EASY EXPERIMENTS TO UNDERSTAND A COMPLICATED EARTH

3. EUREKA! THE CONTINENTS AND OCEANS FLOAT!

Text : Susana A. Alaniz Álvarez and Ángel F. Nieto Samaniego
Illustrated by : Luis David Morán, Translated by :
Yadira A. Hernández Pérez, H. Federico Cruz

Dra. Susana A. Alaniz Álvarez
Dr. Ángel F. Nieto Samaniego
Dr. Manuel Lozano Leyva
Coordinators of the series

Ing. Lluvia Y. Huerta Landaverde
Design and formation

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Centro de Geociencias
Universidad Nacional Autónoma de México
No. 3001, Boulevard Juriquilla, Querétaro
C.P. 76230, México

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EUREKA!

THE CONTINENTS AND OCEANS FLOAT!

Introduction

The Earth is full of mysteries and mankind has always tried to solve them with observation, research, exploration and experimentation. What is inside Earth? Why do mountains exist? Why are there oceans? Why do volcanoes erupt? Why do earthquakes happen? Why isn't the weather always the same? Some mysteries are easier to solve than others, questioning and minute observation may be enough. There are other mysteries that are more difficult to untangle, especially those that happen at a global level, because they occur at such a broad scale that they take longer to happen than humans take to live. All we know about how Earth works comes from observation made by people here and there. Earth is so big and complicated that every phenomenon may be considered as a piece of a huge puzzle. Nevertheless, we should never be discouraged because we may understand very complicated phenomena using very simple experiments.

This book is dedicated to Archimedes (287 b.C. - 212 b.C.), who noticed that his body was lighter whenever he immersed himself in water. One day, when he was taking a bath in his tub, he realized that the decrease in his weight was proportional to the volume of water displaced by his body. In that moment, he shouted: 'Eureka!', which in Greek means: 'I found it!'

Here we will try to show you how buoyancy, discovered by Archimedes several centuries ago, is one of the physical principles that influences phenomena as complicated as climate, the formation of volcanoes and, most of all, the movement of the continents and oceans.


ACEITE
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ALCOH

"Journey to the Center of the Earth"

1.

You may have seen on television that to simulate a situation of «no gravity», astronauts float on an airplane that's in free fall. Astronauts who need to spend more time in that situation, perhaps repairing a space module, simulate it by being inside a pool. Try this experiment, which will help you understand why this is.

Materials

1 tall glass.

Water, alcohol, oil, honey, stone, wood, ice, silver (or any metal), cork, plastic.

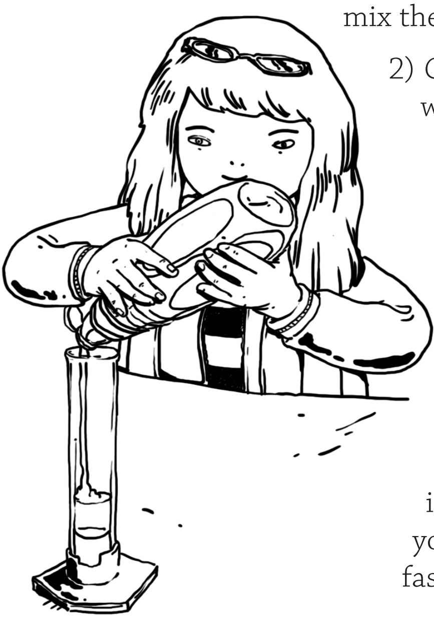
What to do

1) Pour the honey, water, oil and alcohol into the glass slowly, in that order, making sure you do not mix them.

2) Carefully add the solid materials (stone, wood, etc.) that you have found.

3) Test with other materials and try to guess if they will float and on which liquid it will happen.

4) Put all the solid materials into a glass that contains only water.



What happened?

Some materials sink while others float in certain liquids. If you only use water, you can also see that some materials sink faster than others.

What may go wrong?

If the liquids are mixed, you will not be able to see which is denser, since a different liquid will be formed.

Explain it

An object will sink or float in a glass of water depending on its density, that is, how much matter it has in a given space. In other words, how much mass it has per unit volume. A wooden ball of 10 cm in diameter weighs less than the 10 cm diameter ball of water it dislodges when it is submerged, but a 10 cm ball of lead weighs more: the wood floats and the lead sinks. The weight is the force with which the Earth attracts a body and it depends on its mass, while the density depends on its mass as well as its size. Consider a one-liter container: if you fill it with water it will weigh 1 kg; if you fill it with stones, it will weigh about twice as much; if you fill it with gold it will weigh about 20 times more, but if it has only air it will weigh 1000 times less than water (Table 1). Density is measured in g/cm^3, kg/m^3, kg/l. The average density of the Earth is 5.5 g/cm^3.

Returning to the case of astronauts, technicians simulate non-gravity by making the space module and the astronauts with all their equipment have a density equal to that of water; in that way, the effect of gravity will be nullified by the support of the water.

Examples in everyday life

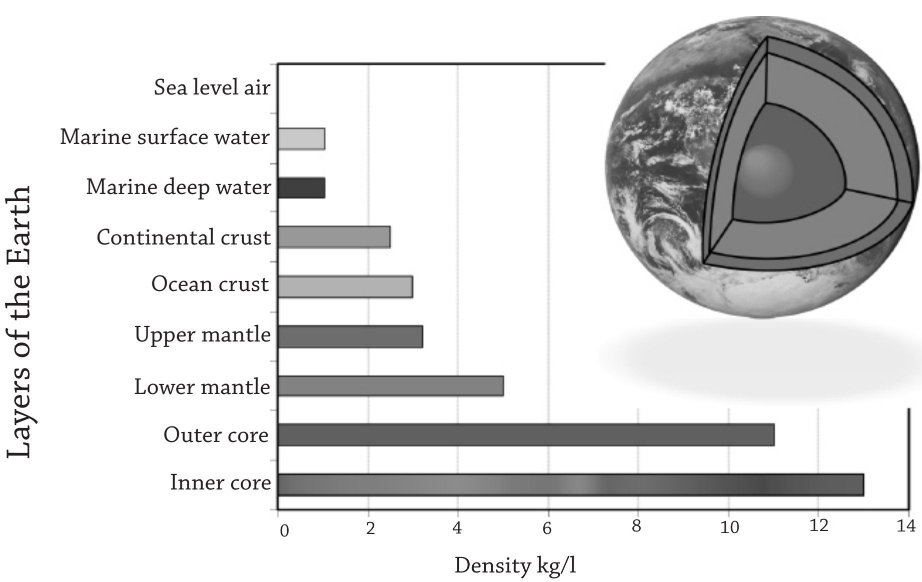
The layers separated by densities can be easily observed in both liquids and gases. For example, in chicken broth, there will be vegetables that float while the chicken sinks and steam rises. Learning about the density of gases is important to know, in the case of a leak, if it will accumulate near the floor or near the ceiling. For example, natural gas is lighter than air and will rise, while Liquefied Petroleum Gas (LP) is heavier than air and will settle close to the ground.

You may create your own column of densities and compare it to Table 1.

Observe it in Nature

Table 1. Density of common materials

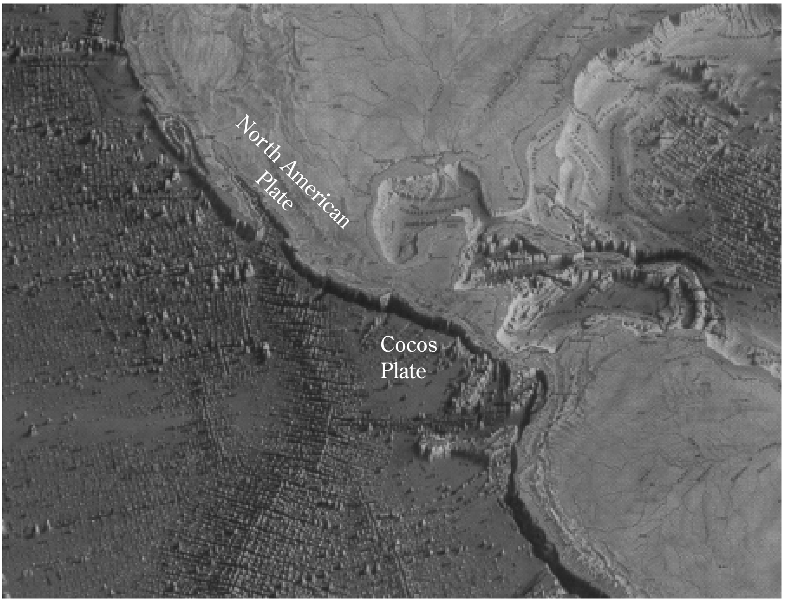
Substance	Medium density [g/cm³ or kg/l]	Substance	Medium density [g/cm³ or kg/l]
Platinum	21.4	Blood	1.6
Gold	19.3	Honey	1.42
Mercury	13.6	PVC	1.3
Lead	11.3	Sea water	1.03
Silver	10.5	Water	1
Steel	7.85	Rubber	0.95
Iron	7.8	Human body	0.95
Earth (planet)	5.5	Oil	0.92
Diamond	3.5	Ice	0.92
Basalt	3	Wood	0.9
Aluminum	2.7	Alcohol	0.78
Granite	2.7	Pumice stone	0.7
Reinforced concrete	2.5	Gasoline	0.68
Glass	2.5	Polyurethane	0.04
Coal	2.26	Air	0.0013
Graphite	2.2		



The Earth is composed of layers of different density. The lightest is, of course, the atmosphere; it is followed by the hydrosphere (seas and oceans), and the densest is the solid Earth. Each of these layers is also stratified by density. In the solid Earth the densest material is in the core; followed by the mantle, and the less dense part is in the crust. Note that there are two types of crust: the continental crust and the oceanic crust.

The shell of the Earth is broken into several rigid plates that are in constant motion floating on a plastic layer softened by the heat given off by the Earth's core. The collision between plates causes earthquakes and volcanic activity at their edges. When a plate with a continental crust collides with an oceanic one, the latter sinks under the former because the oceanic plate is denser. We have an example of this on the coast of the Pacific Ocean in southern Mexico: the Cocos plate, which is oceanic, is sinking under the North American plate, which is continental. The friction of these two plates has been generating many of the earthquakes that are felt in the center and south of Mexico and also the volcanic activity in the center of Mexico. An example of plates that are actually separating occurs in the Gulf of Cortés, where the Baja California peninsula is being detached from mainland Mexico. The Baja California peninsula moves north-northwest at a speed of 3 cm per year, which means that in 20 million years, Baja California will be in front of the Pacific coast of the United States.

Air always tries to escape upwards while water always flows down.



2. "Underwater without getting wet"

Materials

A bucket or a big cup

1 small cup

1 piece of paper

What to do

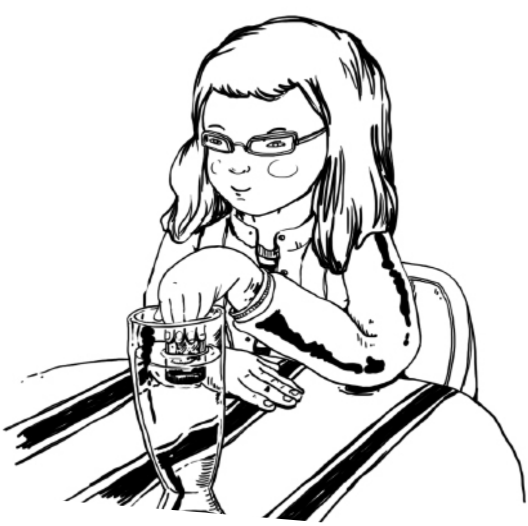
1) Put the piece of paper in the small glass by crumpling it and pressing it into the bottom.

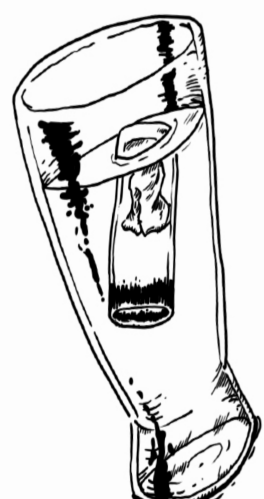
2) Dip the cup (with the paper) face down into the bucket until it is completely submerged in the water.

3) Take the glass out of the water.

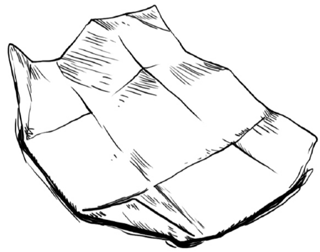
What happened?

The piece of paper you put inside the small glass comes out completely dry.





What may go wrong



If the glass does not enter the water vertically, the air may be able to get out of the cup and the piece of paper will get wet. The cup can easily turn over if it is not held firmly.

Explain it

The air that is inside the glass is immersed in the water along with the paper. It tries to escape upwards but the base of the small glass prevents it. The air compresses against the bottom of the glass and prevents the water from rising and getting the paper wet.

The pressure inside a liquid acts with the same intensity in all directions. The air rises because, being much lighter than water, it takes the path to where the size of the water column is smaller, that is, upwards.

In experiment 1, you may have noticed that the materials rise and sink at different speeds. We have read that a body's free-fall speed in a vacuum is independent of its weight, shape and density. You may have seen when an astronaut dropped a hammer and a feather on the Moon, which has no atmosphere, and both fell at the same time. However, in a fluid such as air or water, the free-fall speed depends on the contrast of densities between the body and the fluid, the shape of the object, and the viscosity of the fluid. Try dropping crumpled paper and stretched paper at the same time.

Viscosity is a measure of a fluid's resistance to flow. A dense fluid is not necessarily more viscous. For example, oil is less dense but more viscous than water.

The place that a solid, liquid or gaseous material occupies within a fluid depends on a balance of forces. Imagine that you push a ball to the bottom of a pool. You know that the ball has weight because it is attracted by the Earth; it «falls» when it is out of the water. However, in the pool you can feel that there is a force that pushes it upwards, this is buoyancy and it depends on the difference in densities. Now, imagine you submerge it in car oil. In that case, it also rises, but the speed at which it rises will not be as fast as in water, because oil viscosity is greater and exerts a greater resistance to movement.

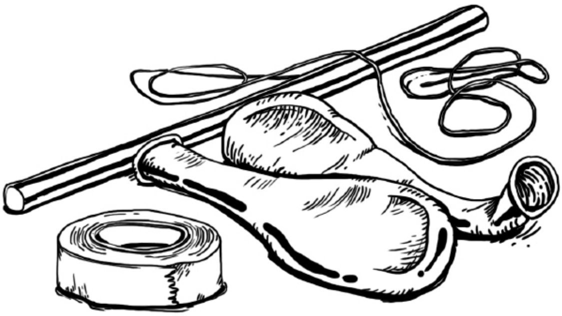
Examples in everyday life

Note that the speed at which air bubbles move in a bottle of shampoo and in one with water is very different; the more viscous liquid does not allow the rapid movement of the bubbles. Also, note that it is harder to get the more viscous materials out of bottles; for example, it is much more difficult to pour tomato sauce (ketchup) than vinegar.

Observe it in Nature

One may think that there is mainly solid rock inside the Earth. However, the study of the speed and trajectory of the waves generated by earthquakes has shown that there are areas where the rock is melted. In the upper part of the mantle, between 100 km and 200 km deep, the rock is near its melting point. We call it 'magma' in the few places where the rock is already molten inside the Earth. We call it 'lava' when the rock is molten and it comes onto the surface of the Earth. We can see lava coming out of a volcano, but gases are released too. Most of the gases inside the Earth are kept in 'magmatic chambers', and are released by 1) the decompression of magma (like a soft drink degasses when the bottle is opened), 2) the interaction of the magma with an aquifer (imagine hot rock in contact with water), or 3) by the reaction between two magmas of different composition. Explosive eruptions, that is, with many gases, are much more dangerous than lava eruptions. In Mexico, explosive eruptions have occurred in the Chichón volcano, the Nevado de Toluca, the Fuego volcano in Colima, the Pico de Orizaba and the Popocatépetl.

3. "Changing air"



Materials

1 straw
a piece of thread
3 balloons
some adhesive tape

What to do

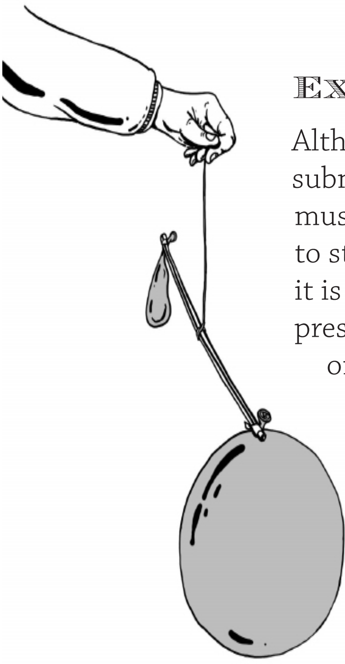
1) Build a weighing scale by tying a thread in the middle of the straw.

2) At the ends of the straw, hang the balloons with the adhesive tape in such a way that your scale is balanced.

3) Change one of the deflated balloons to an inflated one.

Watch

The scale is tilted to where the inflated balloon is. That shows that it weighs more than the deflated one.



Explain it

Although the two balloons contain air and are submerged in air, to inflate the balloon, you must overcome the resistance of the rubber to stretch.What you do when you inflate it is increase the amount of air so that its pressure manages to overcome the resistance of the balloon rubber. That is why the density of the air inside the inflated balloon is greater than the density of the air that is outside. As you can see, although density is a property of the material, it can vary.

For gases, the density increases with pressure, because when the gases compressed, the amount of matter per volume unit increases. The opposite happens with temperature: at higher temperature the molecules separate and there is less matter per volume unit. Liquids cannot be compressed, because they only change their density when the temperature changes, whereas solids may eliminate holes or even change their molecular structure and become another solid with different properties if pressure increases. For example, diamond and graphite are made only of carbon atoms.

Examples in everyday life

Maybe you've heard that people get «altitude sickness.» This happens because the body is used to inhaling a certain amount of oxygen with each breath. When you climb a mountain, where the air has less oxygen, your body reacts in a number of different ways: general discomfort, headaches, breathing problems, etc. Athletes who train in the mountains condition their body to work with little oxygen. Then they will have plenty of oxygen when competing in low areas with higher air density and their performance will increase.

Observe it in Nature

Air density in the atmosphere depends on the temperature and the pressure. The temperature at ground level is higher, since the sun's rays pass through the transparent air and they heat the ground, which in turn heats the air. Thus, temperature decreases from sea level upwards. The temperature at the height at which aircrafts fly is about -50 °C. The atmospheric pressure in an area is caused by the weight of the column of air that it supports. At higher altitudes, for example in the mountains, this column is smaller; it weighs less and so the air column produces lower atmospheric pressure.

"When heat leaves" 4.

Have you noticed that a fire's flames always go up?

Do you know why that happens?

Materials

1 candle

1 match

1 adult to monitor

What to do

1) Light the candle and leave the match on top of the flame.

2) Turn off the candle without extinguishing the match. Leave the match on top of the candle.

What happened?

The candle comes back on even if the match is not in contact with it.

What may go wrong

The candle will not fire up again if the steam of the wax does not reach the flame of the match.

Explain it

For a candle to ignite, the heat of the match must melt the wax, have the melted wax rise through the wick and evaporate. At that moment, when it comes in contact with the oxygen in the air, the fire is ignited. When a gas is heated, like that of evaporated wax, its molecules move faster and need more space between them. Therefore, the same amount of matter takes up more volume and it becomes less dense than room-temperature air. Consequently, it moves upwards. In the experiment, the column of evaporated wax reaches the match and then the candle is lit again.

Examples in everyday life

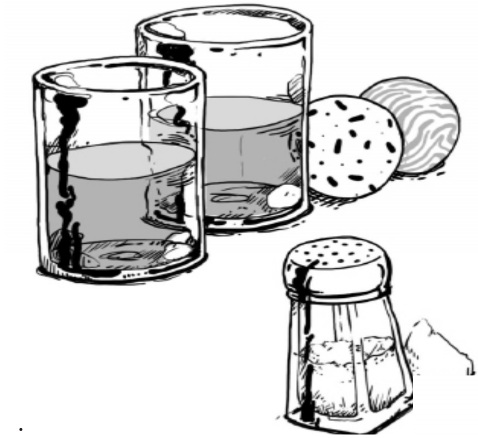
Now that you know that hot air tends to rise, you can improve the microclimate in your home. When it is very cold, isolate the room with the highest ceiling or, the one with an air outlet above.

Observe it in Nature

Heat can be transmitted in three ways: 1. by conduction (like when you touch a hot car), 2. by convection (like water heated on a stove) and, 3. by radiation (like sunshine on a sunny day). Convection takes place through a fluid in motion. You can see this phenomenon by boiling water in a pot with black pepper seeds (you may observe it better if the bottom of the pot is a lighter color). There are two types of convection: natural and induced or forced. The natural one is when you heat water. The forced one is when you stir hot coffee with a spoon. For there to be heat transmission by convection, two conditions need to be met: 1. a variation of temperature (which causes the density of the fluid to change) and, 2. the resistance of the fluid to movement is overcome. On the one hand, the cooler fluid goes down (because it is denser and therefore more attracted by gravity). On the other hand, a warmer fluid is lighter and rises. When it does, it expands because it is under less pressure, it cools and so the cycle continues. Convection, along with the Earth's rotation, largely regulate the movement of air in the atmosphere generating atmospheric currents that then control the climate.

5. "Life is lighter in the sea"

Have you noticed that weight and density are different things?



Materials

2 glasses of water

2 eggs (or lemons or plastic balls)

some salt

What to do

1) Add salt to one of the glasses and stir until it can no longer be dissolved.

2) Put an egg into each glass.

Watch

The egg floats in the salt water, while it sinks in the glass with plain water.

Explain it

The density of an egg is a little greater than that of pure water. When salt is added to the water, its density increases and becomes higher than that of an egg.

What may go wrong

You may not have added enough salt to increase the density of the water beyond that of the egg. The eggs, lemons or plastic balls have to be slightly denser than water.

Examples in everyday life

A human's body density is a little lower than that of water (it is not odd since our body contains 75 % water). That is why we can float in a pool. You can modify the density of your body by inhaling or exhaling air from your lungs. Due to the fact that sea water is denser, you can float in the sea more easily than in a pool.

Observe it in Nature

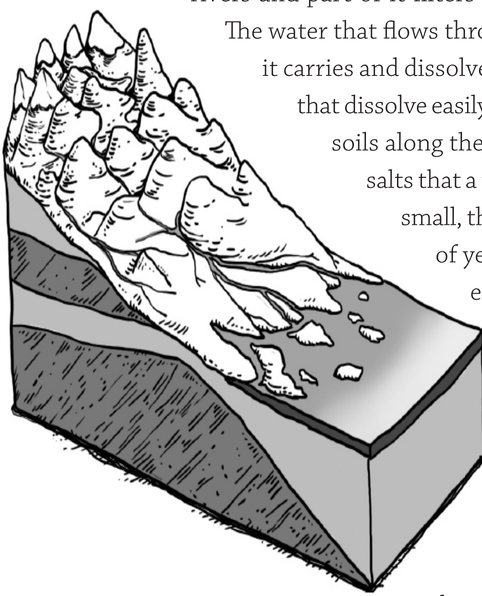
The density of sea water depends on its temperature and the amount of solids (salts) dissolved in it. In general, the density of seawater is between 1.025 to 1.028 kg/liter (which is equal to g/cm^3) and contains about 3.5 % salt. At high latitudes, near the poles, seawater density is greater than that near the equator.

Water has a very different behavior compared to that of other materials. When the temperature drops, water volume increases considerably. Therefore, if we put an ice cube into a press and increase the pressure keeping the temperature constant (freezing), the cube starts to melt, even when the temperature of the room where the experiment takes place is below 0 °C Thus, we know that the density of water changes with temperature. Its maximum density is at 4 °C, where it reaches its characteristic value of 1kg/liter at atmospheric pressure. This feature has allowed life in the lakes of cold countries. The temperature of the lake water decreases throughout the winter; when the water reaches its maximum density at 4 °C, it sinks. Then, the hotter and less dense water moves upwards from the bottom. When it gets in contact with the air, it cools down to 4 °C and sinks again.

Only until all the water in the lake is at 4 °C can the surface water further lower its temperature. When it reaches 0 °C, it gets frozen. Nonetheless, water below the frozen surface is still liquid and full of life. If all the lake water reached 0 °C and got completely frozen, underwater life would end. Happily, spring arrives and water melting begins. Lakes' underwater life has been preserved thanks to the fact that water reaches its maximum density at 4 °C, and not at 0 ºC.

Oceans have a great capacity to transmit heat and therefore have as big of an effect on climate as the atmosphere. Thanks to the California current, which goes from Alaska to Ecuador, the climate at Ensenada is milder than that at Mexicali, even though both cities are located almost at the same latitude and at an altitude close to sea level. But let us focus on a distinctive feature of all seas: salinity.

It is said that river water is «sweet» while that of the ocean is «salty». Where does that difference come from? When sea water evaporates or freezes, it does so without its salts. The evaporated water precipitates as rain in the sea and on the continents; part of this water runs through the rivers and part of it filters through and forms aquifers. The water that flows through the rivers is fresh water, it carries and dissolves salts (chemical compounds that dissolve easily in the water) of the rocks and soils along the long journey. The amount of salts that a river carries in its route is very small, that is why it has taken millions of years for oceans to concentrate enough salt to make it salty. Sodium chloride (chemical composition of table salt) is the main component of dissolved solids in seawater.



Calcium is among the substances that are dissolved by the running water of rivers that reach the sea. When in contact with carbon dioxide, calcium forms a compound that precipitates on the seabed. When it gets accumulated and consolidated, it forms a rock called 'limestone'.

Marine sedimentary rocks are formed when the solids carried by the rivers rain over an area These are the main component of the Sierra Madre Oriental. When one observes these rocks, it is not difficult to imagine that this area must have been submerged under the sea for many years (close to 100 million years), and that long ago (more than 60 million years ago) it surfaced thanks to the thrust of tectonic plates.

"Drowning in a glass of water"

6.

Have you noticed that ships float even if they are made of iron?

Materials

1 glass of water

some coins.

1 marker

1 little plastic cup

Adhesive tape (masking tape)

What to do

1) Stick a piece of masking tape vertically on the glass and mark the water level.

2) Put several coins in the cup and put it into the glass of water simulating a small boat. There should only be a few coins so that it can still float. Mark the new water level.

3) Toss the coins into the water and leave the cup on the water. Measure the level again.

Variations

Mark the water level in a glass. Put an ice cube into it and compare the new water level.

Wait until it melts and measure again.

What happened

The little cup sinks gradually as you add coins.

The water level is lower when the coins are in the bottom than when they were inside the cup.

The water level remains the same when the ice cube floats and when it gets melted.

Explain it

The cup with coins and air is lighter than the water in the glass, so it floats. The coins are much denser than water, so they sink. The volume of water they displace is exactly the same as the volume of the coins. When you put the boat (cup) with the coins inside the water glass, you can see that the displaced water volume is greater than when you put only the coins in the glass. This is because the weight of the displaced water is equal to the weight of the coins and the air inside the cup. The total density of your boat is less than the density of the coins alone, because the volume of the cup is larger. Therefore, with the same weight it occupies a greater volume.

Examples in everyday life

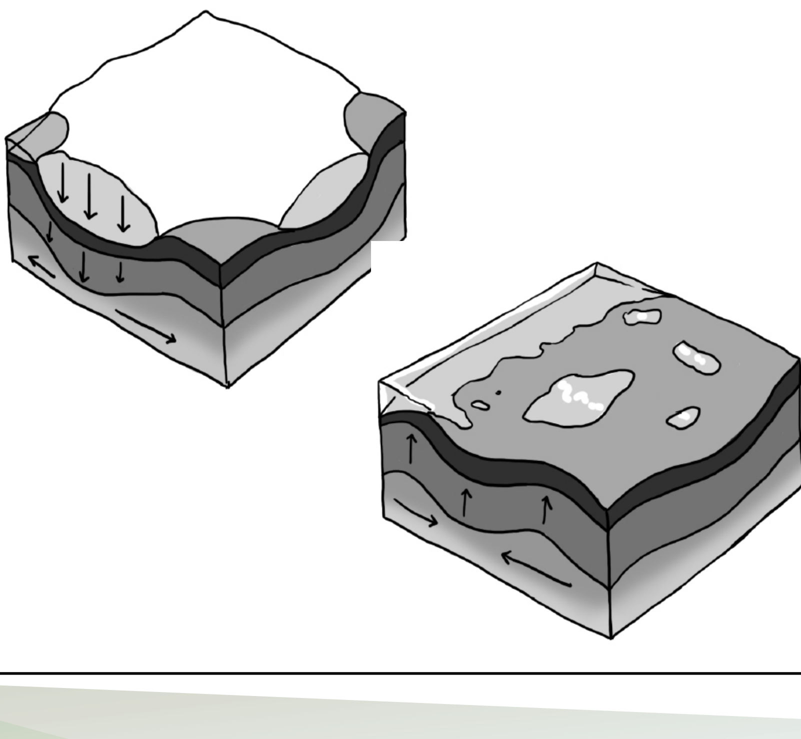
In real life, ships float, even when they are made of metal, because their total density is lower than that of the water. Consider that the density of a ship is obtained by dividing the amount of mass (or weight) contained in the ship (including the hull, furniture, people, and especially the air) between the volume.

Observe it in Nature

We have heard about the problems that global warming would bring by melting the polar ice caps. Let us analyze this. In the North Pole, huge ice masses are in the sea water of the Arctic Ocean. If all that ice melted, the sea level would not change, as you yourself proved in the experiment. At the south pole, the ice is on a continent known as Antarctica. If that ice melts, it will not only increase the water supply to the oceans and raise the sea level, but it will also make Antarctica, by freeing itself of the weight of the ice, rise. Did you know that it has been verified that the Scandinavian Peninsula has risen at least 30 cm in the last 150 years? Why is that happening?

The simplest explanation is that during the last ice age the lands near the poles were covered by a layer of ice several kilometers thick and now that we are in an interglacial stage, it has melted. The peninsula has lost its ice sheet, so its weight has decreased.

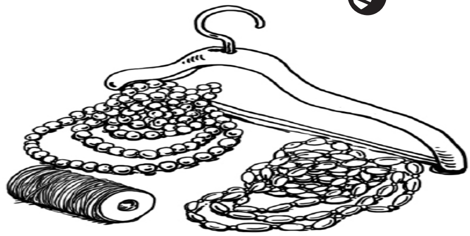
The fact that the Scandinavian Peninsula has risen after losing weight can be seen as evidence that it is located on a solid -but "fluid" layer- that is denser than the peninsula itself. The study of the speed of the waves that are generated during earthquakes has proved this hypothesis. Moreover, it has also been proven that the continents and oceans lie on such a layer as well. This fluid layer is known as 'asthenosphere' and it is denser and less viscous than the Earth's crust.



7.

"What weighs more?"

A kilo of gold or a kilo of silver?
How about underwater?



Materials

1 hook

some thread

2 necklaces or beaded strings made of different materials: glass beads, silver beads, shells, etc. You may make them, just be careful to have each weigh the same as the other. To do so, you may add or take away some beads.

2 big containers with the same amount of water.

What to do

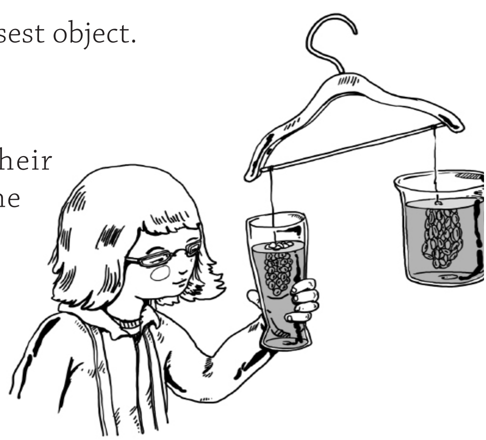
1) Hang a necklace or a string at each end of the hook. The hook will serve as a low precision weighing scale. It has to be even.

2) Place the two containers with water under the necklaces in such a way that they are suspended.

What happened?

The scale will lean towards the densest object.

Explain it



Objects under water decrease their weight by an amount equal to the weight of the displaced water. In this way, if we have two materials with different density but equal weight, the densest one will have less volume and will displace less amount of water. In this case, the scale will indicate that under the water the denser object weighs more. If, for example, we put on our scale a necklace of 2 g of gold that occupies very little space, and on the other side a necklace made of hollow beads, it is easy to imagine that the latter will float and, therefore, our balance will tilt towards the gold necklace.

Examples in everyday life

There is a story about Hiero, governor of Syracuse, Sicily, in the year 250 B.C. Hiero asked his cousin Archimedes, the wisest man in town, if he could tell whether his goldsmith had cheated him by using a piece of silver instead of gold in the crown. Hiero had given him some gold coins which weighed the same as the crown, but the governor was not sure if the goldsmith had used all the gold, or substituted some for silver. How could he be sure? Archimedes considered the matter, it seemed possible that part of the gold could actually have been substituted with some silver. One day, when Archimedes entered the bathtub, he realized that his body weighed less under water and that the water level rose an amount equal the volume of his body. Then, he thought that gold, being so dense, should occupy a small volume, but the same weight of silver would occupy almost twice the volume. He could not measure the difference in volume but he could weigh the displaced water. So, with a scale similar to your hook, he put on one side the same amount of gold Hiero had given to the goldsmith and, on the other, the crown. If the scale was level, the crown was made entirely of gold; if it leaned to the side with the coins, Hiero had been swindled. Fortunately for the goldsmith, the scale was balanced and Archimedes could assure that the crown was made of pure gold.

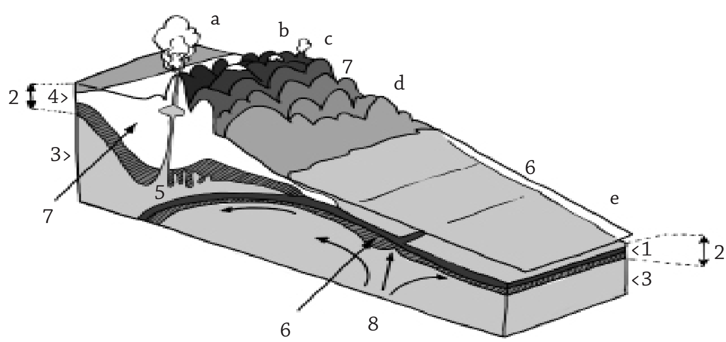
Since then, the Archimedes Principle has been widely accepted: «When a body is partially or totally submerged in a fluid, a force of thrust works on the body. That force has an upward direction and its magnitude is equal to the weight of the fluid that has been dislodged by the body.» With this experiment, Archimedes proved that a kilo of gold or a kilo of silver do not weigh the same when they are under water. Gold weighs 0.948 kilos* while silver weighs 0.9047 kilos.

*Note: In daily language we measure weight in «kilos» and it is expressed by the number in a scale. In technical language, the weight must be in units of force (kilogram force or gram force).

Observe it in Nature
Earth and its different layers

The solid Earth has been divided into layers in two ways. By composition: crust, mantle and core and by mechanical behavior: lithosphere (includes crust and part of the upper mantle), asthenosphere (upper mantle), lower mantle, liquid core, solid core. The second classification has been very useful to explain the movements of the rigid plates (lithosphere) on a «fluid» layer (asthenosphere).

The oceanic crust is formed by mantle material that comes to the surface. The continental crust is also formed by mantle rocks but it has undergone various geological processes such as volcanism, intrusion, metamorphism, erosion, consolidation of particles, etc. These processes have made the rocks of the continental crust lighter. Thus, the continental crust is less dense than the oceanic one while its thickness (between 35 and 45 km) is much larger. The fact that the oceanic crust is, on average, 3800 meters below sea level, and that the continental crust is on average 850 meters above this level, has been explained by a phenomenon known as 'isostasy' which is based on the Archimedes principle.



1_Ocean crust
2_Lithosphere
3_Athenosphere
4_Continental crust
5_Magma generation zone
6_Cocos Plate
7_North American Plate
8_Ocean crust generation zone

a_Gulf of Mexico
b_Sierra Madre Oriental
c_Transmexican Volcanic Belt
d_Sierra Madre del Sur
e_Pacific Ocean

Earth's internal heat

We know that, at a certain temperature, each substance changes its state: from solid to liquid and, from liquid to gas (although there are some odd materials that are transformed directly from solid to gas, such as naphthalene). Pressure makes the difference in these changes: at higher pressure, a substance needs more temperature to change state. The best-known example is that of water: at sea level, it boils at a higher temperature than in Mexico City. That is why soups in Puerto Vallarta (sea level) are hotter than in Toluca (2680 meters above sea level). Something similar happens in the interior of the Earth.

The temperature of the Earth's crust is only partly due to sunlight. We know this because of the warm temperature at deep places such as mine shafts, or the heat from vents, thermal waters and the boiling melted rock coming out from volcanoes. The temperature inside the crust increases at an average of 30 °C per kilometer of depth. It is possible for the temperature to reach 50 °C inside a mine shaft. The pressure also increases as it is directly proportional to the depth.

The outer heat of the Earth comes from solar radiation and the internal heat is due to several causes. During the origin of the Earth, its heat was increased by the addition of material that floated in space. Later, the heat increased due to the impact of large meteorites. Nowadays, the decomposition of radioactive isotopes generates heat. Although the cooling of the Earth in contact with the sideral cold is inevitable, within it there is also heat transfer to its surface, which occurs by conduction, and mainly by convection.

Effects of internal heat on the surface of the Earth

In the asthenosphere, rocks no longer behave as solids but as a fluid of high viscosity and high density. This is due to the pressures and high temperatures. The viscosity of the asthenosphere is very high (although much less than that of the crust), so it allows movement, but this happens along periods of time of thousands or millions of years. Isostasy is the state of gravitational equilibrium in which the lithosphere is floating above the asthenosphere, according to the Archimedes principle. When the weight in the continent increases due to the accumulation of sediments or ice, the lithosphere sinks. If the weight decreases, due to melting or erosion, the lithosphere rises.

The lithosphere is made up of a series of rigid plates. The asthenosphere, like the atmosphere and the hydrosphere, allows the transmission of heat through a «fluid» thus generating currents of convection. Due to the high viscosity of the asthenosphere materials, the movement is very slow, to the tune of a few centimeters per year. This movement of convection in the asthenosphere is the cause of many phenomena of plate tectonics. In Mexico, the movement to the northeast of the Cocos plate, located on the southwest coast, causes it to sink under the North American plate in a process known as subduction. In the Gulf of California, an upward current and a weakening of the lithosphere allow the mantle to emerge in the form of magma, generating new oceanic crust and the expansion of the ocean floor beneath the Sea of Cortez. Further north of the Baja California peninsula there is a lateral movement between two plates along the San Andreas fault.

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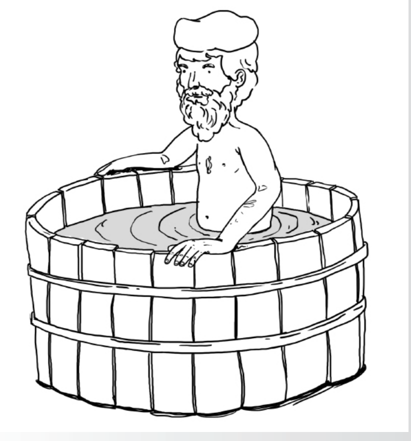

ARCHIMEDES´ discovery in the bathtub has helped explain many phenomena that occur on Earth, such as climate (winds and sea currents), magmatic ascent (volcanism) and plate tectonics (thermal convection in the asthenosphere), among others.

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ABOUT THE AUTHORS

Susana A. Alaniz Álvarez

She is a senior researcher at the Geosciences Center of the National Autonomous University of Mexico (UNAM). She obtained a Ph.D. in Earth Sciences in 1996. She is a member of the Mexican Science Academy and an Academic member of the Engineering Academy. She has written more than 67 scientific articles on the deformation of the upper crust and its relationship with volcanism. She belongs to the National System of Researchers where she has reached level III. She offers a course on Structural Geology at the postgraduate level of Earth Sciences of the UNAM. She was editor in chief of the Mexican Journal of Geological Sciences. In 2004, she was awarded with the Juana Ramírez de Asbaje Prize by the UNAM.

Ángel F. Nieto Samaniego

He is a Doctor in Geophysics by the National Autonomous University of Mexico. He is a graduate professor and member of the Mexican Academy of Sciences. He was president of the Geological Society of Mexico, editor of the commemorative centennial volume for that Society and a member of the editorial board of several national and international magazines. He has published 75 articles on the theory of fracture mechanics and about the Cenozoic deformation on Mexico. Currently, he is a researcher at Geosciences Center of the UNAM in Juriquilla, Querétaro.

LUIS DAVID MORÁN TORRES

He was born in Mexico City in 1984. He studied graphic design and graduated in 2009 at the University of the Valley of Mexico. He has illustrated many books on science dissemination for the Geosciences Center of the UNAM, and participated in various museographic and cultural projects for the State Government of Queretaro. He has participated in collective exhibitions both in Mexico and Sweden. In 2012, he had an arts internship at the Cité des Arts in Paris, France. Currently, he works as a free-lance painter and illustrator at Queretaro city.

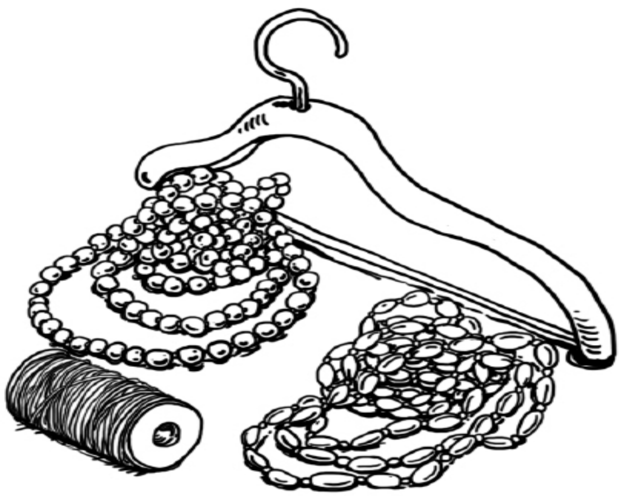
About the translators

Yadira A. Hernández Pérez

She obtained her PhD in Linguistics from UNAM. She is a full-time professor at UNAM. She is currently teaching at high school 5 ¨José Vasconcelos¨ from the UNAM. She has published articles and chapters in books on Psycholinguistics related to foreign languages acquistion. She has taught CLIL courses to students for more than ten years. She has presented academic lectures on the Content Language Integrated Learning approach to teachers. She is responsible for the PAPIME Project PE400216 ¨Foreign languages and science dissemination¨. For the last three years, she has collaborated in the coordination of the translation of the series ¨Simple experiments to understand a complicated Earth¨ to German, French, English and Italian. She was awarded the ¨Alfonso Caso¨ medal by UNAM in 2012.

H. Federico Cruz

Has been studying English since elementary school, having lived in Cincinnati, Ohio for more than 6 years, and has not stopped since. He frequently collaborates with University researchers, revising English work for journal publications and has written popular science articles for online publications. He studied Mathematics at the UNAM, with a focus on Agent Based Modelling. He currently lives and works in Mexico City.



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The collection of booklets entitled 'Easy experiments to understand a complicated Earth' is based on the list of the most beautiful experiments published by Physics World magazine in September 2002. These experiments were chosen for their simplicity, elegance and the transformation they caused in the scientific thought of their time.
Each issue of this collection is dedicated to one of those experiments. Our purpose is to help you understand, through experimentation, phenomena that occur both in our daily lives and on our planet.

This booklet is dedicated to Archimedes' experiment on buoyancy.

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