DILOS™ Participant Guide

Table of contents:

Save the Water™

“A Day in the Life of a Scientist” (DILOS™)

The U.S. ranks 26th compared to other countries in the number of students inclined towards pursuing careers in math and science. *“A Day in the Life of a Scientist”* provides an innovative and enjoyable way to motivate children and adolescents towards science. The complete program can be viewed at the STW™ website.

The program consists of a field trip that will instruct and excite young minds. During the trip, the students will be given a presentation on the water cycle, the scientific method, and facts about water contamination. This will open their minds to why we should protect this valuable resource.

The program is performed outdoors breaking the routine of the school year. An outing to a wetland, river, or lake to collect and analyze water samples is always fun, interesting, and instructive. Making science fun is the purpose of this program. Inspiring children to become the scientists of the future is the primary goal of Save the Water™.

Following the scientific method, the children will first make observations about their surroundings. They will note and record the condition of plants and trees, the presence of minnows on the shore, look for birds, animals, and noticing lack or abundance. They will also look for possible ways pollution and contaminants may be entering the water. Then form a hypothesis about the conditions of the water and the environment.

The experimental part is hands on for the students using field laboratory equipment to test for parameters such as: pH, temperature, turbidity, and conductivity. The results of the tests are then compared with published standards along with the previous observations, and the hypothesis tested.

Their data and conclusions will be recorded and logged into the website to compare with follow-up field trips. Future participants will be able to compare data and assess whether the environmental conditions are improving or deteriorating.

Each participant will have the opportunity to become a member of the AquaSquad™ and receive a framed certificate of completion for the DILOS™ program along with educational material to continue their research.

Save the Water™ is committed to the education of present and future generations to insure the protection and conservation of water. Without clean drinking water no species, plant, animal or human can survive.

Everyone benefits from a sustainable supply of clean water. Whether it is your source of drinking water or the water used to cook the food on your table, clean healthy water is vital to life. As such, every person plays a role in protecting and conserving our water.

Students will use the scientific method during the program:

The scientific method:

Objective: To ask and answer scientific questions by making observations and doing experiments.

- **Note**

Scientists study how nature works. Engineers design and create new things.

Scientific method – steps to follow:

1. Ask a question.
2. Do background research on the question.
3. Construct a theory (hypothesis).
4. Test the theory by doing an experiment based on the theory.
5. Your experiment should be a fair test. A "fair test" occurs when you modify only one variable in your experiment and keep all other conditions the same.)
6. Analyze your information data findings and formulate a final conclusion.
7. Draft your findings and conclusion in a simple but detailed presentation.

Scientific method defined:

Procedure for carrying out tests and experiments used to investigate observations and answer questions. Scientists use the scientific method to investigate the **cause and effect** relationships in the environment.

Scientists plan a test through experimentation so that changes to one item cause something else to differ in an expected manner. The scientific method will assist you to center your science fair project question, construct your theory (hypothesis), plan, carry out, and assess your experiment.

7 Steps of the scientific method:

Note: Even though we demonstrate the scientific method as a progression of the following seven steps, bear in mind that new information or thoughts might cause you to back up and repeat certain steps at some point during the process.

1) Ask yourself a question:

- The scientific method starts when you ask a question about a problem or something that you observe: ***How, What, When, Who, Which, Why, or Where***?
- In order for the scientific method to answer the question it must be about something that you can evaluate and measure, if at all possible with a number.

2) Do the background research on your question:

- Instead of beginning from scratch in putting together a plan for answering your question, use the library and internet research to assist you discover the best way to do things and insure that you don't duplicate mistakes made by others in the past.

3) Formulate your theory (hypothesis):

- A theory or hypothesis is an educated speculation regarding how things work: **"If _____*[I do this]* _____, then _____*[this]*_____ will happen."**
- State your theory in a way that you can straightforwardly calculate and measure.
- The theory should be designed in a way to help you answer the original question.

4) Test your theory (hypothesis) by conducting your experiments:

- Your experiment tests whether your hypothesis is true or false.

5) Conduct fair test experiments:

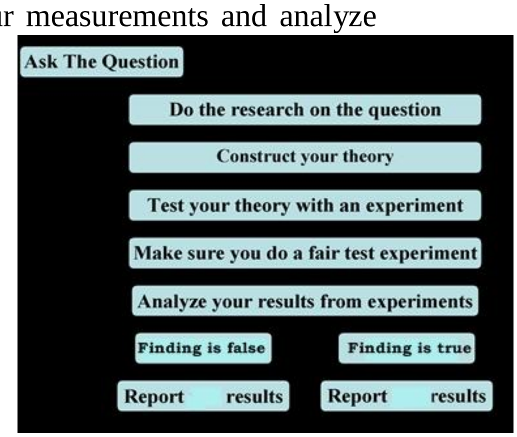
- It is important for your experiment to be a fair test.
- You conduct a fair test by making sure that you change only one factor (variable) at a time while keeping all other conditions the same. Repeat your experiments several times to make sure that the first results weren't just an accident.

6) Analyze the experiment data and come up with your conclusion:

- Once your experiment is complete, you collect your measurements and analyze them to see if your hypothesis is true or false.
- If the theory (hypothesis) was false, you will construct a new hypothesis starting the entire process of the scientific method over again.
- Even if the hypothesis was true, you may want to test it again in a new way.

7) Report your findings:

- Once you are pleased with your results you must now complete your science fair project with final report and/or a display board.



Where does our drinking water come from?

The water cycle.

What is the water cycle?

What is the water cycle? I can easily answer that—it is "me" all over! The water cycle describes the existence and movement of water on, in, and above the Earth. Earth's water is always in movement and is always changing states, from liquid to vapor to ice and back again. The water cycle has been working for billions of years and all life on Earth depends on it continuing to work; the Earth would be a pretty stale place without it.

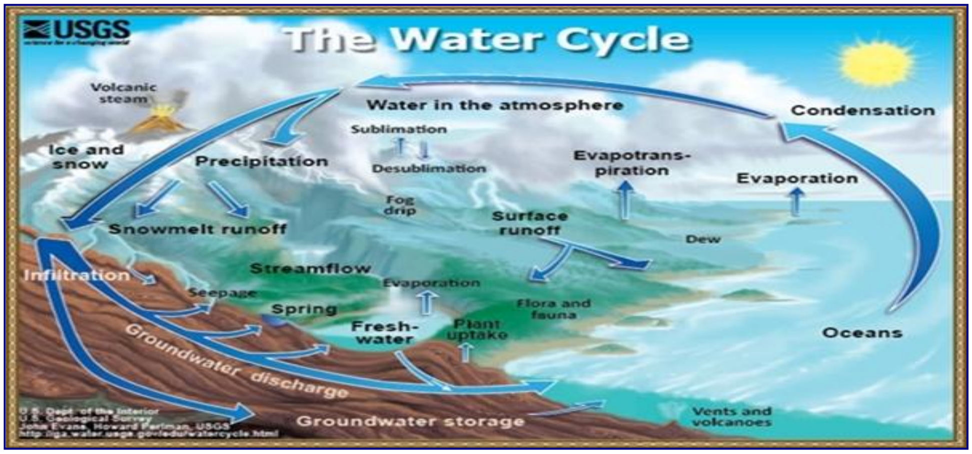
Where does all the Earth's water come from? Primordial Earth was an incandescent globe made of magma, but all magmas contain water. Water set free by magma began to cool down the Earth's atmosphere, and eventually the environment became cool enough so water could stay on the surface as a liquid. Volcanic activity kept and still keeps introducing water into the atmosphere, thus increasing the surface- and groundwater volume of the Earth.

A quick summary of the water cycle:

The water cycle has no starting point, but we'll begin in the oceans, since that is where most of Earth's water exists. The sun, which drives the water cycle, heats water in the oceans. Some of it evaporates as vapor into the air; a relatively smaller amount of moisture is added as ice and snow sublimate directly from the solid state into vapor. Rising air currents take the vapor up into the atmosphere, along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil. The vapor rises into the air where cooler temperatures cause it to condense into clouds.

Air currents move clouds around the globe, and cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Snowpacks in warmer climates often thaw and melt when spring arrives, and the melted water flows overland as snowmelt. Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with streamflow moving water towards the oceans. Runoff, and groundwater seepage, accumulate and are stored as freshwater in lakes.

Not all runoff flows into rivers, though. Much of it soaks into the ground as infiltration. Some of the water infiltrates into the ground and replenishes aquifers (saturated subsurface rock), which store huge amounts of freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as groundwater discharge, and some groundwater finds openings in the land surface and emerges as freshwater springs. Yet more groundwater is absorbed by plant roots to end up as evapotranspiration from the leaves. Over time, though, all of this water keeps moving, some to reenter the ocean, where the water cycle "ends" ... oops - I mean, where it "begins."



We all live in a watershed:

Land is very important to the water cycle. A Watershed is any area of land that water flows across or through. Where is the water going? Downhill of course. Water in a watershed trickles and flows toward a common body of water, such as a stream, river, lake or coast. Watersheds can be big or small, but they usually have high points (like ridges) as their upper boundaries. So watersheds capture water, store it and eventually release it farther downhill.

What sort of land is your watershed made of? It's easy to find out. First you need to know if the land where you live is steep or flat.

- Steep land makes water run off in fast-moving creeks and rushing rivers.
- Flat land allows water to collect into lakes, ponds and swamps.

Now think about what happens when you dig a small hole. Do you find solid rock, fine silt or dirt that is loose and sandy?

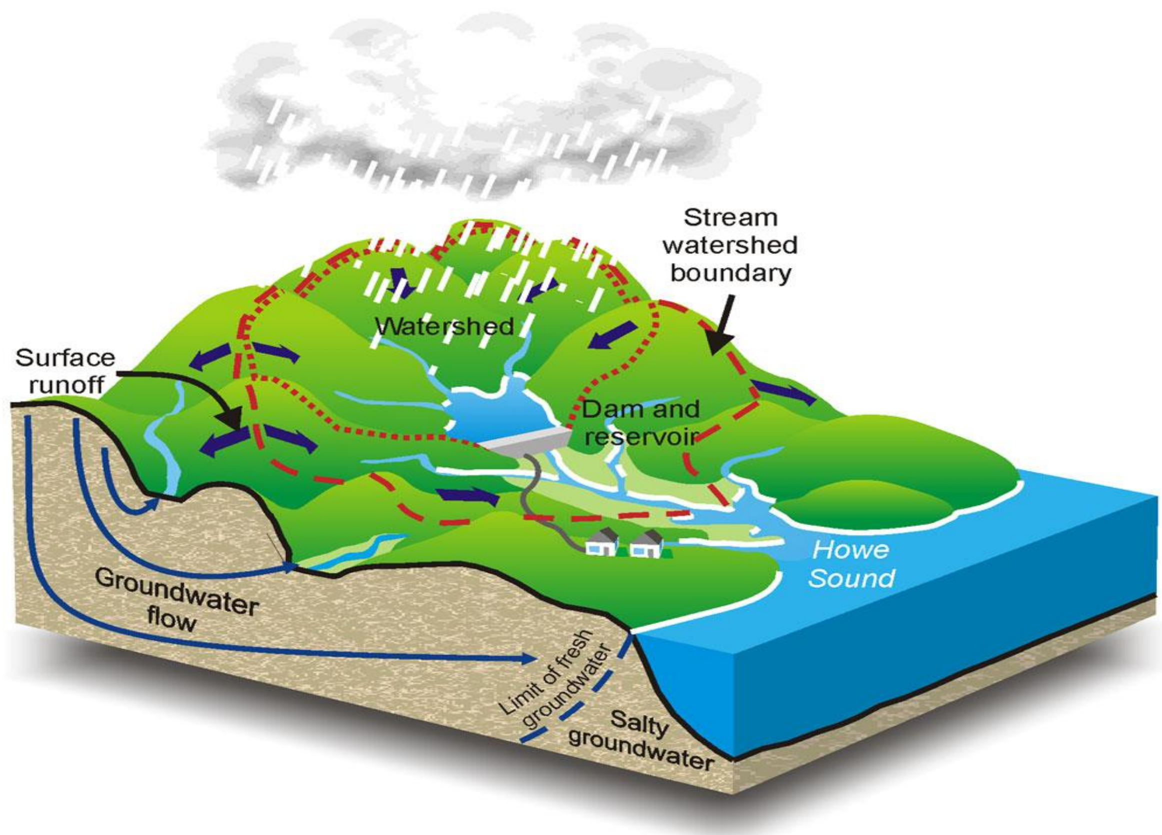
- Loose ground (like gravel or sand) is Porous, which means it has lots of little gaps that water can easily sink into. When water sinks into the ground, we call it Ground water, and it fills an underground water supply called an Aquifer.
- Tightly packed ground, like clay or solid rock, isn't very porous at all, so it's hard for water to move through. Layers like that can trap water at the surface or below ground.

Plants are very important to watersheds. Why? They make water behave differently than it does when the land is bare.

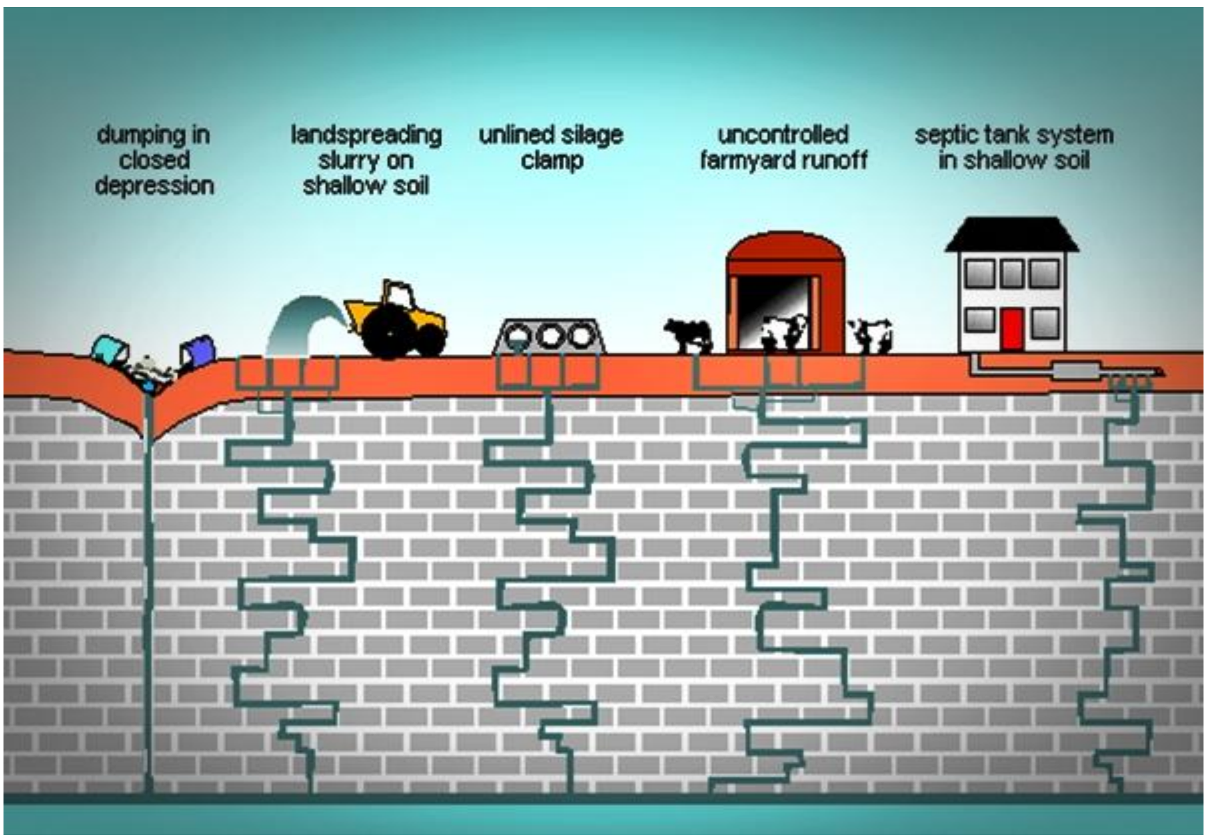
- Plants keep water from washing the soil away. Their roots hold dirt together, and their leaves and branches stop heavy rain from hitting the soil directly.
- Land with a lot of plants growing on it will hold water longer and release it slowly. That helps prevent destructive floods.
- Plants also Transpire water into the air by taking it up through their roots and releasing it as Water vapor.

Now that you know how land and plants affect your watershed, you might look out the window and wonder: Is your watershed healthy?

Healthy watersheds keep recycling clean, fresh water, over and over again. How do they do it? Swamps, marshes and other wetlands can filter polluted water and make it cleaner. Other parts of a watershed, like streams, Ground water and even the beach, are important as well. That's one reason why we need to make sure to leave enough wetlands and other natural areas in each watershed. **Sometimes it's tricky to balance the needs of people with the needs of their watershed, but we sure have to try.** If we do it right, there's still room for plants and animals to live and everybody gets an endless supply of clean water.

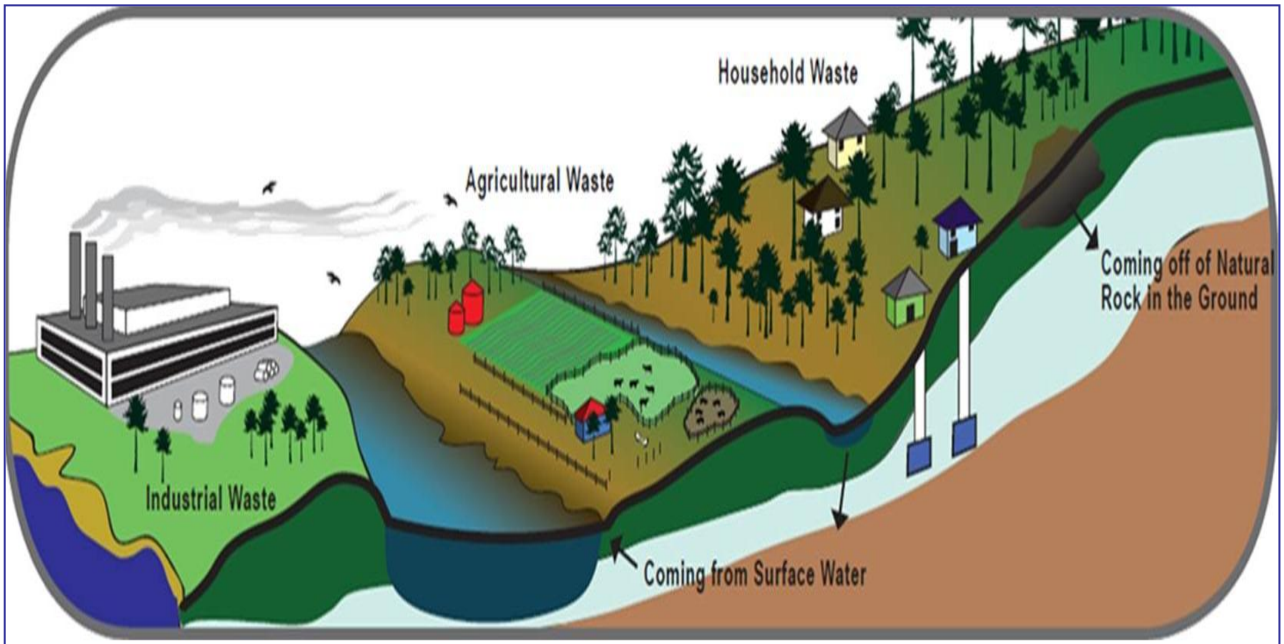



WEED KILLER


dumping in closed depression
landspreading slurry on shallow soil
unlined silage clamp
uncontrolled farmyard runoff
septic tank system in shallow soil

What is an aquifer and why is groundwater important?

Water flows between the soil, clay, and small cracks in underground rocks before it finally becomes groundwater.



(NC Department of Health and Human Services, 2011)

Some contaminants or pollutants can also follow this pathway and may influence the quality of your drinking water.

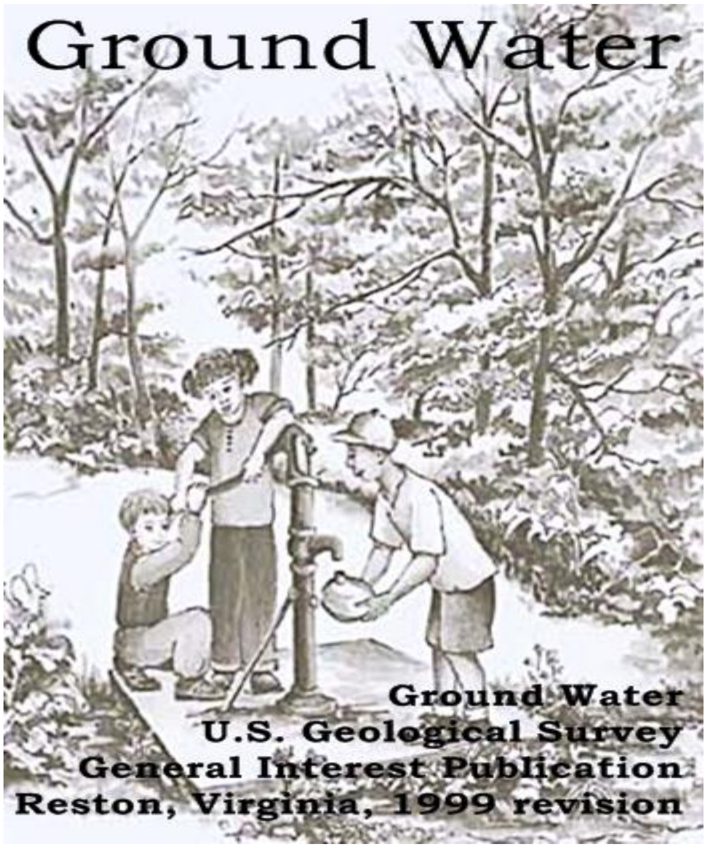
Groundwater can be contaminated by:

- Surface run-off that carries pollutants through the soil and into underground water supplies (such as rainwater that washes off of parking lots and roadways).
- Leaking storage tanks and landfills.
- Industrial discharges into surface waterways, and underground injection of waste products.
- Contaminants can also enter groundwater supplies from natural sources such as the erosion of mineral deposits, volcanic off-gassing and decomposing waste.

Just as the groundwater flow is subject to change, the distribution and concentration of contaminants in an area may change.

Regular groundwater testing is important to identify contamination problems early.

DILOS™ program: On line junior water education.



Ground water research:

Some water underlies the Earth's surface almost everywhere, beneath hills, mountains, plains, and deserts. It is not always accessible, or fresh enough for use without treatment, and it's sometimes difficult to locate or to measure and describe. This water may occur close to the land surface, as in a marsh, or it may lie many hundreds of feet below the surface, as in some arid areas of the West. Water at very shallow depths might be just a few hours old; at moderate depth, it may be 100 years old; and at great depth or after having flowed long distances from places of entry, water may be several thousands of years old.

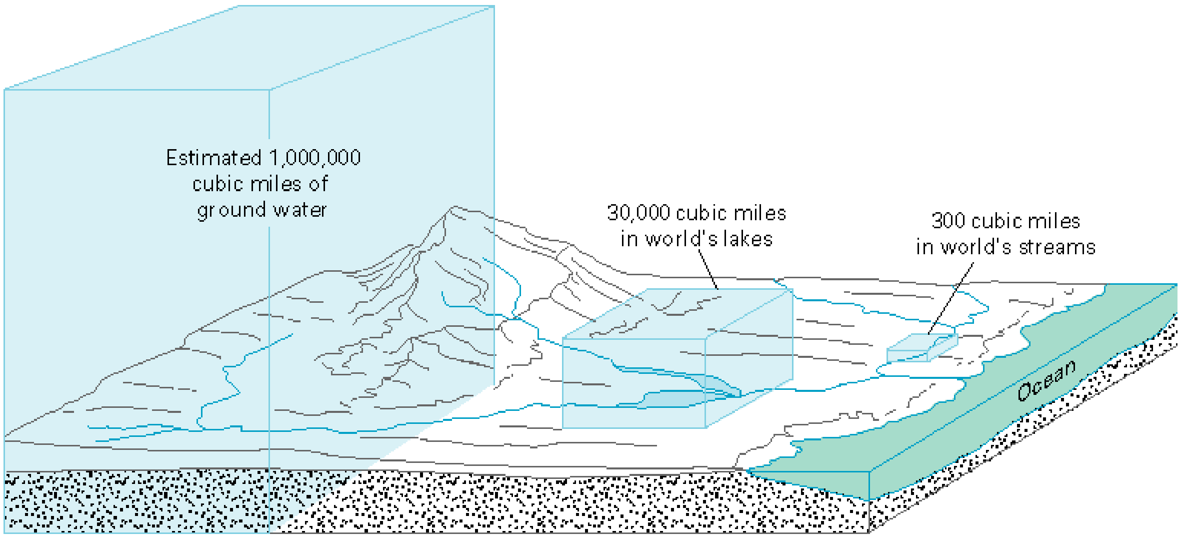
Ground water is stored in, and moves slowly through, moderately to highly permeable rocks called aquifers. The word aquifer comes from the two Latin words, aqua, or water, and ferre, to bear or carry. Aquifers literally carry water underground. An aquifer may be a layer of gravel or sand, a layer of sandstone or cavernous limestone, a rubbly top or base of lava flows, or even a large body of massive rock, such as fractured granite, that has sizable openings. In terms of storage at any one instant in time, ground water is the largest single supply of fresh water available for use by humans.

Springs in Snake River Plain, Idaho.

Ground water has been known to humans for thousands of years. Scripture (Genesis 7:11) on the Biblical Flood states that "the fountains of the great deep (were) broken up," and Exodus, among its many references to water and to wells, refers (20:4) to "water under the Earth." Many other ancient chronicles show that humans have long known that much water is contained underground, but it is only within recent decades that scientists and engineers have learned to estimate how much ground water is stored underground and have begun to document its vast potential for use. An estimated one million cubic miles of the world's ground water is stored within one-half mile of the land surface. Only a fraction of this reservoir of ground water, however, can be practicably tapped and made available on a perennial basis through wells and springs. The amount of ground water in storage is more than 30 times greater than the nearly 30,000 cubic-miles volume in all the fresh-water lakes and more than the 300 cubic miles of water in all the world's streams at any given time.

Comparison of the amount of fresh water in storage.

How ground water occurs: It is difficult to visualize water underground.

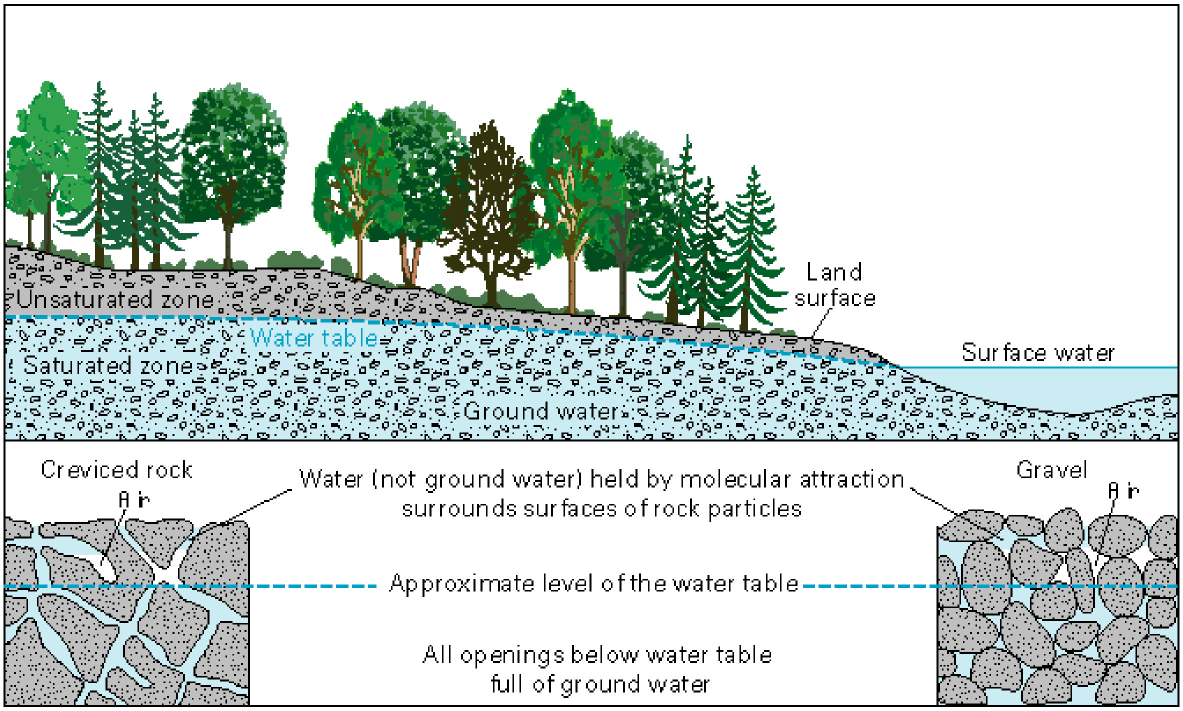


Some people believe that ground water collects in underground lakes or flows in underground rivers. In fact, ground water is simply the subsurface water that fully saturates pores or cracks in soils and rocks. Ground water is replenished by precipitation and, depending on the local climate and geology, is unevenly distributed in both quantity and quality. When rain falls or snow melts, some of the water evaporates, some is transpired by plants, some flows overland and collects in streams, and some infiltrates into the pores or cracks of the soil and rocks.

The first water that enters the soil replaces water that has been evaporated or used by plants during a preceding dry period. Between the land surface and the aquifer water is a zone that hydrologists call the unsaturated zone. In this unsaturated zone, there usually is at least a little water, mostly in smaller openings of the soil and rock; the larger openings usually contain air instead of water. After a significant rain, the zone may be almost saturated; after a long dry spell, it may be almost dry. Some water is held in the unsaturated zone by molecular attraction, and it will not flow toward or enter a well. Similar forces hold enough water in a wet towel to make it feel damp after it has stopped dripping.

How ground water occurs in rocks:

After the water requirements for plant and soil are satisfied, any excess water will infiltrate to the water table–the top of the zone below which the openings in rocks are saturated. Below the water table, all the openings in the rocks are full of water that moves



through the aquifer to streams, springs, or wells from which water is being withdrawn. Natural refilling of aquifers at depth is a slow process because ground water moves slowly through the unsaturated zone and the aquifer. The rate of recharge is also an important consideration. It has been estimated, for example, that if the aquifer that underlies the High Plains of Texas and New Mexico–an area of slight precipitation–was emptied, it would take centuries to refill the aquifer at the present small rate of replenishment. In contrast, a shallow aquifer in an area of substantial precipitation may be replenished almost immediately.

Aquifers can be replenished artificially. For example, large volumes of ground water used for air conditioning are returned to aquifers through recharge wells on Long Island, New York. Aquifers may be artificially recharged in two main ways: One way is to spread water over the land in pits, furrows, or ditches, or to erect small dams in stream channels to detain and deflect surface runoff, thereby allowing it to infiltrate to the aquifer; the other way is to construct recharge wells and inject water directly into an aquifer as shown on page 10. The latter is a more expensive method but may be justified where the spreading method is not feasible. Although some artificial-recharge projects have been successful, others have been disappointments; there is still much to be learned about different ground-water environments and their receptivity to artificial-recharge practices.

A well, in simple concept, may be regarded as nothing more than an extra large pore in the rock. A well dug or drilled into saturated rocks will fill with water approximately to the level of the water table. If water is pumped from a well, gravity will force water to move from the saturated rocks into the well to replace the pumped water. This leads to the question: Will water be forced in fast enough under a pumping stress to assure a continuing water supply? Some rock, such as clay or solid granite, may have only a few hairline cracks through which water can move. Obviously, such rocks transmit only small quantities of water and are poor aquifers. By comparison, rocks such as fractured sandstones and cavernous limestone have large connected openings that permit water to move more freely; such rocks transmit larger quantities of water and are good aquifers. The amounts of water that an aquifer will yield to a well may range from a few hundred gallons a day to as much as several million gallons a day.

Quality of ground water:

For the Nation as a whole, the chemical and biological character of ground water is acceptable for most uses. The quality of ground water in some parts of the country, particularly shallow ground water, is changing as a result of human activities. Ground water is less susceptible to bacterial pollution than surface water because the soil and rocks through which ground water flows screen out most of the bacteria. Bacteria, however, occasionally find their way into ground water, sometimes in dangerously high concentrations. But freedom from bacterial pollution alone does not mean that the water is fit to drink. Many unseen dissolved mineral and organic constituents are present in ground water in various concentrations. Most are harmless or even beneficial; though occurring infrequently, others are harmful, and a few may be highly toxic.

Water is a solvent and dissolves minerals from the rocks with which it comes in contact. Ground water may contain dissolved minerals and gases that give it the tangy taste enjoyed by many people. Without these minerals and gases, the water would taste flat. The most common dissolved mineral substances are sodium, calcium, magnesium, potassium, chloride, bicarbonate, and sulfate. In water chemistry, these substances are called common constituents.

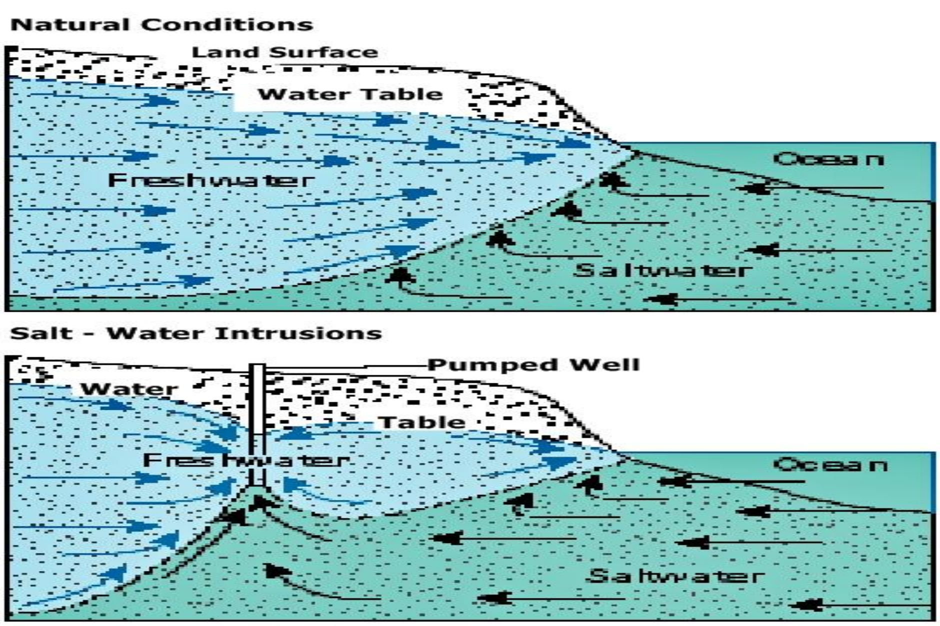
Water typically is not considered desirable for drinking if the quantity of dissolved minerals exceeds 1,000 mg/L (milligrams per liter). Water with a few thousand mg/L of dissolved minerals is classed as slightly saline, but it is sometimes used in areas where less-mineralized water is not available. Water from some wells and springs contains very large concentrations of dissolved minerals and cannot be tolerated by humans and other animals or plants. Many parts of the Nation are underlain at depth by highly saline ground water that has only very limited uses.

Dissolved mineral constituents can be hazardous to animals or plants in large concentrations; for example, too much sodium in the water may be harmful to people who have heart trouble. Boron is a mineral that is good for plants in small amounts, but is toxic to some plants in only slightly larger concentrations.

Water that contains a lot of calcium and magnesium is said to be hard. The hardness of water is expressed in terms of the amount of calcium carbonate-the principal constituent of limestone-or equivalent minerals that would be formed if the water were evaporated. Water is considered soft if it contains 0 to 60 mg/L of hardness, moderately hard from 61 to 120 mg/L, hard between 121 and 180 mg/L, and very hard if more than 180 mg/L. Very hard water is not desirable for many domestic uses; it will leave a scaly deposit on the inside of pipes, boilers, and tanks. Hard water can be softened at a fairly reasonable cost, but it is not always desirable to remove all the minerals that make water hard. Extremely soft water is likely to corrode metals, although it is preferred for laundering, dishwashing, and bathing.

Ground water, especially if the water is acidic, in many places contains excessive amounts of iron. Iron causes reddish stains on plumbing fixtures and clothing. Like hardness, excessive iron content can be reduced by treatment. A test of the acidity of water is pH, which is a measure of the hydrogen-ion concentration. The pH scale ranges from 0 to 14. A pH of 7 indicates neutral water; greater than 7, the water is basic; less than 7, it is acidic. A one unit change in pH represents a 10-fold difference in hydrogen-ion concentration. For example, water with a pH of 6 has 10 times more hydrogen-ions than water with a pH of 7. Water that is basic can form scale; acidic water can corrode. According to U.S. Environmental Protection Agency criteria, water for domestic use should have a pH between 5.5 and 9.

In recent years, the growth of industry, technology, population, and water use has increased the stress upon both our land and water resources. Locally, the quality of ground water has been degraded. Municipal and industrial wastes and chemical fertilizers, herbicides, and pesticides not properly contained have entered the soil, infiltrated some aquifers, and degraded the ground-water quality. Other pollution problems include sewer leakage, faulty septic-tank operation, and landfill leachates. In some coastal areas, intensive pumping of fresh ground water has caused salt water to intrude into fresh-water aquifers.



Intensive ground water pumping can cause salt-water intrusion in coastal aquifers:

In recognition of the potential for pollution, biological and chemical analyses are made routinely on municipal and industrial water supplies. Federal, State, and local agencies are taking steps to increase water-quality monitoring. Analytical techniques have been refined so that early warning can be given, and plans can be implemented to mitigate or prevent water-quality hazards.

Appraising the nation's ground water resources:

Although there are sizable areas where ground water is being withdrawn at rates that cause water levels to decline persistently, as in parts of the dry Southwest, this is not true throughout the country.

For the Nation as a whole, there is neither a pronounced downward nor upward trend. Water levels rise in wet periods and decline in dry periods. In areas where water is not pumped from aquifers in excess of the amount of recharge to the aquifer–particularly in the humid central and eastern parts of the country–water levels average about the same as they did in the early part of the twentieth century.

A major responsibility of the U.S. Geological Survey is to assess the quantity and quality of the Nation's water supplies. The Geological Survey, in cooperation with other Federal, State, and local agencies, maintains a nationwide hydrologic-data network, carries out a wide variety of water-resources investigations, and develops new methodologies for studying water.

The results of these investigations are indispensable tools for those involved in water-resources planning and management. Numerous inquiries concerning water resources and hydrology are directed to the Survey and to State water-resources and geological agencies.

To locate ground water accurately and to determine the depth, quantity, and quality of the water, several techniques must be used, and a target area must be thoroughly tested and studied to identify hydrologic and geologic features important to the planning and management of the resource. The landscape may offer clues to the hydrologist about the occurrence of shallow ground water.

Conditions for large quantities of shallow ground water are more favorable under valleys than under hills. In some regions–in parts of the arid Southwest, for example–the presence of "water-loving" plants, such as cottonwoods or willows, indicates ground water at shallow to moderate depth.

Areas where water is at the surface as springs, seeps, swamps, or lakes reflect the presence of ground water, although not necessarily in large quantities or of usable quality.

Rocks are the most valuable clues of all. As a first step in locating favorable conditions for ground-water development, the hydrologist prepares geologic maps and cross sections showing the distribution and positions of the different kinds of rocks, both on the surface and underground. Some sedimentary rocks may extend many miles as aquifers of fairly uniform permeability.

Other types of rocks may be cracked and broken and contain openings large enough to carry water. Types and orientation of joints or other fractures may be clues to obtaining useful amounts of ground water. Some rocks may be so folded and displaced that it is difficult to trace them underground.

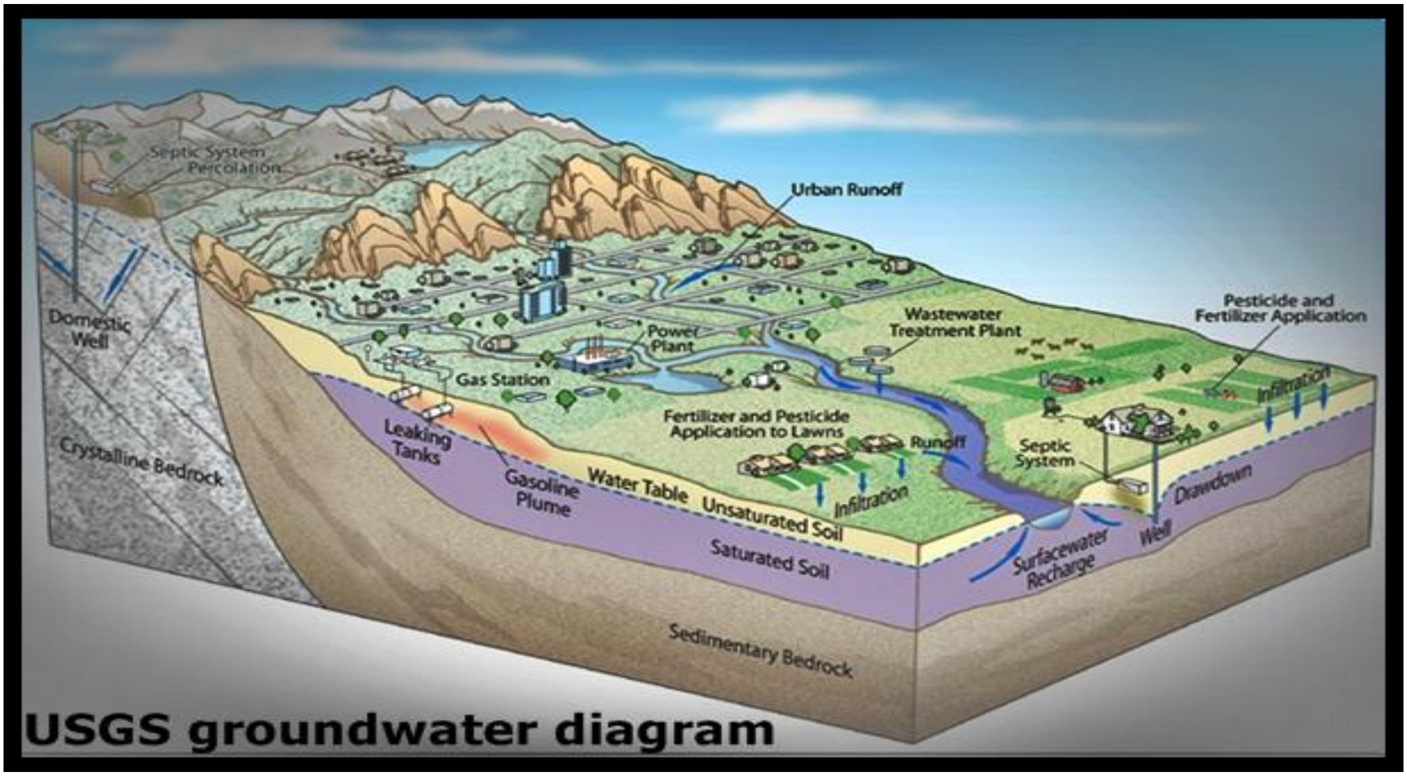
Next, a hydrologist obtains information on the wells in the target area. The locations, depth to water, amount of water pumped, and types of rocks penetrated by wells also provide information on ground water.

Wells are tested to determine the amount of water moving through the aquifer, the volume of water that can enter a well, and the effects of pumping on water levels in the area. Chemical analysis of water from wells provides information on quality of water in the aquifer.

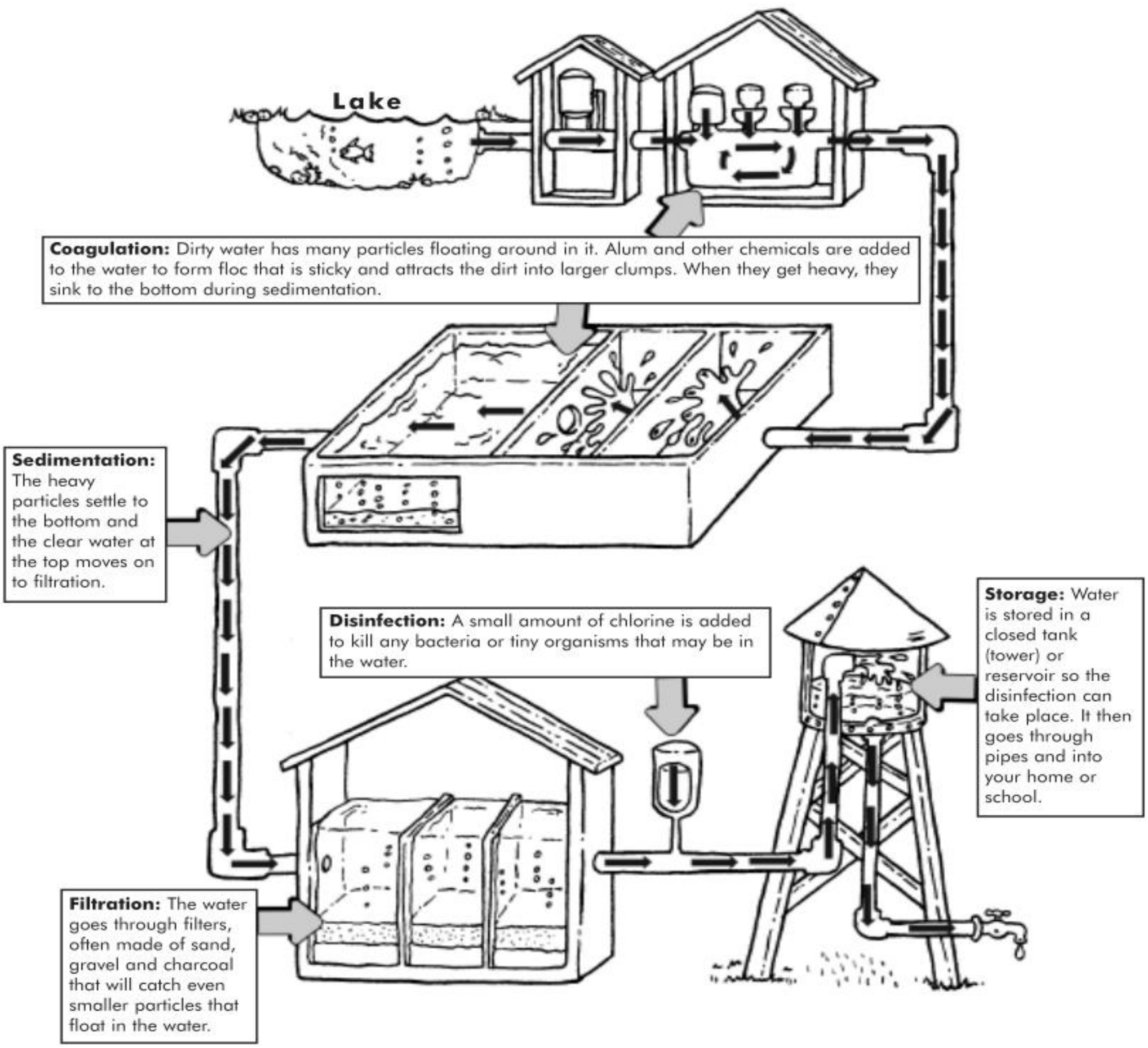
Evaluating the ground-water resource in developed areas, prudent management of the resource, and protection of its quality are current ground-water problems. Thus, prediction of the capacity of the ground-water resource for long-term pumpage, the effects of that pumpage, and evaluation of water-quality conditions are among the principal aims of modern-day hydrologic practice in achieving proper management of ground water.

Ground water, presently a major source of water, is also the Nation's principal reserve of fresh water. The public will have to make decisions regarding water supply and waste disposal-decisions that will either affect the ground-water resource or be affected by it.

These decisions will be more judicious and reliable if they are based upon knowledge of the principles of ground-water occurrence.


Septic System Percolation
Urban Runoff
Domestic Well
Power Plant
Wastewater Treatment Plant
Pesticide and Fertilizer Application
Gas Station
Infiltration
Fertilizer and Pesticide Application to Lawns
Leaking Tanks
Runoff
Septic System
Crystalline Bedrock
Gasoline Plume
Water Table
Unsaturated Soil
Infiltration
Drawdown
Saturated Soil
Surfacewater Recharge
Well
Sedimentary Bedrock
USGS groundwater diagram

Water can get dirty, so before we can drink it, it must be clean. Water is cleaned at a Treatment Plant and then sent to our homes through pipes.

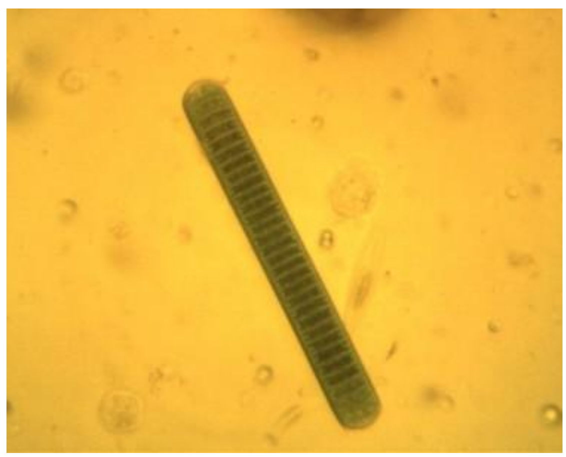


Freshwater microorganisms microscope images.

Protists:

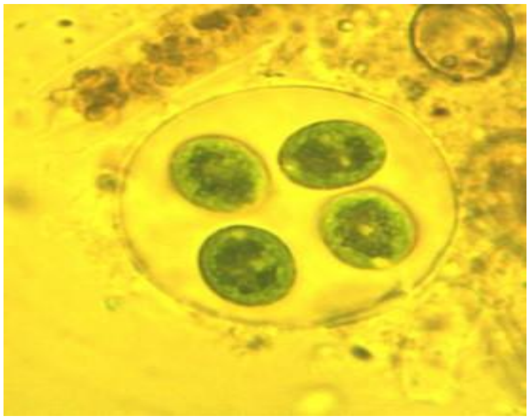
Protists are microscopical, unicellular eukaryotes. They live in almost any environment that contains liquid water. Many protists, such as the algae, are photosynthetic and are vital primary producers in ecosystems, particularly in the ocean as part of the plankton. Other protists, such as the Kinetoplastids and Apicomplexa, are responsible for a range of serious human diseases, such as malaria and others, such as the amoeba, can cause serious illness when their population gets out of control in the body.. Some protists are motile, able to move by using flagella, pseudopodia, or cilia, while others are unable to move.

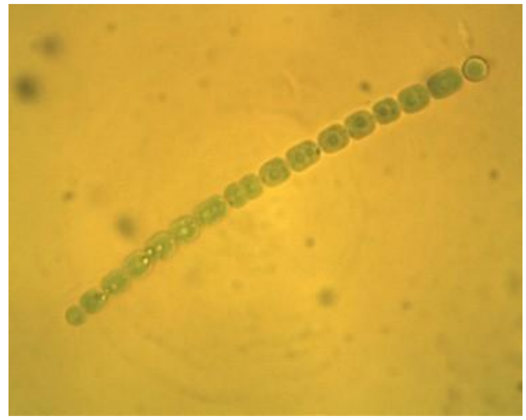
They may live on their own by absorbing energy from sunlight, or they may live symbiotically with a host organism. In some cases, protists may engage in a mutual symbiotic relationship, where they gain energy from the host, and perform some beneficial service in return, but often they are parasitic, simply leeching energy off of the host.



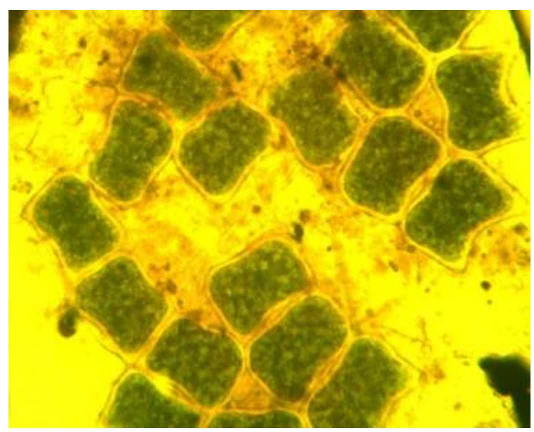
Organisms originally arranged under Kingdom Protoctista included water molds, slime molds, algae, and similar eukaryotic unicellular microorganisms.

Records indicate the smallest organism in Kingdom Protoctista are protists, microscopic single cell organisms such as protozoa. Historically, they were all placed into the kingdom of Protista, but this is no longer the case. They are incredibly diverse, and there is little to bind them together as a grouping except for the simplicity of their structure.





In 1977, Carl Woese and his collaborators introduced the most crowded top-level system yet, with six kingdoms: Eubacteria, Archaebacteria, Protista, Fungi, Plantae, and Animalia. Then, in 1990, the system was simplified by Woese, and decreased to three domains: Bacteria, Archaea, and Eukarya. In some cases, protists form colonies of individuals, though the individuals are generally autonomous. Researchers originally referred these minuscule living beings to the kingdoms of larger organisms. Then, according to the characteristics that a given protist showed, they tried to refer it to the plant kingdom (in the protophyta or algae), the animal kingdom (in the protozoa) or to the fungal kingdom.(1)



This led to a great deal of doubtful classification, for example “algae” deprived of chloroplasts and which fed on other microorganisms, “moulds” endowed with amoeboid movements like animals, or “protozoans” anchored to the substratum by a foot like they were a plant. Intuitively, it is possible to understand why protists often possess characteristics common to animals, plants and fungi: the larger organisms derive from protists. In order to avoid confusion in the classification of these microorganisms, a kingdom has been created, so that they need not be referred to the animals, plants or fungi. Grouping things in kingdoms is arbitrary- in the history of life there is no clear-cut division between protists and eukaryotes.

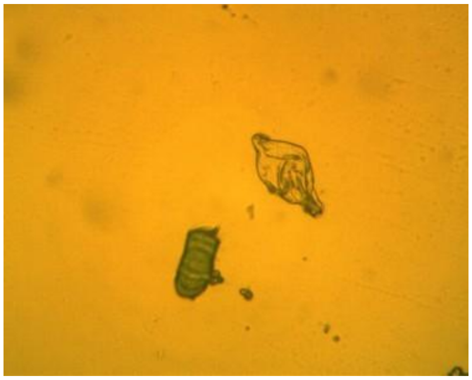
Not all microorganisms are protists:

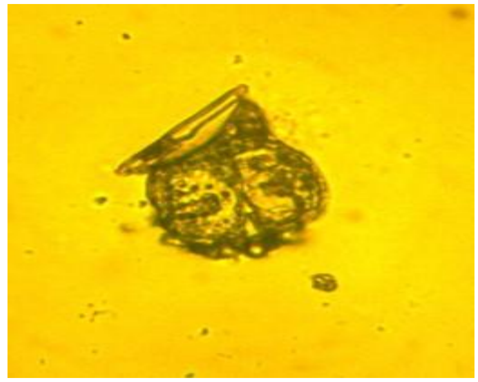
Another "kingdom" contains unicellular microorganisms, the Monera bacteria belong to this kingdom. So what difference is there between bacteria and protists? This distinction is founded on the complexity of a cell's organization. The cellular organization of bacteria is particularly simple -they do not have membranes binding their nuclear material. For this reason they are also named prokaryotes . The cellular organization of protists is more complex they have a membrane -bound nucleus and other organelles distinct from cytoplasm) They are therefore called eukaryotes ("true-nucleus"). Animals, plants and fungi, being derived from protists, are also eukaryotes.(2)

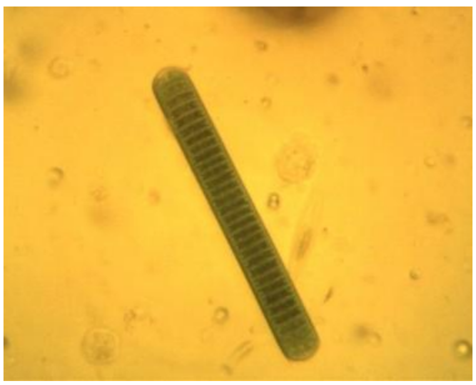
 

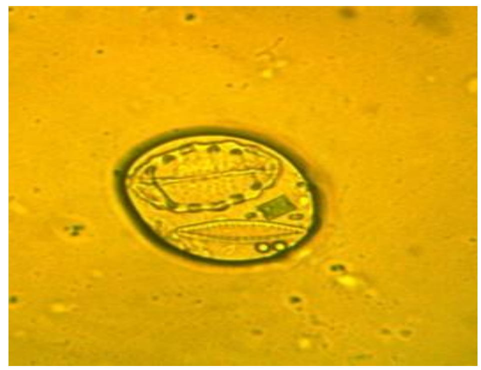
Protist microscope slide images:

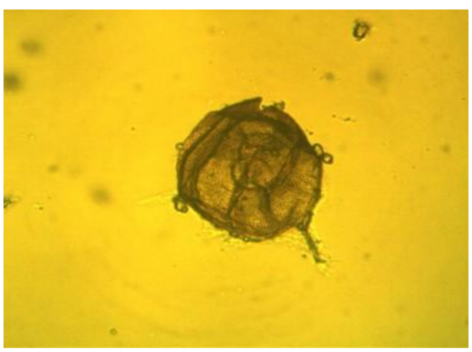
(🔊 pro ʊ tɨst) are a diverse group of eukaryotic microorganisms.

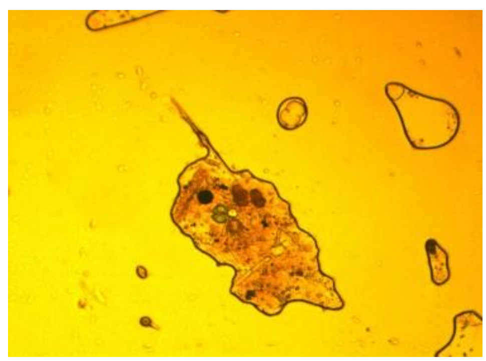


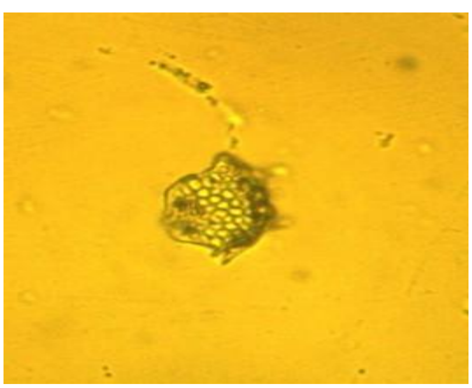








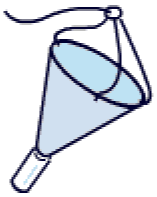




~ How to collect microscopic pond life ~

Some tips for collecting, keeping and culturing micro-organisms

The easiest way to collect micro-organisms and other small pond life is to squeeze the water from water plants or pond scum into a container.



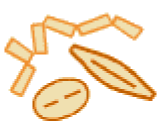
Another method is to scrape the growth from water plants or other things that are covered by a green or brown growth. An old credit card will make an excellent scraper but be careful not to drop it in the pond!

A plankton net is recommended for free swimming (planktonic) species. This is a net made of a very fine meshed cloth with a small container at the end. You can also use the plankton net to concentrate the material squeezed out of water plants.

Desmids: These beautiful small algae are most abundant in waters without too many nutrients or acid waters. Bogs are often good collecting spots. Squeezing *Sphagnum* moss is a good method. Desmids often attach themselves to these plants.

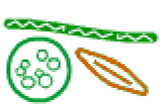
Amoeba: These remarkable protozoa often live feeding on organic material on the bottom sediment of a pond. A good method of collecting them is to lower a jar upside down until it is positioned just above the mud surface. Then slowly let the air escape so the top layer will be sucked into the jar. You can move the jar slowly when tilting so you collect from a larger area.

Hydra: (see first page for links) They can be collected by putting duckweed or other waterweed into a glass jar full of water. Then wait for some hours. The hydras can then be found attached to the glass.

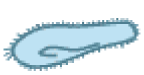


Examining the growth scraped off surfaces with a hand lens can give a clue to the creatures present. If the growth is brown there is a good chance you will find diatoms. White fluffy masses are often colonies of bell animalcules.

Keeping and culturing Algae or Protozoa. It is recommended to keep pond organisms in a shallow container. A large surface with only a couple of centimeters of water will ensure there is enough oxygen in the water.

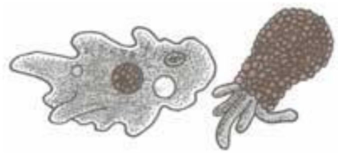


For culturing algae a simple method is to cook some garden soil in water. After cooling you can incubate it with the algae you want to grow.



For bacteria eating protozoa like paramecium you can boil dry grass in water. Wait for one or two weeks until a layer of bacteria grows under the surface. Then incubate it with a bit of pond water containing ciliates.

Kingdom Protista (one-celled plants and animals).



AMOEBAS

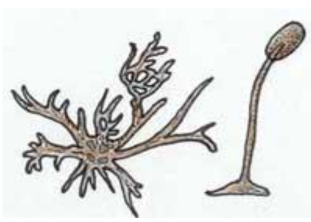
Rhizopoda

Amoebas are among the simplest single-celled animals. Most are jelly-like blobs of protoplasm. They have short pseudopodia or false feet which are arms of protoplasm used to surround food objects. Some continually change shape, but others build cases of specific designs for protection.

BROWN ALGAE

Phaeophyta

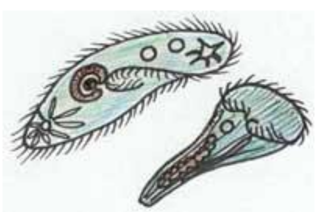
Brown algae range from small cells to very large colonies. This group includes many; typically marine species such as kelp and sargassum.



CELLULAR SLIME MOLDS

Acrasiomycota

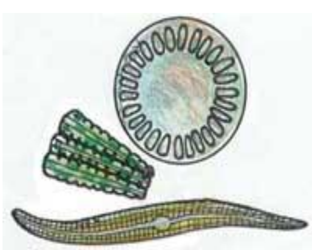
Cellular slime molds usually exist as amoeba-like single cells. However, they can also aggregate into masses and form mushroom-like sporangia.



CILIATED PROTOZOANS

Ciliophora

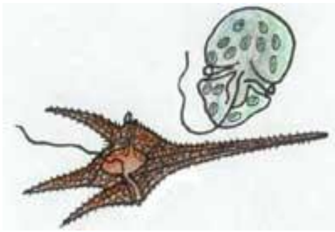
These single-celled or colonial animals have tiny hair-like structures called cilia that are used for locomotion and to obtain food. They are a diverse group with many species and forms.



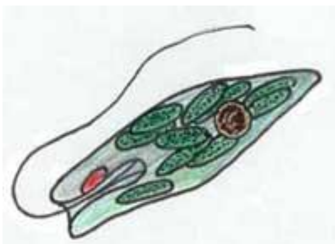
DIATOMS

Bacillariophyta

Diatoms are single-celled algae that produce ornate silicon (glass) cases with a box and lid design. They contain photosynthetic pigments to produce their own food. Deposits of diatom shells are the source of diatomaceous earth used in filters and cleansers.

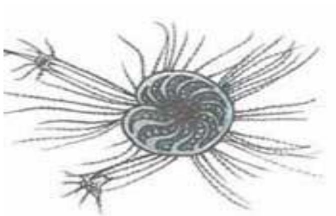


DINOFLAGELLATES
Dinoflagellata
These are single cells with both plant and animal traits. Some species have cell walls and cellulose plates. They have two whip-like flagella for locomotion, one in a central groove and another placed vertically. Some species produce toxins. Red tides are caused by dinoflagellates.

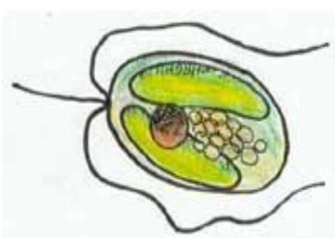


EUGLENOIDS
Euglenophyta
Euglenas and their relative are motile, single cells that also have both plant and animal traits. They contain chlorophyll like plants, but lack cell walls like animal cells. Some have a red eyespot and most are equipped with one or more whip-like flagella for locomotion.

FORAMS



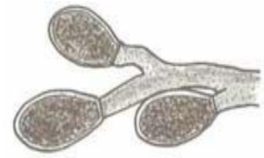
Foraminifera
Formainifera are also amoeba-like protozoa. They differ from rhizopod amoebas by having simple to complex, perforated shells that may be quite ornate and by having with one to many branched pseudopodia.



GOLDEN ALGAE
Chrysophyta
Members of this group often occur as tiny single cells, with yellow-green or golden-brown pigments. They have two whip-like flagella for locomotion and a third appendage called a haptonema used for attachment. Golden algae can produce their own food and at least some prey on other organisms. Some produce potent toxins.

GREEN ALGAE
Chlorophyta
Members of this group range from small single cells to much larger colonies. As their name suggests, they contain green chlorophyll. Green algae are diverse and have an array of forms.

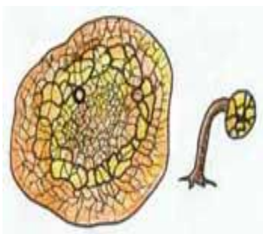
LOWER FUNGI



Chytridomycota
These are among the most primitive species and row as simple fungal strands. They also differ from true fungi and molds by having swimming reproductive cells with flagella.

PLASMODIA

Apicomplexa
These are one-celled parasites that include the species that causes malaria in humans. Many have complex life cycles with multiple life stages. Some require one or more host species and certain species may cause the death of their hosts.



PLASMODIAL SLIME MOLDS

Myxomycota
Plasmodial slime molds usually exists as enormous animal-like, single-cells with thousands of nuclei. However, they can form mushroom like structures called sporangia and assume a very vegetative type of appearance. Sometimes species called slime nets are separated into a third group of slime mold organisms.

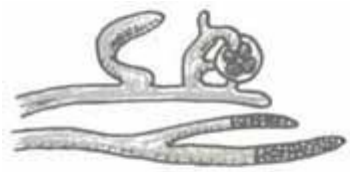
RADIOLARIANS AND HELIOZOANS

Actinopoda
These two groups of amoeba-like protozoa have thin, unbranched pseudopodia that are stiff and radiate outward in some species and are used to capture prey and for locomotion. Some are called sun animalcules. Certain species may have perforated shells of silica or strontium sulfate that can be highly sculptured.

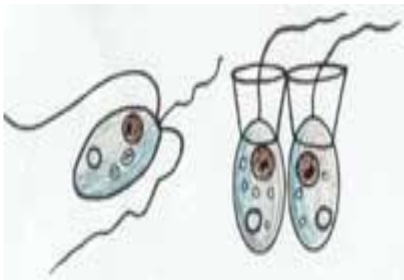
RED ALGAE

Rhodophyta
Red algae are often larger, multi-cellular colonies, but include smaller microscopic species as well. Most are marine, with a few living in fresh water. They contain reddish pigments that mask chlorophyll that is also present.

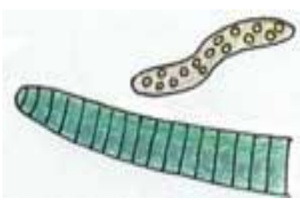
WATER FUNGI



Oomycota
Members of this group grow as mold-like filaments, but lack chitin found in the walls of true fungi. They also have swimming, flagellated sex cells, unlike true fungi.

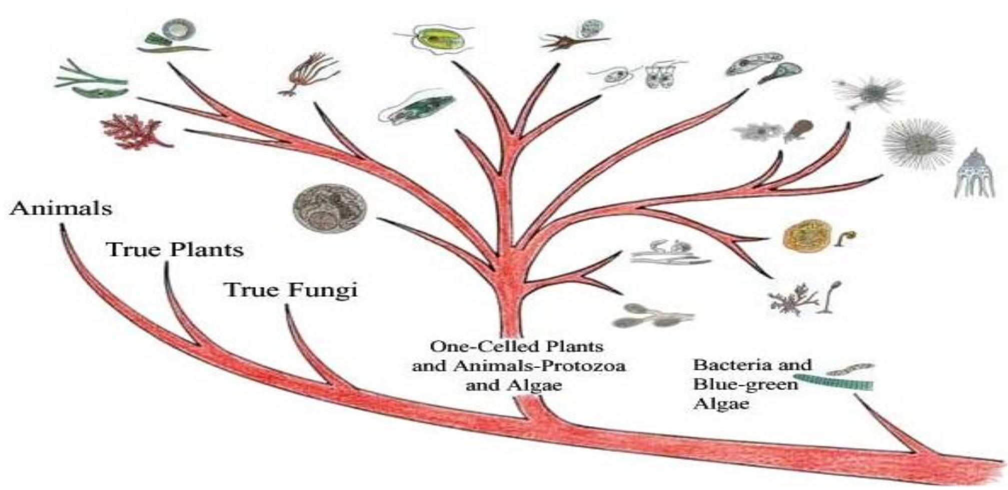


ZOOFLAGELLATES
Zoomastigophora
These are one-celled or colonial animals that are much like euglenoids or Dinoflagellates. However, they lack chlorophyll o r other photosynthetic chemicals typical of plants. Zooflagellates have one or more whip-like flagella for locomotion or to circulate water containing food and oxygen.



NOTE: Blue-green algae (Cyanophyta) are now classified with bacteria because they lack a nuclear membrane.

Prepared by Robert G. Howells, TPWD © Texas Parks and Wildlife Department. STW™ used as education material only.



Illustrations by Robert G. Howells, TPWD.

Ologies

Appendix A

-**ology**, a suffix derived from the Greek *logos*,
meaning the 'study of', 'specialty in' or 'art of' a given scientific or medical field.

The following is a long list of ologies, along with their fields of study.

Many are common and respected - many more are obscure and unusual.

A

Abiology	Inanimate things
Acarology	Mites & ticks
Aceology	Therapeutics
Acology	Therapeutic remedies
Acridilogy	Grasshoppers & locusts
Acropathology	Diseases affecting the extremities
Actinology	The chemical effects of light
Adenology	Glands
Aedoeology	Generative organs
Aerobiology	Airborne microorganisms
Aerogeology	Geological features using aerial observation
Aerolithology	Aerolites
Aerology	Atmosphere
Aeropalynology	Polen & spores in the atmosphere
Aetiology	Causes, especially of diseases
Agathology	The good
Agmatology	Fractures
Agniology	Human ignorance
Agriology	The customs of primitive peoples
Agrobiology	Crop-plants & soil control
Agroclimatology	Agricultural meteorology
Agroecology	Sustainable farming systems
Agrogeology	Geology applied to agricultural needs
Agrology	Agricultural soils
Agrometeorology	The weather's effect on landscape
Agrostology	Grasses
Agrotechnology	Technological farming systems
Aitiology	Aetiology
Alethiology	The nature of truth
Algology	Algae
Alimentology	Nutrition
Allergology	Allergies
Alphabetology	The significance of letters of the alphabet

M

Machirology	Knives
Macrocosmology	The universe
Macrometeorology	Largest-scale aspects of the atmosphere
Magirology	Cookery
Malacology	Mollusks
Malacostracology	Crustaceology
Malariology	Malaria
Mammalogy	Mammals
Mantology	Divination
Mariology	The Virgin Mary
Martyrology	Martyrs
Mastology	Mammalogy
Meconology	Opium
Melissopalynology	Honey
Mellittology	Bees
Membranology	Membranes
Mereology	Part-whole relationships
Mesology	Ecology
Mesometeorology	Mesoscale atmospheric phenomena
Metapsychology	Psychology beyond the limits of experimentation
Meteorology	Atmosphere, weather prediction
Methodology	Order
Metrology	Measurement
Miasmology	Miasmas
Microbiology	Microorganisms
Microclimatology	Microclimates
Micrometeorology	Small-scale weather conditions
Micropalaeontology	Microscopic fossils
Microphytology	Microscopic vegetable organisms
Micrology	Microscopic objects
Microseismology	Small earth tremors
Mineralogy	Minerals
Mixology	Cocktail recipes
Mnesiology	Memory
Molinology	Mills & milling
Momiology	Mummies

Amphibiology	Amphibia
Anaesthesiology	Anaesthesia
Anaplastology	Prosthetic devices
Anarchaeology	Anarchist cultures
Anatripsology	Friction as a medical treatment
Andrology	Male impotence
Anesthesiology	Anaesthesiology
Angelology	Angels & their hierarchy
Anemology	Wind
Angelology	Angelic beings
Angiology	Blood vessels & lymphatics
Angiopathology	Diseased blood vessels
Anthoecology	The relationship of flowers & their environment
Anthropobiology	Human biological relationships
Anthropology	Humans, mankind
Anthropomorphology	The ascribing of non-human beings with human attributes
Anthroposociology	The human races
Anthrozoology	Animal-human relationships
Aphasiology	Speech disorders
Aphnology	Wealth
Apiology	Bees
Arachnology	Arachnids
Araneology	Spiders
Archaeogeology	Geological formations of the remote past
Archaeology	Ancient cultures
Archaeozoology	Past human-animal relationships
Archology	Government
Arcology	Architecture & ecology
Areology	The planet Mars
Aretology	Virtue
Argyrothecology	Moneyboxes
Aristology	Dining
Arteriology	Arteries
Arthrology	Joints
Arthropathology	Diseases of the joints
Asianology	Fine Asian women
Assyriology	Assyria
Astacology	Crayfish
Astheniology	Diseases caused by weakening

Monadology	Monads
Morphology	The structure of organisms
Muscology	Mosses
Museology	Museum management
Musicology	Music
Mycetology	Mycology
Mycology	Fungi
Mycotoxicology	Toxic fungi
Myology	Muscles
Myrmecology	Ants
Mythology	Myths

N

Nanotechnology	Very small objects
Naology	Ecclesiastical buildings
Narratology	Narrative works
Nasology	The nose
Nassology	Taxidermy
Nematology	Nematodes
Neology	New words
Neonatology	Newborn babies
Neossology	Nestling birds
Nephology	Clouds
Nephrology	The kidneys
Nerterology	The dead or the underworld
Neurobiology	The biology of the nervous system
Neuroendocrinology	Neuroendocrine systems
Neurology	Nerve systems
Neuropathology	Diseases of the nervous system
Neuropharmacology	Nervous system medication
Neurophysiology	Functions of the nervous system
Neuropsychology	Psychology based on the nervous system
Neuropterology	Insects of the order *Neuroptera*
Neuroradiology	Radiology of the nervous system
Neurotheology	The biochemical origins of religious experiences
Neurypnology	Hypnotism & sleep
Nidology	Bird's nests
Nomology	Law
Noology	Intuition & reason

Asthmology	Asthma	Nosetiology	Causes of disease
Astrobiology	The search for extraterrestrial life	Nosology	Classification of diseases
Astrogeology	Extraterrestrial geology	Nostology	Senility
Astrolithology	Meteorites	Numerology	The significance of numbers
Astrology	The influence of star movements	Numismatology	Coins & medals
Astrometeorology	The effects of heavenly bodies on weather	Nymphology	Nymphs
		O	
Astroseismology	Star oscillations	Oceanology	Oceans
Astrotheology	Theology founded on observation of celestial bodies	Odology	The mystical force of od
		Odonatology	Dragonflies
Atmology	Watery vapour	Odontology	Teeth
Atomology	Atoms	Oecology	Ecology
Atmospherology	The atmosphere	Oenology	Wines
Audiology	Hearing	Oikology	Domestic economy
Autecology	The ecology of an individual species	Olfactology	Smells
		Oligochaetology	Oligochaete worms
Autobuyology	Car buying	Omenology	Omens
Autology	Oneself	Ombrology	Rain
Autonumerology	Automobile license plate numbers	Omnibology	Motorbuses
		Oncology	Tumours & cancers
Auxanology	The growth & sexual development of children	Oneirology	Dreams
		Onomasiology	Related words & their meanings
Auxology	Growth		
Axiology	The ultimate nature of values	Onomatology	Names
Azoology	Inanimate nature	Ontology	The nature of being
	B	Onychopathology	Diseases of the nails
Bacteriology	Bacteria	Oology	Bird's eggs
Balneology	Natural & medicinal baths	Ophidology	Amphibians & reptiles
		Ophiology	Snakes
Barology	Weight & gravitation	Ophthalmology	Eyes
Bascology	The Basques	Opsonology	Opsonin
Batology	Brambles	Optology	Sight
Bibliology	Books; the Bible	Orchidology	Orchids
Biocenology	Interactions between communities of organisms	Organology	The organs of the body
		Orismology	Definitions of technical terms
Bioclimatology	The effects of climate on living organisms	Ornithology	Birds
		Orology	Mountains
Biocoenology	Ecologically interdependent plant & animal relationships	Orrhology	Blood serums
		Orthopterology	Insects of the order *Orthoptera*
Bioecology	The interaction of life & the environment	Oryctology	Mineralogy or palaeontology
Biology	Physical life	Osmology	Smells & olfactory processes
Biometeorology	Weather & human health	Osphresiology	Osmology
Biospeleology	Cave animal life	Osteology	Bones

Biotechnology	Biological technology
Blogology	Blogs
Bromatology	Food
Brontology	Thunder
Bryology	Mosses
	C
Caliology	Bird's nests
Campanology	Bells
Cancerology	Cancer
Carabidology	Carabids
Carcinology	Crustaceans
Cardiology	Heart function & disease
Caricology	Sedges
Carpology	Fruits & seeds
Cartology	Maps & map-making
Catachronobiology	Deleterious effects of time on a living system
Cecidiology	Insect galls
Cephalogy	The head
Cerebrology	The cerebrum
Cereology	Crop circles
Cetology	Whales
Chaology	Chaos theory
Characterology	Character
Chemoimmunology	Chemical processes in immunology
Chessology	Chess
Chirology	Palmistry
Chondrology	Cartilages
Choreology	Dance movements
Chorology	Geographical distribution
Chresmology	Oracles
Christology	Jesus Christ
Chromatology	Colours
Chronobiology	Biological rhythms
Chronology	Historical records, etc.
Chronooncology	Influence of biological rhythms on neoplastic growth
Chronopharmacology	Rhythmic, predictable-in-time differences effects of drugs
Chrysology	Precious metals
Climatology	Climate
Clinology	Individual decline after maturity
Coccidology	Scale insects
Codicology	Manuscripts
Coleopterology	Beetles & weevils
Osteopathology	Diseases of the bones
Otolaryngology	Diseases of the ear & throat
Otology	The ears
Otorhinolaryngology	Ear, nose & throat medicine
Ourology	Urology
Ovology	Eggs
	P
Pachydermatology	Elephant skin
Paedology	Children
Paidonosology	Paediatrics
Palaeichthyology	Extinct fishes
Palaeoanthropology	Ancient human-like creatures
Palaeobiology	Ancient life
Palaeobotany	Fossil plants
Palaeoclimatology	Climates of the geological past
Palaeodendrology	Fossil trees
Palaeoecology	The ecology of ancient organisms
Palaeoentomology	Fossil insects
Palaeoetiology	Past events in terms of scientific causes
Palaeogeology	Buried geological features
Palaeohydrology	Past hydrologic systems
Palaeolimnology	Lake sediments
Palaeology	Antiquities
Palaeometeorology	Past patterns of global atmospheric transport
Palaeontology	Ancient life, through fossils
Palaeo-ornithology	Fossil birds
Palaeo-osteology	Ancient bones
Palaeopathology	Diseases of the past
Palaeopedology	Early soils
Palaeophytology	Fossil plants
Palaeotempestology	Ancient storms
Palaeozoology	Ancient animals
Palynology	Pollen & spores
Pantology	All branches of knowledge
Pantheology	Theology embracing all religions
Papyrology	Papyri
Parapsychology	Extraordinary mental phenomena

Coloproctology	The colon, rectum & anus
Cometology	Comets
Conchology	Shells
Coniology	Koniology
Conscientology	Consciousness
Conspiratology	Conspiracy theories
Coprology	Pornography
Cosmecology	Astrology
Cosmetology	Cosmetics
Cosmochronology	The age of stars
Cosmology	The universe
Crainiology	Skulls
Crenology	The therapeutic use of mineral springs
Criminology	Crime & criminals
Criteriology	Epistemology
Crustaceology	Crustaceans
Cryobiology	The effects of cold on organisms
Cryology	Snow, ice & frozen ground
Cryopedology	The effects of intense frost on soil
Cryptology	Codes & cyphers
Cryptozoology	Mythical creatures
Crystallology	Crystals
Ctetology	Acquired characteristics
Cyclonology	Cyclones
Cyesiology	Pregnancy
Cynology	Dogs
Cystology	Cysts
Cytology	Cells
Cytopathology	Cell diseases
	D
Dactyliology	Finger-rings
Dactylology	Sign language
Daemonology	Demonology
Dantology	Dante Alighieri & his work
Defectology	Special education
Deltiology	Postcards
Demology	Human activities
Demonology	Demons & evil spirits
Dendrochronolgy	Tree growth rings
Dendroclimatology	Tree growth & climate
Dendrohydrology	Hydrological phenomena using tree-ring data
Dendrology	Trees
Parasitology	Parasites
Paroemiology	Proverbs
Parthenology	Virginity
Pathology	Disease
Patrology	Patristics
Pedology	Soil
Pelology	Mud as a therapy
Penology	Punishment & prison management
Periodontology	Diseases of tissue around teeth
Pernalogy	Pearls
Pestology	Pests, especially insects
Petrology	Rocks
Phagology	Eating
Phallology	The penis
Phantasmology	Spiritualistic manifestations & apparitions
Phantomology	Supernatural beings
Pharmacoendocrinology	The pharmacology of endocrine function
Pharmacology	Drugs
Pharology	Lighthouses
Pharyngology	The pharynx
Phenology	Periodic biological phenomena
Phenomenology	Phenomenons
Pherology	The human carrying capacity of the Earth
Philematology	Kissing
Philology	Language
Phlebology	Veins
Phonology	Speech sounds
Phorology	Disease carriers & epidemic or endemic diseases
Photobiology	The effects of light on living organisms
Photology	Light
Phrenology	Skull form as indication of character
Phthisiology	Pulmonary tuberculosis
Phycology	Seaweeds or algae
Physicology	Physics
Physiology	The functions of living organisms
Phytobacteriology	Plant bacteria
Phytolithology	Palaeobotany

Dendropyrochronology	Wildfires using tree-ring data
Deontology	Moral duty
Dermatology	The skin & related diseases
Dermatoneurology	The nerves of the skin
Dermatopathology	Inflammatory skin diseases
Dermatovenerology	Skin & venereal diseases
Dermonosology	The nomenclature & classification of skin diseases
Desmidiology	Desmids
Desmology	Ligaments & sinews
Diabetology	Diabetes mellitus
Diabology	Devils
Dialectology	Dialect
Diplomatology	Diplomats
Dipterology	Two-winged insects
Docimology	Experimental testing or inquiry
Dosiology	Doses
Draconology	Dragons
Dysteleology	Purposelessness in nature
	E
Ecclesiology	Churches
Eccrinology	Excretion & secretion
Echinology	Echinoderms
Ecology	Interactions in environments
Ecopsychology	Ecology & psychology
Ecotoxicology	Environmental pollutants
Edaphology	Soils
Editology	Editing
Egyptology	Ancient Egypt
Eidology	Mental imagery
Electrobiology	The electric phenomena of living organisms
Electrology	Hair removal using electrical probes
Electrophysiology	Electric phenomena in living organisms
Electrotechnology	Electricity in technology
Emblematology	Emblems
Embryology	Embryos
Emetology	Vomiting
Emmenology	Menstruation
Encephalology	The brain

Phytology	Plants
Phytomorphology	Plant morphology
Phytonematology	Plant nematodes
Phytopaleontology	Fossil plants
Phytopathology	Plant diseases
Phytopharmacology	Medicinal plants
Phytophenology	Plant phenology
Phytophysiology	Plant physiology
Phytosociology	Plant relationships & characteristics
Phytovirology	Plant viruses
Piscatology	Fishing
Pisteology	Faith
Pistology	Pisteology
Placentology	The placenta
Planetology	Planets
Plangonology	Dolls
Planktology	Plankton
Plebology	Adolescents
Plutology	Wealth
Pneumatology	Spiritual existence
Pneumonology	The lungs
Podology	The feet
Poenology	Penology
Pogonology	Beards
Polemology	Wars
Polychaetology	Ploychaete worms
Pomology	Fruit growing
Ponerology	Evil
Posology	Medical doses
Potamology	Rivers
Praxiology	Human action & conduct
Primatology	Primates
Proctology	The anus & rectum
Projectiology	Out-of-body experiences
Promorphology	Crystallography of organic forms
Protistology	Protists
Protoanthropology	Humans prior to the invention of writing
Protoarcheology	Prehistoric human artifacts & fossils
Protozoology	Single-celled animals
Psephology	Elections & voting
Psychobiology	Biology relating to mind & behaviour
Psychology	Mind & behaviour

Endemiology	Indigenous diseases
Endocrinology	Glands
Enigmatology	Puzzles
Enology	Oenology
Enteradenology	The glands of the alimentary canal
Enterology	The intestines
Entomechology	The design of mechanical insects
Entomology	Insects
Entozoology	Animals that live inside other animals
Entreprenology	The creation & extraction of value from an environment
Enzymology	Enzymes
Epidemiology	Epidemic diseases
Epileptology	Epilepsy
Epiphytology	Plant diseases
Epistemology	Knowledge
Epizootiology	Animal diseases
Eremology	Deserts
Ergology	The effects of work on humans
Erotology	Sexual stimuli & behaviour
Escapology	Escape from confinement
Eschatology	Death, resurrection, afterlife, etc.
Esperatology	Esperanto
Esthematology	Senses & sense organs
Esthesiology	Sensory phenomena
Esthesiophysiology	The physiology of sensation & the sense organs
Ethnobiology	Life pertaining to certain peoples
Ethnology	Human races
Ethnoarchaeology	Archaeology of different societies
Ethnomethodology	Everyday human communication by speech
Ethnomusicology	The music of different societies
Ethnopsychology	The comparative psychology of races & peoples
Ethology	Animal or human behaviour
Psychopathology	Mental & behavioural aberrance
Psychopharmacology	The effects of drugs on the mind
Psychophysiology	Mental phenomena
Psychosociology	Issues common to psychology & sociology
Psychotechnology	Psychology in problem solving etc.
Pteridology	Ferns
Pterylology	The arrangement of bird's feathers
Ptochology	Pauperism & unemployment
Pulicologist	Fleas
Punnology	Puns
Pyramidology	Pyramids
Pyretology	Fevers
Pyrgology	Towers
Pyritology	Pyrites
Pyrology	Heat or fever & its effects
Q	
Quinology	The cinchona
R	
Rabdology	Arithmetic using Napier's Bones
Raciology	Racial differences
Radiobiology	The effects of radiation on the body
Radioecology	The environmental impact of radioactive substances
Radiogeology	The relation of radioactivity to geology
Radioimmunology	Immunology using radiology
Radiology	High-energy radiation
Radiotechnology	Radiological technologies
Reactology	Psycholological reactions
Reflexology	Reflexes
Respirology	Respiration
Rhabdology	Rabdology
Rhematology	Rhemes
Rheology	Flow & deformation of matter
Rheumatology	Rheumatism
Rhinology	The nose

Etiology	Aetiology
Etruscology	The Etruscans
Etymology	The origin of words
Exobiology	The possibility of extraterrestrial life
	F
Faunology	The geographical distribution of animals
Fermentology	Beer brewing
Fetology	The fetus in the uterus
Filicology	Ferns
Filmology	Films
Fluviology	Watercourses
Fluviomorphology	The formation & characteristics of river channels
Foliology	Autumnal leaf colour changes
Fontology	Fonts
Fossilology	Fossil organisms
Fromology	Cheeses
Fungology	Fungi
Futurology	The future
	G
Galvanology	Galvanism
Garbology	Waste disposal
Gastroenterology	Diseases of the stomach & intestines
Gastrology	The stomach
Gelotology	Laughter
Gemmology	Gems
Genecology	Animal species & their environment
Geneology	Family history (genealogy)
Genesiology	Heredity or procreation
Geochronology	Geological time
Geohydrology	Subterranean water
Geology	The earth's crust & strata
Geomorphology	Land forms
Geomythology	Geology using folklore
Geotectology	The structure of the earth's crust
Gephyrology	Bridges
Geratology	Ageing & decay
Gerodontology	Age-related oral diseases
Gerontology	Characteristics of old age

Roentgenology	Radiology
Rumpology	Fortune telling by reading the rump
Runology	Runes
S	
Sarcology	Fleshy parts of the body
Satanology	Satan
Scatology	Excrement or obscenity
Scelerology	The outercoat of the eyeball
Scolecology	Helminthology
Sedimentology	Sedimentary rocks
Seismology	Earthquakes
Selenolgy	The moon
Selenomorphology	The lunar surface & landscape
Semantology	The meaning of words
Semasiology	Semantics
Sematology	Semantics
Semeilogy	Semiology
Semiology	Signs & symbols
Serology	Serums
Sexology	Sexual behaviour
Siagonology	Jawbones
Sialosemeiology	Saliva as an aid to diagnosis
Sindology	Shrouds
Sindonology	The Turin Shroud
Sinology	China
Siphonapterology	Fleas
Sitiology	Diet
Sitology	Sitiology
Skatology	Scatology
Sociobiology	Human & animal social behaviour
Sociology	Society
Somatology	The properties of substances
Somatotypology	Somatotypes
Sophiology	Ideas
Sophology	Wisdom
Soteriology	Salvation
Sovietology	The Soviet Union
Spectrology	Spectrum analysis
Spelaeology	Speleology
Speleology	Caves
Spermology	Seeds
Sphagnology	Peat or bog moss

Ghostology	Ghosts
Gizmology	Technological gadgetry
Glaciology	Glaciers
Glossology	The tongue
Glottochronology	The history of language
Glottology	Language
Glycobiology	Molecules containing carbohydrates
Glyptology	Gem engravings
Gnathology	Dental occlusions
Gnomonology	Gnomonics
Gnosiology	Knowledge
Gnotobiology	Germ-free life
Googlology	The Google search engine
Googology	Large numbers
Graminology	Grasses
Grammatology	Writing systems
Graphology	Handwriting
Graphopathology	Handwriting as a symptom of mental disorder
Gynaecology	The functions & diseases of women

H

Haematology	Blood
Haemorheology	Blood viscosity
Hagiology	Saints
Hamartiology	Sin
Harmonology	Harmonisation
Hedonology	Pleasure
Helcology	Ulcers
Heliology	The sun
Helioseismology	Solar wave oscillations
Helminthology	Worms, especially parasitic
Hemipterology	Hemipteras
Hemopathology	Bood diseases
Heortology	Religious festivals
Hepaticology	Liverworts
Herbology	Medicinal herbs
Heresiology	Heresy
Herpetology	Reptiles & amphibians
Heterology	Abnormalities in tissue structure
Hexicology	Ecology
Hexiology	Habits
Hieroglyphology	Hieroglyphs
Hierology	Religious or sacred literature or lore

Sphygmology	The pulse
Splanchnology	The viscera
Splenology	The spleen
Spongology	Sponges
Stasiology	Political parties
Stemmatology	Relationships between texts
Stereology	Geometrical quantities
Stigmeology	Proper punctuation
Stoichiology	Animal tissues
Stomatology	Mouth disorders
Storiology	Folklore
Stromatology	The formation of stratified rocks
Stygobiology	Stygobites
Suicidology	Suicide
Sumerology	The Sumerians
Symbology	Symbols
Symptomatology	Disease symptoms
Synchronology	Comparative chronology
Syndesmology	Ligaments
Synechology	Continuity or union of things
Synecology	Ecological communities
Synosteology	Arthrology
Syphilology	Syphilis
Systematology	Systematics
Systemology	The logic of systems

T

Tartarology	Hell
Taxology	Taxonomy
Technicology	Technology
Technology	Mechanical arts
Tecnology	Children
Tegestology	Beer mats
Teleology	Final causes
Teleseismology	Tremors due to distant earthquakes
Telmatology	Swamps
Tenontology	Tendons
Tephrochronology	Tephra deposits
Teratology	Congenital malformations
Terminology	Terms
Testaceology	Conchology
Teuthology	Cephalopods
Textology	The production of texts

Hippology	Horses
Hippopathology	Diseases of horses
Histiology	Histology
Histology	Organic tissue
Histophysiology	The structure & function of tissues
Historiology	History
Hittitology	The Hittites
Homerology	Homer & his poems
Hoplology	Weapons & fighting systems
Hormonology	Hormones
Horology	The measurement of time
Humorology	Humour
Hydrobiology	The biology of aquatic organisms
Hydrogeology	The geological effects of water
Hydrology	Water
Hydrometeorology	Atmospheric moisture
Hyetology	Rainfall
Hygiology	Hygiene
Hygrology	Humidity
Hylology	Matter
Hymenopterology	Insects with four membranous wings
Hymnology	Hymns
Hypnology	Sleep
	I
Iamatology	Medical remedies
Iatrology	Medicine
Ichnolithology	Ichnology
Ichnology	Fossil footprints
Ichthyology	Fish
Iconology	Images, pictures, etc.
Ideology	Ideas
Idiomology	Idioms
Immunohematology	Blood group antigens & antibodies
Immunology	Immunity
Immunopathology	Diseases of the immune system
Indology	India
Insectology	Entomology
Irenology	Peace
Iridology	The iris of the eye
	J
Japanology	Japan
	K

Thanatology	Death
Thaumatology	Wonders and miracles
Theology	Theistic religion
Thereology	Therapeutics
Theriogenology	Animal reproductive systems
Thermatology	Heat as a medical remedy
Thermology	Heat
Therology	Wild mammals
Thremmatology	Animal & plant breeding
Threpsology	Nutrition
Thymology	The feelings
Tidology	Tides
Timbrology	Postage stamps
Timology	Values
Tocology	Obstetrics
Tonology	Tones or speech intonations
Topology	Geometrical properties & relationships
Toxicology	Poisons
Trachelology	The neck
Traumatology	Wounds
Tribology	Friction & lubrication
Trichology	Hair
Trophology	Nutrition
Tropology	Figures of speech
Tsiganology	Gypsies
Tsiology	Tea
Turkology	Turkey
Typhlology	Blindness
Typology	Types, especially Biblical
Typtology	Spirit rappings
	U
Ufology	Unidentified flying objects
Universology	The universe
Uranology	The heavens
Urbanology	Cities
Uredinology	Rusts
Urenology	Rust moulds
Urinology	Urology
Urogynecology	Female pelvic floor disorders
Urolithology	Urinary calculi
Urology	The urinary system
Uronology	Urine

Kalology	Beauty
Karyology	Cell nuclei & chromosomes
Kidology	Kidding
Kinesiology	Human movement
Kinology	Motion
Koniology	Dust & germs in the atmosphere
Kremlinology	The Russian government
Ktenology	Killing
Kymatology	Wave motion

L

Labology	Beer & wine bottle labels
Lalopathology	Speech disorders
Laryngology	The larynx
Latrinology	Writings on toilet walls
Lectinology	Lectins
Lemology	Epidemic diseases
Lepidopterology	Butterflies & moths
Leprology	Leprosy
Lexicology	Words & their meanings
Lichenology	Lichens
Limacology	Slugs
Limnobiology	Freshwater life
Limnology	Bodies of fresh water
Lipsology	Lip prints
Lithoidology	Rocks
Lithology	The composition, structure & classification of rocks
Liturgiology	Liturgical forms
Logology	Words
Logyology	The study of
Loimology	Plagues
Ludology	Games
Lymphology	The lymphatic system

V

Vaccinology	Vaccines
Venereology	Venereal diseases
Vermeology	Worms
Vexillology	Flags
Victimology	Victims
Vinology	Wines & winemaking
Virology	Viruses
Vitaminology	Vitamins
Volcanology	Vulcanology
Vulcanology	Volcanoes
Vulvology	Vaginas

X

Xenobiology	Extraterrestrial life
Xenozoology	Animal alien life forms
Xylology	The structure of wood

Z

Zoology	Animals
Zoonosology	Zoonotic bacterial diseases
Zoopathology	Animal pathology
Zoophysiology	Animal physiology
Zoophytology	Biology of zoophytes
Zoopsychology	Animal psychology
Zygology	Joining & fastening
Zymology	Fermentation

Water Quality Parameters Appendix B

Temperature

What is it?

Temperature is a measure of how much heat is present in the water.

Why does temperature matter?

Water temperature tells many things about the health of a river. Temperature affects:
1) Dissolved oxygen levels in water – Cold water holds more oxygen than warm water.
2) Photosynthesis – As temperature goes up, the rate of photosynthesis and plant growth also goes up. More plants in the ecosystem grow and at the same time more plants die. When plants die, decomposers microorganisms that eat decaying matter eat them and use oxygen. So when the rate of photosynthesis increases, the amount of oxygen needed by aquatic organisms increases.
3) Animal survival – Many animals need certain temperatures to live. For example, stonefly nymphs and trout need cool temperatures. Dragonfly nymphs and carp can live in warmer water. If water temperatures change too much, many organisms can no longer survive.
4) Sensitivity to toxic waste and disease – Waste often raise water temperatures. This leads to lower oxygen levels and weakens many fish and insects. Weakened animals get sick and die more easily.

How does water get warmer?

In the summer, the sun heats up sidewalks, parking lots and streets. Rain falls on these areas, warms up, and runs into the river. Factories and stations that generate electricity to cool their processes also use water. Warm water enters the river, raises the temperature of the downstream area and changes oxygen levels. These are forms of thermal pollution.

Thermal pollution is one of the most serious ways humans affect rivers. Cutting down trees along the bank of a river or pond also raises water temperature. Trees help shade the river from the sun. When they are cut down, the sun shines directly on the water and warms it up. Cutting down trees also leads to erosion. When soil from the riverbank washes into the river the water becomes muddy (turbid). The darker, turbid water captures more heat from the sun than clear water does. Even murky green water with lots of algae will be warmer than clear water.

Dissolved Oxygen (DO)

What is it?

Like people, aquatic organisms need oxygen to survive and stay healthy. In areas with waves, or where water tumbles over rocks, falling water traps oxygen and mixes it into the water. Unlike people, aquatic organisms breathe oxygen that is dissolved in water. To breathe underwater, fish and other aquatic organisms use gills instead of lungs. These gills breathe the oxygen dissolved in the water. As you know, a fish out of the water will die because it can no longer breathe.

Why does DO matter?

Imagine living in a place with polluted air. As the air quality becomes worse, the health of the people who live there becomes worse. The same is true in water. Clean, healthy water has plenty of DO. When water quality decreases DO levels drop and it becomes impossible for many animals to survive. Some fish such as trout require lots of dissolved oxygen. Others such as carp can live in water with lower levels of DO.

How does Dissolved Oxygen level in the water drop?

The main reason DO levels might fall is the presence of organic waste. Organic waste comes from something living or that was once living. It comes from raw or poorly treated sewage; runoff from farms and animal feedlots; and natural sources like decaying aquatic plants and animals and fallen leaves in water. Organisms, called decomposers, break down the organic waste of the decaying plants and as previously stated use up oxygen in the process of decomposing . Two common types of decomposers are bacteria and protozoa. More waste means more decomposers and more oxygen being used. DO levels can also fall due to any human activity that heats the water.

pH

What is it?

pH is a measurement of the acidity or basic quality of water. For example, lemons, oranges and vinegar are high in acid. Acids can sting or burn, which is what you feel when you eat some kinds of fruit with a sore in your mouth. The pH scale ranges from a value of 0 (very acidic) to 14 (very basic), with 7 being neutral. The pH of natural water is usually between 6.5 and 8.2.

Why does the pH level matter?

At extremely high or low pH levels (for example 9.6 or 4.5), the water becomes unsuitable for most organisms. Young fish and insects are also very sensitive to changes in pH. Most aquatic organisms adapt to a specific pH level and may die if the pH of the water changes even slightly.

How do levels of pH become too high or low?

Water pH can vary from its normal levels (6.5 to 8.2) due to pollution from automobiles and coal-burning power plants. These sources of pollution help form acid rain. Acid forms when chemicals in the air combine with moisture in the atmosphere. It falls to earth as acid rain or snow. Many lakes in eastern Canada, the northeastern US, and northern Europe are becoming acidic because they are downwind of polluting industrial plants. Drainage from mines can seep into streams and ground water and make the water more acidic as well.

Ammonia

What is it?

Ammonia is a compound of nitrogen and hydrogen with the formula NH_3. It is a colorless gas with a characteristic pungent smell. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to food and fertilizers. Ammonia, either directly or indirectly, is also a basic building-block for the synthesis of many pharmaceuticals or is used in many commercial cleaning products. Although in wide use, ammonia is both caustic and hazardous. The global production of ammonia for 2012 is anticipated to be 198 million tons, a 35% increase over the estimated 2006 global output of 146.5 million tons.

Why does it matter?

Ammonium ions are a toxic waste product of the metabolism in animals. In fish and aquatic invertebrates, it is excreted directly into the water. In mammals, sharks, and amphibians, it is converted in the urea cycle to urea, because it is less toxic and can be stored more efficiently. In birds, reptiles, and terrestrial snails, metabolic ammonium is converted into uric acid, which is solid, and can therefore be excreted with minimal water loss.[1]

Toxicity

The toxicity of ammonia solutions does not usually cause problems for humans and other mammals, as a specific mechanism exists to prevent its build-up in the bloodstream. Ammonia is converted to carbamoyl phosphate by the enzyme carbamoyl phosphate synthetase, and then enters the urea cycle to be either incorporated into amino acids or excreted in the urine. However, fish and amphibians lack this mechanism, as they can usually eliminate ammonia from their bodies by direct excretion. Ammonia even at dilute concentrations is highly toxic to aquatic animals, and for this reason it is classified as dangerous for the environment.[1]

Nitrate

What is it?

Nitrate compounds are found naturally on earth. Nitrites are produced by a number of species of nitrifying bacteria. Nitrate compounds for gunpowder were historically produced in the absence of mineral nitrate sources by means of various fermentation processes using urine and dung.

Why does it matter?

Marine toxicity

In freshwater or estuarine systems close to land nitrate can reach high levels that can potentially cause the death of fish. While nitrate is much less toxic than ammonia, levels over 30 ppm of nitrate can inhibit growth, impair the immune system and cause stress in some aquatic species. The main problem of nitrate is that it encourages plant growth and decomposition increasing the number of decomposers and therefore lower DO levels.

In most cases of excess nitrate concentrations in aquatic systems, the primary source is surface runoff from agricultural or landscaped areas that have received excess nitrate fertilizer. This is called eutrophication and can lead to algae blooms. As well as leading to water anoxia and dead zones, these blooms may cause other changes to ecosystem function, favoring some groups of organisms over others. As a consequence, as nitrate forms a component of total dissolved solids, they are widely used as an indicator of water quality.

Nitrate also is a by-product of septic systems. To be specific, it is a naturally occurring chemical that is left after the breakdown or decomposition of animal or human waste. Water quality may also be affected through ground water resources that have a high number of septic systems in a watershed. Septics leach down into ground water resources or aquifers and supply nearby bodies of water. Lakes that rely on ground water are often affected by nitrification through this process.[1]

Human toxicity

Nitrate in drinking water at levels above the national standard poses an immediate threat to young children. Excessive levels can result in a condition known as “blue baby syndrome”. If untreated, the condition can be fatal. Boiling water contaminated with nitrate increases the nitrate concentration and the potential risk.

Nitrite

What is it?

Nitrite (NO2) is the toxic by-product of the nitrifying bacteria (Nitrospira) in a filter or substrate consuming Ammonia. It is only mildly less toxic than Ammonia but it still can kill aquatic animals if its levels get too high. Like ammonia, the toxicity of nitrite is related to pH.

Two forms of nitrite are present in water: the nitrite ion (NO2-) and the more toxic nitrous acid (HNO2). The amount of each of these that will be present is pH dependent and as the pH decreases the HNO2 form prevails and is therefore more toxic. The form HNO2 can diffuse freely across gill membranes and is much more toxic than the nitrite ion. [2]

Why does it matter?

Nitrite poisoning is also known by aquarists as Brown Blood Disease. Nitrite damages the nervous system, liver, spleen, and kidneys of fish and other aquatic animals. Even low concentrations of 0.5 mg/l over extended periods can cause long term damage. Nitrite binds the oxygen carrying hemoglobin in blood therefore fish can suffocate even if the oxygen in the tank is sufficient.

Given time (normally 3–4 weeks) in a normal process of a new tank cycling, nitrites are converted into the much less toxic nitrates by the nitrifying bacteria. However if the levels of nitrites do not come down, then the nitrites will cause the animals to struggle for oxygen as the nitrites damage the gills of fish and will cause long term damage to their immune systems and stress them greatly.

The main problem is the same as nitrate of lower DO.

TDS

What is it?

Total Dissolved Solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in water.

Total dissolved solids are normally discussed only for freshwater systems. The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is not generally considered a primary pollutant (e.g. it is not deemed to be associated with health effects) it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants.

Why does it matter?

High TDS levels generally indicate hard water, which can cause scale buildup in pipes, valves, and filters, reducing performance and adding to system maintenance costs. These effects can be seen in aquariums, spas, swimming pools, and reverse osmosis water treatment systems. Typically, in these applications, total dissolved solids are tested frequently, and filtration membranes are checked in order to prevent adverse effects. Most aquatic ecosystems involving mixed fish fauna can tolerate TDS levels of 1000 mg/l. [1]

Specific gravity

What is it?

Specific gravity is the relation of a substance's density to the density of water. The specific gravity tells you if the substance will rise or sink in the water; those with a specific gravity greater than water will sink, and those with one less than water will float. Usually specific gravity refers to an object's density when compared with the density of water, so this value is a ratio.

The specific gravity of a substance is calculated by dividing the specific gravity of that substance by the specific gravity of water. Thus, the specific gravity of pure water would be a number divided by itself, which will always equal one.

Types

The specific gravity of water depends on the type of water being measured. Pure water at 4 degrees Celsius has a specific gravity of one. If the water has salts in it, the water is denser and the specific gravity will be greater than one. Sea water, for instance, is denser than fresh or pure water. Water with a specific gravity of 1.0 has a weight of 1 gram/ml.

Anything with a specific gravity less than 1 (indicating it is less dense than water) will float on water. Because specific gravity is temperature dependent (the lower the temperature the less the density) the specific gravity of ice is less than that of liquid water. This makes ice float. This is important because, for example, if ice did not float, lakes and other bodies of water in northern climates would be frozen over much of the year.

Here are some examples of various products and their specific gravity:

Water has a specific gravity of 1
Orange essential oil has an approximate specific gravity of 0.89
Glycerin has an approximate specific gravity of 1.21
Sweet Almond oil has an approximate specific gravity of 0.92

Water has a specific gravity of 1 which means 1 fluid ounce weighs 1 ounce.
Orange essential oil has a specific gravity of 0.89 which means 1 fluid ounce weighs 0.89 ounce. Glycerin has a specific gravity of 1.21 which means 1 fluid ounce weighs 1.21 ounces. Sweet Almond has a specific gravity of 0.92 which means 1 fluid ounce weighs 0.92 ounce.

To get a general idea if the sample you want to test has a specific gravity of more than 1 or less than 1 you need a clear jar (mayo jar or canning jar), water and the item you wish to test. Fill the clear jar with water to about 3/4 full. Add a small amount of the sample you want to test. If the sample floats on top of the water the specific gravity is less than 1, if it sinks to the bottom the specific gravity is more than 1. If the sample disperses and you can't tell then the product is water soluble and not a great candidate for this test.

Salinity

What is it?

Salinity is the saltiness or dissolved salt content (such as sodium chloride, magnesium and calcium sulfates, and bicarbonates) of a body of water.

When we measure the salinity of water, we look at how much dissolved salt is in the water, or the concentration of salt in the water. Concentration is the amount (by weight) of salt in water and can be expressed in parts per million (ppm).

Here are the classes of water:

Fresh water – less than 1,000 ppm
Slightly saline water – From 1,000 ppm to 3,000 ppm
Moderately saline water – From 3,000 ppm to 10,000 ppm
Highly saline water – From 10,000 ppm to 35,000 ppm

Why does it matter?

Salinity affects chemical conditions within the freshwater waterways, particularly levels of dissolved oxygen and dissolved inorganic phosphorus in the water. The amount of oxygen that can dissolve in water, or solubility, decreases as salinity increases. The solubility of oxygen in seawater is about 20 percent less than it is in fresh water at the same temperature. Phosphorus, which sticks to particles in freshwater, is released as salinity increased. In tidal freshwater or low salinity reaches of estuaries, dissolved phosphorus is not readily available and tends to limit phytoplankton production.

Salinity affects the physical structure of freshwater waterways and influences patterns of circulation. Because salt water is denser than freshwater, layers of different salinities can form resulting in stratification of the water column. Stratification impedes mixing in freshwater waterways, and increases problems such as low dissolved oxygen at the bottom.

Salinity tolerance leads to zonation in freshwater plants and animals. Freshwater organisms have different tolerances and responses to salinity changes. Many bottom-dwelling animals, like oysters and crabs, can tolerate some change in salinity, but salinities outside an acceptable range will negatively affect their growth and reproduction, and ultimately, their survival. Some groups of animals, such as the echinoderms, which include animals such as sea stars, brittle stars and sea cucumbers, have very few species living in freshwater waterways because of their low tolerance of reduced salinity.

Geographic map of DILOS™ field trip Appendix C

Hydrography DILOS™ field trip Appendix D