Lesson 1:
The Water Crisis

Teacher Materials

Contents

Introduction to the Water Crisis: Teacher Lesson Plan

Orientation

This lesson is an introduction to the context and human need for clean drinking water. Many students in the United States are unaware that in several parts of the world, clean drinking water is unavailable. This introductory lesson is intended to increase students' awareness of the problem in terms of human health and as a potential source of conflict between nations, especially as the world population grows.

A key goal is to spark students' interest by addressing a topic of personal and global significance. It is within the context of the urgent need for clean water by the people of several nations that they will better understand the significance that nanomembrane filtration technology could potentially have on helping to solve one of the current largest global problems. They will refine this understanding over the course of the unit and have a chance to reflect on their initial thoughts at the end of the unit.

- The Water Crisis PowerPoint slide set introduces facts about the global distribution of fresh water geologically. Areas of the world that do not have access to enough clean drinking water are highlighted. Per capita water usage, wealth, and access to sanitation are shown for several countries, and consequences from drinking contaminated water are highlighted. The final slide in the set introduces the driving questions for the unit.
- The Water Crisis: Student Data Worksheet captures the images of the data graphs and tables embedded in the slide set. The questions associated with the data sets that are designed to get students to think about the information portrayed. We recommend that the students do the data sheet as a homework assignment previous to seeing the slides. Alternately, they can complete it as you present the slides, pausing at each slide that portrays a data representation in order to give students time to think about the information depicted.
- The Initial Ideas: Student Worksheet gives students the chance to draw on their existing knowledge to formulate first thoughts about the unit. This is a great tool for eliciting students' prior knowledge (and possible misconceptions) related to the unit topics.
- The Water Crisis: Student Quiz can help you to assess the student understandings before the lesson is taught, so you can adjust the lesson appropriately, or it can be used as a summative evaluation after the lesson.

Essential Questions (EQ)

What essential questions will guide this unit and focus teaching and learning?

(Numbers correspond to learning goals overview document.)

2. How do we make water safe to drink?
3. How can nanotechnology help provide unique solutions to the water shortage?
4. Can we solve our global water shortage problems? Why or why not?

Enduring Understandings (EU)

Students will understand:

(Numbers correspond to the learning goals overview document.)

1. A shortage of clean drinking water is one of the most pressing global issues.

Key Knowledge and Skills (KKS)

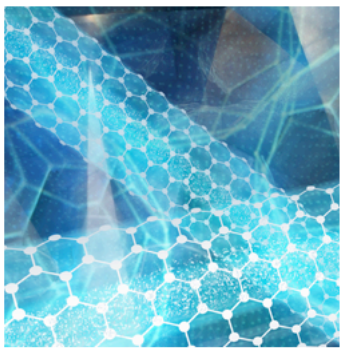
Students will be able to:

(Numbers correspond to the learning goals overview document.)

1. Describe the global distribution of clean drinking water and explain some of the causes and consequences of water scarcity.

Introduction & Initial Ideas Timeline

Day	Activity	Time	Materials
Prior to this lesson	*Homework*: Water Crisis: Student Data Worksheet	*40 min*	Photocopies of Water Crisis: Student Data Worksheet
Day 1 (50 min)	Hand out the Initial Ideas Student Worksheet and have students work alone or in pairs to brainstorm answers to the driving questions. Let students know that at this point they are just brainstorming ideas and they are not expected to be able to fully answer the questions.	10 min	Copies of Fine Filters Initial Ideas: Student Worksheet Fine Filters Initial Ideas: Teacher Instructions
	Show the Water Crisis: PowerPoint Slides, using the question slides and teacher's notes to start the class discussion. Hand out the Water Crisis: Student Data Worksheet if students did not complete it as a homework assignment the night before. Students can interpret the data representations or update their responses as you show the PowerPoint slide set.	30 min	Water Crisis: PowerPoint Slides & Teacher Notes Computer and projector Water Crisis: Student Data Worksheet
	Return to whole class discussion and have students share their ideas with the class to make a "master list" of initial ideas. The goal is not only to have students get their ideas out in the open, but also to have them practice evaluating how confident they are in their answers. This is also a good opportunity for you to identify any misconceptions that students may have to address throughout the unit.	10 min	
Day 2 (10 min)	Optional: Water Crisis: Student Quiz	7-10 min	Photocopies of Water Crisis: Student Quiz Water Crisis: Quiz Answer Key



The Water Crisis

A lack of clean water results in poverty, disease and death

NanoSense
the basic sense behind nanoscience

Question

Have You Ever Gotten Sick from Drinking Impure Water? Do You Know Someone Who Has?

Source: http://www.seykota.com/tribe/FAQ/2003_Aug/Aug_10-16/sick_to_stomach.gif

Clean Water is Necessary for Life

- Drinking
- Bathing
- Agriculture
- Sanitation



Sources: http://www.islamic-relief.com/projects/chechnya/index.htm
http://www.frontlineonnet.com/fl2209/images/20050506001403701.jpg

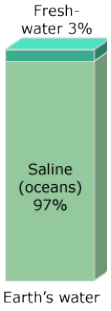
World Water Gap

- Despite the apparent abundance of clean water in the US and most of the developed world, more than 20% of the Earth's population lacks clean, safe drinking water.


Sources: http://www.battelle.org/environment/images/water-drop.jpg
http://www.tribuneindia.com/2004/20040718/pb3.jpg

How is the World's Water Distributed? I

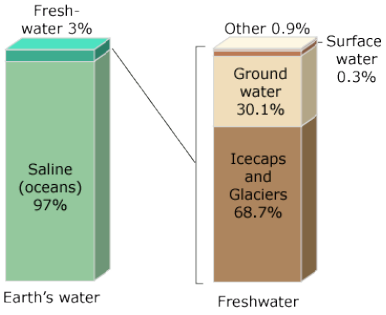
- Less than 3% of Earth's water is fresh water
- The vast majority (97%) is undrinkable salt water in the oceans



Source: http://ga.water.usgs.gov/edu/watercyclesummary.html#global

How is Water Distributed? II

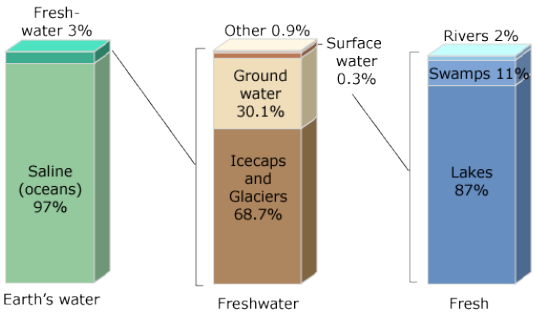
- Of the fresh water, most is in ice caps and glaciers, and some is in ground water
- Less than 1% is in more easily accessible surface water (lakes, swamps, rivers, etc.)



Source: http://ga.water.usgs.gov/edu/watercyclesummary.html#global

How is Water Distributed? III

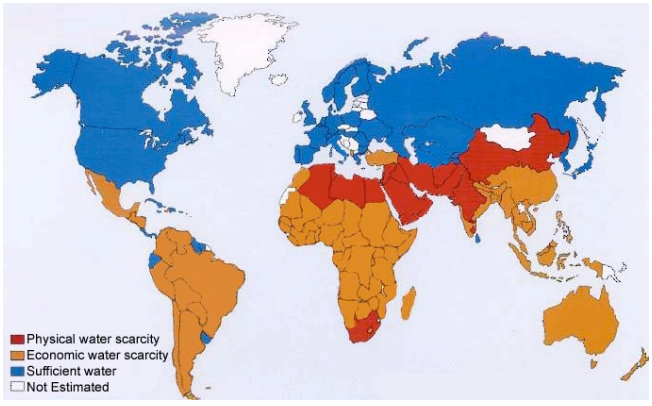
- Most of the surface water is in lakes; a bit is in swamps and rivers
- The point: very little water is easily available for drinking



Source: http://ga.water.usgs.gov/edu/watercyclesummary.html#global

Water is Scarce in Some Regions

- 2.4 billion people live in highly water-stressed areas



Current Water Scarcity: 2006

Source: Adapted from http://www.waterlink.net/assets/images/waterscarity2025.jpg

No Single Cause for the Water Crisis

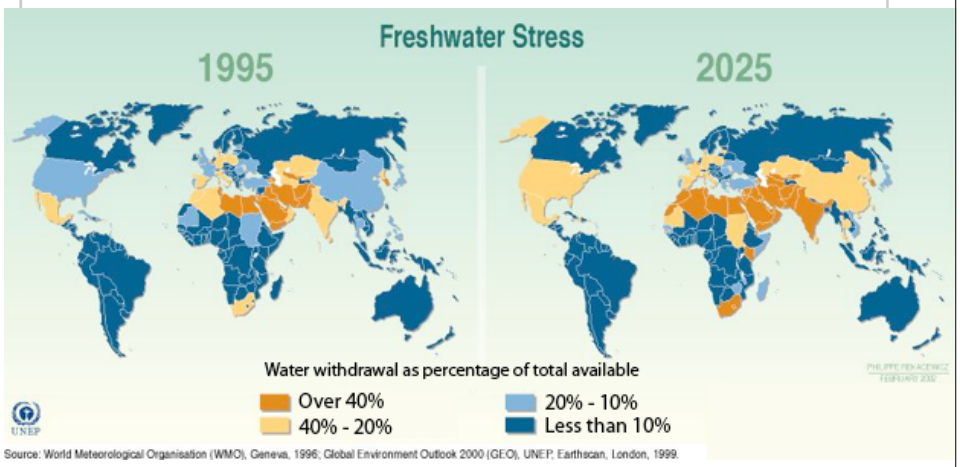
- **Many factors**
  - Climate and geography
  - Lack of water systems and infrastructure
  - Inadequate sanitation
    - 2.6 billion people (40% of the world's population) lack access to sanitation systems that separate sewage from drinking water
    - Inadequate sanitation and no access to clean water have been highly correlated with disease

Pollution is a Big Problem Too

- **Types of pollution in fresh water:**
  - Sewage is the most common
  - Pesticides and fertilizers
  - Industrial waste dumping
  - High levels of arsenic and fluoride

Sources: http://www.marenrecycling.com/polluted_water.JPG
http://mainegov-images.informe.org/agriculture/pesticides/drift/mstblow1.gif

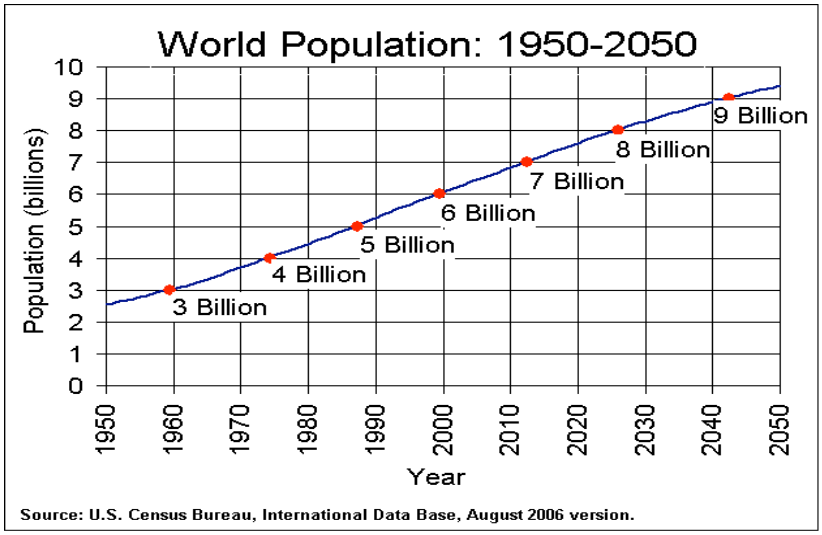
Water Scarcity is Projected to Worsen



Question

Why is the Water Shortage Projected to Worsen?

World Population is Increasing

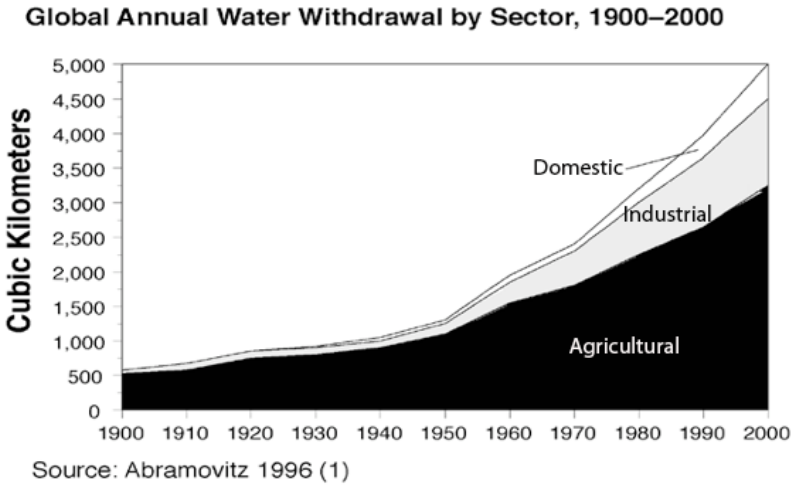


Source: U.S. Census Bureau, International Data Base, August 2006 version.

Question

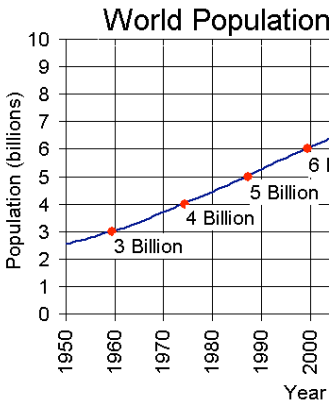
In What Ways Would an Increasing World Population Affect Water Consumption?

Where Clean Water Use is Rising

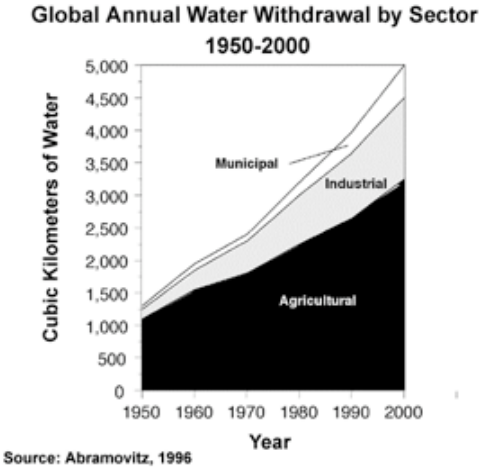


Source: Abramovitz 1996 (1)

Trends in Population and Water Use



Source: U.S. Census Bureau, International Data Base,



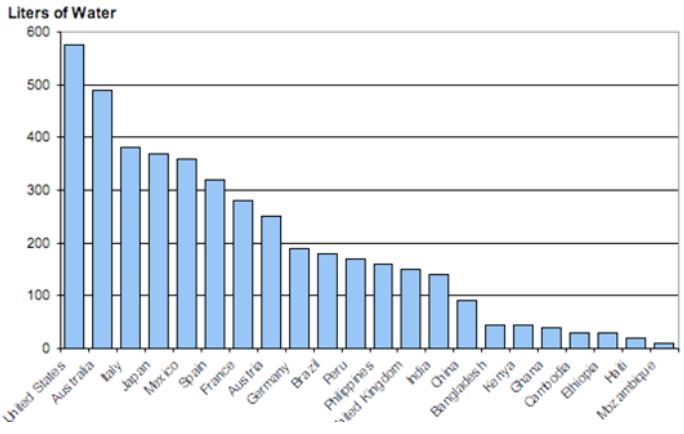
Source: Abramovitz, 1996

Question

Is There a Relationship Between Poverty and a Lack of Clean Drinkable Water?

Countries Differ Widely in Water Usage

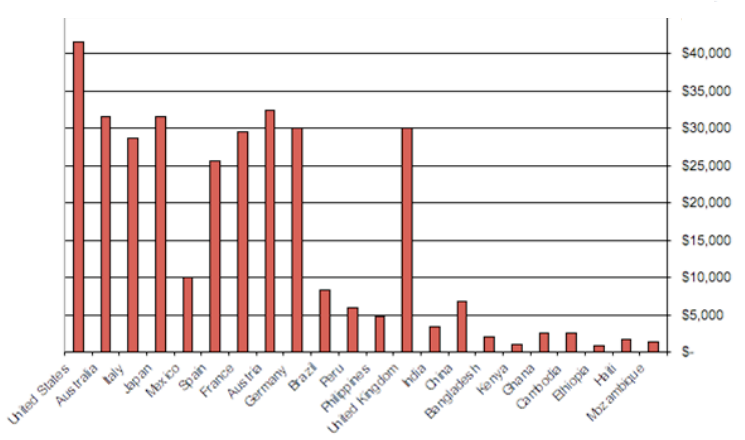
Average Daily Water Use Per Person (1998-2002)
For Selected Countries



Source: http://ww.cia.com

Countries Differ Widely in Wealth

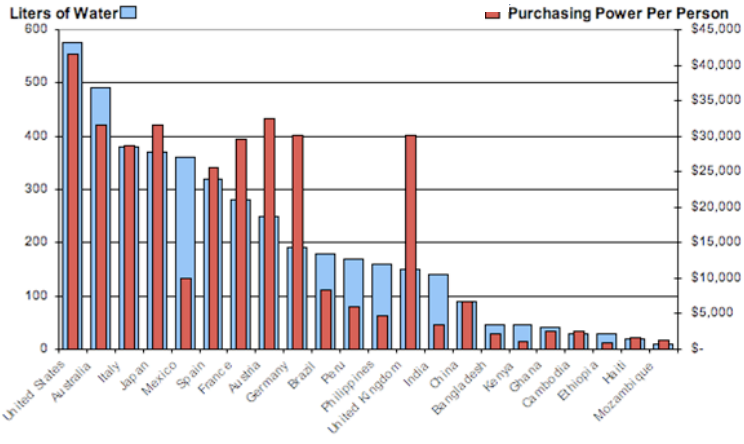
Average Wealth (Purchasing Power Per Person in 2005) For Selected Countries



Source: http://ww.cia.com

Notice Any Correlations?

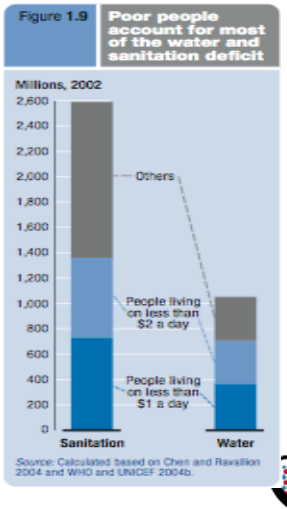
Average Daily Water User Per Person & Wealth For Selected Countries



Source: http://ww.cia.com

Many Without Access Live in Poverty

- **People without clean water**
  - Almost two in three people survive on less than $2 a day, with one in three living on less than $1 a day
- **People without sanitation**
  - Of the 2.6 billion people who do not have adequate sanitation, a little more than half live on less than $2 a day



Impact of Water Scarcity I

- **Health, education, and economic growth are impacted**
- **World Water Forum estimates:**
  - 1.4 billion people lack clean drinking water
  - 2.3 billion people lack adequate sanitation
  - 7 million people die yearly from diseases linked to water
  - Half the world's rivers and lakes are badly polluted
  - Shortages could create millions of refugees seeking homes in a location accessible to water

Source: National Geographic, "The World Water Gap" World Water Forum, The Hague March 17-22, 2000

Impact of Water Scarcity II

- **World Health Organization estimates:**
  - 80% of all sickness in the world is attributable to unsafe water and sanitation
  - The leading causes of death in children under 5 are related to unclean water; there are about 5,000 child deaths every day
  - Without action, as many as 135 million people could die from water-related diseases by 2020

Source: http://homepage.mac.com/mastercommunication/runningdry/Personal36.html

Impact of Water Scarcity III

- **Carrying water takes time!**
  - Women and children can trek miles every day to retrieve water
  - This hard manual labor takes time that they might otherwise spend pursuing education or earning additional income

Photographer: Chantal Boulanger

Sources: http://mamacass.ucsd.edu/~jat/117-1769_IMG.JPG
http://english.people.com.cn/200506/22/images/water1.jpg

Children Carrying Water

Sources:
http://www.flourish.org
http://www.lcweb2.loc.gov

http://www.unhcr.ca/earthwater/images/water_on_head.jpg
http://www.lwr.org/news/00/images/ethwelfd.jpg
http://ag.arizona.edu/OALS/ALN/aln57/gifs/reed7b.jpg

War for Diminishing Resources?

"The next world war will be over water," says Vice President Ismail Serageldin from the World Bank

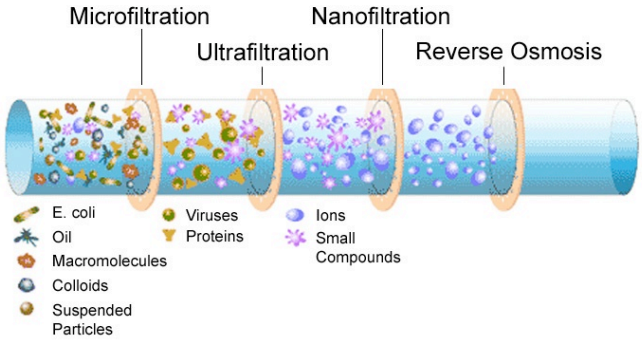
Sources: http://www.missiontohaiti.org/Media/Clean-Water-Color-Mask.jpg

How Can We Address the Water Crisis?

- **Use less water**
  - More efficient irrigation, like drip irrigation
  - Low-flow shower and toilets
  - Use native plants for crops and landscaping
  - Eat less meat
- **Find new sources of clean water**
  - Um… Where? On the moon?
- **Treat the undrinkable water that we have**
  - Use reverse osmosis to desalinize salt (ocean) water
  - Clean polluted water using filters, chemicals, and UV light

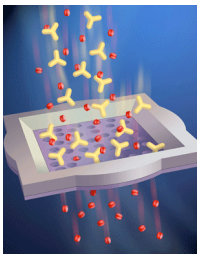
Using Filters to Clean Water

- **Pebbles, sand, & charcoal filter out large particles**
- **Membranes filter out smaller particles**
- **It is efficient to use a series of membranes to filter increasingly smaller particles**



Can Nanotechnology Help?

- **Nanotechnology offers new solutions to filter small particles**
  - Unique properties at the nanoscale mean that membranes can be made to filter by electrical and chemical properties
  - A huge effort to create better, cheaper nanomembrane filters is currently underway!



Membranes clean water by filtering out unwanted substances

Professor Eric Hoek at UCLA is patenting a new nanomembrane filter

Sources: http://www.esemag.com/0902/nano_1.jpg
http://www.simpore.com/pictures/moleculefilter_300.gif

Questions

- **How Do We Make Undrinkable Water Safe to Drink?**
- **How can Nanotechnology Help Provide Solutions to the Water Shortage?**
- **Can We Solve Our Global Water Shortage Problems?**
  - Why or Why Not?

The Water Crisis: Teacher Notes

Overview

This set of slides provides background information on the importance of clean water, why there is a problem with access to clean water, the geographical distribution of fresh water sources globally, a correlation between a country's wealth and water usage, and describes the impact of fresh water shortages on the human population. In this way we establish an important global context for learning about the potential of nanomembranes to help solve this problem of water shortage. These notes are intended to provide you with additional background content for each slide. Some slides will contain questions. These are invitations to engage students in an interactive classroom discussion about the question raised. You will also find a variety of resources for optional use to deepen your own knowledge or to engage students in an activity that relates to key points on the slide.

Slide 1: Title Slide

Slide 2: Have You Ever Gotten Sick from Drinking Impure Water? (Question Slide)

Discuss with your students what their experiences have been (or that they have known about) when someone drinks impure water. This discussion is intended to draw on students' personal understanding of the negative effects of not drinking pure water, so as to better peak their interest in the topic. In the event that students have not had experiences or heard about them, they may have heard about Montezuma's revenge!

Baytel Associates conducted a study to identify drinking water contaminants that cause health problems worldwide. They found so many different contaminants that they prioritized the list to include the twelve "if eliminated" that would have the greatest impact on public health. The twelve contaminants identified are: cholera, enteric bacteria, Rota- and polio viruses, intestinal protozoan, Ascaris (intestinal roundworm), Dracunculus medinensis (Guinea worm), Trichuris trichiura (whipworm), Enerobious vermicularis (pinworm), fluorides, heavy metals, nitrates, and synthetic chemicals.

From the report "Critical Drinking Water Contaminants: A Global Perspective," as reported by *US Water News* online, June 1995. See http://www.uswaternews.com/archives/arcquality/5drink.html

Slide 3: Clean Water is Necessary for Life

Clean water is needed for these four major areas. Sanitation refers to the ability to provide adequate sewage disposal that separates sewage waste from drinking water supplies. Disease in a community is highly correlated with a lack of public sanitation.

Slide 4: World Water Gap

This slide informs students that many people globally do not have access to clean drinking water. The "gap" is a term to describe the difference between the number of people who need clean drinking water compared with the number of people who need clean drinking water. Later we'll see a global map of fresh water distribution.

Based on data from NASA, the World Health Organization, and other agencies, a report produced by the United Nations Environment Programme predicts:

- Severe water shortages already affect at least 400 million people today and are projected to affect 4 billion people by 2050. Southwestern states such as Arizona will face severe fresh water shortages by 2025.
- Adequate sanitation facilities (bathrooms) are lacking for 2.4 billion people, about 40% of humankind.

See http://www.usatoday.com/news/nation/2003-01-26-water-usat_x.htm

Slide 5: How is the World's Water Distributed? I

Slides 5, 6, and 7 show the distribution of water globally. Many students do not know that most of the world's water is salt water (undrinkable and/or unusable for agriculture). The green box shows a physical depiction of the amount of fresh water relative to salt water, globally.

Why can't we use salt water to drink or for agriculture?

Some students do not understand why we cannot drink salt water. Department of Energy's scientist, Prof Bill's, explanation of why we cannot drink salt water is brief and to the point: "Humans can't drink salt water because the kidneys can only make urine that is less salty than salt water. Therefore, to get rid of all the excess salt taken in by drinking salt water, you have to urinate more water than you drank, so you die of dehydration."

Why can't salt water be used for agriculture? In general, too much salt will interfere with the chemistry in a plant that allows the plant to make food and to obtain energy from food. In addition, plants usually get their water through their root system by a process called osmosis (students who have had biology will know about this process). Osmosis involves the passage of water across the membrane of a cell from an area of greater concentration to an area of lesser concentration. If the plant is surrounded by salt water, the plant will tend to pass fresh water from their inside structures to the soil through the roots, causing the plant to lose, not absorb water.

There is a type of plant, called halophytes, that have special structures that separate the salt in such a way that it is prevented from mingling with the rest of the plant, allowing the plant to survive in a salt water environment.

Slide 6: How is Water Distributed? II

This slide depicts the section in the green box representing the proportion of fresh global water, expanded to show where the 3% of fresh water may be found: 68.7% icecaps and glaciers, 30.1% ground water, and only 0.3% surface water.

Slide 7: How is Water Distributed? III

This slide depicts the distribution of the 0.3% surface water: 87% lakes, 11% swamps, and 2% rivers.

Slide 8: Water is Scarce in Some Regions

This calculated approximation, that 2.4 billion people are living in highly water-stressed areas, comes from N. Utsumi, *Thesis,* The University of Tokyo (2006).

Fresh water scarcity or stress is described in a variety of ways.

This is a map from a global view showing the geographic distribution of fresh water, either as surface water or in underground aquifers, as it relates to the population's need for fresh water in that region. Depending on the area's population density and the climate's ability to renew these water supplies, a geographic area can be described by the percent of its available fresh water being used annually compared to how much fresh water is potentially available for use. The higher the percent of water being used compared to what is potentially available, the more **scarce** the fresh water supply. The total potentially available fresh water cannot be completely used. Water availability depends on the climate, the season, the amount of snowmelt, and the infrastructure to capture, store, clean, and deliver it.

Water scarcity is often described in two ways:

Physical water scarcity is a term used to describe an area whose primary water supply is developed at 60% or greater than the total potential capacity. One must understand that the total potential capacity includes water that can never be entirely accessed. These countries do not have sufficient fresh water to meet their demands for agriculture, domestic water, industrial sectors, and environmental requirements. Food has to be imported or salt water must be treated by an expensive desalination process in order to get enough fresh water for agriculture. Agriculture consumes about 70% of fresh water supplies.

Economic water scarcity is a term describing a region that has adequate physical water resources to meet their water supply needs, but must increase the availability of the water through additional storage and conveyance facilities. Most of these countries face severe financial and development capacity problems for increasing the primary water supply, by building the needed infrastructure.

Water shortages are greatest in equatorial regions with increasing populations.

Slide 11 will show freshwater stress simply as the water withdrawal as a percentage of the total available. These are associated with different percentages.

From *Science*, August 25, 2006, published by AAAS:

Water scarcity can be an index defined as Rws = (W-S)/Q where W, S, and Q are the annual water withdrawal by all the sectors, the water use from desalinated water, and the annual renewable fresh water resources (RFWR), respectively.

Slide 9: No Single Cause for the Water Crisis

This slide highlights the major causes for the water crisis. An arid climate does not produce much rainfall. Areas with sufficient rainfall and fresh water supply often lack systems to clean and deliver water to the people, especially in rural areas. It is estimated by the World Health Organization that 40% of the world's population lack sufficient sanitation systems to keep the potable (drinking) water separate from human wastes.

Arsenic and fluoride are pollutants that leach out of rocks into the water in some areas. While small quantities of fluoride are good for teeth, larger quantities are bad. These must be removed before the water is considered to be safe for drinking.

Slide 10: Pollution is a Big Problem Too

The most common type of pollution is untreated sewage that mixes with the drinkable water supply. Sewage contains disease-causing bacteria. Secondly, agriculture contributes pesticides and fertilizer. The pesticides contain poisonous substances that dissolve in water and the fertilizer breaks down to release nitrates into the water. Industrial pollutants contribute heavy metals to the water supply in some areas. All of these must be removed from water, according to clean water standards, for water to be safe to drink.

Slide 11: Water Scarcity is Projected to Worsen

This slide depicts the global distribution of fresh water in the year 1995 and the predicted water distribution in the year 2025. The colors represent the percentage of water withdrawn compared with the total amount of water available. The light orange represents mild water stress and the darker orange represents extreme water stress. The blue areas are considered to be free from freshwater stress.

The graph in the lower right corner shows the amount of people, in billions, suffering from water stress and scarcity, in 1995, then as projected to the year 2050.

It is important to keep in mind that the total possible amount of fresh water can never be fully used. There is high variability of water resources in space and time. River flow depends upon the seasonal climate. An example would be that what is available as snowmelt into the rivers will not be available in the dry season.

Slide 12: Why is the Water Shortage Projected to Worsen? (Question Slide)

Discussion Question for Students: Ask your students why they think that water shortages are predicted to become worse over time.

Although there are current supply problems that need to be solved, as shown by slides 9 and 10, the increase in demand for water is an even bigger factor.

This predicted increase in demand for water is based largely on projected population growth. The larger the population, the more agriculture is required to feed people. Agriculture currently accounts for about 70% of the fresh water usage. The other factor that enters into this prediction is the increasing economics of currently underdeveloped countries.

Slide 13: World Population is Increasing

This graph presents the latest estimates and projections of world population from the U.S. Census Bureau. The world population increased from 3 billion in 1959 to 6 billion in 1999, a doubling that occurred over 40 years. The Census Bureau's latest projections imply that population growth will continue into the 21st century, although more slowly. The world population is projected to grow from 6 billion in 1999 to 9 billion by 2042, an increase of 50% that is in approximately 43 years.

Slide 14: In What Ways Would an Increasing World Population Affect Water Consumption? (Question Slide)

This is a good time for students to brainstorm what water is used for and relatively how much water is used. The next slide depicts an increase in population.

Slide 15: Where Clean Water Use is Rising

This slide depicts the number of cubic kilometers of water withdrawn for municipal, industrial, and agricultural purposes over a period of 100 years, from 1900 to 2000.

The most important point is that agriculture requires at least two-thirds of all of the water withdrawn. As the graph indicates, all uses of water rise as population increases.

Slide 16: Trends in Population and Water Use

This figure shows the two graphs, previously seen, side-by-side, in order to facilitate easier comparisons. Students can easily notice that the trends in the increase of population over time parallel the increase in water consumption.

Slide 17: Is There a Relationship Between Poverty and a Lack of Clean Drinkable Water? (Question Slide)

Answer: There are strong correlations between a country's financial wealth and the presence of clean, drinkable water. To clean and deliver drinkable water requires expensive infrastructures of cleaning systems and pipes to transport the water in areas where water is present in sufficient quantities to meet the populations' needs. In areas where there is not enough natural fresh water sources to meet the needs (drinking water, sanitation, industry, and agriculture) an expensive system must be employed to remove the salt, (desalination), from the water. The World's Water Report says that 1 in 6 people on earth suffer from extreme poverty.[1]

The distribution of access to adequate water and sanitation in many countries mirrors the distribution of wealth. Access to piped water into the household averages about 85% for the wealthiest 20% of the population, compared with 25% for the poorest 20%.

As an optional activity, you may want students to examine a set of tables with information on different countries' water in cubic meters per person and each country's gross national product. Students could work in groups to produce a line graph for these two variables. They could share their interpretation of the graphs. As a less time-consuming alternative activity, students could simply scan the tables with partners to notice the patterns shown by these two variables.

An important understanding to be developed by students during this study of nanofiltration is that the current world water crisis reflects the economic and political decisions made by countries and people.

Information to design an activity like this is available at: https://cia.gov/library/publications/the-world-factbook/index.html.

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[1] *Water: A Shared Responsibility.* UN Report, produced by Berghahn Books and United Nations Education, Scientific and Cultural Organization (UNESCO).

Select a country from the menu at the top.

Slide 18: Countries Differ Widely in their Water Usage

The next three slides are shown to give students an opportunity to make the connection between a country's water usage and per capita wealth. Though for the higher amounts of water usage, there is not an exact correlation with wealth; the low wealth countries consistently show low per person water usage.

This slide depicts a variety of countries' average daily water usage per person between the years of 1998 and 2002. Some of the countries with especially high water usage and some of the countries with low water usage are displayed. For a list of all of the countries' average daily water usage during this same time frame, refer to http://www.cia.com.

Slide 19: Countries Differ Widely in Wealth

This slide shows the same countries' wealth depicted in terms of purchasing power per person for each country in 2005. These figures are from http://www.cia.com.

Slide 20: Notice Any Correlations?

This slide displays the countries' average daily water use per person graph, seen on slide 18, superimposed on the wealth graph (depicted as purchasing power per person).

This is a good opportunity for students to look at the data displayed and make statements about the relationships from the two variables displayed. If students disagree, it is an opportunity for them to choose evidence to support their argument. You might ask them what other information they would need to draw a conclusion.

Question for Students: Is there any evidence that a country's per person water usage has anything to do with a country's per person purchasing power?

Slide 21: Many Without Access Live in Poverty

This graph shows the approximate total number of people, in millions, who don't have access to sanitation (bar on the left) and to clean water (bar on the right). More than two-thirds of the people who don't have access to clean water make less than $2 a day. A little over half of the people who don't have access to sanitation make less than $2 a day.

Slide 22: Impact of Water Scarcity I

This slide highlights the impact of water scarcity on the human condition, globally. This is a good teachable moment. This slide says that 2.3 billion people lack adequate sanitation; slide 9 mentions the estimate of 2.6 billion people.

Question for Students: How hard is it to estimate this phenomenon?

Sanitation and a lack of clean drinking water are related because human feces and urine contain and grow bacteria that cause disease in humans. If there is no way of separating this sewage from a fresh water source, people will become diseased when drinking this water.

Slide 23: Impact of Water Scarcity II

This slide presents additional information from the World Health Organization regarding the impact of water scarcity. It also includes a prediction for 2020 if population continues to rise**,** and fresh water availability continues to be scarce.

The leading cause of death for children in general is associated with respiratory illnesses. The second leading cause of death is diarrhea, which is related to unclean water.

Slide 24: Impact of Water Scarcity III

This slide shows young women and children carrying water to their homes. The impact on a child's or a woman's time in water scarce areas is greater than that on an adult's or a man's, as it is a cultural tradition in many regions to assign the task to children (or more often to very young women) of bringing water from its source to the home. This can require up to 6 miles of walking a day.

Question for Students: How would carrying water a few hours each day for your family impact your life? What would you have to give up?

Slide 25: Children Carrying Water

This is a slide that shows just a few of the amazing pictures publicly available of children carrying water.

Slide 26: War for Diminishing Resources?

This slide highlights a controversial prediction among many authorities. Water is not always a renewable resource. Most of the water used is found stored naturally underground in aqueducts that have been the result of rainwater accumulated over decades, if not centuries. In some regions, like Los Angeles, California, the water is being drained from these aqueducts at a faster rate than natural rainwater can replace. Further, draining the aqueducts at a fast rate can cause subsidence, the collapsing of the land, allowing the ocean to infiltrate and contaminate fresh underground water areas.

Slide 27: How Can We Address the Water Crisis?

Agriculture consumes about 70% of fresh water supplies, so efficiencies there—like more efficient irrigation methods—could have the most impact. But there are a lot of things that we can do on the smaller scale, too, like conserving water at home and in our gardens. Lots of web sites offer water saving tips. A good example is http://www.wateruseitwisely.com

Even eating less meat saves a lot of water. Livestock consume huge resources. Author of *The Food Revolution*, John Robbins, estimates that "you'd save more water by not eating a pound of California beef than you would by not showering for an entire year."

Can we find new sources of water? Not really, but we could treat the undrinkable water that we have. But treatment takes energy and requires technology, so it costs money.

We can't drink salt water or use it for agriculture, but we could treat it to take out the salt using reverse osmosis techniques. This is a particularly expensive process, because it requires a lot of pressure (which means a lot of energy).

Ground water and waste water this is contaminated can also be cleaned. For example, bacteria can be killed by exposing the bacteria-laden water to UV light and chlorine. We can also clean water by filtering it.

Slide 28: Use Filters to Clean Water

Water can be cleaned by pouring it through pebbles, sand, and charcoal. Membranes can also be used to filter out small particles. A membrane is a structure that lets some things through and others not. You may want to check that your students know what a membrane is.

An efficient method of cleaning water is to use a series of increasingly smaller filters that filter out increasingly smaller particles. This picture highlights the membranes that clean water and the particles that each type of membrane removes. In general, the smaller the membrane, the more pressure is needed to push the water through the membrane, and the more expensive is the process. Usually larger membranes are used as prefilters to filter out the larger particles that would easily clog or "foul" the smaller membranes.

Slide 29: Can Nanotechnology Help?

Nanotechnology is a new area of engineering in which many laboratories are working to create innovatively designed membranes that have a hope of filtering water more cheaply and more flexibly that those currently on the market.

Slide 30: Questions

The questions on this slide guide this unit. Though the unit is built around solving the polluted water problem for the town of Jarny, students should also learn something about water purification processes and the basic science of water. This understanding will help them to reflect knowledgably on the global health problem of a lack of clean drinking water.

Resources

The World Water Forum is a group that has met for the fourth time to consider issues related to global water scarcity and fresh water sustainability. The fourth one was attended by governmental delegations from 148 countries, 200 legislators, 160 representatives of local authorities, 185 children, and a plethora of non-governmental organizations, UN agencies, experts, academia, water managers, and media representatives who met in Mexico City from March 16 through March 22 to share their local experiences, in order to make a difference in a world in which billions of people still lack access to safe water and sanitation. This group has published a report that highlights the conclusions and agreements made during this conference. The final report can be found at http://www.worldwaterforum4.org.mx/files/report/FinalReport.pdf.

Water Crisis: Student Data Worksheet
Teacher Instructions & Answer Key

This activity allows student to become actively involved in interpreting the different figures and graphs that are used in the Water Crisis PowerPoint presentation. Providing them with an opportunity to think about what each representation means before presenting the slides will allow for greater engagement on the part of your students and develop their graph interpretation skills. You may want to assign this worksheet as a homework assignment before you show the slides, or have students fill out the worksheet as you come to each of the slides, but before discussing them.

Note: Figure 2 is more easily distinguished in color, so you may want to pass out color copies of the student worksheet to your students. Otherwise, students may need to see the slide presentation to answer the questions associated with Figure 2.

Directions

Using the graphs and maps, answer the following questions. This activity will give you the opportunity to interpret some of the graphs and maps that you'll see during the Water Crisis slide presentation during class.

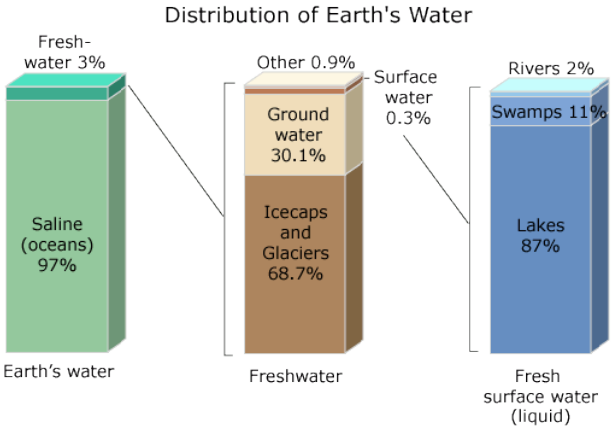

Figure 1. Distribution of earth's water.

1. According to the bar graphs in Figure 1, **what percentage** of the world's water is **fresh water**?

3%

2. What do these three divided bar graphs tell you about **where** the Earth's fresh water resides?

The earth's fresh water resides in icecaps and glaciers, ground water, lakes and swamps and rivers.

Physical water scarcity refers to the lack of water to meet domestic, industrial, and agricultural needs. Areas of physical water scarcity are shown in red on the map in Figure 2 below. Economic water scarcity means that an area or country has insufficient financial resources to deliver safe, clean water to those areas that need it for drinking or agriculture. Areas of economic water scarcity are shown in orange in Figure 2.

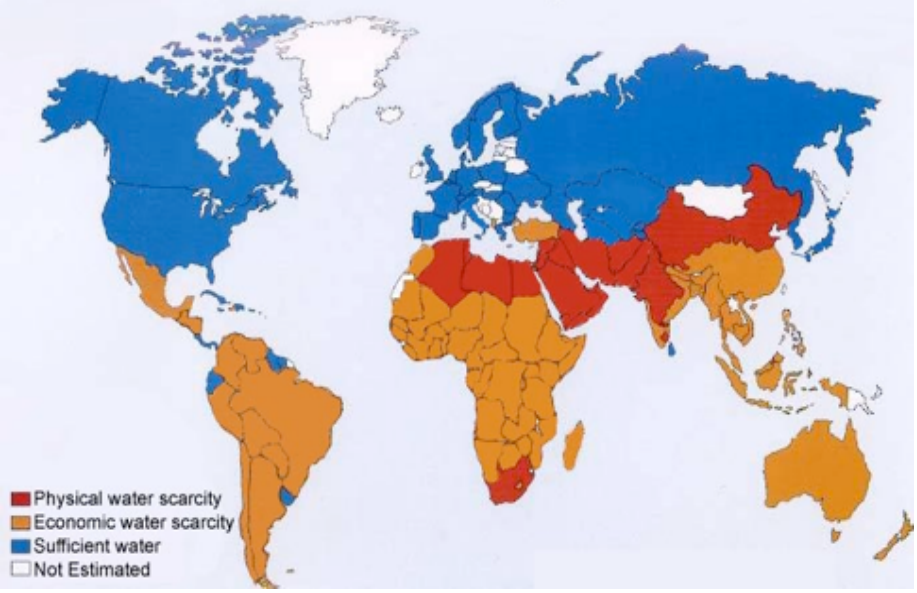

Figure 2. Global map of water scarcity in 2006.

Answer questions 3-8 based on information from the map in Figure 2.

2. Name the countries or global areas that are experiencing **physical water scarcity**.

In Northern Africa: Algeria, Libya, and Egypt. In the Middle East: Saudi Arabia, Iraq, Turkey, Iran, Pakistan, Afghanistan, much of India, Northern China and some smaller countries.

3. What would you predict the climate to be in these areas and why?

These areas would most likely have hot and dry climates, because the map indicates they have a physical water scarcity.

4. Name the countries or global areas that are experiencing **economic water scarcity**.

Central and most of South American, central and much of southern Africa, China, Viet Nam, Laos, Cambodia, the Philippines and the rest of the East Indies, and Australia.

5. Name the countries or global areas that are **not** experiencing any water scarcity.

North American countries and Northern Eurasia.

6. What do you predict the difference in per capita income (average income per person) would be between regions with plenty of water and regions with economic water scarcity?

Because water is needed for personal, industrial and agricultural use, it makes sense that those countries with greatest access to water are among the wealthiest nations as well.

7. The southwestern United States is typically characterized as having a dry, arid climate. Why might this region be shown as having plenty of water even if it is dry and arid?

Students may guess, correctly, that we divert water from northern rivers to the southern drier lands. They may also guess that there are rich sources of underground aquifers that supply water.

When water is taken from a natural source for human use, it is called “water withdrawal.” However, a country can never withdraw all of the fresh water that is theoretically available within its borders. Much of it is seasonal, or part of flood runoff, or rain that cannot possibly all be captured. Countries that withdraw a high percentage of their available fresh water are said to be under “freshwater stress” and are in danger of becoming considered "water scarce." In the map in Figure 3, the light orange represents mild freshwater stress and the darker orange represents extreme fresh water stress. Blue areas are considered to be free from freshwater stress.

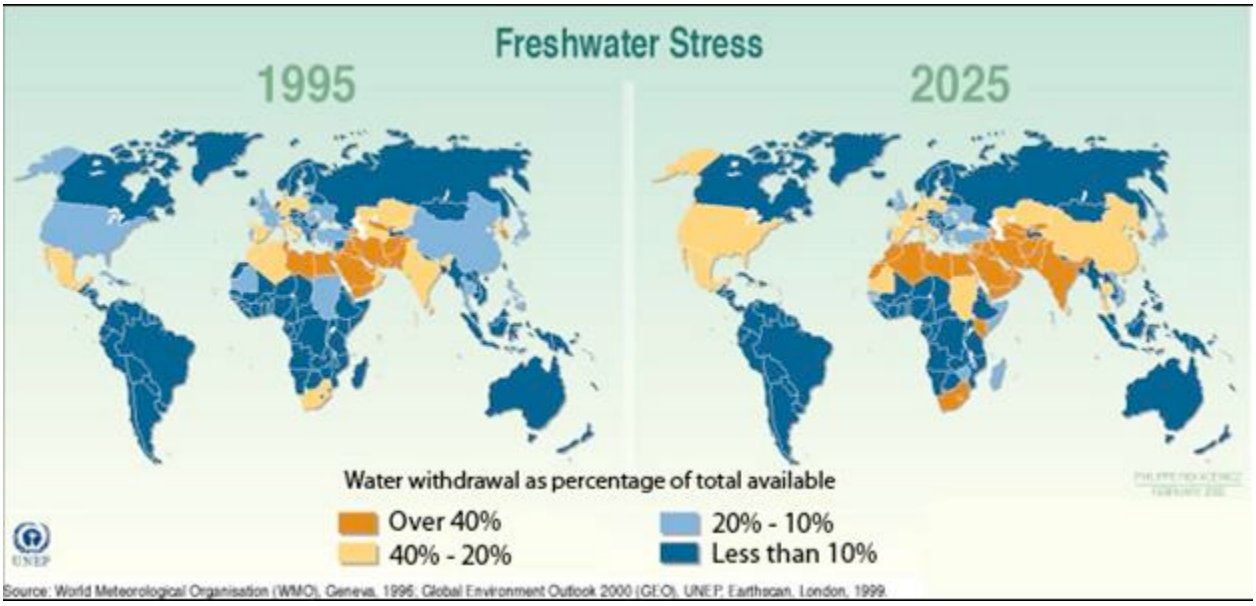

Figure 3. Global map of freshwater stress, 1995 and 2025 (predicted).

8. Compare the two maps above, showing freshwater stress from the year 1995 and projected to the year 2025. What are the changes that you see happening in which areas?

America and Alaska go from a water withdrawal of 10-20% to 20-40%, as does Mauritania and the Sudan in Central Africa. China also increases its’ water use. Experiencing over 40% of water withdrawal now is Uganda, South Africa, and India.

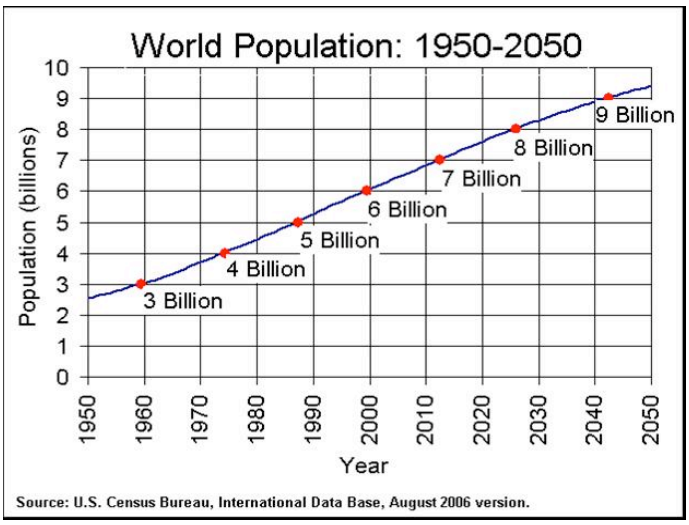

Figure 4. World population from 1950 to 2050 (predicted).

9. In Figure 4, what trend do you see in for the global population?

The population increases by three times from 1950 - 2050.

10. What would you predict the global population to be in 2060? Justify your prediction.

The population would likely increase to 10 billion people, based on the trend depicted for the previous two decades.

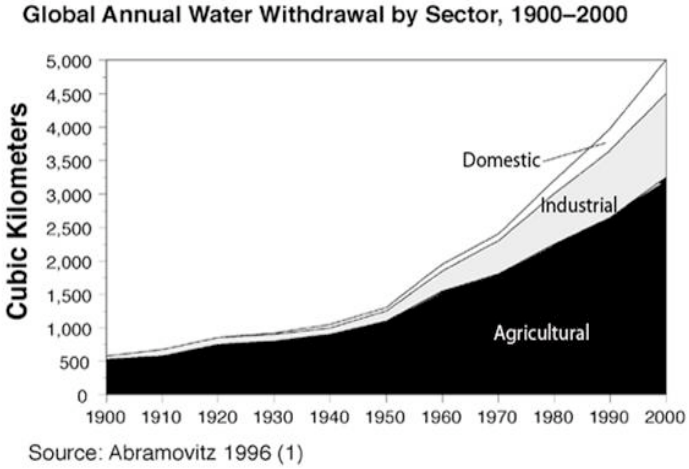

Figure 5. Global annual water withdrawal by sector, 1900-2000.

11. According to the graph in Figure 5, which sector uses the most water?

Agriculture

12. Which sector uses the least amount of water?

Domestic

13. How does the trend in water consumption (Figure 5) compare to the trend in population (Figure 4) for the time period 1950-2000?

The trends parallel each other.

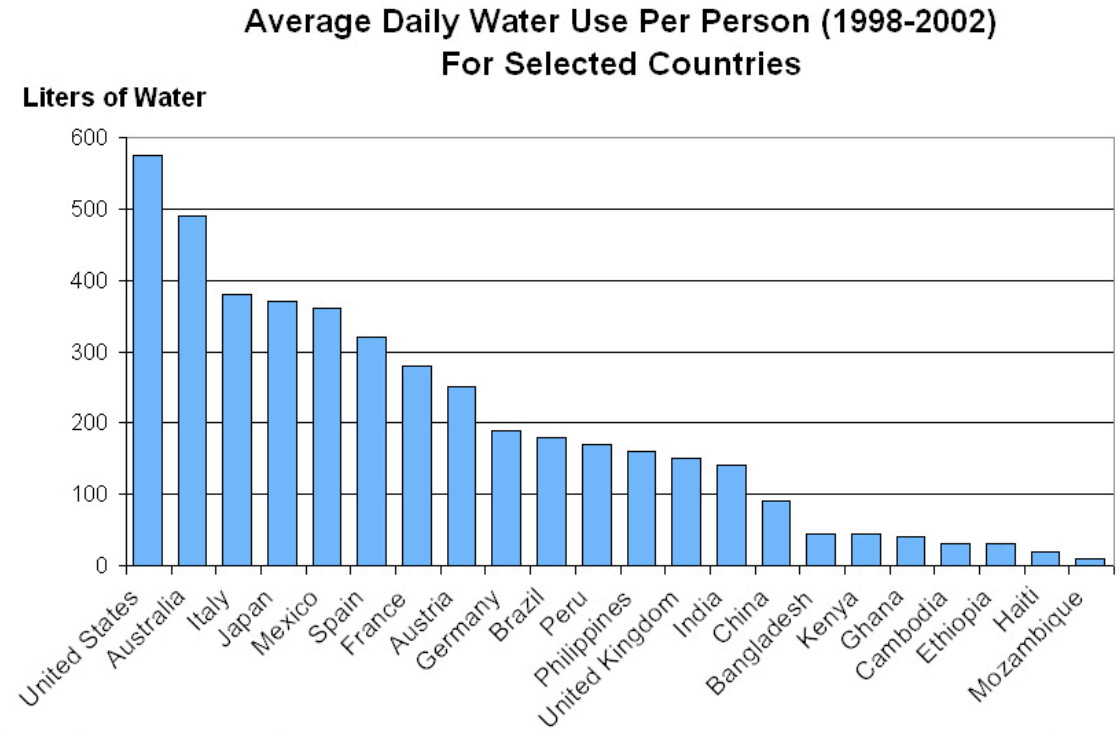

Figure 6. Average daily water use per person for selected countries, from 1998 to 2002.

14. According to Figure 6, which countries consume the most water?

United States, Australia, Italy, Japan, Mexico, Spain, France and Austria.

15. Which countries consume the least water?

China, Bangladesh, Kenya, Ghana, Cambodia, Ethiopia, Haiti, and Mozambique.

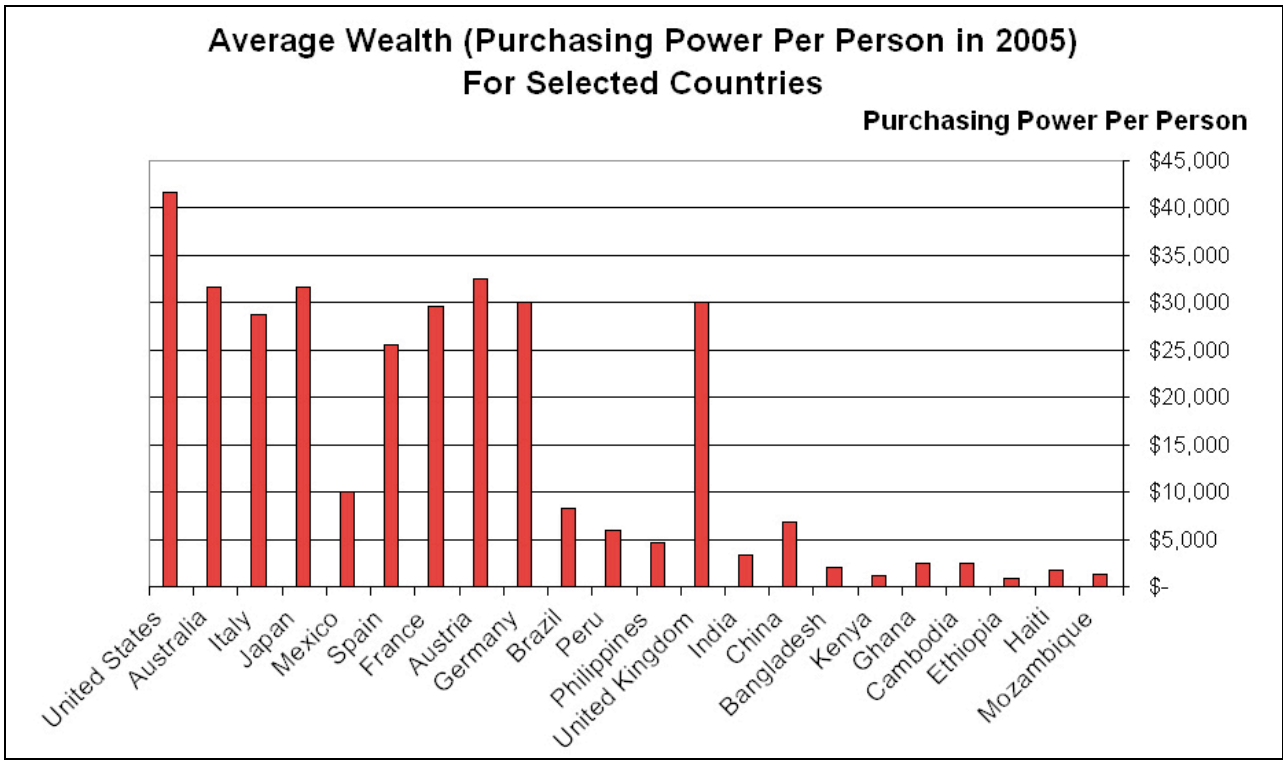

Figure 7. Average wealth for selected countries (purchasing power by person in 2005).

Answer questions 16-19 based on information from the graph in Figure 7.

16. How many countries have an average per person purchasing power of less than $10,000?

13

17. How many countries have an average per person purchasing power of more than $25,000?

9

18. How many countries have an average per person purchasing power of $10,000-$25,000?

Zero

19. What is the difference between the average per person purchasing power in the highest wealth country and the lowest wealth country?

About $41,000/year

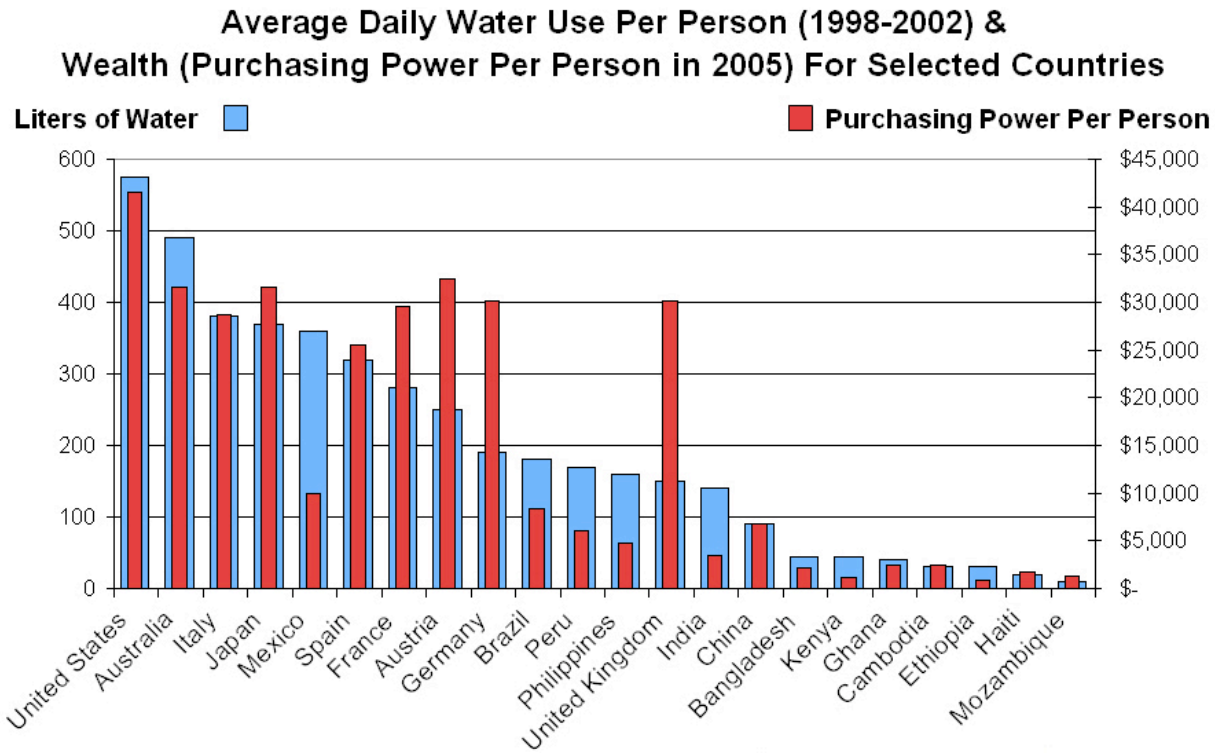

Figure 8. Average daily water use per person and wealth.

20. According to Figure 8, does there seem to be a relationship between a country's wealth and their average daily water consumption? If so, what is the relationship?

In most cases, with a few exceptions, the amount of wealth determines the amount of water consumption. In other words, the greater the wealth of a nation, the more water it consumes, and conversely, the less wealth a nation has, the less water it consumes.

Fine Filters Initial Ideas: Teacher Instructions

The goal of this exercise is to have your students "expose" their current ideas about the current and future availability of water on a global basis before they engage in learning activities that will explore these questions. You should let your students know that this is not a test of what they know and encourage them to make guesses which they will be able to evaluate based on what they learn in the unit. You may also want to have your students share their ideas with the class (there are no "bad" ideas at this stage) and create a giant class worksheet of ideas. Students can then discuss whether or not they think each of these statements is true and why.

Write down your initial ideas about each question below and then evaluate how confident you feel that each idea is true. At the end of the unit, we'll revisit this sheet and you'll get a chance to see if and how your ideas have changed.

1. Why are water's unique properties so important for life as we know it?	**How sure are you that this is true?** Not Sure	Kind-of Sure	Very Sure	**End of Unit Evaluation**
2. How do we make water safe to drink?	**How sure are you that this is true?** Not Sure	Kind-of Sure	Very Sure	**End of Unit Evaluation**
3. How can nanotechnology help provide unique solutions to the water shortage?	**How sure are you that this is true?** Not Sure	Kind-of Sure	Very Sure	**End of Unit Evaluation**
4. Can we solve our global water shortage problems? Why or why not?	**How sure are you that this is true?** Not Sure	Kind-of Sure	Very Sure	**End of Unit Evaluation**

The Water Crisis: Quiz Answer Key

Write down your ideas about each question below.

1. What does it mean to have "clean fresh drinking water"?

   Drinking water that does not contain salt or other contaminants that would be harmful to human health.

2. Explain the term "water scarcity."

   Water scarcity means that there is not enough water to support water for drinking, industry, agriculture or environmental ecosystems.

3. Does water scarcity have an impact on human health? If so, what are some of the consequences?

   Yes. In places of water scarcity, 80% of all child death under the age of five is related to diseases associated with a lack of clean water. Contaminated drinking water can cause severe diarrhea, a variety of other gastrointestinal disorders, and cause the accumulation of life disabling or fatal toxins in body tissues.

4. Describe three reasons why some nations are experiencing a scarcity of clean drinking water.

   1. There is not enough physical water available to support a nation's needs for its population.
   2. There is not enough money to deliver the water to the places that need it for drinking or for agriculture.
   3. There is not enough money to clean the water to make it usable for drinking or for agriculture.

5. Why is the water scarcity problem projected to increase?

   Water scarcity is projected to increase as population increases and puts more demands on water to meet the basic needs of people.

   As underdeveloped countries become more industrialized, the trend is to consume more food that requires more water to produce.

6. Which sector—domestic, industrial, or agriculture—consumes the most water?

   Agriculture.