Fundamentals of Nutrition  
Session 3  
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Agenda
Part 1: Introduction to Proteins  
- To gain an understanding of the role protein has in the diet  
- Understand how quality, insufficiency and excess affect state of health

Part 2: Introduction to Fats  
- To gain an understanding of the role lipids (fats and oils) in the diet  
- Understand how quality, insufficiency and excess affect state of health

Proteins

What Makes Proteins Unique?
- Molecular structure: always contain carbon, hydrogen, oxygen and nitrogen (CHON) and sometimes, sulfur.
- Protein is second only to water in the body’s physical composition = approx. 20% of our body weight.

Why Is Protein Essential?
- needed for growth and maintenance of body tissues; vitally important during childhood, pregnancy and lactation
- Serve as building blocks for manufacture of structural and globular proteins of the body.
- Involved in communication, information processing and cell signaling
- Bodies cannot make all the amino acids that we need for survival.
- Protein deficiency = disease (compromised health).

Protein Functions
1. Growth and maintenance (serve as building blocks)
2. Energy available: 4 calories per gram
3. Building necessary globular proteins:  
   - Enzymes – for digestion, immune, liver and other metabolic functions
   - Hemoglobin – Fe (iron) bearing protein, carries O₂
   - Hormones – examples: insulin, thyroid hormone, estrogen
   - Antibodies – inactivate intruding microbes
4. Fluid and salt balance: protein attracts H₂O
5. Acid-alkaline balance: proteins are acid-forming by nature

Why Is Protein Important?
1) Makes structural components of the body like muscles, hair, nails, skin, eyes, and internal organs, especially the heart (muscle) and brain.
2) Relays messages in hormones, hemoglobin, and enzymes.
3) Immunity is built around it, in the formation of antibodies.
4) Can be used for energy, in extreme circumstances! LAST RESORT FUEL
Amino Acids

- Proteins are made of building blocks called amino acids, of which there are 22.
- Amino acids make up protein in unique sequences and provide 3-dimensional structure.
- Amino acids are grouped into two main classes: essential and non-essential.
  - **Essential** amino acids (9) cannot be made by the body (under any circumstance) and must be obtained from the diet.
  - **Non-essential** amino acids (13) are made by the body (synthesized) from essential amino acids.

Amino Acids continued...

<table>
<thead>
<tr>
<th>Essential</th>
<th>Non-essential</th>
<th>Conditionally Essential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histidine</td>
<td>Alanine</td>
<td>Arginine</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>Asparagine</td>
<td>Cysteine</td>
</tr>
<tr>
<td>Leucine</td>
<td>Aspartic Acid</td>
<td>Glutamine</td>
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<tr>
<td>Lysine</td>
<td>Glutamic Acid</td>
<td>Glycine</td>
</tr>
<tr>
<td>Methionine</td>
<td>Serine</td>
<td>Ornithine</td>
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<tr>
<td>Phenylalanine</td>
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<td>Proline</td>
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<tr>
<td>Threonine</td>
<td>Homocysteine</td>
<td>Tyrosine</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>Selenocysteine</td>
<td></td>
</tr>
<tr>
<td>Valine</td>
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<td>Citrulline</td>
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</table>

Preventing Deficiency

- Deficiency in non-essential amino acids is possible if diet is protein-deficient.
- Co-factors are necessary for non-essential amino acid synthesis, i.e. vitamins & minerals.
  - All foodstuffs contain some amino acids.
  - Different combinations of amino acids are present in foodstuffs.
  - If one food is eaten exclusively, certain amino acids may be deficient.
  - It is recommended to seek complete proteins to ensure proper nutrition.

Complete Proteins

- Complete proteins are foodstuffs that contain, at least, all the 9 essential amino acids in ratios similar to human proteins.
- Only animal proteins fit this description

Sources of complete protein:
  - Meat (beef, bison, pork, lamb)
  - Fish and poultry (chicken, turkey)
  - Dairy (milk, cheese, yogurt, kefir, whey)
  - Eggs

Are Any Vegetable Proteins Complete?

Vegetable sources containing all 9 essential amino acids:
  - Hemp
  - Chia
  - Soy
  - Quinoa
  - Spirulina

- Important: be aware that these foods do not contain the same levels or ratios of essential amino acids that humans require. Other foods are required in the diet for the body to make ‘complete protein’

Incomplete Proteins

- Incomplete proteins are foodstuffs that lack one or more of the 9 essential amino acids.
- Sources of incomplete protein:
  - Vegetables*
  - Grains*
  - Legumes*
  - Nuts*
  - Seeds*

* When considered singularly.
But what if we are a Vegetarian or Vegan?

- Plant source proteins do not contain all of the essential amino acids individually, therefore, they need to be combined to yield complete proteins.

- **Examples:**
  - Grains + beans/legumes
  - Grains + nuts
  - Grains + seeds
  - Grains + green leafy vegetables
  - Grains + soy

  ➢ Can be combined over a 1-2 day period.

How Much Protein Do We Need?

- The average daily protein requirement is 0.8 grams per kilogram of ideal body weight; adults - males and females 19 years and older. (1 kg = 2.2 pounds)
- Requirements increase by 25 grams daily during pregnancy and all months of lactation.
- Requirements also increase during stages of growth and activity.
- Requirements are based on maintaining a positive nitrogen balance in children, and an even-to-positive balance in adults.
- The daily process of protein anabolism and catabolism determines the nitrogen balance of the body.

  ➢ Methods to measure the quality of protein foodstuffs:
    - Biological Value (BV) - nitrogen status in the body (absorbed), pg. 58 in text
    - Net Protein Utilization (NPU) - nitrogen status in the body + digestibility, pg. 58 in text

Protein: Digestion and Metabolism – A Review

2. Stomach – enzymes (pepsin, proteases) and HCl break down proteins into long-chain polypeptides (amino acid chains).
4. Small Intestine – amino peptidases turn tripeptides and dipeptides into single amino acids, which are actively transported through the intestinal wall.

Protein Excess

- Chronic degenerative disease like arthritis, cancer, diabetes (Type II) and cardiovascular disease.
- Excess protein = excess acids = osteoporosis?
- Excess protein can mean a diet high in saturated fats.
- **Quality** is more important than quantity.

Protein Deficiency

- Can be common in "new" vegetarians and vegans
- Faulty eating habits, yo-yo dieting, low calorie diets and inadequate protein sources
- Kwashiorkor – protein deficiency disease (a.k.a. PCM) mostly in Africa
- Marasmus – calorie/food deficiency = tissue wasting and energy loss
- Western cases: the alcoholic; sarcopenia - muscle wasting
- Adequate consumption of daily protein may still lead to deficiency if digestion is poor

- **Symptoms of Chronic Protein Deficiency:**
  - Weight loss
  - Edema – excess fluid retention in hands and feet
  - Nausea or dizziness
  - Poor concentration
  - General, overall weakness
  - Hair dull, loose and falling out
  - Anemia
  - Decreased immunity
  - Premature aging
  - Muscle wasting
  - Low hormone levels

Fats and Oils
Why are Fats and Oils Important?

1) Energy source – 9 calories/gram (2nd choice)
2) Insulate from cold (temperature regulation)
3) Protects from trauma (padding and insulation for internal organs)
4) Part of cell membranes - fluidity & stability
5) Transport nutrients (fat soluble vitamins: A, D, E, and K)
6) Flavor enhancing

Fatty Acids

- Fats are made up of fatty acids.
  = Chains of straight or bent caterpillar-like strings
- Fatty chain of Carbon + Hydrogen atoms and an acid.
- Short, medium and long chains (# of carbon atoms dictates type).
- Water insoluble.

A Little Chemistry: Just A 'Taste'

- Carbon atom has 4 spots open for Hydrogen to bond.
- Single carbon bonds in the chain make the fat saturated with H⁺ ions, and stable - straight, non-reactive.
- Double carbon bonds in the chain take up one of the spots where hydrogen was, leaving a gap/‘hot spot’ in the chain and make the fat unsaturated - bent, reactive.
- Double bonds have either cis or trans configuration = very important!
  - cis = spaces on the same side cause bend, natural and is more stable
  - trans = moving a H⁺ ion to balance, unnatural and is more reactive

Saturated Fats

= saturated with hydrogen
- Short chain fatty acids: 2-5 carbon bonds
- Medium chain fatty acids: 6-13 carbon bonds
- Long chain fatty acids: 14+ carbon bonds
- Sources include:
  - Beef, cheese, chocolate, coconut, butter, lard
  - Generally solid at room temperature; the more saturated the fat, the more likely it is to be solid at room temperature.

Functions of Saturated Fats

- Add structure; stabilize cell membranes
- Stored as energy (adipose tissue)
- Main fuel for making cholesterol
- Raw material for making hormone production and healthy cell membranes
- Adequate intake ensures that other fats serve their proper roles

Unsaturated Fats

- Contain carbon double bonds; thus are missing some hydrogen.
- Longer chain, having at least 18 carbon bonds.
- Show a degree of unsaturation:
  - Monounsaturated = 1 double bond (mono = one)
  - Polyunsaturated = 2+ double bonds (poly = many)
- Add flexibility of cell membranes, as well as communication.
- Chemically unstable and can break down in the body to produce excess levels of free radicals – factors in heart disease and cancer.
- Sources include:
  - Vegetable oils - sunflower, safflower, canola, soy, corn, sesame, olive.
- Liquid at room temperature.
Monounsaturated Fats
- Resist oxidative damage better than other unsaturates.
- Not stackable, a little ‘thick’ on cooling.
- Not depositable in the body.
- Moisturize skin and keep arteries supple.
- The body can synthesize them, thus they are NOT essential
- Examples: olives, avocados, almonds. olive oil. sesame oil, grapeseed oil, sunflower oil

Polyunsaturated Fats
- Essential in our diets because we cannot synthesize them in our bodies
- Named “omega-3”, “omega-6”, etc. for where the double bonds are in the chain, i.e. 3, or 6.
- Attract oxygen and are perishable.
- Virtually unstackable.
- Include Essential fatty acids (EFAs)
  - Omega 3 = alpha linolenic acid, hot spot at the third carbon
  - Omega 6 = linoleic acid, hot spot at the sixth carbon
- Very low viscosity (very fluid); will not even solidify if frozen
- Examples: sunflower, sesame, pumpkin, hemp, flax, walnuts, cold water fish.

Polyunsaturated Fats continued...

<table>
<thead>
<tr>
<th>Omega 3 – alpha linolenic acid</th>
<th>Omega 6 – linoleic acid</th>
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</thead>
<tbody>
<tr>
<td>Flaxseed/oil</td>
<td>Sunflower oil</td>
</tr>
<tr>
<td>Cold water fish</td>
<td>Sunflower oil</td>
</tr>
<tr>
<td>Hemp seed/oil</td>
<td>Evening Primrose oil</td>
</tr>
<tr>
<td>Pumpkin seed/oil</td>
<td>Sesame oil</td>
</tr>
<tr>
<td>Chia seed/oil</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Omega 3 Deficiencies</th>
<th>Omega 6 Deficiencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflammatory diseases (ends w/ “itis”)</td>
<td>Eczema</td>
</tr>
<tr>
<td>Dry skin</td>
<td>Reproductive issues</td>
</tr>
<tr>
<td>High blood pressure</td>
<td>ADD/ADHD</td>
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<tr>
<td>Low metabolism</td>
<td>Etc.</td>
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Functions of the EFAs (Polyunsaturates)
- Energy production
- Oxygen transfer in and out of cells – “oxygen magnets”
- Hemoglobin production
- Membrane components – traffic substances, electrical and structural (fluidity)
- Growth enhancement – increase metabolic rate (weight loss; if EFAs are 12-15% of total calories, more calories will be burned)
- Brain development (fetal, infant)
- Reduce clotting (platelet aggregation)
- Precursors to prostaglandins – short-lived, hormone like chemicals (good and bad; EFAs become good prostaglandins)

Note: None of this will be of benefit without co-factors: vitamins, B3, B6 and C & minerals - Mg (Magnesium) and Zn (Zinc)

Symptoms of EFA Deficiency:
- Rough, dry, flaky or scaly skin
- Dry, brittle hair
- Wounds heal poorly
- Get infections easily
- Fatigue
- PMS

What Happens to EFAs in The Body?
- Transformation...
- We convert them into more highly unsaturated derivatives (further desaturate)
  - Omega 3 → EPA → DHA (pg. 72 in text)
  - Omega 6 → GLA → DGLA → AA ( pg. 72 in text)
- Derivatives are the useable form (EPA, DHA, DGLA, AA) are important to all cells, especially brain cells, sex glands, sensory organs (generate nerve impulses)
- Some derivatives become hormone like prostaglandins (regulation and communication) → DHA does not!
Prostaglandins

Consist of 3 families; depend on what fatty acid they are made from:
- Series 1 (PG1) – good from Omega 6
  - Reduces inflammation, keeps platelets from clumping
- Series 2 (PG2) – bad from Omega 6
  - Causes inflammation, promotes platelet clumping/clots
- Series 3 (PG3) – good from Omega 3
  - Prevents PG2 formation, thereby reducing heart disease and inflammation

Classification of Lipids

<table>
<thead>
<tr>
<th>Triglycerides</th>
<th>Phospholipids</th>
<th>Sterols</th>
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</thead>
<tbody>
<tr>
<td>i.e. omega-3</td>
<td>i.e. cholesterol</td>
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Triglycerides

= 95% of lipids in food and body fat
- Consists of 3 fatty acids + glycerol (can become glucose)
- Storage form of fat
- Excess = overweight and the associated health issues, i.e. elevated triglycerides - indicator of cardiovascular disease

Phospholipids

= less than 5% of lipids in foods and bodies
- Consists of 2 fatty acids + glycerol + phosphorous-containing molecule, ex. phosphatidylcholine

Functions:
- Cell membranes, skin around cells of all living things; holds stuff in and lets stuff out
- Cholesterol ratio control (HDL/LDL)
- Forms nerve cells
- Especially important for neuro-cognitive health (brain, nervous system)
- Highest food sources: egg yolk, soy (as lecithin)

Sterols/Cholesterol

- Sterols include: cholesterol, phytosterols (plant sterols) and some steroid hormones
- Cholesterol
  - 20% we ingest (diet), 80% produced by the body
  - We do not need to eat it-- we make it!
  - More food, more stress = more cholesterol production!
  - Indigestible (not broken down to fatty acids) → excrete it through feces - if everything is in order

Cholesterol

- Is very important!!
- Hard waxy lipid; melts at over 400 F
- Provides structure and rigidity to cell membranes
- Building block of steroid hormones: for ex., estrogen, testosterone, cortisol
- Component of skin
- Required for Vitamin D synthesis in skin
- Component of bile
- Excess = heart disease???
- Regular bowel movements is the only way to get rid of it
Which of these contain cholesterol?

Lipid Digestion: A Review

2. Stomach – enzymes and HCl free fat from foods. Fats rise to the top and are worked on last (slow digestion).
3. Small Intestine – bile from the liver emulsifies fat and pancreatic lipase breaks the fats down into fatty acids and glycerol.
4. Short and medium chain (12 carbons or less in length) fatty acids directly absorbed into lymph.
5. Long chains (14 carbons or more in length) must be transformed in the intestinal wall.

Lipids and Disease

- Disease Risks:
  - High fat diet makes platelets sticky
  - Overeating (in general)
  - High blood pressure
  - Cancer (esp. colon, breast)
  - Inflammatory diseases (arthritis, COPD)

- Disease Prevention:
  - Increase dietary fiber, especially vegetables
  - Low saturated fat diet
  - Broil, bake and steam, instead of frying foods
  - Increase omega-3 fats (cold water fish, nuts, seeds, germs & brans of grains, legumes)
  - Regular cardiovascular exercise
  - Maintain ideal body weight
  - Don’t smoke

Cancer

- Risks:
  - UV light, X-ray exposure
  - Pollution
  - High fat (poor quality) diet – oxidizes, stores chemicals
  - Chemical exposure
  - Smoke
  - Stress

- Prevention:
  - Eat mostly plant source foodstuffs, especially cruciferous vegetables
  - Limit meats, especially red
  - Limit alcohol
  - Avoid salt-cured, smoked, and nitrate-treated foods
  - Maintain ideal body weight
  - Be active (physical activity)
  - 15-30% fat (quality) in diet
  - Limit grilling; direct flame cooking

Homework

- Study for Quiz #2: on Carbohydrates, Fats and Proteins (session 2 and 3 only)
- Prepare your Vitamin or Mineral Assignment (see download for instructions)
- Read Chapters 5 and 6