

Integrated Science: Drinking Water

by:

Sarah Arnold, Alex Bradley, Katie Henderson, Laura Holt, Amanda Knox, Courtney MacPhail

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Dr. P. Pheeny

Rationale

Introduction

Environmental Science is a discipline which encompasses many fields of science such as Biology, Chemistry, Physics, and Math. These are topics which are essential to study at the high school level but which some students do not enjoy because they cannot relate to them. Environmental Science is a field which appeals to many students because it is easy to relate to and to see on a macroscopic level in everyday life. We propose an integrated science unit which focuses on drinking water from an environmental perspective.

Drinking water is a luxury that is often taken for granted. Students will be fascinated to see where their drinking water comes from and how it is made safe to drink. They should all also share an interest in the global water shortages coming into effect and how we can help by conserving water.

Focus and Context

This unit is broken up into four main topics relating to drinking water. This follows the logical pathway from where water comes from (Hydrological cycle) right until it reaches the tap in our homes, and human consumption of this water.

The first section focuses primarily on the hydrosphere. Students will investigate the different stages of the hydrosphere and the human impact on this cycle.

The second section focuses on aspects of water distribution, including wells, water towers, and pipes. Students will investigate protection of water resources, and the physics involved in water distribution.

The third section focuses on water treatment. Students will have a look inside a local water treatment plant, and discover the necessity for these processes.

The fourth section focuses on water once it reaches the home and human uses of water. Students will learn about domestic water consumption rates and the effects of water on the human body.

Surface and Groundwater

- What are the properties of surface and groundwater?
- What are the sources of drinking water?
- What procedures are in place for the protection of groundwater?

Pipes

- What is the civil engineering behind: wells and water towers?
- How is water pumped?



Drinking Water

Water Treatment Plant

- Why do we have to treat water?
- How do you treat/test water that comes from the ground?

House

- What is water used for?
- Why does the human body require water?

Bloom's Taxonomy

Cognitive Level	Students should be able to...
Knowledge and Comprehension	<ul style="list-style-type: none"> ○ Explain and illustrate Earth's hydrological cycle ○ Identify the importance of water and its physical properties ○ Identify sources and uses of fresh water ○ List and classify organisms that could be living in the water and explain their effect on humans ○ Define and explain what a wellfield is. Identify some contaminants that could adversely impact Fredericton's drinking water supply. ○ Identify different contaminants and ways groundwater can become polluted. ○ Identify some contaminants that could adversely impact Fredericton's drinking water supply. ○ Identify and describe the environmental impacts of some of these contaminants. ○ Describe what water towers are for, and how they work. ○ List and complete a table of water usages in households
Application	<ul style="list-style-type: none"> ○ Describe the consequences of overusing freshwater resources ○ Solve a set of problem questions related to vectors
Analysis	<ul style="list-style-type: none"> ○ Explain how water is treated ○ Diagram and compare the functions of the components of the cell
Evaluation	<ul style="list-style-type: none"> ○ Evaluate advantages and disadvantages of bottled water and tap water. ○ Assess water management systems ○ Evaluate the importance of water for human life
Synthesis	<ul style="list-style-type: none"> ○ Create a water conservation plan. ○ Create a scenario and respecting time versus distance graph to demonstrate water flow.

Tasks for Instruction and/or Assessment

Subtopic: Surface and Groundwater

- **What are the properties of surface and groundwater?**
- **What are the sources of drinking water?**
- **What procedures are in place for the protection of groundwater?**

It is expected that the students should be able to...

- Explain and illustrate Earth's hydrological cycle
- Differentiate between surface and ground water
- Identify the importance of water and its physical properties
- Evaluate the importance of water for human life

Class Work

- Colour code and label a diagram of Earth's hydrological cycle [Hydrological Cycle](#)
- Compare and contrast surface and ground water, what are the similarities and differences. (discuss in a group)
- What is the pH? Lab assignment [Water Experiment – What's the pH](#)
- Difference between Hard and Soft Water [Hard and Soft Water Questions](#)

Teaching Resource

- <http://www.lenntech.com/hydrological-cycle.htm>
- <http://www.lenntech.com/processes/softening/faq/water-softener-faq.htm>

Research

- In groups research the social impact of limited freshwater resources and its potential for conflict. Present to the class as a PowerPoint, poster, or movie/narrated photo-story.
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Tasks for Instruction and/or Assessment

Subtopic: Surface and Groundwater

- What are the properties of surface and groundwater?
- **What are the sources of drinking water?**
- What procedures are in place for the protection of groundwater?

It is expected that the students should be able to...

- Identify sources and uses of fresh water
- Describe the consequences of overusing freshwater resources
- Assess water management systems

Class Work

- Brainstorm in groups how freshwater supply to a large city is managed (students will be able to examine their findings with the rest of the class in a group discussion)
- Become familiar with the Federal regulations and health and safety standards for water supply in their province. Compare and contrast them with the WHO'S drinking standards.

1. Canada:

http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index-eng.php

2. WHO- World Health Organization:

http://www.who.int/water_sanitation_health/dwg/guidelines/en/

Teaching Resource

- http://www.who.int/water_sanitation_health/dwg/guidelines/en/
- <http://www.lenntech.com/applications/drinking/faq/drinking-water-faq.htm>

Research

- Working in groups of two, research your towns drinking water. ¹Where does it get its drinking water? ²Is it surface or groundwater? ³Why do some cities use surface water and other use groundwater? ⁴How is your Drinking water treated? ⁵What is added or removed? ⁶Compare and contrast your drinking water to another city in Canada-How are they similar or different?

Tasks for Instruction and/or Assessment

Subtopic: Surface and Groundwater

- What are the properties of surface and groundwater?
- What are the sources of drinking water?
- What procedures are in place for the protection of groundwater?

It is expected that the students should be able to...

- Define and explain what a wellfield is.
- Describe where Fredericton’s drinking water comes from.
- Identify some contaminants that could adversely impact Fredericton’s drinking water supply.
- Identify different contaminants and ways groundwater can become polluted.
- Identify and describe the environmental impacts of some of these contaminants.
- Evaluate advantages and disadvantages of bottled water and tap water.

Class Work

- Investigate unique aspects of Fredericton’s drinking water: its location, and what Fredericton does to protect this valuable resource.
- **Focus question:** what can you or your family do to protect our wellfields? Create a pamphlet or newscast in groups of 3 or 4 to communicate the importance of wellfield protection.
- Discuss with the class some potential sources of pollution near or on the wellfields (gas stations, dry cleaners, etc.)
- Divide the class into 6 groups. Assign each group a contaminant listed below. For each contaminant, research and discuss the environmental impact and a human health impact (ie: how ingesting the contaminant via drinking water could be harmful to your health).
 1. **Bacteria and viruses** (Sources: septic systems/sewer lines, animal waste)
 2. **Petroleum products and solvents** (Sources: home heating tanks or underground tanks, paint thinners) 3
 3. **Chlorinated solvents** (Sources: dry cleaning fluids, metal degreasers)
 4. **Pesticides** (Sources: lawn care/agricultural/forestry management chemicals)
 5. **Inorganic contaminants** (Sources: road salt, inorganic fertilizers)

(Continued)

Tasks for Instruction and/or Assessment

Subtopic: Surface and Groundwater

- What are the properties of surface and groundwater?
- What are the sources of drinking water?
- **What procedures are in place for the protection of groundwater? (Continued)**

It is expected that the students should be able to...

- Define and explain what a wellfield is.
- Describe where Fredericton’s drinking water comes from.
- Identify some contaminants that could adversely impact Fredericton’s drinking water supply.
- Identify different contaminants and ways groundwater can become polluted.
- Identify and describe the environmental impacts of some of these contaminants.
- Evaluate advantages and disadvantages of bottled water and tap water.

Class Work

- Provide the class with some articles on the environmental issues of bottled water vs. tap water. Divide the articles between the students so that each may bring some different knowledge to the table. Divide the class into 2 groups. Have each group share with each other what they learned from their articles. Have a debate between those for bottled water, if there are any, and those against. Summarize the key points raised and produce a brochure for the school.
- **Focus question:** how many bottles of water do you consume per week? Per month? Calculate the number of bottles per year for the entire class.

Teaching resources:

- [What is a wellfield?](#)
- [Learn about Fredericton's wellfields](#)
- [Fredericton's wellfields \(map\)](#)
- [Water treatment plant](#)
- Just for fun: take this quiz as a class and see how much is known about ground water: [quiz](#)
- Water trivia: [trivia](#)
- [Bottled Water Vs. Tap Water | Inside the Bottle](#)
- [Tap water](#)
- [National geographic water.html](#)
- [Bottled water.pdf](#)

Tasks for Instruction and/or Assessment

Subtopic: Pipes

- **What is the civil engineering behind: wells and water towers?**
- How is water pumped?

It is expected that the students should be able to...

- Describe how water gets from the ground to the water treatment plant.
- Explain the attributes and function of Fredericton’s drinking water treatment plant.
- Describe what water towers are for, and how they work.
- Students demonstrate an understanding of area, volume and ratios.

Class Work

- Identify the major attributes of a water well.
- If possible, arrange a tour of the drinking water treatment plant for the students through the City of Fredericton. If a tour is not possible, arrange for a guest speaker to come and give a presentation to the students on the drinking water treatment plant.
- Identify the location of some of Fredericton’s water towers. As a class, discuss what they *thought* they were for, right or wrong. Discuss how water towers work. Students may discover why the water still works during a power outage.
- Lead the class to discuss other important uses for water during a power outage (fire suppression).
- Allow students to work in groups of 3 or 4. Provide students with the density of water and ask them to design a water tower capable of holding 1.5 gallons of water. This model can be used to find the actual sizes of a water tower that holds 1,500,000 gallons of water. Ask students to build a model of their water tower and calculate the cost of painting the model and the actual water tower. Have each group submit a report with assigned responsibilities, sketches, and all calculations.

Teaching resources:

- [All about water wells](#)
- [What is a well?](#)
- [Water towers](#)
- [More on water towers](#)
- [Do water towers freeze](#)

Tasks for Instruction and/or Assessment

Subtopic: Pipes

- What is the civil engineering behind: wells and water towers?
- **How is water pumped?**

It is expected that the students should be able to...

- Analyze graphically and mathematically the relationship among the displacement, velocity and time.
- Use vectors to show velocity and acceleration of water flowing in different areas of the city.

Class Work

- Once students understand vectors, have them apply this knowledge to questions about water flow in pipes (Questions adapted from regular physics textbook).
- This website allows students to make their own distance vs. time graph.
<http://graphs.mathwarehouse.com/distance-vs-time-graph-lesson.php>
Students are then able to use the graph to analyze and make a story of the journey they took in space.
- They can then make their own situation relating to the water in pipes. Suggesting when the water is flowing fast and slow, where the water would not be moving at all. They would then graph this in a distance versus time graph and label the slopes.

Teaching Resources:

- [vect_questions.doc](#)
- <http://www.mathwarehouse.com>

Tasks for Instruction and/or Assessment

Subtopic: Water Treatment Plant

- **Why do we have to treat water?**
- **How do you treat/test water that comes from the ground?**

It is expected that the students should be able to...

- Be able to list and classify organisms that could be living in the water and explain their effect on humans.
- Diagram and compare the functions of the components of the cell.

Class Work

- Do a case study of a historical water contamination issue (i.e. Walkerton). Include information such as what organism caused the issue, its taxonomical classification, where the contamination came from, the effect it had on humans who consumed the water, and how this could have been avoided. Information can be presented as an essay, video, or poster project to be displayed in class.
- Many organisms that contaminate water are single celled organisms. Create your own 3-D model of the cell, accompanied by a legend that explains what each component is and its function in the cell. Points can be awarded for complexity, creativity, number of organelles included, and quality of organelle descriptions. Students should be able to identify whether their cell model is a plant, animal or bacterial cell.

Teaching Resources:

- <http://www.cellsalive.com/>
- <http://www.cellsalive.com/cells/3dcell.htm> (Models)
- There is a link to the powerpoint presentation on the Fredericton [Water Treatment Plant](#)

Tasks for Instruction and/or Assessment

Subtopic: Water Treatment Plant

- Why do we have to treat water?
- How do you treat/test water that comes from the ground?

It is expected that the students should be able to...

- Explain how the water is treated

Class Work

- Review the treatment process that students learned about on the tour of the treatment plant (or from the presentation that a staff member of the plant gave to the students)
 - Identify what chemical processes took place at the water treatment place. Write balanced chemical equations for these processes.
 - In groups of 2-3, create a brochure for the general public or for younger students explaining the water treatment process.
 - [Simulated Water Treatment Plant Lab](#)
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Tasks for Instruction and/or Assessment

Subtopic: House

- **What is water used for?**
- Why does the human body require water?

It is expected that the students should be able to...

- Calculate water usage and analyze and interpret the data.
- Demonstrate understanding of real-world relationships by translating between graphs, tables and written description.

Class Work

- Brainstorm ideas with students about how they use water in their homes.
 - Take the ideas from the brainstorming and make a table (example [table](#)) that students can take home to record the amount of water they used in a week.
 - Using the data the students gathered, calculate in gallons of water the amount they used in a week. This can be achieved using the website given: <http://ga.water.usgs.gov/edu/sq3.html>
 - Collect the data from all students and compile it together. Then used this compiled data to analyze the use of water with the students.
 - In groups no bigger than 4, have them create their own water conservation plan to reduce water usage. This can be achieved by using the data and analysis gathered in class as well as researching ways to reduce water usage.
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Tasks for Instruction and/or Assessment

Subtopic: House

- What is water used for?
- **Why does the human body require water?**

It is expected that the students should be able to...

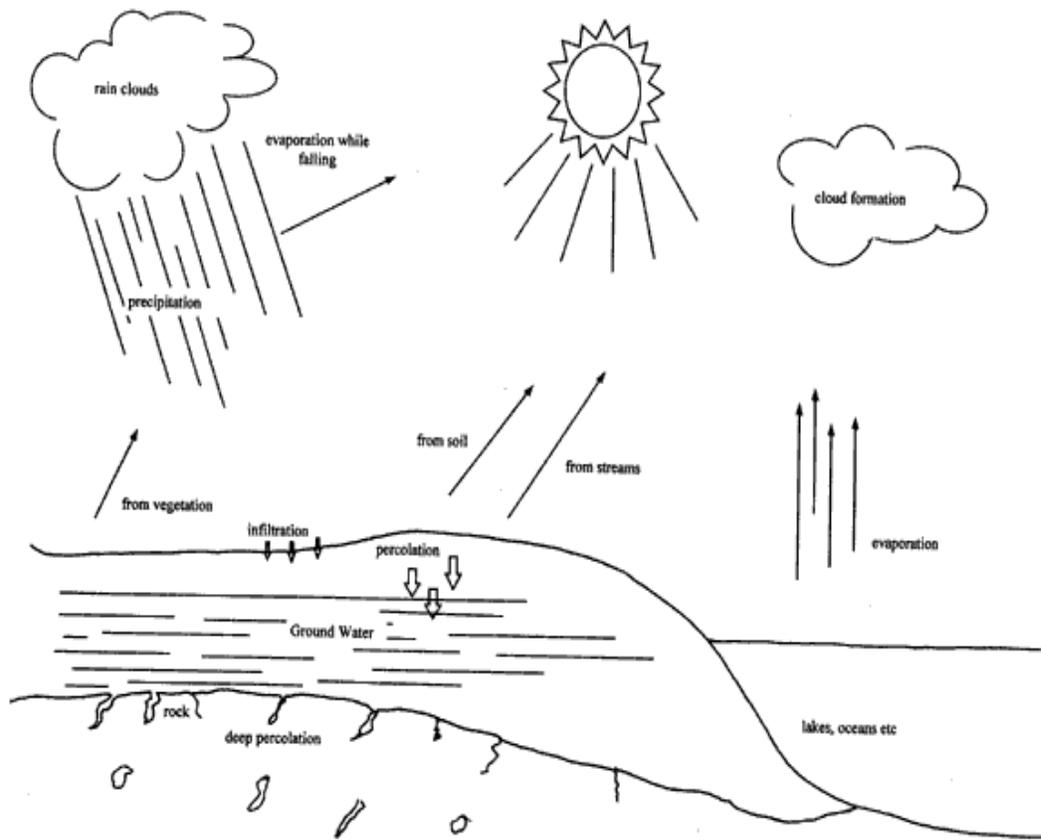
- Explain the significance of water as it relates to the various organ systems.

Class Work

- Create a diagram of a singular nephron in the kidney, label where water is reabsorbed from the filtrate and explain why it is reabsorbed, using your knowledge of osmosis, and active and passive transport. (See [fig 1](#))
 - Individually research the role of water in the process of human digestion. Explain why it is important and how it assists processes of digestion. Discuss your findings on a blog. Then read 3 other student's blog entries and make comments. (See [fig 2](#))
 - Interview a member of a school sports team. Inquire about their experiences with dehydration and ask them what role they think water plays in brain chemistry. Report your findings in a newspaper article and include a clever headline. (See [Focus Questions](#))
 - Write a journal article reflecting on a time you, or someone you know, inhaled water. Explain, on a molecular level, why that person was unable to breathe.
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APPENDIX

The Hydrologic Cycle



Water Experiment – What's the pH

Procedure:

pH of Water

1. Standardize the pH meter in the acidic range as demonstrated in the lab.
2. Measure the pH of each of the acidic solutions provided. Rinse the probe with distilled water after each sample.
3. Recalibrate the pH meter in the basic range.
4. Measure the pH of the basic solutions provided. Rinse the probe with distilled water after each sample.
5. Recalibrate the pH meter and measure the pH of the water

Water pH Answer Sheet

Solutions Tested	Estimated pH	Experimental pH	Acidic, Basic or Neutral?
Water			
1. Tap water			
2. Bottled water			
3. Distilled water			
4. Ground water			
5. Surface water			

Explain your estimated pH values and why they were the same, very close, or different from the experimental values.

Hard and Soft Water Questions

1. Hard water

1.1 What is hard water?

1.2 Which industries attach value to hardness of water?

2. Water softening

2.1 What is water softening?

2.2 What is a water softener?

2.3 Why is water softening applied?

2.4 What does a water softener do?

3. Softening salts

3.1 Which types of salt are sold for application in a water softener?

3.2 Should we use rock salt, evaporated salt or solar salt in a water softener?

3.3 Is it harmful to mix different kinds of salt in a water softener?

3.4 How often should one add salt to a softener?

3.5 How come water sometimes does not become softer when salt is added?

4. Softening drinking water

4.1 Do water-producing companies always produce softened water?

4.2 Is softened water safe to drink?

4.3 Can salt from softening installations enter drinking water?

4.4 How much sodium does one absorb from softened water?

4.5 Will softening drinking water deprive it of essential minerals?

Source: <http://www.lenntech.com/processes/softening/faq/water-softener-faq.htm>

Extra Resources:

[GNB Wellfield protection](#)

[Fun Facts about water conservation](#)

[ground water quality](#)

<http://www.waterworld.com>

[Lift/pump stations](#)

<http://www.insidethebottle.org/us-bottled-water-vs-tap-water>

[20/20 bottled water clip](#)

[CBC tap water](#)

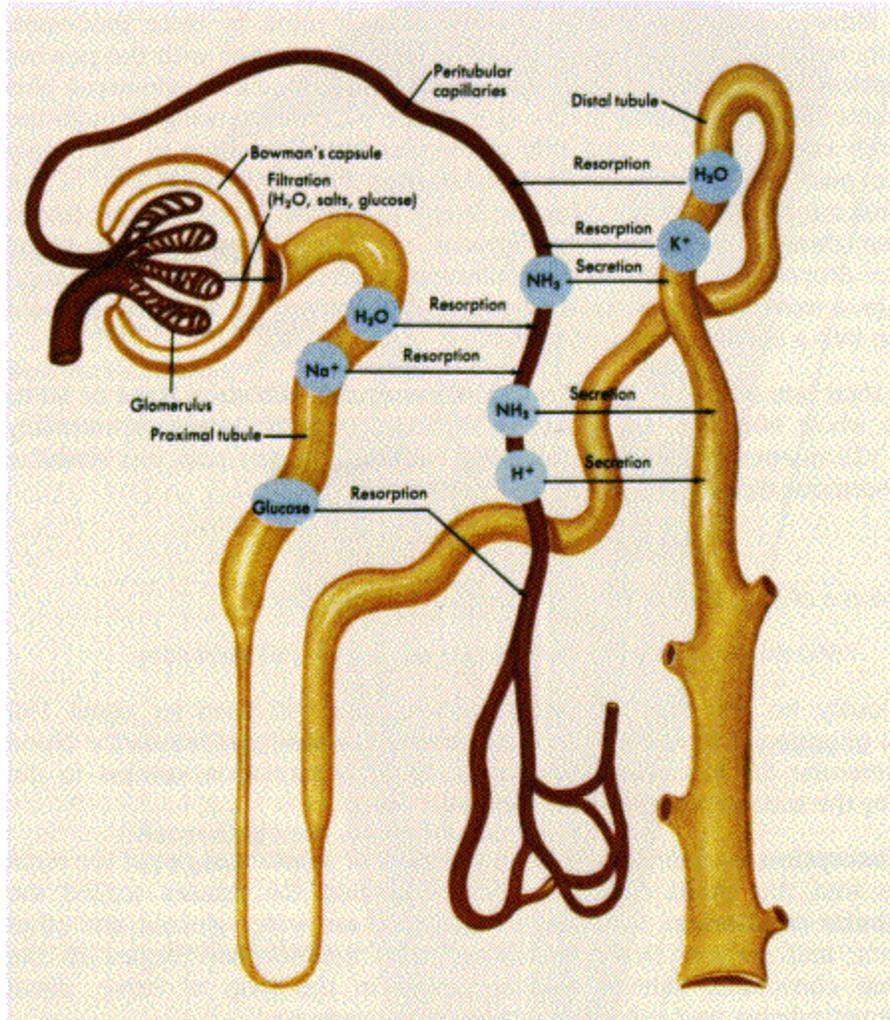


Fig 1. Labelled diagram of an individual kidney nephron, illustrating the locations of various secretions and absorptions.

Source: http://home.bway.net/rjnoonan/humans_in_space/nephron.gif

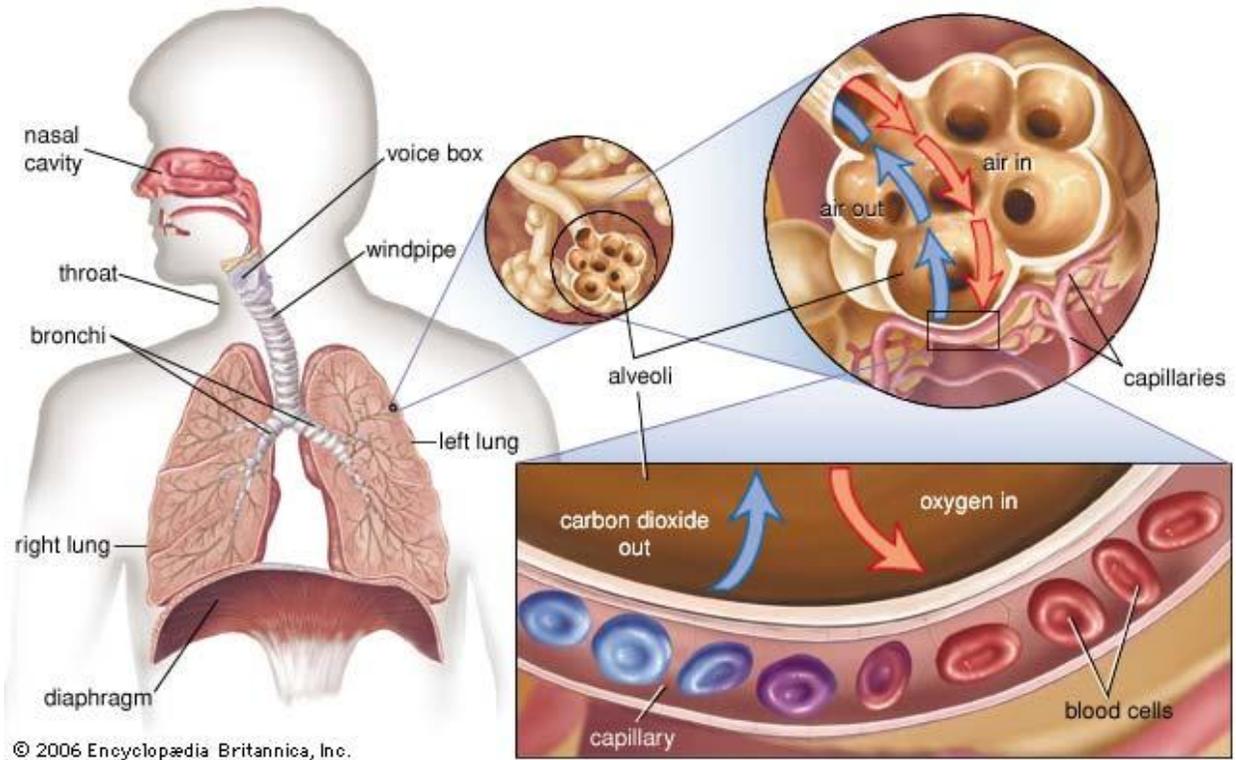


Fig 2. Diagram of the human respiratory system and individual alveoli.

Source: <http://media-2.web.britannica.com/eb-media/37/92937-034-1E4EA526.jpg>

Focus Questions:

- 1) Why is water important in the acid reaction in the stomach?
- 2) What is the relationship between water and the secretion of sodium bicarbonate in the duodenum?
- 3) How does water effect the digestion process in the intestinal tract?

Source: <http://www.innvista.com/health/nutrition/diet/digest.htm>

Water Usage Table

	Amount
Baths Taken	
Showers	
Average shower length	
Teeth brushing	
Hand/Face Washing	
Face/Leg shaving	
Dishwasher Loads	
Dishwashing by hand	
Clothes washing loads	
Toilet Flush	
Water Drunk	