SCIENCE SPOTLIGHT

Photo Credit: Alison Criscitiello

Getting to the Core of Climate Change

GEN ACTION

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Getting to the Core of Climate Change

A Look at How Refrigerants Are Affecting Our Environment through Ice Cores

Origin Story

Drilling for Air

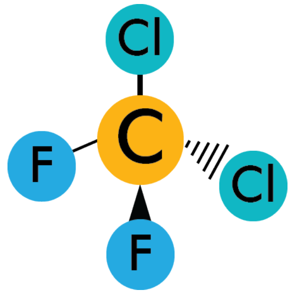
When a harmful chemical, called a pollutant, gets into the air, water, or land, it can end up in a plant and animal that are important to the food chain. The food chain shows how different living things in nature depend on one another for food. Now imagine predators will eat these plants and animals. Since the food they eat daily is contaminated, they will also absorb the pollutant. This continues all the way up the food chain, where apex or top predators might be eating high amounts of that pollutant too. This process is called bioaccumulation.

Photo Credit: Alison Criscitiello

Ice cores are long cylinders of ice that are drilled from ice sheets and glaciers. Some ice does not melt, even in the summer, so the snow that falls on it buries snow from past years. That snow eventually turns into ice that has captured the chemicals that were in the air and on the snow when it formed, including pollutants. Ice cores can reveal atmospheric particles or aerosols (which are tiny invisible pieces of solids or liquids that float in the air and even in our atmosphere!) from thousands of years ago and tell us a lot about what the world used to be like.

What's in your Fridge?

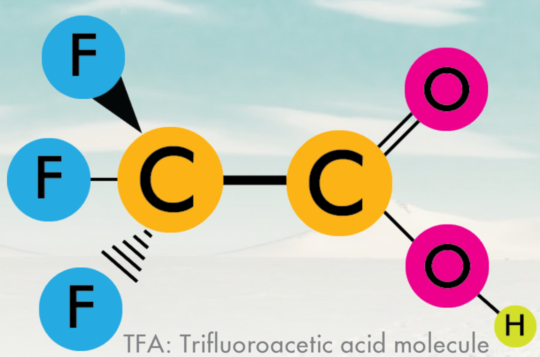
Refrigerators work by pulling heat away from the inside and absorbing it into a refrigerant. Refrigerant is a chemical that helps carry away the hot air leaving in the fridge nice cool air. For the most of its life, this special substance is contained in the tubes at the back of your fridge. But it can sometimes leak especially if a device is not disposed of properly.



CFC: Dichlorodifluoromethane molecule

Chlorofluorocarbons (CFCs) are types of refrigerants that were used in air conditioners, fridges, and aerosol cans from the 1920s until the 1990s. These chemicals are damaging to our ozone layer. The ozone layer is incredibly important because it shields us from the harmful ultraviolet (UV) radiation that comes from the sun by absorbing most of the radiation and filtering it out, keeping us safe from getting severe sunburns and other health problems.

Luckily, most of CFCs are not used anymore, thanks to the Montreal Protocol, an agreement to stop using this type of chemical, signed by many countries in 1989. CFCs were replaced by hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs), these chemicals do not damage our ozone layer, but when both HCFCs and HFCs break down, they can release another harmful pollutant that has an environmental impact.



TFA: Trifluoroacetic acid molecule

HCFCs and HFCs that have leaked into our air eventually break down into smaller chemicals like trifluoroacetic acid (TFA), which can fall to the ground as part of rain or snow. TFA takes a long time to break apart, often being absorbed by plants and animals that cannot break them down easily. This means that when TFA is in the environment, it stays for a long time and can be introduced into the food chain. We do not know every problem that might be caused by TFA, but it can be toxic to living things. We have even found TFA in humans!

A team of scientists wanted to figure out the amount of TFA that has been introduced to the environment in the last few decades, and ice cores are the perfect record for figuring that out. When TFA is created, it mixes with rain and snow and falls to the ground. In most places, this spreads out as water, but in the Arctic, the snow piles on top of other snow, and on Mount Oxford and in the Devon Ice Cap, the snow does not melt. This gives us layers of packed snow that can be melted and checked for TFA.

The team found that the amount of TFA and other chemicals like it have increased since 1990. This is because in 1990, we started replacing ozone-damaging CFCs with HCFCs and HFCs. Saving the ozone layer was a big accomplishment, and now that we have realized that HCFCs and HFCs might be causing other types of damage, we are in need for better solutions to keep our food cold.

Finding so much TFA in the Arctic means that when we throw out refrigerators and air conditioners, leaking HCFCs and HFCs end up moving all over the world. Everything we do can affect the world near us and far from us.

Photo Credit: Alison Criscitiello

Meet Our Local Climate Hero

Dr. Alison Criscitiello is an ice core scientist, and high-altitude mountaineer. Criscitiello's research explores the history of sea ice in polar regions using ice core chemistry, which involves long months of living in a tent and drilling ice cores in places like Antarctica, Alaska, the Canadian High Arctic, and Greenland. She is the Director of the Canadian Ice Core Lab (CICL) at the University of Alberta, and an Adjunct Assistant Professor at the University of Calgary. Criscitiello holds a bachelor's degree in Earth and Environmental Science from Wesleyan University, a master's degree in Geophysics from Columbia University, and the first PhD in Glaciology ever conferred by Massachusetts Institute of Technology (MIT).

When not busy shivering for science, Criscitiello seeks out the cold for fun, whether working as a climbing ranger in the national parks or guiding expeditions to the major peaks in the Andes, Alaska, and the Himalaya.

In 2010, she led the first all-woman ascent of Lingsarmo (6955m) in the Indian Himalaya. She has been the recipient of three American Alpine Club (AAC) climbing awards including one for Borderski, her two-month winter ski traverse of Tajikistan's border in the eastern Pamirs with two other Canadian women. In 2016 she was awarded the Mugs Stump Award and John Lauchlan Award to attempt the first alpine ascent in the Indian Himalaya. Dr. Alison Criscitiello has been named a National Geographic Explorer, and a Fellow of the Explorers Club and the Royal Canadian Geographical Society. Criscitiello is founder and co-director of Girls on Ice Canada.

TIME FOR GenAction!

Try This at Home:

Moving Currents

When it is time to clean under the fridge, ask an adult to let you take a look at the back. Some will have coils attached to the back, which contain HCFCs or HFCs. Most of new fridges will have the coils covered, but they will have a fan that blows hot air away from the fridge; this is the heat that is removed from the inside!

Our atmosphere moves air between lots of spaces through convection currents that is a natural process of heat transfer. To understand how these currents work, try placing a coloured ice cube on top of warm water in a clean container and watch how the colour moves through the water. This shows that air containing pollutants does not stay in one place, these pollutants travel with the air as it moves and changes temperature.

Climate Action

Recycle your Fridge

If your family is getting a new fridge or air conditioner, make sure to recycle the old one properly, so that harmful chemicals do not leak into our atmosphere.

Here are some other actions that are in your power to take.

- Use a spritz bottle instead of an aerosol bottle.
- Learn more about how the Montreal Protocol has been updated over time.
- Investigate other types of bioaccumulations affecting climate change, and what is being done to better control them.

This Science Spotlight was written based on Pickard, H.M., Criscitiello, A.S., Persaud, D., Spencer, C., Muir, D.C.G., Lehnherr, I., et al. 2020. "Ice Core Record of Persistent Short-Chain Fluorinated Alkyl Acids: Evidence of the Impact From Global Environmental Regulations" Geophysical Research Letters, 47, e2020GL087535. https://doi.org/10.1029/2020GL087535

Climate Change
Past, Present, and Future

Earth is the only planet in the solar system known to support life. What makes our home so special? Earth has an atmosphere, a layer of gases between our planet and space. Some of these gases, like carbon dioxide, are called **greenhouse gases**. They are crucial parts of our atmosphere; they trap in the heat of the sun, similar to how heat is trapped in a greenhouse, or in a car on a hot day. This process, called the **greenhouse effect**, keeps Earth's temperature warm enough for living things to thrive.

The sun's rays hit our round, tilted planet unevenly. This uneven heating of Earth's surface leads to differences in temperature, which drives weather patterns. We call the patterns in temperature and weather over long periods of time **climate**. Different parts of the world have vastly different climates; it depends on how much heat they receive, as well as what landscape features are nearby. Water, mountains, ocean currents, and forests all impact our climate. In turn, living things around the world have adapted to the climate they live in.

Something, though, is changing. Over the past two hundred years, humans have been burning fossil fuels, such as coal and oil, to make energy to power our daily lives. Fossil fuels are made from decomposed plant matter and microscopic life millions of years old. This matter is full of carbon, and, burning it releases, or emits, billions of tonnes of **carbon dioxide** gas into the atmosphere every year. When too much carbon dioxide is emitted, the delicate balance of greenhouse gases maintaining

Earth's climate is upset. More and more heat is trapped, causing the planet to warm. Weather patterns change, water levels rise, storms get worse.

Climate has changed many times throughout Earth's history, from ice ages to periods much hotter than today. So why is this time any different? Scientists agree on two things. One, temperatures are rising faster than they ever have in documented climate history. Two, this climate change is driven by human activities, due primarily to greenhouse gas emissions.
Climate change is already impacting people's ways of life all over the world. Powerful storms, droughts, forest fires, and floods are threatening people's access to food, water, and safe homes.

The most important step we can take to prevent serious climate change is to reduce greenhouse gas emissions. Incredibly brave and caring people around the world are finding new ways to reduce emissions and make our communities climate resilient every single day. And you can join them! These Science Spotlights are here to help us learn more about climate change and how you can take action.

Our Commitment to the Decolonization of Science

Institutions of GenAction initiative respect and affirm the inherent and Treaty Rights of all Indigenous Peoples across what we now know as Canada. We give thanks to the Indigenous Peoples who care for this land since time immemorial and pay respect to their traditions and ways of knowing. We acknowledge their many contributions to innovations in Science, Technology, Engineering, and Mathematics, past and present, and are committed to deepening engagement and collaborating with Indigenous Peoples as partners in order to advance truth and reconciliation and the decolonization of science.

Climate Change: Past, Present, and Future is based on...Delmotte, Masson, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, et al. 2021. "Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change." Intergovernmental Panel on Climate Change. Cambridge University Press. In Press.