germs died out within a few hours[9]. Practical epidemiological evidence indicates that the danger of such atmospheric transmission is slight with the bacterial diseases but may be appreciable with the diseases caused by the much smaller viruses. Avoidance of overcrowding is a major factor in avoiding such dangers. The microbic concentration in the atmosphere may be reduced by air change, but since the rate of contamination may be great at local points over short periods of time the hazardous concentration may not be eliminated quickly enough and may even be spread over larger areas by local drafts. The possibility of sterilizing the air supply at the source, or destroying the micro-organisms at their point of admission to the air by ultra-violet light is being studied and offers considerable promise[10].

While in some instances it may be possible to reduce the physical impurities of the air by dilution from a non-contaminated source, such non-contaminated sources are rarely available. Frequently the outside air contains a higher concentration of physical impurities than that within an enclosure. Therefore, it is usually desirable to reduce the concentration of physical impurities by air cleaning methods, as discussed in Chapter 29.

THERMAL INTERCHANGES BETWEEN THE BODY AND ITS ENVIRONMENT

The importance of the thermal factors arises from the profound influence which they exert upon body temperature, comfort and health. Body temperature depends upon the balance between heat production and heat loss. The heat resulting from the combustion of food within the body (metabolism) maintains the body temperature well above that of the surrounding air. At the same time, heat is constantly lost from the body by radiation, convection and evaporation. Since, under ordinary conditions, the body temperature is maintained at its normal level of about 98.6 F, the heat production must be balanced by the heat loss.

In conditioning air for comfort and health it is necessary to know the rate of sensible and latent heat liberation from the human body, which in conjunction with other heat loads (see Chapters 4, 6 and 7) determines the capacity required for proper conditioning. The data in common use are those of the A.S.H.V.E. Research Laboratory[11].

The fundamental thermodynamic processes concerned in heat interchanges between the body and its environment may be described by the equation:

$$M = \pm S + E \pm R \pm C \qquad (1)$$

[9]Air-Borne Infection and Sanitary Air Control, by W. F. Wells (*Journal Industrial Hygiene*, November, 1935).

[10]Sanitary Ventilation in Wards, by W. F. Wells (*Heating and Ventilating*, April, 1939, p. 26). Measurement of Sanitary Ventilation, by W. F. Wells (*American Journal of Public Health*, Vol. 28, 1938, p. 343).

[11]A.S.H.V.E. Research Report No. 830—Heat and Moisture Losses from the Human Body and Their Relation to Air Conditioning Problems, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant (A.S.H.V.E. Transactions, Vol. 35, 1929, p. 245). Thermal Exchanges Between the Human Body and Its Atmospheric Environment, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant (*American Journal of Physiology*, Vol. 88, 1929, p. 386). A.S.H.V.E. Research Report No. 908—Heat and Moisture Losses from Men at Work and Application to Air Conditioning Problems, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant (A.S.H.V.E. Transactions, Vol. 37, 1931, p. 541). Thermal Exchanges Between the Bodies of Men Working and the Atmospheric Environment, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant (*American Journal of Hygiene*, Vol. XIII, 1931, No. 2, p. 415). A.S.H.V.E. Research Report No. 1106—Air Conditioning in Industry, by W. L. Fleisher, A. E. Stacey, Jr., F. C. Houghten and M. B. Ferderber (A.S.H.V.E. Transactions, Vol. 45, 1939, p. 59).

where

M = rate of metabolism.
S = rate of storage.
E = rate of evaporative heat loss.
R = rate of radiative heat loss or gain.
C = rate of convective heat loss or gain.

Factor M, the rate of metabolism, is always positive. The storage, S, may be either positive or negative, depending upon whether heat is being stored or given off, accompanied by a rise or fall in body temperature. Under ordinary circumstances (when the dew-point of the air is below the body surface temperature) the evaporation loss, E, is always positive; that is, heat from metabolism supplies this loss. R and C are positive when the surface temperature of the body is above that of the walls and air, and negative when it is cooler.

The human body possesses remarkable powers of adaptation to a narrow range of atmospheric conditions around an ideal optimum where storage is zero, and metabolism and skin and tissue temperature are at optimum values. As skin temperature and body-tissue temperature rise or fall above or below an optimum, complex adaptive mechanisms come into play, chiefly associated with redistribution of blood supply between the skin and deeper tissues (in a cold environment) and with sweat secretion (in a hot environment). Under cold conditions, the need for more heat and shivering or other muscular movements increase metabolism, which is, again, a reaction favorable to temperature regulation; but under very hot conditions metabolism also rises and this reaction is obviously harmful and indicates a balance of purely chemical over phsysiological control[12] resulting from increased chemical reactions with rise in temperature. In other words, it represents a breakdown or failure of the entire regulative processes. These reactions are governed by nervous or chemical stimuli from both skin and internal tissues. Nerves from the skin, for example, carry the sense impressions to the brain and the response comes back over another set of nerves, the motor nerves, to the musculature and to all the active tissues in the body, including the endocrine glands. In this way, a two-sided mechanism controls the body temperature by (1) regulation of internal heat production (chemical regulation), and (2) regulation of heat loss by means of automatic variation in the rate of cutaneous circulation and the operation of the sweat glands (physical regulation). The reactions involved in cold and in hot environments are on the whole radically different in nature. The mechanisms of adjustment involved are extremely complex and while they are receiving considerable study a complete understanding of their operation is still lacking.

In a certain middle range, normal and easy physiological regulation occurs by slight changes in the distribution of blood carrying heat between the skin and the inner organs, resulting in slight changes in the body surface temperature, and hence, in the rate of heat dissipation to the atmosphere. This easy balance gives a sensation of comfort. Above this

[12]Loc. Cit. Note 11.