Biochemistry 2019 Learning Objectives

Introduction to Metabolism and Carbohydrate Metabolism (Exam 2)

* **Draw and interpret a reaction coordinate diagram.**
  + Delta G over time. Goes up to activation energy, then down. If favorable, the product will be lower than reaction side.
* **Define the key characteristics of an enzyme-catalyzed reaction, and identify what aspects of a reaction are, and are not, affected by the enzyme.**
  + Delta G (whether a reaction is favorable or not) is not affected by an enzyme.
  + Speed of reaction is affected by enzyme
* **Write and interpret rate laws for a chemical reaction.**
* **Compare and contrast the free energy of a reaction and the activation energy.**
  + DeltaGrxn of the reaction tells you whether a reaction is favored or not, but Ea is required to tell you how fast the reaction will occur
* **Relate the magnitude of Ea to the relative amounts of substrate and transition state.**
  + Decreasing Ea will increase speed of reaction from substrate into transition state
* **Write a general reaction involving enzyme catalysis and include the relevant species that are formed in the process.**
  + Enzymes bind to both substrates and products
  + Enzymes are not consumed
* **Describe how the concentration of the substrate and the enzyme affect the rate of product formation.**
  + Enzyme brings substrate into transition state, which then becomes product
* **Describe how an enzyme accelerates a chemical reaction.**
  + Enzymes decrease the activation energy of a reaction, making it more likely to occur. E.g. using the microenvironments of the active site
  + Stabilizes the transition state
* **Explain how KM and Vmax are determined experimentally for an enzyme.**
  + Test velocity at different substrate concentrations, plot double inverse graph (1/V0 vs. 1/KM)
* **Define and interpret the meaning of KM and Vmax for an enzyme, and estimate both values on a graph.**
  + Vmax is the maximum velocity possible
  + KM is a ratio of rate constants that represents when the reaction’s velocity is at half maximal
  + KM is the stability of ES, and the rate of dissociation of what it becomes divided by what you are turning into.
  + Using a double reciprocal plot, KM and V\_0 are the axes, but the reciprocals
* **Recognize the Michaelis-Menten rate equation.**
  + At high levels of saturation, velocity will be close to VMax.
  + At low levels of saturation, velocity will be a fraction of Vmax, dependent on KM.
  + At [S]=KM, velocity will be half of VMax.
* **Explain how reaction rate is related to the amount of ES complex relative to total enzyme.**
  + Vmax is when all the enzymes are bound and converting
* **Explain what information about enzymes is provided by KM/kcat.**
  + k2 = kcat, represents catalytic efficiency/turnover
  + Takes into account the speed at which ES turns into E+P divided by how fast ES breaks down
* **Briefly describe what enzyme cofactors are, and what general purpose they serve.**
  + A cofactor is a molecule that is needed for an enzyme’s function. Often metals, but can be organic coenzyme as well.
* **Recognize how KM and Vmax are affected by different types of reversible inhibitors  
  (competitive, non-competitive, uncompetitive).**

|  |  |  |
| --- | --- | --- |
| **Type** | **Explanation** | **Effect** |
| Competitive | Blocks S from binding to E, but does not prevent product from being formed. Can be overcome with more substrate and still reach Vmax.  E, EI, ES | Increase Km |
| Uncompetitive | Blocks ES from forming product. Km measures dissociation, and ESI keeps it in ES form, dissociating less  E, ES, ESI | Decreases Km and Vmax |
| Noncompetitive | Blocks S from binding to E in addition to blocking ES from forming product  E, ES, EI, ESI | Decrease VMax |

* **Distinguish and plot different types of enzyme inhibition using double-reciprocal plots,  
  and interpret relevant points on the plots.**
  + See above
* **Apply general knowledge of enzymes and inhibitors to new examples.**
* **Explain what the term “alpha” describes for an inhibitor using words, an equation, and graphically.**
  + Alpha is the level of inhibition
  + where
  + Furthermore, it is the change in slope
* **Describe the general catalytic mechanism of serine proteases, including the role of the catalytic triad.**
  + Peptide recognition by serine
  + Histidine abstracts hydrogen, forming oxyanion hole (-) stabilized by 2 hydrogen bonds (+)
  + Acyl enzyme intermediate
  + C terminus leaves (NH3), H2O takes its place
  + Histidine abstracts H2O
  + Product release
* **Compare and contrast different strategies to regulate enzyme function that were discussed in class.**

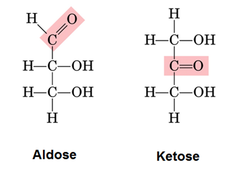
## Membranes

* **Describe how the molecular structure of a cellular membrane prevents polar molecules and ions from crossing membranes.**
  + Phosphlipids contain hydrophilic head and hydrophobic tail. Phospholipids form bilayers by the hydrophobic effect.
  + Small nonpolar and small uncharged polar molecules can pass through easily, but large nonpolar and charged molecules can’t.
* **List the characteristics of different types of membrane transporters (channels, pumps, and carriers).**
  + Down the gradient - moving from higher to lower concentration.
  + Against the gradient - moving from lower to higher concentration.
  + Channels - molecule diffuses down the gradient through pore in the membrane that is open to both sides.
  + Pumps - molecule binds to enzyme that is open only on one side, enzyme hydrolyzes ATP to change conformation and open to the other side. Pump moves molecules against the gradient
  + Carriers - molecule binds to enzyme that is open only on one side, does not use ATP. Moves molecules either (down, down down, down against)
    - Uniporter - moves molecule down the gradients.
    - Symporter - moves two molecules in the same directions.
    - Antiporter - moves two molecules in opposite directions.
    - Note that down/against is independent of the direction, since these are different molecules
* **Analyze the thermodynamic and kinetic characteristics of the transport of molecules across membranes.**
  + 
  + , since molecules inside and outside are inherently the same, this tells us that at equilibrium, there are equal concentration inside and outside the cell (think diffusion).
  + , this tells us whether molecules will move inside or outside the cell, and how much energy.
  + This does not apply for charged molecules
* **Predict the movement of molecules across a membrane through a given type of transporter (channels, pumps, or carriers).**

## Metabolism (general)

* **Define metabolism in your own words.**
* **List the general characteristics of a metabolic pathway.**
  + Metabolite - products and reactants of metabolism, anything that is produced or consumed
  + Enzymes - catalyze chemical reactions
* **Distinguish between anabolic and catabolic pathways.**
  + Catabolic - macromol → mol building blocks and energy (ATP), C for cut
  + Anabolic - mol building blocks and energy → macromol, A for add
* **Explain how ATP acts as a cellular energy source.**
  + Cells keep concentrations of ATP relatively high
  + ATP can phosphorylate another molecule or hydrolysis
  + ATP hydrolysis is thermodynamically favorable (Delta G knot) but kinetically slow (Delta G activation). Specifically, ATP releases a lot of energy, but it requires a high activation energy. Use enzymes to control energy usage!
  + We can couple an unfavorable reaction with ATP:
* **List the number of each type of molecule that is consumed or generated by a particular metabolic pathway or combination of pathways.**
  + In glycolysis, the reaction takes glucose (6C), splits and generates (net) two pyruvates (3C), 2 ATP (2 consumed, 4 generated), 2 NADH
* **Discuss the free energy of metabolic pathways and reactions.**
  + Irreversible reactions have high delta G
* **Identify irreversible reactions in a metabolic pathway.**
  + Unidirectional arrow, rather bidirectional
* **Identify (or predict) the regulated enzymes in each metabolic pathway.**
* **Describe the regulation of the mostly highly regulated enzyme in each metabolic pathway.**
  + Committed step
* **Predict allosteric enzyme regulation for a metabolic reaction or pathway based on your knowledge of the reaction/pathway or information provided.**
* **Evaluate the roles of kinases and phosphatases in the regulation of enzyme activity (either an example provided in class or given sufficient new information).**
  + Kinases attach ATP, phosphatases dephosphorylate
* **Interpret experimental data measuring enzyme activity or the levels of metabolites or energy molecules.**
* **Apply knowledge of general enzyme characteristics (structure, mechanism, cofactors, thermodynamics, kinetics, regulation) to specific metabolic enzymes.** 
  + Structurally
    - Deep cleft or binding site for susbtrate
    - Active site takes up small part of volume of protein
    - Active site has unique microenvironments
    - Substrates bound by weak interactoins
    - Lock and key model, or induced fit, change shape slightly when substrates bind
  + Cofactors - coenzymes or metal ions required for optimal activity
  + Thermodynamics - Michaelis Menten
* **Explain how specific molecules cross specific cellular membranes during metabolic processes.**
* **Describe the reciprocal regulation of two opposing metabolic pathways (for example: glycolysis/gluconeogenesis).**
* **Draw, analyze and interpret diagrams of metabolic pathways.**
  + Arrow in is a substrate, arrow out is a product
* **Identify the molecules that connect metabolic pathways.**
* **Predict the activity of enzymes or metabolic pathways under specific physiological, disease, or experimental conditions.**

## Carbohydrate Metabolism

* **Categorize a carbohydrate based on the number of carbons and presence of a ketone or aldehyde group.**
  + Hexose, pentose, tetrose, triose.
  + 
  + Aldose ends with R-C=O, ketose R-C=O attached to R’.
* **Label the carbons atoms in a carbohydrate using the standard numbering convention.**
  + Look for the carbon that has two oxygens attached to it, that is the ketose/aldose end (lower number) end.
* **Recognize major features of carbohydrate structures in different forms including linear, cyclic, modified, and polymers.**
  + Linear/cyclical are equivalent, use numbering convention to convert between them, OH attacks C=O.
  + Modifications with phosphates or amines.
  + Form polymers with glycosidic bonds, between hydrolyzed monosaccarides.
* **List the biological functions of carbohydrates.**
  + Energy source - complex carbs digested into monosaccharides, converted to energy
  + Nucleotide synthesis - ribose is precursor of nucleotide
  + Physical structure - cellulose in plants and chitin in arthropods
  + Protein and lipid modification - cell-cell recognition, protection, structure, signaling
* **Compare and contrast glycolysis and gluconeogenesis.**
* **Predict whether glycolysis or gluconeogenesis would occur under a set of conditions at the cellular or organismal level.**
* **Explain how blood glucose levels are regulated by insulin and glucagon including the role of glycolysis, gluconeogenesis, glycogen synthesis, and glycogen breakdown.**
  + Insulin goal is to break down glucose, removing it from the bloodstream, promotes glycolysis, glycogen synthesis
  + Glucagon goal is to form glucose, adding it to the bloodstream, promotes gluconeogenesis and glycogen breakdown