

ALTITUDE: WHAT'S IN THE AIR?

GUIDING QUESTION

Why does the amount of oxygen in air change at different elevations, and how does this change affect the human body?

Students analyze a visual representation of air at different elevations, imagine their own activity levels with limited oxygen, and compare with Everest climbers.



Handouts

- Oxygen Levels by Elevation

Film Clip

- “Finding Leo Houlding”

VOCABULARY

- acclimate
- air pressure
- atmosphere
- hypoxia
- molecule

DIRECTIONS

1. Access students' prior knowledge about effects of altitude.

Ask students: *Have you ever ascended or descended quickly and noticed a strange feeling in your ears? Perhaps you went up or down in an elevator, airplane, or a long, steep hill. What caused the blocked feeling in your ears?* That feeling is caused by a change in air pressure. The pressure difference when descending 200 feet is very small, but the eardrum's fine membrane is sensitive to it. Although we don't often notice it, air has weight. Think of a tall stack of books, where the book at the bottom of the stack has much more weight on it than the book at the top of the stack. The air at the bottom of the atmosphere—at sea level—has much more weight, or pressure, on it than the air near the top of the atmosphere. When mountaineers go to higher elevations, the pressure decreases, and the decrease in pressure affects the air they breathe.

2. Collect a sample of air from the room.

Use a small clear plastic bag, such as a bulk food bag from the market. Swing the open bag across the air and hold the opening shut to collect an air sample. Holding the bag of air, explain that this sample of the air in our atmosphere contains over one million molecules of nitrogen, oxygen, and other gases. At any elevation, air in Earth's atmosphere contains roughly 78 percent nitrogen, 21 percent oxygen, and one percent other gases such as argon, carbon dioxide, neon, helium, and hydrogen. Inhale a breath of air from the bag and note how much smaller the bag has become. At the elevation where you live, your body is used to inhaling and using a certain amount of oxygen with each breath. Note: If you exhale into the bag to re-inflate it, note that the molecular makeup of exhaled gas would differ from the air originally collected.

3. Discuss the graphic representation of samples of air at different elevations.

Show students the graphic representation on **Handout 1: Oxygen Levels by Elevation** or project it on screen for the class. Focus students on the bottom of the page, at sea level, then gradually move up to 29,000 feet. Explain that the concentration of nitrogen molecules and oxygen molecules in the air is different at different elevations. Imagine that each box represents the bag of air, collected at different elevations.

At **sea level**, an elevation of zero, the bag contains more than one million molecules of nitrogen and oxygen (each dot = about 10,000 molecules).



ALTITUDE: WHAT'S IN THE AIR?

- nitrogen
- oxygen
- red blood cells
- relative humidity

This air has the entire atmosphere pressing down on it. The molecules are condensed, so there are more molecules in a given space. At lower elevations, the human body over time adjusts to the amount of oxygen received with each breath. The amount of oxygen in a breath of air, however, varies even in U.S. cities such as New York City (sea level) and Denver, Colorado (about 5,000 feet). So if traveling to Denver or higher elevations, your body will work harder, and you may need extra rest until you've adjusted.

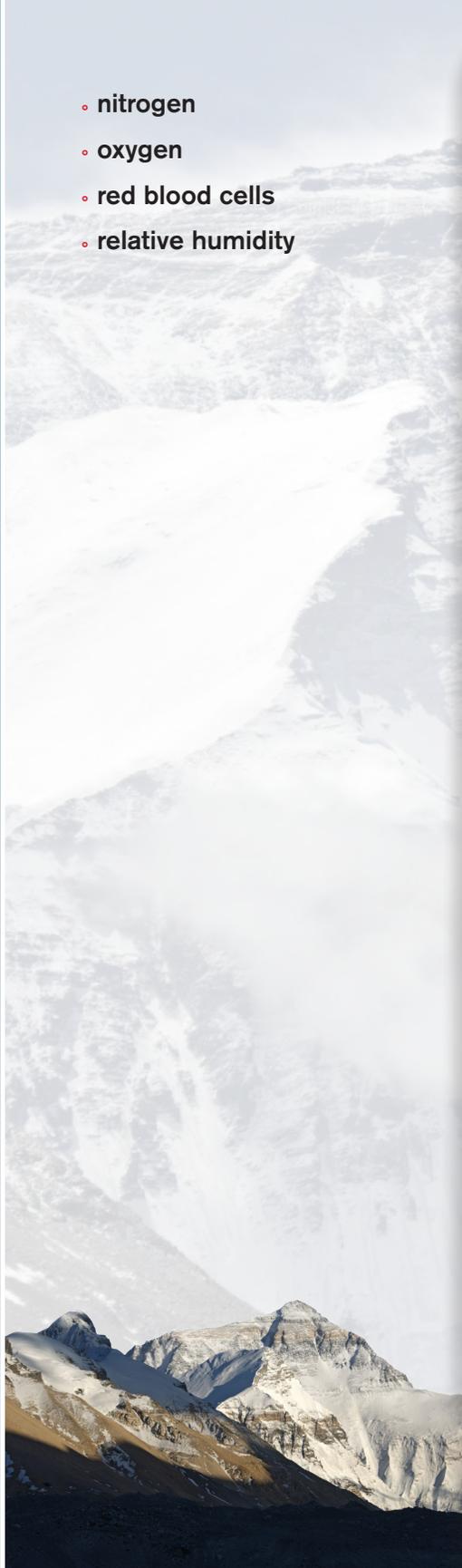
At an altitude of **18,000 feet** there is much less of the atmosphere pressing down. The concentration of nitrogen, oxygen, and other gases is half the concentration at sea level. The air is less dense. This is often referred to as thin air, with molecules more spread out because of the reduced pressure. *Ask: Would you get the same amount of oxygen with each breath?* Not getting enough oxygen with each breath over a long period of time causes hypoxia, or low blood oxygen. Lack of oxygen to the brain, organs, and muscles can cause serious illness, and even death.

At the summit of Mount Everest, **29,035 feet**, there is even less atmosphere pressing down than at 18,000 feet. The concentration of oxygen molecules is one-third the amount at sea level. You could survive a few breaths of air with this amount of oxygen, but not for long. Scientists predict that a person transported directly from sea level to the summit of Everest would die in minutes.

4. Have students imagine the need for more oxygen.

Explain that in this room, it is not possible to change the concentration of oxygen molecules in the air. Students may, however, have already felt the effects of limited oxygen, even at sea level. How? Generate ideas from students, asking: *When have you felt out of breath?* They may cite exercise such as running, hiking, biking, or swimming. During physical exertion, we often need additional oxygen to help us sustain energy over periods of time. Have students imagine what it would be like to have to breathe that heavily—and feel that tired—just from walking across the room. Climbers at high altitudes feel out of breath with just a few steps taken even on level ground.

Students can also do a “thought experiment” where they imagine running in place for one minute. Then have them imagine breathing only through a straw while running in place for the same amount of time. *Ask: How do you think you'd feel while doing this? Do you think it would be possible to run in place for hours breathing only through a straw?* In addition to breathing heavily afterwards to take in more oxygen, they would likely feel dizzy. Climbers on Everest carefully monitor their energy and response to thin air for days or weeks at a time.



ALTITUDE: WHAT'S IN THE AIR?

“Climbers who venture into [the death] zone cannot escape the potentially deadly effects of oxygen deprivation; they can only attempt to minimize and control what breathing the thin air at high altitudes does to their bodies.”

– Brian Handwerk, *National Geographic News*



Some students might be interested to know that competitive swimmers get used to lower levels of oxygen. Swimming laps in the pool can give the feeling of being at high altitude, because the body functions without a lot of oxygen. A swimmer comes up for breaths in a rhythm that limits oxygen intake. Mountain climbers often swim to train for high altitude climbs, holding their breath or going for longer strokes in between breaths.

5. Discuss the mental and physical challenges for an Everest climber, and brainstorm climbers' secrets to survival.

Show the film clip, “Finding Leo Houlding.” Ask: *What was Houlding's chief concern for his upcoming expedition to Everest?* Note that he shares one of the greatest concerns for a mountaineer: how his or her body will react at high altitudes. Despite all of the dangers, climbers do reach the summit of Mount Everest, and most survive the reduced amount of oxygen. How do they do it? Have students brainstorm climbers' secrets of survival.

6. Read the article on the challenge of altitude.

Have students read the online article “[Altitude a Major Challenge to Climbers](#).” Ask them to find out answers to these questions:

- *What happens to the human body with low oxygen levels at high altitudes?* (increased breathing rate, soaring heart rate, thickening of the blood, loss of appetite, inability to sleep, delusions; more serious are buildup of fluid in the lungs or swelling of the brain)
- *What is the secret to survival at high altitudes?* (carry oxygen tanks; acclimate, which means to adapt to a new environment, altitude, or climate. To do this, climbers move to higher altitudes very slowly.)

On Mount Everest, it is typical to climb to 15,000 feet and stay for a short time, then return back down to 12,000 feet and stay for several days. In this way the blood starts to work harder to produce more red blood cells to deliver oxygen throughout the body. The climber then repeats this process from 15,000 to 18,000 feet, and so on.

George Mallory was the one of the first people to climb to these altitudes. During his repeated visits in 1921, 1922, and 1924 he became convinced that climbing high and then coming down again was the key to success. He was a pioneer of the concept of acclimatization.

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EXTENDING THE ACTIVITY

In small groups, have students create their own representation of the contents of air and oxygen's path in the human body at these elevations: 0 feet, 18,000 feet, and 29,000 feet. Students could glue hole-punched colored paper or different colors of dried beans on an outline of the upper body including head, brain, trachea, and lungs. Have them include arrows to show how oxygen moves from the trachea to lungs to the bloodstream, and then to the brain, organs, and muscles.

Have students do research, including the article listed below, about people in Bolivia, Tibet, and East Africa who live at elevations above 12,000 feet. Learn how their bodies have permanently adjusted to altitude.

Research athletes who train at high elevations in Colorado, U.S.A., Kenya, and other parts of the world. Find out how the body adapts to the elevation and helps them become more competitive.

SUGGESTED RESOURCES

National Geographic News: "Altitude a Major Challenge to Climbers"
http://news.nationalgeographic.com/news/2002/05/0513_020514_ADValtitude_2.html

National Geographic News: "Three High-Altitude Peoples, Three Adaptations to Thin Air"
http://news.nationalgeographic.com/news/2004/02/0224_040225_evolution.html



OXYGEN LEVELS BY ELEVATION

Air in Earth's atmosphere contains about 21 percent oxygen, 78 percent nitrogen, and one percent other gases, such as argon, carbon dioxide, neon, helium, and hydrogen. At high altitudes, however, the density of air changes and becomes thin. Thin air is not nearly as rich in oxygen as the dense, more compressed air found at sea level.

