Bil 255 – CMB

Introduction

a brief history of CMB

basic properties of cells & some milestones
Bil 255 - Cell and Molecular Biology...
structure, function, & the molecules of cells with
Professors Glaser and Mallery - Spring Semester

text: Molecular Cell Biology, 6th Edition
by: Lodish et al, Publisher: W.H.Freeman, NY, 2007

read chapter 1 pg 1-30

some web resources:
The Virtual Library of Biochemistry & Cell Biology &
Access Excellence - a national biology education resource of the
National Health Museum (originally sponsored by GENENTECH, Inc.,)
it contains some of excellent graphics: AE STUDENT RESOURCES*

and Mallery's web links for CMB RESOURCES*. 
The goal of cell biology is to understand the molecular basis of cell function and the fundamental cellular processes ranging from cell division and protein trafficking to signal transduction and cell migration, and to the formation of tissues during development and wound healing. The experimental approaches used in studying cell regulation and function are multidisciplinary and include: biochemical and biophysical approaches and molecular and genetic manipulation of function at both the cellular and organismal levels.

CMB is the ultimate reductionist philosophy…

*the methodological approach of 20th century*

Reductionism is the fundamental research protocol of CMB
i.e., "knowing the parts may explain the function of the whole"
1980’s and 1990’s are the dawn of the modern Cell & Molecular Biology Age and is the content of Biology 255

my mother (1906) : auto, airplane, radio, T.V. ... man on the moon
me (1943) : heart transplants (who was 1st ?), antibiotics, DNA & transgenic animals, artificial genes & manipulation, cloning, human genome ....

CMB is part of our modern culture - Movies: Species  Jurassic Park

Nobel Prizes in Physiology & Medicine and Chemistry
to repeat......

The aim of Modern CMB is to interpret the properties of life & organisms through the structure of their constituent cellular molecules.
CMB gave us... the Central Dogma of Molecular Biology
DNA --> RNA --> Protein

"Life begets Life" - is now seen at the molecular level,
as the faithful replication of DNA...

CMB asks... what do all cells have in common...
the answer = "their molecules & chemical reactivity"
their biochemistry, thus
we need to understand Molecular Biology to see how life works

CMB is about energy & reactivity, movement & change, action & reaction;
almost everything that happens in life (happens in cells)...
which likely boils down to ENZYME CATALYSIS.
CMB replaces the gross anatomy and physiological studies of the 17th & 18th century,
with the biology of molecules & molecular systems in 21st century.

but as Erwin Chargaff (former Chair of Bioc @ Columbia U; pic Heineken Prize winner)
has said, "CMB... is the practice of Biochemistry without a license"
CMB is rooted in the 2 major theories of Biology

1. Evolution - Darwinian Natural Selection
   changes in the allele frequency of a population's gene pool
   from one generation to another generation… as influenced by a habitat,
   which enhances population's reproductive fitness,
   & leading to progressively better adaptation via Natural Selection*
   The principles of morphological change and natural selection,
applied repeatedly over millions of cell generations, are basis of evolution
   Voyage of Beagle*  Snoppy  Darwin's books & publications

2. Cell Theory...
   "All living things are made of cells"
   'small, membrane bounded compartments, filled with
   concentrated aqueous solutions of reactive chemicals'
   "All organisms are believed to have descended from
   a common ancestral cell [LUCA] selected for its better fitness
   through the processes of evolution, via Natural Selection"
   Some cell links  Cell Theory Origins
   Schleiden (pic)  &  Schwann
Consequences of Cell Theory

VITALISM vs. MECHANICALISM
living vs. non-living
organic vs. non-organic
Vital Force vs. no vital force

Cell Theory replaces Vitalism... the mainstream scientific thought of 17th century, Vitalism was school of scientific thought, that attempts to explain the nature of life as resulting from a vital force, "a soul", peculiar to living organisms and different from all other physical forces found outside living things.

Mechanists believed that life is essentially a mechanical process, it can be explained entirely by the workings of laws of physics and chemistry without a ‘vital force’.

"There are no Laws of Chemistry or Physics unique to the living condition."
The cell is the fundamental unit of all life, and though man and mouse have very different anatomical structure, their cells & organelles are the same, thus by studying cells in one organism has direct application to other organisms.
Cell Types... (refer to chapter 1) All Living Organisms are grouped into...

EUBACTERIA - true bacteria
ARCHAEA - ancient procaryotes [Collage]
EUCARYA - modern eucaryotes

Carl Woese, (interview) compared the nucleotide sequences of small-unit rRNA from many species... rRNA is found in all cells and therefore, if all cells are derived from a common progenitor[NAS-1], their sequence changes over time can indicate divergence (loss of relatedness) through phylogeny.

The RNA phylogeny tree produced, by comparing similar & divergent sequences, a tree with 3 distinct branches (Domains) (fig 1.29*)

there are only 2 successful Plans of Cellular Organization distinguished primarily by size & type of internal structure (organelles)

PROKARYOTE - "before nucleus"

today prokaryotes includes blue green algae & bacteria...
lack membrane bound organelles
genes "naked DNA" - no "chromosomes?"
little to no internal compartmentation figure* + panel1.2 + E.coli*
size range - 0.1 to 10 µm diameter
3 primary forms of shape of prokaryotic cells (fig 1.10*)
(cocci, bacilli, spirochetes)
EUKARYOTIC  [eu -true  karyon -nucleus...]  
cell plan of multi-cellular organisms  
eukarya: include the fungi, algae, protozoa, slime molds, & all plants & animals.

7 CHARACTERISTIC of EUKARYOTES:  
panel 1-2: animal* & plant* cells  

nucleus - single greatest step in evolution of higher animals  
genes in "chromosomes"  [colored bodies... made of DNA + protein]  
contains more DNA (1,000x more) than procaryotes  
presence of organelles- significant internal compartmentalization of function  
organelle - a subcell part that has a distinct metabolic function  
presence of flexible cell walls (allows phagocytosis)  
presence of cytoskeleton (provides framework to be larger)  
usually larger - cell volume 10X > than bacteria - size 5.0 to 20 μm diameter  
extensive internal membranes  
reproduce sexually
Universal Characteristics of Cells (all Life)

1. all cells store their hereditary information in DNA

2. all cells replicate their hereditary info via templated polymerization

3. all cells transcribe hereditary info into intermediate RNA via templated transcription

4. all cells translate RNA in same mechanistic way via codon:anticodon "Chargaff" pairing
   A : T and G : C
5. all cells regulate rate of gene transcription/translation, so only a portion of full repertoire of possible RNA's/proteins are copied, thus hereditary info dictates not only nature of cell's proteins, but also when/where they are to be made so called, differential gene activity.

6. all cells use protein catalysts (enzymes) to make/break covalent bonds

\[
E + S \rightleftharpoons ES \rightleftharpoons E + P
\]

7. all cells metabolize - consume free energy and are far from chemical equilibrium. Consumption of free energy creates covalent bonds (which resist the disordering effects of thermal motion), thereby creating hereditary info in a DNA sequence.

the methods that cells have evolved to obtain free energy include:

- **heterotrophy** - oxidation of foods (covalent bonds)
- **autotrophy** - capture of light energy via pigments photosynthesis
- **lithotrophy** - chemical electron donors provide energy

\( \text{N}_2 \text{ & CO}_2 \text{ are stable & unreactive} \text{ & reduction to NH}_2 \text{ & CH}_2\text{O uses energy} \)

8. All cells are enclosed in a spontaneously aggregating amphiphilic phospholipid bilayer: membranes regulate nutrient/water transfer, concentrate molecules internally.

All membrane have embedded protein transport molecules.
What cells types will we be looking at?  [see pg 25 - 28]*  
[a freshman review of Prokaryote, Eukaryote, & Virus]  

🌟 Model Organisms*  in Cell & Molecular research include:

**Bacteriophages** - virus infects bacteria; today used as cloning vectors  
**Escheriichia coli** - bacteria common to human colon; work horse

**Giardia** - primitive eukaryotic cell, anaerobic protozoan cell with 2 nuclei

other eucaryotic models -

- single celled -  **Saccharomyces cerevisiae** - yeast  
  plants - mustard plants  **Arabidopsis thaliana**  
  nematode -  **Caenorhabditis elegans** - nematode 
  animals - fruit fly  **Drosophilia melangaster** 

[Mickey] mouse -  **Mus musculus** - common house mouse & its genes

**Single cell culture models**

- for genetic & embryonic development model systems...
  -  **Hela cells** (pic) - (George & Margaret Gey at JHU) 
  - human - fibroblast- connective tissue easily grown in tissue culture 
    immortal stem cells  
    (Stem Cell Journal)