

Biology

SCI102

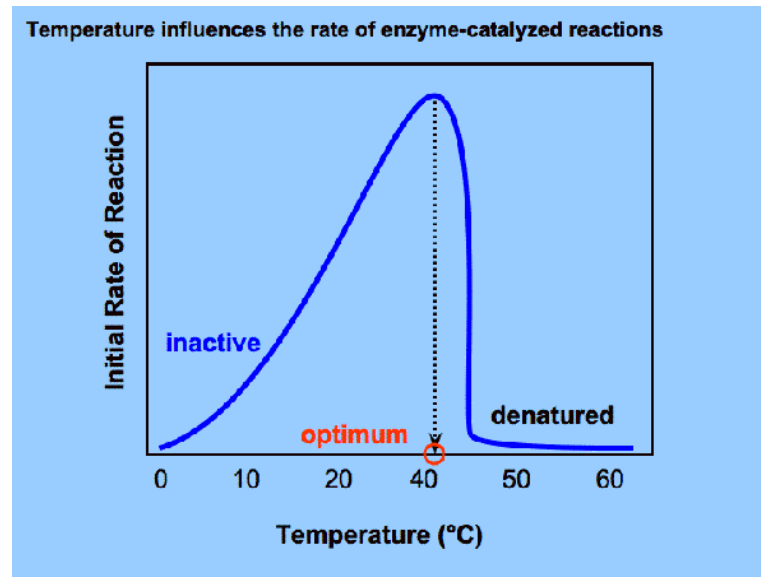
Module 4

Biological responses in context

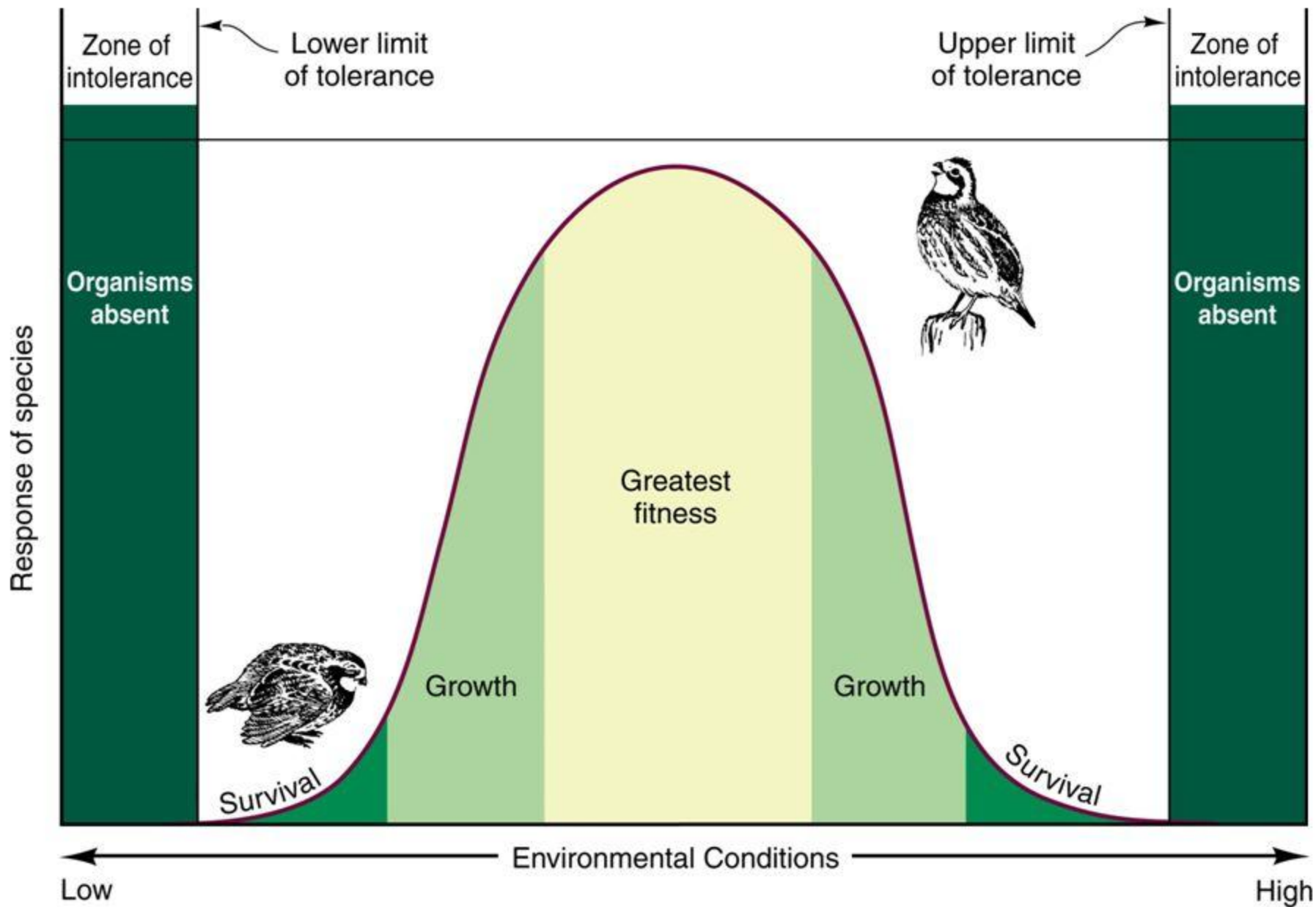
Heat Sources & Sink

BU Need Heat Sources & Sinks

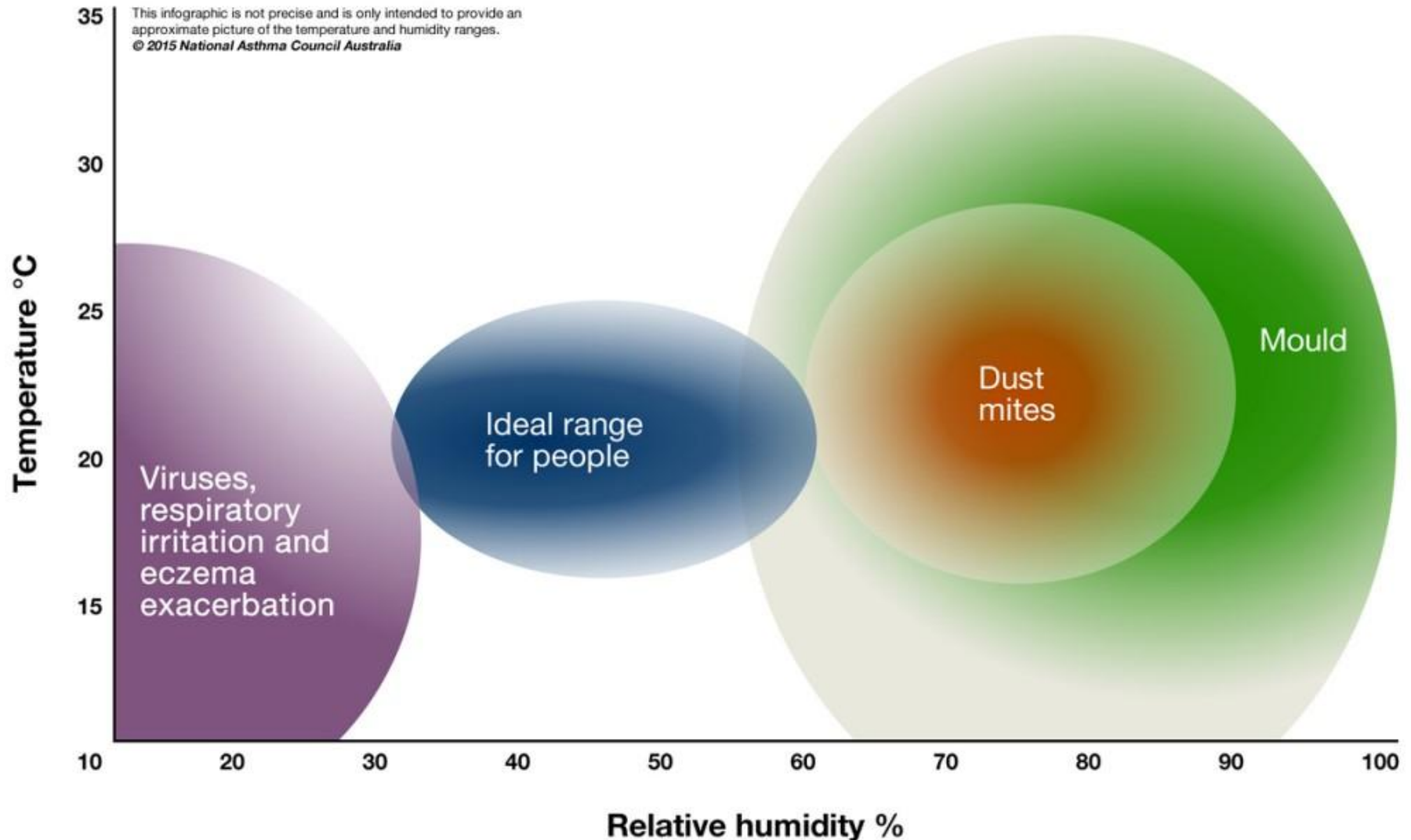
- BU are caught in the middle of needing some heat, but not too much



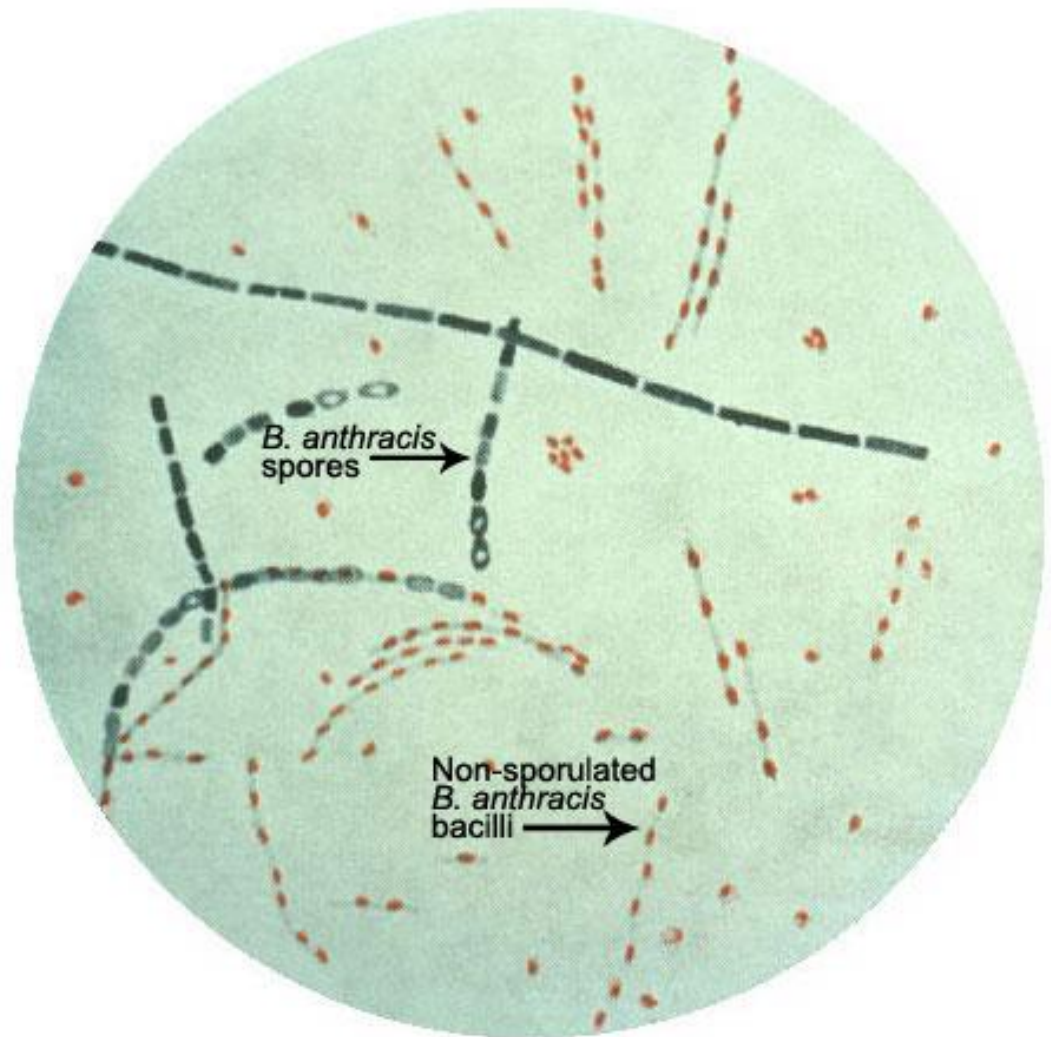
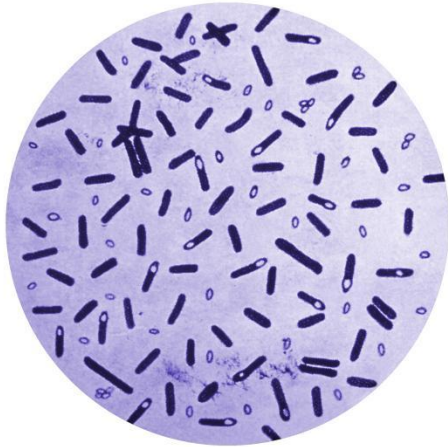
- Temperature intermediate between the phase change of ice to liquid water and the temperature where proteins, including enzymes, lose their functionality
- BU need heat sources from which to extract heat and BU need heat sinks to accept extra heat



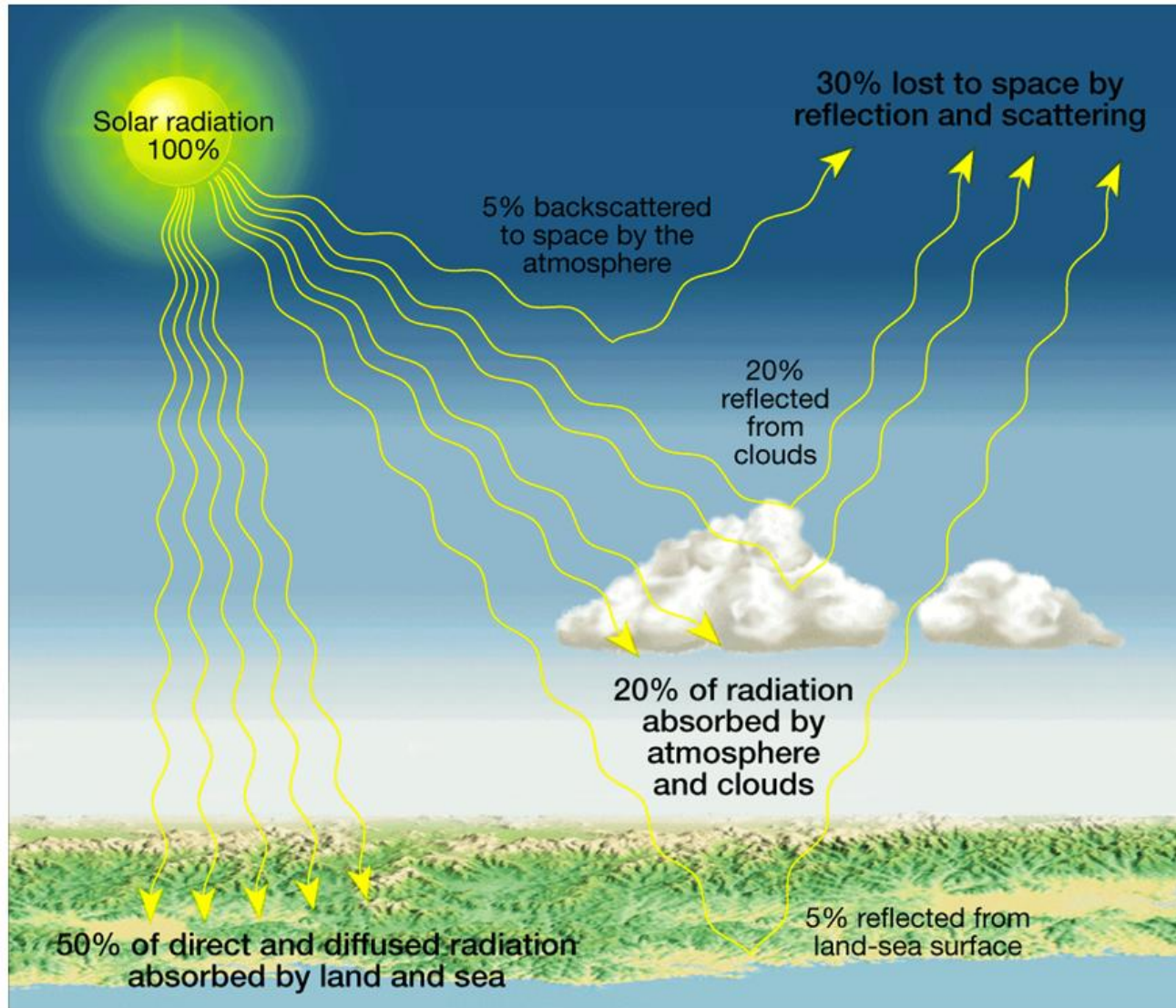
BU Need Heat Sources & Sinks



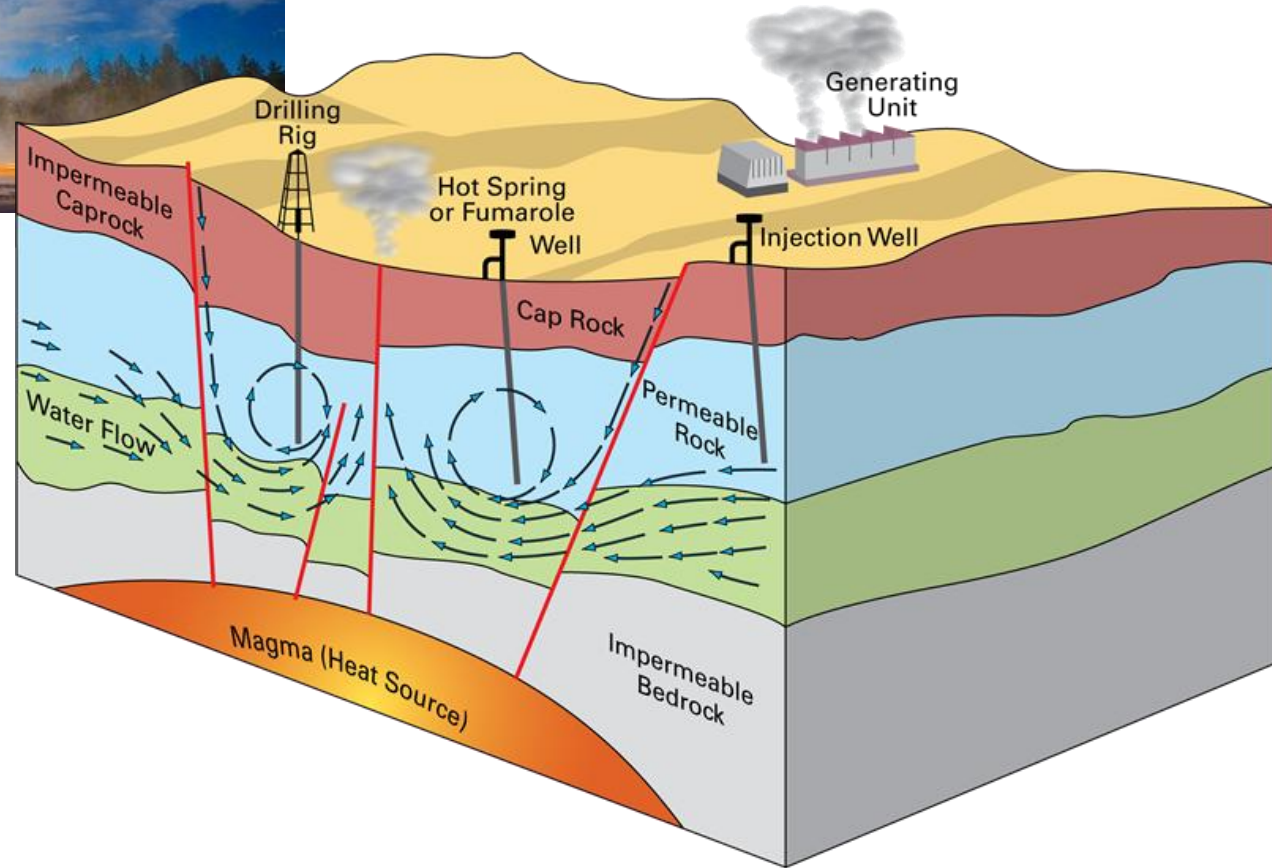
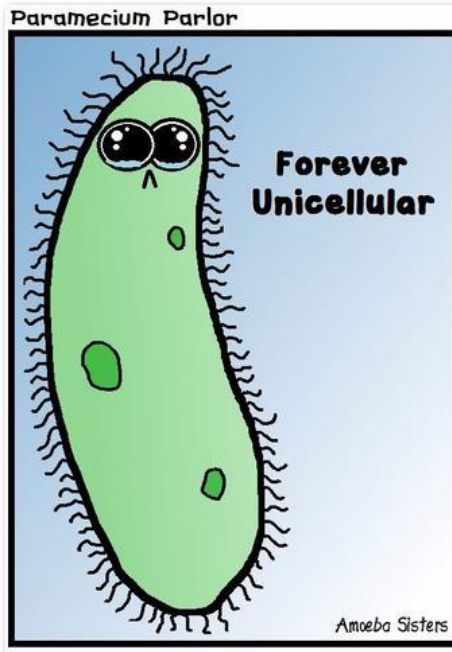
Spores Can Survive Extremes



Heat Sources - Sun



Heat Sources - Geothermal



Heat Transfer

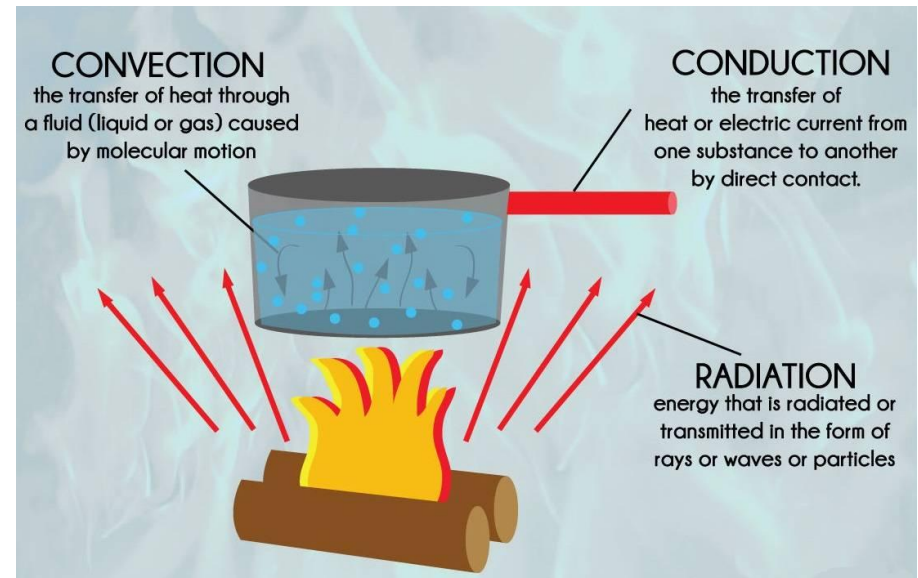
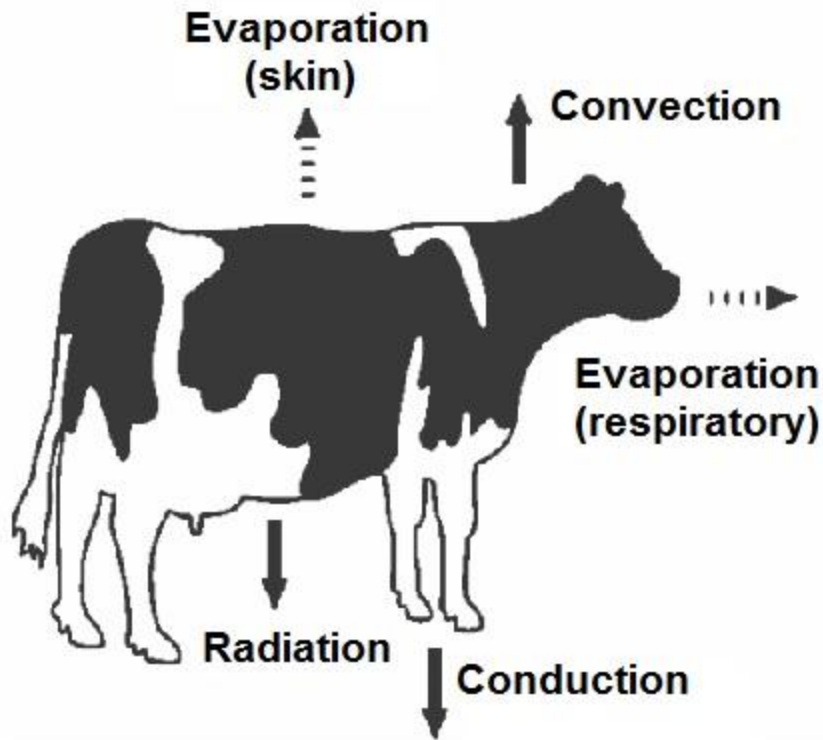
- **The final form of energy is heat.**
- All other forms of energy flow from higher potential to lower, and eventually degrade into heat.
- Heat may be transformed into other forms of energy, but the transmutation is never 100% efficient, and so some heat is left over. This heat can do work as it moves to lower temperature heat sinks, but once it reaches the lowest temperature possible, that is, there are no lower temperature heat sinks available, the heat cannot move any more; it is incapable of producing any other kind of energy.
- This unique position for heat is the reason why heat, of all the forms of energy, needs to be studied in further detail. Heat transfer is thus important to biological organisms. Excess heat must be removed and heat deficiencies must be filled. Otherwise, organisms will not survive.

Heat Transfer

- Heat may be transferred through four common mechanisms: conduction, convection, radiation, and change of state.
- Conduction requires contact for heat to move from one object or fluid to another. Convection requires that there be a moving fluid (liquid or gas) that can heat or cool and move the heat along with the fluid. Radiation requires only that two objects be in line-of-sight contact; heat is moved through electromagnetic means.
- Change of state heat transfer is important when a substance, such as water, evaporates, condenses, melts, or freezes.
- Conduction, convection, and radiation heat transfer happen according to

$$\text{rate of heat transfer} = \frac{(\text{surface area perpendicular to flow})(\text{temperature difference})}{(\text{distance})(\text{insulation value})} \quad (2.7.1)$$

Removing Excess Heat



Heat Transfer

Compare the rate of heat transfer in following animals

Parameters	Human	Cow
Surface Area	100 mm ²	100 mm ²
Temperature difference (ΔT)	2 K	2 K
Distance	10 mm	10 mm
Insulation Value / R-value	1 Km ² W	3 Km ² W

Removing Excess Heat

Cold Adapted Cow



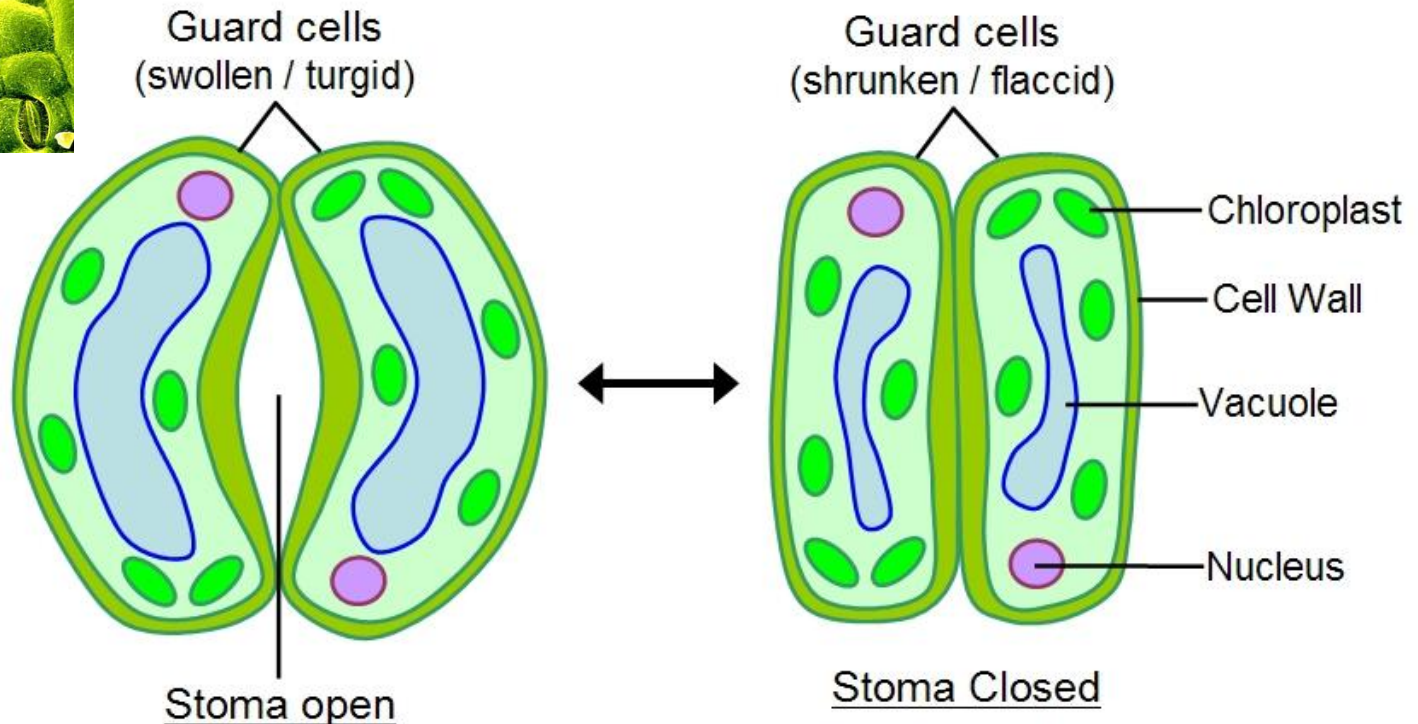
Hot-weather Adapted Cow



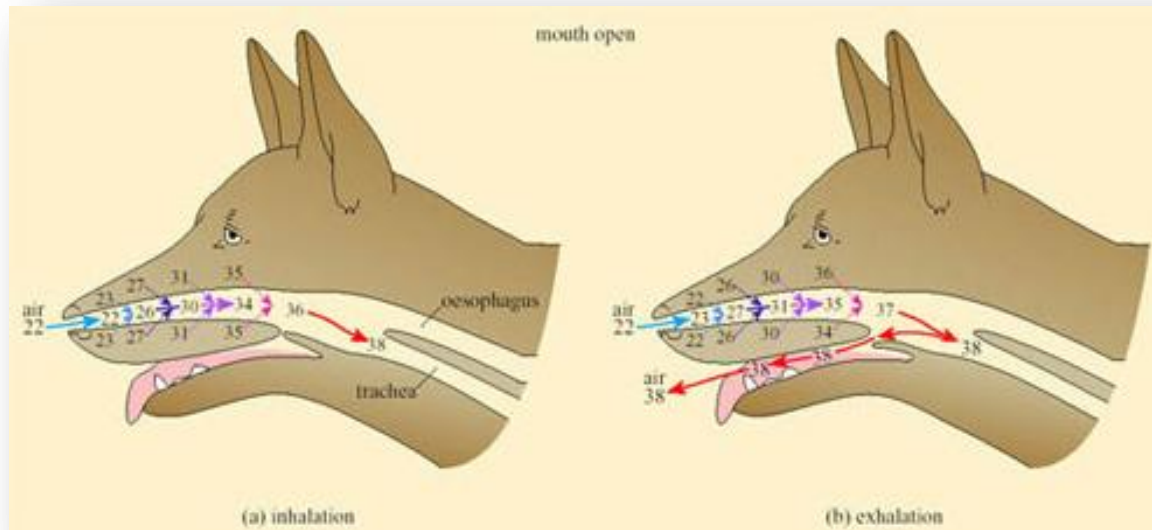
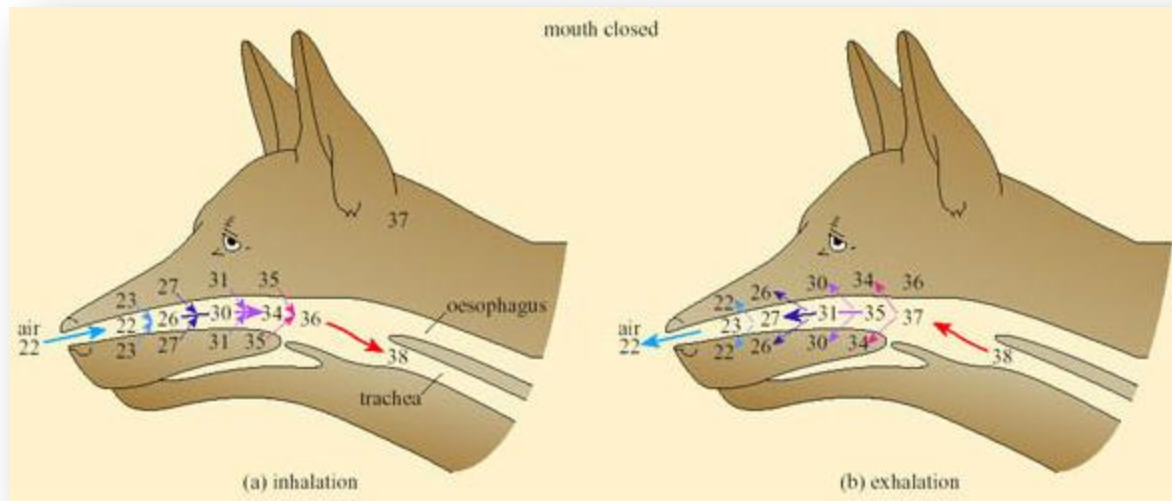
Cattle adapted to colder climates store fat under the skin and between muscle fibers. This fat is poorly vascularized and acts as insulation against heat loss. Hot-weather adapted cattle, however, store most of their fat in the gut, around body organs, and in humps on their backs. These cattle can lose much more heat to the environment than if they had the insulating fat layer underneath their skin.

Evaporative Heat Loss

Water, with its unusually high latent heat of evaporation of $2.447 \times 10^6 \text{ N m/kg}$, can remove a large amount of heat with only a modest loss of mass.



Evaporative Heat Loss



Applications

- When providing ventilation systems for human or animal BU, the possibility of air saturation must be taken into account because the combination of high temperature and high humidity, especially if air movement is limited, can easily be fatal.
- The environment inside an impermeable protective suit, inside a livestock housing facility, or inside a modern apartment building when the air conditioning shuts off can reach this lethal state.
- People and animals have died as a result. Evaporation, of course, is not available as a heat loss mechanism to BU bathed in water.

Cooling a Chicken

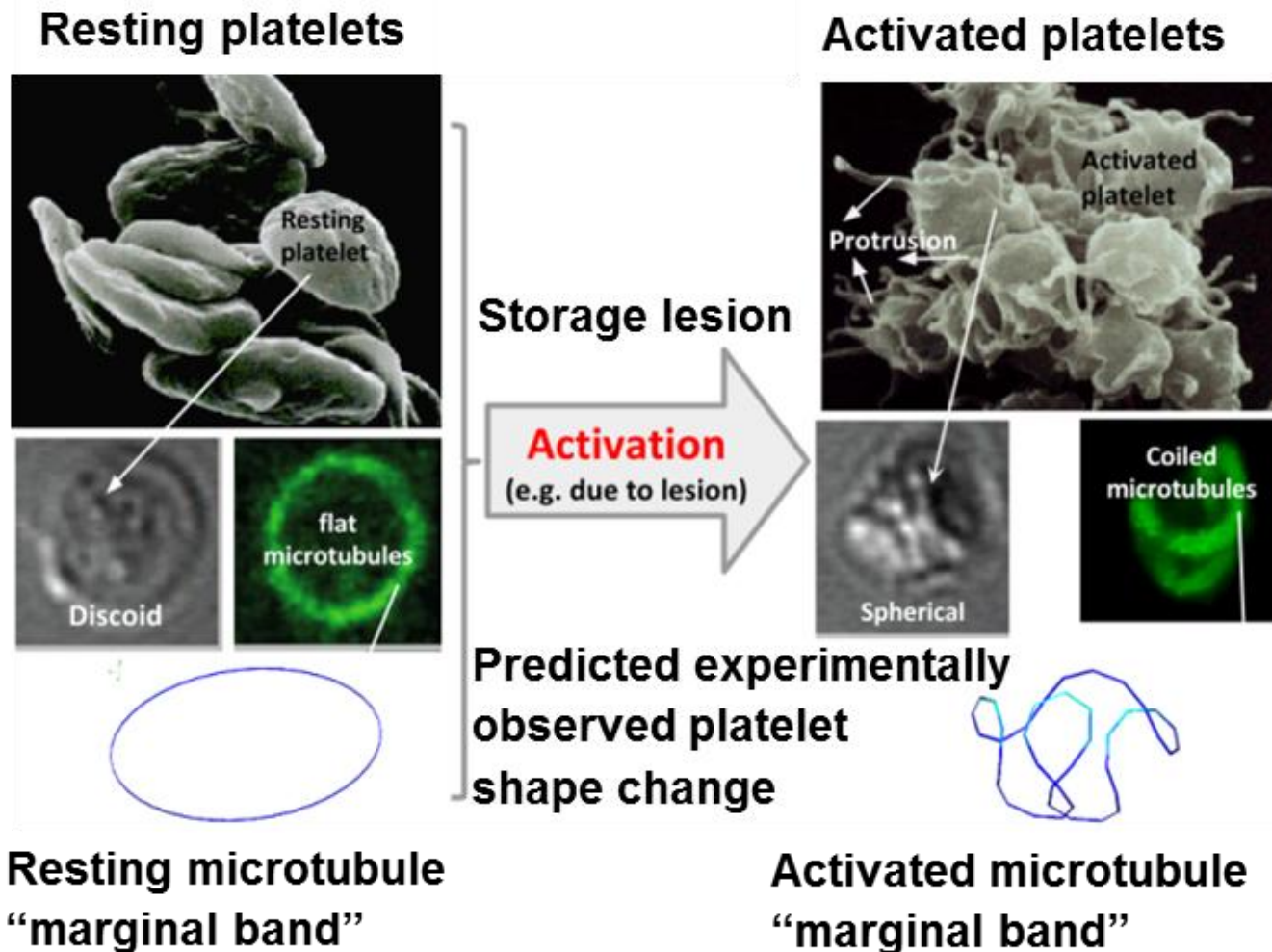


Chickens raised commercially for broilers are raised in flocks of up to 100,000 or more in a single poultry house



Application – Platelet Storage

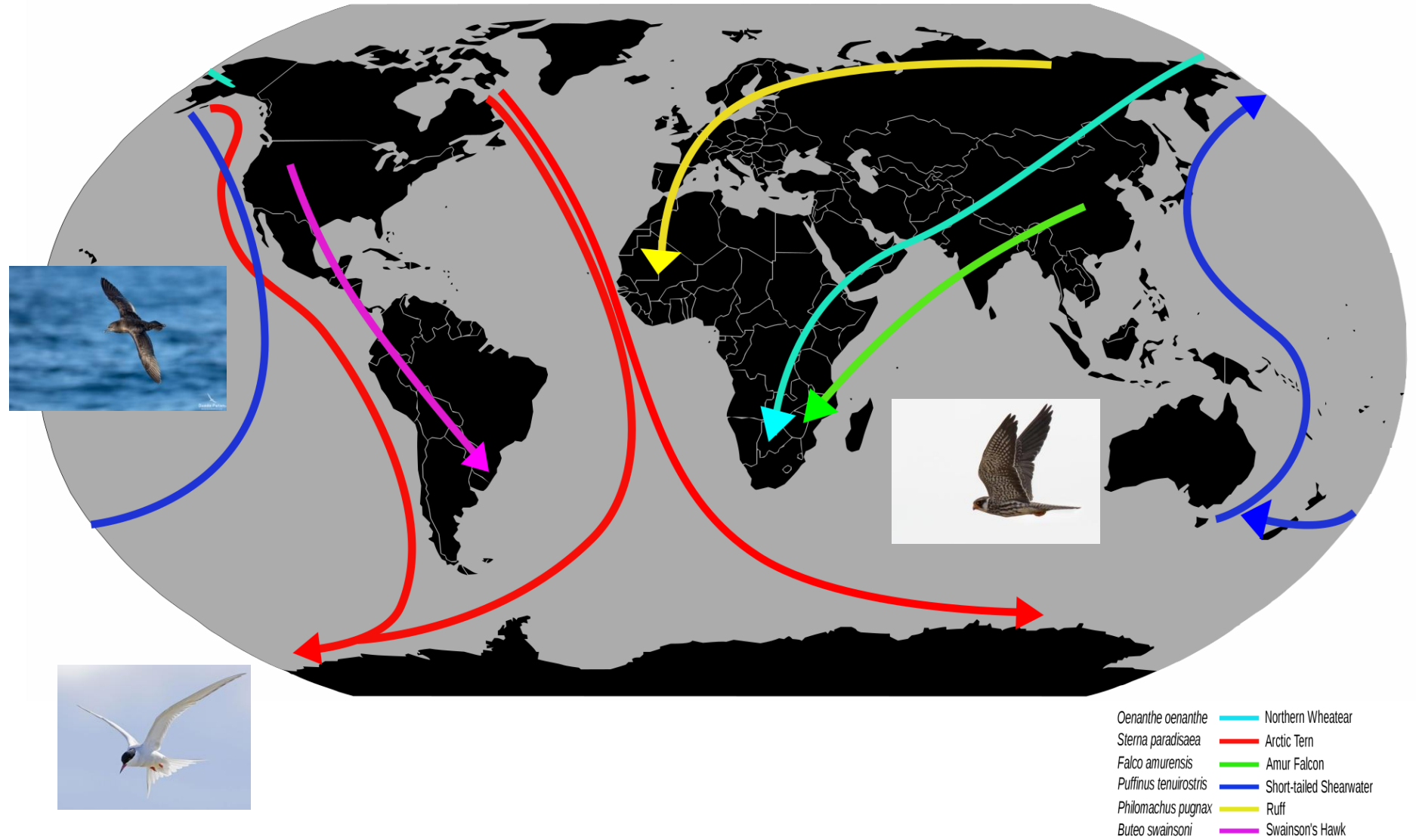
Aggressive cancer chemotherapy can cause the bone marrow to cease functioning, and hence can halt platelet production



Moving to a Better Neighborhood



Migration



Human Thermal Comfort Model

Local regulations

Regulations of the central nervous system

