These notes are posted on my site for the following reasons:

- for students to copy in their own hand-writing
  - in order to complete their class notes
  - if student did not have enough time in class
  - if student was away and missed this section
- for assistants and tutors to follow progress of the concepts taught

Photocopied/printed notes can not be used during the Unit Notebook Check in class.

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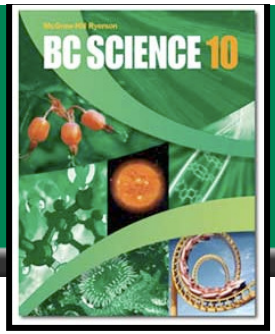
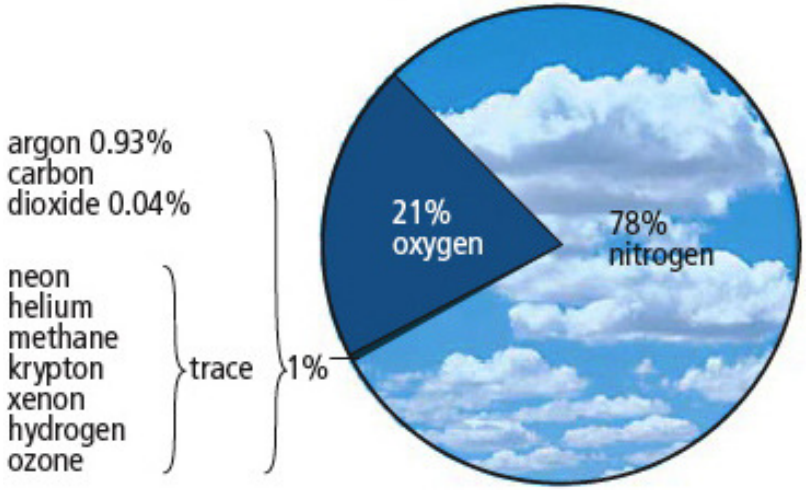
10.2 Energy Transfer in the Atmosphere



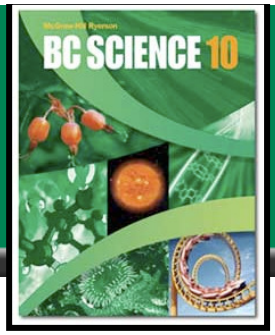
- **Earth's atmosphere is a key factor in allowing life to survive here.**
  - **This narrow band of air has the right ingredients, and maintains the correct temperature, to allow life to form and survive.**
  - **Originally, Earth's atmosphere was very different, and had no oxygen.**
  - **Scientists think that oxygen first came from the breakdown of water by sunlight, then later by photosynthesis by plants.**
  - **Air on Earth is 78% N_2, 21% O_2, 0.92% Ar, 0.04% CO_2 and a variety of others.**
  - **The density of the atmosphere decreases with altitude.**



The composition of Earth's atmosphere.

See pages 436 - 437

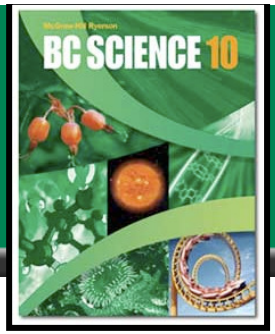
The Layers of the Atmosphere

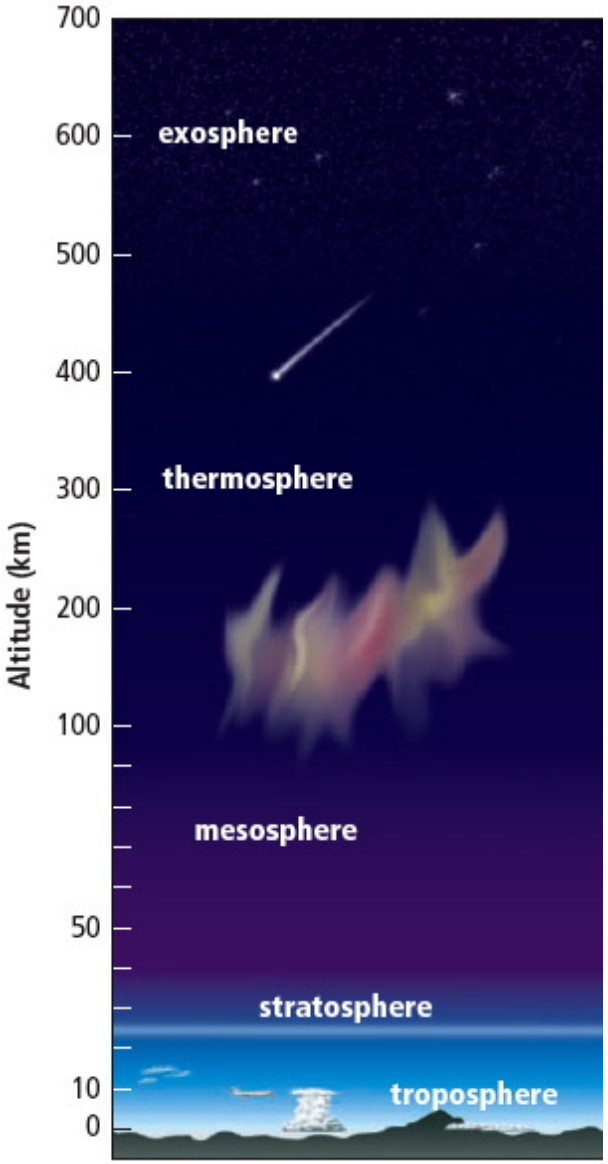


- **Earth's atmosphere is made up of five layers.**
  - **The troposphere: Closest to Earth's surface, 8 km - 16 km thick**
    - **Highest density layer because all other layers compressing it down.**
    - **Almost all water vapour in the atmosphere is found here.**
      - **Therefore, this is where most weather takes place.**
      - **Solar energy and thermal energy from Earth keep air moving**
    - **Temperatures range from average of +15°C at the bottom to –55°C at the top.**
  - **The stratosphere: The second layer, above the troposphere**
    - **10 km to 50 km above Earth, warming from –55°C as altitude increases**
    - **The transition from troposphere to stratosphere is called the tropopause.**
    - **The air is cold, dry and clean in the stratosphere.**
    - **Strong, steady winds, planes often fly here to avoid turbulent troposphere.**
    - **The ozone layer is found here, which blocks harmful UV radiation.**
      - **This is why the upper stratosphere warms more**

See pages 438 - 439

The Layers of the Atmosphere



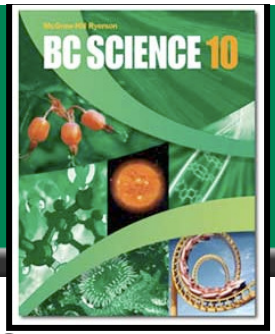


- **The remaining three layers are known as the "upper atmosphere".**
  - **The mesosphere: 50 km to 80 km above Earth**
    - **Temperatures are as low as –100ºC**
    - **This layer is where space debris burns up when it begins to hit particles**
  - **The thermosphere: 80 km to 500 km above Earth**
    - **Temperatures can reach +1500ºC to +3000ºC**
    - **This is where the Northern Lights, *aurora borealis*, are found.**
      - **Charged particles in Earth's magnetic field collide with particles in the thermosphere**
  - **The exosphere: 500 km to 700 km, where it merges with outer space.**

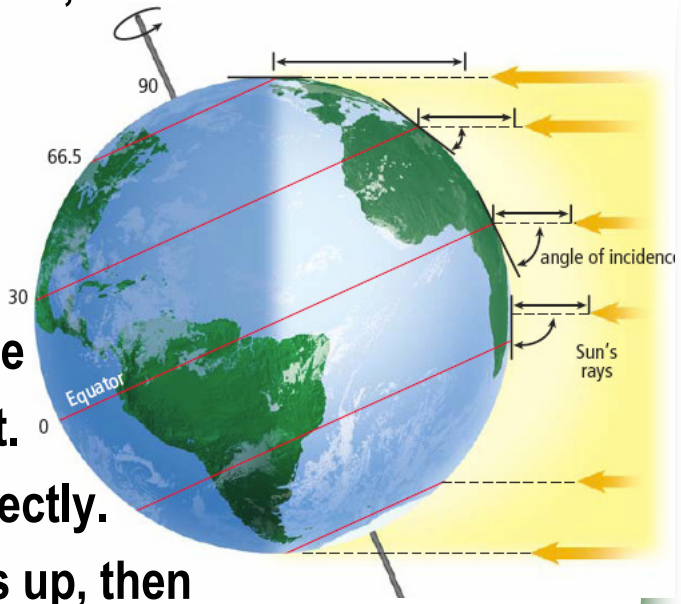
See pages 438 - 439

The layers of Earth's atmosphere.

Radiation and Conduction in the Atmosphere



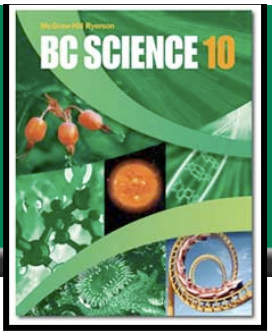
- **Almost all of the thermal energy on Earth comes from the Sun**
  - Yet, this is only a small fraction of the solar radiation that reaches Earth.
  - Most thermal energy is transferred near the equator, which receives a much more direct source of solar radiation.
  - Insolation = amount of solar radiation an area receives, measured in W/m^2)
    - Insolation decreases if there are particles of matter (dust, smoke) in the way, or if the angle of incidence of the solar radiation is too great.
  - Solar radiation does not heat the atmosphere directly.
    - Earth's surface absorbs solar radiation, heats up, then re-radiates the thermal energy into the atmosphere.
      - This provides 70% of the air's thermal energy!
    - Convection in the air spreads the thermal energy around.



Angle of incidence

See pages 440 - 441

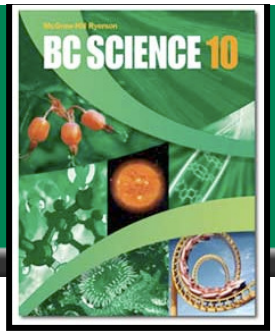
The Radiation Budget and Albedo

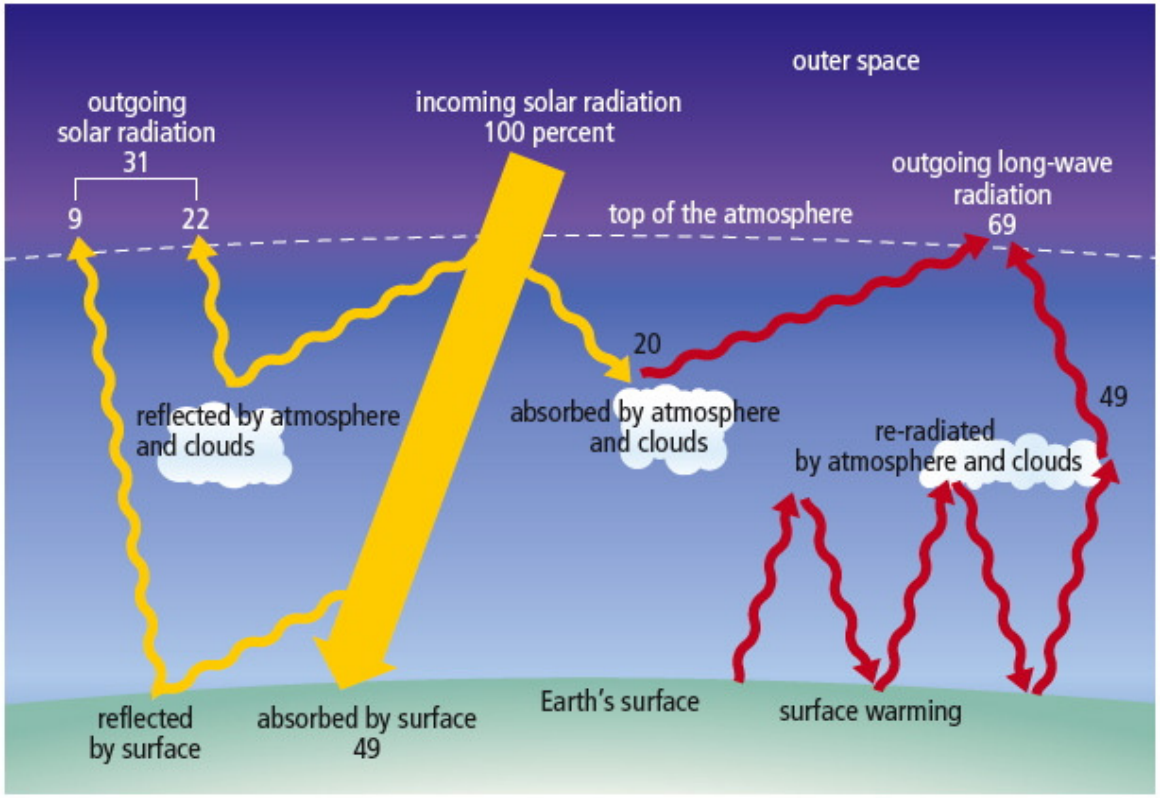


- **The radiation budget is used to explain where all of the solar radiation that reaches Earth actually goes.**
  - **If all 342 W/m^2 of solar radiation that reaches Earth was stored in the atmosphere, it would be far too hot to support life as we know it.**
  - **Earth's radiation budget = heat gained – heat lost**
  - **Of the of the solar radiation that reaches Earth, 15% is reflected by clouds back into space, 7% is reflected by particles back into space, 20% is absorbed by clouds and the atmosphere, and 58% reaches Earth's surface**
    - **9% of this amount is reflected back out into space by Earth's surface**
    - **23% drives the water cycle, 7% creates wind, and 19% is re-radiated from Earth's surface.**

See pages 442 - 443

The Radiation Budget and Albedo

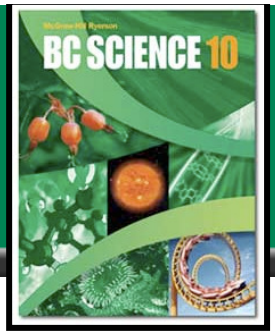




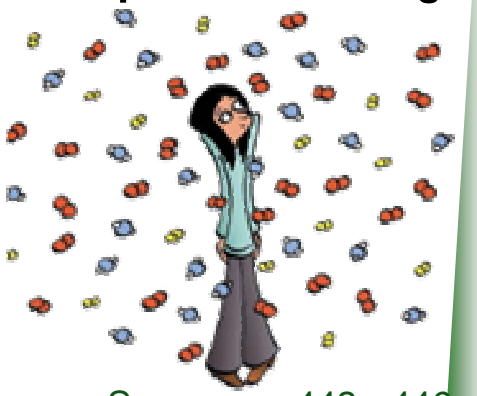
- **<u>Albedo</u> refers to the amount of energy reflected by a surface.**
  - **Light-coloured surfaces have a high albedo, and reflect energy (snow, sand)**
  - **Dark-coloured surfaces have a low albedo, and absorb energy (soil, water)**

See pages 442 - 443

What Is Weather?



- **Weather** is the conditions in the atmosphere at a particular place and time.
  - "Weather" describes all aspects of the atmosphere, and is closely related to the transfer of thermal energy.
  - Atmospheric pressure, measured with a barometer, is the amount of pressure the molecules in the atmosphere exert at a particular location and time.
    - Atmospheric pressure is measured in kilopascals (kPa) = 1 N/m^2
      - Our bodies equalize pressure = why our ears pop with pressure change
    - At sea level, atmospheric pressure = 1 kg/cm^2, and as your increase altitude, the pressure drops.
    - Warm air is lighter and less dense than cool air, and therefore warm hair has a lower pressure than cool air.



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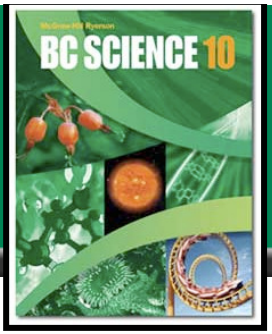
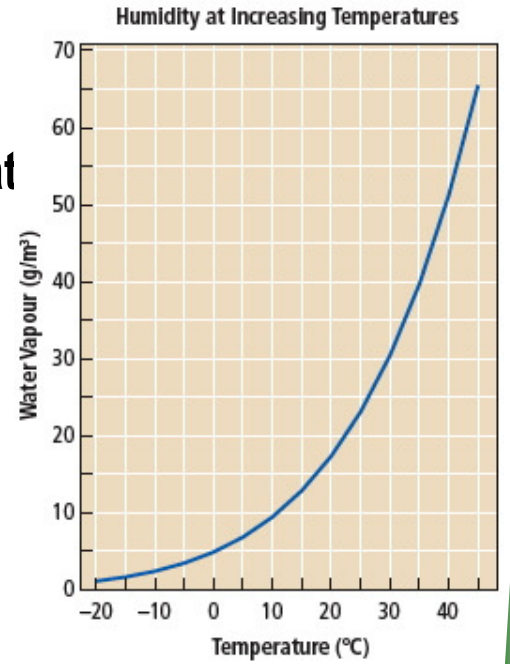
What Is Weather? (continued)

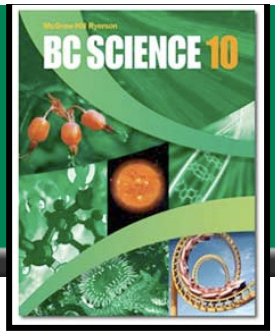


- Humid air (air with more water vapour) has lower pressure than dry air.
  - With pressure drops, meteorologists know warm, moist air is arriving in the area.
  - Specific humidity = the total amount of water vapour in the air
    - Dew point = the temperature where no more water vapour can be held by air.
  - Relative humidity = the percentage of the air that is currently holding water vapour.
    - 45% relative humidity means that the air is holding 45% of the water vapour it could before reaching its dew point.

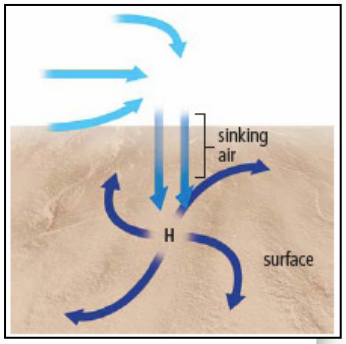


See pages 443 - 446

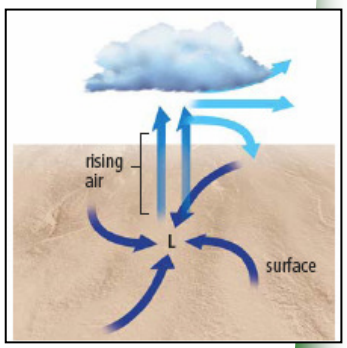
Convection in the Atmosphere



- **Wind** is the movement of air from high pressure to low pressure.
  - An air mass is a large body of air with similar temperature and humidity.
  - Air masses take on the conditions of the weather below.
  - Air masses can be as large as an entire province, or even larger.
- High pressure systems form when an air mass cools.
  - This usually occurs over cold water or land.
  - Winds blow clockwise around the center of the high.



- Low pressure systems form when an air mass warms
  - This usually occurs over warm water or land.
  - Winds blow counter-clockwise around the center of the high.
  - Lows usually bring wet weather.



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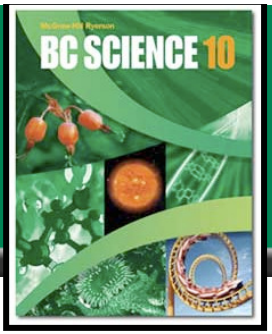
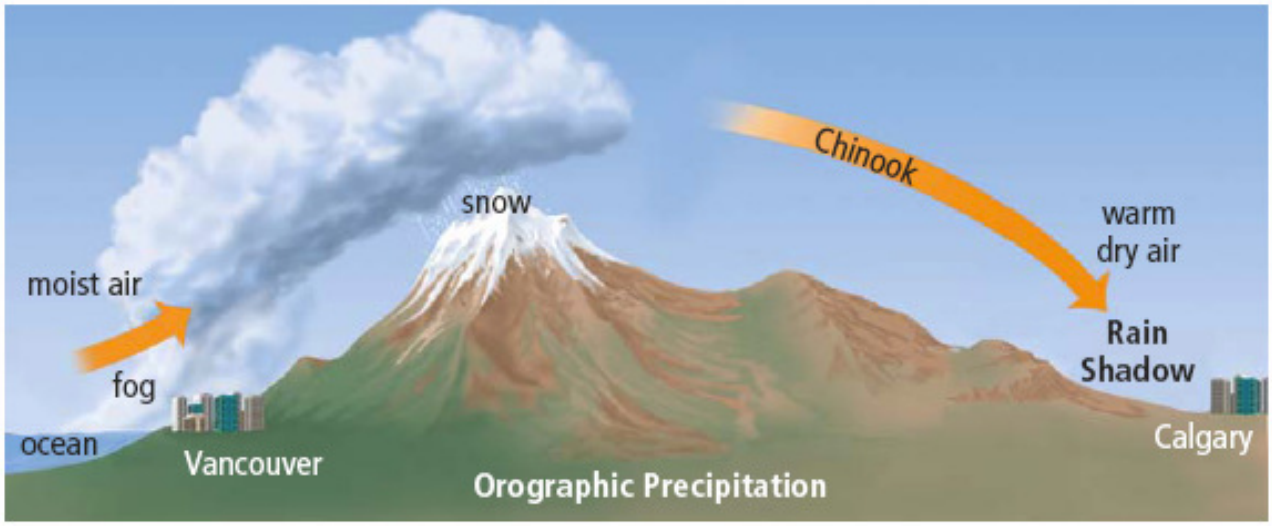
Prevailing Winds



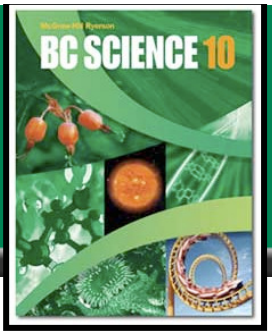
- **Prevailing winds are winds that are typical for a location.**
  - **For example, winds in BC usually blow in from the ocean.**
  - **Precipitation falls as air is forced up the mountain slopes.**
  - **Air gets drier as it moves inland, continuing to drop precipitation.**
  - **Dry air rushes down the far side of the mountains into the prairies.**



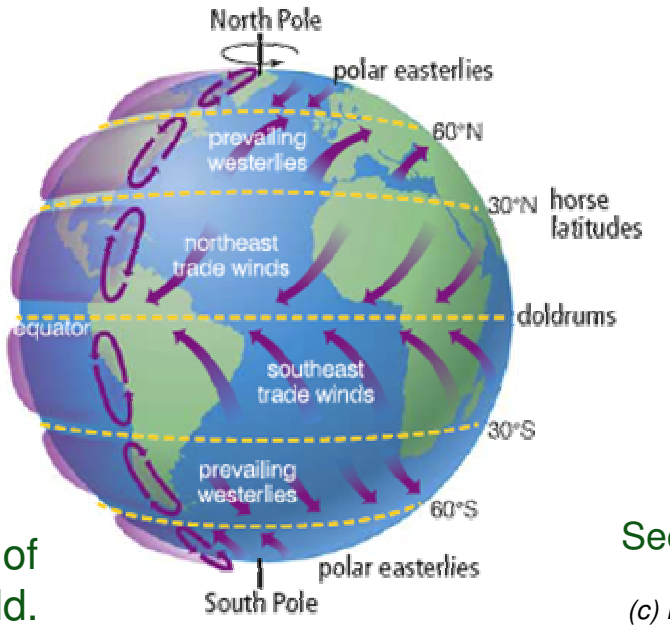
The prevailing winds off BC's coast, crossing into Alberta.

See pages 448-449

The Coriolis effect



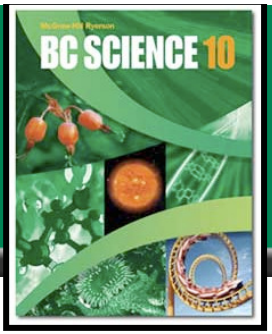
- **Winds move from high pressure to low pressure.**
  - In a simple model, air would warm in the tropics, and rise.
  - Cooler air from the north would rush in below to fill the empty spot.
  - The warm air at higher altitudes would move north to replace the cooler air.
  - This occurs at several latitudes as we move north.
- **As earth rotates, these winds are 'bent" clockwise = <u>Coriolis effect</u>**
  - The equator moves much more quickly than the poles.
- **Wind systems develop**
  - The trade winds
  - The prevailing westerlies
  - The polar easterlies



Wind systems of the world.

See pages 449 - 450

Jet Streams, Local Winds and Fronts



- **Strong winds occur in areas between high and low pressure systems.**
  - The boundaries between the global wind systems thus have very strong winds.
  - In the upper troposphere, between warm and cool air, are the jet streams.
    - Jet streams often look like streams of water.
    - The Polar jet stream can move at 185 km/h for thousands of miles.
    - Planes flying east across Canada “ride” the jet stream, and avoid it flying west.
- **Local winds arise and are influenced by local geography.**
  - In BC, sea breezes blow inland (onshore breeze) when the land warms in the morning, and outward (offshore breeze) when the land cools in the evening.
- **A front is a boundary between two different air masses.**
  - Cold air forces warm air to rise, so fronts usually bring precipitation.

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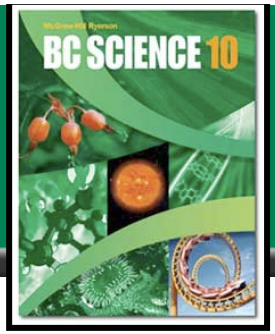
Extreme Weather



- **Air masses often have very large amounts of thermal energy.**
  - **Extreme weather can arise under certain conditions as this energy is released.**
  - **Thunderstorms occur when warm air rises, water condenses (which releases even more energy), building the thunderhead even higher.**
    - **Static energy can be built up and released as lightning.**
    - **Sea breezes in the tropics, and energetic cold (and even warm) fronts can cause thunderstorms.**
- **Tornadoes form when thunderstorms meet fast horizontal winds.**
  - **A "funnel" of rotating air may form, which sometimes extends all the way to the ground with winds of up to 400 km/h.**
- **The tropics, with their intense heat, can often have severe weather.**
  - **Large masses of warm, moist air rise quickly, and cool air rushes in.**
  - **Counter-clockwise in the northern hemisphere, clockwise in the south. Hurricanes = Tropical cyclones = Typhoons**

See pages 452 - 453

Take the Section 10.2 Quiz