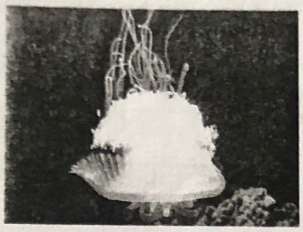
# Mechanisms of Thermoregulation

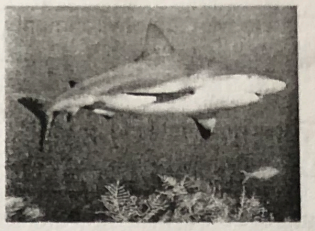


The process of controlling body temperature is called thermoregulation. For many years, animals were classified as either homeotherms or homoiotherms (= constant body temperature) or poikilotherms (= variable body temperature). Unfortunately, these terms are not particularly accurate for many animals; for example, some mammals (typical homeotherms), may have unstable body temperatures. A more recent, thermal classification of animals is based on the source of the body heat: whether it is largely from the environment (ectothermic) or from metabolic activity (endothermic). This classification can be more accurately applied to most animals but, in reality, many animals still fall somewhere between the two extremes.

## How Body Temperature Varies



Aquatic invertebrates like jellyfish are true poikilotherms: their temperature is the same as the environment.



Tuna and some of the larger sharks can maintain body temperatures up to 14°C above the water temperature.

Hibernating rodents and bats let their body temperature drop to well below what is typical for most mammals.

Most birds and mammals maintain a body temperature that varies less than 2°C: they are true homeotherms.

*Increasingly homeothermic* →

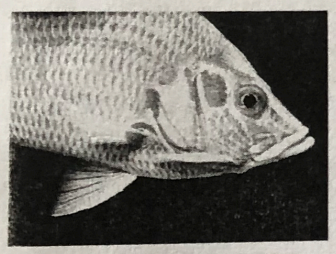
**Poikilothermic**

Body temperature varies with the environmental temperature. Traditionally includes all animals other than birds and mammals, but many reptiles, some large insects and some large fish are not true poikilotherms because they may maintain body temperatures that are different from the surrounding environment.

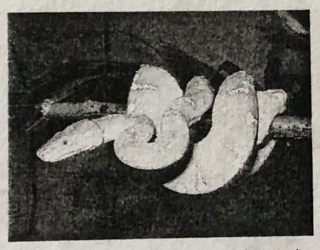
**Homeothermic**

Body temperature remains almost constant despite environmental fluctuations. Traditionally includes birds and mammals, which typically maintain body temperatures close to 37-38°C. Many reptiles are partially homeothermic and achieve often quite constant body temperatures through behavioral mechanisms.

## Source of Body Heat

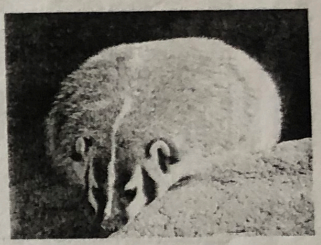


With a few exceptions, most fish are fully ectothermic. Unlike many reptiles they do not usually thermoregulate.



Snakes use heat energy from the environment to increase their body temperature for activity.

Some large insects like bumblebees may raise their temperature for short periods through muscular activity.



Mammals (and birds) achieve high body temperatures through metabolic activity and reduction of heat losses.

*Increasingly endothermic* →

**Ectothermic**

Ectotherms depend on the environment for their heat energy. The term ectotherm is often equated with poikilotherm, although they are not the same. Poikilotherms are also ectotherms but many ectotherms may regulate body temperature (often within narrow limits) by changing their behavior (e.g. snakes and lizards).

**Endothermic**

Endotherms rely largely on metabolic activity for their heat energy. Since they usually maintain a constant body temperature, most endotherms are also homeotherms. As well as birds and mammals, some fast swimming fish, like tuna, and some large insects may also use muscular activity to maintain a high body temperature.

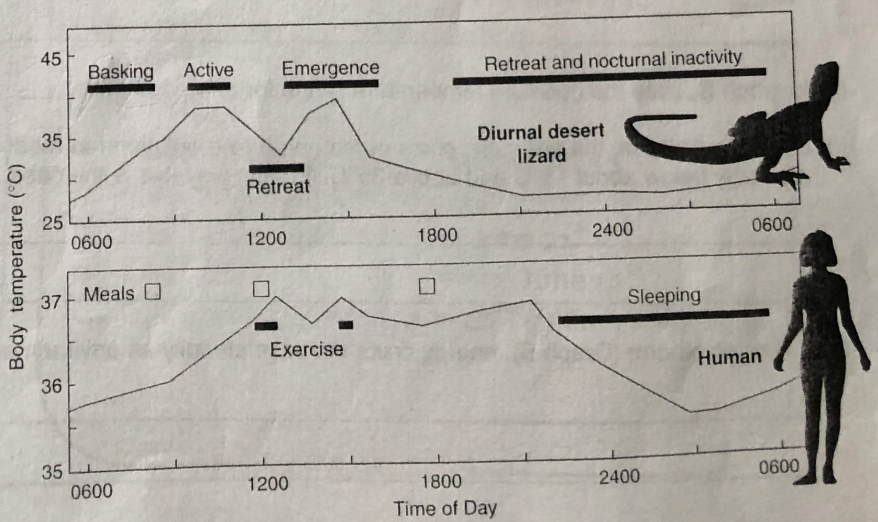
### Daily temperature variations in ectotherms and endotherms

Ectotherm: Diurnal lizard (top right)

Body temperature is regulated by behavior so that it does not rise above 40°C. Basking increases heat uptake from the sun. Activity occurs when body temperature is high. Underground burrows are used for retreat.

Endotherm: Human (bottom right)

Body temperature fluctuates within narrow limits over a 24 hour period. Exercise and eating increase body temperature for a short time. Body temperature falls during rest and is partly controlled by an internal rhythm.



Explain why the term "poikilotherm" is not a good term for classifying many terrestrial lizards and snakes:

Poikilotherm means variable body temperature. Some organisms like lizards & snakes are not true poikilotherms because they maintain body temperatures different from their surroundings.

2. Ectotherms will often maintain high, relatively constant body temperatures for periods in spite of environmental fluctuations, yet they also tolerate marked declines in body temperature to levels lower than are tolerated by endotherms.
   (a) Describe the advantages of letting body temperature fluctuate with the environment (particularly at low temperature):

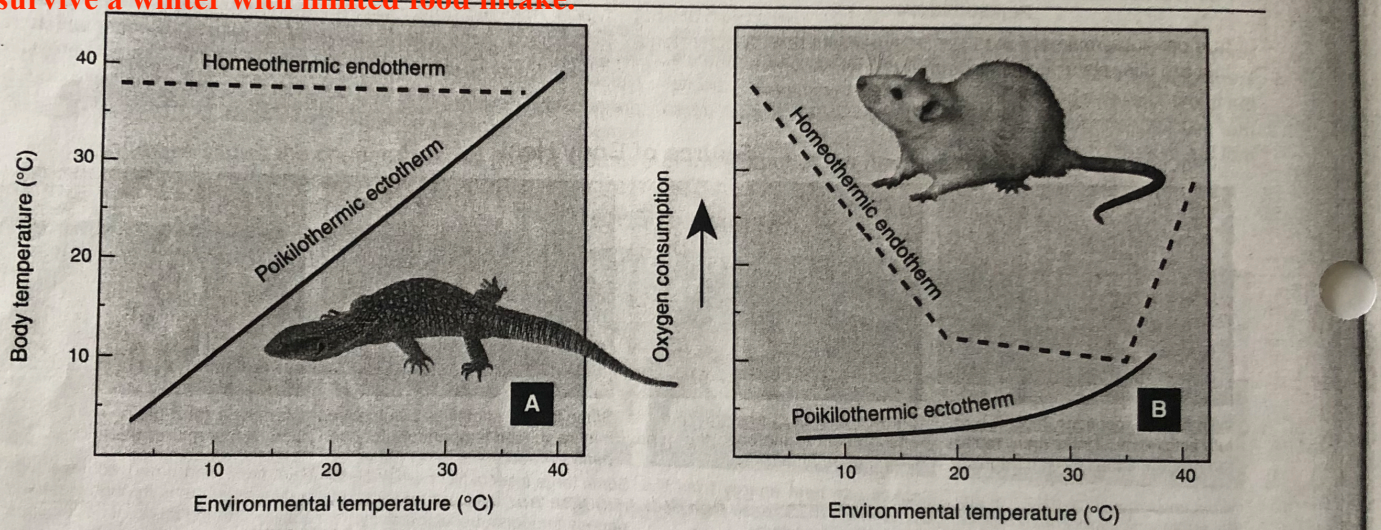
Less need to depend on constant food source, more energy efficient…

   (b) Suggest why ectothermy is regarded as an adaptation to low or variable food supplies:

Metabolism is not the key source of heat energy so less food is required. They can depend on their environments through behavioural actions to regulate temperatures

3. Some endotherms do not always maintain a high body temperature. Some, such as small rodents, allow their body temperatures to fall during hibernation. Explain the advantage of this behavior:

To maintain a high body tempearture a steady food source is required. During hibernation food sources become limited. By not having to constantly eat to try to generate body heat they survive a winter with limited food intake.




4. The two graphs above illustrate the differences in temperature regulation between a homeothermic endotherm and a poikilothermic ectotherm (such as a fish). Graph A shows change in body temperature with environmental temperature. Graph B shows change in oxygen consumption with environmental temperature. Use the graphs to answer the following:
   (a) Explain how ectotherms and endotherms differ in their response to changes in environmental temperature (graph **A**):

Homeo endo maintian body temperature dispite environmental changes. Poik ecto body temperature is directly dependent on environmental temperature.

   (b) Explain why a poikilothermic ectotherm (no behavioral regulation of temperature) would be limited to environments where temperatures were below about 40°C:

Above this key enzymes would begin to denature and required body functions would stop.

   (c) In graph **B**, state the optimum temperature range for an endotherm: 20-35 C

   (d) For an endotherm, the energetic costs of temperature regulation (as measured by oxygen consumption) increase markedly below about 15°C and above 35°C. Explain why this is the case:

Oxygen is used to drive cellular respiration which provides body heat when temps below optimal. Above optimal energy is required to cool the body (sweat, move to shade, dilate blood vessels) the creation of this energy comes from aerobic respiration.

   (e) For an ectotherm (Graph B), energy costs increase steadily as environmental temperature increases. Explain why:

They have to find ways to cool themselves - move to shade, find water… which require energy attained through aerobic cellular respiration.