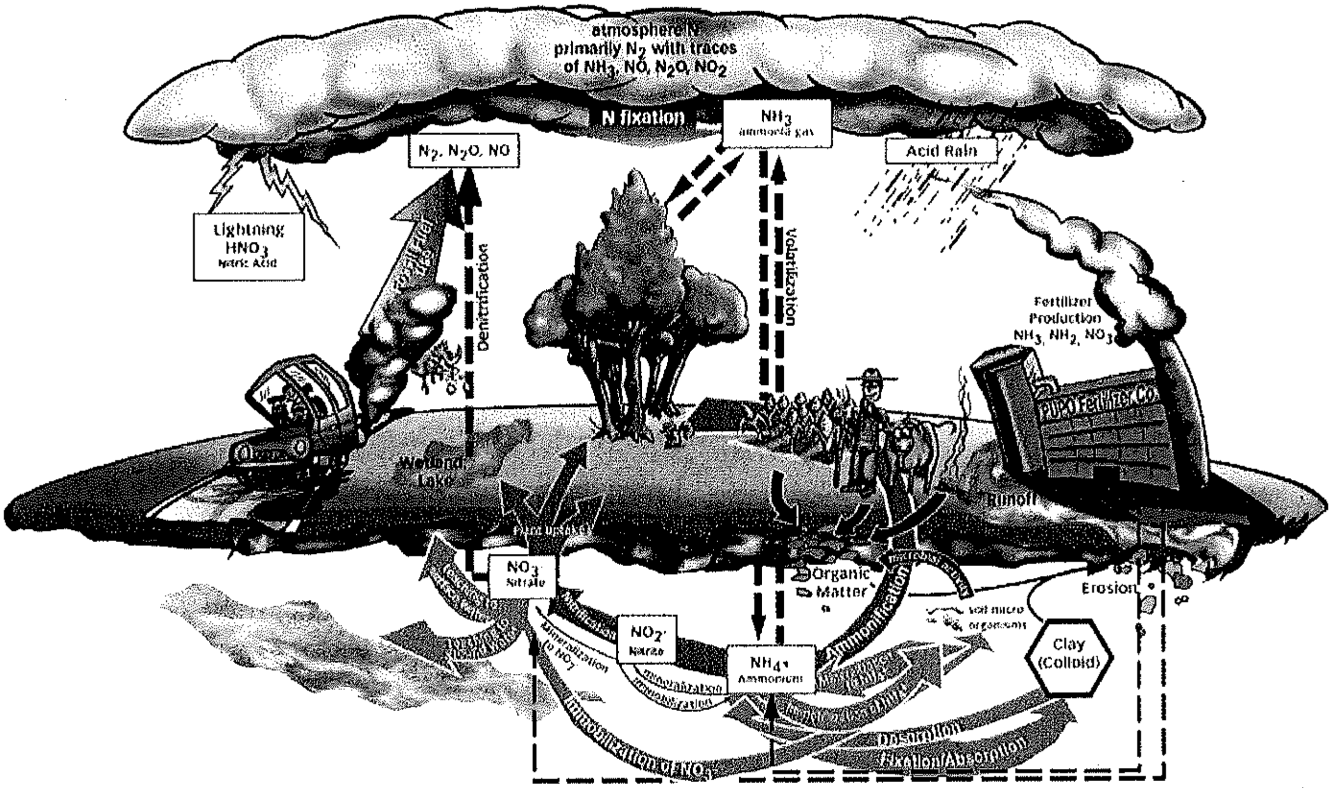

atmosphere N
primarily $N_2$ with traces
of $NH_3$, NO, $N_2O$, $NO_2$
N fixation
$NH_3$
ammonia gas
$N_2$, $N_2O$, NO
Acid Rain
Lightning
$HNO_3$
Nitric Acid
Denitrification
Volatilization
Fertilizer
Production
$NH_3$, $NH_2$, $NO_3$
Wetland
Lake
Runoff
Organic
Matter
Erosion
$NO_3^-$
Nitrate
$NO_2^-$
Nitrite
$NH_4^+$
Ammonium
Clay
(Colloid)
Ammonification
soil micro
organisms
Immobilization of $NO_3$
Desorption
Fixation/Absorption

**Unit Name:** Nitrogen in our Soils and Lives

**Unit Rationale:**

This unit has been designed to expose students to the nitrogen cycle and learn how nitrogen is a vital component of human existence. More and more evidence is coming forward that provides information on how humans are changing the natural cycles of our planet. The movement and levels of nitrogen in various reservoirs is no exception. Today 'going green' is becoming important. Understanding the Earth's cycles, sources of pollution, and the policy that prevents pollution is necessary. An understanding of the Nitrogen cycle will be helpful not only in college but also in future careers

**Targeted Grade Level:** $10^{th}$ – $11^{th}$ grades

**Anticipated Number of Class Sessions Needed:** 3 weeks (15 class periods / 2 laboratory times) + 1 day for cumulative exam at the end of the unit

**Length of Each Session:** 1 class period

**Supplies Needed for Unit:**

*Lesson 1:*

- Computer and Projector
- Blank Paper
- Markers or Colored Pencils
- Nitrogen Cycle Worksheet

*Lesson 2:*

- Computer and Projector
- Nitrogen Cycle Diagrams
- Cups
- Pencils
- Celery
- Knife
- Paper towels
- Water
- Food coloring
- Legume and non legume plants grown
- Note cards with key terms
- Ice cubes to melt
- Apparatus to boil water
- Lesson 2 PowerPoint worksheets

*Lesson 3:*

- Computers with internet access for 1-2 students / computer
- Computer and Projector for teacher use
- Web Soil Survey Worksheets
- Shovels
- Small Ziploc bags

*Lesson 4:*

- Computer and Projector
- Homework Assignment Handout

*Lesson 5:*

- Computer and Projector
- Copies of article and worksheet
- Matching Game pieces – enough for students to form # groups

*Lesson 6:*

- Computer and Projector
- Bare Spots Booklet copies

*Lesson 7:*

- Computer and Projector
- Handouts of Research Project, Topic List and Presentation rubric

*Lesson 8:*

- Computer and Projector
- Soil Lab Directions copies
- Soil Lab Worksheet copies
- Scientific Paper handouts
- Enough 50 mL centrifuge tubes for each student to have 2
- 5.6 grams of Calcium Chloride
- 1 gallon of distilled water
- Scale
- Merckquant Nitrate test strips for each student to have 2
- Calculators
- Transfer pipets for each student to have 2
- Extraction tubes for each student to have 2
- Universal extraction solution
- Ammonia test solution
- Filter paper for each student to have 2
- Plastic funnels for each student to have 1
- Spot plates for each student to have 2
- Ammonia color chart

*Lesson 9:*

- Computer and Projector
- School Yard Report Card handouts

*Lesson 10:*

- Computer and Projector
- Worksheets for PowerPoint
- Handouts for Review

**Pennsylvania Academic Standards and Assessment Anchors:**

4.1.10.A: Describe changes that occur from a stream's origin to its final outflow. Identify Pennsylvania's major watersheds and their related river systems. Describe changes by tracing a specific river's origin back to its headwaters including its major tributaries.

4.1.10.D: Describe the multiple functions of wetlands. Describe wetlands in terms of their effects (e.g., buffer zones, prevention areas, etc.) Explain how a wetland influences water quality and water retention.

4.1.10.E: Identify and describe natural and human events on watersheds and wetlands. Describe how natural events affect a watershed (e.g., drought, floods). Identify the effects of humans and human events on watersheds.

4.2.10.A: Explain that renewable and nonrenewable resources supply energy and materials. Identify alternative sources of energy. Identify and compare fuels used in industrial and agricultural societies. Compare and contrast the cycles of various natural resources.

4.3.10.A: Describe environmental health issues. Identify the effects on human health of air, water and soil pollution and the possible economic costs to society. Explain the costs and benefits of cleaning up contaminants.

4.3.10.B: Explain how multiple variables determine the effects of pollution on environmental health, natural processes and human practices. Explain how human practices affect the quality of the water and soil. Identify local and state environmental regulations and their impact on environmental health.

4.4.10.B: Assess the influence of agricultural science on farming practices. Compare the practices of no-till farming to traditional soil preparation (e.g., plow, disc). Analyze and explain the various practices of nutrient management on the farm. Analyze and explain how farm efficiencies have changed human nutrition.

4.6.10.A: Explain the biotic and abiotic components of an ecosystem and their interaction. Compare and contrast the interactions of biotic and abiotic components in an ecosystem. Analyze the effects of abiotic factors on specific ecosystems. Identify a specific environmental impact and predict what change may take place to affect homeostasis. Examine and explain how organisms modify their environments to sustain their needs. Explain how erosion and sedimentation have changed the quality of soil related habitats.

4.6.10.B: Explain how cycles affect the balance in an ecosystem. Describe an element cycle and its role in an ecosystem. Explain the consequences of interrupting natural cycles.

4.8.10.C: Analyze how human activities may cause changes in an ecosystem. Analyze and evaluate changes in the environment that are the result of human activities. Compare and contrast the environmental effects of different industrial strategies (e.g., energy generation, transportation, logging, mining, agriculture).

4.8.10.D: Explain how the concept of supply and demand affects the environment. Identify natural resources for which societal demands have been increasing. Identify specific resources for which human consumption has resulted in scarcity of supply (e.g., buffalo, lobsters). Describe the relationship between population density and resource use and management.

4.9.10.A: Explain why environmental laws and regulations are developed and enacted. Explain the positive and negative impacts associated with passing environmental laws and regulations. Understand conflicting rights of property owners and environmental laws and regulations. Analyze the roles that local, state and federal governments play in the development and enforcement of environmental laws. Identify local and state environmental regulations and their impact on environmental health.

**Names of Lesson Titles:**

1. The Nitrogen Cycle: Introduction to the Unit and Nitrogen in our soils (1 day)
2. The Many Transformations of Nitrogen, Their Relationship with Plants and Eutrophication (2 days – on 2nd day finish experiments and give quiz)
3. Web soil Survey (1 day)
4. Haber-Bosch Process (1 day)
5. The Effect of Excess Nitrates on the Health and Lives of Humans (1 day)
6. Environmental Policy and Regulations Related to Nutrient Management (1 day)
7. Smarter Farming Techniques and Alternative Energy Production Using Nitrogen (3 days – 1 day for PowerPoint, project explanation and library research, 1 day for research in the computer lab or library, 1 day for presentations)
8. Ammonium and Nitrogen in Our Local Soils (1 day)
9. The State of the Chesapeake Bay (2 days – 1 day for PowerPoint and 1 day for Report Card group work)
10. The Malthusian Dilemma and Review of the Unit (2 days – 1 day for PowerPoint and 1 day for quiz and review group work)

**Unit Goals:**

Upon completion of this 3 week unit on the nitrogen cycle, students will:

1. Understand the importance of nitrogen to our environment and to our health.
2. Understand the nitrogen cycle.
3. Recognize how humans are changing the nitrogen cycle.
4. Understand the benefits and drawbacks to certain farming techniques.
5. Know the policies and regulations surrounding nutrient management.
6. Be able to test and read the level of nitrate and ammonium within soil.
7. Understand the possible use of biofuel and biogas for energy production.

**Specific Daily Learning Objectives Addressed:**

Lesson 1: The Nitrogen Cycle: Introduction to the Unit and Nitrogen in our Soils

Upon completion of class instruction, students will be able to:

1. Identify the components of the Nitrogen cycle to 90% accuracy.
2. Demonstrate knowledge of Nitrogen cycle in creative form to teacher satisfaction.
3. Define vocabulary terms to 80% accuracy.

Lesson 2: The Many Transformations of Nitrogen, Their Relationship with Plants, and Eutrophication

Upon Completion of class instruction, students will be able to:

1. Define vocabulary terms to 80% accuracy.
2. Identify the components of the Nitrogen cycle to 100% accuracy.
3. Complete a lesson quiz with 80% accuracy.

Lesson 3: Web Soil Survey

Upon completion of class instruction, students will be able to:

1. Manipulate the soil survey to complete worksheets to 90% accuracy.

Lesson 4: Haber-Bosch Process

Upon completion of class instruction, students will be able to:

1. Explain the Haber-Bosch process to teacher satisfaction.
2. Compose a 2 – 3 page paper by doing research to teacher satisfaction.

Lesson 5: The Effect of Excess Nitrates on the Health and Lives of Humans

Upon completion of class instruction, students will be able to:

1. Read and answer questions about a scholarly article.
2. Apply information learned form a PowerPoint to a learning card activity.

Lesson 6: Environmental Policy and Regulations Related to Nutrient Management

Upon completion of class instruction, students will be able to:

1. Identify environmental policies and nutrient management practices to teacher satisfaction.
2. Identify and fix schoolyard bare spots to teacher satisfaction.

Lesson 7: Smarter Farming Techniques and Alternative Energy Production using Nitrogen

Upon completion of the class instruction, students will be able to:

1. Identify best management practices and biogas to teacher satisfaction.
2. Write a scholarly paper and give a presentation to teacher satisfaction.
3. Be able to evaluate peers presentations in a formal setting to teacher satisfaction.

Lesson 8: Ammonium and Nitrogen in Our Local Soils

Upon completion of class instruction, students will be able to:

1. Perform tests and analyze results from a Nitrate-Nitrogen Quick Test with 80% accuracy.
2. Perform test sand analyze results from a Ammonia Nitrogen Test with 80% accuracy.
3. Write a scientific lab report to teacher satisfaction.

Lesson 9: The State of the Chesapeake Bay

Upon the completion of class work time, students will be able to:

1. Work cooperatively in a group setting.
2. Be able to use the information learned about the Chesapeake Bay to evaluate the school with a Schoolyard Report Card.

Lesson 10: The Malthusian Dilemma and Review of Unit

Upon the completion of this unit, students will be able to:

1. Recall lesson information to complete a quiz to 80% accuracy.
2. Recall unit information to complete a unit test to 80% accuracy.

**Unit Assessments:**

Throughout this unit there will be several formative assessments:

- Worksheet to be completed with soil survey (Lesson 3)
- Worksheet to be completed with Lesson 1,2,5,10
- Formation of student version of Nitrogen Cycle
- Participation in class activities and group work
- 2 quizzes in Lessons 2 and 10
- Schoolyard Report Card and Bare Sports worksheets
- 2-3 page paper on Haber-Bosch Process
- Card game from Lesson 5
- Completion of research project (5 page paper) and 3-5 minute presentation for Lesson 7
- Participation in lab and writing of scientific paper for Lesson 8
- Lesson Review worksheets and presentations at the end of the unit

The summative assessment will be done individually:

- Students will have 1 class period to complete 35 test questions covering the material from this unit. Comprised of multiple choice, fill in the blank, matching questions, and short answer. (60 points)

**Exceptional Children Strategies/ Accommodations/ Adaptations:**

There are several accommodations and adaptations that can be made with this unit.

1. Provide written instructions for all activities.
2. Offer preferential seating for students with visual or hearing impairments.
3. Assessment accommodations by offering additional time, separating students around the room to reduce distractions.
4. Use different modes of presenting the information.

**A Specific Science and/ or Math and/ or English Enhancement:**

There are three writing assignments within this unit:

- Homework paper for Lesson 4
- Research project paper for Lesson 7
- Scientific Lab Report for Lesson 8

Math is built into this unit through:

- Interpreting data results for Lesson 8

**Nitrogen Cycle Exam**

Name:______________________________

1. **What are the two forms of Nitrogen that exist in the soil?** (2 points)

    a.

    b.

2. **Draw a diagram of the Nitrogen Cycle.** (8 points)

3. **Why is the nitrogen cycle important?** (2 points)

4. **What is the difference between Mineralization and Immobilization?** (2 points)

5. **How can you tell is plants are suffering from Nitrogen deficiency?** (2 points)

6. **What is the most dominant type of soil around the school? Recall the Web Soil Survey worksheet.** (1 point)

7. **What is the primary ingredient in artificial fertilizer?** (1 point)

   a. Potassium

   b. Phosphorus

   c. Nitrogen

   d. Ammonia

8. **Explain the Haber-Bosch Process.** (5 points)

9. **Write out the symbols for Nitrate and Nitrites.** (2 points)

10. True / False – **Nitrates cannot convert to nitrites in nature and vice-versa.** (1 point)

11. **Are nitrates and nitrites water soluble? If so, how do they move within the environment?** (2 points)

12. **What does REAP stand for?** (1 point)

13. **Name 2 sources of pollution for the Chesapeake Bay.** (2 points)

14. **What are the 2 ways that nitrogen can be lost in an agricultural system?** (2 points)

15. **What is the best way to minimize nitrogen loss?** (1 point)

16. **What does BMP stand for?** (1 point)

17. **List 2 items involved in taking a good soil sample.** (2 points)

18. **What is the difference between point source pollution and non-point source pollution?** (1 point)

19. **In 1798,** _____________________ _____________________ wrote an Essay on the Principle of Population. (2 points)

20. **There will be an issue if population increases** ( arithmetically / geometrically ) **and food production increases** ( geometrically / arithmetically ). (2 points)

21. **Define a cultivate system.** (1 point)

22. **How much cropland does industrial agriculture account for?** (1 point)

    a. 25%
    b. 50%
    c. 75%
    d. 100%

23. ____ ______________ __________________ **founded the Green Revolution.** (3 points)

24. True / False : **In soils, phosphorus has a mass 10 times larger than nitrogen.** (1 point)

25. **How do legume crops reduce fertilizer use?** (2 points)

**Match the term to its definition:** (10 points)

1. Dark material that builds up as plants and animals decompose ____________________
2. Movement of Nitrogen in different chemical forms ____________________
3. Oxidation of ammonium into nitrite and then into nitrate by microorganisms ____________________
4. Loss or removal of nitrogen ____________________
5. Mutually beneficial relationship between the host and the parasite ____________________
6. Changes take place in a body of water after inputs of nitrogen ____________________
7. Colorless, pugnet, suffocating, highly water soluble ____________________
8. Plants need to grow, natural material in soil, water soluble ____________________
9. Transitional form of nitrogen, quickly converted ____________________
10. Water flows on the earth's surface into nearby bodies of water ____________________

***Terms***

| | | |
|---|---|---|
| Runoff | Nitrification | Denitrification |
| Ammonium | Nitrites | Nitrates |
| Nitrogen Cycle | Organic Matter | |
| Symbiotic Relationship | Eutrophication | |

**Nitrogen Cycle Exam Answers**

1. Organic and Inorganic

2. Compare cycle drawn by students based upon cycle found in PowerPoint

3. Shows how Nitrogen is recycled throughout the environment, How plants gets usable Nitrogen, Relationship between bacteria and plants

4. Mineralization – when a lot of organic nitrogen in the soil it is converted into inorganic nitrogen – carried out by microorganisms, Immobilization – opposite of Mineralization – inorganic nitrogen converted into organic nitrogen

5. Reduced plant growth, leaves are pale green and yellow at tip or turn brown and die

6. Answer will vary

7. D - Ammonia

8. Synthesis of ammonia ($NH_3$) gas from its elemental nitrogen ($N_2$) and hydrogen ($H_2$) to create fertilizer

9. $NO_3$ and $NO_2$
10. True
11. Yes. They have a high potential for entering surface waters when it rains. They can dissolve in runoff and entre streams or lakes. They can also leach through the soil and enter the groundwater.

12. Resource Enhancement and Protection Program

13. Increase impervious cover, agriculture, sewage, stormwater, air pollution

14. Saturated soil and leaching of nitrate and other nutrient cations

15. Apply when crop is ready to utilize the nitrogen or suitable application rates

16. Best Management Practice

17. Correct timing, clean sampling equipment, sample each unique area separately, take soil core to appropriate depth, mix sample cores well, label and package sample correctly

18. Point-source = attributed to a specific location – non-point = no specific location

19. Thomas Malthus

20. Geometrically, arithmetically

21. Areas where at least 30% of the landscape is in croplands, shifting cultivation, confined livestock production or freshwater aquaculture

22. A – 25%

23. Dr. Norman Borlaug

24. False

25. Symbiosis with bacteria (Rhizobia) attached to the roots of the plant, Biological nitrogen fixation, Take nitrogen right out of the atmosphere and fix for plants use

Matching (1 point each)

1. Organic Matter
2. Nitrogen Cycle
3. Nitrification
4. Denitrification
5. Symbiotic Relationship
6. Eutrophication
7. Ammonium
8. Nitrates
9. Nitrites
10. Runoff

**Terms to Know**

Ammonium

Crop rotation

Cultivated system

Decomposition

Dentitrification

Eutrophication

Immobilization

Leaching

Mineralization

Nitrates

Nitrification

Nitrites

Nitrogen Cycle

Nitrogen Fixation

Non-point source

Organic Matter

Point source

Root Nodules

Runoff

Symbiotic Relationship

Uptake

Volatilization

## The Nitrogen Cycle

The Nitrogen Cycle – good overview of nitrogen cycle and biological and chemical components
http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/N/NitrogenCycle.html

Illinois State Water Survey – nitrogen cycle information, properties of nitrogen
http://www.sws.uiuc.edu/nitro/biogeo.asp

The Nitrogen Cycle – basic information about the nitrogen cycle, does not include uses and health issues
http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/N/NitrogenCycle.html

Nutrient Cycles – Trinity College in Australia. Other information on Australian topics.
http://www.trinity.wa.edu.au/plduffyrc/subjects/science/cycle.htm

Harrison, J. A., 2003, The Nitrogen Cycle: Of Microbes and Men, *Visionlearning* Vol. EAS-2 (4).
http://www.visionlearning.com/library/module_viewer.php?mid=98

## Environmental Impacts

Eutrophication – Site sponsored by Educational Network on Climate
Site describes impact of overload of nutrients on the environment, particularly the ocean and the impacts of eutrophication
http://www.atmosphere.mpg.de/enid/440f6a03086e972e952f1e3e3e99955c,55a304092d09/16e.html

Natural Resource Conservation Service – The Soil Biology Primer – Bacteria and soil nitrogen
http://soils.usda.gov/sqi/soil_quality/soil_biology/bacteria.html

Alberta Government, Environment, Algal Blooms – good resource on causes of algal blooms:
http://www3.gov.ab.ca/env/water/swq/brochures/algalblooms.html

National Health Museum, Sewage systems
http://www.accessexcellence.org/AE/AEPC/WWC/1991/sewage.html

Verstraeten, I. M., Fetterman, G. S., Sebree, S. K., Meyer, M.T., and Bullen, T.D., 2004, Is Septic Waste Affecting Drinking Water From Shallow Domestic Wells Along the Platte River in Eastern Nebraska?: USGS Fact Sheet 07203 http://water.usgs.gov/pubs/fs/fs07203/

Natural Treatment System San Diego County, CA – natural treatment system for dry weather runoff – successfully removes nitrogen
http://www.naturaltreatmentsystem.org/what.html

Goolsby, D. A. and Battaglin, W. A., 2000, Nitrogen in the Mississippi River Basin – estimating sources and predicting flux to the Gulf of Mexico: USGS Fact Sheet 135-00.
http://ks.water.usgs.gov/Kansas/pubs/fact-sheets/fs.135-00.html

Self, J. R. and Waskom, R.M., 1998, Nitrates in Drinking water: CSU Extension – Agriculture – Crops 00517, http://www.ext.colostate.edu/pubs/crops/00517.html

Science Museum of Minnesota, 2004, Hypoxia for Kids http://www.smm.org/deadzone/

Spokes, L., 2003, The Oceans Basics, Unit 2 Nutrients in the Ocean: ESPERE encyclopedia, http://www.atmosphere.mpg.de/enid/2a5b6a7b2ed6f3ac7bb6b5ed88d6f3a8,55a304092d09/oa.html

USGS, 2004, Hypoxia in the Gulf of Mexico and Related USGS Activities http://toxics.usgs.gov/hypoxia/

U.S. EPA, 2004, Mississippi River Basin Challenges, Hypoxia, http://www.epa.gov/msbasin/hypoxia.htm

Water and Rivers Commission, 1997, Water Facts River and Estuary Pollution: Government of Western Australia http://portal.environment.wa.gov.au/pls/portal/docs/PAGE/DOE_ADMIN/FACT_SHEET_REPOSITORY/WRCWF03.PDF

Kosal, E., 2003, The Fish Kill Mystery: National Center for Case Study Teaching in Science: http://www.sciencecases.org/fishkill/fishkill.pdf

## Health Issues

Iowa – increased risk of bladder cancer related to nitrate http://waternet.com/news.asp?mode=4&N_ID=21690

Iowa Women's Health Study http://www.cancer.umn.edu/page/research/prevent6.html

Cancer Risk from Exposure to Nitrites and Nitrates – abstract on study http://infoventures.com/cancer/canlit/eti1195a.html

Nitrates in water not linked to pancreatic cancer Reuters news site http://www.cancer.sutterhealth.org/health/healthinfo/reutershome_top.cfm?fx=article&id=16612

BBC News, 2002, Cancer concern over vegetable nitrates (plants grown in greenhouses), Scotland, http://news.bbc.co.uk/1/hi/scotland/1824156.stm

Allied Kenco Sales – Meat preservation – Information on nitrate and nitrite http://www.alliedkenco.com/data/data_sheets/nitrite_and_nitrate.htm

Nitrate in water tied to colon cancer risk in some, Amy Norton, Reuters Health
Posting Date: November 27, 2003
http://www.oncolink.org/resources/article.cfm?c=3&s=8&ss=23&Year=2003&Month=11&id=10295

Nitrate in Drinking Water Associated With Increased Risk for NHL – National Cancer Institute site: http://cancerweb.ncl.ac.uk/cancernet/600355.html

National Ag Safety Database – Virginia Cooperative Extension Service, Nitrates in Household Water, *Publication Number 356-484, October 1996*
http://www.cdc.gov/nasd/docs/d001201-d001300/d001233/d001233.pdf

ATSDR-CDC – Health Consultation - FORT PECK INDIAN RESERVATION, POPLAR, ROOSEVELT COUNTY, MONTANA Survey and discussion of health problems related to water quality contamination
http://www.atsdr.cdc.gov/HAC/PHA/fortpeck/fpi_p1.html

Agency for Toxic Substances and Disease Registry (ATSDR) – Center for Disease Control site: Information on nitrate in water and methemeglobinemia
http://www.atsdr.cdc.gov/HEC/CSEM/nitrate/clinical_evaluation.html

Allison, C. D., 1998, Nitrate Poisoning of Livestock, Guide B-807Allison,
http://www.cahe.nmsu.edu/pubs/_b/b-807.html

Zublena, J. P. and Cook, M. G., 1993, *Pollutants in Groundwater: Health Effects* Inorganic Chemical Effects, Health Concerns from Nitrate: North Carolina Cooperative Extension Service Publication AG-439-14 – information on health impacts of nitrate on humans and animals,
http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-14/#Inorganic_Chemical_Effects:_Health_Concerns_from_Nitrate

Risk Assessment Information System – nitrates – toxicity summary for nitrate
http://risk.lsd.ornl.gov/tox/profiles/nitrates_f_V1.shtml

Environmental Health Perspectives, NIH, Nitrogen Cycling Out of Control, Scott Fields, July 2004. Good summary of nitrogen cycle interactions with human.
http://ehp.niehs.nih.gov/members/2004/112-10/EHP112pa556PDF.PDF

Physicians for Social Responsibility, 2004, NITRATE, What Health Care Providers Should Know: PSR Drinking Water Fact Sheet # 9
http://www.envirohealthaction.org/upload_files/DWNitrates.pdf

Maryland Department of the Environment, 2004, Top Ten Sources of Nitrogen Oxides (NOx) in the Baltimore Area 1990
http://textonly.mde.state.md.us/Air/air_information/TopTenNOx.asp

Robson, S., 2003, Nitrate and nitrite poisoning in livestock: New South Wales Department of Industries, Agriculture, Agfact A0.9.67,
http://www.agric.nsw.gov.au/reader/an-health/a0967.htm

Scanlan, R. A., 2003, Nitrosamines and Cancer,
http://lpi.oregonstate.edu/f-w00/nitrosamine.html

Kendall, P., 1997, Diet Can Reduce Risk of Cancer
http://www.ext.colostate.edu/pubs/columnnn/nn970430.html

American Cancer Society (ACS), 2004, The Facts about Secondhand Smoke
http://www.cancer.org/docroot/COM/content/div_TX/COM_11_2x_The_Facts_about_Secondhand_Smoke.asp?sitearea=COM

## Resources

World Resources Institute Earth Trends – database of global information on population, water resources, agriculture http://earthtrends.wri.org/

Nitrogen the Family – basic chemical facts about nitrogen
http://www.carondelet.pvt.k12.ca.us/Family/Science/Nitrogen/thefamily.html

The University of Reading tutorial on nitrogen cycle – includes review questions and essay topics
http://www.ecifm.rdg.ac.uk/nutrient.htmhttp://www.ecifm.rdg.ac.uk/nutrient.htm

Rutgers University: Building A Learning Community in Science and Mathematics through Educational Partnerships – nitrogen cycle lesson plan using aquarium.
http://mslc.rutgers.edu/nsfgk12/

USGS Water Posters – groundwater basics, water quality poster for the classroom, free.
http://water.usgs.gov/outreach/OutReach.html

USGS Nutrients in the Nation's Waters--Too Much of a Good Thing?
*By* David K. Mueller and Dennis R. Helsel, *U.S. Geological Survey Circular 1136*; Published 1996.
Excellent discussion of sources of nitrogen and phosphorous contamination.
http://water.usgs.gov/nawqa/circ-1136/circ-1136main.html

USGS: Nitrate in the Ground Waters of the United States--Assessing the Risk
*By* Bernard T. Nolan and Barbara C. Ruddy, USGS FS-092-096, online
http://water.usgs.gov/nawqa/FS-092-96.html

Environmental Health News archives of articles dealing with nitrate issues
http://www.environmentalhealthnews.org/archives.jsp?sm=&tn=0subject&tv=nitrate&ss=1

USGS, 1999, The Quality of Our Nation's Waters, U.S. Geological Survey Circular 1225, *Nutrients and Pesticides*, http://water.usgs.gov/pubs/circ/circ1225/.

Vision Learning module on Nitrogen Cycle – good source of links and background information.
**http://www.visionlearning.com/library/module_viewer.php?c3=&mid=98&l=**

Self, J. R. and Waskom, R. M., 1998, Nitrates in Drinking Water: Colorado State University Cooperative Extension 00517, http://www.ext.colostate.edu/pubs/crops/00517.html

Wisconsin Paper Council, 2004, Paper in Wisconsin, http://www.wipapercouncil.org/

Paper online, http://www.paperonline.org/

Stevens, W. K., 1996, Too Much of a Good Thing Makes Benign Nitrogen a Triple Threat: Current Topics in Chemistry, New York Times, Dec. 10, 1996.
http://cwx.prenhall.com/bookbind/pubbooks/blb/chapter4/medialib/topics/04current2.html

## Uses and Sources of Nitrogen

**Zmaczynski**, R., 2004, Haber-Bosh Process for Fertilizer manufacture: Good site
http://www.princeton.edu/~hos/mike/texts/readmach/zmaczynski.htm

Plambeck , J. A., 1996, Chemical Gateway – Explosives and Fertilizers
http://www.psigate.ac.uk/newsite/reference/plambeck/chem1/p01263.htm

Trinitrotoluene - TNT
http://www.ch.ic.ac.uk/vchemlib/mim/bristol/tnt/tnt_text.htm

Environmental Science Published for Everyone Round the Earth (ESPERE) – Information on eutrification of oceans, worksheets and web links provided. Go to Climate Encyclopedia and then Oceans, basic.
http://www.atmosphere.mpg.de/enid/1442

Nitrite in Meat, Richard J. Epley, Paul B. Addis and Joseph J. Warthesen, FS-00974 Revised 1992, University of Minnesota Extension Service
http://www.extension.umn.edu/distribution/nutrition/DJ0974.htmlhttp://www.extension.umn.edu/distribution/nutrition/DJ0974.html

Allied Kenco Sales – Meat preservation – Information on nitrate and nitrite
http://www.alliedkenco.com/data/data_sheets/nitrite_and_nitrate.htm

Keleher, Sara. 1996. Guano: Bats' Gift to Gardners . BATS. Vol 14. No 1:15-17.

Bats Conservation International http://www.batcon.org/home/index.html

RIVM Dutch National Institute of Health and Environment, Global datasets and maps: Global $NH_3$ Emission Inventory for Agricultural Lands
http://arch.rivm.nl/ieweb/ieweb/index.html?databases/nh3_emission_inv.html

The University of Hawaii NifTAL (Nitrogen Fixation by Tropical Agricultural Legumes) Center – information on legumes
http://www2.ctahr.hawaii.edu/tpss/research_extension/soliresearch/niftal/index.html

Europa – European Union portal – Pulp and paper manufacturing
http://europa.eu.int/comm/enterprise/forest_based/pulp_en.html

StonCor Africa, Pulp and Paper industry
http://www.stoncor.co.za/market_segment/pulpandpaper.html

Eckert, D., 2004, Efficient fertilizer use, Nitrogen, http://www.agcentral.com/imcdemo/05Nitrogen/05-07.htm

Call, C., 2004, How do fireworks work?
http://knowledgenews.net/moxie/tour/fireworks-freedom-2.shtml

Pafko, W., 2000, Nitrogen: Food or Flames: http://www.pafko.com/history/h_s_n2.html

Organ Cave, Civil War History and Gunpowder, 2004, http://www.organcave.com/CWHistory.htm

U.S. National Park Service (USNPS), 2000, *Glimpses of Our* National Parks, (war of 1812, saltpeter)
http://www.cr.nps.gov/history/online_books/glimpses1/glimpses25.htm

Deacon, J., 2004, The Microbial World: The Nitrogen cycle and Nitrogen fixation
http://helios.bto.ed.ac.uk/bto/microbes/nitrogen.htm

Patriquin, D., 2001, Legumes: The Nitrogen Specialists, http://www.dal.ca/~dp/vigs/legume.html

Natural Resource Conservation Service – The Soil Biology Primer – Bacteria and soil nitrogen
http://soils.usda.gov/sqi/soil_quality/soil_biology/bacteria.html

Barbarick, K. A., 2003, Nitrogen Sources and Transformations, Colorado State Extension Service Circular no. 0.550, http://www.ext.colostate.edu/pubs/crops/00550.html

Bellis, M. 2004, Early Rockets and Gunpowder - How Fireworks Work
http://inventors.about.com/library/inventors/blrocketfirework.htm

Gruenewald, F.P., 2002, All You Need To Know About Whipped Cream And Equipment,
http://www.whipcream.com/corpinfof.htm

Harris, T. 2004, How Aerosol Cans Work, http://www.whipcream.com/corpinfof.htm.

BOC Industries, 2004, Inspiring Gases, http://www.boc.com/education/index.html

Getty, V.M., 1998, How and Why to Use Sodium Nitrite, Nitrite and Nitrate: An Update
http://www.askthemeatman.com/how_and_why_to_use_sodium_nitrite.htm

Heitmiller, E., 2004, How Anesthesia Works, http://health.howstuffworks.com/anesthesia.htm

Cameron, E. and May,P., 2004, Nitrous Oxide - Laughing Gas
http://www.chm.bris.ac.uk/motm/n2o/n2oh.htm

Begeman, J., 1998, Monsoon Rains Have Hidden Benefits for Plants, Arid-Southwestern Gardening Information, *Gardening Tips*, http://ag.arizona.edu/gardening/news/articles/16.6.html

Uhereck, E., 2004, Lower Atmospheric Basics, Nitrogen oxides – formation and relevance: Environmental Science Published for Everyone Round the Earth (espere): http://www.atmosphere.mpg.de/enid/23b.html

Vaughn, M. 2004, Student project on denitrification, Good graphic of process: http://www.smuhsd.k12.ca.us/bhs/science-dept/vaughn/mvaughn/Student%20Projects/Elizabeth%20and%20Lasse/Denitrification.html

Vitousek, P. M., Aber, J., Howarth, R. W., Likens, G. E., Matson, P. A., Schindler, D. W., Schlesinger, W.H., and Tilman, G. D., 1997, Human Alteration of the Global Nitrogen Cycle: Causes and Consequences: Ecological Society of America, Issues in Ecology, issue 1, p. 1-17. http://www.epa.gov/OWOW/watershed/wacademy/acad2000/pdf/issue1.pdf

Skyring, G. and Webb, A., 2004, Denitrification, http://www.ozestuaries.org/indicators/Def_denitrification.html

## Experiments

Orchard Project
Test for nitrogen gas in the atmosphere: http://www.orchardproject.org/nitrogen.htm

THE NITROGEN CYCLE: PRINCIPLES OF BIOREMEDIATION by Mark Murdock: Experiments dealing with soil nitrates and bacterial effects on nitrate content in soils http://www.che.wsu.edu/home/modules/98modules/murdock/NSF-WSU MODULE.htm - act1

Calculating Fertilizer Rates from Soil Test Recommendations, C. Owen Plank, Univ. Georgia Cooperative Extension Service, How to estimate fertilizer use for lawns http://www.cropsoil.uga.edu/lawn/

Ohio State Curriculum on Factors affecting nitrates in groundwater http://www-cms.ag.ohio-state.edu/AgSciLPs.html Environmental Science lesson plan Activity 3-3 has activity on nitrate leaching related to amount of fertilizer applied, placement of fertilizer, and role of plant matter and leaching of nitrate. Looks like a great experiment.

**Daily Plan 1**

**Title:**

Nitrogen in our Soils and Lives

**Instructional Area:**

The Nitrogen Cycle: Introduction to the Unit and Nitrogen in our Soils

**Situation:**

Students will be given the facts about the nitrogen and how it's a component of the soil, works with plants and functions within in the nitrogen cycle.

**PA Academic Standard(s) Met:**

4.6.10

4.8.10

**Materials Needed:**

Computer and Projector

Blank Paper

Markers or Colored Pencils

Nitrogen Cycle Worksheet

**Interest Approach:**

Students will be making their own nitrogen cycle diagrams. The diagram can be graded, but the teacher should leave hints that a nitrogen cycle diagram may be on a quiz or exam. This will encourage the class to put in the proper amount of effort into creating an effective diagram.

**Objectives:**

1. The students will have personally made a study tool that will accompany them throughout the unit and can easily be referred to if the student has questions about a specific part of the cycle.
2. The students will have gained a thorough understanding of the nitrogen cycle by creating their own version on paper.

**Content:**

**Teacher Will Do:**

1. Teacher prepares to present the PowerPoint.
2. Teacher writes on the chalkboard all of the answers to the initial question they ask.
3. Teacher starts PowerPoint presentation.
4. Teacher passes out blank paper to each student and distributes markers or colored pencils.

**Teacher Will Say:**

1. We are starting a new unit today. What can anyone tell me about nitrogen?
2. The nitrogen cycle is incredibly important to our planet and unfortunately more evidence is coming forward that humans are having a dramatic effect on this cycle.
3. There are notes on what to say during the PowerPoint included.
4. Now you are all going to create your own study tool. I want you to take all of the information on this slide and create a diagram. This will solidify the diagram in your mind and make it much clearer. Make it as colorful and fun as you want and remember this diagram may be extremely useful come exam time.

**Review / Conclusion / Opportunity to Learn:**

1. The objective of the class was to gain a thorough understanding of the nitrogen cycle and all of its components.
2. All the diagrams will be handed in to the teacher for a grade if the teacher so chooses. This will allow the teacher to gain an understanding of how well the class understands the nitrogen cycle.
3. An alternative to collecting the diagram would be to have a quick quiz the following day to by asking the students to recreate the diagram.

# The Nitrogen Cycle Lesson 1: Worksheet

1. **Organic Matter :** Dark material that builds up as plants and animals decompose

2. The two forms of Nitrogen that exist in the soil are:
   a. **Organic**

   b. **Inorganic**

3. Bacteria converts Nitrogen in the soil in two ways:
   a. **Convert atmospheric Nitrogen into inorganic forms**

   b. **Convert organic Nitrogen from wastes into inorganic forms**

4. **Symbiotic Relationship :** Mutually beneficial relationship between the host and the parasite. In this case, a mutually beneficial relationship between the bacteria and the plant.

5. **Nitrogen Cycle :** Movement of Nitrogen in different chemical forms

6. **Nitrogen Fixation :** Convert atmospheric nitrogen gas into forms used by plants

7. **Nitrification:** Oxidation of ammonium into nitrite and then into nitrate by microorganisms

8. **Denitrification :** Loss or removal of nitrogen

9. **Leaching :** Various chemicals dissolved and carries to groundwater

**10. Runoff :** Water flows on earth's surface into nearby bodies of water

**11. Eutrophication :** Changes take place in body of water after inputs of nitrogen

**12. Ammonium :** Colorless, pungent, suffocating, highly water-soluble

**13. Nitrates :** Plants need to grow, natural material in soil, water soluble

**14. Nitrites :** Transitional form of nitrogen, quickly converted

# The Nitrogen Cycle Lesson 1: Worksheet

1. ______________________: Dark material that builds up as plants and animals decompose

2. The two forms of Nitrogen that exist in the soil are:
   a.

   b.

3. Bacteria converts Nitrogen in the soil in two ways:
   a.

   b.

4. ______________________: Mutually beneficial relationship between the host and the parasite. In this case, a mutually beneficial relationship between the bacteria and the plant.

5. ______________________: Movement of Nitrogen in different chemical forms

6. ______________________: Convert atmospheric nitrogen gas into forms used by plants

7. ______________________: Oxidation of ammonium into nitrite and then into nitrate by microorganisms

8. ______________________: Loss or removal of nitrogen

9. ______________________: Various chemicals dissolved and carries to groundwater

10. ______________________________: Water flows on earth's surface into nearby bodies of water

11. ______________________________: Changes take place in body of water after inputs of nitrogen

12. ______________________________: Colorless, pungent, suffocating, highly water-soluble

13. ______________________________: Plants need to grow, natural material in soil, water soluble

14. ______________________________: Transitional form of nitrogen, quickly converted

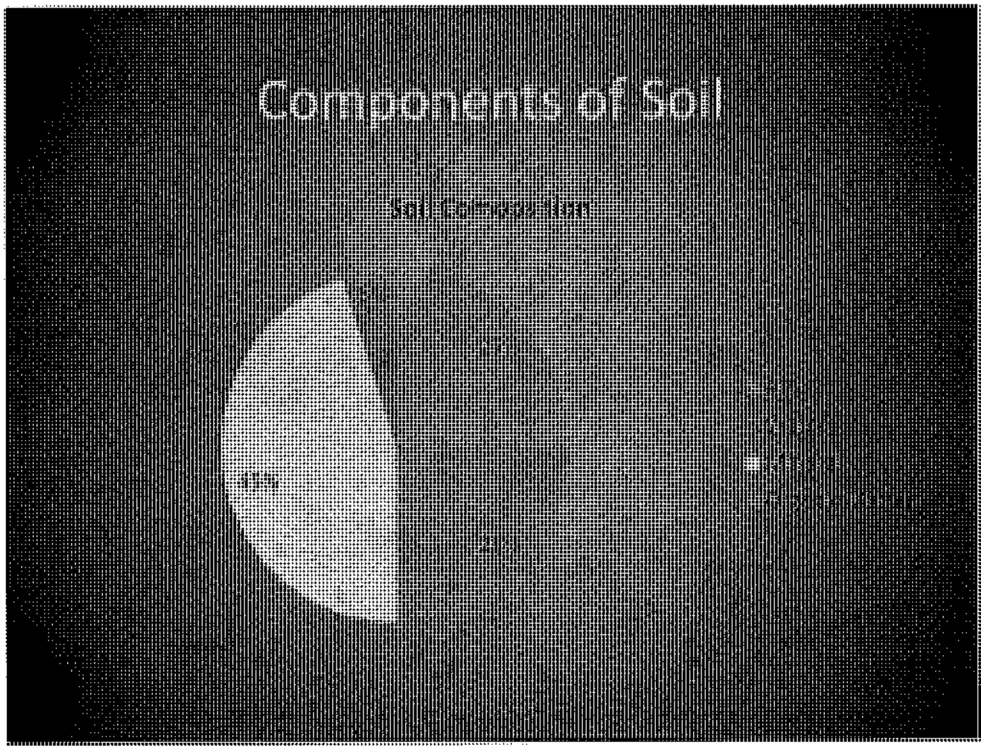
# Nitrogen 101

Understanding Nitrogen and Our Soils


What do we know about soils?

Main uses

- Medium for growing plants and trees – this is important because it provides food and shelter for humans and animals
- Solid Foundation for building homes
- Natural filter for water




How many of you have seen this diagram before?

Does it make sense to you?

Can someone explain why there is air in the soil?

- Air helps to create pore space
  - Allows roots to grow
  - Hold water

What is organic matter?

- The dark material that builds up as plants and animals decompose
- Full of nutrients

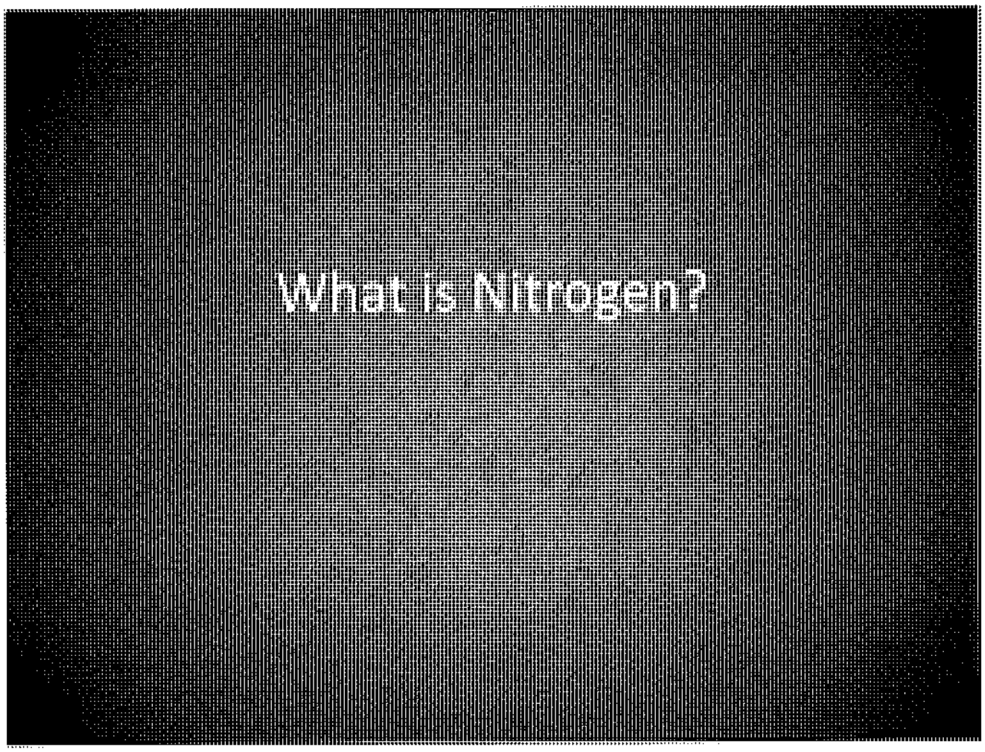
Where would Nitrogen fit in this chart?

- Organic Matter


Why would nitrogen be released as plants and animals decompose?

- Nitrogen is in the plants and animals as part of proteins and other structures
- As they die and decompose it gets released back into nature

A small amount of nitrogen can be found in the mineral component of soils, but the major source is the organic material.

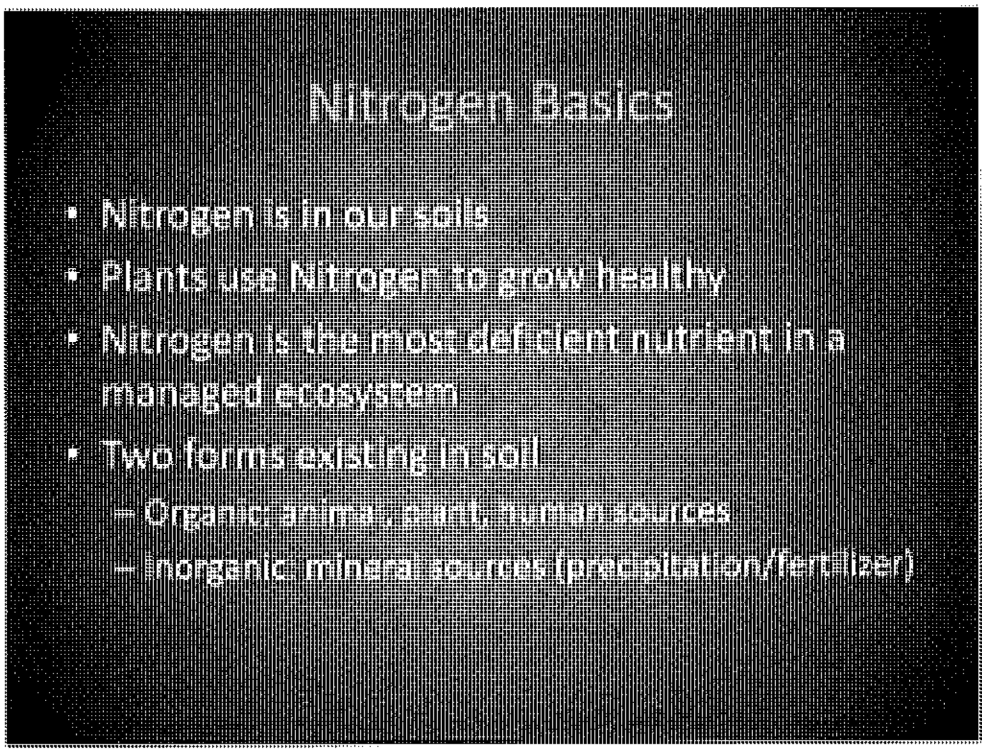



What else do we know about nitrogen?

- Chemical Element
- Fertilizer
- Liquid Nitrogen for freezing/storing
- Gas/Atmosphere

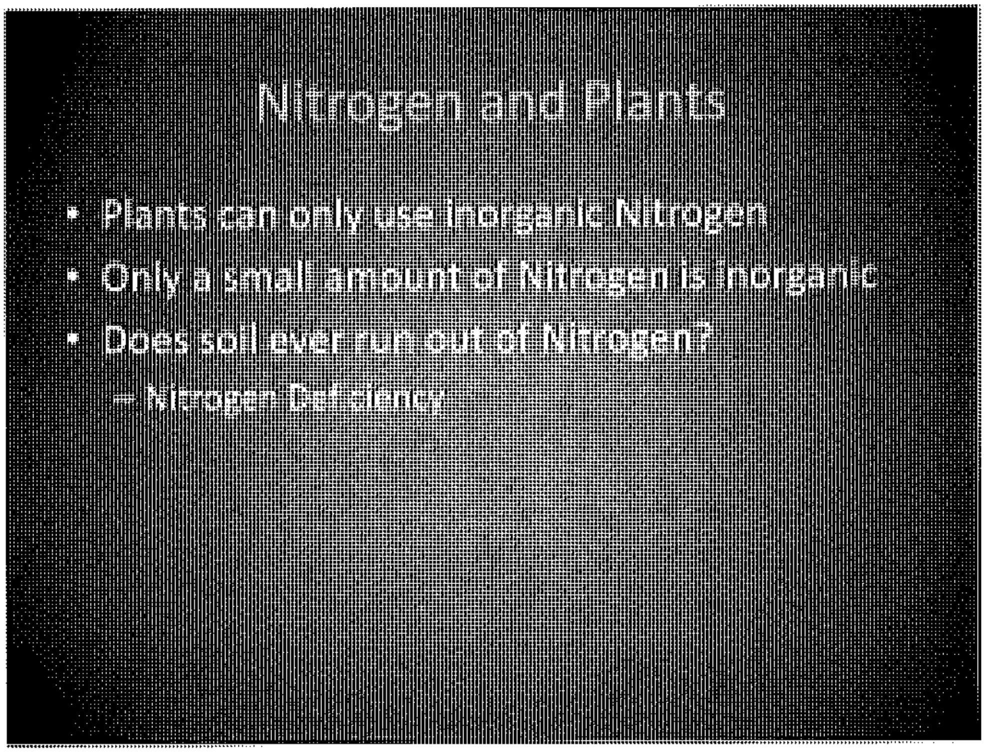
*Optional: Take five minutes for students to use various texts to find the different uses of nitrogen and share with the class.*

During class for the next two weeks, we are going to focus on the element as it is found in the environment and as fertilizer.




There are two different forms of Nitrogen found in our soils

- Organic nitrogen
  - From the waste products of animals, plants and humans
  - Can you name what these waste products would be?
    - Answers: sewage waste, compost, decomposing roots/leaves, manure
- Inorganic nitrogen
  - From mineral sources
  - Forms of Nitrogen are in the atmosphere they come to the earth's surface when it precipitates
  - Nitrogen can also come from the synthetic fertilizers applied on farm fields and lawns

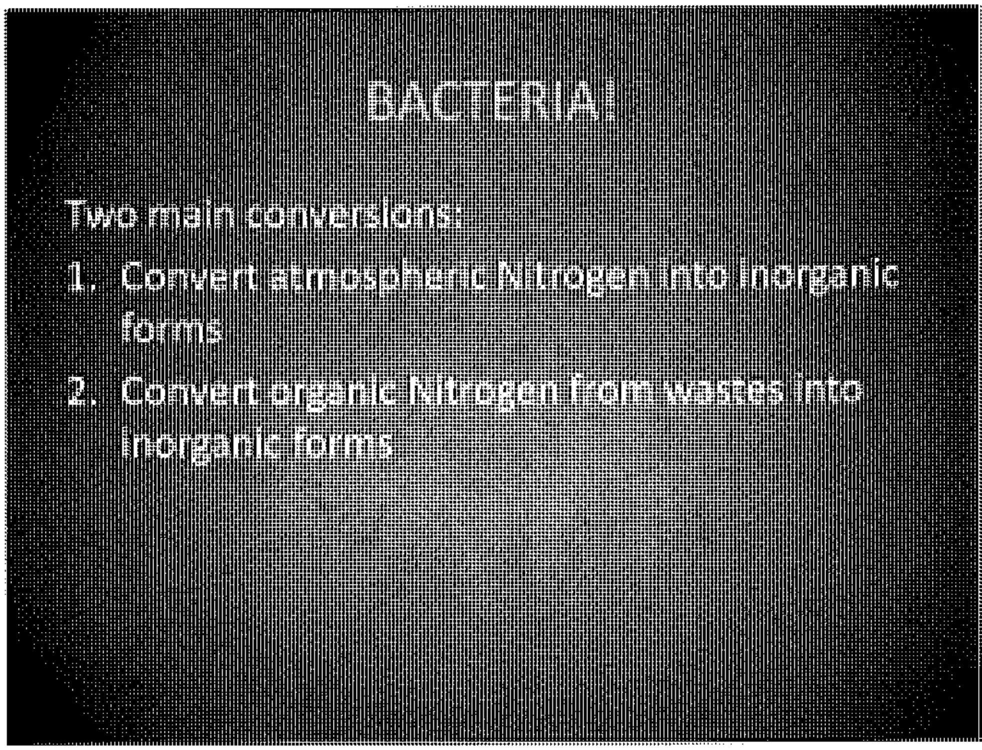



Plants can only utilize the inorganic form of nitrogen

- What are those inorganic sources again?
  - Mineral sources and fertilizers
    - Only a small amount of inorganic nitrogen available from these

Soil sometimes have low amounts of nitrogen

- Called nitrogen deficiency
- Evidence of this can be seen when leaves on plants yellow or when plan growth is stunted



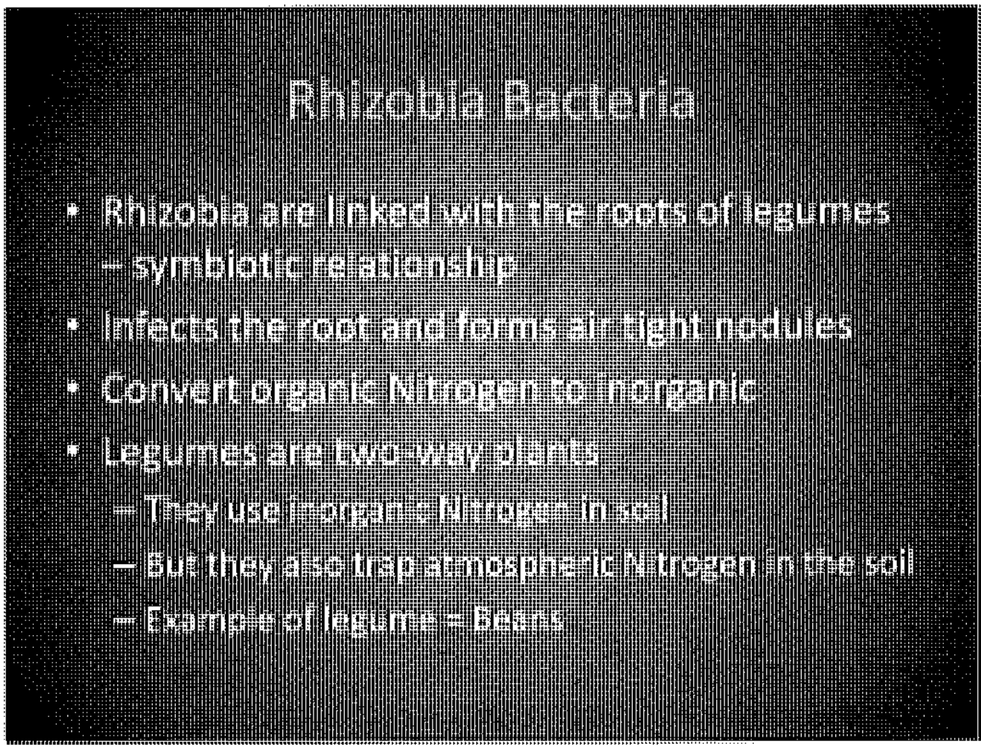

Bacteria living in soil has two main conversions

1 - Change the gaseous nitrogen in the atmosphere into an inorganic form that plants can use

2 - Alters the nitrogen found in the organic matter of soil

Why would the nitrogen in the organic matter need to be changed?

- The nitrogen from decomposition is still in the organic form and plants can not use organic nitrogen




Rhizobia bacteria are an example of nitrogen converting bacteria

Rhizobia bacteria form a symbiotic relationship with legume plants

What does symbiotic mean?

- There is a mutually beneficial relationship between the host and the parasite. For instance in this case, there is a mutually beneficial relationship between the bacteria and the plant

These bacteria are found in the soil and infect the roots of legume plants

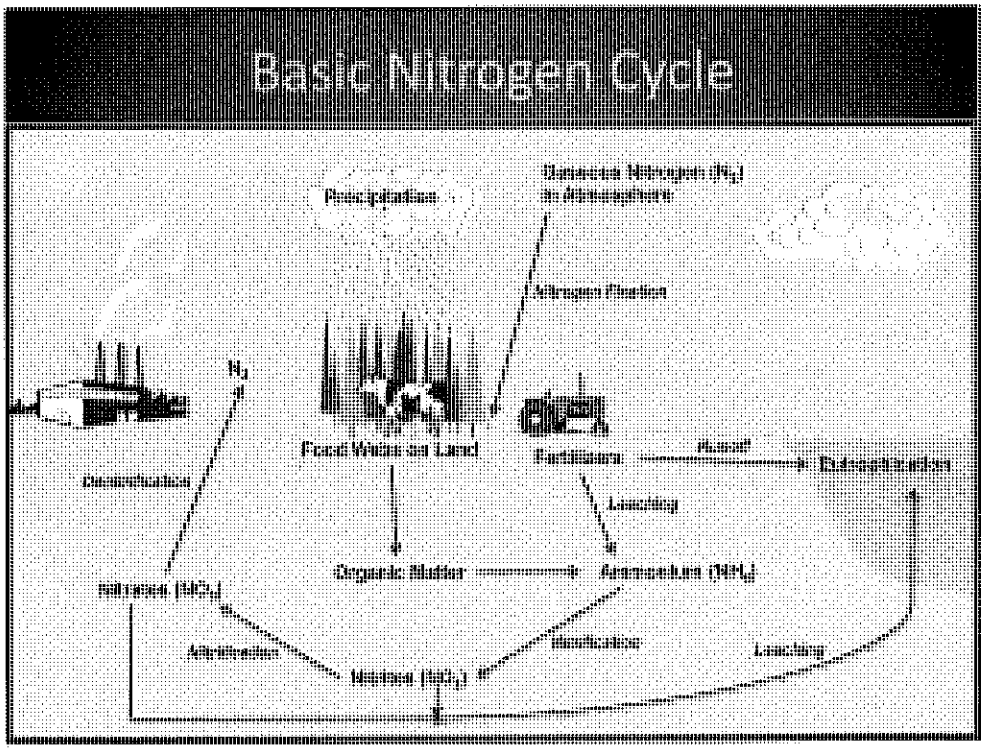
These bacteria help plants utilize organic nitrogen

Some farm crops, such as legumes, can take atmospheric Nitrogen and trap it in the soil

Legume plans are used in rotational cropping systems to add nitrogen back into the soil for the next crop to utilize

# Let's Put it Together

- How do the soil, plants, bacteria and Nitrogen work together?


Basic Nitrogen Cycle

# What Do These Terms Mean?

- Nitrogen Cycle – Movement of Nitrogen in different chemical forms
- Nitrogen Fixation – Convert atmospheric nitrogen gas into forms used by plants
- Nitrification – Oxidation of ammonium into nitrite and then into nitrate by microorganisms
- Denitrification – Loss or removal of nitrogen
- Leaching – Various chemicals dissolved and carried to groundwater
- Runoff – Water flows on earth's surface into nearby bodies of water

# Terms Continued

- Eutrophication – Changes take place in body of water after inputs of nitrogen
- Ammonium – Colorless, pungent, suffocating, highly water-soluble
- Nitrates – Plants need to grow, natural material in soil, water soluble
- Nitrites – Transitional form of nitrogen, quickly converted

# In-Class Assignment

- Make your own version of the Nitrogen Cycle
- BE CREATIVE!
- Make sure that it makes sense
- Using the pervious slide
  - Make sure to include all components listed
  - Words in *italics* are modes of "transportation" for Nitrogen

## Daily Plan 2

**Title:**

Nitrogen in our Soils and Lives

**Instructional Area:**

The Many Transformations of Nitrogen, Their Relationship with Plants, and Eutrophication

**Situation:**

Now that the students have a comprehensive nitrogen cycle diagram, it is time to focus on specific parts of the diagram. The students will learn more of the science behind nitrogen fixation, denitrification, mineralization, etc. Students will learn what forms of nitrogen are useful to plants and how some plants are able to conduct nitrogen fixation. Also eutrophication of our waterways will be introduced. This plan will be lecture focused with a PowerPoint. It is important that students learn to pay attention in a class that is not forcing the students to be fully engaged.

**PA Academic Standard(s) Met:**

4.3.10

4.6.10

4.8.10

**Materials Needed:**

Computer

Projector

Nitrogen Cycle Diagrams – All students need to have these, have extra cycle handouts prepared in case a student missed the pervious class or forgot theirs)

For Experiments and in class activities

- cups
- pencils
- celery
- knife
- paper towel
- water
- food coloring
- legume and non legume plants grown
- note cards with key terms
- ice cubes to melt
- apparatus to boil water

**Interest Approach:**

This plan does not have a unique interest approach but will rely on the teacher's ability to engage the class using the PowerPoint to convey the information in an interesting manner. Once again, it is crucial that the students master the ability to learn the material in a lecture atmosphere. It also involves in class experiments to keep students interested.

**Objectives:**

1. To successfully and clearly convey the science of the different transformations of nitrogen in the nitrogen cycle.
2. To teach students why and how plants utilize nitrogen and also introduce them to eutrophication.
3. To instill in the students the need to be able to learn from a basic lecture class that does not directly and constantly engage the students.

**Content:**

**Teacher Will Do:**

1. Teacher walks in and turns on projector to present PowerPoint.
2. Teacher starts the presentation and goes through the slides.

**Teacher Will Say:**

1. Today we will be examining the specifics of the nitrogen cycle, so take out the diagrams you created yesterday so you can refer to them.
2. Teacher goes through the slides and refers to notes included with the PowerPoint.

**Review / Conclusion / Opportunity to Learn:**

1. The objective of the class was to teach the students about the various transformations of nitrogen through the nitrogen cycle.
2. To have emphasized to the class that plants can only take up certain forms of nitrogen and how some plants facilitate the nitrogen cycle. Also to have introduced eutrophication.
3. This class was designed as a lecture because students need to have the skills to be able to learn from a lecture class.
4. This is a good stopping point for some kind of assessment to check on the students understanding.

**Name** ______________________________ **Date** ____________

______________________- Organic nitrogen is released from the breakdown of plants, animals and wastes

______________________- Soil microorganisms convert the nitrogen into a gaseous state

______________________- Water becomes extremely rich in nutrients and results in water plant growth and loss of dissolved oxygen

______________________- Microorganisms convert inorganic nitrogen into organic nitrogen

______________________- Nitrogen dissolved in water is removed from the soil and moves into the ground water

______________________- Microorganisms convert organic nitrogen into inorganic nitrogen during the decay of organic matter

______________________- Legume plants pull nitrogen from the air into the soil and convert it into the inorganic form

______________________- Bacterial infected spot on plant root responsible for nitrogen fixation

______________________- When additional water is added to saturated soil, it simply moves away taking the dissolved nitrogen with it

______________________- Inorganic nitrogen moves from the soil and water into plant roots

______________________- Process of moving gaseous nitrogen out of the soil and into the atmosphere

**Name** ______________________________ **Date** ____________

**Decomposition** ________ - Organic nitrogen is released from the breakdown of plants, animals and wastes

**Denitrification** ________ - Soil microorganisms convert the nitrogen into a gaseous state

**Eutrophication** ________ - Water becomes extremely rich in nutrients and results in water plant growth and loss of dissolved oxygen

**Immobilization** ________ - Microorganisms convert inorganic nitrogen into organic nitrogen

**Leaching** ________ - Nitrogen dissolved in water is removed from the soil and moves into the ground water

**Mineralization** ________ - Microorganisms convert organic nitrogen into inorganic nitrogen during the decay of organic matter

**Nitrogen Fixation** ________ - Legume plants pull nitrogen from the air into the soil and convert it into the inorganic form

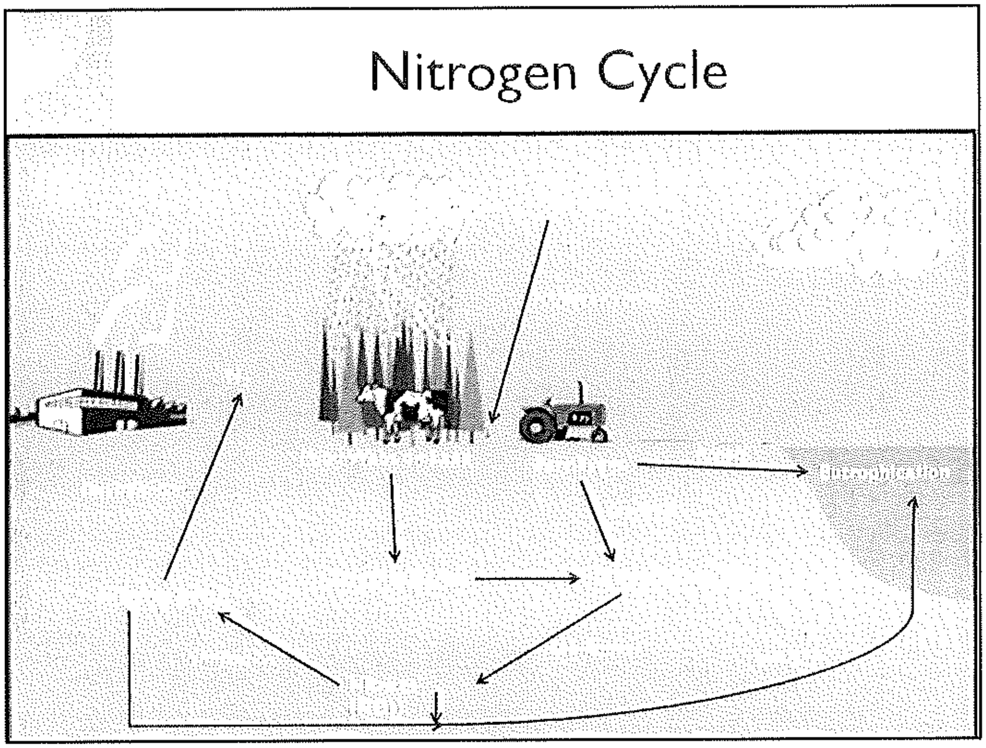
**Root Nodules** ________ - Bacterial infected spot on plant root responsible for nitrogen fixation

**Runoff** ________ - When additional water is added to saturated soil, it simply moves away taking the dissolved nitrogen with it

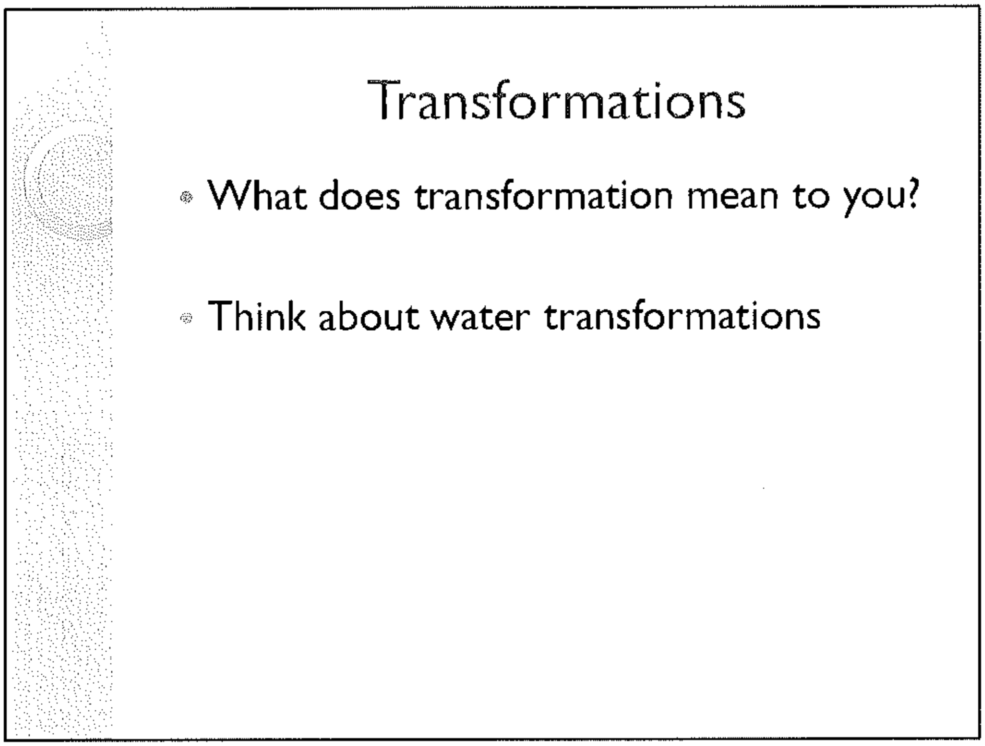
**Uptake** ________ - Inorganic nitrogen moves from the soil and water into plant roots

**Volatilization** ________ - Process of moving gaseous nitrogen out of the soil and into the atmosphere

# How Does Nitrogen Change and Where Does It Hide?

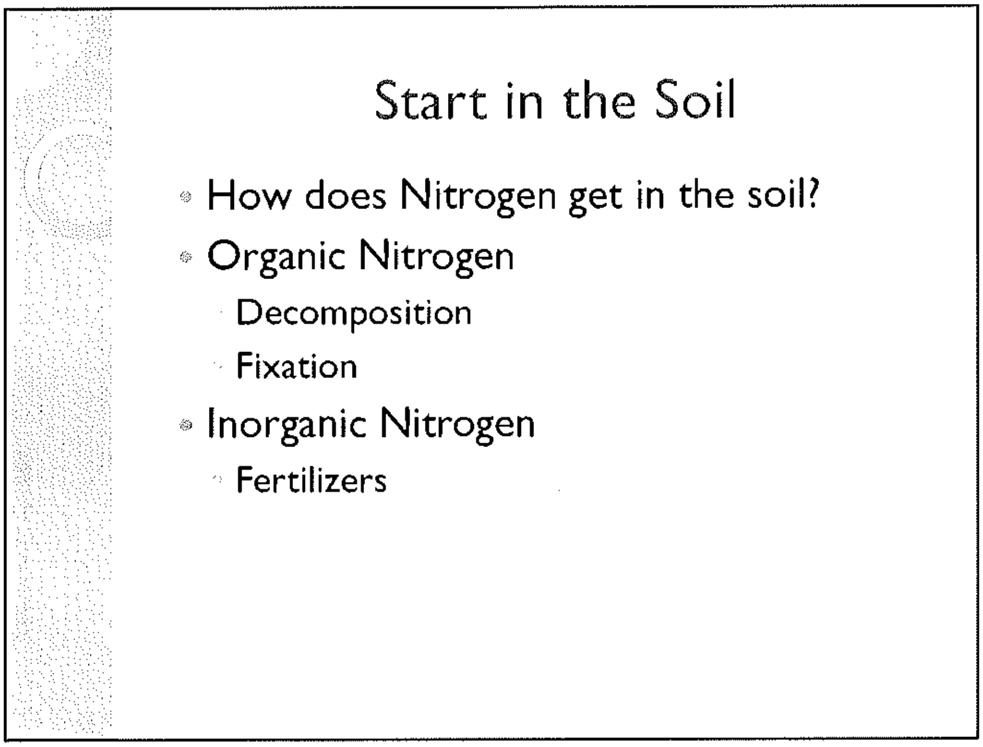



- Here is the Nitrogen Cycle we looked at yesterday.
- Who can tell me why the nitrogen cycle is important?
    - It shows how nitrogen is recycled throughout the environment
    - How plants can get usable nitrogen
    - Relationship between bacteria and plants
    - Etc.
- Everyone should get their diagrams they filled in yesterday. If you weren't here, there are a few extra copies up front. Also, take one of today's handouts.




- Okay, what does transformation mean to you?
    - To change the nature, appearance or function of something
- Who wants to come up front and help demonstrate the different water transformations?
    - Have students melt ice cubes, and boil water.
    - What is the phase that we are missing in our demonstration? Liquid to solid

- Just as water can take on different forms and properties, so can nitrogen. Today we are going to learn about the different nitrogen transformations, the terms for the changes, and how they relate to one another.




- Using the information we learned yesterday, plus looking at your diagrams, who can tell me how nitrogen enters the soil?
  - Decomposition
    - Organic nitrogen is released from the decomposition of plants, animals and wastes
  - Fixation
    - Plants pull nitrogen from the air and convert it to inorganic nitrogen in the soil
  - Fertilizers
    - Inorganic nitrogen is added to farm fields and yards to increase plant growth

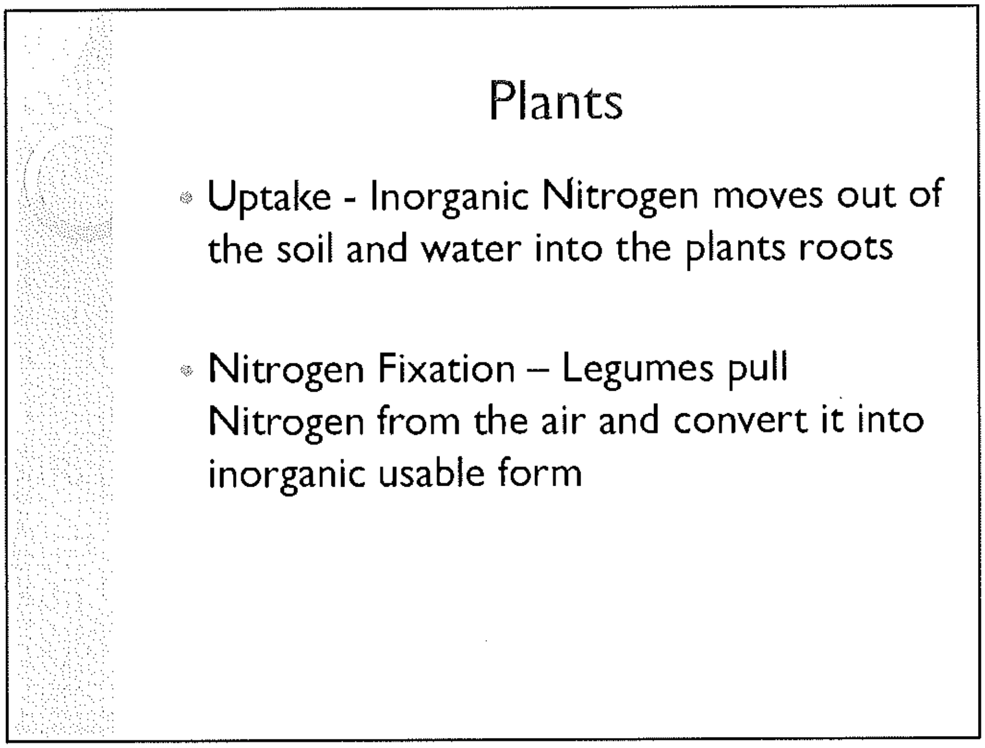
# Organic Nitrogen

- Decomposition – To break down, decay

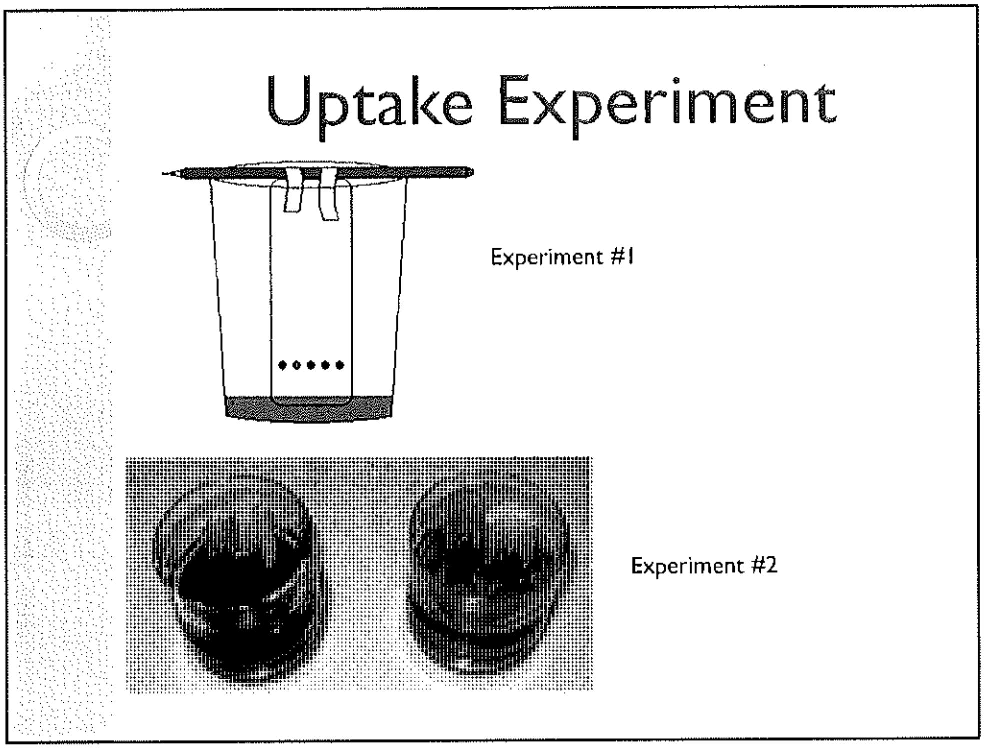
This is a compost bin, which is decomposing plant and food wastes

- Mineralization – During the decay of organic matter, microorganisms convert organic nitrogen into inorganic nitrogen
- Immobilization – Microorganisms convert inorganic nitrogen into organic nitrogen

- We know organic nitrogen enters the soil through decomposition.
- Once there is a lot of organic nitrogen in the soil, it is converted to inorganic nitrogen.
    - This is called Mineralization and is carried out by microorganisms.
- Immobilization is the opposite of Mineralization.
    - Here the microorganisms are converting inorganic nitrogen into organic nitrogen.
- Both mineralization and immobilization can occur at the same time.




- Who wants to explain how these work?
- Can you give an example of something we see that would be similar to uptake? What about fixation?
  - Uptake
    - Example = sponge soaking up water
    - Bring sponge into class to demonstrate transformation
  - Fixation
    - Example = When the air is damp or humid, cardboard gets soft and squishy




- We are going to conduct an experiment to see how uptake can move nutrients through a plant

**Experiment One**

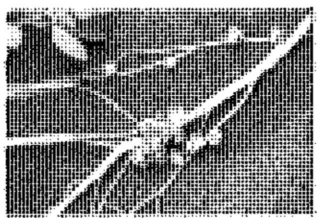
1. All students will take a cup, fill ¼ full with water.
2. Add three drops of food coloring.
3. Attach a two inch strip of either paper towel, coffee filter or white fabric to a pencil with tape so that it just touches the water.
4. Balance the pencil across the top of the cup.
5. Ask students to record what they observed (appearance, speed of absorption, etc.) in their notebooks
6. Share results with the class.

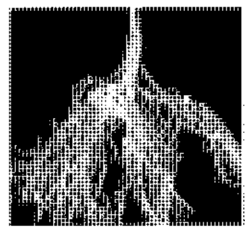
**Experiment Two**

1. In groups of three to four, students will place two stalks of celery in a jar.
2. One stalk should have the bottom sliced, the other not.
3. Fill the jar a ¼ of the way full with water and add three drops of food coloring.
4. Have students put the celery in the jar.
5. Observe the celery over the next four days to see what happens.
6. Have students record what they observe over the four days in their notebooks

## Nitrogen Fixation Facts

- Most common and largest source of nitrogen fixation comes from the symbiosis of legumes and bacteria (*Rhizobium* or *Bradyrhizobium*).
  - Examples include soybean, alfafa, and clover.
- The bacteria infect the root hairs of the plant and the plant responds by forming root nodules, which is the site of nitrogen fixation.





- We talked about this yesterday, but lets review.
- The relationship that the bacteria and the plant have is known as symbiosis
  - Symbiosis means there is a mutually beneficial to both parties.
- The plant supplies the bacteria with energy from photosynthesis that the bacteria use to conduct nitrogen fixation. The bacteria in turn then supplies the plant with the usable nitrogen-compounds obtained from nitrogen fixation. When the bacteria encounter a suitable plant, they infect the root hairs of the plant. The plant reacts to the infection by forming root nodules where the root hairs used to be and the bacteria use these nodules as the location for the nitrogen fixation.

**Hands-On Activity:**

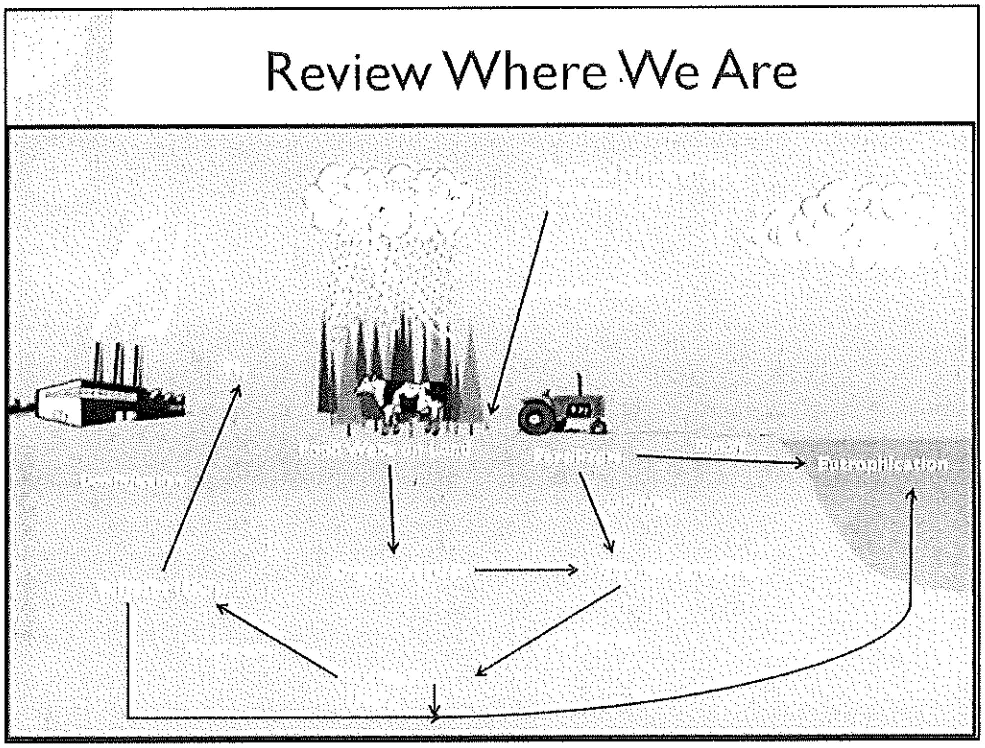
1. Start growing legumes and non-legumes prior to the unit.
2. At this time students can wash soil off of the roots.
3. Ask students to look at the roots and make observations.
4. Students can cut open the nodules to see the inside.

- Why are these nodules so important?
  - Without them, plants wouldn't be able to get enough nitrogen so farmers would have to apply more fertilizers. This would increase runoff into the environment and increase food costs at the grocery store.

## More Nitrogen Fixation Facts

- Non-legume plants are capable of forming symbiosis with other bacteria that can also conduct nitrogen fixation.
  - Examples: Alder tree species and flowering Gunnera
- Termite – Gut bacteria
- Lightning converts atmospheric nitrogen gasses into a water soluble form

- Symbiosis can also occur between the bacteria and non-legume plants such as the alder (yes, the tree) and certain species of the flowering herbaceous plant species, Gunnera.
- Termites get the requirements of nitrogen for their diet through the bacteria in the gut. Without these bacteria, the termites would be in big trouble because they cannot use the nitrogen found in the environment.
- There are many types of nitrogen gasses. Lightning will break the bonds in more complex nitrogen gas, causing it to become a form that is water soluble and can be rained down to the Earth's surface. Once it hits the ground, this water soluble nitrogen naturally fertilizes the soils.




- So we have talked about how nitrogen gets into the soils through decomposition, nitrogen fixation and fertilizer application.
- We have talked about the process of mineralization to convert organic nitrogen from decay into inorganic nitrogen.
- Plants can either uptake inorganic nitrogen, or use bacteria in the roots for nitrogen fixation.

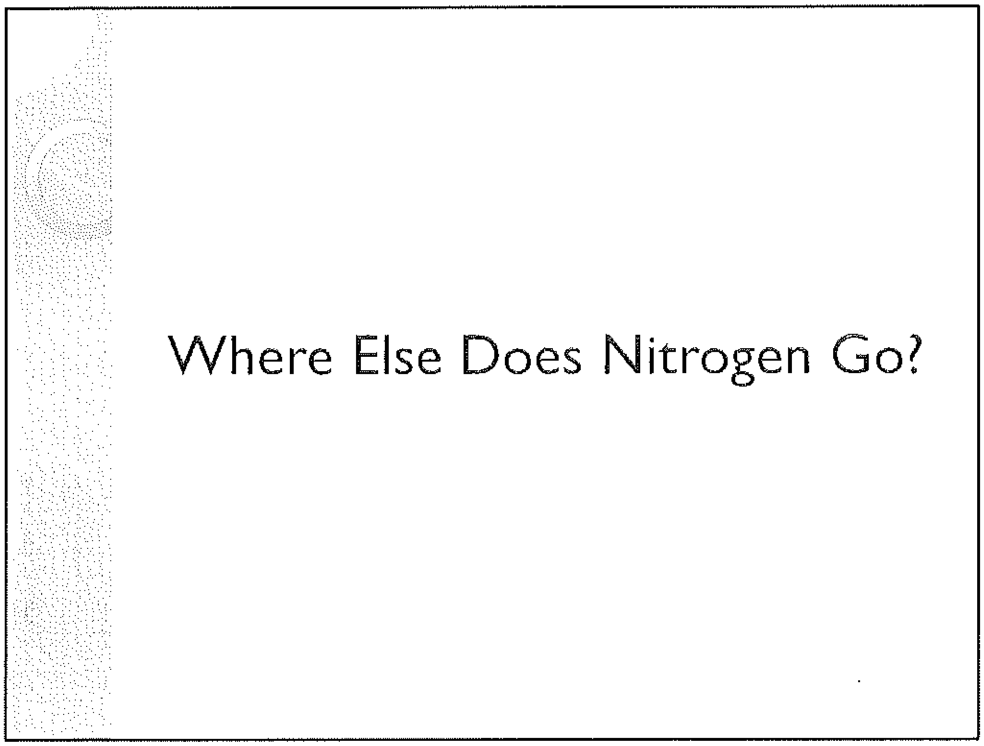
## Benefits of Nitrogen

- Helps control metabolic processes related to plant growth
- Lots of growth and dark green color

## Lack of Nitrogen

- Reduced plant growth
- Leaves are pale green and yellow at tips
- If severe deficiency, leaves turn brown and die

- Here we see the importance of nitrogen to plant growth and what will happen without nitrogen.
- Which type of plant will be more likely to suffer from a nitrogen deficiency: corn or soybeans? Corn, Why?
  - Soybeans are legumes and can use nitrogen fixation, corn has to rely on mineralization and fertilizers.




- Okay, flip your Nitrogen cycles over so you can't look at them. Where else does nitrogen go besides into plants?
    - Water
    - Air
    - Soil
- Now we are going to learn the terms that go with those locations

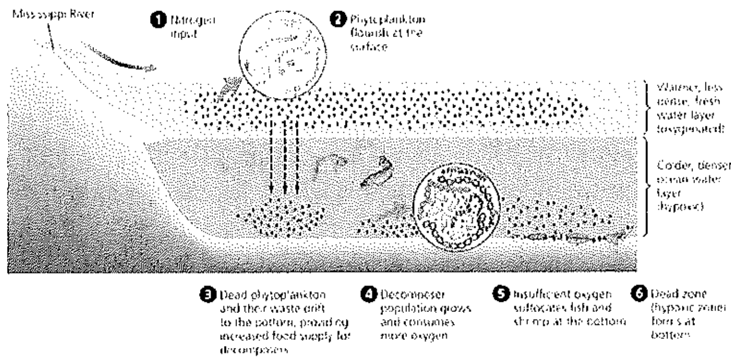
# Water

- Leaching – Removal of soluble Nitrogen dissolved in water from soil
- Runoff – Soil can no longer hold water, so additional water moves across soil surface, taking Nitrogen with it

- Leaching occurs when rain and flooding seeps into the ground and carries dissolved nitrogen into the ground water.
- Runoff occurs when the ground can no longer hold anymore water. When additional water comes along through rain, irrigation or flooding, the water picks up soil that may have organic or inorganic forms of nitrogen.

- Why would this be bad?
    - Putting nitrogen into the water system – encourage growth of bad plants and water pollution
    - Waste money on fertilizers

- Eutrophication - Nitrogen lost through leaching makes its way into the groundwater and the groundwater becomes polluted.



- The nitrogen leaches into the groundwater and then travels to our waterways thereby in effect fertilizing our waters. This causes the water to become richer in nutrients. So if there are plants in the water, what will happen with the increased level of nitrogen?

  - The plants will use this extra nitrogen to grow bigger and when they die, the decomposing microorganisms use up more of the limited oxygen available in the water. This reduces the total oxygen available to fish and other aquatic life. Since the fish can't live without oxygen, parts of water bodies are declared "dead zones" because of the absence of aquatic life.

# Air

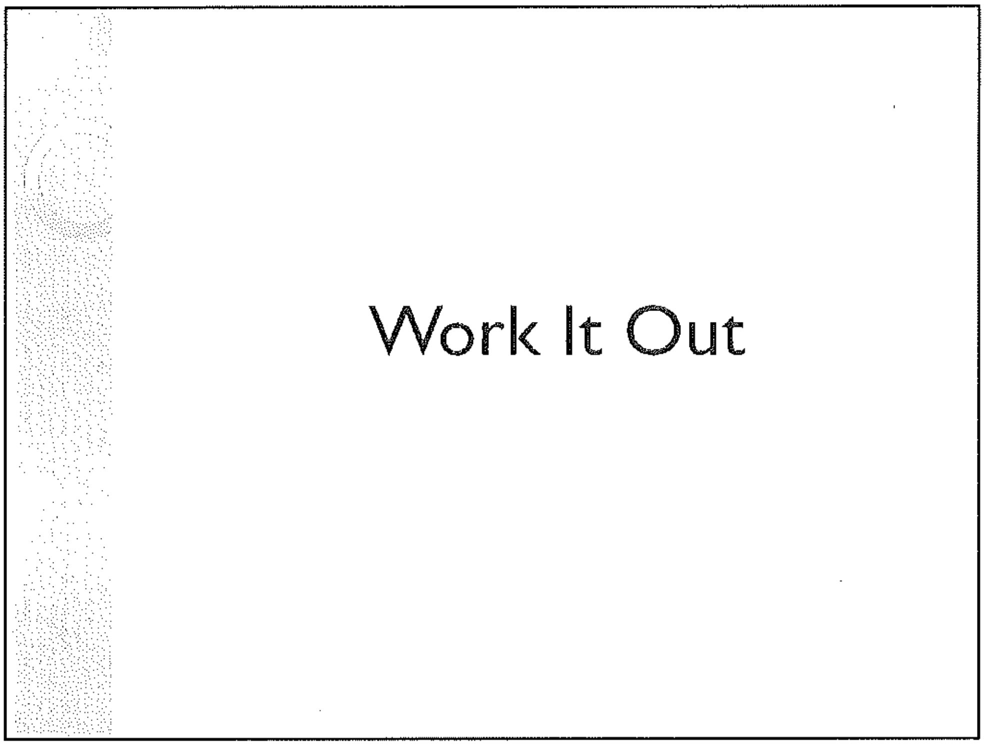
- Denitrification – The nitrogen in waterlogged soils is changed by bacteria into nitrogen gasses.
- Volatilization – Process of moving the nitrogen gasses out of the soil and into the atmosphere.

- The changing of soil nitrogen into atmospheric nitrogen primarily occurs in wet soils, such as swamps. Here, bacteria will convert the nitrogen in the soil into a gas form of nitrogen. This conversion is called denitrification.
- When the nitrogen gasses move into the atmosphere it is called volatilization.
- Think of these two processes being similar to the evaporation stage in the water cycle. Denitrification and volatilization is the natural returning of nitrogen back to the atmosphere, where it was to begin with.
- What pulled it out of the atmosphere?
    - Nitrogen fixation
- Why would this be bad?
    - Increases the percent of nitrogen in the atmosphere which contributes to green house gases, comes back down as acid rain.
- What are green house gases?
    - Gases like Nitrogen, Carbon Dioxide, and Methane that build up in the atmosphere and cause the Earth to warm up.

# Soil

- The Nitrogen may bond with the soil particles because they have opposite charges
- This attachment helps prevent leaching
- Cavities inside certain soil structures "hide" the nitrogen

- Soil has a negative charge so that it can attract and hold many of the different minerals that plants require to grow healthy.
- The nitrogen has a positive charge, so it is attracted to the soil like a magnet. By attaching to the soil particles, the nitrogen is less likely to be leached into the groundwater.
- There are many different ways that soils can be arranged and certain arrangements have little cavities that can store nitrogen and hide it away from the plants. It will be used eventually, just at a much slower rate.
- This is a picture of vermiculite which is arranged in layers which create many cavities that allow it to hold lots of nutrients for plants.

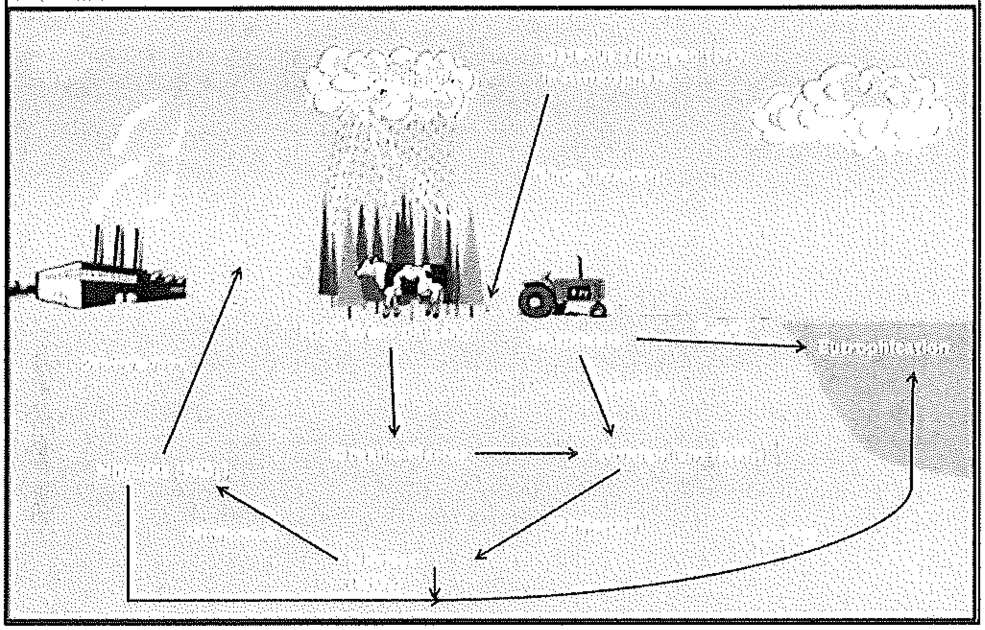



-The Motion E-Moment

1. In a moment, I am going to pass out a note card. On this card are three key terms from today's lesson that we have covered.
2. You are going to create an action to describe each of these three terms with a partner.
3. When I say "Work It" you are going to get with your lab partner and develop your actions.
4. When the 3 minute timer goes off, we are going to share our actions with each other.
5. What questions are there?
6. Ready, "Work It!"

- Vocabulary Terms (Groups will repeat terms)
    - Decomposition
    - Denitrification
    - Erosion
    - Eutrification
    - Green House Gases
    - Immobilization
    - Leaching
    - Legumes
    - Mineralization
    - Root Nodules
    - Nitrogen Fixation
    - Runoff
    - Uptake
    - Volitilization

## Nitrogen Cycle




- Today, we learned what most of these terms mean and how they interact.
- Did anyone miss a definition on the worksheet?
- Now that we have discussed the Nitrogen cycle and its transformations, each of you are going to complete a note packet individually for a grade.

Name:______________________________ Date:____________

# Quiz on Nitrogen Transformation

**1. Why is the Nitrogen Cycle important?**

**2. Match the following terms to their definitions**

| *Definitions* | *Terms* |
|---|---|
| Plants pull Nitrogen from the air and convert it to inorganic Nitrogen in the soil | Decomposition |
| Organic Nitrogen is released from the decomposition of plants, animals and wastes | Fertilizers |
| Inorganic Nitrogen is added to farm fields and yards to increase plant growth | Fixation |

**3. What is the difference between Mineralization and Immobilization?**

**4. List examples for the following terms:**

**A. Uptake**

**B. Fixation**

**5. How does Nitrogen Fixation occur in the roots of plants?**

**6. How can you tell if a plant is suffering from Nitrogen deficiency?**

**7. Match the following terms to their definitions:**

| *Definitions* | *Terms* |
|---|---|
| Nitrogen in waterlogged soils is changed by bacteria into nitrogen gasses | Leaching |
| Process of moving the Nitrogen gasses out of the soil and into the atmosphere | Runoff |
| Soil | Eutrophication |
| Nitrogen | Denitrification |
| Soil can no longer hold water so additional water moves across soil surface, taking Nitrogen with it | Volatilization |
| Nitrogen lost through leaching makes its way into groundwater, which then becomes polluted | Positive Charge |
| Removal of soluble Nitrogen dissolved in water from soil | Negative Charge |

**Name:**______________________________ **Date:**____________

# Quiz on Nitrogen Transformation Answers

**1. Why is the Nitrogen Cycle important?**

- Shows how Nitrogen is recycled throughout the environment
- How plants gets usable Nitrogen
- Relationship between bacteria and plants

**2. Match the following terms to their definitions**

| *Definitions* | *Terms* |
|---|---|
| Plants pull Nitrogen from the air and convert it to inorganic Nitrogen in the soil (1) | Decomposition (2) |
| Organic Nitrogen is released from the decomposition of plants, animals and wastes (2) | Fertilizers (3) |
| Inorganic Nitrogen is added to farm fields and yards to increase plant growth (3) | Fixation (1) |

**3. What is the difference between Mineralization and Immobilization?**

- Mineralization – when a lot of organic nitrogen in the soil it is converted into inorganic nitrogen – carried out by microorganisms
- Immobilization – opposite of Mineralization – inorganic nitrogen converted into organic nitrogen

**4. List examples for the following terms:**

**A. Uptake**

- sponge soaking up water

**B. Fixation**

- cardboard gets soft and squishy when air is damp or humid

**5. How does Nitrogen Fixation occur in the roots of plants?**

- Symbiosis – mutually beneficial to bacteria and plant
- Plant gives bacteria energy from photosynthesis, which bacteria uses to conduct nitrogen fixation – bacteria then supply plant with usable nitrogen
- Bacteria infect roots of plants by forming root nodules where root hairs are

**6. How can you tell if a plant is suffering from Nitrogen deficiency?**

- reduced plant growth
- leaves are pale green and yellow at tip or turn brown and die

**7. Match the following terms to their definitions:**

| *Definitions* | *Terms* |
|---|---|
| Nitrogen in waterlogged soils is changed by bacteria into nitrogen gasses (1) | Leaching (7) |
| Process of moving the Nitrogen gasses out of the soil and into the atmosphere (2) | Runoff (5) |
| Soil (3) | Eutrophication (6) |
| Nitrogen (4) | Denitrification (1) |
| Soil can no longer hold water so additional water moves across soil surface, taking Nitrogen with it (5) | Volatilization (2) |
| Nitrogen lost through leaching makes its way into groundwater, which then becomes polluted (6) | Positive Charge (4) |
| Removal of soluble Nitrogen dissolved in water from soil (7) | Negative Charge (3) |

## Daily Plan 3

**Title:**

Nitrogen in our Soils and Lives

**Instructional Area:**

Web Soil Survey

**Situation:**

The class will be split into pairs if necessary and will look at Web Soil Survey on the internet. The teacher hands each student a simple worksheet. They are first taught how to use the Survey and then asked what soil types are at certain areas of the school and around their home. Finally the students will choose (or be assigned) a spot to collect a soil sample to bring to class the following week.

**PA Academic Standard(s) Met:**

4.1.10

4.3.10

4.6.10

4.8.10

**Materials Needed:**

Enough computers with internet access for each student or for each pair of students

Projector for teacher to show how to use Web Soil Survey

Worksheets to hand out to students while working on Web Soil Survey

Shovels

Bags

**Interest Approach:**

The students will be in front of a computer with direct hands on use of Web Soil Survey. The worksheet will direct the student on how to use the Survey and ask specific questions that the student will have to answer on their own. Also the students may be working in pairs to encourage engagement in the program. Finally the students will be asked to obtain soil a sample on their own from a location that is assigned or is of their choosing.

**Objectives:**

1. To have the students obtain a hands-on experience with Web Soil Survey, this will allow them to further learn about soils.
2. To have the students do their own field work and collect soil samples.

**Content:**

Before class the teacher will familiarize him or herself with Web Soil Survey so as to anticipate any problems or questions the students will have. (Tutorial included)

**Teacher Will Do:**

1. The teacher will walk in and have the students split into pairs (if needed). Then have the students go to the computers.
2. The teacher shows students how to run basics of Web Soil Survey that was taught to the teacher from the tutorial.
3. The teacher hands out a worksheet (see sample worksheet attached with the tutorial) that is personalized for each school.
4. The teacher will split the class into thirds and assign each group to get soils from either an urban, forest or agricultural site. This will be for a class one week from this lesson (Lesson 8). Teacher assists each group and makes sure it is possible for each student to reach these places. If this is not possible, the teacher can provide students with his or her sample or an optional after school trip to go collect the soil.

**Teacher Will Say:**

1. Today we will be working on computers with a website called Web Soil Survey. Please split into pairs and find a computer.
2. Now follow along with me as I show you the basics in running the survey. Teacher follows tutorial.
3. This worksheet has questions to answer about the school location. After you have the questions answered and a map printed out, you can try looking up your house and seeing the soils around that. Be sure to check out whether the soil is good for basements, lawns or even roads.
4. Now I'm going to split each of you into 3 groups. One group will collect soils from farm areas, one from urban areas and one

form forest areas. Decide on a type of soil you can collect and sign up on that list. At the location to collect a good shovel full of soil in a quart Ziploc bag.

**Review / Conclusion / Opportunity to Learn:**

1. The objective of this class was to have the students obtain hands on time with Web Soil Survey and to have gained an understanding of an everyday tool used by soil scientists.
2. The second objective was to have the students work effectively in pairs and accomplish an important task for a future class outside of the classroom.
3. The work sheet could be graded and would be a good way to keep the students engaged while providing them an easy opportunity for them to make their grade stronger. Also a deduction of points if the student fails to bring soil in the following week is possible too if the student did not talk to the teacher about any difficulties in obtaining the soil.

# USDA Web Soil Survey Tutorial

1. Launch web soil survey: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm
2. On the home page, click on Start WSS (in a green button).
3. Click on the Area of Interest Tab.
4. Under the quick navigation heading, put desired location into the survey.
    a. Located on the left side of the screen.
    b. Enter address
    c. Press view
5. Above the map, there is a toolbar. Select the hand to drag the map to the correct position.
6. Use the zoom function in the toolbar above the map to zoom in the location.
    a. Drag a rectangle over the area of interest and click to zoom in.
    b. Continue zooming to reach desired location.
    c. The blue arrow in the map toolbar is the "undo" zoom button.
7. There are two AOI buttons in the map toolbar.
    a. Select the AOI button with the red rectangle.
    b. Draw a square around the area of interest on the map.
8. The map will reload with blue lines shading the selected area.
9. Next, click on the soil map tab at the top of the page.
    a. This tab is located next to the Area of Interest tab
10. This map shows the locations of different soils of the selected area.
    a. Click on a soil type under the map unit legend and get more information about the soil.
11. Next click on the Soil Data Explorer tab.
12. Open the building site development category.
    a. Click on the different topics, and then select view ratings to view soil suitability.
    b. The map will show areas in different colors in regards to suitable or unsuitable.
    c. The table below the map offers additional rating information.
    d. Other categories can be investigated in the same manner.
13. If students need to print a specific map, select printable version in the top right corner.
    a. A screen opens, select view.
    b. This creates a PDF that can be printed or saved.

# Web Soil Survey Worksheet

1. Open Web Soil Survey following the directions on the worksheet.
2. Enter in the school address
    a. Road, City, State, Zip code
3. Adjust the map so the school grounds are in the window.
4. Refer to the direction worksheet to answer the following questions.
    a. What is the most dominant type of soil around the school?

    b. The baseball or football field is built on what type of soil?

    c. What is the drainage rating for the soil at the school?

    d. What is the farmland soil classification for the area nearest to the school?

    e. List five additional ratings about the school soil.

5. Print out the map of the school from the soil map tab.
6. Explore the soil around your home.
    a. Conduct a new search with your address.
    b. What is the most dominant type of soil around your home?
    c. What is the farmland soil classification for the area nearest to the school?
    d. List five additional ratings about the soil around your home.

## Daily Plan 4

**Title:**

Nitrogen in our Soils and Lives

**Instructional Area:**

Haber-Bosch Process

**Situation:**

After examining the nitrogen cycle the focus is now upon the Haber-Bosch Process. In this plan, the teacher will show a PowerPoint presentation on the process and then assign a graded homework assignment.

**PA Academic Standard(s) Met:**

4.1.10

4.3.10

4.4.10

4.6.10

4.8.10

**Materials Needed:**

Computers

Projector

Homework Assignment Handouts

**Interest Approach:**

This plan does not have a unique interest approach but will rely on the teacher's ability to engage the class using the PowerPoint to convey the information in an interesting manner. Once again, it is crucial that the students master the ability to learn the material in a lecture atmosphere. This lesson also includes a graded homework assignment in which the student can pick their topic to allow the student to explore their own interests deeper.

**Objectives:**

1. To have allowed the students to research a topic of their own choosing more closely.
2. To have gained a more thorough knowledge of the Haber-Bosch Process.

**Content:**

**Teacher Will Do:**

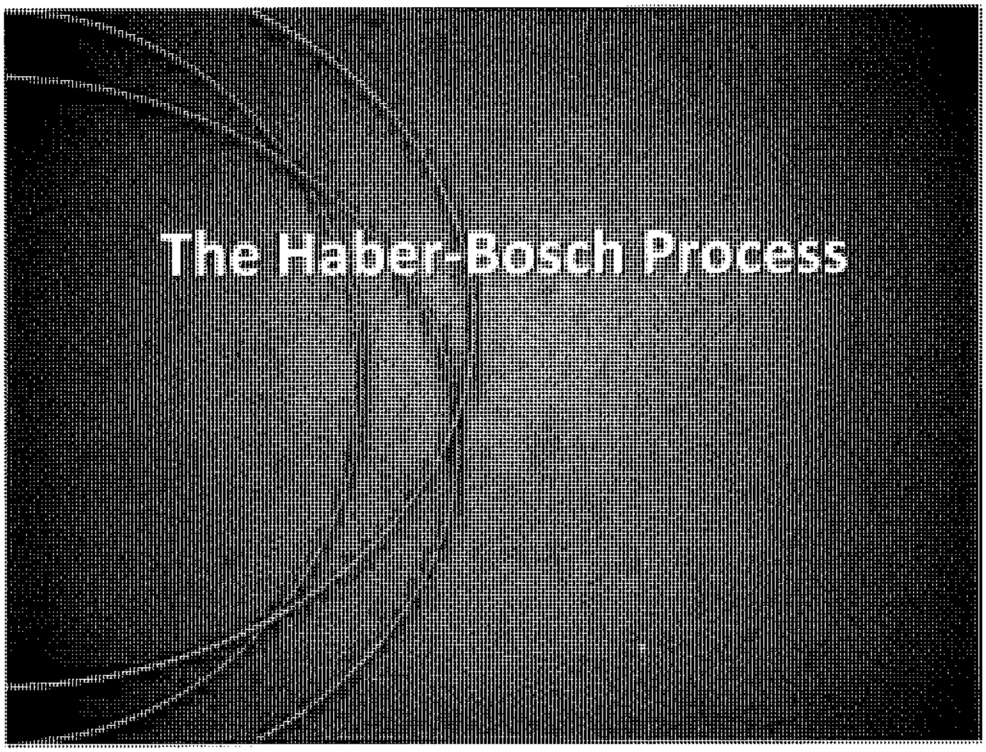
1. Teacher walks in and turns on projector to present PowerPoint.
2. Teacher starts the presentation and goes through the slides.
3. Teacher hands out homework assignment handout.

**Teacher Will Say:**

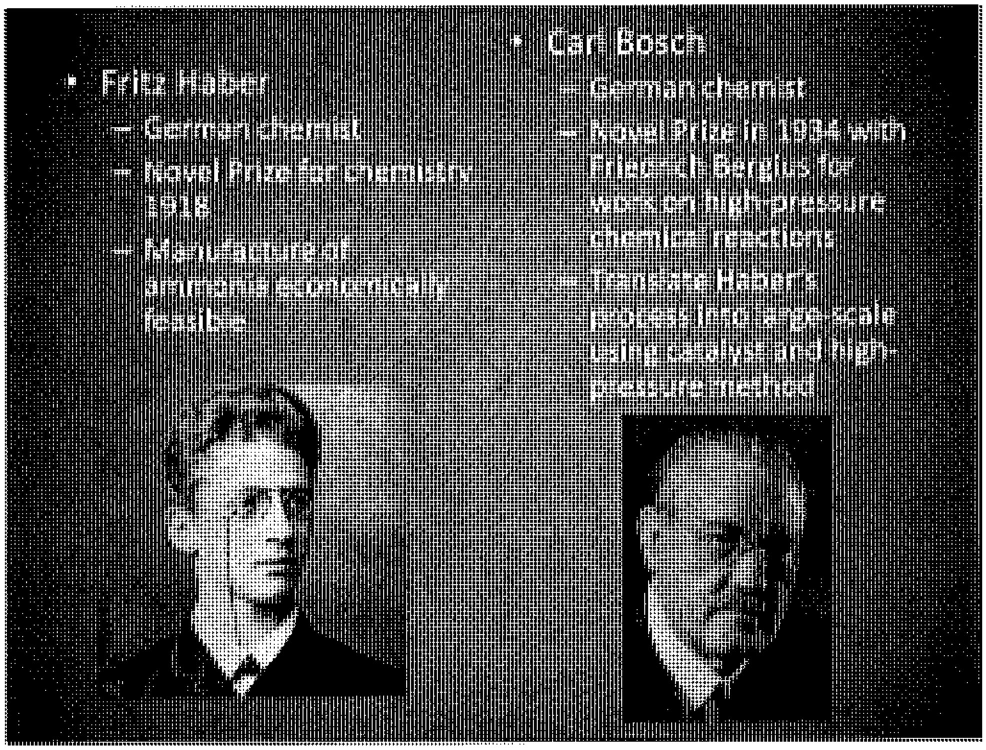
1. Today we will be examining the specifics of the nitrogen cycle, so take out the diagrams you created yesterday so you can refer to them.
2. Teacher goes through the slides and refers to notes included with the PowerPoint.
3. This is your next homework assignment. We will now go through the details. Does anyone have any questions?

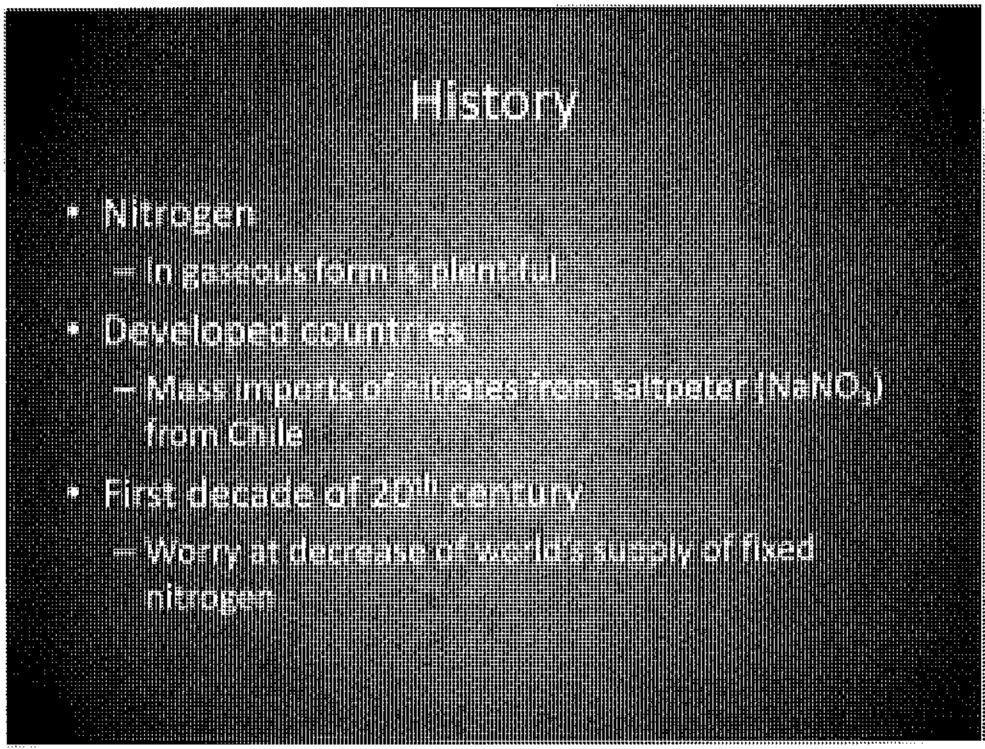
**Review / Conclusion / Opportunity to Learn:**

1. The objective of this was to have the students explore the topic more deeply on their own time.
2. The second objective was to have the students discover more details on the Haber-Bosch Process.




-Called the most important technological advancement of the 20th century
- First industrial chemical process to make use of extremely high pressures


• Fritz Haber
– German chemist
– Novel Prize for chemistry 1918
– Manufacture of ammonia economically feasible
• Carl Bosch
– German chemist
– Novel Prize in 1934 with Friedrich Bergius for work on high-pressure chemical reactions
– Translate Haber's process into large-scale using catalyst and high-pressure method

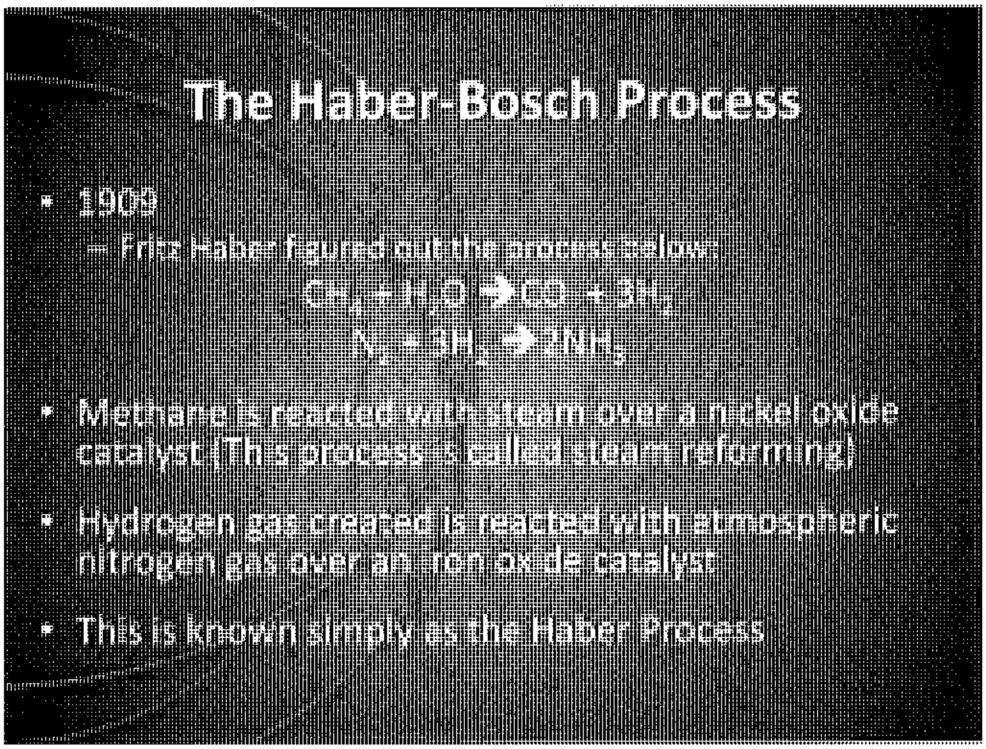


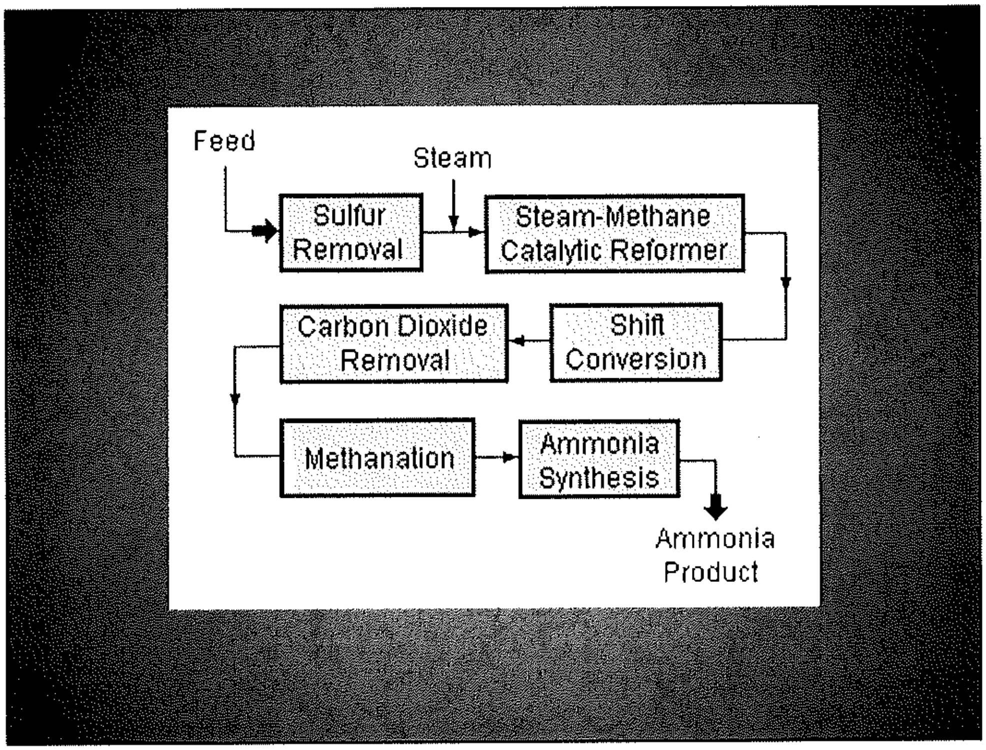

-Developed in World War 1

- Chemistry and techniques behind effective synthesis of ammonia spread to the rest of the world during the 1920s and 1930s

# Before Haber & Bosch

- Natural fertilizers
  - Animal wastes and ground animal bones
  - Crop rotation and letting soil lie fallow
- 1840's
  - Established need nitrogen, potassium and phosphorus for plant growth
- Sources of Nitrogen fertilizer before the early 20th century included:
  - Guano from Peru, the Midway Islands, etc.
  - Chilean nitrate salts
  - Remains of bituminous coal


The Haber-Bosch Process
• 1909
– Fritz Haber figured out the process below:
$CH_4 + H_2O \rightarrow CO + 3H_2$
$N_2 + 3H_2 \rightarrow 2NH_3$
• Methane is reacted with steam over a nickel oxide catalyst (This process is called steam reforming)
• Hydrogen gas created is reacted with atmospheric nitrogen gas over an iron oxide catalyst
• This is known simply as the Haber Process



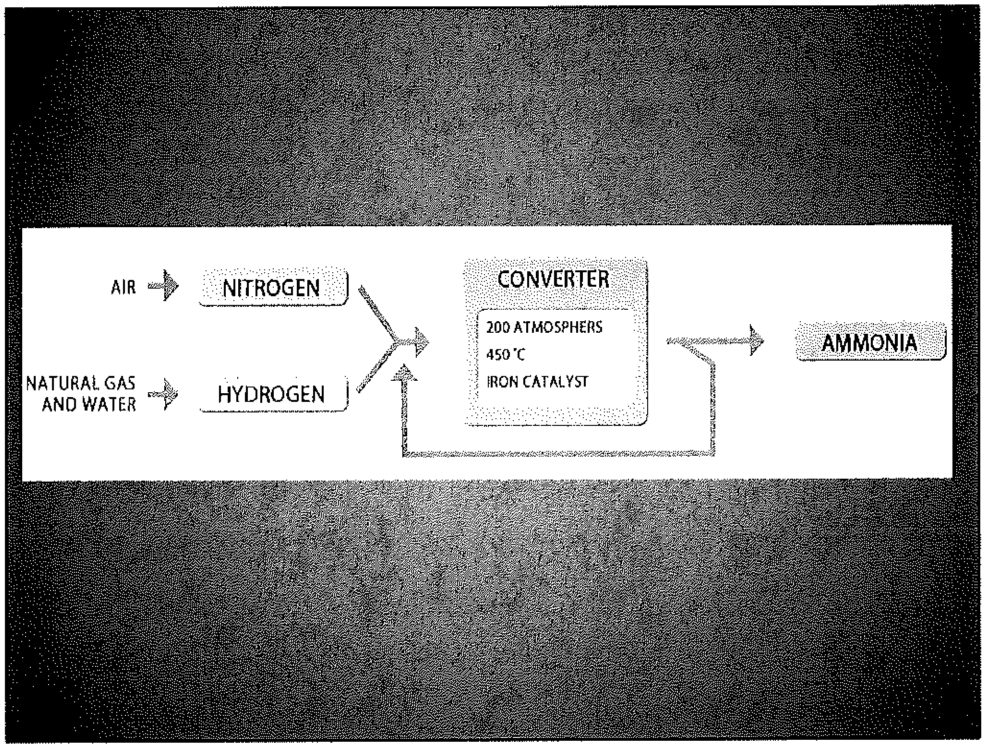

- Haber process

# The Haber-Bosch Process

- 1913
  - Carl Bosch found a way to industrialize Haber's process and to mass produce the ammonia
- Synthesis of ammonia ($NH_3$) gas from its elemental nitrogen ($N_2$) and hydrogen ($H_2$)
- Initial use to create fertilizer in Germany
- World War I
  - Used to create explosives and chemical weapons for the German army

# Ammonia

- Primary ingredient in artificial fertilizers
  - Helps produce 40 – 60 % of food
- Directly synthesize ammonia from hydrogen and nitrogen
- Also known as
  - Haber ammonia process
  - Synthetic ammonia process

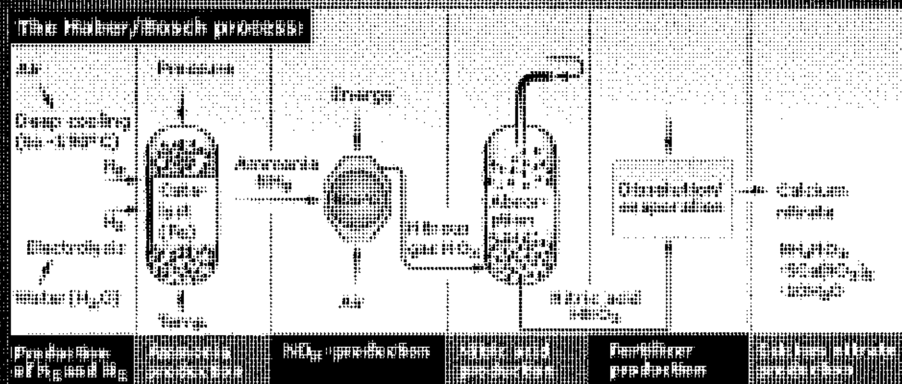



1. Natural gas is highly compressed and mixed with high-temperature, high-pressure steam
    1. Mixture heated to 1600 degrees F in a reaction furnace which forms hydrogen gas and carbon monoxide
2. Hydrogen gas and carbon monoxide are mixed with compressed air in a secondary chamber at 842 degrees F with an iron catalyst
    1. Carbon monoxide is converted to carbon dioxide and removed
    2. Synthesis
        1. In compression tank – pressure, temperature and iron catalyst cause nitrogen and hydrogen to combine with ammonia
3. Final step yields anhydrous ammonia

-

# Fertilizer Manufacturing

- Before make fertilizer
  - Convert ammonia into nitric acid



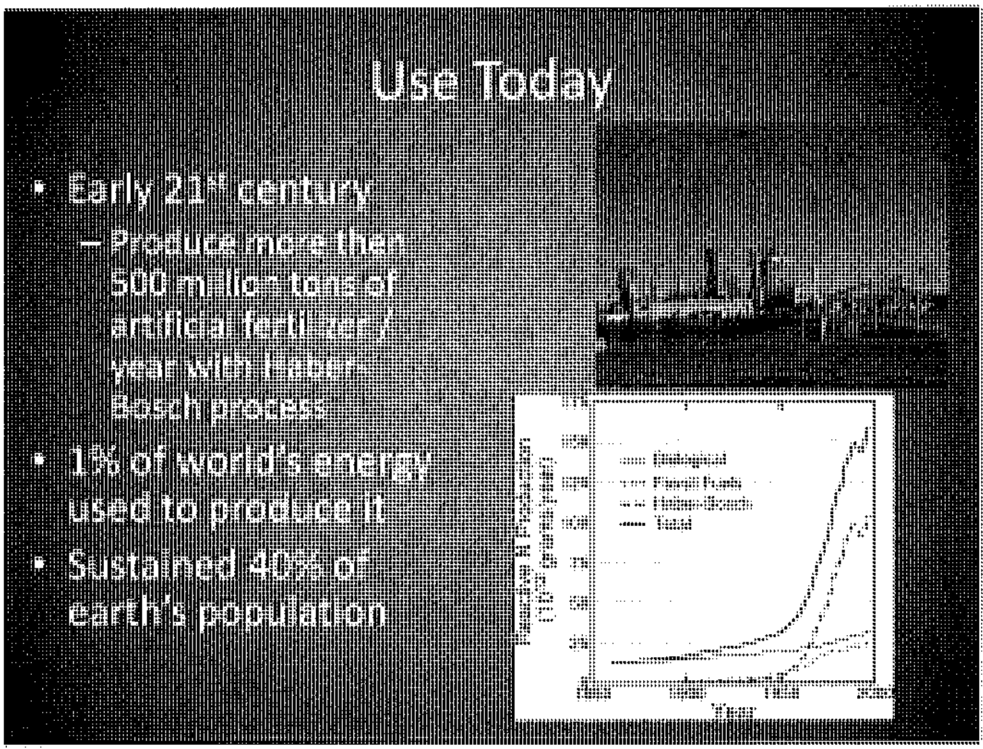



Photo = Plant where Haber-Bosch plant takes place


- Inorganic = man made
- Some of these methods do not produce enough Nitrogen to support conventional agricultural systems

**Haber-Bosch Homework Assignment**

1. Choose one of the following sources of Nitrogen to do research on. If you have problems finding information about a topic, the instructor for help.

    a. Anhydrous ammonia
    b. Rhizobium bacteria
    c. Mineralization of organic matter
    d. Animal wastes
    e. Composted plant residues
    f. Legumes plowed under as green manure
    g. Rainfall in form of nitric acid ($HNO_3$)
    h. Nitrification
    i. Denitrification
    j. Urea and Urea-Ammonium Nitrates
    k. Ammonium Nitrate
    l. Phosphorus fertilizers (contains small amounts of Nitrogen)

2. Write a **2 - 3 page paper** about your chosen nitrogen source. This paper can include any information you find as long as it comes from a **credited** source (**NO WIKIPEDIA**).

3. Your final page should include all of your references in MLA format.

    **NOTE:** The reference page does not count as part of the 2 – 3 page criteria. Therefore, you need at least 2 pages of information and a 3rd or 4th page for your references.

4. Make sure to include a **title page** with your name, title of your paper, the date and class section. (This also **does not** count as a page!)

5. This paper is worth **(insert number)** points and is due no later than **(insert date)**. Points will be deducted for late papers.

**Daily Plan 5**

**Title:**

Nitrogen in our Soils and Lives

**Instructional Area:**

The Effect of Excess Nitrates on the Health and Lives of Humans

**Situation:**

Now that students have had a comprehensive look at the nitrogen cycle and how humans have case an imbalance in the cycle, the students will be encouraged to talk about the effects these imbalances are causing in the environment and with human health.

**PA Academic Standard(s) Met:**

4.3.10

4.4.10

4.8.10

**Materials Needed:**

Computer

Projector for PowerPoint Slides

Article and worksheets copied for all students

Matching game pieces copies, cut out and laminated – enough for students to form # of groups

**Interest Approach:**

The need for the teacher to encourage discussion and to keep the students engaged will be the main approach to garnering interest.

**Objectives:**

1. To encourage the students to utilize their newly acquired knowledge of the nitrogen cycle.
2. To encourage students to work together to solve a puzzle.
3. To encourage students to be able to read, comprehend and answer questions about a written article.

**Content:**

**Teacher Will Do:**

1. Teacher walks in and turns on projector to present PowerPoint. The teacher uses the notes from the PowerPoint to inform students.
2. Teacher breaks students into groups to work on the matching game.
3. Teacher will pass out worksheet and reading for students to work on.

**Teacher Will Say:**

1. Today we will be talking about how nitrogen can affect the health of humans.
2. I want you now to break into # of groups. I'm going to pass out some instructions and a game. Let me know when you are done.
3. I want you all to go back to your own seats and now silently work on this worksheet, using the reading to find the information.

**Review / Conclusion / Opportunity to Learn:**

1. The objective of this class was to show the students how nitrogen affects the environment and human health.
2. Class participation may be graded so as to encourage the students to participate. Grades may also be given based upon how well the students do on the worksheet / reading comprehension.

# Nitrate and Nitrite

| Symbol: | $NO_3$ / $NO_2$ |
|---|---|
| Molecular Weight: | 62 / 46 |

*What Are They?* Nitrate and nitrite are compounds that contain a nitrogen atom joined to oxygen atoms, with nitrate containing three oxygen atoms and nitrite containing two. In nature, nitrates are readily converted to nitrites and vice versa. Both are anions, or ions with a negative charge. They tend to associate with cations, or ions with a positive charge, to achieve a neutral charge balance.

*How Are They Used?* Nitrates are used primarily to make fertilizer, but they are also used to make glass and explosives. These compounds also are used in various chemical production and separation processes. Nitrites are manufactured mainly for use as a food preservative, and both nitrates and nitrites are used extensively to enhance the color and extend the shelf life of processed meats.

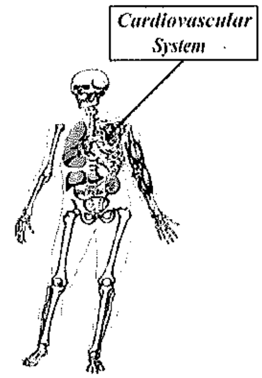
*What's in the Environment?* Nitrates are naturally present in soil, water, and food. In the natural nitrogen cycle, bacteria convert nitrogen to nitrate, which is taken up by plants and incorporated into tissues. Animals that eat plants use the nitrate to produce proteins. Nitrate is returned to the environment in animal feces, as well as through microbial degradation of plants and animals after they die.

Microorganisms can convert nitrate or the ammonium ion (which is a nitrogen atom combined with four hydrogen atoms) to nitrite; this reaction occurs in the environment as well as within the digestive tract of humans and other animals. After bacteria convert (reduce) nitrate to nitrite in the environment, the nitrogen cycle is completed when they then convert the nitrite to nitrogen. Normally, this natural cycling process does not allow excessive amounts of nitrates or nitrites to accumulate in the environment. However, human activities have increased environmental nitrate concentrations, with agriculture being the major source. This includes increased use of nitrogen-containing fertilizers as well as concentrated livestock and poultry farming; the latter two produce millions of tons of nitrate-containing manure each year. Nitrate and nitrite compounds are very soluble in water and quite mobile in the environment. They have a high potential for entering surface water when it rains, as nitrates in applied fertilizers can dissolve in runoff that flows into streams or lakes; they also have a high potential for entering groundwater through leaching. The concentration associated with soil particles has been estimated to be about half the concentration in interstitial water (the water in the pore spaces between the soil particles).

*What Happens to It in the Body?* Nitrate is a normal component of the human diet, with the average daily intake from all sources estimated at 75 milligrams (mg), or about 0.0026 ounce. Upon ingestion, about 5% of the nitrate taken in by healthy adults is converted (reduced) to nitrite by bacteria in saliva. Further nitrate is converted by bacteria inside the alimentary tract. Certain conditions in the stomach can increase the conversion of nitrate to nitrite, specifically when the pH of the gastric fluid is high enough (above 5) to favor the growth of nitrate-reducing bacteria. This process is of major concern for infants, whose gastrointestinal systems normally have a higher pH than those of adults. Nitrites in the stomach can react with food proteins to form N-nitroso compounds; these compounds can also be produced when meat containing nitrites or nitrates is cooked, particularly using high heat. While these compounds are carcinogenic in test animals, evidence is inconclusive regarding their potential to cause cancer (such as stomach cancer) in humans.

*What Are the Primary Health Effects?* Nitrates themselves are relatively nontoxic. However, when swallowed, they are converted to nitrites that can react with hemoglobin in the blood, oxidizing its divalent iron to the trivalent form and creating methemoglobin. This methemoglobin cannot bind oxygen, which decreases the capacity of the blood to transport oxygen so less oxygen is transported from the lungs to the body tissues, thus causing a condition known as methemoglobinemia.

Normal individuals have low levels (0.5 to 2%) of methemoglobin in their blood. When this level increases to 10%, the skin and lips can take on a bluish tinge (cyanosis), and levels above 25% can cause weakness and a rapid pulse. At levels above 50 to 60%, a person can lose consciousness, go into a coma, and die. Infants are much more sensitive than adults to nitrates/nitrites, and essentially all deaths from nitrate/nitrite poisoning have been in infants. Long-term exposure to lower levels of nitrates and nitrites can cause diuresis (an increase in the amount of urine, and starchy deposits and hemorrhaging of the spleen).




*Primary system affected when nitrate/nitrite is ingested.*

*What Are the Risks?* The U.S. Environmental Protection Agency (EPA) has developed toxicity values to estimate the risk of non-cancer health effects from ingesting nitrates and nitrites. The toxicity value used to estimate a non-cancer effect following ingestion is called a reference dose (RfD). An RfD is an estimate of the highest dose that can be taken in every day without causing an adverse effect.

The RfD for nitrate was developed considering the concentration at which methemoglobinemia was indicated at levels above 10% for 0- to 3-month-old infants. This was based on a daily intake of formula made with water containing 10 mg per liter (mg/L) of nitrate as nitrogen. (This reflects the amount of nitrogen within a nitrate molecule, where 1 mg nitrate as nitrogen = 4.4 mg nitrate as measured in the water.) Most cases of infant methemoglobinemia are associated with exposure to formula prepared with drinking water at nitrate-nitrogen levels at least two times higher, or exceeding 20 mg/L nitrate-nitrogen. For nitrite, the RfD is based on a 10-kg (22-pound [lb]) child drinking 1 liter, or about 1 quart, of water every day. The RfD represents a "safe daily dose" and so is compared to the amount an individual is estimated to take in every day, as a ratio. No adverse effects have been linked with inhaling nitrates or nitrites, so reference concentrations (RfCs), which are used to assess inhalation toxicity, have not been developed. The contribution of nitrites, and indirectly nitrates, to potential human carcinogenicity and the magnitude of the associated risk are unclear. Nitrites react with secondary amines in food to form nitrosamines, many of which are carcinogenic in experimental animals and exert other toxic effects. While the EPA has not developed slope factors (toxicity values used to estimate cancer risk) for nitrates or nitrites, some are available for nitrosamines.

| *Chemical Toxicity Values* | |
|---|---|
| Non-Cancer Effect | |
| *Oral RfD: $NO_3$* | *Oral RfD: $NO_2$* |
| 1.6 mg/kg-day | 0.1 mg/kg-day |

*What Are Current Limits for Environmental Releases and Human Exposure?* The EPA requires that sodium nitrite releases of more than 100 lb (45.4 kg) and nitrate releases of more than 10,000 lb (4,540 kg) be reported immediately and that normal releases be reported annually for inclusion in the nationwide Toxics Release Inventory. The limits for nitrosamines range from 1 to 10 pounds. The EPA primary drinking water standards for nitrate and nitrite are 10 and 1 parts per million (ppm), respectively. The Food and Drug Administration allows these compounds to be used as food additives as long as they are of food grade and are added only in the amount needed. The maximum amount of nitrite allowed in smoked and cured fish and meat is 200 ppm.

*Where Can I Find More Information?* More information on nitrates and nitrates can be found in the primary information sources used to prepare this overview: (1) Consumer Fact Sheet on Nitrates/Nitrites, EPA Office of Groundwater and Drinking Water, available through http://www.epa.gov/OGWDW/dwh/c-ioc/nitrates.html; (2) the EPA's Integrated Risk Information System, http://www.epa.gov/iris/subst/0076.htm (nitrate) and /0078.htm (nitrite); and (3) the National Library of Medicine Hazardous Substances Data Bank (http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB).

Nitrate and Nitrite Worksheet Answers

1. **Write out the symbols for Nitrate and Nitrites.**

   $NO_3$ and $NO_2$

2. **True / *False* – Nitrates cannot convert to nitrites in nature and vice-versa.**

3. **List 3 ways that nitrates and nitrites are used.**

| **Uses** | **Nitrate or Nitrite** |
|---|---|
| a. Fertilizer | Nitrate |
| b. Glass | Nitrate |
| c. Explosives | Nitrate |
| d. Various chemical production and separation processes | Nitrate |
| e. Food preservative | Nitrate and Nitrite |

4. **Explain how nitrates are incorporated into the Nitrogen cycle.**

   Nitrates are present in the soil, water and food. Bacteria convert Nitrogen to nitrates. Nitrates are taken up by plants. Animals eat these plants and convert the nitrate into proteins. Nitrates are returned to the environment via animal feces and through degradation of plants and animals after they die.

5. **Explain how nitrites are incorporated into the Nitrogen cycle.**

   Microorganisms convert nitrate to nitrite within the environment or within the digestive tract of animals and humans. Nitrite is then converted into nitrogen to complete the cycle.

6. **Are nitrates and nitrites water soluble? If so, how do they move within the environment?**

   Yes. They have a high potential for entering surface waters when it rains. They can dissolve in runoff and entre streams or lakes. They can also leach through the soil and enter the groundwater.

7. **How does a person contract the condition methemoglobinemia? What happens after a person has this condition?**

   Nitrates are converted to nitrites when swallowed and react with the hemoglobin in the blood. It oxidizes the iron into a trivalent form. This creates methemoglobin. Methemoglobin cannot bind oxygen which decreases the capacity of the blood to transport oxygen. Can cause death in infants and diuresis in adults.

8. **What does RfD stand for / what is it definition?**

Reference dose. Toxicity value used to estimate non-cancer effect following ingestion. "Safe daily dose".

9. ***<u>True</u>*** **/ False – There are no adverse effects when a human inhales nitrates or nitrites.**

10. **What is the EPA primary drinking water standards for nitrates and nitrites?**

Nitrate – 10 ppm

Nitrite – 1 ppm

Name:____________________

## Nitrate and Nitrite Worksheet

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|---|---|
| A. | |
| B. | |
| C. | |

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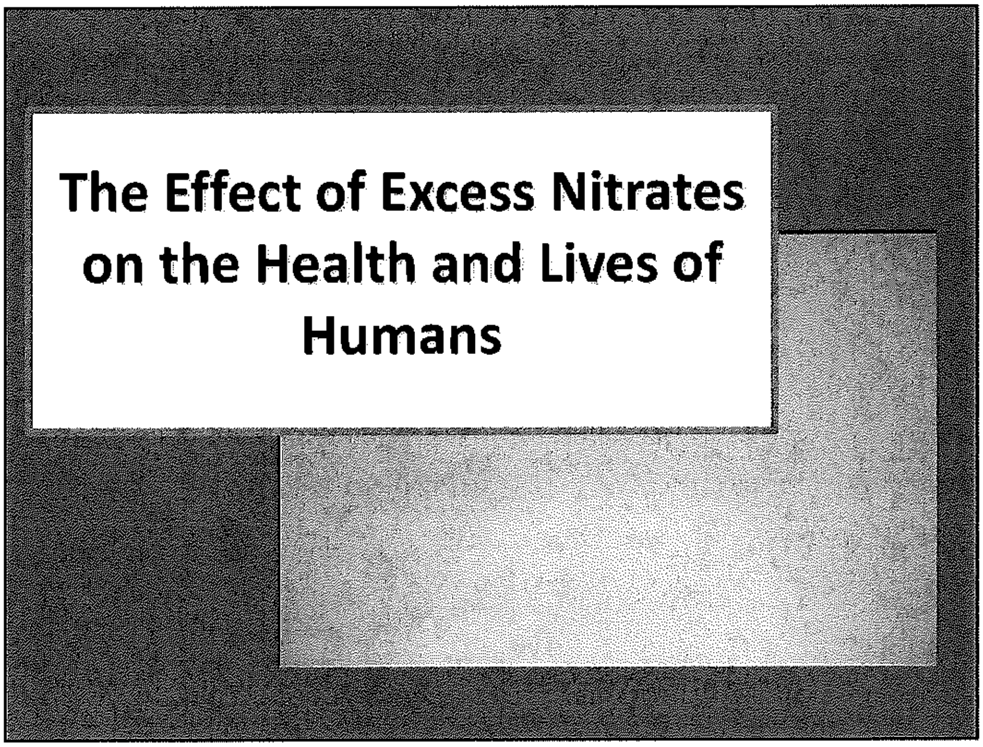
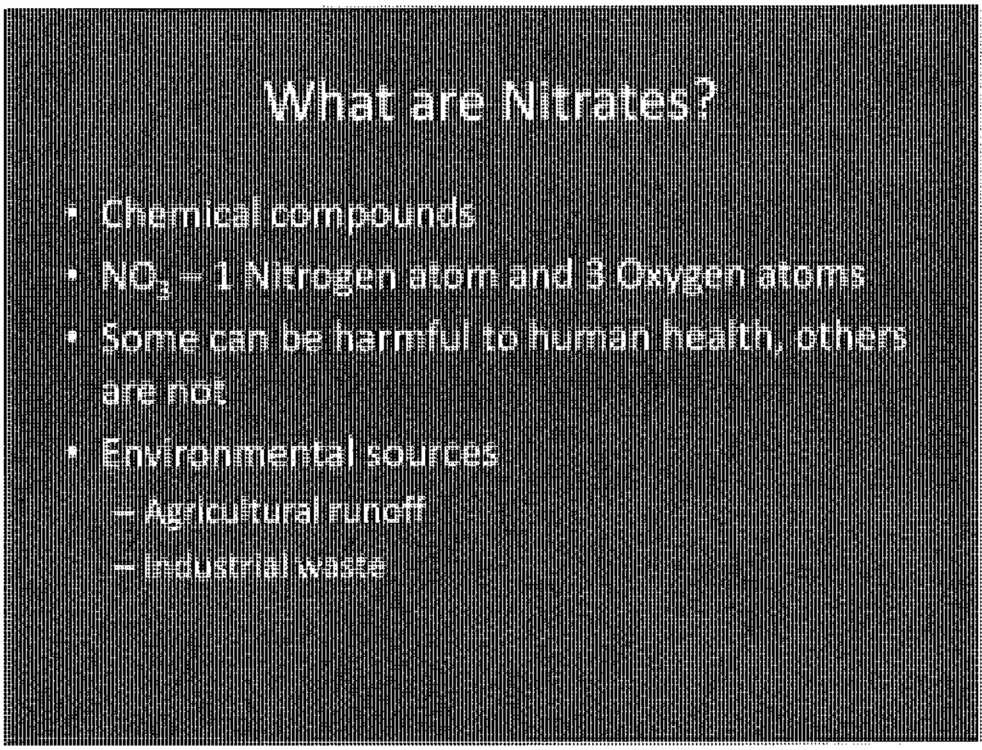
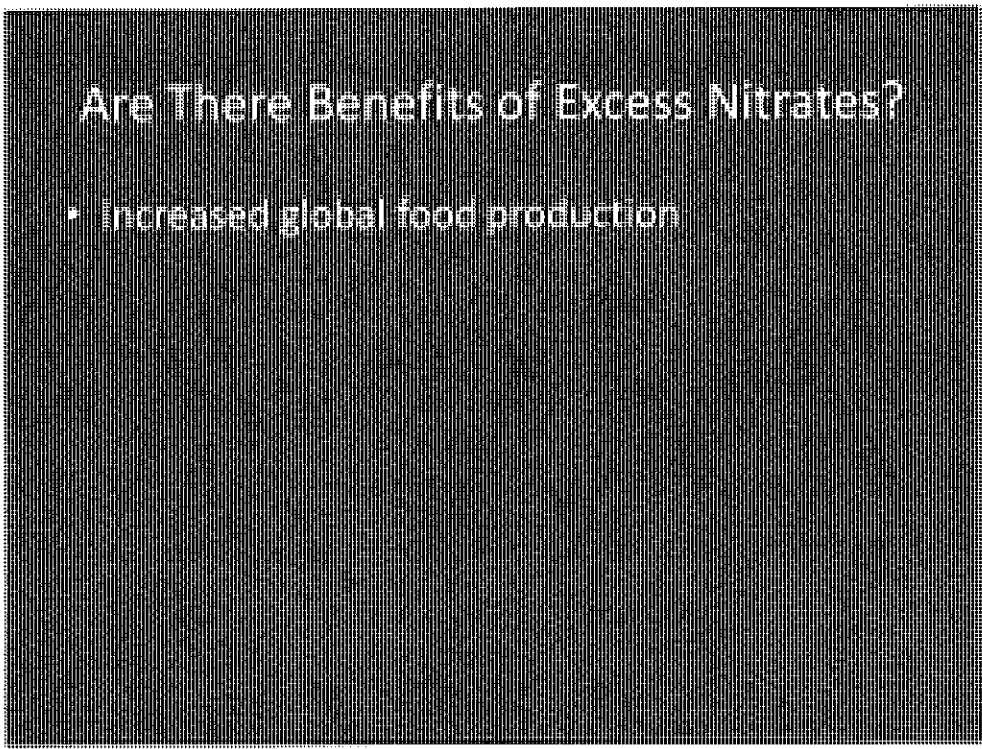


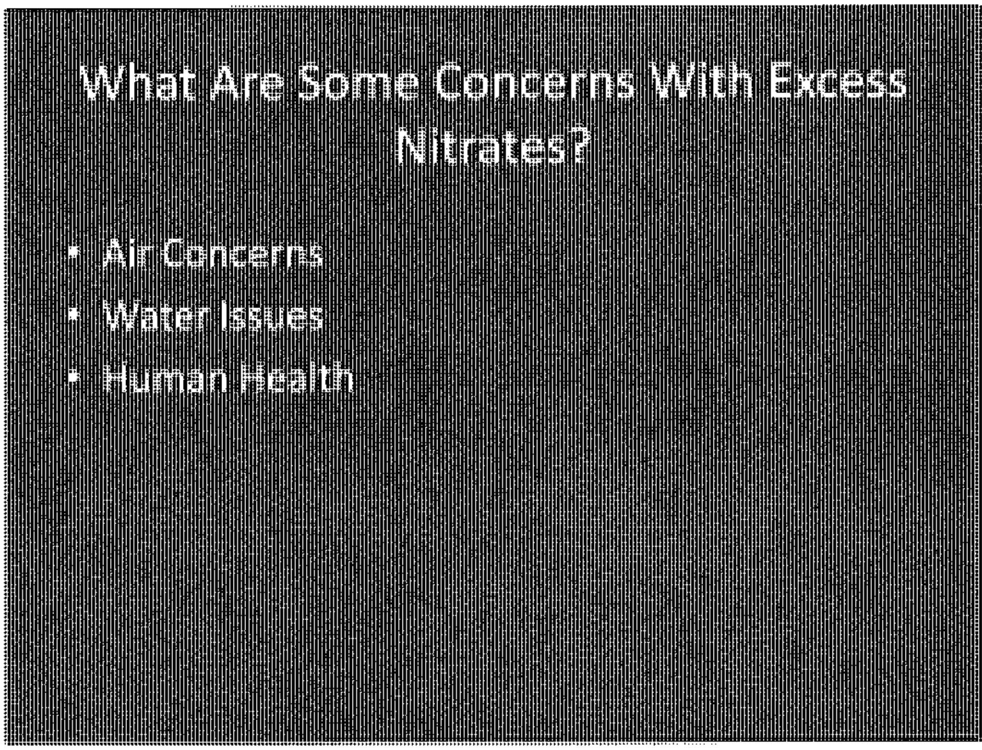

http://serc.carleton.edu/NAGTWorkshops/health04/activities/21756.html – card match game




-Nitrates
- -Colorless, odorless, tasteless compound
- -Proper management of fertilizers, manures, and other nitrogen sources help to minimize the contamination of drinking water supplies
- -Naturally occurring in soil
- -High mobility
- -Form when microorganisms break down fertilizers, decaying plants, manures or other organic residues – usually taken up by plants, but sometimes leached into groundwater
- -Sources
  - -Fertilizers and manure
  - -Animal feedlots
  - -Municipal wastewater and sludge
  - -Septic systems
  - -N-fixation from atmosphere by legumes, bacteria and lightning




-Nitrogen is the most common yield-limiting nutrient
- Help produce excess food (especially animal foods) and also boosts agricultural exports

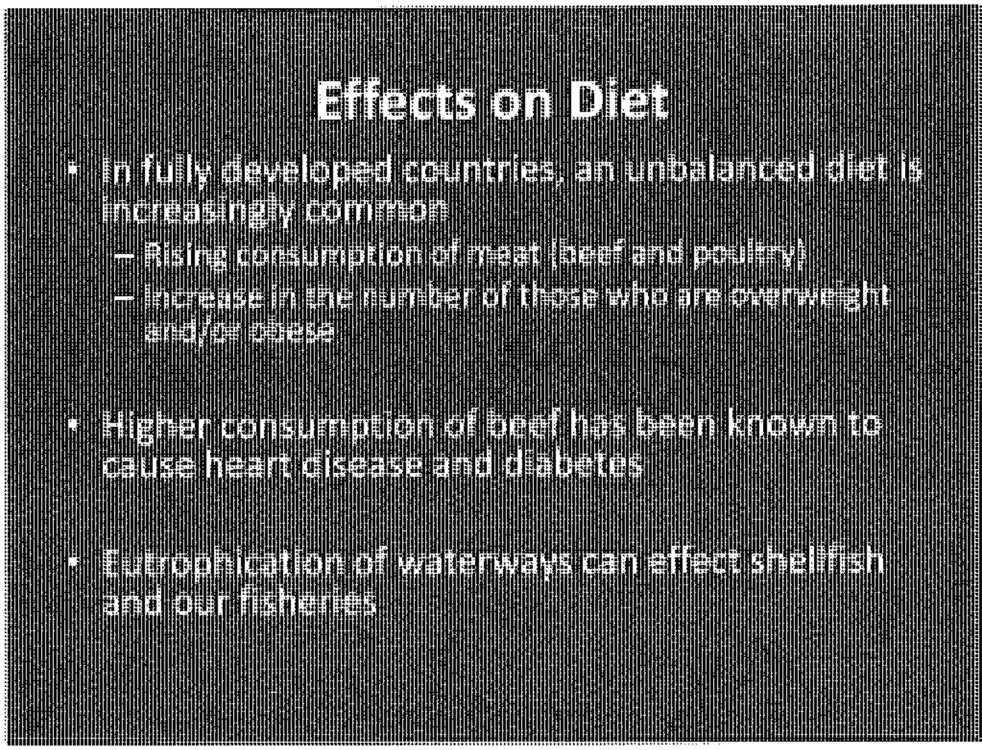



Examples:

- Air Concerns
  - Poor air quality
  - Asthma
  - Allergies
- Water Issues
  - Dead zones
  - Blue baby syndrome
    - Also known as methemoglobinemia
  - Poor water quality
- Human Health
  - Reproduction
  - Cancer
  - Cholera

## Effects on Third World Countries

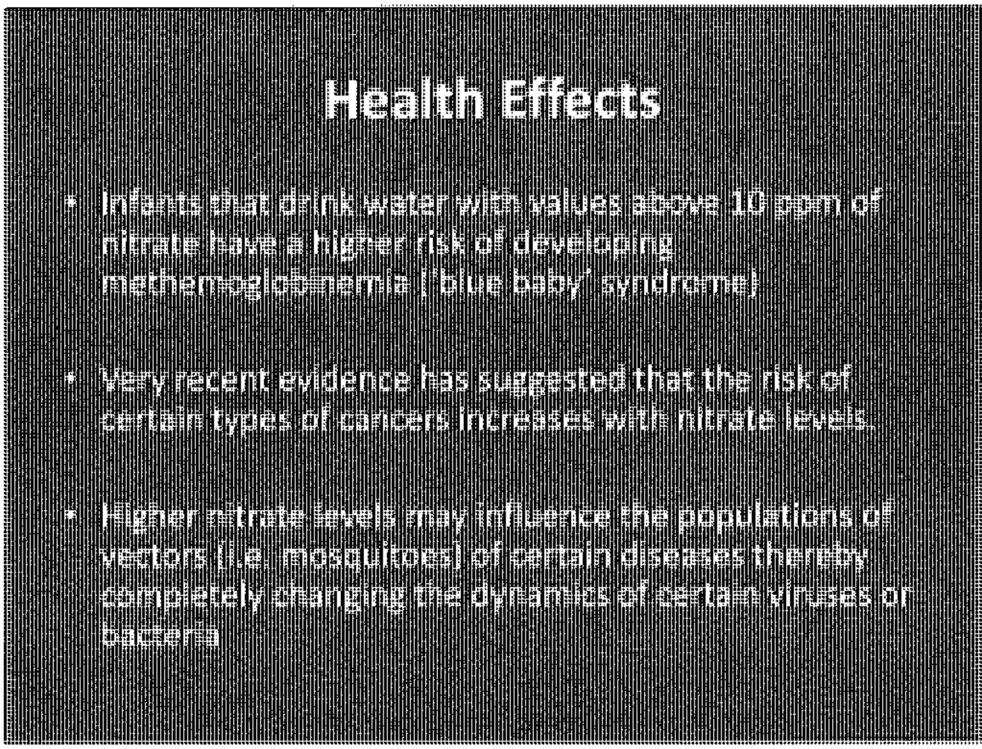
- Moderate use of fertilizers in developing countries will increase:
  - Nutrition
  - Food availability
  - Infrastructure
  - Public health
- Problems created:
  - More land will be used to provide feed for livestock
  - Taking away land for crop production




- Recall definition of eutrophication

## Effects on Air Quality

- Higher levels of $NO_3$ lead to higher levels of ozone
  - Contributes to asthma rates and respiratory diseases
- Fine particulates in the air (including those formed from $NO_3$) correlates to:
  - cardiovascular diseases, reduced lung function, overall mortality, etc
- It has been proven that increased nitrogen levels increase the pollen count in some plants, aggravating allergies of effected people.




Blue Baby Syndrome

- Infant's blood cannot carry enough oxygen
- Rise of methemoglobin in the blood
    - Non-Oxygen-carrying enzyme in the blood

Townsend, M. A., Rule, A. C., Meyer, M. A., Dockstader, C. J., 2007, Teaching the nitrogen cycle and human health interactions: Journal of Geoscience Education, v. 55, p. 158-168. Online in March, 2008.

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Paper in Journal of Geoscience Education gives an overview of the lesson and how to use the cards. A brief synopsis is presented below.

**Overview of Lesson**

1) Before engaging in lessons, students attempt to draw a diagram of a nitrogen cycle and add as many components as they can. This allows them to self-assess (and the teacher to assess) what they know about the nitrogen cycle.

2) Students research some of the nitrogen cycle components online at various websites or read printouts from websites provided by the teacher. They choose three or facts of interest about their component and report to the rest of the class. Suggested nitrogen websites are provided in **Web sites for nitrogen information.pdf.**

3) Each small group of students is given a set of materials including the 20 objects (black and white), 20 picture-cards, 20 nitrogen cycle component explanation cards, the 20 title cards for each nitrogen cycle component, heading cards for different environments such as the atmosphere, soil, water, etc., and many small arrows. **(Cards for Cutting Out Nitrogen cycle 2008.pdf)**

4) The students work together to pair each object with its corresponding title card, description card, and picture card. Then these are all arranged to form a possible nitrogen cycle with various components clustered around heading cards and arrows used to show movement of nitrogen from one object to another. An example of a possible N-cycle is presented with the pdf of the cards to be used for cutting out **(Card Associations and Example N Cycle.pdf)**.

5) Students then write humorous (limerick, couplet) poems or more serious poems (haiku) or structured poems (cinquain, diamante) to tell several facts about a component of the nitrogen cycle. They share their poems with the class.

6) Students may also engage in experiments with nitrogen fertilizer. Typing in **classroom experiments nitrogen fertilizer** in a search engine such as Google provided a number of experiments that would work in or out of a classroom to illustrate the effects of too much versus enough fertilizer on plant growth; other topics that showed up were dealing with composting which helps deal with organic fertilizer.

Use the pre-test/post-test for evaluation purposes **(Pretest Posttest.pdf)** if you wish. Directions concerning how to use the test are provided with the test.

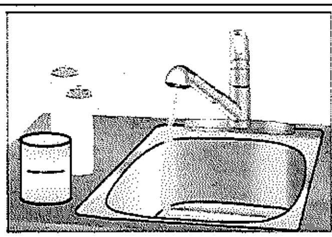
## Algae Bloom

Tiny water plants capture the sun's energy and support the food web. Dissolved nitrogen can lead to sudden overabundance, which blocks sunlight to water, kills fish by using the water's oxygen, produces scum or odor, and in some cases, produces toxins.

## Human Cancer


Cooking can convert nitrite ions from food preservatives to nitrosamines, which are known carcinogens. Bacon, in particular, because of its high cooking temperature can produce nitrosamines. Addition of ascorbic acid can prevent their formation.

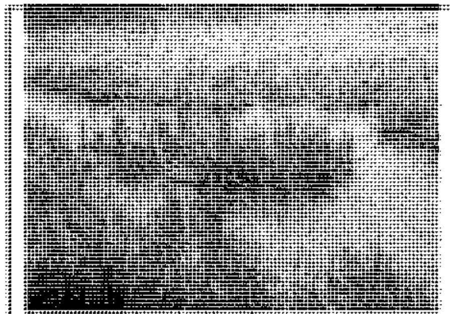
## Blue Baby Syndrome



Powdered formula mixed with tap water could contain nitrate.

An illness that occurs when a child drinks water containing a large amount of nitrates. The body's digestive system converts these to nitrites, changing oxyhemoglobin to metheglobin, which cannot carry oxygen. Mucous membranes turn blue, impairing functions.

## Excess Water Weeds

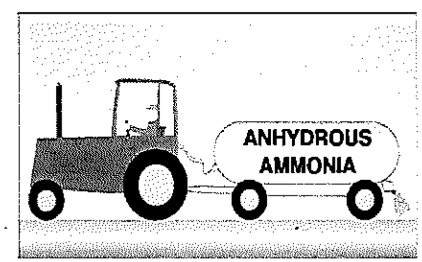


Dense beds of underwater plants occur in shallow nitrogen-enriched water. These plants block navigation, trap sediment, and cause unpleasant odors when they decay.

## Young Animal Illness

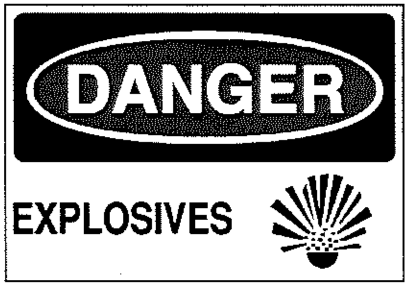
High levels of nitrate in water lead to increased livestock and wildlife stillbirth rates, low birth weight, slow weight gain, and reduced vitality.

## Agricultural Fertilizer



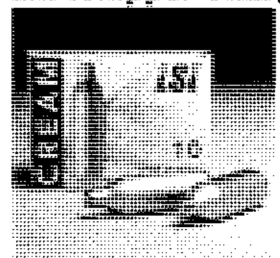

Living organisms use nitrogen to build proteins, enzymes, DNA, RNA, vitamins, and hormones. Most animals derive their nitrogen from plants, which convert simple compounds to more complex ones. Adding simple nitrogen compounds to soil increases plant growth.

## Explosives and Munitions




Nitrogen is a major component in gunpowder, TNT (bombs and shells), and nitroglycerin (dynamite). Nitrogen has a triple bond (N≡N) which releases a great deal of energy when broken by chemical processes, including heat such as explosions or firing a gun.

## Sterile Food Packing

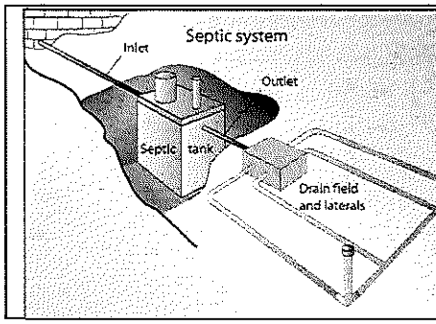



Oxygen allows bacterial growth and chemical breakdown of foods. Food is often vacuum-packed to remove oxygen or packed with nitrogen. $N_2O$ is soluble in fats and used as a propellant for canned whipped cream.

## Lawn Fertilizer


Nitrogen is a major nutrient for plant growth. Lawn fertilizer recommendations across the US are based on turf (lawn) research. The 16-4-8 shown on the bag is the percentage of nitrogen, phosphorous, and potassium in a 50 lb bag (16% * 50 lb = 8 lb nitrogen).

## Sewers and Septic Tanks

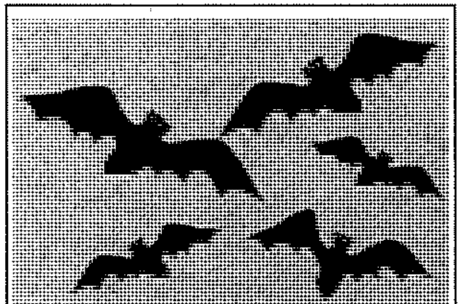



Human urine contains a large amount of ammonia. Soil bacteria oxidize ammonia to form nitrates. Leaking septic tanks or sewer systems release the wastes into the soil, ground water, and surface water systems.

## Pet Waste

Dog, cat, and other domestic animal waste contains ammonia which is converted by bacteria into nitrates. If animal droppings are left on the ground, the nitrates and bacteria will enter the ground and pollute surface and ground water.

## Bat Guano



Many caves have large deposits of droppings (guano) from bats. This material is enriched in nitrogen and is used as fertilizer. Deposits in Mammoth Cave, Kentucky, were mined during the War of 1812 as saltpeter (potassium nitrate), an ingredient in black gunpowder.

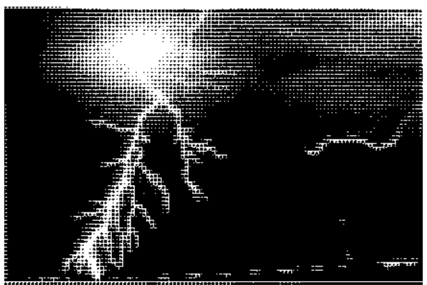
## Dentistry/Medicine

Nitrous oxide ($N_2O$), also known as "laughing gas," is a mild anesthetic used in dentistry. Nitric oxide (NO) is a short-lived gas that acts as a signaling molecule in the body for blood pressure. "Nitro" drugs like nitroglycerin lower blood pressure by increasing NO.

## Meat Preservative

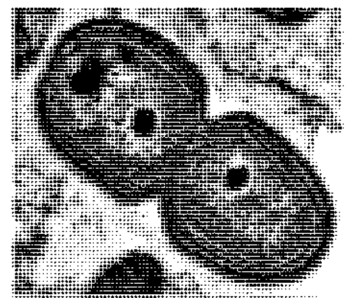
Sodium nitrite is a salt that prevents bacterial growth and botulism. When added to meat, the nitrite turns to nitric oxide and combines with myoglobin, the red pigment in meat, turning it the pink color of ham and hotdogs.

## Lightning Strikes



The high temperatures and pressures that surround electric storms form nitric oxide (NO) and nitrogen dioxide ($NO_2$), which react with rain to form nitric acid ($HNO_3$). Nitrates formed by the interaction of nitric acid and soil provide nitrates for plant growth.

## Soil Bacteria



Microbes in the ground conduct denitrification, a process that converts nitrates back to nitrogen gas. This process also produces nitrous oxide, which is a greenhouse gas contributing to global warming.

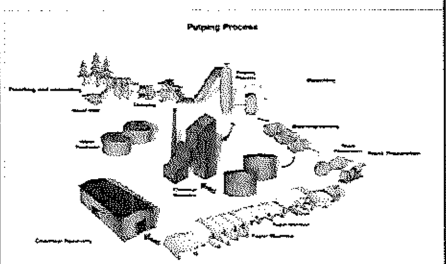
# The Nitrogen Cycle

## Plants

## Animals

## Humans

## Paper Industry



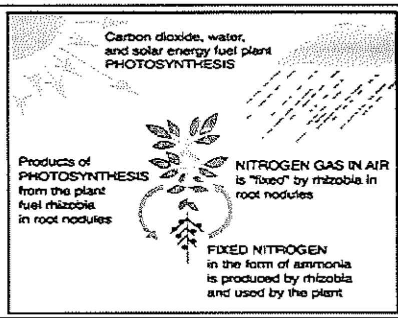

StonCorAfrica

The pulp and paper industry processes wood with heat, pressure, and caustic solutions. Possible polluting byproducts include methanol, NOx, carbon dioxide emissions, and ammonia and nitrates releases in wastewater. Current methods result in cleaner air and water.

## Farm Animal Waste

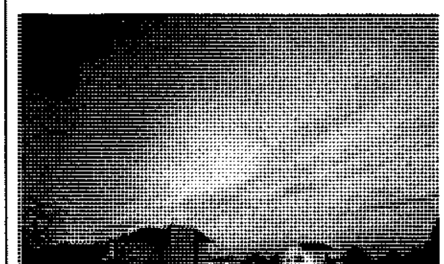
Barnyards, dairies, and feedlots produce a lot of animal waste. Bacteria convert the ammonia in this waste to nitrates that enter the ground or surface water systems. Bacteria from animal waste is also a contaminant.

## Legumes




Plants of this family (beans, peas, alfalfa) are able to use biological nitrogen fixation (BNF) to obtain nitrogen from the air for growth. N-fixing soil bacteria (rhizobia) in root nodules support plant growth and symbiotically receive sugars and carbohydrates in return.

## Atmospheric Gas



Nitrogen gas makes up 78% of the Earth's atmosphere by volume. The Aurora Borealis is created when ions collide with gases such as nitrogen in the Earth's atmosphere.

Nitrogen Gas
$N_2$

Nitrate
$NO_3^-$

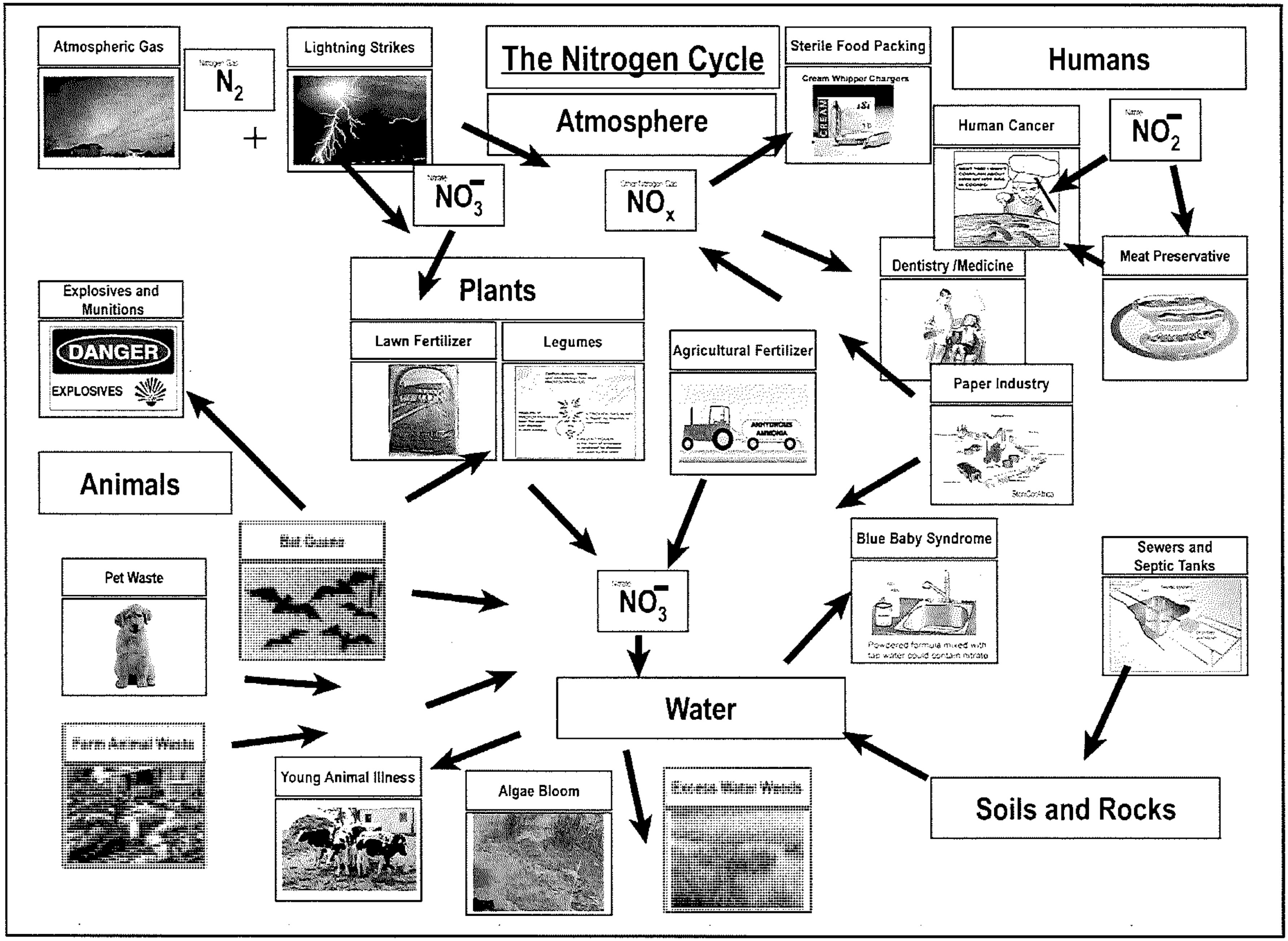
Nitrite
$NO_2^-$

# Atmosphere

# Water

Other Nitrogen Gases
$NO_x$

# Soils and Rocks



The Nitrogen Cycle
Atmospheric Gas
$N_2$
+
Lightning Strikes
$NO_3^-$
Atmosphere
$NO_x$
Sterile Food Packing
Cream Whipper Chargers
Humans
Human Cancer
$NO_2^-$
Meat Preservative
Dentistry /Medicine
Paper Industry
Explosives and Munitions
DANGER
EXPLOSIVES
Plants
Lawn Fertilizer
Legumes
Agricultural Fertilizer
Animals
Pet Waste
$NO_3^-$
Blue Baby Syndrome
Powdered formula mixed with tap water could contain nitrate
Sewers and Septic Tanks
Water
Young Animal Illness
Algae Bloom
Soils and Rocks

Algae Bloom

Human Cancer

Blue Baby Syndrome

Excess Water Weeds

Young Animal Illness

Agricultural Fertilizer

Soil Bacteria

Paper Industry

Legumes

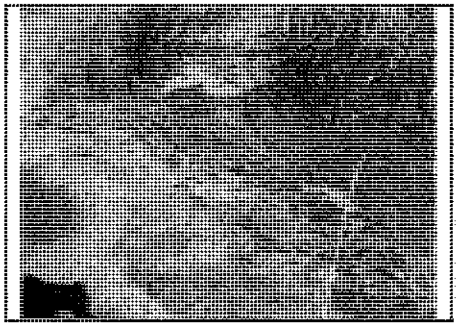
Farm Animal Waste

Water

Atmospheric Gas

Nitrite $NO_2^-$

Nitrate $NO_3^-$



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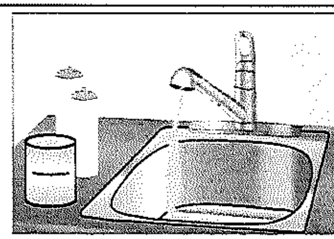

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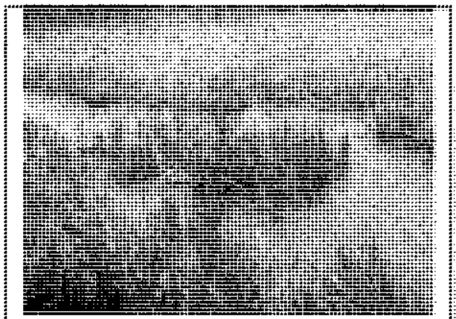

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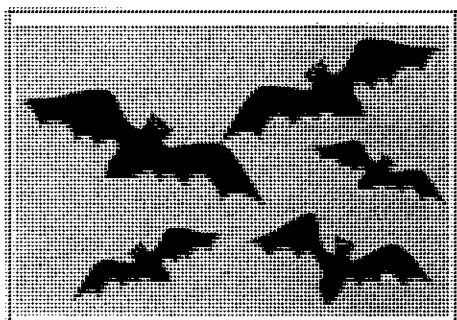


Many caves have large deposits of droppings (guano) from bats. This material is enriched in nitrogen and is used as fertilizer. Deposits in Mammoth Cave, Kentucky, were mined during the War of 1812 as saltpeter (potassium nitrate), an ingredient in black gunpowder.

The high temperatures and pressures that surround electric storms form nitric oxide (NO) and nitrogen dioxide ($NO_2$), which react with rain to form nitric acid ($HNO_3$). Nitrates formed by the interaction of nitric acid and soil provide nitrates for plant growth.

# The Nitrogen Cycle

Explosives and Munitions

Sterile Food Packing

Lawn Fertilizer

Sewers and Septic Tanks

Pet Waste

Bat Guano

Dentistry/Medicine

Meat Preservative

Lightning Strikes

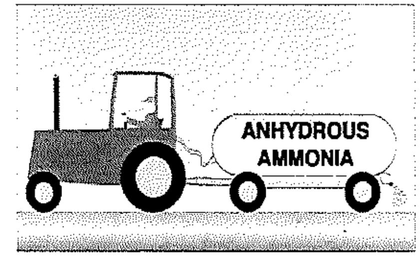
## Animals

## Humans

## Atmosphere

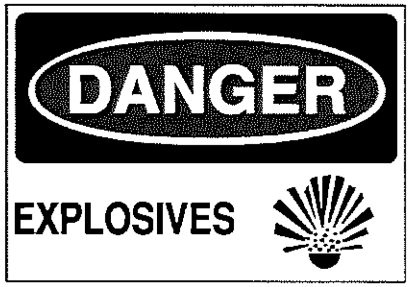
## Plants

## Soils and Rocks



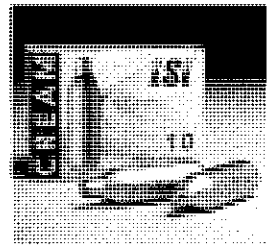

Living organisms use nitrogen to build proteins, enzymes, DNA, RNA, vitamins, and hormones. Most animals derive their nitrogen from plants, which convert simple compounds to more complex ones. Adding simple nitrogen compounds to soil increases plant growth.

High levels of nitrate in water lead to increased livestock and wildlife stillbirth rates, low birth weight, slow weight gain, and reduced vitality.




Nitrogen is a major component in gunpowder, TNT (bombs and shells), and nitroglycerin (dyna-mite). Nitrogen has a triple bond (N≡N) which releases a great deal of energy when broken by chemical processes, including heat such as explosions or firing a gun.

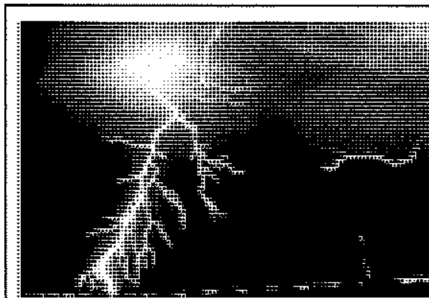
**Cream Whipper Chargers**

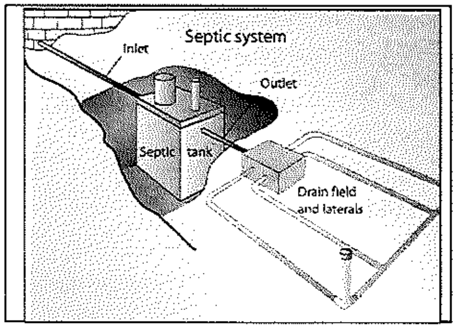


Nitrous oxide ($N_2O$), also known as "laughing gas," is a mild anesthetic used in dentistry. Nitric oxide (NO) is a short-lived gas that acts as a signaling molecule in the body for blood pressure. "Nitro" drugs like nitroglycerin lower blood pressure by increasing NO.

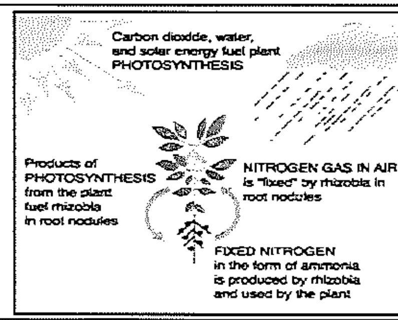
Oxygen allows bacterial growth and chemical breakdown of foods. Food is often vacuum-packed to remove oxygen or packed with nitrogen. $N_2O$ is soluble in fats and used as a propellant for canned whipped cream.


The pulp and paper industry processes wood with heat, pressure, and caustic solutions. Possible polluting byproducts include methanol, NOx, carbon dioxide emissions, and ammonia and nitrates releases in wastewater. Current methods result in cleaner air and water.





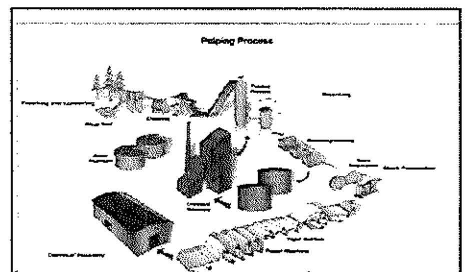

Human urine contains a large amount of ammonia. Soil bacteria oxidize ammonia to form nitrates. Leaking septic tanks or sewer systems release the wastes into the soil, ground water, and surface water systems.



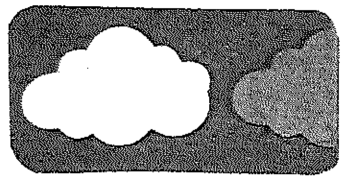

Microbes in the ground conduct denitrification, a process that converts nitrates back to nitrogen gas. This process also produces nitrous oxide, which is a greenhouse gas contributing to global warming.

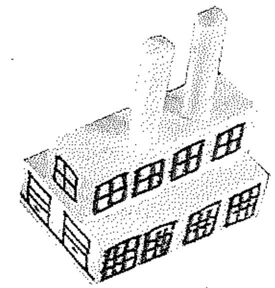
Nitrogen is a major nutrient for plant growth. Lawn fertilizer recommendations across the US are based on turf (lawn) research. The 16-4-8 shown on the bag is the percentage of nitrogen, phos-phorous, and potassium in a 50 lb bag (16% * 50 lb = 8 lb nitrogen).

Nitrogen gas makes up 78% of the Earth's atmosphere by volume. The Aurora Borealis is created when ions collide with gases such as nitrogen in the Earth's atmosphere.

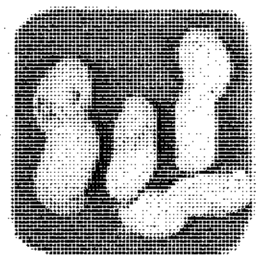


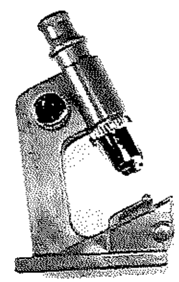

StonCorAfrica

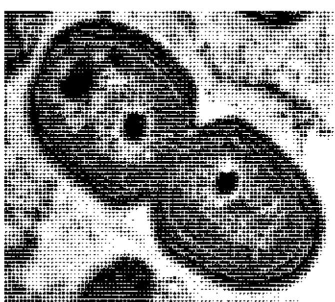




Sodium nitrite is a salt that prevents bacterial growth and botulism. When added to meat, the nitrite turns to nitric oxide and combines with myoglobin, the red pigment in meat, turning it the pink color of ham and hotdogs.

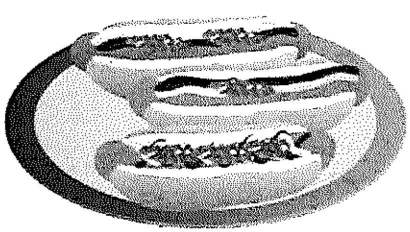






Other Nitrogen Gases

$NO_x$



Nitrogen Gas

$N_2$


Green Grow
FOR LAWNS
15-15-15
DYNAMITE

**Daily Plan 6**

**Title:**

Nitrogen in Our Soil and Lives

**Instructional Area:**

Environmental Policy and Regulations Related to Nutrient Management

**Situation:**

There is a large amount of nitrogen being released into the system as a result of human change. This includes but is not limited to the Haber-Bosch process, the increased farming of legumes and the burning of fossil fuels. Students will first be introduced to why nutrient management policies are needed and what policies are already in place. The students will be introduced to the Chesapeake Bay situation and will participate in an activity that will help reduce the amount pollution in the Chesapeake Bay.

**PA Academic Standard(s) Met:**

4.1.10

4.3.10

4.9.10

**Materials Needed:**

Computer

Projector

Printed Handouts from the Bare Spots booklet

**Interest Approach:**

Only the beginning portion of this class will be lecture. The rest of the class time will be dedicated to determining how to improve the school grounds to decrease pollution runoff. This will encourage the students to understand the material better, as well as to actively participate in a project to decrease runoff.

**Objectives:**

1. To convey to the students the need for nutrient management and the current state of nutrient management regulations and policies in Pennsylvania.
2. To have the students gain a better perspective on how to decrease pollution run off that affects the Chesapeake Bay.

**Content:**

**Teacher Will Do:**

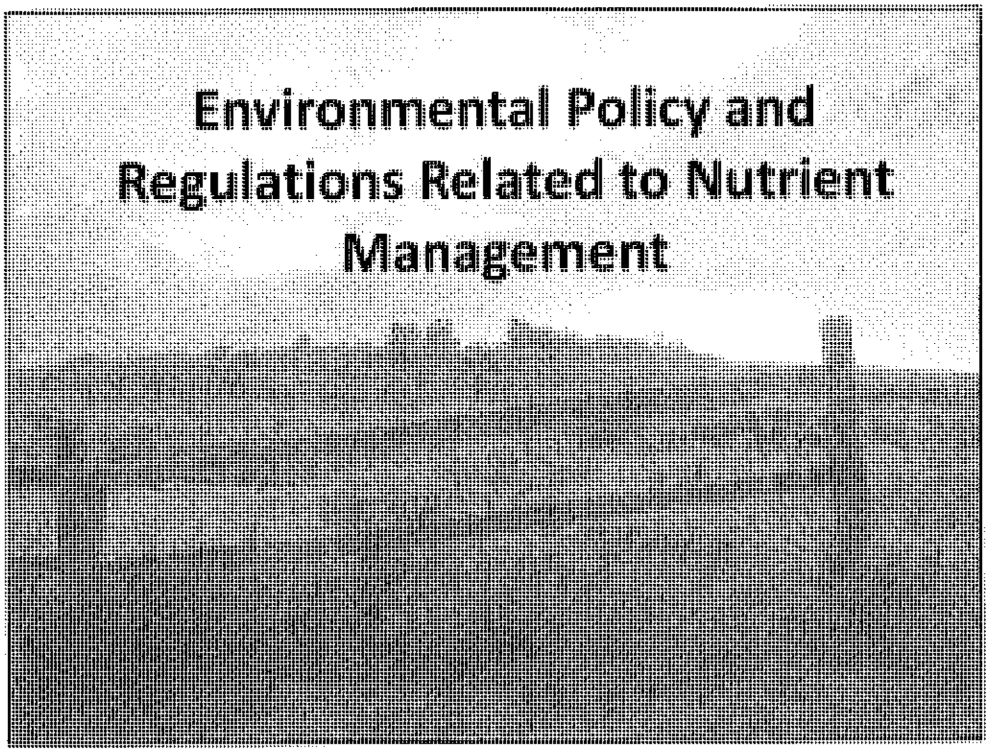
1. Teacher walks in and starts projector to show a PowerPoint.
2. Teacher allows students to work in groups to come up with a solution to fix the school grounds bare spots.

**Teacher Will Say:**

1. Today we are going over nutrient management policy.
2. Now, I'm going to split you into groups and allow you to come up with a solution to fixing the bare spots around the school grounds.

**Review / Conclusion / Opportunity to Learn:**

1. Students gained a better understanding of the problems that our waterways are facing with mismanaged nutrients and an idea of the current state of nutrient management regulation.
2. Students will have gained the opportunity to participate actively in the planning process to help fix the school grounds bare spots.
3. Students could potentially be graded on their involvement in the planning process and of course the information from the PowerPoint could be tested at a later date.


Environmental Policy and Regulations Related to Nutrient Management

## Major Change for Farms in the Nitrogen Cycle

- Farms are becoming specialized
- In the past the manure produced on a farm would be used for the crops on that farm
- Now there are specialized CAFO farms (Concentrated Animal Feeding Operation),and the use of the manure is not nearly as effective

Farms becoming more specialize

- Many no longer have both crops and animals
- Instead they have one or the other

# Statistics

- Pennsylvania's livestock produces approximately 30 million tons of manure annually that contains 171,000 tons of nitrogen.
  - If not applied at the right time, rate or location, manure becomes a pollutant

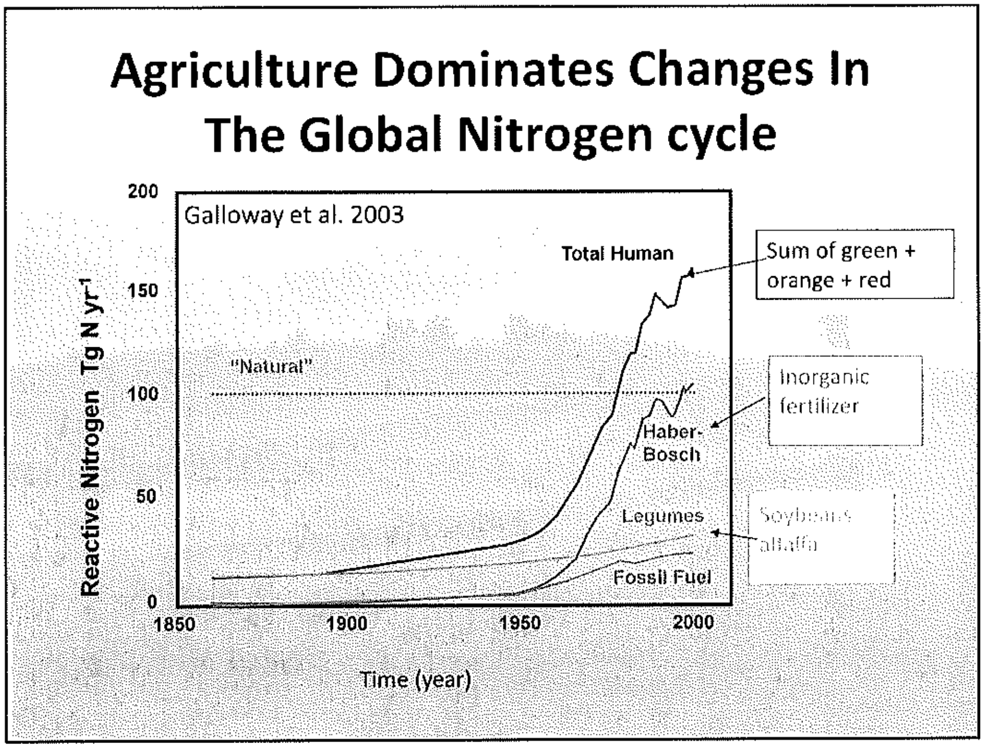
- 3,903 miles of Pennsylvania's streams are impaired from agricultural activities
  - Clean Water Act

# Clean Water Act

- Regulate discharge of pollutants into the water
- Quality standards for surface waters
- Enacted 1948, Expanded in 1972 , Amendments in 1977
- Unlawful to
  - Discharge pollutants from point source into waters unless get permit

## Clean Water Act

- National Legislation
- Sets up definitions for AFO (Animal Feeding Operations) and CAFO
- Uses values from the Unified Nutrient Management Strategy
    - National strategy for setting up nutrient management plans.
- TMDL (Total Maximum Daily Loads)
    - Determined by investigation




- Manure a large problem for nutrient management
- Synthetic fertilizers that are applied by farmers from the Haber-Bosch process, along with the burning of fossil fuels and the increased farming of legumes also cause nutrient management problems

# Haber-Bosch Process

- Most economical for nitrogen fixation
- Fritz Haber and Carl Bosch
  - Chemists
- Synthetic ammonia process
  - Ammonia from hydrogen and nitrogen
  - Combine nitrogen from air with hydrogen under extremely high pressure and moderately high temperatures
  - Uses iron catalyst

# Act 38 (Formerly Act 6)

- All CAOS (concentrated animal operations) must have an approved nutrient management plan
  - It is considered a CAO if there are more than two animal equivalent units (AEU = 1,000 pounds of live weight of an animal)
- Included in the plan:
  - Amount of manure generated
  - Nutrient content of the manure
  - Manure application rates and handling procedures
  - Levels of Manure Exported
  - Agriculture Erosion and Sedimentation Control Plans
  - Both nitrogen and phosphorus based management

# REAP Program

- REAP – Resource Enhancement and Protection Program of Act 55 of 2007
- Provides tax credits to farms that implement Best Management Practices (BMPs)
- The amount of tax credit depends on the BMP used. But farms can receive between 50% and 75% of project costs as tax credits.
- This encourages farms to implement such BMPs as:
  - Specific Equipment for Better Handling of Manure or No Till Practices
  - Erosion / Nutrient Management Plans
  - Constructed Wetlands
  - Etc.

# Chesapeake Bay

- Formed 12,000 years ago when glaciers melted and flooded the Susquehanna River
- 200 miles long
- Runs from the mouth of the Susquehanna River to the Atlantic Ocean
- Encompasses 6 states
  - Delaware
  - Maryland
  - New York
  - Pennsylvania
  - Virginia
  - West Virginia
- Chesapeake Bay watershed include
  - Tidal shoreline
  - Tidal wetlands and islands

# Chesapeake Bay

- Critical Condition
- Overload of pollution
  - Mercury
  - Nitrogen and Phosphorus
    - Algae blooms cause "dead zones"
- Sources of pollution
  - Major Reason
    - Increased impervious cover
  - Agriculture
  - Sewage
  - Stormwater
  - Air pollution

- Impervious cover
  - Does not allow precipitation or runoff to reach the soil
  - Example
    - Roads, rooftops, parking lots, etc.
- Dead Zones
  - Caused by extreme algae growth
  - Algae blooms block sunlight and consume oxygen
  - Less oxygen = kills marine life

## Chesapeake Bay Agreement

- Originally from 1983
  - Goals weren't set until 1987
  - Reduce pollution from sewage treatment
- In 1992
  - Wider strategy needed
  - Inputs were attempted to be reduced further upstream in the tributaries
- In 2000
  - Goal set to have the Chesapeake Bay in an acceptable healthy range by 2010

## Fix Your Schoolyard Bare Spots

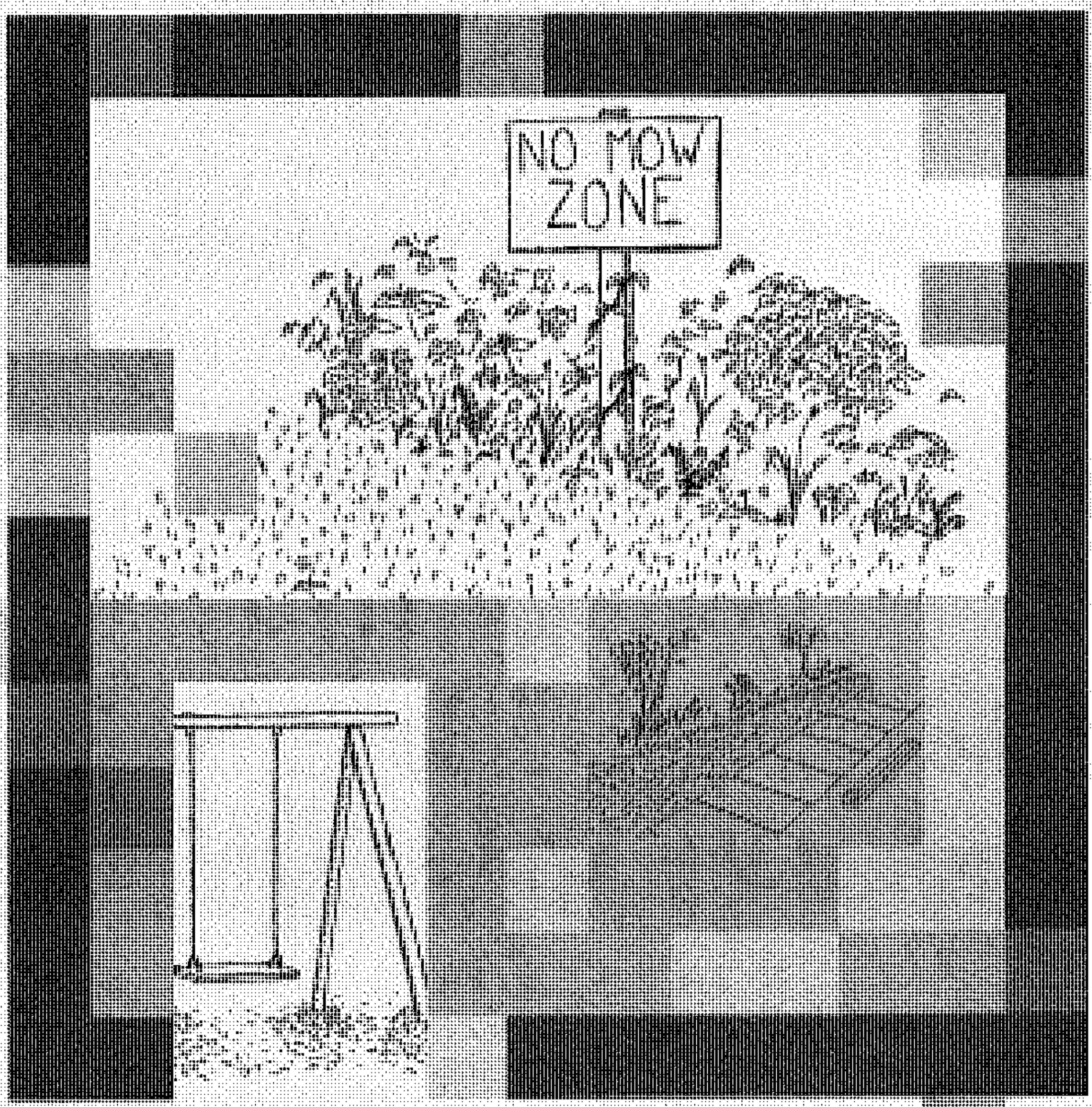
- Bare Spots
  - Vegetation no longer exists
- Where are the bare spots on school grounds?
- Why are these spots bare?
- How could we fix these areas?

- By fixing bare spots we will help to decrease pollution that could be contributing to the Chesapeake Bay

http://www.cbf.org/document.doc?id=29

- this is the link to the Fix Your Schoolyard Bare Spots workbook

# Fix Your Schoolyard Bare Spots




Chesapeake Bay Foundation
*Save the Bay*

## What Are Bare Spots?

Bare spots are places where vegetation (such as plants, shrubs, grasses, flowers) no longer exists in the soil. Bare spots come in all shapes and sizes. The outcome of having any type of bare spot is the same: stormwater hits the ground and is not able to soak into the land. Think about your school grounds. Where do you think you would find bare spots? The following are some common problem areas:

- heavily traveled foot paths
- underneath dense canopies
- drainage areas
- play grounds, playing fields
- slopes
- entrances/exits

You may not have the funds or permission to revamp your whole schoolyard, but this Chesapeake Bay Foundation step-by-step guide will help you identify problem areas and find solutions in order to slow, decrease, and improve the quality of stormwater runoff. The plans to fix bare spots in this guide are inexpensive and easy enough for most students to complete with minimal help from adults. Although this guide is specifically written with the schoolyard in mind, the projects would work just as well at a home, community center, religious center, or any other private property.

## Why Fix Bare Spots?

Did you know that during an average rainstorm (1 inch in 24 hours) more than 700 gallons of water run off the roof of a typical home? That's enough water to take 17 baths or 58 showers! Just imagine how much water might be running off the roof of your school on a rainy day. Virtually every school ground has a substantial amount of impervious surface (area that rainwater cannot soak into) that affects the quality of stormwater runoff. When rain runs off the roof or directly falls onto an impervious surface, it cannot soak into the ground and will eventually enter a storm drain or a nearby creek. This excess water (called runoff) causes the soil in its path to erode more rapidly than it would naturally. Gravity then causes this runoff to flow downhill and into the closest stream or other waterway, carrying with it nutrients, sediment, pesticides, fertilizers, and other pollutants it encounters along the way. *By intercepting stormwater with plants, trees, rocks, or mulch you can stop it from rapidly pushing the land into rivers and streams.* You just might make your school more attractive too!

*Scientists have found that nutrient and sediment pollution are the largest threats to water quality in the Chesapeake Bay watershed. Here is something you can do about it!*

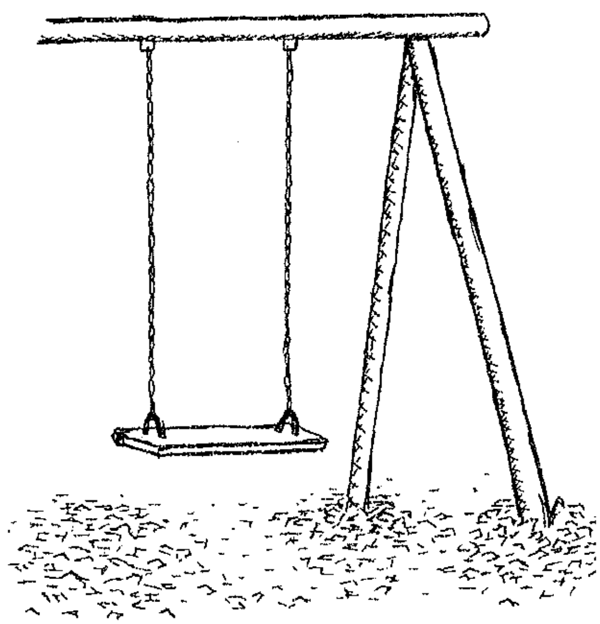
## Getting Started

Getting started isn't as difficult as you might think. Just follow these steps:

- First, get a teacher or adult leader involved. Ask if he or she would be interested in helping you and your fellow students with the project by providing advice, supervision, and support.
- Before you plant or place anything in your schoolyard, you will need to get the approval of the school administrators, such as your principal. It is also important to discuss your plans with the custodial staff at your school—they may even be able to help you and will probably want to approve the location of the project. Some schools have PTA members that are involved in making decisions about the schoolyard; if any such groups exist at your school, it would be a good idea to speak with them as well.
- Next, you will need to determine where your bare spots are located.

## Identify Your Bare Spots

INVESTIGATE! Identifying bare spots can be almost as much fun as fixing them. Don't forget, the trouble with bare spots is that they can't soak up water. This means it is best to investigate where your bare spots are when it is raining. Don't forget your raincoat! There are some great activities in the Chesapeake Bay Foundation's curriculum materials that can help you with your investigation — copies of two activities, *Schoolyard Report Card* and *Down the Drain*, are included in your packet. You might find it useful to complete one of these before you begin.



As you survey your school grounds, pay attention to where the water runs and where it is collecting. Any place that you can see fast-running water, puddles, or hard, bare soil with no vegetation is an indicator that you have a bare spot.

It is important to do detective work before you purchase any materials so that you can determine what you need. Each project in this guide is very different and so are the materials needed for each.

## Diagnose Why the Spot Is Bare

THINK! Once you have identified a bare spot, you then need to figure out why it is bare. This way you can solve your problem appropriately. For example, you wouldn't want to plant trees where people are trying to walk! Think about the following possible causes for a bare spot:

1. A lot of activity in this area causes the ground to be compact and bare (example: a walking trail or playground).

2. The area is susceptible to erosion (example: a slope).

3. The area is not exposed to enough sun for vegetation to grow.

4. Water constantly runs, falls, or collects in this area.

Which one fits best with the problem site you have found? There may be more than one reason you have a bare spot.

## Determine Your Solution

SOLVE! Now that you have decided the cause of your bare spot, you are ready to solve the problem. Look through this packet to determine which solution will work best for your schoolyard.

Bare Spots Projects

## Project: Mulch Your Bare Spots

**Problem 1:** A lot of activity in this area causes the ground to be compact and bare.

**Example:** Walking trail, playground.

**Solution:** Loosen the ground and add a layer of mulch.

## What is mulch?

Mulch is a material, such as bark, woodchips, and/or hay, used to cover the soil in order to suppress weeds, retain moisture, prevent soil erosion, and most importantly improve drainage!

## Budget Worksheet

| Materials | Quantity | Price Each | Total Price | Source |
|---|---|---|---|---|
| 1. Mulch | | | | |
| 2. Shovels, Rakes | | | | |
| 3. Measuring tape | | | | |

### Materials List:

- Bagged mulch or woodchips from a local gardening center or local town/city municipality—donated or buy ($0-3 per bag)
- Rakes—borrow or buy ($0-15 each)
- Shovels—borrow or buy ($0-20)

### Mulching Your Bare Spot

1. To determine the amount of mulch you need, measure the length and width of the bare spot.

2. Typically, mulch is measured in cubic feet and works best when applied at least three inches thick. To determine how much mulch you need, use this formula: *length x width x height*. Don't forget, all your units of measurement need to be the same. Here's an example:

> A plot that needs to be mulched has a length and width each of 10 feet. The mulch (height) needs to be spread 3 inches over the entire plot. Here's the right calculation:
>
> 10 ft x 10 ft x 3 inches/12 inches = 100 x $^{1}/_{4}$ = 25 cubic feet of mulch (3/12 comes from converting inches into feet: 12 inches in 1 foot)

3. With the help of an adult, buy your mulch—or you may even be able to have it delivered for free.

4. Using your shovels, turn over the top layer of soil that will be covered with mulch. Doing this will bring air to the soil and help rain to permeate the ground.

5. Now you can use your shovels to thickly spread the mulch (about 3 inches) over the entire area.

6. Rake the mulch so that it is evenly distributed and easy to walk on, especially if it is a highly used area. Be careful not to cover or harm nearby plants or trees.

### Maintaining Your Mulched Area

Bark and woodchip mulch will last for quite some time. You may want to check on it every four months to see if it needs to be refreshed with a new layer.

Bare Spots Projects

## Project: Create a No-Mow Zone

| | |
|---|---|
| Problem 2: | The area is susceptible to erosion. |
| Example: | A grass slope or edges of a parking lot, road, or stream bank. |
| Solution: | Create a "no-mow" zone. |

### What is a "No-mow" Zone?

A no-mow zone is an area of your schoolyard that is left to grow rather than be mowed.

Letting vegetation grow rather than cutting it down encourages the plants' roots to grow deep into the ground. This helps keep soil in place instead of letting it erode into a storm drain. A no-mow area can also attract wildlife and important pollinators for nearby plants and/or gardens.

### Materials List:

- Good detective skills
- A list of maintenance workers at your school
- Paper and pen or computer and printer
- Scrap wood (free at a local hardware store)


**Budget Worksheet**

| Materials | Quantity | Price Each | Total Price | Source |
|---|---|---|---|---|
| 1. Scrap wood | | | | |
| 2. Hammer | | | | |
| 3. Nails | | | | |
| 4. Acrylic paint | | | | |

- Hammer and nails (ask your maintenance workers at school)
- Acrylic, non-toxic paint ($5-$10 per can)

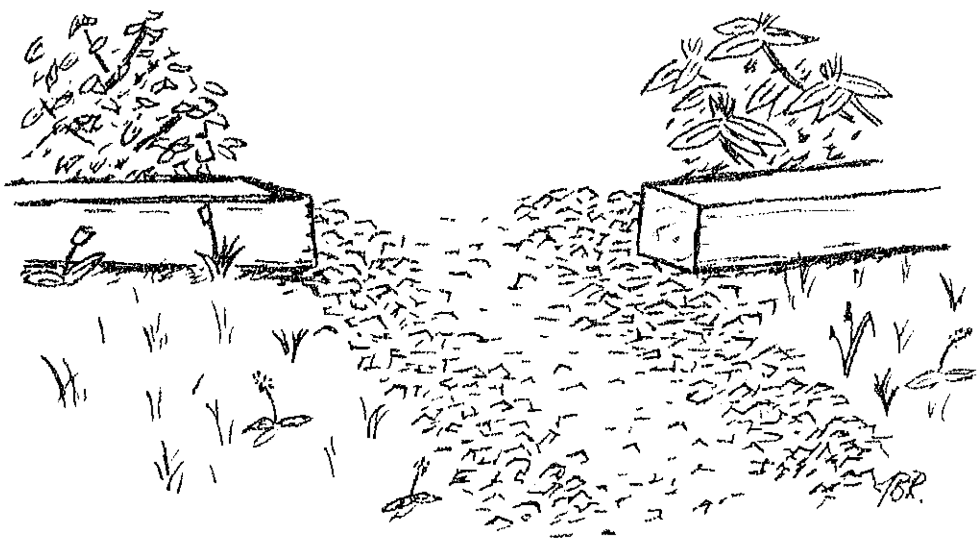
## Creating Your "No-mow" Area

1. Find those areas in your schoolyard that are mowed but don't need to be. Examples might include: grassy areas that are not used for anything, slopes or other areas that are difficult to keep mowed. Notice where the most wear and tear has happened due to walking or playing.

2. Choose a potential no-mow area that is both needed and practical (where erosion is obvious, but where long grass won't get in the way of foot traffic).

3. Talk to or write a letter to your school maintenance staff regarding information on no-mow areas and set up a time to show them the potential sites for vegetation growth. Explaining why a no-mow zone is important and can help the school.

4. Once you have permission and have reached an agreement with the maintenance staff, make sturdy signs out of wood and paint them so that you can inform and remind your school where the no-mow areas are located. (It is best not to play in these areas so that vegetation has the best possible chance to grow!)





## Project: Use Native Plants

| | |
|---|---|
| Problem 3: | The area is not exposed to enough sun for vegetation to grow. |
| Example: | Underneath or near tall or dense vegetation. |
| Solution: | Plant native, shade tolerant plants. |

### What Does Native Mean?

Native species are plants that evolved within a particular regional environment. For example, a coconut tree is native to the coast of Mexico, and an American Holly is native to the Chesapeake Bay watershed. Advantages of planting native species are that they need little maintenance, they support local pollinators and wildlife, and they will not compete aggressively with surrounding vegetation.

### What Does Shade Tolerant Mean?

When a plant is shade tolerant it means that it grows best in an area with little direct sunlight. Ferns in a forest are shade tolerant; they grow well underneath the tall canopy of trees. Your group can research native, shade tolerant plants on the Internet using the Helpful Resources at the end of this guide.

### Why Plant?

Planting vegetation in what was once bare soil can increase the quality of runoff coming from your schoolyard. Plants stop run-away soil from entering storm drains and help absorb excess nutrients.

### Materials List:

- PH kit—borrow from school, pool owner, or buy from pet store ($0-20)
- Shovels—borrow or buy ($0-$20 each)
- Trowels—borrow or buy ($0-$5 each)
- Topsoil—donated or buy (approx. $3 per bag)
- Mulch or straw—donated by farm or buy (approx. $5 a bale)
- Native plants—donated or buy (costs will vary depending on quantity and variety)

### Planting Your Shade Tolerant Natives

1. Read the instructions on your PH kit to determine how acidic your soil is. This will help you determine what kind of plants will best survive in this area.

2. After determining which plants would best suit your site, purchase your plants.

3. Dig holes for your new plants that are the depth of the root ball (the part of the plant that is in the pot) and at least twice as wide as the root ball. Most bought plants will have spacing instructions.

## Budget Worksheet

| Materials | Quantity | Price Each | Total Price | Source |
|---|---|---|---|---|
| 1. PH kit | | | | |
| 2. Trowels | | | | |
| 3. Shovels | | | | |
| 4. Topsoil | | | | |
| 5. Mulch or straw | | | | |
| 6. Native plants | | | | |

(Be careful not to take the plant out of its pot until you are ready to put it into the ground—otherwise the roots can dry out and become damaged).

4. Place your plants in the holes that you dug and replace the soil around the roots, being careful not to cover the stem. Press firmly with your hands to make sure the plant is securely in the ground.

5. Water your new plants. A watering can works best for new plantings. If you use a hose, be sure to water your plants gently.

### Maintaining and Caring For Your Plants

Because the native plants you chose can tolerate periods of dry weather, you won't need to water your plants unless it doesn't rain for a long time (two to three weeks). While your plants are still young and new to the area, it might be a good idea to check on their progress each week and make sure they are not getting stepped on. You could even paint a sign letting people know what the plants are and why they are important.

Bare Spots Projects

### Project: Create a Gravel Trench

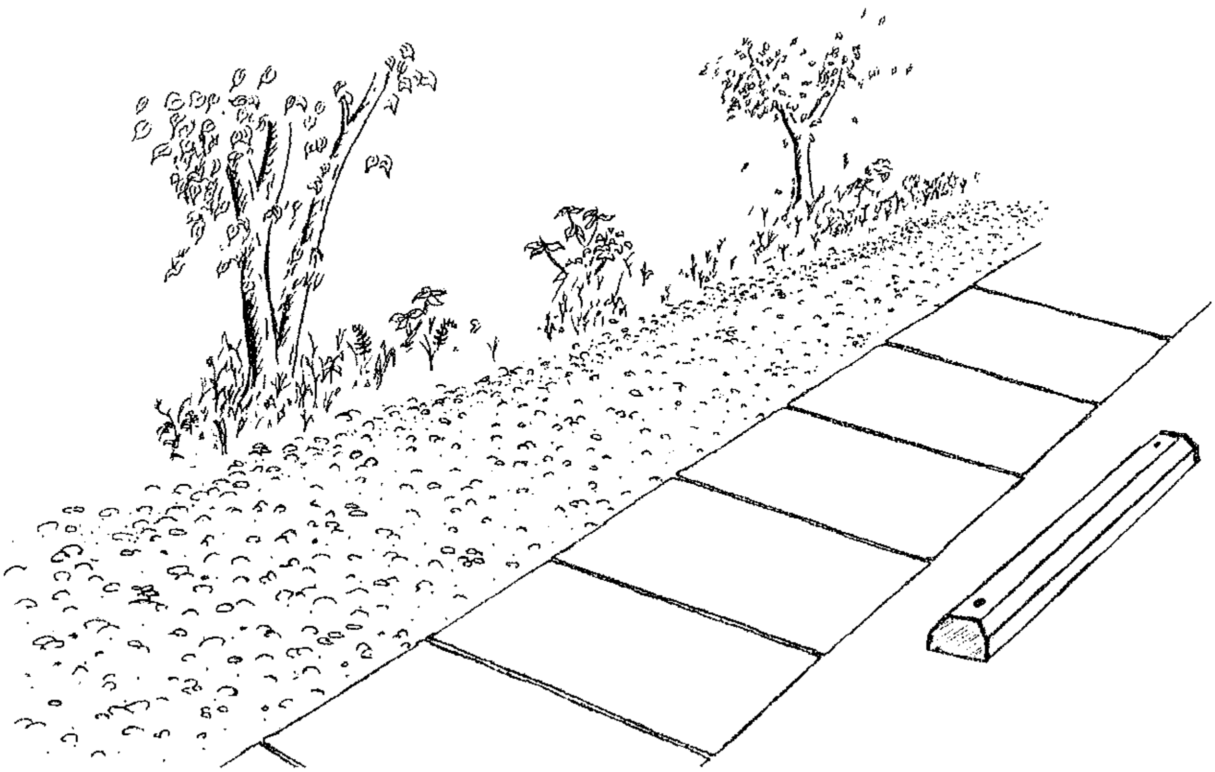
Problem 4: Water constantly runs, falls, or collects in this area.

Example: Drainage areas or alongside impervious surfaces.

Solution: Install gravel trenches along asphalt/impervious surfaces, such as walkways, roads, playgrounds.

## Budget Worksheet

| Materials | Quantity | Price Each | Total Price | Source |
|---|---|---|---|---|
| 1. Gravel | | | | |
| 2. Shovels | | | | |
| 3. Gloves | | | | |
| 4. Rakes | | | | |
| 5. Wheelbarrow | | | | |



## What Is a Gravel Trench?

A gravel trench is a long, dugout area filled with small stones or gravel. Ideally a gravel trench runs along an impervious surface such as a parking lot, sidewalk, or playground and also runs parallel to an area of vegetation on the opposite side. Together, the gravel trench and vegetation slow down and filter runoff from the impervious surfaces.

## Materials List:

- Gravel/small stones—donated, buy (approx. $3/per bag or less at a bulk rate)
- Shovels—borrow or buy ($20 each)
- Gloves—buy ($3-5 a pair)
- Rakes—borrow or buy ($15 each)
- Wheelbarrow—borrow or buy ($40-70 each)

## Dig Your Trench

1. Once you've located your problem area, measure to see how long your trench needs to be. Ideally it should run the length of your asphalt area.

2. You will need to determine how much gravel to buy using the formula for the volume of space your trench will take up (length x width x height = volume). Gravel is measured in cubic feet. Some schools have land use needs that will determine the width of your trench, but we recommend it be at least 12 inches wide and approximately 6 inches deep. You may want to talk to the maintenance staff at your school to discuss the width of your trench.

(12 ft x 1 ft) x (6 in x 1 ft/ 12 in) = 12 x $^1/_2$ = 6 cubic feet of gravel (length x width) x height = volume

3. Now it is time to dig the area for your gravel trench. The soil you dig up can be transferred to a garden or a well-vegetated area of your schoolyard (ideally you will be able to use it for a vegetated area that runs alongside your trench). It is best not to leave the soil in piles, as it will get washed down the storm drain in the next rainstorm.

4. Fill your trench with gravel using your hands, shovels, and/or wheelbarrow. Fill the trench so that you leave about $^1/_2$ inch below the edge so that rocks do not spill onto the nearby land and become a tripping hazard. Also, water can easily filter throughout the whole system this way.

5. A strip of vegetation, no less than 2 feet, should grow on the other side (the non-asphalt side) of the gravel trench to absorb any water that flows through the gravel. One option is to create a no-mow zone along this strip. If you want to get really creative, you could create a wild meadow area with native wildflower seed or plant native shrubs or trees in this area.

### Maintaining and Caring for Your Gravel Trench

For the most part, your gravel trench will take care of itself. However, it is not a bad idea to check on the trench every couple of weeks to make sure it is evenly spread and that any stray rocks are put back into the trench. A rake might help you keep your trench in good condition.

## Funding Your Project

There are many ways to get funding for all of the things you will need. For example, you could hold a fundraiser at your school, or you could ask your principal if there is money in the school's budget. You could also write a grant requesting money from a funding organization. Below is a list of organizations that offer grants to students, teachers, and school groups.

**MARYLAND**
Chesapeake Bay Trust
www.chesapeakebaytrust.org

**WASHINGTON, D.C.**
Garden Resources Of Washington (GROW)
1419 V St. NW
Washington, DC 20009
202.234.0591 fax: 202.234.0592

Dept. of Health-Watershed Protection Division
51 N. St. NE
Washington, DC
202.535.2239

**PENNSYLVANIA**
PA Bay Education Office
4999 Jones Town Rd. Suite 203
Harrisburg, PA 17109
717.545.8878

League of Women Voters, Water Resources Education Network
226 Forester St.
Harrisburg, PA 17102
800.692.7281
www.pa.lwv.org/wren

**VIRGINIA**
Virginia Environmental Endowment
1051 East Cary St. Suite 1400
PO Box 790
Richmond, Virginia 23218-0790
http://freenet.vcu.edu/vee/mini.htm

## Helpful Resources

Alliance for the Chesapeake Bay
http://www.acb-online.org/bayscapes.htm
410.377.6270

BayScapes Program
US Fish and Wildlife Service
Annapolis, MD 21401
410.573.4581
www.fws.gov/r5cbfo/bayscapes.htm

Environmental Concern, Inc.
PO Box P, 210
W. Chew Ave.
St. Michaels, MD 21663
410.745.9620
www.wetland.org

Maryland Native Plant Society
www.mdflora.org

Native plants for Conservation, Restoration, and Landscaping
http://www.dcr.state.va.us/dnh/native.htm

Your Local Yellow Pages

Gardening Supply Centers

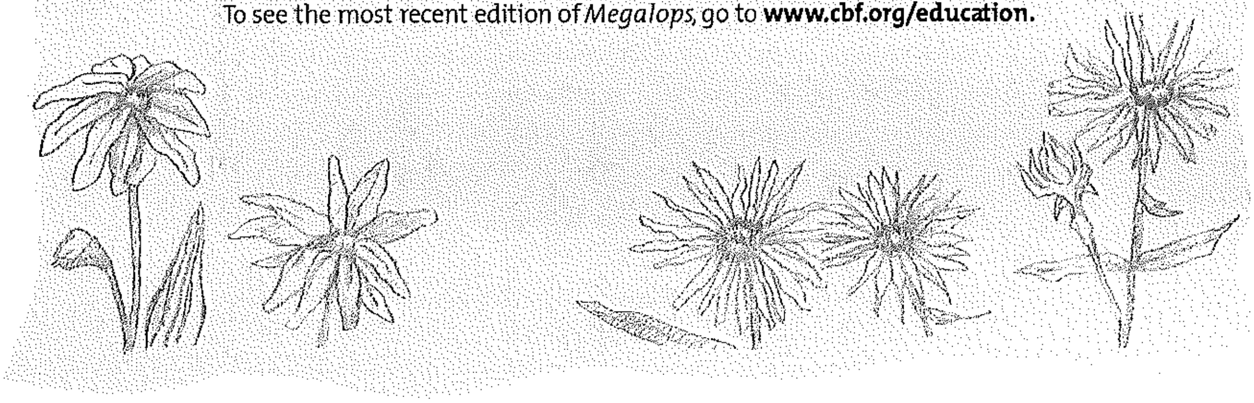
Town or City Works Department

Local Landscaper, Gardener, or Farmer

**Congratulations!** You are now ready to go out and rid your school grounds of bare spots! Because of your project, less nitrogen and sediment will enter the Chesapeake Bay. This has the direct effect of improving water quality. If you would like to write an article about your project, please submit one to the Chesapeake Bay Foundation's *Megalops* quarterly student newsletter.

The *Megalops* is a web-based newsletter that highlights student leadership and action around the Chesapeake Bay watershed.

To see the most recent edition of *Megalops*, go to **www.cbf.org/education.**



CHESAPEAKE BAY TRUST

This publication was funded in part by the Chesapeake Bay Trust, www.chesapeakebaytrust.org, a private, non-profit organization that seeks to promote public awareness and participation in the protection and restoration of the Chesapeake Bay and its Maryland tributaries.

Arlington Echo Outdoor School contributed technical knowledge to the publication of this guide.

*Illustrations by Jeff Rogge.*

## Identifying Bare Spots Worksheet

| Site Number | Investigation | Diagnose | Solve |
|---|---|---|---|
| Example | Where is the problem area? Name the site | Why is there a problem? How is the area used? | What solutions would fix this problem? |
| Site #1 | Playground | A lot of activity here has caused the ground to be compacted and bare. When it rains, muddy puddles form in some areas, and a stream of mud drains into the nearby sewer. | By loosening the soil, water would be able to sink into the ground. Adding a layer of mulch on top of the soil would help stop the loosened soil from flowing into the sewer when it rains. Gravel would work too, but it would hurt if you fell on top. The sewer is far enough from the playground that we could put gravel around it. |
| Site #2 | | | |
| Site #3 | | | |
| Site #4 | | | |

## Choosing and Completing Your Project Sheet

Project: (Example) Loosen the soil and add a layer of mulch to the playground.

Project:________________________________________

| Tasks | Who does this? | By when? | Date task was completed? |
|---|---|---|---|
| Get an adult leader and school staff approval | | | |
| Create a budget | | | |
| Find a source of money for your project | | | |
| Set a date or timeline for project completion | | | |
| Find people to help complete the project | | | |
| Get materials | | | |
| Do the project! | | | |
| Share the results (ex. Megalops, school newspaper, local newspaper, local TV) | | | |

Chesapeake Bay Foundation
Headquarters
Philip Merrill Environmental Center
6 Herndon Ave., Annapolis, MD 21403
410/268-8816
410/269-0481 (from Baltimore metro)
410/261-2350 (from D.C. metro)

Maryland Office
Philip Merrill Environmental Center
6 Herndon Ave., Annapolis, MD 21403
410/268-8833
410/269-1870 (from Baltimore metro)
301/261-1131(from D.C. metro)

Pennsylvania Office
The Old Water Works Building
614 North Front St., Suite G,
Harrisburg, PA 17101
717/234-5550

Virginia Office
Capitol Place, 1108 E. Main St.,
Suite 1600
Richmond, VA 23219
804/780-1392

Anacostia River Office (DC)
202/544-2232

Hampton Roads Office (VA)
757/622-1964

Salisbury Office (MD)
410/543-1999

Website: www.cbf.org
E-mail: chesapeake@cbf.org
Membership Information:
1-888-SAVETHEBAY

## Daily Plan 7

**Title:**

Nitrogen in Our Soil and Lives

**Instructional Area:**

Smarter Farming Techniques and Alternative Energy Production using Nitrogen

**Situation:**

This plan will emphasize smarter farming techniques along with details about better management practices (BMPs) as encouraged by the REAP program. Also included will be a short section on biogas and the opportunity for farms (especially CAFOs) to create a new fuel source to run various farm implements. This plan will be mainly lecture based with a PowerPoint. It is important that students learn to pay attention in a class that is not forcing the students to be fully engaged. This plan also allows for the students to do independent or group research on a related topic. The students will write  paper and give a presentation. Their peers will critique them on their presentation.

**PA Academic Standard(s) Met:**

4.2.10

4.4.10

4.8.10

**Materials Needed:**

Computer

Projector

Handouts

**Interest Approach:**

This plan does not have a unique interest approach but will rely on the teacher's ability to engage the class using the PowerPoint to convey the information in an interesting manner. Once again it is crucial that the students master the ability to learn material in a lecture atmosphere. The students will also have a chance to do research of their choosing.

**Objectives:**

1. To be successfully and clearly convey smart farm practices using Best Management Practices (BMPs).
2. To teach the students about the biogas practice and the ability for farms to do something productive and economically beneficial for themselves.
3. To instill in the students the need to be able to learn form a basic lecture from a basic lecture class that does not directly and constantly engage them.
4. To teach the students how to do independent or group research on an assigned topic.
5. To allow the students the chance to practice their public speaking skills.

**Content:**

**Teacher Will Do:**

1. Teacher walks in and turns on projector to present PowerPoint.
2. Teacher starts the presentations and goes through the slides.
3. Teacher hands out information on how to do the project.

**Teacher Will Say:**

1. Today we will be looking at smarter farming techniques as well as best management practices (BMPs) mentioned by the REAP program. We'll also look at biogas production.
2. Teacher goes through the slides and refers to the notes included with the PowerPoint.

3. We will be working on this project during class and outside of the class. I will assign you or your group a topic. This project will consist of a paper and presentation.

**Review / Conclusion / Opportunity to Learn:**

1. The objective of the class was to teach the students about smarter farming practices as a result of using certain aspects of the Nitrogen Cycle on an agricultural land. Better Management Practices (BMPs) will also have been examined.
2. To have introduced the idea of biogas to the class and the idea that manure does not only have to be used strictly as fertilizer, but also as a power source.

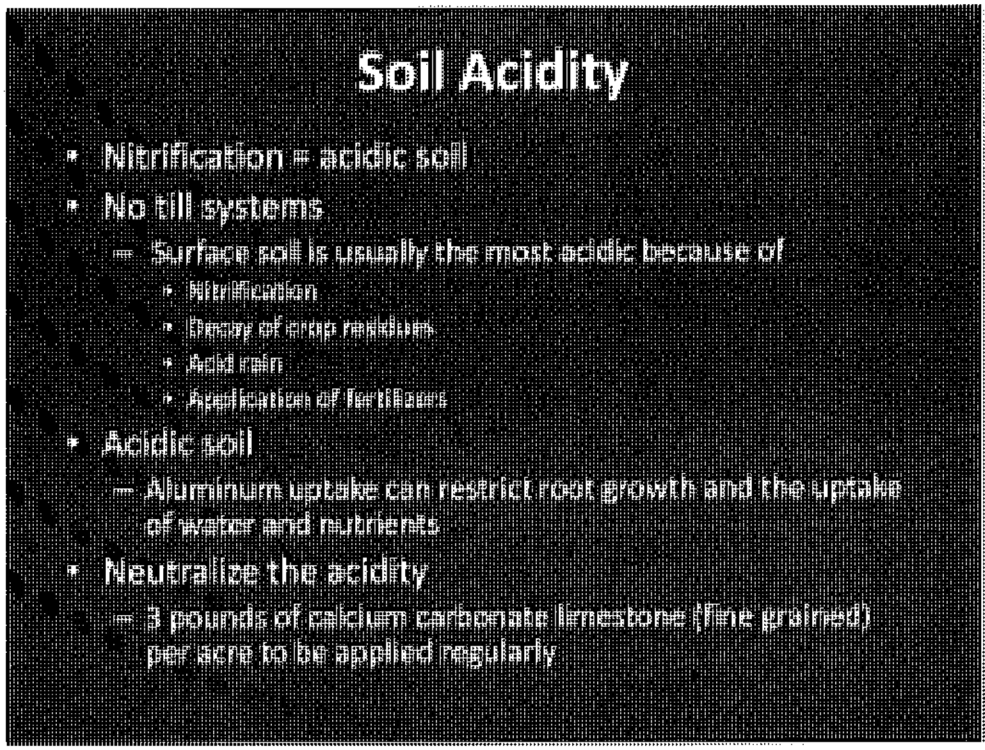
3. This class was designed as a lecture because students need to have the skills to learn from a less engaging lecture class.
4. This class was designed to allow students to work during class time and outside of the classroom on a project in either a group or on an individual basis. This project also allowed students to practice public speaking and give constructive criticism of their peer's public speaking abilities.

# Smarter Farming Techniques and Alternative Energy Production using Nitrogen

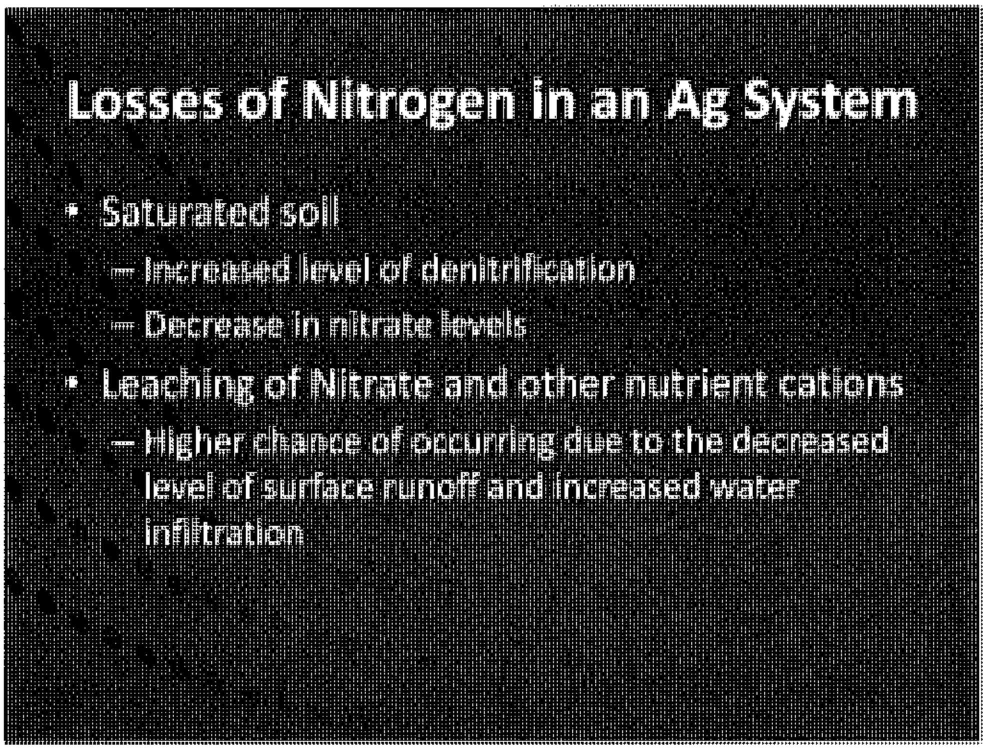
# Conservation (No) Tillage vs. Conventional Tillage

| Conservation Tillage | Conventional Tillage |
|---|---|
| Decreased Erosion due to Crop Residue | Increased Erosion due to lack of Crop Residue |
| Lack of Incorporating Fertilizers and Manure | Thorough Incorporation of Fertilizers and Manure |
| Increase of Microbial Activity | Decrease of Microbial Activity |
| Increase of Water Infiltration | Decreased Water Infiltration |
| Stratified Nutrient Levels and pH | Mixed Nutrient Levels and pH |
| Roots Concentrated Near Surface | Roots Uniform throughout Rooting Zone |
| Lower Soil Temperatures | Higher Soil Temperatures |
| Increased Chance for Increased Denitrification | Normal Chance for Increased Denitrfication |

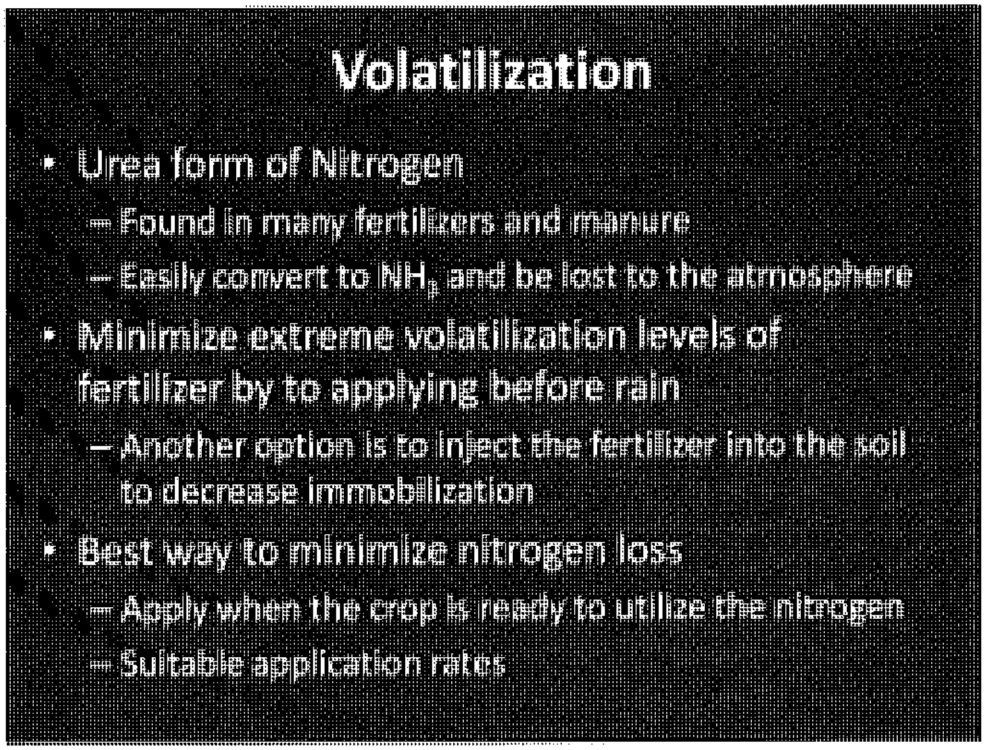
- Increase / Decrease of Microbial Activity
    - This will influence Nitrogen behavior
- Water Infiltration
    - Increased = increased leaching
    - Decreased = decreased leaching
    - Leaching = Removes beneficial and harmful materials from the soil by filtration
- Who remembers what denitrification is?
    - Loss or removal of nitrogen



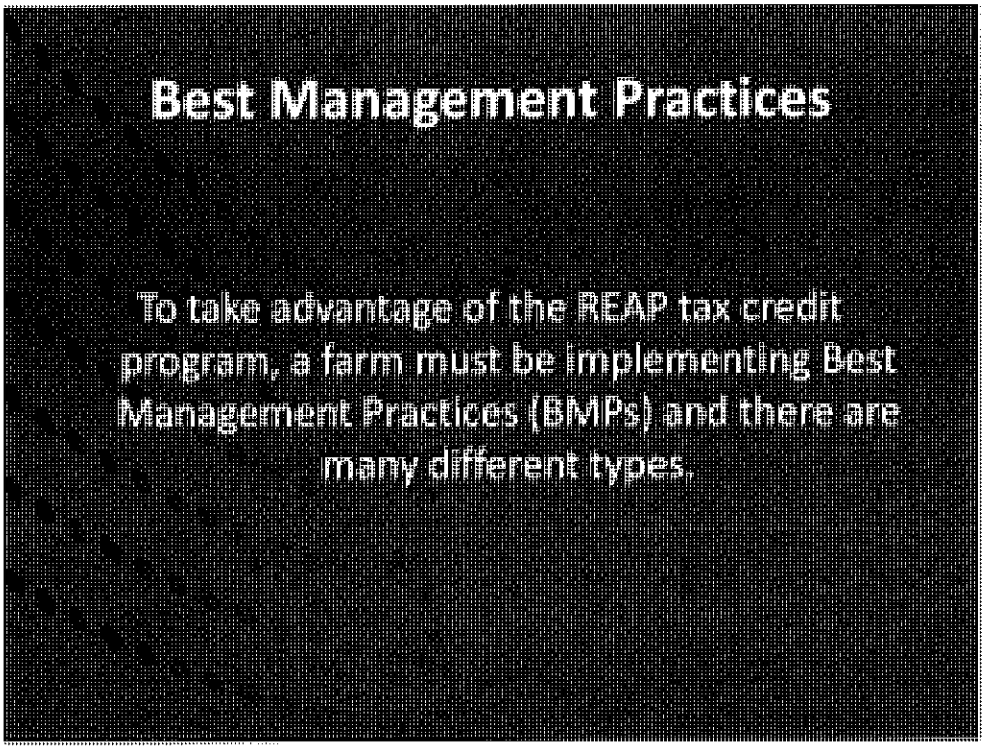

- Who remembers what nitrification is?
    - Oxidation of ammonium into nitrite and then into nitrate by microorganisms




- Saturation
  - Occurs when the soil cannot hold anymore water



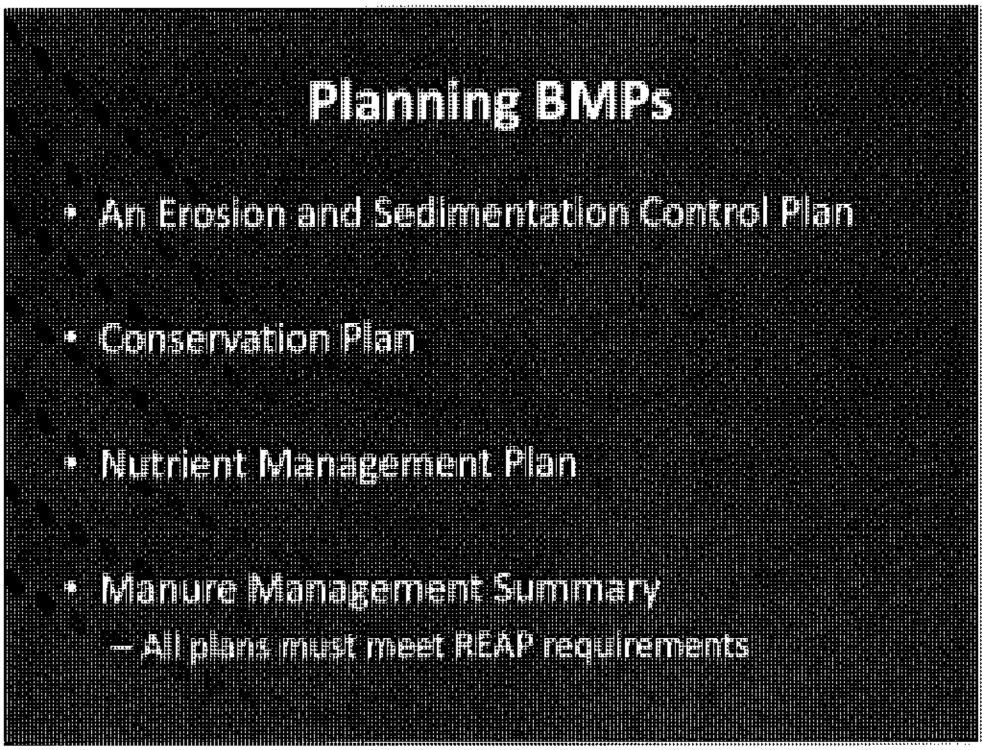

- Ammonia Volatilization
    - Ammonia gas is lost from the soil and returns to the atmosphere
    - Nitrogen usually in the form of Urea
- Causes
    - Occurs when soil is moist and warm and urea is close to or on the soil surface
    - Can take place on alkaline soils
- Prevent
    - Manure and urea fertilizers applied with cool temperatures or right before rain
    - Physically mix into soil
- Impact
    - Net loss of Nitrogen from soil system




- Best Management Practice
    - -BMP
    - -Timing, rate and method of application
- -REAP
    - -Resource Enhancement and Protection
    - -Earn tax credit in place of having BMPs
    - -Eligible applicants may receive between 50% and 75% of project costs as state tax credits for up to $150,000 per agricultural operation
    - -To be eligible for REAP need
        - -Current Plans
        - -Properly protected barnyards
        - -Fully implemented crop field and BMP

# Steps to BMP

- Have your soil tested
- Follow soil test recommendations
- Set realistic yield goals
- Choose the most suitable nitrogen source
- Apply nitrogen and phosphorus correctly
- Time nitrogen applications appropriately
- Use manure as a nutrient source
- Control erosion
- Manage water flow
- Fence animals away from streams, drains and critical areas




-Erosion and sedimentation control plan

-Important for when clear vegetation and have topsoil exposed

-Conservation plan

-Manage natural resources on the farm

-Soil, water, air, animals and plant resources

-Nutrient management plan

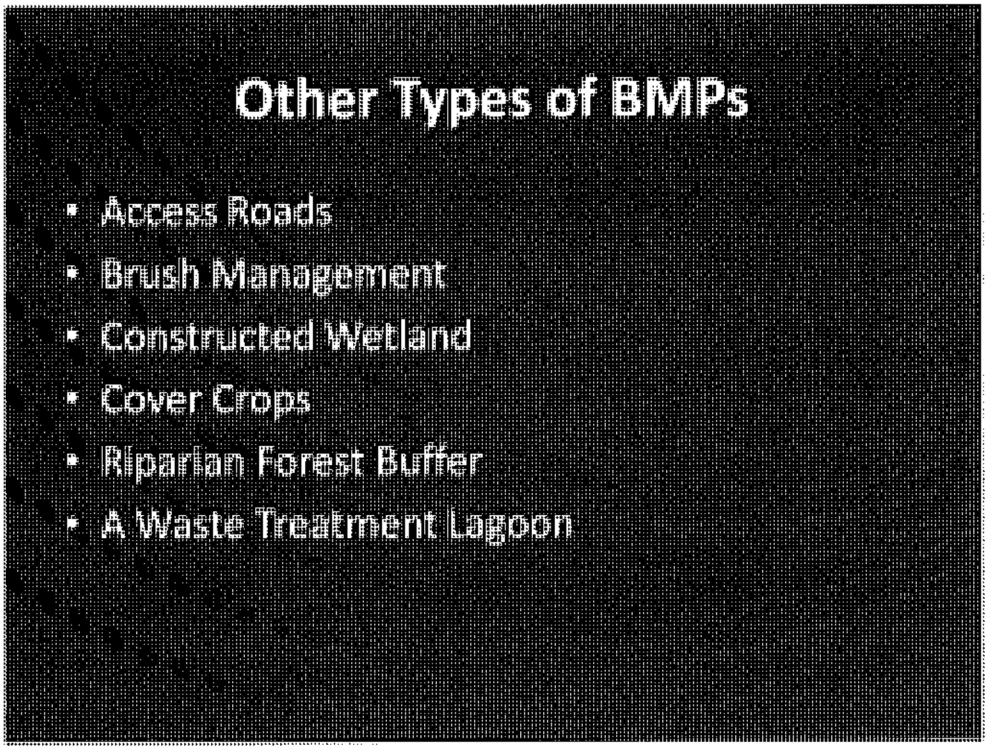
-Managing the amount, source, placement, form and timing of the application of nutrients

-Manure management summary

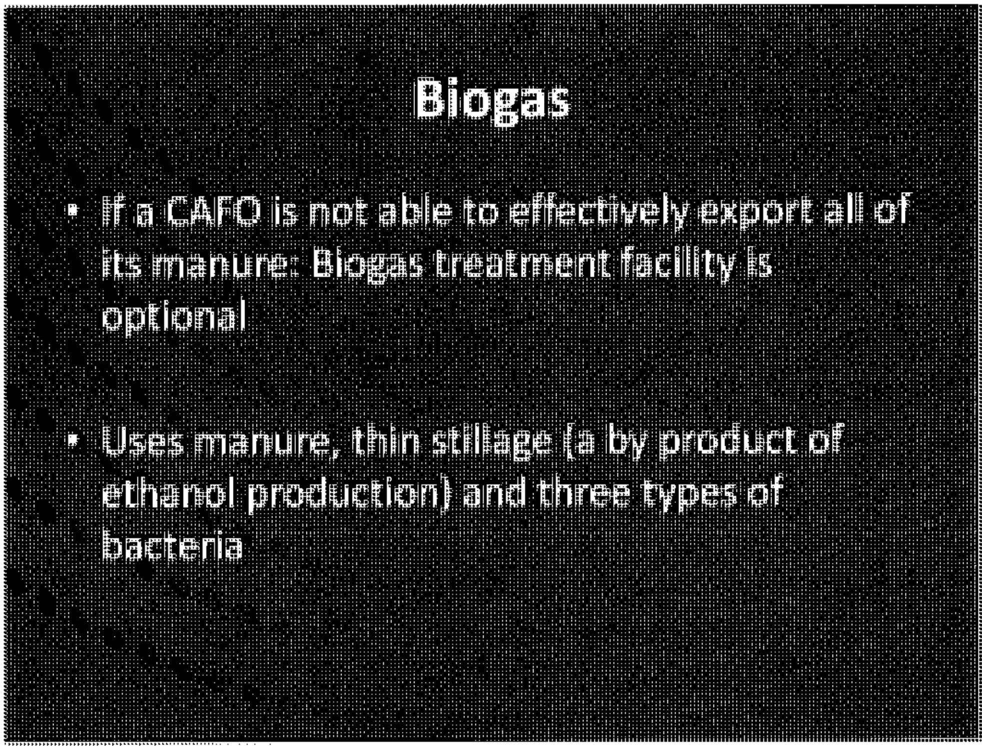
-Managing amount, source, timing and placement of manure application

# Equipment BMPs

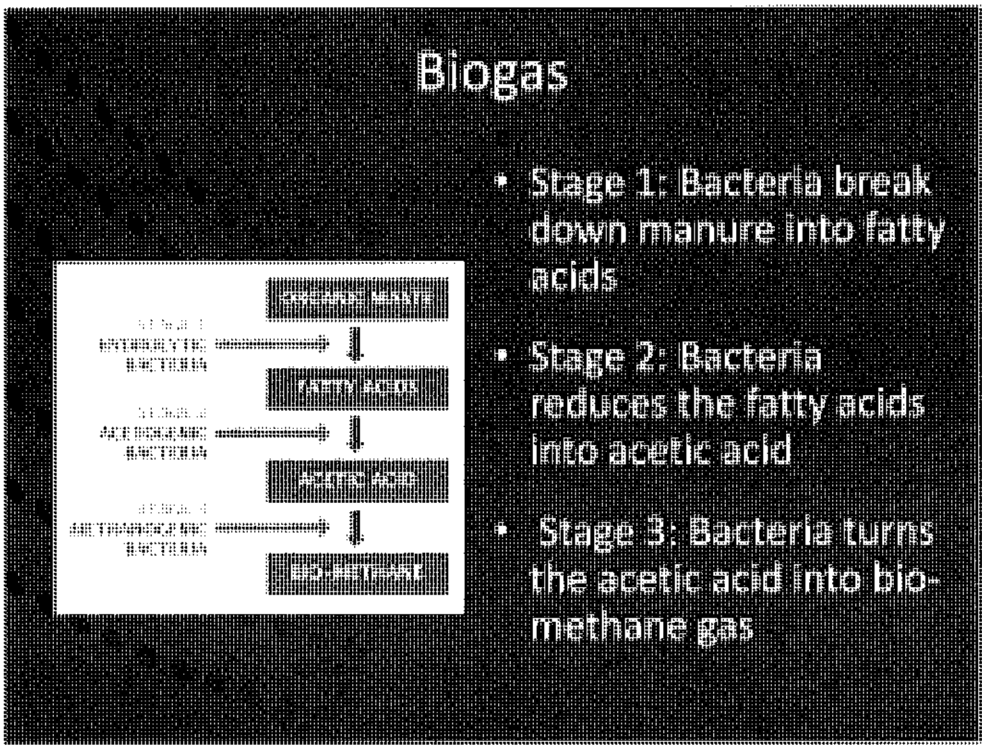
- Composting Equipment
  - Will provide another source of fertilizer for crops
- Manure Equipment
  - Equipment for Manure Incineration, Incorporation, and Separation
- No Till or Conservation Tillage Equipment




- Access roads can be built so that a certain BMP can be carried out
- Brush management
  - Removal, reduction, or manipulation of non-herbaceous plants
  - May be used as part of the conservation plan for a BMP
- Constructed wetlands
  - Used to decrease water pollution from point and non-point sources
- Cover Crops
  - Crops planted to manage soil fertility, soil and water quality, weeds, pests, diseases, biodiversity and wildlife
- Riparian Forest Buffer
  - Most trees and shrubs adjacent to and up-gradient from water bodies
  - Improve riparian habitat, decrease runoff into water, etc.
- Waste Treatment Lagoon
  - Waste treatment made by constructing an embankment or excavating a pit
  - Treat waste (ie manure) and decrease pollution potential




- CAFO = concentrated animal feeding operations
- Biogas
  - Gaseous fuel produced by fermentation of organic matter
  - Anaerobic digestion of agricultural and animal wastes
    - Anaerobic digestion – microorganisms breakdown in the absence of oxygen
  - Mostly methane


Biogas
• Stage 1: Bacteria break down manure into fatty acids
• Stage 2: Bacteria reduces the fatty acids into acetic acid
• Stage 3: Bacteria turns the acetic acid into bio-methane gas

## Biogas

- The byproduct of this process enters a nutrient recovery process and becomes a natural fertilizer than can still be exported by the CAFO
- CAFO has essentially free fuel that it can use to power portions of its farm

**Research Project**

1. Choose a group or work on an individual basis
   - No more then 3 people in a group

2. Pick a topic
   - We have touched the surface of these topics in class, so take a few days to research further on the topic and choose a topic you feel you would enjoy researching the most. Make sure to choose to your top 3 topics incase your first choice is reserved by another student.
   - Inform me of your topic by **(insert date)**
   - **Note:** No repeat topics, everyone must choose something different

3. Research information about your topic
   - We will be going to the library or computer lab on **(insert date)** during the class period. During this time you will find information about your topic including but not limited to:
     - Background information
     - Important dates
     - Explanations of how your BMP works
     - How this technique would be implemented on a farm
     - Experience you may have had with this topic

4. Presentation
   - We will be giving our presentations in class on **(insert date(s))**. You may present your project as either as poster, PowerPoint, or any other creative way that you feel may fit your topic. If you choose to do a PowerPoint, a copy must be sent electronically to me.
   - Your presentation must be 3-5 minutes in length.
   - During your presentation, your peers will be critiquing you. As an individual student, you will be receiving a grade on this critique.
   - Be prepared to answer questions asked by myself or other students.

5. Paper
   - If you work in a group, you may submit one paper that you all contributed to. The paper should include the following:
   - A maximum of 5 pages
   - Double spaced
   - Size 11-12
   - Times New Roman or Cambria or Calibri
   - References written in MLA, including in-text citations

## Topic List

Conservation Tillage

Conventional Tillage

Soil Acidity

Volatilization

REAP tax credit program

Erosion and Sedimentation Control plan

Conservation plan

Nutrient management plan

Composting equipment

Manure Equipment

Brush management

Constructed wetlands

Waste treatment lagoon

Cover crops

Riparian forest buffer

Biogas

CAFO's

**Student Presentation Evaluation Form**

Your Name:______________________________ Date:__________

Presenter Name(s): ______________________________

Topic: ______________________________

*Scale:* 5 = Excellent, 4 = Good, 3 = Satisfactory, 2 = Needs Improvement, 1 = Poor

A. Clearly communicates the subject matter 5 4 3 2 1
- Few um's, uh's, etc.
- Has practiced
- Good pace (not to fast or slow)
- Effective use of note cards (does not often use)

B. Eye Contact 5 4 3 2 1
- Looks at whole class

C. Uses visuals appropriately 5 4 3 2 1
- Easy to see
- References during presentation
- Does not read off of it

D. Is knowledgeable of topic 5 4 3 2 1
- Answers questions
- Gives thought to answers

E. Presentation is informative 5 4 3 2 1
- Did it have a clear focus
- Did you learn something new?

F. Organization / Clarity 5 4 3 2 1
- Easy to follow
- Flow

G. Constructive criticism / compliments: ______________________________

______________________________

______________________________

______________________________

______________________________

## Daily Plan 8

**Title:**

Nitrogen in Our Soil and Lives

**Instructional Area:**

Ammonium and Nitrogen in Our Local Soils

**Situation:**

The students will be instructed to use techniques that are used by soil scientists. The techniques are used with soil samples to determine the values of ammonium and nitrates. The teacher will have a proven set of standards with which to create a curve in order to read the students samples. One third of the students will have samples from urban sites (such as their front yard, or school grounds), one third from agricultural sites (conventional or no till), and one third from forested sites. The students will prepare their sample on their own after being given clear instructions. The teacher will assist students as necessary. The students will also learn how to write an official lab report.

**PA Academic Standard(s) Met:**

4.3.10

4.4.10

4.6.10

4.8.10

**Materials Needed:**

See Lab Directions for lab materials needed

Handout for students to use during lab

Projector

Computer

**Interest Approach:**

The students will be interested in the results of this experiment because they prepared these samples. If everything runs accordingly, the students will see useful data results from their samples and they will be able to learn the differences between the different land types.

**Objectives:**

1. To have the students gain valuable experience using techniques that soil scientists use.
2. To show soils in their own backyard can tell them something about the nitrogen cycle.

**Content:**

**Teacher Will Do:**

1. Teacher walks in and checks each student to confirm that each has a suitable sample.
2. Teacher hands out directions that detail how the students are to prepare their samples.

**Teacher Will Say:**

1. Today we will be working to find out how much nitrate and ammonium is in the soils that you collected. Place your sample on your desk so I can take a quick look at them.
2. Now to prepare your samples, please read these handouts. All the materials you will need are located in the back

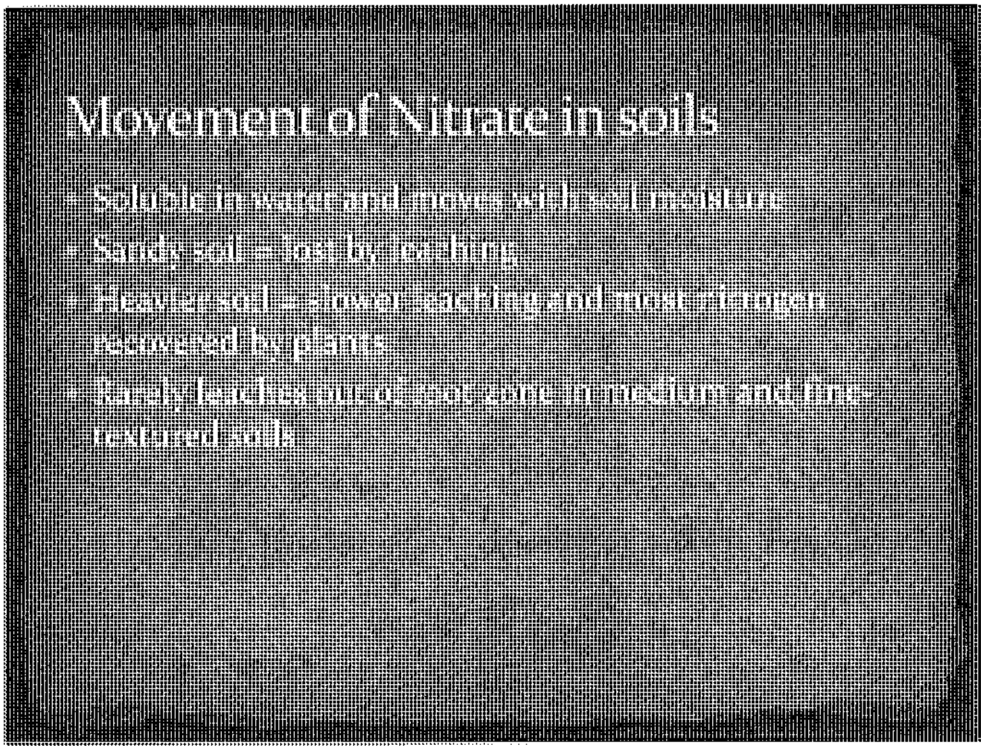
**Review / Conclusion / Opportunity to Learn:**

1. The students will have gained valuable hands-on experience with a technique used by many soil scientists.
2. The students will have learned the differences among the land types by examining the levels of ammonium and nitrates.
3. One level of assessment is to have the students write a lab report about their findings.


Ammonium and Nitrogen in Our Local Soils

# Nitrate in Soils

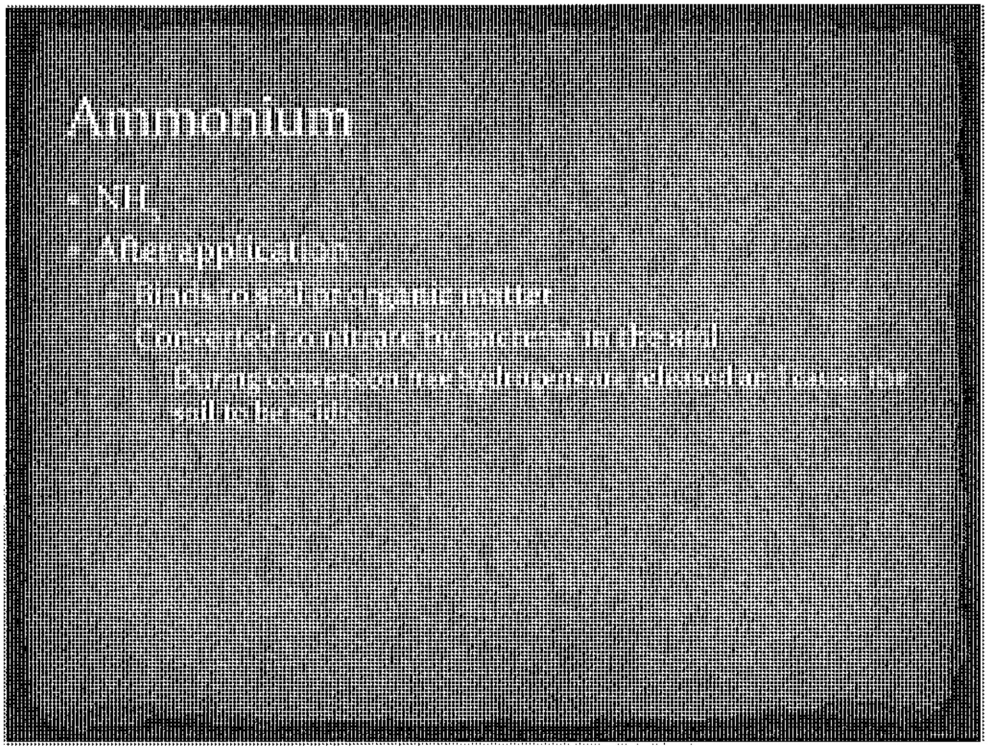
- Nitrogen
  - Important for growth and reproduction in plant and animal life
  - Basic constituent of proteins
- Nitrate
  - $NO_3$
  - Natural material in soils
  - More than 90% of nitrogen absorbed by plants in Nitrate form
  - Most of non-protein nitrogen fraction
  - Important in animal production and in human food
    - Potential toxicity when excessive amounts ingested




- Leaching
    - Soluble chemical or mineral drains away from the soil

# Nitrate in Plants

- Nitrate under normal growing conditions rapidly reduced to intermediate compounds and converted to amino-nitrogen
- Nitrate reduction occurs in aerial portion and roots of plants


Ammonium
$NH_4$
After application
Binds to soil or organic matter
Converted to nitrate by bacteria in the soil
During conversion the hydrogens are released and cause the soil to be acidic

# Soil Testing

- Elements are chemically removed from soil and measured
  - Show when have too little or too much of a nutrient
- Plant growth increased by showing fertilizer recommendations

# Taking A Good Soil Sample

- Correct timing
- Clean sampling equipment
- Sample each unique area separately
- Take soil core to the appropriate depth
- Mix sample cores well
- Label and package sample correctly

# Soil Lab Directions

## Nitrate-Nitrogen Quick Test

Supplies

1. Two 50 mL centrifuge tubes
2. 5.6 grams of Calcium Chloride
3. One gallon of distilled water
4. Merckquant Nitrate test strips

Procedure

1. Collect 8-10 random samples from the field. Core samples should be at a depth of 12", do not include top 2" of soil. Mix samples thoroughly.
2. Fill tube to 30 mL level with calcium chloride solution.
3. Add soil until level rises to 40 mL. Cap tube and shake vigorously. Let sit to settle the particles.
4. When solution is clear, dip test strip into solution, shake off excess, and wait 60 seconds.
5. Compare strip to color chart.
6. Run the test again.

Interpretations / Calculations

1. Test strips measure $NO_3$ in parts per million (ppm).
2. Use the following formula to approximate conversion of reading to ppm for dry soils.
    a. Test strip reading (ppm $NO_3$) / correction factor = ppm $NO_3$ in dry soil
    b. Correction Factors

| Soil Texture | Moist Soil | Dry Soil |
|---|---|---|
| Sand | 2.3 | 2.6 |
| Loam | 2 | 2.4 |
| Clay | 1.7 | 2.2 |

    c. Example
        i. Test strip reading = 30ppm
        ii. Soil texture = sand
        iii. 30 / 2.3 = 13.04 ppm

3. Use the number generated to convert Nitrate-N in the soil to existing pounds of available nitrogen / acre in a 12" sample. Multiply the number obtained in step 2 by 4.
    a. Example
        i. Step 2 # = 13.04
        ii. 13.04 * 4 = 52.16 pounds of nitrogen / acre available to crop
    b. Note
        i. If your soil sample was only taken at a depth of 6", you will need to multiply by 2.

## Ammonia Nitrogen Test

Supplies

1. Transfer pipet
2. Extraction tube x2
3. Universal Extract Solution
4. Ammonia Test solution x2
5. Plastic soil measure
6. Filter paper
7. Plastic funnel
8. Spot plate
9. Ammonia Color Chart

Procedure

1. Extraction Procedure
    a. Fill extraction tube to 14 mL line with extracting solution
    b. Use plastic soil measure to add 2 level measures of soil to the tube. Cap and shake for 1 minute.
    c. Use filter paper and plastic funnel to filter soil solution. Catch filtrate in a second extraction tube.
2. Ammonia Nitrogen Test
    a. Use transfer pipet to transfer 4 drops of general soil extract (filtrate) to one of the large depressions in the spot plate
    b. Add one drop of ammonia test solution
    c. Stir with clean stirring rod. Allow stand for 1 minute.
    d. Run the test again.

Results

1. Compare color in tube with Ammonia color chart.
    a. Values converted to ppm
        i. Very low = 0-5 ppm
        ii. Low = 5-10 ppm
        iii. Medium = 40 ppm
        iv. High = 100 ppm
        v. Very high = 150 ppm

# Soil Lab Worksheet

## Nitrate-Nitrogen Quick Test

1. Your test strip reading:
   a. Test 1 =

   b. Test 2 =

2. Conversion outcome:
   a. Test 1 =

   b. Test 2 =

3. Pounds of available nitrogen
   a. Test 1 =

   b. Test 2 =

## Ammonia Nitrogen Test

1. Color of tube
   a. Test 1 =

   b. Test 2 =

2. Ammonia color chart
   a. Test 1 =

   b. Test 2 =

3. Ammonia Values
   a. Test 1 =

   b. Test 2 =

Name
Date
Class
Teacher

# Title

**I. Introduction**

This section should provide background information about the lab. For instance for this lab, this section should include information about soil tests, Nitrates and Ammonium.

**II. Purpose**

This section states what your experiment attempts to do. You should also include how you expect the lab to turn out, or your hypothesis.

**III. Materials**

List the materials you used in a bulleted format.

**IV. Procedure**

This is a step-by-step explanation of how you carried out the experiment. Write the steps in order as a paragraph.

**V. Results**

List the data you collected in paragraph form.

**VI. Analysis**

Describe what happened during the experiment and if the results turned out as you expected. Explain any problems or complications. Include and make any reference to any tables, graphs, or charts here.

**VII. Conclusion**

Talk about the significance of the results. Apply experiment to real life by discussing any issues, problems or information related to your findings.

**VIII. References**

Make sure to include an MLA or APA (depending on your teacher's preference) reference list and in-text citation.

| Item | Place | Phone number |
|---|---|---|
| ***Nitrate Lab*** | | |
| Nitrate Test Strips | Ben Meadows | 1-800-241-6401 |
| Calcium Chloride | VWR Scientific | 1-800-932-5000 |
| Centrifuge Tubes | VWR Scientific | 1-800-932-5000 |
| Soil Probe | JMC Soil Investigation Equipment | 1-800-247-6630 |
| | Ben Meadows | 1-800-241-6401 |
| ***Ammonia Lab*** | | |
| Transfer Pipet | LaMotte | |
| Extraction Tube | LaMotte | |
| Ammonia Test Solution | LaMotte | |
| Universal Extract Solution | LaMotte | |
| Plastic Soil Measure | LaMotte | |
| Ammonia Color Chart | LaMotte | |
| Spot Plate | LaMotte | |

| Catalog / Part # | Price |
|---|---|
| Catalog # 4JB-7830 | $50/100 strips |
| Part # JT1332-1 | $55 / 500 grams |
| Part # 20171-034 | $103 / 500, 50 mL tubes |
| Part # 031 | $60 |
| Catalog # 4JB-220106 | $68 |
| Part # 0364 | |
| Part # 0704 | |
| Part # 5103 | |
| Part # 5173 | |
| Part # 0819 | |
| Part # 1302 | |
| Part # 0159 | |

**Daily Plan 9**

**Title:**

Nitrogen in our Soils and Lives

**Instructional Area:**

The State of the Chesapeake Bay

**Situation:**

The Chesapeake Bay is a national treasure yet its health has been severely degraded over the past several decades. Central Pennsylvania is in the Chesapeake Bay Watershed, therefore this area is partly responsible for its degradation. It is important to understand not only the severity of this issue but also what is and should be done to improve the bay. In this plan, the teacher will split the class into 4-5 groups (depending on if you plan to use the bonus section of not) and have each group fill in a different section of the schoolyard report card. Then have them come up with a plan of action on how to increase their score. If time / resources allow, you can have the class vote on one plan of action and can implement it.

**PA Academic Standard(s) Met:**

4.1.10

4.8.10

**Materials Needed:**

Printed School Yard Report Card Handouts

Projector

Computer

**Interest Approach:**

Students working together will stimulate interest in the subject and increase discussion about the subject matter.

**Objectives:**

1. To have the students work in a group atmosphere on subject matter that will be new to many of the students.
2. To have the students teach their fellow classmates.

3. To gain a more thorough knowledge of the severe degradation of the Chesapeake Bay and how they may be able to help slow nutrient contributions to the Bay.

**Content:**

**Teacher Will Do:**

1. Teacher walks in and is fully prepared with handouts and materials available to the students.
2. Teacher will split the class into 4 or 5 groups (either have the students pick their partners, or the teacher picks groups).
3. Teacher gives each group its handout.

**Teacher Will Say:**

1. Today we are going to do something similar to what we did a few days ago. I'm going to split you into groups and give each group a schoolyard report card. Each group is responsible for a different sections and will fill out the scorecard. Once done, you will come up with a solution as to how to increase the score. You will be examining, discussing and the presenting what you discovered.
2. Let's split you guys into 4-5 groups.
3. In about 15-20 minutes (or as much time as you'd like to allow) we will reconvene to have you present to your fellow classmates what you have discovered about our school.

**Review / Conclusion / Opportunity to Learn:**

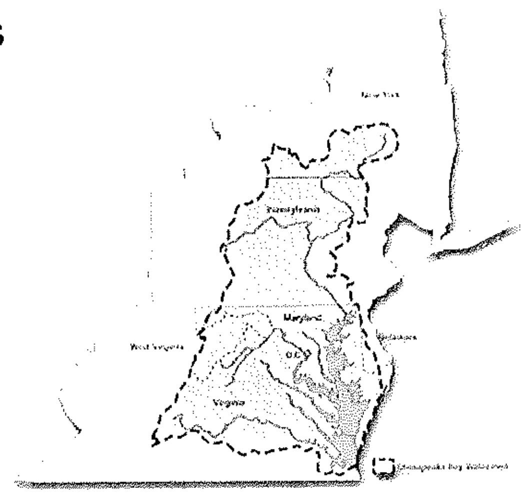
1. The objective of this class was to have the students effectively work together to convey information to their peers.
2. The second objective was to have the students discover the extent of the degradation of the Chesapeake Bay and what is being done to rectify the situation.
3. How the students work together and their final product could potentially be graded.

# The Chesapeake Bay

A case study in the balance between food production and environmental quality at the regional scale.

# The Chesapeake Bay

- One of the world's richest estuaries
- High productivity
- High aquatic diversity
- Important economically

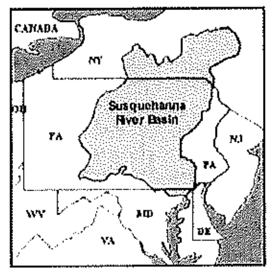



-64,000 square mile watershed

-Home to more then 17 million people in 6 different states

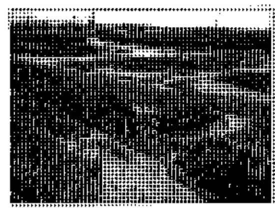
## The Susquehanna

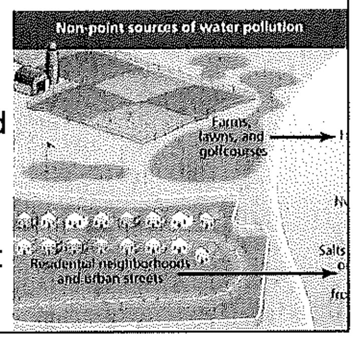
- Most important tributary to the "upper bay"
- 2005's "most endangered river"
- Contributes ½ of the freshwater to the Bay
- Sediment and nutrient pollution of total inputs to the Bay
  - Nitrogen: 44 %
  - Phosphorus: 21 %
  - Sediment: 21%



# Nutrient Pollution

- 64% is non-point source
- Farm runoff
  - Decrease with improved management and decrease in amount of farms
- Lawns, golfcourses, streets
- Residential Neighborhoods
  - Septic systems
    - Increase with development beyond sewer systems
  - Stormwater
    - Increased with urban development

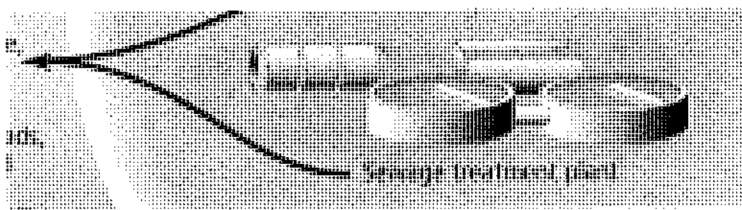





- Non-point source
  - Not attributed to a specific location
  - Septic systems
    - More input then system can handle
  - Stormwater
    - Increase in paved surfaces = increase runoff = more then the treatment plant can handle

## Where Does Nutrient Pollution Originate From?

- 36% is **point-source**
  - Wastewater treatment
    - Generally decreasing
    - Phosphate detergent ban
    - Improved biological treatment technology

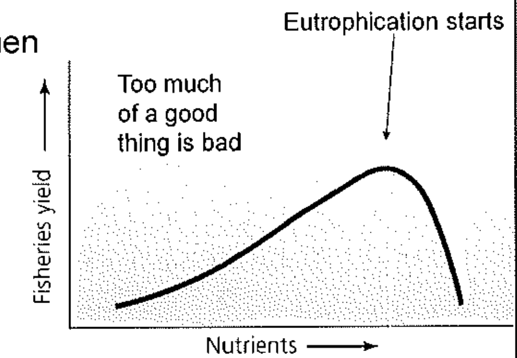


-Point-source

-Attributed to specific location

# Nutrients Affect Aquatic Ecosystems

- Eutrophication
  - Increase in nitrogen and phosphorus
  - Excess nutrients in water lead to:
    - Algal blooms
    - Low dissolved oxygen
    - Death of fish




-Nitrogen and phosphorus

-Usually found at low levels in a body of water

-Algal blooms

-AKA – Red Tide

-Rapid increase in algae in aquatic system

-Green, yellowish-brown, red or bight green

-Result of blue-green algae (cyanobacteria) or increase of nitrogen and phosphorus

-As algae and plants grow other plants may die along with aquatic life – bacteria eats this dead organic matter as it decomposes and then as more food is available, numbers of bacteria increase

-Causes dead zones and increases in the likelihood of other wildlife or humans who may drink from this area in getting a neurotoxin

-Dissolved oxygen

-Oxygen dissolves in water at low concentrations

-Levels in water usually at 10 ppm – at 3 ppm there is stress to fish – below 2 ppm death occurs to some species

-Sources

-Atmosphere

-Plants in the water – primary source

-Microscopic algae (phytoplankton)

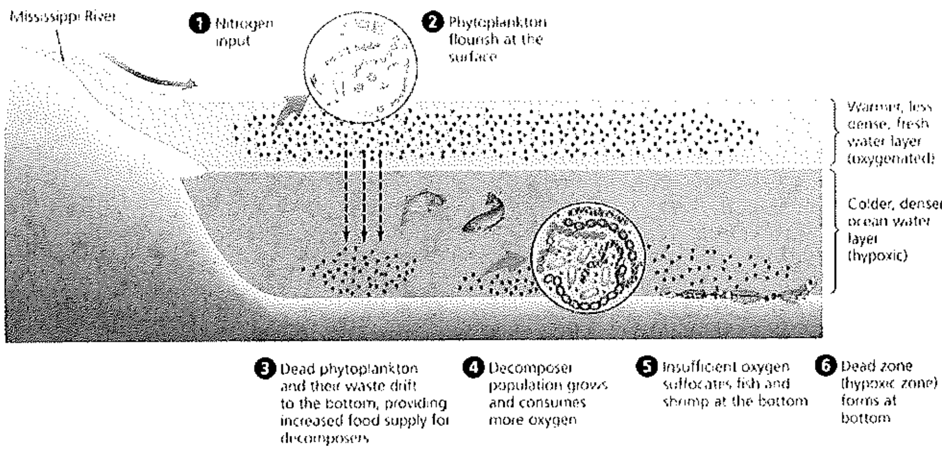
-In presence of sunlight produce oxygen through photosynthesis and release oxygen into body of water

-Oxygen depletions

-Summer months

-Warm water holds less dissolved oxygen

# Eutrophication of estuaries

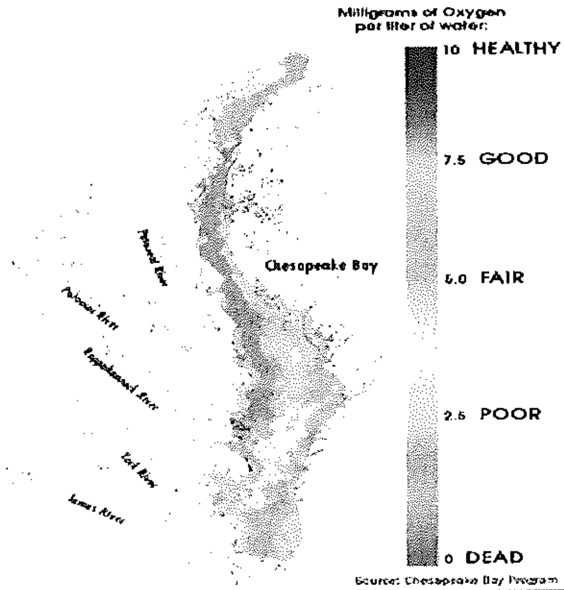





-Estuaries

-Tidal mouth of a river – where tide meets the stream

# Eutrophication in the Chesapeake




Source: Chesapeake Bay Program

# Chesapeake Bay Agreement

- 1983: First agreement
  - "Lets talk about doing something"
  - Pennsylvania, Maryland, Virginia, District of Columbia
- 1987: Sets goals
  - Focuses on sewage treatment
  - Reduce N and P by 40% by 2000
    - Goal missed by a long shot
- 1992: Tributary strategy
  - Reduce nutrient inputs upstream
  - More emphasis on non-point sources

# Clean Water Act

- Late 1990's
  - EPA sued to enforce Clean Water Act for Chesapeake bay tributaries
- The Clean Water Act sets a national minimum goal
  - All waters that are "fishable and swimmable."
  - Many groups sue for TMDL
  - One ruling requires EPA to enforce a TMDL for the Bay by 2011
- States scared of TMDL
  - New agreement in 2000 setting specific goals for 2010

-Total Maximum Daily Load

-TMDL

-Total amount of a pollutant that a body of water can receive and still meet water quality standards

-f

## Goals of 2000 agreement

- Increase in native oysters
  - Eastern Oyster
- Remove barriers to migratory fish
- Restore crab fishery
- Restore crabs/fish habitat
  - Aquatic vegetation
- No-net loss of wetland acreage
- Restore 2,010 miles of "riparian" buffers
  - Riparian – streamside ecosystems
- 30% decline in sprawl rate
  - Preserve forests and farms
- 40% nutrient reduction goal
- "Free of toxins"

-Oysters

-Provide habitat for aquatic reef

-Source of food

-Filter water

- Pump large volumes of water through their gills and filter out plankton

-Get food

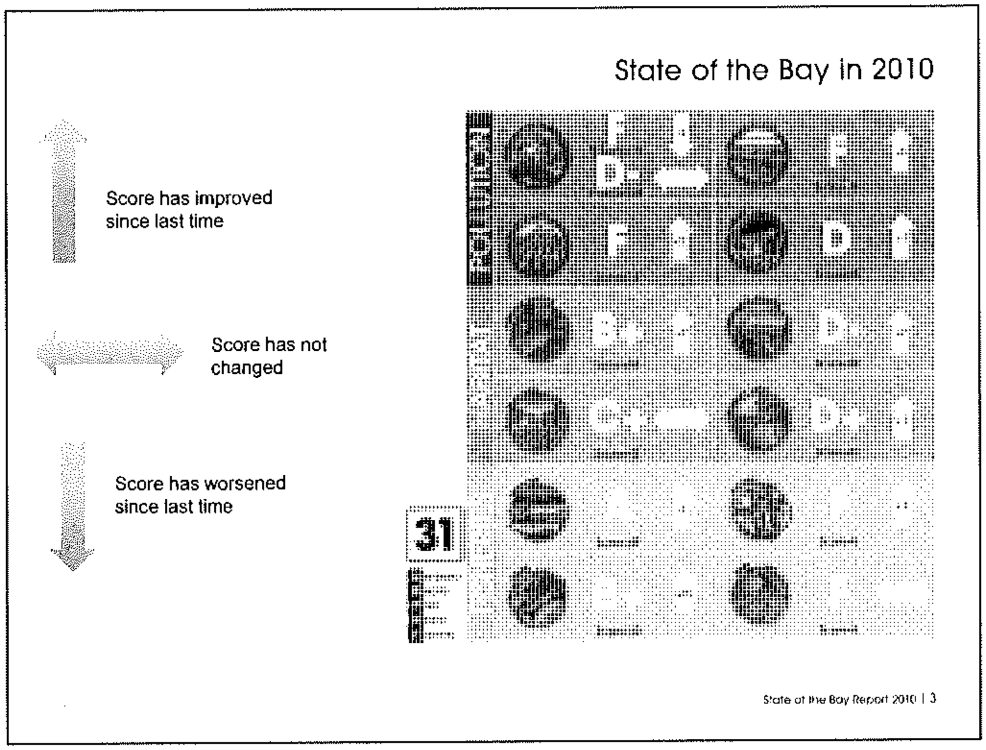
-Remove nutrients, suspended sediments and chemical contaminants = keeps water clear and bay clean for aquatic wildlife and plants

-Riparian Buffers

-Vegetated area next to water that protect water from non-point source pollution

-Provide bank stabilization

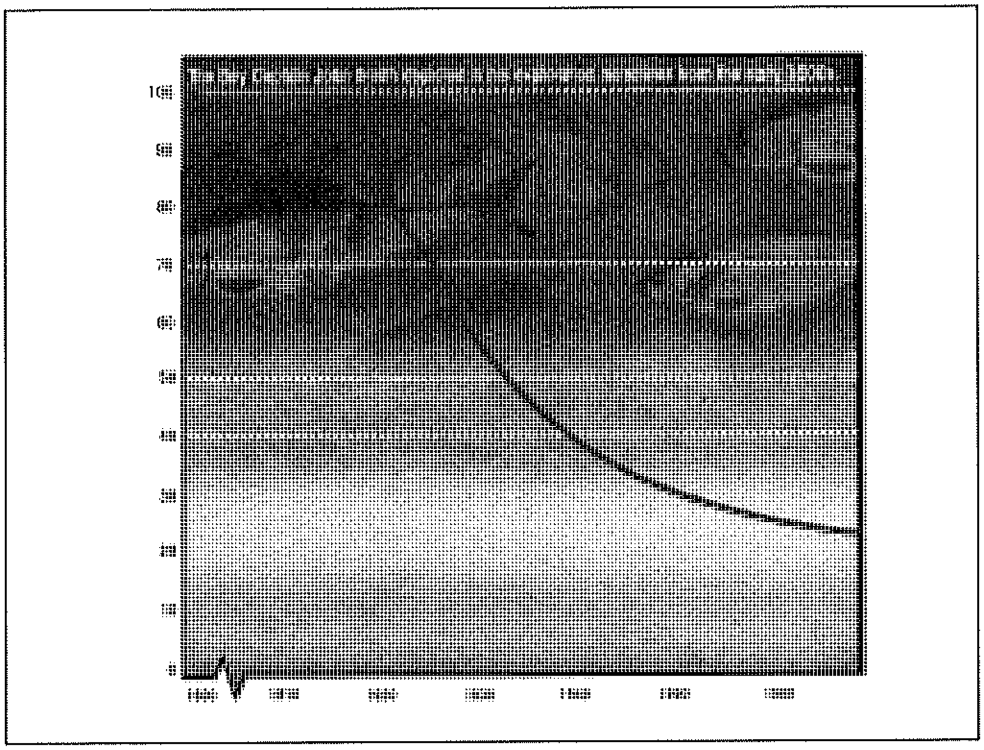
-Grasses, trees or both



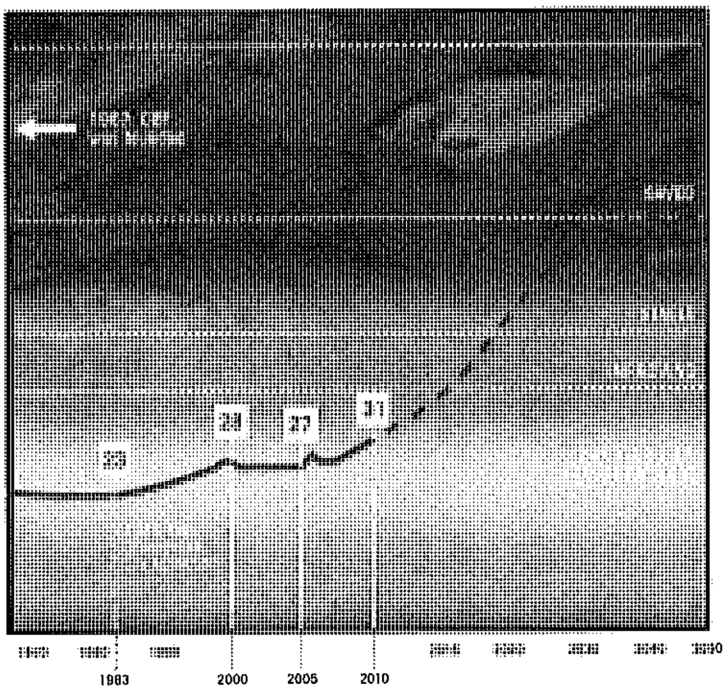

-Overall Bay health score is 31 / 100

-State of the Bay report for 2010 with additional explanations on the grades and categories

-http://www.cbf.org/document.doc?id=596



- Chart showing the health of the Bay overtime




- CBF = Chesapeake Bay Foundation

## EPA is establishing TMDL for the Bay

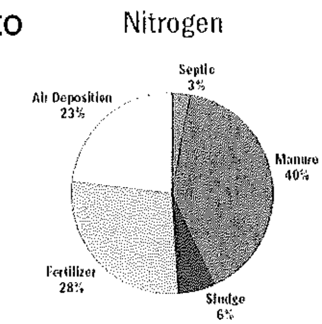
- States failed to meet the goals of the 2000 agreement so…
  - Based on 1990s law suit and the Clean Water Act the EPA needed to do this
  - TMDL in place for December 2010
  - Measures to meet TMDL must be in place by 2025
- From the EPA:
  - "It will be the largest and most complex TMDL ever, involving interstate waters.... 17 million people, 88,000 farms, 483 significant treatment plants, thousands of smaller facilities and many other sources"

-TMDL

-Total Maximum Daily Load

# What is the link to PA farms?

- Farms are a major source of N to the bay
- PA Nutrient Management Act
- Clean Water Act
  - Future TMDL by EPA
- Both focus on
  - CAFO
  - BMP




-Pie chart shows nitrogen inputs for the Bay

-Nutrient Management Act

  -Certification program from PA Department of Agriculture with the State Conservation commission

  -Certify nutrient management specialists to write and review nutrient management plans

  -2005

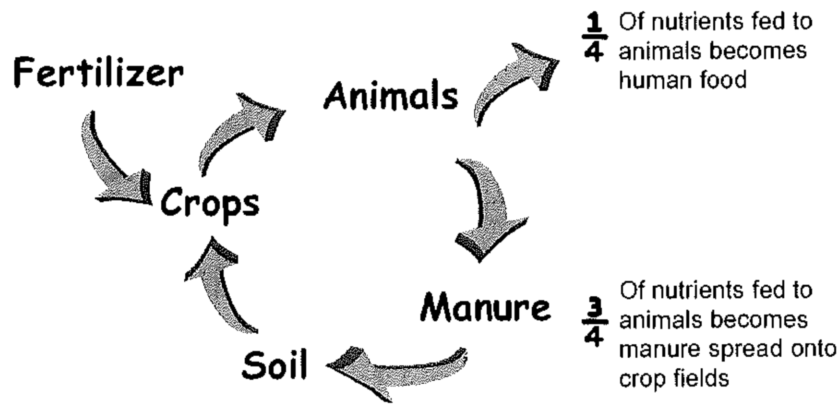
-CAFO

  -Concentrated animal feeding operations

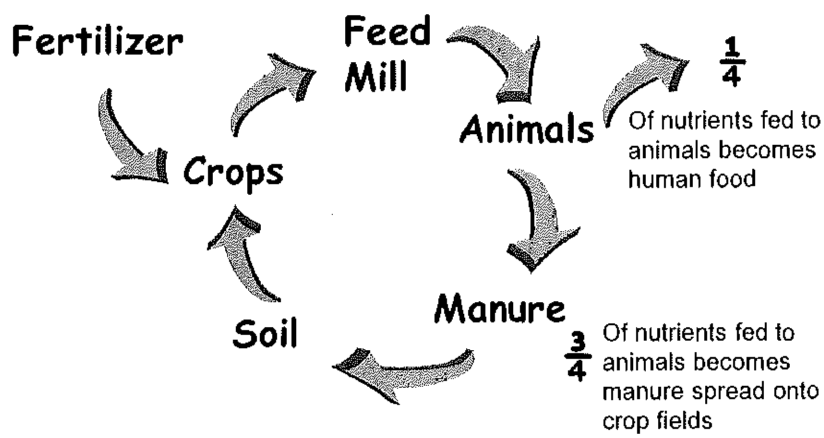
-BMP

  - Best Management Practice

# Traditional Nutrient Cycle



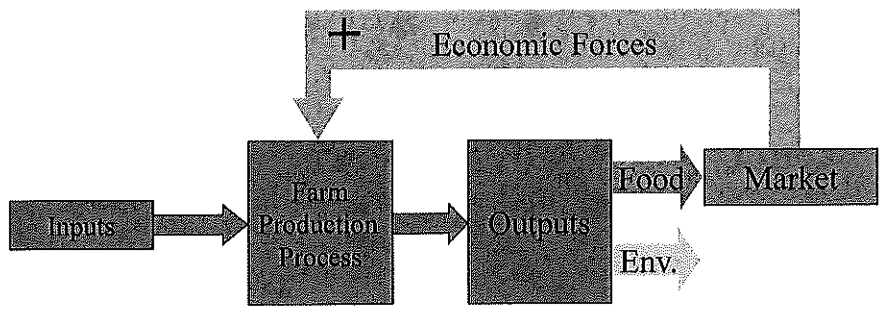
## Contemporary Nutrient Cycle



## Pollution Problems Due To Nutrients

- Changing structure of animal agriculture
  - Self-sufficient farms to specialized farms
    - Haber-Bosch fertilizer after World War II
    - Subsidies for corn production
    - Farms grow crops specially for animal feed
      - Example: Farm in Iowa grows feed for animals in PA
  - Economies of scale
  - Concentration of Agriculture industries
  - Farmers respond to us: cheap food (meat)

## Nutrient Pollution Problem



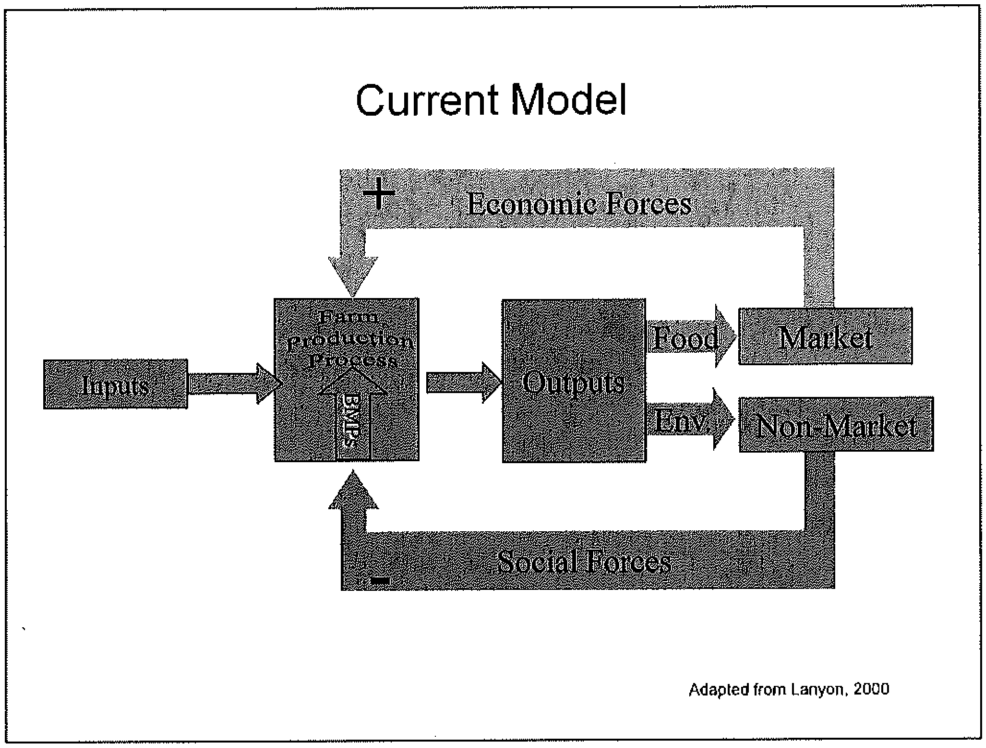

Adapted from Lanyon, 2000

-Environmental impacts of production are outside the market

- -Market demands low cost food
- -Manure has no market value

-Changing structure of animal agriculture

- -Self-sufficient farms to specialized farms
  - -Haber-Bosch fertilizer after World War II
  - -Subsidies for corn production
  - -Farms grow crops specially for animal feed
    - -Example: Farm in Iowa grows feed for animals in PA
- -Economies of scale
- -Concentration of Agriculture industries
- -Farmers respond to consumer
  - - We want cheap food




-Ask farmer to change without market incentive

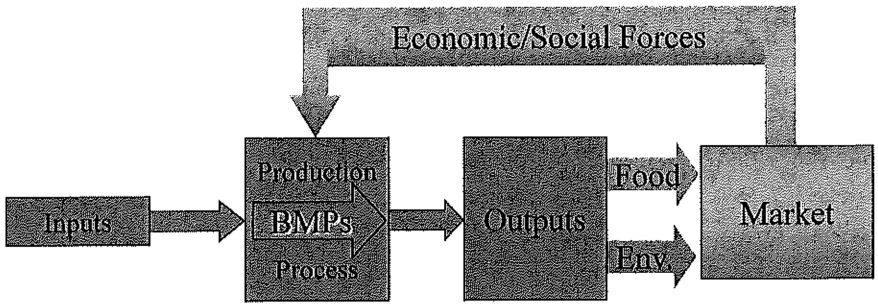
-Economic and social forces squeeze the farmer out of the picture

# Example of Current BMP's

- Many of these are funded by the State / Federal Government
  - Cover crops and No-till
  - Riparian tree buffers or fencing
  - Manure storage facilities
  - Manure Transport to nearby farms
  - Manure/feed treatment to facilitate nutrient balance
- None of these help farm economies

- Best Management Practice = BMP

## How The Model Should Look




Adapted from Lanyon, 2000

- Needs to be a way to have both food and environmental outputs incorporated into the market value

# Recent Examples

- **Nutrient Trading**
  - Municipalities buy nutrient credits when they don't want to upgrade
  - Not a 1:1 trade
    - Municipality releases 1 g of N and pays farmers to reduce by 4 g
  - Examples
    - Farmer goes to no-till; sells credit
    - Red Barn Trading exports manure out of watershed
- **REAP**
  - $10 million in tax credits to farmers to recover costs of implementing new BMPs
  - Farmers can't use credits so they transfer them
    - Sell on open market for less than total credit to businesses with big tax bills
    - Get businesses to invest in the farm and then take the credit

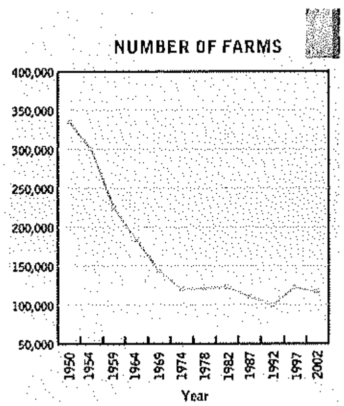
-Examples of the Market and the Envrionment

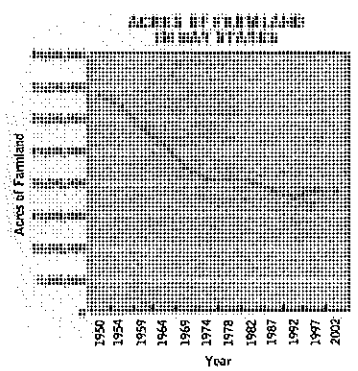
-REAP – Resource Enhancement and Protection

# A Future Example

If states fail to meet TMDLs the EPA could increase the number of farms that are point sources

- EPA
  - Make farms with with over a designated number of animals become a CAFO point source
  - CAFOs pay large permitting fees
  - Would citizens really choose Bay water quality over farms?
    - This model squeezes the farmer further




- Due to cost of CAFO's, small farms couldn't survive

# Addressing Pollution Problems Due To Nutrients

- Do more than just improving on-farm nutrient management
- Requires changes and restructuring in our agricultural systems
- Immediate action
  - Implementing a nutrient management plan to minimize impact of the system

# *Schoolyard Report Card~*

*-By the Student Action Team of the Chesapeake Bay Foundation*

*How is your schoolyard doing? Is it helping the Chesapeake Bay or is it contributing to the Bay's current condition? Follow this Report Card and find out...*

## Runoff/ Erosion:

1. After looking at your schoolyard map describe where in this range it falls.

1 2 3 4 5 6 7 8 9 10

(1=Entirely made of concrete ) (10=Totally Forested)

2. Your school roof drains rainwater into mostly:
   a) well vegetated trees and shrubs or un-mowed grass (10 pts)
   b) mowed grass (5 pts)
   c) bare soil or impervious surface (4 pts)
   d) directly into storm drain (0 pts)
   e) even mix of all (5pts)

3. Look for patches of bare soil and signs of erosion such as areas where rainwater has carved out ditches or washed out vegetation. The schoolyard has:
   a) very little erosion and few patches of bare soil (10 pts)
   b) several patches of bare soil or areas where soil is eroding (7 pts)
   c) mostly bare, exposed soil or impervious surfaces (0 pts)

4. Does your school have any of these run-off control systems:

   Rain Garden.......................2 pts
   Rain Barrel....................... 2 pts
   Meadow...........................2 pts
   Wetland...........................2 pts
   Forested buffer zone (More than 50 feet wide ).....2 pts

**Helpful and fun solutions:**

- ☐ Use the Bare Spot protocol
- ☐ Install a **Rain Barrel**
- ☐ Plant your own **Rain Garden**
- ☐ Plant a **Buffer** of trees next to your stream
- ☐ Get involved in building a **Wetland** or **Pond**

Your Score

1. ______

2. ______

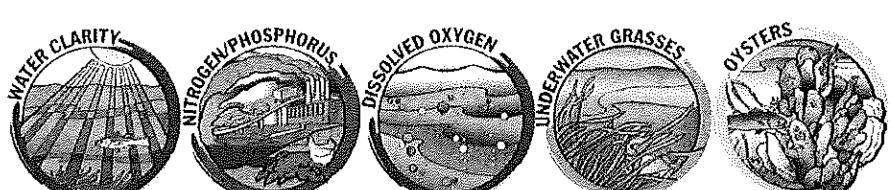
3. ______

4. ______

Runoff/ Erosion Total

☐

*Excess runoff will affect these indicators of Bay health:*



# Transportation:

1. Determine the number of people employed at your school (teachers, maintenance staff, food service staff, administrators, etc.) by asking office staff. Look at the school parking lot and determine the number of vehicles relative to the number of employees.
   a) there are 50% fewer cars in the parking lot than employees (10 pts)
   b) there are 25% fewer cars in the parking lot than employees (7 pts)
   c) there is about one car per employee in the parking lot (5 pts)

2. Are there bicycle racks at your school and do people use them?
   a) the bike rack is full of bikes (10 pts)
   b) the school has a bike rack but there are only a few bikes in it (7 pts)
   c) the school has no bike rack and no bikes on the property (0 pts)

3. Is there any reward or encouragement for teachers or students who walk to school, ride their bikes, carpool or take public transit?
   a) Yes (10 pts)
   b) No (2 pts)

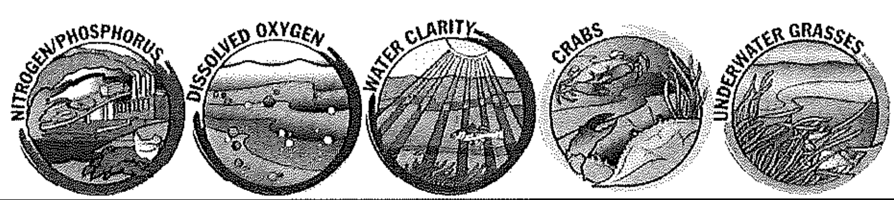
4. Where does rain water drain after hitting the parking lot?
   a) highly vegetated area (10 pts)
   b) mowed or slightly vegetated drainage ditch (7 pts)
   c) storm drain marked "Chesapeake Bay Drainage"
   d) unmarked storm drain

| Your Score |
|---|
| 1. ____ |
| 2. ____ |
| 3. ____ |
| 4. ____ |
| Trans. Total |
| |

**Low Score? Try these solutions:**

- ❑ Incentives to **carpool**, use public transportation or ride a bicycle to school
- ❑ Install and use **Bike** racks
- ❑ Storm drain **stenciling**
- ❑ **Letter writing** to county for bike lanes
- ❑ **Vegetated** run-off control for parking lot and roads

*Cars and trucks release contaminants that enter the Bay's ecosystem, affecting these indicators:*



# Vegetation:

1. Describe the vegetation on your schoolyard:
    a) Trees and bushes cover a significant part of the schoolyard (10 pts)
    b) Trees and bushes dot the landscape of the schoolyard (6 pts)
    c) There are few or no trees on the schoolyard (0 pts)

2. How much of the grass and vegetated areas in your school are being mowed?
    a) less than 50 % (10 pts)
    b) between 50% and 80% (6 pts)
    c) over 80% (4 pts)

3. Ask your school's lawn service or school maintenance staff how the mowed grass on the school grounds is fertilized.
    a) Grass clippings are left on the grounds as natural fertilizer (10 pts)
    b) Lawn fertilizer is used according to a formula after doing soil tests (8pts)
    c) Lawn fertilizer is used according to instructions (6 pts)
    d) Lawn fertilizer is applied randomly (5 pts)

4. Describe the vegetation in the lowest lying part of your schoolyard.
    a) well vegetated with trees and shrubs (10 pts)
    b) vegetated with unmowed grass (8 pts)
    c) mowed grass (7 pts)
    d) bare soil, pavement, or concrete (0 pts)

Your Score

1. ______

2. ______

3. ______

4. ______

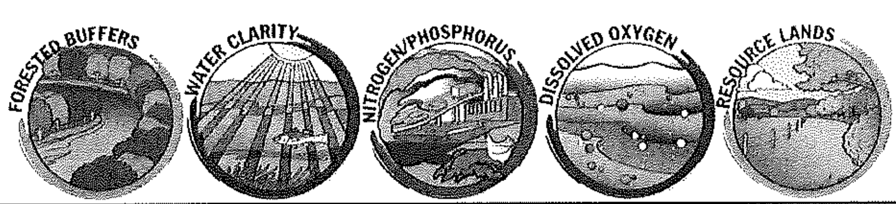
Veg. Total

[ ]

**Any of these projects can add colorful habitat:**

- ❑ Plant a wild **Meadow**
- ❑ Follow the CBF protocol to build a **Rain Garden**
- ❑ Begin your own **Micronursery** for tree plantings
- ❑ Scrub and shrub
- ❑ Attract wild colorful butterflies and birds by planting a **Wildlife Garden**
- ❑ Be aggressive and build a **Wetland**

*Poor vegetation causes problems with these indicators of Bay health:*



# Biodiversity:

1. By counting the different types of leaves or bark, how many different types of trees are there on your schoolyard?
   a) 10 or more (10 pts)
   b) 7-9 (8 pts)
   c) 4-6 (5 pts)
   d) less than 4 (4 pts)

2. By counting the different types of leaves and berries, how many different types of shrubs are there on your schoolyard?
   a) 7 or more (10 Pts)
   b) 4-6 (7 pts)
   c) less than 4 (4 pts)

3. Below are examples of habitats for animals. Which of the following apply to your schoolyard? (4 pts. for each)
   a) woodlands with many layers of plants and trees
   b) tall grassy fields/meadow
   c) thick brush and brambles or a brush pile
   d) dead standing trees or rotting logs on the ground
   e) streams with forested buffers

Your Score

1. ______

2. ______

3. ______

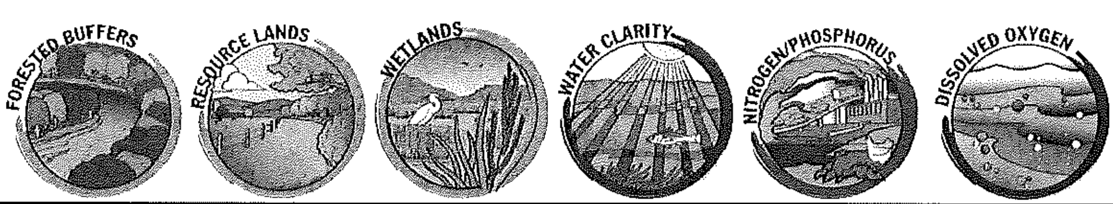
Biodiv. Total

[ ]

To bring more **LIFE** to your schoolyard:

- ❑ **Plant native** shrubs and flowers that attract wildlife
- ❑ Identify what local **animals** may **need** and restore their habitat
- ❑ Ask your teacher how to **get involved**
- ❑ Plant **trees**

*Preserving and restoring habitat increases biodiversity and helps improve these indicators :*



# ******BONUS******

## Awareness:

1. Does your school have an environmental club, offer environmental science classes or a bay unit in science class? (1 point for each yes)
2. Is there a stream on your schoolyard? Is there access? (1 point for each yes)
3. Are there energy saving devices? (1 point for each yes)
   - -compact fluorescent
   - -skylights
   - -signs reminding you to turn off lights
4. Test your principal/administrator/science teacher: (2 points for each correct answer)
   a. Is there a body of water attached to your schoolyard
   b. What is the closest sewage treatment plant?
   c. Where is the closest landfill?
   d. Is there incentive for the staff to use public transit? (2 pt. for yes)
   e. Does your school recycle? (2 pt. for yes)
   f. Do you want to improve your schoolyard? (2 pt. for yes)

| Your Score |
|---|
| 1. ______ |
| 2. ______ |
| 3. ______ |
| 4. ______ |
| Bonus Points |
| |

**How to find out more:**

- ❑ **Study** the Bay
- ❑ Go on a Chesapeake Bay Foundation **field experience**
- ❑ **Read** about the Bay
- ❑ Ask your teacher about the **Chesapeake Bay**

*Awareness of the Bay and solutions to its problems will improve all these indicators of Bay Health:*


---

Now it's time to add your scores together to find out the health of your schoolyard…

| | |
|---|---|
| Runoff/Erosion | ______ |
| Transportation | ______ |
| Vegetation | ______ |
| Biodiversity | ______ |
| **Total** | ______ |
| Total + bonus points | |

If you scored:

**100-80 A-B:** Your school is **excellent** habitat for many plants and animals and is a very healthy part of the watershed!
**79-60 C-D:** You are on the right track but there is more work to do if we want to Save the Bay!
**59 or less:** Poor habitat. Many schools fall in this category so please help us in making your schoolyard a better place by doing one of the many projects listed at www.cbf.org.

# Daily Plan 10

**.le:**

Nitrogen in our Soils and Lives

**Instructional Area:**

The Malthusian Dilemma and Review of Unit

**Situation:**

This is meant to be a two day lesson so as to leave time at the end of the second class for a review exercise. The students will gain information on global agriculture and also be updated on the world's food levels and if we will be able to keep up with the population growth. This plan will be focused on the PowerPoint. It is important that students learn to pay attention in class that is not forcing them to be fully engaged. At the end of the PowerPoint lesson, the students will be split into 10 groups and each group will be asked to present what they thought were the most important points from one of the 10 lessons.

**PA Academic Standard(s) Met:**

4.4.10

4.8.10

**Materials Needed:**

Computer

Projector

Worksheet handouts for PowerPoint

Handouts for Review

**Interest Approach:**

This plan will rely on the teacher's ability to engage the class using the PowerPoint to convey the information in an interesting manner. Once again it is crucial that the students master the ability to learn material in a lecture atmosphere. The second half of the class will encourage the students to convey the important parts of the past 10 lessons for a quick review session. This will allow them to start thinking about how they will review the material.

**Objectives:**

1. To convey a brief history of the Green Revolution.
2. To explain the world's current predicament regarding food and if food production will be able to keep up with population growth.
3. To have the students review the material effectively by having their peers present to them the important parts of the past 10 lessons.

**Content:**

**Teacher Will Do:**

1. Teacher walks in and turns on projector to present PowerPoint.
2. Teacher starts the presentations and goes through the slides.
3. Teacher splits the class into 10 groups.

**Teacher Will Say:**

1. Today we will be examining the Malthusian Dilemma. We will also focus on the world food shortage and if current food production will be able to keep up with population growth.
2. Teacher goes through the slides and refers to the notes included with the PowerPoint.
3. Each group is assigned to a specific lesson from the last 2 weeks and is responsible for presenting the most important part that sum up the lessons to the class.

**Review / Conclusion / Opportunity to Learn:**

1. The objective of this class was to give the students more information about the Malthusian Dilemma.
2. To have emphasized to the class the importance of modern agriculture to suppot the growing population and need for food.
3. The students will have been able to review via each group presenting the most important things from each lesson. If a group leaves something crucial out, the teacher should add the material after the group is done. This provides the students a second chance to learn the material verbally from a different source other than the teacher.

Worksheet Answers

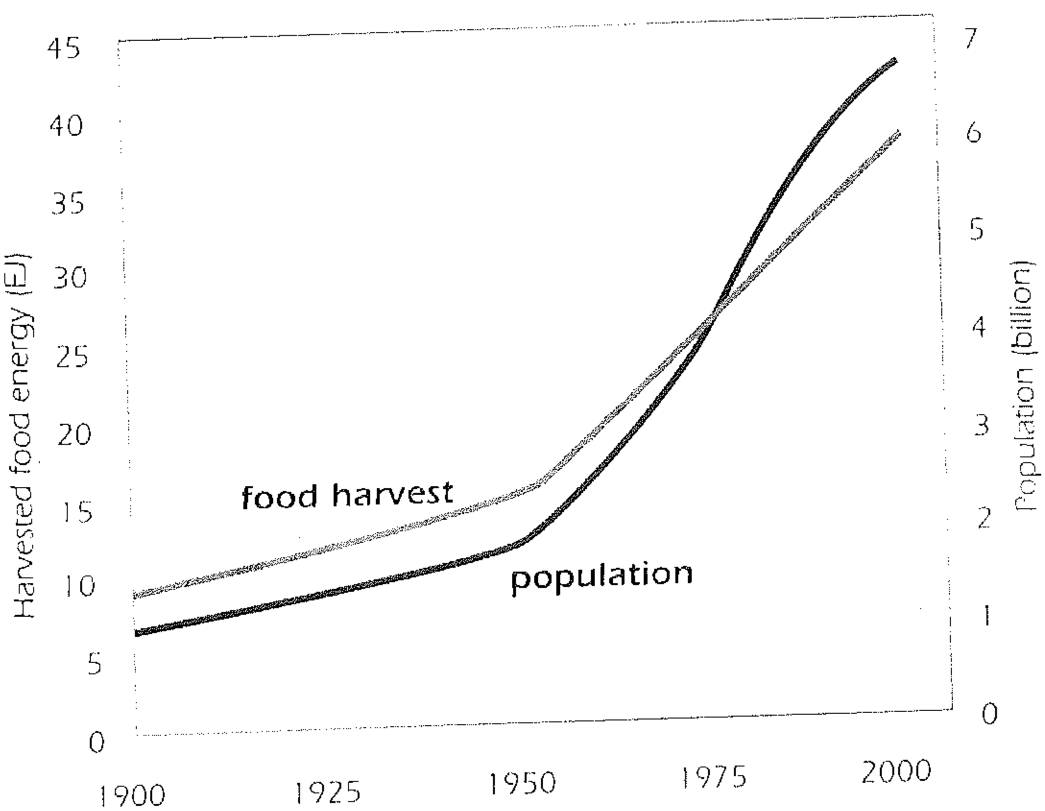
1. In 1798, *__Thomas__* *__Malthus__* wrote an Essay on the Principle of Population.

2. There will be an issue if population increases ( arithmetically / *__geometrically__* ) and food production increases ( geometrically / *__arithmetically__* ).

3. Paul Ehrlich believed that this would cause mass starvation in the 1970's and 1980's.

   Population bomb or mass starvation

4. Draw a graph of the global population vs. the global harvested food energy.




5. What is the current number of people starving?

   1 billion

6. **Where is the most recent famine taking place?**

   a. Europe
   b. Chine
   c. Ireland
   d. **Horn of Africa**
   e. Ethiopia

7. **Define a cultivated system.**

   Areas where at least 30% of the landscape is in croplands, shifting cultivation, confined livestock production or freshwater aquaculture

8. **How much cropland does industrial agriculture account for?**

   a. **25%**
   b. 50%
   c. 75%
   d. 100%

9. ***Dr. Norman Borlaug*** **founded the Green Revolution.**

10. **What was involved in the green revolution?**

    Movement to increase crop production per acre of land via:
    - Improved plant breeding
    - Increased number of harvests per year
    - Using irrigation and fertilizers
    - Mechanized plowing / harvesting / etc.
    - Pesticides
    - Bringing modern agriculture to under-developed countries

11. **Give an example of a dwarf variety.**

    Wheat in Mexico
    - Traditional – 1 m high and 25% plant mass used
    - New cultivar – less than .75 m high and 50% plant mass used

12. **Name 3 impacts of genetic engineering of plants.**

    - Plants outperform traditional varieties
    - Limited genetic diversity
    - Seeds must be purchased

13. **What is crop rotation?**

- Crops grown year round on the same spot

14. **How many cm of water are required to grow corn?**

- 80 – 100 cm

15. True / ***False*** : **In soils, phosphorus has a mass 10 times larger than nitrogen.**

16. **Using only traditional agriculture, how much land would be needed to support a population of 10 billion people?**

- Double or triple currently cultivated lands
- Complete deforestation to acquire land

17. **How do legume crops reduce fertilizer use?**

- Symbiosis with bacteria (Rhizobia) attached to the roots of the plant
- Biological nitrogen fixation
- Take nitrogen right out of the atmosphere and fix for plants use

18. **What is mechanized cropping used for?**

- Preparing seed beds
- Controlling weeds
- Applying fertilizers / pesticides
- Harvesting

19. True / False : **Pesticide use has increased globally.**

20. **What year did Dr. Borlaug win the Nobel Peace Prize?**

a. 1975
**b. 1970**
c. 1972
d. 1969

21. **What are the results of the Green Revolution?**

- Increased food production
- No increase in the amount of agricultural land
- Diminished environmental quality
- Possibilities for further yield increases

22. **What is the current issue that causes famine and food availability issues globally?**

- Social factors

Worksheet

1. In 1798, ______________ ______________ wrote an Essay on the Principle of Population.

2. There will be an issue if population increases ( arithmetically / geometrically ) and food production increases ( geometrically / arithmetically ).

3. Paul Ehrlich believed that this would cause mass starvation in the 1970's and 1980's.

4. Draw a graph of the global population vs. the global harvested food energy.

5. What is the current number of people starving?

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**21. What are the results of the Green Revolution?**

**22. What is the current issue that causes famine and food availability issues globally?**

# The Malthusian Dilemma

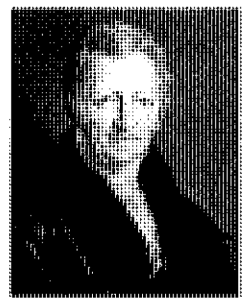
How have we succeeded in feeding the world?

## Thomas Malthus

- 1798
  - Essay on the Principle of Population
- If population increases geometrically
  - 1, 2, 4, 8, 16, 32, 64, 128

And food production increases arithmetically
  - 1,2,3,4,5,6,7,8

Then we are in trouble



-Malthus's observation:

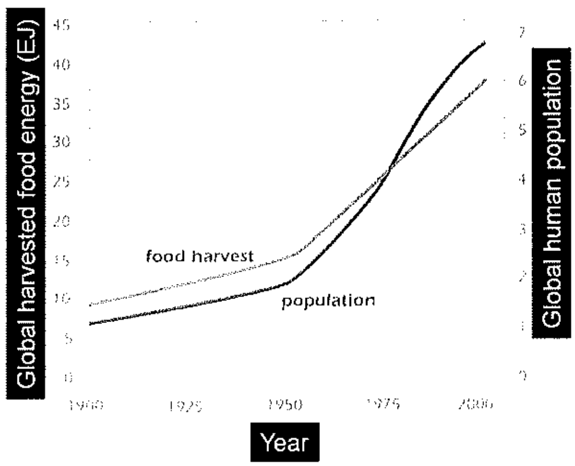
- In nature plants and animals produce far more offspring than can survive
- Man is also capable of overproducing if left unchecked
- Conclusion:
  - Family size needs to be regulated or else man's misery of famine would become globally epidemic and eventually consume Man
  - Poverty and famine are natural outcomes of population growth and food supply was not popular among social reformers who believed that with proper social structures, all ills of man could be eradicated.

## "neo-Malthusians"

- Believe humanity is doomed
- Assume population, affluence and technology are independent of each other
- Paul Ehrlich
  - Population Bomb
    - Mass starvation in 1970's and 1980's overpopulation

# Malthus's Incorrect Guess

Both population and food harvests have grown geometrically



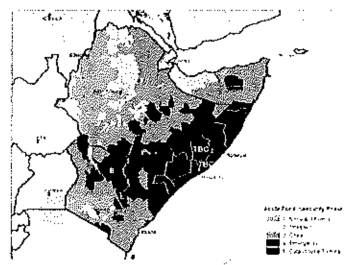

- Can we continue to increase crop yields non-linearly?
- Will Malthus eventually be right?
- What are the "costs" of increasing yields?

EJ = exajoule = $10^{18}$ Joules

## Recent Famines NOT Caused By Global Food Shortages

- Europe: 1300's
  - Medieval warm period ended; less food produced
- Irish potato famine: 1850's
  - Social, climate, and pest factors (blight)
- China in 1950's and 60's
  - Population growth combined with poor leadership
- Ethiopia in the 1970's and 80's
  - Sociopolitical
- Horn of Africa Famine in 2011
  - Somalia, Ethiopia and other neighboring countries
  - Severe drought

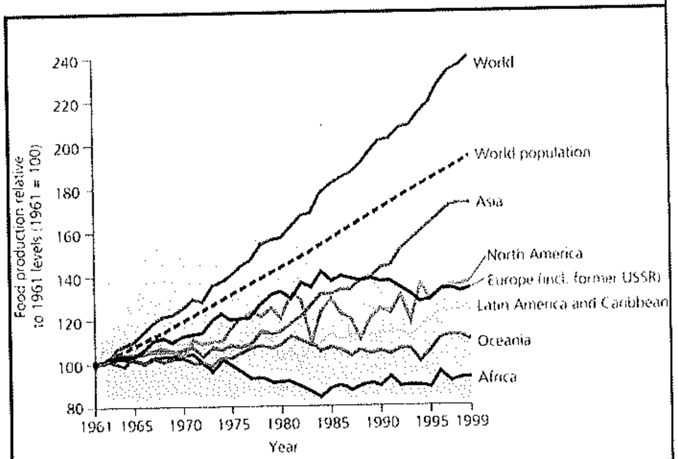
East Africa Famine



- Currently: 1 billion people are hungry

# Recent Food Production Changes Linked To Politics

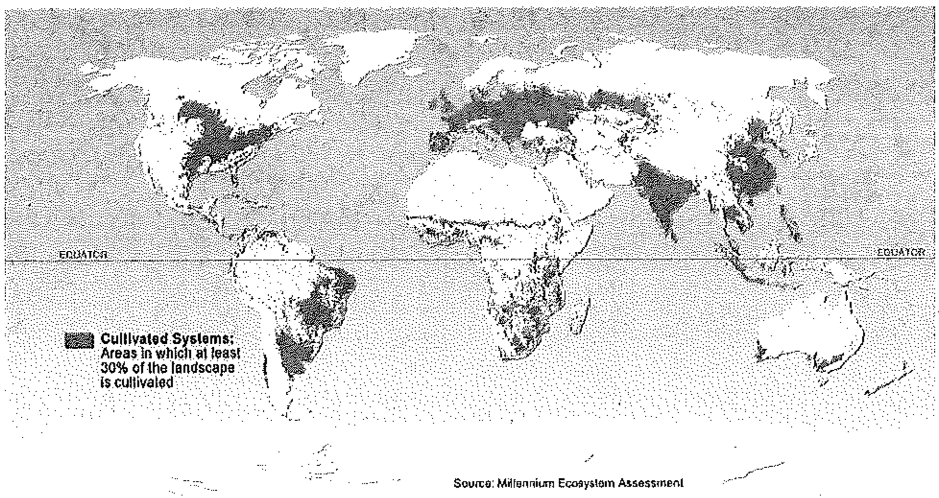
- Decline of USSR
- Subsidies in Europe/US
- Turmoil in Africa






- Global food production is increasing, however food production per person is not increasing.

# Increasing Food Supply



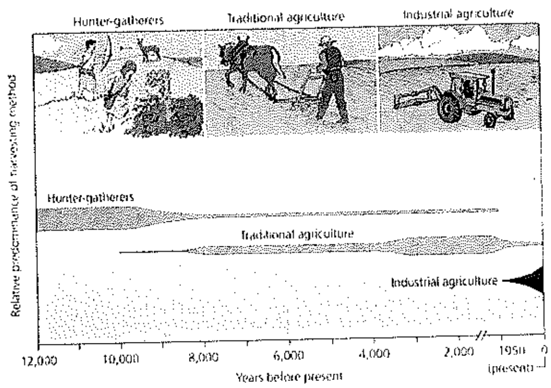

Cultivated Systems in 2000 cover 25% of Earth's terrestrial surface

-Cultivated systems – defined as areas where at least 30% of the landscape is in croplands, shifting cultivation, confined livestock production or freshwater aquaculture

- Increased cultivated land area
    - More land was converted to cropland in the 30 years after 1950 than in the 150 years between 1700 and 1850.

## Increasing Food Supply

- Industrial agriculture accounts for 25% of cropland
- Industrial agriculture is a fairly new concept
- It would not be possible to feed the world with traditional agriculture

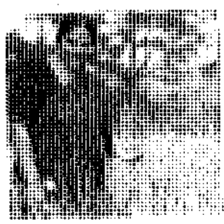



-Goal of industrial agriculture is to increase yield and decrease the cost of production

- Goal
  - -Low food prices
  - -Cheap feed for animals
  - -Potential energy source
  - -Exports

-Has high environmental impacts

## Vandana Shiva



- "Water has grown scarcer in India, as Green Revolution water-guzzling agriculture replaces traditional practices attuned to local water conditions and local needs."

## Norman Borlaug

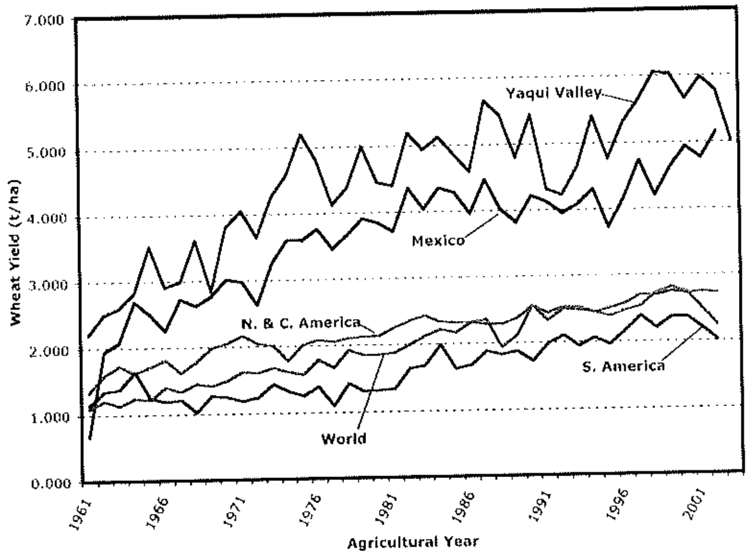
- "Millions of farmers who have successfully grown the new wheat, rice, and maize varieties have greatly increased their income. And this has stimulated the rapid growth of agro-industry by increasing the demand for fertilizers, pumps, machinery, and other materials and services."

- Two different views of how industrial agriculture has impacted the world

# Green Revolution

- Founded by Dr. Norman Borlaug
- A movement to increase the crops produced per acre of farmland by
  1) Improved plant breeding
  2) Increasing the number of harvests per year
  3) Giving plants the resources they need to grow fast
     A) Irrigation
     B) Fertilizers
  4) Mechanized plowing/harvesting/etc
  5) Pesticides
  6) Bringing modern agriculture to under-developed countries

# Yaqui Valley --
# "The Home Of The Green Revolution"




-Annual precipitation in Yaqui Valley – 30 cm / year

-Comparison of the world wheat yields to the Yaqui Valley

# 1) Plant breeding

- Began in Mexico in 1944
  - 1944 – Mexico imported half of its wheat
    - The Rockefeller Foundation, Dr. Borlaug and the Mexican government established a plant-breeding station in NW Mexico
  - 1956 – Mexico self sufficient in wheat production
  - 1964 – Mexico exports ½ million tons of wheat

## Genetic Engineering

- Breeding crops in the lab to choose the best cultivars
- Used plant varieties from all over the world and crossed them
- Crops have same photosynthetic efficiency as wild ancestors
- They are now "dwarf" varieties and have disease resistance

Norman Borlaug

# Dwarf Varieties

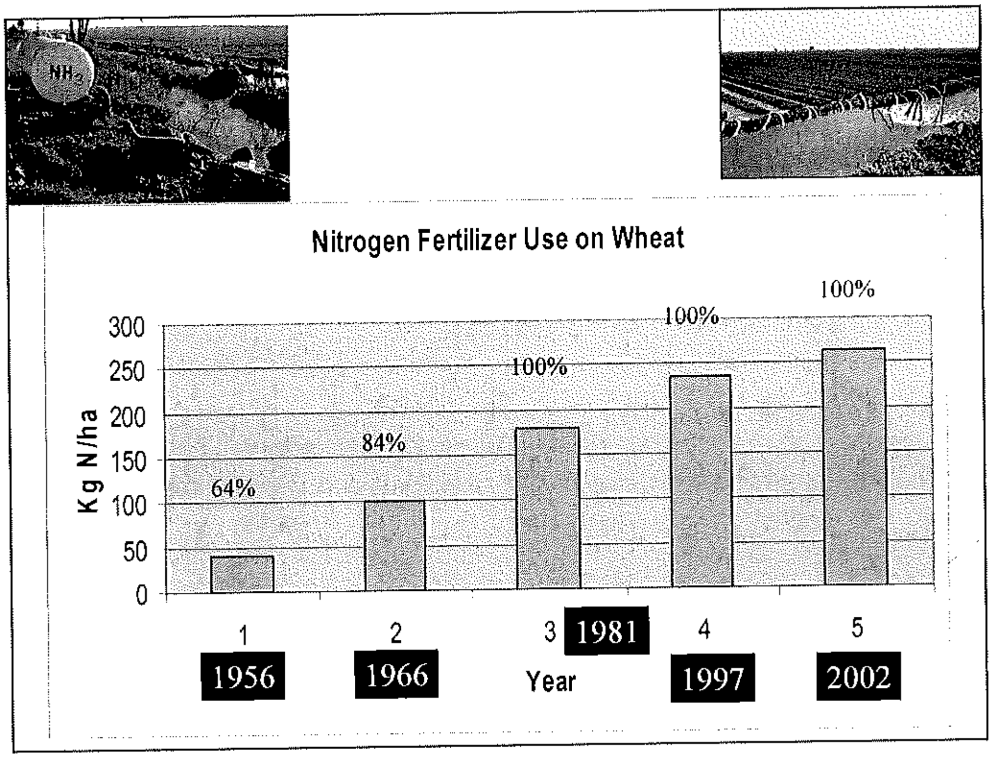
- More of the tissue we want
  - Seeds
  - Leaves
  - Tubers
- Example
  - Traditional Wheat in Mexico = 1 meter high and only 25% of plant mass used
  - New cultivar = Less than .75 m tall and 50% of mass used
- Less lodging

-Lodging

- Plant is flattened

- Occurs in root or stalk

-Can be caused by overuse of fertilizer




-Amount of nitrogen fertilizer applied to wheat over time

- Percentage represents the proportion of the area that is fertilized

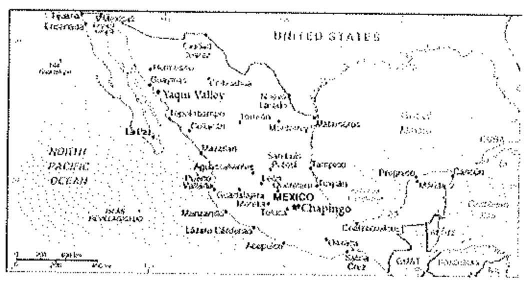
## Long-term Impacts

- Plants outperform traditional varieties
  - Less global famine
  - Less agriculture land area
  - Requires irrigation, pesticides, and fertilizers
    - If these are not available, traditional varieties can do better
    - Requires dependence on high inputs
- Limited genetic diversity
- Seeds must be purchased
  - Previously farmers could save seeds, now they buy them
  - Leads to ownership of crop types by current biotech companies such as Pioneer

- Must purchase because the best varieties are infertile F1 hybrids

# 2) Increasing The Number Of Harvests Per Year

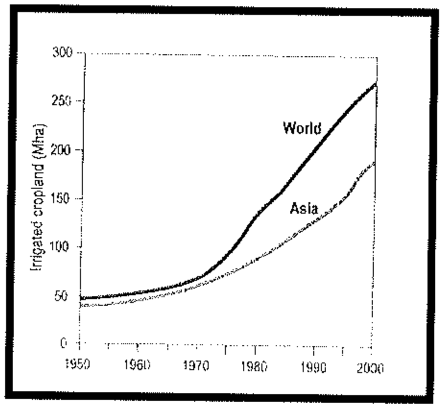
- Dr. Borlaug had the idea to plant crops in the mountains in the summer and in the Yaqui Valley during the winter
- This lead to modern crop rotations:
  - Crops grown year round on the same spot




-During crop rotation, different crops are planted

- Example: Wheat then Barley, grain crop then legumes, etc.

# 3) A. Increased Irrigation:

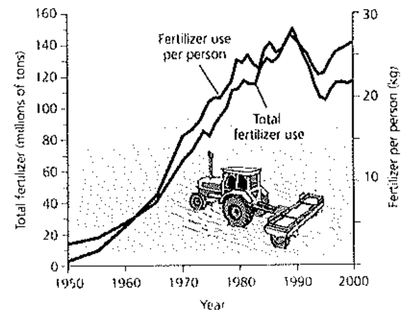



- Plants require
  - 450 – 1300 moles of water per mole $CO_2$ absorbed
- Seasonal Crop Water Requirements
  - 25 – 50 cm for small grains
  - 80 – 100 cm for corn
  - >100 cm for alfalfa, sugarcane and rice

-1 mole of water = 18.02 grams

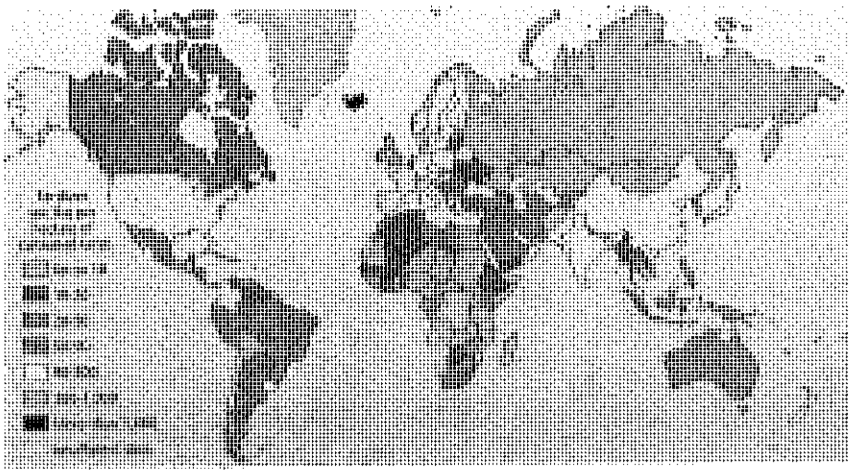
- 1 mole of $CO_2$ = 44 grams

# 3) B. Increased Fertilizer Use




- Plants composition:
  - Carbon from the atmosphere
  - From soil
    - Nitrogen, Phosphorus, and Potassium
    - Nitrogen mass is 10 times larger than phosphorus; Potassium is in between
- If soils can't provide Nitrogen, Phosphorus, or Potassium
  - Plants grow slowly
    - Less food
  - Every harvest soils are depleted of these nutrients
  - Add nutrients in as fertilizers

# Global fertilizer applications



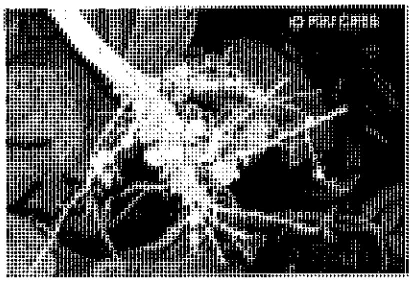
(a) World fertilizer use, 1998

# Keeping Traditional Nutrient Applications

- Traditional agriculture used organic wastes to return nutrients to soil
  - The only way to support 10 billion people by traditional cropping (i.e. only organic waste additions) would be to double or triple amount of cultivated land.
  - This would require complete deforestation of tropical rainforests to acquire land
- To give up inorganic N fertilizers alone means that the global population would need to decline by 2 to 3 billion

# Legume Crops Reduce Fertilizer Use

- Some crops have symbiosis with a bacteria attached to roots (Rhizobia)
  - Called "biological nitrogen fixation"
  - Can take nitrogen right out of atmosphere



-Examples of crops with symbiosis

-Soy beans

-Alfalfa

-Peas

- Plants provide carbon (energy) to bacteria
- Bacteria "fix" atmospheric nitrogen and give it to the plant

## Fertilizer Most Important Nitrogen Input

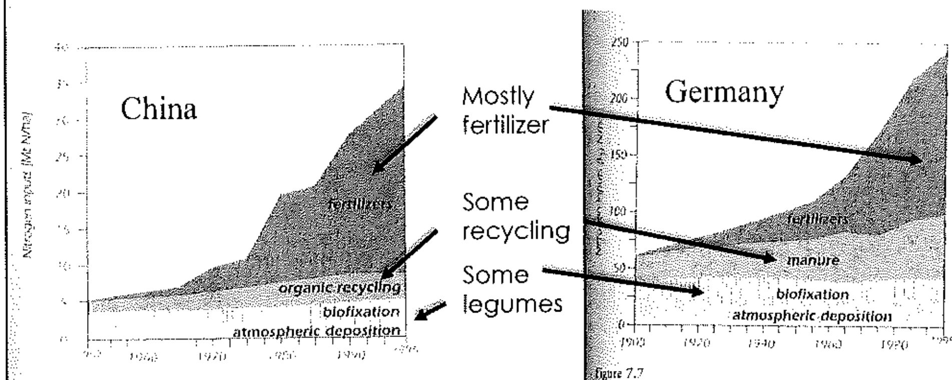
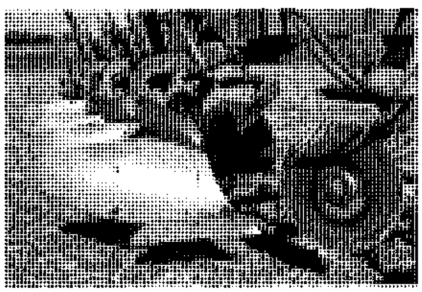


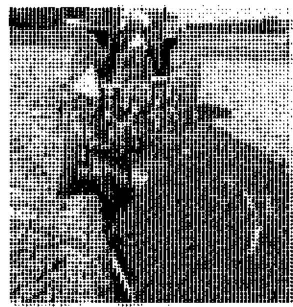

Figure 7.5
Nitrogen inputs into China's cropping, 1952–1996.

Figure 7.7
Nitrogen inputs into German cropping, 1900–1995.

# 4) Mechanized Cropping

- Used for
  - Preparing Seed Beds
  - Controlling Weeds
  - Applying fertilizers / pesticides
  - Harvesting

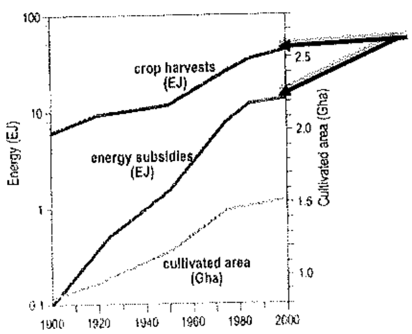




- Exposed soil erodes away easily

# Increases Energy Use

- Energy breakdown
  - 45% Fertilizer
  - 45% Machine operation
  - 2% pesticides



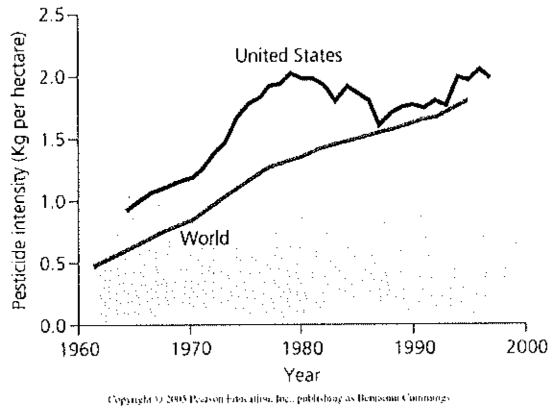

Crop harvests and energy subsidies (from fossil fuels) have increased by several orders of magnitude (left axis)

-Makes agriculture dependent upon fossil fuels

- Total cultivated area has increased by 50% since 1940 but very little since 1975

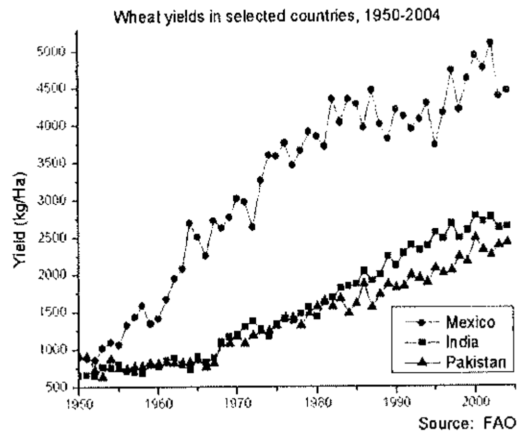
# 5) Pesticide Use

- Increasing globally
- Insects
- Fungi
- Weeds



# 6) Expanding Into Developing Countries

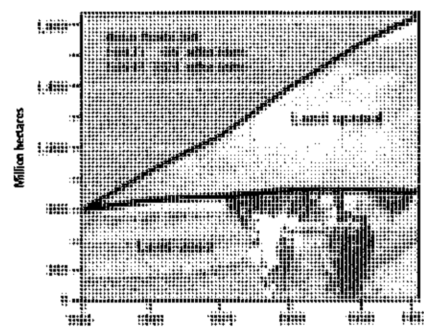
- For this Dr. Borlaug won the Nobel Peace Prize in 1970



# Results Of The Green Revolution

- Increased food production in many regions and globally
- Allowed agricultural land area to remain the same
- Failed in some cases and diminished environmental quality
- Possibilities for further yield increases from these methods are limited

World Cereal Production-Area Saved Through Improved Technology, 1950-1998



## Synthesis

- Malthus predicted famine
  - Population grow faster then production
- Green Revolution
  - Helped avoid famine by increasing production / acre
  - Used: Breeding, fertilizer, irrigation, pesticides, mechanized cultivation
  - Drawbacks
- Global food production continues to increase while food production / person is not
  - Current food availability and famine problems caused by social factors

**Quiz**

1. **In 1798, ______________________ __________________________ wrote an Essay on the Principle of Population.**

2. **There will be an issue if population increases** ( arithmetically / geometrically ) **and food production increases** ( geometrically / arithmetically ).

3. **Define a cultivated system.**

4. **How much cropland does industrial agriculture account for?**

    a. 25%
    b. 50%
    c. 75%
    d. 100%

5. **______ _________________________ ____________________ founded the Green Revolution.**

6. **Name 3 impacts of genetic engineering of plants.**

    **1.**

    **2.**

    **3.**

7. **Define crop rotation.**

**8.** True / False : **In soils, phosphorus has a mass 10 times larger than nitrogen.**

**9. Explain how legume crops reduce fertilizer use?**

**10.** True / False : **Pesticide use has increased globally.**

Quiz Answers

1. **In 1798, *Thomas Malthus* wrote an Essay on the Principle of Population.**

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7. **What is crop rotation?**

   - Crops grown year round on the same spot

8. True / ***False*** **: In soils, phosphorus has a mass 10 times larger than nitrogen.**

9. **How do legume crops reduce fertilizer use?**

   - Symbiosis with bacteria (Rhizobia) attached to the roots of the plant
   - Biological nitrogen fixation
   - Take nitrogen right out of the atmosphere and fix for plants use

10. **True** / False : **Pesticide use has increased globally.**

**Unit Review Handouts Instructions for Teacher**

1. Each Lesson Packet includes a copy of the PowerPoint slides or background information presented from that lesson.

2. The students should review this information closely and take some notes about the portions that they think were the most important.

3. Students should then put together a presentation of some form to present to present to the class.

    a. This presentation can be a PowerPoint, poster, diagram, skit, etc. The students can choose what they feel is the best way to convey their information. The teacher can award bonus points to the most creative group to avoid all the student groups doing PowerPoint's or posters.

    b. Presentation should be given a maximum time limit to avoid being to lengthy of a review session.

    c. Presentations should include all of the most pertinent information from that lesson. The teacher should add information at the end of the information if they feel there was an important point skipped over by the students.

    d. This should be a fun way to review all of the information before the unit test.

    e. The teacher can grade the presentation based upon information presented, way information was conveyed and by students individual contributions to the group. A grading rubric similar to that as used in Lesson 7 could be used.

**Student Presentation Evaluation Form**

Your Name:__________________________________ Date:____________

Presenter Name(s): ______________________________

Topic: ______________________________________

*Scale:* 5 = Excellent, 4 = Good, 3 = Satisfactory, 2 = Needs Improvement, 1 = Poor

A. Clearly communicates the subject matter 5 4 3 2 1
- Few um's, uh's, etc.
- Has practiced
- Good pace (not to fast or slow)
- Effective use of note cards (does not often use)

B. Eye Contact 5 4 3 2 1
- Looks at whole class

C. Uses visuals appropriately 5 4 3 2 1
- Easy to see
- References during presentation
- Does not read off of it

D. Is knowledgeable of topic 5 4 3 2 1
- Answers questions
- Gives thought to answers

E. Presentation is informative 5 4 3 2 1
- Did it have a clear focus
- Did you learn something new?

F. Organization / Clarity 5 4 3 2 1
- Easy to follow
- Flow

G. Constructive criticism / compliments: ______________________________

____________________________________________________________

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**Lesson 1 Review Packet**

**Lesson Title**: Nitrogen 101

**Use this space to list the important facts from this lesson:**

**Presentation Idea:**

**Jobs of each group member:**

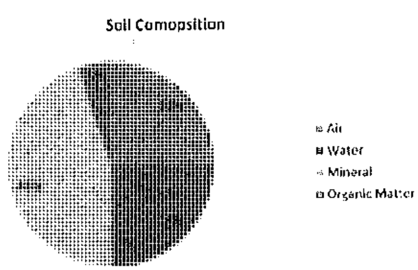
# Nitrogen 101

Understanding Nitrogen and Our Soils

## Soil is EVERYTHING!

- Soil allows plants and trees to grow
- Provides animals and humans with food
- Foundation for homes and roads
- Soil filters the water we drink

## Components of Soil




## Where Does Nitrogen Fit?

- Nitrogen is part of soil organic material
- Humus is another name for organic material
  - Formed by the decomposition of plant or animal wastes
- Small amount in minerals

## What is Nitrogen?

## Nitrogen Basics

- Nitrogen is in our soils
- Plants use Nitrogen to grow healthy
- Nitrogen is the most deficient nutrient in a managed ecosystem
- Two forms existing in soil
  - Organic: animal, plant, human sources
  - Inorganic: mineral sources (precipitation/fertilizer)

## Nitrogen and Plants

- Plants can only use inorganic Nitrogen
- Only a small amount of Nitrogen is inorganic
- Does soil ever run out of Nitrogen?
  - Nitrogen Deficiency

## BACTERIA!

Two main conversions:

1. Convert atmospheric Nitrogen into inorganic forms
2. Convert organic Nitrogen from wastes into inorganic forms

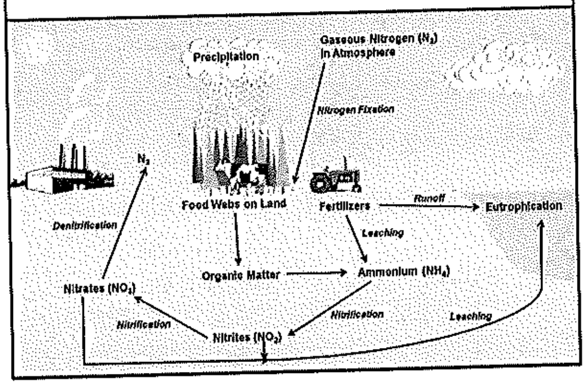
## Rhizobia Bacteria

- Rhizobia are linked with the roots of legumes
  - symbiotic relationship
- Infects the root and forms air tight nodules
- Convert organic Nitrogen to inorganic
- Legumes are two-way plants
  - They use inorganic Nitrogen in soil
  - But they also trap atmospheric Nitrogen in the soil
  - Example of legume = Beans

## Let's Put it Together

- How do the soil, plants, bacteria and Nitrogen work together?

## Basic Nitrogen Cycle




## What Do These Terms Mean?

- Nitrogen Cycle – Movement of Nitrogen in different chemical forms
- Nitrogen Fixation – Convert atmospheric nitrogen gas into forms used by plants
- Nitrification – Oxidation of ammonium into nitrite and then into nitrate by microorganisms
- Denitrification – Loss or removal of nitrogen
- Leaching – Various chemicals dissolved and carried to groundwater
- Runoff – Water flows on earth's surface into nearby bodies of water

## Terms Continued

- Eutrophication – Changes take place in body of water after inputs of nitrogen
- Ammonium – Colorless, pungent, suffocating, highly water-soluble
- Nitrates – Plants need to grow, natural material in soil, water soluble
- Nitrites – Transitional form of nitrogen, quickly converted

## In-Class Assignment

- Make your own version of the Nitrogen Cycle
- BE CREATIVE!
- Make sure that it makes sense
- Using the pervious slide
  - Make sure to include all components listed
  - Words in *italics* are modes of "transportation" for Nitrogen

**Lesson 2 Review Packet**

**Lesson Title**: How Does Nitrogen Change and Where Does It Hide?

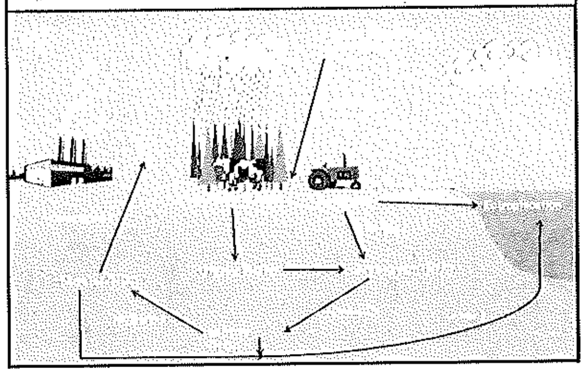
**Use this space to list the important facts from this lesson:**

**Presentation Idea:**

**Jobs of each group member:**

## How Does Nitrogen Change and Where Does It Hide?

## Nitrogen Cycle



## Transformations

- What does transformation mean to you?
- Think about water transformations

## Start in the Soil

- How does Nitrogen get in the soil?
- Organic Nitrogen
  - Decomposition
  - Fixation
- Inorganic Nitrogen
  - Fertilizers

## Organic Nitrogen

- Decomposition – To break down, decay

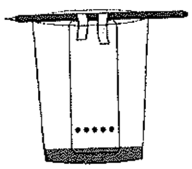
This is a compost bin, which is decomposing plant and food wastes

- Mineralization – During the decay of organic matter, microorganisms convert organic nitrogen into inorganic nitrogen
- Immobilization – Microorganisms convert inorganic nitrogen into organic nitrogen

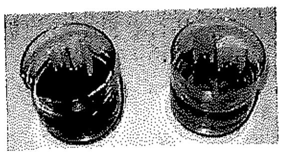
## Plants

- Uptake - Inorganic Nitrogen moves out of the soil and water into the plants roots
- Nitrogen Fixation – Legumes pull Nitrogen from the air and convert it into inorganic usable form

## Uptake Experiment



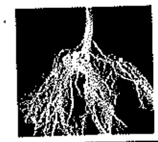
Experiment #1



Experiment #2

## Nitrogen Fixation Facts

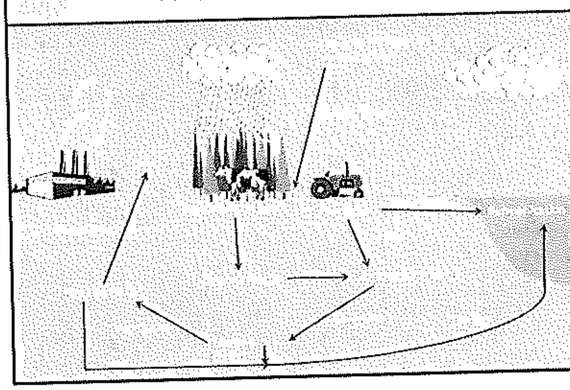
- Most common and largest source of nitrogen fixation comes from the symbiosis of legumes and bacteria (*Rhizobium* or *Bradyrhizobium*).
  - Examples include soybean, alfafa, and clover.
- The bacteria infect the root hairs of the plant and the plant responds by forming root nodules, which is the site of nitrogen fixation.



## More Nitrogen Fixation Facts

- Non-legume plants are capable of forming symbiosis with other bacteria that can also conduct nitrogen fixation.
  - Examples: Alder tree species and flowering Gunnera
- Termite – Gut bacteria
- Lightning converts atmospheric nitrogen gasses into a water soluble form

## Review Where We Are

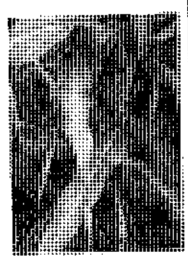


## Benefits of Nitrogen

- Helps control metabolic processes related to plant growth
- Lots of growth and dark green color

## Lack of Nitrogen

- Reduced plant growth
- Leaves are pale green and yellow at tips
- If severe deficiency, leaves turn brown and die

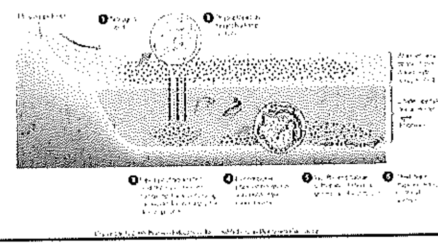


## Where Else Does Nitrogen Go?

## Water

- Leaching – Removal of soluble Nitrogen dissolved in water from soil
- Runoff – Soil can no longer hold water, so additional water moves across soil surface, taking Nitrogen with it

- Eutrophication - Nitrogen lost through leaching makes its way into the groundwater and the groundwater becomes polluted.

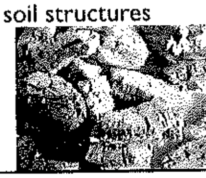


## Air

- Denitrification – The nitrogen in waterlogged soils is changed by bacteria into nitrogen gasses.
- Volatilization – Process of moving the nitrogen gasses out of the soil and into the atmosphere.

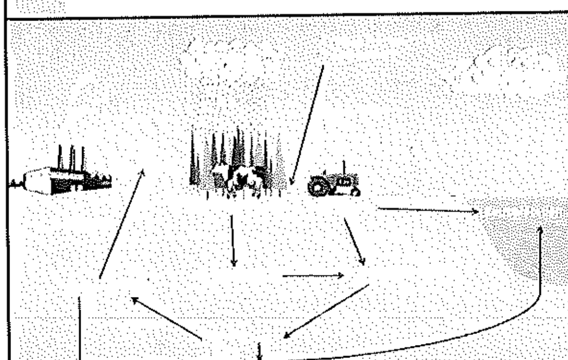
## Soil

- The Nitrogen may bond with the soil particles because they have opposite charges
- This attachment helps prevent leaching
- Cavities inside certain soil structures "hide" the nitrogen



## Work It Out

## Nitrogen Cycle



**Lesson 3 Review Packet**

**Lesson Title**: USDA Web Soil Survey

*Note: For this lesson, use the answers from your web soil survey worksheet and the tutorial handout.*

**Use this space to list the important facts from this lesson:**

**Presentation Idea:**

**Jobs of each group member:**

# USDA Web Soil Survey Tutorial

1. Launch web soil survey: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm
2. On the home page, click on Start WSS (in a green button).
3. Click on the Area of Interest Tab.
4. Under the quick navigation heading, put desired location into the survey.
    a. Located on the left side of the screen.
    b. Enter address
    c. Press view
5. Above the map, there is a toolbar. Select the hand to drag the map to the correct position.
6. Use the zoom function in the toolbar above the map to zoom in the location.
    a. Drag a rectangle over the area of interest and click to zoom in.
    b. Continue zooming to reach desired location.
    c. The blue arrow in the map toolbar is the "undo" zoom button.
7. There are two AOI buttons in the map toolbar.
    a. Select the AOI button with the red rectangle.
    b. Draw a square around the area of interest on the map.
8. The map will reload with blue lines shading the selected area.
9. Next, click on the soil map tab at the top of the page.
    a. This tab is located next to the Area of Interest tab
10. This map shows the locations of different soils of the selected area.
    a. Click on a soil type under the map unit legend and get more information about the soil.
11. Next click on the Soil Data Explorer tab.
12. Open the building site development category.
    a. Click on the different topics, and then select view ratings to view soil suitability.
    b. The map will show areas in different colors in regards to suitable or unsuitable.
    c. The table below the map offers additional rating information.
    d. Other categories can be investigated in the same manner.
13. If students need to print a specific map, select printable version in the top right corner.
    a. A screen opens, select view.
    b. This creates a PDF that can be printed or saved.

**Lesson 4 Review Packet**

**Lesson Title**: The Haber-Bosch Process

**Use this space to list the important facts from this lesson:**

**Presentation Idea:**

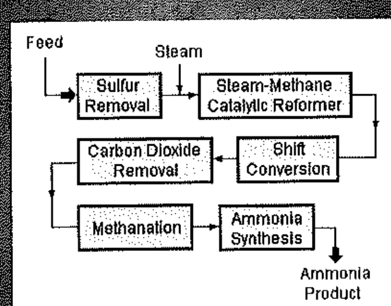
**Jobs of each group member:**

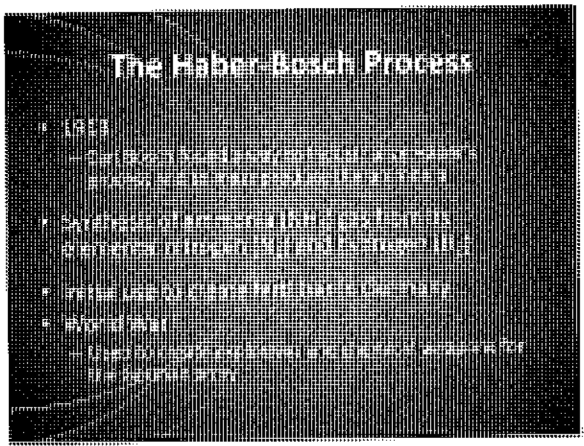
# The Haber-Bosch Process

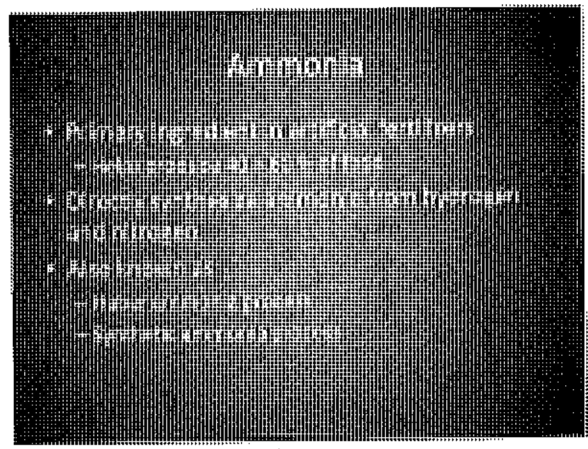
## History

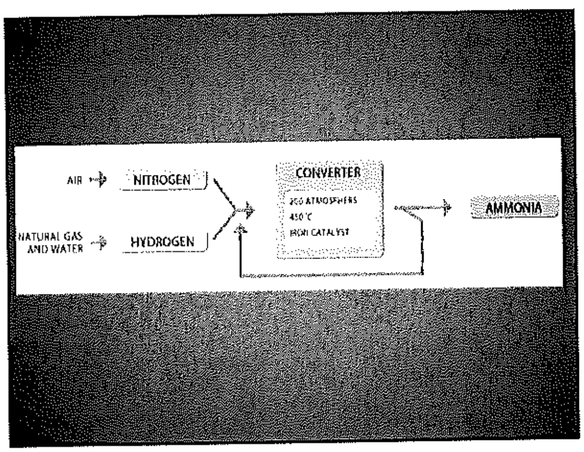
## Before Haber & Bosch

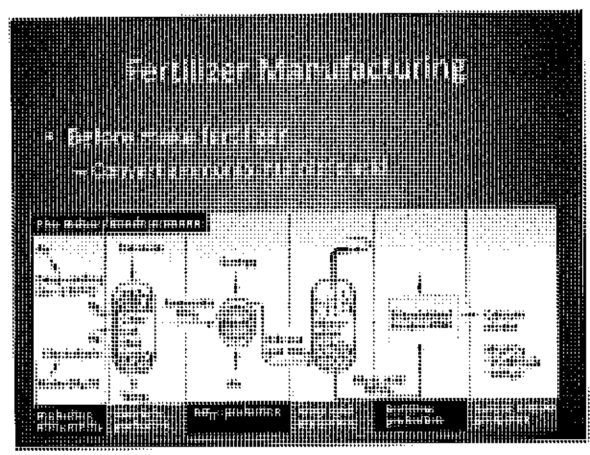
## The Haber-Bosch Process

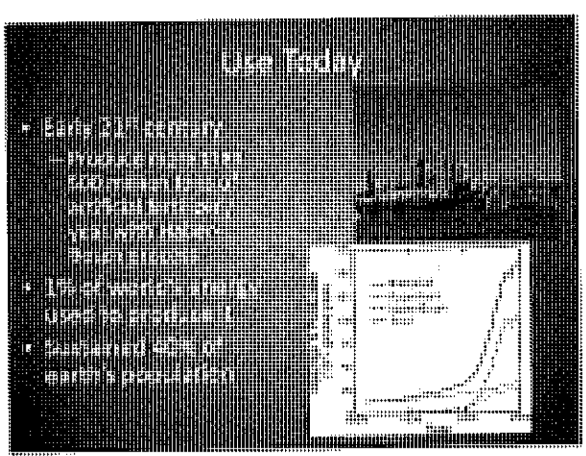


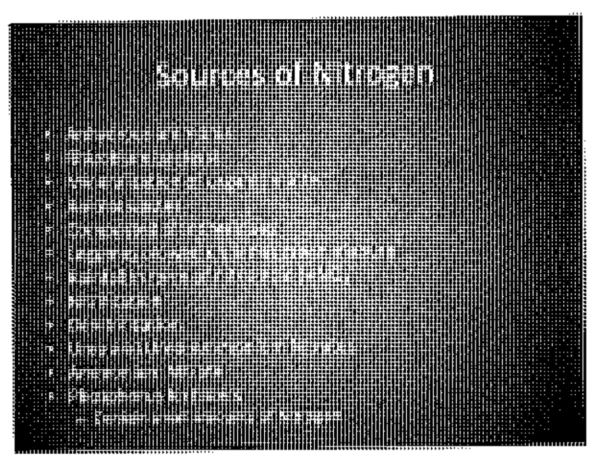

The Haber-Bosch Process


Ammonia


AIR
NITROGEN
NATURAL GAS AND WATER
HYDROGEN
CONVERTER
200 ATMOSPHERES
450°C
IRON CATALYST
AMMONIA


Fertilizer Manufacturing


Use Today


Sources of Nitrogen

## Lesson 5 Review Packet

**Lesson Title**: The Effects of Excess Nitrates on the Health and Lives of Humans

**Use this space to list the important facts from this lesson:**

**Presentation Idea:**

**Jobs of each group member:**

**The Effect of Excess Nitrates on the Health and Lives of Humans**

## What are Nitrates?

- Chemical compounds
- $NO_3$ – 1 Nitrogen atom and 3 Oxygen atoms
- Some can be harmful to human health, others are not
- Environmental sources
  - Agricultural runoff
  - Industrial waste

## Are There Benefits of Excess Nitrates?

- Increased global food production

## What Are Some Concerns With Excess Nitrates?

- Air Concerns
- Water Issues
- Human Health

## Effects on Third World Countries

- Moderate use of fertilizers in developing countries will increase:
  - Nutrition
  - Food availability
  - Infrastructure
  - Public health
- Problems created:
  - More land will be used to provide feed for livestock
  - Taking away land for crop production

## Effects on Diet

- In fully developed countries, an unbalanced diet is increasingly common
  - Rising consumption of meat (beef and poultry)
  - Increase in the number of those who are overweight and/or obese
- Higher consumption of beef has been known to cause heart disease and diabetes
- Eutrophication of waterways can effect shellfish and our fisheries

## Effects on Air Quality

- Higher levels of $NO_3$ lead to higher levels of ozone
  - Contributes to asthma rates and respiratory diseases
- Fine particulates in the air (including those formed from $NO_3$) correlates to:
  - cardiovascular diseases, reduced lung function, overall mortality, etc
- It has been proven that increased nitrogen levels increase the pollen count in some plants, aggravating allergies of effected people.

## Health Effects

- Infants that drink water with values above 10 ppm of nitrate have a higher risk of developing methemoglobinemia ('blue baby' syndrome)
- Very recent evidence has suggested that the risk of certain types of cancers increases with nitrate levels.
- Higher nitrate levels may influence the populations of vectors (i.e. mosquitoes) of certain diseases thereby completely changing the dynamics of certain viruses or bacteria

## Lesson 6 Review Packet

**Lesson Title**: Environmental Policy and Regulations Related to Nutrient Management

**Use this space to list the important facts from this lesson:**

**Presentation Idea:**

**Jobs of each group member:**

## Environmental Policy and Regulations Related to Nutrient Management

## Major Change for Farms in the Nitrogen Cycle

- Farms are becoming specialized
- In the past the manure produced on a farm would be used for the crops on that farm
- Now there are specialized CAFO farms (Concentrated Animal Feeding Operation),and the use of the manure is not nearly as effective

## Statistics

- Pennsylvania's livestock produces approximately 30 million tons of manure annually that contains 171,000 tons of nitrogen.
  - If not applied at the right time, rate or location, manure becomes a pollutant
- 3,903 miles of Pennsylvania's streams are impaired from agricultural activities
  - Clean Water Act

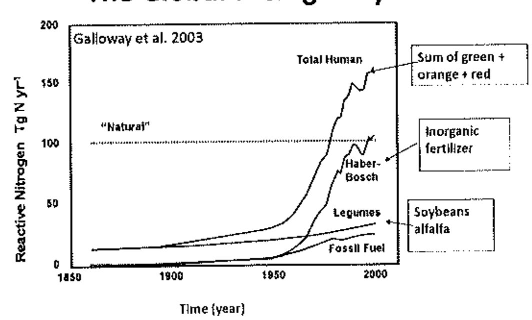
## Clean Water Act

- Regulate discharge of pollutants into the water
- Quality standards for surface waters
- Enacted 1948, Expanded in 1972 , Amendments in 1977
- Unlawful to
  - Discharge pollutants from point source into waters unless get permit

## Clean Water Act

- National Legislation
- Sets up definitions for AFO (Animal Feeding Operations) and CAFO
- Uses values from the Unified Nutrient Management Strategy
  - National strategy for setting up nutrient management plans.
- TMDL (Total Maximum Daily Loads)
  - Determined by investigation

## Agriculture Dominates Changes In The Global Nitrogen cycle



## Haber-Bosch Process

- Most economical for nitrogen fixation
- Fritz Haber and Carl Bosch
  - Chemists
- Synthetic ammonia process
  - Ammonia from hydrogen and nitrogen
  - Combine nitrogen from air with hydrogen under extremely high pressure and moderately high temperatures
  - Uses iron catalyst

## Act 38 (Formerly Act 6)

- All CAOS (concentrated animal operations) must have an approved nutrient management plan
  - It is considered a CAO if there are more than two animal equivalent units (AEU = 1,000 pounds of live weight of an animal)
- Included in the plan:
  - Amount of manure generated
  - Nutrient content of the manure
  - Manure application rates and handling procedures
  - Levels of Manure Exported
  - Agriculture Erosion and Sedimentation Control Plans
  - Both nitrogen and phosphorus based management

## REAP Program

- REAP – Resource Enhancement and Protection Program of Act 55 of 2007
- Provides tax credits to farms that implement Best Management Practices (BMPs)
- The amount of tax credit depends on the BMP used. But farms can receive between 50% and 75% of project costs as tax credits.
- This encourages farms to implement such BMPs as:
  - Specific Equipment for Better Handling of Manure or No Till Practices
  - Erosion / Nutrient Management Plans
  - Constructed Wetlands
  - Etc.

## Chesapeake Bay

- Formed 12,000 years ago when glaciers melted and flooded the Susquehanna River
- 200 miles long
- Runs from the mouth of the Susquehanna River to the Atlantic Ocean
- Encompasses 6 states
  - Delaware
  - Maryland
  - New York
  - Pennsylvania
  - Virginia
  - West Virginia
- Chesapeake Bay watershed include
  - Tidal shoreline
  - Tidal wetlands and islands

## Chesapeake Bay

- Critical Condition
- Overload of pollution
  - Mercury
  - Nitrogen and Phosphorus
    - Algae blooms cause "dead zones"
- Sources of pollution
  - Major Reason
    - Increased impervious cover
  - Agriculture
  - Sewage
  - Stormwater
  - Air pollution

## Chesapeake Bay Agreement

- Originally from 1983
  - Goals weren't set until 1987
  - Reduce pollution from sewage treatment
- In 1992
  - Wider strategy needed
  - Inputs were attempted to be reduced further upstream in the tributaries
- In 2000
  - Goal set to have the Chesapeake Bay in an acceptable healthy range by 2010

## Fix Your Schoolyard Bare Spots

- Bare Spots
  - Vegetation no longer exists
- Where are the bare spots on school grounds?
- Why are these spots bare?
- How could we fix these areas?

# Lesson 7 Review Packet

**Lesson Title**: Smarter Farming Techniques and Alternative Energy Production using Nitrogen

**Use this space to list the important facts from this lesson:**

**Presentation Idea:**

**Jobs of each group member:**

# Smarter Farming Techniques and Alternative Energy Production using Nitrogen

## Conservation (No) Tillage vs. Conventional Tillage

| Conservation Tillage | Conventional Tillage |
|---|---|
| Decreased Erosion due to Crop Residue | Increased Erosion due to lack of Crop Residue |
| Lack of Incorporating Fertilizers and Manure | Thorough Incorporation of Fertilizers and Manure |
| Increase of Microbial Activity | Decrease of Microbial Activity |
| Increase of Water Infiltration | Decreased Water Infiltration |
| Stratified Nutrient Levels and pH | Mixed Nutrient Levels and pH |
| Roots Concentrated Near Surface | Roots Uniform throughout Rooting Zone |
| Lower Soil Temperatures | Higher Soil Temperatures |
| Increased Chance for Increased Denitrification | Normal Chance for Increased Denitrfication |

## Soil Acidity

- Nitrification = acidic soil
- No till systems
  - Surface soil is usually the most acidic because of
    - Nitrification
    - Decay of crop residues
    - Acid rain
    - Application of fertilizers
- Acidic soil
  - Aluminum uptake can restrict root growth and the uptake of water and nutrients
- Neutralize the acidity
  - 3 pounds of calcium carbonate limestone (fine grained) per acre to be applied regularly

## Losses of Nitrogen in an Ag System

- Saturated soil
  - Increased level of denitrification
  - Decrease in nitrate levels
- Leaching of Nitrate and other nutrient cations
  - Higher chance of occurring due to the decreased level of surface runoff and increased water infiltration

## Volatilization

- Urea form of Nitrogen
  - Found in many fertilizers and manure
  - Easily convert to $NH_3$ and be lost to the atmosphere
- Minimize extreme volatilization levels of fertilizer by to applying before rain
  - Another option is to inject the fertilizer into the soil to decrease immobilization
- Best way to minimize nitrogen loss
  - Apply when the crop is ready to utilize the nitrogen
  - Suitable application rates.

## Best Management Practices

To take advantage of the REAP tax credit program, a farm must be implementing Best Management Practices (BMPs) and there are many different types.

## Steps to BMP

- Have your soil tested
- Follow soil test recommendations
- Set realistic yield goals
- Choose the most suitable nitrogen source
- Apply nitrogen and phosphorus correctly
- Time nitrogen applications appropriately
- Use manure as a nutrient source
- Control erosion
- Manage water flow
- Fence animals away from streams, drains and critical areas

## Planning BMPs

- An Erosion and Sedimentation Control Plan
- Conservation Plan
- Nutrient Management Plan
- Manure Management Summary
  - All plans must meet REAP requirements

## Equipment BMPs

- Composting Equipment
  - Will provide another source of fertilizer for crops
- Manure Equipment
  - Equipment for Manure Incineration, Incorporation, and Separation
- No Till or Conservation Tillage Equipment

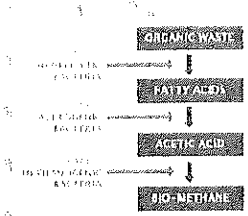
## Other Types of BMPs

- Access Roads
- Brush Management
- Constructed Wetland
- Cover Crops
- Riparian Forest Buffer
- A Waste Treatment Lagoon

## Biogas

- If a CAFO is not able to effectively export all of its manure: Biogas treatment facility is optional
- Uses manure, thin stillage (a by product of ethanol production) and three types of bacteria

## Biogas




- Stage 1: Bacteria break down manure into fatty acids
- Stage 2: Bacteria reduces the fatty acids into acetic acid
- Stage 3: Bacteria turns the acetic acid into bio-methane gas

## Biogas

- The byproduct of this process enters a nutrient recovery process and becomes a natural fertilizer than can still be exported by the CAFO
- CAFO has essentially free fuel that it can use to power portions of its farm

## Lesson 8 Review Packet

**Lesson Title**: Ammonium and Nitrogen in Our Local Soils

**Use this space to list the important facts from this lesson:**

**Presentation Idea:**

**Jobs of each group member:**

# Ammonium and Nitrogen in Our Local Soils

## Nitrate in Soils

- Nitrogen
  - Important for growth and reproduction in plant and animal life
  - Basic constituent of proteins
- Nitrate
  - $NO_3$
  - Natural material in soils
  - More then 90% of nitrogen absorbed by plants in Nitrate form
  - Most of non-protein nitrogen fraction
  - Important in animal production and in human food
    - Potential toxicity when excessive amounts ingested

## Movement of Nitrate in soils

- Soluble in water and moves with soil moisture
- Sandy soil = lost by leaching
- Heavier soil = slower leaching and most nitrogen recovered by plants
- Rarely leaches out of root zone in medium and fine-textured soils

## Nitrate in Plants

- Nitrate under normal growing conditions rapidly reduced to intermediate compounds and converted to amino-nitrogen
- Nitrate reduction occurs in aerial portion and roots of plants

## Ammonium

- $NH_3$
- After application
  - Binds to soil or organic matter
  - Converted to nitrate by bacteria in the soil
    - During conversion free hydrogens are released and cause the soil to be acidic

## Soil Testing

- Elements are chemically removed from soil and measured
  - Show when have too little or too much of a nutrient
- Plant growth increased by showing fertilizer recommendations

## Taking A Good Soil Sample

- Correct timing
- Clean sampling equipment
- Sample each unique area separately
- Take soil core to the appropriate depth
- Mix sample cores well
- Label and package sample correctly

**Lesson 9 Review Packet**

**Lesson Title**: The Chesapeake Bay

**Use this space to list the important facts from this lesson:**

**Presentation Idea:**

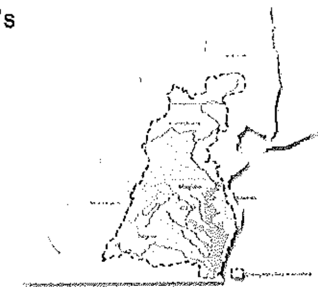
**Jobs of each group member:**

## The Chesapeake Bay

A case study in the balance between food production and environmental quality at the regional scale.

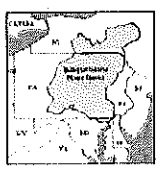
## The Chesapeake Bay

- One of the world's richest estuaries
- High productivity
- High aquatic diversity
- Important economically



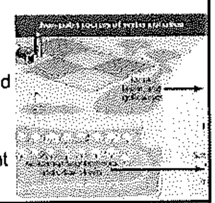
## The Susquehanna

- Most important tributary to the "upper bay"
- 2005's "most endangered river"
- Contributes ½ of the freshwater to the Bay
- Sediment and nutrient pollution of total inputs to the Bay
  - Nitrogen: 44 %
  - Phosphorus: 21 %
  - Sediment: 21%



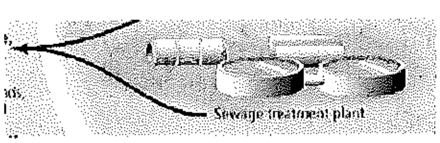
## Nutrient Pollution

- 64% is non-point source
- Farm runoff
  - Decrease with improved management and decrease in amount of farms
- Lawns, golfcourses, streets
- Residential Neighborhoods
  - Septic systems
    - Increase with development beyond sewer systems
  - Stormwater
    - Increased with urban development



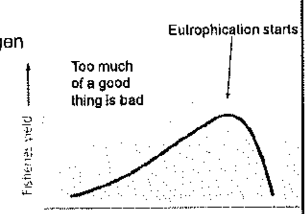
## Where Does Nutrient Pollution Originate From?

- 36% is **point-source**
  - Wastewater treatment
    - Generally decreasing
    - Phosphate detergent ban
    - Improved biological treatment technology

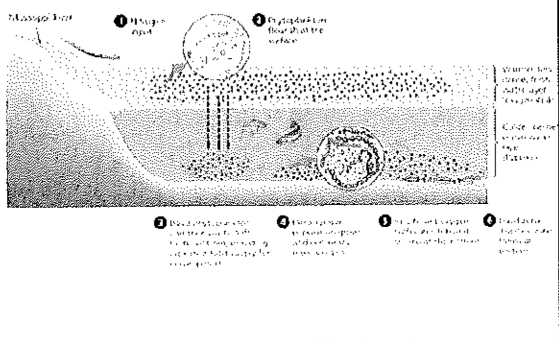



## Nutrients Affect Aquatic Ecosystems

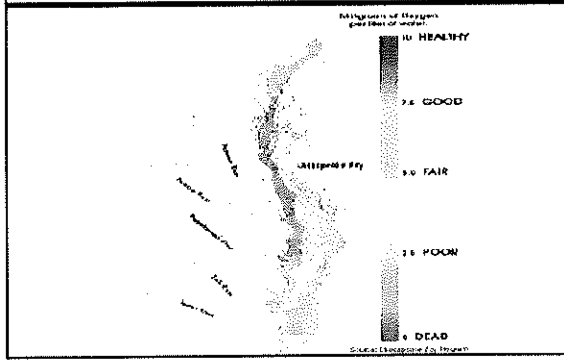
- Eutrophication
  - Increase in nitrogen and phosphorus
  - Excess nutrients in water lead to:
    - Algal blooms
    - Low dissolved oxygen
    - Death of fish



## Eutrophication of estuaries



## Eutrophication in the Chesapeake




## Chesapeake Bay Agreement

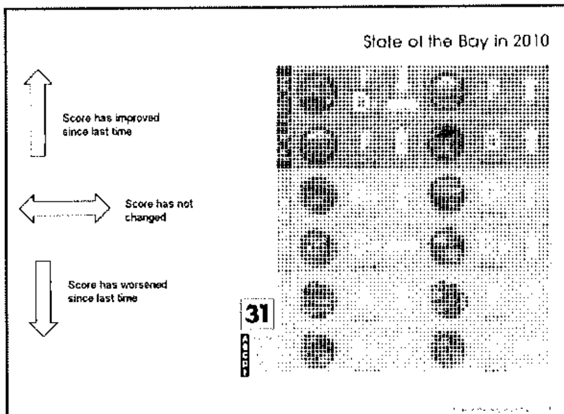
- 1983: First agreement
  - "Lets talk about doing something"
  - Pennsylvania, Maryland, Virginia, District of Columbia
- 1987: Sets goals
  - Focuses on sewage treatment
  - Reduce N and P by 40% by 2000
    - Goal missed by a long shot
- 1992: Tributary strategy
  - Reduce nutrient inputs upstream
  - More emphasis on non-point sources

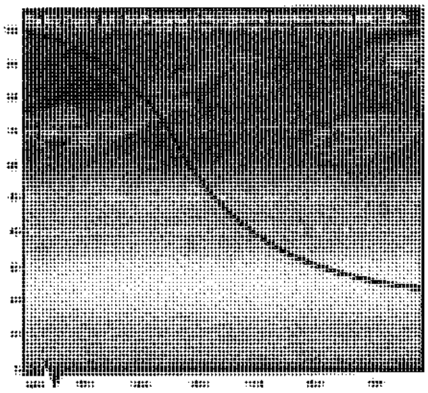
## Clean Water Act

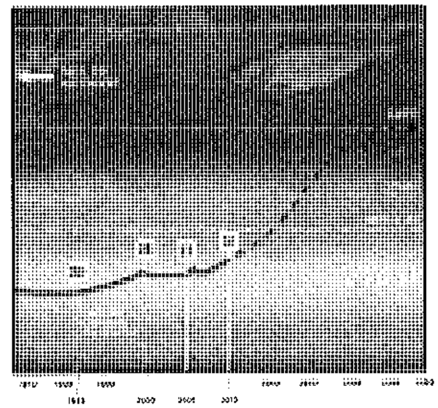
- Late 1990's
  - EPA sued to enforce Clean Water Act for Chesapeake bay tributaries
- The Clean Water Act sets a national minimum goal
  - All waters that are "fishable and swimmable."
  - Many groups sue for TMDL
  - One ruling requires EPA to enforce a TMDL for the Bay by 2011
- States scared of TMDL
  - New agreement in 2000 setting specific goals for 2010

## Goals of 2000 agreement

- Increase in native oysters
  - Eastern Oyster
- Remove barriers to migratory fish
- Restore crab fishery
- Restore crabs/fish habitat
  - Aquatic vegetation
- No-net loss of wetland acreage
- Restore 2,010 miles of "riparian" buffers
  - Riparian – streamside ecosystems
- 30% decline in sprawl rate
  - Preserve forests and farms
- 40% nutrient reduction goal
- "Free of toxins"





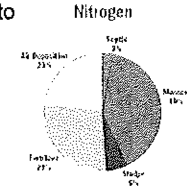


## EPA is establishing TMDL for the Bay

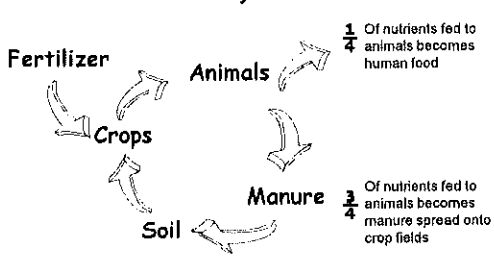
- States failed to meet the goals of the 2000 agreement so…
  - Based on 1990s law suit and the Clean Water Act the EPA needed to do this
  - TMDL in place for December 2010
  - Measures to meet TMDL must be in place by 2025
- From the EPA:
  - "It will be the largest and most complex TMDL ever, involving interstate waters…. 17 million people, 88,000 farms, 483 significant treatment plants, thousands of smaller facilities and many other sources"

## What is the link to PA farms?

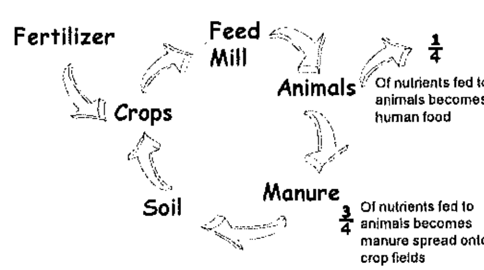
- Farms are a major source of N to the bay
- PA Nutrient Management Act
- Clean Water Act
  - Future TMDL by EPA
- Both focus on
  - CAFO
  - BMP




## Traditional Nutrient Cycle



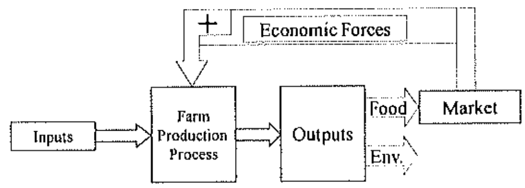

## Contemporary Nutrient Cycle



## Pollution Problems Due To Nutrients

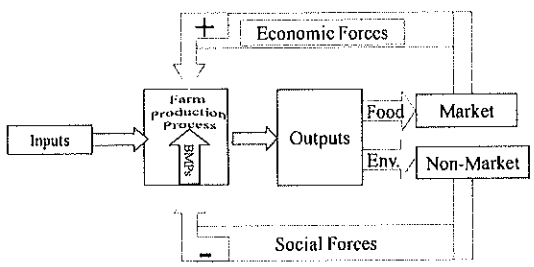
- Changing structure of animal agriculture
  - Self-sufficient farms to specialized farms
    - Haber-Bosch fertilizer after World War II
    - Subsidies for corn production
    - Farms grow crops specially for animal feed
      - Example: Farm in Iowa grows feed for animals in PA
  - Economies of scale
  - Concentration of Agriculture industries
  - Farmers respond to us: cheap food (meat)

## Nutrient Pollution Problem




Adapted from Lanyon, 2000

## Current Model

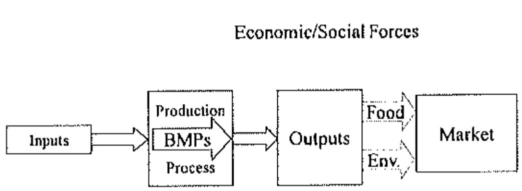



Adapted from Lanyon, 2000

## Example of Current BMP's

- Many of these are funded by the State / Federal Government
  - Cover crops and No-till
  - Riparian tree buffers or fencing
  - Manure storage facilities
  - Manure Transport to nearby farms
  - Manure/feed treatment to facilitate nutrient balance
- None of these help farm economies

## How The Model Should Look




Adapted from Lanyon, 2000

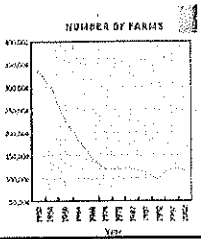
## Recent Examples

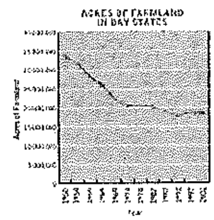
- **Nutrient Trading**
  - Municipalities buy nutrient credits when they don't want to upgrade
  - Not a 1:1 trade
    - Municipality releases 1 g of N and pays farmers to reduce by 4 g
  - Examples
    - Farmer goes to no-till; sells credit
    - Red Barn Trading exports manure out of watershed
- **REAP**
  - $10 million in tax credits to farmers to recover costs of implementing new BMPs
  - Farmers can't use credits so they transfer them
    - Sell on open market for less than total credit to businesses with big tax bills
    - Get businesses to invest in the farm and then take the credit

## A Future Example

If states fail to meet TMDLs the EPA could increase the number of farms that are point sources

- EPA
  - Make farms with with over a designated number of animals become a CAFO point source
  - CAFOs pay large permitting fees
  - Would citizens really choose Bay water quality over farms?
    - This model squeezes the farmer furlher




## Addressing Pollution Problems Due To Nutrients

- Do more than just improving on-farm nutrient management
- Requires changes and restructuring in our agricultural systems
- Immediate action
  - Implementing a nutrient management plan to minimize impact of the system

## Lesson 10 Review Packet

**Lesson Title**: The Malthusian Dilemma

**Use this space to list the important facts from this lesson:**

**Presentation Idea:**

**Jobs of each group member:**

# The Malthusian Dilemma

How have we succeeded in feeding the world?

## Thomas Malthus

- 1798
  - Essay on the Principle of Population
- If population increases geometrically
  - 1, 2, 4, 8, 16, 32, 64, 128

And food production increases arithmetically
  - 1,2,3,4,5,6,7,8

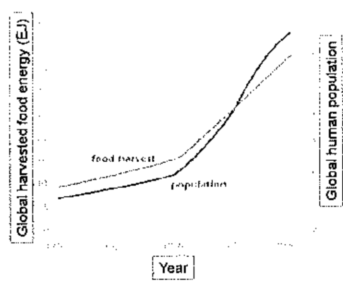
Then we are in trouble

## "neo-Malthusians"

- Believe humanity is doomed
- Assume population, affluence and technology are independent of each other
- Paul Ehrlich
  - Population Bomb
    - Mass starvation in 1970's and 1980's overpopulation

## Malthus's Incorrect Guess

Both population and food harvests have grown geometrically

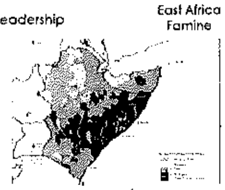



- Can we continue to increase crop yields non-linearly?
- Will Malthus eventually be right?
- What are the "costs" of increasing yields?

## Recent Famines NOT Caused By Global Food Shortages

- Europe: 1300's
  - Medieval warm period ended: less food produced
- Irish potato famine: 1850's
  - Social, climate, and pest factors (blight)
- China in 1950's and 60's
  - Population growth combined with poor leadership
- Ethiopia in the 1970's and 80's
  - Sociopolitical
- Horn of Africa Famine in 2011
  - Somalia, Ethiopia and other neighboring countries
  - Severe drought

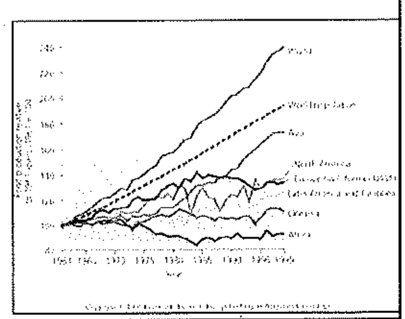
East Africa Famine



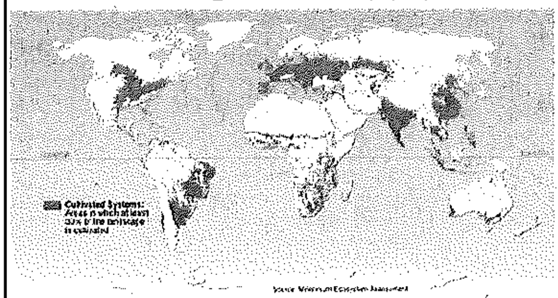
- Currently: 1 billion people are hungry

## Recent Food Production Changes Linked To Politics

- Decline of USSR
- Subsidies in Europe/US
- Turmoil in Africa



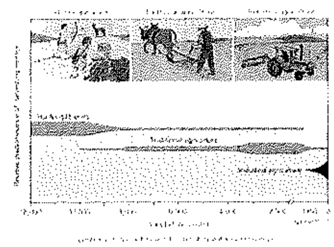
## Increasing Food Supply



Cultivated Systems in 2000 cover 25% of Earth's terrestrial surface

## Increasing Food Supply

- Industrial agriculture accounts for 25% of cropland
- Industrial agriculture is a fairly new concept
- It would not be possible to feed the world with traditional agriculture



Vandana Shiva

- "Water has grown scarcer in India, as Green Revolution water-guzzling agriculture replaces traditional practices attuned to local water conditions and local needs."

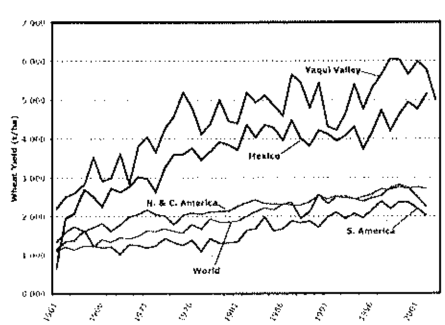
Norman Borlaug

- "Millions of farmers who have successfully grown the new wheat, rice, and maize varieties have greatly increased their income. And this has stimulated the rapid growth of agro-industry by increasing the demand for fertilizers, pumps, machinery, and other materials and services."

## Green Revolution

- Founded by Dr. Norman Borlaug
- A movement to increase the crops produced per acre of farmland by
  1) Improved plant breeding
  2) Increasing the number of harvests per year
  3) Giving plants the resources they need to grow fast
     A) Irrigation
     B) Fertilizers
  4) Mechanized plowing/harvesting/etc
  5) Pesticides
  6) Bringing modern agriculture to under-developed countries

## Yaqui Valley -- "The Home Of The Green Revolution"




## 1) Plant breeding

- Began in Mexico in 1944
  - 1944 – Mexico imported half of its wheat
    - The Rockefeller Foundation, Dr. Borlaug and the Mexican government established a plant-breeding station in NW Mexico
  - 1956 – Mexico self sufficient in wheat production
  - 1964 – Mexico exports ½ million tons of wheat

## Genetic Engineering

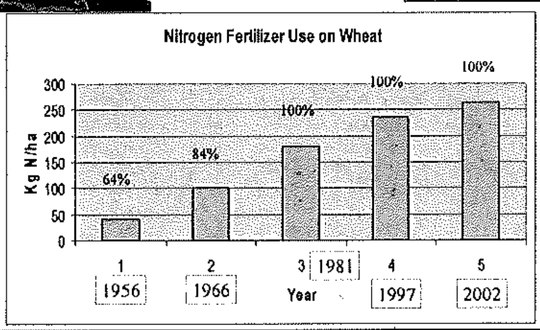
- Breeding crops in the lab to choose the best cultivars
- Used plant varieties from all over the world and crossed them
- Crops have same photosynthetic efficiency as wild ancestors
- They are now "dwarf" varieties and have disease resistance


Norman Borlaug

## Dwarf Varieties

- More of the tissue we want
  - Seeds
  - Leaves
  - Tubers
- Example
  - Traditional Wheat in Mexico = 1 meter high and only 25% of plant mass used
  - New cultivar = Less than .75 m tall and 50% of mass used
- Less lodging





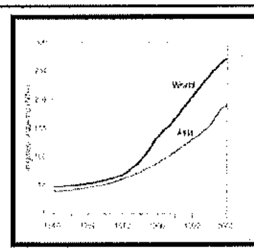

## Long-term Impacts

- Plants outperform traditional varieties
  - Less global famine
  - Less agriculture land area
  - Requires irrigation, pesticides, and fertilizers
    - If these are not available, traditional varieties can do better
    - Requires dependence on high inputs
- Limited genetic diversity
- Seeds must be purchased
  - Previously farmers could save seeds, now they buy them
  - Leads to ownership of crop types by current biotech companies such as Pioneer

## 2) Increasing The Number Of Harvests Per Year

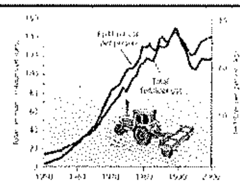
- Dr. Borlaug had the idea to plant crops in the mountains in the summer and in the Yaqui Valley during the winter
- This lead to modern crop rotations:
  - Crops grown year round on the same spot

## 3) A. Increased Irrigation:



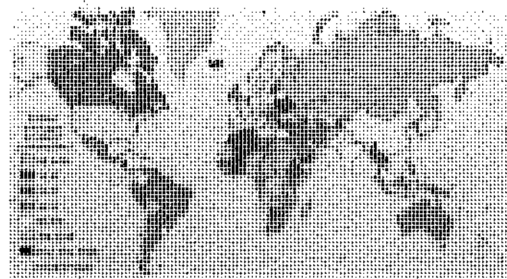
- Plants require
  - 450 – 1300 moles of water per mole $CO_2$ absorbed
- Seasonal Crop Water Requirements
  - 25 – 50 cm for small grains
  - 80 – 100 cm for corn
  - >100 cm for alfalfa, sugarcane and rice

## 3) B. Increased Fertilizer Use



- Plants composition:
  - Carbon from the atmosphere
  - From soil
    - Nitrogen, Phosphorus, and Potassium
    - Nitrogen mass is 10 times larger than phosphorus; Potassium is in between
- If soils can't provide Nitrogen, Phosphorus, or Potassium
  - Plants grow slowly
    - Less food
  - Every harvest soils are depleted of these nutrients
  - Add nutrients in as fertilizers

## Global fertilizer applications

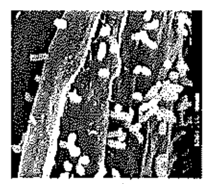


## Keeping Traditional Nutrient Applications

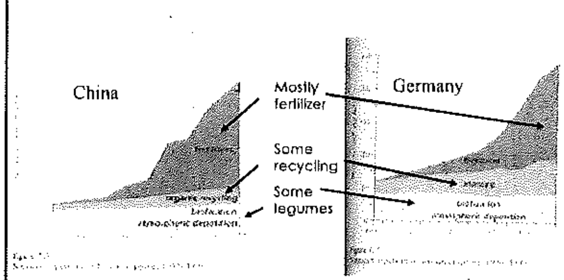
- Traditional agriculture used organic wastes to return nutrients to soil
  - The only way to support 10 billion people by traditional cropping (i.e. only organic waste additions) would be to double or triple amount of cultivated land.
  - This would require complete deforestation of tropical rainforests to acquire land
- To give up inorganic N fertilizers alone means that the global population would need to decline by 2 to 3 billion

## Legume Crops Reduce Fertilizer Use

- Some crops have symbiosis with a bacteria attached to roots (Rhizobia)
  - Called "biological nitrogen fixation"
  - Can take nitrogen right out of atmosphere

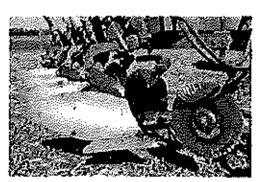


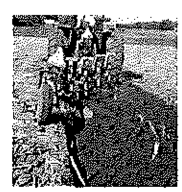
## Fertilizer Most Important Nitrogen Input




## 4) Mechanized Cropping

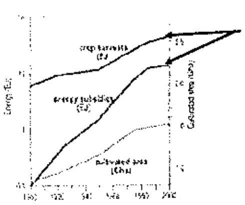
- Used for
  - Preparing Seed Beds
  - Controlling Weeds
  - Applying fertilizers / pesticides
  - Harvesting





## Increases Energy Use

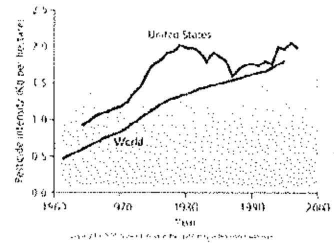
- Energy breakdown
  - 45% Fertilizer
  - 45% Machine operation
  - 2% pesticides



Crop harvests and energy subsidies (from fossil fuels) have increased by several orders of magnitude (left axis)

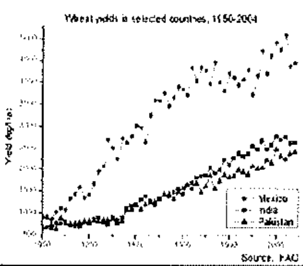
## 5) Pesticide Use

- Increasing globally
- Insects
- Fungi
- Weeds



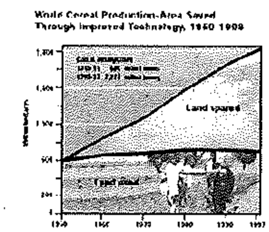

## 6) Expanding Into Developing Countries

- For this Dr. Borlaug won the Nobel Peace Prize in 1970




## Results Of The Green Revolution

- Increased food production in many regions and globally
- Allowed agricultural land area to remain the same
- Failed in some cases and diminished environmental quality
- Possibilities for further yield increases from these methods are limited




## Synthesis

- Malthus predicted famine
  - Population grow faster then production
- Green Revolution
  - Helped avoid famine by increasing production / acre
  - Used: Breeding, fertilizer, irrigation, pesticides, mechanized cultivation
  - Drawbacks
- Global food production continues to increase while food production / person is not
  - Current food availability and famine problems caused by social factors