All Living Matter contains Enzymes

- Nearly all metabolism is controlled by enzymes
- We and our food are the product of enzyme action
- Enzymes provide energy and synthesize cellular components

Nutrition

- Digestion
  - Hydrolysis of proteins
  - Hydrolysis of carbohydrates
  - Hydrolysis of fats
- Synthesis of cellular components (amino acids, lipids...)
- Production of heat and other energy

Health and Disease

- Diagnosis of disease, e.g.,
  - Myocardial infarction
  - Lactate dehydrogenase (LDH)
    or creatine (phospho)kinase (CPK)
  - Enzyme deficiency can lead to disease
    - enzyme is produced at insufficient levels,
    - is defective or unstable, or
    - doesn’t occur in the right tissue.
  - More than 400 enzyme deficiency diseases are known. See:

Tay-Saks Disease

- Associated with Eastern European Jews
- Absence of a hexoseaminidase that cleaves GlcNAc from ganglioside GM₂
- A sphingomyelin derivative accumulates in the brain
- Babies lose mobility and sight
- Death occurs within 3 years
  - (autosomal recessive - chromosome 15)

Additional Resources

- Web Page
- Reading “Assignments” in Enzymology for the Food Sciences
- Molecular graphics software and images
- Links to nomenclature sites, etc.
- “Homework” in manual
- The Literature, especially Methods Enzymol, The Enzymes, etc.
**Lesch-Nyan Syndrome**
- Absence of a phosphoribosyl transferase:
  \[ \text{Guanine} + \text{phosphoribosyl pyrophosphate} \rightarrow \text{GMP} + \text{PPi} \]
- Required for guanosine and inosine metabolism
- Children are disoriented, short attention span
- Have gout and other uric acid deposits
- Eat fingers, tongues
- Reach IQ of 30 - 65
- (sex-linked - X chromosome)

**Cystic Fibrosis**
- Absence of CF transmembrane conductance regulator, CFTR
- A Cl⁻ ion channel
- Leads to:
  - Salty skin
  - Fibrosis of the pancreas
  - Digestive difficulties
  - Fluid buildup in the lungs
  - Death by pneumonia (Pseudomonas aeruginosa)

**Phenylketonuria - PKU**
- Absence of phenylalanine hydroxylase (PAH)
- Cannot make Tyr from Phe (Tyr deficiency)
- Aromatic ketones appear in urine
- Mental retardation
- Posture problems
- (autosomal recessive - chromosome 12)

**Problems with Milk Sugar-LI**
- Absence of β-galactosidase
- In intestinal mucosa - req’d for transport
- Lactose intolerance, common, normal

**Problems with Milk Sugar**
- Absence of galactokinase
  - Galactosuria, cataracts
  - Continues throughout life
- Absence of phosphogalactose uridylyl transferase
  - Galactosemia
  - Cataracts, retardation, death
  - Disappears in adulthood
Enzymes are Tools
- For Analysis (*Methods of Enzymic Analysis*, Bergemeyer)
  - Colorimetric assays (coupled enzyme assays)
  - Enzyme electrodes
  - As indicators (e.g., ELISA)
- Cleaning
- Biotransformations
  - Molecular biology
  - Reactors, immobilized enzymes
- Food Processing

Food “Processing”
- Blanching, Determining of heat history
- Clot milk for cheese (chymosin)
- Hydrolyze starch for corn sweetener (amylose, glucose isomerase)
- Endogenous enzymes
  - Ripening (sweetening, softening) of fruit
    - Cellulases
    - Pectic enzymes
  - Muscle to meat transformation
  - Proteases (tenderness)
  - Other enzymes for resolution of rigor

Enzymes in Baking

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Enzyme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produce fermentable sugars</td>
<td>α- and β-amylose</td>
</tr>
<tr>
<td>Modify gluten, liberate AAs</td>
<td>proteases</td>
</tr>
<tr>
<td>Increase [Glc] and [Gal]</td>
<td>β-galactosidase</td>
</tr>
<tr>
<td>Improve gluten strength</td>
<td>lipoxygenase,</td>
</tr>
<tr>
<td></td>
<td>peroxidase, catalase,</td>
</tr>
<tr>
<td></td>
<td>protein disulfide isomerase, polyphenol oxidase</td>
</tr>
<tr>
<td>(bad)</td>
<td>lipase</td>
</tr>
</tbody>
</table>

Enzymes in Cloning

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Enzyme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymerase Chain Reaction</td>
<td>Heat-stable polymerase (e.g., Taq)</td>
</tr>
<tr>
<td>DNA from RNA</td>
<td>Reverse transcriptase</td>
</tr>
<tr>
<td>Sequence-specific cuts</td>
<td>restriction endonucleases</td>
</tr>
<tr>
<td>Removing phosphate</td>
<td>phosphatase</td>
</tr>
<tr>
<td>&quot;Splicing&quot;</td>
<td>ligase</td>
</tr>
<tr>
<td>Selectable markers</td>
<td>antibiotic resistance</td>
</tr>
<tr>
<td></td>
<td>(chloramphenicol acetyltransferase, β-lactamase)</td>
</tr>
</tbody>
</table>

Enzymes are Catalysts
- Increase the rate of chemical reaction
- Therefore, control the reactions of life

Enzymes are Proteins
- There are other catalysts: platinum, palladium, H⁺, OH⁻; RNA-ribozymes…
- But, these are not enzymes.
In this class, we will study
- Structure of Proteins
  - Amino acids, peptide bonds, sequence, 1° structure
  - Rotations about $\phi$, $\psi$ and $\omega$ bonds, 2° structure
  - Folding into a 3-dimensional shape, 3° structure
  - Subunits (>1 polypeptide chain), 4° structure

Properties of Proteins...
- Chemical and physical properties
- Separation and analysis of proteins based on these properties
- Purification methods
- Determination of purity
- Measurement of Activity - kinetics

Kinetics and Mechanism
- Velocities of Reactions
- How velocities depend on
  - [Enzyme], [substrate], [inhibitor]
  - pH
  - Temperature
  - Inhibitors
- Mechanisms - how enzymes work
- Nomenclature, Classification
- Examples