Course: Animal form and function

Chapter: Temperature And Body Fluid Regulation

- Homeostasis and Temperature Regulation
- Heat Gains and Losses
- Temperature Regulation in Invertebrates
- Invertebrate Excretory Systems
- Vertebrate Excretory Systems

❑Homeostasis and Temperature Regulation

- Zoologists believe that the ability of some higher animals to maintain a constant (homeostatic), relatively high body temperature is a major reason for their evolutionary success.
- This ability to control the temperature of the body is called **thermoregulation ("heat control").**
- thermoregulation involves the nervous, endocrine, respiratory, and circulatory systems in higher animals.

THE IMPACT OF TEMPERATURE ON ANIMAL LIFE

- When the temperature rises above the temperature optima the rates decline as the enzymes begin to denature and chemical interactions holding the enzymes in their three-dimensional shape are also disrupted
- The results of enzyme evolution have frequently been enzymes with temperature optima that reflect an animal's habitat.
- For example, a digestive enzyme in a trout might function optimally at 10° C, whereas another enzyme in the human body that catalyzes the same reaction functions best at 37° C.

HEAT GAINS AND LOSSES

The total body temperature is a result of an interaction of these factors and can be expressed as:

Body temperature = heat produced metabolically

+heat gained from the environment

-heat lost to the environment

- **Animals use four physical processes to exchange heat with the environment:**

1) **Conduction**
2) **Convection**
3) **Evaporation**
4) **Radiation**

1) Conduction

- Direct transfer of thermal motion (heat) between molecules of the environment and those on the body surface of an animal.
- Transfer is always from an area of higher temperature to one of lower temperature because heat moves down thermal gradients.
- For example, when you sit on the cold ground, you lose heat, and when you sit on warm sand, you gain heat.

2) Convection

- Convection is the movement of air (or a liquid) over the surface of a body
- Contributes to heat loss if the air is cooler than the body or heat gain if the air is warmer than the body.

3) Evaporation

- Loss of heat from a surface as water molecules escape in the form of a gas. It is useful only to terrestrial animals.

4) Radiation

- Emission of electromagnetic waves that objects, such as another animal's body or the sun, produce.
- Radiation can transfer heat between objects that are not in direct contact with each other, as happens when an animal suns itself

Fig: Radiation Warms an Animal. After a cold night in its den on the Kalahari Desert, a meerkat (*Suricata suricatta*) stands at attention, allowing the large surface area of its body to absorb radiation from the sun.

SOME SOLUTIONS TO TEMPERATURE FLUCTUATIONS

Ectotherms

- Derive most of their body heat from the environment rather than from their own metabolism.
- Low rates of metabolism and are poorly insulated.
- Tend to move about the environment and find places that minimize heat or cold stress to their bodies.
- Reptiles, amphibians, fishes, and invertebrates are ectotherms, although a few reptiles, insects, and fishes can raise their internal temperature.

Endotherms

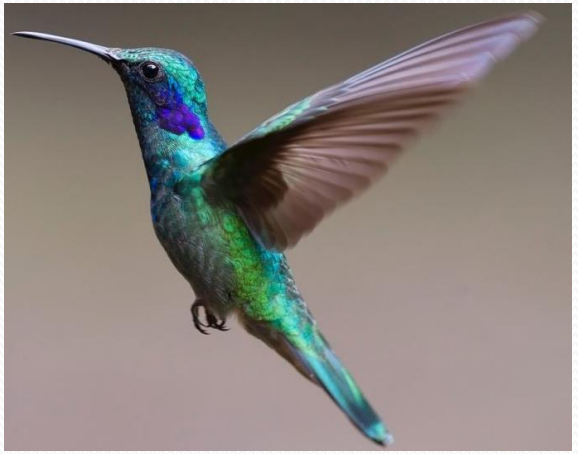
- They obtain their body heat from cellular processes.
- A constant source of internal heat allows to maintain a nearly constant core temperature, despite the fluctuating environmental temperature.
- Most endotherms have bodies insulated by fur or feathers and a relatively large amount of fat.
- Endothermy allows some animals to colonize habitats denied to ectotherms.

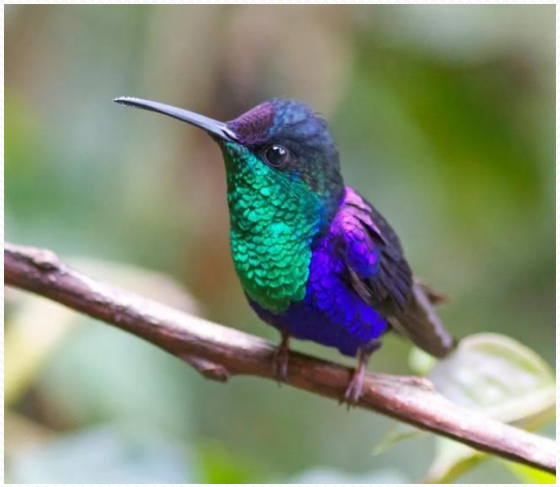
Homeotherms and heterotherms

- Another way of categorizing animals is based on whether they maintain a constant or variable body temperature.
- Most endotherms are **homeotherms** (maintain a relatively constant body temperature).
- Most ectotherms are **heterotherms** (have a variable body temperature).

daily torpor

- Some birds (e.g., hummingbirds) and mammals (e.g., shrews) can only maintain a high body temperature for a short period.
- When not feeding, hummingbirds rapidly run out of energy unless their metabolic rates decrease considerably.
- At night, hummingbirds enter a sleep-like state, called daily torpor, and their body temperature approaches that of the cooler surroundings.
- Some bats also undergo daily torpor to conserve energy.





Temperature Regulation in Invertebrates

Mechanisms for surviving temperature extremes:

❖ Physical Mechanism:

- **Temperate-zone insects avoid freezing by reducing the water content in their tissues as winter approaches.**
- **Other insects can produce glycerol or other glycoproteins that act as an antifreeze.**
- **Some moths and bumblebees warm up prior to flight by shivering contractions of their thoracic flight muscles.**

❖ Evaporative cooling mechanisms

- **Most large, flying insects have evolved a mechanism to prevent overheating during flight; blood circulating through the flight muscles carries heat from the thorax to the abdomen, which gets rid of the heat—much as coolant circulating through an automobile engine passes through the radiator.**

- **Certain cicadas (*Diceroprocta apache*) that live in the Sonoran Desert have independently evolved the complete repertoire of evaporative cooling mechanisms that vertebrates use.**

❖ By Body posture and orientation of wings:

- It can markedly affect the body temperature of basking insects.

For example, perching dragonflies and butterflies can regulate their radiation heat gain by postural adjustments.

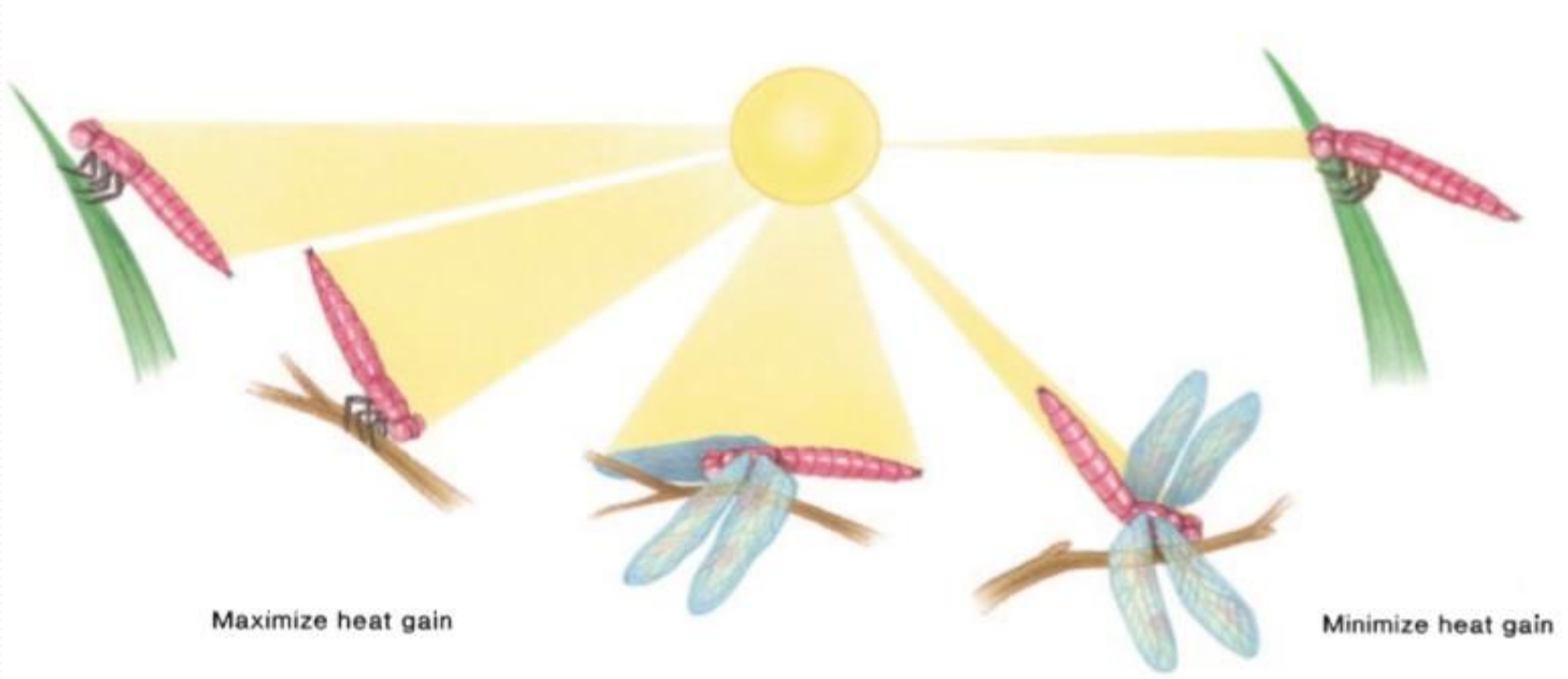


Fig: Heat Gain in an Insect. Postures a dragonfly adopts to either maximize or minimize heat gain.

- **Many ground-dwelling arthropods (*Tenebrio* beetles, locusts, scorpions) raise their bodies as high off the ground as possible to minimize heat gain from the ground.**

❖ Waxes

- **Some desert-dwelling beetles can exude waxes from thousands of tiny pores on their cuticle. These "wax blooms" prevent dehydration and also are an extra barrier against the desert sun.**

❖ Color

- **A black surface reflects less radiant energy than a white surface.**
- **many black beetles may be more active earlier in the day because they absorb more radiation and heat faster.**
- **white beetles are more active in the hotter parts of the day because they absorb less heat.**