1 **Nutrition, Culture, and Metabolism of Microorganisms**
Chapter 5

2 **5.1 Microbial Nutrition**

- *Metabolism*
  - *Catabolic reactions (catabolism)*
    - Energy-releasing metabolic reactions
  - *Anabolic reactions (anabolism)*
    - Energy-requiring metabolic reactions
- *Nutrients*
  - Supply monomers (or precursors) required by cells
  - *Macronutrients*
  - *Micronutrients*

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4 **5.1 Microbial Nutrition**

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- *Carbon*
  - ~50% (by dry weight)
  - Heterotrophs & Autotrophs
- *Nitrogen*
  - ~12% (by dry weight)
  - proteins, nucleic acids
- *Phosphorus (P)*
  - nucleic acids & phospholipids
- *Sulfur (S)*
  - structural in amino acids
  - vitamins

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- *Potassium (K)*
  - enzyme activity
- *Magnesium (Mg)*
  - Stabilizes ribosomes, membranes and nucleic acids
- *Calcium (Ca)*
  - stabilize cell walls in microbes
  - heat stability of endospores
- *Sodium (Na)*
  - Required by some microbes
- *Iron*
  - involved in electron transport

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9 **5.2 Culture Media**

- *Culture Media*
  - Nutrient solutions used in laboratory
- Two broad classes
  - *Defined media*:
    - precise chemical composition is known
  - *Complex media*:
    - digests (yeast & meat extracts)

10 **5.2 Culture Media**

- *Selective Media*
  - selectively inhibit growth of some microbes
- *Differential Media*
  - Contains an indicator to detect particular chemical reactions

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12 **5.3 Laboratory Culture of Microorganisms**

- *Pure culture*:
  - single kind of microbe
- *Contaminants*:
  - unwanted organisms
- Solid media
  - prepared by addition of *agar*
  - on solid media, cells form *colonies*

13 **5.4 Bioenergetics**

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- Energy
  - units of kilojoules (kJ), measures heat energy
- *Free energy (G)*:
  - energy released that is available to do work
  - In chemical reaction some energy is lost as heat
  - $\Delta G^{\circ\prime}$
    - change in free energy during a reaction

14 **5.4 Bioenergetics**

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- *Exergonic*
  - negative $\Delta G^{\circ\prime}$ (release free energy)
- *Endergonic*
  - positive $\Delta G^{\circ\prime}$ (require energy)
- To calculate free energy yield of a reaction
  - need *free energy of formation* (G_f°; energy released or required during formation of molecule)

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16 **5.5 Catalysis and Enzymes**

- Free energy calculations do not provide information on reaction rates
- *Activation energy*:
  - energy required to reach reactive state
  - catalysis required to breach activation energy barrier

17 **5.5 Catalysis and Enzymes**

- *Enzymes*
  - Biological catalysts
  - Typically proteins (though some RNAs)
  - Highly specific
  - larger than substrate
  - weak bonds
    - hydrogen bonds, van der Waals forces, hydrophobic interactions
  - *Active site*: region of enzyme that binds substrate

18 **5.5 Catalysis and Enzymes**

Enzymes (cont'd)

- Increase the rate 10^8-10^{20} times the spontaneous rate
- Enzyme catalysis: E + S E - S E + P

19 **5.5 Catalysis and Enzymes**
- *Prosthetic groups*
  - Bind tightly to enzymes
  - covalently and permanently (heme group in cytochromes)
- *Coenzymes*
  - Loosely bound to enzymes
  - derivatives of vitamins (NAD^+/NADH)

20 **5.6 Oxidation-Reduction**
- *Redox*
  - oxidation-reduction
- energy-rich compounds (ATP)
- Redox reactions occur in pairs (two *half reactions*)
- *Electron donor*:
  - oxidized in a redox reaction
- *Electron acceptor*:
  - reduced in a redox reaction

21 **5.6 Oxidation-Reduction**
- *redox tower*
  - range of possible reduction couples in nature

22 **5.7 NAD as a Redox Electron Carrier**
- Redox reactions involve intermediates (*carriers*)
  - Prosthetic groups (attached to enzymes)
  - Coenzymes (diffusible; NAD+, NADP)
    - NAD+ and NADH facilitate redox reactions

23 **5.8 Energy-Rich Compounds and Energy Storage**
- energy released in redox reactions
  - conserved in phosphorylated compounds
    - ATP; the prime energy currency
    - Coenzyme A

24 **5.8 Energy-Rich Compounds and Energy Storage**
- insoluble polymers
  - prokaryotes
    - Glycogen
    - Poly-β-hydroxybutyrate & polyhydroxyalkanoates
    - Elemental sulfur
  - eukaryotes
    - Starch
    - Lipids (simple fats)

25 **5.9 Energy Conservation**
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- chemoorganotrophs
- Differ in ATP synthesis
  - *Fermentation*:
    - substrate-level phosphorylation
  - *Respiration*:
    - oxidative phosphorylation

26 **5.10 Fermentation**
- Net: 2 ATP

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29
- Flavoproteins
  - Protein & riboflavin prosthetic
    - Accepts electrons & protons
    - Donate electrons
  - Nonheme iron-proteins
    - Iron-sulfur
  - Cytochromes
    - Iron containing prosthetic
  - Quinones
    - Hydrophobic
    - Related to vitamin K
      - Accepts electrons & protons
      - Donate electrons
    -

30
- Electron transport chains
  - Proton motive force

31
- ATP synthase

32 **5.13 Citric Acid Cycle**
- Release CO2
- Load electron carriers

33 **Overview of Aerobic Respiration**
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39 **Energy Output**
40 **5.14 Anabolism**
- Anerobic
  - Alternate electron acceptors
- Chemolithotrophy
  - Inorganic electron donors
- Phototrophy
  - Phototrophic

41 **Light Dependent Reactions**
42 **5.18 Regulation of Activity of Biosynthetic Enzymes**
- *Feedback Inhibition*: mechanism for turning off the reactions in a biosynthetic pathway
  - End product binds to the first enzyme
    - inhibiting its activity
  - inhibited enzyme is an *allosteric* enzyme
    - Two binding sites: active and allosteric
  - Reversible reaction

43 **5.18 Regulation of Activity of Biosynthetic Enzymes**
- *Isoenzymes*
  - Different enzymes - catalyze same reaction - subject to different regulatory

controls

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44 **5.18 Regulation of Activity of Biosynthetic Enzymes**

- Biosynthetic enzymes can be regulated by covalent modifications
  - attachment or removal of a small molecule to the protein
  - Results in conformational change that inhibits activity
  - Common modifiers
    - adenosine monophosphate (AMP)
    - adenosine diphosphate (ADP)
    - inorganic phosphate (PO_4^{2-})
    - methyl groups (CH_3)