GAS LAWS &

WHAT HAPPENS IF SCUBA DIVERS HOLD THEIR BREATH WHILE MAKING EMERGENCY ASCENTS TO THE SURFACE FROM DEPTHS OF 30 METERS OR MORE?

WHY SHOULDN'T DIVERS FLY OR TAKE HOT SHOWERS SOON AFTER DEEP DIVES?

IS CONTAMINATED COMPRESSED AIR MORE DANGEROUS TO THE DIVER AT THE SURFACE OR AT A DEPTH OF 30 METERS?

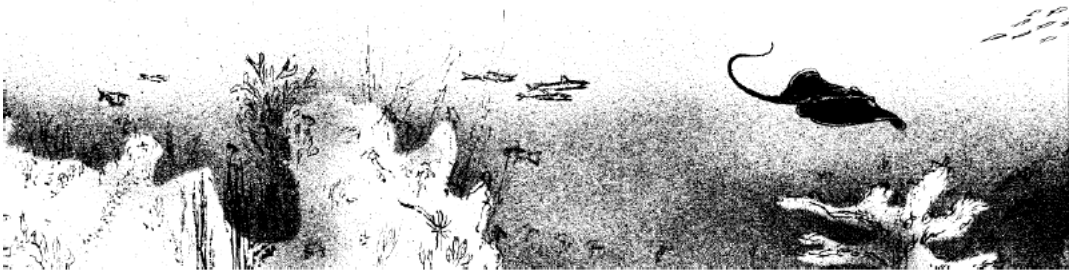
Pressure

We live in a sea of air. Since air molecules constantly bombard us, we always experience a pressure of about 760 mm of mercury (or one atmosphere) at the Earth's surface. This is equivalent to 14.7 lb on each square inch of surface. If we zoom to the top of a tall building in an elevator we are no longer as deep in the sea of air as at ground level and, therefore, the pressure around us becomes lower. Ears are usually the first to respond to this change. Wiggling your jaw or swallowing sometimes corrects any discomfort or strange sensations in the ear by opening the tubes connecting the inner ear and throat, allowing the inside pressure to equalize with the outside. A reverse pressure effect is obvious during a rapid airplane descent or during a drive from a mountain pass to the valley floor below.

Divers are surrounded by water molecules in constant motion that exert pressure on their bodies. When you dive to the bottom of the deep end of a swimming pool, you feel a great deal of pressure exerted by the water. Because water is much more dense than air, pressure changes are much greater for a given change in depth in water than for the same depth change in air. For example, water exerts over 100 lb of force on the surface of a one-gallon metal can pushed just one foot below the water surface. If the metal can contains air, it would not have to be pushed very far below the water surface before the can would start to collapse due to water pressure. Can divers be crushed by the pressure of water in the same manner as the can if they go too deep? After all, for every 10 meters (about 33 ft) in depth, divers experience an additional pressure of one atmosphere.

Pressure–Volume Effects

The changes in pressure experienced by divers are most noticeable on body cavities that contain air, such as the lungs, the middle ear, and the sinus cavities. Boyle's law describes how these gas volumes respond to changes in pressure. For a constant amount of gas at a constant tempera-



SCUBA DIVING

ture, Boyle's law states: *The volume of a gas sample varies inversely with its pressure.*

If divers descend without scuba gear, the amount of gas contained in their body cavities is constant and the volume of these cavities decreases as the surrounding water pressure becomes greater. However, this crushing effect or squeeze is not experienced by divers using scuba gear because the regulator on their air tanks delivers air at the same pressure as the surroundings. This means that the air in divers' lungs is at a pressure equivalent to four atmospheres at a depth of 30 meters. If divers must make emergency ascents from this depth they must remember to breathe out regularly as they return to the surface. If they don't, the pressure of the air in their lungs will cause their lungs to expand. The extreme distortion of the lungs can cause some of the alveoli (the small sacks in the lungs) to rupture. If this happens, air can enter the bloodstream and cause a blockage that may lead to a variety of problems including loss of consciousness, brain damage, and heart attacks.

The rate of lung expansion increases dramatically as the divers ascend. According to Boyle's law the volume of a flexible gas container will approximately double when the surrounding pressure decreases to one-half its original value. If the divers ascend while holding their breath from a depth of 30 meters (where the pressure is about four atmospheres), their lungs would have to double in volume when they are at 10 meters (where the pressure is about two atmospheres) to equalize the pressure of the water. Of course, this does not happen because the lungs are contained by the rib cage and the muscle system, and the divers are forced to breathe out.