UNIT 9 ACTIVITIES

Step 1. Read Chapters 9 and 10 in your textbook (Principles of Environmental Science, by Cunningham and Cunningham) and answer the questions in these worksheets. For hints, or to double-check your answers, go to the Biology 105 website.

Step 2. For 12 assignment points, do the “Global Climate Change Internet Activity.” This is a web-based activity that can be completed at home. The instructions for the activity are on the Biology 105 website. You can submit your answers online or turn in a hardcopy. Your instructor will grade your assignment and return it to you in a few days to a week after it is due.

Step 3. For 12 assignment points, do the “Atmospheric Ozone Internet Activity.” This is a web-based activity that can be completed at home. The instructions for the activity are on the Biology 105 website. You can submit your answers online or turn in a hardcopy. Your instructor will grade your assignment and return it to you in a few days to a week after it is due.

Step 4. Optional: Learn more about climate and pollution in the news on the class website.

Step 5. Prepare for the Unit 9 Exam. Study your completed worksheets, and take the online multiple-choice self test (on the Biology 105 website).

Step 6. Come in to the Biology Learning Center to take your Unit 9 Exam. The exam will consist of 40 multiple-choice questions.

STEP 1: TEXTBOOK WORKSHEETS

Read Chapters 9 and 10 in your textbook and answer the following questions. For hints, or to double-check your answers, go to the Biology 105 website. [NOTE: Read the textbook to learn and understand the subject, but be sure to focus on the UNIT 9 LEARNING OBJECTIVES.]

1. These chapters contain a great deal of information about atmosphere and climate. To help you organize this information, it may help to divide the information into the five following categories.
   a. The Atmosphere and Climate (including weather and climate patterns, solar radiation, and structure of the atmosphere)
   b. Climate Change (including ENSO and greenhouse effect)
   c. Air Pollution
   d. Interactions between Climate Processes and Air Pollution (including ozone depletion)
   e. Effects of Air Pollution (including acid deposition)

These headings will be used below. Although these are listed as separate categories, the concepts within the categories are often interrelated.
CHAPTER 9
WHAT IS THE ATMOSPHERE?
2. Distinguish between weather and climate.

3. Describe the origin of the molecular oxygen in the atmosphere.

4. Name the four most common gases (other than water vapor) in the atmosphere.

5. Define aerosols.

6. Name (in order from the earth out to space) and describe the characteristics of the four zones of the atmosphere.

7. What is ozone? In which zone of the atmosphere is it concentrated? What role does it play in this zone?
8. Explain why there is very little mixing between the troposphere and stratosphere.

WHAT IS THE ATMOSPHERE? THE ATMOSPHERE CAPTURES ENERGY SELECTIVELY

9. Describe what happens to incoming solar energy.

10. Define and describe albedo.

11. Explain what happens to absorbed energy, and name the law of thermodynamics that describes this [you’ll need to review the laws of thermodynamics and think about this!].

12. Explain the “greenhouse effect” of the atmosphere.

WHAT IS THE ATMOSPHERE? EVAPORATED WATER STORES AND REDISTRIBUTES HEAT

13. Explain how water vapor helps distribute heat.

13. Your textbook describes some fundamentals of atmospheric science in this section. Read the text, then circle the appropriate choices in the following statements.
   a. Warm air is (more dense / less dense) than cold air.
   b. Warm air (rises above / falls below) cold air.
   c. Where air rises, the air pressure at the earth’s surface is (low / high).
d. Where air sinks, the air pressure at the earth’s surface is (low / high).
e. Air currents near the surface of the earth move from (high pressure to low pressure / low pressure to high pressure).
f. As air rises, it (cools down / warms up).
g. Water condenses as air (cools down / warms up).
h. In general, air is rising at (the equator / 30 degrees latitude).
i. Most rainforests are located near (the equator / 30 degrees latitude).
j. In general, air is falling at (the equator / 30 degrees latitude).
k. Most deserts are located near (the equator / 30 degrees latitude).
l. Summary: Tucson is located near (the equator / 30 degrees latitude), generally has (high pressure / low pressure) over us in the atmosphere, and is basically a (rainforest / desert).

**WHAT IS THE ATMOSPHERE? LARGE-SCALE WINDS DON’T MOVE IN A STRAIGHT LINE**

15. Past editions of your textbook devoted an entire subsection to large-scale winds. I’ve summarized what you need to know here:

Large-scale winds on the earth’s surface don’t travel in a straight line—they curve because of the **Coriolis effect**. The Coriolis effect is the tendency for air above the earth to be deflected to the right (in the northern hemisphere) or the left (in the southern hemisphere) because of the earth’s rotation (from glossary).

The Coriolis effect tends to be a very difficult concept for students. Here’s the best way I can explain it: Picture a globe in your head. Because of intense heating by the sun at the equator, the air at ground level at the equator warms up. Because the air is warm, it rises. The air then descends back to the surface at 30 degrees latitude, and returns to the equator near the earth’s surface. This circulation of air (rising at equator, sinking at 30 degrees latitude) is called a **Hadley cell**. Because the earth is spinning, and a point on earth at the equator is moving from left to right, the wind (moving from 30 degrees latitude back to the equator) is deflected west (to the left side of the globe). Therefore, due to this Coriolis effect, the path of the air is deflected to the right north of the equator, and to the left south of the equator.

**Jet streams** are very strong wind currents with shifting paths that can have a major effect on weather and climate.
WHAT IS THE ATMOSPHERE? OCEAN CURRENTS ALSO REDISTRIBUTE HEAT

16. Explain the forces that create surface ocean currents and deep ocean currents.

17. What is the thermohaline circulation?

THE ATMOSPHERE AND CLIMATE: SEASONAL WINDS AND MONSOONS HAVE POWERFUL EFFECTS

18. Past editions of your textbook devoted an entire subsection to seasonal winds and monsoons. I’ve summarized what you need to know here:

Monsoons are regular seasonal rains, such as the rains in India and Bangladesh. Because the sun hits the earth above the equator part of the year, and below the equator during the other part of the year, there is a seasonal reversal of wind patterns caused by different heating and cooling rates of the oceans and continents. The seasonal rains provide the water for growing agricultural crops. If the rains do not occur, it can lead to crop failures and famines.

CLIMATE CHANGES OVER TIME

19. Your textbook describes several climatic changes that have occurred over the last several million years. The important message here is that climate has indeed changed over time. Major climate changes often result in the extinction of many species. We use many different tools (gas bubbles from ice cores, etc.) to try to learn about and understand the causes and effects of these climate changes.

CLIMATE CHANGES OVER TIME: EL NIÑO-SOUTHERN OSCILLATION IS ONE OF MANY REGIONAL CYCLES

**How Do We Know the Climate Is Changing Faster Than Usual? Scientific Consensus Is Clear**

21. Describe the change in CO$_2$ levels since 1958. Why isn’t the change a straight line (when graphed)?

**How Do We Know the Climate Is Changing Faster Than Usual? Changes in Heat Waves, Sea Level, and Storms Are Expected**

22. Globally, average temperatures are expected to increase between 2 to 4 degrees Celsius (3 to 8 degrees Fahrenheit) by 2100. [By the way, the difference between current temperatures and the last ice age, when glaciers covered much of North America, was only about 5 degrees Celsius (9 degrees Fahrenheit).]

23. In addition to a hotter climate, what are some of the impacts of the changing climate discussed in this section?

**How Do We Know the Climate Is Changing Faster Than Usual? The Main Greenhouse Gases Are CO$_2$, CH$_4$, and N$_2$O**

24. You should be able to name the four most important greenhouse gases and describe their sources.

   a. **carbon dioxide**: comes mainly from the burning of fossil fuels and burning of forests. Carbon dioxide is also a natural waste product from cellular respiration. Carbon dioxide does not have as great a capacity for holding heat as some other greenhouse gases, but carbon dioxide is the most important greenhouse gas because it is put into the atmosphere in such great quantities.

   b. **methane**: a waste product given off by bacteria, including bacteria in the guts of cattle. Other methane sources include swamps and marshes. Arctic tundra holds methane hydrates under the permafrost, and these methane hydrates will be released into the atmosphere if global warming causes thawing of permafrost. Natural gas fuel is methane, and a great deal of methane leaks from natural gas pipelines.

   c. **chlorofluorocarbons** (CFCs): CFCs are a group of artificial chemicals, made entirely by humans (therefore called "anthropogenic"). CFCs are used in refrigerators, air conditioners, and as propellants in aerosol cans (although many uses of CFCs as propellants have been outlawed). In addition to being an important greenhouse gas, CFCs are the most important of the ozone-depleting gases.
d. **nitrous oxide**: occurs naturally from the breakdown of nitrogen compounds in soil, water, and animal waste. Humans greatly increase the emission of nitrous oxide by adding chemical fertilizers to agricultural land, by raising livestock, and by deforestation.

**How Do We Know the Climate Is Changing Faster Than Usual? What Consequences Do We See?**

25. Describe some of the current evidence of global climate change.

26. Describe the two ways in which global warming could affect sea level.

27. Your textbook doesn’t mention feedback loops, which are also important in determining global climate. Feedback loops will be described in more detail in the assignments for this unit.
HOW DO WE KNOW THE CLIMATE IS CHANGING FASTER THAN USUAL? CONTROLLING EMISSIONS IS CHEAP COMPARED TO CLIMATE CHANGE
28. The Stern Report (discussed in this section) estimates that climate change will cost (or is costing!) at least 5% of the global GPD per year. Every dollar invested now could save $20 later in this century.

HOW DO WE KNOW THE CLIMATE IS CHANGING FASTER THAN USUAL? WHY ARE THERE DISPUTES OVER CLIMATE EVIDENCE?
29. List and discuss the eight most common statements made about climate change and the responses to those claims.

ENVISIONING SOLUTIONS
30. What is emissions trading?
ENVISIONING SOLUTIONS: INTERNATIONAL PROTOCOLS HAVE TRIED TO ESTABLISH COMMON RULES
31. What is the Kyoto Protocol? Does the United States officially support the Kyoto Protocol?

ENVISIONING SOLUTIONS: A WEDGE APPROACH COULD FIX THE PROBLEM
32. Describe four ways to reduce CO₂ greenhouse emissions.

ENVISIONING SOLUTIONS: LOCAL INITIATIVES ARE EVERYWHERE
33. What is “carbon neutral”?

34. What can you do? Make sure you are familiar with the 15 actions you can take that are listed on the graph the What can you do? box.

CHAPTER 10
AIR POLLUTION AND HEALTH
35. Overall, are the impacts of air pollution obvious or subtle? What are these impacts?

AIR POLLUTION: THE CLEAN AIR ACT REGULATES MAJOR POLLUTANTS
36. Distinguish between primary and secondary pollutants.
AIR POLLUTION AND HEALTH: CONVENTIONAL POLLUTANTS ARE COMMON AND SERIOUS

37. You should know the names of the following air pollutants and be able to describe the sources of each.
   a. **sulfur dioxide**: a corrosive gas that can be oxidized (in sunlight) and combined with water vapor to create sulfuric acid, a component of acid rain. Sulfur dioxide is released mainly from the burning of coal to generate electricity.
   b. **nitrogen oxides**: burning ANY fuel in our nitrogen-rich atmosphere produces nitrogen oxides. The largest contributor is automobiles, when gasoline is burned. Nitrogen oxides can combine with water vapor to create nitric acid, a component of acid rain. The brown haze over Tucson (and many other cities) is mostly nitrogen oxides (from car exhaust) reacting in sunlight.
   c. **carbon monoxide**: produced by the incomplete burning of any fossil fuel. Cars produce less carbon monoxide when fitted with a catalytic converter. Carbon monoxide is extremely dangerous because it binds irreversibly to hemoglobin in the blood, which prevents organisms from using oxygen.
   d. **ozone and other photochemical oxidants**: Ozone is a molecule made of three oxygen atoms. (Normal oxygen that we breathe is made of two oxygen atoms.) Ozone in the troposphere is a very reactive molecule, damaging lung tissue. However, ozone in the stratosphere protects us from ultraviolet radiation.
   e. **volatile organic hydrocarbons (VOCs)**: These include many gases from natural sources, but it is the artificial (anthropogenic) gases that contribute the most to air pollution. These include benzene, toluene, formaldehyde, vinyl chloride, etc. Sources include automobiles, chemical plants, and petroleum refineries.
   f. **toxic metals**: including lead, mercury, arsenic, nickel, etc. Sources include burning of coal, ore processing (from mining), garbage incinerators, and industrial chemical plants.
   g. **particulates**: include dust, ash, soot, lint, smoke, pollen, spores, etc. Particulates also include aerosols, which are minute particles or liquid droplets suspended in the air. Particulates also include asbestos and cigarette smoke.

AIR POLLUTION AND HEALTH: HAZARDOUS AIR POLLUTANTS CAN CAUSE CANCER AND NERVE DAMAGE

38. Why are hazardous air pollutants (HAPs) so dangerous? Give some examples of HAPs.

AIR POLLUTION AND HEALTH: MERCURY IS A KEY NEUROTOXIN

39. Mercury is a particularly widespread and persistent toxin that accumulates in the brain and nervous system, causing nerve damage even at very low doses. Most airborne mercury is released by coal-burning power plants. Once this mercury enters fresh and marine waters, it accumulates in living tissues. People are then exposed when they eat fish. Even though
the United States has been fully regulated by the Clean Air Act in 2000, globally mercury is still a growing problem.

**Pollutants and Health: Indoor Air Can Be Worse Than Outdoor Air**

40. Why is indoor air worse than outdoor air, in terms of exposure to pollution? What is the most important indoor air contaminant in developed countries? The most important in developing countries?

**Air Pollution and the Climate: Air Pollutants Travel the Globe**

41. Describe long-range transport of air pollutants.

**Air Pollution and the Climate: Carbon Dioxide and Halogens Are Key Greenhouse Gases**

42. Does the United States consider greenhouse gases, like carbon dioxide, to be pollutants?

**Air Pollution and the Climate: CFCs Also Destroy Ozone in the Stratosphere**

43. Describe patterns, causes, and consequences of stratospheric ozone depletion.
44. There are a few other facts about ozone depletion you should know:
   a. When we refer to ozone depletion, we are referring to STRATOSPHERIC ozone.
      Ozone in the stratosphere has taken millions of years to build up to levels adequate
      to protect living things from ultraviolet light. (In fact, living things could not move
      from the ocean to land until stratospheric ozone began reducing the solar radiation.)
   b. The ozone-depleting gases include CFCs (a refrigerant in air conditioners and
      refrigerators), halons (used by industry, and in some fire extinguishers), and carbon
      tetrachloride and methyl chloroform (both of which are important industrial
      solvents).
   c. Ozone in the TROPOSPHERE is a dangerous pollutant that damages lung tissue.
      Ozone in the troposphere DOES NOT move up into the stratosphere to replenish the
      ozone destroyed by CFCs.

HEALTH EFFECTS OF AIR POLLUTION
45. It might be helpful to list some of the general effects of air pollution. 1) impact on
human (and animal) health, including respiratory diseases, heart attacks, and lung cancer; 2) destruction of vegetation, and reduction of crop yields; and 3) reduction of visibility from haze and smog

HEALTH EFFECTS OF AIR POLLUTION: ACID DEPOSITION RESULTS FROM SO₄ AND NOₓ
46. Define acid precipitation, and describe the pH of normal and acid rain.

47. Describe the effects of acid deposition.

HEALTH EFFECTS OF AIR POLLUTION: URBAN AREAS ENDURE INVERSIONS AND HEAT ISLANDS
48. Define the following:
   a. temperature inversions
b. heat islands

c. dust domes

**AIR POLLUTION CONTROL**

49. Your textbook describes the following:
   a. There are several pollution control methods that are described. However, most of the control methods only lessen the severity of the problem and do not solve the problem. Many of the pollution problems are related to generating electricity by burning coal and other fossil fuels, and to burning gasoline in automobiles. Only a complete switch to energy sources other than fossil fuels will solve the problem.
   b. Anti-pollution legislation has brought about improved environmental conditions in the United States, but it remains controversial. Recent government plans may actually increase air pollution.

**THE ONGOING CHALLENGE**

50. Your textbook describes the following
   a. In the United States, air quality has overall improved in the past few decades. However, particulates and nitrous oxides are still major problems with negative health consequences.
   b. In much of the rest of the world (except western Europe), air pollution has not improved or is worsening.

51. You need to be able to locate and identify the following 3 regions and countries (all of which are discussed in Chapters 9 and 10) on a map of the world for your Unit 9 test: Antarctica, Hawaii, and Australia.

You also need to be able to identify all of the regions and countries assigned in previous units: Galápagos Islands (part of Ecuador), Sonoran Desert (S. Arizona & N. Mexico), Lake Victoria (in Africa), Greenland, North America, Western Europe, Japan, China, India, sub-Saharan Africa, California, Amazon, Atlantic Ocean, the Gulf of Mexico, Thailand, Mexico, Russia, Bangladesh, Yellowstone National Park (Wyoming), Canada, New Zealand, Madagascar, Brazil, Argentina, the Philippines, United Kingdom (Britain, Wales, N. Ireland), Nigeria, Great Lakes, and Egypt

There are two foldout maps at the back of your textbook to help you.

End of Step 1.