VENTILATION.

Following is the full text of a lecture on the above important and much abused subject, delivered by Dr. James E. Talmage in his course of lectures on general chemistry at the Church University. The lecture was given on the evening of Monday, April 23, before the large evening class, composed of the University laboratory workers, and the special students. The greatest attention was paid throughout the address, and it is to be hoped that the excellent instruction so imparted will be put to good service in an earnest attempt to correct some of the many flagrant violations of the laws of health, now so common amongst us through the wilful and almost criminal disregard of our need for pure air. Dr. Talmage said—

In ordinary usage the term "Ventilation" is applied to any process designed to remove impure air from enclosed spaces, and to provide for the introduction of pure air in its place. In considering this subject we have to inquire: (1) What is pure air, and wherein lies its indispensable service in the body? (2) By what means and at what rate is the atmosphere generally contaminated? (3) How may the purity of the air of dwellings be maintained?

1. PURE AIR is air in its normal condition; this we say in general terms consists of about four-fifths nitrogen, a little less than one-fifth oxygen, with very small amounts of carbon dioxid and vapor of water. More accurately speaking, pure air consists of the following, the proportions being by volume:

Nitrogen	79.00 per cent
Oxygen	20.96 "
Carbon dioxid	.04 "
Watery vapor	variable amounts.

The presence of each of these ingredients has been demonstrated by conclusive experiments in this class. Oxygen, you will remember, is the universal and vigorous supporter of combustion. To its presence is due the possibility of burning ordinary fuel. Nitrogen is the dilutent gas, efficient is restraining the ardor of the fiery oxygen. It may be separated from the oxygen by burning out the latter through the agency of phosphorus in a bell jar. Carbon dioxid alone will not support combustion. Its inhalation in quantity is fatal to life, not because of any specifically poisonous properties in the gas itself, for in its effects it is generally inert, but because of its taking the place of the invigorating oxygen in the lungs. Carbon dioxid is a colorless gas; its presence in the atmosphere may be proved as has been shown here in experiments, by aspirating a quantity of air through clear lime water; the carbon dioxid enters into combination with the lime which is in solution, forming calcium carbonate, and this substance, being insoluble in the water, appears as a solid precipitate giving a faint milkiness or a deeper turbidity to the water. That water is present in the atmosphere is here proved by placing a freezing mixture of ice and salt in a beaker of thin glass, the outside of the vessel being clean and dry; in a short time a dew appears on the glass. This increases in quantity and by the intense cold is congealed, so that now we have a thick layer of hoar frost on the glass; and the moisture so deposited and frozen could have been derived from the atmosphere only, in direct contact with the glass. Such is the composition of the atmosphere, in its undefiled condition—the state in which the Creator designed it to be breathed by His earthly children. Although these atmospheric ingredients are of widely varying specific gravities, there is no separation into layers; on the contrary, the atmospheric gases evince a decided tendency to mingle uniformly; so that air taken from the earth's surface—if there be no local cause of contamination—or from different elevations, over land or above water, the same relative proportion is discovered. Through that strange property of fluids, known as diffusion, both liquids and gases tend to mix; this may be shown by the following simple experiment: You see here two wide mouth glass jars, each capable of holding about a quart; one of them we will fill with dry hydrogen, a gas which is fully 14½ times lighter than air; now let us invert the bottle containing hydrogen over the one containing air, the vessels being placed, as you see, mouth to mouth. It would seem that hydrogen, the lightest and most buoyant substance known to chemists, would tend to rise toward the bottom of the inverted jar; and the air, 14½ times heavier than the upper gas, would tend to remain at the bottom. On the contrary, as a light is applied to the mouth of each of the bottles, an explosion occurs, indicating that in each there was a mixture of hydrogen and air, for neither hydrogen nor air is alone explosive, but when together they form a highly explosive mixture. It is clear then that the very light gas, hydrogen, has sunk, and the comparatively heavy substance, air, has risen, to produce a uniform mixture in the two bottles. By similar diffusion, the atmospheric ingredients mingle together to our great advantage.

Air is absolutely indispensable to the respiratory processes of living beings; let us take the human subject as an example. We are conscious of a continuous bellows action of the lungs and certain adjacent organs as long as life lasts; this we call the breathing act; and this when analyzed is seen to consist of alternate inhalations and exhalations, with a short interval between. During the inhalation a certain quantity of air is drawn into the lungs, and in the succeeding expulsive action a corresponding quantity of gaseous matter is thrown from the lungs; but a careful chemical investigation would show a great difference in composition between the air taken in and that exhaled. Let us examine this process more in detail. Here is an excellent model of the human lungs, with the heart nestling between, life size, and true in color. This large pipe, composed of rings of cartilage with connective tissue between, leads from the mouth cavity to the lungs; it is the *trachea* or wind pipe. As it enters the lungs it divides into two main branches, each called a *bronchus*; these divide into bronchial tubes, and these again are subdivided until the divisions become so fine that the unaided eye fails to trace them. The microscope, however, reveals the fact that the ultimate branches of these tubes terminate in tiny bladder-like enlargements called air vesicles, which are clustered about the tubes like bunches of grapes. As air is taken into the lungs, entering through mouth and nostrils, thence through the trachea and its many divisions, the air vesicles become inflated. Tiny blood vessels, called from their minuteness *capillaries* (meaning hair-like) convey the blood to the exterior walls of these vesicles, and while passing round them, the life fluid is separated from the air only by the extremely thin walls of the vesicles and blood vessels themselves. It has already been seen that fluids tend to diffuse if brought together; but there is another tendency, even more wonderful than diffusion, by which fluids are caused to pass through separating walls, if these partitions be at all permeable; this is the phenomenon of *osmosis*, and through it, the gases collected by the blood in its passage through the body, pass from the veins into the vesicle chambers, to be subsequently expelled from the lungs, while the life-sustaining oxygen diffuses from the vesicle cavity into the blood vessels, and so purifies or aerates the blood. If a person's respiration be checked, as by choking, or by immersing his head in an inert gas or liquid, no oxygen can enter the lungs to aerate the blood, and if not relieved, the person dies of suffocation; or as physicians say, of *asphyxia*, he has in fact been poisoned by the foul products of his own vital energies. Pure air, then, is indispensable to health, in fact it is essential to life.

2. AIR CONTAMINATION is constantly in progress, and were it not for a counteracting process of purification, the entire atmosphere would soon become foul. In closed spaces, such as the rooms of dwelling houses, however, there is no chance for purification of the air once befouled, and the only possible course is to expel the mephitic atmosphere and replace it by pure air from without. Carbon dioxid in abnormal quantity is one of the most constant ingredients of contaminated air; and this is in accordance with what would be very generally supposed from the known facts that carbon dioxid is a constant product of animal and vegetable decay, of animal and human respiration, of ordinary combustion, and of fermentation. Remembering the easy test afforded by lime water becoming turbid in the presence of carbon dioxid, we can readily test for this gas. Take a goblet containing some clear lime water; as one breathes through this tube into the liquid you see the milkiness becoming apparent. You will remember in a recent lecture on combustion the gaseous products resulting from the burning of a candle were drawn through lime water with a similar result. If the gases rising from fermenting wort, or from decaying plants be passed into lime water, the presence of the gas will be proved conclusively. The amount of carbon dioxid in air has been regarded as a proper index of purity; though it must not be forgotten that other contaminating substances are formed in many of the processes already referred to. As already seen, the quantity of carbon dioxid ordinarily present in pure air is .04 per cent, or 0.4 parts in a thousand. Experiment has shown that an adult person in a restful condition will