

# What You Can Learn From Amino Acid Analysis

It's more than just protein!

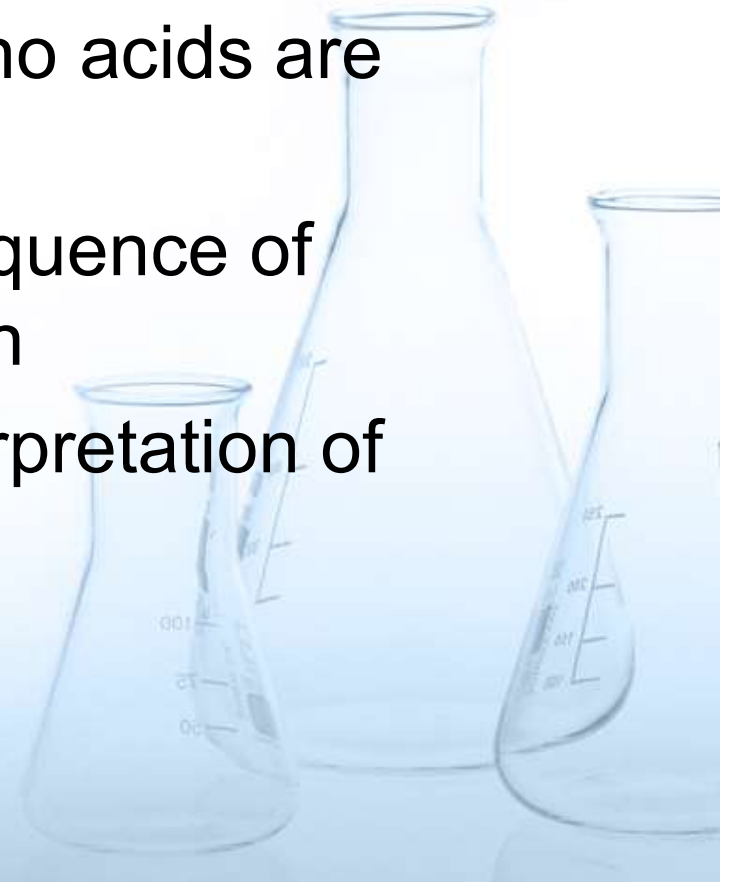


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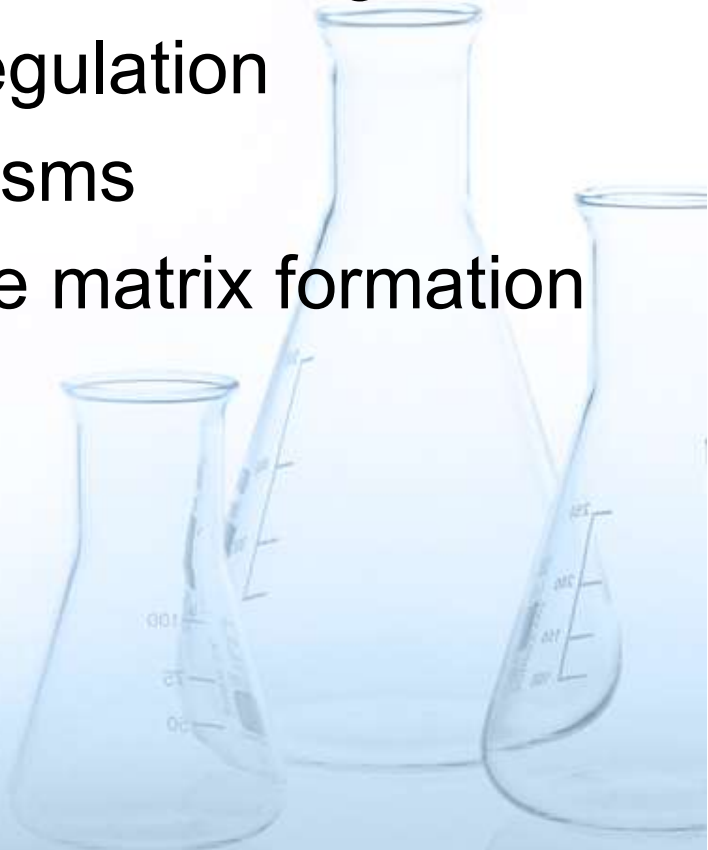
# Objectives

- Learn what conditions are most often amino acid-related
- Learn what groups of amino acids are reported
- Learn to determine the sequence of nutritional supplementation
- Learn where to go for interpretation of unusual results



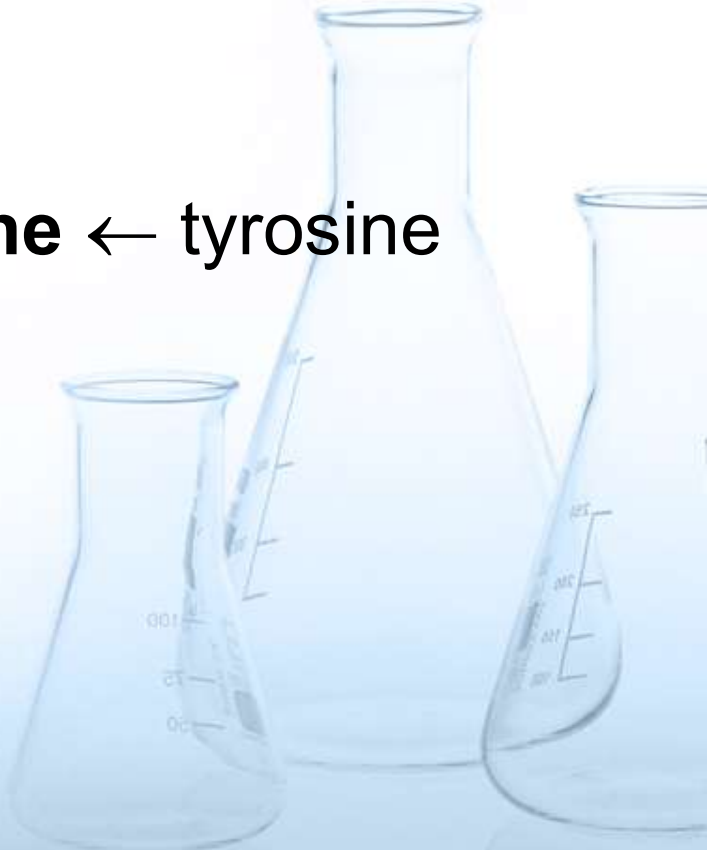


# Amino Acid Functions

- Regulation of muscular activity
  - Transmission and control of neural signals
  - Hormonal synthesis and regulation
  - Nutrient transport mechanisms
  - Ligament, tendon and bone matrix formation
  - Enzyme functions
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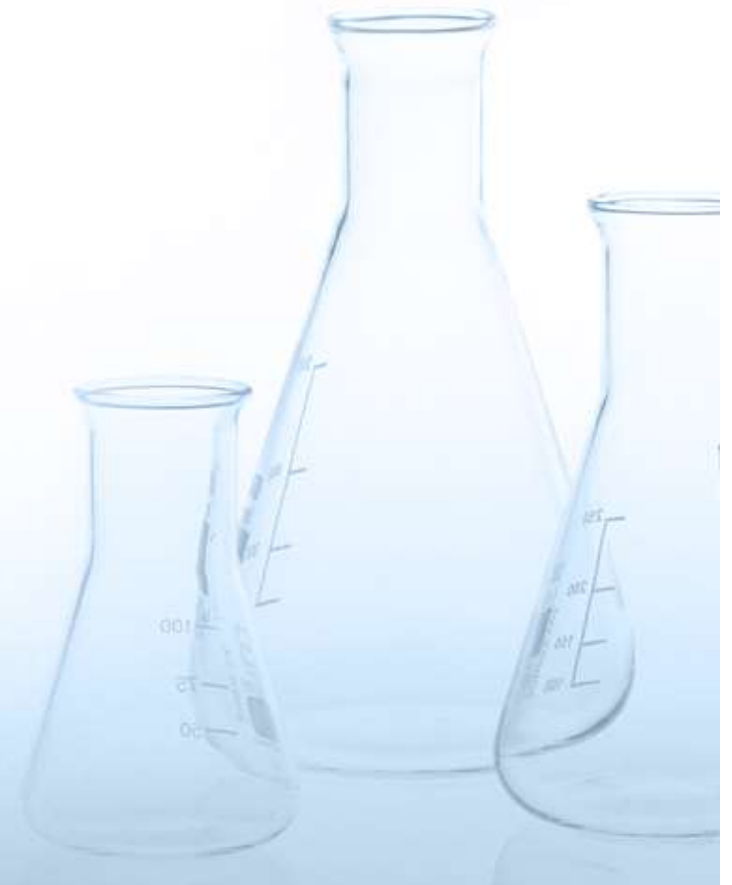
# Amino Acids as Neurotransmitter Precursors


- **Acetylcholine** ← methionine (serine and glycine)
  - **GABA** ← glutamic acid
  - **Dopamine, norepinephrine** ← tyrosine (phenylalanine)
  - **Serotonin** ← tryptophan
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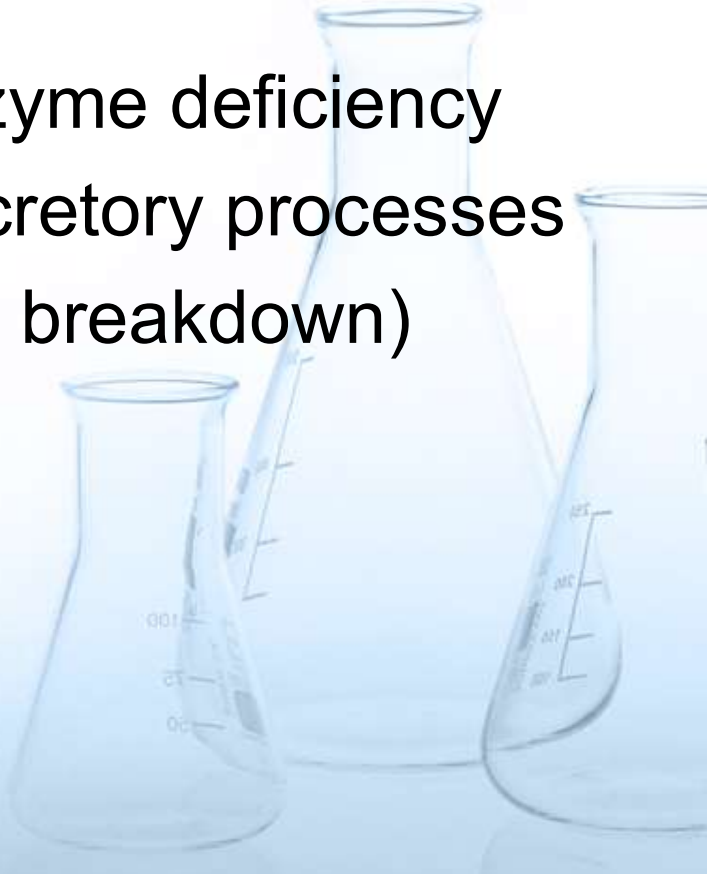
# Amino Acids: Availability

- Composition of dietary protein
- Protein digestion
- Assimilation & utilization
  - enzyme cofactors
  - tissue dependency



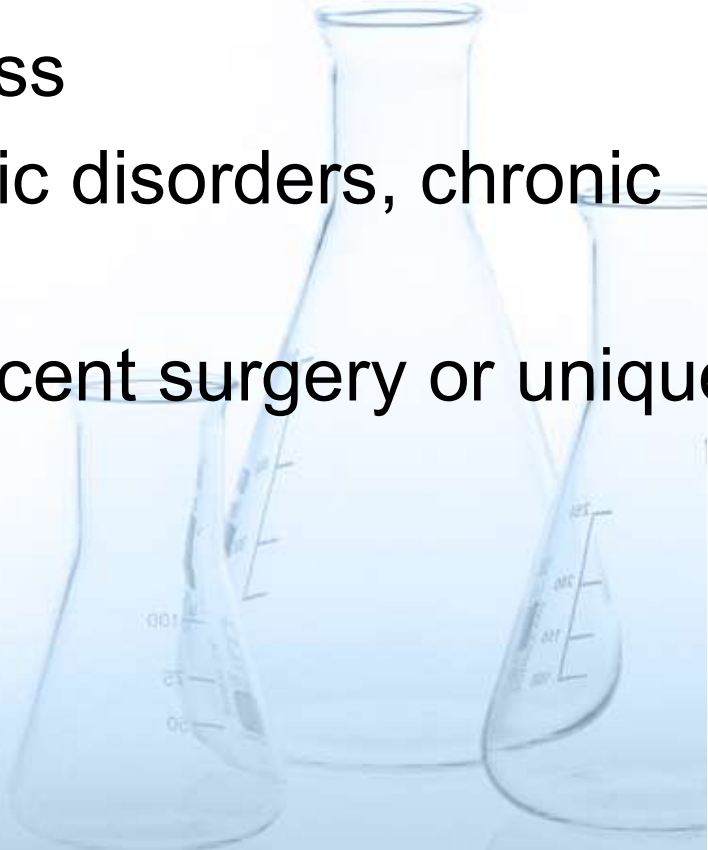


# Amino Acids: Adequacy Factors

- Dietary protein restriction
  - HCl insufficiency
  - Gastric and pancreatic enzyme deficiency
  - Hormonal regulation of secretory processes
  - Stress demands ( $\uparrow$ protein breakdown)
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# Amino Acids: Demand Variables

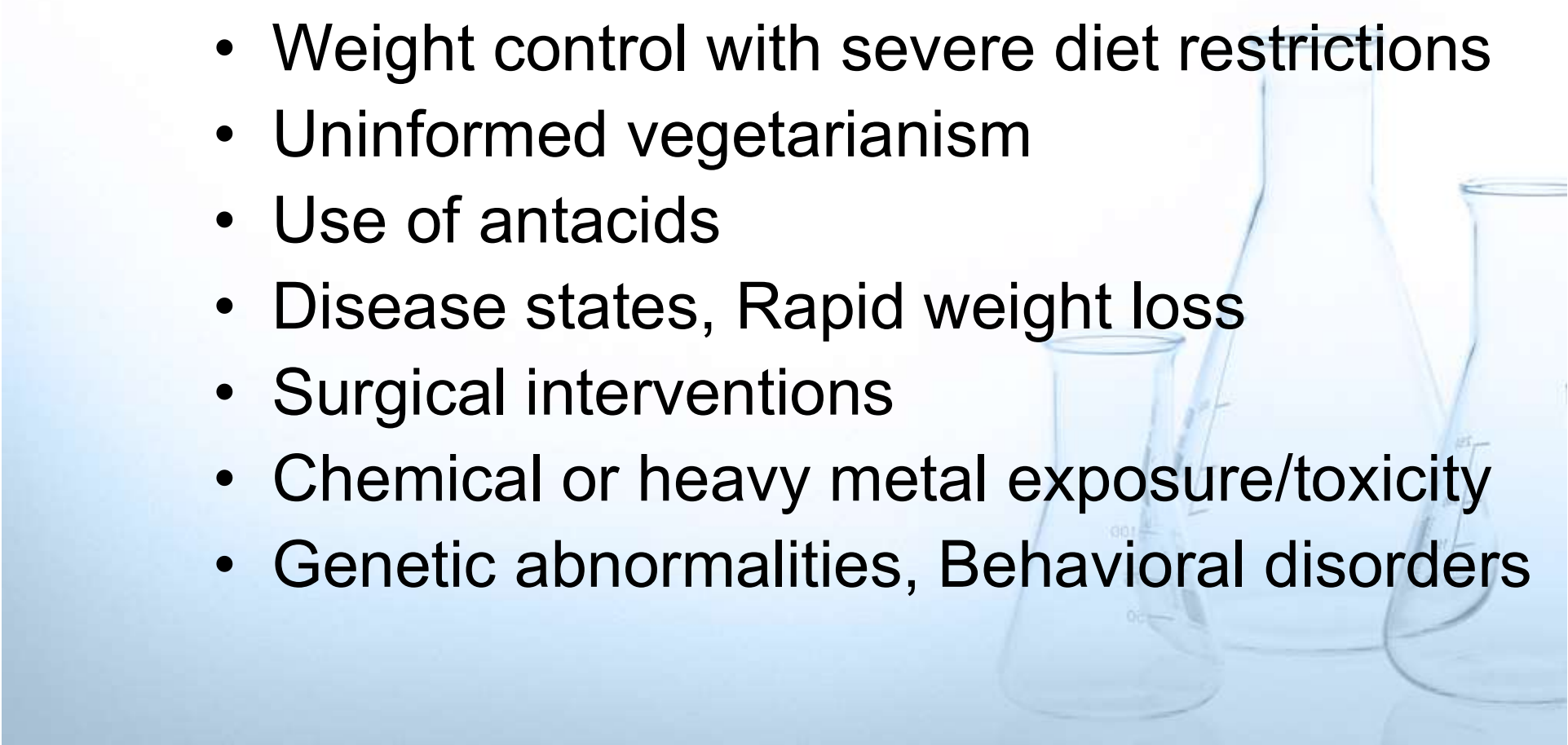
- Heavy work or physical exercise
  - Very warm or very cold climates
  - Aging and the aging process
  - Health problems - metabolic disorders, chronic diseases, injuries
  - Use of drugs or alcohol, recent surgery or unique genetic demand
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# Amino Acids: “Non-Essentials”

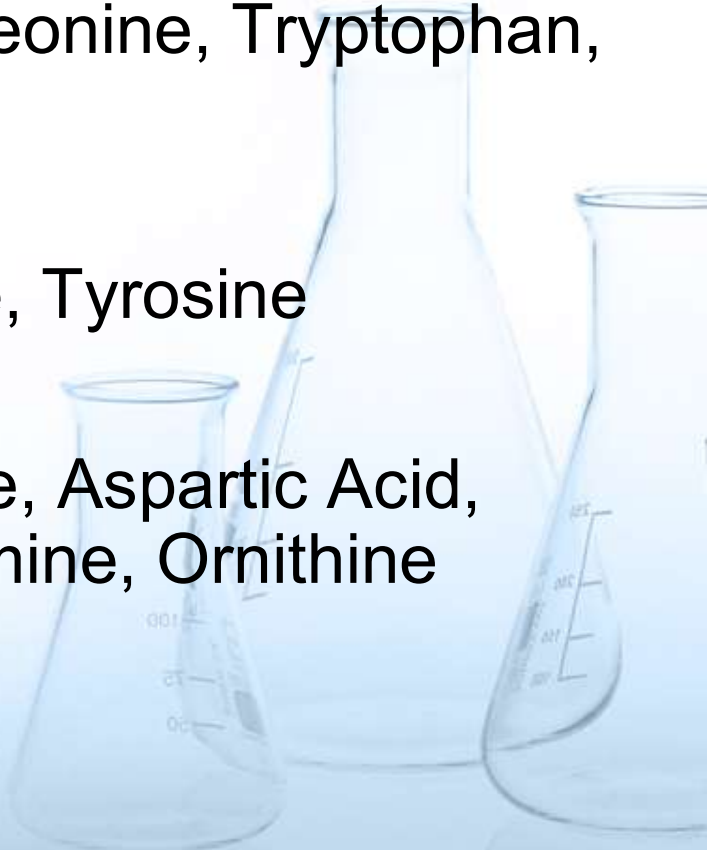
Numerous situations require amounts impossible to achieve from dietary intake:

- Weight control with severe diet restrictions
  - Uninformed vegetarianism
  - Use of antacids
  - Disease states, Rapid weight loss
  - Surgical interventions
  - Chemical or heavy metal exposure/toxicity
  - Genetic abnormalities, Behavioral disorders
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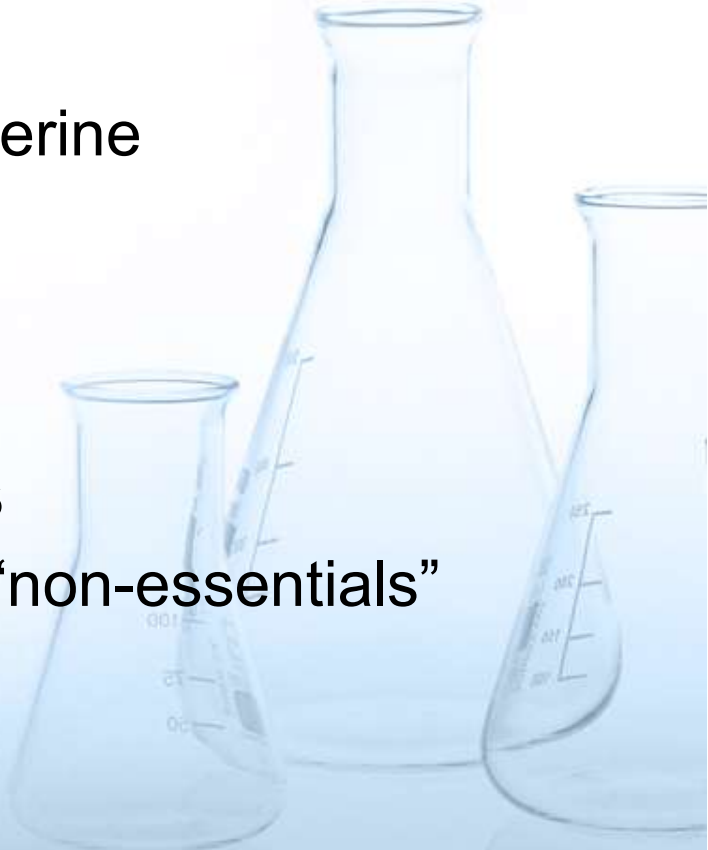


# Amino Metabolic Functions

- **Essential Amino Acids**
    - Arginine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan, Valine
  - **Neuroendocrine Metabolism**
    - GABA, Glycine, Serine, Taurine, Tyrosine
  - **Ammonia/Energy Metabolism**
    - A-Aminoadipic Acid, Asparagine, Aspartic Acid, Citrulline, Glutamic Acid, Glutamine, Ornithine
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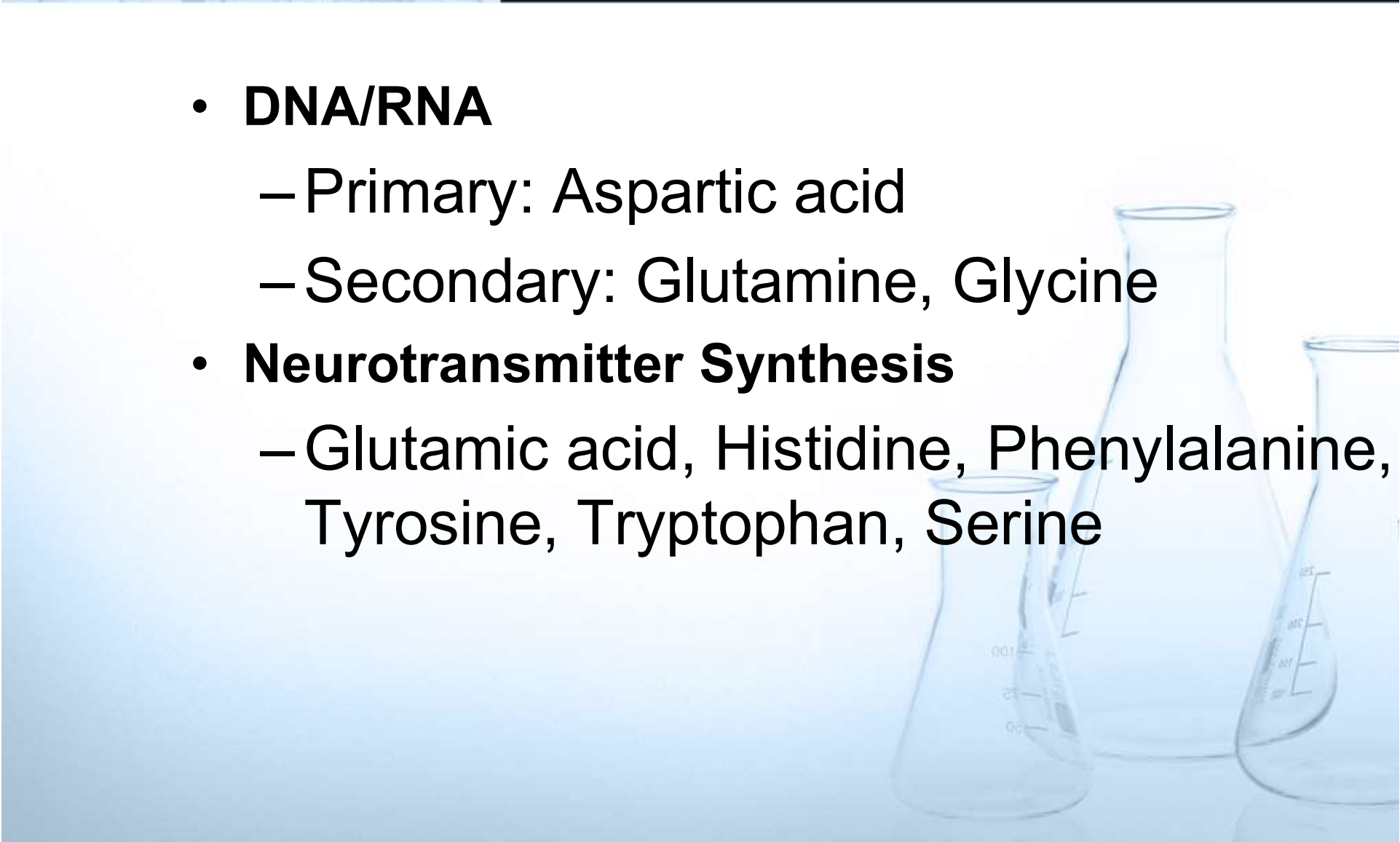


# Amino Metabolic Functions

- **Sulfur Metabolism**
    - Cystine, Cystathione, Homocystine
  - **Glucose Synthesis**
    - Primary: Alanine, Glycine, Serine
    - Secondary: All the rest
  - **Creatine**
    - Arginine, Glycine
  - **Tissue Protein Synthesis**
    - All of the 20 essentials and “non-essentials”
- 



# Amino Metabolic Functions

- **DNA/RNA**
    - Primary: Aspartic acid
    - Secondary: Glutamine, Glycine
  - **Neurotransmitter Synthesis**
    - Glutamic acid, Histidine, Phenylalanine, Tyrosine, Tryptophan, Serine
- 



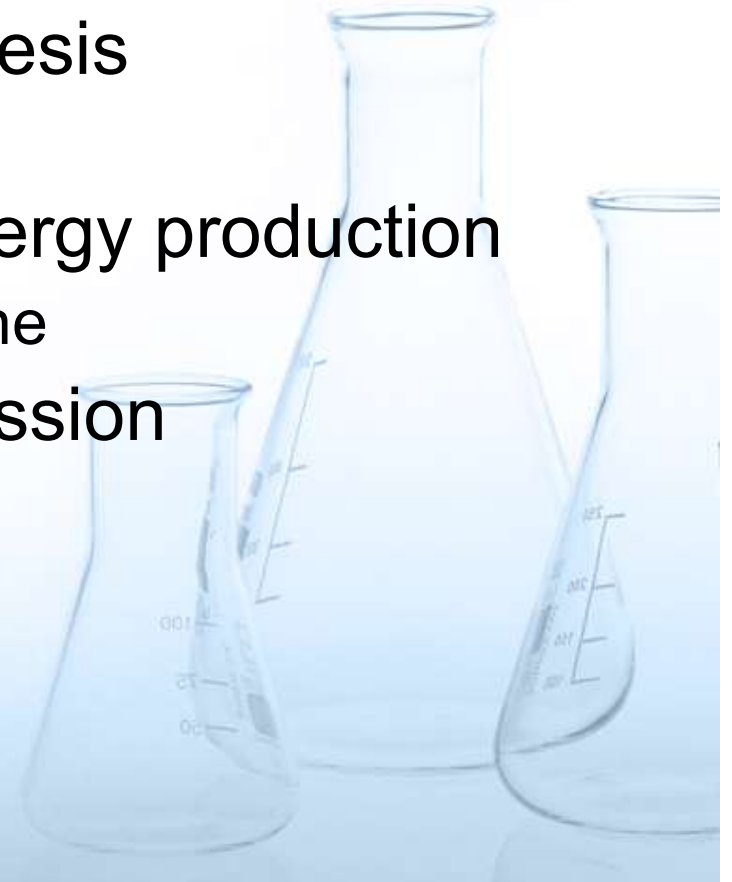
# Amino Metabolic Functions

- **Derived Amino Acids**
    - Glutamic Acid - Asparagine, Proline, Arginine
    - Methionine - Serine, Cysteine
    - Phenylalanine - Tyrosine
    - Serine - Glycine
- 



# Amino Acids: N Compounds

- **Glutathione - antioxidant, detox pathway**
  - Cysteine, Glycine, Glutamine
- **Carnitine - fatty acid synthesis**
  - Lysine, Methionine
- **Creatine - key factor in energy production**
  - Arginine, Glycine, Methionine
- **Carnosine - nerve transmission**
  - Histidine,  $\beta$ -alanine



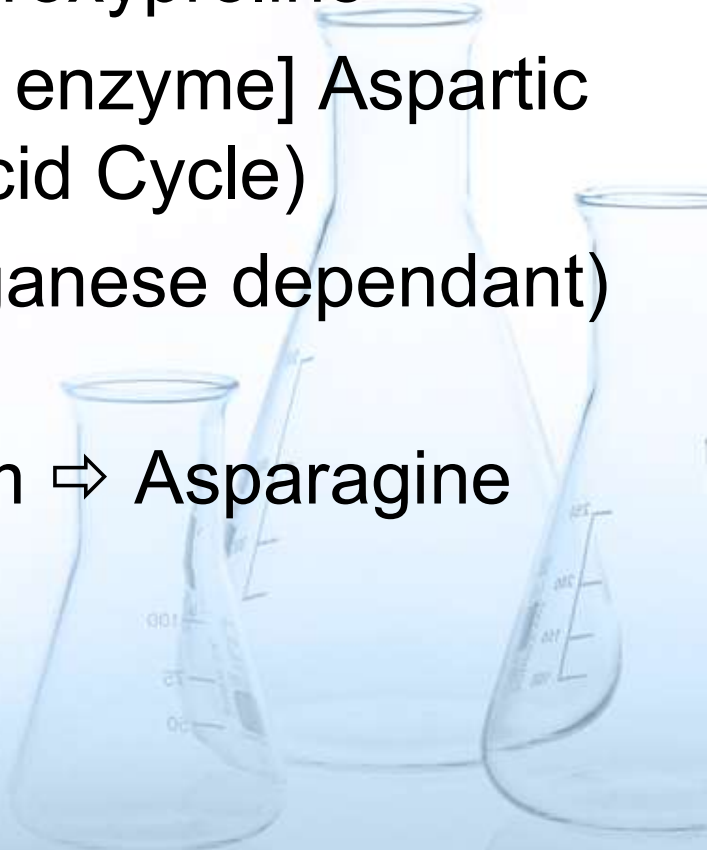


# Amino Acids: Pathways

- Threonine  $\Rightarrow$  Serine  $\Rightarrow$  Glycine
- Threonine  $\Rightarrow$  Serine  $\Rightarrow$  Acetylcholine
- BCAA's  $\Rightarrow$  Alanine  $\Rightarrow$  Glutamine  $\Rightarrow$  Glucose
- Methionine  $\Rightarrow$  Homocysteine  $\Rightarrow$  Serine  $\Rightarrow$  Cystathionine  $\Rightarrow$  Cysteine  $\Rightarrow$  Taurine
- Methionine  $\Rightarrow$  Glycine (methyl group transfer)
- Glutamic Acid + AKG  $\Rightarrow$  Glutamine



# Amino Acids: Pathways

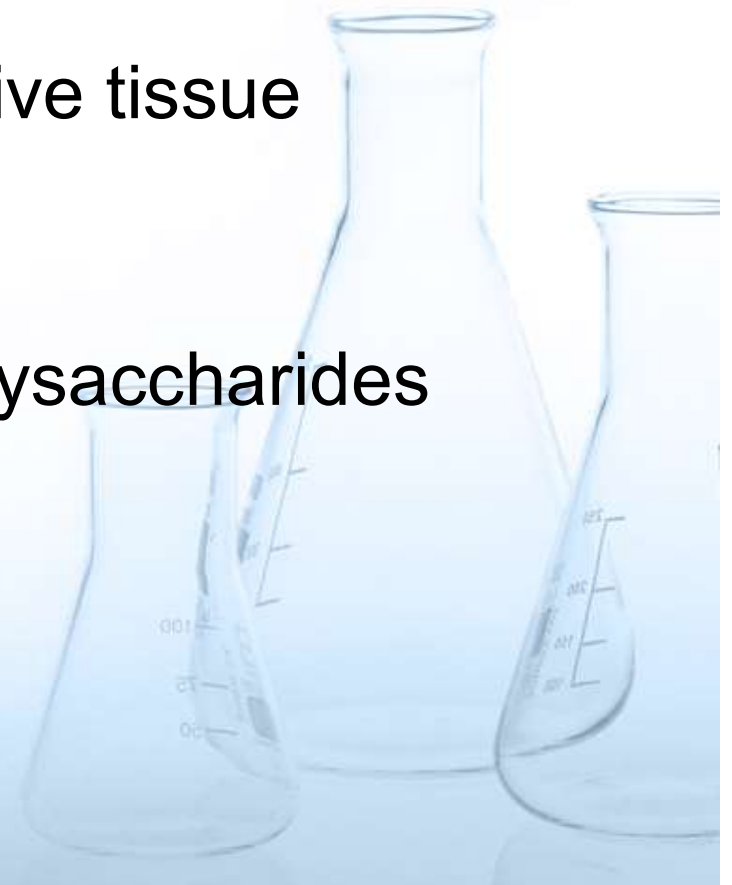
- Proline + Niacin  $\Rightarrow$  Glutamic Acid
  - Proline + Vitamin C  $\Rightarrow$  Hydroxyproline
  - Citrulline + [Mg dependant enzyme] Aspartic Acid  $\Rightarrow$  Fumarate (Citric Acid Cycle)
  - Arginine + Arginase (Manganese dependant)  $\Rightarrow$  Urea
  - Aspartic Acid + Magnesium  $\Rightarrow$  Asparagine
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# Methionine is Precursor to:

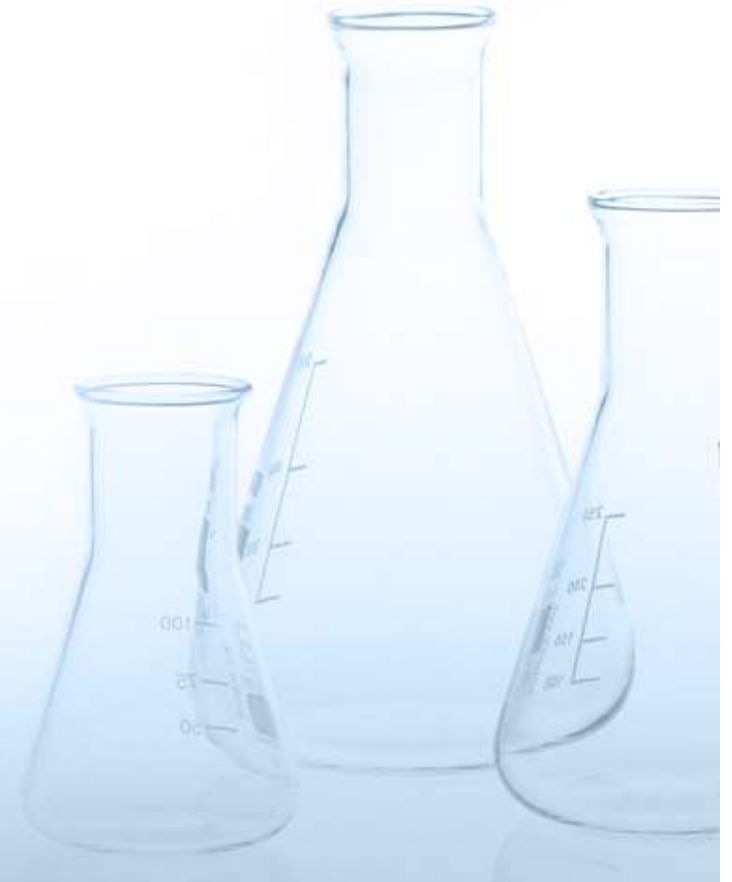
- Choline
- Acetylcholine
- Creatine
- Epinephrine
- Antibodies
- Cysteine
- Glutathione
- Coenzyme A
- Taurine
- Connective tissue proteins
- Sulfo-mucopolysaccharides





# Classic Signs of Amino Acid Deficiencies

- Slow growth (children); poor wound healing
- Attention deficit disorders
- Chronic fatigue
- Emotional disorders
- Loss of mental energy
- Immune suppression
- Night blindness
- Infertility and impotence



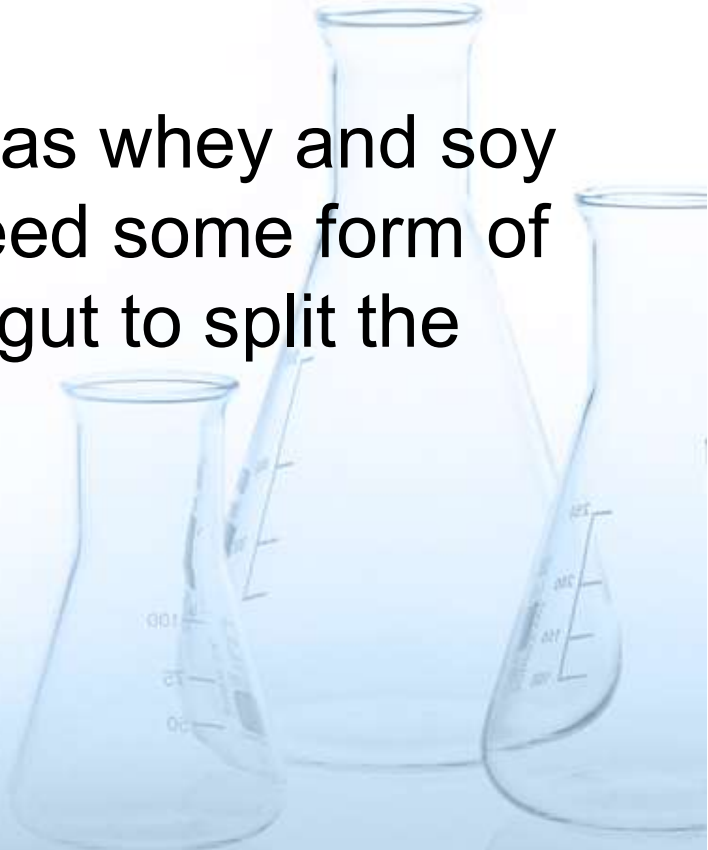


# Positive Responses to Free-Form Amino Acids

- Childhood development
  - Behavior disorders (ADD)
  - Autistic Spectrum Disorders (ASD)
  - Addiction(s)
  - Depression
  - Bipolar disorder
  - Chronic fatigue
  - Obesity
  - Multiple food sensitivity
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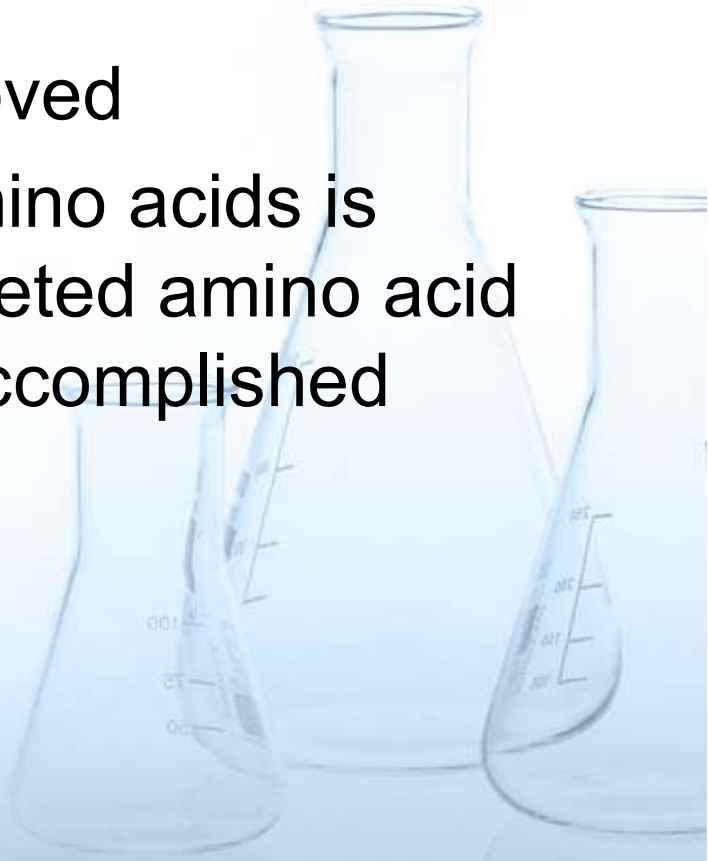


# What are free-form amino acids?

- A free-form amino acid is one that stands alone such as Glycine, Arginine, Lysine, etc.
  - Protein supplements such as whey and soy contain amino acids but need some form of breakdown to occur in the gut to split the amino acids up.
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# Benefits of free-form amino acids

- No digestion necessary
  - Absorption is greatly improved
  - The quantity of specific amino acids is carefully controlled so targeted amino acid supplementation can be accomplished
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# Why so many respond to amino acids

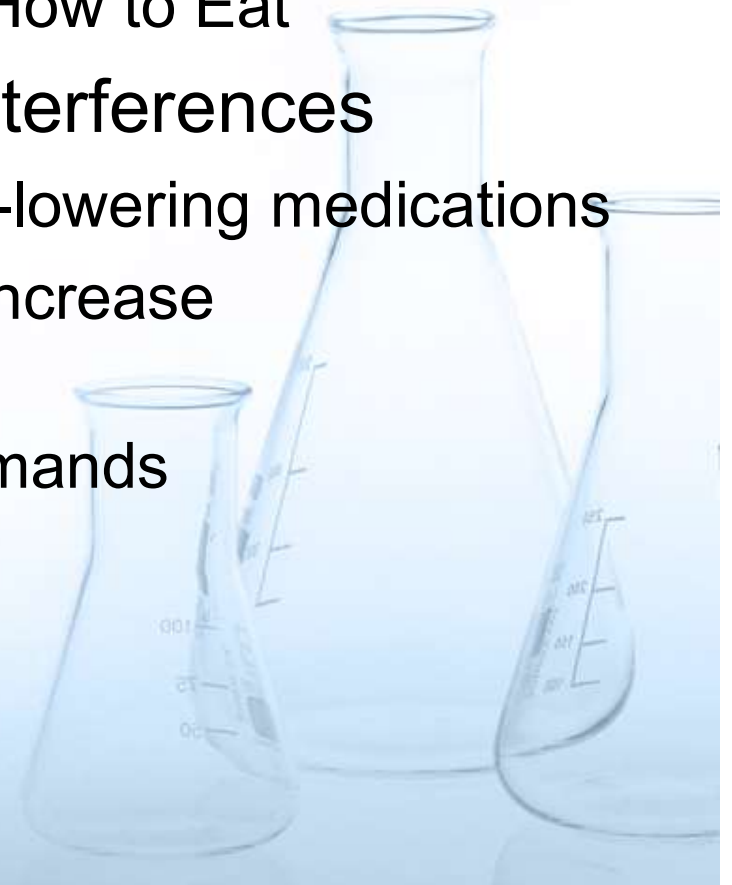
- Protein- & fat-restricted diets
  - The myth of “Fat is Bad”
  - Misinformed attempts at weight loss
- Drug-induced digestive interferences
  - Acid blockers & antacids
  - NSAID’s – Gut effects
  - Antibiotic degradation of gut ecology






# Why so many respond to amino acids

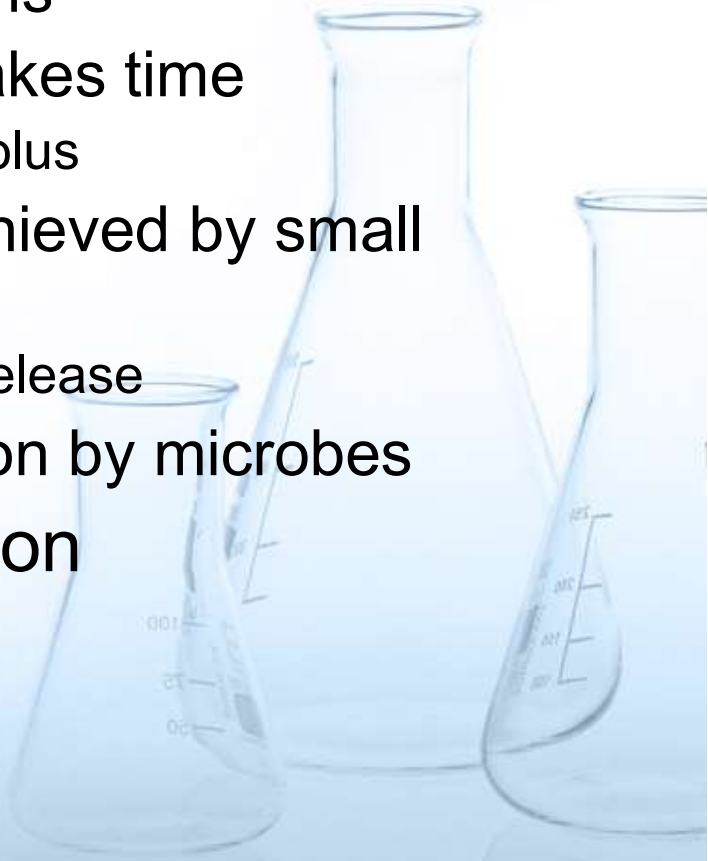
- National habit of rushing meals
  - Remember importance of “How to Eat”
- Drug-induced metabolic interferences
  - Cholesterol and triglyceride-lowering medications
  - SSRI and other drugs that increase neurotransmitter turnover
  - Increased detoxification demands





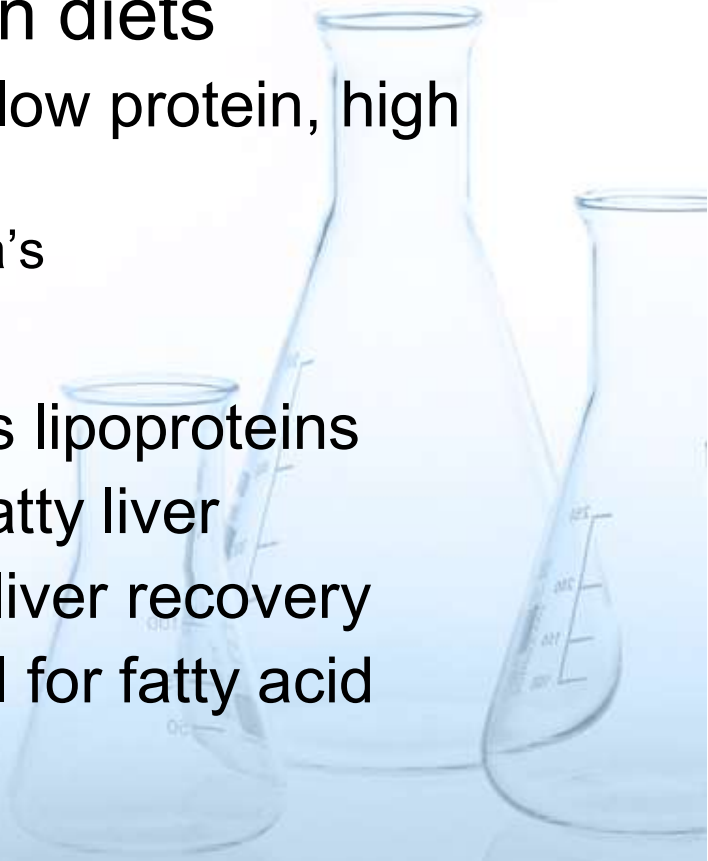


# Amino acid status and the “Fat is bad” myth

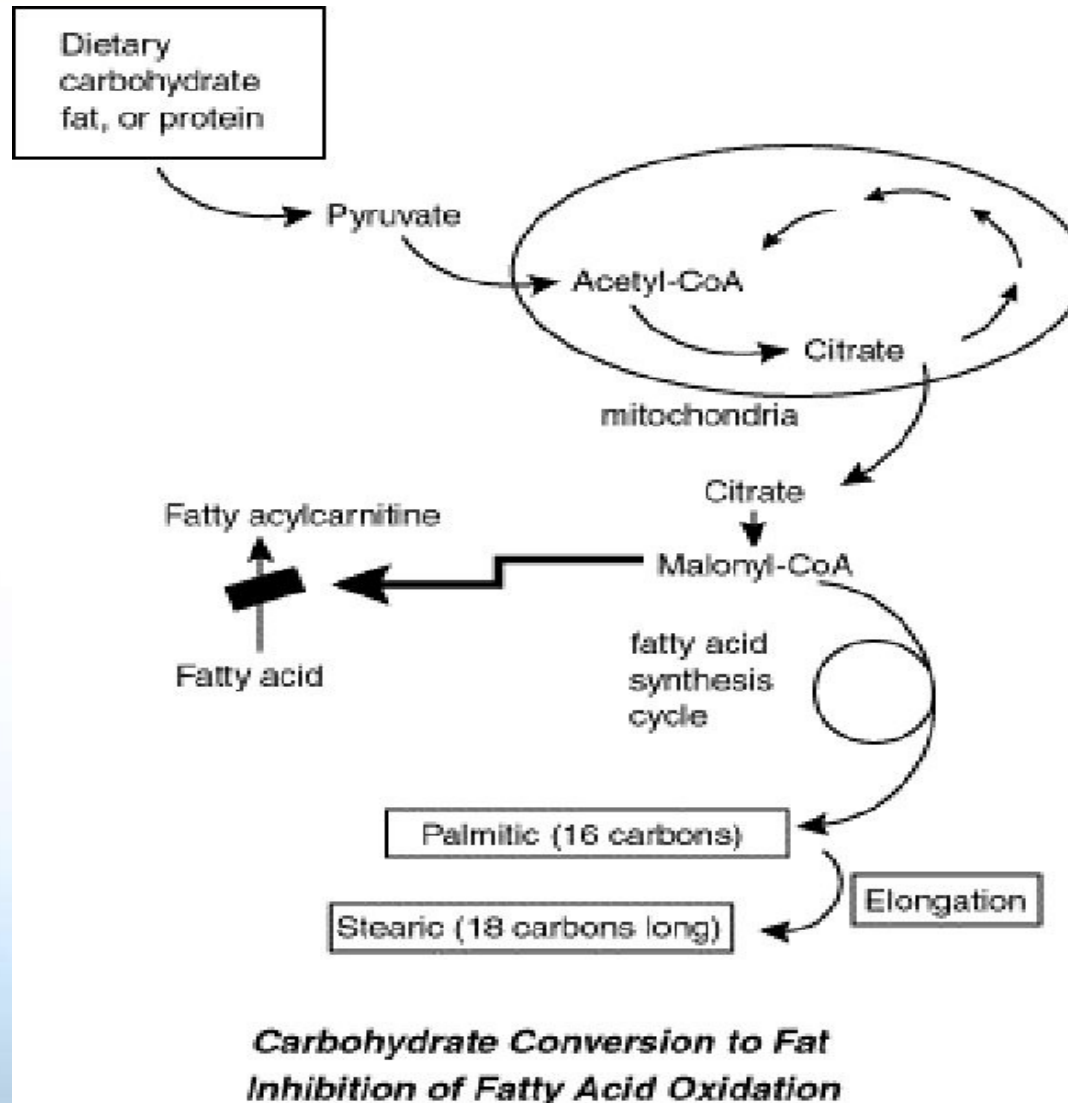
- Fat aids protein digestion
    - Stomach residence increased
    - Bile acids help unfold proteins
    - Pancreatic enzyme action takes time
      - Works best on small chyme bolus
    - Final amino acid release achieved by small intestinal enzymes
      - Rapid passage yields partial release
    - Undigested peptides acted on by microbes
  - Amino acids aid fat utilization
    - Lipoprotein apoproteins
    - Choline and Carnitine
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# Protein-Fat Relationships

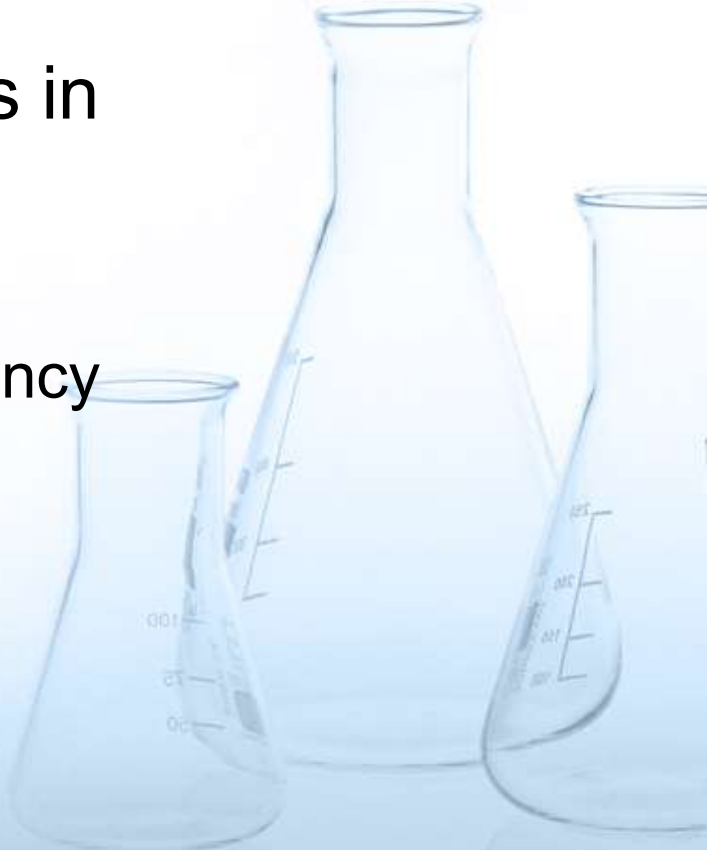
- Protein-rich foods contain fat
    - Meats, Milk products, Nuts, Eggs, Beans
  - Low fat diets are low protein diets
    - The worst combinations are low protein, high carbohydrate diets
      - Insulin drives breakdown of aa's
  - Protein-Fat connections
    - Fat is transported in blood as lipoproteins
    - Inhibit protein synthesis → fatty liver
    - Choline (from AA) aids fatty liver recovery
    - Carnitine (from AA) essential for fatty acid oxidation
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# Carbohydrate Conversion to Fat

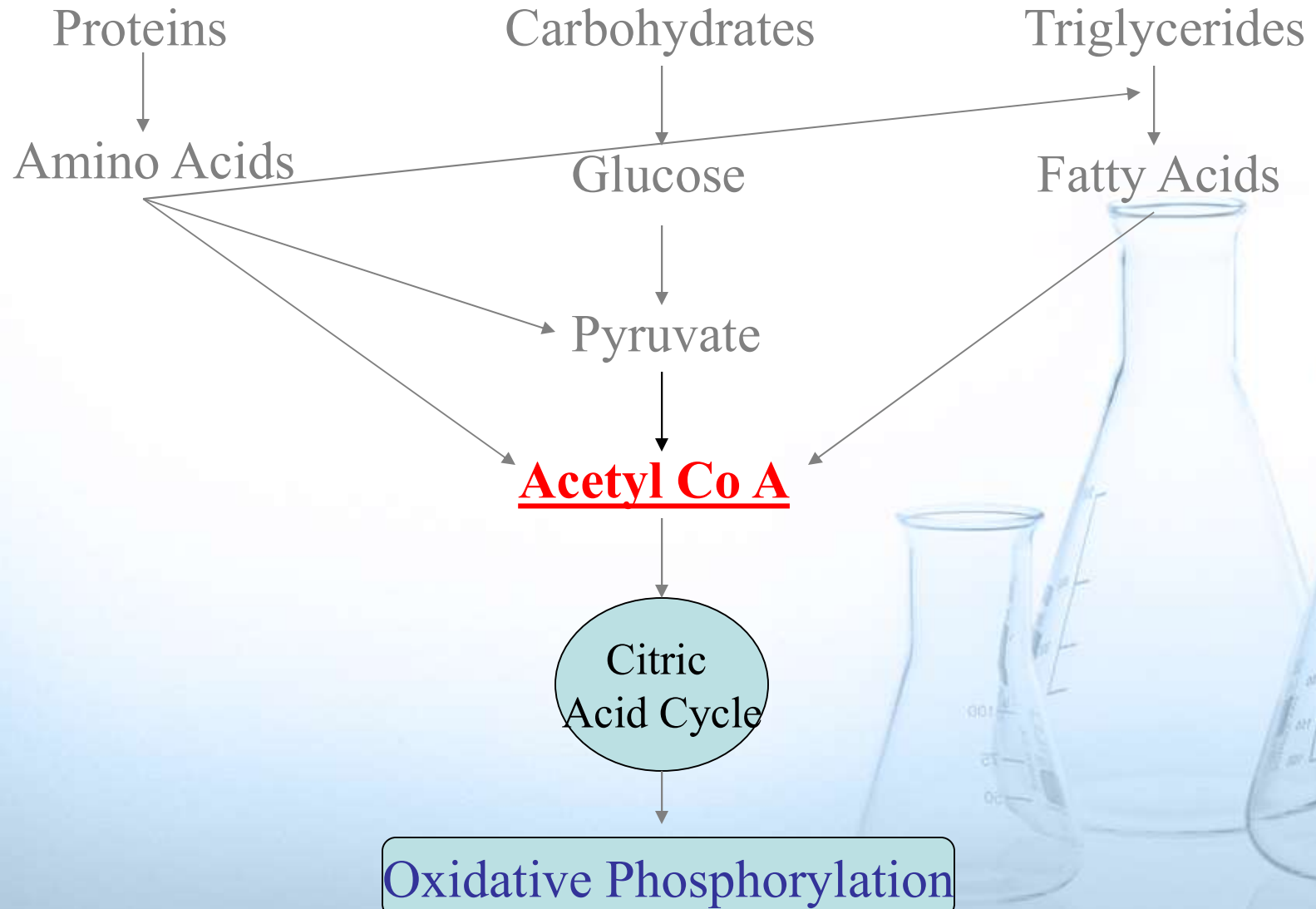




# Fatty Acids: Synthesis

- Carnitine synthesis from Methionine, Lysine, Iron and Vitamin C
  - Carnitine deficiency results in
    - impaired fatty acid oxidation
    - failure of gluconeogenesis
    - results from histidine deficiency
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# Oxidative Energy Metabolism





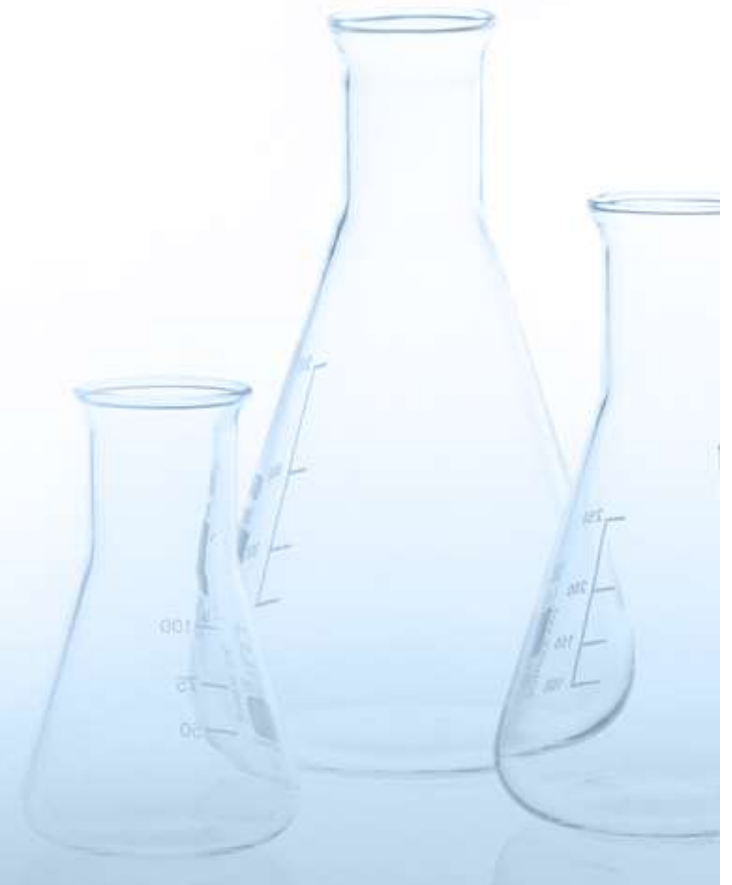
# Factors Leading to Low Amino Acid Levels

- **Leucine, Isoleucine, Valine & others**
    - Low dietary intake
  - **Phenylalanine / Tyrosine**
    - Increased hormone turnover
  - **Tryptophan**
    - Increased neurotransmitter turnover
  - **Methionine**
    - Limiting dietary amino acid
  - **Arginine**
    - Increased nitric oxide production
- 



# Factors Leading to Low Amino Acid Levels

- **Inadequate dietary supply**
  - Many snack or ‘diet’ foods of low protein quality
- **Loss of gastric function**
  - Esp. in geriatric population
- **Loss of pancreatic function**
  - Esp. with Zn deficiency
- **Malabsorption**
  - Esp. in IBD
- **Increased utilization**
  - Glycine for detox & heme
- **Renal failure to resorb**
  - in Glutathione inadequacy







# Digestive Demands of Dietary Protein

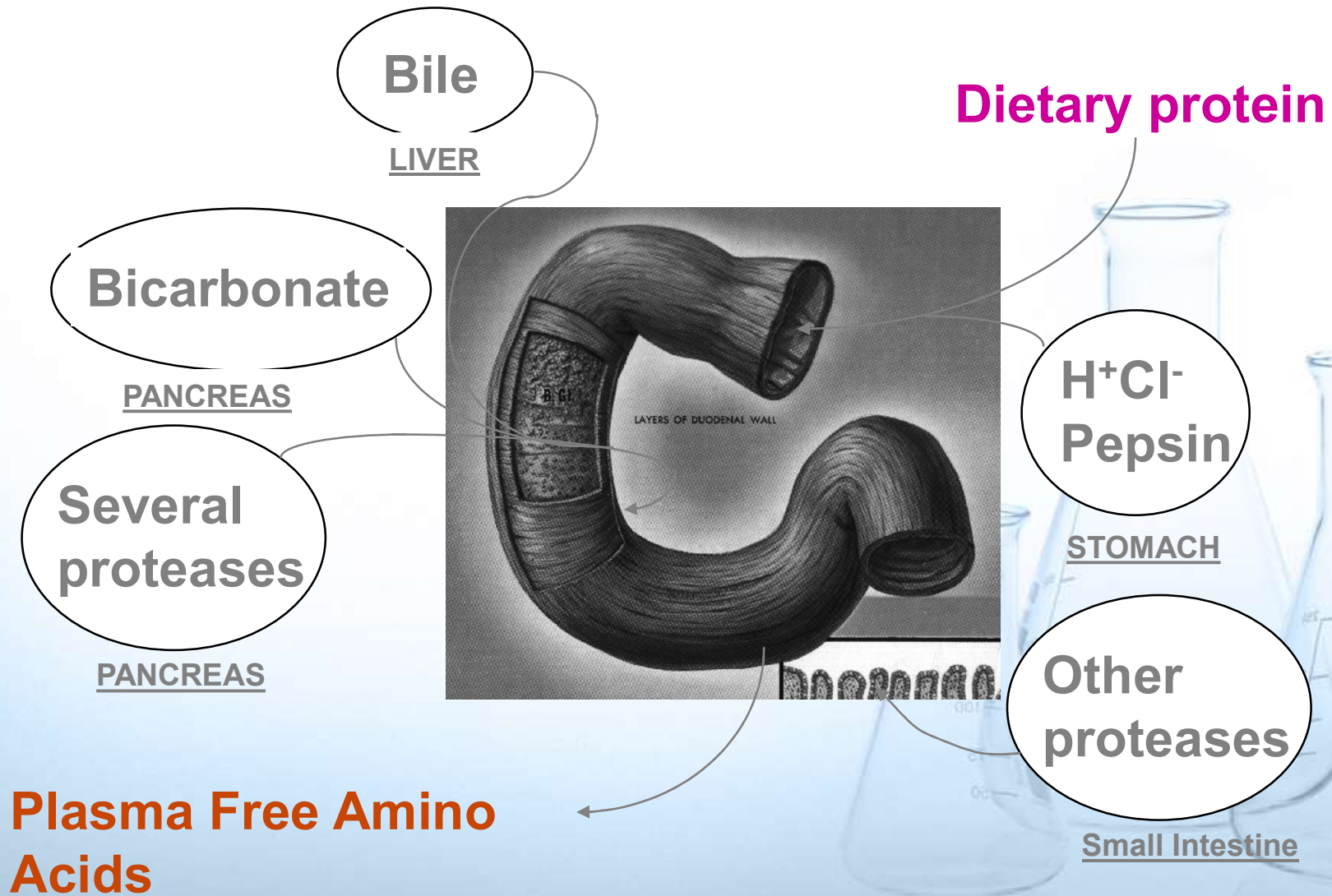
**Dietary protein**

**NOT SO SIMPLE**

**Plasma Free Amino Acids**

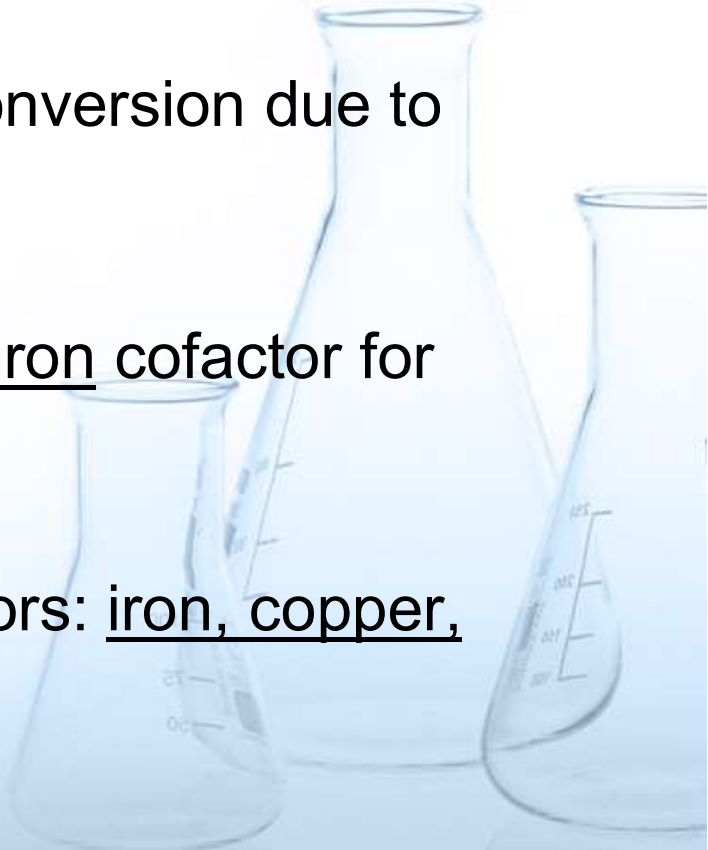


# Digestive Demands of Protein



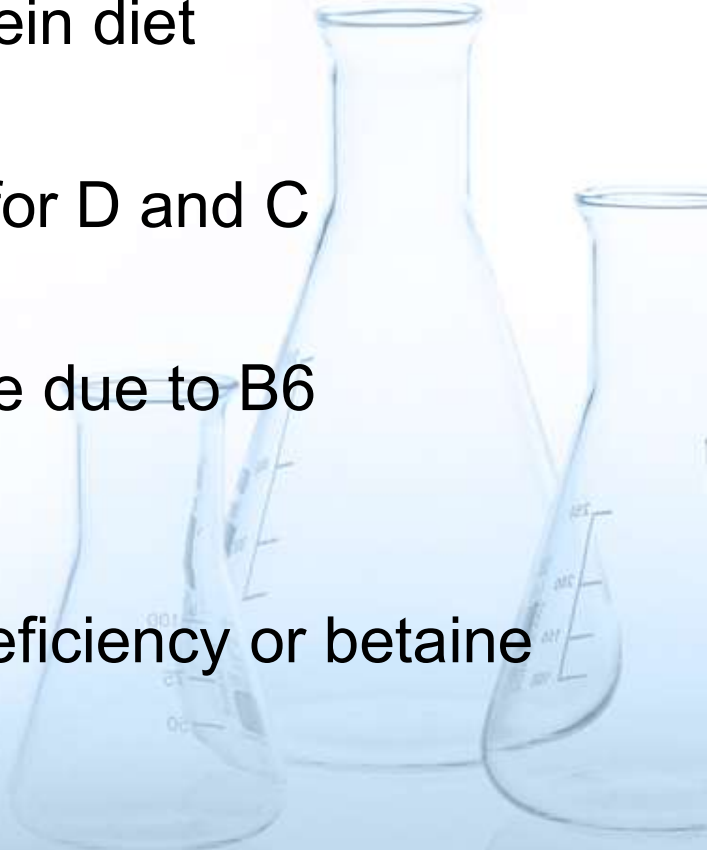


# Causes of High Plasma AA

- **Leucine, Isoleucine, Valine, Methionine**
    - High dietary intake, vitamin B6 deficiency
  - **Glutamic acid**
    - Poor Glutamine ---> AKG conversion due to niacin deficiency
  - **Phenylalanine**
    - Phenylketonuria (neonate); iron cofactor for conversion to Tyrosine
  - **Tyrosine**
    - Inadequate catabolic cofactors: iron, copper, iodine, B6 & C
- 



# Causes of High Plasma AA

- **Arginine, Ornithine, Glutamine**
    - Poor arginase activity due to Manganese deficiency consider low protein diet
  - **Hydroxyproline, Proline**
    - Collagen breakdown; need for D and C
  - **GABA**
    - Poor conversion to succinate due to B6 deficiency
  - **Phosphoethanolamine**
    - Functional B12 and folate deficiency or betaine need
- 



# Causes of High Plasma AA

- **$\alpha$ -Amino adipic acid**
    - B6 and AKG for amine group transfer
  - **3-Methylhistidine**
    - Muscle wasting disorders
  - **1-Methylhistidine**
    - Inadequate methyl group transfer due to B12, folate, DMG def.
  - **$\beta$ -Alanine**
    - Poor renal tubular resorption
- 