and toluidine, which form methemoglobin; nitrobenzene, which has the nitrite effect, forms methemoglobin, lowers blood pressure, disturbs and finally halts breathing; and hydrogen sulfide, which causes respiratory paralysis. (See also lung irritants.)

3. *Anesthetics and Narcotics*

This group exerts its principal action as simple anesthesia without serious systemic effects, and the members have a depressant action on the central nervous system governed by their partial pressure in the blood supply to the brain. The following examples are arranged in the order of their decreasing anesthetic action compared with other actions: (*a*) acetylene hydrocarbons (acetylene, allylene, crotonylene); (*b*) olefin hydrocarbons (ethylene to heptylene); (*c*) ethyl ether and isopropyl ether; (*d*) paraffin hydrocarbons (propane to decane); (*e*) aliphatic ketones (acetone to octanone); (*f*) aliphatic alcohols (ethyl, propyl, butyl, and amyl); (*g*) esters (not particularly anesthetic, but placed here for want of a better classification)—they hydrolyze in the body to organic acids and alcohols.

4. *Systemic Poisons*

(*a*) Materials that cause organic injury to one or more of the visceral organs: the majority of the halogenated hydrocarbons.

(*b*) Materials damaging the hematopoietic system: benzene, phenols, and, to some degree, toluene, xylene, and naphthalene.

(*c*) Nerve poisons: carbon disulfide, methyl alcohol, thiophene.

(*d*) Toxic metals: lead, mercury, cadmium, antimony, manganese, beryllium, etc.

(*e*) Toxic nonmetal inorganics: compounds of arsenic, phosphorus, selenium, and sulfur; fluorides.

5. *Particulate Matter Other Than Systemic Poisons*

(*a*) Fibrosis-producing dusts: silica, asbestos.

(*b*) Inert dusts: carborundum, carbon, emery.

(*c*) Dusts causing allergic reactions: pollen, wood, resins, and many other organic dusts.

(*d*) Irritants: acids, alkalies, fluorides, chromates.

(*e*) Bacteria and other microorganisms.

II. Respiration

A. MECHANICS OF RESPIRATION

During inspiration, air forced by atmospheric pressure enters the nasal openings, passes through the pharynx, larynx, trachea, bronchi and bronchioles,

through the terminal bronchioles, the respiratory bronchioles and alveolar ducts, into the air sacs or alveoli, filling the void created by involuntary muscular expansion of the thoracic cavity. Expiration may be either by muscular effort or by elastic contraction of lung tissue, but in quiet breathing contraction is thought to be entirely passive. The normal function of respiration is to supply atmospheric oxygen through the alveolar walls to the blood for distribution to the tissues and to remove carbon dioxide resulting from oxidation within the cells. The oxygen and carbon dioxide exchange in the tissues is sometimes referred to as tissue or internal respiration, as distinguished from the aeration of the lungs or external respiration.

B. LUNG STRUCTURE, VITAL CAPACITY, AND THE DEAD SPACE

The tracheobronchial tree as described by Miller[2] is supported by cartilage, the trachea being a series of open cartilaginous rings or crescents connected on the posterior side by bundles of muscle. The rings are joined to each other by a dense layer of connective tissue. The result is a rather rigid ribbed tube capable of some adjustment in diameter. This tube divides into the right and left main bronchi extending downward at approximately 20 degrees for the right, and 40 degrees for the left branch. The bronchi are further divided and subdivided into smaller and smaller bronchial passages. There is a muscular network essentially transverse to these passages, and as the passages decrease in diameter the cartilaginous rings become less complete, finally losing their cresent shape to become merely small plates of cartilage. As the cartilage decreases there is an increase in the proportion of muscular tissue. Cartilaginous support finally disappears toward the outer end of the bronchioles, where the diameter is about 0.5 mm. These terminal bronchioles connect with respiratory bronchioles which branch into alveolar ducts, terminating in the alveoli. These bronchioles range from 1.5 to 0.2 mm. in length and are about 0.2 to 0.4 mm. in diameter.

Normally the lungs fill about 80 per cent of the total chest cavity. An average man can inhale about $3^1/_2$ liters of air by forced effort after an ordinary exhalation. Likewise, he can forcibly exhale about 1 liter after an ordinary exhalation. The sum of these, about $4^1/_2$ liters, is called the vital capacity. There is in addition about 1 to $1^1/_2$ liters residual air which cannot be expelled by forced exhalation but remains in the lungs to aerate the blood during exhalation. Thus there is a total volume in excess of $5^1/_2$ liters, of which less than 10 per cent is used in normal breathing. The approximately 500 ml. of air inhaled and exhaled during normal respiration is called tidal air, and of this 500 ml. about 150 ml. is required to fill the tracheobronchial tree or anatomical dead space—that portion of the respiratory tract consisting of thick-walled passages through which no interchange of gases between blood and air can occur. During an ordinary 500 ml. inspiration, then, 150 ml. practically unaltered atmospheric air fills the dead space while 350 ml. enters the alveoli and respiratory exchange area of the lungs.

[2] W. S. Miller, *The Lung*. Thomas, Springfield, Ill., 1937.