Comparative Physiology

Principles of physiology- introduction to respiration:

Define physiology and describe what it encompasses:

- Physiology
    - Living function of organs and systems (dead→anatomy)
    - How an org adjusts to its enviro (adaptations)
    - How org regulates it functions/how the functions are integrated to produce an adapted organism
    - Study of how animals work (animal function)
    - Study of mechanism and evolution of animal function
- Comparative physiology
    - Comparing physiologies of diff animals and understanding why they are different (why are they necessary)
- Encompasses
    - Evolution, ecology, biomechanics, maths, morphology, micro→macroscopic
    - Underlying physics, chem, biochem
        - Why→ because there are basic physical and chemical laws that all matter/energy must adhere to
        - Physiology is sum of molecular interactions/processes→ subject to laws

Understand the difference between the external and internal environment, its relation to an orgs complexity and the tendency to adopt homeostasis as complexity increases:

- Internal environment of cells/orgs are different to external environment
- Generally higher levels of water inside than outside, different levels of various substances inside/outside
- Claude Bernard→ one founder of experimental physiology
    - Cells within an org experience their own internal environment different to and distinct from that occupied by the org (external enviro)
- Advantages→Many different levels- e.g. multicellular→ multiple internal enviros

Conformity and regulation:

- Conformity- internal conditions= external conditions
- Regulation- internal conditions remain constant irrespective of external conditions
- Conditions- environmental variables, e.g. temp, pH, conc of molecules (osmotic balance)/gases
- Most orgs show some form of regulation, but may not regulate against all environmental changes (unlike us), e.g. salmon- regulate salt conc but not temp when switching between ocean and rivers

Temperature regulation:

- Ectothermic- depend on external sources to regulate body temp
    - Poikilothermic- changeable temp, fluctuates due to changes in environment
    - Homeothermic- body temp relatively constant due to enviro temo remaining constant, e.g. fish
    - Heterothermic- can regukate (mainly behaviourally) their temp but will conform when faced with extremes
- Endothermic- maintain their internal body temp through metabolic activity (internal heat)
    - Homothermic- same temp (only birds and mammals)→ deep sea animals won't experience any temp change in environment and are temp conformers so we don't consider them homotherms

Homeostasis:

- The maintenance of constant internal conditions in face of varying external environments
- Constancy of internal environment
- Coordinated physiological processes maintain most of constant states in the org
- Advantages- allow to live in a variety of environments
- Cost- e.g. in cold environments→ energy, trade off
    - Regulation- costs energy but permits cells to function in steady conditions IND of external variation
    - Conformity- energetically cheap (trade off), cell functionality is determined by external variation, e.g. if it gets cold you slow down/stop
- Increase level of organisation→ homeostasis becomes more prevalent→ because of increased internal environments
- As a rule, complexity/specialisation drives the necessity for homeostasis, but there are alternatives (antitheses of homeostasis)

Describe how basic physical principles (physics) underlie all of physiology and how orgs are constrained by them:

Composition of air:

- Nitrogen 78%, Oxygen 21%, CO2 0.03%...

Concentration (molarity) and pressure:

- Ideal/universal gas law→ PV=nRT
    - P= pressure, V= Vol, n= no. of moles, R=universal gas constant, T=temp
- Dalton's law of partial pressure
    - Pressure of a mixture of gases is equal to sum of pressures of all the constituent gases alone
    - $Pressure_{total}$= $Pressure_1$ + $Pressure_2$...
    - If pressure doubles, the partial pressure will double
- At sea level= 1 atm
- Altering total pressure has no effect on relative conc. Of a gas

Temp and water vapour:

- Air in equilibrium with water = saturated (100% relative humidity), i.e. the max amount of water we can put in air at that temp (anymore→rain)
- As we increase temp, the % that water vapour accounts for increases such that at 100°C the %=100%
- At 37°C the air in lungs is fully saturated (water vapour makes up 6.2% of total volume
- If breathing in air from cold/high altitude, when enters lungs (37%), water vapour condenses as effectively drown

Air pressure and altitude:

- As we move higher the total pressure reduces and hence partial pressure of gases
- At 6000m, total pressure is 1/2atm, hence partial pressure of oxygen is 0.1atm
    - Sea level partial pressure: Oxygen= 0.2095, nitrogen= 0.7808, etc. → same % as conc in atmosphere
- Easier to boil water at higher altitudes
- Implications- limits range of habitats, i.e. altitudes

Explain allometry (laws of scaling), the universality of the 0.7 rule in physiology (physiologies magic no.), and Rubner's law and its implications for physiological processes:

Allometry- biological scaling relationships:

- Huxleyu and Tessier (1936) coined the term→ determined that various morphological features of an org were related to each other, and hence would change in a predictable way
- Log (Y) = log (a) + b log (X)
    - X= body size
    - Y= organ size
    - Log b is y-intercept
    - a (α)= slope of line → allometric coefficient
    - Where X and Y are different body and organ sizes at differential developmental stages, the allometric coefficient (slope) captures the differential growth ratio between the organ and body as a whole
- Organ size is roughly proportional to body size

Kleiber's constant- ¾ rule (metabolism vs. mass):

- Kleiber's constant**= 0.75**
- Rates of oxygen consumption plotted against body mass→ regression line of 0.75

Rubner's surface law (maintenance of body temp vs. mass):

- SA is proportional to the square of lengths and Vol to the cube of lengths
- As VOL increases, SA increases by 2/3 power of the VOL → **0.67**
- Smaller the org, the bigger is SA:Vol (big SA, low Vol)
    - Big orgs (big Vol, low SA)→ smaller SA:Vol
- The SA:Vol decreases as an org gets larger