

Respiration Misconceptions

In this episode, I will be covering 5 respiration-related misconceptions as follows:

- 1) Respiration and breathing are the same thing
- 2) Air is mostly oxygen
- 3) The air that we exhale has no oxygen in it
- 4) Plants photosynthesize and animals respire
- 5) Burning a candle under glass can prove that air is 20% oxygen

1) Respiration and breathing are not necessarily the same thing. The problem is that there are two types of respiration, cellular and physiological. Most of the time when the word “respiration” is used in a science class (such as in “photosynthesis and respiration”), it is cellular respiration that is being referred to. Cellular respiration is a chemical process that happens at the cellular level to convert carbohydrates to energy. Breathing is the act of inhaling and exhaling air and is one step in the process of Physiological Respiration. Physiological respiration is the entire act of getting gases from the air to the cells including ventilation (breathing), gas exchange within the lungs, gas transport, and gas exchange with the cells. Although these processes are related, they are clearly not the same thing.

When a doctor measures your respiration rate, they are really measuring your ventilation rate. Respiration cannot be measured with a stethoscope.

2) Many people use the terms oxygen and air interchangeably. As a SCUBA diver, I constantly hear the tanks referred to as oxygen tanks. On the contrary, I also hear people say that a fire needs air to burn. In reality, SCUBA tanks are filled with air and a fire needs oxygen to burn. I used to have my students do an element hunt where they had to bring in 8 pure elements in order to learn the difference between elements, compounds and mixtures. They could not bring salt in for sodium because it is a compound, not an element. Many students would bring in air-filled balloons as elemental oxygen not realizing that air is a mixture, not a pure element. It turns out that air isn't even $\frac{1}{4}$ oxygen. It is 78% nitrogen, 21% oxygen, and only .04% carbon dioxide. The exception to this is Los Angeles where the air is 40% smog . . . just kidding. The bottom line is that air is mostly nitrogen.

3) Many students also think that we breathe in oxygen-rich air and when we breathe out, all of that oxygen has been converted to carbon dioxide. In actuality, the percentage of oxygen only goes down to 16.5% and CO_2 goes up to 4% of the air. Even if you hold your breath for as long as you can stand it, you will not use up all of the oxygen in the air.

4) Students also seem to think that photosynthesis is a process for plants and respiration is a process only for animals. Really, plants do both. In very simplified terms, during photosynthesis, energy from the sun is stored in carbohydrates like sugars. In respiration, that stored energy is used to perform tasks. Plants need to perform tasks too like growing, opening flowers, and producing seeds. The energy to do those things comes from the sun, is stored in carbohydrates, and then is extracted through the process of respiration. Humans eat the carbohydrates from plants or animals that have eaten the carbohydrates from plants and utilize that energy via respiration. So the big difference is that animals get our energy from eating

plants and other animals and plants get their energy from the sun via photosynthesis. But we both utilize that energy via cellular respiration.

5) A common demonstration that teachers do to show that air is only 20% oxygen is to burn a candle under a glass on a saucer of water. When the candle burns out, the water rises up in the glass. The explanation is that all of the oxygen is burned so water had to come in to replace it. But, if you write the equation for the combustion of a carbon-based substance like wax, the oxygen that is burned is converted into carbon dioxide and there is no net change in the amount of gas under the cup. Also, if you repeat the demonstration three times with 1, 2, and 3 candles, the water will rise up higher the more candles you have. Also, if you watch carefully, the water does not rise as the candle is burning, it only rises after the candle goes out.

The oxygen burning is clearly not the explanation for this phenomenon. The part that is left out is that the heat from the candle flame makes the air in the glass expand. When the candle goes out, the air cools and contracts which allows the water to be forced up into the glass by the atmosphere. The more candles you have, the more heat, the more expansion, the more contraction, the more water rising.

There is, however, a demonstration that does show the 20% oxygen in the atmosphere. For this demonstration, you take a wad of steel wool, wet it, and lodge it in the bottom of a graduated cylinder. You then turn the graduated cylinder upside down in a beaker of water and mark where the water level is. Over several days, the steel wool will rust and remove the oxygen from the air and the water level will rise. It will rise approximately 20% of the way to the top. It is only approximate because the temperature and pressure in the room will change over several days and the steel wool takes up some, but not all, of the volume that it occupies at the top of the cylinder. This is a much better demonstration to show this fact. One could also use a gas analyzer if there is a university nearby or a smog test device if there is a mechanic willing to bring one or have one videotaped.

To summarize: Respiration and breathing are not the same thing, air is mostly nitrogen, the air that we exhale only has slightly less oxygen than the air that we inhale, plants photosynthesize as well as respire, and the candle burning demo does not prove that air is 20% oxygen.