University of California, Riverside
College of Natural and Agricultural Sciences

STUDY GUIDE for the video

EARTH 101: WHERE DOES YOUR WATER COME FROM?

by **Dr. Daniel Schlenk**

Professor of Aquatic Exotoxicology, Department of Environmental Sciences, University of California, Riverside

and **Dean Nielsen**

Mathematics Teacher, Murrieta Valley High School, Murrieta Valley Unified School District, Murrieta, California

In March through May 2012, the College of Natural and Agricultural Sciences (CNAS) and the community support group Science Circle presented the fifth in their annual series of science lectures. The four lectures in the series, named "Earth 101: What You Need to Know about Life on Our Planet," were delivered to standing-room-only audiences in the University of California, Riverside, Extension Center. The lectures were delivered a second time, and videotaped, in the campus's television studio to small audiences of middle- and high school students. The teachers of these students had partnered with the faculty lecturers during development of the lectures, and subsequently the pairs wrote these study guides to be used in conjunction with the videos, to help educate young people about important issues facing our planet.

For more information about the Science Lecture Series, email sciencedean@ucr.edu or visit cnas.ucr.edu/sciencelectures/.

The other three lecture videos are:
Earth 101: Too Many People?
Earth 101: What's Your Carbon Footprint?
Earth 101: What Hollywood Can Teach Us about Our Planet

These 58-minute videos and their study guides are available for download at http://cnas.ucr.edu/sciencelectures/slsvideos.html.

Background Essay

The Water Cycle

The water cycle refers to the continuous movement of water between the Earth's surface and its atmosphere. The water cycle is driven by energy from the sun, whose rays cause liquid water to heat and change into gas in a process called evaporation. As gaseous vapor rises and circulates in the atmosphere, it cools and changes back into liquid in a process known as condensation. Tiny droplets of water in the atmosphere accumulate to form clouds, which then return the water to Earth as precipitation, namely rain or snow.

If you had to guess how much of Earth's water is fresh water — the kind that humans and most other living things rely on to live — what would you guess? Remarkably, only 3 percent of Earth's total supply of 1,386 million cubic kilometers (332.5 million cubic miles) of water is fresh water. Of that 3 percent, nearly seven-tenths is trapped in the icecaps and glaciers found in mountainous regions and at the poles. Another three-tenths is stored in underground aquifers. About one-third of the fraction that remains — or 0.007 percent of all the water on the planet — comprises fresh water sources on the surface: the lakes, rivers, and swamps that we commonly see around us.

The hydrologic cycle — also known as the water cycle — is the continuous exchange of water between Earth's surface and the atmosphere. As the planet's natural mechanism for transporting and recycling water, the hydrologic cycle is critical for maintaining conditions on Earth. There are five basic steps within the water cycle: condensation, precipitation, infiltration, runoff, and evapotranspiration.

Gaseous water vapor in the atmosphere condenses to form clouds, which can produce precipitation. Rain, snow, and sleet return water from the atmosphere to Earth's surface. On the ground, the water cycle continues with infiltration, the process in which surface water seeps into the soil where it can become groundwater. The amount of water that infiltrates into the ground depends on many factors, such as soil type and rock type. Topography also influences infiltration — a steeper slope forces the water to run off more quickly, preventing much infiltration. In addition, if the soil is already saturated with water, it cannot absorb much more, which leads to an increase in runoff. Land cover, such as vegetation or man-made surfaces, also affects the movement and infiltration of water.

Water that doesn't infiltrate the ground is called surface runoff. When water flows over land, it follows a path to the lowest point, running down hills to creeks, streams, and rivers until it eventually reaches a sea or ocean. Rainwater and melted snow and ice that move too quickly to infiltrate the ground become runoff. Runoff replenishes the water on Earth's surface and helps to continue the water cycle.

The next step in the cycle — evapotranspiration — returns water to the atmosphere. The sun causes evaporation by heating liquid water on Earth's surface. Transpiration — the evaporation of water from pores in the leaves of plants — also releases water vapor into the atmosphere. Water vapor in the air is invisible; visible clouds and steam are actually millions of tiny droplets of liquid water or ice that form when water vapor molecules condense around small particles in the air. However, as more water molecules collect on the cloud droplets, the drops get too heavy and fall from the cloud back to Earth's surface as precipitation.

— Daniel Schlenk

California Issues

Three major water imbalances

Seasonal
- Snow and rain in winter
- High water demand in summer

Geographical
- North is water rich (all water comes from Sierra Nevada)
- Sierra to Sea website (http://sierratosea.ucdavis.edu/ca.html#)
- South is demand heavy

Climatic
- Periodic flooding
- Prolonged droughts

Past solutions to California imbalances

California Aqueduct
Colorado River Aqueduct
Los Angeles Aqueduct (Owens valley tapped out)

California Aqueduct issues

Energy drain (elevation changes for movement)
Bay Delta water removal
- Antiquated unstable levees
- Endangered species concerns
- Increased use
- Decreased supply (climate change leads to loss of Sierra snowpack)

Colorado River water removal
- Increase demand upstream (urban development in Colorado, Utah, Arizona)

New solutions to CA water issues

Groundwater recharge (Orange County Water District)
Municipal water re-use/recycling (Riverside County, Orange County, LA County, SD County all pursuing re-use practices)
Desalination (energy costs are less than moving water from Northern California or Colorado)
Conservation
- Water footprint (http://environment.nationalgeographic.com/environment/freshwater/water-footprint-calculator/)
- Turn off the tap (shaving, brushing teeth)
- Buckets to catch hot water in shower—use for toilet flush
- High efficiency washing machines and toilets
- Drought tolerant landscaping at home (drip systems irrigation; fix leaks)
- Food choice (meat costs more than vegetables in water costs)

Issues with new solutions

Emerging contaminants?
- Occurrence does not equal toxicity.
- Dose determines the poison. The highest concentration of Prozac found in surface water was 8 ng/L. You would need to drink ~7 million 12oz glasses of water to get a daily dose of Prozac (20mg).

Questions

1. Make a prediction: How much of the water on Earth is fresh water? Salt water? Where is fresh water found? Where is salt water found?
2. Use this resource to check your prediction. Were you surprised by anything? How would you revise your prediction based on this information?
3. What is so striking about these bar graphs when you consider that all life on land depends on fresh water?
4. Considering the percentage of usable fresh water, what should humans be concerned about when they use water?
5. What would probably happen to these percentages if global warming caused the Earth's temperature to eventually rise by a few degrees? What would happen if we suddenly went into another ice age?
6. In what form does water occur in each of the five phases of the hydrologic cycle depicted here?
7. Why is the hydrologic cycle an important process for Earth?
8. Is there a beginning or end to the hydrologic cycle? Explain.
9. Where does your water come from? How could these "new" chemicals get into your water supply?
10. What do you think was meant by the "recycling" of water?
11. Why do you think regulation has not kept up with the number of chemicals entering the water supply?

Standards

Global Water Distribution
Earth Sciences

California Geology

9. The geology of California underlies the state's wealth of natural resources as well as its natural hazards.

   As a basis for understanding this concept:

c. Students know the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.

Biology/Life Sciences
Ecology

6. Stability in an ecosystem is a balance between competing effects.

   As a basis for understanding this concept:

d. Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.

Earth Sciences
Biogeochemical Cycles

6. Stability in an ecosystem is a balance between competing effects.

   As a basis for understanding this concept:

b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population.

7. Each element on Earth moves among reservoirs, which exist in the solid earth, in oceans, in the atmosphere, and within and among organisms as part of biogeochemical cycles.

   As a basis for understanding this concept:

c. Students know the movement of matter among reservoirs is driven by Earth's internal and external sources of energy.

Biology/Life Sciences
Ecology

Energy in the Earth System

6. Climate is the long-term average of a region's weather and depends on many factors.

   As a basis for understanding this concept:

b. Students know the effects on climate of latitude, elevation, topography, and proximity to large bodies of water and cold or warm ocean currents.

California Geology