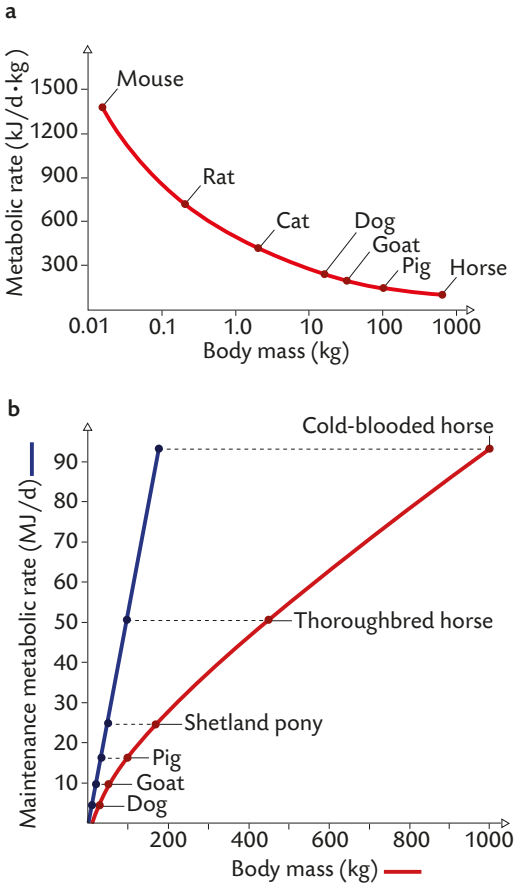

Figure 21.3 **a** Maintenance metabolic rate (kJ/d) calculated per kg body mass (BM) in laboratory animals and some domestic animals. The metabolic rate per unit BM declines with increasing BM. **b** Maintenance metabolic rate of domestic animals as a function of body mass (red line) and as a function of metabolic body mass ($BM^{0.75}$, blue line). Metabolic rate is linearly related to metabolic body mass.

- deposition of lipids and proteins during growth and pregnancy
- production of eggs, milk, and wool

Each of these functions requires an extra supply of energy and a supply of appropriate nutrients. The energy required is calculated by adding the requirements for each function to the maintenance requirement. For example, if a pregnant mare is used for riding, the mare's energy requirement is the sum of the maintenance requirement and the requirements for fetal growth and physical activity.

An animal's energy budget is maintenance energy plus energy required for each function the animal performs

Measurement of Metabolic Rate

The metabolic rate can be estimated by two methods:

- direct calorimetry
- indirect calorimetry

Direct calorimetry

The maintenance metabolic rate can be determined by measuring the amount of heat dissipated by an animal over a given period of time, provided that there is no external work and no net change in energy stores. Under such conditions, all energy released in the body is converted to heat energy. This method is called *direct calorimetry*.

Direct calorimetry is measurement of heat dissipation

During direct calorimetry, the animal is kept in an enclosure in which heat production can be measured. Direct calorimetry is time-consuming, labor-intensive, and impractical for large animals. However, this method is commonly used for small animals, such as mice and rats. Direct calorimetry was formerly also used to measure metabolic rates in humans, but has now generally been replaced by indirect methods.

Indirect measurement of metabolic rate

In indirect measurement of metabolic rate, a parameter closely correlated with heat production is estimated. Under aerobic conditions, O_2 is consumed and H_2O is formed in the final pathway of nutrient oxidation in the body. Therefore, the metabolic rate can be calculated by measuring the rate of O_2 consumption. However, if a portion of an animal's heat production occurs by anaerobic metabolism, calculations based on the O_2 uptake alone result in underestimation of the metabolic rate.

Metabolic rate can be estimated by measuring O_2 uptake

Uptake of O_2 from the inhaled air is measured by spirometry (p. 525). However, it is difficult to train animals to use a spirometer. Therefore, small experimental animals, such as mice and rats, are placed in a closed chamber in which consumption of O_2 can be measured. In larger animals, such as dogs and horses, O_2 consumption can be measured by placing a ventilated breathing mask over the mouth and nostrils. By using such a mask, it is also possible to measure the O_2 consumption in exercising animals, for example horses trotting on a treadmill, or birds flying in a wind tunnel.