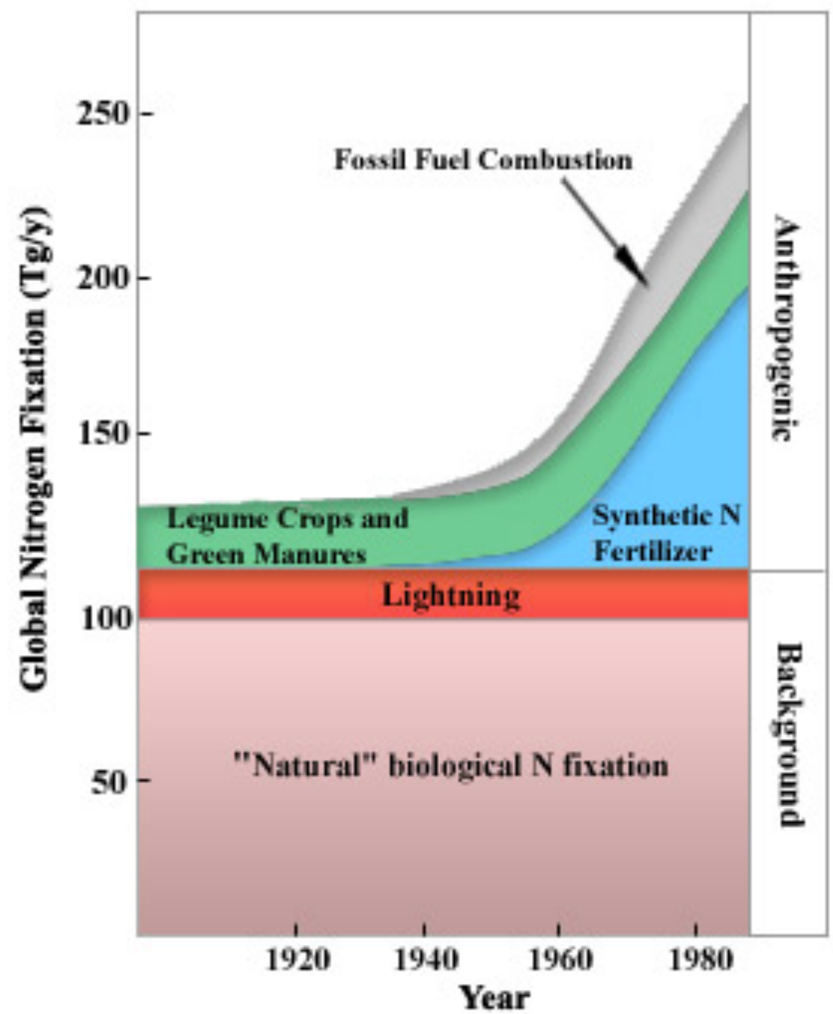

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- Nitrogen-rich fertilizers can cause nutrient runoff
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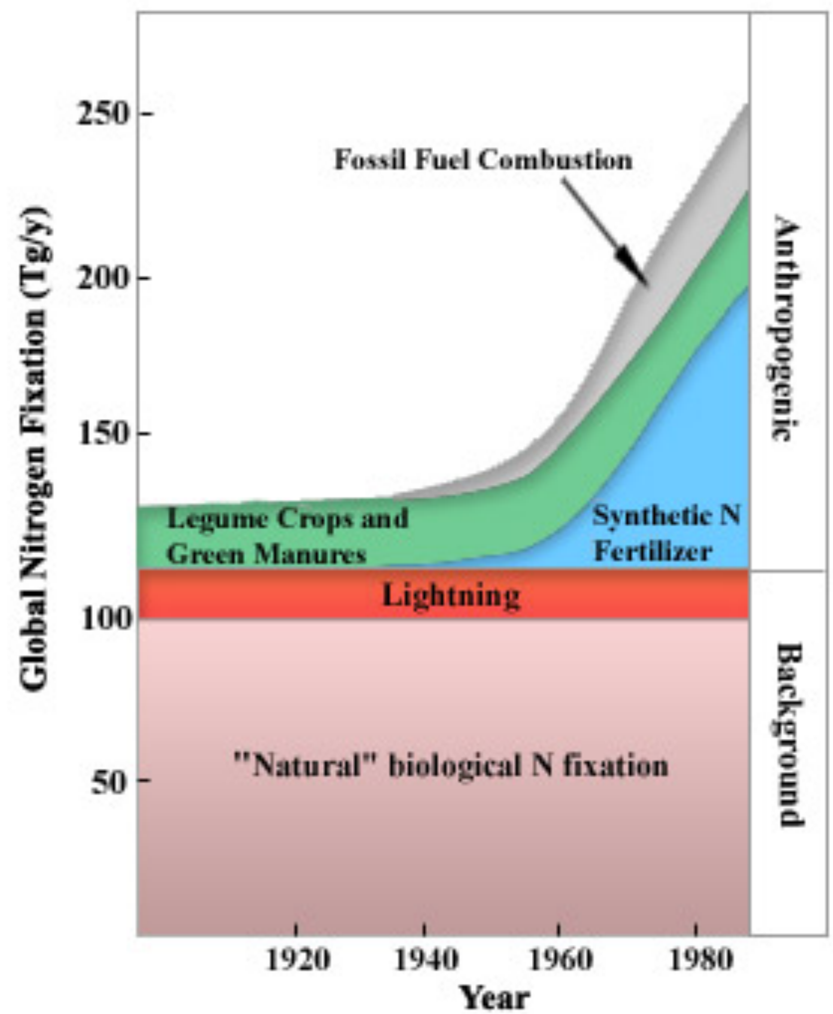
- Burning fossil fuels and forests releases various forms of Nitrogen.
- Waste from livestock releases a large amount of Nitrogen into soil and water.
- Sewage waste adds Nitrogen to soils and water.



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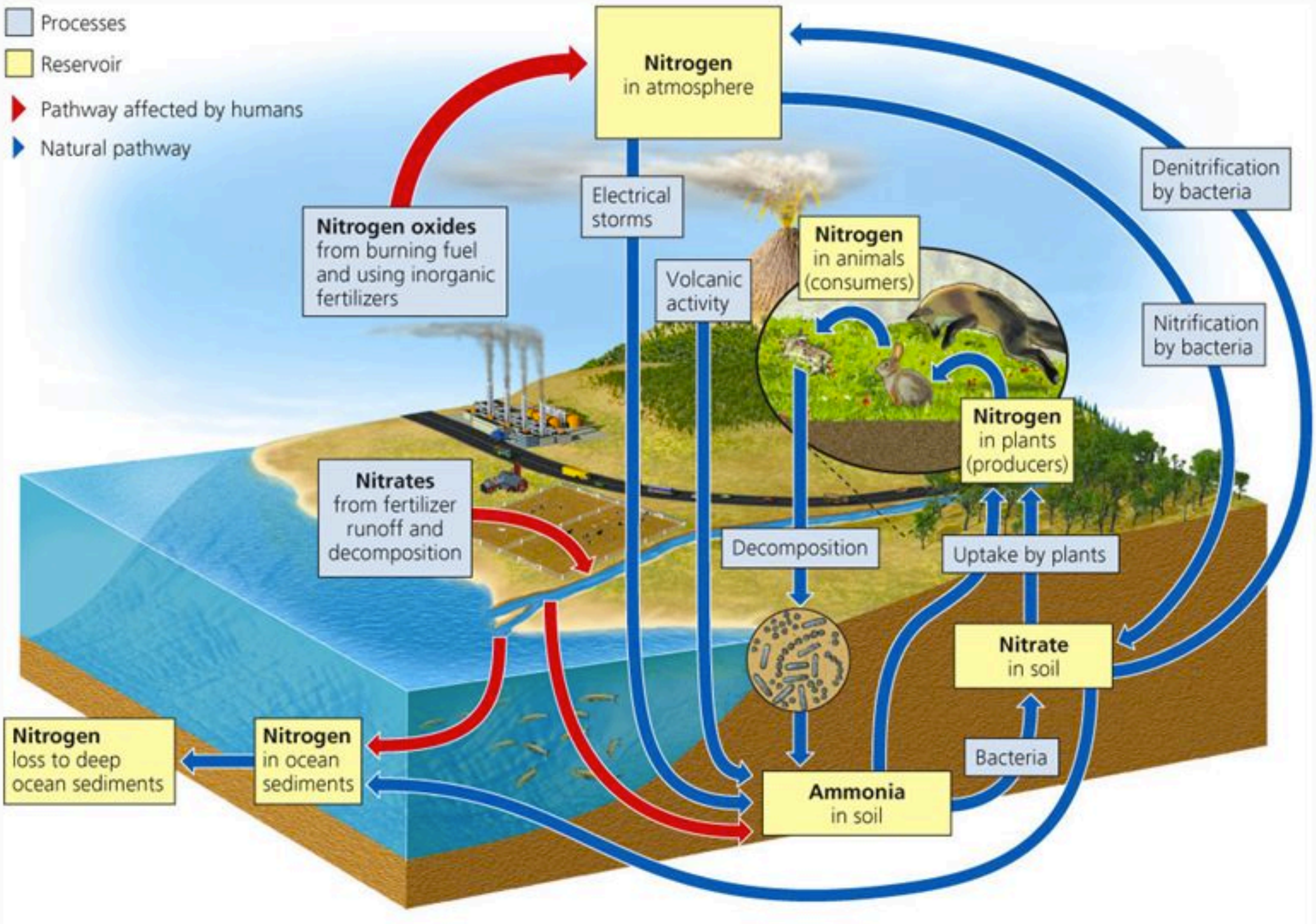
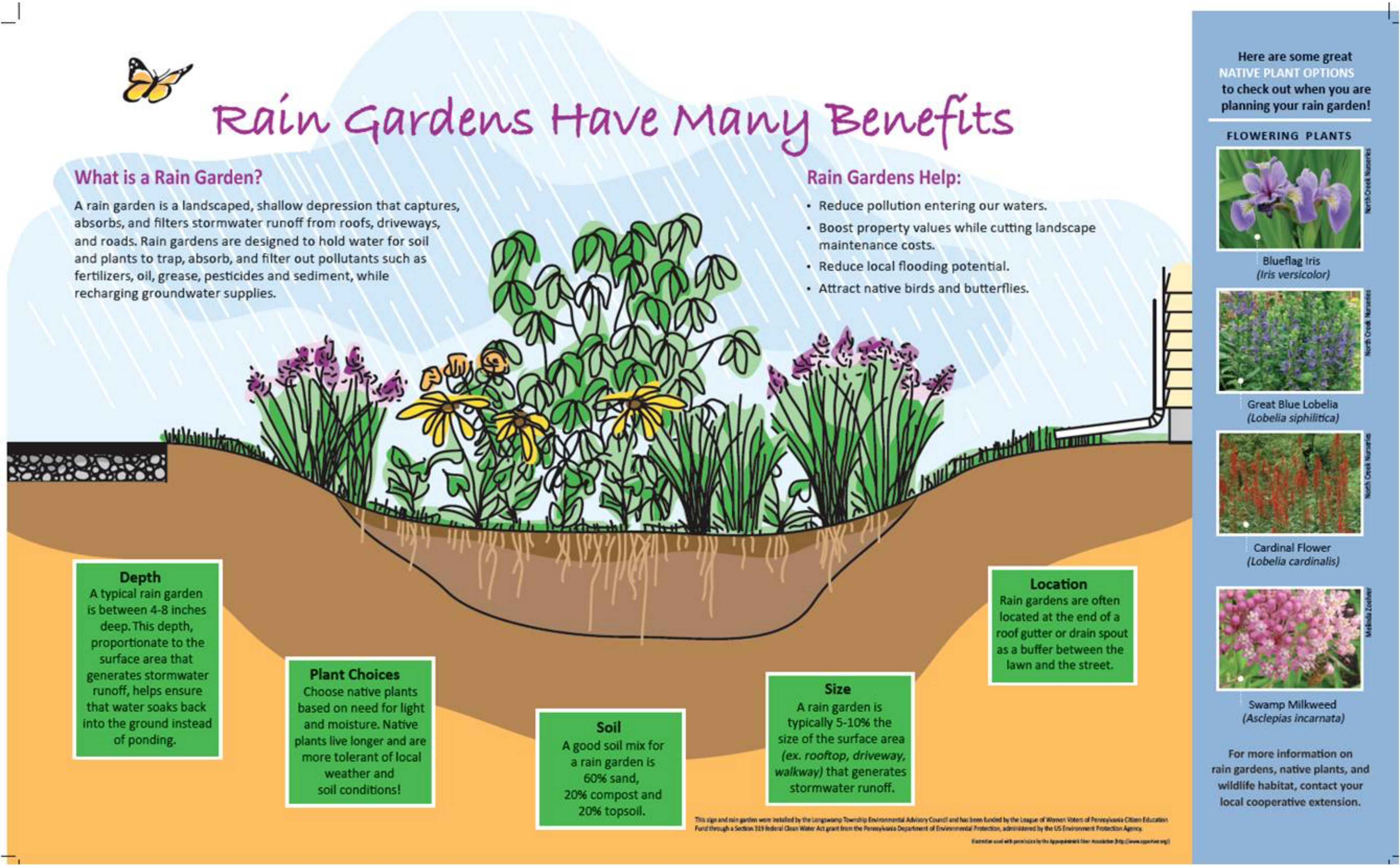
Nitrogen Cycle in a Terrestrial Ecosystem with Major Harmful Human Impacts



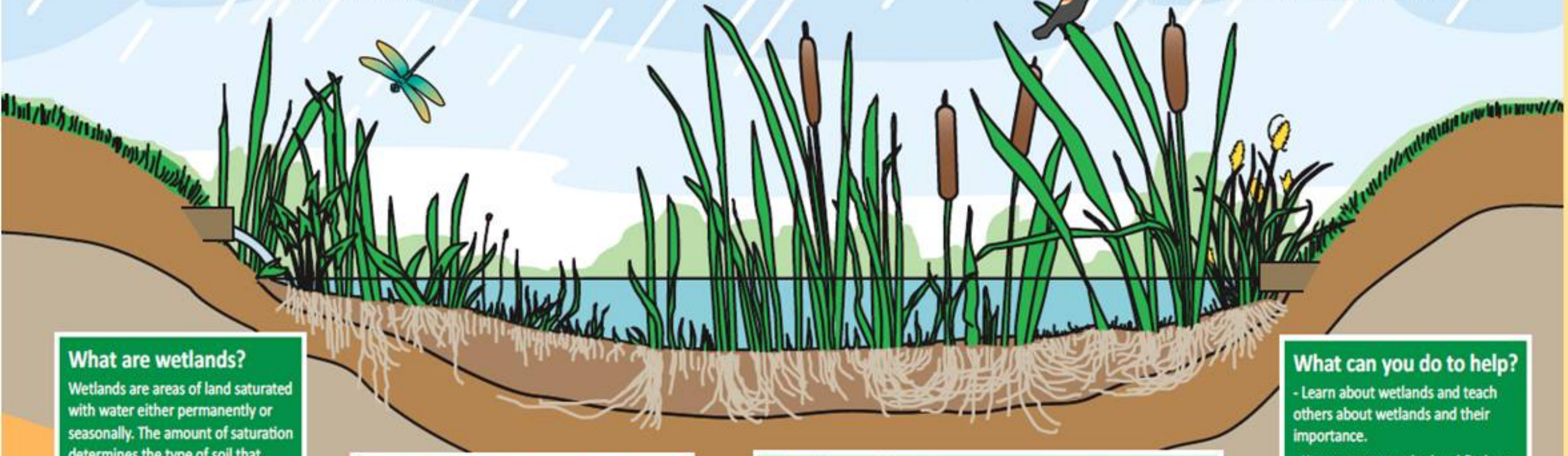

Rain Gardens Have Many Benefits
What is a Rain Garden?
A rain garden is a landscaped, shallow depression that captures, absorbs, and filters stormwater runoff from roofs, driveways, and roads. Rain gardens are designed to hold water for soil and plants to trap, absorb, and filter out pollutants such as fertilizers, oil, grease, pesticides and sediment, while recharging groundwater supplies.
Rain Gardens Help:
• Reduce pollution entering our waters.
• Boost property values while cutting landscape maintenance costs.
• Reduce local flooding potential.
• Attract native birds and butterflies.
Depth
A typical rain garden is between 4-8 inches deep. This depth, proportionate to the surface area that generates stormwater runoff, helps ensure that water soaks back into the ground instead of ponding.
Plant Choices
Choose native plants based on need for light and moisture. Native plants live longer and are more tolerant of local weather and soil conditions!
Soil
A good soil mix for a rain garden is 60% sand, 20% compost and 20% topsoil.
Size
A rain garden is typically 5-10% the size of the surface area (ex. rooftop, driveway, walkway) that generates stormwater runoff.
Location
Rain gardens are often located at the end of a roof gutter or drain spout as a buffer between the lawn and the street.
This sign and rain garden were installed by the Longswamp Township Environmental Advisory Council and has been funded by the League of Women Voters of Pennsylvania Citizen Education Fund through a Section 319 federal Clean Water Act grant from the Pennsylvania Department of Environmental Protection, administered by the US Environment Protection Agency.
Here are some great NATIVE PLANT OPTIONS to check out when you are planning your rain garden!
FLOWERING PLANTS
North Creek Nurseries
Blueflag Iris
(Iris versicolor)
North Creek Nurseries
Great Blue Lobelia
(Lobelia siphilitica)
North Creek Nurseries
Cardinal Flower
(Lobelia cardinalis)
Swamp Milkweed
(Asclepias incarnata)
For more information on rain gardens, native plants, and wildlife habitat, contact your local cooperative extension.

Wetlands Have Many Benefits

What you are looking at is a storm water basin. Basins like these capture storm water and hold it to be released slower into our streams. By releasing the water at a slower rate, we protect our creeks from erosion and flooding. This is becoming increasingly important as we add more impervious surfaces (buildings, roads and parking lots) and therefore increasing the volume of storm water our streams receive.

This particular basin has been retrofitted to act like a wetland. This means that it holds a permanent pool of water and has been rebuilt with native plants and soils so that it now offers many of the benefits of wetlands. Wetlands are often called the "kidneys of the earth" because they help purify water by filtering out pollutants and sediment. Acting like sponges, they help reduce flooding and slow runoff from surfaces like roofs and driveways.

Wetlands create vital habitat for creatures like the ones pictured on the right. Pennsylvania alone lost more than 50% of its wetlands from 1970-1980. Wetland loss can occur from development or being drained for farming. Remaining wetlands are often degraded. Wetland loss and degradation over the centuries makes man made wetlands like this one increasingly important. And of course, we must protect the wetlands that remain.



What are wetlands?

Wetlands are areas of land saturated with water either permanently or seasonally. The amount of saturation determines the type of soil that develops and the vegetation that can grow there. Wetlands are determined by looking at 3 factors...
- hydrology
- plants
- soil

There are 4 main types of Wetlands:

- Marshes - Swamps - Bogs - Fens

Healthy wetlands are not an uncontrolled breeding ground for mosquitoes. Healthy wetlands sustain populations of mosquito eating creatures like,

- fish - amphibians - insects - birds - bats

What can you do to help?

- Learn about wetlands and teach others about wetlands and their importance.
- Know your watershed and find out where wetlands are in your area.
- Encourage your community and local government to protect wetlands and create new wetlands.

This sign was installed by the Longswamp Township Environmental Advisory Council and has been funded by the League of Women Voters of Pennsylvania Citizen Education Fund through a Section 319 federal Clean Water Act grant from the Pennsylvania Department of Environmental Protection, administered by the US Environment Protection Agency.

WETLANDS PROVIDE HABITAT

to a great variety of plants and animals. Here are just a few:

WETLAND SPECIES

Gray Tree Frog
(Hyla versicolor)

Green Darner Dragonfly
(Anax junius)

Eastern Newt (Red Eft)
(Notophthalmus viridescens)

Red-winged Blackbird
(Agelaius phoeniceus)

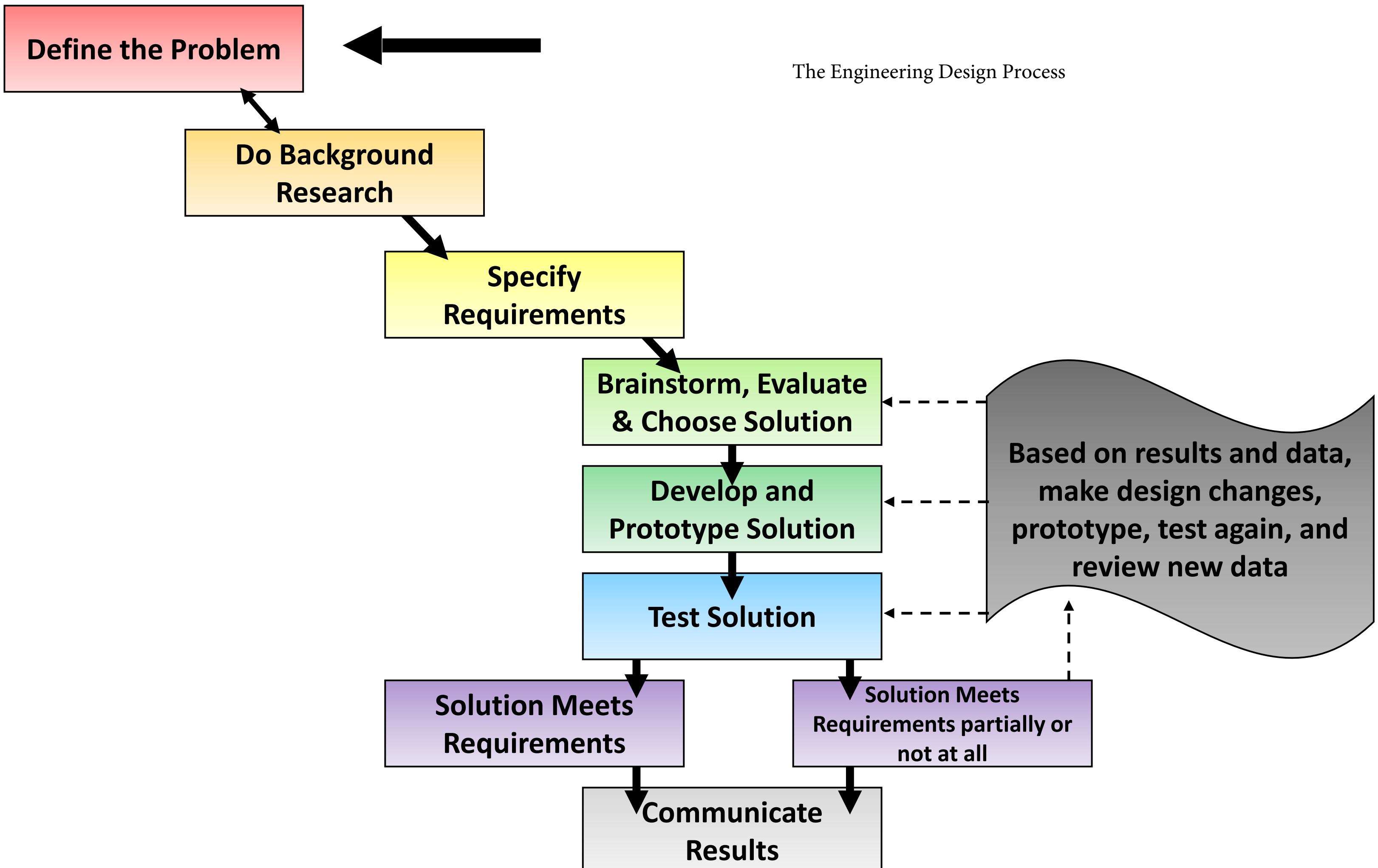
Bog Turtle
(Glyptemys muhlenbergii)

WETLANDS…A SOLUTION?

https://vimeo.com/98341690

How Wetlands Work
Wetlands use plants as part of the natural process to filter impurities from water. Other vegetation around the wetlands provides habitat for animals.
TRES RIOS
Riparian Vegetation: these plants grow near or around water and include Cottonwood and Willow trees, Elderberry, Colorado River Hemp, Seep Willows, shrubs, bushes and grasses. these areas help balance the wetlands ecosystem by providing food, a place for predators to reside, and a hiding place for small animals. Many migratory birds use riparian areas along their routes.
Transitional Plants: located on the water' s perimeter, these plants include Spike Rush, Knot Grass, and several desert shrubs and grasses. they help stabilize wetland banks, provide food for mammals and birds, and allow safe access to and from the water.
Emergent Marsh Plants: rooted to the bottom in depths greater than 3 feet. these include Cattail, Bulrush and common Reed. these plants provide food, safe haven, and nesting sites for fish, mammals and birds. the plants also help remove pollutants.
Wetlands improve water quality using sunlight, plants, bacteria and wind.
Wastewater Treatment Plant
Wetlands
Sunlight, Plants, Bacteria, Wind
Cleaner Water
Sunlight assists photosynthesis, causes chemical reactions, and kills pathogens and bacteria.
Plants remove nutrients, trap metals, minerals and solids, prevent algae growth, and add oxygen.
Bacteria remove nutrients, and transform organics into food sources and non-harmful by-products.
Wind provides energy for mixing, prevents stagnation, removes airborne gases and particles, and adds oxygen.
Desert/Upland: this vegetation surrounds the wet areas, but can't live in wet soil. In Arizona, trees like Mesquite and Palo Verde, shrubs like Quail-bush and Salt-bush, and assorted desert grasses make up this habitat. This vegetation provides food and shelter, as well as safe access to the wetlands.
Floating Aquatic Plants: rooted in bank or bottom, these plants spread across the water surface as they grow. This category includes Pennywort and False Loosestrife. Floating plants shade the water below the surface, reducing algae growth and producing clearer water. They also provide food for muskrat and some birds, and refuge and breeding sites for turtles and fish.
Submerged Aquatic Plants: rooted to the bottom in depths greater than 3 feet. In Arizona wetlands, Parrots Feather, Coons Tail, Potamogeton and Polygonum generate Oxygen, provide surface area for beneficial bacteria, and help lessen the effects of decaying material.

ENGINEERING DESIGN



The Engineering Design Process

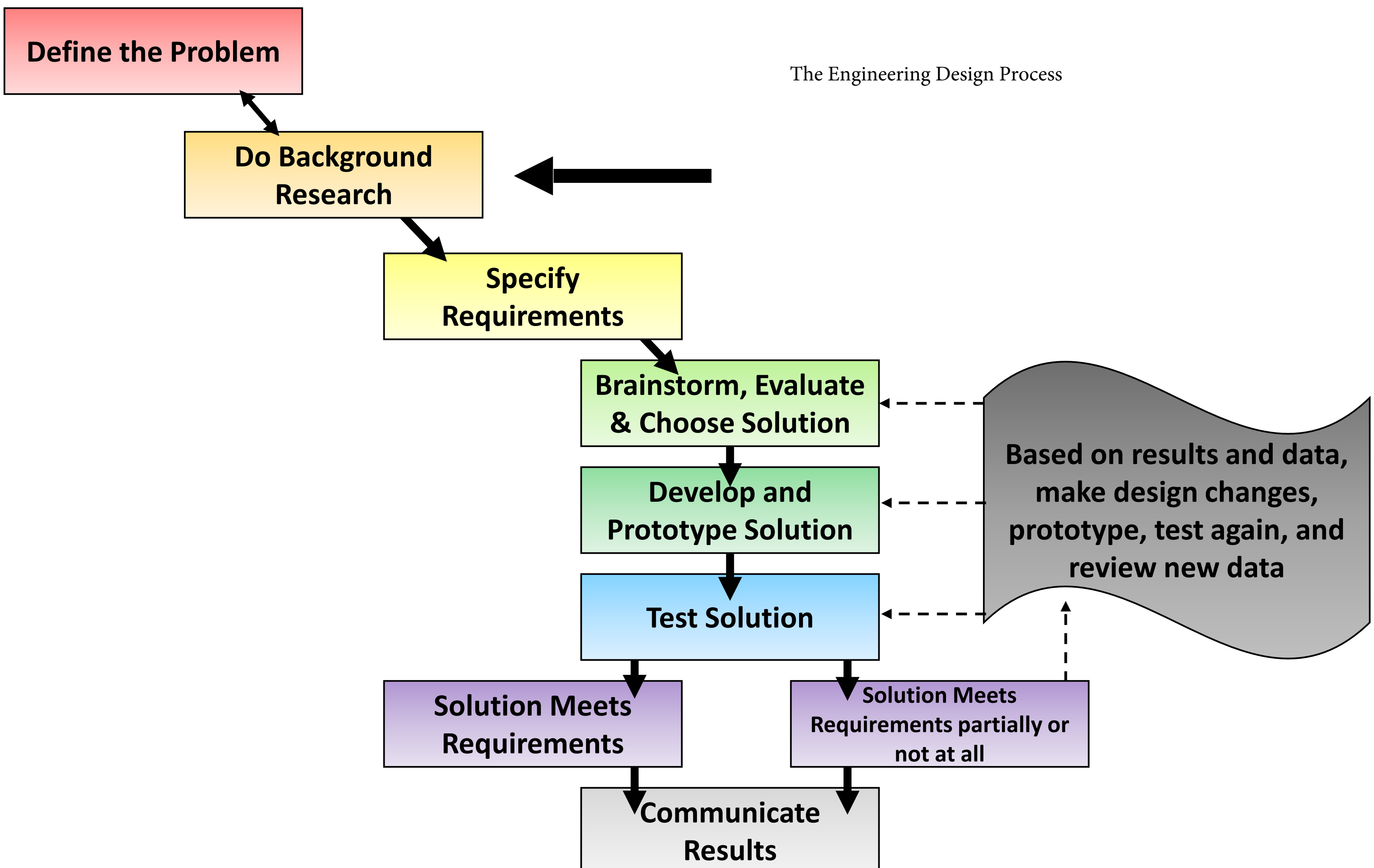
Adapted from Science Buddies (2016).

How can we mimic the water cleaning processes of a wetland?

"GOOD ARTISTS COPY; GREAT ARTISTS STEAL"

Biomimicry seeks sustainable solutions to human challenges by emulating (copying) nature's time-tested patterns and strategies.

ENGINEERING DESIGN

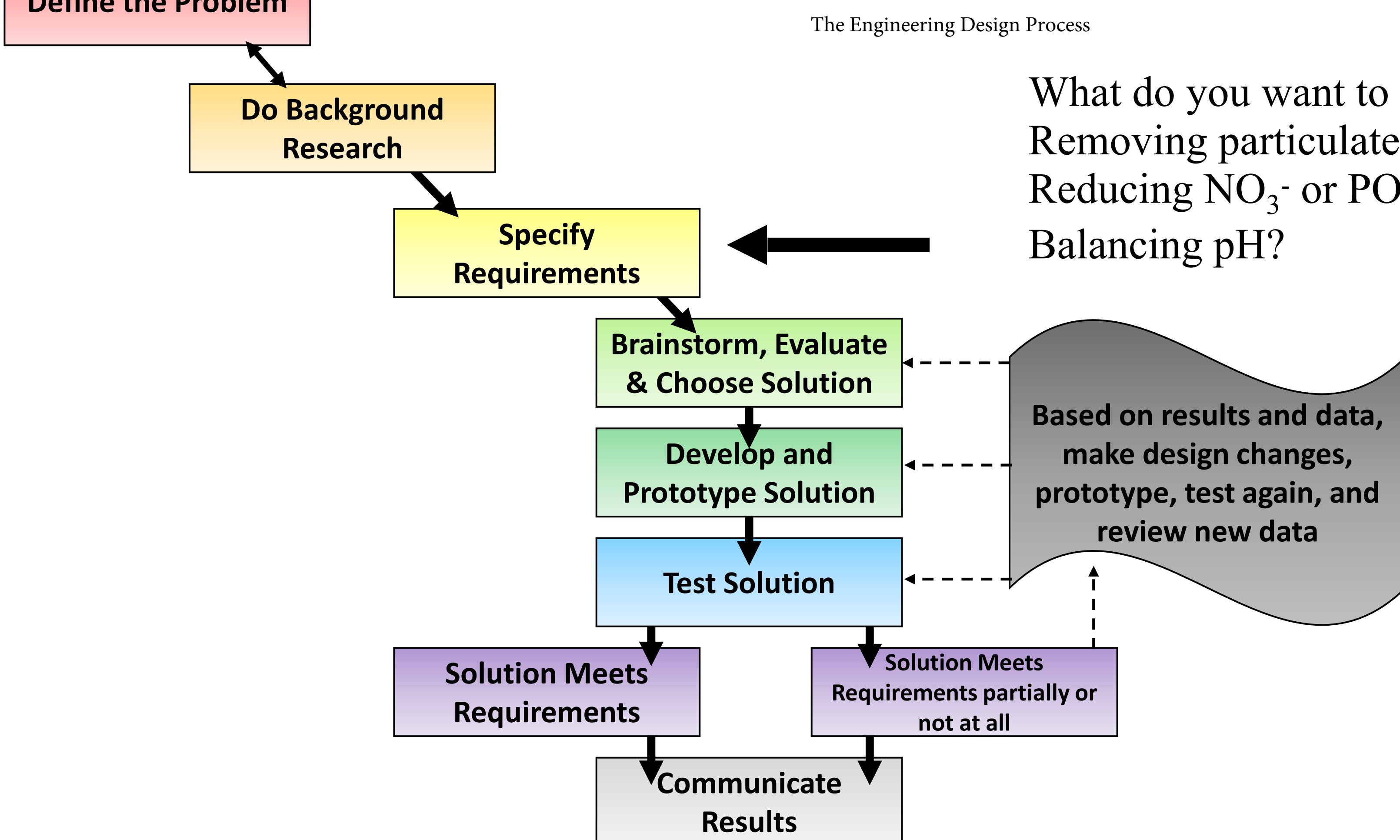


Adapted from Science Buddies (2016).

DAY 3: WELCOME BACK

Date	Title	Page
	Area Profile Notes	
	Water Stations	
	The Nitrogen Cycle	
	Biomimicry Notes	

ENGINEERING DESIGN

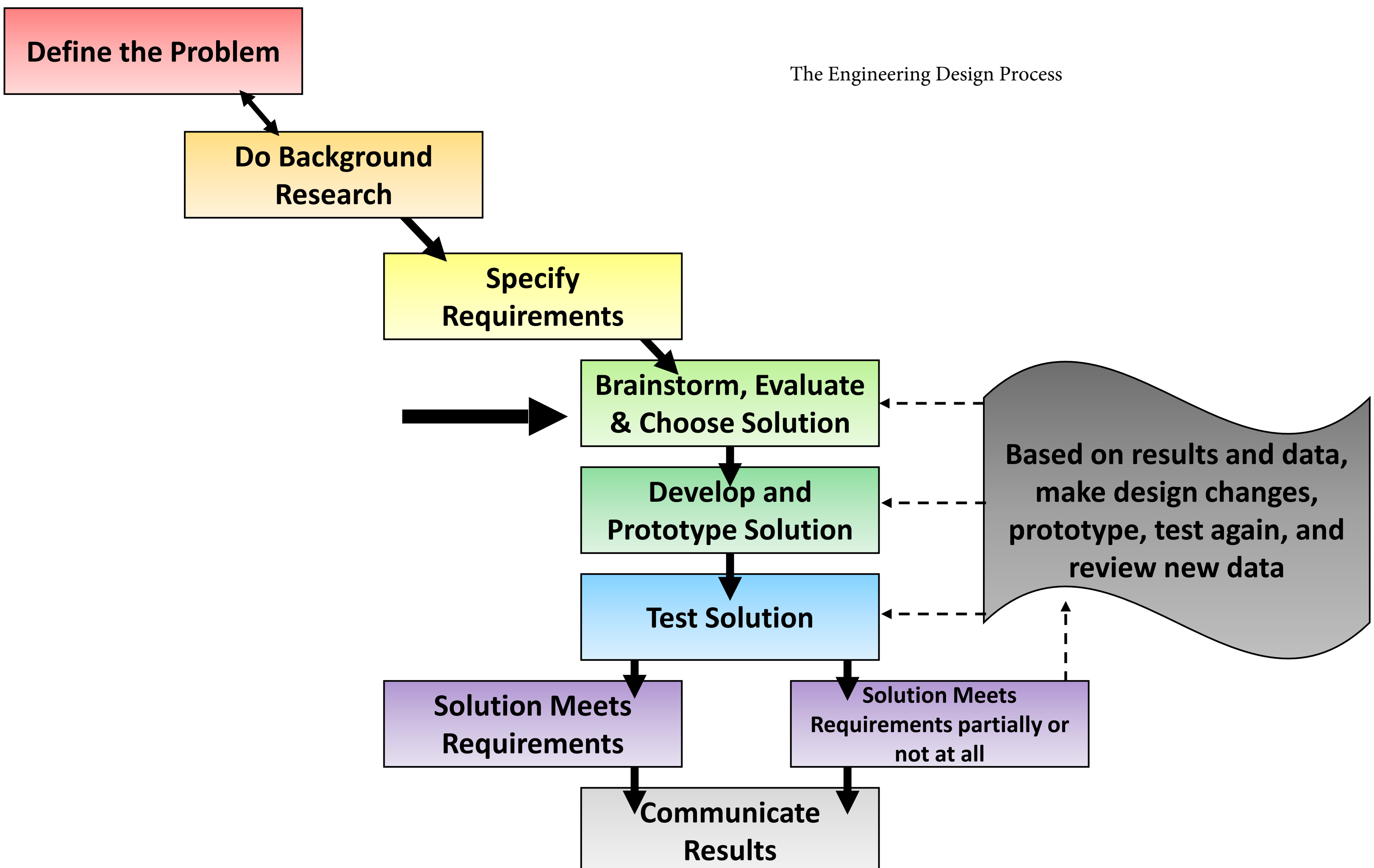


Adapted from Science Buddies (2016).

What do you want to focus on?
Removing particulate matter?
Reducing NO_3^- or PO_4^- levels?
Balancing pH?

ENGINEERING DESIGN

The Engineering Design Process



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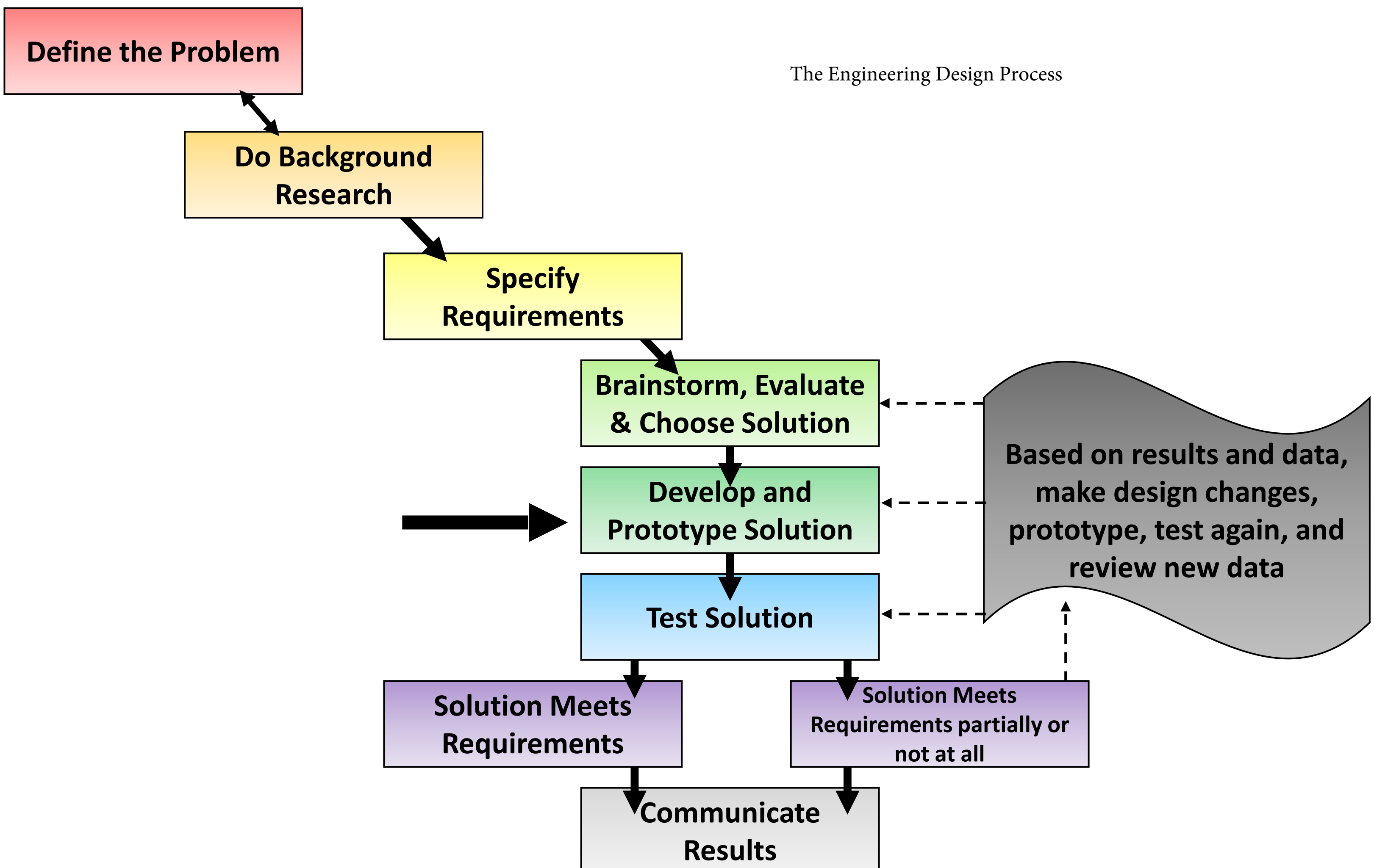
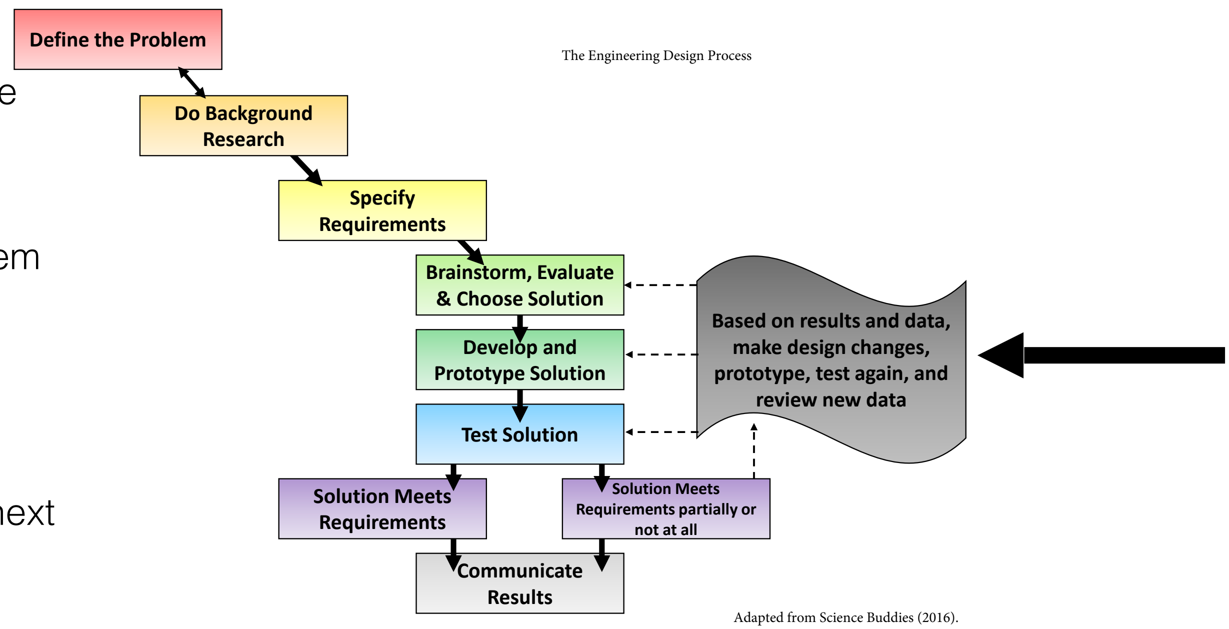


Adapted from Science Buddies (2016).

NEXT PAGE: PROTOTYPE 1

- After your initial testing, Record the following in your journal
  - A drawing of one or more prototype you worked on
  - A list of the materials you used
  - A description of the specific problem you were trying to solve
  - A personal reflection on the successes of your prototypes you saw
  - A personal reflection on potential next steps.



- The next step will be to test your prototype with “dirty” water.

NEXT PAGE: TECHNICAL DRAWING

- Next you will produce a detailed, technical drawing that will help you envision what parts and materials needed and how exactly they will fit together.

- Your drawing should be to scale.

- You should produce multiple views of your prototype
  - Front, top, bottom, left, right, or exploded views.