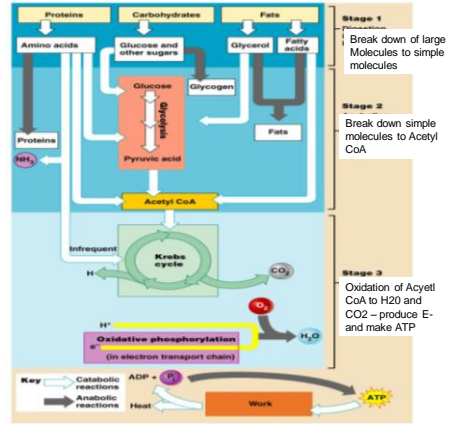




Fat and Protein Metabolism

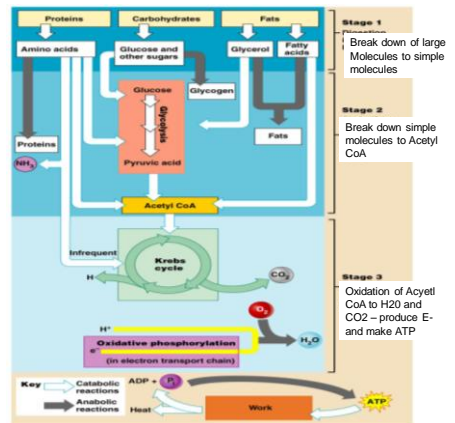
5-31



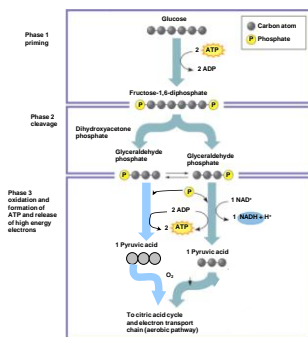
Fats and Proteins as Energy Sources

- ▶ Fats can be hydrolyzed to glycerol and fatty acids
 - ▶ These can be modified to run through Krebs!
- ▶ Proteins can be broken down to amino acids
 - ▶ Which can be deaminated and run through Krebs!
- ▶ These pathways can be used to interconvert carbohydrates, fats, and proteins

5-32



Review



5

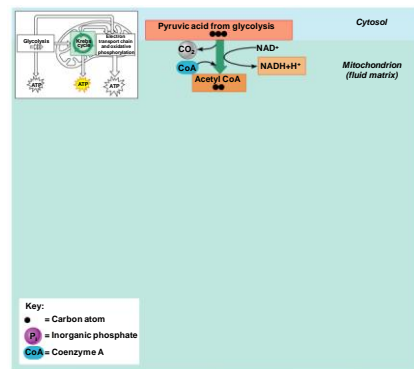
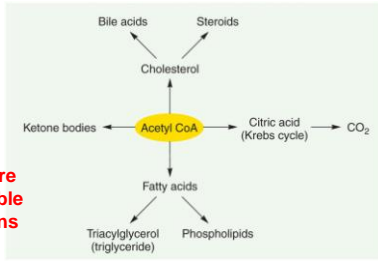


Figure 24.7

Acetyl CoA

Is a common substrate for energy and other pathways

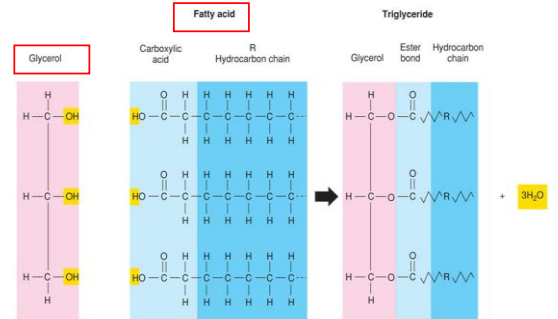
Many are reversible reactions



5-34

Lipids - Triglycerides

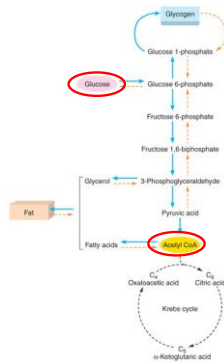
Formed by condensation of 1 glycerol and 3 fatty acids



2-36

Energy Storage

- When more energy is taken in than consumed, ATP synthesis is inhibited
- Glucose converted into
 - glycogen
 - fat



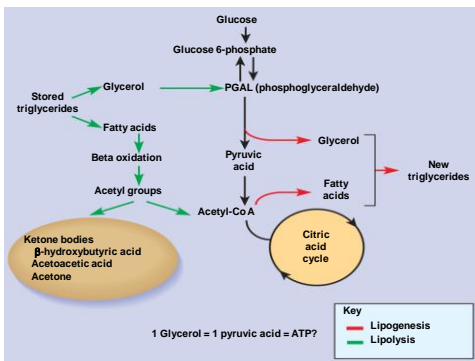
5-33

Fat Synthesis (Lipogenesis)

- Acetyl CoAs (2Cs) can be linked together to form fatty acids
 - Fatty acids + glycerol = Fat (**triglycerides**)
- Occurs mainly in **adipose and liver tissues**
- Fat is major form of energy storage in body
 - Yields 9 kilocalories/g
 - Carbs and proteins yield only 4 kc/g
- Body Energy
 - 80 - 85% energy in a body is stored as fat
 - Some as Glycogen (Muscles mainly & liver)
 - 15-20% protein (not used much)

5-35

Lipogenesis and Lipolysis Pathways



26-11

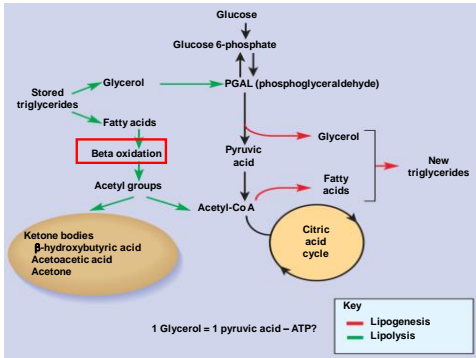
Lipolysis

- Is breakdown of fat into fatty acids and glycerol
 - Via hydrolysis by **lipase**

- Glycerol produces a few ATP
 - Released into blood
 - Liver converts most to Glucose (gluconeogenesis)
- Free fatty acids serve as major energy source for many tissues (Acetyl CoA!!!!)

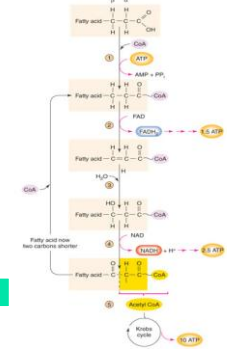
5-36

Lipogenesis and Lipolysis Pathways



Beta-Oxidation of a Fatty Acid

- ▶ **Beta-oxidation**
- ▶ clips 2 C acetic Acid
- ▶ Leaves CoA to enter Krebs
- ▶ Which can be run thru Krebs's giving 10 ATPs each
- ▶ Plus β -oxidation itself yields 4 ATPs



16 C fatty acid = 108 ATP!!!!!!

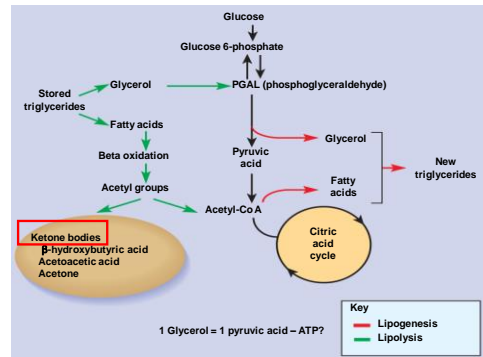
5-37

Brown Fat

- Is major site for thermogenesis
- ▶ Brown fat produces an uncoupling protein
 - causing H^+ to leak out of inner mitochondrial membrane
 - ▶ Less ATP is produced, causing electron transport system to be more active
 - ▶ Heat produced instead of ATP!!!!!!!!!!!!!!

5-38

Lipogenesis and Lipolysis Pathways

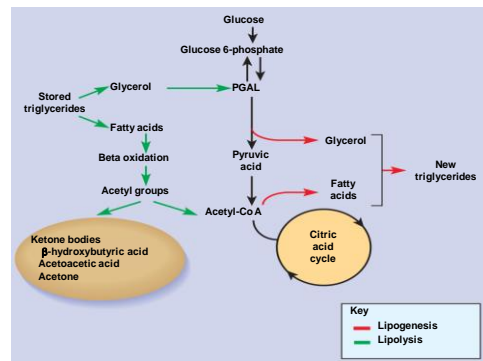


Ketone Bodies

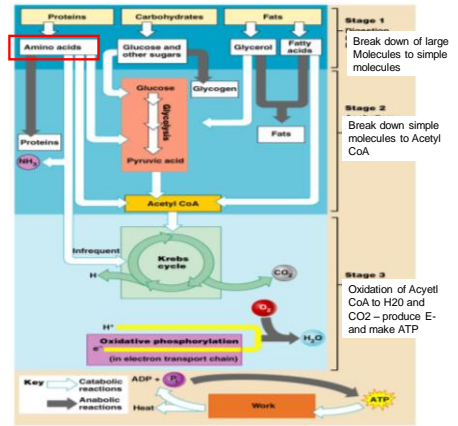
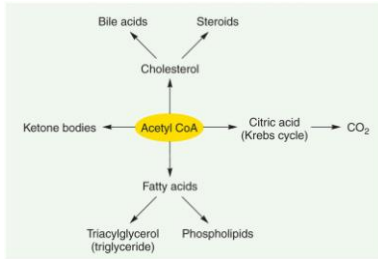
- ▶ Triglycerides are continually broken down and resynthesized
 - ▶ Ensures blood contains fatty acids for aerobic respiration
- ▶ **If lipolysis exceeds fatty acid use** - i.e., fasting (& diabetes) (i.e., lots of fat is broken down very quick)
 - blood conc. of fatty acids increases
 - acetyl CoA derived from fatty acids makes **ketone bodies**
 - 2 acetyl CoA combined to form a 4 C molecule
 - acetoacetic acid/B-hydroxybutyric acid/acetoacetic acid (3 C)
 - ▶ Can be used for E under normal condition
 - ▶ High levels cause acidic blood (acidosis)
 - ▶ Gives breath an acetone smell

5-39

Lipogenesis and Lipolysis Pathways



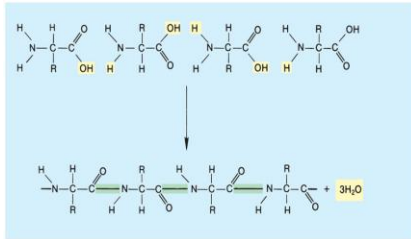
Acetyl CoA - Review



5-34

Proteins - Peptides

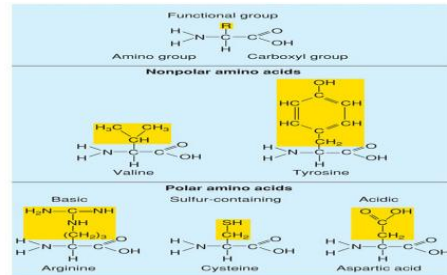
- ▶ Short chains of amino acids
 - ▶ Amino acids are linked by **peptide bonds**
 - ▶ Formed by dehydration synthesis reactions (condensation)



2-45

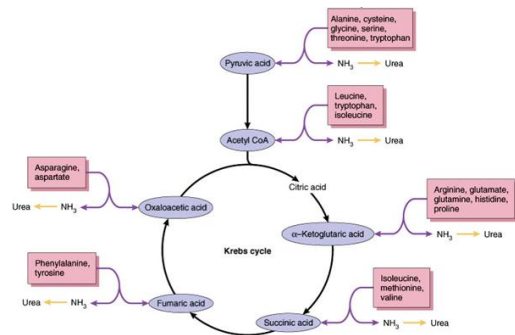
Amino Acid Metabolism

- ▶ Nitrogen (N) is ingested primarily as protein (i.e., amino groups on the amino acids)
- ▶ Excess is excreted mainly as urea



Nitrogen (N) Balance

- ▶ Nitrogen balance = N ingested minus N excreted
 - ▶ **Positive N balance:** more N ingested than excreted
 - ▶ **Negative N balance:** less N ingested than excreted
- ▶ In healthy adults amount of N excreted = amount ingested
- ▶ Excess amino acids can be converted into carbs and fat



5-41

5-47

Essential and Non-essential Amino Acids

▶ 20 amino acids are used to build proteins

Table 5.3 The Essential and Nonessential Amino Acids

Essential Amino Acids	Nonessential Amino Acids
Lysine	Aspartic acid
Tryptophan	Glutamic acid
Phenylalanine	Proline
Threonine	Glycine
Valine	Serine
Methionine	Alanine
Leucine	Cysteine
Isoleucine	Arginine
Histidine (in children)	Asparagine
	Glutamine
	Tyrosine

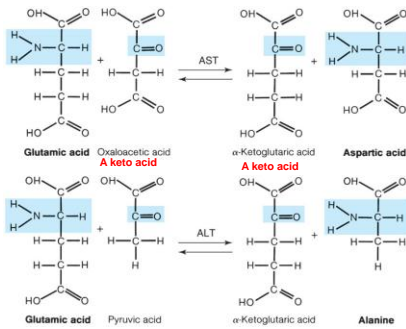
5-42

Making amino acids (so we can make proteins!)

- ▶ New amino acids can be obtained by **transamination**
- ▶ Amine group transferred from one A.A. to another molecule to form a different A.A.
 - ▶ Catalyzed by **transaminase**

5-43

Transamination

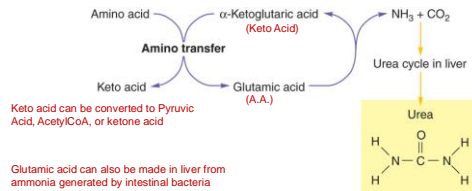


5-44

Oxidative Deamination – in liver!

If more A.A. are present than needed to make protein

- ▶ excess amino acids are eliminated
- ▶ -NH₂ is removed from glutamic acid, forming keto acid (and ammonia)
- ▶ Ammonia is converted to urea and excreted
- ▶ Keto acid goes to Krebs or to fat or glucose



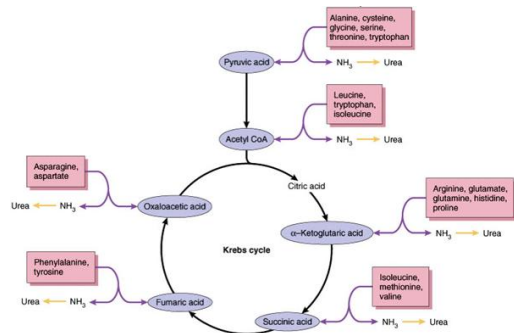
5-45

Gluconeogenesis

- ▶ Occurs when amino acids or other non-carbos are converted to Keto acids, then pyruvate, then glucose
- ▶ i.e., making glucose from non-carbohydrates
- ▶ Pyruvic acid and acids of Krebs Cycle are **keto acids**
 - ▶ They possess a Keto group C=O

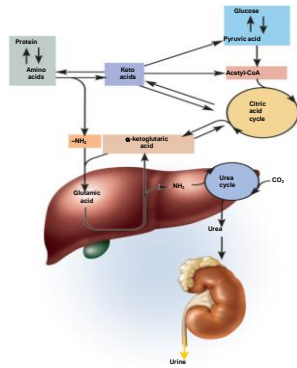
5-46

Gluconeogenesis

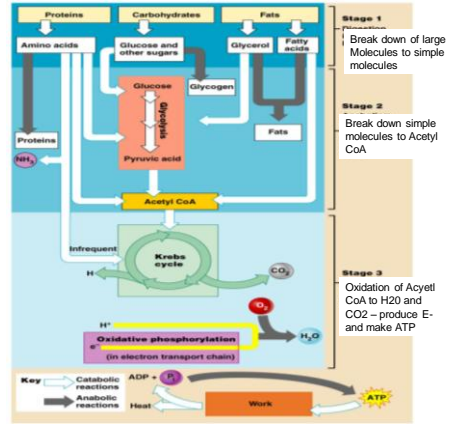


5-47

Pathways of Amino Acid Metabolism



26-31



Uses of Different Energy Sources

- › Different cells have different preferred energy substrates
- › Brain uses glucose as its major source of energy

Table 5.4 Relative Importance of Different Molecules in the Blood with Respect to the Energy Requirements of Different Organs

Organ	Glucose	Fatty Acids	Ketone Bodies	Lactic Acid
Brain	+++	-	+	-
Skeletal muscles (resting)	+	+++	+	-
Liver	+	+++	++	+
Heart	+	++	+	+

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