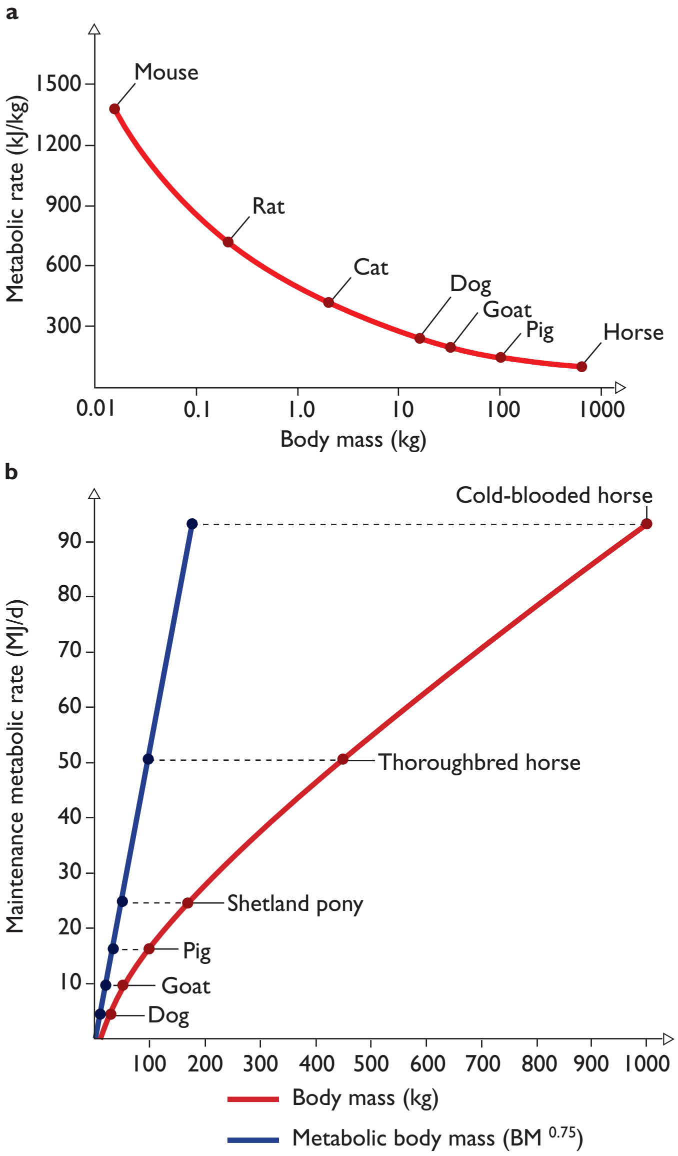

Figure 20.3 ***a*** *Maintenance metabolic rate (kJ/d) calculated per kg body mass (BM) in laboratory animals and some domestic animals, using 525 kJ per unit metabolic mass (BM$^{0.75}$).* ***b*** *Maintenance metabolic rate of domestic animals as a function of body mass (red line) and as a function of metabolic body mass (blue line).*

The relationship between the metabolic rate and metabolic body mass also holds true for birds, reptiles, amphibians and fish. The numerical value for the constant **a** in the equation for MEM, however, differs between endothermic and ectothermic animals. When adjusted for the temperature difference, or when measured at the same body temperature, the specific metabolic rate in endothermic vertebrates is 8–10 times greater than in ectothermic vertebrates. This is primarily due to the greater permeability of the cell membrane of endothermic animals to ions. In order to maintain ion gradients across the cell membrane, endothermic animals must therefore use much more chemical energy for active pumping of ions. This energy is converted to heat energy in the body. The question remains as to how and why such an energy-demanding process has developed through evolution. One possible explanation is that the greater heat production in endothermic species makes it possible to maintain higher body temperatures, and therefore higher activity under unfavorable environmental conditions, for example during cold nights and in cold climates. As a result of this difference in metabolic intensity, ectothermic animals achieve greater growth for a given amount of feed than endothermic animals. This is one of the reasons why aquaculture, which is based on cultivation of ectothermic animals, has come to play an increasingly important role in the world's food production.

Like the metabolic rate, the *body surface area* in animals is also proportional to a power function of body mass (BM$^{0.67}$). However, the exponent of 0.75, used as the scaling parameter for metabolic body mass, is greater than what would be expected if it were the body surface area that determines the metabolic rate.

Calculation of Energy Requirements of Animals

To justify their role in agriculture, production animals have to deliver a product in addition to staying alive. The most important contributions are:

- physical work, such as that performed by draught animals or animals used for riding
- 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 one uses a pregnant mare for riding, the mare's energy requirement is the sum of the maintenance requirement and the requirements for fetal growth and physical activity.

Measurement of Metabolic Rate

The metabolic rate can be estimated by two methods:

- direct calorimetry
- indirect calorimetry

Direct calorimetry

The metabolic rate can be determined by measuring the amount of heat dissipated by an animal over a given period of time, provided there is no external work and no net change in energy stores. This is called *direct calorimetry.*