• **Chapter 4-Carbohydrates**
  
  • Sugars, Starches, and Fibers
  
  • Introduction
  
  • Brain
    
    – Glucose
  
  • Muscles
    
    – Glucose
    
    – Glycogen
    
    – Fat
  
  • Sources of carbohydrates
  
  • “Fattening” – mistaken thinking
  
  • Carbohydrate Family
    
    — **Simple Carbohydrates**
      
      — **Monosaccharides**
        
        • Glucose
        
        • Fructose
        
        • Galactose
      
      — **Disaccharides**
        
        • Maltose
        
        • Sucrose
        
        • Lactose
    
    • **Complex Carbohydrates**
      
      — **Polysaccharides**
        
        • Starches and fibers
  
  • Chemist’s View of Carbohydrates
• Simple Carbohydrates

• Monosaccharides
  – C₆H₁₂O₆
    • Glucose
    • Fructose
    • Galactose

• The Simple Carbohydrates

• **Monosaccharides** are single sugars
  – **Glucose**:
    • essential energy source
    • blood sugar or dextrose.
  – **Fructose**:
    • is the sweetest
    • occurs naturally in honey and fruits
    • added to many foods in the form of high-fructose corn syrup.
  – **Galactose** rarely occurs naturally as a single sugar.

• The Simple Carbohydrates

• **Disaccharides**:
  • pairs of monosaccharides
    • one of which is always glucose
  – **Maltose**:
    • consists of two glucose units.
  – **Sucrose**:
    • fructose and glucose combined.
    • refined from sugarcane and sugar beets
- tastes sweet, and is readily available.
  - **Lactose**
    - galactose and glucose combined
    - found in milk and milk products.
- **Simple Carbohydrates**
  - **Condensation:**
    - reactions link monosaccharides together.
  - **Hydrolysis:**
    - reactions split molecules and commonly occur during digestion.
- Condensation
- Other Chemical Structures
- Major Sugars
- Hydrolysis
- **The Complex Carbohydrates**

**Polysaccharides**
- **Glycogen**-
  - Storage form of glucose in the animal body
  - Rapid release of energy when needed
- **Starches**-
  - Storage form of glucose in plants
  - Found in grains, tubers and legumes
- **Fibers**-
  - Structure in stems, roots, trunks, leaves of plants
- **The Complex Carbohydrates**
- **Dietary fibers**
– Provide structure in plants
– Found in all plant foods
  • Vegetables, fruits, whole grains, legumes
– Cannot be broken down by human enzymes
  • A Whole Wheat Plant and a Single Kernel
• Chemist’s View of Carbohydrates
• Polysaccharides
  – Fibers
    • Soluble fibers – benefits
    • Insoluble fibers – benefits
    • Functional fibers
    • Resistant starches
    • Phytic acid
• Complex Carbohydrates

Soluble fibers
  • Dissolve in water, form gels (viscous)
  • Can be digested by colonic bacteria
  • Found in oats, barley, citrus fruits, and legumes.
  • Protect against heart disease and diabetes
  • Complex Carbohydrates

Insoluble fibers
  • Are nonviscous
  • Not digested by intestinal bacteria.
  • Found in whole grains (bran) and vegetables
  • Help promote bowel movements, alleviate constipation and prevent diverticulitis
• Complex Carbohydrates

• Functional fibers
  – are health-benefiting fibers that are added to foods or supplements.

• Resistant starches
  – escape digestion
  – found in legumes, raw potatoes

• Phytic acid or phytate
  – found in foods with fiber
  – binds some minerals such as zinc, iron, calcium.

• Fibers

• Cellulose-
  – Plant cell walls
  – Found in fruits, vegetables and legumes

• Hemicellulose-
  – Main constituent of cereal fibers

• Pectins-
  – Found in vegetables, fruits
  – Used in food industry as a thickener

• Gums and Mucilages-
  – Secreted from plants
  – Thicken processed foods

• Lignin-
  – Nonpolysaccharide fiber
  – Woody part of vegetables, carrots, small seeds
  – Carbohydrate Digestion in the GI Tract
• **Carbohydrate in Food Becomes Glucose in the Body**

• **Absorption of Monosaccharides**

• **Digestion and Absorption of Carbohydrates**

• **Lactose Intolerance**
  
  – **Symptoms:**
    
    • include bloating,
    
    • abdominal discomfort
    
    • and diarrhea.
  
  – **Causes:**
    
    • Lactase decreases with aging
    
    • damaged intestinal villi.
  
  – **Prevalence**
    
    • Lowest in Scandinavians and northern Europeans
    
    • Highest in Southeast Asians and Native Americans, African Americans, Mediterranean peoples

• **Digestion and Absorption of Carbohydrates**

• **Lactose Intolerance - Dietary Changes**
  
  – Increase consumption of milk products gradually.
  
  – Mix dairy with other foods.
  
  – Spread dairy intake throughout the day.
  
  – Use of acidophilus milk, yogurt, and kefir (fermented products)
  
  – Use of enzymes
  
  – Individualization of diets
  
  – Careful to avoid vitamin and mineral deficiencies

• **Preview**
  
  Carbohydrate Metabolism
How do we store glucose?

**Storing glucose as glycogen**

- When you have adequate glucose supply-
  - liver makes glycogen from extra glucose and stores it
- When your blood glucose is low-
  - liver breaks glycogen into glucose and releases it into the bloodstream
- Liver stores 1/3 of the body’s total glycogen
- Muscle cells store the rest (2/3), which is used in exercise
- Preview-Carbohydrate Metabolism

**Using glucose for energy**

- Used for energy in most body cells
- Glucose is converted to energy inside the cell
- Preferred energy source for the brain, nerve cells and developing red blood cells
- Carbohydrate Metabolism
- **Making glucose from protein**
  - Glucose is the preferred energy for brain cells, nerve cells, and developing red blood cells
  - When the glucose supply is inadequate-the body’s protein is broken down to make glucose via **gluconeogenesis**
  - **Having adequate dietary carbohydrate can prevent this process**
- Carbohydrate Metabolism

**What happens with inadequate carbohydrate?**

Making ketone bodies from fat fragments

- With inadequate carbohydrate, fat breakdown increases
- Fat fragments form ketone bodies
  - are then used for energy
• When ketone production exceeds use,
  – ketosis occurs, disturbing the body’s acid-base balance
• 50-100 grams of CHO are needed to prevent ketosis
• Carbohydrate Metabolism

What about too much carbohydrate?

Converting Glucose to Fat

• When glycogen stores are full
  – Excess carbohydrate is converted to fat.
• The liver makes triglyceride (fat) from excess glucose, which is then stored in fat cells
• Glucose in the Body
• The Constancy of Blood Glucose
  – Maintaining Glucose Homeostasis
    • Cells depend on glucose for fuel
    • Low blood glucose
      – may cause dizziness and weakness
    • High blood glucose
      – may cause fatigue.
• Extreme fluctuations can be fatal.
• Normal blood glucose (fasting): 70-100 mg/dl
• Balanced meals help maintain normal blood glucose - Complex carbohydrates, fiber, protein, and fat
• Glucose in the Body
• The Constancy of Blood Glucose
  – The Regulating Hormones
    • Insulin
      – moves glucose into the cells
- helps to lower blood sugar levels.

- **Glucagon**
  - brings glucose out of storage
  - raises blood sugar levels.

- **Epinephrine**
  - acts quickly to bring glucose out of storage during times of stress.

- **Glucose in the body**
  - Balance glucose within the normal range
    - by eating balanced meals regularly with adequate complex carbohydrates.

  - Blood glucose can fall outside the normal range with hypoglycemia or diabetes.

- **Glucose in the Body**
- **The Constancy of Blood Glucose**
  - **Diabetes- blood glucose remains high after a meal**
    - Type 1 diabetes
      - is the less common type with no insulin produced by the body.
    - Type 2 diabetes
      - is the more common type where fat cells resist insulin.
    - Prediabetes
      - is blood glucose that is higher than normal but below the diagnosis of diabetes.
  - **Hypoglycemia**
    - is low blood glucose and can often be controlled by dietary changes.

- **Glucose in the Body**
- **The Glycemic Response**
how quickly the blood glucose rises after a person eats and how quickly it returns to normal

- Glycemic index classifies foods according to their potential for raising blood glucose.
- Glycemic load refers to a food’s glycemic index and the amount of carbohydrate the food contains.
- The benefit of the glycemic index is controversial.

Nutrient Deficiencies

- “Empty Calories” - extra added sugar with limited nutrients
  - Examples: candy, cake, soda
- Added sugars include:
  - honey, corn syrup, dextrose, corn sweetener, molasses, brown sugar, high fructose corn syrup, confectioners sugar, dextrose, maltose, raw sugar, fructose
  - Naturally occurring sugars from fruits, vegetables and milk are acceptable sources.
  - The Empty Calories of Sugar

Dental Caries

- Bacteria in the mouth ferment sugar and produce acid which dissolves tooth enamel
- Related to:
  - how long sugar stays in the mouth
  - how often teeth are exposed
- Bacteria produce acid 20-30 minutes after each exposure
- Health Effects of Sugars
• **Prevention of Dental Caries:**
  - Eat sugary foods with meals
  - Limit between meal sugary snacks
  - Rinse with water if unable to brush
  - Brush and floss regularly

• **Accusations Against Sugar**

• **Does sugar cause obesity?**
  Excessive sugar intake can contribute to the development of body fat. Excess **total** intake vs output will lead to obesity
  20 oz soda has 17 tsp sugar - over 250 kcalories
  1 can per day = 26 pounds per year

• **Does sugar cause heart disease?**
  Sugar may be able to alter blood lipid levels and contribute to heart disease in some.

• **Accusations against sugar**

• **Does sugar cause misbehavior in children and criminal behavior in adults?**
  There is no scientific evidence that sugar causes misbehavior in children and criminal behavior in adults

• **Does sugar cause cravings and addictions?**
  There is a theory that sugar increases serotonin levels, which can lead to cravings and addictions.

• **Recommended Intakes of Sugar**

• **DRI**
  - No more than 25% of total energy intake

• **World Health Organization and Food and Agriculture Organization** recommend:
  - Restrict your consumption of added sugar less than 10% of your total energy intake

• **Recommended Intakes of Sugar**
• 1 tsp sugar =
  – 1 tsp brown sugar
  – 1 tsp candy
  – 1 tsp corn sweetener or corn syrup
  – 1 tsp honey
  – 1 tsp jam or jelly
  – 1 tsp maple sugar or maple syrup
  – 1 tsp molasses
  – 1 ½ tsp carbonated soda
  – 1 tbsp catsup

• Recommended Intakes of Sugar

• Each of these provide about 500 kcalories
  – 40 oz cola
  – ½ cup honey
  – 125 jelly beans
  – 23 marshmallows
  – 30 teaspoons of sugar
  – Alternative Sweeteners

• Artificial sweeteners
  – Non-nutritive sweeteners
    – Large doses and adverse effects

• Stevia – an herbal product
  – Generally recognized as safe (GRAS)

• Sugar alcohols
  – Provide kcalories
– Benefits and side effects

• Health Effects and Recommended Intakes of Starch and Fibers

• Heart Disease
  – May be some protection from heart disease and stroke
    • Whole grains and soluble fibers
    • Soluble fibers bind with bile acids (which are made from cholesterol) and thereby lower blood cholesterol levels.
    • Eating 5-10 grams of soluble fiber daily reduces blood cholesterol by 3-5%

• Health Effects of Starch and Fiber

• Diabetes
  – Reduce the risk of type 2 diabetes by decreasing glucose absorption

• GI Health
  – Enhance the health of the GI tract
  – Insoluble fiber increases stool weight and reduces transit time
  – Alleviate constipation
  – Prevent hemorrhoids
  – Prevent diverticula

• Health Effects and Recommended Intakes of Starch and Fibers

• Cancer
  – Protects against colon cancer
    • binding and removing potential cancer-causing agents

• Weight Control
  – Provide less fat and added sugar
  – Feeling of fullness
  – Increased satiety
  – Decrease food intake
• Health Effects of a High Fiber Diet
• Harmful Effects-
  – Abdominal discomfort, gas, diarrhea, obstruction
• Recommendations:
  • Increase fiber gradually over several weeks
  • Increase fluids
  • Eat a variety- Fruits, vegetables, legumes, whole grain breads and cereals
• Recommended Intakes of Starch & Fibers
  • DRI for carbohydrates
    – 45 to 65% of energy requirement
  • RDA for carbohydrates
    – 130 grams per day
    – DV is 300 grams per day
• Health Effects and Recommended Intakes of Starch and Fibers
• Recommended Intakes of Fiber
  – FDA sets the Daily Value:
    • 25 grams for a 2,000-kcalorie diet.
    • Based on 11.5 grams per 1000-kcalories
    – DRI is 14 g per 1000 kcalorie intake
    • (28 grams for a 2,000 kcalorie diet)
    – World Health Organization suggests no more than 40 g per day.
    – No UL
• Highlight 4
• Carbs, kCalories, and Controversies
• Sugars’ Share in the Problem
• Increase in consumption of added sugars
  – High-fructose corn syrup
  – Body fat stores
• Carbohydrate cravings
  – Self-imposed labeling of foods
• Carbohydrate addictions
  – Not physiological or pharmacological
• Carbohydrates’ kCalorie Contributions
• Obesity and the link to carbohydrates
  – Total daily energy intakes have increased
  – Activity levels have declined
  – Increase in body weight
• Epidemiological studies
  – Inverse relationship between carbs & weight
• Weight loss
  – kCalorie intake
• Sugars’ Share in the Problem
• Simple to swallow
  – Sweetened beverages
• Appetite control
  – Fructose and insulin
    • Flaws in plausibility
  – Food form – liquid or solid
• Energy regulation
• Insulin’s Response
• Surge of insulin levels
• Glycemic effect
  – Factors impacting glycemic effect
    • Glycemic index and body weight
• Insulin resistance
  – Fructose
    • Prediabetes and metabolic syndrome
• Body’s insulin response