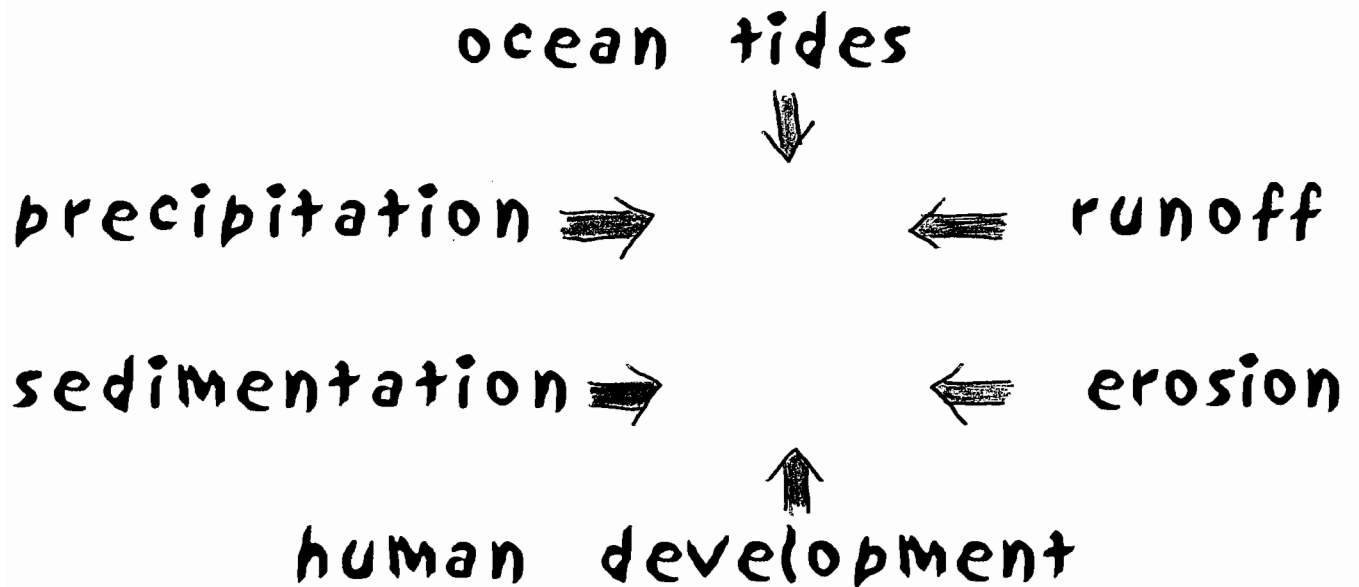


## Part 1

# What Shapes the Lagoon?



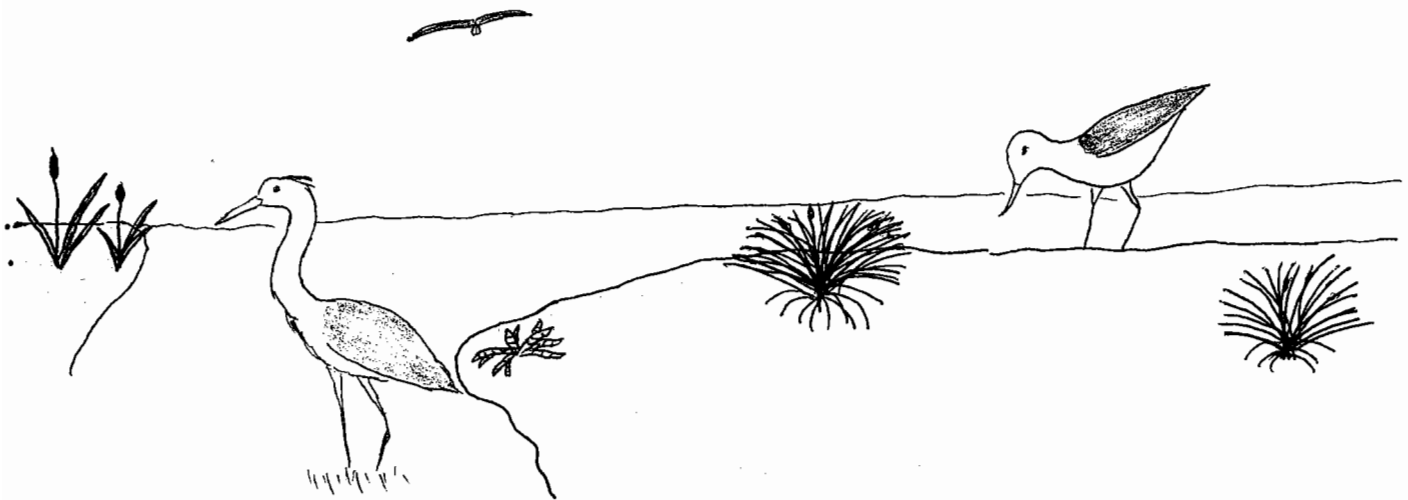
# What are Wetlands?

Wetlands may be called swamps, marshes, bogs, or sloughs. Any land that is covered with shallow water all or part of the time may be a wetland.

Along the coast, these green oases offer wild creatures important and remarkable refuges, though wetlands are threatened by our towns, farms, pollution and carelessness.

Native Americans and early pioneers used wetlands for their resources. Later settlers and developers hated "swamps" and drained or filled them. As human populations increased, wetlands were used as dumping grounds, outlets for sewage, or paved over with asphalt.

Now, at last, we are coming to appreciate the rare beauty of wetlands, and the role they play in preserving nature. By understanding the lagoons - and the plants and animals that depend on them for survival - we may help to preserve their beauty and resources for future generations.



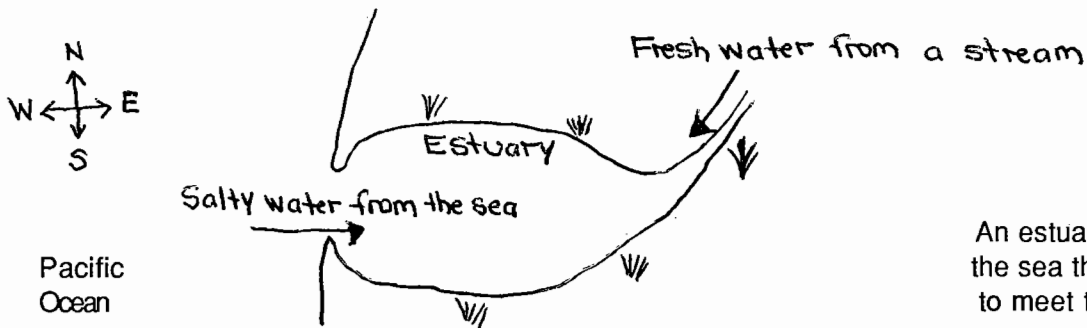
## **Why are wetlands valuable?**

- 1. Wetlands are homes for native plants and animals.**  
Many species are endangered, and will not survive elsewhere.
- 2. Wetlands are sheltered nurseries for young creatures.**  
Many animals seek the sheltered environment of wetlands to give birth and raise their young.
- 3. Wetlands act as sponges to filter sediments and pollution from runoff before it reaches the ocean.**
- 4. Wetlands slow the effects of waves eroding the coast.**  
Wetlands act as a buffer zone.
- 5. Wetlands provide flood control.**  
The roots of wetland plants slow the flow of water.
- 6. Wetlands provide a chain of stopovers for birds along their annual migration pathways.**  
Birds require periodic stops for rest and food.

# The story of an estuary

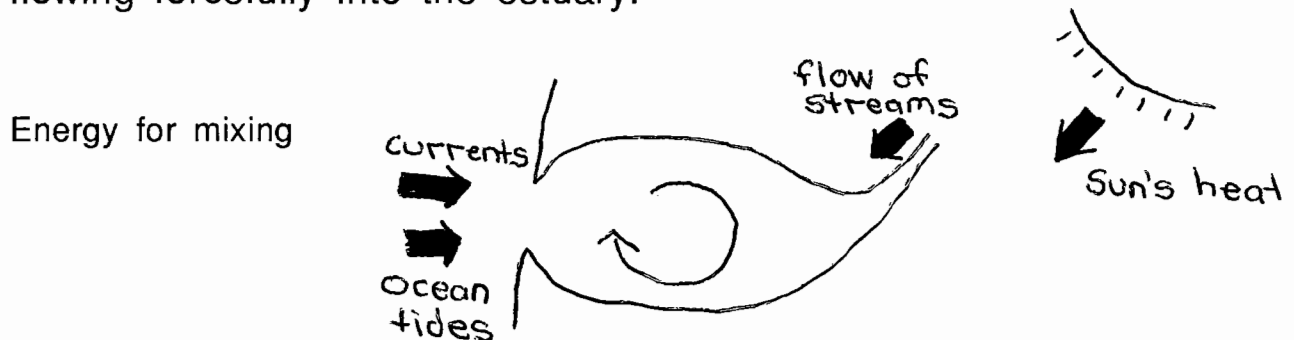
A lagoon is a shallow body of water sheltered from the ocean. The water may be fresh, salty or partly salty. In San Diego, lagoons are found where fresh water from a creek flows down to meet the sea. Meanwhile, salty ocean water pushes inland with the tides.

This area where fresh and salty water mix is an **estuary**, a link between land and sea. An estuary serves as a mixing bowl.



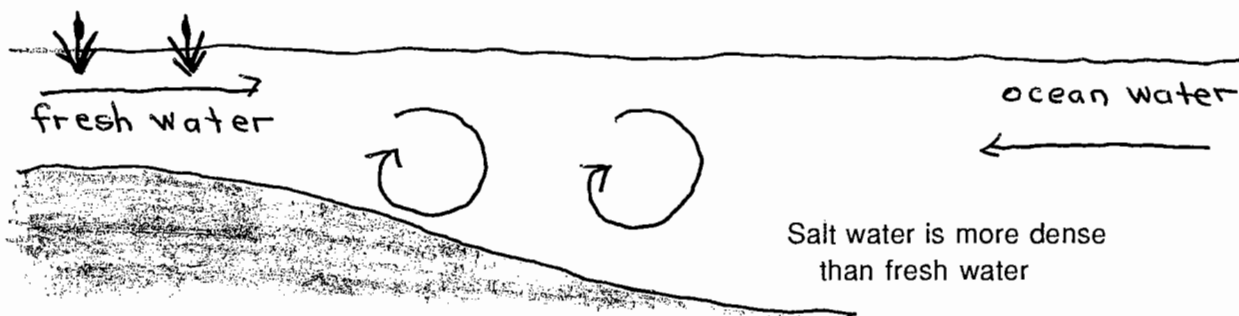
An estuary is an arm of the sea that extends inland to meet the mouth of a river.

In an estuary, mixing is fueled primarily by ocean tides, which rise and fall twice a day. Energy for mixing also comes from the sun heating the estuary's shallow water, as well as ocean currents and waves driven by wind. After heavy rains, creeks may swell and flood, flowing forcefully into the estuary.



## Layering in an estuary

Salt water is heavier, more **dense** than freshwater, due to dissolved salt. So salty ocean water sinks beneath fresh water, which tends to flow on the surface. Eventually they mix.



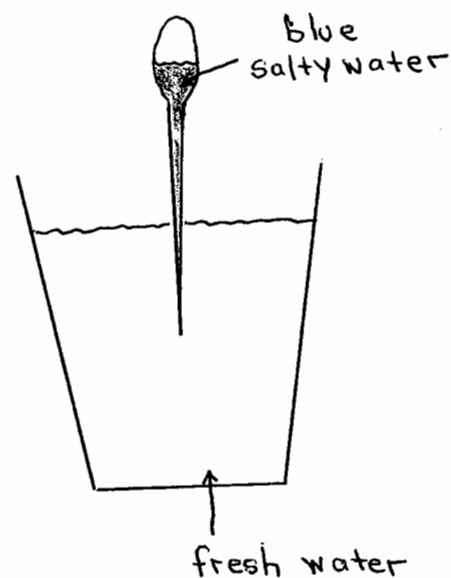
### Mini-Experiment: Density of saltwater

1. Take a clear plastic cup. Fill it three-fourths full of water.
2. In another cup, create a salty solution, by adding 2 tablespoons of salt. Add blue food coloring to deeply color this salty water.
3. Use an eyedropper to add salty water carefully to the middle of the fresh water.

**Observations:** Observe from the side.  
Where does the saltwater go?

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There may also be layering due to temperature differences. Colder water is more dense than warmer water. Try the above experiment again. This time, prepare some icy cold water, and deeply color it blue. Add the cold water to the middle of a cup of room temperature water. Where does the cold water go?

# What is the freshwater carrying?

Freshwater flowing into the lagoon is carrying:

1. Inorganic (nonliving) particles, such as silt and sand
2. Organic particles (remains of living things)
3. Pollutants

Tiny particles of silt are suspended in the water, contributing to the cloudiness, or **turbidity** of the water. This turbidity can block sunlight from reaching plants in the water.

## Mini-Experiment: Make a suspension

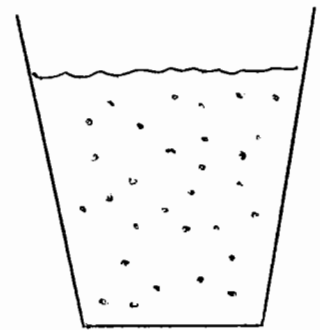
Take a clear glass of water. Add a spoonful of flour and stir.

**Observations:** Do the particles settle?  
How clear or cloudy is the water?

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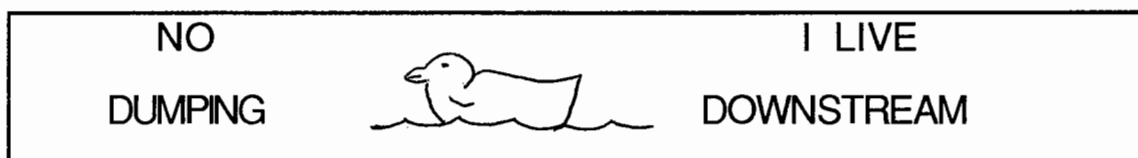
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# Where do pollutants come from?

Motor oil washed from driveways or streets can enter the watershed. Trash dumped into drainage ditches flows into the lagoon. Excess fertilizer and pesticides from home lawns pollutes the water. Manure from animals also adds contaminants.

Notice the warnings stencilled on curbside storm drains:



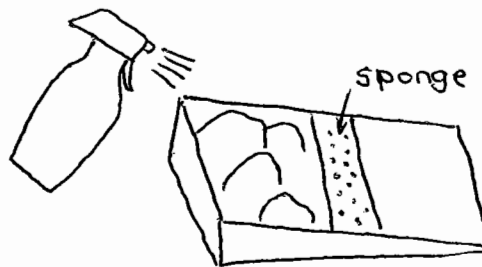
# We all live in a watershed

The area of land that drains into a system of streams or rivers is called a **watershed**. Rainfall in this area soaks into the ground, or flows into streams, joining with other streams to form creeks that flow downhill into the lagoon.

## Mini-Experiment: Make a watershed model

Take a sloping paint tray. These can be purchased inexpensively at a hardware or paint store.

1. Mold a landscape on the upper part of the tray, using aluminum foil or clay. This will be your **watershed**.
2. On the lower edge of your watershed, fit a kitchen sponge. The sponge will act as your **wetland** area.



3. Add contaminants to your watershed: a squeeze of chocolate or maple syrup, tiny pieces of paper, glitter, or dirt. These will act as **pollutants**.
4. Use a spray bottle to make rain fall on the watershed.

### Observations:

What happens to the water as it flows downhill?

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What happens to the contaminants?

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Try it again without the sponge. How do wetlands trap sediment?

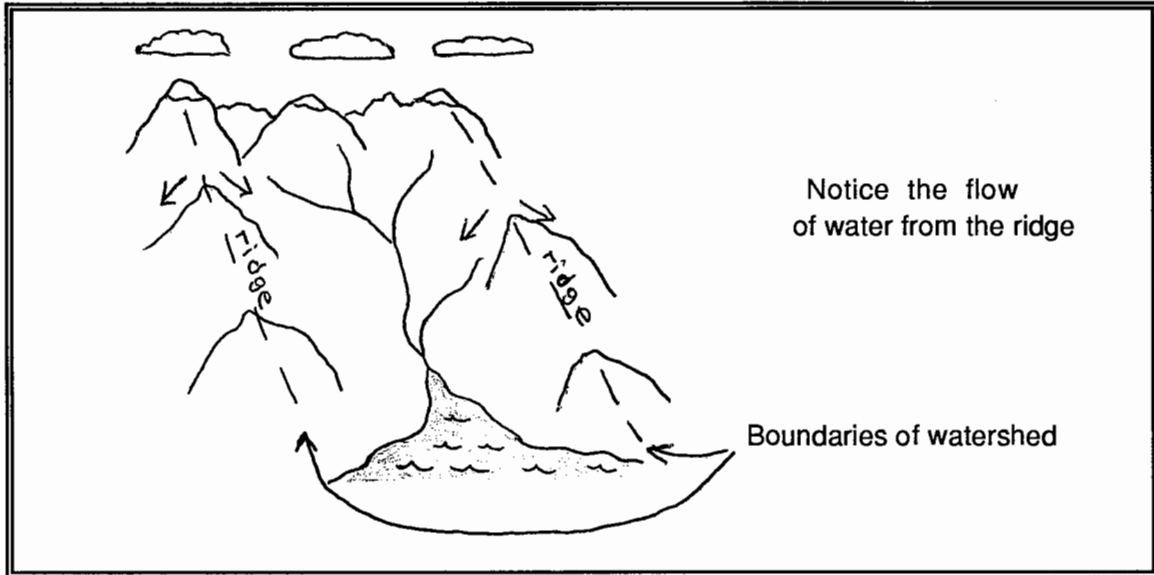
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# What does a watershed look like?

A watershed depends upon the lay of the land (topography). Where are the hills, mountains, and valleys? How steeply sloped is the land?

Water flows downhill from high elevations (mountains, hills) to low elevations (valleys, lakes or ocean). Gravity always wins!



Streams may originate as mountain springs, melting snowpack on mountains, or as rain accumulating on hillsides

The smallest (1st order) streams join with other small streams to form larger (2nd order) streams. These join with others to form still larger (3rd order) streams. This forms a branching pattern that looks like a tree.



# What affects the flow of freshwater?

The lagoon is fed by freshwater streams and creeks. However, their flow changes drastically through the year, and has been permanently altered by human development.

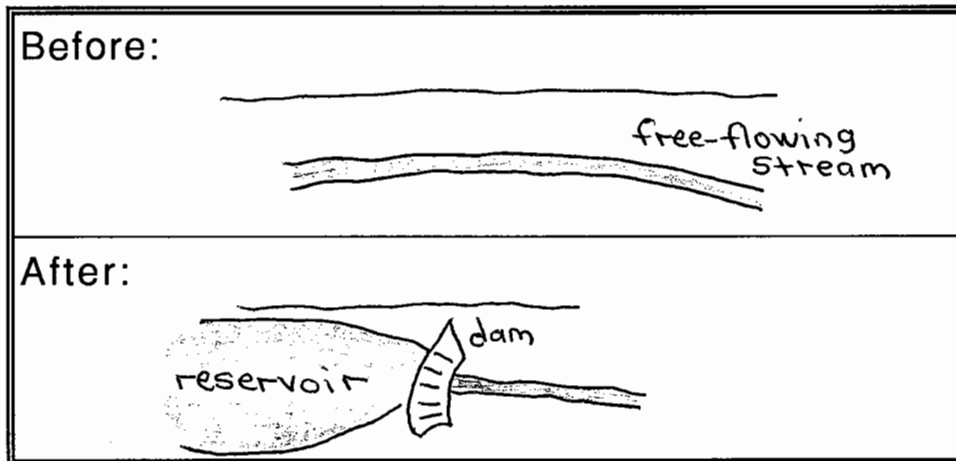
1. In a dry summer, the stream may decrease to a trickle, even run dry, leaving the lagoon saltier. Winter and spring bring increased rain, and the lagoon may be less salty.

2. During heavy rainstorms, the streams are deep and the water moves quickly. Runoff increases, and areas can be flooded. Storms wash pollution downstream, such as oil from street surfaces and parking lots, as well as dirt from construction sites.



3. As more people move to the area, and surrounding cities have grown, water is piped in from outside the local watershed. More water is released from lawn irrigation, commercial use, street cleaning, etc.

4. Dams have been built, forming reservoirs upstream. This has permanently changed the natural drainage of the watershed:



# What wears away the land?

Over time, **erosion** by wind or water wears away rocks, disintegrating them to tiny particles, which are carried away and deposited elsewhere as sediment.



Ocean waves break against the land, shaping and sculpting coastal lands. Streams flowing downstream cut through the land, carving riverbeds or canyons, transporting particles downstream.

Wetlands are a key factor in erosion; their plants help hold soil in place, reducing erosion by rivers, tides and waves.

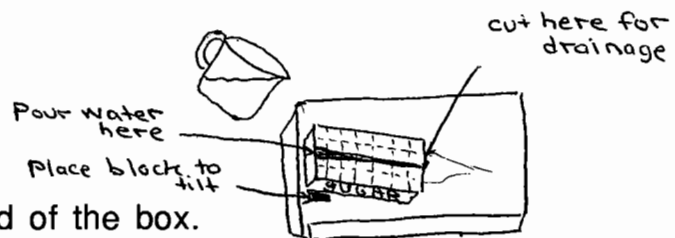
## Mini-Experiment: Model the erosion of a river canyon

Use a shallow paint tray or brownie pan.

Place inside a full box of sugar cubes.

Place a block under one end of the sugar box to tilt it.

Cut an opening at the lower end of the sugar box for drainage.



Pour a little water on the upper end of the box.

Just pour a trickle then let it set.

Return every ten minutes to trickle more water onto the upper end.

Pour onto the same spot each time.

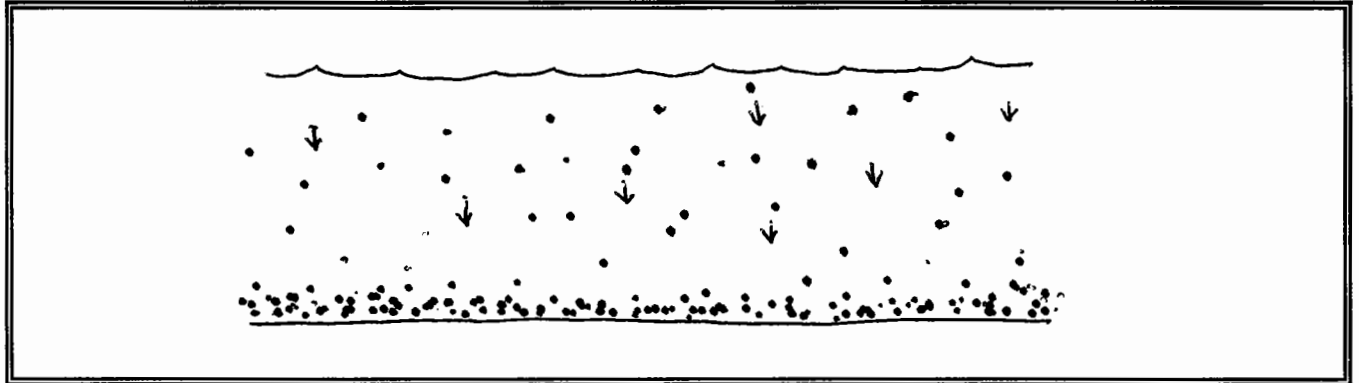
The water will begin to dissolve the sugar, and carry away the grains, carving a 'river canyon.' Continue adding water as the canyon gets deeper.

**Observations:** What happens to the sides of the canyon?

What happens to sediments washed downstream?

# What happens when fresh water flows into the ocean?

Fast-moving water can carry more particles than still water. These particles drop out, or settle in streams, valleys, estuaries or the ocean. This is called **sedimentation**.



Heavier particles, such as pebbles or sand will drop out first, leaving finer silt suspended in the water.

## Mini-Experiment: Sedimentation

Take a clear glass jar or cup.  
Fill it with water.  
Add a spoonful of soil and a spoonful of sand. Stir.  
Now leave the glass to settle.

**Observations:** Which settles first: heavier or lighter particles?

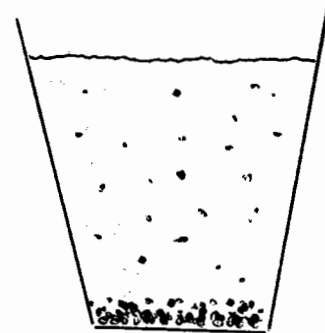
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What is left suspended in the water?

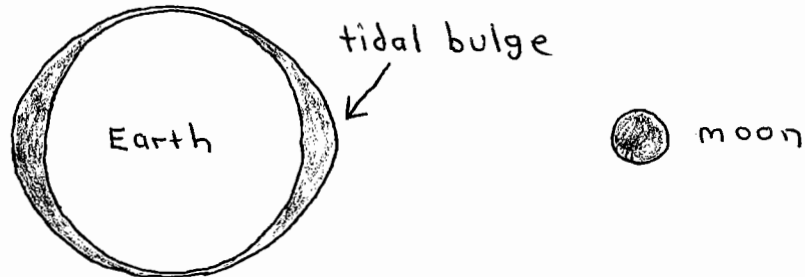
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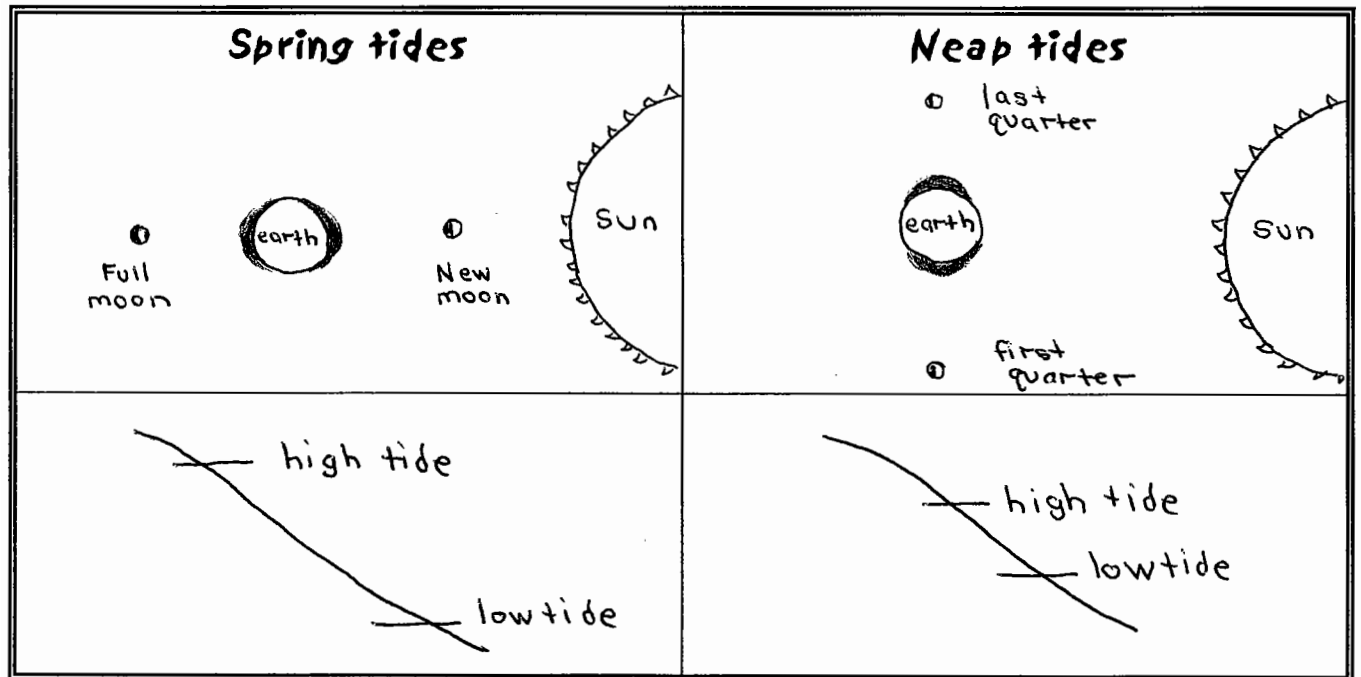


# Why do the tides rise and fall?

Ocean tides are caused by the gravitational pull of the moon and to a smaller degree, the sun. Water on earth bulges on the side facing the moon, and on the side facing away. There are two high tides each day, and two low tides, due to the rotation (spinning) of the earth.



High tides are highest, and low tides are lowest when the sun and moon are aligned. These are called spring tides. Neap tides produce a smaller difference between high and low tides.

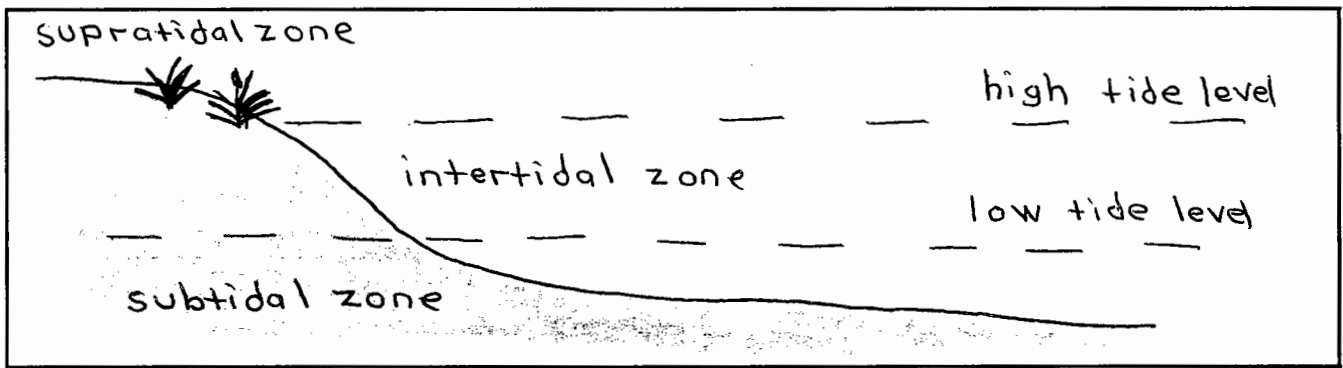


# What happens when tides rise and fall?

The area between high tide and low tide is called the **intertidal zone**. Tides rise twice a day to flood this zone.

As tides rise, they deliver minerals, nutrients, and oxygen to plants in the lagoon. Tides recede, carrying away living and decaying matter, food for ocean animals. As a result, fish congregate near the mouth of the lagoon, waiting for a meal.

To survive, animals and plants must be adapted to being flooded, then left high and dry by retreating water. Crabs and clams may burrow into the mud to avoid drying out. Shoreline plants must be able to live in salty water.



Check your local paper to find the times of high and low tides.

| Day        | High Tide | Height | Low Tide | Height |
|------------|-----------|--------|----------|--------|
| January 7  | 8:19 am   | 6.4'   | 2:05 am  | 2.3'   |
| January 21 | 8:12 am   | 7.3'   | 1:56 am  | 1.9'   |

What is the difference in height between high and low tide for these days? Jan 7: \_\_\_\_\_ Jan 21: \_\_\_\_\_

Which of these dates has spring tides? \_\_\_\_\_

# Geology: A brief history of the lagoons

San Diego was born at the bottom of the sea. Evidence comes from rocks containing fossils of ancient sea life.

I wonder how it all began...



Earth's crust is broken into pieces called plates. San Diego is on the Pacific Plate, apart from the North American Plate.

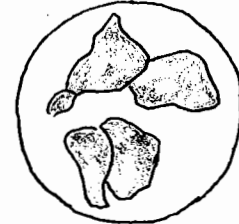


San Diego's oldest rocks are a few hundred million years old, laid in shallow seas off the coast of the supercontinent, Pangaea. All continents were joined as one.

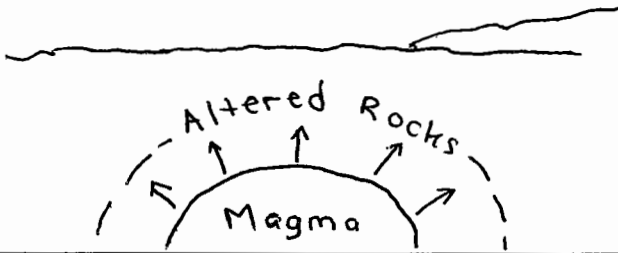
North America was south of its current location.



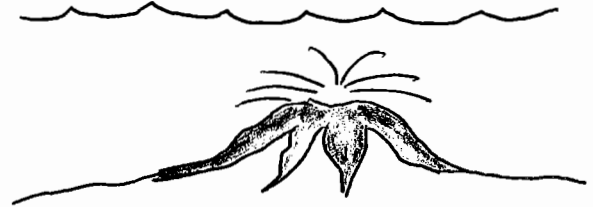
From deep inside the earth, tectonic forces split Pangaea apart. About 200 million years ago, North America began to travel north.



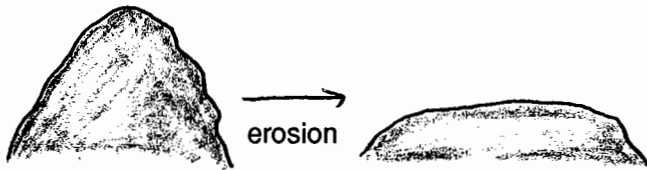
Underground, hot magma rose, cooling slowly to form granite. The magma's heat altered surrounding rocks to metamorphic rocks.



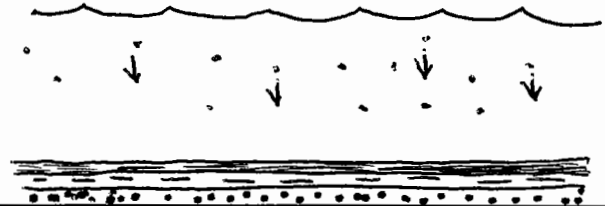
140 million years ago, underwater volcanoes spewed lava and ash, forming igneous rocks. Some magma made it to the surface.



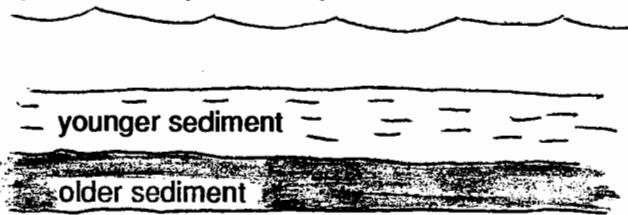
The land was uplifted. Erosion wore away at the volcanic peaks, exposing the underground granite. Sediments were carried downstream and deposited.



Most rocks around San Diego's coast are sedimentary, formed as mud and sand settled in oceans.



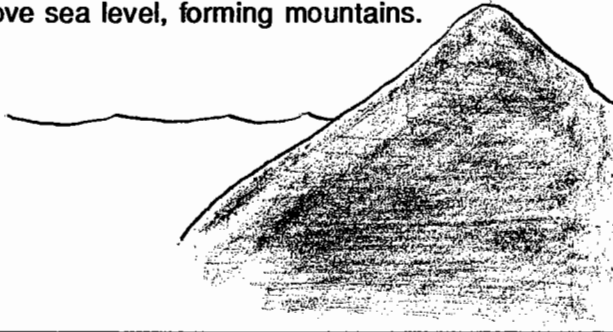
In shallow offshore seas, sand was deposited and cemented into sandstone. The oldest sandstones are 45 million years old. More recent sand was deposited on top, like a layer cake.



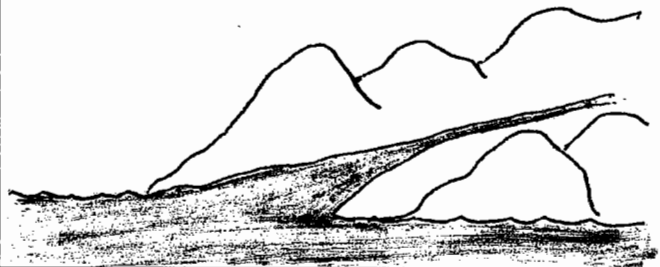
40 million years ago, San Diego was off the coast of Mexico, near old volcanic flows. Raging rivers wore away lava rocks, rounding them to the purple cobbles now found on San Diego beaches.



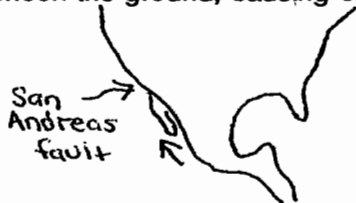
Tectonic forces pushed the lands of San Diego above sea level, forming mountains.



Erosion wore away the mountains; rivers cut through them, forming valleys.



The lands of San Diego were pushed north, and crashed into North America, about 15 million years ago. San Diego then began moving along the San Andreas fault, about 2 inches a year. Rapid shifts shook the ground, causing earthquakes.



Ocean waves cut away at the coast, forming cliffs and beaches. Further uplift and wave erosion formed a series of flat terraces along the coast.



About 2 million years ago, the Ice Ages trapped much of Earth's water in vast ice sheets, lowering sea levels.

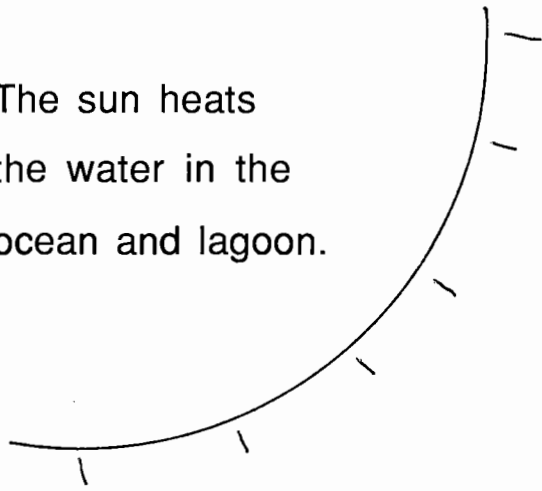


Starting about 20,000 years ago, the ice melted, sea levels rose. River valleys were flooded, forming the lagoons.

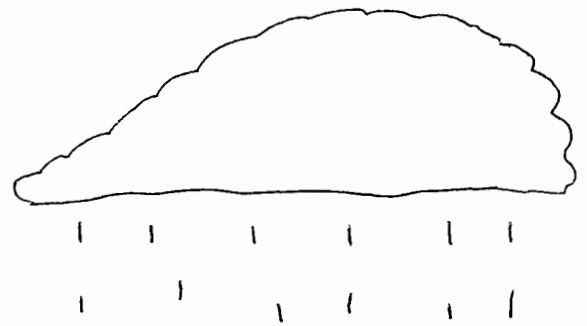
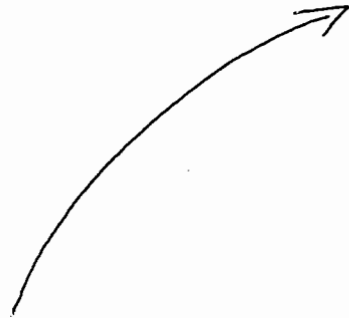


# The Water Cycle

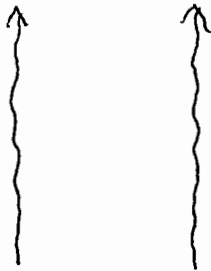
The sun heats the water in the ocean and lagoon.



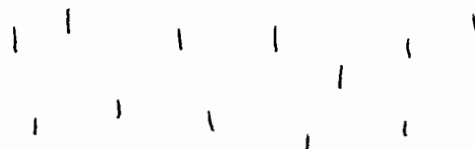
As water vapor rises, it cools, **condensing** to liquid drops in clouds.



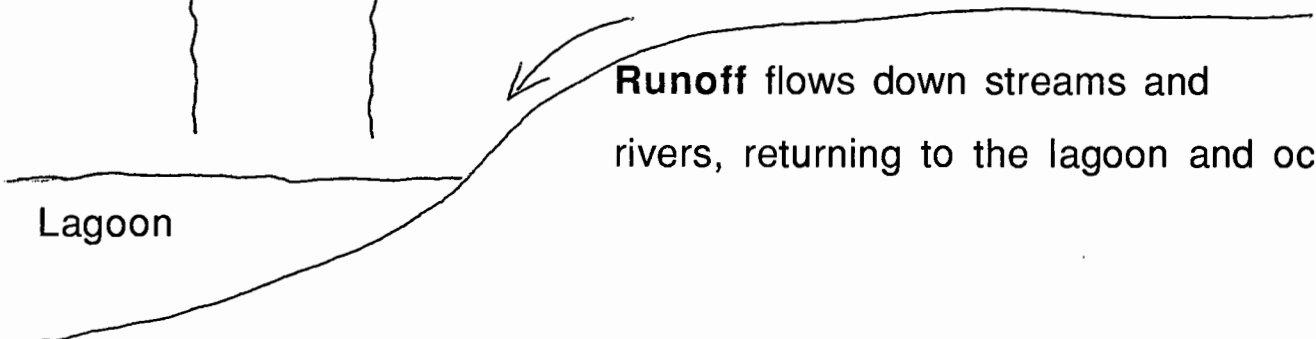
Water **evaporates**, forming water vapor in the air.



**Precipitation:** When clouds grow heavy with water, rain falls.



**Runoff** flows down streams and rivers, returning to the lagoon and ocean.



Lagoon

# Weather in San Diego

To monitor weather in the lagoon, you could measure:

1. Precipitation: the amount of rainfall
2. Temperature: how hot or cold it is
3. Air Pressure: the weight of air pressing down
4. Wind speed: how fast the wind is blowing
5. Humidity: the amount of moisture in the air

Match the instruments to the weather conditions they measure:

|             |                        |
|-------------|------------------------|
| thermometer | measures wind speed    |
| barometer   | measures temperature   |
| anemometer  | measures air pressure  |
| hygrometer  | measures water content |

San Diego's climate is mild but dry. Average rainfall is only 10 inches a year. Below are the average high and low temperatures for each month.

|                  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ave low (F)      | 49  | 51  | 53  | 56  | 59  | 62  | 66  | 67  | 66  | 60  | 54  | 49  |
| Ave high (F)     | 66  | 67  | 66  | 68  | 69  | 72  | 76  | 73  | 77  | 75  | 70  | 66  |
| Rainfall(inches) | 1.8 | 1.5 | 1.8 | 0.8 | 0.2 | 0.1 | 0.2 | 0.1 | 0.2 | 0.4 | 1.5 | 1.6 |

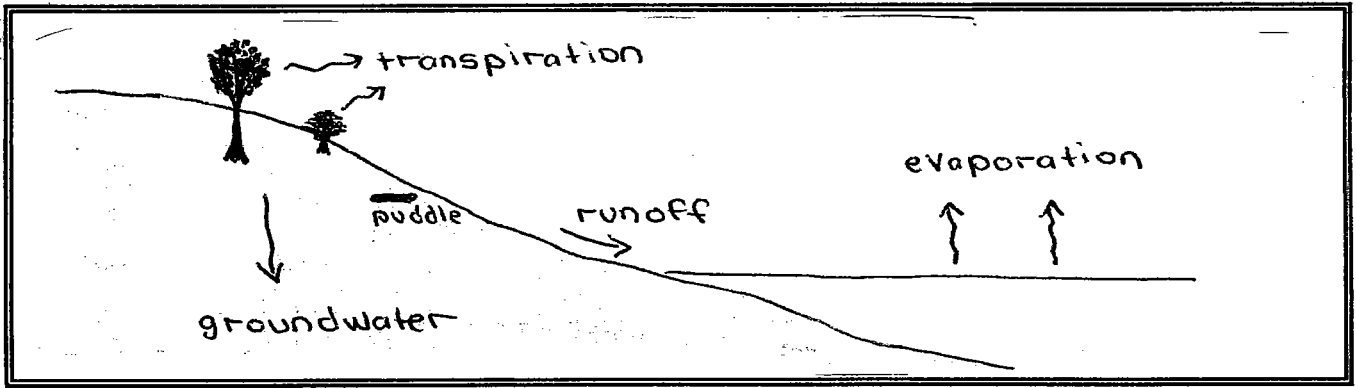
When is the rainy season for San Diego? \_\_\_\_\_

When is the dry season for San Diego? \_\_\_\_\_

Which month is the coldest? \_\_\_\_\_

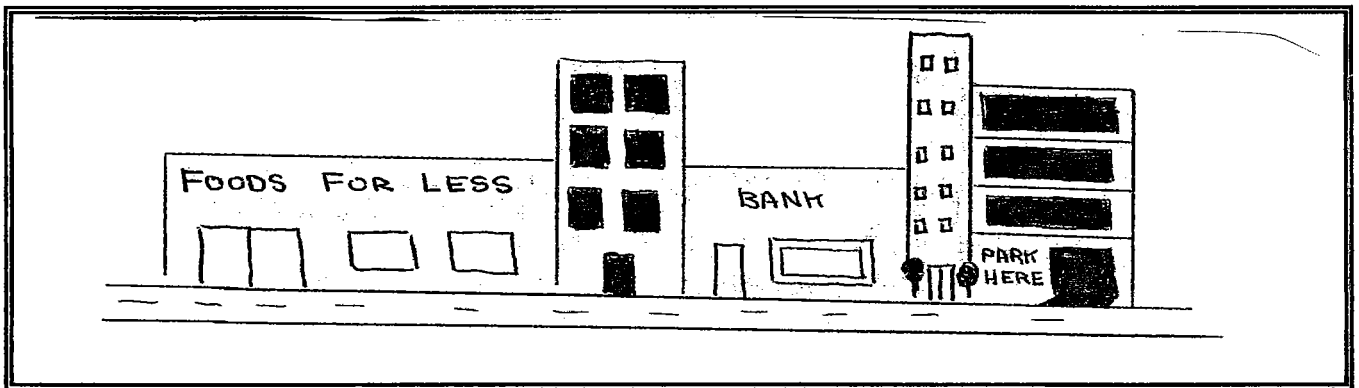
Which month is the hottest? \_\_\_\_\_

## Where does the rain go?



**In a natural setting**, soil is permeable (it absorbs water).

- Some rainwater soaks into the ground, and recharges groundwater.
- Some rainwater accumulates in puddles.
- Some is drawn into plants, then lost by transpiration.
- Some returns to the atmosphere by evaporation.
- Some flows down hills as runoff, to join creeks and streams.



**In a city**, much of the surface area is covered by roads, sidewalks, driveways, parking lots, buildings, and houses. These asphalt and concrete surfaces are **impervious**, and can not absorb much water, so water flows along the surface. This runoff flows down gutters, joining storm drains. Along the way, the runoff picks up oils or chemicals.

## A Delicate Balance:

### How does rainfall affect the lagoon?

When heavy rain falls, there is increased runoff into the lagoon. This incoming freshwater dilutes the salt in the lagoon, lowering the salinity.

When there is low rainfall, and little input of freshwater, the lagoon becomes much saltier. The sun continues to evaporate water, leaving salt behind. This can form dry salt flats.

|             |   |                           |
|-------------|---|---------------------------|
| Heavy rain  | → | Lower salinity in lagoon  |
| Little rain | → | Higher salinity in lagoon |

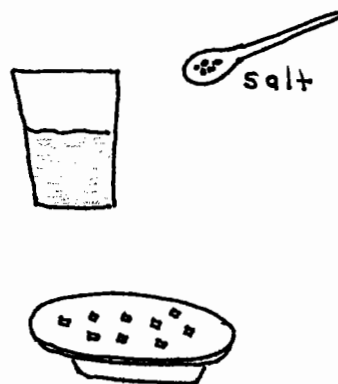
Look at the chart of San Diego rainfall on the previous page.

During which months would you expect the salinity to be highest in the lagoons? \_\_\_\_\_

#### Mini-Experiment: Make a salt flat

Add 2 Tablespoons of salt to a cup of warm water. Stir until dissolved.

Take a shallow pie pan, and fit a circle of black construction paper to the bottom. Pour a shallow layer of salty water onto the black paper. Leave it for a few days.



**Observations:** What do the crystals look like? Use a magnifying glass or low-power microscope to see them.