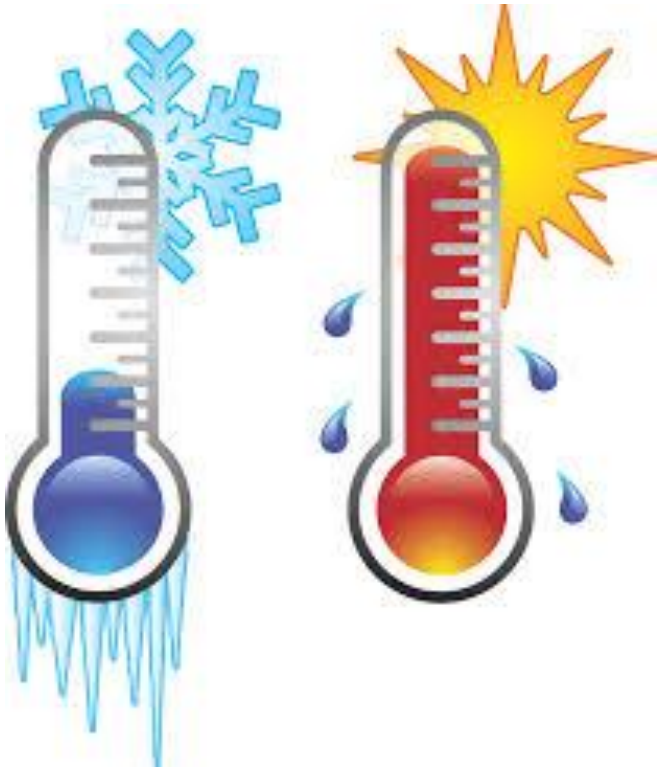
Science 14
Unit B: Energy Transfer Technologies

Chapter 5

Heat and Heat Transfer

pp. 80-103



WORKBOOK

Name: _____

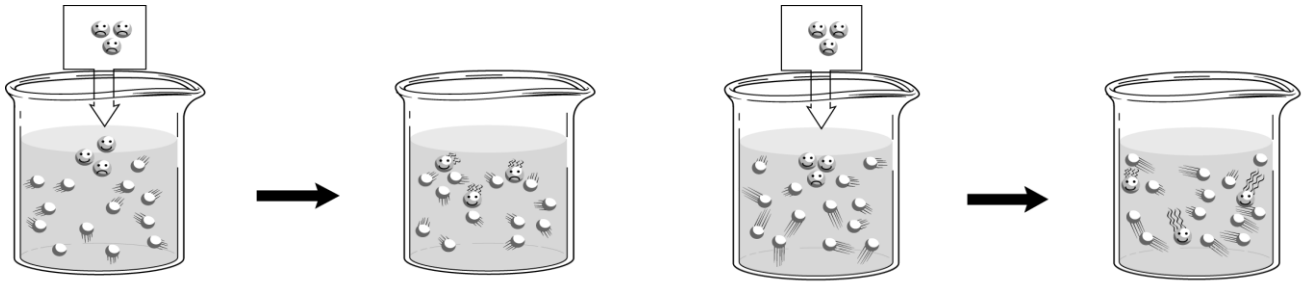
5.1 - The Nature of Heat

pp. 82-85

→ Read pp. 82-83

- **Friction Theory** states that when two surfaces are rubbed together, the parts that touch will resist movement, creating friction.
- Count Rumford made the first observations about friction while watching metal being cut, which caused it to heat up. *See Figure 5.1 – p. 82*
- Robert Brown observed pollen grains under a microscope bouncing around in a drop of water.
    - As temperature increased the random, vibrating motion (**Brownian Motion**) increased.
    - He reasoned that water must be made of tiny, unseen particles that are constantly moving and colliding, although he didn't know what the particles were.

→ *Demonstrate & Discuss INV 5A – pp. 84-85*



Cold Water
Slow moving water molecules bump and move the food colouring. Food colouring spreads slowly.

Hot Water
Hot water molecules move quickly and smash around the food colouring. Food colouring spreads fast.

→ Read "Did You Know" – p. 85

→ *Discuss CYU – p. 85 #1-3*

5.2 – Heat and Temperature

pp. 86-87

→ Read p. 86

- Robert Brown was the first to start the theory of heat.
    - Heat energy (**thermal energy**) comes with heat and is related to the vibrating particles in a substance.
    - Heat *always* flows from hot to cold

- **Kinetic Energy**, E_k → is the energy of movement.
    - It measures the amount of motion a particle has and explains the difference between heat and temperature
        - **Heat** – total *sum* of all kinetic energies of all particles in an object
        - **Temperature** – *average* of all kinetic energies of all particles in an object

- Temperature can be the same in objects, but the object that is larger will have more heat because it has more particles.

- All particles have different kinetic energies and collide at different speeds.

→ Read "Did You Know" – p. 86

→ *Discuss CYU – p. 87 #1-2*

5.3 – Transfer of Heat

pp. 87-91

→ Read "Science Myths" – p. 88

→ Read pp. 88-89

Forms of Heat Transfer

Conduction → heat transfer that occurs when there is <u>contact</u> between two objects

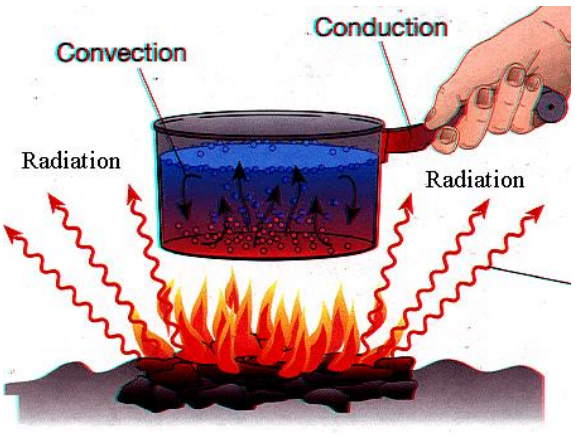
- Contact causes the molecules of the hotter object to collide with the slower molecules of the colder object, resulting in a transfer of kinetic energy from the hot to the colder objects.
- Transfer by direct contact (or collision) of objects (or particles)

Convection → heat transfer that involves movement of matter in the form of <u>currents</u>

- Occurs only in liquids and gases
- Heat is transferred from a hot object to the molecules touching it.
- Molecules gain kinetic energy and thus vibrate faster and get further apart.
- Warm molecules are farther apart than the colder ones, so the warmer is less dense than the colder, which forces the warmer particles to rise, creating a warm current because cool, denser particles rushes in to take the place of the warmer particles that are rising.
- Circulation from different densities of liquid or gas currents

Radiation → heat transfer that involves <u>electromagnetic waves</u>

- Produced by vibrating electrons that make electromagnetic waves.
- Radiation moves through empty space
- Radiated waves are absorbed or reflected by objects they contact
- Electromagnetic waves travel from a heat source, strike the cold object and transfer heat energy to the molecules of the cold object, causing the molecules of the cold object to vibrate faster.

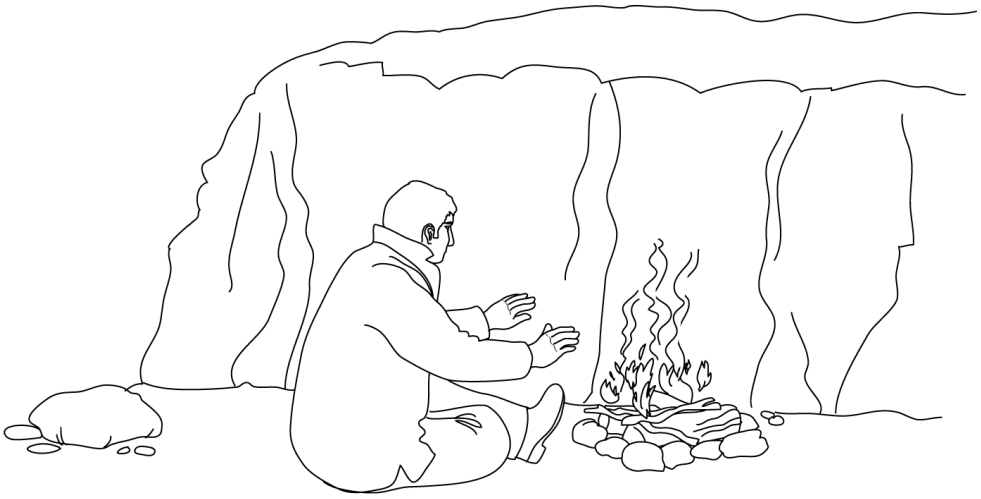


→ Read "Did You Know" – p. 89

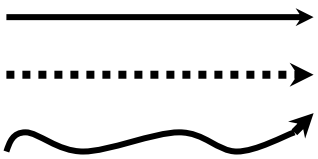
→ *Discuss CYU – p. 91 #1-4*

Heat Transfer Review

BLM 5-6



1. What forms of heat transfer are suggested by the sketch? Use the following symbols to identify the forms of heat transfer shown in the diagram. You may need a symbol more than once.



= conduction

= convection

= radiation

2. Which one form of heat transfer is most useful to the man pictured? Explain.

3. Survivalists advise building a fire next to a solid object such as a large rock or wall.

(a) Why would this practice heat a person better than a fire in the open?

(b) What form of heat transfer is responsible for this heating wall improvement?

Midpoint Review

BLM 5-7

What to Do

Using point form or a series of diagrams, write sample responses for each of the following questions. If you need to review, the section numbers in the brackets show you where these terms were introduced.

1. Describe Brownian Motion and state what causes the motion to occur. (5.1)

2. Explain how particle motion is affected by a change in temperature. (5.1)

3. Suppose there were 20 students walking at different random speeds and directions in a classroom. Answer the following questions as though the motion of the students were compared to the motion of particles in an object. (5.2)

(a) What type of energy would describe their motion?

(b) What would the sum of all their kinetic energies represent?

(c) What would the average of all their kinetic energies represent?

4. What happens to the temperature of an object when its average kinetic energy changes? (5.2)

5. Explain what determines the total heat energy of an object. (5.2)

6. Explain the difference between heat and temperature. (5.2)

7. Use a diagram with + and – signs to demonstrate the transfer of heat that occurs when a hot object touches a cold object. (5.3)

8. In a chart similar to the one shown here, define and give an example of each kind of heat transfer. (5.3)

Heat Transfer	Definition	Example
conduction		
convection		
radiation		

Application Questions

9. A drop of water is placed on a hot frying pan. It bounces around the pan. (5.1)

(a) What would happen to the motion of the bouncing water drop if the temperature of the skillet were hotter?

(b) How is this similar to Brownian Motion?

10. During his honeymoon, James Prescott Joule carefully measured the temperature of water at the top and then at the bottom of a waterfall. Would he have found a difference in the temperatures? Explain your answer. (5.2)

11. When you slap or rub your hands together you feel heat. The heat occurs because collisions and rubbing cause an increase in temperature. Provide another example of when you might expect an increase in temperature as a result of collisions. (5.2)

12. A cube of copper and a cube of ice, each having a mass of 500 grams, are placed in the same freezer overnight. The next day they are removed and left in the Sun for five minutes. (5.2)

(a) How will their temperatures compare when they leave the freezer?

(b) How will their temperatures compare after five minutes?

(c) After five minutes, which sample will have a greater average kinetic energy? Explain.

5.4 – Heat Transfer in Nature

pp. 92-97

→ Read pp. 92-95

- Warm air rises and cold air sinks. The circular movement this creates is convection.
- All winds start with convection currents that are formed by land and sea breezes.
    - These are both caused by a difference in temperature near the surface of Earth.
        - Heat is absorbed and lost quickly by land.
        - Water heats slowly and looses the heat slowly.

Sea Breezes – cool on hot <u>days</u>

- hot summer days – blows cool wind from the water toward the land (ocean → land)
- stronger with larger temperature difference

    A) sun's rays warm land more rapidly than they warm water.

    B) Warm air is less dense and rises above cold air

    C) Air over water is cooler and the cool air is more dense, causing it to sink

    D) Cool air flows toward land to replace the warm air that has risen, creating a wind.

Land Breezes – warmer on cold <u>nights</u>

- evening – flows from land to ocean, weaker than sea breezes due to less temperature difference at night (land → ocean)
- weaker than sea breezes

    A) The sea looses heat more slowly than the land.

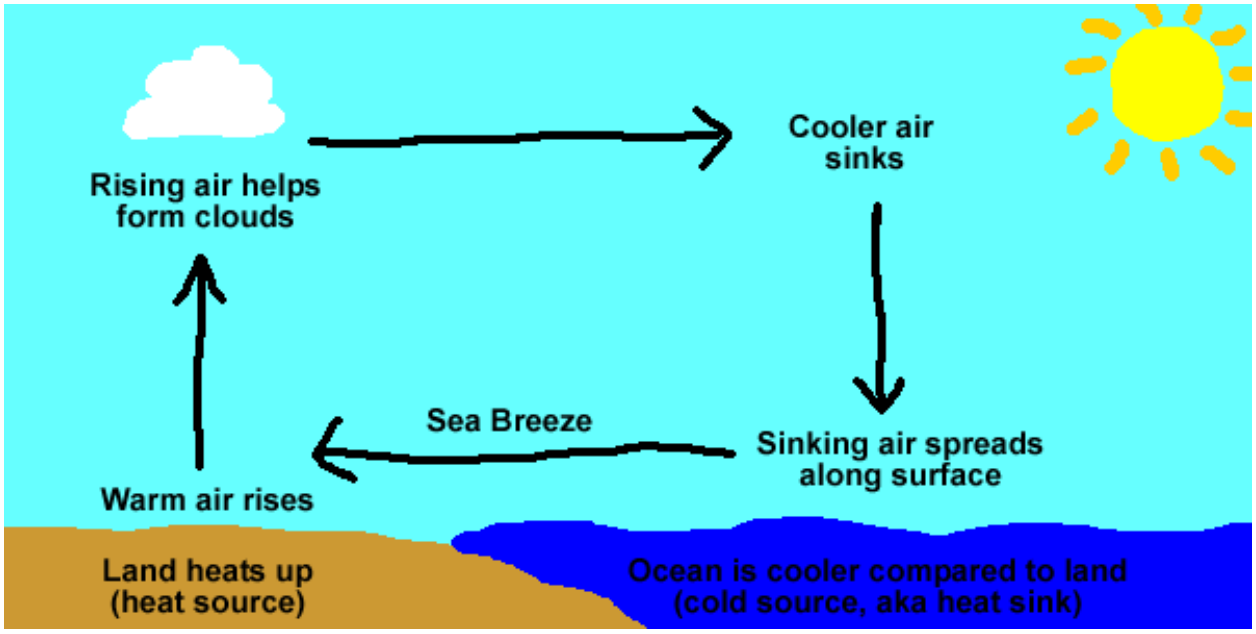
    B) Warm air over the sea rises.

    C) Air over the land is cooler, denser and therefore sinks.

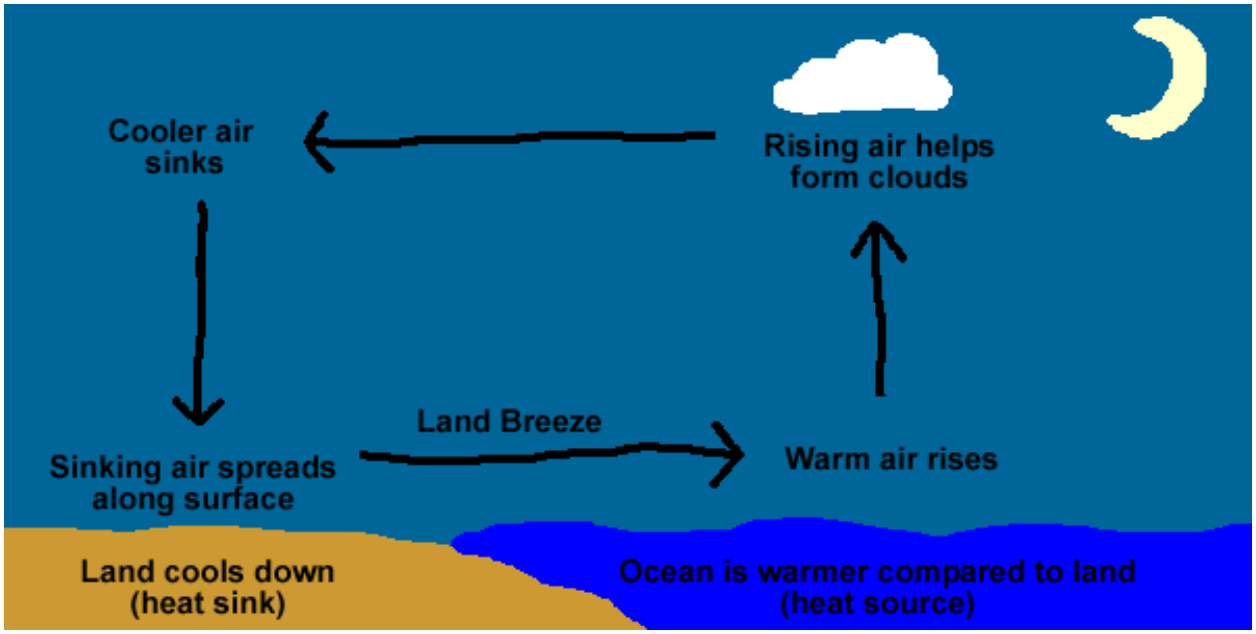
    D) Cool air flows toward the sea to replace the warm air that has risen.

→ Read "Did You Know" – p. 95

SEA BREEZE

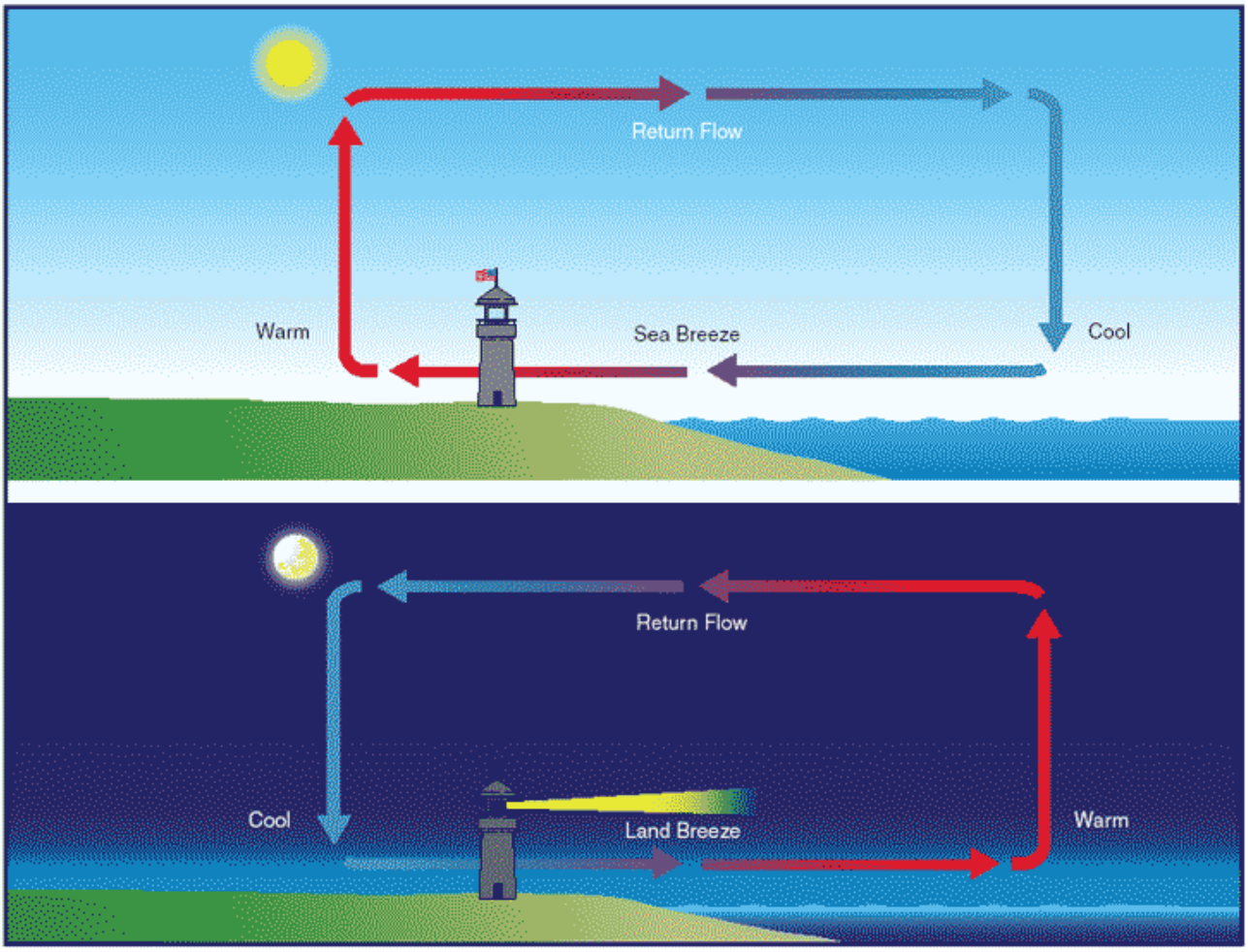


LAND BREEZE



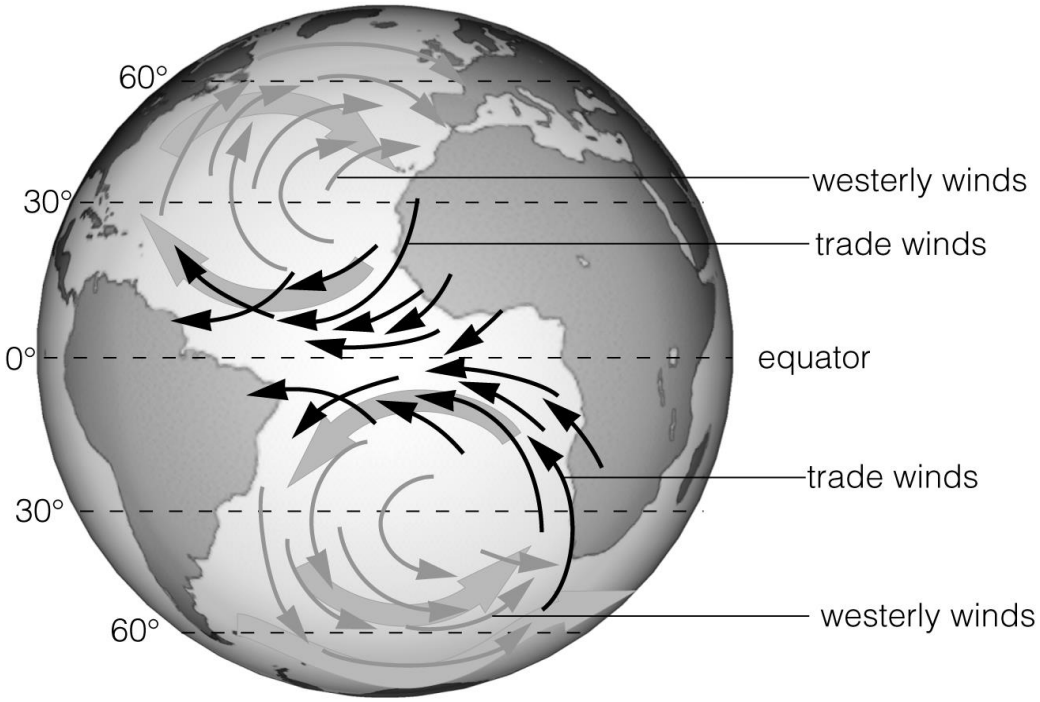
→ Read p. 97

- Oceans **moderate** the climate of the land around them
  - prevent it from getting too hot or cold
  - In cold weather, the ocean releases lots of heat and warms the land without cooling itself off much.
  - If warm weather, the heat from the air will flow into the water, cooling the air. If it the air gets too cold, heat will flow back from the ocean to the air and warm thing up again.



Global Circulation of Wind

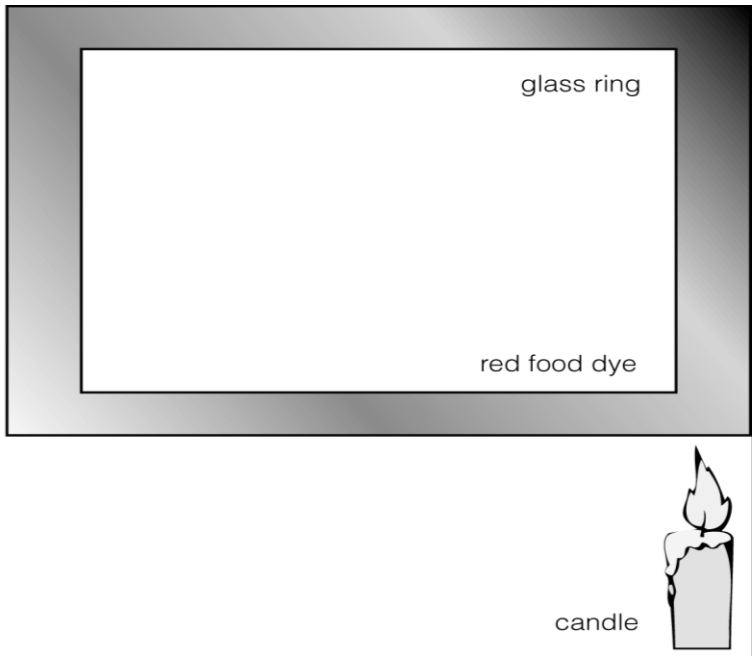
BLM 5-8



Heat Ring

BLM 5-9

Use this diagram to answer the following questions.



1. Add arrows to show what direction the dye flows in the closed heat ring.

2. Explain why the dye flows in this direction.

3. How would the direction of flow change if the candle were replaced by a bag of ice placed at the top right corner?

How Oceans Affect Climate

INVESTIGATION 5-D

p. 96

Think About it

Does being near a large body of water, such as an ocean or large lake, affect climate?

Predictions

Write a prediction to answer the above question and support your educated guess with the scientific knowledge you have learned.

Write your statement in the form of "I think….because….."

Analyze the climate data from several Canadian cities to see if your prediction was correct.

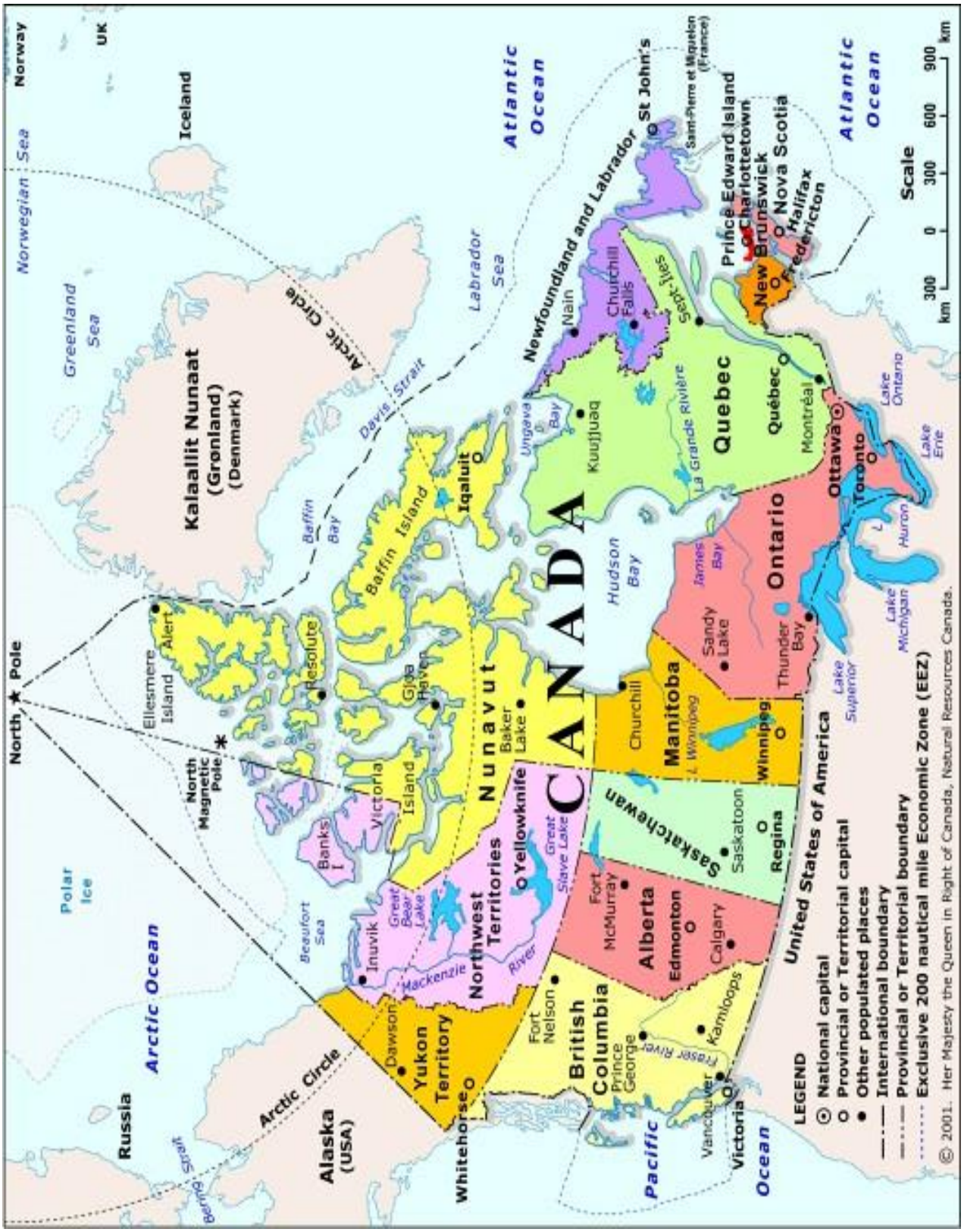
What to Do

Follow the instructions listed on page 96 in the textbook.

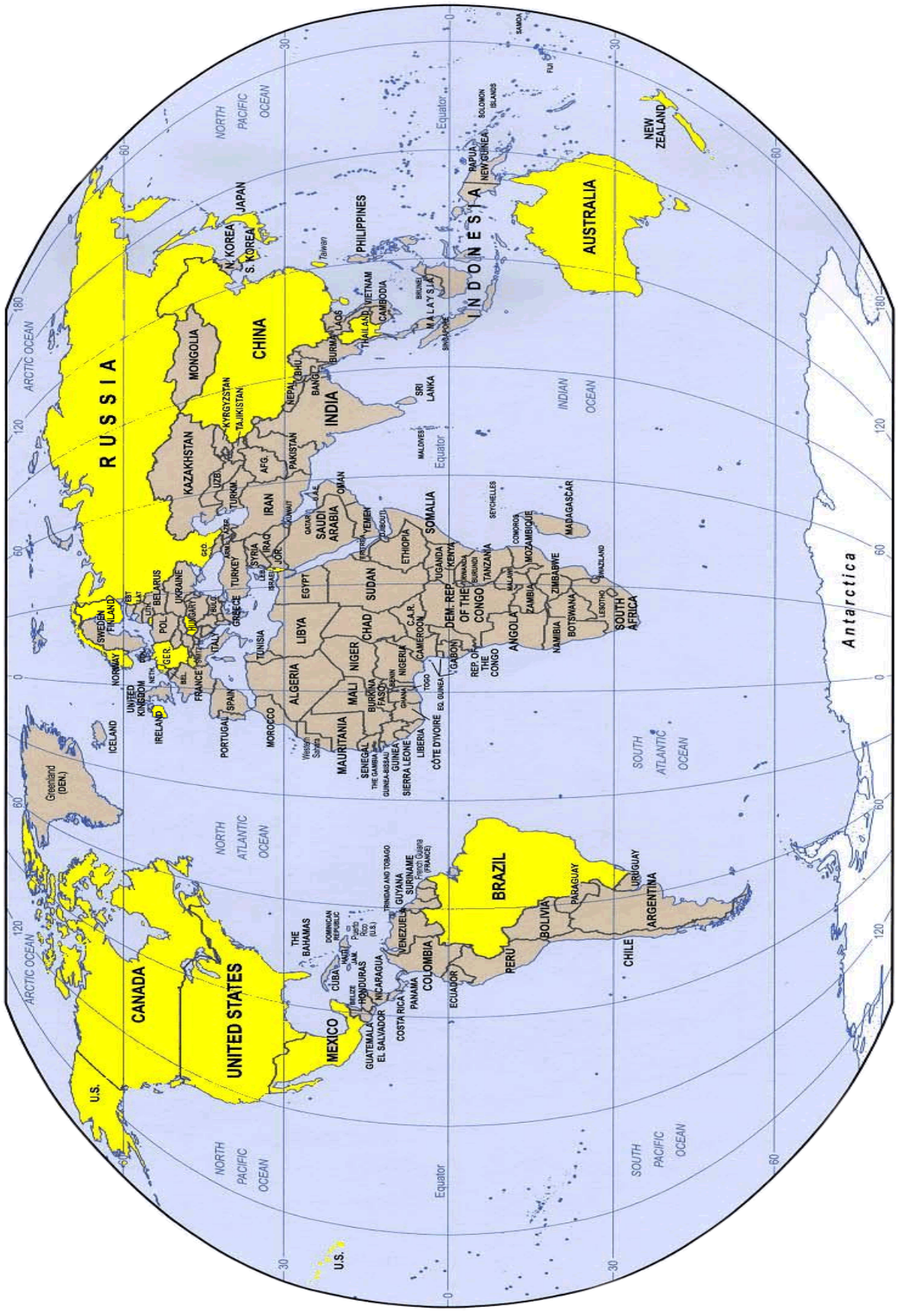
Use the maps of the following pages to complete part two.

There is space in your workbook to construct the bar graphs.

How Oceans Affect Climate
Continued

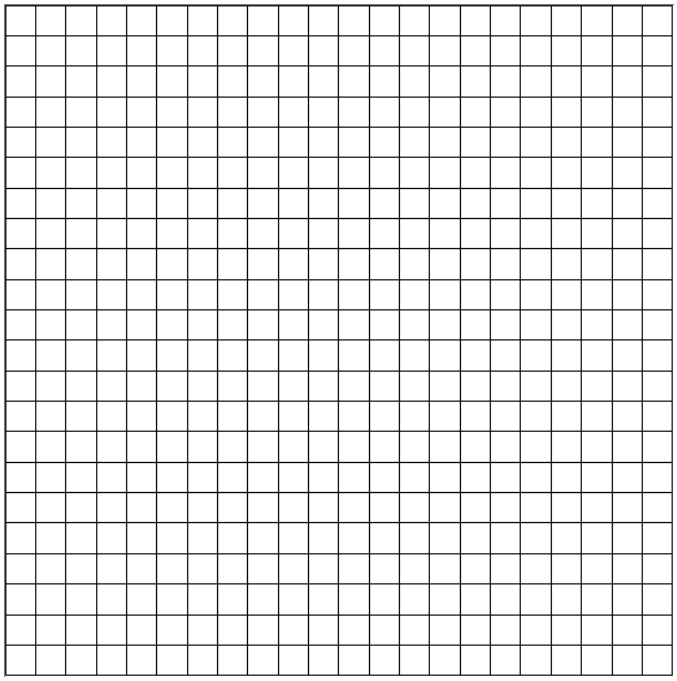


How Oceans Affect Climate
Continued

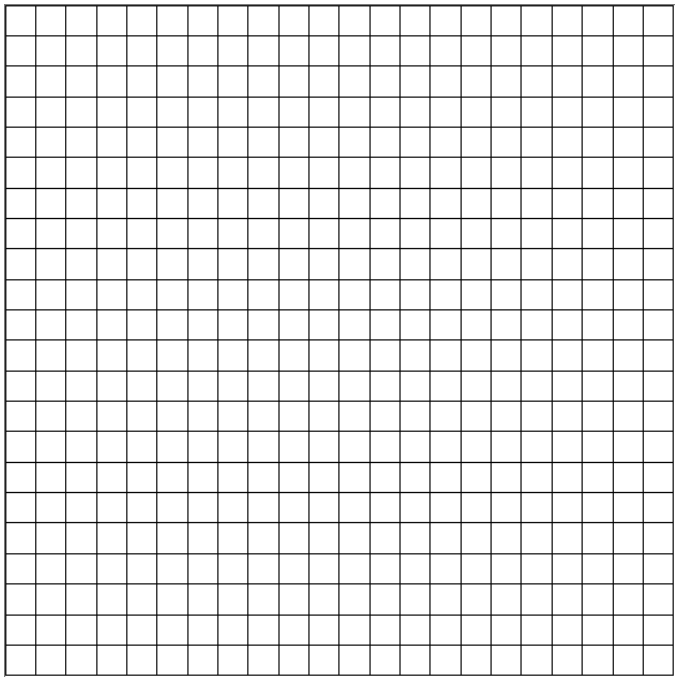


How Oceans Affect Climate
Continued

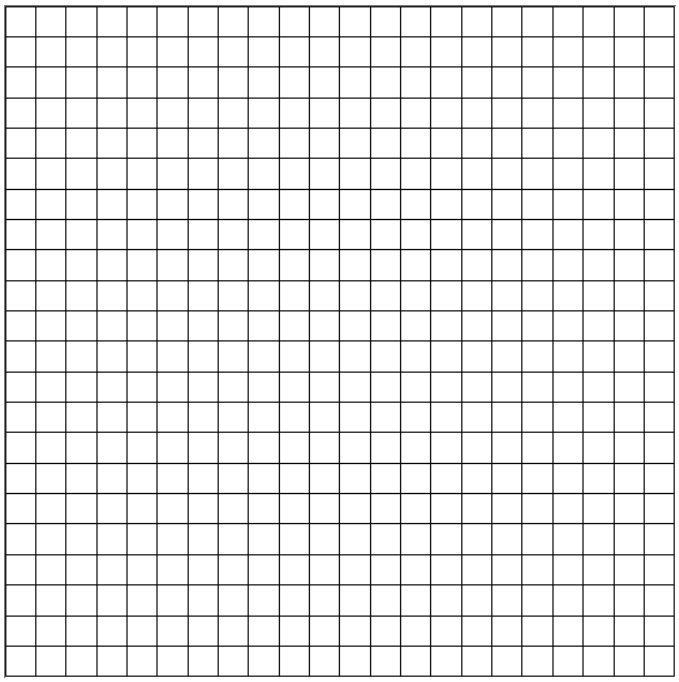
Mean January Temperature



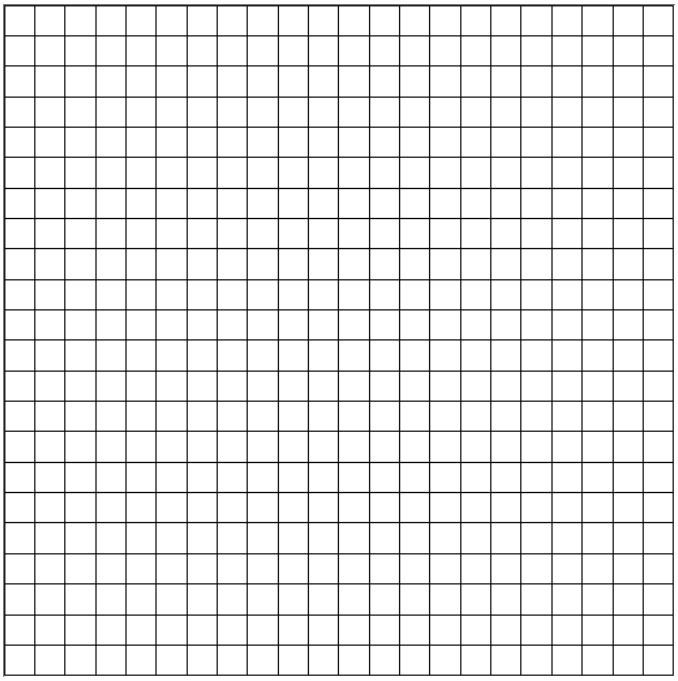
Mean July Temperature



Annual Precipitation



Average Annual Sunshine



How Oceans Affect Climate
Continued

Analyze

1. Compare the mean temperatures, annual precipitation, and number of annual sunshine hours in Vancouver to those in the other cities. What effect does nearness to the ocean seem to have?

2. Why is Vancouver warmer in winter than Calgary? Use your knowledge of heat transfer to explain.

Conclude and Apply

3. Use climate data to help you choose a place to live. Explain which city would you choose to live in if:

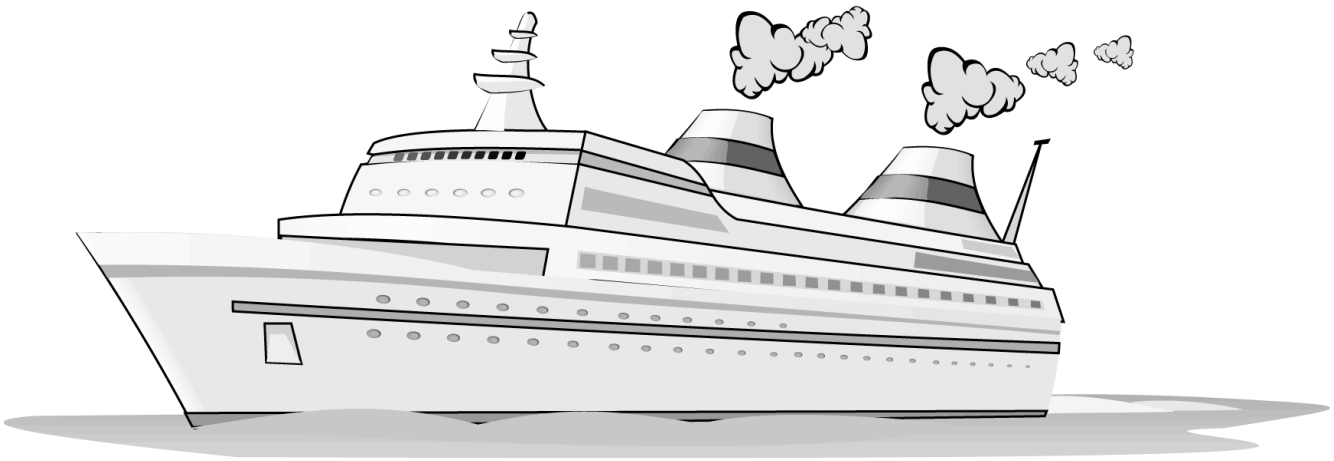
a. You did not like cold temperatures.

b. You wished to grow vegetables that require a lot of sunshine and water.

c. You suffered from arthritis that causes severe joint pain when damp weather approaches.

Smoke from the Stack of an Ocean Liner

BLM 5-10



1. Why does the smoke from a ship rise into the air and not fall onto the deck?

2. If the ship were travelling slowly in a very cool climate, what would happen to the smoke?

3. **(a)** If you took the historic steam train from Stetler, Alberta, would you expect the same effect with smoke? Explain.

(b) What weather conditions might change your answer?

→ *Discuss CYU – p. 97 #1-3*

5.5 – Heat Transfer and Technologies

pp. 98-101

→ Read pp. 98-99

- Many household technologies either transfer or prevent the transfer of heat through conduction, convection or radiation.

Cooking

- Plastic or wooden handles on pots to *prevent* heat transfer to your hand via conduction.

- Pots heat food via *conduction* because they are touching the heat element.
  - Food is touching the pot so it is first heated via conduction
  - The less dense, warm food rises to the top of the pot and colder food is then pushed to the bottom of the pot where it is then heated.
    - A circular motion of food is created, and this *convection* current heats the food to a uniform temperature that is even throughout.

- In an oven, *convection* air currents move heat around in the oven to help cook food.
  - Hot oven walls also *radiate* heat in all directions.
  - There is also *conduction* with the food touching the baking pan.

→ Read "Did You Know" – p. 99

→ Read "Career Connect" – p. 99

→ Read p. 100

- Combustion of fuel inside an engine produces a lot of heat. If it is not allowed to escape, the engine will overheat and be damaged. In order to prevent this:
  - Engines have a cooling system with a liquid coolant. Heat is conducted from the engine to the coolant (heat is taken away by touching the coolant liquid).
    - *See Figure 5.18 – p. 100*
  - Coolant then goes to the radiator (metal honeycomb shape). Heat from the engine is conducted through this to the air.
    - Transfer heat from surface by conduction
    - metal alloy acts as a good conductor
  - Air is forced through the radiator and heat is transferred to the air that goes through the radiator.

→ Read p. 101

Cooling by Evaporation:

- Water absorbs heat from the surface that it is touching and evaporates.
- This removes heat energy as the water molecules leave the water and move into the air. You then feel cooler.
- Heat is conducted away from you via the water that was touching you.
  - *See Figure 5.20 – p. 101*

→ *Discuss CYU – p. 101 #1-4*

Heat Transfer Word Search

BLM 5-13

Complete the word search puzzle by finding the 11 key terms listed below. Circle the words as you find them.

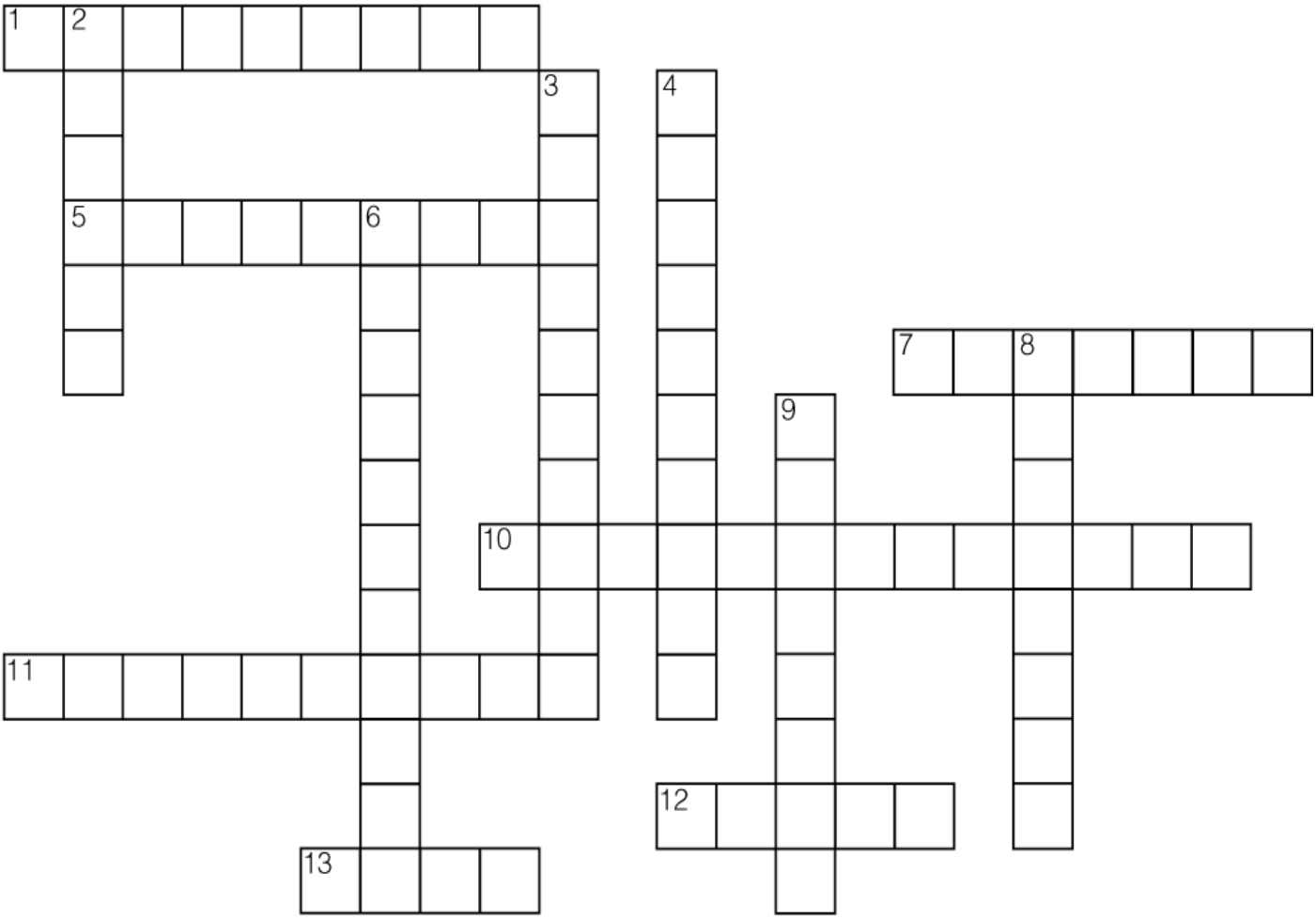
Hint: *The words may be hidden in any direction, but they will always be in a straight line.*

V	F	B	J	V	B	K	M	N	H	T	R	K	B	K
G	U	R	Y	I	Y	I	O	P	E	T	V	I	M	U
K	N	K	I	K	J	I	T	M	D	D	N	N	L	W
W	A	O	G	C	T	D	P	J	R	W	Z	E	D	Q
I	N	B	I	A	T	E	S	U	X	Z	E	T	W	J
X	B	W	I	T	R	I	M	Q	F	E	Z	I	E	Q
I	W	D	O	A	C	F	O	F	I	A	E	C	S	K
D	A	Z	T	R	O	E	C	N	S	B	E	V	R	O
R	Y	U	Z	R	B	Z	V	R	T	L	R	K	G	Z
H	R	J	D	E	V	A	V	N	A	W	B	M	Y	O
E	K	O	O	N	I	H	C	T	O	R	D	B	D	M
H	W	Z	M	A	W	V	N	I	D	C	N	T	X	A
N	O	I	T	C	U	D	N	O	C	O	A	A	D	Z
S	E	A	B	R	E	E	Z	E	W	F	L	E	B	T
X	H	I	O	G	J	A	D	P	F	D	Z	H	R	K

Brown
conduction
convection
friction
heat
kinetic
land breeze
radiation
Rumford
sea breeze
temperature

Heat Transfer Crossword Puzzle

BLM 5-14



Complete the crossword using the clues provided.

Across

1. wind toward land (2 words)
5. electromagnetic waves
7. person who disproved caloric theory
10. measure of motion of particles (2 words)
11. heat transfer between touching objects
12. person who suggested motion of invisible particles
13. total kinetic energy

Down

2. ability to do work
3. circular flow
4. evening breeze (2 words)
6. average kinetic energy
8. neither hot nor cold
9. results when hands rub together

Chapter 5 Review Questions

1. Describe Brownian motion and state what causes the "jiggling of the molecules" to occur. (5.1)

2. How did Robert Brown explain the zigzag motion of the pollen grains that he saw under his microscope? (5.1)

3. Explain how particle motion is affected by a change in temperature. (5.2)

4. Use an organizer like the below to show the relationship that exists among kinetic energy, movement of particles, and the temperature of a gas. Demonstrate particle movement with sketches or sentences. (5.2)

Kinetic Energy	Particle Movement	Temperature
		low
		room temperature
high energy		

5. Explain the difference between heat and temperature. (5.2)

6. Use labelled diagrams to show the transfer of heat that occurs when a hot object is put in contact with a cold object. (5.2)

7. Define the following terms: conduction, convection, radiation. (5.3)

8. Give two reasons why it is possible to boil water at the top of a test tube while the bottom stays cool. (5.3)

9. On a labelled diagram, show how land breezes are formed in the late afternoon after a sunny day. (5.4)

10. Show how an ocean helps moderate the climate of coastal cities. Use labelled diagrams. (5.4)

11. Use sentences or a labelled sketch to describe how convection currents occur in a pot of water that is heated on a stove. (5.4)

13. Explain the processes used in a refrigerator to keep food cold. In your explanation, consider what happens in the freezer section, the cooling vanes on the back or at the bottom, and in the compressor. (5.5)

13. List three technologies that use radiation to transfer heat. (5.5)

- **Complete Chapter 5 Review Questions – p. 102 #1-7**

Please record your answers below or on an attached sheet of loose leaf.