Introduction
Unit: The Atmosphere

Grade: 8th grade.

Content-based ESL class

Talina Tapia
You might be particularly interested on how this teacher:

- Created excellent Functional-Notional charts for each lesson.
- Writes language and content objectives for each lesson.
- Proposes the use of prompts to help students academic language (see an example on page 32 Activity 4).
- Modifies activities to help beginner students in page 31 Handout 11.
- Proposes different activities to develop vocabulary (see an example on page 23 “lift the flap books” and on page 26 “idioms activity).
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Introduction to Unit.

Title. The Atmosphere.

Grade level. 7th Grade Science.

Target group. Content-based ESL class (the primary purpose of students is language development).


Lessons:

- Lesson 1. Importance of the Atmosphere.
- Lesson 2. The Weather.
- Lesson 5. Air Quality.
Learning goals.

Content goals:

After completing the unit, students will be able to:

1. state how the atmosphere is important to living things;
2. explain why weather is important in their lives.
3. identify the gases that are present in Earth's atmosphere;
4. name the layers of the atmosphere;
5. name the main sources of air pollution;
6. explain how pollution affects our health.

Language goals:

At the end of the unit students will be able to:

1. use different language functions to perform academic tasks;
2. recognize and use academic vocabulary in a variety of situations (group work, instructional conversations, worksheets, puzzles, etc);
3. write down a narrative on their personal experience with the unit;
4. comprehend readings from their books.
### Goals and Objectives.

<table>
<thead>
<tr>
<th>Language</th>
<th>Content</th>
<th>Strategies</th>
</tr>
</thead>
</table>
| - To expand students’ lexicon.  
  - To improve and increase students academic oral and written language.  
  - To equip students with functions and notions to perform in the mainstream classroom.  
  - Whenever possible, to expand students knowledge of idiomatic expressions used in their textbooks. | - To learn major concepts related to the Weather and Climate.  
  - To use English language skills in an academic setting. | - Teacher will convey meaning by providing students with comprehensible input.  
  - Teacher will provide students with opportunities for output by interacting among themselves. |

### Objectives of Disposition:

<table>
<thead>
<tr>
<th>Language</th>
<th>Content</th>
<th>Strategies</th>
</tr>
</thead>
</table>
| - To be aware that different language functions are used to convey different meanings. | - To be aware that the Atmosphere plays a major role in our lives.  
  - To be cognizant that we are all responsible of taking care of our natural resources. | |

### Objectives of Knowledge:

<table>
<thead>
<tr>
<th>Language</th>
<th>Content</th>
<th>Strategies</th>
</tr>
</thead>
</table>
| - To know the necessary functions and notions to participate and understand class discussions.  
  - To know different idiomatic expressions used in their textbooks. | - To have an understanding of the following concepts:  
  - Atmosphere.  
  - Components of the Atmosphere. | To make input comprehensible:  
  - visuals.  
  - Modeling.  
  - Pace of speech.  
  - Graphic Organizers. |
### Objectives of Skills:

<table>
<thead>
<tr>
<th>Language</th>
<th>Content</th>
<th>Strategies</th>
</tr>
</thead>
</table>
| - To recall and demonstrate proficiency in the spelling of the notions studied in the unit by being able to take dictations and write paragraphs related to the topic.  
- To use context to infer the meaning of unfamiliar words.  
- To use prefixes and suffixes to infer the meaning of unfamiliar words.  
- To use correct capitalization of words. | - Students will be able to analyze, hypothesize, interpret and predict using information related to the aforementioned concepts.  
- To describe what atmosphere is and to explain why it makes conditions on earth suitable for living.  
- To predict and experiment on what the functions of the components of the atmosphere are.  
- To recognize and analyze the function that each layer of the atmosphere plays in our lives.  
- To propose different ways in which they may contribute to improve the quality of our air.  
- To predict different weather conditions depending upon their own observations. | - Working on hands-on activities.  
- Giving oral presentations.  
- Small group work. |
Narrative.

I believe that all children regardless of race, religion and socio-economic status are entitled to the best education. Even though many people are involved in this effort, it is up to us, mainstream teachers to make that happen.

This is not an easy task, but I am convinced it is possible. The following unit and its modifications for ELLs is an attempt to accomplish the task of providing students with the best education.

The original unit of “The Atmosphere,” came out of a middle school textbook. As part of the modifications that I implemented, I split the first lesson into two, creating a new lesson focusing on the weather which was only touched upon in the first original lesson. I thought that students would have a better understanding of the topic if I expanded on how the atmosphere is connected to the weather around them.

As far as sheltered strategies used throughout the unit, I included a number of them. In this narrative I have selected to highlight the following ones as examples:

- stating clearly defined content and language objectives to will provide teachers with information on what concepts and language functions will be addressed during each lesson. In my opinion, this is one of the most important components since it provided me with the exact teaching points I needed to planned for;

- functional notional charts. From my perspective, this is another crucial component of each lesson. It clearly states what vocabulary, language functions and grammar points my students will learn throughout the lesson. This was the springboard that helped me carefully plan the sequence of required activities in order to facilitate the students’ acquisition of subject and language contents;

- activating background knowledge in the beginning of each lesson; thus, students could connect prior experiences to new knowledge;
creating pictures that go along with the concepts of the topic such as the ozone, the different types of weather, air pressure, composition of the atmosphere, atoms and molecules to name a few. By using these pictures, I hope to be able to address the needs of my visual learners as they learn very abstract concepts as part of this unit;

developing vocabulary such as the words layer and gases by creating an activity whereby students spell the words, define them using their own words, give examples of them and finally get to illustrate the words;

modeling activities. I believe that discourse needs to be accompanied with gestures and with body language in order to model tasks students need to accomplish. This will provide students with comprehensible input.

the second lesson calls for the use of realia and other visual clues that are also meant to expand the students’ use of functional English. Functional academic English is necessary for students to accomplish school tasks; therefore, communicative activities were a main component in the design of each lesson;

creating activities suitable for beginning students. Whenever a task required intermediate to advance levels of English proficiency, it had to be slightly restructured to provide beginners with an opportunity to have access to the lesson. Therefore, modeling instructions, restructuring questions, modifying written materials and filling in worksheets beforehand were some of the strategies used in order to address the needs of beginning students.

adjusting discourse. I have made notations at the beginning of each lesson for teachers to pace their speech according to the level of proficiency of students. Example: My suggestions include a caution to avoid slangs and idioms.

cooperative group work. Many activities call upon the practice and application of recently learned concepts. Most of this activities make exceptional use of cooperative group work. In turn, this provides students with the opportunity to have equal participation in each activity, regardless of factors such as personality and English proficiency level. Beginning students receive support from the teacher so as to scaffold them and give them the necessary tools to participate in the activity.
I believe the aforementioned activities will equip students with the necessary tools to successfully achieve the goals and objectives previously set for this unit. Furthermore, I want to mention that I have previous experience teaching science classes to mainstream students, and that I would definitely implement every activity used in this lesson plan for a regular classroom.

As one can see, planning for ELLs is a laborious process, but in turn this lessons could be reused as needed.

In conclusion, the experience of planning this unit it has been really valuable to me since it has given me another perspective on how teachers can teach both language and content to students who are in need of both.
Lesson 1
Lesson 1. Importance of the Atmosphere.

Objectives.

Content Objectives:
- Students will be able to:
  - Define the concept of atmosphere.
  - State how the atmosphere is important to living things.
  - Predict what conditions on Earth would be without the atmosphere.

Language objectives:
- Students will be able to:
  - Define the concept of atmosphere.
  - Explain ways in which the atmosphere is important to life on Earth.
  - Describe what conditions on Earth would be without the atmosphere.
  - Identify and use imperatives orally and in a written form.
### Functional Notional Chart

<table>
<thead>
<tr>
<th>Vocabulary</th>
<th>Functions</th>
<th>Formulas</th>
<th>Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>atmosphere</td>
<td>Defining orally and in writing</td>
<td>..... is .....</td>
<td></td>
</tr>
<tr>
<td>layer</td>
<td>Predicting</td>
<td>I think this is the picture of...</td>
<td></td>
</tr>
<tr>
<td>gas</td>
<td>Talking about hypothetical situations</td>
<td>If ... would ...</td>
<td>Second conditional (If ... would)</td>
</tr>
<tr>
<td>surround</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>living things</td>
<td>Giving reasons</td>
<td>Because ...</td>
<td></td>
</tr>
<tr>
<td>nonliving things</td>
<td>Imperatives</td>
<td>Verb + complement.</td>
<td></td>
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<tr>
<td>put on</td>
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<td>stick</td>
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<td>light</td>
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<td>push</td>
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<td>hold</td>
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<td>lower</td>
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<td>relight</td>
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<td>remove</td>
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<td></td>
<td></td>
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<tr>
<td>blow</td>
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</tbody>
</table>
Lesson 1. Importance of the Atmosphere.

Important: In most activities of this lesson, students will have to refer to pages 14 and 15 of the Original Student’s Material. The former is included within this unit after the Vocabulary Checklist on page 51. Activities for beginning students will refer to pages 14 and 15 of the Modified Material included after the Original Student’s Material.

Rate of speech and modeling strategies:

Whenever necessary model instructions to your students, you may use gestures and body movements to do so. Remember also to pace your speech accordingly to your students English proficiency level. Paraphrase and restate important concepts and directions given to students. Avoid slangs and idiomatic expressions.

Activating prior knowledge:

Start the discussion by asking students to open their books on page 14 of the original material (page 14 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist). Ask them to take a look at the picture at the bottom of the page (Figure 1). Pair them up and ask them to take turns explaining to their partners what they think the picture may be. Write some oral prompts on the board to help them out start the discussion. (I think ...).

Beginning students.
Use a more explicit prompt: “I think this is a picture of ...”
Pair beginning with intermediate students.

Once students have shared their opinions have them read the subheadings on pages 14 and 15 (pages 14 and 15 are part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist). Make sure they understand which headings are subheadings.

Subheadings:
Importance of the Atmosphere.
Composition of the Atmosphere.
Beginning students.
Ask them to point out to the subheadings on pages 14 and 15 of the Modified Material (pages 14 and 15 of the Modified Material come after the Original Student's Material and are designed specially to give beginning students access to the text).

Write the subheadings on pages 14 and 15 (pages 14 and 15 are part of the Original Student's Material included within this Instructional Unit after the Vocabulary Checklist) on the board. Bring the class together and have your students report back their predictions. Confirm their predictions and conclude that they will begin studying a unit on Earth's atmosphere.

Developing language, vocabulary and concepts:

Activity 1.
Write the following words on the board: layer, gas, surround.
Divide your students into groups of three. Ask each member of the group to pick up a word from the list. Each student will have to complete a Spell, Say, Define and Draw chart (Handout 1) for their word. After completing their charts. Each member of the group will share the definition of the word with its colleagues.

Beginning students.
Model the activity of creating a Spell, Say, Define and Draw chart in the groups where you have beginning students. If necessary, you may also give them filled out charts. (Handouts 2-4).

Activity 2.
Ask your students to read from their books on pages 14 and 15 the paragraph about the Importance of the Atmosphere (pages 14 and 15 are part of the Original Student's Material included within this Instructional Unit after the Vocabulary Checklist) and to complete the following Concept definition Map (Handout 5 contains a Concept Definition Map template):
Create a group’s Concept Definition Map. You may also show your students Picture 13 (The atmosphere).

**Activity 3.**
To clarify some of the most important characteristics of the atmosphere, discuss with your students what living and nonliving things are. Draw a T-list on the board and ask them to come up with examples of living and nonliving things (Handout 6 contains a T-list format in case you wanted your students to fill out their individual T-lists).

<table>
<thead>
<tr>
<th>Living things</th>
<th>Nonliving things</th>
</tr>
</thead>
<tbody>
<tr>
<td>eagle</td>
<td>rock</td>
</tr>
<tr>
<td>roses</td>
<td>computer</td>
</tr>
<tr>
<td>humans</td>
<td>book</td>
</tr>
</tbody>
</table>

**Activity 4.**
Have your students write a paragraph about the importance of Earth’s atmosphere (ask them to use information from the Concept Definition Maps they created in Activity 2).

**Beginning students.**
Use the following prompt: 
*The atmosphere is ... Some characteristics of the atmosphere are: ... The atmosphere is important because...*
Activity 5.
Break your students into groups of four. Using construction paper ask them to create a collage about the atmosphere. (Provide them with magazines and newspapers). They may draw some ideas from their Atmosphere's Concept Definition Map.

Once your students have completed their collages pose the following question on the board:

- What conditions would be on Earth without the atmosphere?

Prompt your students answers with the following phrases:

- If atmosphere didn’t exist, (what/who) would/ wouldn’t …

Earth, life, etc.

Activity 6.
Number off students from 1-4. Designate someone by number to begin sharing their response to the question on the board. After that person has answered, the next numbered person on each team responds until everyone has shared an answer. Be sure students know they are expected to stop after everyone has shared an answer.

Call on some teams and ask them to share their answers with the class. Write their answers on the board and ask your students to write a paragraph with what it is stated on the board. An example follows:

“If Earth’s atmosphere didn’t exist, water wouldn’t exist as a liquid on Earth’s surface. Earth would be exposed to meteoroids and dangerous radiation from the sun and life wouldn’t be possible on Earth without the oxygen and other gases that living things need.”

Ask students to make a drawing to illustrate their texts.

Ask students to read some of their paragraphs to the class. Help them understand the role of the second conditional in English. Explain to them that the second conditional is used to talk about things that are unreal (not true or not possible) in the present or the future; things that don’t or won’t happen. Information about second conditional is provided:

A second conditional sentence consists of two clauses, an "if" clause and a main clause:
**if clause** | **main clause**
---|---
If I had a million dollars, I would buy a big house.

If the "if" clause comes first, a comma is usually used. If the "if" clause comes second, there is no need for a comma:

**main clause** | **if clause**
---|---
I would buy a big house if I had a million dollars.

We use different verb forms in each part of a second conditional:

**if clause** | **if + subject + simple past verb**
---|---
I am not you -- this is unreal.

**Main clause** | **subject + would + verb**
---|---
Jan will not leave -- that's not going to happen.

If I were you, I would drive more carefully in the rain.

Paula would be sad if Jan left.
If dogs had wings, they would be able to fly. *Dogs don't have wings -- that's impossible.*

Have students create sentences using hypothetical situations.

**Practice/ Application activities:**

**Activity 1**
Write on the board the following vocabulary:
- goggles
- modeling clay
- aluminum pie pan
- candle
- glass jar
- stopwatch
- oven mitt

Explain this is the material students will be using during the Discover Activity on page 14 (*page 14 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist*). Using real objects demonstrate each item to students. (You might even ask them to copy and illustrate with a drawing the words from the board on their notebooks).

Model the Discover activity on page 14 (*page 14 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist*).
Let students carry out the activity and within their groups ask them to answer the question posed at the end of the activity. "How would you explain any differences between your results in Steps 4 and 5? Discuss the answer with the class. If you require further information about the process and the results of the activity, please turn to page 14 of the Teacher’s Material (*The original Teacher’s Material is also included within this unit. You may find it after the section of Modified Material*).

You may need to use some prompts such as: The difference between steps 4 and 5 is because...
Point out that instructions for the experiment are given in the imperative. The verb is used without a subject, but the subject is understood to be you. Write the following examples on the board.

1. (You) Put on your goggles.
2. (You) Stick a small piece of modeling clay onto an aluminum pie pan.

Ask your students to find other examples of imperatives on the Discover Activity on page 14 (page 14 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist). Ask students to write them down on their notebooks.

Use Handout 7 and ask students to underline the imperatives of the sentences. Explain to students that recipes are commonly written in imperative.

Have students work in groups of three and write directions for an everyday activity, such as how to operate a vending machine. Provide help with vocabulary and make sure that the steps are described in chronological order. Then have the groups orally read directions to other groups, who try to guess what they are doing.

Optional activities:

You may keep a word wall with the most important vocabulary items learned in this lesson. You may find some examples of words to be put up in your word wall in the Realia section (The realia section comes as the last component of this instructional unit).

Spell: ______________________

Say: ______________________

Define: © Meaning ______________________

© Use ______________________

Draw: ______________________
Handout 2. Spell, Say, Define, Draw. (layer)

Spell: layer

Say: (How would you say it in your language?)

Define: Meaning an amount of a substance that covers all of a surface.

Use Earth's atmosphere is the layer of gases that surrounds the planet.

Draw:

- layer
Handout 3. Spell, Say, Define, Draw. (gas)

Spell: gas (singular) gases (plural)

Say: (How would you say it in your own language?)

Define: ◎ Meaning: a substance like air that is not liquid or solid, cannot be seen.
◎ Use: 1. hydrogen gas
2. Earth's atmosphere is the layer of gases that surrounds the planet.

Draw:
Handout 4. Spell, Say, Define, Draw. (surround)

**Spell:** surround

**Say:** How would you say it in your own language? $^5$

**Define:** Meaning to be all around someone or something.

- Use 1: A lake surrounded by trees.
- Use 2: Earth's atmosphere is the layer of gases that surrounds the planet.

**Draw:**

- Surrounded by water
Handout 5. Concept Definition Map.

- **What is it?**
  - (category)

- **What is it like?**
  - (property)
  - (property)
  - (property)

- **What are some examples?**
  - (illustration)
  - (illustration)
  - (illustration)

© New Definition
Handout 6. T-list.
Handout 7. Chocolate Chip Cookies.

What's Cooking?
Chocolate Chip Cookies

You will need:
1 cup butter
1 1/2 cups sugar
1 Tablespoon molasses
1 teaspoon vanilla
2 eggs
3 cups flour
1 teaspoon salt
1 teaspoon baking soda
2 cups chocolate chips

1. Preheat the oven to 375°.
2. Mix the butter, sugar, and molasses together in a bowl.
3. Add the vanilla and eggs. Mix well.
4. Add the flour, salt, and baking soda.
5. Fold in the chocolate chips.
6. Drop the batter—a tablespoon for each cookie—on an ungreased cookie sheet.
7. Bake in the oven for 8-10 minutes.
Picture 13. (atmosphere)
Lesson 2
Lesson 2. The Weather.

Objectives.

Content Objectives:
- Students will be able to:
  - Define the concept of weather.
  - Describe the weather conditions in their neighborhoods.
  - Explain why weather is important in their lives.
  - Predict weather conditions without using instruments.
  - Describe how they would use their senses in order to describe the weather.

Language objectives:
- Students will be able to:
  - Define the concept of weather.
  - Describe the weather.
  - Express general ideas on why the weather is important in their lives.
  - Express general abilities using the modal can.
  - Identify and tell idioms and expressions related to the weather.
  - Predict weather conditions.
### Functional Notional Chart.

<table>
<thead>
<tr>
<th>Vocabulary</th>
<th>Functions</th>
<th>Formulas</th>
<th>Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>weather</td>
<td>Defining orally and in writing</td>
<td>... is ..... Weather is important because...</td>
<td></td>
</tr>
<tr>
<td>sunny</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cloudy</td>
<td>Describing the weather</td>
<td>What’s the weather like? It’s ...</td>
<td></td>
</tr>
<tr>
<td>rainy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>snowy</td>
<td>Describing general abilities</td>
<td>I can ....</td>
<td>Modal can</td>
</tr>
<tr>
<td>windy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hailing</td>
<td>Using Idioms and Sayings about the weather.</td>
<td>Depending on the particular expression.</td>
<td></td>
</tr>
<tr>
<td>foggy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>drizzling</td>
<td>Describing and predicting weather conditions.</td>
<td>On week one the weather was... On week two the weather was... I would like to know more about ... If I had had a ... I would have measured ... I think that the weather for next week will be...</td>
<td>Second conditional (review)</td>
</tr>
<tr>
<td>muggy</td>
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<tr>
<td>hazy</td>
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<tr>
<td>sleetig</td>
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<td></td>
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<tr>
<td>raining cats and dogs</td>
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<td></td>
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<tr>
<td>head in the clouds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>runs like the wind</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>runs like the wind</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>under the weather</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a breeze</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April showers bring May flowers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sunny personality</td>
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<td></td>
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<tr>
<td>snowed under</td>
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<td></td>
<td></td>
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<tr>
<td>to break the ice</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>stormy personality</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Lesson 2. The weather.

Important: In some activities of this lesson, students will have to refer to page 14 of the Original Student’s Material. The former is included within this unit after the Vocabulary Checklist on page 51. Activities for beginning students will refer to page 14 of the Modified Material included after the Original Student’s Material.

Rate of speech and modeling strategies:

Whenever necessary model instructions to your students, you may use gestures and body movements to do so. Remember also to pace your speech accordingly to your students English proficiency level. Paraphrase and restate important concepts and directions given to students. Avoid slangs and idiomatic expressions.

Activating prior knowledge:

Stick Picture 1 on the board and ask your students what is their favorite weather and why? After doing so, have them come up with ideas about the weather and write them on the board in the form of a web.

Beginning students.

At the beginning of the lesson pass Handout 8 out to your beginning students. (Handout 8 contains a graphic organizer partially filled out).

Developing language, vocabulary and concepts:

Activity 1.
Ask students to read again the paragraph about the importance of the Atmosphere from their books on page 14 (page 14 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist) and to complete the following Concept Definition Map: (Handout 5 contains a Concept Definition Map template).
Beginning students.
Use page 14 of the modified unit (page 14 of the Modified Material comes after the Original Student's Material) to help students complete the assignment.
They may also use Handout 8 to complete the Concept Definition Map.

Ask students to share their definitions of the weather.

Write some of their weather examples on the board. Make sure to include the following vocabulary: sunny, cloudy, rainy, snowy, windy, hailing, foggy, drizzling, muggy, hazy and sleetting. Use Pictures 2 to 12 as visual clues.

Activity 2.
Students pick up four words from the list and prepare a Lift-the-Flap book. Model steps to students:

Directions to prepare a Lift-the-Flap book.

1. Fold an 8 1/2 x 11 " piece of paper in half lengthwise,
2. make four equal flaps by cutting the folds,
3. on each flap write one of your words,
4. under each flap add appropriate information about the word: its definition, a sentence that contains the word and a picture that represents the word.
Activity 3.
Ask the following question: Is weather important in your life? Why? Have students brainstorm some ideas and then elaborate on their answers. Weather is important in our lives because it affects us in many ways: what clothes we wear, what activities we do, and even our mood.

Give some prompts to students: Weather is important because...
At this point, ask students to observe and take notes on the weather conditions over a period of two weeks. Ask them to record their observations on a daily weather log. Ask them to observe every detail that may hint them information about the weather: clouds, wind, temperature, etc. Ask them to look for patterns and pose the following questions for them to discuss in the presentation of their project: What weather conditions would you like to know more about? What factors could you have measured more accurately with instruments? What kind of predictions can you make from your observations for the week after you finished your weather journal?

<table>
<thead>
<tr>
<th>Day</th>
<th>Weather Conditions</th>
</tr>
</thead>
</table>

Beginning students.
You may change the questions for beginners to:
When did you record sunny (rainy, etc) days?
What is your favorite weather? My favorite weather is...
What do you think the weather will be the week after you finished your weather log? I think the weather will be...

Activity 4.
Generate some ideas on how to observe the weather by discussing with students what weather conditions they can perceive using their senses.
Ask the following question:
How do you use your senses to describe the weather?

Use the following prompt to help students answer the question:

I can ...

(describe the wind speed by feeling the wind on my face, describe the wind speed by observing the school flag, describe the temperature by observing what clothing I need to wear, describe the temperature by feeling how warm or chilly the air is, describe the sky conditions by observing the clouds, etc).

Explain to students the use of the modal can as to express general abilities such as: I can swim, I can sing, Maria can play the piano, etc.

Structure of Can

subject + can + verb
The verb is always the bare infinitive (infinitive without "to").

<table>
<thead>
<tr>
<th>subject</th>
<th>auxiliary verb</th>
<th>main verb</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ I</td>
<td>Can</td>
<td>play</td>
</tr>
<tr>
<td>- He</td>
<td>Cannot</td>
<td>play</td>
</tr>
<tr>
<td></td>
<td>can't</td>
<td></td>
</tr>
<tr>
<td>? Can</td>
<td>You</td>
<td>play</td>
</tr>
</tbody>
</table>

Notice that:

- Can is invariable. There is only one form of can.
- The main verb is always the bare infinitive.
Use of Can: Possibility and Ability

We use can to talk about what is possible, what we are able to do:

- She can drive a car.
- John can speak Spanish.
- I cannot hear you. (I can't hear you.)
- Can you hear me?

Activity 5.
Weather idioms and sayings are common in English. Write on the board: Today is a sunny day. Ask students if they like sunny days and if more people feel happier in sunny days. Then write: Mark has a sunny personality. Have students in pairs speculate about the kind of personality Mark has. Lead them to conclude that his personality is pleasant. Then use some other examples, such as green thumb, to explain what an idiom is.

Pass out Handout 9 and ask students to answer it. Pair up students and have them share their answers. Give the correct answers and ask students to draw an illustration for every idiom and saying.

Practice / Application activities:

Activity 1.
Write on the board the following sentences:

Customer: I’d like to make a trip to .... What’s the weather going to be like next ...(summer, spring, fall, winter) ?.
Travel agent: It’s usually ... (cloudy, sunny, etc) in that time of the year. What kind of weather do you like?
Customer: I like...
Travel agent: Then let me to recommend you ... instead. It has ... weather all year around.

Pair up students and ask them to role play a travel agency. Each student has to take turns and role play both, the travel agent and the customer. Explain students that they may use the dialog on the board as a prompt.
Use postcards and travel spots pictures as prompts. (Some are included in the Realia section).

Activity 2.
Break your students into groups of four and arrange them in circles. Hand out a set of animal cards from Handout 10 to each group. Ask each group to place their cards facedown on their desks. Ask students to draw one card at a time without allowing their peers to see it. The student with the card has to hint his/her peers with information of what his/her animal can/can’t do. The other students have to guess the animal. For example, if the animal is a koala bear, students might say:
It can climb trees.
It can carry its baby.
You can’t buy one in a shop.

Activity 3.
After the two-weeks period, ask students to present their findings on their weather observations. Ask them to create a poster with their observations. Prior to their presentations, give them some prompts on how they should present their findings to the class.

On week one the weather was...
On week two the weather was...
I would like to know more about ...
If I had had a ... I would have measured ...
I think that the weather for next week will be...

Optional activities:
Add new vocabulary to the word wall.
Handout 8. The Weather

- snowing
- sunny
- cloudy
- raining
- hailing
- windy
Draw a line from each idiom to its meaning. (Hint: A breeze is a soft wind)

1. Take your umbrella with you or you'll get soaked under this downpour! It's raining cats and dogs.
2. Last week Adam had his head in the clouds. He forgot his mom's birthday.
3. Joan runs like the wind. She won the school gold medal in the race.
4. Sharon is under the weather. She has had fever for two days.
5. Kim studied hard every day, so she thought the English test was a breeze.
6. Cheer up! Remember that April showers bring May flowers.
7. Marta has such a sunny personality. She's always happy and in a good mood.
8. Luis is snowed under. He has two tests and he has to help the science teacher after school.
9. Stan is very shy. When he goes to a party where he doesn't know many people, he finds it hard to break the ice.
10. Tom has a stormy personality. Whenever he doesn't like how I talk to him he tells me off.
Handout 10. Animal Cards.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Bird" /></td>
<td><img src="image" alt="Dog" /></td>
<td><img src="image" alt="Fish" /></td>
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<tr>
<td><img src="image" alt="Cat" /></td>
<td><img src="image" alt="Tiger" /></td>
<td><img src="image" alt="Giraffe" /></td>
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<tr>
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<td><img src="image" alt="Stamp" /></td>
</tr>
<tr>
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<td><img src="image" alt="Horse" /></td>
<td><img src="image" alt="Kangaroo" /></td>
</tr>
<tr>
<td><img src="image" alt="Camel" /></td>
<td><img src="image" alt="Horse" /></td>
<td><img src="image" alt="Cow" /></td>
</tr>
<tr>
<td><img src="image" alt="Camel" /></td>
<td><img src="image" alt="Horse" /></td>
<td><img src="image" alt="Cow" /></td>
</tr>
</tbody>
</table>

SCSU
Weather and Climate
Picture 2. (Sunny)
Picture 3. (Cloudy)
Picture 4. (raining)
Picture 5. (snowing)
Picture 6. (windy)
Picture 7. (hailing)
Picture 8. (foggy)
Picture 9. (drizzling)
Picture 10. (sleeting)
Picture 11. (hazy)
Picture 12. (muggy)
Picture 14. (sight)
Picture 15. (smell)
Picture 16. (hearing)
Picture 17. (taste)
Picture 18. (touch)
Lesson 3
Lesson 3. Composition of the Atmosphere.

Objectives.

Content Objectives:
- Students will be able to:
  - Identify the gases that are present in Earth's atmosphere;
  - Predict how would the amount of carbon dioxide in the atmosphere change if there were no plants? If there were no animals?
  - Predict what would happen to living things if the amounts of nitrogen and carbon dioxide dramatically changed.

Language objectives:
- Students will be able to:
  - Describing hypothetical situations (orally and in writing).
  - Predict what would happen to burning candles if they used up all of the oxygen around them.
  - Predict what would happen to living things if the amounts of nitrogen and carbon dioxide dramatically changed.
  - Demonstrating sequenced activities.
<table>
<thead>
<tr>
<th>Notions</th>
<th>Functions</th>
<th>Formulas</th>
<th>Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>air</td>
<td>Describing hypothetical situations (orally and in writing)</td>
<td>If ... would ...</td>
<td>(Second conditional (review))</td>
</tr>
<tr>
<td>gas</td>
<td>Predicting orally</td>
<td>I think ...</td>
<td></td>
</tr>
<tr>
<td>atom</td>
<td></td>
<td>I believe ...</td>
<td></td>
</tr>
<tr>
<td>molecules</td>
<td></td>
<td>I’m certain that ...</td>
<td></td>
</tr>
<tr>
<td>nitrogen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>oxygen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>carbon dioxide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>water vapor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>proteins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ozone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>particles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>put on</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>blow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>suck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>drink</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>beaker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>limewater</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>straw</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Warning: Make sure that...
Remember to...
Lesson 3. Composition of the Atmosphere

Important: In most activities of this lesson, students will have to refer to pages 15 to 17 of the Original Student’s Material. The former is included within this unit after the Vocabulary Checklist on page 51. Activities for beginning students will refer to pages 15 to 18 of the Modified Material included after the Original Student’s Material.

Rate of speech and modeling strategies:

Whenever necessary model instructions to your students, you may use gestures and body movements to do so. Remember also to pace your speech accordingly to your students English proficiency level. Paraphrase and restate important concepts and directions given to students. Avoid slangs and idiomatic expressions.

Activating prior knowledge:

Ask students to draw a cake. When students finish their drawings, ask them to brainstorm some ideas about what the cake’s ingredients may be (eggs, sugar, vanilla extract, flour, butter, baking powder, etc.). Ask them to write the cake’s ingredients next to their drawings.

Draw the following chart on the board

<table>
<thead>
<tr>
<th>Ingredients in a cake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour (75%)</td>
</tr>
<tr>
<td>Eggs (9%)</td>
</tr>
<tr>
<td>Butter (12%)</td>
</tr>
<tr>
<td>All other ingredients (4%)</td>
</tr>
</tbody>
</table>

Sugar
Vanilla extract
Baking powder
Have students predict what they think this picture is: Pose the following question: What do you think this picture is? Confirm and expand students’ predictions by explaining to them that this is a graph (picture) that gives an overview of the ingredients’ used to bake a cake. Pose the following question: What three ingredients make up most of the cake? Confirm students answers.

Ask students to open their books on page 15 (page 15 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist), read the subheading (The composition of the Atmosphere) and look at Figure 2 at the bottom of the page. Ask them what they think the picture is about? Conclude that they will learn about the Composition of the atmosphere. Pose the following question: What three ingredients make up most of the air? Confirm and expand your students answers.

Beginning students.
You may want to use picture 21 to provide a visual clue for beginners. You may also use some prompts to elicit answers from them: I think the picture is ...

Developing language, vocabulary and concepts:

Activity 1.
Read with students the first paragraph about the Composition of the Atmosphere on page 15 (page 15 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist). Ask students to write down any new word they may come up to. Following the reading ask students for new words they encountered and write them on the board. Make sure the list includes the following words: air, gas, atom, molecule nitrogen, oxygen, carbon dioxide, vapor, proteins, ozone and particles. Divide students into groups of four and have each member of the group look up two or three of the words in their dictionaries. Each student has to share his/her findings with the rest of the group.

You may use pictures 19,20, 22 and 23 to provide visual clues.

Beginning students.
Give your students Handout 11. to help them look up the meanings of the words.
Activity 2.
Divide students into 6 groups. Assign each group the reading of each one of the elements that compose the atmosphere. They will have to read pages 15 to 17 of the original material to complete this assignment (pages 15 to 17 are part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist).
Each member of the group has to fill out a chart like the one provided in Handout 12. When students have completed the assignment, have each member move to a different group to share his/her findings. At the end of the activity, each student should have one vocabulary chart per element.

Beginning students.
Have beginner students use page 18 of the modified Material (page 18 of the Modified Material come after the Original Student’s Material and is designed specially to give beginning students access to the text).

Activity 3.
Draw on the board a describing wheel like the one provided in Handout 13. Have students complete the wheel by writing a component of the atmosphere and its most important characteristic in each space of the wheel. They may draw information from the charts created in Activity 2.

Activity 4.
Write the following question on the board: How would the amount of carbon dioxide in the atmosphere change if there were no plants? If there were no animals? Pair up your students and have them take turns to share their answer. Give students the following prompts:
I believe… If there were no plants/animals
I'm certain that …
I think …

Beginning students.
You may expand prompts to:
I believe that if there were no plants/animals …

Conclude that without plants there would be less oxygen and more carbon dioxide; without animals there would be less carbon dioxide and more oxygen.

Now, pose the following question: What would happen to living things if the amounts of nitrogen and carbon dioxide dramatically changed. Have your students individually write down the answer and later share it with a peer. Confirm and expand their answers.
Practice / Application activities:

Activity 1
Write on the board the following vocabulary:
- beaker
- limewater
- straw
- put on
- fill
- blow

Explain this is the material students will be using during the Try This activity on page 16 of the original material (page 16 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist). Using real objects demonstrate each item of the list to students. (You might even ask them to copy and illustrate with a drawing the words on their notebooks).

Model the Try this activity on page 16 (page 16 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist).
Let students carry out the activity and within their groups ask them to answer the question posed at the end of the activity. (What do you think would happen if you did the same experiment after jogging for 10 minutes? If you tried this, what might the results tell you about exercise and carbon dioxide?) Discuss the answer with the class. You may need to use some prompts such as: I think that ...

Beginning students.
You may change the question What do you think would happen if you did the same experiment after jogging for 10 minutes? for Do you think something would happen if you did the same experiment after jogging for 10 minutes?

If you require further information about the process and the results of the Try This activity, please turn to page 16 of the Teacher’s Material. (The original Teacher’s Material is also included within this unit. You may find it after the section of Modified Material).
Activity 2.
Write the following formula on the board. Ask students to predict what it may be used for. Confirm and expand students’ predictions. Explain to students they could use this formula to report on sequenced activities.

**Topic:** I’d like to demonstrate how to ...
**Demonstration Plan:** There are ... main steps.
**Sequencers:** First, Next, Then, After that, Finally
**Commands:** Put on, Fill, Blow,
**Warnings:** Make sure that... / Remember to ...

Beginning students.
Expand prompts and possibly fill out one of the examples in Handout 13.

Cut Handout 13 into strips. Divide class into groups of three. Pass out Handout 13 to each group and have each person on the group report what the strip says by using the formula.

Activity 3.
Pair up students. Have one student demonstrate how to carry out the Discover Activity on page 14 (page 14 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist) of the original material and have the other student demonstrate the Try This Activity on page 16 of the original material (page 16 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist).

Optional activities:
Add new vocabulary to the word wall.
Handout 12. Vocabulary Chart.

Element

Characteristics
Handout 11. Definitions.

air (noun)
the mixture of gases that we breathe and that surrounds the Earth: Let's go outside and get some fresh air.

atom (noun)
one of the smallest parts that any substance can be divided into, that combines with other atoms to make a molecule.

gas (noun)
[countable, uncountable] a substance like air that is not liquid or solid, and usually cannot be seen: hydrogen gas.

molecule (noun)
the smallest unit into which any substance can be divided without losing its own chemical nature, usually consisting of two or more atoms.

nitrogen (noun)
a gas that is an element and is the main part of the earth's air.

oxygen (noun)
a gas in the air that has no color, smell, or taste, and that all plants and animals need in order to live.

carbon dioxide (noun)
the gas produced when animals breathe out, when carbon is burned in air, or when animals and plants decay.

vapor (noun)
many small drops of liquid that float in the air: water vapor.

protein (noun)
one of the many substances in foods such as meat and eggs that helps your body to grow and be healthy.

ozone (noun)
a triatomic very reactive form of oxygen that is a bluish irritating gas of pungent odor, that is formed naturally in the atmosphere by a photochemical reaction and is a major air pollutant in the lower atmosphere but a beneficial component of the upper atmosphere, and that is used for oxidizing, bleaching, disinfecting, and deodorizing.

particle (noun)
a very small piece of something: dust particles.

Composition of the Atmosphere

To make tea:
- Finally, in the third step...
- Pour into the tea cups
- Let the tea into the tea cups
- Fill the teapot
- Set for 3 minutes
- With hot water
- In the teapot

To call the police:
- First...
- Second...
- Third...
- Press 911
- Lift the receiver
- Find the pay phone
- The volume

To watch a video:
- First...
- Finally...
- Next...
- Turn on the VCR
- Adjust the volume
- Turn off the lights
Picture 19. (atom)
Picture 20. (molecule)
Picture 21. (cake)
Picture 22. (air)
Picture 23. (composition of the atmosphere)
Lesson 4

Objectives.

Content Objectives:
- Students will be able to:
  - Name the different layers of the atmosphere.
  - Describe the main characteristics of the layers of the atmosphere.

Language objectives:
- Students will be able to:
  - Name the different layers of the atmosphere.
  - Identify and name words from other languages that are commonly used English words.
  - Describe the characteristics of the layers of the atmosphere.
Functional Notional Chart.

<table>
<thead>
<tr>
<th>Notions</th>
<th>Functions</th>
<th>Formulas</th>
<th>Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>layers</td>
<td>Naming components</td>
<td>The ... are ...</td>
<td>Word roots</td>
</tr>
<tr>
<td>altitude</td>
<td>Word origins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>temperature</td>
<td>Describing the main characteristics of an object</td>
<td>The name of the ...is... The altitude of the ... is ... The temperature of the ...is... The main characteristics of ... are... A representative drawing could be...</td>
<td></td>
</tr>
<tr>
<td>air pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>aurora borealis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ionosphere</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>exosphere</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>thermosphere</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mesosphere</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stratosphere</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>troposphere</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SCSU
Weather and Climate
Lesson 4. Layers of the Atmosphere

Important: In most activities of this lesson, students will have to refer to pages 31 to 36 of the Original Student’s Material. The former is included within this unit after the Vocabulary Checklist on page 51. Activities for beginning students will refer to pages 30 to 36 of the Modified Material included after the Original Student’s Material.

Rate of speech and modeling strategies:

Whenever necessary model instructions to your students, you may use gestures and body movements to do so. Remember also to pace your speech accordingly to your students English proficiency level. Paraphrase and restate important concepts and directions given to students. Avoid slangs and idiomatic expressions.

Activating prior knowledge:

Ask students to open their books on page 31 of the original material (page 31 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist) and take a look at the picture at the bottom of the page. Ask them what they think it is and what they think it is used for. Conclude that this is a hot air balloon and that it is generally used to make trips in the air. Ask them to close their eyes and think they are on a hot air balloon. They are taking a trip upward into the atmosphere. They begin on the playground of the school and up they go. Earth’s surface gets farther away. As the balloon rises they begin to see things smaller and air gets cold. As they continue to rise, they begin having trouble breathing. It is time to come back!

Ask them to predict why they think this happens. Conclude that as you rise farther up through atmosphere, the air pressure and temperature change dramatically.

Have you ever gone to the top of a mountain and found it harder to breathe? That happens because the higher we go, the less air there is. Show them picture 25 as a visual clue.

Developing language, vocabulary and concepts:

Activity 1.
Use pictures 21 to 24 to explain and introduce the following vocabulary. Have students create a sentence for each concept.
Activity 2.
Use picture 26 to explain to students that atmosphere has five main layers. Ask them to open their books on page 33 of the original unit (page 33 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist), and name the five layers of the atmosphere.

Write the five names on the board and ask them to compare them. Guide them to find the similarities between the words. Have them predict what the word “sphere” might mean.

Explain to them that these words are derived from two Greek words and that many other words in the English vocabulary are derived also from the Greek language.

Troposphere = turning or changing + ball or globe
Stratosphere = layer or spreading out + ball or globe
Mesorosphere = middle + ball or globe
Thermosphere = heat + ball or globe
Ionoosphere = + ball or globe
Exosphere = outer + ball or globe

Ask them to come up with more compound words using the word “Thermo” as a prompt. They may say: thermometer, thermostat, thermos, etc.

Activity 3.
Break up students into groups of six. Each member of the group has to read the description of one layer of the atmosphere on pages 31 to 36 of the original unit (pages 31 to 36 are part of the Original Student’s Material included within this instructional Unit after the Vocabulary Checklist), and complete the corresponding section of Handout 15. Each member of the group have to report back on his/her findings. To do so, provide the following prompts to your students:

The name of the layer is...
The altitude of the ... is ...
The temperature of the... is...
The main characteristics of... are...
A representative drawing could be...

Beginning students.
Handout 15B has a table partially filled. They may also use page 30 of the modified unit to complete the assignment. (page 30 of the Modified Material comes after the Original Student's Material).

Each group has to complete one table of the components of the atmosphere. Bring your class back and check their answers by drawing an identical table on the board and completing it with the correct information. You may expand this activity by having each group draw their tables in construction paper and having them present them to the class. If necessary, use pictures 26 to 30 to provide visual clues.

Practice/Application activities:

Activity 1.
Pair up your students and have them complete Handout 16. One student has to complete the Definition, Composition and Other Important Information sections and the other student has to complete the section on the Layers of the Atmosphere. Check students answers on the board.

Optional activities:

Add new vocabulary to the word wall.
Handout 15 A. Information Table.

<table>
<thead>
<tr>
<th>Layers of the Atmosphere</th>
<th>Altitude</th>
<th>Temperature</th>
<th>Characteristics</th>
<th>Representative Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Troposphere</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stratosphere</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Mesosphere</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Thermosphere</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ionosphere</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exosphere</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layers of the Atmosphere</td>
<td>Altitude</td>
<td>Temperature</td>
<td>Characteristics</td>
<td>Representative Drawing</td>
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<tr>
<td>--------------------------</td>
<td>--------------</td>
<td>-------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Troposphere</td>
<td>0-12 Km.</td>
<td>Temperature decreases as altitude increases.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stratosphere</td>
<td></td>
<td></td>
<td>Contains a layer of ozone, that converts sun radiations into heat.</td>
<td></td>
</tr>
<tr>
<td>Mesosphere</td>
<td></td>
<td>Temperatures drop with altitude.</td>
<td>It's the hottest layer of the atmosphere.</td>
<td>![Image]</td>
</tr>
<tr>
<td>Thermosphere</td>
<td>Above 80 Km.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ionosphere</td>
<td>80 to 550 Km.</td>
<td></td>
<td>The aurora borealis occurs here.</td>
<td></td>
</tr>
<tr>
<td>Exosphere</td>
<td></td>
<td></td>
<td>Satellites orbit in this layer.</td>
<td></td>
</tr>
</tbody>
</table>
ESS-5: The Atmosphere
Picture 24. (temperature)
Picture 25. (air pressure)

At sea level (0 km), there is more air and less pressure. As you go up to 2 km, there is less air and less pressure. At 8 km, there is more pressure due to the increased altitude and decreased air density.
Picture 26. (layers of the atmosphere)
Picture 27. (ozone)
Picture 28. (meteoroids)
Picture 29. (aurora borealis)
Picture 30. (satellites)
Lesson 5
Lesson 5. Air quality.

Objectives.

Content Objectives:
- Students will be able to:
  ◦ Name the main sources of air pollution.
  ◦ Explain what parts of the body are most affected by air pollution.
  ◦ Identify and describe the respiratory system.

Language objectives:
- Students will be able to:
  ◦ Name the main sources of a problem.
  ◦ Describe diseases.
  ◦ Request more information.
  ◦ Persuade an audience.
  ◦ Write a paragraph.
## Functional Notional Chart.

<table>
<thead>
<tr>
<th>Notions</th>
<th>Functions</th>
<th>Formulas</th>
<th>Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>air pollution</td>
<td>Naming the main sources of a problem</td>
<td>... is caused by ...</td>
<td></td>
</tr>
<tr>
<td>harmful</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>haze</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pollutants</td>
<td>Requesting more information</td>
<td>Could you tell me some more about...?</td>
<td></td>
</tr>
<tr>
<td>fossil fuels</td>
<td></td>
<td>Would you mind telling me more about...?</td>
<td></td>
</tr>
<tr>
<td>coal</td>
<td></td>
<td>I'd like to know more about...</td>
<td></td>
</tr>
<tr>
<td>oil</td>
<td></td>
<td>I'm sorry, that's not really what I mean. What I'd like to know is...</td>
<td></td>
</tr>
<tr>
<td>gasoline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>diesel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>human health</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>breath</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>eye</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>nose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mouth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>throat</td>
<td>Describing a disease</td>
<td>... (am/are) going to present information on ...</td>
<td></td>
</tr>
<tr>
<td>irritation</td>
<td></td>
<td>Common symptoms are ...</td>
<td></td>
</tr>
<tr>
<td>cough</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>chest pains</td>
<td>Persuading an audience</td>
<td>Wouldn't it be better if...</td>
<td></td>
</tr>
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<td>lung diseases</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>trachea</td>
<td>Writing a paragraph</td>
<td></td>
<td>Capitalization and Punctuation (periods).</td>
</tr>
<tr>
<td>bronchial tubes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lungs</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>diaphragm</td>
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<td></td>
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<tr>
<td>allergies</td>
<td></td>
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<td></td>
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<tr>
<td>dizziness</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>headaches</td>
<td></td>
<td></td>
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</tbody>
</table>
Lesson 5. Air pollution

Important: In most activities of this lesson, students will have to refer to pages 20 and 21 of the Original Student’s Material. The former is included within this unit after the Vocabulary Checklist on page 51. Activities for beginning students will refer to pages 20 and 21 of the Modified Material included after the Original Student’s Material.

Rate of speech and modeling strategies:

Whenever necessary model instructions to your students, you may use gestures and body movements to do so. Remember also to pace your speech accordingly to your students’ English proficiency level. Paraphrase and restate important concepts and directions given to students. Avoid slangs and idiomatic expressions.

Activating prior knowledge:

Show students pictures 31, 32 and 33. Have them brainstorm places and situations where they have seen scenes similar to those in the pictures. Ask them to open their books on page 20 of the original material (page 20 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist) and read the main heading (Air quality). Pair up your students and have them give their opinions on what they think they will be learning in this lesson. Write some prompts on the board. I think this lesson is about...

Developing language, vocabulary and concepts:

Activity 1.
Pass out Handout 17. to your students and ask them to complete the word column with the following words:

- air pollution
- harmful
- haze
- pollutants
- fossil fuels

Beginning students.
You may partially fill out Handout 17.
- coal
- oil
- gasoline
- diesel
- human health

After writing down the words on their charts, ask students to complete the Guessed Meaning column with their own guesses for the words. Have students read the paragraph “Air pollution” on pages 20 and 21 of the original material (pages 20 and 21 are part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist), and ask them to complete the Context Meaning column of their charts. Finally, ask your students to look up these words on their dictionaries and to write their definitions on the Dictionary Meaning column of the charts. Check for understanding.

Beginning students.
Have them use pages 20 and 21 of the modified unit to complete the assignment. (Pages 20 and 21 of the Modified Material come after the Original Student’s Material).

Activity 2.
Pass out some index cards and ask students to write down one question they have from their readings.

Introduce the following phrases to request more information to your students. Have your students ask you their questions using the formulas they have just learned.

Could you tell me some more about...?
Would you mind telling me more about...?
I’d like to know more about...
I’m sorry, that’s not really what I mean. What I’d like to know is...
Activity 3.
Have your students look at Picture 5, at the bottom of page 20 of the original material (page 20 is part of the Original Student’s Material included within this Instructional Unit after the Vocabulary Checklist). Pair them up and have them predict what they think this picture represents. Ask them what parts of the body are most affected by pollution?

Beginning students.
They may point to the parts of the body instead of answering the question.

Write some of students’ responses on the board. Explain to them that the respiratory system is usually the most affected system in our bodies.

Activity 4.

Demonstrate the respiratory system to your students. Ask students to do the following:
1. Take two deep breaths, one breathing through the nose and one breathing through the mouth. Explain that these two passages are connected.
2. Using their fingers, students trace the pathway of the air through the body (nose/mouth, trachea, bronchial tubes and lungs). Write the name of the organs on the board for them to familiarize with them.
3. Pass out Handout 18. and ask students to fill in the names of the parts of the respiratory system. Ask them also to trace the pathway of the air through the system.

Use Picture 34. to provide visual clues. If possible at all, show your students a poster of the Respiratory System.

Activity 5.

Divide students into six groups. Each group has to choose a recorder and a presenter. Assign each group one of the following diseases:
- Dizziness and Headaches.
- Eye, nose, and throat irritation.
- Lung diseases.
- Chest pains.
- Allergies.
- Cough.

Students have to search information related to the disease and prepare a 2-minutes presentation about it. Provide the following prompts:

(am/are) going to present information on ...
Common symptoms are ...

Practice/Application activities:

Activity 1.
Break up students into groups of three. Ask them to create a poster persuading people to prevent air pollution. Give them the following prompt:

Wouldn’t it be better if...

Collocate all posters on the notice board.

Activity 2.
Students write a paragraph with new information they learned from this unit and how they would use it for their daily lives. Explain how to use capital letters and periods. Check for spelling and punctuation.

To help students come up with ideas, ask them to brainstorm new information they learned in this unit. Have them write their responses on the board. Pass out Handout 19. and help them organize their ideas using the sequenced format of the map.

Beginning students.
Give them Handout 19. partially filled.
Capitalization Rules:

1) Capitalize the pronoun I.
Example: Jennifer and I went to the movies yesterday.

2) Capitalize the first letter of the first word of each sentence.
Example: Learning to capitalize correctly will improve your writing.

3) Capitalize the first letter of names of people, organizations, and places.
Example: Juan went on a trip to Tokyo, Japan for his company, General Motors Corporation.

4) Capitalize the first letter of adjectives that are made from the names of people and places.
Example: I like Mexican food.

5) Capitalize initials.
Example: My brother's favorite author is H.G. Wells.

6) Capitalize the first letter of directions only when they are used to designate actual places, not when they point in a direction.
Example: When we visited the Southwest, we actually had to drive north.

7) Capitalize the first letter of the names of months and the days of the week.
Example: My birthday will be on a Friday next June.

8) Capitalize the official title of a person (including abbreviations), but only when you use it with the person's name.
Example: Did Clarissa recommend Dr. Montoya to you?
9) Capitalize the first letter of important words in a title of a book, magazine, story, essay, etc.

Example: I enjoyed Mark's essay, "The Truth About Being a Good Student."

10) Capitalize historical events and documents.

Example: The Emancipation Proclamation was issued during the Civil War.

11) Capitalize the name of languages, races, nationalities, and religions.

Example: I learned in Spanish class that several Hispanics are Catholic.

12) Capitalize acronyms. (An acronym is a word formed by the first, or first few, letters of words in a long name of an organization.)

Example: CARE is the Cooperative for American Relief Everywhere.

Using Periods

1) Use a period at the end of a sentence. Example: I enjoyed the movie.

2) Use a period after an initial. Example: M. E. Kerr is a wonderful author.

3) Use a period after an abbreviation. Example: We welcomed Mrs. Simmons to our team.

4) Use a period as a decimal point. Example: The workers received a 2.1 percent raise.

5) Use a period to separate dollars and cents. Example: The book cost $4.95.

Optional activities:

Add new vocabulary to the word wall.
Handout 17. Guessed Meanings.

<table>
<thead>
<tr>
<th>Word</th>
<th>Guessed Meaning</th>
<th>Context Meaning</th>
<th>Dictionary Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
Handout 18. Respiratory System.
Handout 19. Sequence Map.

In this unit I learned

I can use this information to...

In sum...
Picture 31. (pollution)
Picture 32. (pollution 2)
Picture 33. (pollution 3)
Picture 34. (respiratory system)
# Functions Checklist.

<table>
<thead>
<tr>
<th>Functions</th>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Unit 3</th>
<th>Unit 4</th>
<th>Unit 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining orally and in writing</td>
<td></td>
<td>Defining orally and in writing</td>
<td>Describing hypothetical situations (orally and in writing)</td>
<td>Naming components</td>
<td>Naming the main sources of a problem</td>
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<tr>
<td>Predicting</td>
<td></td>
<td>Describing the weather</td>
<td>Predicting orally</td>
<td>Word origins</td>
<td>Requesting more information</td>
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<tr>
<td>Talking about hypothetical situations</td>
<td></td>
<td>Describing general abilities</td>
<td>Demonstrating sequenced activities</td>
<td>Describing the main characteristics of an object</td>
<td>Describing a disease</td>
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<td>Giving reasons</td>
<td></td>
<td>Using Idioms and Sayings about the weather</td>
<td>Warning</td>
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<td>Persuading an audience</td>
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<td>Imperatives</td>
<td></td>
<td>Describing and predicting weather conditions.</td>
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<td></td>
<td>Writing a paragraph</td>
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<tr>
<td>Unit 1</td>
<td>Unit 2</td>
<td>Unit 3</td>
<td>Unit 4</td>
<td>Unit 5</td>
<td></td>
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<td>--------</td>
<td></td>
</tr>
<tr>
<td><strong>Formulas</strong></td>
<td><strong>... is ...</strong></td>
<td><strong>... is ...</strong></td>
<td><strong>If ... would ...</strong></td>
<td><strong>... is caused by ...</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weather is important because...</td>
<td>I think ...</td>
<td>The ... are ...</td>
<td>Could you tell me some more about...?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>What's the weather like?</td>
<td>I believe ...</td>
<td>The name of the ... is ...</td>
<td>Would you mind telling me more about...?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>It's ...</td>
<td>I'm certain that ...</td>
<td>The altitude of the ... is ...</td>
<td>I'd like to know more about...</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I can ...</td>
<td>I'd like to report on ...</td>
<td>The temperature of the ... is ...</td>
<td>I'm sorry, that's not really what I mean. What I'd like to know is...</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depending on the particular expression.</td>
<td>This is an experiment on ...</td>
<td>The main characteristics of ... are...</td>
<td>(am/are) going to present information on ...</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>First, Next, Then, After that, Finally I concluded that ...</td>
<td>A representative drawing could be...</td>
<td>Common symptoms are ...</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Make sure that...</td>
<td></td>
<td>Wouldn't it be better if...</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remember to...</td>
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</table>
Grammar Checklist.

<table>
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<th>Grammatical structures</th>
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<th>Unit 3</th>
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<td>Second conditional (If ... would)</td>
<td>Modal can</td>
<td>Second conditional (review)</td>
<td>Word roots</td>
<td>Capitalization and Punctuation (periods).</td>
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# Vocabulary Checklist.

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<th>Unit 1</th>
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<td>air</td>
<td>layers</td>
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<td>layer</td>
<td>sunny</td>
<td>gas</td>
<td>altitude</td>
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<td>gas</td>
<td>cloudy</td>
<td>atom</td>
<td>temperature</td>
<td>haze</td>
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<td>surround</td>
<td>rainy</td>
<td>molecules</td>
<td>air pressure</td>
<td>pollutants</td>
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<tr>
<td>living things</td>
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<td>nitrogen</td>
<td>aurora borealis</td>
<td>fossil fuels</td>
<td></td>
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<tr>
<td>nonliving things</td>
<td>windy</td>
<td>oxygen</td>
<td>ionosphere</td>
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<td>put on</td>
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<td>carbon dioxide</td>
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<td>light</td>
<td>drizzling</td>
<td>proteins</td>
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<td>push</td>
<td>muggy</td>
<td>ozone</td>
<td>exosphere</td>
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<td>hold</td>
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<td>troposphere</td>
<td>eye</td>
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<td>relight</td>
<td>raining cats and dogs</td>
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<td>remove</td>
<td>head in the clouds</td>
<td>blow</td>
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<td>blow</td>
<td>runs like the wind</td>
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<td>under the weather</td>
<td>drink</td>
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<td>a breeze</td>
<td>beaker</td>
<td>stratosphere</td>
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<td>April showers bring</td>
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<td>May flowers</td>
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<td>snowed under</td>
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<td>bronchial tubes</td>
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<td></td>
<td>to break the ice</td>
<td></td>
<td></td>
<td>lungs</td>
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<tr>
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<td>stormy personality</td>
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<td>diaphragm</td>
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<td>allergies</td>
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<td>dizziness</td>
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<td></td>
<td></td>
<td></td>
<td>headaches</td>
<td></td>
</tr>
</tbody>
</table>
Weather and Climate

Chapter 1: The Atmosphere
1 The Air Around You
2 Integrating Environmental Science: Air Quality
3 Air Pressure
4 Layers of the Atmosphere

Chapter 2: Weather Factors
1 Energy in the Atmosphere
2 Integrating Physics: Heat Transfer
3 Winds
4 Water in the Atmosphere
5 Precipitation

Chapter 3: Weather Patterns
1 Air Masses and Fronts
2 Storms
3 Integrating Health: Floods
4 Predicting the Weather

Chapter 4: Climate and Climate Change
1 What Causes Climate?
2 Climate Regions
3 Long-Term Changes in Climate
4 Integrating Environmental Science: Global Changes in the Atmosphere

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Watching the Weather

The air is cool and clear—just perfect for a trip in a hot-air balloon. As you rise, a fresh breeze begins to move you along. Where will it take you? Hot-air balloon pilots need to know about the weather to plot their course.

In this chapter, you will learn about the air around you. As you learn about the atmosphere, you will use your senses to collect information about weather conditions. Even without scientific instruments it is possible to make many accurate observations about the weather.

Your Goal To observe weather conditions without using instruments and to look for hints about tomorrow's weather in the weather conditions today.

Your completed project must
- include a plan for observing and describing a variety of weather conditions over a period of two to three weeks
- show your observations in a daily weather log
- display your findings about weather conditions

Get Started Begin by discussing what weather conditions you can observe. Brainstorm how to use your senses to describe the weather. For example, can you describe the wind speed by observing the school flag? Can you describe the temperature based on what clothes you need to wear outside? Be creative.

Check Your Progress You'll be working on this project as you study this chapter. To keep your project on track, look for Check Your Progress boxes at the following points.

Section 1 Review, page 17: Collect and record observations.
Section 4 Review, page 36: Look for patterns in your data.

Wrap Up At the end of the chapter (page 39), use your weather observations to prepare a display for the class.
How Long Will the Candle Burn?

1. Put on your goggles.
3. Hold a small glass jar by the bottom. Lower the mouth of the jar over the candle until the jar rests on the pie pan. As you do this, start a stopwatch or note where the second hand is on a clock.
4. Watch the candle carefully. How long does the flame burn?
5. Wearing an oven mitt, remove the jar. Relight the candle and then repeat Steps 3 and 4 with a larger jar.

Think It Over
Inferring How would you explain any differences between your results in Steps 4 and 5?

As you walk home from school, the air is warm and still. The sky is full of thick, dark clouds. In the distance you see a bright flash. A few seconds later, you hear a crack of thunder. As you turn the corner onto your street, raindrops start to fall. You begin to run and reach your home just as the downpour begins. That was close! From the shelter of the entrance you pause to catch your breath and watch the storm.

Importance of the Atmosphere
Does the weather where you live change frequently, or is it fairly constant from day to day? Weather is the condition of Earth's atmosphere at a particular time and place. But what is the atmosphere? Earth's atmosphere (AT muh sfeer) is the layer of gases that surrounds the planet. To understand the relative size of the atmosphere, imagine that the planet Earth is the size of an apple.

Figure 1 When seen from space, Earth's atmosphere appears as a thin layer near the horizon. The atmosphere makes life on Earth possible.
If you breathe on the apple, a thin film of water will form on its surface. Earth’s atmosphere is like that water on the apple—a thin layer of gases on Earth’s surface.

Earth’s atmosphere makes conditions on Earth suitable for living things. The atmosphere contains oxygen and other gases that you and other living things need to live. In turn, living things affect the atmosphere. The atmosphere is constantly changing, with atoms and molecules of gases moving around the globe and in and out of living things, the land, and the water.

Living things also need warmth and liquid water. By trapping energy from the sun, the atmosphere keeps most of Earth’s surface warm enough for water to exist as a liquid. In addition, Earth’s atmosphere protects living things from dangerous radiation from the sun. It also prevents Earth’s surface from being hit by most meteoroids, or chunks of rock from outer space.

**Checkpoint** What would conditions on Earth be like without the atmosphere?

**Composition of the Atmosphere**

The atmosphere is made up of a mixture of atoms and molecules of different kinds of gases. An atom is the smallest unit of a chemical element that can exist by itself. Molecules are made up of two or more atoms. Earth’s atmosphere is made up of nitrogen, oxygen, carbon dioxide, water vapor, and many other gases, as well as particles of liquids and solids.

**Nitrogen** As you can see in Figure 2, nitrogen is the most abundant gas in the atmosphere. It makes up a little more than three fourths of the air we breathe. Each nitrogen molecule consists of two nitrogen atoms.

![Gases in Dry Air](image)

**Figure 2** Dry air in the lower atmosphere always has the same composition of gases. *Interpreting Data* What two gases make up most of the air?
Nitrogen is essential to living things. Proteins and other complex chemical substances in living things contain nitrogen. You and all other organisms must have nitrogen in order to grow and to repair body cells.

Most living things cannot obtain nitrogen directly from the air. Instead, some bacteria convert nitrogen into substances called nitrates. Plants then absorb the nitrates from the soil and use them to make proteins. To obtain proteins, animals must eat plants or other animals.

**Oxygen** Most oxygen molecules have two oxygen atoms. Even though oxygen is the second-most abundant gas in the atmosphere, it makes up less than one fourth of the volume. Plants and animals take oxygen directly from the air and use it to release energy from food in a usable form.

Oxygen is also involved in other important processes. Any fuel you can think of, from the gasoline in a car to the candles on a birthday cake, uses oxygen as it burns. Without oxygen, a fire will go out. Burning uses oxygen rapidly. During other processes, oxygen is used slowly. For example, steel in cars and other objects reacts slowly with oxygen to form iron oxide, or rust.

Have you ever noticed a pungent smell in the air after a thunderstorm? This is the odor of ozone, which forms when lightning interacts with oxygen in the air. **Ozone** is a form of oxygen that has three oxygen atoms in each molecule instead of the usual two.

**Carbon Dioxide** Each molecule of carbon dioxide has one atom of carbon and two atoms of oxygen. Even though the atmosphere contains only a small amount of carbon dioxide, it is essential to life. Plants must have carbon dioxide to produce food. Animals, on the other hand, give off carbon dioxide as a waste product.

When fuels such as coal and gasoline are burned, they release carbon dioxide. Burning these fuels increases the amount of carbon dioxide in the atmosphere. Rising carbon dioxide levels may be raising Earth's temperature. The issue of Earth's rising temperature, or global warming, is discussed in Chapter 4.
Other Gases  Oxygen and nitrogen together make up 99 percent of dry air. Carbon dioxide and argon make up most of the other one percent. The remaining gases are called trace gases because only small amounts of them are present.

Water Vapor  The composition of the air discussed so far has been for dry air. In reality, air is not dry because it contains water vapor. Water vapor is water in the form of a gas. Water vapor is invisible—it is not the same thing as steam, which is made up of tiny droplets of liquid water. Each water molecule contains two atoms of hydrogen and one atom of oxygen.

The amount of water vapor in the air varies greatly from place to place and from time to time. Air above a desert or polar ice sheet may contain almost no water vapor. In tropical rain forests, on the other hand, as much as five percent of the air may be water vapor.

Water vapor plays an important role in Earth's weather. Clouds form when water vapor condenses out of the air to form tiny droplets of liquid water or crystals of ice. If these droplets or crystals become large enough, they can fall as rain or snow.

Particles  Pure air contains only gases. But pure air exists only in laboratories. In the real world, air also contains tiny solid and liquid particles of dust, smoke, salt, and other chemicals. Sometimes you can see particles in the air around you, but most of them are too small to see.

Figure 4  This lush vegetation grows in a rain forest in Costa Rica. The percentage of water vapor in the air in a rain forest may be as high as five percent.

Section 1 Review

1. Describe two ways in which the atmosphere is important to life on Earth.
2. What are the four most common gases in dry air?
3. Why are the amounts of gases in the atmosphere usually shown as percentages of dry air?
4. Thinking Critically  Applying Concepts  How would the amount of carbon dioxide in the atmosphere change if there were no plants? If there were no animals?

Check Your Progress  Have you determined how, where, and when, you will make your observations? Organize a notebook to record them. Think of ways to compare weather conditions from day to day. Make your observations without weather instruments or TV weather reports. (Hint: You can estimate how much of the sky is covered by clouds.) For your own safety, do not try to make observations during storms.
Imagine taking a trip upward into the atmosphere in a hot-air balloon. You begin on a warm beach near the ocean, at an altitude of 0 kilometers.

You hear a roar as the balloon’s pilot turns up the burner to heat the air in the balloon. The balloon begins to rise, and Earth’s surface gets farther and farther away. As the balloon rises to an altitude of 3 kilometers, you realize that the air is getting colder. As you continue to rise, the air gets colder and colder. At 6 kilometers you begin to have trouble breathing. The air is becoming less dense. It’s time to go back down.

What if you could have continued your balloon ride up through the atmosphere? As you rose farther up through the atmosphere, the air pressure and temperature would change dramatically. The four main layers of the atmosphere are classified according to changes in temperature. These layers are the troposphere, the stratosphere, the mesosphere, and the thermosphere.

**The Troposphere**

You live in the inner, or lowest, layer of Earth’s atmosphere, the troposphere (TROH puh sf eer). *Tropo*- means “turning” or “changing”; conditions in the troposphere are more variable than in the other layers. The troposphere is where Earth’s weather occurs.
Although hot-air balloons cannot travel very high into the troposphere, other types of balloons can. To measure weather conditions, scientists launch weather balloons that carry instruments up into the atmosphere. The balloons are not fully inflated before they are launched. Recall that air pressure decreases as you rise through the atmosphere. Leaving the balloon only partly inflated gives the gas inside the balloon room to expand as the air pressure outside the balloon decreases.

The depth of the troposphere varies from more than 16 kilometers above the equator to less than 9 kilometers above the North and South Poles. Even though it is the shallowest layer of the atmosphere, the troposphere contains almost all of the mass of the atmosphere.

As altitude increases in the troposphere, the temperature decreases. On average, for every 1-kilometer increase in altitude the air gets about 6.5 Celsius degrees cooler. At the top of the troposphere, the temperature stops decreasing and stays constant at about –60°C. Water here forms thin, feathery clouds of ice.

A Checkpoint Why are clouds at the top of the troposphere made of ice crystals instead of drops of water?

The Stratosphere

The stratosphere extends from the top of the troposphere to about 50 kilometers above Earth’s surface. Strato- is similar to stratum, which means “layer” or “spreading out.”

The lower stratosphere is cold, about –60°C. You might be surprised to find out that the upper stratosphere is warmer than the lower stratosphere. Why is this? The upper stratosphere contains a layer of ozone, the three-atom form of oxygen. When the ozone in the stratosphere absorbs energy from the sun, the energy is converted into heat, warming the air.

As a weather balloon rises through the stratosphere, the air pressure outside the balloon continues to decrease. The volume of the balloon increases. Finally, the balloon bursts, and the instrument package falls back to Earth’s surface.

The Mesosphere

Above the stratosphere, a drop in temperature marks the beginning of the next layer, the mesosphere. Meso- means “middle,” so the mesosphere is the middle layer of the atmosphere. The mesosphere begins 50 kilometers above Earth’s surface and ends at 80 kilometers. The outer mesosphere is the coldest part of the atmosphere, with temperatures near –90°C.
EXPLORING Layers of the Atmosphere

The atmosphere is divided into four layers: the troposphere, the stratosphere, the mesosphere, and the thermosphere. The thermosphere is further divided into the ionosphere and the exosphere.

**Exosphere above 550 km**
Phone calls and television pictures often reach you by way of communications satellites that orbit Earth in the exosphere.

**Ionosphere 80 to 550 km**
Ions in the ionosphere reflect radio waves back to Earth. The aurora borealis occurs in the ionosphere.

**Thermosphere above 80 km**
The thermosphere extends from 80 km above Earth's surface outward into space. It has no definite outer limit.

**Mesosphere 50 to 80 km**
Most meteoroids burn up in the mesosphere, producing meteor trails.

**Stratosphere 12 to 50 km**
The ozone layer in the stratosphere absorbs ultraviolet radiation.

**Troposphere 0 to 12 km**
Rain, snow, storms, and most clouds occur in the troposphere.
If you watch a shooting star streak across the night sky, you are seeing a meteoroid burn up as it enters the mesosphere. The mesosphere protects Earth's surface from being hit by most meteoroids, which are chunks of stone and metal from space. What you see as a shooting star, or meteor, is the trail of hot, glowing gases the burning meteoroid leaves behind.

**Checkpoint** What is the depth of the mesosphere?

**The Thermosphere**
Near the top of the atmosphere, the air is very thin. The air 80 kilometers above Earth's surface is only about 0.001 percent as dense as the air at sea level. It's as though you took a cubic

**Explorers of the Atmosphere**
The atmosphere has been explored from the ground and from space.

1643
**Torricelli Invents the Barometer**
Italian physicist and mathematician Evangelista Torricelli improved existing scientific instruments and invented some new ones. In 1643 he invented the barometer, using a column of mercury 1.2 meters high.

1746
**Franklin's Experiment with Electricity**
American statesman and inventor Benjamin Franklin and some friends in Philadelphia experimented with electricity in the atmosphere. To demonstrate that lightning is a form of electricity, Franklin flew a kite in a thunderstorm. However, Franklin did not hold the kite string in his hand, as this historical print shows.

1804
**Gay-Lussac Studies the Upper Troposphere**
French chemist Joseph-Louis Gay-Lussac ascended to a height of about 7 kilometers in a hydrogen balloon to study the upper troposphere. Gay-Lussac studied pressure, temperature, and humidity.
meter of air at sea level and expanded it into 100,000 cubic meters at the top of the mesosphere. The outermost layer of the atmosphere, the **thermosphere**, extends from 80 kilometers above Earth’s surface outward into space. It has no definite outer limit. The atmosphere does not end suddenly at the outer edge of the thermosphere. Gas atoms and molecules there are so far apart that the air blends gradually with outer space.

The *thermo-* in thermosphere means “heat.” Even though the air in the thermosphere is thin, it is very hot, up to 1,800°C. The temperature in the thermosphere is actually higher than the temperature in a furnace used to make steel! But why is the thermosphere so hot? Energy coming from the sun strikes the thermosphere first. Nitrogen and oxygen molecules convert energy from the sun into heat.

**In Your Journal**

Imagine you were one of the first people to go up into the atmosphere in a balloon. What would you need to take? Find out what the early explorers took with them in their balloons. Write at least two paragraphs about what you would take, and why.

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**1931**

**Piccard Explores the Stratosphere**

Swiss-Belgian physicist Auguste Piccard made the first ascent into the stratosphere. He reached a height of about 16 kilometers in an airtight cabin attached to a huge hydrogen balloon. Piccard is shown here with the cabin.

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**1900**

**1960**

**First Weather Satellite Launched**

TIROS-1, the first weather satellite equipped with a camera to send data back to Earth, was put into orbit by the United States. As later weather satellites circled Earth, they observed cloud cover and recorded temperatures and air pressures in the atmosphere.

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**1994**

**Space Shuttle Investigates the Atmosphere**

The NASA space shuttle Atlantis traveled to a height of 300 kilometers in the thermosphere. Atlantis carried the ATLAS-3 research program, which observed the sun’s influence on the atmosphere.
Despite the high temperature, however, you would not feel warm in the thermosphere. An ordinary thermometer would show a temperature well below 0°C. Why is that? Temperature is the average amount of energy of motion of each molecule of a substance. The gas molecules in the thermosphere move very rapidly, so the temperature is very high. However, the molecules are spaced far apart in the thin air. And there are not enough of them to collide with a thermometer and warm it very much. So an ordinary thermometer would not detect the molecules’ energy.

**The Ionosphere** The thermosphere is divided into two layers. The lower layer of the thermosphere, called the ionosphere (eye AHN uh sfeer), begins 80 kilometers above the surface and ends at 550 kilometers. Energy from the sun causes gas molecules in the ionosphere to become electrically charged particles called ions. Radio waves bounce off ions in the ionosphere and then bounce back to Earth’s surface.

The brilliant light displays of the **aurora borealis**—the Northern Lights—also occur in the ionosphere. The aurora borealis is caused by particles from the sun that enter the ionosphere near the North Pole. These particles strike oxygen and nitrogen atoms in the ionosphere, causing them to glow.

**The Exosphere** Exo- means “outer,” so the **exosphere** is the outer layer of the thermosphere. The exosphere extends from 550 kilometers outward for thousands of kilometers. When you make a long-distance phone call or watch television, the signal may have traveled up to a satellite orbiting in the exosphere and then back down to your home. Satellites are also used for watching the world’s weather and carrying telescopes that look deep into space.

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**Section 4 Review**

1. Describe one characteristic of each of the four main layers of the atmosphere.

2. What is a shooting star? In which layer of the atmosphere would you see it?

3. What is the aurora borealis? In which layer of the atmosphere does it occur?

4. **Thinking Critically Drawing Conclusions** Why is the mesosphere the coldest part of the atmosphere?

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**Check Your Progress**

At this point, review your weather log. What do you notice about the weather on one day that might allow you to predict the next day’s weather? What weather conditions changed the most from day to day? Continue to record your observations and start thinking about how you will present them.
Air Quality

What's On the Jar?

1. Put on your goggles.
2. Put a small piece of modeling clay on a piece of aluminum foil. Push a candle into the clay. Light the candle.
3. Wearing an oven mitt, hold a glass jar by the rim so that the bottom of the jar is just above the flame.

Think It Over

Observing: What do you see on the jar? Where did it come from?

GUIDE FOR READING

- What are the main sources of air pollution?
- How do photochemical smog and acid rain form?

Reading Tip: As you read, look for evidence to support this statement: Most air pollution is caused by human activities. What facts support this statement? What facts do not support it?

One hundred years ago, the city of London, England, was dark and dirty. Factories burned coal, and most houses were heated by coal. The air was full of soot. In 1905, the term smog was created by combining the words smoke and fog to describe this type of air pollution. Today, people in London burn much less coal. As a result, the air in London now is much cleaner than it was 100 years ago.

Air Pollution

As you are reading this, you are breathing without even thinking about it. Breathing brings air into your lungs, where the oxygen you need is taken into your body. You may also breathe in tiny particles or even a small amount of harmful gases. In fact, these particles and gases are a concern to people everywhere.

If you live in a large city, you probably already know what air pollution is. You may have noticed a brown haze or an unpleasant smell in the air. Even if you live far from a city, the air around you may be polluted. Harmful substances in the air, water, or soil are known as pollutants. Figure 5 shows some of the effects of air pollution on human health.

Figure 5: Air pollution can cause many different problems. Some air pollutants are natural, but most are caused by human activities. Interpreting Photographs

What parts of the body are most affected by air pollution?
Some air pollution occurs naturally, but much of it is caused by human activities. **Most air pollution is the result of burning fossil fuels such as coal, oil, gasoline, and diesel fuel.** Almost half of the air pollution from human activities comes from cars and other motor vehicles. A little more than one fourth comes from factories and power plants that burn coal and oil. Burning fossil fuels produces a number of air pollutants, including particles and gases that can form smog and acid rain.

**Checkpoint** What are two sources of air pollution that you see every day?

**Particles**

As you know, air contains particles along with gases. When you draw these particles deep into your lungs, the particles can be harmful. Particles in the air come from both natural sources and human activities.

**Natural Sources** Many natural processes add particles to the atmosphere. When ocean waves splash salt water against rocks, some of the water sprays into the air and evaporates. Tiny salt particles stay in the air. The wind blows particles of molds and plant pollen. Forest fires, soil erosion, and dust storms add particles to the atmosphere. Erupting volcanoes spew out clouds of dust and ashes along with poisonous gases.

**INTEGRATING** Even fairly clean air usually contains particles of dust and pollen. Figure 6 shows pollen, a fine, powdery material produced by many plants. The wind carries pollen not only to other plants, but also to people. One type of allergy, popularly called “hay fever,” is caused by pollen from plants such as ragweed. Symptoms of hay fever include sneezing, a runny nose, red and itchy eyes, and headaches. Weather reports often include a “pollen count,” which is the average number of pollen grains in a cubic meter of air.

**Human Activities** When people burn fuels such as wood and coal, particles made mostly of carbon enter the air. These particles of soot are what gives smoke its dark color. Farming and construction also release large amounts of soil particles into the air.
Smog
London-type smog forms when particles in coal smoke combine with water droplets in humid air. Fortunately, London-type smog is no longer common in the United States. Today sunny cities like Los Angeles often have another type of smog. The brown haze that forms in cities is called photochemical smog. The *photo*- in photochemical means “light.” Photochemical smog is caused by the action of sunlight on chemicals.

Photochemical smog is formed by a complex process. All fossil fuels contain hydrocarbons, which are substances composed of carbon and hydrogen. When fossil fuels are burned, some hydrocarbons are not burned completely and escape into the air. At the same time, the high temperatures that accompany burning cause some of the nitrogen in the air to react with oxygen to form nitrogen oxides. The nitrogen oxides, hydrocarbons, and other air pollutants then react with each other in the presence of sunlight to form a mix of ozone and other chemicals called photochemical smog. The ozone in photochemical smog irritates breathing passages, harms plants, and damages rubber, paint, and some plastics.

**Checkpoint** How do natural conditions combine with human activities to create photochemical smog?

Acid Rain
One result of air pollution is acid rain. The burning of coal that contains a lot of sulfur produces substances composed of oxygen and sulfur called sulfur oxides. Acid rain forms when nitrogen oxides and sulfur oxides combine with water in the air to form nitric acid and sulfuric acid.

![Figure 8](image_url) This scientist is studying trees damaged by acid rain. Acid rain is one of the results of air pollution.
Rain, sleet, snow, fog, and even dry particles carry these two acids from the air to trees, lakes, and buildings. Rain is naturally slightly acidic, but rain that contains more acid than normal is known as acid rain. Acid rain is sometimes strong enough to damage the surfaces of buildings and statues.

As Figure 8 shows, needle-leaved trees such as pines and sprucè are especially sensitive to acid rain. Acid rain may make tree needles turn brown or fall off. It also harms lakes and ponds. Acid rain can make water so acidic that plants, amphibians, fish, and insects can no longer survive in it.

**Improving Air Quality**
The United States government and state governments have passed a number of laws and regulations to reduce air pollution. For example, pollution-control devices are required equipment on cars. Factories and power plants must install filters in smokestacks to remove pollutants from smoke before it is released into the atmosphere. These filters are called scrubbers.

Air quality in this country has generally improved over the past 30 years. The amounts of all major air pollutants have decreased. Newer cars cause less pollution than older models. Recently-built power plants are less polluting than power plants that have been in operation for many years.

However, there are now more cars on the road and more power plants burning fossil fuels than in the past. Unfortunately, the air in many American cities is still polluted. Many people think that stricter regulations are needed to control air pollution. Others argue that reducing air pollution is very expensive and that the benefits of stricter regulations may not be worth the costs.

### Section 2 Review

1. How is most air pollution produced?
2. Name two natural and two artificial sources of particles in the atmosphere.
3. How is photochemical smog formed? What kinds of harm does it cause?
4. What substances combine to form acid rain?
5. **Thinking Critically Inferring** Do you think that photochemical smog levels are higher during the winter or during the summer? Explain.
Modified Materials
PROJECT 1

Watching the Weather

The air is cool and clear—just perfect for a trip in a hot-air balloon. As you rise, a fresh breeze begins to move you along. Where will it take you? Hot-air balloon pilots need to know about the weather to plot their course.

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**Get Started** Begin by discussing what weather conditions you can observe. Brainstorm how to use your senses to describe the weather. For example, can you describe the wind speed by observing the school flag? Can you describe the temperature based on what clothes you need to wear outside? Be creative.

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**Section 4** Layers of the Atmosphere

Discover: Is Air There?
1. Put on your goggles.
3. Hold a small glass jar by the bottom. Lower the mouth of the jar over the candle until the jar rests on the pie pan. As you do this, start a stopwatch or note where the second hand is on a clock.
4. Watch the candle carefully. How long does the flame burn?
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Think It Over
Inferring How would you explain any differences between your results in Steps 4 and 5?

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Figure 1 When seen from space, Earth's atmosphere appears as a thin layer near the horizon. The atmosphere makes life on Earth possible.
Earth's Atmosphere:

- makes conditions on Earth suitable for living things,
- contains oxygen and other gases that living things need to live,
- is constantly changing with gases moving around the Earth.

What would conditions on Earth be like without the atmosphere?

- If atmosphere didn’t exist water wouldn’t exist as a liquid on Earth's surface.
- If atmosphere didn’t exist Earth would be exposed to meteoroids and dangerous radiation from the sun.
- If atmosphere didn’t exist life wouldn’t be possible on Earth without the oxygen and other gases that living things need.

Composition of the Atmosphere

The atmosphere is made up of a mixture of atoms and molecules of different kinds of gases. An atom is the smallest unit of a chemical element that can exist by itself. Molecules are made up of two or more atoms. Earth's atmosphere is made up of nitrogen, oxygen, carbon dioxide, water vapor, and many other gases, as well as particles of liquids and solids.

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<table>
<thead>
<tr>
<th>Gases in Dry Air</th>
<th>Other Gases</th>
<th>Percentage by Volume</th>
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<tr>
<td>Nitrogen (78%)</td>
<td>Argon</td>
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<td>Oxygen (21%)</td>
<td>Carbon dioxide</td>
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<td>All other gases (1%)</td>
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<tr>
<td></td>
<td>Hydrogen</td>
<td>0.00005</td>
</tr>
</tbody>
</table>

Figure 2 Dry air in the lower atmosphere always has the same composition of gases. Interpreting Data What two gases make up most of the air?
Nitrogen is essential to living things. Proteins and other complex chemical substances in living things contain nitrogen. You and all other organisms must have nitrogen in order to grow and to repair body cells.

Most living things cannot obtain nitrogen directly from the air. Instead, some bacteria convert nitrogen into substances called nitrates. Plants then absorb the nitrates from the soil and use them to make proteins. To obtain proteins, animals must eat plants or other animals.

Oxygen. Most oxygen molecules have two oxygen atoms. Even though oxygen is the second-most abundant gas in the atmosphere, it makes up less than one fourth of the volume. Plants and animals take oxygen directly from the air and use it to release energy from food in a usable form.

Oxygen is also involved in other important processes. Any fuel you can think of, from the gasoline in a car to the candles on a birthday cake, uses oxygen as it burns. Without oxygen, a fire will go out. Burning uses oxygen rapidly. During other processes, oxygen is used slowly. For example, steel in cars and other objects reacts slowly with oxygen to form iron oxide, or rust.

Have you ever noticed a pungent smell in the air after a thunderstorm? This is the odor of ozone, which forms when lightning interacts with oxygen in the air. Ozone is a form of oxygen that has three oxygen atoms in each molecule instead of the usual two.

Carbon Dioxide. Each molecule of carbon dioxide has one atom of carbon and two atoms of oxygen. Even though the atmosphere contains only a small amount of carbon dioxide, it is essential to life. Plants must have carbon dioxide to produce food. Animals, on the other hand, give off carbon dioxide as a waste product.

When fuels such as coal and gasoline are burned, they release carbon dioxide. Burning these fuels increases the amount of carbon dioxide in the atmosphere. Rising carbon dioxide levels may be raising Earth's temperature. The issue of Earth's rising temperature, or global warming, is discussed in Chapter 4.
Other Gases  Oxygen and nitrogen together make up 99 percent of dry air. Carbon dioxide and argon make up most of the other one percent. The remaining gases are called trace gases because only small amounts of them are present.

Water Vapor  The composition of the air discussed so far has been for dry air. In reality, air is not dry because it contains water vapor. Water vapor is water in the form of a gas. Water vapor is invisible—it is not the same thing as steam, which is made up of tiny droplets of liquid water. Each water molecule contains two atoms of hydrogen and one atom of oxygen.

The amount of water vapor in the air varies greatly from place to place and from time to time. Air above a desert or polar ice sheet may contain almost no water vapor. In tropical rain forests, on the other hand, as much as five percent of the air may be water vapor.

Water vapor plays an important role in Earth’s weather. Clouds form when water vapor condenses out of the air to form tiny droplets of liquid water or crystals of ice. If these droplets or crystals become large enough, they can fall as rain or snow.

Particles  Pure air contains only gases. But pure air exists only in laboratories. In the real world, air also contains tiny solid and liquid particles of dust, smoke, salt, and other chemicals. Sometimes you can see particles in the air around you, but most of them are too small to see.

Figure 4  This lush vegetation grows in a rain forest in Costa Rica. The percentage of water vapor in the air in a rain forest may be as high as five percent.

Section 1 Review

1. Describe two ways in which the atmosphere is important to life on Earth.
2. What are the four most common gases in dry air?
3. Why are the amounts of gases in the atmosphere usually shown as percentages of dry air?
4. Thinking Critically  Applying Concepts
   How would the amount of carbon dioxide in the atmosphere change if there were no plants? If there were no animals?
## Composition of the atmosphere

<table>
<thead>
<tr>
<th>Nitrogen</th>
<th>Oxygen</th>
<th>Carbon Dioxide</th>
<th>Other Gases</th>
<th>Water Vapor</th>
<th>Particles</th>
</tr>
</thead>
</table>
| - It molecule has two nitrogen atoms.  
- Most abundant gas in the atmosphere.  
- More than \( \frac{3}{4} \) the air we breathe.  
- Is essential to living things.  
- Bacteria convert nitrogen into nitrates. Plants absorb nitrates from soil and make proteins. Animals eat plants to get proteins. See Picture 1. | - Each molecule has two oxygen atoms.  
- Second most abundant gas in the atmosphere.  
- Makes up less than \( \frac{1}{4} \) of the air we breath.  
- Any fuel uses oxygen as it burns.  
- Oxone is a form of oxygen. | - Each molecule has one atom of carbon and two atoms of oxygen.  
- Is essential to life.  
- Plants need carbon dioxide to produce food.  
- Animals give off carbon dioxide as a waste product.  
- Burning fuels release carbon dioxide. | - Are called trace gases.  
- Are less than 1%. | - Each molecule has two atoms of hydrogen and one atom of oxygen.  
- Water vapor is water in the form of gas.  
- Is invisible.  
- Its amount varies from place to place.  
- Clouds are formed thanks to it. See Picture 2. | - Tiny solid and liquid particles of dust, smoke, salt, and other chemicals.  
- Too small to see them. |

**Picture 1**

**Picture 2**
Layers of the Atmosphere

Earth's atmosphere is not uniform; its properties change with altitude. Two properties that change with altitude are air temperature and air pressure. Scientists use these properties to describe a model of the atmosphere that has five layers.

**Exosphere** (300 km– >600 km)
- Outermost layer of the atmosphere
- Temperature goes up with altitude
- Satellites orbit in this layer

**Thermosphere** (90 km–300 km)
- Temperature goes up with altitude; this is the hottest layer of the atmosphere
- Curtains of light called **auroras** occur in this layer

**Mesosphere** (50 km–90 km)
- Temperatures drop with altitude; this is the coldest layer of the atmosphere
- Meteors burn up in this layer
- Radio waves reflected to Earth in this layer

**Stratosphere** (16 km–50 km)
- Temperature goes up with altitude
- Most jets fly here
- Protective ozone layer at top of stratosphere

**Troposphere** (0–16 km)
- Layer nearest Earth
- All weather happens here
- More than half of air in total atmosphere in this layer
- Temperature drops as altitude increases
Imagine taking a trip upward into the atmosphere in a hot-air balloon. You begin on a warm beach near the ocean, at an altitude of 0 kilometers.

You hear a roar as the balloon’s pilot turns up the burner to heat the air in the balloon. The balloon begins to rise, and Earth’s surface gets farther and farther away. As the balloon rises to an altitude of 3 kilometers, you realize that the air is getting colder. As you continue to rise, the air gets colder and colder. At 6 kilometers you begin to have trouble breathing. The air is becoming less dense. It’s time to go back down.

What if you could have continued your balloon ride up through the atmosphere? As you rose farther up through the atmosphere, the air pressure and temperature would change dramatically. The four main layers of the atmosphere are classified according to changes in temperature. These layers are the troposphere, the stratosphere, the mesosphere, and the thermosphere.

**The Troposphere**

You live in the inner, or lowest, layer of Earth’s atmosphere, the troposphere (TROH puh sfer). Tropo- means “turning” or “changing”; conditions in the troposphere are more variable than in the other layers. The troposphere is where Earth’s weather occurs.
Although hot-air balloons cannot travel very high into the troposphere, other types of balloons can. To measure weather conditions, scientists launch weather balloons that carry instruments up into the atmosphere. The balloons are not fully inflated before they are launched. Recall that air pressure decreases as you rise through the atmosphere. Leaving the balloon only partly inflated gives the gas inside the balloon room to expand as the air pressure outside the balloon decreases.

The depth of the troposphere varies from more than 16 kilometers above the equator to less than 9 kilometers above the North and South Poles. Even though it is the shallowest layer of the atmosphere, the troposphere contains almost all of the mass of the atmosphere.

As altitude increases in the troposphere, the temperature decreases. On average, for every 1-kilometer increase in altitude the air gets about 6.5 Celsius degrees cooler. At the top of the troposphere, the temperature stops decreasing and stays constant at about \(-60^\circ\text{C}\). Water here forms thin, feathery clouds of ice.

**Checkpoint** Why are clouds at the top of the troposphere made of ice crystals instead of drops of water?

### The Stratosphere

The **stratosphere** extends from the top of the troposphere to about 50 kilometers above Earth’s surface. *Strato-* is similar to *stratum*, which means “layer” or “spreading out.”

The lower stratosphere is cold, about \(-60^\circ\text{C}\). You might be surprised to find out that the upper stratosphere is warmer than the lower stratosphere. Why is this? The upper stratosphere contains a layer of ozone, the three-atom form of oxygen. When the ozone in the stratosphere absorbs energy from the sun, the energy is converted into heat, warming the air.

As a weather balloon rises through the stratosphere, the air pressure outside the balloon continues to decrease. The volume of the balloon increases. Finally, the balloon bursts, and the instrument package falls back to Earth’s surface.

### The Mesosphere

Above the stratosphere, a drop in temperature marks the beginning of the next layer, the **mesosphere**. *Meso-* means “middle,” so the mesosphere is the middle layer of the atmosphere. The mesosphere begins 50 kilometers above Earth’s surface and ends at 80 kilometers. In the outer mesosphere temperatures approach \(-90^\circ\text{C}\).
EXPLORING Layers of the Atmosphere

The atmosphere is divided into four layers: the troposphere, the stratosphere, the mesosphere, and the thermosphere. The thermosphere is further divided into the ionosphere and the exosphere.

Exosphere above 550 km
Phone calls and television pictures often reach you by way of communications satellites that orbit Earth in the exosphere.

Ionosphere 80 to 550 km
Ions in the ionosphere reflect radio waves back to Earth. The aurora borealis occurs in the ionosphere.

Thermosphere above 80 km
The thermosphere extends from 80 km above Earth's surface outward into space. It has no definite outer limit.

Mesosphere 50 to 80 km
Most meteoroids burn up in the mesosphere, producing meteor trails.

Stratosphere 12 to 50 km
The ozone layer in the stratosphere absorbs ultraviolet radiation.

Troposphere 0 to 12 km
Rain, snow, storms, and most clouds occur in the troposphere.
If you watch a shooting star streak across the night sky, you are seeing a meteoroid burn up as it enters the mesosphere. The mesosphere protects Earth’s surface from being hit by most meteoroids, which are chunks of stone and metal from space. What you see as a shooting star, or meteor, is the trail of hot, glowing gases the burning meteoroid leaves behind.

**Checkpoint** What is the depth of the mesosphere?

**The Thermosphere**
Near the top of the atmosphere, the air is very thin. The air 80 kilometers above Earth’s surface is only about 0.001 percent as dense as the air at sea level. It’s as though you took a cubic...
meter of air at sea level and expanded it into 100,000 cubic meters at the top of the mesosphere. The outermost layer of the atmosphere, the thermosphere, extends from 80 kilometers above Earth's surface outward into space. It has no definite outer limit. The atmosphere does not end suddenly at the outer edge of the thermosphere. Gas atoms and molecules there are so far apart that the air blends gradually with outer space.

The *thermo-* in thermosphere means "heat." Even though the air in the thermosphere is thin, it is very hot, up to 1,800°C. The temperature in the thermosphere is actually higher than the temperature in a furnace used to make steel! But why is the thermosphere so hot? Energy coming from the sun strikes the thermosphere first. Nitrogen and oxygen molecules convert energy from the sun into heat.

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**In Your Journal**

Imagine you were one of the first people to go up into the atmosphere in a balloon. What would you need to take? Find out what the early explorers took with them in their balloons. Write at least two paragraphs about what you would take, and why.

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**1931**

Piccard Explores the Stratosphere

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**1900**

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**1960**

First Weather Satellite Launched

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**1994**

Space Shuttle Investigates the Atmosphere

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Chapter 1 1 - 35
Despite the high temperature, however, you would not feel warm in the thermosphere. An ordinary thermometer would show a temperature well below 0°C. Why is that? Temperature is the average amount of energy of motion of each molecule of a substance. The gas molecules in the thermosphere move very rapidly, so the temperature is very high. However, the molecules are spaced far apart in the thin air. And there are not enough of them to collide with a thermometer and warm it very much. So an ordinary thermometer would not detect the molecules’ energy.

**The Ionosphere** The thermosphere is divided into two layers. The lower layer of the thermosphere, called the ionosphere (eye ahn uh sheer), begins 80 kilometers above the surface and ends at 550 kilometers. Energy from the sun causes gas molecules in the ionosphere to become electrically charged particles called ions. Radio waves bounce off ions in the ionosphere and then bounce back to Earth’s surface.

The brilliant light displays of the aurora borealis—the Northern Lights—also occur in the ionosphere. The aurora borealis is caused by particles from the sun that enter the ionosphere near the North Pole. These particles strike oxygen and nitrogen atoms in the ionosphere, causing them to glow.

**The Exosphere** Exo- means “outer,” so the exosphere is the outer layer of the thermosphere. The exosphere extends from 550 kilometers outward for thousands of kilometers. When you make a long-distance phone call or watch television, the signal may have traveled up to a satellite orbiting in the exosphere and then back down to your home. Satellites are also used for watching the world’s weather and carrying telescopes that look deep into space.

**Section 4 Review**

1. Describe one characteristic of each of the four main layers of the atmosphere.
2. What is a shooting star? In which layer of the atmosphere would you see it?
3. What is the aurora borealis? In which layer of the atmosphere does it occur?
4. **Thinking Critically** Drawing Conclusions
   Why is the mesosphere the coldest part of the atmosphere?
Air pollution is the process of making air dangerously dirty and not good enough for people to breathe.

One hundred years ago, the city of London, England, was dark and dirty. Factories burned coal, and most houses were heated by coal. The air was full of soot. In 1905, the term smog was created by combining the words smoke and fog to describe this type of air pollution. Today, people in London burn much less coal. As a result, the air in London now is much cleaner than it was 100 years ago.

**Air Pollution**

As you are reading this, you are breathing without even thinking about it. Breathing brings air into your lungs, where the oxygen you need is taken into your body. You may also breathe in tiny particles or even a small amount of harmful gases. In fact, these particles and gases are a concern to people everywhere.

If you live in a large city, you probably already know what air pollution is. You may have noticed a brown haze or an unpleasant smell in the air. Even if you live far from a city, the air around you may be polluted. Harmful substances in the air, water, or soil are known as pollutants. Figure 5 shows some of the effects of air pollution on human health.

**Figure 5** Air pollution can cause many different problems. Some air pollutants are natural, but most are caused by human activities. Interpreting Photographs: What parts of the body are most affected by air pollution?
Some air pollution occurs naturally, but much of it is caused by human activities. **Most air pollution is the result of burning fossil fuels such as coal, oil, gasoline, and diesel fuel.** Almost half of the air pollution from human activities comes from cars and other motor vehicles. A little more than one fourth comes from factories and power plants that burn coal and oil. Burning fossil fuels produces a number of air pollutants, including particles and gases that can form smog and acid rain.

**Checkpoint** What are two sources of air pollution that you see every day?

**Particles**

As you know, air contains particles along with gases. When you draw these particles deep into your lungs, the particles can be harmful. Particles in the air come from both natural sources and human activities.

**Natural Sources** Many natural processes add particles to the atmosphere. When ocean waves splash salt water against rocks, some of the water sprays into the air and evaporates. Tiny salt particles stay in the air. The wind blows particles of molds and plant pollen. Forest fires, soil erosion, and dust storms add particles to the atmosphere. Erupting volcanoes spew out clouds of dust and ashes along with poisonous gases.

**Integrating Health** Even fairly clean air usually contains particles of dust and pollen. Figure 6 shows pollen, a fine, powdery material produced by many plants. The wind carries pollen not only to other plants, but also to people. One type of allergy, popularly called “hay fever,” is caused by pollen from plants such as ragweed. Symptoms of hay fever include sneezing, a runny nose, red and itchy eyes, and headaches. Weather reports often include a “pollen count,” which is the average number of pollen grains in a cubic meter of air.

**Human Activities** When people burn fuels such as wood and coal, particles made mostly of carbon enter the air. These particles of soot are what gives smoke its dark color. Farming and construction also release large amounts of soil particles into the air.

**Soot** Carbon dust formed by incomplete combustion.
Teacher Materials
Watching the Weather

Most people make observations about the weather almost every day of their lives, but they might not be very aware of specific weather conditions and how they change. Of course they notice when a storm is raging, but they might not notice the red clouds at sunset that may indicate a storm is coming. Most students may not think much about the conditions that make up the weather. If they think about the weather at all, they may just think of it as good or bad.

**Purpose** In this project, students will become more aware of the weather and the variables such as temperature, precipitation, and wind speed that make up weather conditions. Students also will develop ways of observing weather variables.

**Skills Focus** Students will be able to:
- design and implement a plan for observing and recording daily weather conditions;
- look for patterns in their observations that will help them understand the weather and how it changes;
- create data tables and other means of displaying their observations for the rest of the class.

**Project Time Line** The entire project will take a minimum of two weeks. The longer students make and record weather observations, the more likely they are to see trends in their data. On the first day, allow class time for introducing the project and brainstorming how students can use their senses to describe the weather. Students should decide as soon as possible which weather variables they will observe and how they will observe them. Students also must devise a way to record their observations. Additional class time will be necessary during the two-week period to monitor students' progress and give extra guidance to students who are having difficulty. At the end of the project, students will need time to review and organize their data and present their results to the rest of the class. For more detailed information on planning and supervising the chapter project, see Chapter 1 Project Teacher Notes, pages 6–7 in Teaching Resources.

**Suggested Shortcuts** To reduce the amount of time students spend on the project, you may assign each student or group of students just one weather variable, such as temperature or precipitation, to monitor. Then, at the end of the project, students can pool their results and the whole class can work together to look for patterns in the data.

**Possible Materials** Each student will need a log for recording his or her observations, but no other materials or equipment are needed. In fact, you should stress to students that they are to rely only on their senses and not instruments such as thermometers or wind vanes. However, students will need to depend on various materials in their environment, such as the school flag or the clothes people are wearing, to observe weather conditions. Urge students to be creative in the materials they use for their observations. Smoke rising from chimneys, for example, can reveal the direction and speed of the wind as well as flags flying from poles can.
Launching the Project  To help students start thinking of weather variables they might observe, hand out copies of newspaper weather reports. On the chalkboard, have a volunteer list the weather variables given in the reports, such as temperature, humidity, barometric pressure, and wind speed and direction. Then challenge students to think of ways these weather variables could be observed without instruments. For example, ask: If a thin skin of ice forms on puddles during the day, what does that tell you about the temperature? (It has fallen below the freezing point of water.) If the school flag is flying straight out from its pole, what does that tell you about the wind? (It is blowing at a high speed.) Urge students to think of other observations that could give them information about weather conditions.

Performance Assessment

The Chapter 1 Project Scoring Rubric on page 12 in Teaching Resources will help you evaluate how well students complete the Chapter 1 Project. You may wish to share the scoring rubric with your students so they know what will be expected of them. Students will be assessed on:
- how thoroughly they collect and record observations of a variety of different weather conditions;
- how accurately they interpret their data to predict weather conditions and identify weather trends;
- how complete and creative their presentation of results are;
- if they work in groups, how much they contribute to their group’s effort.
The Air Around You

Objectives
After completing the lesson, students will be able to:
- state how the atmosphere is important to living things;
- identify the gases that are present in Earth's atmosphere.

Key Terms weather, atmosphere, ozone, water vapor

1 Engage/Explore

Activating Prior Knowledge
Ask students to recall the fire triangle, which many will have learned about in fire safety demonstrations. After drawing a large triangle on the chalkboard, ask:
What is the fire triangle? (A triangle representing the three components needed for fire to burn: fuel, heat, and air) As students explain, label the sides of the triangle on the chalkboard. Then relate the fire triangle to the composition of air by asking: What is in air that fire needs to burn? (oxygen) Point out that living things also need oxygen, and oxygen is just one of the components of air they will learn about in this section.

Skills Focus inferencing
Materials modeling clay, aluminum pie pan, short candle, matches, small glass jar, stopwatch or watch with second hand, large glass jar
Time 15 minutes
Tips You can use beakers instead of jars for this activity. You may wish to have students practice using stopwatches before they begin the activity.
Expected Outcome Students should observe that the candle quickly burns out under the small jar and that it burns somewhat longer under the large jar.
Think It Over The gas needed for the candle to burn is oxygen. The candle burned longer under the large jar because the large jar contained more oxygen.

How Long Will the Candle Burn?
1. Put on your goggles.
3. Hold a small glass jar by the bottom. Lower the mouth of the jar over the candle until the jar rests on the pie pan. As you do this, start a stopwatch or note where the second hand is on a clock.
4. Watch the candle carefully. How long does the flame burn?

5. Wearing an oven mitt, remove the jar. Relight the candle and then repeat Steps 3 and 4 with a larger jar.

Think It Over
Inferring How would you explain any differences between your results in Steps 4 and 5?

GUIDE FOR READING
- How is the atmosphere important to living things?
- What gases are present in Earth's atmosphere?

Reading Tip Before you read, preview Figure 2. As you read, write a sentence about each of the major gases in the atmosphere.

As you walk home from school, the air is warm and still. The sky is full of thick, dark clouds. In the distance you see a bright flash. A few seconds later, you hear a crack of thunder. As you turn the corner onto your street, raindrops start to fall. You begin to run and reach your home just as the downpour begins. That was close! From the shelter of the entrance you pause to catch your breath and watch the storm.

Importance of the Atmosphere
Does the weather where you live change frequently, or is it fairly constant from day to day? Weather is the condition of Earth's atmosphere at a particular time and place. But what is the atmosphere? Earth's atmosphere (ah muh shee) is the layer of gases that surrounds the planet. To understand the relative size of the atmosphere, imagine that the planet Earth is the size of an apple.

Figure 1 When seen from space, Earth's atmosphere appears as a thin layer near the horizon. The atmosphere makes life on Earth possible.

Reading Strategies
Reading Tip Make sure students understand how the two parts of Figure 2 are related by pointing out that the table shows the gases that make up the tiny wedge of the circle that is not nitrogen or oxygen. After students have read the section and written their sentences, suggest that they form pairs, read their sentences to each other, and try to identify which gas each sentence describes. Also urge them to work together to resolve any factual errors they detect in each other's sentences.

Study and Comprehension Before students read the section, have them use the main headings and subheadings to make an outline. Be sure they understand which headings are main headings and which are subheadings. Then, as they read the section, have them write down at least one important fact under each heading on their outline.
If you breathe on the apple, a thin film of water will form on its surface. Earth's atmosphere is like that water on the apple—a thin layer of gases on Earth's surface.

Earth's atmosphere makes conditions on Earth suitable for living things. The atmosphere contains oxygen and other gases that you and other living things need to live. In turn, living things affect the atmosphere. The atmosphere is constantly changing, with atoms and molecules of gases moving around the globe and in and out of living things, the land, and the water.

Living things also need warmth and liquid water. By trapping energy from the sun, the atmosphere keeps most of Earth's surface warm enough for water to exist as a liquid. In addition, Earth's atmosphere protects living things from dangerous radiation from the sun. It also prevents Earth's surface from being hit by most meteoroids, or chunks of rock from outer space.

CheckPoint What would conditions on Earth be like without the atmosphere?

Composition of the Atmosphere

The atmosphere is made up of a mixture of atoms and molecules of different kinds of gases. An atom is the smallest unit of a chemical element that can exist by itself. Molecules are made up of two or more atoms. Earth's atmosphere is made up of nitrogen, oxygen, carbon dioxide, water vapor, and many other gases, as well as particles of liquids and solids.

Nitrogen As you can see in Figure 2, nitrogen is the most abundant gas in the atmosphere. It makes up a little more than three fourths of the air we breathe. Each nitrogen molecule consists of two nitrogen atoms.

![Gases in Dry Air](image)

**Figure 2** Dry air always has the same composition of gases.

<table>
<thead>
<tr>
<th>Gases in Dry Air</th>
<th>Percentage by Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (78%)</td>
<td></td>
</tr>
<tr>
<td>Oxygen (21%)</td>
<td></td>
</tr>
<tr>
<td>All other gases (1%)</td>
<td></td>
</tr>
</tbody>
</table>

Other Gases Percentage by Volume

- Argon 0.93
- Carbon dioxide 0.036
- Neon 0.0018
- Helium 0.00052
- Methane 0.0014
- Krypton 0.0011
- Hydrogen 0.0005

**CheckPoint** What two gases make up most of the air?

Language Arts CONNECTION

The word atmosphere comes from two Greek words: **atmos** meaning "vapor," and **sphere** meaning "ball," or "globe." So the atmosphere is the vapors or gases surrounding a globe—in this case, Earth.

In Your Journal

As you read this chapter, write down all the words that end in -sphere. Look up the roots of each word in a dictionary. How does knowing the roots of each word help you understand its meaning?

Facilitate

Importance of the Atmosphere

Language Arts CONNECTION

Point out that many scientific terms are based on Greek words. Ask: Why do you think English borrowed many scientific terms from Greek? (The Greeks were among the first Western people to study and write about the natural world. The words they used were passed on to people throughout Europe.)

In Your Journal Other words ending in -sphere are terms for the layers of the atmosphere. For each term, have students write the meaning of the prefix.

learning modality: verbal

Composition of the Atmosphere

Building Inquiry Skills: Making Models

Earth's atmosphere is composed largely of just a few gases, but even gases present in small amounts may be important to life. Also, the gases in Earth's atmosphere are present in the same proportions everywhere. To reinforce these concepts, invite students to explain how a cake models the composition of the atmosphere. Provide a simple cake recipe first. Ask: In what ways are the ingredients in a cake like the gases in Earth's atmosphere? (A cake is made up largely of just a few ingredients, especially flour. Ingredients, such as baking powder, included in small amounts may be essential for the cake. The ingredients in the cake are always in the same proportions.) learning modality: logical/mathematical

Answers to Self-Assessment

CheckPoint

Water could not exist as a liquid on Earth's surface. Earth would also be exposed to meteoroids and dangerous radiation from the sun. There would be no life on Earth without the oxygen and other gases that living things need.

Caption Question

Figure 2 Nitrogen and oxygen

Program Resources

- Teaching Resources 1-1 Lesson Plan, p. 13; 1-1 Section Summary, p. 14

Media and Technology

- Audiotapes English-Spanish Summary 1-1
- Transparencies "Gases in Dry Air," Transparency 1

Ongoing Assessment

Oral Presentation Call on students at random to state ways that the atmosphere contributes to life on Earth.

Chapter 1
Composition of the Atmosphere, continued

Integrating Life Science

The text gives just a short summary of the nitrogen cycle. Divide the class into groups and challenge each group to research the nitrogen cycle further and then make an illustrated flowchart of it. Each student in the group should take responsibility for learning about and illustrating one part of the cycle. Urge groups to share their flowcharts and work together to resolve any discrepancies. Display their best efforts in the classroom.

Building Inquiry Skills: Inferring

Materials tall glass jar, large cake pan, clean steel wool, water, tape

Time 5 minutes one day; 5 minutes the next day

Estimate the amount of oxygen in the atmosphere by having students follow these instructions: Fill a cake pan almost full of water. Push steel wool down into the bottom of a tall glass jar so it will not fall out when the jar is turned over. (CAUTION: Remind students to handle glass carefully.) Fill the jar with water, cover the mouth with a hand, and place the jar upside down in the cake pan. Remove the hand and tilt the jar slightly to let out enough water so that the water level in the jar is just above the water level in the pan. Mark the water level in the jar with a piece of tape and leave the jar where it is. Have students check the water level the next day. It should be about one fifth higher than it was.

Explain that oxygen in the air combines with iron in steel wool to form rust. Ask: From this experiment, how can you tell how much oxygen there is in air? (About one fifth of the air is used up, so the air must be about one fifth oxygen.)

Learning modality: logical/mathematical

TRY THIS

Breathe In, Breathe Out

How can you detect carbon dioxide in the air you exhale?
1. Put on your goggles.
2. Fill a glass or beaker halfway with limewater.
3. Using a straw, slowly blow air through the limewater for about a minute. CAUTION: Do not stick on the straw or drink the limewater.
4. What happens to the limewater?

Developing Hypotheses What do you think would happen if you did the same experiment after jogging for 10 minutes? If you tried this, what might the results tell you about exercise and carbon dioxide?

Nitrogen is essential to living things. Proteins and other complex chemical substances in living things contain nitrogen. You and all other organisms must have nitrogen in order to grow and to repair body cells.

Most living things cannot obtain nitrogen directly from the air. Instead, some bacteria convert nitrogen into substances called nitrates. Plants then absorb the nitrates from the soil and use them to make proteins. To obtain proteins, animals must eat plants or other animals.

Oxygen Each oxygen molecule has two oxygen atoms. Even though oxygen is the second-most abundant gas in the atmosphere, it makes up less than one fourth of the volume. Plants and animals take oxygen directly from the air and use it to release energy from food in a usable form.

Oxygen is also involved in other important processes. Any fuel you can think of, from gasoline in a car to the candles on a birthday cake, uses oxygen as it burns. Without oxygen, a fire will not go out. Burning uses oxygen readily. During other processes, oxygen is used slowly. For example, steel in cars and other objects reacts slowly with oxygen to form iron oxide, or rust.

Have you ever noticed a pungent smell in the air after a thunderstorm? This is the odor of ozone, which forms when lightning interacts with oxygen in the air. Ozone is a form of oxygen that has three oxygen atoms in each molecule instead of the usual two.

Carbon Dioxide Each molecule of carbon dioxide has one atom of carbon and two atoms of oxygen. Even though the atmosphere contains only a small amount of carbon dioxide, it is essential to life. Plants must have carbon dioxide to produce food. Animals, on the other hand, give off carbon dioxide as a waste product.

When fuels such as coal and gasoline are burned, they release carbon dioxide. Burning these fuels increases the amount of carbon dioxide in the atmosphere. Rising carbon dioxide levels may be raising Earth's temperature. The issue of Earth's rising temperature, or global warming, is discussed in Chapter 4.

Background

History of Science Scientists began searching for the components of air more than 300 years ago. In the 1600s, an English scientist named Robert Boyle discovered that air contains a substance needed for life when he noted that living things died if deprived of air. He called this substance "vital air." We now call it oxygen.

Almost 100 years later, Joseph Black, a Scottish medical student, found that limestone mixed with acid gives off a substance that puts out flames. He called it "fixed air." We now know it as carbon dioxide.

About 15 years later, one of Black's students, Daniel Rutherford, used a liquid to absorb vital air and fixed air. The substance that remained he called "noxious air," because it put out flames and killed living things. We now know it as nitrogen.
Other Gases  Oxygen and nitrogen together make up 99 percent of dry air. Carbon dioxide and argon make up most of the other one percent. The remaining gases are called trace gases because only small amounts of them are present.

Water Vapor  The composition of the air discussed so far has been for dry air. In reality, air is not dry because it contains water vapor. Water vapor is water in the form of a gas. Water vapor is invisible—it is not the same thing as steam, which is made up of tiny droplets of liquid water. Each water molecule contains two atoms of hydrogen and one atom of oxygen.

The amount of water vapor in the air varies greatly from place to place and from time to time. Air above a desert or polar ice sheet may contain almost no water vapor. In tropical rain forests, on the other hand, as much as five percent of the air may be water vapor.

Water vapor plays an important role in Earth's weather. Clouds form when water vapor condenses out of the air to form tiny droplets of liquid water or crystals of ice. If these droplets or crystals become large enough, they can fall as rain or snow.

Particles  Pure air contains only gases. But pure air exists only in laboratories. In the real world, air also contains tiny solid and liquid particles of dust, smoke, salt, and other chemicals. Sometimes you can see particles in the air around you, but most of them are too small to see.

Try This  
Skills Focus  developing hypotheses  
Materials  glass, limewater, straw  
Time  10 minutes  
Tips  Make sure students are careful not to splash or ingest any of the limewater.

Expected Outcome  Students should observe that the limewater becomes cloudy when they blow into it because of carbon dioxide in their breath. After exercise, more carbon dioxide is exhaled, causing the limewater to get cloudier.

Extend  Invite students to detect carbon dioxide in carbonated water by adding some of it to the limewater. 

Learning modality: kinesthetic

Section 1 Review  
1. Describe two ways in which the atmosphere is important to life on Earth.
2. What are the four most common gases in dry air?
3. Why are the amounts of gases in the atmosphere usually shown as percentages of dry air?
4. Thinking Critically Applying Concepts  How would the amount of carbon dioxide in the atmosphere change if there were no plants? If there were no animals?

Check Your Progress  
Have you determined how, where, and when you will make your observations? Organize a notebook to record them. Think of ways to compare weather conditions from day to day. Make your observations without weather instruments or TV weather reports. (Hint: You can estimate how much of the sky is covered by clouds.) For your own safety, do not try to make observations during storms.

Section 1 Review Answers  
1. Any two: Provides oxygen and other gases living things need, traps energy from the sun to keep Earth's surface warm, and protects from meteoroids and radiation from the sun
2. Nitrogen, oxygen, argon, carbon dioxide
3. Because the amount of water vapor in air varies greatly
4. Without plants there would be less oxygen and more carbon dioxide; without animals there would be less carbon dioxide and more oxygen.

Check Your Progress  
Encourage students to observe several different weather variables. They should record the date, time, and place of each observation and also any unusual weather events, such as violent storms.

Answers to Self-Assessment  
Caption Question  
Figure 3  Their flames would go out.

Program Resources  
- Teaching Resources  1-1 Review and Reinforce, p. 15; 1-1 Enrich, p. 16  
- Science Explorer Series  
- Environmental Science, Chapter 2, explains the nitrogen cycle.

Performance Assessment  
Writing  Have students write a paragraph identifying the three most important gases in air for living things, the percentage of each, and why the gas is important.
Layers of the Atmosphere

Is Air There?
1. Use a heavy rubber band to tightly secure a plastic bag over the top of a wide-mouthed jar.
2. Gently try to push the bag into the jar. What happens? Is the air pressure higher inside or outside of the bag?
3. Remove the rubber band and line the inside of the jar with the plastic bag. Use the rubber band to tightly secure the edges of the bag over the rim of the jar.
4. Gently try to pull the bag out of the jar with your fingertips. What happens? Is the air pressure higher inside or outside of the bag?

Think It Over
Predicting Explain your observations in terms of air pressure. How do you think differences in air pressure would affect a weather balloon as it traveled up through the atmosphere?

I magine taking a trip upward into the atmosphere in a hot-air balloon. You begin on a warm beach near the ocean, at an altitude of 0 kilometers.

You hear a roar as the balloon's pilot turns up the burner to heat the air in the balloon. The balloon begins to rise, and Earth's surface gets farther and farther away. As the balloon rises to an altitude of 3 kilometers, you realize that the air is getting colder. As you continue to rise, the air gets colder and colder. At 6 kilometers you begin to have trouble breathing. The air is becoming less dense. It's time to go back down.

What if you could have continued your balloon ride up through the atmosphere? As you rose farther up through the atmosphere, the air pressure and temperature would change dramatically. The four main layers of the atmosphere are classified according to changes in temperature. These layers are the troposphere, the stratosphere, the mesosphere, and the thermosphere.

The Troposphere
You live in the inner, or lowest, layer of Earth's atmosphere, the troposphere. (trop- means “turning” or “changing”). Conditions in the troposphere are more variable than in the other layers. The troposphere is where Earth's weather occurs.

GUIDE FOR READING
- What are the characteristics of the main layers of the atmosphere?

Reading Tip: Before you read, preview Exploring Layers of the Atmosphere. Make a list of unfamiliar words. Look for the meanings of these words as you read.

 Layers of the Atmosphere

Objectives
After completing this lesson, students will be able to:
• describe the characteristics of the main layers of the atmosphere.

Key Terms
troposphere, stratosphere, mesosphere, thermosphere, ionosphere, aurora borealis, exosphere

1 Engage/Explore

Activating Prior Knowledge
Ask: Did you ever see a shooting star? (Most students probably will say yes.)
What is a shooting star? (A meteoroid burning up because of friction as it falls through Earth's atmosphere) Point out that most shooting stars are visible from about 50 to 80 km above Earth in a layer of the atmosphere called the mesosphere. This layer protects us from being bombarded by shooting stars and other space debris. The mesosphere is just one of four major layers of the atmosphere students will read about in this section.

Skills Focus: predicting
Materials: heavy rubber band, plastic bag, wide-mouthed glass jar
Time: 10 minutes
Tips: Make sure the rubber band is tight and the plastic bag does not have holes in it. Caution students to push gently on the bag to avoid breaking the bag or the jar.
Expected Outcome: Students should find it difficult to push the bag into or pull it out of the jar.

Think It Over: Trying to push the bag into the jar decreases the volume and increases the air pressure inside the jar. Trying to pull the bag out of the jar increases the volume and decreases the air pressure inside the jar. As a weather balloon traveled up, it would expand until it burst as the air pressure outside the balloon became lower than the air pressure inside.
The Troposphere

Building Inquiry Skills: Graphing
Challenge students to calculate the temperature for every 1,000 m above Earth's surface in the troposphere, starting at sea level and ending at 10,000 m. They should assume that the temperature is 15.0°C at sea level and decreases 0.5 Celsius degrees for each 1,000-m increase in altitude. Then have students draw a graph that shows the relationship between altitude and temperature in the troposphere.

learning modality: logical/mathematical

The Stratosphere

Addressing Naive Conceptions
In Section 2, students read that ozone is a harmful chemical in smog. In this section, they read that ozone is a natural component of the atmosphere that protects Earth from solar radiation. Students may wonder if ozone is harmful or not. Explain that the ozone in the stratosphere absorbs and thus protects us from, too much sunlight. Ozone in this layer occurs naturally. However, ozone in the troposphere harms our health and contributes to photochemical smog. Ozone in this layer is caused by pollution. limited English proficiency

The Mesosphere

Building Inquiry Skills: Inferring
Challenge students to explain why there is a temperature reversal between the stratosphere and mesosphere. Ask: Why is the mesosphere colder than the stratosphere? (Because it contains no ozone molecules to absorb solar radiation and convert the radiation into heat)

learning modality: logical/mathematical

Although hot-air balloons cannot travel very high into the troposphere, other types of balloons can. To measure weather conditions, scientists launch weather balloons that carry instruments up into the atmosphere. The balloons are not fully inflated before they are launched. Recall that air pressure decreases as you rise through the atmosphere. Leaving the balloon only partly inflated gives the gas inside the balloon room to expand as the air pressure outside the balloon decreases.

The depth of the troposphere varies from more than 16 kilometers above the equator to less than 9 kilometers above the North and South Poles. Even though it is the shallowest layer of the atmosphere, the troposphere contains almost all of the mass of the atmosphere.

As altitude increases in the troposphere, the temperature decreases. On average, for every 1-kilometer increase in altitude the air gets about 6.5 Celsius degrees cooler. At the top of the troposphere, the temperature stops decreasing and stays constant at about -60°C. Water here forms thin, feathery clouds of ice.

Checkpoint Why are clouds at the top of the troposphere made of ice crystals instead of drops of water?

The Stratosphere

The stratosphere extends from the top of the troposphere to about 50 kilometers above Earth's surface. Strato- is similar to stratus, which means "layer" or "spreading out."
The lower stratosphere is cold, about -60°C. You might be surprised to find out that the upper stratosphere is warmer than the lower stratosphere. Why is this? The upper stratosphere contains a layer of ozone, the three-atom form of oxygen. When the ozone in the stratosphere absorbs energy from the sun, the energy is converted into heat, warming the air.

As a weather balloon rises through the stratosphere, the air pressure outside the balloon continues to decrease. The volume of the balloon increases. Finally, the balloon bursts, and the instrument package falls back to Earth's surface.

The Mesosphere

Above the stratosphere, a drop in temperature marks the beginning of the next layer, the mesosphere. Meso- means "middle," so the mesosphere is the middle layer of the atmosphere. The mesosphere begins 50 kilometers above Earth's surface and ends at 80 kilometers. The outer mesosphere is the coldest part of the atmosphere, with temperatures near -90°C.

Background

Facts and Figures You may wish to share the following facts and figures about the mesosphere with students.
- The mesosphere is the coldest part of the atmosphere. Temperatures there reach lows that are as cold as the lowest temperatures ever recorded anywhere on Earth.
- Oddly, air temperatures in the mesosphere are colder in summer than in winter. Temperatures there also are colder over the equator than over the North and South poles.
- The clouds that form in the mesosphere are unlike any other clouds in the atmosphere. They are formed of ice crystals and are called noctilucent clouds because they are visible only at night.
EXPLORING **Layers of the Atmosphere**

The atmosphere is divided into four layers: the troposphere, the stratosphere, the mesosphere, and the thermosphere. The thermosphere is further divided into the ionosphere and the exosphere.

**Materials**
- Posterboard
- Colored markers
- Index cards
- Buttons and other small objects for game pieces

**Time**
30 minutes

Divide the class into groups and have each group use the information presented in the feature to create a board game. The object of the game should be to get from the ground to the top of the atmosphere. Reaching the objective might involve overcoming various obstacles in the different layers of the atmosphere, such as clouds and storms in the troposphere, very high temperatures in the stratosphere, meteoroids in the mesosphere, electrically charged ions in the ionosphere, and orbiting satellites in the exosphere. To advance through the layers of the atmosphere, players might be required to correctly answer questions about each layer, such as the layer's temperature or height above Earth's surface. Group members should work together to brainstorm the objectives and rules of the game. The actual work of constructing the game board and other parts of the game should be divided up among individual group members. Suggest that the groups exchange games and try them out.

**Cooperative Learning**

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**Media and Technology**

**Exploring Earth Science Videodisc**
Unit 2, Side 2, "A Trip Through the Earth"

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**Answers to Self-Assessment**

**Caption Question**

*Figure 13* The first layer is the troposphere.

**Checkpoint**

Because the temperature at that altitude is always below the freezing point of water.

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**Ongoing Assessment**

**Writing** Challenge students to write a short story describing their imaginary ascent up through the troposphere and stratosphere in a hydrogen balloon. They should describe the conditions they pass through in each layer.

**Portfolio** Students can save their stories in their portfolios.
The Mesosphere, continued

Integrating Space Science

Stress that the mesosphere protects Earth from meteoroids that are pulled toward the planet by gravity. Tell students that the moon has gravity, too, but no atmosphere to protect it from meteoroids. As a result, meteoroids crash on the moon's surface, forming large depressions called craters. Challenge students to draw labeled diagrams showing what happens to meteoroids that fall toward the moon as compared with those that fall toward Earth.

limited English proficiency

Point out that exploring the atmosphere is difficult because it requires scientists or their instruments to reach high altitudes. Ask: What are some ways explorers of the atmosphere have made scientific observations at high altitudes? (By climbing to the tops of mountains, ascending in hydrogen balloons, flying kites, and attaching instruments to balloons and satellites)

What have these explorers learned through these means? (That air pressure decreases with altitude, that lightning is a form of electricity, how the sun influences the atmosphere, and the temperature, air pressure, and humidity at various altitudes)

In Your Journal Ask volunteers to read their paragraphs aloud to the class. The students should join in with them should show they understand how the atmosphere changes with altitude. For example, warm clothing would be necessary above an altitude of just a few kilometers because temperature declines steadily with increasing altitude. Also, a supply of oxygen would be needed above about 7 km. Instruments should include at least a thermometer for measuring changes in temperature and a barometer for measuring changes in air pressure.

learning modality: verbal

Background

Facts and Figures At sea level, an air molecule can travel just a fraction of a centimeter before colliding with another, whereas in the upper thermosphere it can travel as far as 10 km before colliding with another. Because of their very high temperatures, air molecules in the upper thermosphere move at speeds of up to 40,000 km per hour, allowing many to escape into outer space. Therefore, where the thermosphere ends and outer space begins is arbitrary. Air molecules become farther and farther apart as you travel higher above Earth's surface until, somewhere thousands of kilometers above the surface, there are no more air molecules.
meter of air at sea level and expanded it into 100,000 cubic meters at the top of the mesosphere. The outermost layer of the atmosphere, the thermosphere, extends from 80 kilometers above Earth's surface outward into space. It has no definite outer limit. The atmosphere does not end suddenly at the outer edge of the thermosphere. Gas atoms and molecules there are so far apart that the air blends gradually with outer space.

The *thermo-* in thermosphere means "heat." Even though the air in the thermosphere is thin, it is very hot, up to 1,800°C. The temperature in the thermosphere is actually higher than the temperature in a furnace used to make steel. But why is the thermosphere so hot? Energy coming from the sun strikes the thermosphere first. Nitrogen and oxygen molecules convert energy from the sun into heat.

**In Your Journal**

Imagine you were one of the first people to go up into the atmosphere in a balloon. What would you need to take? Find out what the early explorers took with them in their balloons. Write at least two paragraphs about what you would take, and why.

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**Building Inquiry Skills: Modeling**

**Time** 5 minutes

Challenge a group of student volunteers to pretend they are atoms and molecules and to demonstrate the density and speed of atoms and molecules in the atmosphere. First, at sea level, then in the thermosphere. For sea level, students should stand close together and move very slowly. For the thermosphere, they should stand as far apart as possible and move very quickly. Point out that the classroom would have to be much larger for them to be as far apart as atoms and molecules really are in the thermosphere. Ask: How much larger would the classroom have to be? (Almost 100,000 times larger)

**Learning Modality:** kinesthetic

**Including All Students**

To help students whose native language is not English remember that the defining characteristic of the thermosphere is its high temperature, stress that the prefix *thermo-* means "heat." Ask: What are some other words that start with this prefix? (thermometer, thermostat, thermal, thermos) Have students explain how each of the terms is related to heat. **limited English proficiency**

**Program Resources**

**Interdisciplinary Exploration Series**

"Wagons West," p. 41

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**Checkpoint**

The mesosphere extends from 50 to 80 km above Earth's surface, so it has a depth of 30 km.

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**Ongoing Assessment**

**Oral Presentation** Call on students to describe density, temperature, and pressure of air in the thermosphere as compared with the troposphere. Call on other students to explain why the thermosphere has these characteristics.
The Thermosphere, continued

Integrating Technology
Help students understand why satellites orbit Earth at such high altitudes. First point out that molecules in air create resistance that can slow down objects orbiting Earth. Then ask: What happens to the density of molecules in air as you go higher above Earth’s surface? (It decreases.) Why do you think satellites orbit Earth at such high altitudes? (The lower density of air molecules creates less resistance to slow down orbiting satellites.)

Learning modality: logical/mathematical

3 Assess

Section 4 Review Answers
1. Answers may vary. The troposphere is where weather occurs. The stratosphere contains the ozone layer. The mesosphere is where most meteoroids burn up. The thermosphere is very hot.
2. A shooting star, or meteor, is a trail of hot, glowing gas left by a meteoroid as it burns up in the atmosphere. You would see it in the mesosphere.
3. A glowing light display caused when energy from the sun causes gas molecules to become electrically charged; it occurs in the lower layer of the thermosphere.
4. Because it does not absorb much energy from the sun

Check Your Progress
Students may observe such trends in their observations as cooler temperatures after a storm and fair weather after an increase in air pressure. Which weather conditions changed most will depend partly on how precisely the variables were measured. Also, some weather variables, such as temperature and wind speed, have a greater range than others, including air pressure.

Despite the high temperature, however, you would not feel warm in the thermosphere. An ordinary thermometer would show a temperature well below 0°C. Why is that? Temperature is the average amount of energy of motion of each molecule of a substance. The gas molecules in the thermosphere move very rapidly, so the temperature is very high. However, the molecules are spaced far apart in the thin air. And there are not enough of them to collide with a thermometer and warm it very much. So an ordinary thermometer would not detect the molecules’ energy.

The Ionosphere The thermosphere is divided into two layers. The lower layer of the thermosphere, called the ionosphere (eye AHN uh sfer), begins 80 kilometers above the surface and ends at 550 kilometers. Energy from the sun causes gas molecules in the ionosphere to become electrically charged particles called ions. Radio waves bounce off ions in the ionosphere and then bounce back to Earth’s surface.

The brilliant light displays of the aurora borealis—the Northern Lights—also occur in the ionosphere. The aurora borealis is caused by particles from the sun that enter the ionosphere near the North Pole. These particles strike oxygen and nitrogen atoms in the ionosphere, causing them to glow.

The Exosphere Exo- means “outer,” so the exosphere is the outer layer of the thermosphere. The exosphere extends from 550 kilometers outward for thousands of kilometers. When you make a long-distance phone call or watch television, the signal may have traveled up to a satellite orbiting in the exosphere and then back down to your home. Satellites are also used for watching the world’s weather and carrying telescopes that look deep into space.

Check Your Progress
At this point, review your weather log. What do you notice about the weather on one day that might allow you to predict the next day’s weather? What weather conditions changed the most from day to day? Continue to record your observations and start thinking about how you will present them.

Background

Facts and Figures Another sphere around Earth, called the magnetosphere, extends above the atmosphere to more than 65,000 km above Earth’s surface. It is a magnetic field that traps charged particles from the sun. The trapped particles follow the lines of magnetic force and bounce back and forth from one pole to the other, sometimes breaking through into the ionosphere to produce auroras.
Section 2 Air Quality

Objectives
After completing the lesson, students will be able to
- name the main sources of air pollution;
- explain how photochemical smog and acid rain form.

Key Terms pollutant, photochemical smog, acid rain

Engage/Explore

Activating Prior Knowledge
Guide students in recalling weather reports they may have seen or heard that included an air quality index or pollen count. Alternatively, share copies of newspaper weather reports that include these measures. Then ask: Why do weather reports include warnings about pollution and pollen in the air? (Because high levels of pollution and pollen in the air can make people sick)

What is the source of pollen in the air? (plants) What are some sources of pollution in the air? (cars and factories)

Discover

Skills Focus observing Activity modeling clay;

Materials aluminum foil, candle, matches, glass jar

Time 10 minutes

Tips Before students light their candles, be sure the candles are firmly in place in the modeling clay. When students put their jars near the flame, caution them to avoid touching the wax or wick.

Expected Outcome Students should see black powder collect on the part of the jar just above the flame. In addition to soot, students may see condensation form on the jar from water vapor in the air.

Think It Over The black powder on the jar is soot, which came from the incomplete burning of the wax candle.

Reading Strategies

Reading Tip Evidence supporting the statement that air pollution is caused by human activities includes the fact that most air pollution is the result of burning fossil fuels. Evidence contradicting the statement includes the fact that many natural processes add particles to the air. Some particles from natural sources are ocean salt, molds, plant pollen, soil, and ashes from forest fires and volcanoes.

Program Resources
- Teaching Resources 1-2 Lesson Plan, p. 17; 1-2 Section Summary, p. 18.
- Integrated Science Laboratory Manual, I-1, "Examining Acid Rain"
- Science Explorer Series Environmental Science, Chapter 5, gives more information on the causes of air pollution.

One hundred years ago, the city of London, England, was dark and dirty. Factories burned coal, and most houses were heated by coal. The air was full of soot. In 1905, the term smog was created by combining the words smoke and fog to describe this type of air pollution. Today, people in London burn much less coal. As a result, the air in London now is much cleaner than it was 100 years ago.

Air Pollution
As you are reading this, you are breathing without even thinking about it. Breathing brings air into your lungs, where the oxygen you need is taken into your body. You may also breathe in tiny particles or even a small amount of harmful gases. In fact, these particles and gases are a concern to people everywhere.

If you live in a large city, you probably already know what air pollution is. You may have noticed a brown haze or an unpleasant smell in the air. Even if you live far from a city, the air around you may be polluted. Harmful substances in the air, water, or soil are known as pollutants. Figure 5 shows some of the effects of air pollution on human health.

Figure 5 Air pollution can cause many different problems. Some air pollutants are natural, but most are caused by human activities. Interpreting Photographs What parts of the body are most affected by air pollution?
Some air pollution occurs naturally, but much of it is caused by human activities. Most air pollution is the result of burning fossil fuels such as coal, oil, gasoline, and diesel fuel. Almost half of the air pollution from human activities comes from cars and other motor vehicles. A little more than one fourth comes from factories and power plants that burn coal and oil. Burning fossil fuels produces a number of air pollutants, including particles and gases that can form smog and acid rain.

Checkpoint What are two sources of air pollution that you see every day?

Particles
As you know, air contains particles along with gases. When you draw these particles deep into your lungs, the particles can be harmful. Particles in the air come from both natural sources and human activities.

Natural Sources Many natural processes add particles to the atmosphere. When ocean waves splash salt water against rocks, some of the water sprays into the air and evaporates. Tiny salt particles stay in the air. The wind blows particles of molds and plant pollen. Forest fires, soil erosion, and dust storms add particles to the atmosphere. Erupting volcanoes spew out clouds of dust and ashes along with poisonous gases.

Even fairly clean air usually contains particles of dust and pollen. Figure 6 shows pollen, a fine, powdery material produced by many plants. The wind carries pollen not only to other plants, but also to people. One type of allergy, popularly called "hay fever," is caused by pollen from plants such as ragweed. Symptoms of hay fever include sneezing, a runny nose, red and itchy eyes, and headaches. Weather reports often include a "pollen count," which is the average number of pollen grains in a cubic meter of air.

Human Activities When people burn fuels such as wood and coal, particles made mostly of carbon enter the air. These particles of soot are what gives smoke its dark color. Farming and construction also release large amounts of soil particles into the air.

Figure 6 These pollen grains from a ragweed flower have been greatly magnified to show detail. Pollen can cause people who are allergic to it to sneeze.

Air Pollution

Demonstration Materials cotton ball, fingernail polish remover, glass jar with lid, rayon cloth, tape
Time 5 minutes one day, 5 minutes the next day

Point out that air pollution is bad for clothing and other materials as well as for people. To show students the effect of air pollution on cloth, saturate a cotton ball with fingernail polish remover, which contains acetone, and place it in the bottom of a glass jar. Tape a small piece of rayon to the inside of the jar lid and put the lid on tightly. Place another small piece of rayon beside the jar and leave both overnight. The next day, invite students to compare the two pieces of cloth. Ask: Why did the cloth in the jar weaken? (The fingernail polish produced acetone vapors that attacked fibers in the cloth.) Add that similar vapors pollute the air over cities. Learning modality: kinesthetic

Particles

Integrating Health

Invite students to learn more about allergies such as hay fever by working in groups to conduct a survey. Each group member should ask family members, friends, and neighbors if they suffer from hay fever or other allergies. Then group members should pool their results and use the data to identify the frequency of such allergies. Cooperative learning

Answers to Self-Assessment

Caption Questions

Figure 5 The respiratory system, including the nose, throat, and lungs

Figure 7 It might have caused respiratory and other health problems.

Checkpoint
Motor vehicles and factories or power plants that burn coal or oil

Figure 7 These people in Pontianak, Indonesia, are being given dust masks to protect them from smoke caused by widespread forest fires. Inferring What effects do you think this smoke might have had on the people who live in this area?

Media and Technology

Audio Tapes English-Spanish Summary 1-2

Transparencies "Effects of Air Pollutants on Humans?" Transparency 2

Ongoing Assessment

Concept Mapping Have students make a concept map of particles found in the air, including sources and examples.
Sharpen your Skills

Predicting

Time: 10 minutes

Expected Outcome: The amount of pollutants may vary by time of day and day of week. Cars and trucks produce the most pollution during morning and evening rush hours, and factories and plants produce pollutants throughout the workday. Thus, pollution levels are likely to be higher late in the day and on Fridays after pollutants have accumulated.

Extend: Have students predict how pollutants in air might vary by season.

learning modality: logical/mathematical

Acid Rain

Inquiry Challenge

Materials: two saucers, two pennies, tap water, vinegar

Time: 10 minutes one day; 5 minutes the next day

Challenge small groups to brainstorm a way to use the materials to show the effects of acid rain on metal. (The most likely way is to place each penny on a saucer, cover one penny with vinegar and the other with water, and let them stand overnight.)

cooperative learning

Background

Facts and Figures: The 99.9% of the atmosphere that is made up of nitrogen, oxygen, and argon has remained relatively stable for the past 100 million years. Chemical interactions among fewer than 0.1% of molecules in the atmosphere are the cause of all the air quality problems facing us today, including smog and acid rain.

The average pH of rain water is about 4.2, which means that it is weakly acidic. Rain in remote areas little affected by pollution is less acidic and may have a pH as high as 4.8. Considerably more acidic water is found in the smog over Los Angeles. It may have a pH as low as 1.8. To put these values in perspective, consider that tomato juice has a pH of 4.3, vinegar a pH of 2.8, and battery acid a pH of 0.8.
Rain, sleet, snow, fog, and even dry particles carry these two acids from the air to trees, lakes, and buildings. Rain is naturally slightly acidic, but rain that contains more acid than normal is known as acid rain. Acid rain is sometimes strong enough to damage the surfaces of buildings and statues.

As Figure 8 shows, needle-leaved trees such as pines and spruce are especially sensitive to acid rain. Acid rain may make tree needles turn brown or fall off. It also harms lakes and ponds. Acid rain can make water so acidic that plants, amphibians, fish, and insects can no longer survive in it.

**Improving Air Quality**

The United States government and state governments have passed a number of laws and regulations to reduce air pollution. For example, pollution-control devices are required equipment on cars. Factories and power plants must install filters in smokestacks to remove pollutants from smoke before it is released into the atmosphere. These filters are called scrubbers.

Air quality in this country has generally improved over the past 30 years. The amounts of all major air pollutants have decreased. Newer cars cause less pollution than older models. Recently-built power plants are less polluting than power plants that have been in operation for many years.

However, there are now more cars on the road and more power plants burning fossil fuels than in the past. Unfortunately, the air in many American cities is still polluted. Many people think that stricter regulations are needed to control air pollution. Others argue that reducing air pollution is very expensive and that the benefits of stricter regulations may not be worth the costs.

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**Section 2 Review**

1. How is most air pollution produced?
2. Name two natural and two artificial sources of particles in the atmosphere.
3. How is photochemical smog formed? What kinds of harm does it cause?
4. What substances combine to form acid rain?
5. Thinking Critically Inferring Do you think that photochemical smog levels are higher during the winter or during the summer? Explain.

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**Science at Home**

- It's easy to see particles in the air. Gather your family members in a dark room. Open a window shade or blind slightly, or turn on a flashlight. Can they see tiny particles suspended in the beam of light? Discuss with your family where the particles came from. What might be some natural sources? What might be some human sources?

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**Answers to Self-Assessment**

Pollutants in the air produced by human activities react with each other in the presence of sunlight to form photochemical smog.

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**Improving Air Quality**

**Building Inquiry Skills: Inferring**

Point out that nitrogen dioxide and sulfur dioxide have decreased over the past 30 years. Ask: How do you think the level of acid in rain has been affected by these trends in air pollutants? (Nitrogen dioxide and sulfur dioxide cause acid rain, so as they have decreased in the air, the amount of acid in rain probably has decreased as well.) Learning Modality: logical/mathematical

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**Section 2 Review Answers**

1. By the burning of fossil fuels
2. Natural: ocean salt, molds, plant pollen, forest fires, soil erosion, volcanoes; Artificial: burning of fossil fuels, farming, and construction
3. It forms when nitrogen oxides, hydrocarbons, and other pollutants react in the presence of sunlight. It can irritate breathing passages, harm plants, and damage rubber, paint, and some plastics.
4. Nitrogen oxides, sulfur oxides, and water in the air
5. During the summer, because the production of photochemical smog requires sunlight and the sun's rays are more direct then

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**Science at Home Tips**

Students will see more particles if they stir up dust first. Point out that most particles in the air are too small to be seen without a microscope. Natural sources include plant pollens and molds. Human sources include soot from motor vehicles and soil from farming and construction.

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**Writing**

Challenge students to write letters to a newspaper to raise peoples' awareness of the causes and dangers of air pollution.