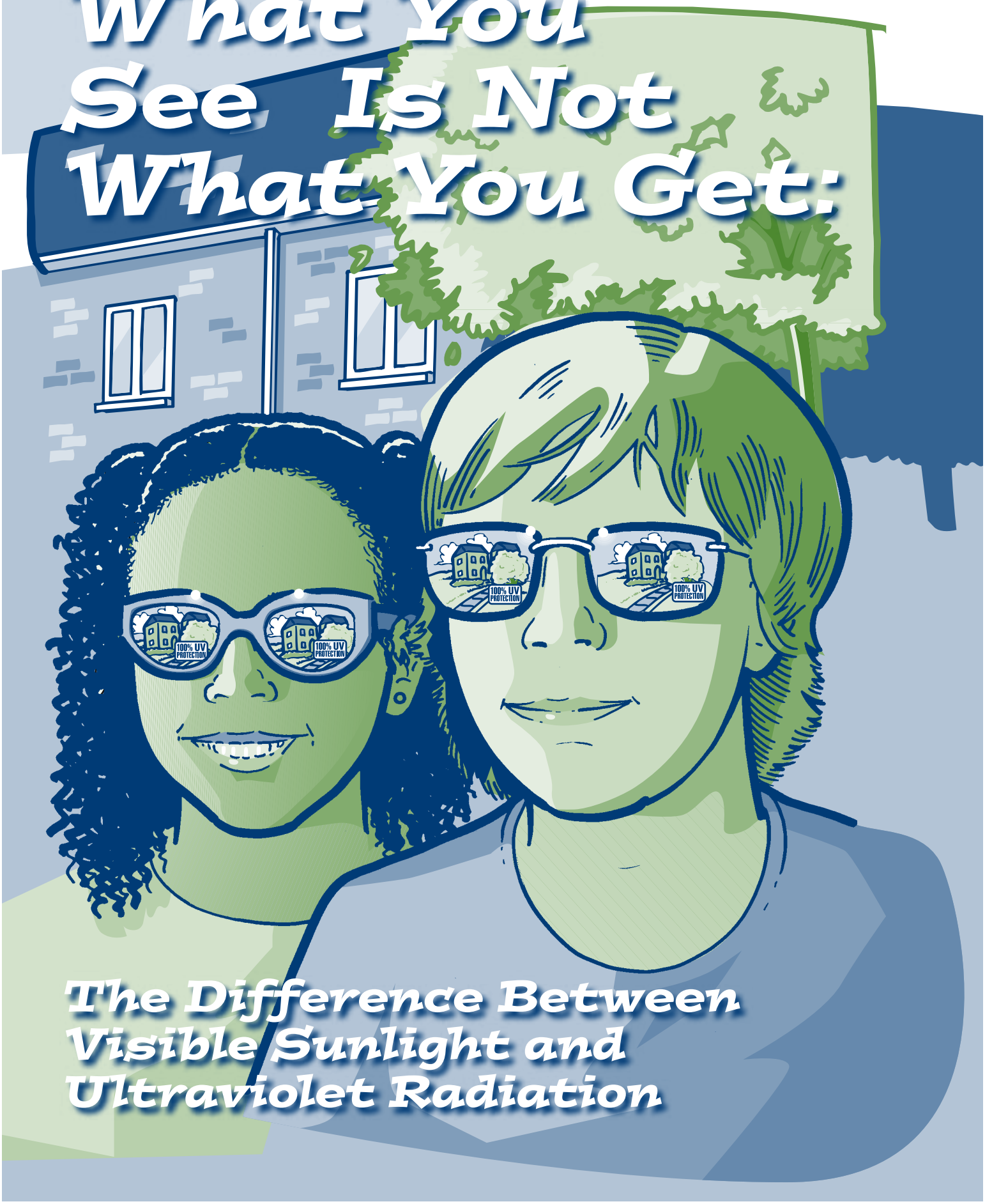
What You See Is Not What You Get:



The Difference Between Visible Sunlight and Ultraviolet Radiation

Meet the Scientists

Dr. Grant: ▼ My favorite experience as a scientist is solving a puzzle of why something in nature acts like it does or discovering an explanation for something I have seen many times but did not know why it happened.

Dr. Heisler: ▲ My favorite experience as a scientist is getting to understand something about how nature works. I also like to successfully develop or use a method to measure how nature works.

Thinking About Science

Scientists use many ways to discover new knowledge. Sometimes collecting existing information from many sources and putting it together in one report is a valuable addition to science. This is similar to what you do when you write a paper using information from the library and the Internet. In this study, the scientists collected information from past research and added it to their own research findings. In this research, the scientists wanted to know how much is already known about *ultraviolet radiation* in urban areas.

Glossary:

ultraviolet radiation (**all** tra vi o let ra de a shun): Invisible rays of light lying beyond the violet end of the spectrum.

immune system (im **myoon sis** tem): The system within the body that protects the body from disease; includes white blood cells and antibodies.

relationship (re **la** shun ship): Two or more things that are connected in some fashion.

optical (**op** tuh kül): Relating to vision or to light.

species (**spe** sez): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure.

quantity (**kwän** tä ti): An amount or portion.

tree crown (**tre** krown): The upper green section of a tree with leaves or needles.

reflectivity (re flek **tiv** uh te): The property of casting back light, heat, sound, etc.

average (**av** rij): The usual kind or amount. The number gotten by dividing the sum of two or more quantities by the number of quantities added.

canopy (**kan** uh pe): Anything that covers like a roof. On a tree, the area of leaves that cover the ground.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	ng	as in sing

Accented syllables are in **bold.**

Thinking About the Environment

All life on Earth needs the sun because it is the original source of all of our energy and food. Sometimes, however, we can get too much of a good thing. Take ultraviolet radiation, for example. Ultraviolet radiation, or UV radiation, comes from the sun and is invisible. UV radiation is a part of the **electromagnetic** (e **lek** tro mag **net** ik) spectrum (**figure 1**). What makes UV radiation good? UV radiation causes the skin to create Vitamin D, which helps people to absorb calcium. A little bit of sunlight can also protect people from some kinds of nonskin cancers. Too much UV radiation, however, can be hazardous to human health. If you are going to be in the sun for a long time, use sunscreen or cover your skin. Some of the negative impacts of too much UV radiation include sunburn, eye damage, and skin cancer. Because too much UV radiation may damage a person's *immune system*, other cancers and diseases may be related to having too much sun exposure.

Introduction

Scientists have known that there is a difference between the sun's visible radiation and invisible ultraviolet radiation from the sun. (**See figure 1.**) Ultraviolet radiation is separated into 3 types: UVA, UVB, and UVC. UVB radiation is best known for its ability to cause damage to human health. At the short end of the UVB wavelength, where UVB meets UVC, almost all of the radiation is absorbed by ozone in the atmosphere. At the longer end of the wavelength, UVB meets UVA radiation. Ozone does not absorb very much of the radiation at this end of the UVB spectrum (**figure 2**).

When it is hot or very sunny, people often seek the shelter of a tree's shade to protect them from the sun. This is because the tree's leaves provide shade from the sun's visible radiation. Although leaves protect people from the sun's visible radiation, they may not protect people from invisible UVB radiation. The scientists in this study were interested in trees growing in urban areas. They wanted to know whether the shade that we can see under urban trees protects people from UVB radiation. Ultimately, it is shade from the UVB radiation that is the most important for human health.

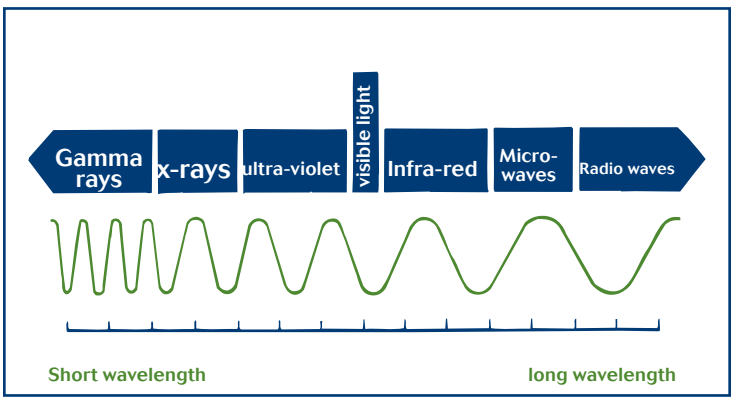


Figure 1. Electromagnetic Spectrum

Reflection Section

- What question did the scientists want to answer?
- Why is this question important?

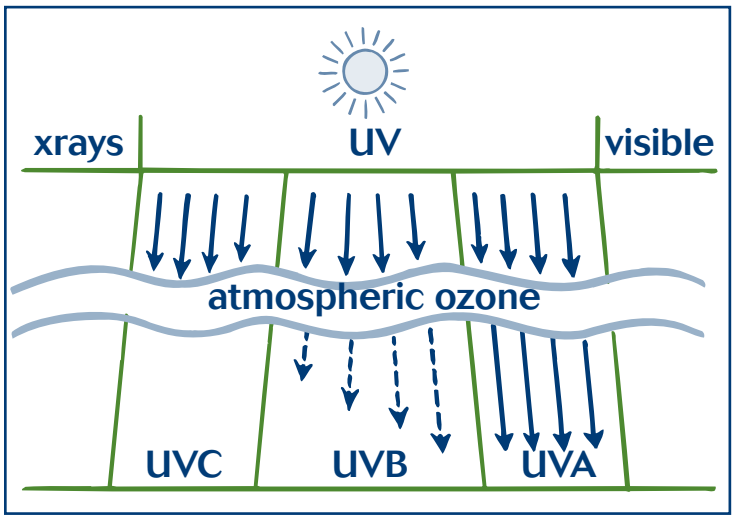


Figure 2. UVA, UVB, and UVC radiation and their *relationship* to ozone in the atmosphere.

Method

The scientists read over 100 research papers that were related in some way to the question about the sun's radiation on urban trees. Urban trees are the trees that grow where people live, work, and play. The scientists also had the results from their own previous research. The scientists were most interested in the *optical* properties of leaves. They read research papers that reported how much of the sun's visible radiation and UVB radiation passes through leaves. They read research about how the leaves from different tree *species* reflect visible radiation and UVB radiation. They read research about how the *quantity* of visible radiation compares with the quantity of UVB radiation in the sunny areas near urban trees. They included the information they had collected themselves about the amount of radiation reaching the area under urban trees. Then, they put all of the information together into one report.

Reflection Section

- Name two reasons why is it important to find out what is already known about something before doing an experiment or collecting your own information about it.
- From your own observation, would you say that leaves allow the sun's visible radiation to pass through them? Why or why not?

Findings

The scientists found that while leaves allow some of the sun's visible radiation to pass through them, *tree crowns* do not allow much light to pass to the ground. This is because most of the sun's rays encounter many leaves as they attempt to get through the crown. Therefore, the scientists focused their attention on the *reflectivity* of leaves (**figure 3**). They found that the reflectivity of visible radiation is much higher than invisible UVB

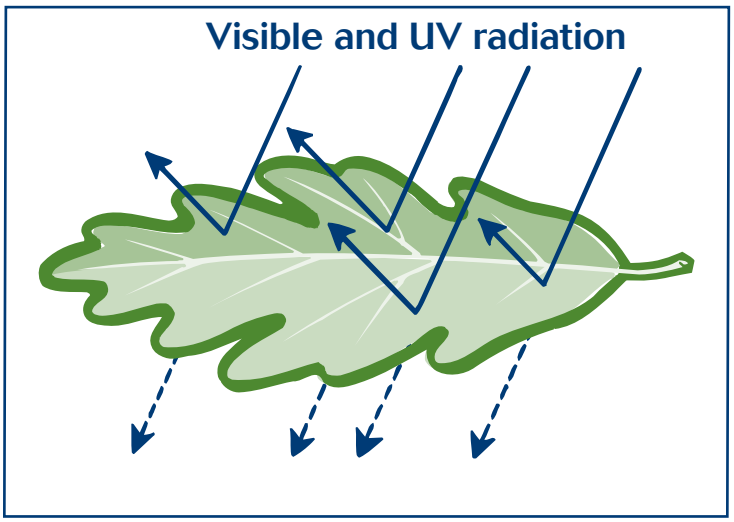


Figure 3. The reflection of the sun's radiation off of a leaf.

radiation. For example, about 10 to 30 percent of the sun's visible radiation is reflected off of leaves. About 3 to 6 percent of the sun's UVB radiation is reflected off of leaves.

In dense forests you can usually only see a small part of the sky from the forest floor. In these forests, only a little visible radiation and UVB radiation reach the forest floor. This is because there are many layers of leaves shielding the forest floor from the sky.

The situation is very different in urban forests. In urban forests, trees either are planted alone or with just a few others (**figure 4**). In urban forests, people can usually see the

Figure 4. In an urban forest, people can see the sky beyond the edge of the tree crown.

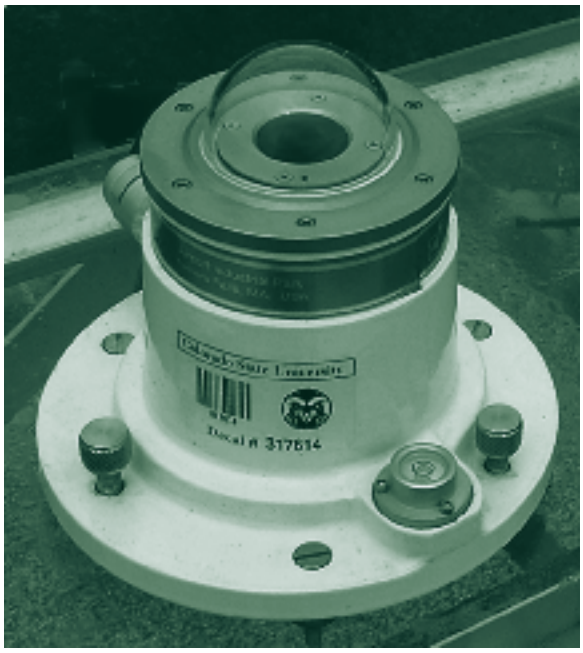


Figure 5. Scientists use special sensor equipment placed under a tree or on the ground to measure the amount of the sun's radiation reaching the ground. Notice the clear bubble on the top of the equipment.

sky beyond the edge of the tree crown. The scientists used special equipment to measure the amount of radiation reaching the ground, both in the open and under urban trees (**figures 5 and 6**). UVB radiation is widely scattered across the sky. If a person can see much of the sky, the UVB radiation reaches them even when they are under a tree.

The scientists reported some of their own research, in which they measured the amount of radiation reaching six types of areas (**table 1**). The six areas were:

1. Sunlit areas under a tree in summer (with leaves)
2. Shady areas under a tree in summer (with leaves)
3. Sunlit areas under a tree in winter (no leaves)
4. Shady areas under a tree in winter (no leaves)
5. Sunlit areas under a tree in winter with a building nearby (no leaves)
6. Shady areas under a tree in winter with a building nearby (no leaves)

Figure 6. If the equipment could see, this is an example of what it would see.

Area Under Tree Canopy	Percent Reduction in UVB Radiation	Percent Reduction in Visible Radiation
1. Sunlit Area–With Leaves	39	3
2. Shady Area–With Leaves	63	84
3. Sunlit Area–No Leaves	40	6
4. Shady Area–No Leaves	56	73
5. Sunlit Area and Building–No Leaves	59	5
6. Shady Area and Building–No Leaves	70	47

Table 1. *Average* percent reductions in the sun's visible radiation and invisible UVB radiation below a street tree *canopy*.

Look closely at **table 1**. If our eyes were able to see UVB radiation, the shadows cast by UVB radiation would be different than the shadows cast by visible radiation. Compare the numbers in areas 1 and 2 in each column. Then look at the numbers in areas 3 and 4 in each column. Now look at the numbers in areas 5 and 6 in each column. You can see that the reduction in UVB radiation was more similar in sunny and shady areas than the reduction in visible radiation in sunny and shady areas. In sunny areas, not much visible radiation is reduced. In shady areas, a lot of the visible radiation is reduced. The radiation that we can see is not like the UVB radiation that we cannot see. The UVB radiation is scattered across the sky. When you can see a part of the sky from where you are standing, you are receiving some UVB radiation.

The scientists also found that in sunny areas close to urban trees, a greater percentage of UVB radiation was reduced even though the

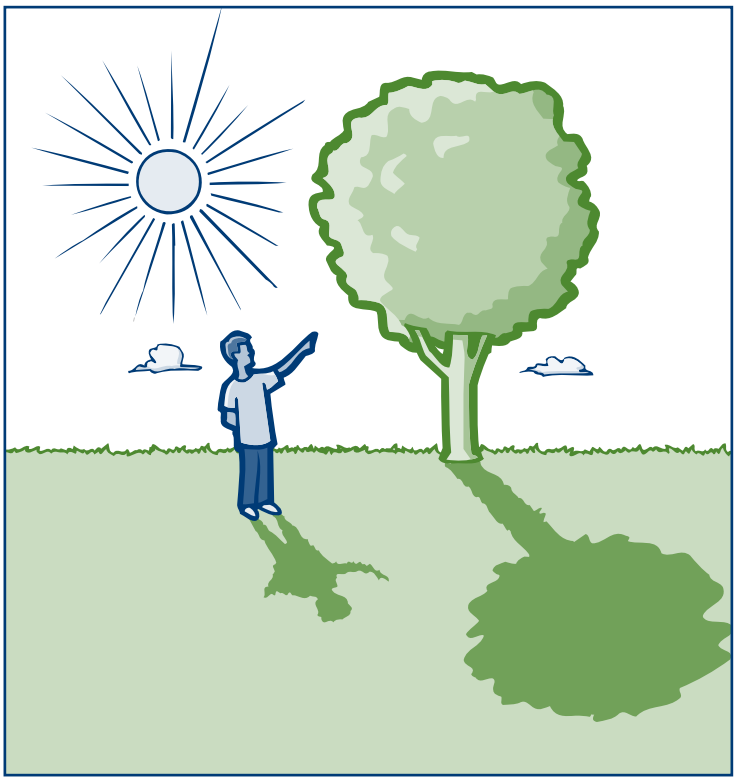


Figure 7. Sunny areas near urban trees experienced a greater reduction in UVB radiation than visible radiation.

Thinking About Ecology

No matter what you look at in nature, it is a part of a system. Systems can exist at a number of different levels, from small and simple to large and complex. Your body is a good example. You have different organs that are systems composed of cells. Your whole body is a larger, more complex system that is composed of different organs. As systems get larger and more complex, new properties appear that were not evident at the smaller and simpler levels. In this study on UVB radiation, the crowns of trees demonstrate this idea. Tree crowns are made up of many individual leaves growing on branches. An individual leaf is one type of system. When hundreds or thousands of leaves make up a tree crown, new things are possible. Now, visible radiation and UVB radiation from the sun can be partially blocked. The temperature under the tree is now lower in the warm summer months. Birds now have a place to build nests. As systems get larger and more complex, new things are possible that were not possible before. ■

visible radiation was not reduced (**figure 7**). This is because when people stand close to a tree, part of the sky is blocked by the tree. When a part of the sky is blocked, some of the UVB radiation is blocked as well.

Reflection Section

- Look at **table 1** and read the paragraph below it. Put the scientists' findings in your own words.
- What do you think these findings mean for protecting yourself from harmful UVB radiation?

Implications

If you are in a densely forested area and cannot see part of the sky above you, you are probably protected from UVB radiation. If you are standing under an urban tree or a small group of trees and you can see part of the sky beyond the edge of the tree crown, you still receive some UVB radiation. The amount of UVB radiation you receive depends on how much of the sky you can see. Larger, older trees provide more protection from UVB than smaller, younger trees. If you are in the sun but just outside of the shade of a large tree, you receive a smaller amount of UVB than if you were standing in the sun farther away from the tree's shade. ■

Reflection Section

- In urban areas, some UVB radiation can be reflected off of buildings, sidewalks, streets, and fountains. Should you consider this source of UVB radiation when trying to protect yourself from the sun? Why or why not?
- Reread the last sentence in the last paragraph above. Why do you think that you receive less UVB radiation when standing in the sun next to a tree than when standing in the sun away from a tree?

From Heisler, G. M. & Grant, R. H. (2000). Ultraviolet radiation, human health, and the urban forest. USDA Forest Service General Technical Report NE-268, Newtown Square, PA.