are thus close to the upper limit compatible with life, signifying that cellular activity is close to maximal at normal body temperatures.

Hypothermia

Hypothermia denotes a drop in body temperature to levels below the normal range. Most cells tolerate cooling to near to 0 °C without sustaining damage. The metabolic rate of the tissues decreases by about 10 % for each degree that the temperature falls. Cooling is therefore a useful strategy when performing surgery on organs that are particularly sensitive to lack of oxygen, for instance the heart and the brain. In contrast to individual organs, the whole body of most mammals usually does not tolerate cooling down to less than about 25 °C. Any further reduction results in the circulatory system and respiratory system gradually failing. However, some specialized mammals and birds can survive shorter or longer periods at body temperatures that are 20–30 °C below normal (hibernation and torpor, p. 677).

Skin Temperature

While the core temperature normally remains essentially constant, skin temperature (shell temperature) varies considerably. When the ambient temperature is lower than the core temperature, the temperature of the skin surface is lower than the core temperature (Fig. 18.3). In contrast, in a particularly warm environment, the skin temperature can be higher than the core temperature, because heat is then transferred from the environment to the skin surface. It should be emphasized that adjustment of skin temperature is the body's most important mechanism for regulating the loss of heat from the body, thereby enabling an animal to maintain a nearly constant core temperature (see later).

Cooling of the body is useful during surgery on the heart and brain

Balance between Heat Production and Heat Loss

In contrast to core temperature, skin temperature varies considerably

The body temperature is a reflection of the total heat energy of the body (Fig. 18.4). In order to maintain a stable total heat content in the body, and thus a stable body temperature, heat input must equal heat output. Heat input has two components:

- internal heat production
- heat transfer from the environment (external heat input)

Skin temperature is a major determinant of heat loss from the body

In mammals and birds, the total amount of heat in the body is largely a result of internal heat production, and these animals are called *endothermic*. In most invertebrates, fish, amphibians, and reptiles, the body's total heat content is primarily determined by external sources of heat, and such animals are described as *ectothermic*. Mammals and birds, in addition to being endothermic are also *homeothermic*, meaning that the body temperature is maintained within narrow limits. In contrast, most ectothermic animals are *poikilothermic*, which denotes that their body temperature varies according to the ambient tempera-

Mammals and birds are both endothermic and homeothermic

Body temperature reflects the total heat energy of the body

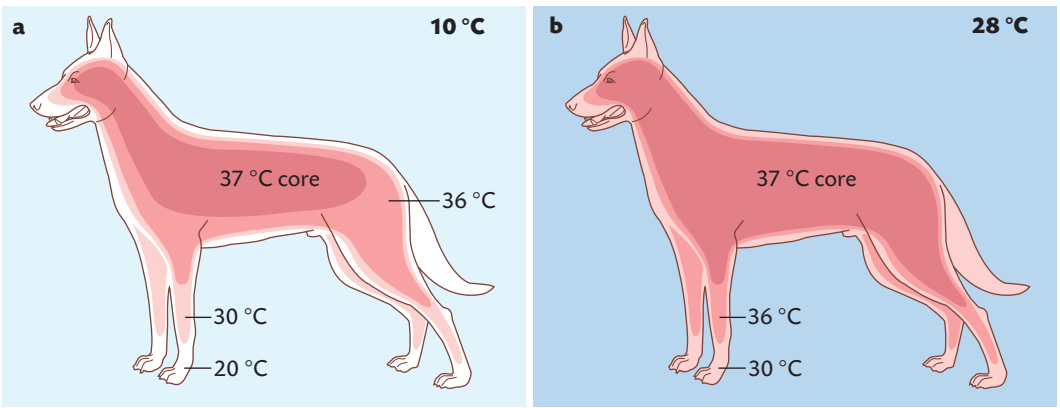

Figure 18.3 The temperatures in the body's core and shell at two different ambient temperatures. The temperature of the shell (light red and white) varies with the ambient temperature. The shell is most extensive in a cold environment. **a** Cold environment (10 °C). **b** Warm environment (28 °C).