CONCEPT LIST

1) EVOLUTION OF THE CELL

1.1 The molecules of life may have had an abiotic origin

Example 1: the Stanley Miller experiment
Problem : Pasteur's swan neck flasks with the Miller experiment product

1.2 RNA is a potentially self-replicating catalyst

Example 1: the RNA virus
Counterexample 2: RNase P
Example 3: In vitro selection of RNA ligases
Problem : Use the examples to illustrate the strategy of discrimination

1.3 Amphiphilic lipids assembled in bilayers can form compartments

Example 1: Lipid bilayers
Counterexample 2: Emulsions and salad dressing
Example 3: Cells
CMAP training : Put given key words in hierarchy

1.4 RNA instability may have lead to specialization : DNA as information storage and proteins as catalysts

Example 1: DNA can be replicated or repared by complementary strands
Example 2: Chemical variation in amino acids
Example 3: RNA is intermediate between DNA and protein
CMAP training : Select key words from concept

1.5 Nutient availablity may have driven procaryote evolution

Example 1: Sequential reactions
Example 2: New environments and deep sea archebacteria
Example 3: Photosynthesis
CMAP training : Select linking words for a concept map with given key words and hierarchy

1.6 Eukaryotes may have arisen through endosymbioses

Example 1: Chloroplasts
Counterexample 2: ER
Example 3: Mitochondria and hydrogenosomes
CMAP training : select key words, organize them in a hierarchy and add linking words

1.7 Modern cells have a common ancestor

Example 1: Conservation of the genetic code
Counterexample 2: All cells have DNA
Example 3: Mutations and phylogenetic trees
Problem : Figure 1.6 (MBoC4, a problems approach)

2) STRUCTURE AND FUNCTION OF MACROMOLECULES

2.1 Recognition between macromolecules requires complementarity

Example 1: DNA strands in double helix
Example 2: Antibody and antigen reactions
Problem : Use the strategy of analogy to find complementarity in everyday life

2.2 Different macromolecules have different sequences

Example 1: Fred Sanger and the first protein sequence
Example 2: DNA fingerprinting in forensics
Problem : Figure 8-15 (MBoC4, a problems approach)

2.3 Different sequences form different three dimensional structures

Example 1: Crystallization of Urease
Counterexample 2: The DNA double helix
Example 3 : The surface of the double helix

2.4 Three dimensional structures have defined functions

Example 1: DNA functions in replication and repair
Example 2: Chymotrypsin
Example 3: Ras and allostery
Problem : Renaturation of RNase with and without mercaptoethanol

2.5 Macromolecular construction is modular

Example 1: Secondary structure
Example 2: Protein motifs and domains
Example 3: Polymers
Problem : Figure 3-8 (MBoC4, a problems approach)

3) VISUALIZATION OF STRUCTURES

3.1 The resolution of the light microscope is limited by diffraction

Example 1: Diffraction in a microscope
Example 2: Magnifying glass
Example 3: Consequences of diffraction (DEMO: laser through microscope grid)
Problem : Strategy of generalization : similarities between microscope and telescope

3.2 Observing samples is also limited by thickness and contrast

Example 1: Thick sections
Example 2: Contrast

3.3 Transmission electron microscopy and X-ray diffraction also produce diffraction patterns

Example 1: TEM
Example 2: X-ray crystallography

3.3 Diffraction and refraction can be exploited to produce better images

Example 1: Dark field
Example 2: Phase contrast
Example 3: DIC

3.4 Some microscopes use light that does not pass through the sample

Example 1: Scanning microscope
Example 2: Fluorescence microscope
Example 3: Confocal microscope
Problem : The use of GFP bunny

3.5 Specific colorants can give precise information on macromolecular location

Example 1: DAPI
Example 2: OsO4
Example 3: Antibodies
Example 4: In situ hybridization
Problem : Figure 3-17 (MBoC4, a problems approach)

4 EXTRACELLULAR MATRIX AND THE PLASMA MEMBRANE

4.1 All cells have an extracellular matrix outside the plasma membrane

Example 1: ECM of animal cells
Example 2: ECM of plant cells

Problem : Matrix metalloproteinases as cancer treatments

4.2 The plasma membrane is a lipid bilayer with two distinct sides

Example 1: Langmuir trough
Example 2: Vectorial labeling
Problem : Table 10-2 (MBoC4, a problems approach)

4.3 The membrane is a bidimensional fluid

Example 1: Recovery of fluorescence after photodecoloration
Example 2: Membrane melting temperatures
Problem : Flatland (E. Abbott) and membrane life

4.4 Proteins are not always free to diffuse in the plane of the membrane

Example 1: Bacteriorhodopsin
Example 2: Tight junctions
Problem : Figure 10-12 (MBoC4, a problems approach)

4.5 Transmembrane proteins typically have short non-polar alpha helical regions

Example 1: Hydrophobicity index
Counter example 2: ß barrels
Problem : Problem 10-33 (MBoC4, a problems approach)

4.6 Membrane permeability is selective

Example 1: Tonicity and aquaporins
Example 2: Plasmolysis
Example 3: Protein transporters
Example 4: Active transport
Example 5: K+ channel
Analogy : What membrane component is like a bridge? A ferry?

4.7 Animal cells have a Na^+/K^+ dependant ATPase in the membrane

Example 1: Na^+/K^+ dependant ATPase and osmotic strength
Example 2: type V H+ pump in plants
Example 3: ABC transporters
Problem : Behavior of artificial vesicles with Na^+/K^+ dependant ATPase

4.8 K^+ channels produce a membrane potential

Example 1: specificity of K+ channel
Example 2: Nernst equation
Problem : Meiosis in invertebrate eggs initiated with KCl

4.9 Changes in the permeability of the membrane toward an ion can result in membrane potential changes

Example 1: Voltage gated Na+ channel
Example 2: Substrate gated channels
Example 3: Synaptic vesicles
Problem : Meiosis in invertebrate eggs not initiated with KCl without Ca++

5) CYTOPLASM

5.1 Eukaryotic cells have internal membranes and an extensive cytoskeleton

Example 1: Eukaryotic cell
Counter example 3: Prokaryotic cells
Problem : Role of creS in Caulobacter (Ausmees 2003 Cell 115 705)

5.2 Actin filaments are abundant in the cell cortex

Example 1: Monomer polymerization

Example 2: Cell cortex
Example 3: Adherent junctions
Example 4: Focal contacts and integrines
Problem : Figure 16-12 (MBoC4, a problems approach)

5.3 Intermediate filaments support the plasma membrane and the nuclear envelop
Example 1: Monomer polymerization
Example 2: Keratines
Example 3: Nuclear lamins
Example 4: Desmosomes
Problem : Dynamism of IFs (Ho 1998 J.Cell Sci. 111 1767)

5.4 Microtubules arise from centrosomes
Example 1: Monomer polymerization
Example 2: MTOC
Example 3: Mitotic spindle
Problem : Figure 16-22 (MBoC4, a problems approach)

5.5 Motor proteins move along directional filaments
Example 1: Cytoplasmic streaming
Example 2: Fish scale color
Example 3: Cilia and flagella
Problem : Figure 16-33 (MBoC4, a problems approach)

5.5 Transfer RNAs are cytoplasmic adaptors that decode the DNA
Example 1: genetic code
Example 2: Anticodon
Example 3: Aminoacyl tRNA synthases
Problem : Figure 6-28 (MBoC4, a problems approach)

5.6 A ribosome is a cytoplasmic protein synthesis factory
Example 1: Different subunits
Example 2: Binding sites
Example 3: Initiation
Example 4: Elongation
Example 5: Termination
Problem : Figure 6-54 (MBoC4, a problems approach)

5.7 Translation can be regulated by RNA sequences
Example 1: eIF2 and viral infection
Counter example 2: RNA amount and protein synthesis
Example 3: Iron response element binding protein
Problem : Translational control

5.8 Protein activity can be regulated after translation is complete
Example 1: Chaperones
Example 2: Phosphorylation
Example 3: Allostery
Example 4: Ubiquitination
Problem : Figure 6-41 (MBoC4, a problems approach)

6) SUBCELLULAR COMPARTMENTS

6.1 Eukaryotes have the same types of organelles
Example 1: Nucleus

Example 2: Mitochondria and chloroplasts
Example 3: Endoplasmic reticulum
Problem : Strategy of analogy : what steps are needed to put groceries away in the fridge

6.2 Nuclear pores connect the cytoplasm with the inside of the nucleus
Example 1: Nuclear pore structure
Example 2: Karyopherins and NLS
Problem : Figure 12-9 (MBoC4, a problems approach)

6.3 Signal peptides target proteins to the mitochondria and chloroplasts
Example 1: Signal peptide
Example 2: TIM and TOM
Problem : Interpretation of ribosomes on mitochondria in presence of cycloheximide

6.4 The ER plays several roles in the cell
Example 1: Smooth and rough ER
Example 2: Lipid synthesis, scramblases and flippases
Example 3: Sarcoplasmic reticulum
Problem : Can RER and SER be contiguous membranes with different protein complements?

6.5 Protein entry in the ER is co-translational
Example 1: Signal peptide
Example 2: SRP
Example 3: Stop transfer signals and topology
Example 4: KDEL
Problem : Problem 12-84 (MBoC4, a problems approach)

6.6 Proteins can be modified in the ER
Example 1: Disulfide isomerase
Example 2: Oligosacharide transferase
Example 3: GPI anchors
Problem : Strategy of analogy: what steps are needed to move goods by truck?

6.7 Transport between the ER and the Golgi is specific and tightly regulated
Example 1: COPII coats
Example 2: Sar1 and vesicle formation
Example 3: Rabs and SNAREs and docking specificity
Problem : Botulinum Toxin : Lethal weapon or magic bullet?

6.8 The Golgi has different regions with different functions
Example 1: Golgi regions
Example 2: COPI, ARF and brefeldin A
Example 3: Protein sorting
Problem : What has to happen to SNAREs after vesicles fuse?

6.9 Lysosomes are intracellular sites for digestion
Example 1: The dinosaurs in Jurassic Park
Example 2: M6P
Example 3: Clathrin and adaptine
Problem : Melanosomes, adaptin mutants and mutant pale furred mice

6.10 Vesicular transport to the exterior of the cell can be constitutive or controlled
Example 1: Default pathway of protein secretion
Example 2: Secretory vesicles

Problem : Amount of VSV G-protein in vesicles and Golgi: concentration in transport vesicles?

6.11 Endosomes sort molecules coming from the plasma membrane

Example 1: Coated pits
Example 2: Phagocytosis
Problem : Figure 13-16 (MBoC4, a problems approach)

7) ENERGY CONVERSION: MITOCHONDRIA AND CHLOROPLASTS

7.1 Mitochondria and chloroplasts exploit the chemiosmotic process

Example 1: $\Delta G = -nF\Delta E$
Example 2: Proton pumps
Example 3: Proton motive force
Problem : Calculate ΔG from several Eo' values

7.2 Mitochondria have four different regions

Example 1: Mitochondrial structure
Example 2: Separation of mitochondrial regions by centrifugation
Example 3: Porines in the outer membrane
Example 4: Functions in mitochondrial vesicules
Example 5: Stromal enzymes
Problem : Figure 14-6 (MBoC4, a problems approach)

7.3 L'ATP synthase interconverts energy in ATP and in a pH gradient

Example 1: ATP synthase in mitochondrial vesicles
Example 2: Proton gradients and membrane potential
Example 3: ATP synthase structure and function
Problem : Use of dinitrophenol as weight loss treatment.

7.4 The electron transport chain pumps protons out of the matrix

Example 1: Electron transport proteins
Example 2: NADH dehydrogenase complex
Problem : What happens to a cell exposed to cyanide?

7.5 Electron transport complexes may have evolved before high O_2 levels

Example 1: Fermentation
Problem : Intelligent design and the electron transport chain

7.6 Mitochondria and chloroplasts have their own DNA

Example 1: DAPI and chloroamphenicol
Example 2: Petit mutants in yeast
Example 3: Missing genes in mitochondria
Problem : Is *Giardia lamblia* an ancestral eukaroyte without mitochondria?

7.7 Chloroplasts have an additional compartment compared to mitochondria

Example 1: Cloroplast structure
Example 2: Thylakoids
Example 3: Stromal enzymes
Problem : Strategy of discrimination : similarity between thylakoids and cristae.

7.8 There are only three photosystems in organisms using solar power

Example 1: Bacteriorhodopsin
Example 2: Sulfobacteria and photosystem I
Example 3: Purple bacteria and photosystem II
Problem : Why are purple bacteria not green?

7.9 Cyanobacteria combined two of the three different photosystems to take electrons from H_2O

Example 1: Z-scheme
Example 2: Water as a source of electrons
Example 3: Cyclic photophosphorylation
Problem : Figure 14-20 (MBoC4, a problems approach)

7.10 Rubisco catalyses CO_2 fixation

Example 1: Rubisco and photorespiration
Example 2: C4 plants
Problem : Figure 14-14 (MBoC4, a problems approach)

8) NUCLEUS

8.1 The nucleus protects the DNA and newly synthesized RNA

Example 1: Prokaryotes and motor proteins
Example 2: Prokaryotes and RNA modification

8.2 Genetic information is stored as genes on chromosomes

Example 1: Mendel's deductions
Example 2: Chromosomes fulfill Mendel's requirements
Example 3: Gene structure
Example 4: Repetitive DNA
Problem : Figure 4-5 (MBoC4, a problems approach)

8.3 Linear chromosomes have a centromere, two telomeres and several origins of replication

Example 1: Replication and Okazaki fragments
Example 2: Telomere logic
Example 3: Centromeres
Problem : Figure 4-6 (MBoC4, a problems approach)

8.4 Chromosomes have different structures in interphase and mitosis

Example 1: FISH and interphase chromosomes
Example 2: Mitotic chromosomes

8.5 Nuclear DNA is compacted by histones

Example 1: Nucleosomes
Example 2: 30 nm fiber
Example 3: Histone code
Problem : Random or specific nucleosome formation?

8.6 RNA synthesis from genes requires an RNA polymerase

Example 1: Prokaryotic RNA polymerase, TATA and GACA boxes
Example 2: Eukaryotic RNA polymerases
Problem : Figure 6-5 (MBoC4, a problems approach)

8.7 Many factors regulate the rate of messenger RNA synthesis

Example 1: Structure and function of specific transcription factors
Example 2: DNA structure and the LCR
Problem : Figure 7-14 (MBoC4, a problems approach)

8.8 Eukaryotic messages are modified after transcription

Example 1: 7-mG Cap
Example 2: Polyadenylation
Example 3: Splicing
Problem : Figure 6-17 (MBoC4, a problems approach)

8.9 The nucleus contains compartments with specialized functions

Example 1: Nucleolus
Example 2: Splicing islands

8.10 The nucleus undergoes major changes during mitosis

Example 1: Cell division cycle
Example 2: Phases of mitosis
Example 3: Cytokinesis

8.11 Chromosome separation can be understood by the behavior of motor proteins

Example 1: Prophase and kinesine
Example 2: Prometaphase, dyneine and kinesine
Example 3: Metaphase
Example 4: Anaphase, dyneine and kinesine
Problem : Figure 18-18 (MBoC4, a problems approach)

8.11 Cell division happens differently in different cells

Example 1: Animal cells
Example 2: Plant cells
Example 3: Bacteria
Problem : Figure 18-21 (MBoC4, a problems approach)

8.11 Meiosis allows recombination between homologous chromosomes

Example 1: Meiosis and behavior of homologous chromosomes
Example 2: Recombination nodules
Example 3: Recombination frequency