Name:______________________________ Period:______________ Date:___________________

HW 3 Hydrosphere

Hydrosphere

1. What does the word Hydros mean? ______________________________

2. What % of the hydrosphere is contained in the oceans? __________

3. Of the remaining water, that is fresh water, how much is trapped in polar ice caps and glaciers? ____________

Precipitation and Groundwater

4. The oceans are ultimately the source to all water on land. Evaporation of seawater introduces water into the __________________ in the form of invisible water ________________ and visible ______________.

5. What are the two main forms of precipitation? ___________________ & ____________

6. What is infiltration?

7. What eventually happens to the water from infiltration?

Groundwater Storage

8. What is porosity? What kind of sediment has higher percentage?

The Zone of Saturation

9. What is the Zone of saturation?

10. What is the water table?

11. What is the strict definition of ground water?

Ground Movement

12. Fill in the chart on Permeability

Permeability:	
Examples of High Permeability	Examples of Low Permeability

Please draw the Water Cycle.

Include: Ocean, (river, lake, or ice), ground water
Evaporation, condensation, and precipitation

Discovery Lab

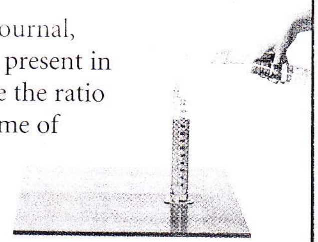
Model Underground Water Storage

Beneath your feet, there are vast amounts of water. This water fills in the pore spaces of sediments and rocks deep in the ground. In this activity, you will discover how much water can be stored in sand.

1. Fill a 250-mL graduated cylinder with dry sand.
2. Fill another 250-mL graduated cylinder with water.
3. Pour water from the second cylinder into the sand-filled cylinder until the water level is flush with the surface of the sand. Measure and record the volume of saturated sand in the cylinder.
4. Measure and record how much water is left in the second cylinder.

CAUTION: Always wear safety goggles and an apron in the lab.

Observe In your science journal, describe how much water is present in the saturated sand. Calculate the ratio of water volume to the volume of sand. Infer how many liters of water could be stored in a cubic meter of sand.



SECTION 10.1 *Movement and Storage of Groundwater*

OBJECTIVES

- **Describe** *how groundwater is stored and moves underground.*
- **Explain** *what an aquifer is.*

VOCABULARY

infiltration
porosity
zone of saturation
water table
permeability
aquifer

If you drill a deep enough hole anywhere on Earth, it will partially fill with groundwater, even in the desert! Groundwater is present everywhere beneath the surface of the land, but nevertheless is a small fraction of all the water on Earth.

THE HYDROSPHERE

The water on and in Earth's crust makes up the hydrosphere, named after *hydros,* the Greek word for "water." About 97 percent of the hydrosphere is contained in the oceans. The water contained by landmasses—nearly all of it freshwater—makes up only about 3 percent of the hydrosphere.

Freshwater is one of Earth's most abundant and important renewable resources. However, of all the freshwater, more than 90 percent is in the form of polar ice caps and glaciers. You may be surprised to

Table 10-1 World's Water Supply				
Location	**Surface Area (km^2)**	**Water Volume (km^3)**	**Percentage of Total Water**	**Estimated Average Residence Time of Water**
Oceans	361 000 000	1 230 000 000	97.2	Thousands of years
Atmosphere	510 000 000	12 700	0.001	Nine days
Rivers and streams	—	1200	0.0001	Two weeks
Groundwater: shallow, to a depth of 0.8 km	130 000 000	4 000 000	0.31	Hundreds to many thousands of years
Lakes (freshwater)	855 000	123 000	0.009	Tens of years
Ice caps and glaciers	28 200 000	28 600 000	2.15	Tens of thousands of years and longer

learn that most of the remaining freshwater is groundwater. All the rivers, streams, and lakes on Earth represent only a small fraction of Earth's liquid freshwater, as shown in ***Table 10-1.***

Precipitation and Groundwater

The ultimate source of all water on land is the oceans. Evaporation of seawater introduces water into the atmosphere in the form of invisible water vapor and visible clouds. Winds and weather systems move this atmospheric moisture all over Earth, much of it over the continents. Precipitation brings atmospheric moisture back to Earth's surface, mostly in the form of rain and snow. Some of this precipitation falls directly into the oceans, and some falls on land.

Much of the precipitation that falls on land enters the ground through the process of **infiltration** and becomes groundwater. Only a small portion of precipitation becomes runoff and is returned directly to the oceans through streams and rivers. Solid precipitation, such as snow, may cover the ground for long periods of time before it melts and becomes runoff or infiltrates to become groundwater. Groundwater slowly moves through the ground, eventually returns to the surface through springs, and then flows back to the oceans.

Groundwater Storage

Puddles of water that are left after a rain quickly disappear, partly by evaporating and partly by percolating into the ground. On sandy soils, rain soaks into the ground almost immediately. Where does that water go? Subsurface Earth materials are not totally solid, but instead contain countless small openings, or pores, which make up a large portion of some of these materials, as you see in ***Figure 10-1.***

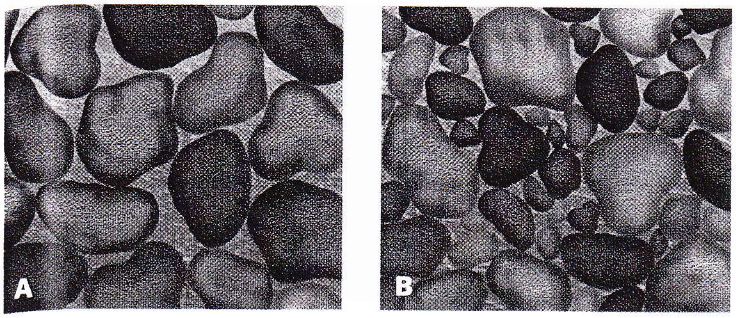


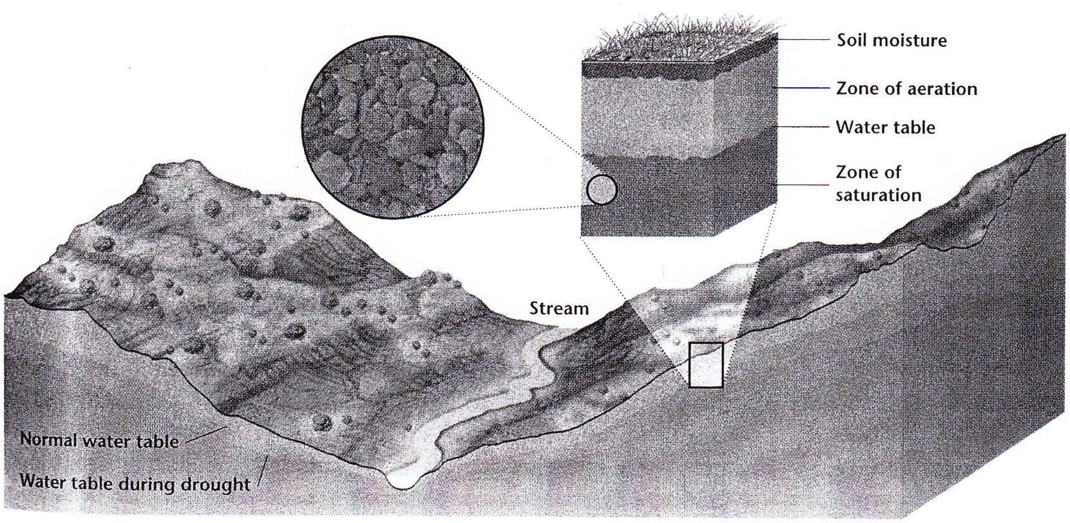
Figure 10-1 Pore spaces in sediments: the highest percentage of porosity is found in well-sorted sediments **(A)** while poorly sorted sediments **(B)** have a lower percentage.

The percentage of pore space in a material is called its **porosity.** Subsurface materials have porosities ranging from 2 or 3 percent to more than 50 percent. For example, the porosity of well-sorted sand is typically around 30 percent. In poorly sorted sediments, however, smaller particles of sediment occupy some of the pore spaces and reduce the overall porosity of these sediments. Similarly, the cement that binds the grains of sedimentary rocks together reduces the rocks' porosity. Nevertheless, enormous quantities of groundwater are stored in the pore spaces of rocks and sediments.

The Zone of Saturation

The depth below Earth's surface at which groundwater completely fills all the pores of a material is called the **zone of saturation.** The upper boundary of the zone of saturation is the **water table,** as shown in ***Figure 10-2.*** Strictly speaking, only the water in the zone of saturation is called groundwater. In the zone of aeration, which

Figure 10-2 Groundwater flows toward valleys where the water table is close to the surface. During dry periods the level of the water table falls.



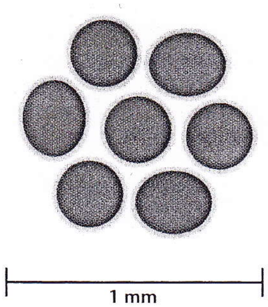
is above the water table, materials are moist, but the pores contain mostly air. Water in the zone of saturation can be classified as either gravitational water or capillary water. Gravitational water is water that trickles downward as a result of the force of gravity. Capillary water is water that is drawn upward from the water table and is held in the pore spaces of rocks and sediments as a result of surface tension. Materials that are directly above the water table, especially fine-grained materials, are nearly saturated with capillary water. Capillary action is similar to the action of water that is drawn upward through the pore spaces of a paper towel when the end of it is dipped into water.

The Water Table The depth of the water table varies depending on local conditions. For example, in stream valleys, groundwater is close to Earth's surface, and thus the water table is a few meters deep at most. In swampy areas, the water table is almost at Earth's surface, whereas on hilltops or in arid regions, the water table can be tens to hundreds of meters or more beneath the surface. As shown in ***Figure 10-2,*** the topography of the water table follows the topography of the land above it. For example, the water table slopes toward valleys and forms hills under topographic hills. Water-table topography forms in this way because water underground moves extremely slowly, and conforms to surface contours.

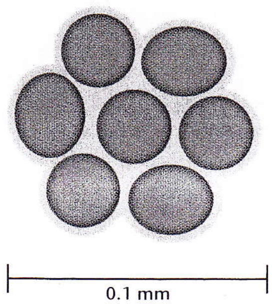
Because of its dependence on precipitation, the water table fluctuates with seasonal and other weather conditions. It rises during wet seasons, usually in spring, and drops during dry seasons, often in late summer.

Figure 10-3 In a saturated material, all grains are coated with a thin film of motionless water. In coarse-grained material like sand **(A)** this film occupies a relatively small fraction of the pore space, and moving water can pass freely through the pores. In fine-grained material like silt **(B)** this film occupies most of the pore space and blocks the movement of water. As a result, sand has a much higher permeability than silt.

A



B



Groundwater Movement

Groundwater flows downhill in the direction of the slope of the water table. In most cases, this downhill movement is extremely slow because the water has to squeeze through numerous tiny pores in the subsurface material. In fact, if the pores are extremely small, not even individual water molecules can squeeze through. The ability of a material to let water pass through it is called **permeability.** Materials with large, connected pores, such as sand and gravel, as shown in ***Figure 10-3A,*** have high permeabilities and permit relatively high flow velocities, up to 1m/h or more. Other permeable subsurface materials include sandstone, limestone, and all highly fractured bedrock.

Fine-grained materials typically have low permeabilities because their pores are so tiny, as shown in ***Figure 10-3B.*** These materials are said to be impermeable. Flow velocities in impermeable materials are so low that they are often measured in meters per year. Some examples of impermeable materials are silt, clay, and shale. Clay is so

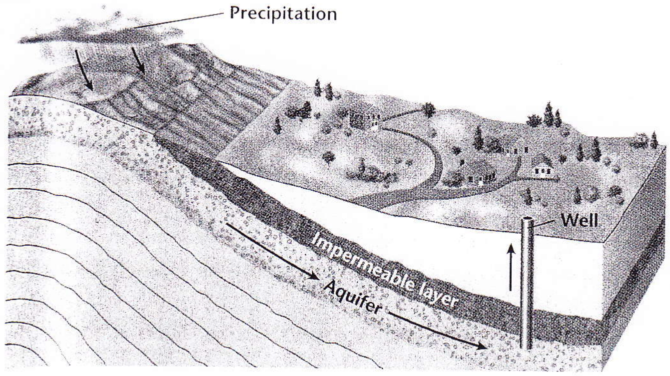


Figure 10-4 The aquifer is located in a permeable sandstone layer that is sealed beneath a capping layer of impermeable rock.

impermeable that a clay-lined depression will hold water. For this reason, clay is often used to create artificial ponds and landfills.

The flow velocity of groundwater depends on the slope of the water table, because the force of gravity pulling the water downward is greater when the slope of the water table surface is steeper. You have experienced a similar effect if you have ever ridden a bicycle down a steep street and a gently sloping street. Although the flow velocity of groundwater is proportional to both the water-table slope and the permeability of the material through which the water flows, permeability is the major factor. Thus, flow velocities through permeable materials are always higher than those through impermeable materials, regardless of the slope of the water table. Most groundwater flow takes place through permeable layers, called **aquifers,** such as the one shown in ***Figure 10-4.*** Impermeable layers, called aquicludes, are barriers to groundwater flow. In the next section, you'll discover what happens when groundwater moves slowly through materials.

SECTION ASSESSMENT

1. What is the greatest source of freshwater on Earth?
2. Where is the water table closest to Earth's surface: in the floodplain of a river, in a swamp, or on a hilltop?
3. What two factors determine the flow velocity of groundwater?
4. What is an aquifer?
5. **Thinking Critically** What is the difference between porosity and permeability in subsurface materials?

SKILL REVIEW

6. **Making and Using Tables** Design a data table that compares and contrasts the porosity and permeability of sand and a mixture of sand and gravel. Which material has the greater porosity? The greater permeability? For more help, refer to the *Skill Handbook*.