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NOISY KNUCKLES AND HENRY'S LAW

By Doris R. Kimbrough

"HEY!!! STOP THAT! YOU'LL GET ARTHRITIS FROM CRACKING THOSE KNUCKLES!"

Are you someone who can't resist cracking your knuckles? Or do you cringe and shudder every time your lab partner starts the "Snap, Crackle, Pop" routine, popping the joints on every finger before moving on to the toes? Or maybe you have joints that crack and pop naturally whenever you move. What causes those sudden loud noises that come from your knuckles when you crack them?

Your noisy knuckles are governed by the same scientific principle that causes your carbonated soft drink to fizz when you open it or a scuba diver to get "the bends" when she surfaces too soon after a particularly deep dive. All three of these phenomena are explained by the relationship between the pressure of a gas and its solubility in a liquid. This relationship is described by Henry's Law:

$$P_{gas} = kHC$$

P_{gas} is the pressure of the gas that is dissolving; kH is a temperature-dependent constant (the Henry's Law constant) related to the particular gas/solvent solution; and C is the concentration of the dissolved gas in the liquid. In other words, as you increase the pressure of a gas above a solvent, more of the gas will dissolve in that solvent. As you decrease the gas pressure, less gas will dissolve.

This is how soft drinks are carbonated. At the bottling plant, the beverage is placed in the can or bottle under high pressures of carbon dioxide. These high pressures force the carbon dioxide to dissolve in the liquid. When you "pop the top", the pressure decreases and gas begins to leave the solution, forming bubbles—fizz. Eventually, most of the carbon dioxide leaves the solution, and the drink is flat.

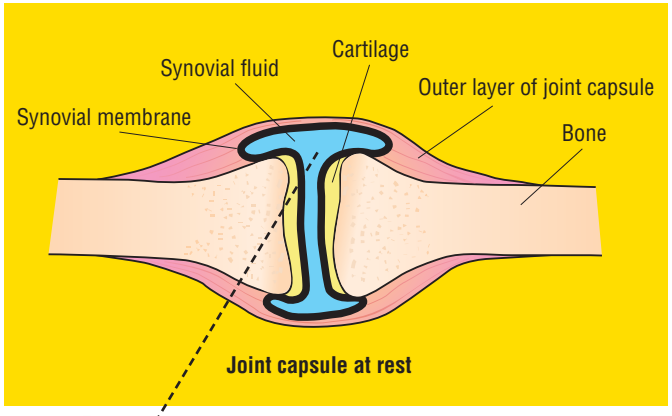
Having bubbles leave a solution is fine for a soft drink but can be life threatening if you are scuba diving. As you go deeper into the ocean, external pressure builds, and you inhale more deeply to equalize pressure. This extra inhaling forces more and more nitrogen to dissolve in your blood. If you surface too rapidly, the gas will come out of solution, causing a painful and dangerous condition called the "bends". Gas bubbles produced in your bloodstream block capillaries, preventing the body's tissues from getting needed oxygen. The bends can be fatal if the oxygen supply to the brain is cut off.

Deep divers learn to avoid the bends by "decompressing". This means that they ascend slowly and wait for a period of time at a series of intermediate pressures. By this method, the dissolved nitrogen in their blood

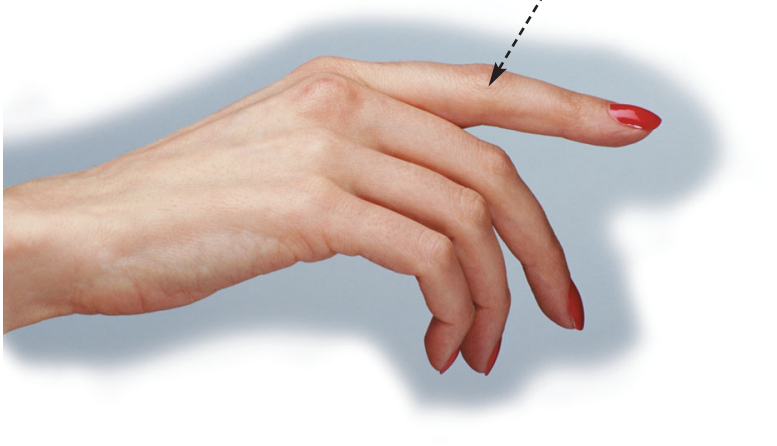
comes out of solution slowly and gets carried away without forming capillary-blocking bubbles. By using this technique, the divers can remove the nitrogen a little at a time before reaching the surface unharmed.

But what about those noisy knuckles? How are they related to dissolving gases? Your knuckles represent the joints in your hand. A joint is where two bones join, hence the name "joint". Joints that move around a lot—*diarthroidial joints*—are the noisiest. In diarthroidial joints, the ends of the two bones don't touch, but they are connected to each other through an enclosure called a *joint capsule*. The joint capsule allows the two bone ends to move freely in relation to each other.

The joint capsule is a complicated structure made up of ligaments, membranes and cartilage. Think of it as a short, flexible tube that has a bone stuck in each end. Between bones, there is a cavity filled with a thick liquid. This *synovial fluid* acts as a gooey lubricant so that the two bone ends don't grind into each other. As a result, the joint moves smoothly. Doctors sometimes analyze the synovial fluid and use the results to diagnose diseases such as osteoarthritis, rheumatoid arthritis, gout, and other inflammatory diseases.



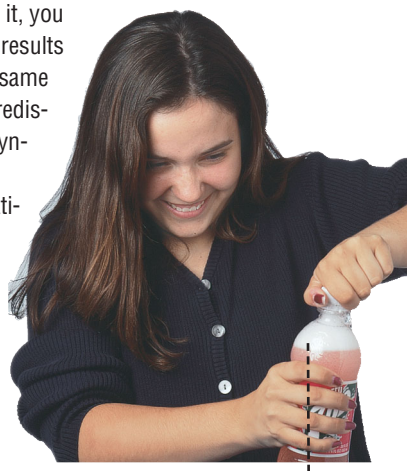
Joint capsule at rest



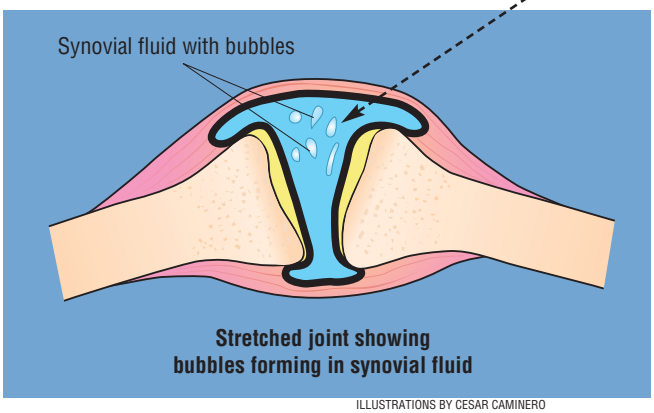
Gases dissolve in the synovial fluid just as they do in most bodily fluids. Carbon dioxide is thought to make up about 80% of this dissolved gas, with the remaining 20% a mixture of nitrogen and oxygen. The gases stay dissolved in the synovial fluid as long as the pressure in the joint capsule doesn't change. However, pulling or stretching the joint will suddenly increase the volume of the joint capsule. This increase in volume decreases the pressure on the liquid. Picture the plunger of a piston being pulled out to create a partial vacuum.

Henry's Law says that this decrease in pressure will cause some of the gas dissolved in the synovial fluid to come out of solution and form a bubble. This sudden formation of a bubble—technically, a *vapor cavity*—as a result of pressure change is called *cavitation*. Sudden cavitation disrupts the fluid, causing vibration. These vibrations, moving differently through liquid and gas, produce the loud noise or *pop*.

If you X-ray a joint right after cracking it, you can see the bubble in the joint capsule that results from cavitation. Before you can crack that same knuckle again, you must wait until the gas redissolves into the synovial fluid. This happens automatically with the increased pressure in the joint capsule when it returns to its resting position. When the bubble has completely disappeared, you can stretch the cavity again for another firing.


Opening a bottle of soda decreases the gas pressure of the solution. Gas leaves the solution forming bubbles—fizz!

Is cracking your joints really harmful? Medical experts aren't sure. There is fairly substantial evidence that the habit does *not* cause arthritis as once thought. But evidence suggests that habitual knuckle cracking may decrease hand strength and function. Some researchers think that the pressure changes associated with cavitation will damage joints in much the same way cavitation wears out ship propellers. Others believe that the actual cracking isn't harmful, but the constant pulling and stretching of the joints might damage cartilage and ligaments over the long term.



Stretched joint showing bubbles forming in synovial fluid

ILLUSTRATIONS BY CESAR CAMINERO

So if your lifelong goal is to become a concert pianist or professional thumb wrestler, it's wise to lay off cracking those knuckles. But if all you want to do is annoy your little sister, you can probably accomplish that without any significant long-term damage. Maybe the next time your mother yells at you to stop cracking your joints, you can just smile sweetly and say, "Mom, I'm just demonstrating Henry's Law—you know—the one that relates pressure to gas solubility!"

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