What it takes to get a breath of fresh air.

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We can store hundreds of photos in a space the size of a postage stamp, but even in this age of scientific miracles, the technology for getting air to divers, miners and astronauts remains firmly rooted in the 19th century. As the Sago mining tragedy demonstrated so brutally last week, and the story of the miners trapped in Melville, W.Va., did Friday, giving or getting enough air to people in dangerous situations is a difficult proposition. The challenge of making sure miners have enough air is similar to the problem facing divers, astronauts and firefighters: Balancing weight, duration and convenience. There are two ways to provide air to people where there is none: Pipe it in or store it (i.e., have them carry it). Both have their upsides and downsides, and both are limited by the laws of physics, the needs of human biology and the circumstances. The simplest way to get air to someone is to use a tube, whether they're hiding in a swamp and breathing through a straw, or you're pumping air to someone walking at the bottom of the ocean. That technique is old; in the late 1600s a French physicist named Denis Papin devised a way to pump air to a diver. (Before that divers were limited to whatever air was in the container they used.) But piping air only works in nonhazardous environments -- running a hose through a burning building wouldn't work, for example. Hoses won't work in coal mine rescues, said Tom Novak, head of Virginia Tech's mining engineering department. "Mining is a dynamic process, meaning that it continuously is moving. The equipment and men are moving," he said. "So it's not like you could just put an emergency borehole down here and get oxygen to them." The most common way to keep breathing somewhere is to bring your air with you in pressurized tanks. Firefighters, scuba divers, astronauts and submariners all carry those. It's also not as new as you might think. In 1825, an Englishman named William James created the first diving suit that used a tank of compressed air. Later in the 19th century, thanks to the Industrial Revolution, companies were able to build smaller, high-pressure air tanks. (In 1943, Jacques Cousteau and Emile Gagnan ushered in the modern era of breathing systems when they added a regulator valve to the air tanks, so that divers only used what they needed. Previously, the air flowed out at a constant rate.) Self-contained breathing apparatus (SCBA) systems, as they're known -- scuba gear adds the "U" for "underwater" -- have limits. Air has weight, and so do the steel or aluminum tanks that hold it. You can only carry so much, and you can only squeeze so much into a tank. Although scuba divers can take advantage of their buoyancy in water (anyone who's been in a pool knows how much lighter you feel), carrying more than a few hours of air gets cumbersome. Even the folks at NASA who worry about keeping astronauts supplied with air recognize the problem. Spacesuits only hold so much air. "That's still one of the areas that needs more work," admitted Fred Smith, who holds the lengthy title of air revitalization element lead for NASA's Exploration Life Support group. "Typically for our application we only worry about an hour or so." But an hour or so isn't very long. One way to make air tanks last longer is by a process known as "scrubbing." When we breathe, we inhale air -- nitrogen and oxygen for the most part -- and exhale carbon dioxide. That CO_2 has to be cleaned out. Chemicals such as soda lime or lithium hydroxide will absorb it. (During the Apollo 13 flight, astronauts had to jury rig a lithium hydroxide canister from the command module to remove CO_2 from the lunar module where they were stuck for most of the flight.) The science isn't new. In the early 1600s, a Dutch inventor working in England, Cornelius **Drebbel**, created the first submarine. Oar-powered, it contained a chemical mixture that provided oxygen but also created sodium hydroxide, which absorbed carbon dioxide from the air. **Drebbel**'s scrubber wasn't intentional, but one made by Briton Henry Fluess in 1879 was. He built breathing devices that used lye to absorb CO_2 so that mine workers trapped by water could be rescued. Fluess' invention was the first of what's now known as a "rebreather" or "closed-circuit breathing device." A typical scuba diver uses what's called an "open circuit" device, meaning he breathes air from his tank, then exhales into the water leaving a trail of bubbles. But what we exhale isn't all carbon dioxide; there's a lot of useful air as well.

By incorporating a CO_2 scrubber in the mix, that exhaled air can be recovered, and the air in the tank can last a lot longer. One of the most common emergency-air devices used by miners is Ocenco's EBA self-contained self rescuer, which provides up to eight hours of air for a resting miner, or 90 minutes for one exerting himself, by combining a small air tank with a

CO_2 scrubber. (See the sidebar, "Mining Issues.") Although new, lighter-weight materials have improved on the designs of air-delivery technology, the basic principles have remained unchanged since the early 1800s. And while new technologies might deliver better ways to carry or create the air we need, they can't change our basic need to take a deep breath.

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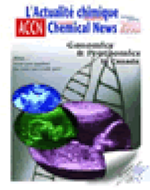

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