The Carbohydrates: Sugars, Starches, and Fibers

Chapter 4

Introduction

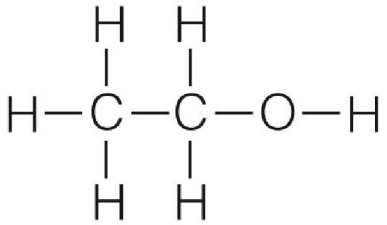
- Brain
  - Glucose
- Muscles
  - Glucose
  - Glycogen
  - Fat
- Sources of carbohydrates
- “Fattening” – mistaken thinking

Chemist's View of Carbohydrates

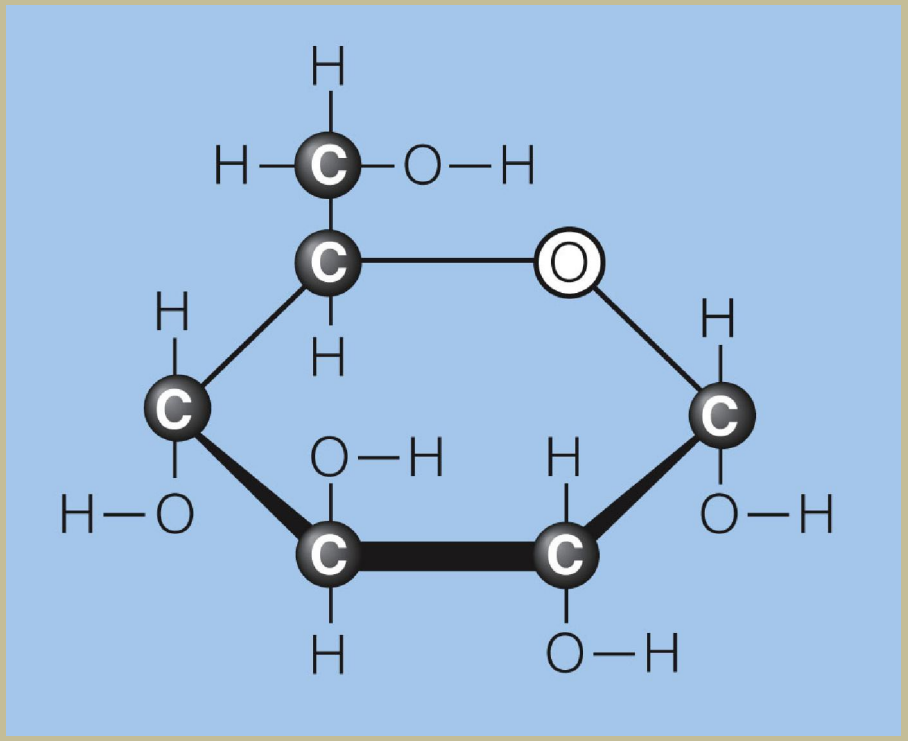
- Carbohydrate family
  - Atoms and chemical bonds
  - Monosaccharides
    - Chemical shorthand
    - Glucose, fructose, galactose
  - Disaccharides
    - Maltose, sucrose, lactose
  - Polysaccharides

Chemist's View of Carbohydrates

Each atom has a characteristic number of bonds it can form with other atoms.



Notice that in this simple molecule of ethyl alcohol, each H has one bond, O has two, and each C has four.



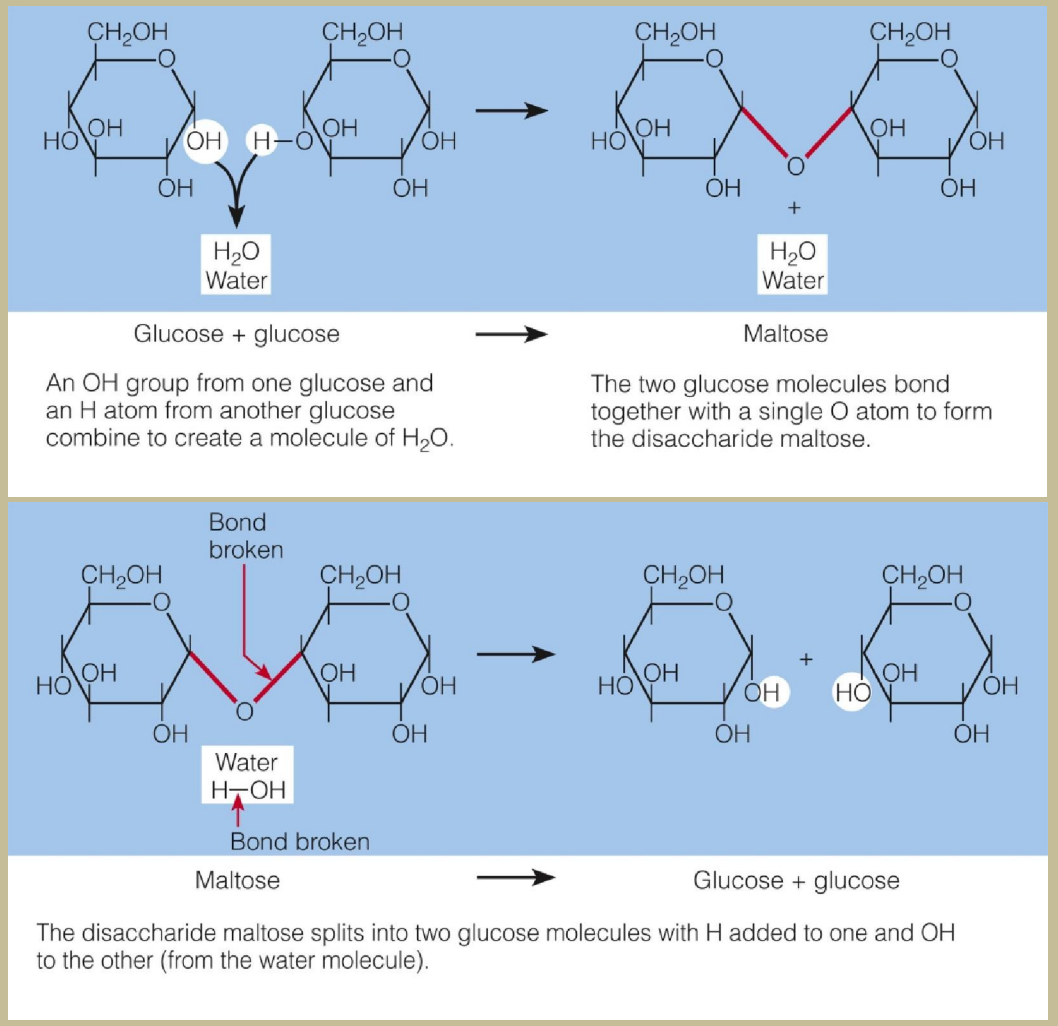
Chemist's View of Carbohydrates

- Monosaccharides – three
  - Same numbers and kinds of atoms
    - Differing sweetness
  - Glucose – blood sugar
    - Part of every disaccharide
  - Fructose
    - Sweetest of the sugars
  - Galactose
    - Only in a few foods

Chemist's View of Carbohydrates

- Disaccharides
  - Pairs of three monosaccharides
    - Maltose – two glucose units
    - Sucrose – glucose and fructose
    - Lactose – galactose and glucose
  - Condensation
    - Links two monosaccharides together
  - Hydrolysis
    - Breaks a disaccharide in two

Chemist's View of Carbohydrates



Chemist's View of Carbohydrates

- Polysaccharides
  - Glycogen
    - Storage form of energy in the body
    - Glucose units
  - Starch
    - Storage form of energy in plants
    - Glucose units

Chemist's View of Carbohydrates

- Polysaccharides
  - Fibers
    - Differ from starches
    - Soluble fibers – benefits
    - Insoluble fibers – benefits
    - Functional fibers
    - Resistant starches
    - Phytic acid

Carbohydrate Digestion

- Ultimate goal
  - Glucose for absorption and use
- Hydrolysis via enzymes
- Mouth
  - Amylase
- Stomach
  - Stomach acid & protein-digesting enzymes
  - Role of fiber

Carbohydrate Digestion

- Small intestine
  - Most carbohydrate digestion
  - Pancreatic amylase
  - Specific disaccharide enzymes
    - Maltase
    - Sucrase
    - Lactase
- Large intestine
  - Fibers

STARCH

Mouth and salivary glands
The salivary glands secrete saliva into the mouth to moisten the food. The salivary enzyme amylase begins digestion:

Starch —(Amylase)→ Small polysaccharides, maltose

Stomach
Stomach acid inactivates salivary enzymes, halting starch digestion.

Small intestine and pancreas
The pancreas produces an amylase that is released through the pancreatic duct into the small intestine:

Starch —(Pancreatic amylase)→ Small polysaccharides, maltose

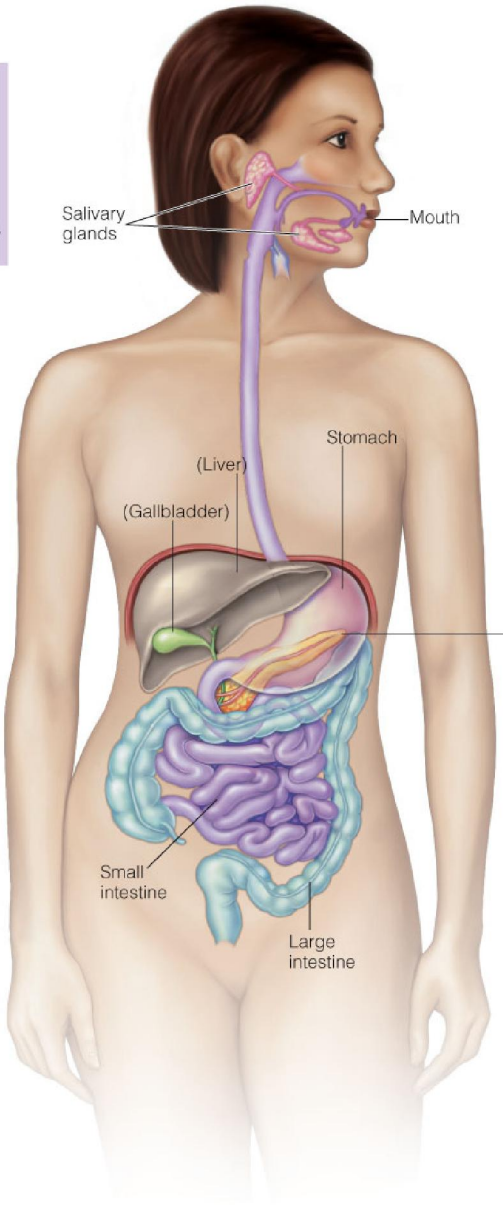
Then disaccharidase enzymes on the surface of the small intestinal cells hydrolyze the disaccharides into monosaccharides:

Maltose —(Maltase)→ Glucose + Glucose

Sucrose —(Sucrase)→ Fructose + Glucose

Lactose —(Lactase)→ Galactose + Glucose

Intestinal cells absorb these monosaccharides.



FIBER

Mouth
The mechanical action of the mouth crushes and tears fiber in food and mixes it with saliva to moisten it for swallowing.

Stomach
Fiber is not digested, and it delays gastric emptying.

Small intestine
Fiber is not digested, and it delays absorption of other nutrients.

Large intestine
Most fiber passes intact through the digestive tract to the large intestine. Here, bacterial enzymes digest fiber:

Some fiber —(Bacterial enzymes)→ Short-chain fatty acids, gas

Fiber holds water; regulates bowel activity; and binds substances such as bile, cholesterol, and some minerals, carrying them out of the body.

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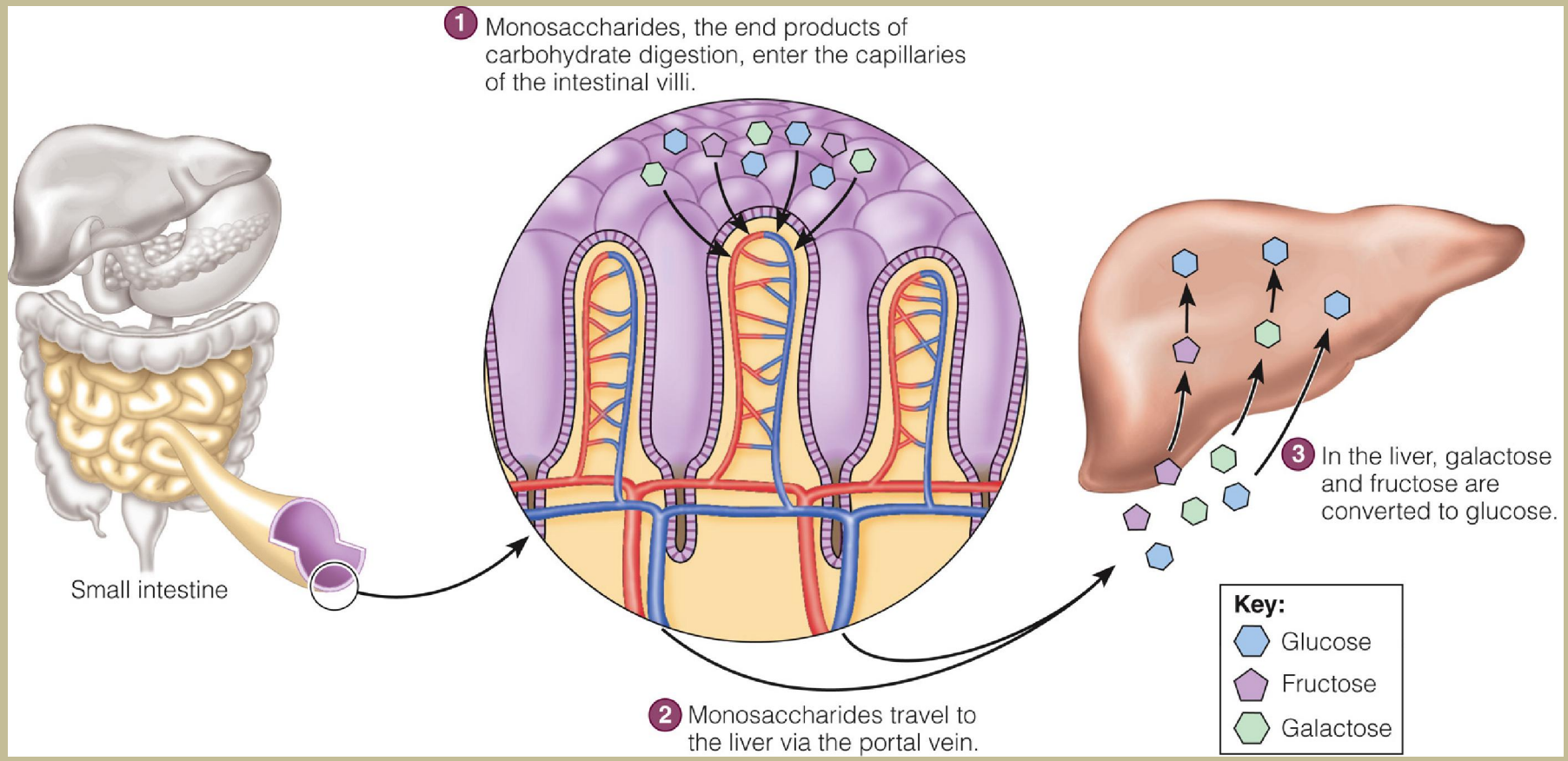
Carbohydrate Absorption

- Active transport
  - Glucose
  - Galactose
- Facilitated diffusion
  - Fructose
- Liver
  - Conversion of fructose and galactose

Carbohydrate Absorption



Lactose Intolerance

- Lactase activity
  - Highest immediately after birth
  - Declines with age
- Symptoms of intolerance
- Causes of intolerance beyond age
- Prevalence
  - Genetically determined

Lactose Intolerance

- Dietary changes
  - Manage dairy consumption rather than restriction
    - GI bacteria
  - Fermented milk products
  - Individualized diets
  - Potential nutrient deficiencies
    - Riboflavin, vitamin D, and calcium

Carbohydrate Metabolism

- Glucose is key player
- Storing glucose as glycogen
  - Liver storage
    - Condensation into glycogen
    - Hydrolysis for release of glucose when needed
  - Muscle storage
    - Selfishly hoards glycogen

Carbohydrate Metabolism

- Glucose for energy
  - Fuels most of body's cells
    - Preferred source for brain, nerve cells, and developing red blood cells
  - Cellular breakdown of glucose
- Making glucose from protein
  - Amino acid conversion
  - Gluconeogenesis

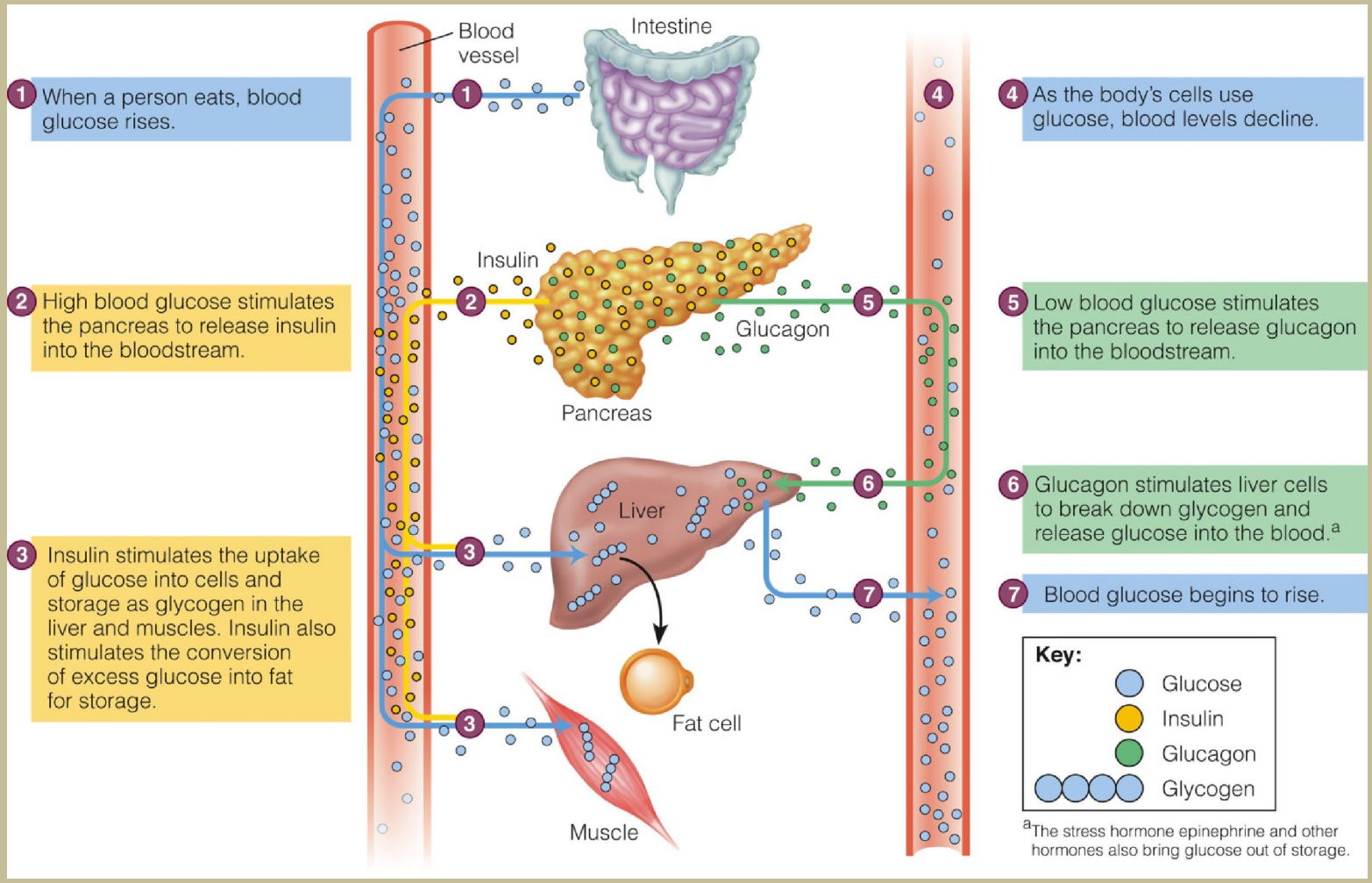
Carbohydrate Metabolism

- Ketone bodies from fat fragments
  - Inadequate supply of carbohydrates
    - Fat metabolism shifts
    - Ketone body formation – starvation
    - Ketosis – acid-base balance
- Carbohydrate needs for protein sparing and prevention of ketosis
- Using glucose to make fat

The Constancy of Blood Glucose

- Steady supply in blood stream
  - Intestines – food
  - Liver – glycogen
- Blood glucose homeostasis
  - Insulin
    - Glucose from blood into cells
  - Glucagon & epinephrine
    - Brings glucose out from storage

Blood Glucose Homeostasis



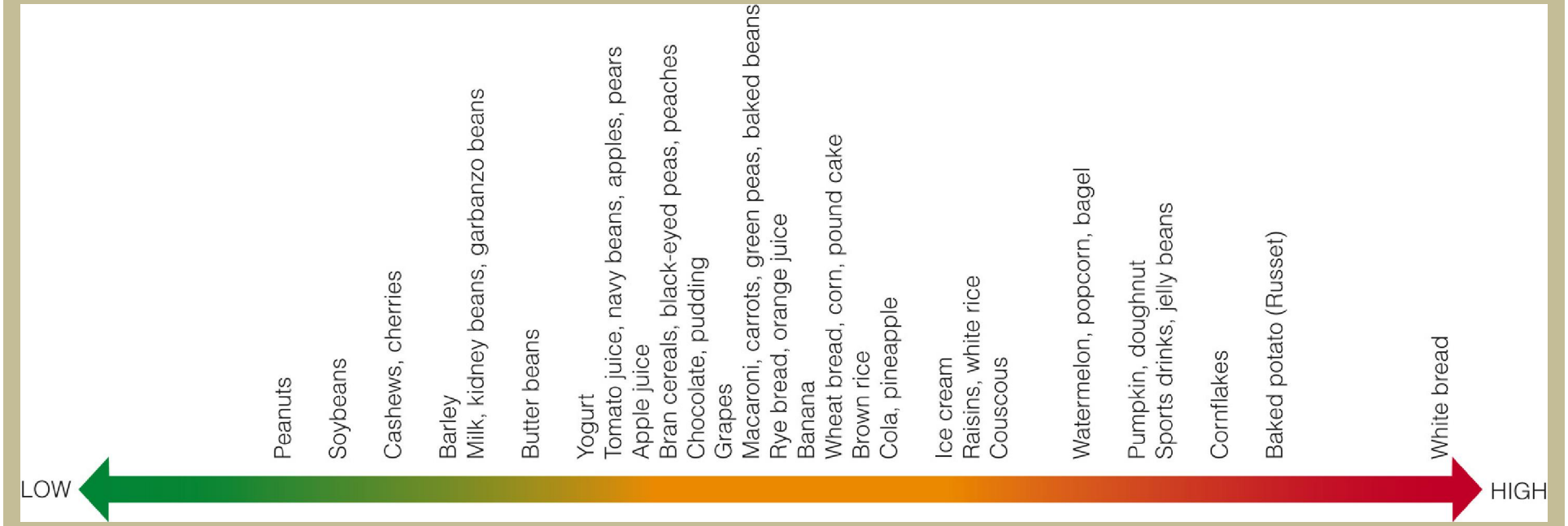
The Constancy of Blood Glucose

- Balancing within the normal range
  - Balanced meals at regular intervals
- Diabetes
  - Insulin is either inadequate or ineffective
  - Type 1 diabetes
  - Type 2 diabetes
- Hypoglycemia
  - Prevalence

The Constancy of Blood Glucose

- Glycemic response
  - Speed of glucose absorption, level of blood glucose, and return to normal glucose levels
  - Low glycemic response
    - Desired
  - High glycemic response
  - Glycemic index
    - Benefits
    - Utility

Glycemic Index of Selected Foods



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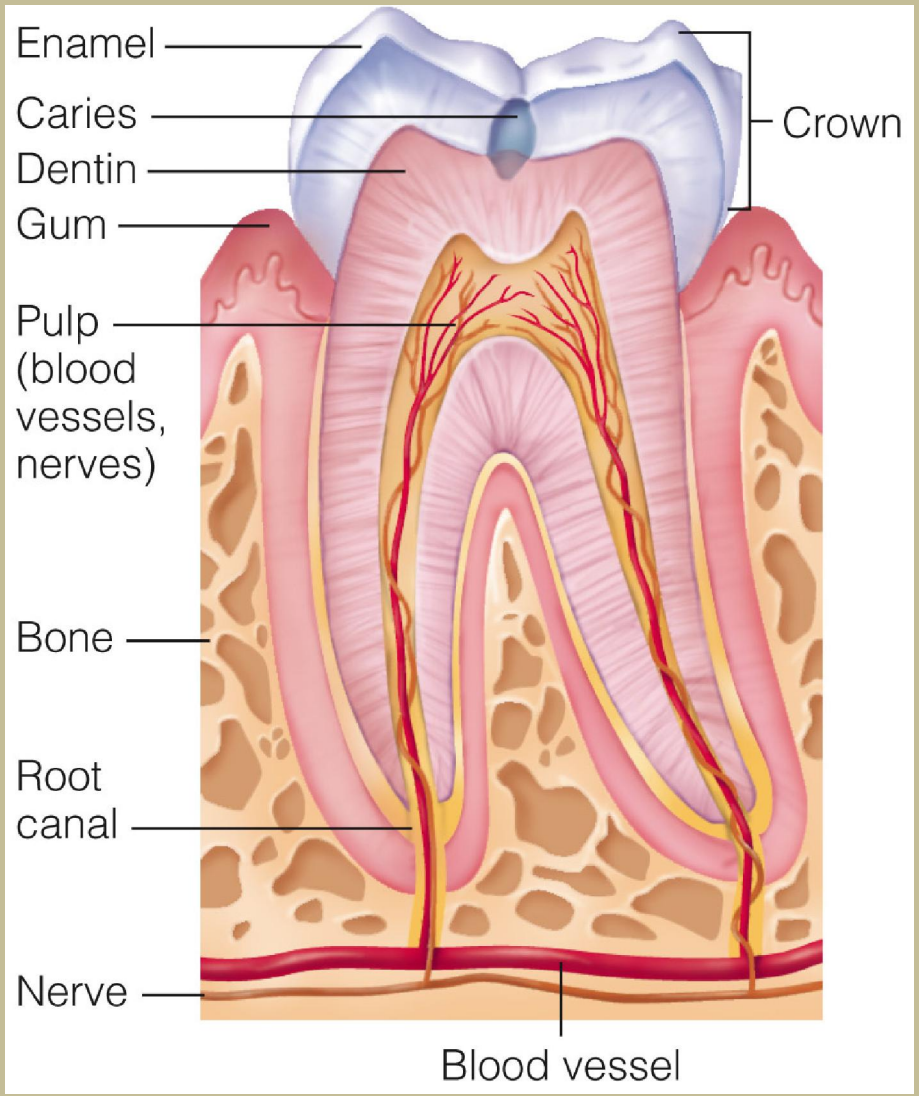
Health Effects of Sugars

- Pleasure in moderate amounts
- Nutrient deficiencies
  - Energy with few other nutrients
  - Discretionary kcalories
  - Honey
    - More energy per spoonful
    - Health benefits
  - Sugar sources

Health Effects of Sugars

- Dental caries
  - Bacteria ferment sugars producing acid
  - Food factors associated with tooth decay
    - Time of food in mouth
    - Sticky foods
    - Frequency of sugar consumption
  - Food choices
  - Factors associated with tooth decay

Dental Caries



Recommended Intakes of Sugars

- Dietary Guidelines
  - Choose and prepare foods with little added sugar
- DRI
  - Added sugars
    - No more than 25% of day's total energy
    - Impact on other food groups
- WHO and FAO recommendations

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 of Starch and Fibers

- Heart disease
  - Whole grains
    - Sources
  - Soluble fibers
    - Sources
  - Improving heart disease risk factors
  - Diet composition for reducing heart disease risk

Health Effects of Starch and Fibers

- Diabetes
  - High-fiber foods
- GI health
  - High-fiber foods
  - Ample fluids
- Weight management
  - High-fiber foods and whole grains
    - Feeling of fullness

Health Effects of Starch and Fibers

- Cancer
  - Dietary fiber and colon cancer
    - Fiber supplements
  - Sources of dietary fiber
    - Phytochemicals
  - Preventing colon cancer
    - Diluting, binding, and removing
    - Bacterial fermentation

Health Effects of Starch and Fibers

- Excessive fiber
  - Insufficient energy or nutrient needs
  - Abdominal discomfort, gas, diarrhea
  - GI obstruction
  - Nutrient absorption
  - Dietary goals
    - Balance, moderation, variety

Dietary Fibers: Characteristics, Sources, & Health Effects

TABLE 4-3 Dietary Fibers: Their Characteristics, Food Sources, and Health Effects in the Body

Fiber Characteristics	Major Food Sources	Actions in the Body	Health Benefits
Soluble, viscous, more fermentable • Gums and mucilages • Pectins • Psyllium[a] • Some hemicelluloses	Whole-grain products (barley, oats, oat bran, rye), fruits (apples, citrus), legumes, seeds and husks, vegetables; also extracted and used as food additives	• Lower blood cholesterol by binding bile • Slow glucose absorption • Slow transit of food through upper GI tract • Hold moisture in stools, softening them • Yield small fat molecules after fermentation that the colon can use for energy	• Lower risk of heart disease • Lower risk of diabetes
Insoluble, nonviscous, less fermentable • Cellulose • Lignins • Psyllium[a] • Resistant starch • Many hemicelluloses	Brown rice, fruits, legumes, seeds, vegetables (cabbage, carrots, brussels sprouts), wheat bran, whole grains; also extracted and used as food additives	• Increase fecal weight and speed fecal passage through colon • Provide bulk and feelings of fullness	• Alleviate constipation • Lower risks of diverticulosis, hemorrhoids, and appendicitis • May help with weight management

[a]Psyllium, a fiber laxative and cereal additive, has both soluble and insoluble properties.

Recommended Intakes of Starch & Fibers

- DRI for carbohydrates
  - 45 to 65% of energy requirement
- RDA for carbohydrates
  - 130 grams per day
- Fiber
  - DV: 11.5 grams per 1000-kcalories
  - DRI: 14 grams per 1000-kcalories
  - No UL

From Guidelines to Groceries

- Grains
  - 1 ounce provides about 15g of carbohydrate
  - “Three are key” message
- Vegetables
  - Starch content
- Fruits
- Milk and mil products
- Meat and meat alternatives

From Guidelines to Groceries

- Read food labels
  - Total carbohydrate
    - Starch, fibers, sugars
  - Sugars
    - Added and natural sugars

Highlight 4

Carbs, kCalories, and Controversies

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

- 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

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