LESSON PLAN

Subjects: Science, math, social studies, writing
Grades: 4-8
Duration: 2-4 hours

Objective:
When a solid, like ice, goes straight to the gaseous state without becoming a liquid, the process is called sublimation. There are many local occurrences of sublimation, some of which are helpful, and some of which are harmful. The student will understand the local implications of sublimation.

Vocabulary
Sublimation- When a solid goes directly to the gaseous state without becoming a liquid.
Glaze- A frozen coating of water or water/sugar that covers a fish to prevent sublimation.
Crust time- The time of year (April) when snow melts in the day, and freezes to form a crust at night thick enough that people can travel on it.
Ablation- When the ice of a glacier sublimes. The ice becomes less dense.
Dry ice- Dry ice isn’t dry, and isn’t ice. It is solid carbon dioxide.
Albedo- The reflection of light off the surface of snow or ice.
Freezer burn The common word for sublimation of food in a freezer.

CONTENT READING
We live in a cold part of the world. Over half of the days in our year include temperatures below 32° where sublimation continually takes place. Sublimation of water effects the quality of food that we store. It impacts winter travel. Sublimation dries our clothes on the clothesline wintertime.

Sometimes we try to avoid sublimation, and sometimes we try to increase it. We have been watching and experiencing sublimation most of our lives without understanding it well. Now is our chance to gain control of the process.

Sublimation is when a solid goes directly to the gaseous state without becoming a liquid. With water, it usually occurs below 32°. Water isn’t the only substance to sublimate.

Drying clothes. When we hang cloths on an outdoor line in winter, the clothes dry by sublimation. We bring the clothes out wet and hang them on the line. They freeze
quickly. Even though they are solid frozen, when they are brought into the house days later, they are only slightly damp, requiring a short drying time over the stove. Sublimation has removed a considerable amount of water from the clothes.

**Salmon strips.** We cut salmon strips in the summer, drying them to keep bacteria from rotting them. We put the strips in the cache, and when we eat them in wintertime, the strips are much dryer than when we put them away in the fall. They are more difficult to eat and don’t taste as good as they did in the fall.

Sublimation dries them out during the winter months. That is why we often dry our strips in the summer, vacuum seal them in plastic, and put them in the freezer. The plastic of the vacuum seal bag keeps them from spoiling and from drying too much by sublimation.

**Local Research:** Ask local experts how they protect their fish from drying out too much during the winter. (Many people put them in zip-loc bags and put them in the freezer, or jar them right after removing from the smokehouse.)

**Activity:** In the fall, take salmon strips that have been dried during the summer and weigh several of them, marking them. In January, take the same strips out of the cache and weigh them again. Did they lose weight by sublimation during the cold winter months? You will need a scale that measures accurately as the loss isn’t great. (They won’t lose much weight, but they will lose flavor.) Long ago we had no freezers, and the quality loss was an accepted part of life.

**Tanned skins.** After old timers cleaned a moose or caribou skin for tanning, they hung it outside in cold weather to dry slowly. They said the skin was far softer if it dried slowly by sublimation than if it dried quickly in the house hanging over the stove.

**Local Research:** Ask the Elders in your community if they dried a tanned skin outdoors to soften it. What do they say about the process. (Yup. It works.)

**Moose hanging.** When we hang a moose in the smokehouse during the late fall, even if it is frozen, meat dries by sublimation. That is why the old timers often left the skin on the legs and other parts to prevent drying. The outer surface gets a crust on it that resists blowflies before the cold weather comes.

**Activity:** Weigh a piece of meat hanging in the smokehouse once the weather turns very cold in the fall. Then weigh that same piece of meat in December or January.

Has it lost weight to sublimation? Do you think there is a difference in taste as well as moisture content? (It is certainly less palatable.)

**Freezer paper.** We use freezer paper and/or plastic to wrap our meat, fish or food to prevent “freezer burn” in the freezer. Freezer burn is nothing more than drying out the food in temperatures below 32 degree by sublimation.
**Class Observation:** Look closely at freezer paper. How is it different from other paper? (Wax on one side.)

**Activity:** Wrap a piece of meat in freezer paper. Wrap another similar piece of meat in paper from a paper bag. Wrap another piece in plastic wrap, vacuum seal, or ziploc bag. Cut another piece of meat and don’t wrap it at all. What change do you predict for the different pieces of meat in the freezer or in the smokehouse if it is very cold? After three to four weeks, what difference do you observe, if any? Which piece of meat would you rather eat? Why? (There is slight freezer burn even with plastic wrap, but not as much as the paper bag.)

**Local Research:** Ask old timers about the impact of freezers on village life and the storage of food. (Tremendous difference! Before, we had to dry everything. Now we can seal and keep fish and meat for long periods of time.)

**Glazing fish:** When whole fish are put in the freezer, sublimation removes moisture, making the fish taste “old.” Many people freeze whole fish solid, then dip them in water, or a water/sugar solution to glaze them. The glaze acts like freezer paper, protecting the meat from drying out. The reason people use water/sugar for the glaze is that combination is more flexible than water alone, and is less apt to chip and break off, exposing the meat of the fish to drying by sublimation.

**Class Discussion or Local Research:** Ask the local experts how they freeze whole fish. Do they remove the guts and head? Just the guts? Or freeze the fish whole? How do they keep it from drying by sublimation in the freezer, or do they not worry about drying? Do they glaze the whole fish? Do they use sugar in the glaze or not?

**Freeze Dried Food:** Freeze dried food takes advantage of the sublimation process. Food is first cooked and prepared. Then it is frozen. Then the atmospheric pressure is reduced to encourage sublimation of the frozen product. It becomes quite dry. It is then packaged.

- It is extremely light, and will not spoil for a long period of time.
- To prepare the food, put hot water in the container, and let it set for a short while. The water reconstitutes the food.
- Considering the process it goes through, the food tastes amazingly good… most of the time.

**Brief Activity:** Get different packages of freeze dried foods. Test and taste them. Research how the freeze drying process is done. Compare freeze dried coffee with regular coffee. Visually study how the water reconstitutes the freeze dried foods. Do some parts absorb water quicker than others? Will cold water reconstitute freeze dried food as quickly as hot water?
**Airplane Wings:** Pilots are always concerned with frost accumulation on the wings of their planes. If the frost is rough, it can disrupt the airflow over the wing, greatly reducing the lift. Yet, once the plane is in the air, the frost rapidly vanishes by sublimation because of the rapid airflow over the wing. Some pilots would rather fly the frost off with a light load than spend a long time scraping it. Of course, the best solution is to put wing covers on the wings before sundown to protect the wings from frost.

Frost on the fuselage of a plane doesn’t influence flight characteristics, and pilots watch the influence of sublimation as the frost quickly vanishes from the fuselage during flight.

**Local Research:** Ask local pilots about frost on the wings and its effect on flight characteristics. (Frost can destroy the airfoil.) Ask them about flying off the frost. (Only with an empty plane after first scrubbing the frost smooth.) Ask them how they get frost off the wings of their planes. Does running a rope back and forth over the wing help at all? (It at least polishes the frost. It is the rough surface of the frost that destroys the flow of air over the wing. Low wing Cherokees are easy to clean. High wing planes are difficult.)

Ask local pilots if frost forms on the wings on nights when the wind is blowing hard. (No frost when it’s windy.)

**Crust on Snow:** Occasionally, winter temperatures rise above freezing. The upper surface of the snow gets wet by melting. We hope that it will form a crust for us to travel upon. However, when temperatures drop, the damp snow that could possibly freeze into a crust is dried by sublimation. The end product is dry powder snow from top to bottom. We seldom get a good crust until spring time when melting occurs on a daily basis.

**Local Research:** Ask the Elders in your area about “crust time.” What did it mean to them? (Lotsa fun!) Was it a safe time to travel? (If you go out on the crust and weather warms up and doesn’t freeze again, it can take DAYS to get home.) What was the advantage of not leaving tracks? (Game warden can’t follow you from the air.) What did the crust do to dogs’ feet? (Their feet wore out and became bloody rather quickly.) What activities took place during crust time? (Moose hunting.) Did they look forward to crust time each year? (It was the hi-lite of the year! This is no longer the case as most people don’t have dogs.)

**Campfire Coffee:** Making tea over a campfire requires skill. If the coffee pot is packed only with snow, much of the snow will sublimate into a vapor. Sublimation carries away large amounts of water before liquid water can be produced. It is possible to sublimate away every bit of the snow and not get any water at all.

The secret of making water in a pot over a campfire is to start with a small amount of water or ice, then, as that turns to warm liquid water, add snow. The warm water melts the snow creating more water. The snow won’t sublimate if there is
warm water in the pot. If there is only snow in the pot, snow rapidly sublimes, taking a long time to produce enough water for a pot of coffee. Chop ice from the creek to get the melting started, then add snow.

**Glacial ice:** Glacial ice is exposed to the effects of sublimation all winter. The result is that the density of the ice on the surface of a glacier can be less than the density of the ice under the surface. This form of sublimation is called “ablation” of a glacier.

**Dry ice:** Dry ice is carbon dioxide that has been cooled to become a solid. When it is warmed, it sublimes from a solid state to a vapor. It does not pass through the liquid state.

**Activity:** If you can get dry ice to the village, experiment with it. It isn’t expensive. Whee does the vapor go? Is there any evidence of the dry ice going through a liquid stage before becoming a vapor? What is it made of? Can it bring the contents of a cooler below 32 degrees? Be careful in handling it. Use gloves. There are many good dry ice demonstrations on Youtube. Dry ice gives a good demonstration of sublimation, as it sublimes so visibly before our eyes.

**Spring Melt:** In the spring, when snow starts to melt, huge amounts of moisture are carried away by sublimation.

At the base of trees, where the dark bark absorbs heat from the sun, or around brush protruding from the surface of the snow, or at the edge of exposed tundra, the heat from the sun warms the darker surfaces. Most of the adjacent snow does not actually melt and drip and run off, but sublimes into the atmosphere, from a solid to a gaseous state.

If all the snow melted and ran to the river, breakup would be far more dramatic than it is and our towns and villages would be severely and frequently flooded.

A large percentage of the snow that falls in the wintertime is carried away by sublimation in April before it can ever turn to run-off.

**Class Observation:** Go out on a spring day, and watch where the bare tundra meets the snow. Mark the point of connection. Does the snow recede? If so, do you think it is melting and running off, or sublimating? Observe closely. (Most is sublimating.)

**Albedo:** The melting of polar ice exposes dark earth beneath. This reduces reflection from the snowy surface (albedo) and increases the amount of light absorbed and converted to heat by the earth’s surface. Those concerned about global warming blame the loss of ice, reduced albedo and resultant sublimation and runoff for some of the warming.
Albedo acts to reflect much of the sun’s light/heat in the spring. But exposed plants and dirt absorb great amounts of heat, enhance the sublimation of the adjacent snow that vanishes quickly.
In urban centers, pavement converts the sun’s rays into a tremendous amount of heat. This is the exact opposite of albedo.

**Local Research:** Ask old timers about snowblindness in the spring. What did it feel like? What did they do to prevent it? Was it worse on a cloudy or sunny day? Why do you think snowblindness occurs in the spring, and doesn’t occur in the summer when there is more sunlight? What does this tell you about reflection of light from the snow? How does this relate to albedo?

**Experiment #1: Sublimation.**
The purpose of this experiment is to determine whether sublimation occurs below freezing temperatures and determine whether wind enhances sublimation.

**Materials**
- Paper towels
- Accurate scale
- Ziploc bag

1. Wet two identical paper towels.
2. Weigh each one. Record the weight.
3. Squeeze the heavier one until they both are close to the same weight.
4. Put one in a plastic bag, and leave the other one exposed.
5. Bring them both outside during extremely cold weather.
6. Weigh them after three days,
7. Record the weights.
8. Do the same experiment again when temperatures have warmed up to around 0 degrees. Put the towels in a place away from wind.
9. Does sublimation occur more or less rapidly in severely cold weather?
10. What percent of the original weight was lost during the first 24 hours?
11. Do the same experiment again when temperatures have warmed up to around 32 degrees.
12. Does sublimation occur more or less rapidly in severely cold weather?
13. At 0 degrees on a windy day, wet a paper towel. Record the weight. Put it outside exposed in a very windy place. (Or put a fan on it) Record the weight after 24 hours. What percent of the original weight was lost? Does wind enhance sublimation?
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<thead>
<tr>
<th>Weight of towel in plastic bag before.</th>
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**Experiment #2: Sublimation in a Campfire Coffee Pot**

**Materials**
- Campfire coffee pot made of a #10 can.
- Scale

1. Make sure the coffee pot is blackened on the outside before doing the experiment.
2. Pack a coffee pot with powdered snow.
3. Weigh the coffee pot.
4. Put the coffee pot on the campfire until the snow has melted into water.
5. Weigh the coffee pot before the water boils. How much weight was lost by sublimation?

Do the experiment again.
1. However, this time, put a little water in the bottom of the coffee pot, then pack it with snow as before.
2. Weigh it.
3. Put the coffee pot on the campfire again.
4. When all the snow has melted, weigh the coffee pot. How much weight was lost?

5. Compare the weight loss of the first and second experiments. The second experiment should have lost less weight, as the water in the bottom of the pot warmed in the campfire, melted the snow, and prevented loss of snow through sublimation.
Writing
Write a clear story or description, at least half a page, about one of the following subjects:

- Record a story from the old timers about traveling on the crust with dog teams, and how we used to hunt in April. Relate that to predator advantage in April.
- Out in the woods we had a hard time to make coffee because the snow kept vanishing from our coffee pot over the campfire.
- This is how our family takes care of their salmon strips so they don’t dry out in the winter.
- This is what we do to our moose meat when we hang it, especially the ribs, to keep them from drying out too much.
- Tell a story about children running around and playing on the crust spring-time.

Assessment: Answer in complete sentences.

1) What is sublimation?

2) How do we prevent sublimation of our salmon strips during the winter?

3) What is the purpose of freezer paper?

4) How is freeze-dried food dehydrated?

5) Frost is dangerous on an airplane wing. How can a pilot get the frost off before hauling a big load?

6) What happens when we put snow in a coffee pot over the campfire?

7) Do you think more snow sublimates or runs off in the spring?

8) What is albedo?

STANDARDS

Cultural Standards
A.1: Recognize the validity and integrity of the traditional knowledge systems.
A.2: Utilize the Elders’ expertise in multiple ways in their teaching.
A.3: Provide opportunities and time for students to learn in settings where local cultural knowledge and skills are naturally relevant.
A.4: Provide opportunities for students to learn through observation and hands on demonstration of cultural knowledge and skills
B.1: Regularly engage students in appropriate projects and experiential learning activities in the surrounding environment
B.3: Provide integrated learning activities organized around themes of local significance and across subject areas
B.5: Seek to ground all teaching in a constructive process built on a local cultural foundation
D.3: Seek to continually learn about and build upon the cultural knowledge that students bring with them from their homes and communities
E.2: Provide learning opportunities that help students recognize the integrity of the knowledge they bring with them and use that knowledge as a springboard to new understandings
E.3: Reinforce the student’s sense of cultural identity and place in the world
E.4: Acquaint students with the world beyond their home community in ways that expand their horizons while strengthening their own identities

Common Core Standards/English Language Arts
#2: Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.
#7: Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

Science
A3) A student should develop an understanding that culture, local knowledge, history, and interaction with the environment contribute to the development of scientific knowledge, and local applications provide opportunity for understanding scientific concepts and global issues.
D2) A student…should develop an understanding of the origins, ongoing processes, and forces that shape the structure, composition, and physical history of the Earth.
E.3) A student should understand the relationships among science, technology, and society, and should develop an understanding of how scientific discoveries and technological innovations affect and are affected by our lives and cultures.

Social Studies/Geography
C1) A student should understand the dynamic and interactive natural forces that shape the Earth’s environments and should analyze the operation of the Earth’s physical systems, including ecosystems, climate systems, erosion systems, the water cycle, and tectonics.

Math Standards
B. 3) The student formulates mathematical problems that arise from everyday situations.
E.1) The student explores problems and describes results using graphical, numerical, physical, algebraic, and verbal mathematical models or representations.