**Nutrition, Metabolism, and Biosynthesis**  
(see pages 102-108)

Metabolism
- Defined as the sum of all chemical processes taking place within a cell
- Two distinct classes of reactions
  - Anabolic
  - Catabolic

Why are we concerned with these aspects of cellular life?
- Identification
- Control
- Understanding life processes

Nutrition
- Growth of cells in culture means that all nutrients must be supplied
- Bacteria are osmotrophs
- Critical macronutrients
  - Nitrogen
  - Phosphorus
  - Carbon
  - Sulfur
- Critical micronutrients
  - Potassium
  - Magnesium
  - Calcium
  - Sodium
  - Iron
  - Trace metals

How supplied
- Defined medium
- Undefined medium
- Semi-defined medium

If nutritional requirements of cells are well known, media may be modified to take advantage of the cells requirements
- Selective medium
- Differential medium
Review growth in closed systems (see pages 136-144; 150-165)
- Define
  - Growth
  - Growth rate
  - Multiplication
  - Binary fission
  - Exponential growth ($N_f = N_02^n$ where $n$ is the number of generations)
  - Balanced vs. unbalanced (figures from Madigan et al. 2002)
The growth curve (a reflection of growth in closed systems, Figure below from Madigan et al. 2002)

- Lag phase
- Log phase
- Stationary phase
- Death phase

Things that influence growth (Figure at right from Madigan et al. 2000)

- Nutrients
Environmental factors (Figures from Madigan et al. 2002)

- Temperature
  - Cardinal points of temperature
    - Psychrophiles (0-20 opt ~15)
    - Mesophiles (15-45 opt ~35)
    - Thermophiles (45- ~ 100 opt >50)
Oxygen
- Obligate vs facultative organisms
- Microaerophiles
- Anaerobes
- Acidity (Figure at right from Madigan et al. 2002)
- Water

Ok…..so what is it that cells actually use to grow?

**Physiologic diversity**
(see pages 28-34; Figure from Madigan et al. 2002)

Bacteria are extremely diverse metabolically. Convention to describe general classes of nutritional types of cells

Based on:
- Source of energy
  - Light
  - Chemical…inorganic
  - Chemical…organic
- Source of carbon

Classes
- Photolithotroph
  - Light energy, inorganic electron donor, CO₂ as a source of carbon
- Photoorganotroph
  - Light energy, organic electron donor, and organic carbon source
- Chemolithotroph
  - Inorganic energy source, inorganic electron donor CO₂ carbon source
- Chemoorganotrophs
  - Organic energy source, organic electron donor and organic carbon source

![Chemolithotrophy and Phototrophy](https://example.com/chemistry-diagram.png)

*Figure 2.8* Metabolic options for obtaining energy. The organic and inorganic chemicals listed here are just a few of the many different chemicals used by various chemotrophic organisms. Oxidation of the organic or inorganic chemicals yields ATP in chemotrophic organisms while conversion of solar energy to chemical energy (again, in the form of ATP) occurs in phototrophic organisms.
What does this mean: Carbon source, Energy Source and Electron donor (see pages 111-131; Figures from Madigan et al. 2002)

**Carbon Source**
The carbon containing molecule that is manipulated by the cell to make cells stuff

Manipulated by enzymes

Review enzymes

- Proteins
- Specific substrates and products
- Structure
- Binding sites and active site
- Associated components
  - Prosthetic groups (non-protein)
  - Coenzymes
Energy and Electron donors/acceptors (Figures at bottom from Madigan et al. 2002)

- Energy usually refers to the ultimate source of energy to create ATP. Energy conservation is usually mediated by reactions that involve the movement of electrons and protons from one molecule to another or from inside the cell to outside the cell.
- May take many forms and used in many ways
  - Oxidation
    - removal of electrons
  - Reduction
    - Gain of electrons

Example pyruvic acid to lactic acid

![Chemical reaction diagram](image)
So…...who can be an electron donor or an electron acceptor?
A pattern of electron movement (Figure at right from Madigan et al. 2002).

OK….So where are we?
Catabolism supplies components of cell stuff

- Anabolism builds new components of cell stuff
- Redox reactions and Electron carriers allow for all the rearrangements of the components supplied by catabolic pathways and built by anabolic pathways
- What is still missing? Biological energy.
- Why ATP (Figure below from Madigan et al. 2002)
How does all of this come together in catabolism (and anabolism) to yield energy, reducing power, and cell stuff?

Major metabolic pathways take the form of (Figure from Madigan et al 2002)

- fermentations
- respiration
- The concept of the terminal electron acceptor.
Respiration (Figure from Madigan et al. 2002)

- Problems with fermentation
  - Energy still contained in molecules i.e. they can be further oxidized
  - Fermentations terminate because there is not another electron acceptor available...think of muscles.
  - If we have other electron acceptors available, the catabolic pathways can work thru further oxidations and reductions
So in a respiration… who is the terminal electron acceptor? (Figures from Madigan et al. 2002)

- Coupling of catabolism with electron flow
- The membrane potential
- Generation of ATP
Some key features revisited.

- Energy comes from three types of processes
  - Substrate-level phosphorylations
  - Oxidative phosphorylations
  - Photo-phosphorylations

(Figures from Madigan et al. 2002)

Metabolic diversity is great….so terms like chemolithotrophic and photolithotrophs have meaning relative to the diversity of electron donor and electron acceptors and the general form of metabolism.
References:
