Resources for biosynthesis: Assimilation

- **Degradation of large molecules**

  Degradation of carbohydrates
  Degradation of proteins
  Degradation of lipids

- **Structure of the cytoplasmic membrane**
  a.k.a the plasma membrane
- **Transportation of nutrients into cell**

Nutrients and metabolism

- **Metabolism needs inputs of "nutrients"**
  - for assimilation into cellular components
  - generation of energy if heterotrophic not assimilation
  - lithotrophs - inorganic 'nutrients' for energy
- **Not all nutrients are used by all bacteria, because of**
  - too large molecular size to enter cell without degradation
  - lack of metabolic apparatus, or, "pathways", to absorb nutrients
  - lack of metabolic pathways to utilise nutrient in cell
- **Passage of nutrients depends on**
  - exoenzymes, transfer enzymes
  - plasma membrane structure
  - energy
  - Genetic code determines pathways

Degrading large molecules

- **Only small molecules can enter cell**
- **Large molecules need to be degraded by exoenzymes**
  - excreted into periplasm of cell wall
  - evolved as response to need for microbial decomposition of plants, animals and other organisms
  - useful in industry - see industrial microbiology

Degradation of polysaccharides

- **Polysaccharides: polymers of monosaccharides**
- **Various bond links in polymer *e.g.***

  Starch
  - amylose – Linear with α-1,4-glucosidic bonds
  - amylopectin - branched with α-1,6-glucosidic bonds

  Glycogen
  α-1,4 and α-1,6-glucosidic bonds

  Cellulose
  β-1,4-glucosidic bonds
- **Determines the type of hydrolytic exoenzyme required**

  e.g. for α-1,4-glucosidic bonds: α-amylase
  for β-1,4-glucosidic bonds: cellulase

Degradation of polysaccharides 2

- **Degradation**
  Polymer > oligomer > monomer
  e.g. Starch > dextrins > glucose
  or cellulose > cellobiose > glucose
- **Final products include:**
  - disaccharides (maltose, sucrose, lactose)
  - monosaccharides (glucose, fructose)
- **Phosphorolysis**
  - **addition of P_i to end unit as it is lysed from the polymer**

Degradation of proteins

Proteins are polymers of amino acids
e.g. casein, gelatine

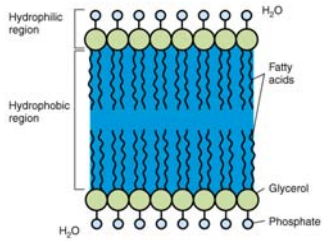
- **Proteases hydrolyse the peptide bond between amino acids**
  outside cell - exoenzymes
  inside cell to degrade unstable proteins
  - **Exopeptidases**
    remove single amino acid from end of protein chain
  - **Endopeptidases**
    break peptide bonds at any position in protein >>> polypeptides, peptides, amino acids
- **Amino acids are transported into cell for**
  oxidation
  incorporation into proteins intracellularly

Degradation of lipids

- **Fats, lipids, triglycerides degraded by lipases**
- **Different lipases hydrolyse different ester bonds**
  - Fats (esters of glycerol and fatty acids): Hydrolysed by lipases
  - Phospholipids: Hydrolysed by phospholipases A, B, C and D
- **Glycerol and fatty acids transported into cell**
  - Glycerol enters glycolysis pathway
  - Through β-oxidation, fatty acids oxidized to acetyl-CoA

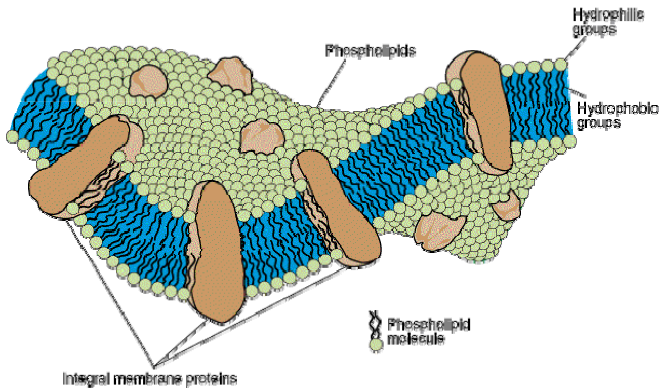
Structure of the cytoplasmic membrane

- **Cell wall and cytoplasmic membrane form a barrier**
  - peptidoglycan and other compounds cross-linked in wall
    - porins allow hydrophilic, low MW molecules through
  - not attacked by exoenzymes
- **The cytoplasmic membrane is a phospholipid bilayer**
  - hydrophilic region outside (phosphate)
    - in contact with exoenzymes and binding proteins
  - hydrophobic region inside (fatty acids)
    - in contact with cytoplasmic proteins/ enzymes



Structure of the cytoplasmic membrane 2

- **Proteins embedded in membrane**
  - integral membrane proteins - membrane transport proteins



Structure of the cytoplasmic membrane (Brock *et al.*, 2000; Fig. 3.18)

Transportation of nutrients into cell

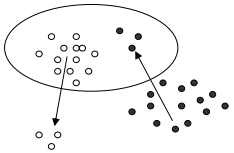
- **Selective permeability of plasma membrane**
  - small non-polar and fat-soluble substances may pass through by dissolution
  - charged and hydrophilic molecules cannot pass through without transport assistance

- **Two types of mechanisms:**
  1. **Along a concentration gradient and with no energy requirement**
  2. **Against a concentration gradient and with energy requirement**

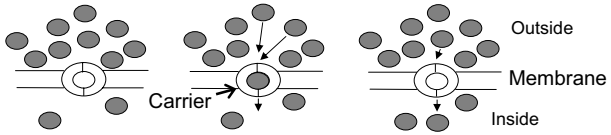
Transportation of nutrients into cell 2

1. Along a concentration gradient and with no energy requirement

a. Passive Diffusion



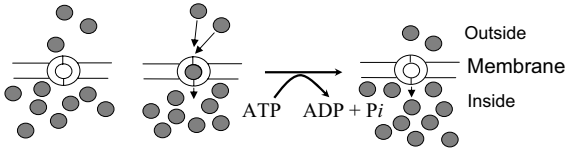
b. Facilitated Diffusion



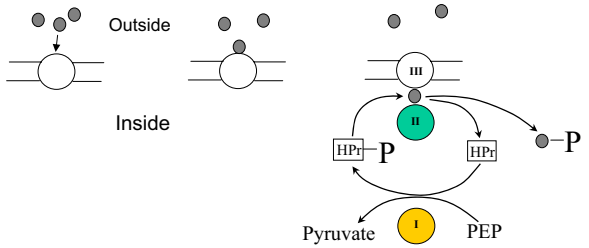
Transportation of nutrients into cell 3

2. Against a concentration gradient and with energy requirement

a. Active Transport



b. Group Translocation



Fate of assimilated nutrients

- **Intermediate metabolites**
  - glycolytic and TCA components
  - sugars, amino acids, fatty acids, purines, pyrimidines *etc*
  - incorporation of minerals into organic compounds
- **Anabolism**
  - carbohydrates: starch, cellulose, storage compounds
  - lipids, sterols, aromatic ring compounds (*e.g.* antibiotics)
  - nucleotides, nucleic acids
  - peptides, proteins formed into
    - structural components of cells
    - enzymes in metabolic pathways
- **Energy** - see next lecture
  - ATP - other ‘high energy’ compounds
  - NAD - reducing power in electron transport chains