Pathways/Reactions that you need to memorize (not given to you on the exam)

Pyruvate \xrightarrow{\text{Lactate dehydrogenase}} \text{Lactate} \quad \text{CYTO}

\text{Lactate} \xrightarrow{\text{NADH}} \text{NAD}^+

\text{NAD}^+ \xrightarrow{\text{CoA}} \text{CO}_2

Pyruvate \xrightarrow{\text{Pyruvate dehydrogenase}} \text{Acetyl-CoA} \quad \text{MM}
FATTY ACID BREAKDOWN

Cytoplasm

Triacylglycerol → Fatty Acid (Acyl-CoA synthetase)

Mitochondrial matrix

Acyl-CoA → Acyl-AMP → Acyl-CoA synthetase → acyl-CoA

Acyl-CoA

FAD

NAD

Acyl-CoA

FATY ACID SYNTHESIS

Mitochondrial matrix

Acetyl-CoA

Cytoplasm

Fatty Acid Synthase

Acetyl-ACP

Malonyl-CoA

Citrate
Understanding enzyme location is helpful for understanding how different metabolic pathways interact.

**Enzyme Location**

<table>
<thead>
<tr>
<th>Process</th>
<th>Cytosol (CYTO)</th>
<th>Mitochondrial Matrix (MM)</th>
<th>Endoplasmic Reticulum (ER)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycolysis</td>
<td>✗</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gluconeogenesis</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Lactate dehydrogenase</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Pyruvate dehydrogenase</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Citric Acid Cycle</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Understand that all these metabolic pathways are usually regulated through negative feedback targeting enzymes that catalyze irreversible reactions (think PFK-1 and α-ketoglutarate dehydrogenase).

Understand the pathways of electrons through the electron transport chain:

- For electrons originating in NADH, they are first dropped off at Complex I -> Coenzyme Q -> Complex III -> Cytochrome C -> Complex IV -> O2.
- For FADH2, they are dropped off at Complex II -> Coenzyme Q -> Complex III -> Cytochrome C -> Complex IV -> O2.
  - **Note that coenzyme Q carries 2 electrons at a time while Cytochrome C carries 1**

Work out your own way of interpreting this ETC figure (provided on the exam) and you will never have to memorize a thing. You should be able to fill out the chart below using only this figure.
Be able to calculate # of H+ pumped from ETC

- NADH pumps 10 H+ while FADH2 pumps 6 H+ (since FADH2 does not use Complex I; instead, it uses Complex II, which does not pump any H+ itself)

Be able to predict how ETC efficiency changes if you tweak the proteins involved (ex: knock out/mutate Complex IV)

Understand the structure of ATP synthase (preclass video does a fantastic job)

Understand the steps of ATP production from ATP synthase

1. Aspartic acid residue is protonated in the intermembrane space half channel
2. C-subunit rotates into membrane
3. C-subunit moves into matrix half channel
4. Aspartic acid residue is deprotonated
5. C-subunit moves into intermembrane space half channel
   a. Cycle repeats. Movement of C-subunits results in the physical rotation of C-ring
6. C-ring rotation causes gamma subunit to rotate
7. Gamma subunit rotation causes conformational changes in the Beta-subunits of the F1 subunit
8. Conformational changes in Beta-subunits causes ATP production from ADP+Pi

Important concept – each full rotation of the F1 subunit generates 3 ATP

- If there are 9 c subunits, then you need 9 H+ to create a full rotation
- If 12 c subunits, then you need 12H+ for full rotation etc
Know these numbers and how to calculate them

<table>
<thead>
<tr>
<th>Electron Donor</th>
<th>Protons Pumped</th>
<th>Oxygen Consumed</th>
<th>ATP Produced (Theoretical maximum)</th>
<th>ATP Produced (Estimate of realistic maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NADH</td>
<td>10</td>
<td>$\frac{1}{2}O_2$</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>FADH$_2$</td>
<td>6</td>
<td>$\frac{1}{2}O_2$</td>
<td>2</td>
<td>1.5</td>
</tr>
</tbody>
</table>