ICE

the cool form of water

In the natural world, there is no other element as important as water. Water is the basis for all life. Water is both simple and complex. It has the ability to create landscapes, transform from a liquid to a gas, or even become a solid.

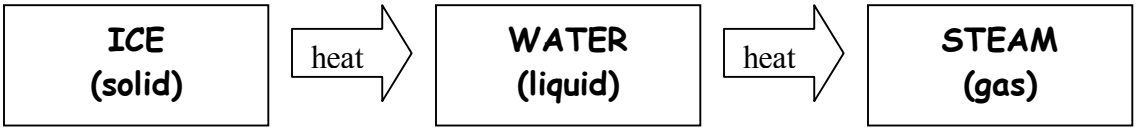
With over 70% of the earth being covered in water, water seems like a resource that is dependable and ever-present. However, for humans there is a limited amount of usable water. Think about how much of the water is salt water. Since it is such an important resource, we need to be able to recognize it in its various forms and how water shapes our lives and our natural environment.

Forms of Water

As you may already know water can take the form of a gas, solid, or liquid. Water is the only natural substance on earth that can be found in all three states (solid, liquid, gas).

So how does water change its form? The answer is temperature change. How is water changed into ice? Remove the heat. How do you create steam? Add heat. You probably already know the answers to these questions, but are you aware of the processes that go on in order for water to change its form?

Basically anytime heat is removed or added to water, it will change the density of the water. The molecular structure of the water determines its density. As water freezes the molecules become more tightly packed together. As water is turned into steam, the water molecules spread out. Yet, unlike most elements, water actually becomes less dense as a solid. Water's composition will still be the same, H2O.



Types of Ice

The type of ice formed is dependent on the type of water that has been frozen. Ice that has been made from sea water behaves and looks differently than rain water that has frozen. At first glance, all ice is basically the same. It is a solid. It has the same chemical composition as water. However there are three basic types of ice, all with unique sets of behaviors and all impact the earth differently.

Sea Ice

Sea ice, or pack ice, is basically what you think it would be. It's frozen salt water. Sea ice is most prevalent near the northern (Arctic) and southern (Antarctica) Polar regions. Sea ice forms a boundary between warmer ocean temperatures and the cooler atmosphere.

Sea water has salt molecules in it as well. The salt molecules do not change their density as heat is removed or added, like the molecules of water. What happens to water molecules as water freezes? They pack together very tightly to become a solid. However when the become packed together, they squeeze all of the salt molecules out of the ice.

So, do you think that sea ice is safe to drink? The answer is yes. Because there isn't much room for the salt molecules to be trapped within the ice, the molecular change that occurs during ice formation acts like a molecular water filter. Sea ice is basically de-salinized water that's been frozen.

Sea is also more thin and fragile than you might think at first. When sea ice first forms it's very smooth. Think of a really big ice cube. During its first season of formation, sea ice can vary in thickness anywhere from 18" to 3'. As the sea ice is exposed to winds and precipitation, the ice becomes marked and rough. Ridges also develop on sea ice, due to constant compression and pressure. Ridges vary in thickness.

Sea ice is generally broken up into floes. A floe is any contiguous piece of sea ice. Floes can vary in size from a few meters to 20 or more kilometers. Floes less than 20 meters across are called cakes. Cakes will eventually become floes as they join together.

Once sea ice has survived a few consecutive winters, it becomes rougher and thicker. Sea ice can grow to be 3-5 meters thick in only two years. You would imagine that an ice floe that's a 20 kilometers wide and 6 feet thick would be really heavy. It is, but it still floats. This is because the ice is less dense than the water it floats in. Second-year ice also continues to grow. It grows thicker and stands higher out of the water.

Sea ice is an excellent index to measure the effects of global warming. As green house gasses are emitted into the atmosphere, the average temperature of the Arctic region is rising at a rate of 1.9ºC per decade. The increase in temperature is causing the formation of sea ice to decline in average thickness, weaken, and in some cases stop entirely.

If Arctic sea ice continues to decline, not only will it affect wildlife, but will alter the whole earth's climate

Since the 1960s researchers have noticed a 40% decline in the thickness of the perennial Artic sea ice. The thinning of sea ice can have drastic impacts on the Arctic ecosystem as a whole. Since the Arctic ecosystem acts as a thermostat for the world's oceans, should the Artic region warm the world's oceans will also become warmer. Plants and animals in the ocean are very vulnerable to temperature changes, and could die as a result.

Glaciers

Glaciers are made up of frozen snow that over a few hundred years has been compacted to create large, thick ice sheets. They can be found on every continent. Glaciers are really interesting because they have the ability to move on their own. Acting essentially like very slow moving rivers, glaciers can carve out a landscape and transport and transform all of the geological material it comes in contact with.

Roughly 10% of the earth is covered by glaciers today. Most glaciers can be found in the Polar Regions of the Arctic and Antarctica.

When I think of glaciers I think of huge, icy bulldozers. Glaciers have the ability to race forward or retreat, given the climate of the region where the glacier is located. Even though most glaciers move tremendously slowly, some glaciers can move over the land at amazing speeds (up to 10 meters per day!). Just think about moving a piece of ice the size of a giant skyscraper 10 meters per day. It would take a tremendous amount of energy.

Glaciers move like slow moving rivers

So how do glaciers move? The answer is simple: gravity. The glacier's immense size has quite a bit to do with its movement as well. When glaciers are growing, the pressure on the bottom of the glacier caused by the weight of the ice above and the friction of the earth's surface causes the lower layers to turn into a softer ice. I like to think of it as a gel. As the weight of the glacier is compressed upon itself, the glacier rolls and tumbles over anything in its way. It's sort of like a sticky ball that picks up dirt and dust when rolled over a carpet.

When glaciers move down mountains or valleys, they can alter the landscape, form rivers and lakes, and deposit sediment.

There are several types of glaciers. Ice shelves, ice sheets, and ice caps, and ice fields are all different types of glaciers that are found in the Artcic and Antartica. Mountain glaciers, piedmont glaciers, and valley glaciers are found often flowing out of ice fields in

the Himalayas, Andes, Canadian and Colorado Rockies. Since each type of glacier has a specific region, each glacier has a special purpose and result.

Glaciers have been used by people for a variety of purposes. Today, people visit Alaska, the Alps, and Antarctica for a chance to see glaciers in action. In parts of Asia and South America, people also rely on glaciers to provide fresh drinking water and to irrigate crops, and provide hydroelectric power.

In addition to moving and shaping the land, glaciers also affect the world's oceans. When a glacier moves into the sea, the ocean warms the ice and causes large parts of the glacier to break off, or calve, and form icebergs that float off into the sea. The majority of an iceberg's mass is below the water's surface, and they can be enormous. Icebergs have measured to equal the size of Rhode Island or even the size of Belgium.

As the average global temperature rises, more and more icebergs are calving from the polar icecaps. What do you think are some of the potential environmental consequences of this?

Icebergs eventually melt, re-supplying the ocean with water. Icebergs are amazing, and scientists have studied them in great detail. Because icebergs float, they go wherever the winds and tides take them.

Freshwater Ice

Lake Ice

We all know that when the temperature dips below 32ºF (0ºC), water freezes. During the winter months in the boreal forest, every body of water freezes. But the process of freezing is more intricate than meets the eye.

During the summer months, when temperatures are highest, the coldest water of the lakes is at the bottom. Just think of when you swim in a lake and dive a few feet below the surface. The temperature quickly gets colder. However, as fall approaches and the air temperature begins to drop regularly, the surface temperature of the lake begins to near 39.2ºF. It is at 39.2ºF that water reaches its maximum density, causing the surface water to sink because it is more dense than the water below. Thus the water that was once the surface water, ends up on the bottom of the lake.

The water that was below the surface during the summer months is now on top of the lake, and becomes even cooler. Once the water reaches 32ºF, it freezes over in a sheet of solid ice.

As lakes freeze, their ice expands. When the ice expands it buckles and bends, creating cracks and pressure ridges. Cold air temperatures, without snow fall, make ice rapidly. During that time, the ice begins to groan and shriek loudly. It's an amazingly haunting noise to hear ice forming.

Often during winter travel, we come to an area of open water or thin ice. Even though the air temperature might be well below freezing, there might not be ice covering sections of rivers or streams.

How could ice get melted if the temperature doesn't get higher than 15ºF all day? The answer is pressure. If it begins to snow heavily, the pressure from the accumulated snow piles up on top of the ice and creates downward pressure. The downward pressure causes the ice to bend down toward the water below the ice.

Since the unfrozen water beneath the ice's surface is warmer, it causes the ice to melt. The snow above the ice's surface acts as an insulator and causes the ice to melt or get softer, just like the bottom of a glacier.

River Ice

Rivers are always changing. Rivers change levels with the season, and those levels are dependant on precipitation and run off. During the winter, rivers shrink in volume because all the precipitation that falls freezes and cannot be transported in the form of run-off.

Because the river is always changing, river ice is a little more complex than lake ice. The river's current may keep the river's water un-frozen. If the current is strong enough, the river will stay open all winter long. Also if the water is flowing just beneath the ice's surface, the friction caused by the running water will melt the ice or keep it thinner than other sections.

River's current's change from region to region. In areas that the river's current in faster, ice is more reluctant to form.

Also when rivers are deposited into lakes, the water temperature ranges from 39ºF to 33ºF, thus making it more difficult for ice to form.

Travel on Ice

Lakes and rivers with more than one inch of uniform ice will hold a person. Ice conditions are rarely similar from day to day, though, because of temperature change and snow fall. This makes winter travel a bit more interesting.

Imagine you're pulling your toboggan on a nice clear, cold day and you come to an area of open water. Of course you wouldn't want to get wet, so you need to find out how to make your way around the open water.

The open water in a particular section of river is referred to as a lead. Leads can pose problems for winter travelers because each lead brings with it a new set of circumstances.

Usually when we encounter a lead we have to figure out a way around it. Usually we can skirt the edge of the river or stay close o the lead because the surrounding ice is safe for travel.

However, if there is a sizable stretch of open water, we may need to look to the shoreline to provide safe passage. Blazing a trail through the boreal forest's dense flora and fauna can be quite difficult. The snow gets deep, dogs get tangled, adventure guides get frustrated, and travel becomes slow and laborious.

Yet, it's all worth it. The bounty of the boreal forest in the winter provides for amazing sights and natural phenomena.

Activities for the Classroom

Discover how water transforms

Objective: Students will gain a greater understanding of the water cycle and its ability to transform its state. Students will learn about key concepts such as evaporation, sublimation, and condensation. Students will learn and apply concepts that describe properties of matter. Students will learn and describe properties of solids and liquids

Skills Used: Scientific method and reasoning, guided internet research, vocabulary strengthening exercises, and apply theories of matter transformation.

Procedure: Have students visit http://ga.water.usgs.gov/edu/sc3.html and take the on-line Water Challenge Quiz.

Discuss the physical properties of water and how it can change from a solid, to a liquid, and then to a gas. Ask students if they know how the processes of freezing and thawing occur. Introduce concepts of sublimation, evaporation, and condensation. Illustrate these concepts with a group guided experiment of bringing a cup of ice to a boil. Make sure to note the water's transformation. Ask students to define how the water's density has changed with the introduction of a heat source.

Answer the first 7 questions on the How Does Water Change Its Form? Worksheet.

Fill two containers with ice or snow. Label containers #1 and #2. Leave container #1 alone in room temperature. Define this container as the control group.

Add a small amount of water to container #2 of ice or snow.

Have students develop a hypothesis as to why they believe one container of ice or snow will melt more rapidly.

Record the amount of time it takes for all of the ice or snow to melt in both containers.

Have students evaluate their hypothesis.

Why Does Water Change It's Form?

1. In order for water to change its form, what needs to be added or removed? _____

2. The process known as evaporation changes water to _____.

3. The process known as sublimation changes water to _____.

4. The gas form of water is called _____.

5. The solid form of water is called _____.

6. Ice has a greater or lesser density than water? _____.

7. Why does ice float?_____
   _____

Create a hypothesis by filling in the rest of the sentence.

I think that Container _____ will melt faster than Container _____, because_____
_____
_____

Record your findings in the table below

	TIME NEEDED TO MELT
CONTAINER 1	
CONTAINER 2	

Was your hypothesis correct? Why or why not?

_____
_____
_____

What Makes Glaciers So Cool?

Objective: Students will write about different forms of ice using descriptive language. Students will gain a greater understanding of descriptive and figurative language. Students will better understand Inuit culture through language acquisition.

Skills Used: Respond to literary and visual stimuli to produce organized, written thoughts, Respond to stimuli from creative points of view, writing for description and narration.

Procedure: Have students visit: http://www.glacier.rice.edu/land/5_whatisaglacier.html to research the different types of glaciers and vocabulary specific to glaciers.

Explain that some cultures have 100s of words for snow and ice, each describing particular characteristics of specific ice patterns and uses. Visit http://www.teelfamily.com/activities/snow/activities.html for a list of words that Inuit people use to describe snow.

Students will come up with a list on their own of descriptive words for glaciers. You may want to put limits on the descriptive word list, banning over-used words like cold, white, snowy.

Students will then have to write an expository narrative using 80% of the words from their list. The story must be well-organized and logical.

Questions for the Chat Room or Classroom Discussion

Topic: The Land of Ice and Snow. What makes ice so cool?

Suggested Questions

Why is traveling on ice so different than traveling on water?

Besides cold weather what causes ice to form? What causes ice to melt?

Why are glaciers so important to each ecosystem?

How does global warming affect ice? What will this mean to the earth?

How does water in all of its forms affect winter travel?

What role does water vapor play in everyday life?

What do you do if you encounter an open stretch of water, or lead?

How does snow affect the formation of ice?

What is happening to sea ice?

Can you drink sea ice? Why?

When do icebergs occur, and how do they affect to the oceans?

When was the last Ice Age? When is the next Ice Age predicted to occur?

How did the last Ice Age affect the earth?

How thick does ice need to be in order to walk on?

How do you measure the thickness of the ice?

How do you get water on the trail?

How do the dogs get water while on the trail?