Can-U-Read

How Breathing Works

Fish breathe water. People breathe air. Why can’t we breathe water, too?

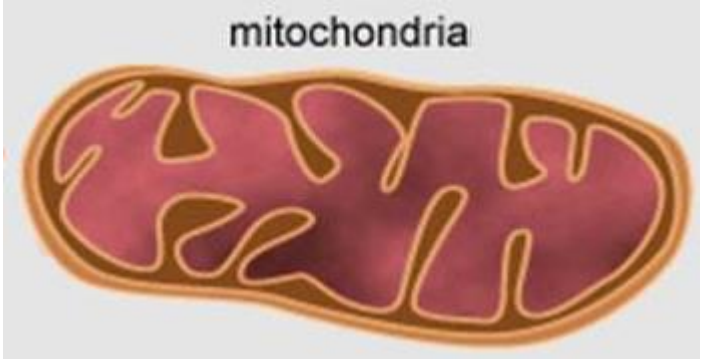
That is a really hard question and the answer may be that we ***can*** breathe water. I don’t know.

Let’s try to understand the problem better.

Maybe the first question is why do we breathe at all? Why do we die if we don’t breathe?

Our bodies are made up from cells. Cells need energy. We get energy from our food.

Inside our cells are ***mitochondria***, little machines that turn food into energy.

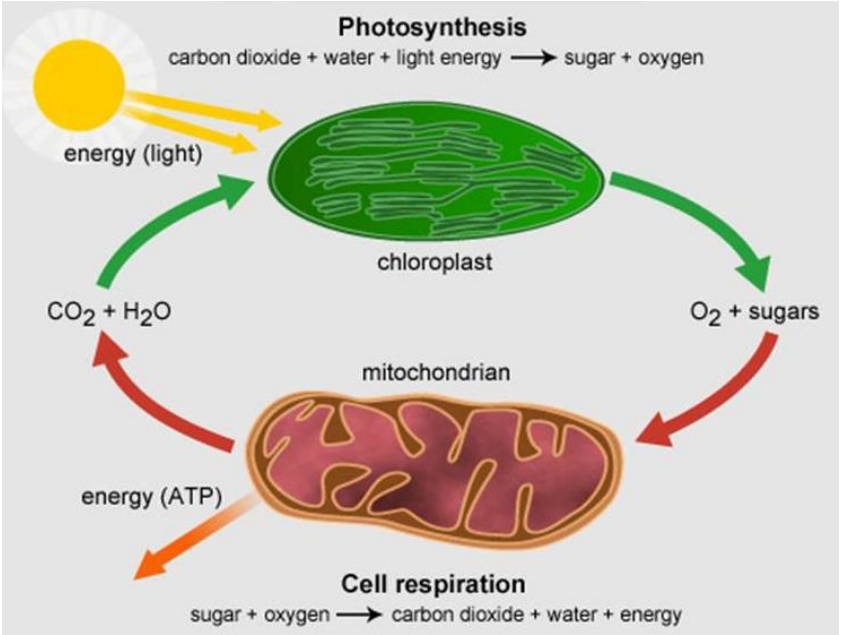


We don’t need to breathe. We need oxygen. The mitochondria need oxygen to turn the food into energy.

Where does the oxygen come from? Plants make it. Inside the plants are ***chloroplasts***, another little machine that turns sunlight into food.

Chloroplasts take in water (H_2O) and ***carbon dioxide*** (CO_2) to make sugar (CH_2O). It traps power from sunlight in the sugar. The sugar is food.

The extra oxygen (O_2) is just left over. It is a ***waste*** product—trash. The mitochondria uses the extra oxygen and the sugar to get the energy back out. They work together.



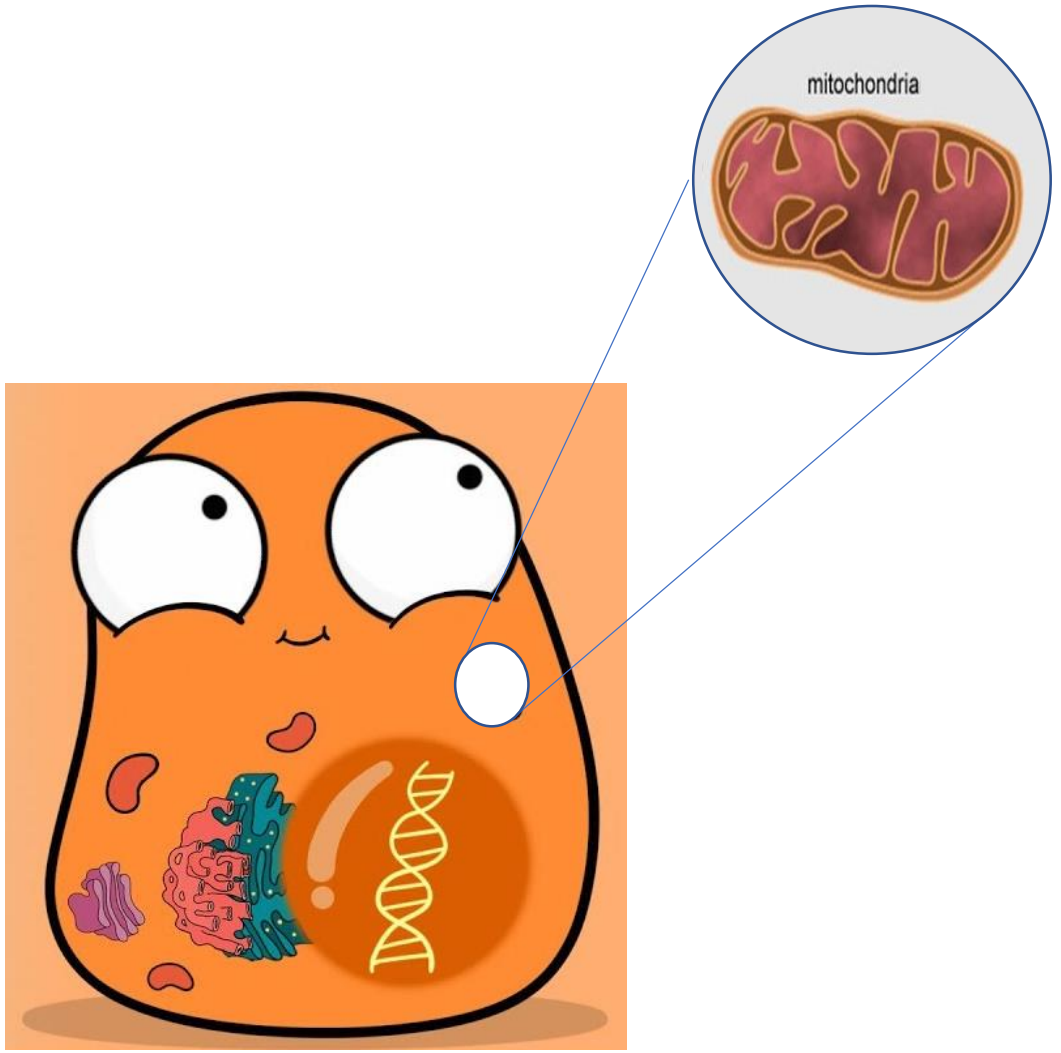
Once our earth was a very different place. The air was mostly really gross stuff that came out of volcanoes. It was not the kind of place where we would want to live.

Chloroplasts changed that. They sucked up all those chemicals and made it into oxygen. The waste oxygen went back into the air and began to change our planet. It gave us the nice blue sky, but it was also a terrible poison.

A lot of creatures died, poisoned by the new oxygen in the air.

But the mitochondria were smart. They figured out that oxygen could be used to release all that energy from the food. Instead of being a poison, oxygen was the best idea.

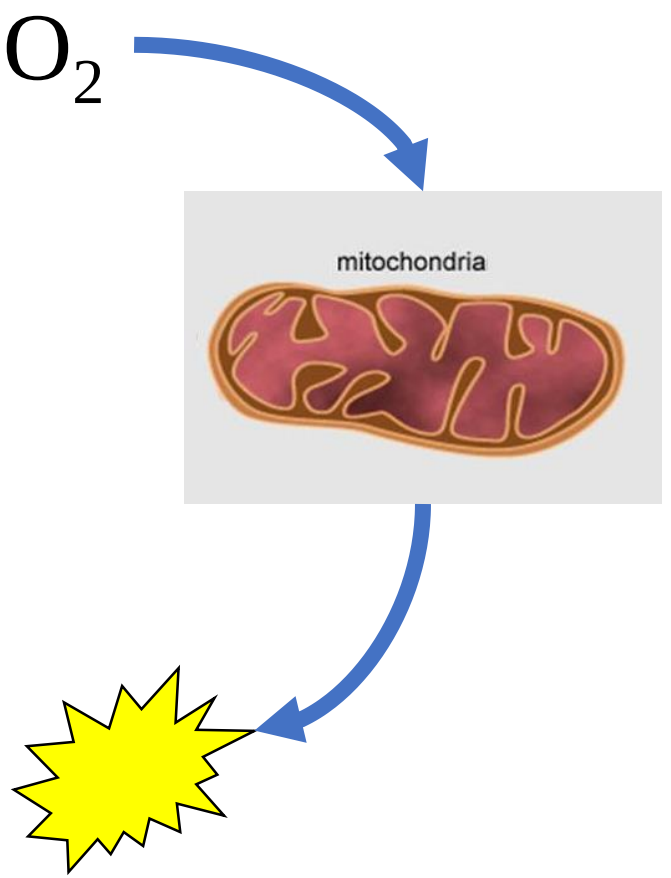
Later, bigger cells learned to live with the mitochondria. Once the mitochondria were inside and protected by the bigger cell, they could just make lots of energy. They didn’t have to protect themselves from the rest of the world.



So that is why we breathe. We need the oxygen in the air. The mitochondria use the oxygen to make food into energy.

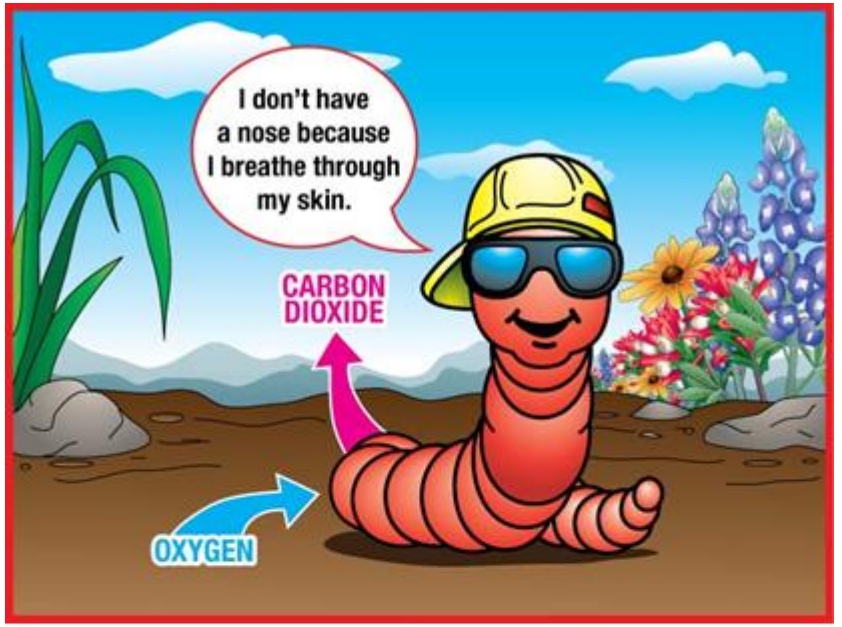
If you don’t get any oxygen, your cells can’t get any energy. In just three minutes, your brain will start to die. Once that happens, your whole body shuts down. You must have oxygen.

But do you need to breathe?



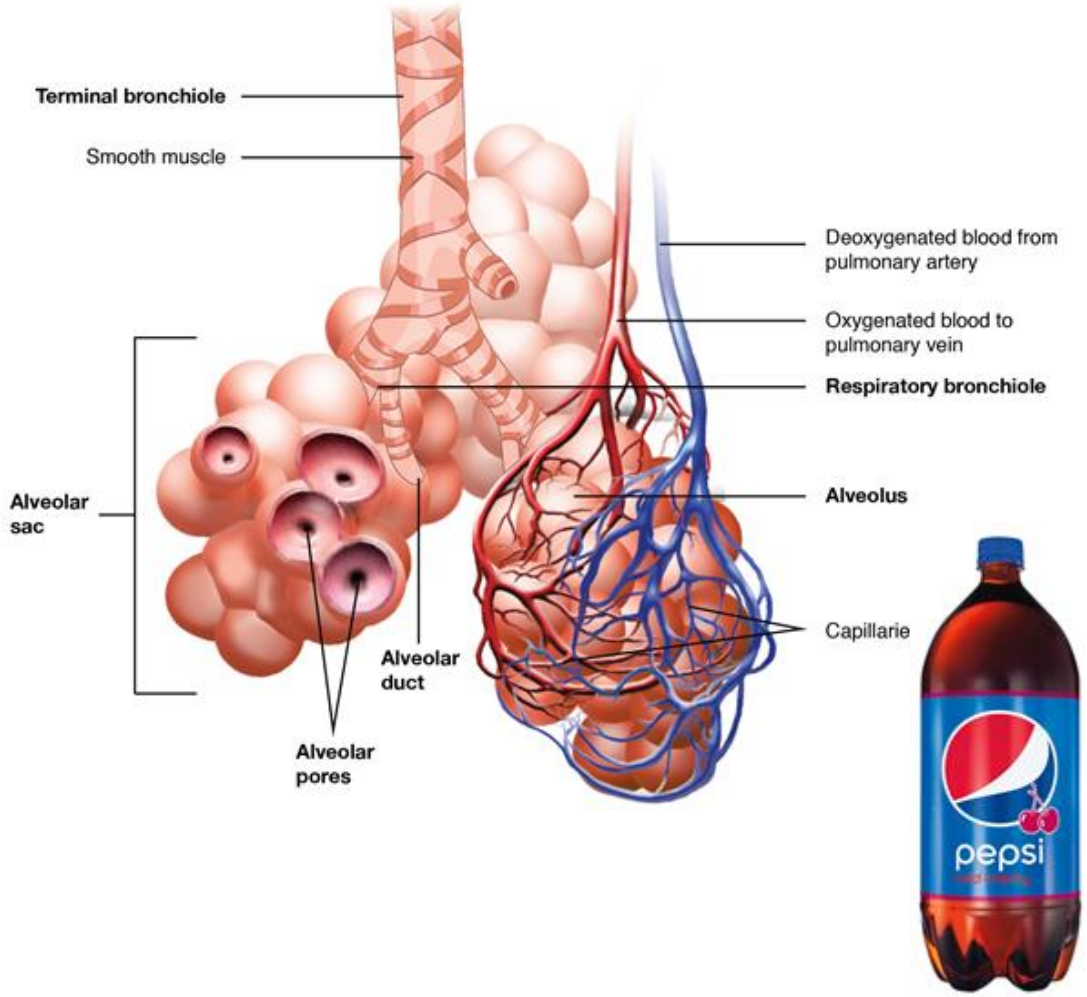
Not all living things breathe. Well…not like we do. Worms don't have a nose or lungs. Their skin is a ***tissue*** thin enough that oxygen can go right through. They also die if they lose too much water through that thin skin.

Personally, I like being able to play in the sun, so I'm happy that our skin is thicker. Our lungs, however, have the same sort of thin wet skin. That is why we use our lungs to breathe.



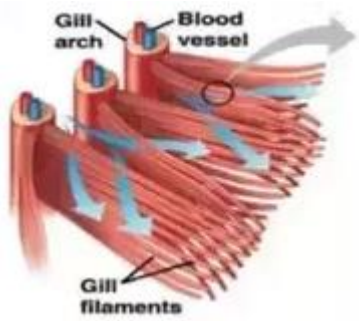
Inside our lungs there are very small sacks called ***alveola***. The alveola are filled by the air, but their walls stay soft and wet. We do lose a little water by breathing, but only about as much as one big soda bottle.

Very small blood vessels wrap around the alveola. These vessels are called ***capillaries***. They are so small that oxygen can pass through the walls of the alveola and into the blood. That is how the oxygen gets into our blood.



Fish use a completely different tool. They ***gills*** are red because the blood moves through the thin tissue. Oxygen is already in the water and it passes directly from the water into the fish's gill.

Gills are made to work in water. Just like worm's skin, gills dry out very easily. The gills also float in water. Floating makes them look more like feathers and less like a fin. This is one strategy to increase ***surface area***.

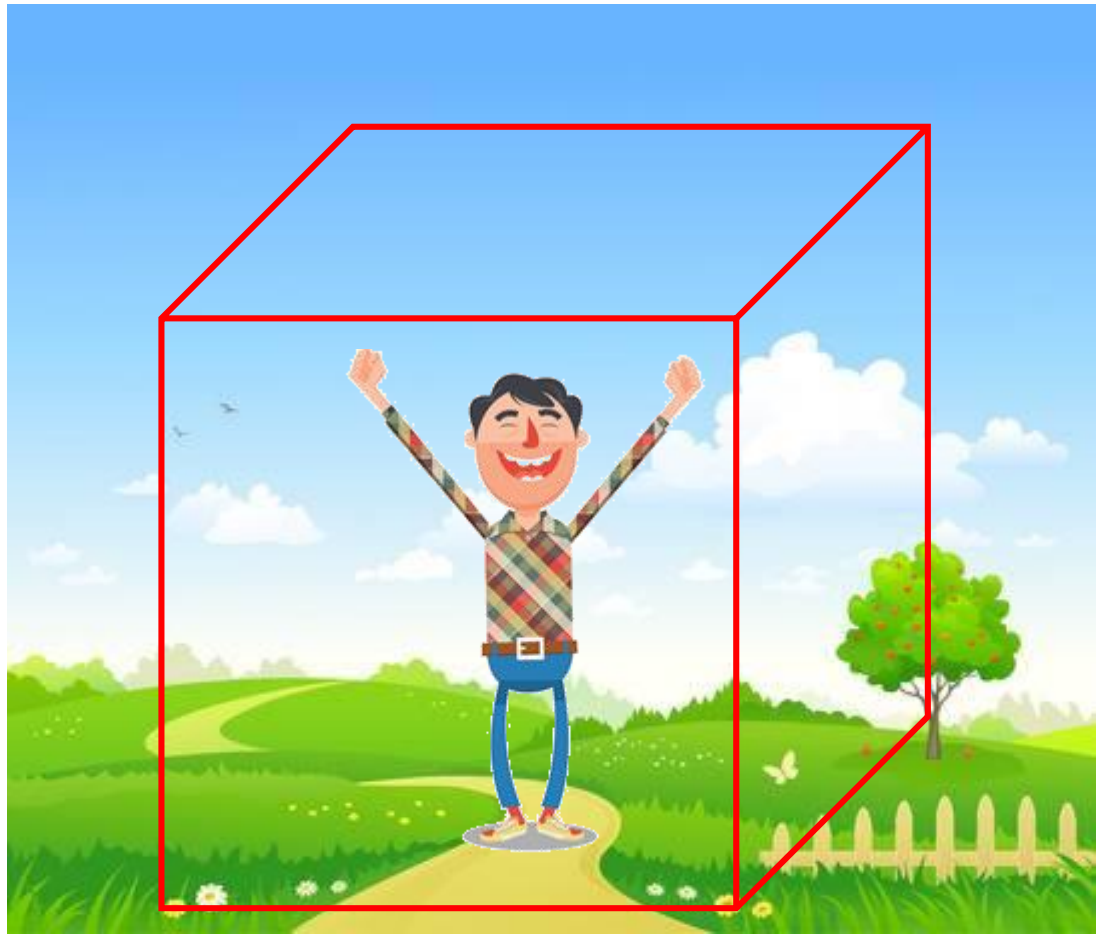


Surface area is a measure of how much tissue can be touched. Every little inch of tissue means more space for oxygen to get in.

The alveola in our lungs are a fancy way of folding more surface area into a small space. If you unfolded your lungs it would be enough tissue to cover a box ten feet wide.

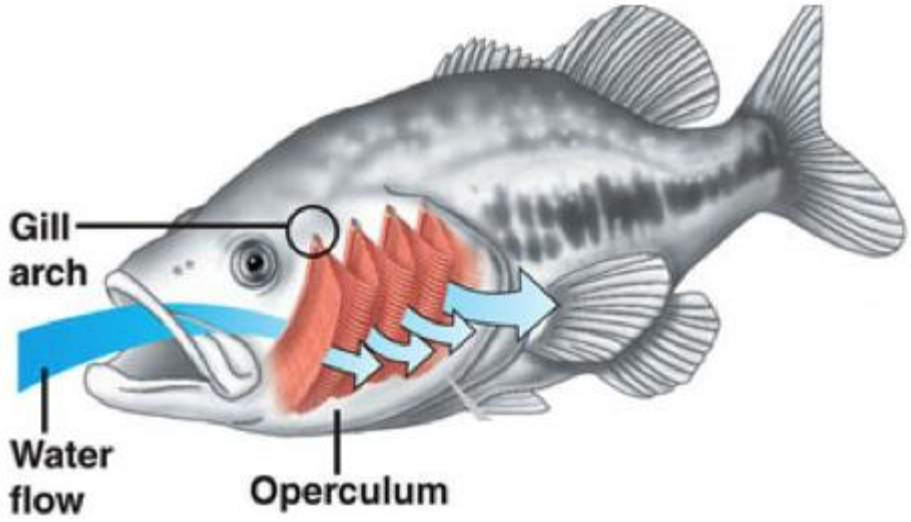
Gills use their feathery structure to do the same thing.

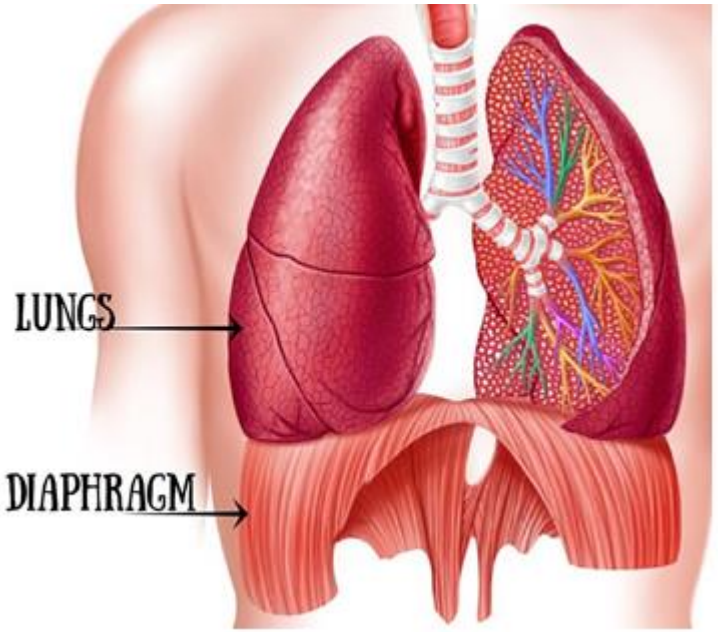
So we have lungs and they could breathe under water, right?



Well, there is a problem with the way we breathe. As fish swim, water goes through their mouth and out through their gills. All the oxygen they need goes right through their body. All this takes no extra energy.

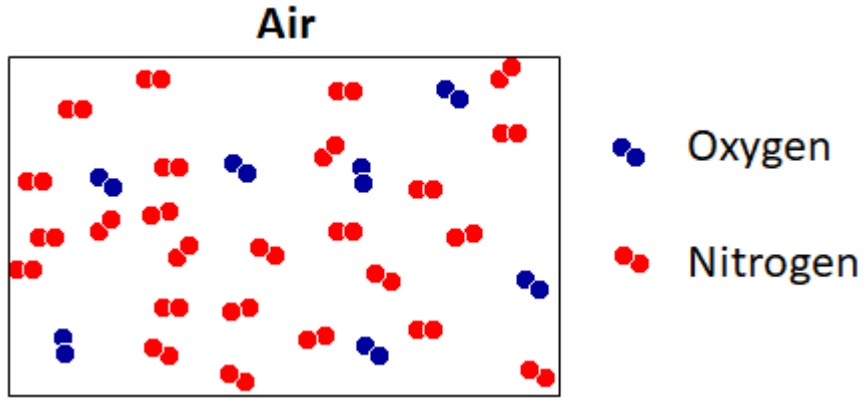
Humans use their muscles to breathe. The diaphragm is a U-shaped muscle that pulls your ribs together to push air out of your lungs. Hiccups happen when the muscle gets a cramp. The diaphragm isn't strong enough to push water out. You would get one breath and then… nothing.

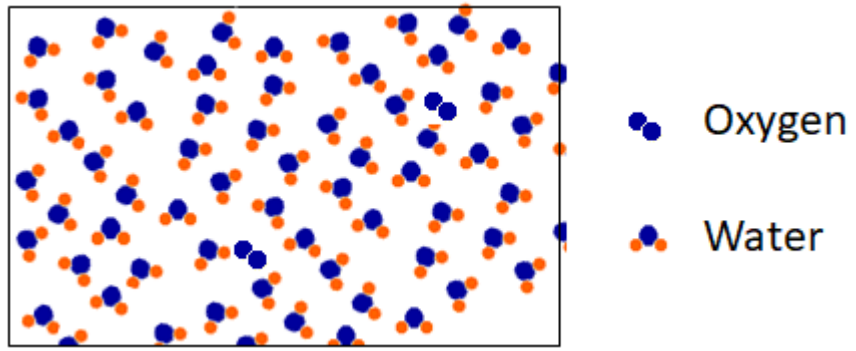




The last problem with breathing water is how much oxygen is in the water. Air is really full of oxygen. 20% of air is oxygen. Our lungs are spoiled brats! They are good at breathing only because there is so much oxygen.

Water doesn't have that much oxygen. Maybe 0.0007%. Gills are really good at getting the oxygen out of water. Lungs wouldn't work well enough. You would get some oxygen, but not enough to survive long.





So we can’t breathe under water.

- It is too much work.
- There is not enough oxygen.

Our body is just not made to do it.

But could we cheat?

It turns out that scientists have already figured out how to breathe liquids.

This mouse is in a liquid called perfluorocarbon (PFC). PFC will not hurt the lungs and it can hold a lot of oxygen. The mouse has to work much harder to breathe, but it does work.

Would you like this kind of breathing? You would get tired from so much work. Your body would always think it was drowning. Not much fun.

One designer is working on a wearable gill. It has surfaces that pull oxygen from the water just like a gill. The human would be able to breath normally.

Does it work yet? Not quite. It needs a very large surface area. They haven’t learned how to fold that well yet. It also is outside the body, so it takes no more work to breathe. If it works for humans, we could swim underwater without scuba gear!

For right now, the best tool is the **S**elf-**C**ontained **U**nderwater **B**reathing **A**pparatus (SCUBA). Scuba diving is free of surface tubes. You bring your air with you, but you can’t stay in the water forever.

Maybe one day—if someone can figure it out—we could stay underwater all the time.