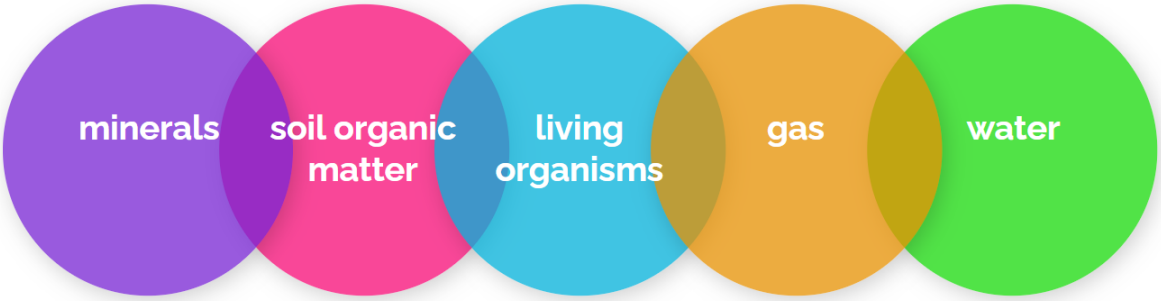
ARCTIC SOILS AND NUTRIENT CYCLE

Introduction

Soil is a material composed of five ingredients - what are they? Read a recipe for soil.

SOIL IS... A RECIPE WITH **FIVE INGREDIENTS**



Soil minerals are divided into three size classes — clay, silt, and sand; the percentages of particles in these size classes is called soil texture. The mineralogy of soils is diverse. The most common mineral in soils is quartz

Soil organic matter is plant, animal, and microbial residues in various states of decomposition; it is a critical ingredient — in fact the percentage of soil organic matter in a soil is among the best indicators of agricultural soil quality.

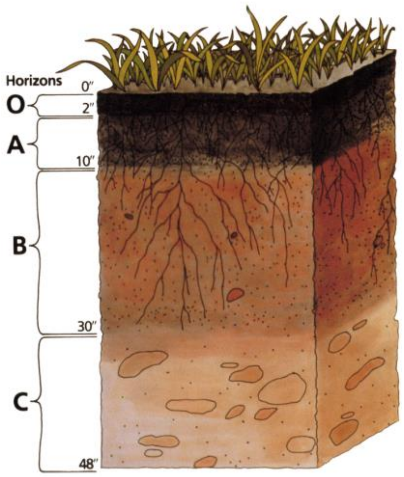
Living organisms present in soil include archaea, bacteria, fungi, algae, protozoa, and a wide variety of larger soil fauna, including mites, nematodes, earthworms, ants, insects that spend all or part of their life underground, and larger organisms such as burrowing rodents (like moles)

Soil gases are the gases found in the air space between soil components. The primary soil gases include nitrogen, carbon dioxide and oxygen.[1] The oxygen is critical because it allows for respiration of both plant roots and soil organisms.

Soils can process and hold considerable amount of water. They can take in water, and will keep doing so until they are full Soil water retention is essential to life. It provides an ongoing supply of water to plants between periods of infiltration, so as to allow their continued growth and survival.

Project office: Księcia Janusza 64, 01-452, Warsaw, Poland edu-arctic2.eu **edukacja@igf.edu.pl**
EDU-ARCTIC 2: from polar research to scientific passion – innovative nature education in Poland and Norway receives a grant of ca. 240 000 EUR received from Iceland, Liechtenstein and Norway under EEA funds. The purpose of the EDU-ARCTIC 2 project is to: enhance the knowledge about nature, geography, natural resources, political specificities concerning polar regions and increase awareness of environmental issues and climate change, increase of interest in pursuing STEM education and careers due to enhancement of knowledge about scientific research, and their place in the modern world, familiarizing young people with scientific career opportunities; introduce innovative tools by way of an e-learning portal and effective methods of teaching science in schools

This is a typical SOIL PROFILE - cross section of layers, also known as soil HORIZONS. Name them using prepared terms.



humus	topsoil	parent material	subsoil

How are soils formed? Learn the basics about processes that lead to soil formation. This process is known as pedogenesis (presentation pdf HOW ARE SOILS FORMED).

What is CLORPT?
How can you determine a soil's CLORPT? Wait, what is CLORPT? CLORPT is an acronym for the five factors of soil formation. Click and check what these letters stand for.

CL - Climate describes weather characteristics over a long period of time, including temperatures and rainfall. Soils that formed with 50 cm of rain per year are much different from soils that formed in a desert climate with only 10 cm of rain per year!

O – Organisms e.g. plants and animals that influence the way soils are formed. For example, many years of falling pine needles can make a soil slightly acidic (low pH). Similarly, earthworms have long been associated with healthy, productive soils.

R – Relief (topography) Relief describes the shape of the earth's surface, such as mountains, hills, and plains. Have you ever noticed how soils in low-lying areas are wetter than soils on ridges? Soils

on north-facing slopes tend to be cooler because the sun doesn't shine on them as much as on south-facing slopes. That's the "topography factor" in action.

P – Parent material Parent material describes the kinds of rocks or transported sediments that the soil formed in. Examples include alluvial, colluviums, eolian, glacial, residual, and organic soils.

T – Time Older soils usually have more differences in color, structure, and texture as you go down from the soil surface. Reddish colors might be caused by iron oxides and certain kinds of clay that have been washed down and concentrated at a lower level (soil horizon). Younger soils such as a big deposit of windblown dune sand or floodplain might have similar characteristics throughout the soil profile.

Why are soils important? Soils are complex mixtures of minerals, water, air, organic matter, and countless organisms that are the decaying remains of once-living things. It forms at the surface of land – it is the "skin of the earth."

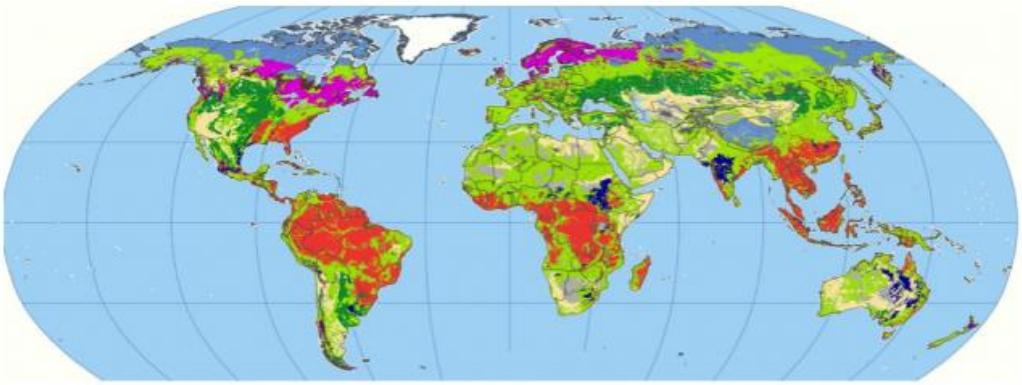
Learn about their role in ecosystem.

INQUIRY

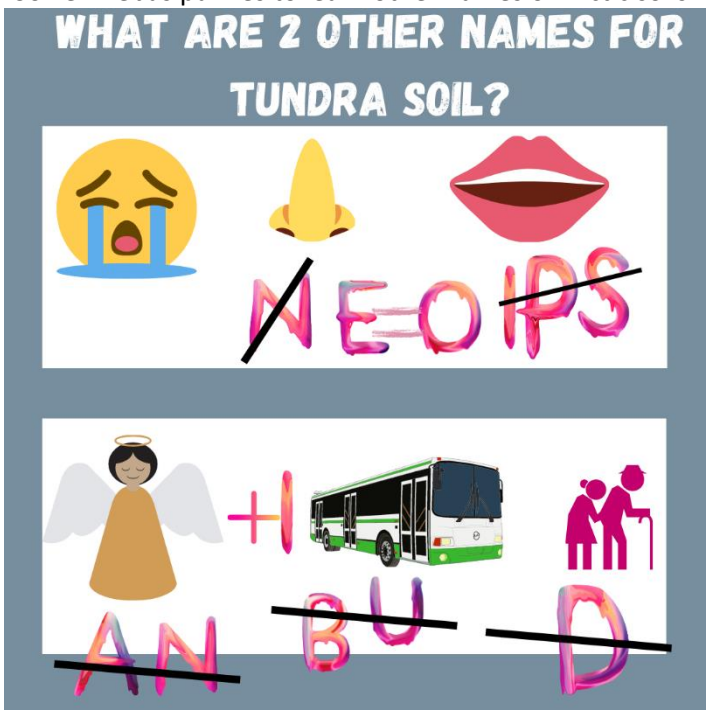
Arctic soils are very special, with unique processes and full of paradoxes. What is their relation with climate change?

Arctic soils vary in mineral composition, snow cover, water content, type of vegetation, organic content, and extent of permafrost. While united by low temperatures, the heterogeneity of abiotic factors results in a mosaic of site-specific conditions across the Arctic.

This mosaic is unique to the Arctic and contributes to the site-specific biogeochemical regimes and microbial communities that develop.



Solve 2 rebus puzzles to learn other names of Arctic soils.



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Where can we find gelisols and what are their properties? Match columns to create full sentences.

These soils are limited geographically to	processes such as decomposition of organic materials	to proceed very slowly
Low soil temperatures cause soil-forming	the high-latitude polar regions and	high mountain elevations
Gelisols are soils of very	cold climates that contain permafrost within	2 meters of the surface
Gelisols are estimated to occupy	about 9.1% of the Earth's ice-free	land area

LINK TO ONLINE ACTIVITY: https://www.purposegames.com/game/gelisols

How does nutrient cycling work?
Soil stores, moderates the release of, and cycles nutrients and other elements. During these biogeochemical processes, analogous to the water cycle, nutrients can be transformed into plant available forms, held in the soil, or even lost to air or water.Nutrient cycling is the process by which beneficial microorganisms harvest nutrients from soil organic matter and also from the 'parent material'. Watch the video to find how this process works.
VIDEO MATERIAL: How does nutrient cycling work?

LINK TO VIDEO MATERIAL: https://youtu.be/NVhY4ssMtbI

Now that you've watched the video, try to summarize why is it important to maintain "healthy" soils from the point of view of

1) farmers

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2) consumers

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3) environment

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How about Arctic soils? The Arctic environment is rather specific, or even extreme. Knowing all you've learnt about the Arctic so far, (especially the climate) what are your assumptions about the NUTRIENT CYCLE in the Arctic?

Nutrient cycle in Arctic soils is generally

- ○ fast
- ○ slow

Are Arctic soils rich or poor? Fill in the blanks.

[ ] and biological processes that govern soil nutrient cycling operate at different [ ] depending on a number of environmental factors. In arctic systems, these processes are generally [ ] than in most other ecosystems due to low soil [ ], short [ ] season, strong seasonal fluctuations and sometimes also the occurrence of [ ]. Furthermore, slow-growing plants with high contents of [ ] and phenolic secondary compounds often dominate tundra vegetation. Tundra nutrient cycling is thus limited by the nature of the plant residues, that [ ] slowly. Since the deglaciation of the region after the last [ ] ca. 3,000–8,000 years ago, organic matter decomposition has been slower than primary [ ], resulting in the accumulation of [ ] in tundra soils. In contrast to most tropical ecosystems, where majority of the organic matter is in the living biomass, a considerable portion of the C in tundra ecosystems is in the non-living part of the system, i.e. in the litter and [ ]. Due to the imbalance between production and decomposition of organic matter, arctic tundra is a strong sink for [ ] at the global scale. It is estimated that tundra soils contain [ ] of the world's soil carbon.

Terms:

11%	**carbon**	**decompose**	**growing**	**Ice Age**	**lignin**	**microbial**

Organic matter	**permafrost**	**production**	**rates**	**slower**	**low**	**temperature**

LINK TO ONLINE ACTIVITY: https://learningapps.org/watch?v=ph8uak1wa20

Now read the full text and name 3 factors that lower the rate of organic matter decomposition in Arctic soils. Indicate which are BIOTIC and which are ABIOTIC.

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Are Arctic soils rich or poor? Used predefined concepts to create a concept map. Now look at your concept map and explain what THE ARCTIC SOILS PARADOX means.

Remember: a paradox is a seemingly contradictory statement or proposition which when investigated may prove to be true.

Terms:	**low temperatures**	**Trapped carbon**	**low activity of microorganisms**	**limited availability of liquid water**	**Low nitrogen level**
slow decomposition	**lots of organic matter**	**low number of organisms (earthworms)**	**Plants grow slowly**	**Thin humus layer**	**Low phosphorus level**

Research

There are some areas where Arctic soils are much more rich and abundant in nutrients. It means they have higher fertility, allowing plants to develop. Let's learn what's the reason behind it.

What is a a soil horizon?

A. A factor influencing how soil is formed
B. A layer of soil
C. An organism found within the soil

Which three layers form the soil

- A topsoil, subsoil and parent material
- B Air. water and soil
- C Clay, silt and sand

Arctic soils accumulate a lot of

- A snow
- B carbon
- C earthworms

There is a lot of organic matter trapped in Arctic soils because

- A microorganisms are extremely active
- B of parental rock chemical composition
- C it's too cold for the decomposition

Which one is NOT the name of Arctic soils?

- A permasoils
- B cryosols
- C gelisols

Acronym for 5 factors influencing soils is

- A COULWE
- B DFIWLR
- C CLORPT

The ability of a soil to supply essential nutrients to plants is called

- A humidity
- B fertility
- C none of the above

The solution (of online version) is LITTLE AUK, a bird species forming large colonies in the Arctic, e.g. on Spitsbergen, Svalbard.

Link to online quiz: https://view.genial.ly/5f9ffe6e8519011e966a7031/learning-experience-challenges-what-brings-nutrients-to-arctic-soils

The secret behind more prolific parts of tundra are so called ORNITHOGENIC SOILS. Use pdf presentation (Ornithogenic soils) and learn how they are formed!

LINK TO ONLINE VIDEO PRESENTATION: https://view.genial.ly/5fa014364a95b80d82de95c5/video-presentation-ornithogenic-soils

Experiment on Spitsbergen

Researchers from Department of Vertebrate Ecology and Zoology, University of Gdańsk conducted field studies on ornithogenic tundra in Spitsbergen. They argued that different bird species have different impact on the vegetation structure and chemical composition of the ornithogenic tundra, depending on locations of the colony. Try to imagine what their experiment looked like and describe its selected elements.

What about Antarctic? Do you think that similar phenomenon occurs in the Antarctic? What animals could cause it there? Write your answers.

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Activities

Look at the photo. Describe what's particular about these soil horizons.

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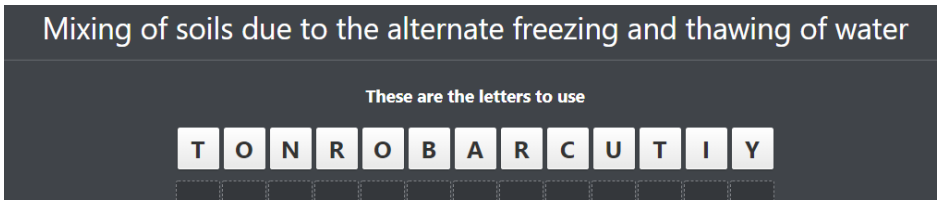
Unscramble letters and learn the name of the process shaping Arctic soils.



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Arctic soils are often characterized by extensive mixing by frost action, which is called cryoturbation. Cryoturbation occurs to varying degrees in most gelisols. Cryoturbation moves soil material resulting in broken and convoluted soil horizon. Cryoturbation tends to mix of bury surface material (containing organic materials) with mineral material.

Think and answer following questions:

1) how will climate change affect cryoturbation?

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2) is there any way that cryoturbation may counteract climate change?

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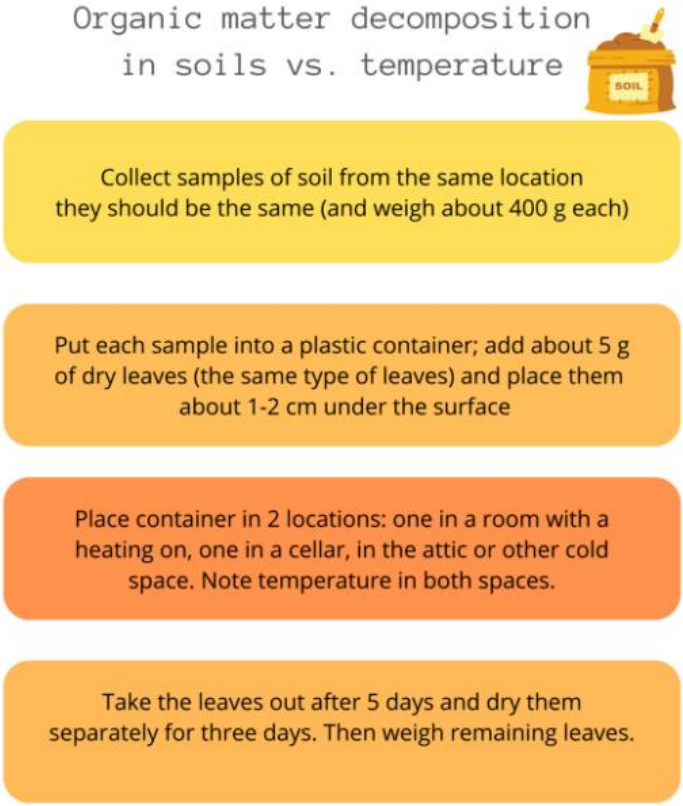
HINTS: moving SOC (soil organic carbon) down in the profile; in cold layers decomposition is very slow; deeper layers are colder;

TIME FOR EXPERIMENT!



Now enter your data and experiment results.

	Initial weight of soil	**Initial weight of leaves**	**Temperature in room**	**Weight of leaves after 5 days**	**Weight of dry leaves**	**Weight loss (%)**
SAMPLE 1						
SAMPLE 2						

What are your conclusions? How does temperature affect organic matter decomposition in soils in general? How does it affect carbon storage?

Is temperature the only limiting factor? Solve the TRUE-FALSE quiz!

Arctic plant growth is predominantly nitrogen (N) limited
TRUE/FALSE

Low temperature results in high microbial activity
TRUE/FALSE

Animals such as earthworms can cut plant litter into smaller fragments and translocate them deeper into the soil where they are more easily processed by other decomposers.
TRUE/FALSE

Cutting organic matter into smaller fragments lowers decomposition rate
TRUE/FALSE

Decomposition enhances the release of nitrogen from the soil.
TRUE/FALSE

Earthworms are able to mineralize and physically translocate litter and soil organic matter
TRUE/FALSE

Earthworms move nutrients down to the roots through a network of horizontal and vertical tunnels
TRUE/FALSE

With more nutrients down the roots, there would be more plants
TRUE/FALSE

With more plants, albedo would rise
TRUE/FALSE

So … what else affects lack of nutrients in Arctic soils?
After solving the quiz, answer the questions

1) what is another major factor causing low level of nutrients in Arctic soils, other than low temperatures?

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2) is this "another factor" totally unrelated to low temperatures?

……

3) if this factor changed - what would it mean for the Arctic? Would it be beneficial in a long term? How would it affect ecosystems, albedo and climate?

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Wrap up

Time to sum up what you've learnt!

Write 3 things you find most important from these package that you'd like to remember for the future.

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You can use Presentation(Pdf, Arctic soils) to return to basic information from these materials