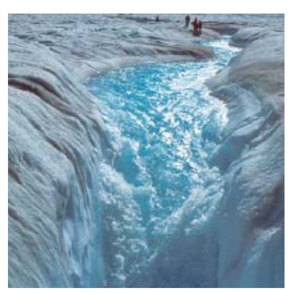
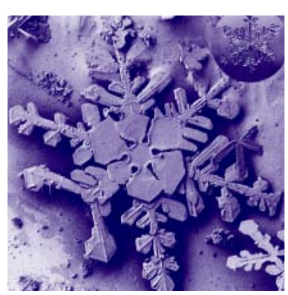
ICE FLOATS

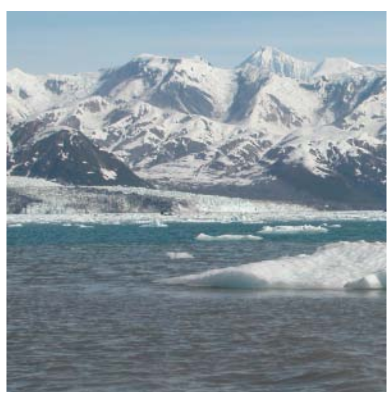
Exploring Ice

IN THE SOLAR SYSTEM

MAIN MENU







SCIENCE & LITERATURE

Archimedes is credited for first explaining the underlying principle of why things float. When he immersed himself in a bath, he is said to have leaped up in the excitement of his discovery about displacement, that he ran out into the street, shouting "Eureka!"

> "Any solid lighter than a fluid will, if placed in the fluid, be so far immersed that the weight of the solid will be equal to the weight of the fluid displaced."
>
> — Archimedes of Syracuse, *On floating bodies* I, prop 5.

> "Eureka, Eureka.
> I have found [it]."
>
> — Quoting Archimedes, V Pollio, *De Architectura* ix, 215

ICE FLOATS

CONCEPT OVERVIEW

This lesson develops precursor understanding about how and why ice floats. Water is less dense in its solid phase than in its liquid phase. Ice displaces less water than its volume.

Concepts:

- Buoyancy
- Density
- Floating
- Displacement

This activity provides a concrete experience of:

- Archimedes' principle of displacement
- Ice floating in water
- Measuring displacement of floating ice
- Near-freezing water sinks

PRE K–GRADE 2 CONCEPTS

- If you push down on water, you can feel it push back up. This is upthrust, or buoyancy.
- When water freezes, it expands.
- Ice is less dense than water.
- Ice floats in water.

GRADE 3–5 CONCEPTS

- The random motion of water molecules creates water pressure; floating is a result of upthrust (buoyancy), the upward direction of water pressure.
- As water changes into ice, it takes up more space than it does as liquid water, which is to say, ice is less dense than water.
- Ice floats. Ice is about 91% as dense as liquid water. This means that about 91% of floating ice is underwater and about 9% of the ice is above the water line.

LESSON SUMMARY & OBJECTIVES

Young children know that ice floats. One objective of this lesson is to invite students to understand why it happens. This leads us into the relationships of several concepts: displacement, buoyancy, and density.

Objective 1: Notice that if you push down on water, the water pushes back.
The random motion of water molecules produces water pressure in all directions. The combination of gravity, air pressure, and water pressure results in a net upward force that you can feel, called upthrust.

Objective 2: Notice that ice floats in water.
Anything that floats is less dense than the liquid it is floating in. Ice floats in liquid water. Unlike most substances, water is denser in its liquid phase than in its solid phase. There are more molecules per unit volume in liquid water than in solid ice.

Objective 3: Notice that ice sinks part way into water.
When ice is floating in water, a small portion of the ice emerges above the water level while most of it is submerged.

Objective 4: Notice that liquid water close to the freezing point actually sinks.
Cooler water is denser than warmer water and is most dense just above freezing

STANDARDS

PROJECT 2061 BENCHMARKS:

1B—The Nature of Science: Scientific Inquiry

GRADES K–2, PAGE 10

- People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens.

GRADE 3–5 PAGE 11

- Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, and social questions.

4D The Physical Setting Structure of Matter

GRADES 6–8, PAGE 78

- Equal volumes of different substances usually have different weights.

NSES:

Content Standard E Science and Technology: Understanding about science and technology

GRADES K–4, PAGE 138

- People have always had questions about their world. Science is one way of answering questions and explaining the natural world

Content Standard B Physical Science: Properties and changes of properties in matter

GRADE 5–8, PAGE 154

- A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances by using one or more characteristic properties.

ICE FLOATS

ESSENTIAL QUESTION

Why is it important that ice floats?
What can we learn by studying the floating of ice in natural conditions such as lake ice, river ice, pond ice, sea ice, and icebergs? What can we say, draw, or write about ice floating?

ACTIVITY QUESTION

Why does ice float?
What can we learn about ice by watching how ice floats? What observations about ice floating can we record? What can we say, draw, or write about ice floating? What can we say, draw, write about ice floating that we look at, touch, and examine in class?

BACKGROUND

This activity connects to the principles of buoyancy, displacement, and gives students a tool to measure relative density of ice compared to liquid water.

The notion of relative density has to do with the proportion of a floating object that will be submerged. If the body is two thirds as dense as the fluid, then two thirds of its volume will be submerged, displacing in the process a volume of fluid whose weight is equal to the entire weight of the body.

In the case of a submerged body, the apparent weight of the body is equal to its weight in air less the weight of an equal volume of fluid. The fluid most often encountered in applications of Archimedes' principle is water, and the specific gravity of a substance is a convenient measure of its relative density compared to water, where water has a specific gravity of 1.

Archimedes (287–212 BC)
Archimedes was a Greek scientist, who lived in Syracuse on the island of Sicily. The classic story of Archimedes is that he spent all day thinking and thinking. After a long day of thinking, Archimedes decided to take a bath.

As he stepped into the water… something interesting happened.

He noticed that as he immersed himself into the water, the water level rose. When he put his whole body into the water, the water level rose even more than before. When he stepped out, the water level dropped back down to where it was before.

Then he made the great leap of understanding: the water level rose by exactly the amount of space that his body volume took up—he displaced the water by exactly the amount of his own volume!

This was so amazing that he leaped out of the bath and shouted "Eureka!" which means I've got it! I found it! I discovered it! He ran out into the street shouting "Eureka!" It is also said that even as Archimedes ran out, he forgot a towel to cover his bathing body! So as he cried "Eureka!" the townspeople shouted "Eek!" At least, so goes the story.

Historically, this resulted in Archimedes writing a thesis *On Floating Bodies*, which influenced scientific thought even down to today!

How can we apply this to understand more about ice floating in water?
Archimedes' principle describes buoyancy, or upthrust, the upward direction of fluid pressure. A body immersed in water experiences an upward force equal to the mass of the fluid displaced by the body.

If the weight of an object is greater than the weight of displaced fluid, it will sink. If the weight of the object is less than the weight of displaced fluid, it will float. If the two are equal, it is suspended, neither floating nor sinking.

ICE FLOATS

For example, when an object is placed in water, it will displace its own volume of water, and that water will push back against it proportionally, producing an upthrust.

Water has a weight density of 62 pounds per cubic foot. If an object weighing 62 pounds has a volume that displaces 2 cubic feet of water, it will float. The displaced water will weigh 124 pounds and the pressure of that water would be enough to keep the object floating.

Another more densely packed object, also weighing 62 pounds, has a volume that displaces 1/2 a cubic foot of water. This object will sink. The displaced water will weigh 31 pounds and the pressure of that water would not be enough to keep the object afloat.

We can also explain this example in metric units. One liter of water has a mass density of 1 kilogram.

Ice is water. By observing ice closely, we can measure the displacement of the ice: 91% of ice is submerged; 9% emerges above the water line. Ice is 91% as dense as water. A cubic foot of ice displaces a cubic foot of water. A cubic foot of ice is only 91% of the weight density of a cubic foot of water, or about 56 pounds. So 56 pounds of ice displaces 62 pounds of water. The 62 pounds of water pushes back with a resultant upthrust that floats the ice so that the difference in the two weight densities is up out of the water, 9%, or about 6 pounds.

If an object displaces more than its weight in water, it will float; if an object displaces less that its weight in water, it will sink.

Water within 4°C of its freezing point is at its most dense, denser than warmer water. Near-freezing water displaces less than its weight in warmer water and it will sink. This can also be observed.

Part 2 of the Main Activity is designed to communicate the effect of water at just above the freezing point, when it is at its densest. At this temperature, the colder, denser water sinks toward the bottom, and the warmer water (less dense) moves up toward the top. On Earth, this process helps the oceans circulate, as cold water descends in Arctic regions and invigorates the ocean depths.

In nature, as air gets colder, ice crystals form (and float), eventually, the top freezes over, and the ice floats, creating an insulating layer.

This dynamic system makes it possible for liquid water to remain below the surface of ice in ponds, lakes, rivers, and oceans—which also means that life can survive in those conditions.

More background on the density of near-freezing water:

Campbell, N.A. 1996. Biology (4th edition). Benjamin/Cummings Publ. Co. Inc. Menlo Park, CA, USA.
http://wow.nrri.umn.edu/wow/student/water/unique.html

Frozen Lake Density

When the surface temperature in a lake reaches 0°C, ice forms and floats on top of the lake. The ice becomes an insulating layer on the surface of the lake; it reduces heat loss from the water below and enables life to continue in the lake. When ice absorbs enough heat for its temperature to increase above 0°C, the hydrogen bonds can be broken and allow the water molecules to slip closer together. If ice sank, lakes would be packed from the bottom with ice, and many of them would not be able to thaw out, since the energy from the air and the sunlight does not penetrate very far.

Density Relationships of Water

A lake's physical, chemical, and metabolic dynamics are governed to a very great extent by differences in density. Ice is almost ten percent less dense than liquid water. Liquid water's density is at a maximum at 3.98°C, and its density decreases as its temperature increases. Therefore, warmer waters are always found on top of cooler water in lakes and produce layers of water called strata. This is typical of a lake that is stratified during the summer. In winter the density differences in water cause a reverse stratification where ice floats on top of warmer waters.

ACT OUT THE SCIENCE

Mime Activity: *Movement Integration Mediating Experience*

The story of Archimedes and Archimedia, Chips off the Old Block (of Ice)

Narrative	Movement	Concept
There were once some blocks of ice named Archimedes and Archimedia, named for a wise Greek scientist of the same name. Funny how that works—when you get named for somebody, you both have the same name, or slightly different but pretty much the same. Anyway, Archimedes and Archimedia, the blocks of ice, were curious about everything.	Invite everyone to participate as the characters, boys as Archimedes, girls as Archimedia.	Blocks of ice.
Mainly, they were curious about floating. They noticed that every time they jumped into the water, they floated. Sometimes, they could manage to dive completely under the water, but they would also bob right back up to the surface, just enough to peek out and see what's going on. It seemed like they were always mostly underwater and just a little bit poked up above the waterline.	Mime jumping into water, floating about. Show motion of diving down and bobbing back up to the surface. Keep legs bouncing to simulate the buoyancy. Indicate a distinct water line that everyone is just peeking over.	Floating as a familiar experience.
Archimedes and Archimedia wanted to understand why they floated and why they always floated at the same level. So they decided to investigate. One day at home, just before taking a nice freezing cold bath—you see, Archimedes and Archimedia didn't like warm water, they were afraid they'd melt away into nothingness—well, they're blocks of ice after all—anyway, they decided to test out a brilliant idea.	Have everyone climb out of the water, scratch their heads, thinking, then show getting an idea. (Optional: Invite everyone to get a partner for the next part, even though everyone is showing the actions at the same time.) Show getting a bath ready with c-c-c-old water.	Moving toward inquiry.

ICE FLOATS

Narrative	Movement	Concept
Archimedia drew a line on the tile right where the waterline was at the start. Then Archimedes jumped in. Sure enough, once again, he floated. Only Archimedia noticed that the waterline was higher than a moment ago. She drew a line on the tile to match the new level. Then, she pushed down on Archimedes just enough so that the top of his block was even with the waterline and she drew that line on the tile, which was higher still. Then Archimedes hopped out and the water level returned to where it was at the beginning.	Invite one partner to draw the line, the other to "jump in the bathwater." Gesture marking a definite initial water level. As the partner gets in the water, gesture that all the water levels rise —mark that! One partner mimes pushing down, the water level rises again. Hopping out, the water level returns to its initial level.	Observing buoyancy in action. The experience of upthrust. Noticing the changes in the water level.
Just to be sure, they conducted a second trial, that is, they repeated the experiment. This time, Archimedes drew the starting place waterline on the tile. Archimedia jumped into the water. Sure enough, the water level rose again. Archimedes marked the level—but it was at a different place than when he jumped in. Hmmm. Then, he pushed down on Archimedia just enough so that the top of her block was even with the waterline, and he drew that line on the tile, also higher, but also at a different place then his mark. Then Archimedia hopped out and the water level returned to where it was at the beginning.	Reverse roles, so everyone has a chance to play out the story.	Observing buoyancy in action. The experience of upthrust. Noticing the changes in the water level.
Interesting. There were five different lines on the tile:	Create a tableau of the moments that correspond to each line.	The water line reflects the amount of displacement.
1. The waterline before and after they each jumped in;	Use the arms to shows the level.	

Narrative	Movement	Concept
2. A slightly higher waterline when Archimedes was floating;	Use the arms to show a slightly raised water line.	Floating, the waterline reflects the amount of the displacement. The submerged portion equals the displacement of water. That it floats means that the ice has a bigger volume than the water it displaces.
3. A similar line, but not exactly at the same place marking when Archimedia was floating;	Use the arms to show a slightly raised water line.	Two different volumes of ice will displace different amounts of water.
4. An even slightly higher line, marking the water level when Archimedes was fully submerged; and	Use the arms to show a slightly raised water line.	By pushing the ice so that it is just completely submerged, it raises the water level to a new, higher level—this displacement reflects the total volume of the ice.
5. A similar line, but not exactly at the same place marking when Archimedia was fully submerged.		Similarly, Two different volumes of ice will displace different amounts of water.
All of a sudden, Archimedes shouted "Eureka! I've got it!" and Archimedia shouted "Encyclopedia! I can explain it!" And they went running outside in the afternoon sun with nothing on! And sure enough, they melted into a refreshing pool of water that looked very much like seats at their desks in a classroom, before they had a chance to tell the world of their wonderful discovery about ice floating.	Have everyone melt back into their seats.	Eureka! is that famous exclamation of discovery.
The good news is that the wise Greek scientist Archimedes of Syracuse was a chip off the old block of ice.		

Small Group Mime Activity: ***Movement Integration Mediating Experience***

Invite students to form small groups (about three to five students), to create their own mime and narrated story about ice floating or a version of the Archimedes story told in their own way.

MATERIALS

The activity enables students to experience the buoyancy of ice in water. The activity works best when a variety of see-through containers are selected in order to observe below the waterline.

For all activities, to record reflections, observations, calculations, etc.

- Science Notebooks: writing and drawing utensils
- Drawing materials

Demonstration

- Several see-through containers
- 12-gallon or larger plastic or Plexiglas aquarium tank(s)
- Several 10, 20 or 25-lb blocks of ice
- Water
- Collection of objects that float or sink
- Select items such as: bathtub toys, wood, coins, rocks, foil opened flat, foil balled up, foil folded like a boat

Main activity

Whole Group:

- Varied large blocks of ice, as well as ice cubes

Small Groups:

- Plastic trays large enough to hold water and let ice float without touching the bottom of the container.

Individual or Pairs:

- Clear plastic cups to place water and an ice cube
- Food coloring & eyedropper
- Thermometer sensitive at the freezing point of water

Science Resource Materials

Graphics of icebergs and other examples of ice frozen over water

DEMONSTRATION

The purpose of this demonstration is to provide an opportunity for students to observe objects float and sink and to think about how and why things float.
By comparing a variety of objects of different shapes and materials, patterns emerge. Through guided discussion, students can gain insight into concepts of buoyancy, upthrust, density, and displacement.

Fill a 12-gallon aquarium about 3/4 full with water to use for the demonstration.

PRE K–2

Open a discussion with the question:

Have you ever noticed that when you push your hand into water, it feels like the water also pushes back?

Give students the opportunity to recall this experience in discussion and to experience it by trying it out in the classroom, at an exploratory zone, and/or as part of the demonstration.

Why do some things float and some things sink? Do you think it has to do with that pressure you felt when the water pushed back on your hand?

What floats? What sinks? How do these words help us describe what we see happen when we place an object into the water?

Direct students' attention to a collection of a variety of familiar objects such as: several pieces of wood, some marbles, and several typical bathtub toys.

Invite students to predict what will sink and what will float. Test it out.

Ask questions such as:

- Do you think this object will sink or float?
- What is it about this object that makes you think so?
- Does the object push down on the water with its weight?
- Does the water push back with its pressure?

Guide students toward experiential understanding of density (mass/volume): for example: compare a plastic bottle empty, nearly filled with water, filled with sand. How does the plastic bottle float or sink in each instance?
Guide students to notice changes in the water level with each investigation. Relate this to the notions of the density of water and displacement.

Record student-generated questions and observations and refer to them during the rest of the lesson.

3–5

Invite students to collect 2 or 3 objects for the sink or float test. Show them the size of the aquarium that will be used. Let them know that it will be filled about 3/4 with water. Show them a few of the items you have already selected.

Suggest a range of additional objects such as:

- small toys
- pieces of woods
- rocks
- small bottles
- metal foils

Form active inquiry teams of 3-5 students. Invite students to organize a selection of objects for testing in some sensible way. Notice what patterns of comparison seem sensible to the students. Invite them to discuss their reasoning. For example, relative size, relative weight, density, what they are made of, what shape they have, how much air may be in or part of the object (connects to ideas about density).

Once they have arranged objects for testing, have students select and prepare to test several items. As part of the preparation, ask students to predict whether an object will sink or float and explain why they think so.

Have students record their predictions and explanations in their science notebooks. Then invite them to design a way to conduct their investigation and to do it, and to keep track of their results.

Regroup as a whole and lead a discussion, inviting students to share findings.

MAIN ACTIVITY

PREPARATION

This activity involves observing that ice floats under a variety of conditions.

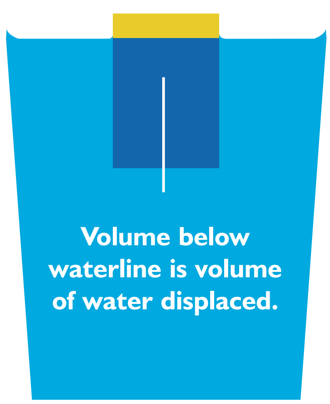
Calibrate a 12-gallon aquarium tank by marking off the levels corresponding to the amount of water (1L, 5L, 10L etc).

Prepare the classroom to be a general exploratory zone for students to place objects and ice into water to see how they float or sink.

- A central area where everyone can see
- Several stations around the room for small groups

In addition to experiential areas, prepare a gallery of images of ice in nature, especially sea ice and icebergs, to be viewed in the context of ice floating.

The ice cube has a bigger volume than the water it displaces.

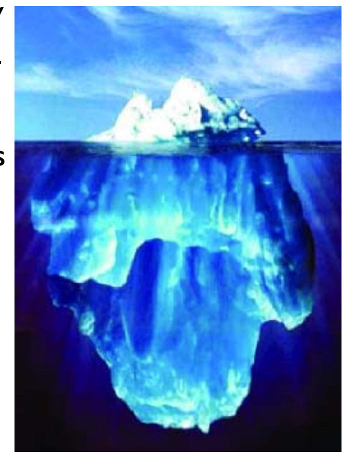


Source: http://www.grow.arizona.edu
Source: http://www.mbc.qld.edu.au./oxford/ch7q35.gif

TEACHING TIPS

Explore

Listen for students' personal conceptions as they predict what they think will float or sink. Observing that ice floats is a commonplace experience, but it is not necessarily easily understood. This activity utilizes hands-on exploration of ice floating in water. It also encourages students to test how much is above and below the waterline.



Diagnose

Listen to student ideas about floating. What else floats in water? Why do things float? Be prepared to help students understand density—for example, a steel boat floats, because the density of the boat includes the air within its holds. Likewise the density of water ice includes the air in the spaces within its crystal lattice structure.

Design

There are many ways to explore ice floating. Part of the challenge is to create a way to observe ice floating that overcomes the process of rapid melting. Observation focused on floating works better with larger blocks of ice and colder water—to slow the melting process and accent the measurability of the floating.

Discuss

Archimedes' story may engage student interest in the significance of floating and displacement. In this context, observing that ice floats, and seeking an explanation, leads toward another way to understand the structure of ice crystals. This further lays the foundation for conceptually understanding the molecular structure of water and ice.

Use

This activity lays the groundwork for applying concepts of density, buoyancy, and displacement to broaden understanding of other related topics.

WARM-UP AND PRE-ASSESSMENT

Listen carefully to notice whether you hear anything when you place an ice cube in warm water.

Why do ice cubes sometimes make a cracking sound when they are put into a warm drink?

Mimediate Explanation: If you have ever looked into the freezer before the ice cubes are fully frozen, you might have noticed that when an ice cubes freezes, the outer shell freezes first. The last bit of liquid water is in the middle. Let one hand be the outer shell of ice: Make your hand tense, so that it holds that shape. Let your other hand make a loose fist to be that last bit of liquid water. Fit it in loosely into the other hand. So you have a loosely held fist surrounded by a rigid shell of ice: your tensely held other hand.

We know that as water freezes, the molecules move slightly apart in order to bond together as ice crystals. Let your loosely held fist open up, pushing against the inside of the other hand, the icy shell, until both are frozen. The stress of the expanding inner ice pushes out against the outer shell, with a bit of pressure from the inside. There's your ice cube. Now, if you were to put that ice cube into warm water or a soda pop, the outer shell starts to melt pretty fast—allowing the inner pressure room to move. As it adjusts, some of the bonds of the ice crystal break and we hear CRACK!

PROCEDURES

PART 1.

Observe the dynamics of ice floating. This can be done in several ways, depending on the dynamics of the class, whichever allows students the most direct experience, while also remaining as orderly as a scientific laboratory. (Be prepared: water is likely to spill at any rate.)

Whole Group Activity or as a Small Group Exploratory Zone

1. Fill a 12-gallon aquarium tank about 3/4 full.
2. Draw a line to mark the water level.
3. Place a 10, 20, or 25-lb block of ice in the water.
4. Notice that the water level rises. Mark the level.
5. Push the ice to the point that the top of the ice is even with the top of the water. Mark that level.
6. Observe and record what happens.
7. Pose questions about what happened.
8. Measure how much of the ice floats and how much is submerged.

Small groups, in pairs, or as individuals

1. Fill a small clear container about 3/4 full.
2. Draw a line to mark the water level.
3. Place a chunk of ice or an ice cube into the water.
4. Notice that the water level rises. Mark the level.
5. Push the ice to the point that the top of the ice is even with the top of the water. Mark that level.
6. Observe and record what happens.
7. Pose questions about what happened.
8. Describe how much of the ice floats and how much is submerged. (Precise measurement may be difficult with smaller containers and smaller pieces of ice.)

Exploring Ice Floating in Earth

1. View a gallery of images and videos of sea ice and icebergs.
2. View a gallery of images and videos of freshwater ice: ponds, lakes, and rivers.
3. Optional: investigate how ice floats in water as salty as the ocean.

This table is a guide to the range of observations in this activity.

Phenomenon	Measurement/Description
a. Ice floats (observable directly)	■ Measure how much ice is above and below surface ■ Notice/measure change in water level
b. Ice displaces water and floats	■ Capture overflow of displaced water
c. If you push on the ice, the water level rises again, and then it pops back up	■ Describe what happens as the water pushes up on the ice ■ Describe/measure how much of the ice is above and below the water line
d. Icebergs float in the ocean (observable via video and imagery)	■ Make inferences about how much more of the iceberg is under water
e. Test ice floating in salty water (salt water is denser than fresh water)	■ Describe/measure differences in the way ice floats in salty water

PART 2.

Observe the dynamics of near-freezing water sinking.

Lead off a discussion with questions such as:

Have you ever noticed that when you put cold ice cubes into a warm soft drink, a moment later the liquid at the bottom is colder than the liquid at the top? You can get to that refreshing coldness with your straw.

Or when you go swimming, have you ever noticed that the water down below is cooler than near the surface?

What's going on?

Pick out two different colors of food coloring. Keep one at room temperature or warmer (perhaps have someone hold the food coloring bottle in their hands). Place the other color near the ice to get close to freezing.

Obtain two see-through containers large enough to hold sufficient water to enable a 10-pound block of ice to float. Fill each container with water at room temperature.

Test out how the warm food coloring behaves when a small droplet is placed in the water at room temperature. Then test out how the cold food coloring behaves. Do they behave differently?

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Now, place a 10-pound block of ice in the other container. Notice that it floats. Notice also that this is like a big ice cube in a soft drink. Now place a droplet of each food coloring (warm and cold) near the big ice block. What happens?

Proposed explanations may emerge from discussion. Here's the scoop:
The cold liquid next to the ice cube cools down to close to the freezing point and then sinks to the bottom. As water gets colder, the molecules get closer together. Just above the freezing point 0° to 4°C, the water is at its MOST DENSE — and THAT NEAR FREEZING WATER actually SINKS (that's why you see the food-coloring sink in next to the ice. The warm food coloring might take just a moment longer to first cool and then sink. Near-freezing water will SINK. Frozen water (ice) will float.

DISCUSSION & REFLECTION

What explains the buoyant pressure of water?

The molecules in a fluid, in this case, water, move about and create a pressure in all directions. Because of the Earth's system as a whole, with its gravitational field always present, water experiences a downward pressure that increases with depth. The combination of forces, including air pressure, results in a net upward force, so things weigh less in water. The mass has not changed; the upthrust just counteracts against gravity. The result is that the water pushes upward on an object immersed in it.

Why is it important to living things that ice floats?

One observation that might trigger discussion and reflection on this point is that when puddles, ponds, lakes, rivers, and oceans freeze, the upper surface freezes first. Liquid water persists beneath the ice, especially in larger bodies of water, where living things abound.

What would be different if ice were heavier than water? What would happen to life if bodies of water froze from the bottom up? How does this affect our thinking about a place like Europa, a moon of Jupiter, covered with a surface of ice, harboring an ocean beneath that surface?

CURRICULUM CONNECTIONS

This lesson presents a marvelous opportunity for literacy connections. The meanings of words to express science concepts, such as weight, volume, density, mass, buoyancy, pressure, and upthrust—all depend on both an experiential context and an interpretive explanatory context.

Have students tell and write about situations that use these words. Guide them toward exploration and understanding of the nuances of meaning. For example,

- How do boats stay afloat?
- How do fish maneuver underwater?
- How do hot air balloons maneuver through the atmosphere?

ASSESSMENT CRITERIA

Exemplary

- Students write and illustrate a personal ice floating experience and share it dynamically with both a small group and the whole group.
- Students display drawings, constructions, and dynamic kinesthetic models drawn from their science notebooks and web-based research.
- Students identify and extend science questions drawn from direct observation and extended research about ice floating.
- Students explore a rich range of observations about ice floating and relate it to prior shared experiences.
- Students ask a rich and extensive range of questions about ice floating.
- Students extend learning by considering implications of the molecular structure of H_2O as an explanation for ice floating.
- Students relate ideas to the whole context of exploring ice in the solar system.

Emerging

- Students write and illustrate a description of ice floating and share it with both a small group and the whole group.
- Students pose science questions drawn from their observations and research of ice floating.
- Students observe examples of ice floating.
- Student display results using a variety of ways to represent examples of ice floating.
- Students ask a rich range of questions about density and buoyancy.
- Students make speculations about possible explanations for ice floating.

Formative

- Students recognize that ice floats and that the features of ice floating can be measured.
- Students identify characteristics of density and buoyancy, connected to ice floating.
- Students pose science questions drawn out of the context of observing ice float.

RESOURCES

Archimedes On-line

http://www.maa.org/pubs/books/arc.html
The Mathematics Association of America recommendation of the book:
Archimedes: What Did He Do Besides Cry Eureka? By Sherman Stein

http://www.thewalters.org/archimedes/frame.html

Explore the oldest surviving manuscript of Archimedes' writings

http://www.engineering.usu.edu/jrestate/workshops/buoyancy/buoyancy.php
Utah State University, Junior Engineering site focused on buoyancy, featuring the work of Archimedes and some hands-on activities

Buoyancy or Hydrostatic Upthrust

http://www.zephyrus.co.uk/upthrust.html
A one-page visual glimpse into the meaning of the term upthrust

http://www.plus2physics.com/hydrostatics/study_material.asp?chapter=3
Plus 2 Physics series section on buoyancy

Images

Link to image gallery

ICE FLOATS

Caption: Ice floes in the Antarctic Sea.

Credit: Courtesy of Hermann Engelhardt, JPL/CalTech.

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Caption: Ice floes in the Antarctic Sea.

Credit: Courtesy of Hermann Engelhardt, JPL/CalTech.

ICE FLOATS

Caption: A very large section of the ice shelf has broken away.

Credit: Courtesy of Hermann Engelhardt, JPL/CalTech.

ICE FLOATS

Caption: Pancake Ice, forms as small (1–3 m in diameter) floating discs when slushy ice is clumped together by ocean wave action.

Credit: Courtesy of NASA/JPL.