Contents

1 Animals and Environments

Introduction

- ▷ What is physiology?
  - Form and function of organisms; the study of how organisms work.
- ▷ Central questions of physiology: mechanism and origin.
  - Mechanism:
    - Refers to the components of living organisms and understanding how components interact to enable the organism to function.
  - Origin:
    - Asks why a mechanism exists, or what is the mechanistic adaptive significance of the mechanism.
  - Mechanism and adaptive significance are distinct concepts; knowing about one doesn't necessarily mean you know anything about the other.
- ▷ Krogh's principle:

  > "For such a large number of problems there will be some animal of choice or a few such animals on which it can be most conveniently studied."

  - This idea is central to disciplines that rely on the *comparative method*. The key take away: there is unity in diversity; many organisms are very much alike at the most fundamental levels.
- ▷ Physiology subdisciplines:
  - Mechanistic: emphasizes the mechanisms by which organisms perform their life functions.
  - Evolutionary: emphasizes evolutionary origins and the adaptive significance of traits.
  - Comparative: emphasizes the way in which diverse phylogenetic groups resemble and differ from each other.
  - Environmental: emphasizes the ways in which physiology and ecology interact.
  - Integrative: emphasizes the importance of all levels of organization, from genes to proteins and tissues to organs in order to better understand whole physiological systems.

Homeostasis

- Important ideas to remember:
  - Organisms are structurally dynamic; form stays relatively static while individual cells recycle frequently.
  - Most cells are exposed to the internal environment, not external.
  - Internal cells may vary or kept constant with the environment.
- Temperature regulation:
  - **Conformity**: organism's internal temperature correlates with external temperature in a particular range of temperatures.
  - **Regulation**: internal environment is held mostly contant using celluar mechanisms.
- **Homeostasis**: the coordinated physiological processes that maintain a relatively constant state in the organism.
  - Positive feedback: less common in homeostasis due difficulty in regulation; leads to runaway effect easily.
  - Negative feedback: more common in homeostasis due to self correcting nature.
  - **Effector**: executes the change in action that produces an effect, e.g. signals to increase temperature.
  - **Sensor**: sense changes in environment and sends information to the effector.

Physiology and Time

- Timeframes of physiological change:
  - **Acute**: short-term, reversible, and quick to adapt to changes in environment. Usually minutes to hours.
  - **Chronic**: long-term after prolonged exposure to new environments. Changes are usually reversible, but often slower.
    - Chronic can be termed acclimation, or phenotypic plasticity/flexibility.
    - Repetitive acute responses usually lead to chronic responses.
  - **Evolutionary**: changes due to alteration in gene frequencies in populations exposed to new environments.
- Acclimation is not the same as adaption.

- *Adaption* is an evolutionary trait presnet at high frequency in a population due to survival/reproductive advantages.
- Not all traits are adaptations.
- The amount of natural variation in a trait must be considered across populations, species etc.

2 Molecules and Cells in Animal Physiology

Cell Membrane Review

- Major cell memberane structures:
  - **Glycoproteins**: carbohydrate chain attached to a protein.
  - **Glycolipids**: similar to glycoproteins, but attached to lipid molecues.
  - *Glycocalyx*: combination of glycoproteins and glycolipids on the surface of cell.
  - **Integral proteins**: embedded in phospholipid bilayer.
  - **Peripheral proteins**: associated with one side of the bilayer.
- **Unsaturated phospholipid**: whey hydrocarbon tails contain double bonds (less hydrogen).
  - Increase membrane fluidity due to extra space created.
- The fluidity of the cell membrane allows proteins to from complexes and dynamically change shape.

Enzyme Fundamentals

- **Enzymes**: a protein catalyst that plays two primary roles: accelerating and regulating chemical reactions.
- *Substrates*: the initial reactants of the reaction that an enzyme catalyzes.
- **Enzyme-substrate-complex (E-S)**: a combination of enzyme (E) with a molecule of substrate (S) that starts a reaction.
  - Usually stabalized by non-covalent bonds.
  - The substrate is converted to a product by first becomeing an *enzyme-product complex (E-P)*, then dissociates to yield free product and free enzyme.
  - $E + S \rightleftharpoons$ E-S $\rightleftharpoons$ E-P $\rightleftharpoons E + P$
- **Saturation kinetics**:
  - $\mathbf{V_{max}}$: the maximum velocity of a reaction and is determined by:
    - the number of active enzyme molecues present relative to substrate.
    - the catalytic effectiveness of each enzyme molecule.
    - These properties usually undergo heavy selection pressure.

- *Saturated*: all enzymes are occupied by a substrate molecule nearly all the time and now unable to increase reaction velocity.
- **Hyperbolic**: asymptotically approaches V_{max}
  - Tends to happen when enzymes have just one substrate binding site.
  - Or when substrate sites behave independently
- **Sigmodal**: approaches V_{max} with a sigmodal trajectory.
  - When multiple sites influence each other.
- **Turnover number (k_{cat})**: the total effectiveness, expressed as the number of substrate molecules coverted to product per second by each enzyme molecule when saturated.
  - Depends partly on the *activation energy* of the enzyme-catalyzed reaction.
  - **Activation energy**: the energy required for the substrate to enter the *transition state*.
  - **Transition state**: the intermediate chemical state between substrate and product.
  - Enzymes lower the activation energy required to enter transition state.

▷ **Enzyme-substrate affinity**:

- The proclivity of the enzyme to form a complex with the substrate when they meet.
  - Likely complex formation results in high-affinity.
  - Unlikely complex formation results in low-affinity.
- Affinity affects the shape of the reaction velocity.
  - Higher affinity produces a steeper velocity, and lower produces a more linear result.
- **Half-saturation constant, K_m**: the substrate concentration required to attain one-half maximum reaction velocity.
  - K_m and enzyme-substrate affinity areinversely related.
  - i.e. low-affinity enzyme has a greater K_m.

3 Genomics and Proteomics

▷

4 Physiological Development

▷

5 Transport of Solutes and Water

▷

27 Water and Salt Physiology: Mechanisms

▷

7 Nutrition, Feeding, and Digestion

▷