CHAPTER 25
NUTRITION, METABOLISM, AND TEMPERATURE REGULATION

CHAPTER OVERVIEW: This chapter defines metabolism and nutrition and explains how the major nutrient groups are utilized within the body. The important relationships among nutrients, vitamins and minerals are described and the relations (and interrelations) with the processes of energy extraction, the use of energy, and the control of metabolism in cells are explained.

OUTLINE (one to three fifty-minute lectures):
Seeley, A&P, 5/e

Chapt. Object.	Topic Outline, Chapter 25	Figures & Tables	Transparency Acetates
	I. Nutrition, p. 832		
1	A. Component Processes		
	1. Digestion		
	2. Absorption		
	3. Transport		
	4. Cell Metabolism		
	B. Nutrients		
	1. Essential Nutrients		
	2. Food Guide Pyramid	Fig. 25.1, p.832	TA-518
2	C. Kilocalories		
	1. Unit of Energy		
	a. 1 cal. = Energy Needed to Raise 1 g of Water 1⁻ C		
	b. 1 Kcal. (or Cal.) = 1000 cal.		
	2. Food Sources of Energy	Table 25.1, pp.833-834 Clinical Note, p.832	
3	D. Carbohydrates		
	1. Sources in the Diet		
	a. Simple Sugars		
	b. Complex Carbohydrates		
	2. Uses in the Body		
	a. Primary Energy Source		
	b. Part of Nucleotides		
	c. Glycoproteins		
	3. Recommended Amounts	Clinical Focus, p.852	
	a. 125 to 175 g / Day		
	b. Complex Forms Preferred		
3	E. Lipids		
	1. Sources in Diet		
	a. 95% as Triacylglycerol	Fig. 2.16, p.44 Clinical Note, p. 835	TA-30
	b. Remaining 5%		
	2. Uses in the Body		
	a. Energy Sources		
	b. Triacylglycerols in Adipose Tissue		
	c. Cholesterol		
	d. Prostaglandins = Fatty Acid Derivatives		
	e. Phospholipids in Plasma Membranes and Myelin Sheaths		
	3. Recommended Amounts	Clinical Focus, p.854-855	

a. <30% of Total Calorie Intake
b. Essential Fatty Acids — Clinical Note, p.835

3 F. Proteins

1. Sources in the Diet
a. Nine Essential Amino Acids = Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan, and Valine
b. Remaining Eleven Naturally Occurring Amino Acids are Non-Essential
c. Complete Protein Food Contains Adequate Amounts of All Nine Essential Amino Acids = "Meat Group" - Meat, Fish, Poultry, Milk, Cheese, and Eggs
2. Uses in the Body
a. Collagen and Structural Proteins
b. Contractile Apparatus of Muscle Cells
c. Enzymes and Functional Proteins
d. Plasma Buffers
e. Hemoglobin = O_2 Transport
f. Membrane Proteins
g. Immune Response Compounds
3. Recommended Amounts
a. 0.8 g / Kg Body Weight - About 12% of Total Kcals.
b. Balance of Several Incomplete Foods can Provide all Essential Amino Acids
c. Nitrogen Balance - When Amount of Nitrogen from Protein Ingested = Amount of Nitrogen Excreted from Body

4 G. Vitamins — Table 25.2, p.837-838

1. Required for Normal Metabolism in Small Amounts
2. Many Function as Coenzymes
3. Many Heat Sensitive — Clinical Note, p.838
4. Fat Soluble = A,D,E, and K
a. Can be Stored
b. Hypervitaminosis Possible
5. Water Soluble = B Complex and C, Cannot be Stored — Predict Quest. 1

5 H. Minerals — Table 25.3, p.839

1. Inorganic Nutrients
2. Necessary for Normal Metabolism
3. 4-5 % of Total body Weight
4. Adequately Provided in a Balanced Diet — Clinical Note, p.839

II. Metabolism, p. 840 — Fig. 25.3, p.841 — TA-520

A. Anabolism - Energy-using Processes by Which Small Molecules Made into Larger Molecules

	B. Catabolism - Energy-Releasing Processes by Which Large Molecules Broken into Smaller Molecules			
	C. Cellular Respiration = Cellular Metabolism			
	D. ATP = Energy "Currency" of the Cell		Fig. 25.2, p.840	TA-519
	III. Carbohydrate Metabolism, p. 840			
6	A. Glycolysis			
		1. Input of ATP for Phosphorylation	Fig. 25.4, p.842-843	TA-521, 522
		2. Sugar Cleavage		
		3. Reduced Nicotinamide Adenine Dinucleotide (NADH) Production		
		4. ATP and Pyruvic Acid Production	Table 25.4, p.844	TA-533
9	B. Anaerobic Respiration		Fig. 25.5, p.844	TA-523
		1. Absence of O_2		
		2. Lactic Acid Production		
		3. Oxygen Debt Created		
		4. Net Gain of 2 ATP		
	C. Aerobic Respiration			
		1. Acetyl Coenzyme A (Acetyl-CoA) Formation with NADH Production	Fig. 25.6, p.845	TA-524
7		2. Citric Acid Cycle		
		a. Direct ATP Production		
		b. Production of NADH and Reduced Flavin Adenine Dinucleotide ($FADH_2$)		
		c. Carbon Dioxide Production		
8		3. Electron Transport Chain	Fig. 25.7, p.846	TA-525
		a. Oxidation of NADH and $FADH_2$		
		b. O_2 as Final Electron Acceptor		
		c. H_2O Formed		
		d. H^+ Movement Leads to ATP Formation ñ Chemiosmotic Model	Predict Quest. 2	
9		4. Summary of ATP Production from One Molecule of Glucose	Clinical Note, p.847	
		a. Aerobic Respiration Yields 36 or 38 Molecules of ATP (Depending on Cell Type)		
		b. 6 CO_2 and 6 H_2O Also Produced		
10	IV. Lipid Metabolism, p. 847		Fig. 25.8, p.848	TA-526
	A. Long-Term Storage for Energy			
		1. 99% Lipid, Primarily Triacylglycerols		
		2. 1% Glycogen (Shorter-Term)		
	B. Free Fatty Acids in Blood Usage Form			
	C. Beta-Oxidation of Fatty Acids to Acetyl-CoA			
	D. Ketogenesis		Clinical Note, p.847	
		1. Formation of Ketone Bodies when Excess Acetyl-CoA Present		
		2. Converted Back to Acetyl-coA in Skeletal Muscle and Used in Citric Acid Cycle		
11	V. Protein Metabolism, p. 847			
	A. Amino Acids (AA) used to synthesize Needed Proteins			
	B. Biosynthesis of Non-Essential AA			
		1. From Keto Acids	Fig. 25.10, p.849	TA-528
		2. Transamination	Fig. 25.11, p.850	TA-529
	C. Amino Acids as an Energy Source		Fig. 25.9, p.849	TA-527

12 VI. Interconversion of Nutrient Molecules, p. 848 — Clinical Note, p. 849; Fig. 25.12, p.850 — TA-530

A. Glycogenesis
B. Lipogenesis

13 VII. Metabolic States, p. 851

A. Absorptive State — Fig. 25.13, p.851 — TA-531
1. Nutrients being Absorbed
2. For 4 hrs. Following Each Meal
3 Nutrient Use
a. Glucose used as Energy Source by Cells
b. Fats Deposited in Adipose Tissue
c. Amino Acids for

B. Post-Absorptive State — Fig. 25.14, p.852 — TA-532
1. Between Meals
2. Maintenance of constant Blood Glucose
a. Normal Blood Glucose = 70-110 mg / 100 ml
b. Interconversion of Other Compounds into Glucose

14 VIII. Metabolic Rate, p. 853

A. Metabolic Rate = Total Amount of Energy Produced and Used by Body per Unit Time
1. ATP Exists for Less than 1 min so ATP Production Roughly Equivalent to Energy Use.
2. One L O_2 commonly Produces 4.825 Kcal of Energy
3. Body Energy Balance
a. If Input of Kcal > Usage Body Weight is Gained — Clinical Note, p.853
b. If Input of Kcal < Usage Body Weight is Lost

B. Basal Metabolic Rate
1. Calculated as Kcal Expended per m^2 of Body Surface Area/ hr. After 12 hr. Fast
2. Energy Needed to Keep Resting Body Functional - About 60% of Total Energy Expenditure
3. Males have Higher BMR than Females (Pregnancy can Increase BMR by 20%)
4. Long-Term and Short-Term Hormonal Regulation of BMR

C. Thermic Effect of Food
1. Energy Cost to Assimilate Food
a. Increased Muscular Contraction
b. Increased Glandular Secretion
c. Increased Active Transport
d. Increased Liver Interconversion of Nutrients
2. About 10% of Body Energy Expenditure

D. Muscular Activity
1. Muscular Activity Consumes 30% of Body's Energy
a. Skeletal Muscle Activity
b. Contraction of the Heart

		c. Muscles of Respiration		
		2. Aspect of Energy Usage Over Which Most Conscious Control		
15	IX. Body Temperature Regulation, p. 853			
	A. Humans as Homeotherms			
		1. Enzymes are Temperature Sensitive		
		2. Body Temperature Kept within Narrow Range		
	B. Result of Balance Between Heat Production and Heat Loss		Fig. 25.16, p.856 Predict Quest. 3 Predict Quest. 4	TA-534
	C. Mechanism of Heat Loss		Fig. 25.15, p.850	
		1. Radiation		
		2. Conduction		
		3. Convection		
		4. Evaporation		
	D. Thermoregulatory Control Center in Posterior Hypothalamus Maintains Core Body Temperature Set-Point		Clinical Focus, p.857	

IMPORTANT CONSIDERATIONS: If there is only one lecture session available for these topics, stress the highlights of the energy relationships and the relationship between metabolism and body temperature. If three sessions are available, use one for review of nutrients and their routes of entry into the body, one on cellular metabolism and one on metabolic states, metabolic rates and body temperature regulation.

The details of the catabolism of organic molecules are found in Chapter 24. Have students review this material if necessary. Discuss the meaning of "essential" nutrients as a foreshadowing of the interconversion processes to be discussed later in this chapter.

Students may not be familiar with heat as a form of metabolic waste, so the relationship between metabolic rate and body temperature may not be immediately apparent to them. Humans are homeothermic endotherms. Students should be asked to relate the maintenance of a constant body temperature (usually higher than the environment) to homeostasis and efficiency of metabolism.

SEE INSTRUCTOR'S MANUAL AND COURSE SOLUTIONS MANUAL FOR ADDITIONAL RESOURCES.