14.1 Why does an endotherm’s metabolic rate increaseabove the upper lethal temperature? And why does themetabolic rate fall below the lower lethal temperature?

The Q10 effect has taken over in the region above the upper lethal temperature, and the animal can no longer control its own metabolism. As the body temperature rises, biochemical processes speed up, and the heat that is released warms the body still more and increases the rate of metabolism even further. This cycle causes an explosive increase in body temperature that leads to death. The Q10 effect is also responsible for the decrease in metabolic rate below the lower lethal temperature: as the body temperature begins to fall, biochemical processes slow down and produce less heat, accelerating the fall of body temperature and further slowing metabolism until the animal dies of hypothermia.

14.2 The density of sweat glands in human skin is10 times that of a chimpanzee’s as the result ofenhanced expression of the Engrailed 1 gene.Why are sweat glands more important for humansthan for chimpanzees?

The hair on a chimpanzee’s body prevents solar radiation from reaching the skin. Bare-skinned humans rely on sweat to counteract heating by solar radiation and convection.

14.3 Although most fishes are ectotherms, the efficiencyof secondary production by fishes is substantiallylower than the average of 50% measured forterrestrial ectotherms. What difference betweenaquatic and terrestrial environments might accountfor this difference?

Chapter 4 referred to the energy cost of osmoregulation, and that is a plausible hypothesis to explain the lower efficiency of secondary production by fishes. Evidence to support the hypothesis is equivocal because two different methods of measuring the cost of osmoregulation yield very different results:

Measurements of oxygen consumption of fishes indicate that 20 to 50 percent of a fish’s daily energy budget is devoted to osmoregulation. Furthermore, most (but not all) freshwater and marine fishes grow best in water that has a salinity between 5 and 18 parts per thousand.

In contrast to these whole-animal studies, estimates of the cost of osmoregulation extrapolated from the cost of Na+ transport in isolated tissues indicate that the cost of osmoregulation is no greater than 10 percent of the energy budget.

(G. Boeuf and P. Payan. 2001. How should salinity influence fish growth? Comparative Biochemistry and Physiology C 130:411−423.)

14.4 Most mammals have a layer of cutaneous fat beneaththe skin, but dromedaries concentrate fat storage intheir hump. What is the significance of that difference for the thermoregulation of dromedaries?

Subcutaneous fat provides a layer of insulation that impedes the movement of heat across the skin of an animal, slowing heating when the air temperature is higher than the body temperature of the animal and retarding cooling when the body temperature is higher than the air temperature. Dromedaries rely on losing heat at night to dissipate the heat that they store during the day, and a layer of subcutaneous fat would interfere with that heat loss. Of course, subcutaneous fat would retard heating during the day, but dromedaries accomplish that by lying side by side with other dromedaries during the day.

14.5 Sea otters, *Enhydra lutris*, are the smallest marinemammals. They live in the north Pacific, where watertemperatures range from 0° to ~15°C. Sea otters havea resting metabolic rate about 3 times the rate expectedfrom their body size. What does this observationsuggest about their ability to live in cold water?

Non-shivering thermogenesis is a reasonable hypothesis that was confirmed by measurements of metabolism of muscle tissue from sea otters. (Wright et al. 2021. Skeletal muscle thermogenesis enables aquatic life in the smallest marine mammal. Science 373:223-225. DOI: 10.1126/science.abf4557.)

14.6 To qualify as a scientific hypothesis, a proposedexplanation of a phenomenon must be capable of beingfalsified—that is, disproved by an experiment or byapplication of data previously gathered. Do any of theproposed explanations of the evolution of endothermy(thermogenic opportunity, warmer is better, indirect selection, parental care) meet that criterion?

In our opinion, none of the proposals is a good hypothesis. Indirect selection and parental care can be evaluated with existing data (see section 14.5), but not convincingly falsified. The thermogenic opportunity and warmer is better proposals are even less falsifiable.