COLD CLIMATE HOUSING RESEARCH CENTER
CCHRC

UAF UNIVERSITY OF ALASKA FAIRBANKS

NNA Ice-Rich Permafrost Systems IRPS

PERMAFROST EDUCATIONAL WORKSHEETS

See the pages below for worksheets, coloring sheets, word searches and other activities for students to help remember various terms and principles of permafrost.

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WORD SEARCH

Permafrost and Landscape - Change in the Arctic

A	N	C	R	D	E	G	D	E	W	E	C	I	U	E
F	C	C	N	D	P	V	C	N	N	S	G	T	O	I
M	X	T	O	S	T	A	B	L	E	X	Z	N	N	A
V	N	O	I	B	W	H	G	S	R	K	O	O	U	O
T	X	L	S	V	P	M	C	B	W	E	I	I	B	N
X	L	T	O	B	E	L	S	M	E	T	T	B	S	O
C	W	F	R	P	I	L	M	Z	A	Y	U	K	O	M
W	J	P	E	M	U	H	A	D	T	Y	Z	T	D	W
H	G	J	A	O	E	N	N	Y	H	Q	C	Y	D	R
B	I	T	T	R	Y	U	S	T	E	V	U	W	S	L
W	E	H	K	V	O	J	X	T	R	R	W	W	A	D
S	A	D	M	F	P	E	R	M	A	F	R	O	S	T
X	W	H	T	L	V	N	M	X	H	B	Q	B	N	W
T	R	I	T	G	A	J	B	T	S	R	L	W	G	W
V	U	L	G	W	H	P	T	J	H	N	G	E	A	W

WORD BANK:

- THAW
- EROSION
- FOUNDATION
- STABLE
- UNSTABLE
- PERMAFROST
- ACTIVELAYER
- WEATHER
- CLIMATE
- ICEWEDGE

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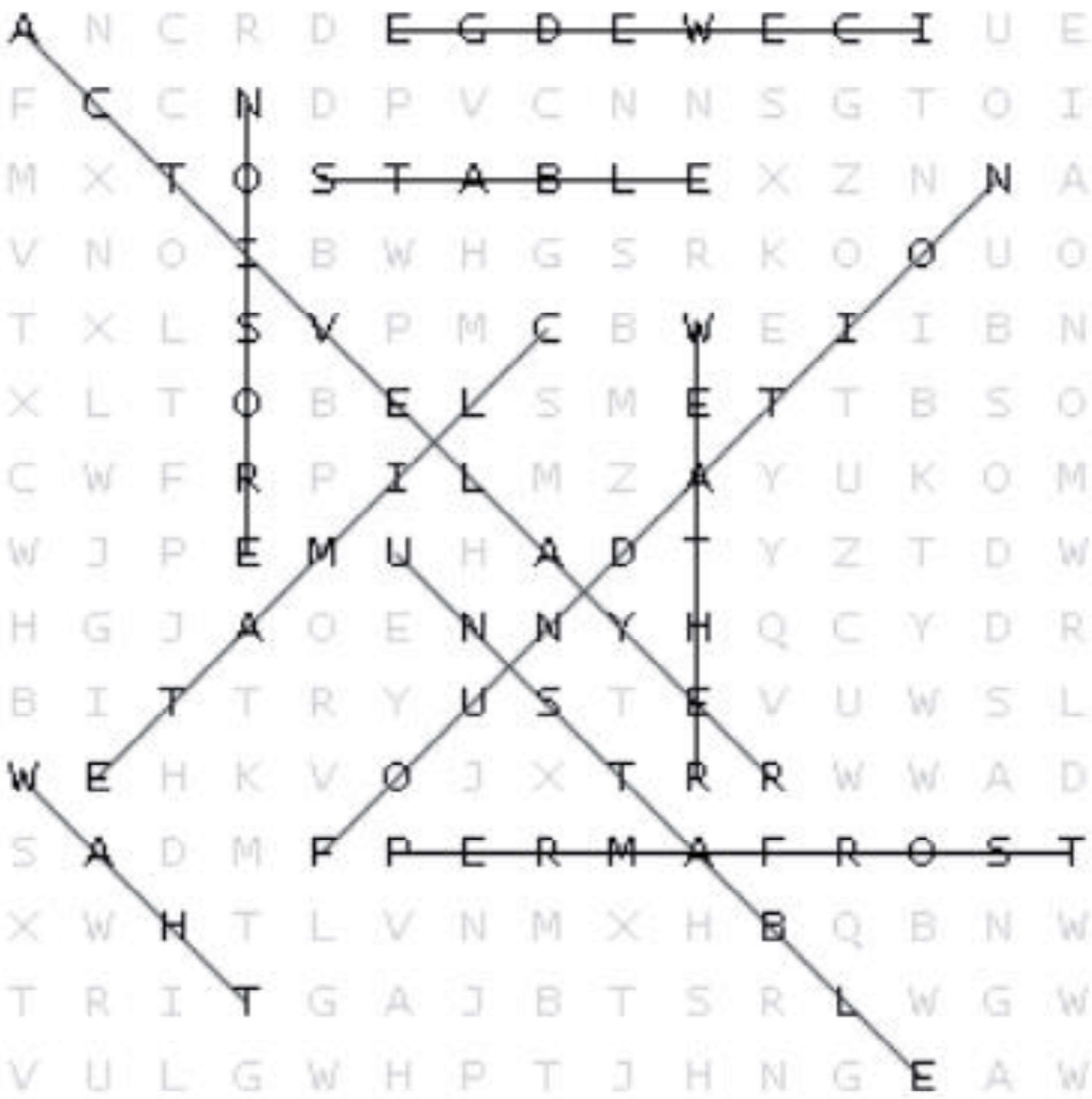
WORD SEARCH ANSWERS



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CROSSWORD PUZZLE

Permafrost and Landscape - Change in the Arctic

WORD BANK:

- PERMAFROST
- ACTIVELAYER
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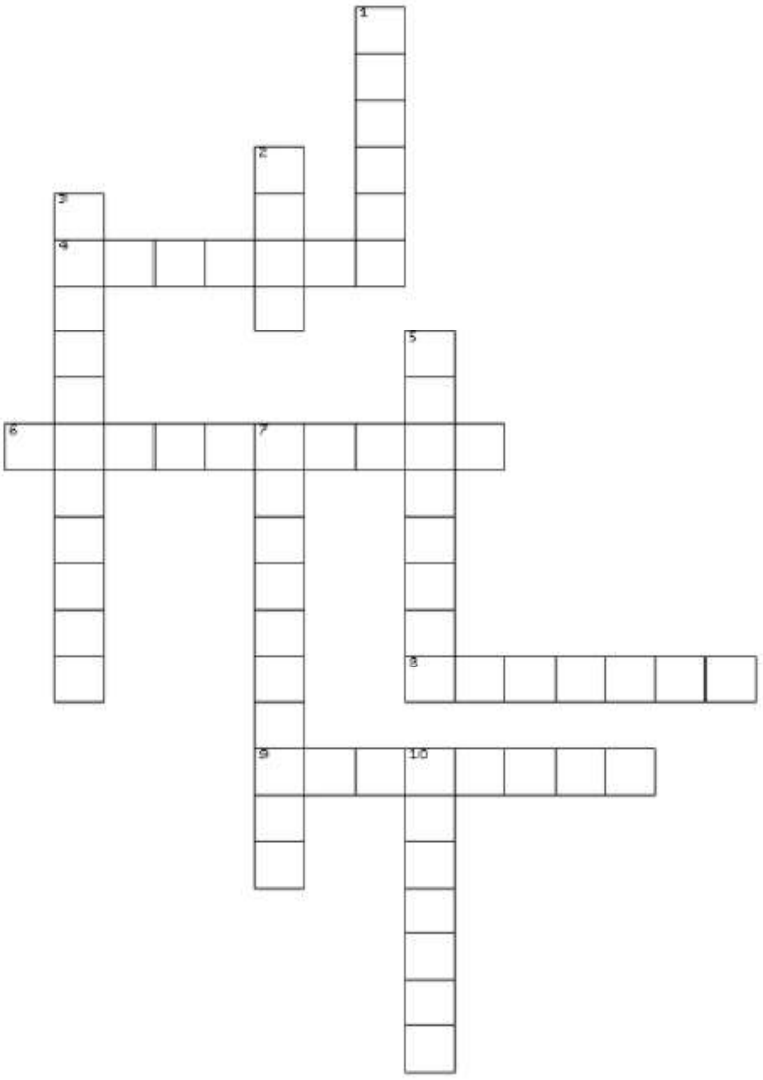

ACROSS

4. The usual weather conditions in a place.
6. The permanently frozen subsoil layer or areas found in arctic and subarctic regions.
8. The wearing away of the earth's surface by wind or water.
9. Ground ice that forms in cracks in permafrost and that can grow larger over time.

DOWN

1. Fixed, firm, or steady in position; not shaky or easily moved.
2. To go from being a frozen solid to being a soft solid or a liquid.
3. The top layer of soil above permafrost that thaws in summer and refreezes in the fall.
5. Likely to change suddenly; not steady; not securely fixed.
7. The part of the building that provides structure and support from underneath.
10. Sunshine, clouds, temperature, and rain are a few examples of this condition.

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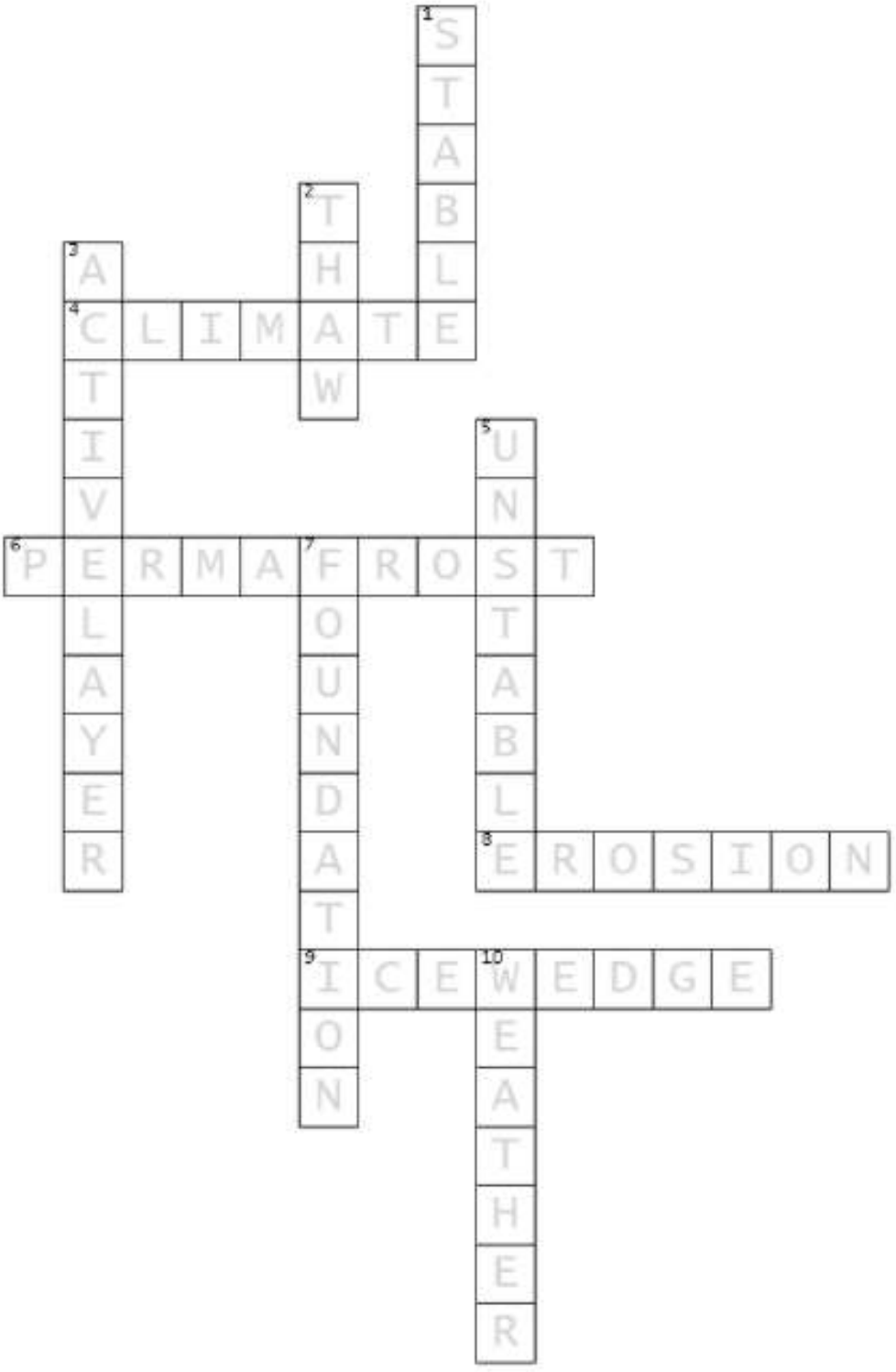
CROSSWORD PUZZLE ANSWERS



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Common Types of Ground Ice & Periglacial Landforms in Northern Alaska

DIRECTIONS: MATCH THE TERM WITH THE CORRECT PICTURE

FOLDED MASSIVE ICE BODY

HIGH-CENTERED ICE-WEDGE POLYGONS

SYNGENETIC ICE WEDGES

EPIGENETIC ICE WEDGES

LOW-CENTERED ICE-WEDGE POLYGONS

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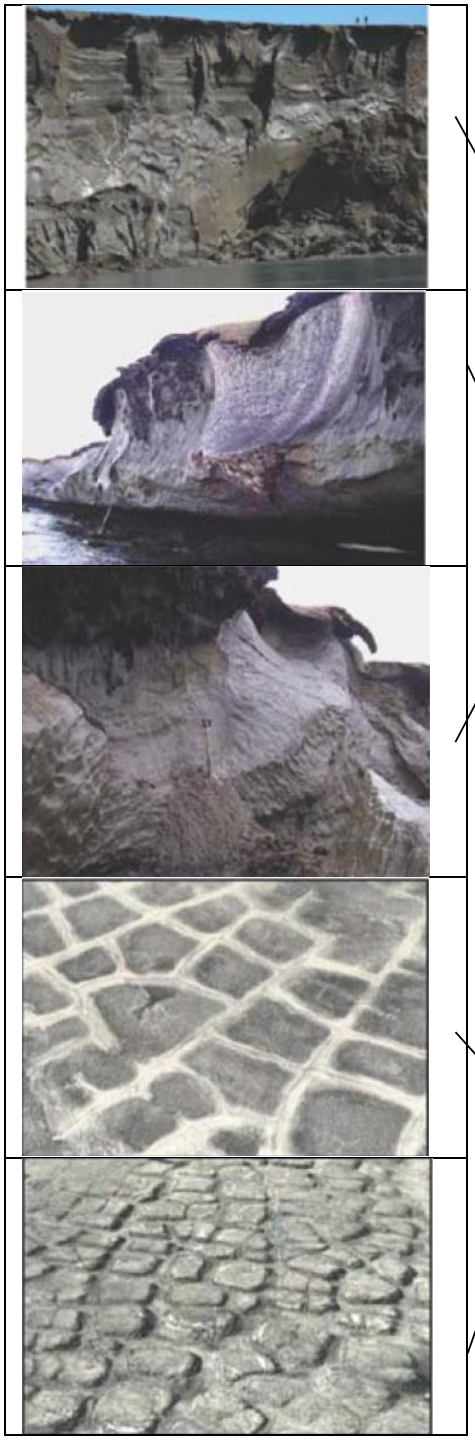
NNA IRPS Ice-Rich Permafrost Systems

Common Types of Ground Ice & Periglacial Landforms in Northern Alaska

KEY



FOLDED MASSIVE ICE BODY

HIGH-CENTERED ICE-WEDGE POLYGONS

SYNGENETIC ICE WEDGES

EPIGENETIC ICE WEDGES

LOW-CENTERED ICE-WEDGE POLYGONS

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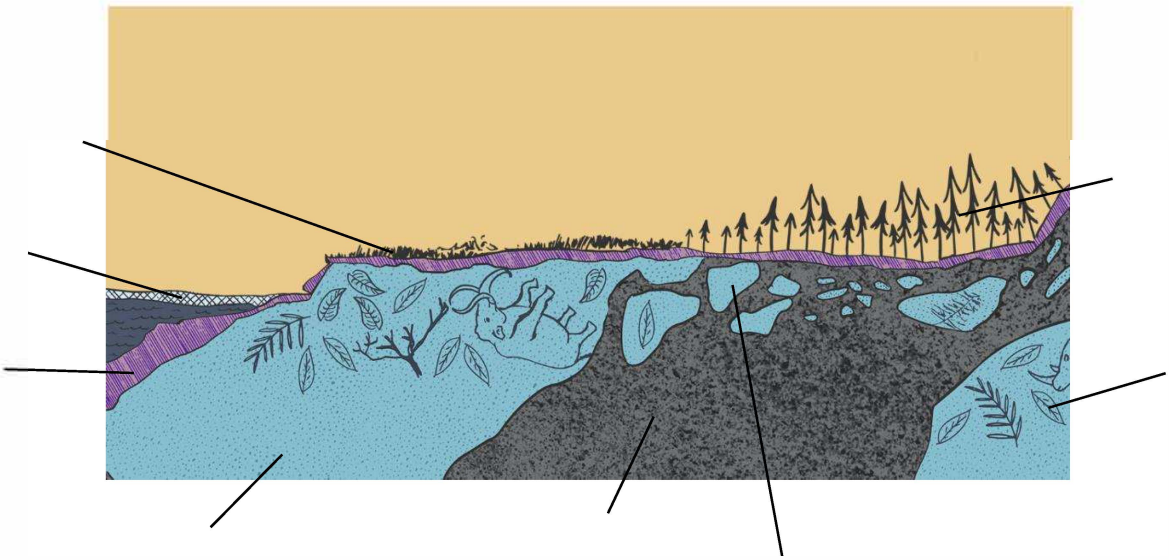
Thawing Permafrost Activity

DIRECTIONS:

Go to the following webpage: Thawing permafrost puts global climate warming in spotlight (https://graphics.reuters.com/CLIMATE-CHANGE/PERMAFROST/oakveelglvr/index.html)

After reading and scrolling through the information, answer the following questions.

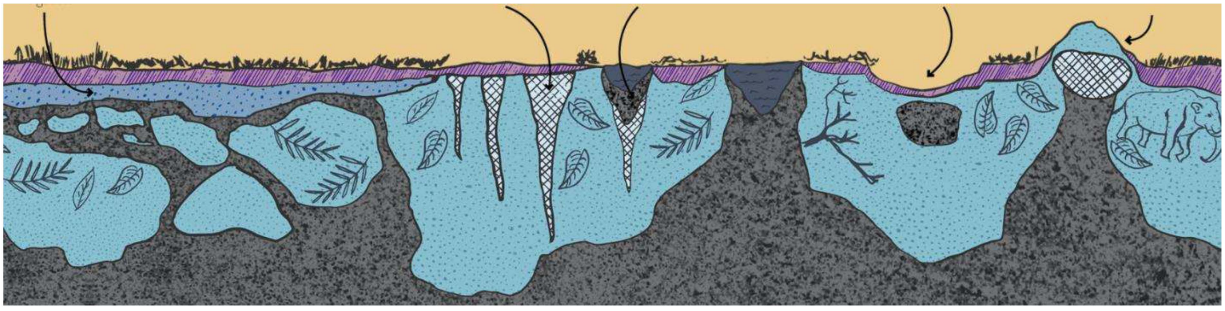
1) Fill in the labels for the following diagram:
   Hint: note the difference between continuous and discontinuous permafrost



2) What factors contribute to how deep the permafrost in a region is?

3) Where are thin active layers found and where are thick active layers found? Why do think this is?

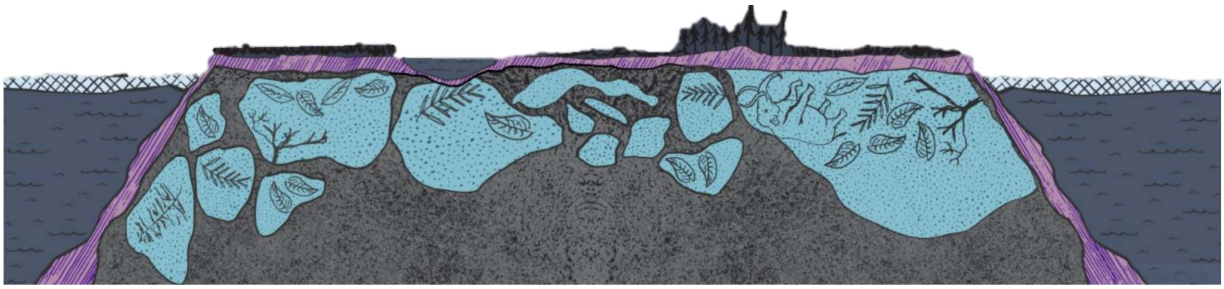
4) Label the five formations in the image below.



5) List 5 ways that climate change and human activity are impacting permafrost.

6) How does thawing permafrost further contribute to climate change? What might change that will make this worse?

7) Explain the cycle of permafrost using the following image. You can use a combination of arrows, drawings, and words to explain what is happening.



8) What is the albedo effect?

9) What do you think is the most worrying aspect of thawing permafrost? What do you think should be done to address it?

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Earth's Permafrost is Heating Up

Science News for Students

By Sid Perkins
February 22, 2019

Read the article and answer the following questions.

1. How many consecutive years does soil need to be frozen to qualify as permafrost?

2. How has a warming climate influenced your community?

3. How can melting permafrost affect manmade structures? Have you noticed this anywhere in your community? If your community does not have permafrost, what are ways that the changing climate has affected manmade structures?

4. How can melting permafrost affect the natural ecosystem? Have you noticed this or other ways the changing climate has affected the natural ecosystem near where you live?

5. How does melting permafrost add to the issue of climate change and rising temperature?

ScienceNews for Students

EARTH

Earth's permafrost is heating up

Climate change is warming soil that's been frozen for centuries — and in some places thawing it

As climate change brings warmer temperatures to the Arctic, the permafrost along this lakeshore in northern Alaska is thawing and falling apart.

BENJAMIN JONES/USGS

By **Sid Perkins**

February 22, 2019 at 6:45 am

It's no secret that climate change is melting Earth's ice caps and glaciers. In many cases, the ice is disappearing right before our eyes. Less well known has been what's happening below ground. A first-of-its kind global survey has just revealed that the planet's permafrost is also warming. Scientists now worry that could help make the planet even hotter.

Scientists Say: Permafrost

Permafrost is frozen soil, but not the type you might find in your yard in winter. This soil has to stay frozen constantly for at least two years to qualify as permafrost. Near the poles and high in the mountains, some permafrost has remained frozen since the last ice age ended thousands of years ago. And we're not just talking about a thin layer of soil. In many places, permafrost is more than 10 meters (33 feet) thick, notes Boris Biskaborn. He's a polar researcher at the Alfred Wegener Institute in Potsdam, Germany.

But this frigid dirt is in danger. Since the Industrial Revolution, the planet has been warming. On average, Earth has warmed by about 1 degree Celsius (1.8 degrees Fahrenheit) since 1850. Air temperatures in polar regions, especially the Arctic, have warmed even more. Over time, this extra heat has gradually soaked into the ground, warming it, too.

In many places, the effects of thawing permafrost are obvious. Once-stable shorelines have been tumbling into the sea. Once-frozen landscapes are turning to mush. Such changes can undermine roads and weaken the foundations of buildings. But Biskaborn and his colleagues wanted to assess less-obvious sites, ones far underground.

Explainer: Global warming and the greenhouse effect

They turned to soil collected from a number of deep *boreholes*. Some bores had been drilled by other teams many years ago, for various studies. Others were drilled more than a decade ago as part of a two-year-long study of polar regions. The holes were bored in North America, Europe, Asia and Antarctica. In all, the team identified more than 120 boreholes where the data record covered a decade. That 10-year period stretched from 2007 through 2016.

Close to the surface, soil temperature changes with the seasons. But if you dig far enough down, you'll reach a depth where the permafrost temperature stays the same year-round. For each borehole, the team found that depth. It was usually at least 10 meters (33 feet) underground.

Then the researchers looked at how permafrost temperature at that depth had changed over time. In soils from 40 of the boreholes, permafrost temperature had been stable from 2007

through 2016. In 12 of the holes, the permafrost cooled slightly. But in 71 boreholes, permafrost temperature warmed quite a bit.

Biskaborn's team reported its findings January 16 in *Nature Communications*.

Eroding seashores in Alaska are evidence that climate change is affecting Earth's permafrost. Data gleaned from deep boreholes drilled worldwide show this frozen soil is warming globally.

USGS

Not so permanent?

In northern North America, permafrost warmed up an average of 0.23 degree C (0.41 degree F). In northern Asia, frozen soil warmed up by 0.33 degree C (0.59 degree F). In mountainous regions, permafrost warmed by 0.19 degree C (0.34 degree F). Worldwide, the planet's permafrost has warmed an average of about 0.29 degree C (0.52 degree F).

Half a degree Fahrenheit doesn't sound like a lot of warming. But it may not take much to melt some permafrost. In five of the boreholes, soil temperature rose above freezing (0 °C, or 32 °F). At these sites, the permafrost had thawed.

When permafrost thaws, it can have consequences far beyond the local landscape, notes Ted Schuur. He's an ecosystems ecologist at Northern Arizona University in Flagstaff. Yes, he notes, when permafrost on the ground's surface thaws, it affects roads, bridges and buildings. But it also affects lakes, streams and other ecosystems. For example, when permafrost thaws, shrubs can take hold and grow. That, in turn, means the landscape can support more herbivores such as moose, hares and birds.

And there's more. Permafrost holds the remains of plants that lived and died long ago. While they were alive, those plants took up carbon from the atmosphere, just as plants do today. But thawing permafrost could unlock that carbon. If ice melts and the water drains away, that lets oxygen reach the dead plants. Now they can start to decompose.

Explainer: CO_2 and other greenhouse gases

Their rotting may generate vast amounts of carbon dioxide, explains Schuur. It could also support the growth of methane-making microbes in the soil. As those microbes thrive, they will release large amounts of methane, another climate-warming greenhouse gas. This might make global climate change even worse. This is why effects of thawing permafrost can affect people living as far away as the tropics, Schuur says.

A few years ago, he was part of a team that in 2015 estimated the possible effects of thawing permafrost. They used detailed computer programs for their study. By the year 2100, they estimated, thawing permafrost could release enough carbon dioxide and methane to raise the average global temperature by 0.13 to 0.27 degree C (0.23 to 0.49 degree F).

That increase, Schuur notes, would be *in addition to* any boost in global temperatures from the greenhouses gases that factories and farms emit during that time. And it would be on top of the 1 degree C (1.8 degrees F) that average temperatures have already risen since 1850.

"Warming permafrost is a largely unknown dimension of climate change," Schuur says. The new study shows that deep underground in chilly, remote parts of the world, big changes may be brewing.

CITATIONS

Journal: B.K. Biskaborn et al. Permafrost is warming at a global scale. *Nature Communications*. Vol. 10, January 16, 2019. doi: 10.1038/s41467-018-08240-4.

Journal: E.A.G. Schuur et al. Climate change and the permafrost carbon feedback. *Nature*. Vol. 520, April 9, 2015. doi: 10.1038/nature14338.

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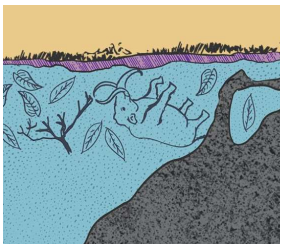
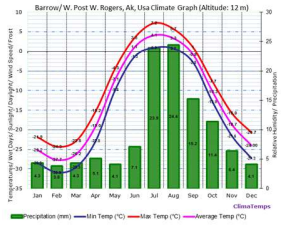
Words About Permafrost and Landscape Change in the Arctic

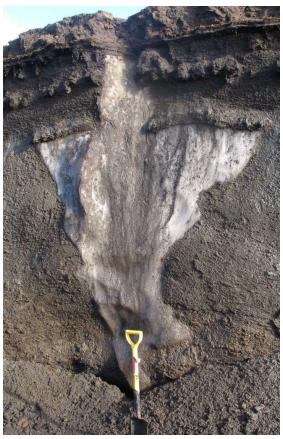
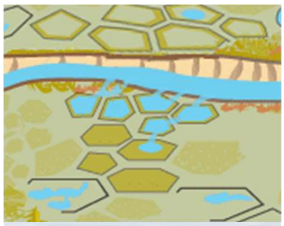
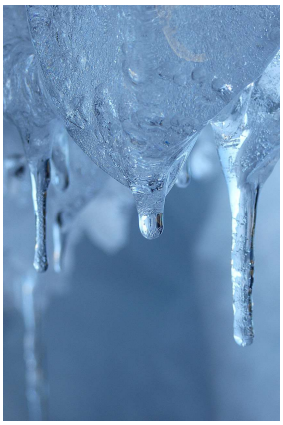
Navigating the New Arctic in Ice-rich Permafrost Systems
Grades 1-2

This vocabulary worksheet is for first and second grade students to complete over the winter break.

Instructions:
Learn the vocabulary words related to permafrost and landscape change. If possible, interview an older family member or neighbor to learn if they know an Iñupiaq name or another local word for the same thing.

Picture	Word	Meaning	Iñupiaq or local word
	permafrost	Ground that remains frozen all year long. Permafrost is made of ice, soil, rocks, and sand, and may contain the remains of ancient plants and animals.	
	active layer	The top layer of soil above permafrost that thaws in summer and refreezes in the fall.	
	weather	Day-to-day variation in local temperature, wind, rain and snow conditions	
	climate	Typical weather patterns in a region measured over many years.	

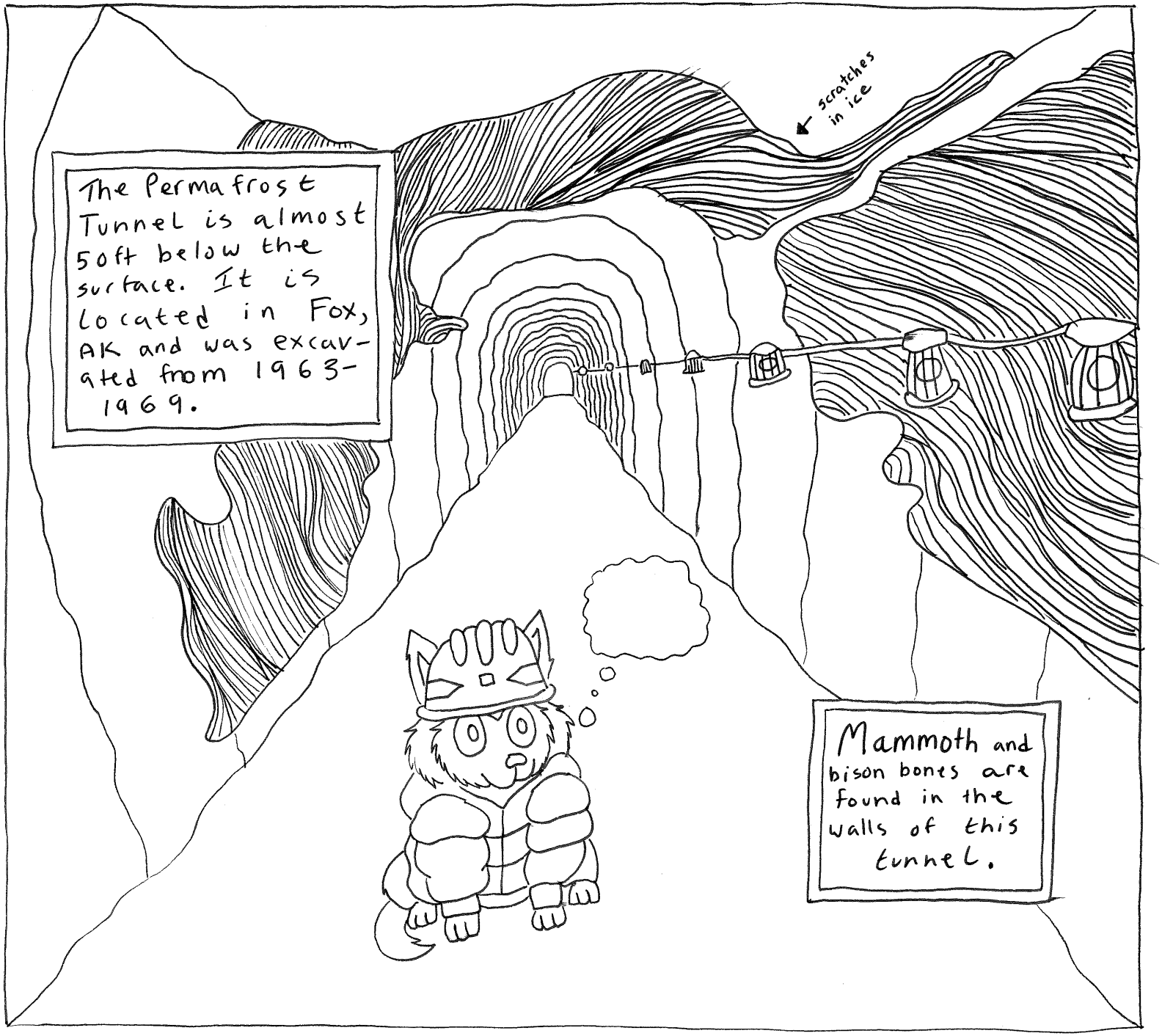
Navigating the New Arctic in Ice-rich Permafrost Systems

	Ice wedge	Ice that forms when water flows into the cracks in the permafrost and freezes. Ice wedges can grow very large over time.	
 	Ice-wedge polygons	A landscape pattern that forms on the ground above ice wedges in permafrost landscapes. Some polygons become flooded with water from melting snow or nearby lakes and rivers.	
	thaw	The melting or softening of ice, snow and other frozen things as the result of warming.	
	erosion	The wearing away of the earth by water, wind, and other forces.	

Navigating the New Arctic in Ice-rich Permafrost Systems

	foundation	The lowest part of a building that supports the weight of the building and connects it to the ground.	
	stable	Firmly fixed	
	unstable	Likely to change or move	

Photo and picture credits: Ben Jones, Mikhail Kanevskiy, Jana Peirce, Thot Pro, Inc., GRID-Arendal, reuters.com



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Words About Permafrost and Landscape Change in the Arctic

Navigating the New Arctic in Ice-rich Permafrost Systems
Middle - High School

Instructions:

Middle and high school students are asked to interview one or more older family members or neighbors over the winter break about observations related to permafrost and landscape change over time, including changes in village housing.

Here are some options for the assignment:

- The student can make an audio or video recording of the interview, with the permission of the interviewee.
- The student can walk around the community during or after the interview and take photos or video of some of the landscape changes or features discussed.
- The student can take a photo of the house foundation.
- Students may be asked to summarize what they learn in a short paper, poster or video.

The Interview

Questions about the interview:

- Name of person being interviewed (the "interviewee")
- Age of interviewee
- Photo of interviewee (with their permission)
- Name of the student (the "interviewer")
- Date of interview

Questions about landscape changes:

- How many years have you lived in Point Lay?
- What changes have you noticed in the natural landscape since you've lived in Point Lay?
- What do you think has caused the changes you see?
- How have people had to adapt to the changing landscape? For example: Are there ways that daily life or seasonal activities are different now?

Questions about changes in houses in Point Lay:

- When was your house built?
- What kind of foundation does your house have? (The foundation is the lowest part of the house that supports its weight and connects it to the ground. The student should take a photo of the foundation if possible.)
- Has your house's foundation settled or become unstable? How can you tell?
- If the answer is yes:
    - How does that impact you or your family? For exampie, are there things you do differently because of the foundation's instability?
- What is causing some house foundations to settle more than others in your opinion?
- Besides the foundations, what other changes have you noticed in and around village homes that are affecting daily or seasonal life in Point Lay?

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Types of Permafrost

Name: _____

Draw and name 4 types of permafrost based on their description

1. _____	3. _____
2. _____	4. _____

1. A form of permafrost that exists across a landscape as an unbroken layer.

2. A form of permafrost that contains numerous scattered pockets of unfrozen ground.

3. A form of permafrost that exists at high altitudes in mountainous environments.

4. A form of permafrost that exists beneath the sea in ocean sediments.

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NNA Ice-Rich Permafrost Systems IRPS

KEY

Types of Permafrost

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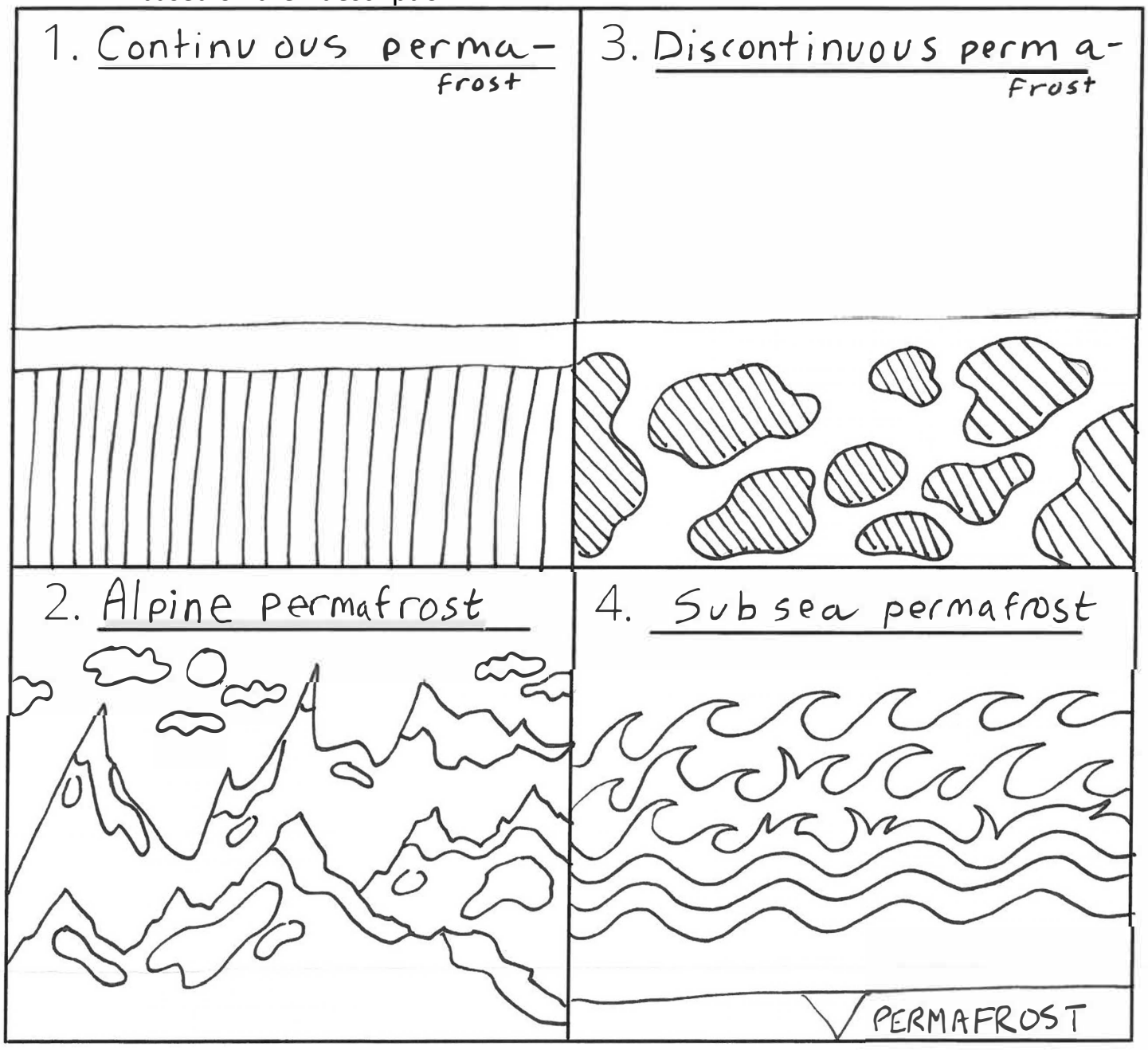

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From Ice Wedge Polygon to Thermokarst Lake! _____

During winter, cold temperatures create cracks in the ground. These cracks run through the active layer and permafrost.	Snow and ice melt as temperatures rise during spring. Ice wedges are formed when water that trickles into the cracks freeze and expand. This is because the water is chilled by the cool temperature of the ground.	In summer, the active layer and the tops of the ice wedges thaw.
Next winter, cracks will form in the same places as last. The ice wedges expand during spring when water fills the cracks.	The ice wedges push soil up as they grow. From above, these soil ridges make up the shape of a polygon.	If an ice wedge is exposed, it will begin to melt. A pond will form if the active layer and ice wedge melt lower.
During summer, the temperature of the pond causes the active layer to melt even lower. Eventually, the ice wedge melts completely and a thermokarst lake is formed.	Soil keeps the lake contained. If the soil breaks down, the lake will drain. Without water to insulate the active layer, the top of it refreezes in the winter.	The part of the active layer that does not freeze is called a **talik**. It is very wet soil that remains suspended in the permafrost layer.

COLD CLIMATE
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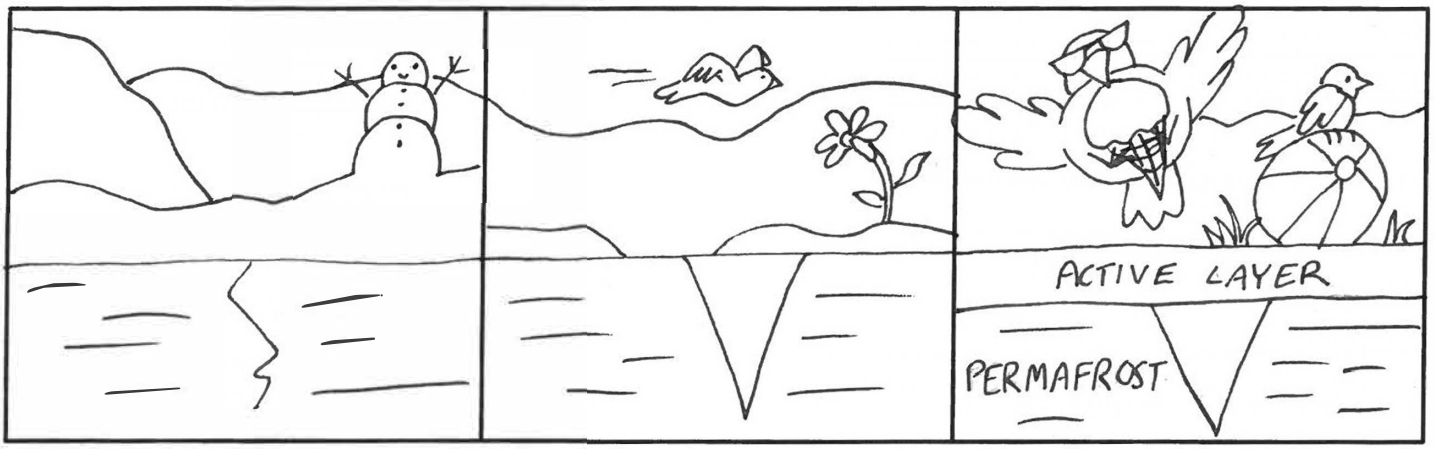
From Ice Wedge Polygon to Thermokarst Lake!

KEY



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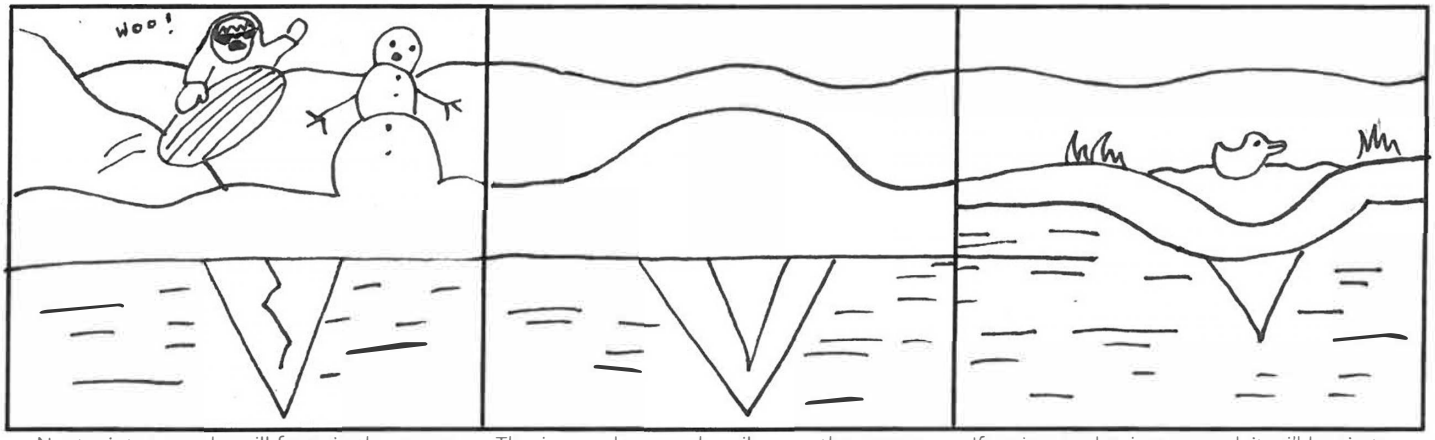

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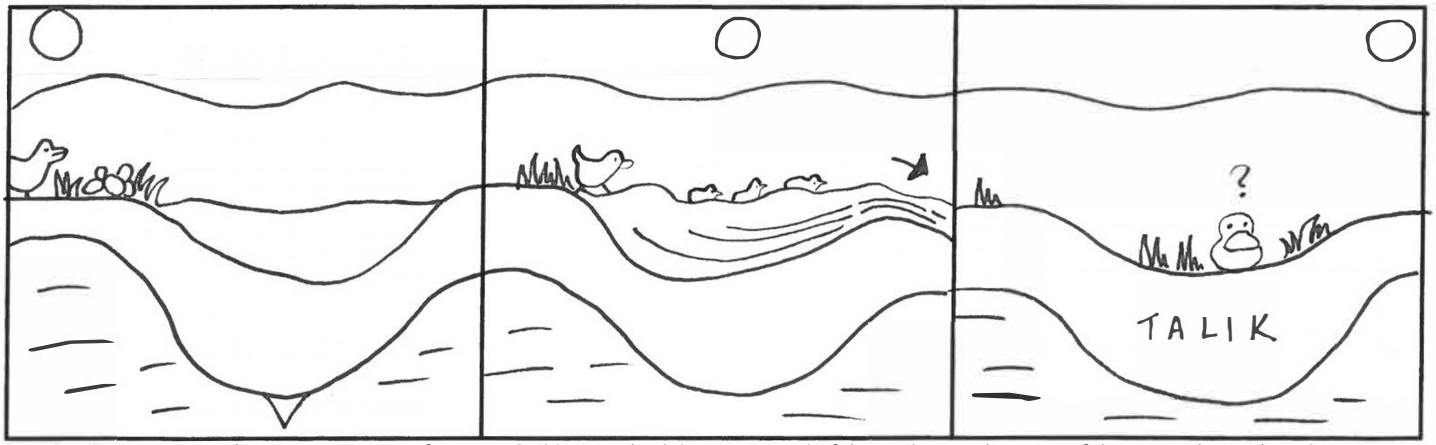

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Soil keeps the lake contained. If the soil breaks down, the lake will drain. Without water to insulate the active layer, the top of it refreezes in the winter.

The part of the active layer that does not freeze is called a **talik**. It is very wet soil that remains suspended in the permafrost layer.

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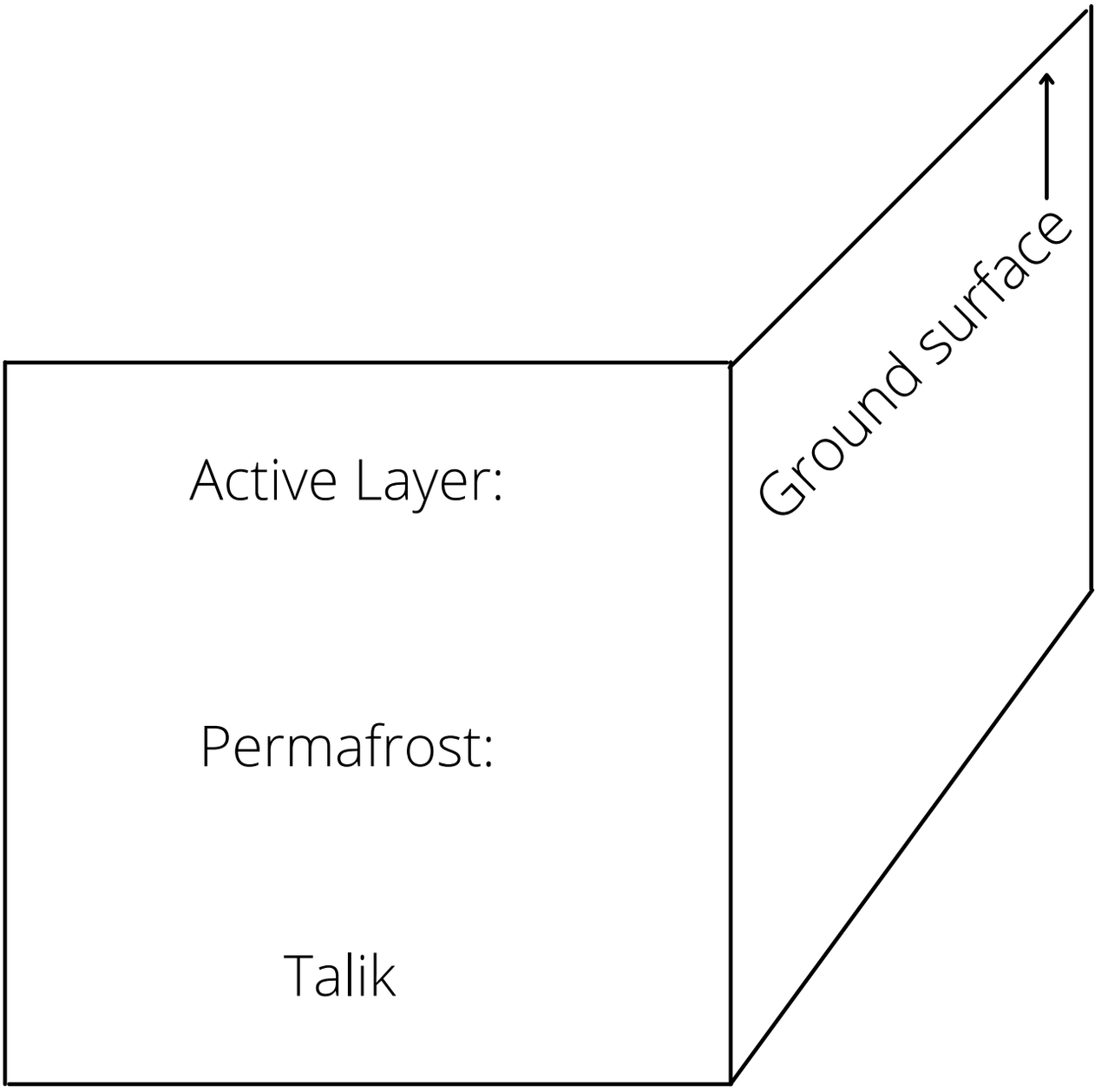
What is permafrost?

Directions: Define the 3 permafrost vocabulary words and draw a house on an appropriate foundation.



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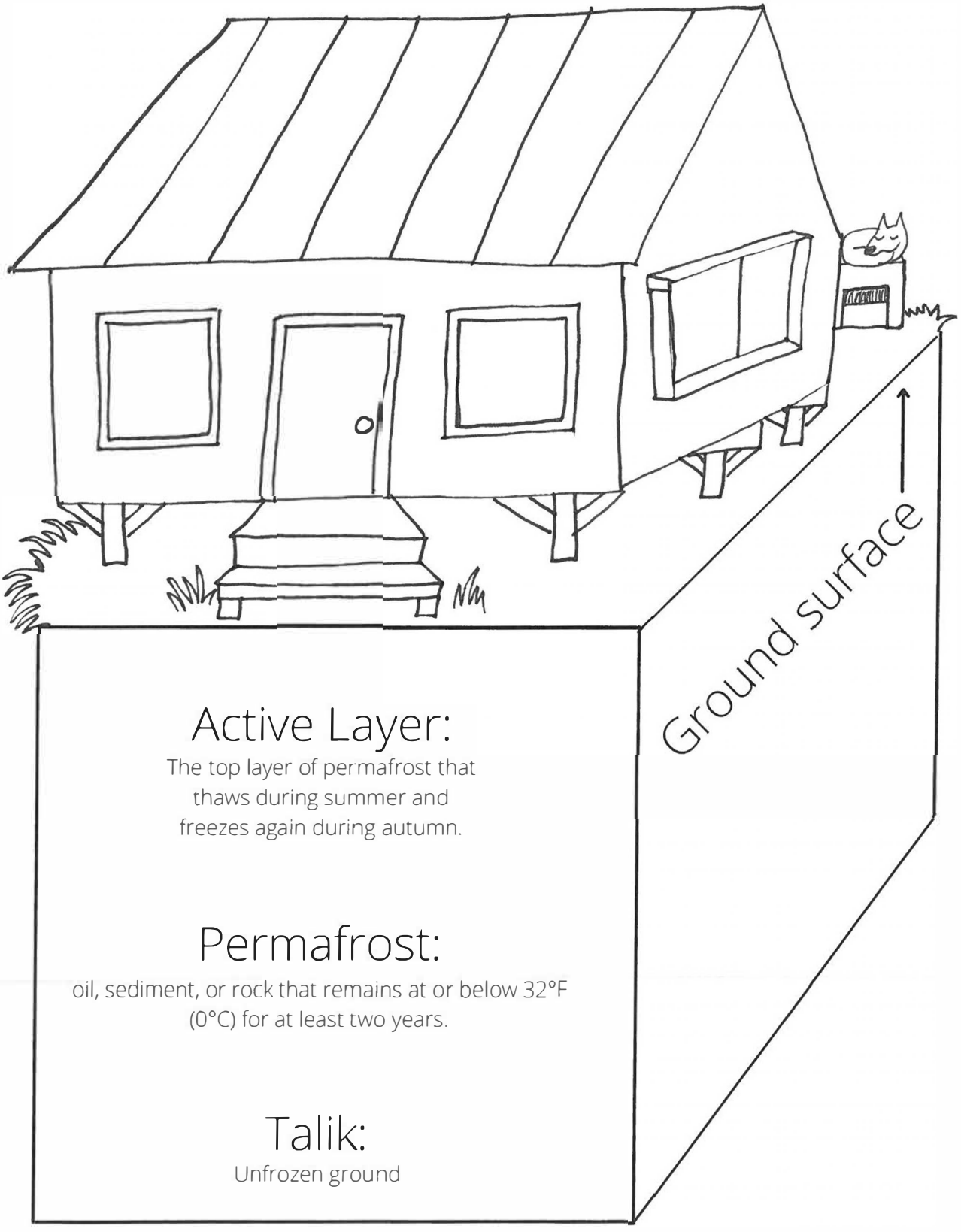

Active Layer:

The top layer of permafrost that thaws during summer and freezes again during autumn.

Permafrost:

oil, sediment, or rock that remains at or below 32°F (0°C) for at least two years.

Talik:

Unfrozen ground