FISH GET GAS, TOO

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Background on Pressure

If you have ever held your breath and dived to the bottom of a swimming pool, you may have felt pressure on your ears, this **hydrostatic pressure** is due to the weight of water pressing on submerged objects. (Hydro means, "water"; static means "at rest")

Pressure is related to force. Pressure is calculated by dividing the amount of force by the surface area on which it rests.

Water exerts pressure that changes with depth. The air we live in also exerts pressure, even though we are seldom aware of its presence.

We live at the bottom of a layer of air more than 550 km thick that surrounds the earth. Gravity pulls the air toward the earth. Density within the layer gradually increases from least dense at the earth's surface. The average pressure at the earth's surface, measured at sea level, is defined by 1 atmosphere (atm).

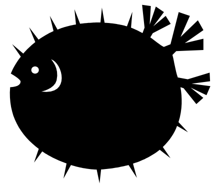
1 atm = average pressure of atmospheric layer (at sea level)

As we move toward the outer edges of the atmosphere, pressure decreases. Below sea level-in an air filled mine for example-atmospheric pressure increases more than 1 atm. Our bodies, adapted to living at 1 atm, are sensitive to pressure changes. For example, our ears feel pressure changes when we drive up and down a mountain road or when we go up and down in an elevator in a tall building.

Seawater is about 800 times denser than air. A column of seawater 10m high exerts the same pressure as the entire 550 km layer of air above it.

1 atm = pressure exerted by 10 m seawater

Using the atmosphere as a unit of pressure, we can account for the total pressure exerted on a submerged object. A fish 10m under the surface sea is under 2 atm of pressure-1atm from the water above it and 1 atm from the air above the water. If the fish swims down 20 m, perhaps to escape a predator, it is under 3 atm of pressure.



Because of pressure, living in the ocean differs from living on land. Air pressure changes very little with vertical movement; water pressure changes rapidly. If we walk down the stairs in a building from the third floor to the ground level, a vertical distance of about 10 m, the atmospheric pressure exerted on us essentially does not change. But if we dive from the surface of the ocean to a depth of 10 m, the atmospheric pressure exerted on us doubles from 1 to 2 atm. If we dive to 20 m, the pressure triples.

Marine mammals are like humans in many ways. They breathe air at the surface and hold their breath when they dive into the ocean. Their bodies have adapted for breath holding and diving.

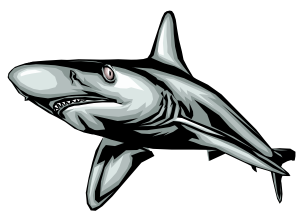
Consider what happens to a free diver (also known as a skin diver). At the surface, an adult male free diver can inhale and hold about 5 L of air in his lungs. The inhaled air is at a pressure of 1 atm. If he dives to a depth of 10 m, he is under 2 atm of pressure.

Greater pressures under water affect the lungs and other air-filled spaces that connect to the outside of the body. These spaces include the middle ear, which is connected by the Eustachian tube to the throat, and the nasal sinuses, which are connected to the nasal passage.

As divers descend, they quickly feel the effects of increasing pressure as it compresses air in the body spaces. Pressure effects on delicate membranes in the airs and sinuses can cause sensations that divers call "squeezes".

The eardrum between the middle ear and the outer ear is particularly sensitive to pressure changes. To avoid pain and damage to their eardrums, divers must equalize the water pressure outside and the air pressure inside their throat and ears. To do this they yawn, swallow forcefully, wiggle the jaw, or pinch the nose closed and blow gently. This opens the Eustachian tube and lets air from the throat enter the middle ear. The sensation divers feel when "clearing the ears" is like the popping you feel when you travel up a mountain or take off in a plane.

Injuries caused by pressure differences are called **barotrauma** (baro refers to pressure, trauma to injury). If the pressure is not equalized and the Eustachian tube remains closed, a diver may suffer pain, bleeding in the middle ear, or even a rupture of the eardrum- injuries that can lead to an infection or even permanent hearing loss. Pressure imbalances can also affect nasal sinuses blocked by congestion.



Background on Baking Soda

What is baking powder and how does it work?

- **An acid**
- **A base**
- **A filler** of some sort

All three need to be **dry** powders that can be mixed together. For example, baking soda (a base), cream of tartar (an acid) and corn starch (the filler) are three common ingredients.

In school, you may have done the experiment where you mix baking soda (a base) and vinegar (an acid) and get a bubbling reaction. Baking powder works the same way. When you add water to baking powder, the dry acid and base go into solution and start reacting to produce **carbon dioxide** bubbles.

- **Single-acting** baking powder produces all of its bubbles when it gets wet.
- **Double-acting** baking powder produces bubbles again when it gets hot.

If you want to prove to yourself that this is how baking powder works, simply try mixing a teaspoon of baking powder into a cup of hot water. As long as the baking powder is fresh, you will definitely see the reaction!

Baking soda, also known as sodium bicarbonate, has the chemical formula $NaHCO_3$. **Cream of tartar**, also known as tartrate salt, has the formula $KHC_4H_4O_6$. The reaction is:

$$\mathbf{NaHCO_3 + KHC_4H_4O_6 \text{ ----> } KNaC_4H_4O_6 + H_2O + CO_2}$$

Some baking powders contain **sodium aluminum sulfate**: $NaAl(SO_4)_2$. The reaction there is:

$$\mathbf{NaAl(SO_4)_2 + 3\ NaHCO_3 \text{ ----> } Al(OH)_3 + 2\ Na_2SO_4 + 3\ CO_2}$$

Many recipes call simply for baking soda rather than baking powder. Usually these recipes use some kind of liquid acid like buttermilk or yogurt to react with the baking soda to produce the bubbles.

The reason why people often prefer baking powder to yeast is because yeast takes so long -- usually two to three hours -- to produce its bubbles. Baking powder is **instant**, so you can mix up a batch of biscuits and eat them 15 minutes later.

Now that you understand how baking powder works, you can understand two things you often see in recipes:

1. Many recipes instruct you to mix all of the dry ingredients together and then add the liquid. That keeps the baking powder from reacting until the end of the mixing process.
2. Many recipes tell you to mix only briefly -- just until the ingredients are moistened. That minimizes the escape of the gas from the batter. If you were to stir for a long time, the reaction would end and the stirring would have allowed the bubbles to escape.

Here are some interesting links:

If you have read How Bread Works, then you understand how the release of carbon dioxide by yeast can cause bread to rise. Many recipes, however, use no yeast. Things like muffins, biscuits, cakes and cookies usually use **baking powder** instead.

- How Bread Works
- How Sourdough Bread Works
- How Low-Fat Baking Works
- Baking Soda vs. Baking Powder
- FatFree.com: Baking-powder recipe
- Exploratorium: Bubble Bomb

Background on Alka Seltzer

Alka-Seltzer and other effervescent tablets contain sodium bicarbonate ($NaHCO_3$), a base, and citric acid ($C_6H_8O_7$), an acid. (They also contain acetylsalicylic acid (aspirin) as a pain reliever, but it is not involved in making the fizz.)

In the solid tablet the acid and base do not react, but when placed in water the components dissolve and the sodium bicarbonate reacts with the citric acid in an acid-base neutralization reaction. The products are sodium citrate (which sucks up hydrogen ion - the acid - produced in the stomach), carbon dioxide gas (which causes the fizz), and water, which is the product of the acid-base reaction between the hydroxide ion (OH- from the sodium bicarbonate) and the hydrogen ion (H+ from the citric acid). The overall chemical reaction is:

$$NaHCO_3(aq) + C_6H_8O_7(aq) \dashrightarrow NaC_6H_7O_7(aq) + H_2O(l) + CO_2(g)$$