



Water

WATER QUALITY: SNOW & WINTER

The first two pages are background information for students. The remaining pages should be printed double-sided and can act as a visual for the “SCREW Factor.”

Water is a particularly special substance on the planet earth. Life as we know is made possible by the molecular properties of water in both simple and complex ways. A water molecule is chemical compound made of hydrogen and oxygen (H₂O) and is considered to be one of the most unique features of this particular planet. In the living world (**hydrosphere**), water is considered to be a universal **solvent** because it allows many important molecules and chemicals to operate through solution. Driven by the energy of the sun, water **cycles** back and forth between the atmosphere, the land, and living things. In northern Canada, a negative **energy** balance affects this cycle during the winter months, and water is **stored** for extended periods of time as snow and ice.

Interestingly, water behaves in a completely unorthodox manner (**anomaly**) because water expands as it freezes! Consequently, ice floats on water because the solid phase has less **density** than the liquid phase. Snow begins as gaseous water molecules crystalize in the atmosphere at temperatures of 0 degrees Celsius or lower. When they become heavy enough they fall to the earth's surface and are stored in various forms. The accumulation of snow on the ground is called **snowpack** and the layers have many interesting characteristics and complexities. Fresh snow often falls as snowflakes and creates a fluffy layer because of the airspaces trapped as they pile up on the ground. In time, **sublimation** and numerous **freeze-thaw** cycles create a transition from snowflake to ice through a process called “**destructive metamorphism**” – and really is the “water” story of winter in Canada.

As the snowfalls of October and November begin to be stored on the ground, the snow (like any form of **precipitation**) carries with it a broad variation of chemical properties. Just like in liquid water, there will be different pH, alkalinity, and dissolved oxygen levels. If there are any pollutants in the air, they will also be dissolved in the ice crystals that fall from the sky. Consequently, the levels of nitrate and sulfate can accumulate in the snowpack. Industrial airborne pollutants are carried on the winds of weather systems and as a result can affect the water quality of regions “downwind” - and will eventually enter a different **watershed** and surface drainage system. Therefore, in the spring this can potentially create a pulse of toxicity that hits the aquatic ecosystem as the snow melts and drains into the various wetlands, lakes, and rivers.

So, one might ask the question, “What is winter exactly”? Winter ecology textbooks often use the acronym **SCREW** to help define and summarize the following factors or vectors of winter: Snow . . . Cold . . . Radiation . . . Energy . . . Wind. Snow is the result of precipitation that freezes at 0 degrees Celsius. Cold is the sensation we feel and is an expression that we



use to describe a “lack of heat”. Because the top half of the earth is tilted away from the sun during the winter season the ground receives less incoming solar radiation (**insolation**). As a result, there is less kinetic energy available for plants to create food and therefore less food is available for animals. Wind is a powerful agent (**wind chill**) that can quickly move heat away from living things and also blows snow around. These are the major factors that have shaped the adaptations, physiology and behaviors of all the plants and animals that live in snow and winter.

People who live with snow during winter often create names [powder, sugar, hoar frost] for the various types of snow that can be found in layers over the course of a winter. The Inuit people of northern Canada have a surprising 17 different words for snow. Regardless, the layers in a snow bank tell the story of the weather that took place over the course of a winter. In reality, animals and plants either benefit and/or suffer because of the way snow accumulates during the winter. Animals can be conveniently grouped into three different categories depending on their adaptations to snow. **Chionophobes** (snow haters) avoid snow, **Chionophores** tolerate snow in varying degrees, and **Chionophiles** (snow lovers) actually thrive in the snow. You probably know some human beings who belong to each of these categories! Unfortunately, all living things can be adversely affected if the water contained within their cells freezes expands, and the resulting ice crystals rupture the cell membranes. This can lead to serious injury (**frostbite**) and/or death (**hypothermia**) of the organism.

Native plants must also have adaptations that allow them to survive the cold and snow. Interestingly, the two categories of trees in the boreal forest illustrate perfectly the types of strategies that allow these species to cope, suffer, or thrive during the severe winters of northern Canada. Evergreen **coniferous** species [spruce, pine, fir] retain their leaves [needles] so they can begin to photosynthesize as soon as temperatures are approximately 10 degrees Celsius and warmer. The branches of these trees are also perfectly designed to shed snow as it accumulates on the branches and needles. **Deciduous** species on the other hand shed their leaves in the fall. Even though they are forced to shut down **photosynthesis** earlier in the fall and begin photosynthesis later in the spring, the branches of these trees don't build up with snow at all. Therefore, their branches won't break under the weight of snow. However, just like animals, all species of plants must also have strategies to prevent water from freezing in all of their cells – not just in the leaves.



WHAT IS WINTER?

Winter is SNOW . . .

. . . and snow is the result of precipitation that freezes at 0 degrees Celsius or colder.



WHAT IS WINTER?

Winter is COLD . . .

. . . and cold is only a sensation we feel and when we attempt to communicate a “lack of heat”. Therefore, a lack of heat can lead to hypothermia, frostbite, and/or freezing to death.



WHAT IS WINTER?

Winter is less RADIATION . . .

Because the top half of the earth is tilted away from the sun during the winter season . . . the ground receives less incoming solar radiation . . . or insolation.



WHAT IS WINTER?

Winter is less ENERGY . . .

As a result, there is less kinetic energy available for plants to create food . . . and therefore, less food is available for animals.



WHAT IS WINTER?

Winter is WIND . . .

. . . and wind is a powerful agent (wind chill) that can quickly move heat away from living things . . . and also blows snow around.



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