San Diego Natural History Museum

Water

H_2O=Life

AND

water

A CALIFORNIA STORY

Teachers Guide

Inside

- **Key Concepts** to prepare for your visit
- **Gallery Inquiries** and **Classroom Activities** for your students
- **California Content Standards** for each applicable section

Guide made possible through the generous support of the McCarthy Family Foundation.

Contents

Dear Educator,

This guide includes an exhibition overview, links (in colored text), questions to investigate during your visit, and curriculum to use in your classroom. Writing implements are not permitted in the exhibition. The exhibits are thoughtfully designed to engage students' eyes, hands, and minds. Please encourage your students to enjoy the galleries with contemplation and delight.

References to California Content Standards are included where appropriate. Full text of standards is available at http://www.cde.ca.gov/index.asp.

If you have questions related to this guide, please call the Museum's Education Department at 619.255.0311 or email education@sdnhm.org.

About

Water: H_2O=Life

Water covers more than two-thirds of the Earth's surface, an abundance that is unique in our solar system. Water continuously changes from one form to another in a vast cycle as it moves through the crust, oceans, and atmosphere—and it is a finite resource. All the water that is here now is all the water that there will ever be on Earth. ***Water: H_2O=Life*** explores where water occurs on Earth, how it's used, and how we can become better stewards of our water planet.

In the gallery, your students will be able to explore the connections between H_2O and life.

Water: A California Story

About 85% of southern California's water supplies are imported. ***Water: A California Story*** explores our connection to this precious resource through an examination of the natural world.

In the Museum's Discovery Center your students will consider our shared dependence on the limited supply of fresh water though natural history specimens, live animals, and interactive exhibits.

Prepare: Key Concepts

Life began in water

Biochemical reactions that are essential to the processes of life are dependent upon the molecular structure of water—the ultimate solvent. The special properties of this amazing molecule propelled the course of evolution.

Every living organism is dependent upon water to survive. We find the largest diversity of species in the ocean, but no quarter of the planet is without inhabitants. Life has adapted exquisitely to an amazing variety of marine, fresh water, and terrestrial habitats—even the very driest ones.

The amount of available water in a habitat determines the life forms that live there. San Diego's varied topography supports several distinct vegetation zones, and these habitats have varied supplies of fresh water. As a result of these differences, San Diego County is home to myriad plant and animal species; it is a "hotspot" of biodiversity.

Our Mediterranean climate is typified by long dry summers and wet winters. Individual species have adapted an array of strategies to overcome vulnerability during long dry periods and to make the most of winter rains. However, variability in yearly climate cycles results in some years that are exceptionally dry.

Ask your students to visit Project Clean Water at http://www.projectcleanwater.org/html/watershed_sdhr.html. Identify the watershed for your area. Then visit the UCSD Science Matters website to learn about our county's biodiversity: www.ucsd.tv/sciencematters/lesson4-bio.shtml#TOP. Increased urban demand for water and space will alter native vegetation zones and impact the viability of some endangered species. Why is the preservation of San Diego's biodiversity important to human beings?

California State Content Standards

Grade 3 Life Science 3a, b

Grade 5 Earth Science 3a–e

Grade 7 Life Science; Evolution 3a

Grades 9–12 Earth Science California Geology 9c

Grades 9–12 Biology/Life Sciences, Ecology 6a, b, d, g

Grades 9–12 Science; Investigation and Experimentation 1d, l, m

Winds blow, clouds form, rain falls

This cycling of water around the oceans, the land, and the atmosphere is made possible by the unique molecular properties of the water molecule. H_2O molecules constantly form, break, and reform bonds with other H_2O molecules. Water is perpetually moving through all three phases of matter as it travels from atmosphere to Earth to atmosphere again and again. It shapes the planet through erosion and regulates climate. Oceans store and transport heat in great quantities, and ocean currents and atmospheric vapor modify and drive climatic patterns.

Ask your students to study the weather pages of the newspaper for several days. Have them chart the high and low temperatures for the coastline and the desert. You may also access data for specific coastal and inland cities at http://www.weather.com. What can students infer about the tempering effect of the ocean?

California State Content Standards

Grade 5 Earth Science 3a–e, 4b

Grades 9–12 Earth Science; Energy in the Earth System 5a, c, g

Earth's water is a finite resource

The availability of water on land varies due to weather patterns, evaporation rates, and other factors such as pollution. Most of Earth's water is stored in the oceans. Less than 3% of all water on Earth is fresh, and less than one-third of that is available. Water that is fresh and available makes up less than 1% of the water on Earth. Billions of people live without safe water or sanitation; global thirst is growing along with the world's population.

Ask your students to calculate how much water each student uses in a day with the help of the U.S. Geological Survey Water Calculator: http://ga.water.usgs.gov/edu/sq3.html. Form discussion groups to compare disparities in usage, and brainstorm ways to reduce their daily water use. Visit www.waterfootprint.org/?page=files/home to investigate the water costs accrued in the production of various consumer items.

California State Content Standards

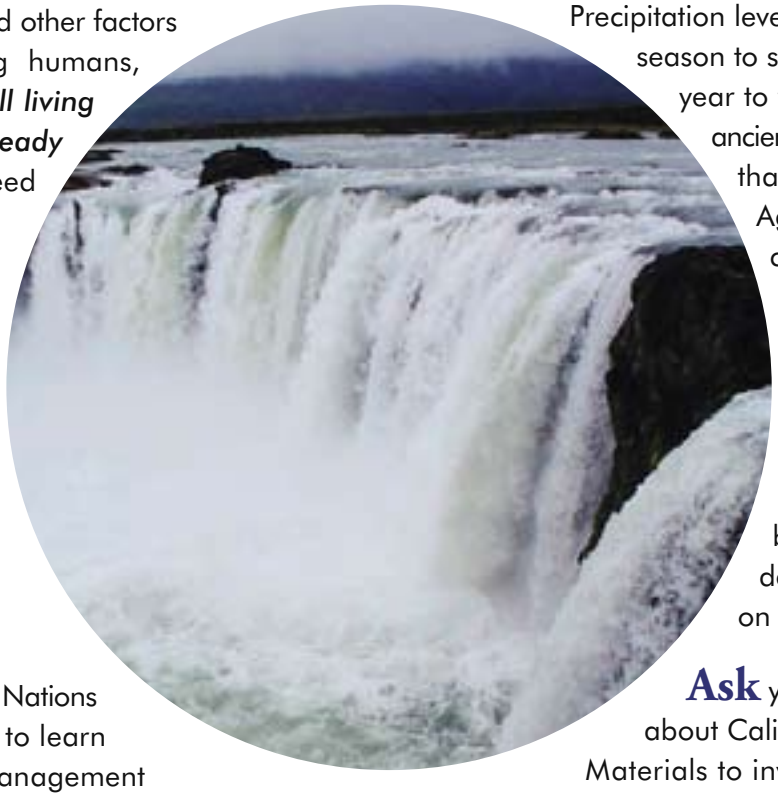
Grade 5 Earth Science 3a–e

Grades 9–12 Earth Science; California Geology 9c

Grades 9–12 Science; Investigation and Experimentation 1d, l, m

Increased human population

Increased human population directly impacts the availability of water in a given area. Our ability to devise methods to move water and to support communities in dry areas has been a cornerstone of civilization, but there is a cost. Dams, irrigation, and depletion of underground aquifers have lasting environmental impacts. Rivers, lakes, and groundwater can be depleted or polluted, making them unavailable or unsuitable for life. Oceans are under threat from chemical pollution, over fishing, sedimentation, habitat destruction, and other factors All species, including humans, live "downstream"—***all living things use water already used by others***. We need to use water more efficiently, conserve where possible, protect water quality, and make informed decisions to balance competing demands among species.



Ask your students how can we be better stewards of our water planet? Visit the United Nations Water for Life website to learn about global water management http://www.un.org/waterforlifedecade. While the world's aquatic systems have a limited capacity to absorb waste, they can be resilient. Actions we take today can revitalize and sustain this essential resource.

California State Content Standards

Grade 3 Life Science 3a, b

Grade 5 Earth Science 3a–e

Grade 7 Life Science; Evolution 3a

Grades 9–12 Earth Science; California Geology 9c

Grades 9–12 Biology/Life Sciences; Ecology 6a, b, d, g

Grades 9–12 Science; Investigation and Experimentation 1d, l, m

Every year California counts on

about 71 million acre-feet of runoff–water resulting from winter precipitation. One acre-foot of water is 325,851 gallons, about enough for six people for one year. Some of this water comes from our wet north coast and the Sacramento River basin, both of which are far away from San Diego County. Southern California is bordered on the east by the Colorado River, and we receive over four million acre-feet of water from this out-of-state source.

Precipitation levels vary not only from season to season but also from year to year. Age-dating of ancient tree stumps indicates that during the Middle Ages, there were two century-long droughts. In fact, the 20th century is one of the wettest in 2000 years, and Californians have taken advantage of these good times by building cities and developing agriculture on a grand scale.

Ask your students to think about California's water history. Materials to investigate the role water has played in California's development are included in "Geography of Water" (4th–8th grade), a curriculum set available through the San Diego County Water Authority at www.sdcwa.org/education/teachers-materials.phtml. Can your students engineer their own plans for water sustainability in our state?

California State Content Standards

Grade 5 Earth Science 3a–e

Grades 9–12 Earth Science California Geology 9c

Grades 9–12 Science; Investigation and Experimentation 1d, l, m

Explore: Gallery Investigations

Water: H_2O=Life

What physical features enable some organisms to survive where others can not?

All living things need water, but resourceful adaptations have met the challenges of varying supplies. Both the kangaroo rat and the wood frog have developed unique organ systems that allow them to meet the challenges of their contrasting environments. The wood frog, which lives in vernal pools, is able to survive ice formation in its extra cellular fluids because its liver stores glucose as antifreeze. The kidneys of the desert-dwelling kangaroo rat are four times more efficient than those of a human being. This creature lives its entire life without taking a sip of water.

In *Water: H_2O=Life*, your students will be able to compare and contrast the way different plants and animals have adapted to extreme environments such as the driest deserts, the hottest water, and the saltiest seas. Pair your students up and ask them to discuss the similarities and differences between two organisms represented in the gallery. Compare and contrast their environments and adaptive features. Would these creatures be able to trade habitats?

California State Content Standards

Grade 3 Life Science 3a, b

Grade 5 Earth Science 3a–e

Grade 7 Life Science; Evolution 3a

Grades 9–12 Biology/Life Sciences, Ecology 6a, b, d, g

Where has your water been?

All the water on the Earth today is the same water that has been cycling through the land, oceans, and atmosphere throughout Earth's history. In ***Water: H_2O=Life***, your students will see an astonishing geological specimen: a 3.8-billion-year-old rock. This sample of Ishua schist presents evidence for the presence of water very early in Earth's history. Most scientists who have studied this rock think it accumulated from tiny particles that could only have been transported by—and deposited in—water.

California State Content Standards

Grade 4 Earth Sciences 4–5

Grade 5 Earth Sciences 3a–e

Where is fresh water found?

Ours is a watery planet, but very little of this water is available for use in the sustenance of terrestrial life. The tiny fraction of fresh water that is readily available to humans is not evenly distributed around the world. In ***Water: H_2O=Life***, the Science on a Sphere globe is an animated model of global water distribution. Ask your students how conflict and scarcity of water resources are correlated. Can they identify the richest and poorest continents in terms of water wealth? Is there a connection between scarcity of water and civil unrest?

California State Content Standards

Grade 5 Earth Science 3a–e

Grades 9–12 Science; Investigation and Experimentation 1m

Grades 9–12 Historical and Social Science Analysis Skill; Historical Interpretation 5

Grades 9–12 Historical and Social Science Analysis Skill; Chronological and Spatial Thinking 3

What do humans use water for?

Humans put water to work. In ***Water: H_2O=Life***, your students will study wall graphs analyzing how water is used around the world, play a virtual game show to test their knowledge of how much water it takes to get a job done, and see a section of irrigation pipe from Oaxaca, Mexico, that is nearly 1500 years old. Ask your students how technology can make water usage more efficient. Ask them to identify some technologies and production methods that are not water-efficient. What happens at the artesian well interactive if you pump too much water out of the ground?

California State Content Standards

Grade 6 World History and Ancient Civilizations 6.2

Grade 8 Physical Science; Forces 2d, e

Grades 9–12 Science; Investigation and Experimentation 1d, l, m

Grades 9–12 Historical and Social Science Analysis Skill; Historical Interpretation 5

Grades 9–12 Historical and Social Science Analysis Skill; Chronological and Spatial Thinking 3

How do water challenges get solved?

Some places or seasons are extremely wet, others very dry. In ***Water: H_2O=Life***, students will explore some of the wettest, driest, and iciest places in the world. Investigate how life has adapted to these extremes. How do people use technology to increase access to water? Climate change is likely to create new and possibly more extreme weather patterns. Ask your students to consider how longer droughts and more powerful floods may affect us. Are we ready to adapt?

California State Content Standards

Grade 4 Science; Investigation and Experimentation 6a

Grade 5 Science; Investigation and Experimentation 6h

Grade 6 Science; Investigation and Experimentation 7h

Grades 9–12 Science Investigation and Experimentation 1d, l, m

What can we do?

In the last part of the ***Water: H_2O=Life*** gallery, your students will use multimedia stations to discover how much water they use in daily activities. Have students suggest ways in which they could use less water. Ask students to consider making a single specific change that would protect and conserve water in their daily lives. What could they do to reduce water pollution around home or school?

California State Content Standards

Grade 5 Earth Science 3a–e

Grades 9–12 Earth Science California Geology 9c

Grades 9–12 Science; Investigation and Experimentation 1d, l, m

Civilization was born on a river bank. What are we doing today to preserve our connection to wetland habitats?

In ***Water: H_2O=Life***, a 4000-year-old cuneiform tablet and a 5000-year-old Sumerian water jug reinforce the idea that some of the world's oldest civilizations owe their existence to the life-giving waters of the Tigris and the Euphrates rivers. All living things are connected in their dependence on water. Aquatic ecosystems are both alarmingly fragile and surprisingly resilient. Ask your students to investigate the stories of habitat restorations at Mono Lake, the Mississippi River Delta, and the Mesopotamian marshes. Should these efforts be increased in other places? Is this feasible with a growing population? What costs to human society are likely if wetlands are destroyed?

California State Content Standards

Grade 6 Social Sciences 6.2, 1; 6.5, 1

Grades 9–12 Historical and Social Science Analysis Skills; Historical Interpretation 1.5; Chronological and Spatial Thinking 3

Water: A California Story

What's at the root of San Diego's incredible biodiversity?

San Diego's diverse landscapes receive uneven amounts of precipitation. Humid air masses move inland from the ocean and bump into our eastern mountains. The moist air cools as it rises, resulting in rain and snow on our mountaintops. The desert behind these mountains is called a rain-shadow desert. The plants and animals who have adapted to life in the desert are distinct from those living downstream of mountain snow pack. Varied topography, varied climate, varied amounts of available fresh water—these are the natural aspects encouraging the profusion of biodiversity in our region.

In ***Water: A California Story***, ask your students to study the vegetation zone dioramas. Compare and contrast the flora and fauna. Can they identify adaptive features? Look at the rattlesnakes in the mountain pine case, the dry desert case and the shrubland case. How do these snakes differ from each other? Do these differences contain a clue about the habitats?

California State Content Standards

Grade 3 Life Science 3a, b

Grade 7 Evolution 3.1

Grades 9–12 Earth Science California Geology 9c

Grades 9–12 Biology/Life Sciences, Ecology 6a, b, d, g

Grades 9–12 Science; Investigation and Experimentation 1d, l, m

Where does our water come from?

Water is part of the matter that came together when the Earth was formed. Ask your students to reflect upon this idea. In almost four billion years, where has your water been? How does this knowledge inform your feelings about toilet-to-tap water reclamation plans? Until the 1940s, local rivers and aquifers supplied water for all of San Diego's needs. Now, more than 80% of our water comes from somewhere else.

In ***Water: A California Story***, ask your students to study the Colorado River model. With whom do we share this water resource? Neighboring states negotiated shares of the river way back in 1922, and 21st-century legislation has redirected a portion of our share from agricultural use to urban areas. Every drop is accounted for, and yet the movement and allocation of this water has left some of our partners high and dry. The lush woodland habitats of the Colorado River Delta are no more. Ask your students if development is more important that the conservation of native habitats.

California State Content Standards

Grade 3 Life Science 3a, b

Grade 5 Earth Science 3a–e, 4b

Grade 7 Evolution 3a

Grades 9–12 Earth Science California Geology 9c

Grades 9–12 Biology/Life Sciences, Ecology 6a, b, d, g

Grades 9–12 Science; Investigation and Experimentation 1d, l, m

Grades 9–12 Earth Science; Energy in the Earth System 5a, c, g

What can we do?

Nearly 20% of California's energy use relates to water collection, transportation, and treatment. We import almost all of our water, and that takes a lot of energy. In ***Water: A California Story***, ask your students to try lifting the jug of water. Think about how difficult it would be to carry the water needed to produce a brown-bag lunch. A cheese sandwich and a cup of apple juice have a water footprint of about 300 liters—more than 600 pounds of water! Make that lunch a roast beef sandwich and they will need to lift another 1700 liters for a total of 4000 pounds.

Ask your students to calculate ways that they can save water using the information in the gallery. Can they pledge to make one small change in their daily lives like eating less meat or taking shorter showers? We can all contribute to conservation and no contribution is too small.

California State Content Standards

Grade 5 Earth Science 3a–e

Grades 9–12 Earth Science California Geology 9c

Grades 9–12 Science; Investigation and Experimentation 1d, l, m

How do our water choices affect the wild communities around us?

In ***Water: A California Story***, ask your students to study the photographs in the ocean portion of the gallery. What's the difference between a sanitary drain, like the one your toilet flushes into, and a storm drain on the street? The sanitary drain goes to the water treatment plant on its way to the ocean; the storm drain goes directly to the ocean.

Spend a minute with your students brainstorming evocative language describing the image of the kelp forest. Then visit the magnetic poetry wall. Ask your students if the images and information in the exhibition gave them ideas about their role in California's water story.

California State Content Standards

Grade 6 English Language; Writing 1.1

Grades 7–8 Visual and Performing Arts; Visual Arts 5.3

Expand Classroom Activities

Which water?

Conduct a blind taste test that includes tap water and at least three brands of bottled water. Divide the class into teams and assign one brand to each. Ask them to research the source and purification standards for that brand. How is the brand marketed—with a mountain stream or a waterfall? Does this accurately reflect the water's source? Investigate and discuss the benefits and disadvantages of bottled water. Think about the amount of water used to recycle plastic water bottles. Isn't a reduction in bottle manufacturing a wiser water conservation goal? For more information, visit http://www.allaboutwater.org/environment.html and http://scienceline.org/2008/05/05/ask-intagliata-plastic/.

California State Content Standards

Grades 5 Visual and Performing Arts; Visual Arts 5.2

Grades 6 Visual and Performing Arts; Visual Arts 5.4

Grades 9–12 Science; Investigation and Experimentation 1d, l, m

Wastewater Wisdom

Visit http://www.sandiego.gov/mwwd/pdf/ptl-wprocess.pdf and take a look at the Point Loma Wastewater Treatment Plant schematic. Ask your students to think about the labor, energy, and technology required to treat wastewater. How can they help to create less waste? Never use the toilet as a trash can. Compost kitchen waste, and never put cooking oil down the drain.

You can do this simple experiment to see how the first stages of wastewater treatment work.

Materials:

One-liter soda bottle

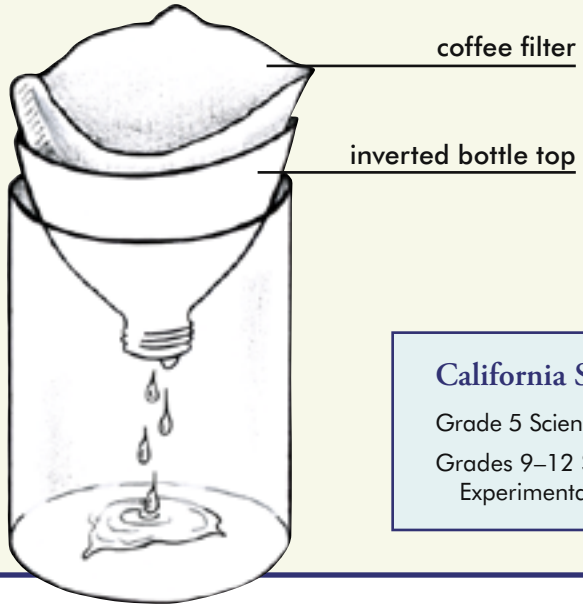
Paper coffee filter

Some sand

Muddy water (you can substitute cocoa for soil)

Barbeque charcoal ground into a powder

1. Remove the lid of the bottle.
2. Cut the bottle's top off about three inches down from the lid.
3. Invert the top and place it in the bottom half of the bottle.
4. Place a coffee filter in the inverted lid.
5. Layer wet sand and charcoal inside the coffee filter.
6. Pour muddy water through your "grit chamber."
7. You can vary the experiment by excluding the charcoal or the sand and comparing results.



California State Content Standards

Grade 5 Science; Investigation and Experimentation 6d, e

Grades 9–12 Science; Investigation and Experimentation 1d, l, m

Water water everywhere

Just how much fresh water is out there? Create a water ratio model.

Materials:

One-liter soda bottle

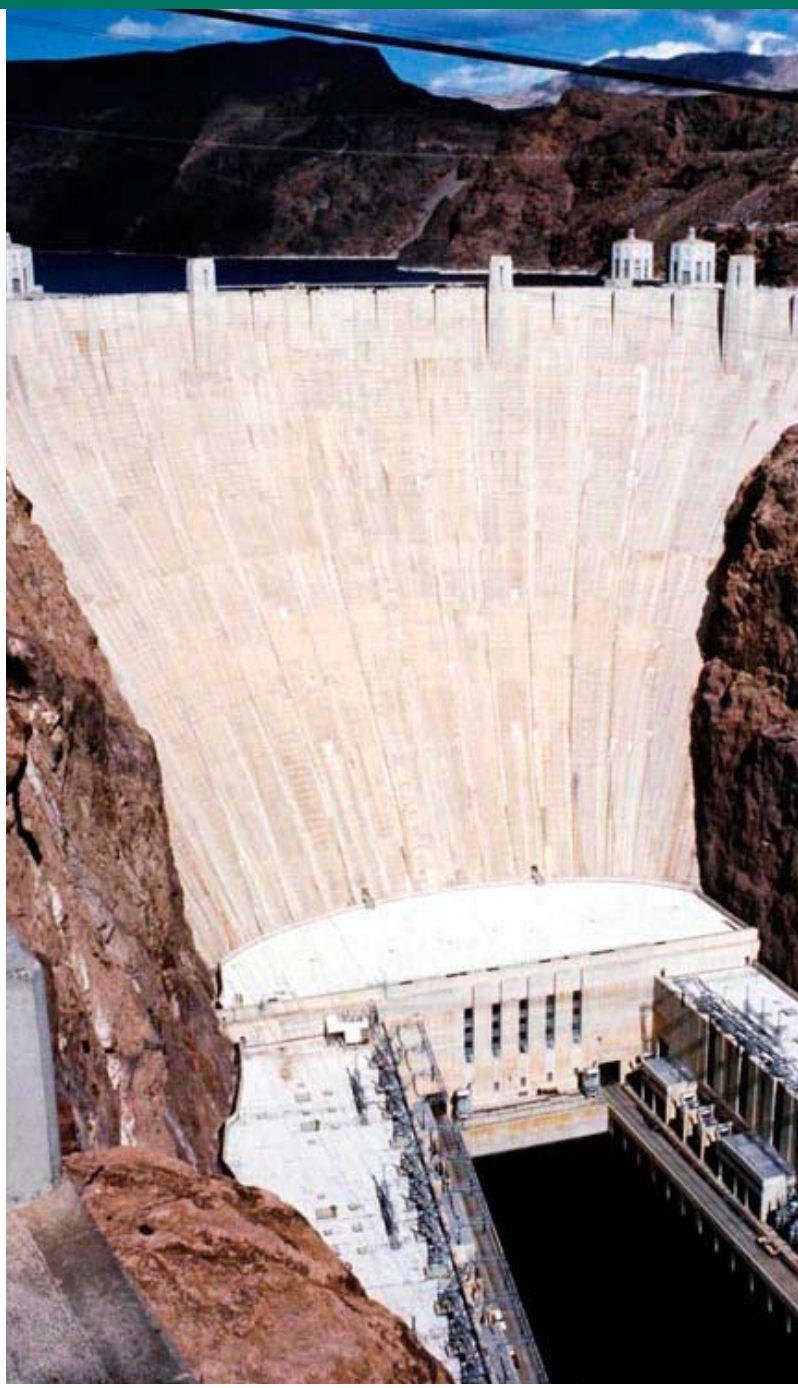
Graduated cylinder

Bottle cap

One liter of water, tinted blue with food coloring

1. Fill one-liter soda bottle with blue water. Tell your students that this represents all the water in the world.
2. Pour three milliliters into a graduated cylinder. This represents all the fresh water.
3. Pour one-half of a milliliter from the three milliliters into another small cylinder or a bottle cap. This last amount represents all the fresh available water on the Earth.
4. Ask your students to use the proportions in your demonstration to devise their own model of the Earth's water using another set of materials. Lengths of paper, carefully weighed lumps of clay, representative seats in a stadium, or portions of a chocolate bar all work well.

Go a little deeper. Ask your students to keep a journal of their water use for three days. Access the water calculator at http://ga.water.usgs.gov/edu/sq3.html for details about typical usage. Then investigate the geographical distribution of potable water at http://www.mapsofworld.com/world-freshwater-resources.htm and http://maps.grida.no/go/graphic/global_freshwater_resources_quantity_and_distribution_by_region. This report, produced jointly with the United Nations World Health Organization and UNICEF, indicates that 1.1 billion people are still without safe drinking water. Are we using more than our share?



California State Content Standards

Grade 5 Earth Science 3a–e

Grade 6 Science; Investigation and Experimentation 7b

Grade 7 Science; Investigation and Experimentation 7a

Grade 7 Mathematics; Measurement and Geometry 1.1, 1.2

Grades 9–12 Historical and Social Science Analysis Skill; Historical Interpretation 5

Grades 9–12 Historical and Social Science Analysis Skill; Chronological and Spatial Thinking 3

Weighty water

The human body is more than two-thirds water. Ask you students to find out how much water is in a fellow classmate. Get a volunteer to stand on a scale. Ask teams to develop an equation that will show how much of the volunteer's weight is H_2O. (They may decide to multiply the weight by $^2/_3$ or divide the weight by 3 and then multiply by 2.)

Or try this challenge: The average brain contains 4.5 cups water. This water weight represents about ¾ of the brain's total weight. How much does an average brain weigh? (One cup of water weighs .5 lbs., multiply this by 4.5 to determine the weight of the water and then divide the result by .75.)

California State Content Standards

Grades 3–4 Mathematics; Algebra and Functions 1.1–1.5

Grade 5 Mathematics; Number Sense 2.4, 2.5

Grade 6 Mathematics; Number Sense 1.2–2.3

Grade 7 Mathematics; Measurement and Geometry 1.1, 1.2

That's a funky chunk

Water is a most unusual compound. It is less dense as a solid than it is in its liquid form. Unlike almost every other liquid found on Earth, water expands when it freezes. Everyone knows that ice cubes float. This is because the regular crystalline shape of frozen water has space between the adjacent molecules where air is trapped, causing the ice to float. What would happen to the wintering wildlife in a frozen mountain lake if water had greater density as a solid than it does as a liquid?

Explore the mystery and beauty of ice by making your own iceberg.

Materials:

Balloon
Water
Food coloring
Freezer
Tank or large clear punch bowl
Flashlight

1. Fill a balloon with tap water and add a couple of drops of food coloring to the balloon before tying the neck.
2. Place it in a large plastic bag and freeze it overnight.
3. Cut the balloon away from the ice.
4. Float your iceberg in a tank or bowl.
5. Use a magnifying glass to observe the shapes and patterns that you can see in the crystals of ice.
6. Repeat observations using a flashlight.

California State Content Standards

Grade 5 Earth Science 3a–e

Whet wet writing

Wetlands provide a variety of natural services such as water purification through decomposition and nutrient cycling, and the prevention of erosion during floods. Find out more about what makes a wetland a precious resource for terrestrial and marine species. Visit the San Diego Wetlands web site at http://www.buschgardens.org/swc/wetlands/whatarewetlands.htm. Ask your students to write a personal narrative about a trip to a wetland preserve. Authors may decide to make this trip as a human being or as a bird migrating south on the Pacific flyway and stopping in the wetland for a rest.

California State Content Standards

Grade 5 English Language; Writing Applications 2.4
Grade 6 English Language; Writing Applications 2.5
Grades 7–8 English Language; Writing Applications 2.4

Ask your students to write a persuasive letter to someone in their family detailing the compelling reasons we all have for being involved in the conservation of water.

California State Content Standards

Grades 3–5 English Language; Writing Applications 2.1
Grades 4–6 English Language; Writing Strategies 1.0–1.2
Grades 7–12 English Language; Writing Applications 2.1

Read the following poem. Discuss how the imagery in this poem intersects with the ideas in the exhibition.

Ask your students to write a poem in response.

Water

Something more and less than blood—it spills without injury, and courses unmarked through stone and flesh.

Breath and vapor, tide and torrent—it inhabits the peach and the plum snuggly. When bitten they glisten like gems.

California State Content Standards

Grade 6 English Language; Writing Applications 2.4
Grades 7–12 English Language; Writing Applications 2.2

Resources

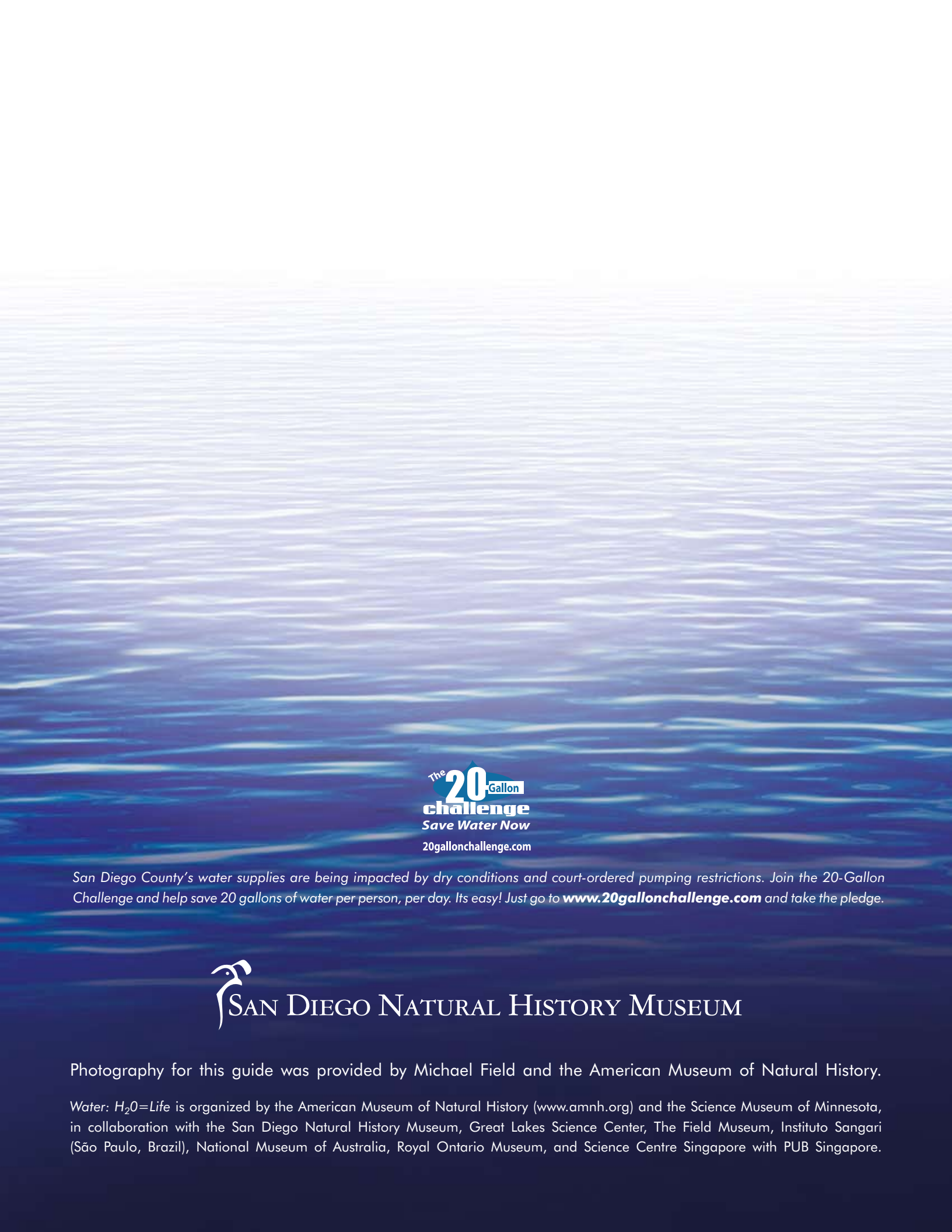
Carle, David. *Introduction to Water in California*. Berkeley, CA: University of California Press, 2004

De Villiers, Marq. *Water, the Fate of Our Most Precious Resource*. Boston, MA: Houghton Mifflin, 2000

Glennon, Robert. *Water Follies*. Washington, DC: Island Press, 2002

Royte, Elizabeth. *Bottlemania: How Water Went on Sale and Why We Bought It*. USA: Bloomsbury, 2008

Shiva, Vandana. *Water Wars*. Cambridge, MA: South End Press, 2002



San Diego County's water supplies are being impacted by dry conditions and court-ordered pumping restrictions. Join the 20-Gallon Challenge and help save 20 gallons of water per person, per day. Its easy! Just go to ***www.20gallonchallenge.com*** *and take the pledge.*

San Diego Natural History Museum

Photography for this guide was provided by Michael Field and the American Museum of Natural History.

Water: H_2O=Life is organized by the American Museum of Natural History (www.amnh.org) and the Science Museum of Minnesota, in collaboration with the San Diego Natural History Museum, Great Lakes Science Center, The Field Museum, Instituto Sangari (São Paulo, Brazil), National Museum of Australia, Royal Ontario Museum, and Science Centre Singapore with PUB Singapore.