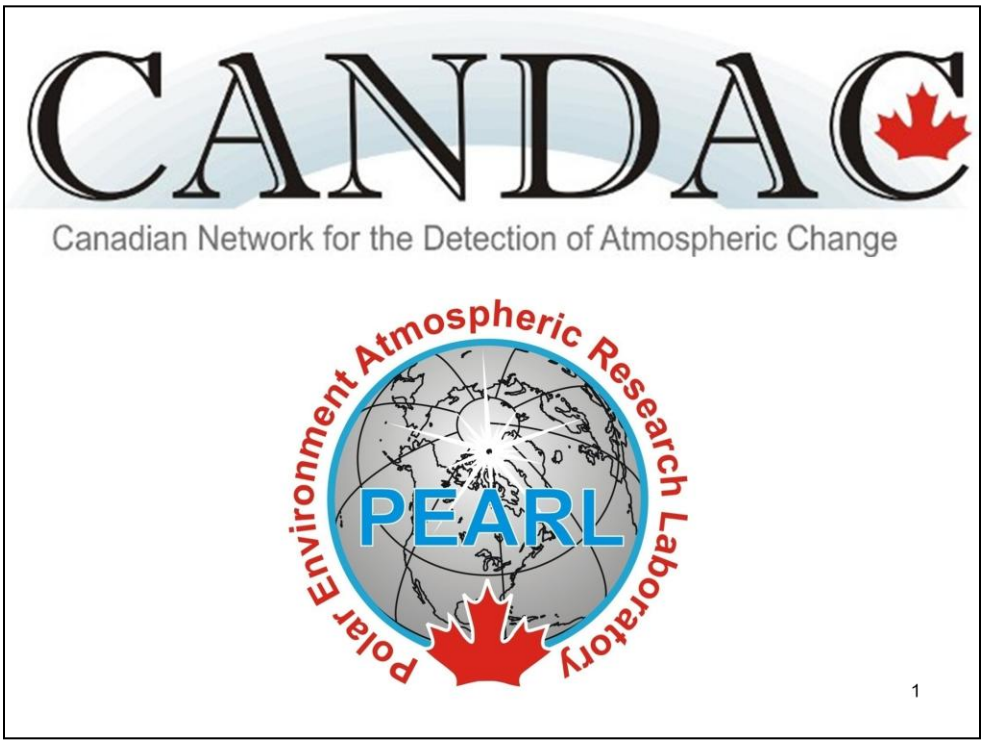


This will be a lesson for students in grades 6-8. The subject matter explores the three major ways that humans impact the atmosphere (emission of greenhouse gases, ozone-depleting substances and air pollutants).

This presentation was assembled as part of the outreach initiative for the Canadian Network for the Detection of Atmospheric Change.

CANDAC

Canadian Network for the Detection of Atmospheric Change

- In 2002, a group of university researchers joined together under the title of the Canadian Network for the Detection of Atmospheric Change (CANDAC) with the objective of improving the state of observational atmosphere research in Canada.
- This group recognized the need for an Arctic laboratory and identified the Polar Environment Atmospheric Research Laboratory (PEARL) in Eureka, Nunavut as the ideal station.
- They worked enthusiastically to raise funds to run the facility and had a fully-functional Arctic lab operating in 2005.
- Since then, researchers have been taking various measurements to monitor and better understand current atmospheric conditions.

2

Funding for CANDAC has been provided by:

Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)
Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA)

Ontario Innovation Trust

Canada Foundation for Innovation
Fondation canadienne pour l'innovation

Environment Canada

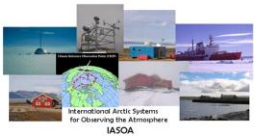
Environnement Canada

NSERC CRSNG

Ontario MINISTRY OF RESEARCH & INNOVATION

CSA ASC

NOAA

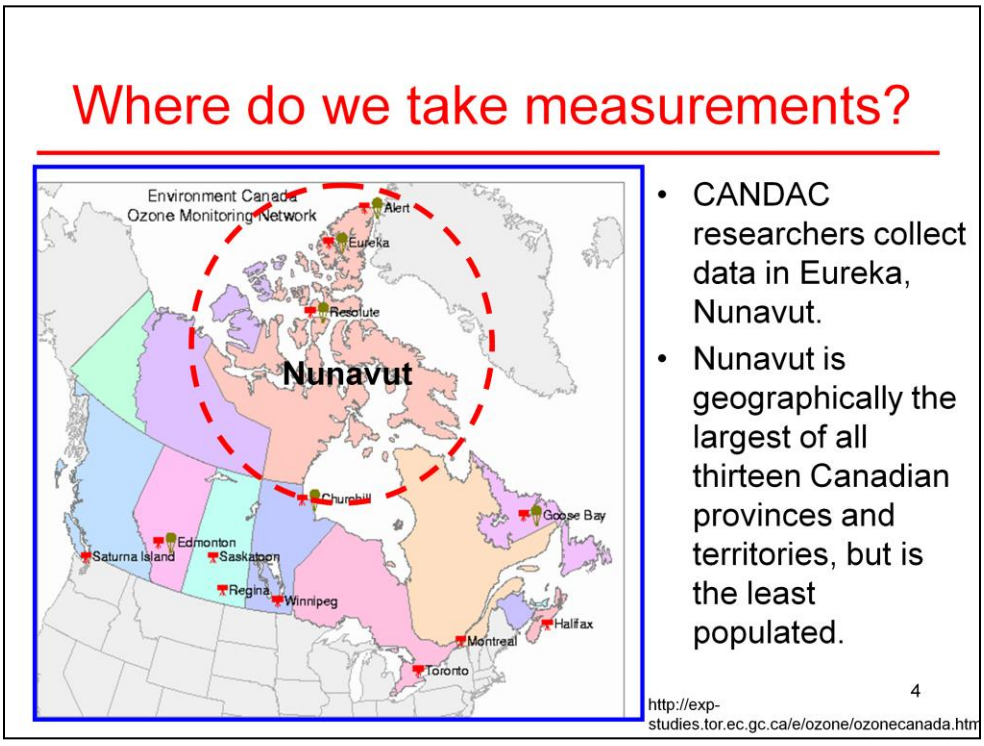


INTERNATIONAL POLAR YEAR 2007-2008

Nova Scotia Research and Innovation Trust

Polar Continental Shelf Project (PCSP)

3



Teacher: What else do you know about Nunavut?

Responses will vary depending on student knowledge and experience.

Addition al Information:

Facts about Nunavut can be found at: http://www.gov.nu.ca/en/Facts.aspx.

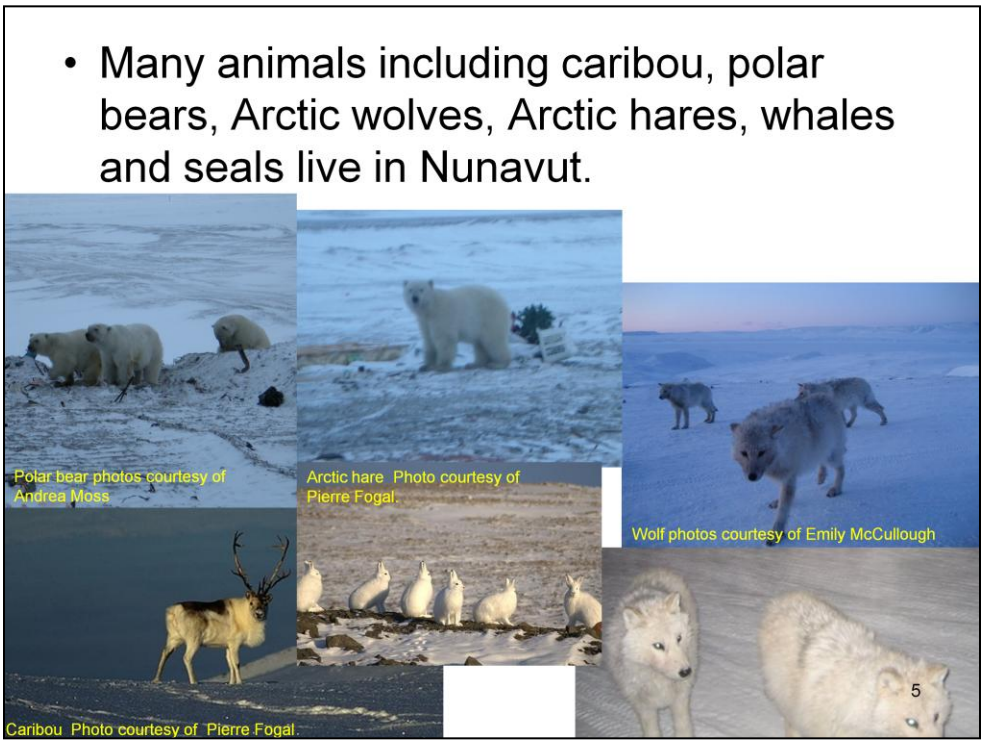
• Nunavut means “our land” in Inuktituk.

• Iqaluit is the capital city of Nunavut.

• Nunavut is the newest Canadian territory; it officially separated from Northwest Territories on April 1st, 1999.

• The total area of Nunavut is 2,093,190 km^2.

• The total population is 33,220.

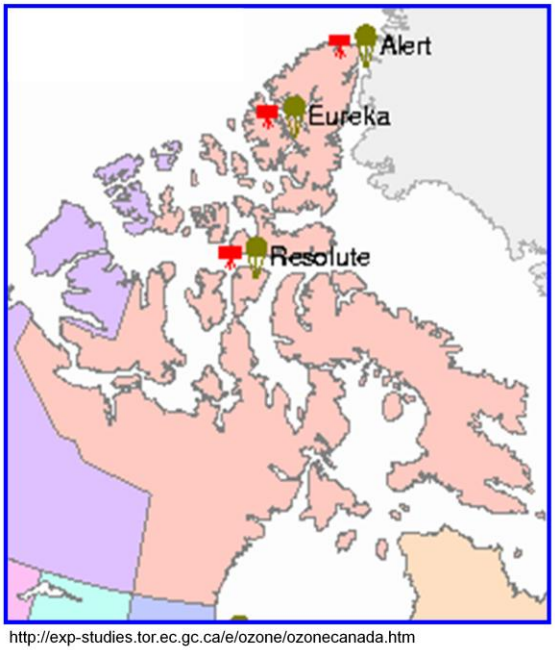


Teacher: What similarity do you notice in all of the animals shown?

Response: All of the animals have white fur.

Teacher: Correct. Why do you think many of the animals in the Arctic have white fur?

Response: They need fur to maintain a warm body temperature. Their fur is white because it provides excellent camouflage in their snow and ice-covered environment.



- Eureka is located on Ellesmere Island in the High Arctic.
- It is the second-northernmost permanent research community in the world.
- Eureka experiences complete darkness from mid-October until late February and complete Sunlight from early April to late August.

http://exp-studies.tor.ec.gc.ca/e/ozone/ozonecanada.htm 6

Teacher: Nunavut is the geographically the largest of all thirteen provinces and territories, but is the least populated.

Photo courtesy of Pierre Fogal

- Many CANDAC researchers operate their instruments from the Polar Environment Atmospheric Research Laboratory (PEARL) located in Eureka.
- Researchers typically travel to PEARL by airplane.


Photo courtesy of Pierre Fogal

7

CANDAC International Polar Year Legacy Project: Educational Resources

- As part of the International Polar Year (IPY) Legacy Project, CANDAC has created educational resources aimed at enhancing environmental science education in classes from kindergarten to grade 12.
- Educational materials can be found at: http://candac.ca/candac/Outreach/Outreach.php .
- This particular presentation is about:

Human Impacts on the Atmosphere

8

Big questions about our atmosphere

- How is the Ozone Layer changing?
- How is the Earth's climate changing?
- How is air pollution changing our atmosphere?

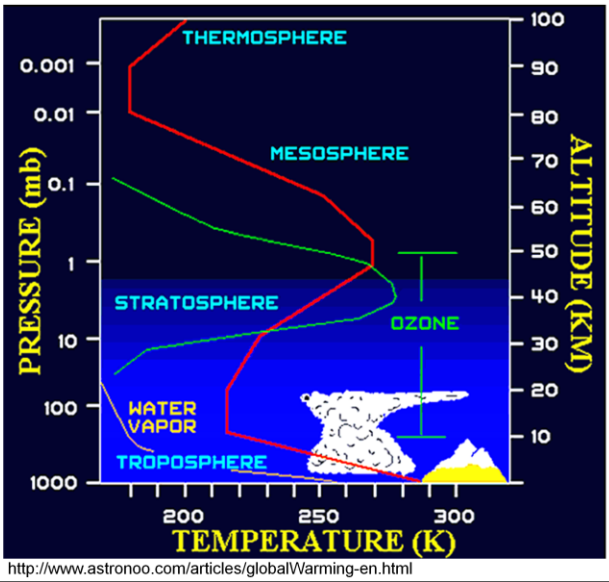
9

Teacher: Ask diagnostic questions to make sure that students have a general understanding of the atmosphere. Examples: What is the atmosphere? What type of gases are found in the atmosphere? Why is the atmosphere important? Can you name any parts of the atmosphere?

Responses will vary and answers are revealed in subsequent slides.

Atmospheric researchers have three major areas of interest. These areas are studied in Canada and in many other places in the world. This presentation will give a brief explanation of each area as well as the different methods for studying each.

Structure of the Atmosphere



http://www.astronoo.com/articles/globalWarming-en.html

10

Important Points:

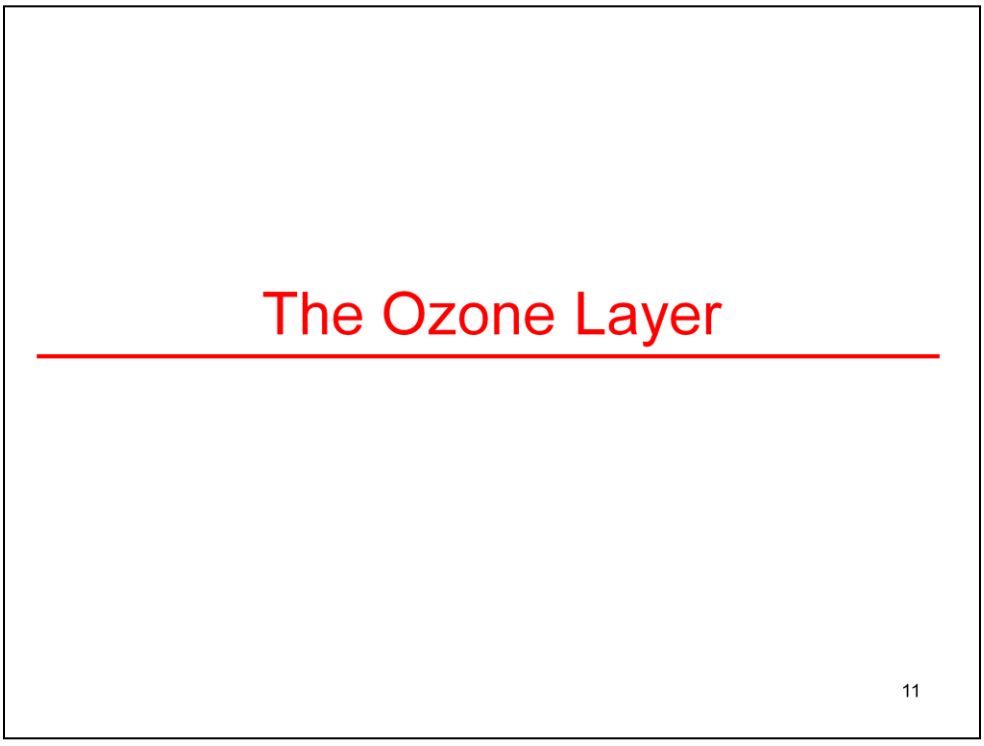
- The atmosphere is made up of layers.
- It extends to approximately 100km above the Earth's surface.
- The ozone layer is located at about 25km in altitude.
- Weather occurs in the lowest parts of the atmosphere called the troposphere.

Information courtesy of: http://www.srh.noaa.gov/srh/jetstream/atmos/layers.htm

Teacher: Air becomes less dense as you move away from the Earth's surface. Why might this be the case?

Response: The force of gravity is strongest close to the surface of the Earth; this means that most of the atmosphere's air is held close to the surface (in the troposphere).

Additional Information: Pressure is displayed in mb (millbars), where 1mb = 100 kPa = 1 atm.

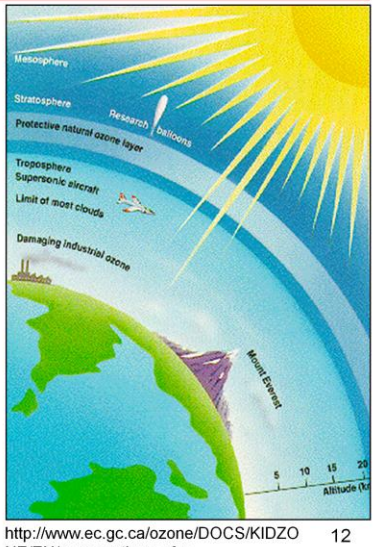


Teacher: Raise your hand if you have heard of the ozone layer. What is special about the ozone layer?

Response: It protects us from the Sun, chemicals can cause it to break apart, it allows life on Earth to exist, it keeps the Earth at temperatures warm enough for life to exist.

Ozone in the Atmosphere

- Ozone is a molecule made up of three oxygen atoms.
- The oxygen that we breathe is a molecule made up of two oxygen atoms.
- Ozone protects the Earth by blocking harmful UV light from the Sun.



http://www.ec.gc.ca/ozone/DOCS/KIDZONE/EN/ozoneupthere.cfm

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Addition Information: The ozone layer is a very important part of the Earth's atmosphere. It blocks out ultraviolet (UV) light which is responsible for such things as Sunburns and skin cancer. The ozone layer continues to be an important area of research.

Why is there less ozone?

- The ozone layer has gotten thinner because humans have emitted chemicals into the atmosphere.
  - For example, for many years, humans emitted Chloroflourocarbons (CFCs) into the air which damaged the ozone layer.
- Scientists need to measure and monitor ozone in order to better understand what is happening.

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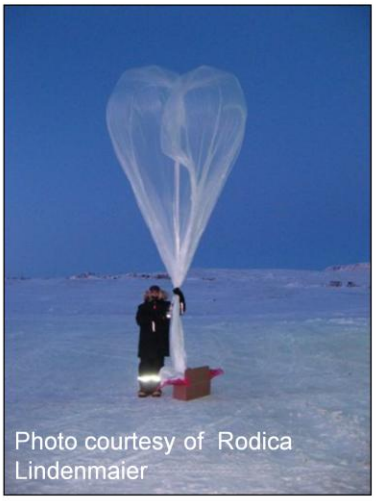
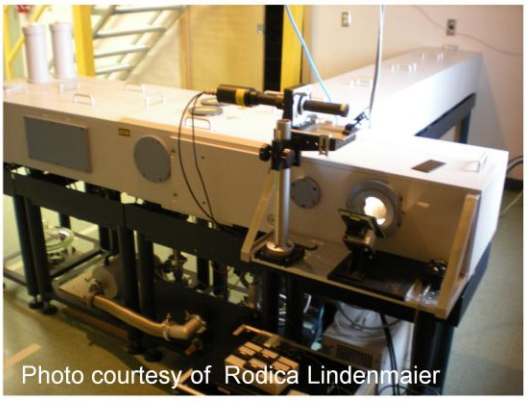
Teacher: Humans are no longer emitting CFCs into the atmosphere, but it is still important to monitor the state of the ozone layer to see how it is changing year to year and to see if it is recovering.

How do we measure ozone?

Ozonesondes launched on balloons



Ground-based instruments such as a spectrometer



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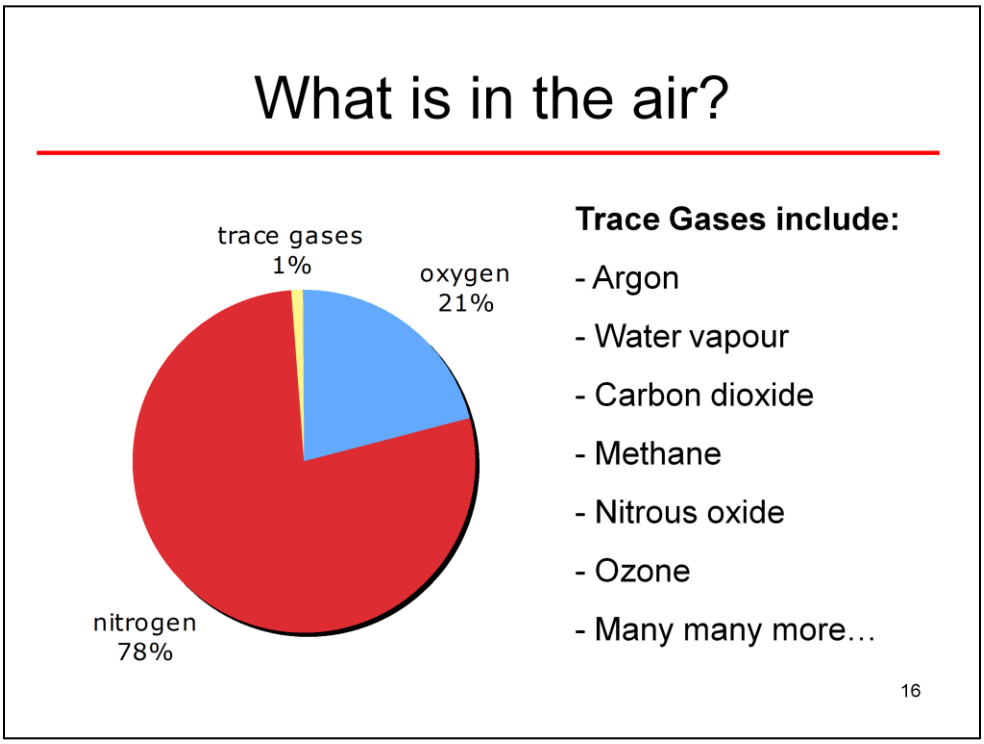
Additional Information: Ozonesondes are instruments that are launched by balloon into the atmosphere. They measure the amount of ozone found in layers of the atmosphere as it rises and then transmit the information to computers on the ground using radiowaves (http://www.ozonelayer.noaa.gov/action/ozonesonde.htm).

There are many ways to measure ozone from instruments on the ground. One example is a spectrometer. There are different types of spectrometers (all shapes and sizes). A spectrometer can measure the amount of Sunlight that is absorbed by certain gases in the air. This can be analyzed to determine the amount of each gas (http://exp-studies.tor.ec.gc.ca/e/ozone/ozone.htm). Further details will be given later in the presentation.

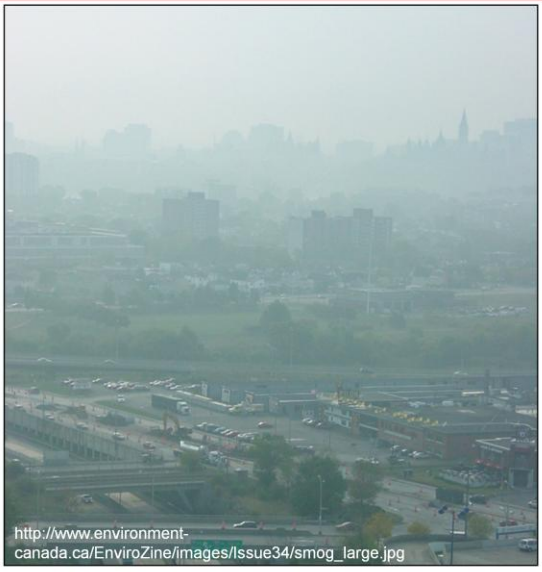
Atmospheric Pollution



Teacher: What are the two major gases found in Earth's atmosphere?

Response: The atmosphere is primarily made up of nitrogen and oxygen. The last one percent is made up of everything else (such as trace gases). These exist at levels such as parts per million or parts per thousand.

What else is in the air?



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Teacher: Included in trace gases are the gases that are emitted by humans (called air pollution). Several different types of gases can be considered air pollution. The picture above shows Ottawa covered by a layer of smog.

Additional Information: Smog is an air pollutant that compromises air quality. It is recognizable as a brownish-yellow haze or thick, dirty fog visible in the sky. Although mainly generated in big cities, smog can be transported far away from the source, thus causing rural and subrural areas to have high levels of smog. Smog contains two main pollutants: ground-level ozone (O_3) and particulate matter (PM). Many people, both young and old, may experience eye, nose and throat irritation when exposed to smog. People with pre-existing heart and/or lung conditions are most at risk and may experience further irritation or a worsening in their condition. Since many senior citizens are affected by heart and/or lung problems, they are especially sensitive to air pollution. Children can also be sensitive to the effects of air pollution because their respiratory systems are still developing and they tend to have an active lifestyle.

Information courtesy of: http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/smog-eng.php

What is air pollution?

- Air pollution affects many people in the world.
  - Smog is one example of air pollution. It can cause breathing problems and irritation for asthmatics.
- Most of these gases and particles are produced by human activity.
  - Vehicles, factories, power plants and homes produce the majority of these pollutants.
- Some contributions come from natural sources.
  - Forest fires, trees and volcanoes emit pollutants; however, these are much smaller than those emitted by humans.

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Teacher: What is pollution?

Response: The introduction of contaminants into a natural environment that causes instability, disorder, harm or discomfort to the ecosystem.

Additional Information: According to Environment Canada, “Air pollution is a broad term applied to any chemical, physical, or biological agent that modifies the natural characteristics of the atmosphere. Examples include particulate matter and ground-level ozone” (http://www.ec.gc.ca/default.asp?lang=En&n=499D6B13-1). There are many different types of pollutants; individual pollutants differ from each other in terms of their chemical composition, persistence, and impacts. Air pollution is caused by both human and natural means, but each source emits pollutants differently. Human-made air pollution is consistent and persistent, while natural sources tend to be more episodic.

How do we measure air pollution?

- From the ground
  - Ground-based instruments are stationed all over the world including PEARL.
- From balloons
  - Balloons are launched from various locations around the globe including PEARL.
- From space
  - Satellites can carry scientific instruments that measure gases related to atmospheric pollution. This allows us to see all parts of the globe and help understand how pollution is transported.

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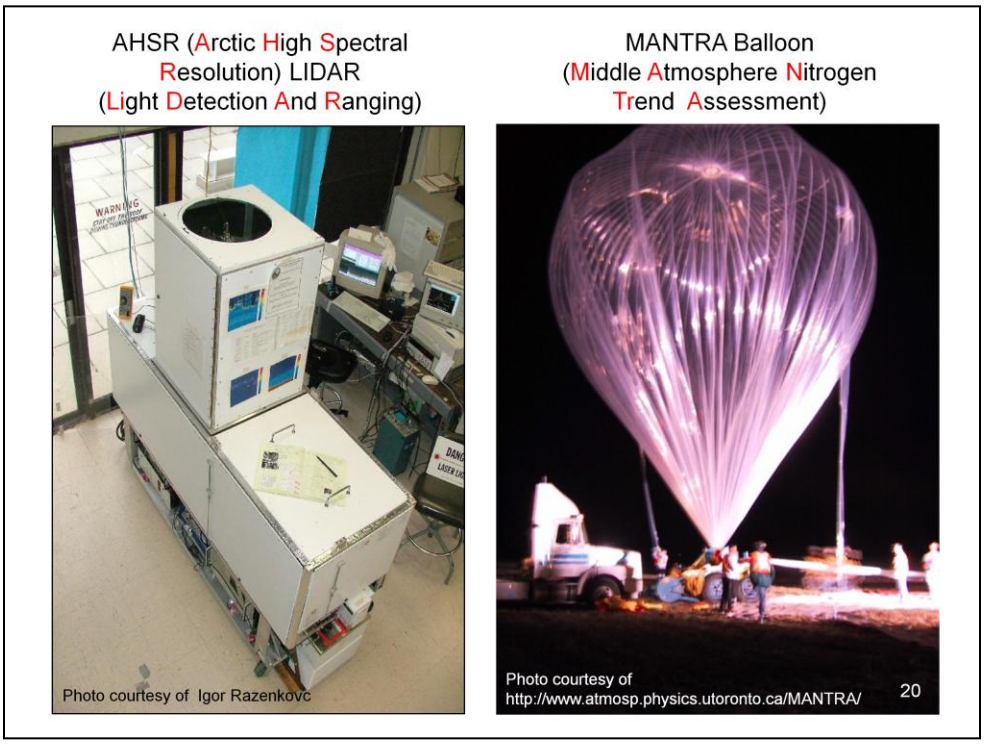
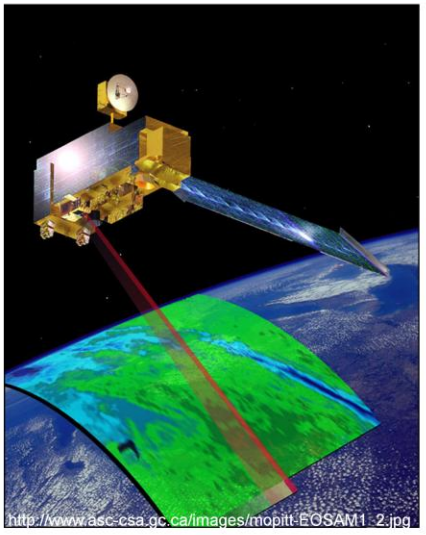


Teacher: The picture on the left is of a AHSR (**A**rctic **H**igh **S**pectral **R**esolution) LIDAR (**Li**ght **D**etection **A**nd **R**anging) which is an instrument that shines laser light into the atmosphere and uses the scattered light to measure different types of air pollution http://candac.ca/candac/Instruments/Docs/HSRL_info_en.pdf). The picture on the right is the MANTRA (**M**iddle **A**tmosphere **N**itrogen **Tr**end **A**ssessment) balloon which is launched into the atmosphere to measure pollutants up to approximately 30km above the surface of the Earth (http://www.atmosp.physics.utoronto.ca/MANTRA/).

MOPITT

(Measurements Of Pollution In The Troposphere)

- MOPITT was successfully launched on December 18 1999, onboard the NASA Terra satellite.
- It was Canada's first major instrument to measure pollution from space (carbon monoxide).



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Additional Information: "The MOPITT instrument was launched on the Terra platform of NASA's Earth Observing System (EOS) on December 18, 1999. The Terra satellite is in a 705km, Sun-synchronous orbit with a 10:30am equator crossing time. MOPITT has been measuring carbon monoxide over the globe since that time. Carbon monoxide is measured because it helps demonstrate how the troposphere reacts to various stimuli. These stimuli can range from natural phenomena such as the growth of forests, through agricultural sources such as rice paddies, to catastrophic events such as biomass burning." (http://www.atmosp.physics.utoronto.ca/MOPITT/MOPoverview.html).

Weather vs. Climate

The next two slide will point out the important differences between weather and climate. It should be a quick review.

Weather

- Weather is the current condition of the atmosphere in a specific location.
- The weather in one area changes daily and sometimes hourly.
- The weather on any one date cannot be predicted from the weather on that date in previous years.

Climate

- By taking weather information from several years, we can describe the climate in a specific location.
- Climate describes the typical weather you can expect in a region.
- For example, using precipitation and temperature as a guide:
  - Vancouver has a lot of rain (typical Coastal climate).
  - Halifax has a lot of fog (typical Maritime climate).

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Atmospheric Change

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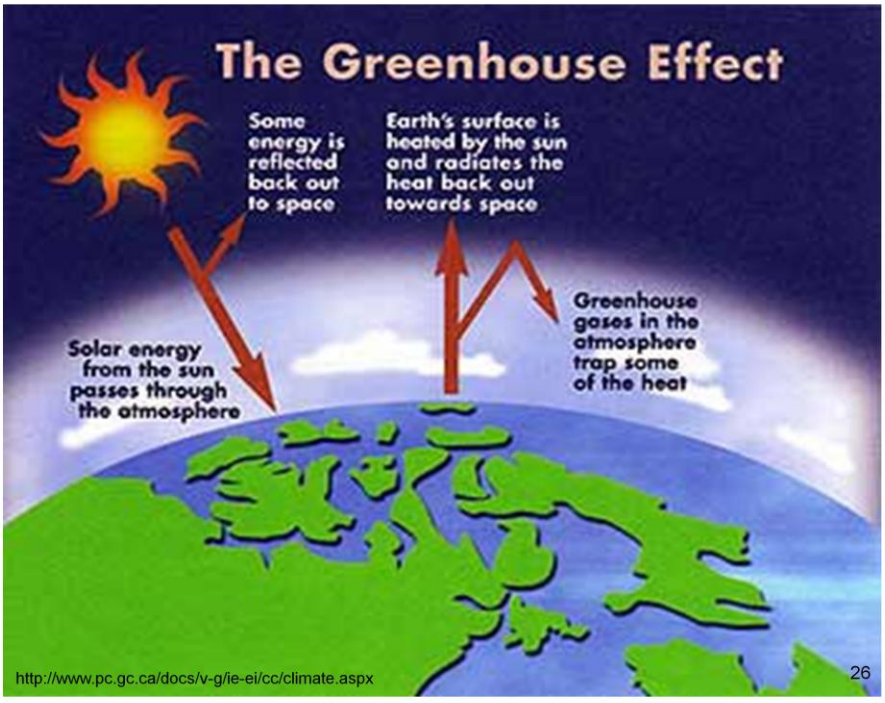

Teacher: Raise your hand if you have heard of the Greenhouse Effect. Would someone like to try to explain or guess what is might mean?

Response: The greenhouse effect is a naturally occurring phenomena that is required for life to exist on Earth. Greenhouse gases in the atmosphere trap some of the heat that would otherwise be emitted back into space, thus maintaining a much warmer average global temperature (http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=FBF8455E-1).

The Greenhouse Effect

- Without our atmosphere, based on the Earth's distance from the Sun, the average temperature on Earth would be about -18°C instead of +14°C.
- There are 4 main greenhouse gases (GHGs) that contribute to the Greenhouse Effect:
  - Water Vapour (H_2O) → most influential GHG
  - Carbon Dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous Oxide (N_2O)

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Teacher: What do you think that Earth's temperature would be is the Greenhouse Effect did not exist? Allow many students to make a guess.

Response: -18°C

Teacher: What are the names of some GHGs?

Response: Water vapour, carbon dioxide, methane, and nitrous oxide

Information courtesy of: http://adaptation.nrcan.gc.ca/posters/ac/ac_03_e.php

Where do they come from?

- Sources of GHGs can be either natural or human-made (anthropogenic).
  - Some natural GHG sources include plants, animals, soil and oceans.
  - Some anthropogenic GHG sources include burning fossil fuels, farming and industry.
- Human activities are increasing GHG emissions, and thus enhancing the greenhouse effect.
- There is a concern that GHGs are causing the global climate to change.

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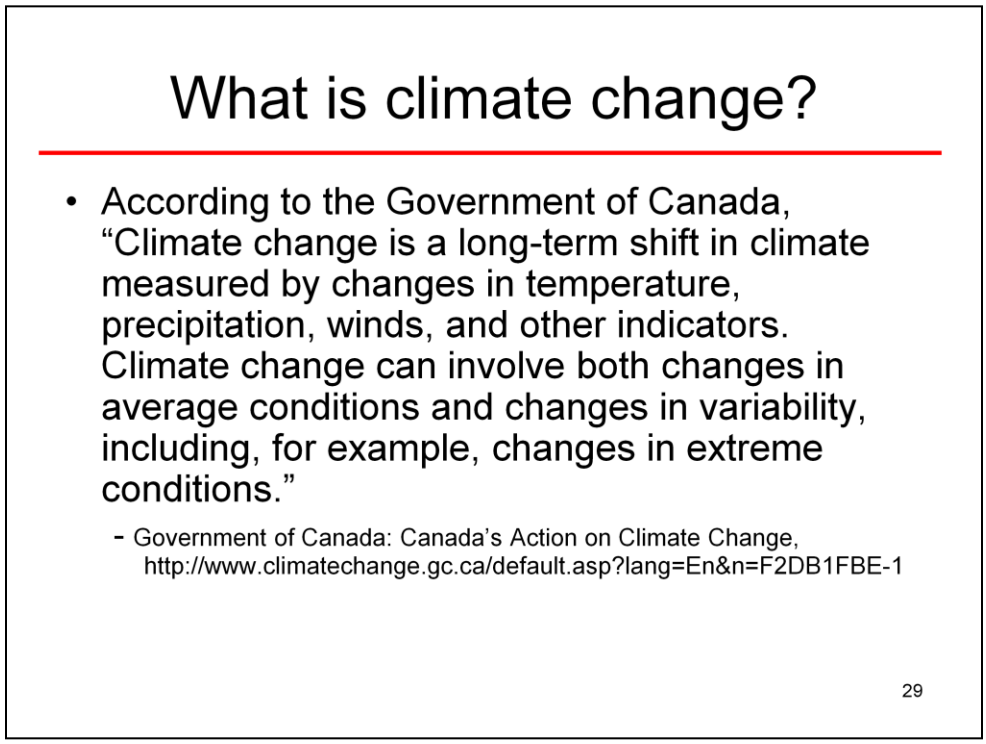
Teacher: Allow students to work in small groups to brainstorm possible sources of GHGs and then lead a classroom discussion.

Response: Humans are emitting greenhouse gases to the atmosphere in addition to those that are naturally occurring. Excessive amounts of these gases are increasing the effects of the greenhouse effect. Some sources include plants, animals, soil, oceans, burning fossil fuels, farming and industry.

Information courtesy of: http://adaptation.nrcan.gc.ca/posters/ac/ac_03_e.php



Teacher: Allow students to provide their own definitions of climate change before showing the one above. Work with a partner to come up with a list of possible effects (can be good or bad) of climate change. Be prepared to allow short discussions/debates about their responses.

Responses:

- Less sea ice
- Ice on rivers and lakes forming later and breaking up sooner
- Receding glaciers
- Accelerated sea level rise
- Longer, more intense heat waves
- Stronger storms
- Plant and animal ranges shift
- Tress flowering sooner
- Biodiversity loss through species extinction in many tropical areas and oceans
- Changed agricultural yields
- Shift in growing seasons
- Shifts in rainfall and snow fall patterns

How can we monitor GHGs?

- We can learn about the Earth's climate in past centuries a few different ways.
  - Paleoclimatology is the study of climate using natural sources such as tree rings, ice cores, corals, and ocean and lake sediments.
- We can also study the present state of the atmosphere a few different ways.
  - Climatology is the study of the climate using measurements from satellites, balloons and the ground.

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- Measurements can be made from satellites, balloons and the ground.

Additional Information: "The **MANTRA** (**Middle Atmosphere Nitrogen TRend Assessment**) balloon is an example of a Canadian balloon mission to study trace gases in the atmosphere. The MANTRA project involved a series of high-altitude balloon flights to investigate changes in the concentrations of mid-latitude stratospheric ozone, and of constituents that play a role in ozone chemistry. Four balloons were launched from Vanscoy, Saskatchewan, in August 1998, August 2000, September 2002, and September 2004. Each carried a payload of instruments to measure vertical concentration profiles of stratospheric trace gases, and made observations from a float altitude of about 35 km for one day. Several of these instruments were flown 15-20 years ago and thus provide a link to historical data predating the onset of mid-latitude ozone loss" (http://www.atmosp.physics.utoronto.ca/MANTRA/)

"**SCIAMACHY** (**SCanning Imaging Absorption spectroMeter for AtmosphericCartograpHY**) is a passive remote sensing spectrometer observing backscattered, reflected, transmitted or emitted radiation from the atmosphere and Earth's surface, in the wavelength range between 240 and 2380 nm. The instrument flies on board ENVISAT which was launched on 1 March 2002. The primary scientific objective of SCIAMACHY is the global measurement of various trace gases in the troposphere and stratosphere, which are retrieved from the solar irradiance and Earth radiance spectra. The large wavelength is also ideally suited for the determination of aerosols and clouds. Validation of SCIAMACHY is essential to ensure the quality of these derived products" (http://www.sciamachy.org/).

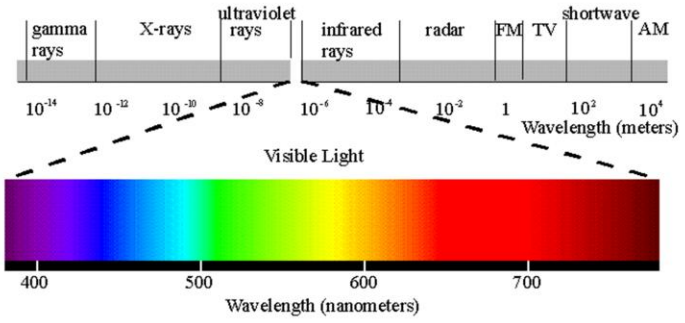
Spectrometers and Spectroscopes

Spectrometers

- Spectrometers are a common way to measure greenhouse gases and other gases in the atmosphere.

Additional Information: Spectrometers are ground-based instruments that are used to measure gases in the atmosphere. Spectrometers gather Sunlight and analyze it to get information about gases in the atmosphere (http://acebox.uwaterloo.ca/eureka/Eureka2008/Our%20Instruments.html). Spectroscopes are a small hand-held instruments that allow the user to view the spectrum of a light source.

The Electromagnetic Spectrum



http://www.yorku.ca/eye/spectru.htm

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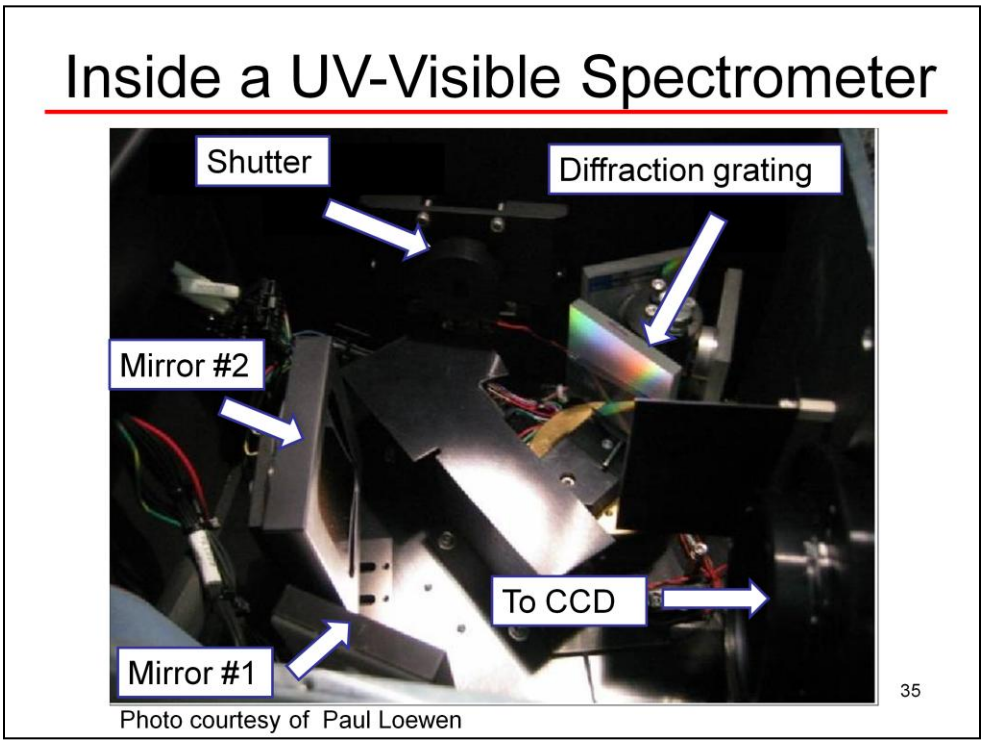
Additional Information: A basic understanding of the light spectrum is important. Students should be reminded that white light can be broken down into the visible spectrum. This can be done in several ways (prism, diffraction grating). This effect can be seen in the light reflected from the surface of a CD/DVD or rainbow in the sky.

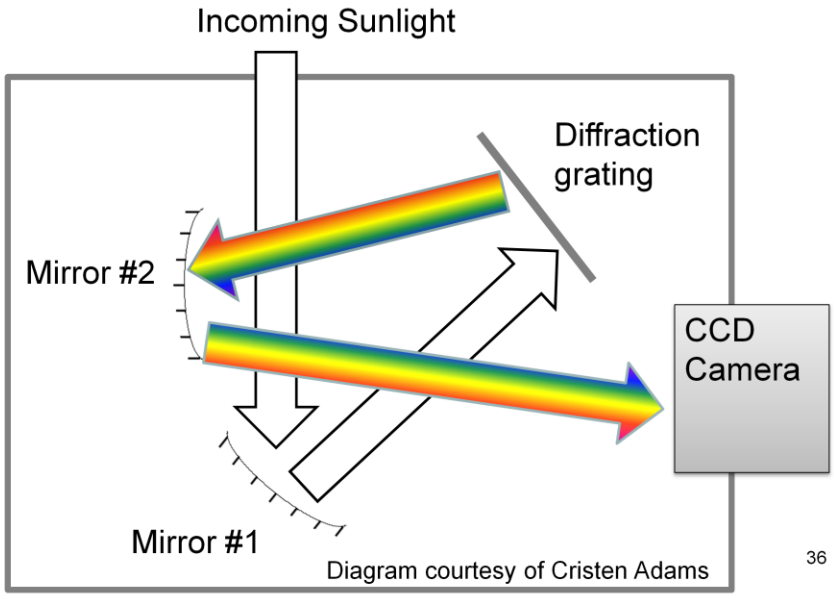
If possible, use a prism to demonstrate white light being split into the visible light spectrum of colours.



This is a picture of the inside of a UV-visible spectrometer. The spectrometer is about the size of a microwave. Sunlight enters the spectrometer through the shutter. It is reflected by mirror #1 and sent to the diffraction grating. The diffraction grating splits the light into a spectrum. You can see this because the diffraction grating has rainbows across its surface. The spectrum then reflects off of mirror #2 and into the CCD. The CCD is a very high-quality camera. This is used to record the spectrum, which is then analyzed to determine the trace gas concentrations present in the atmosphere.

Information courtesy of Cristen Adams.

Inside a UV-Visible Spectrometer



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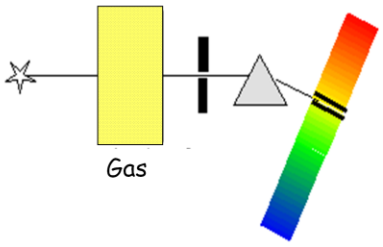
‘Fingerprints’

- Each person has their own set of fingerprints, and so too do gases in the atmosphere.
- A particular gas or molecule absorbs a unique pattern of colours.
- When the light reaches the spectrometer, the spectrum will be missing pieces where the light has been absorbed by the gases in the atmosphere.



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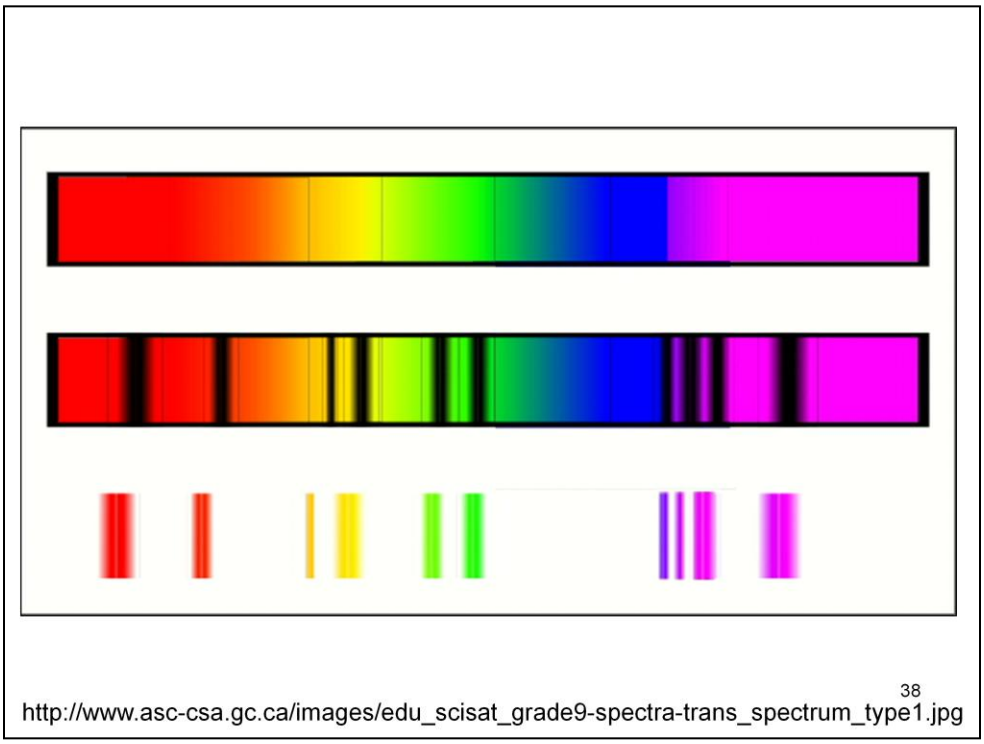
Teacher: The Sun emits light which gives an effectively complete spectrum. Each gas in the atmosphere absorbs specific wavelengths of light. When the light reaches the spectrometer, the spectrum will be missing regions where the light has been absorbed by the gases in the atmosphere. The missing parts of the spectrum are used to give information about the gases in the atmosphere.



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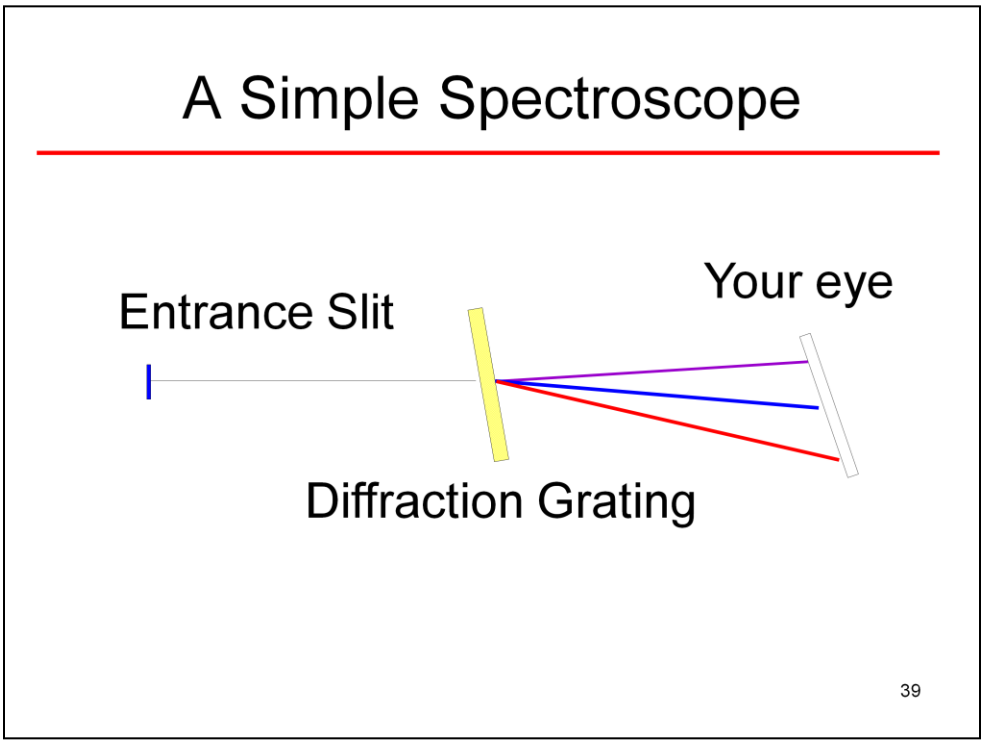
http://www.asc-csa.gc.ca/images/edu_scisat_grade9-spectra-trans_spectrum_type1.jpg

Teacher: The top spectrum is an example of light coming from the Sun. The middle spectrum is an example of light that has passed through a gas(es). The gas(es) has absorbed some of the wavelengths resulting in the pieces missing from the spectrum. The bottom spectrum is an example of the fingerprint of the gas(es).



Teacher: This slide shows how a spectroscope (simple spectrometer) works. The light enters the instrument through an entrance slit. The light hits a diffraction grating which breaks it up into the spectrum. The light then travels to the viewer's eye where the spectrum can be seen and analyzed.

Build a Spectroscope

For instructions visit:
http://jchemed.chem.wisc.edu/HS/Journal/Issues/2006/Jan/clicSubscriber/V83N01/p56.pdf

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