

## **BIOL 230 (Part IV): Major Terms & Concepts (this is NOT an exhaustive list!!) 12/5/2011**

### ❖ **16b. REVIEW: Eukaryotic Genome & Gene**

**Regulation:** **Eukaryotic Genome & Gene**

**Regulation:** Nuclear envelope, compartmentalization. Satellite DNA, telomeres, telomerase. ... (GGAATT)<sub>n</sub>...

**Levels of Control:** *Transcription, Post-Tsc/RNA Processing, Translation, Post-translation.*

**Promoter, Transcription Factors, Enhancer, Silencer, Activator, Repressor; Coordinate Regulation; Alternate Splicing.**

Primary transcript/ Pre-mRNA; **Spliceosome'**  
**Introns, Exons, RNA Splicing -- snRNPs**  
**5'-GTP "Cap", 3'-polyA "Tail".**

**Rpol I (rRNA), II (mRNA), III (tRNA and snRNAs).**

Alternate splicing, mRNA stability; Heterochromatin, Euchromatin; **XIST** gene; X-inactivation, Barr Body. Signal Sequences, Signal Recognition Particle Polysomes, protein modification, Ubiquitin, Proteasome.

[[& See Ch. 16 "Review" summary slides!!]].

### 11. **Ch. 9/11: Cell Cycle & Cell Division:**

Prokaryotic chromosome – covalently-closed circle  
Fission; mitochondria and chloroplast DNA  
*Mitosis – precision; Meiosis – diversity; Cytokinesis = imprecise; Interphase – G1 (gap), S, G2 phases; Cyclins, CDK's*

Mitosis or Meiosis = NUCLEAR division!!

Eukaryotic chromosome – chromatin, chromatids, centromere, Histones, H1, Nucleosomes;  
**Condensin, Separase, securin.**

**Mitosis:** Prophase, Prometaphase/Metaphase, Anaphase, Telophase; Kinetochores, Kinetochore microtubules, Polar microtubules, molecular motors

**Cytokinesis** – CYTOPLASMIC division; contractile ring (actin filaments; myosin), **cleavage furrow** – animals; **cell plate** – Plants.

**Meiosis** – sexual reproduction and diversity

**Meiosis I** – reductional division; Prophase I, Metaphase I, Anaphase I, (Telophase I);  
**Synapsis, Chiasmata, Crossing-over!!** No second DNA synthesis!

**Diversity = Prophase I crossing over, and sorting of homologs at meta/anaphase I.**

**Meiosis II** – Pro, Meta, Ana, and Telophase II;  
Meiosis (II) vs. Mitosis; **Diploid (2n), Haploid (n)**, Homologous pairs, Homologs, Sister Chromatids; Daughter chromosomes; Gametes, zygote.

**Nondisjunction, aneuploidy;** trisomy 21, Down's syndrome. **Apoptosis, Necrosis.**

### 12. **Ch. 10/12: Eukaryotic Genetics: Mendel & Beyond:**

Artificial Selection/Breeding; **Blended Inheritance**, **Gregor Mendel, Characters, Traits**, Garden Pea; Reciprocal crosses; Seven suitable characters; **true-breeding** varieties

Generations: Parental (**P**), First Filial (**F1**), Second Filial (**F2**). Monohybrid, Dihybrid.

Hereditary units/genes, Monohybrid cross, **Dominant, Recessive, 3:1 Phenotypic ratio; 1:2:1 genotypic ratio; Particulate Inheritance vs. Blending Inheritance;** Homozygote; *Heterozygote*

• **Mendel's First Law – Segregation;** monohybrid cross; *Genes, Alleles; Phenotype, Genotype.*

• Dihybrid Cross; **Mendel's Second Law – Independent Assortment.** 9:3:3:1 Phenotypic Ratio. **Genes, Alleles, Locus,** Particulate Inheritance. Punnett Squares; Meiotic separation of chromosomes and alleles

**Test Cross, Tester. 1:1:1:1 Dihybrid test cross ratio** (phenotypic); Recombinant Progeny, Parental Progeny

**Probabilities:** Sum Rule, Product Rule

**Human Pedigrees:** Autosomal Recessive, Autosomal Dominant; Sex-linked Recessive; Sex-linked Dominant; **Consanguineous** mating

**Allelic Interactions:** Multiple Alleles, Incomplete Dominance, **Codominance** (Human Blood group antigens). **Pleiotropy**

**Gene Interactions: Epistasis, Complementary Genes;** Multiple Genes – continuous variation.

Environmental variables: *Penetrance, Expressivity*

**Sex chromosomes: Humans/Flies = X, Y. Humans:** Y chromosome (**SRY** gene) determines maleness (inhibits X chromosome **DAX1** gene); **Flies:** Males < 2X; **Females, =2 or more Xs, despite Y (X chrom/autosome ratio ≥1 in Females).** Birds, Moths, Butterflies = Z, W (ZZ=male, ZW=female).

**Sex Linkage/X-Linkage** and reciprocal crosses; **Hemizygous Males, Carrier Females**

**Cytoplasmic Inheritance** = maternal! Mitochondria and Plastids.

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**Linkage:** Linked Genes; Linkage Group.

**Recombination Frequency** = # recomb. Progeny/ # Total progeny (% recombination, or Map Units, or centiMorgans); **RF < 50% (in a Dihybrid Test Cross!!), = linked genes!!** Use RF to calculate genetic distance on a chromosome.

Recombinant Gametes in Prophase I, Crossing Over

## BIOL 230 f'11: Cell & Molecular Biology – Final Exam, part IV: Study Questions

### ❖ Possible Short Essay Topics (be prepared to draw diagrams as well!):

1. Describe the two major components in Eukaryotic Cell Cycle regulation, and how such proteins can serve as effective, but transient, controls on the progression of the cell cycle. How is cell cycle progression induced by these proteins, and then halted (what regulates the regulators)? [hint: see also the end of chapter 16/14] **Be sure to mention the main phases of the whole Cell Cycle!!**
  2. Describe 3 types of protein factors that function in chromosome condensation and adhesion, both during interphase and just before nuclear division, that help condense 6 feet of genomic DNA into a 5 $\mu$ m nucleus. Mention the properties of the protein factors that allow them to bind and coil DNA so tightly.
  3. **Using DIAGRAMS, compare and contrast the most important similarities and differences between Mitosis and Meiosis (especially Meiosis I). How do these differences serve the biological purpose of each process? EXPLAIN the biological purposes of Mitosis, and of Meiosis.** (Hint: genetic constancy vs. genetic diversity).
  4. Diagram and compare/contrast **Cytokinesis** (cytoplasmic division) in plant cells and in animal cells. What kinds or cellular factors, such as cytoskeleton and membrane dynamics, are involved in each?
5. **Practice Mitosis/Meiosis Problems:** Diagram all phases of each process (M, Me-I, Me-II) as exemplified below:
- a. Diagram a cell (nucleus), with a diploid (2n) number of six chromosomes, during mitotic Anaphase, and during Anaphase I of meiosis.
  - b. Diagram a cell (nucleus), with a diploid (2n) number of eight chromosomes, during mitotic Metaphase, and during Metaphase II of meiosis.
6. Name **five experimental factors/conditions that Mendel practiced** to produce the reliable and clearly-interpretable results that he observed from his work with garden pea plants. How is each of Mendel's practices "good science" even in the modern definition of the scientific method? [refer also to Ch. 1, and our first few lectures of the semester]
  7. **Describe the differences between Particulate Inheritance and Blending Inheritance. Explain how Mendel's experiments specifically disproved one of these theories, and proved the other. Be sure to mention both his experimental setup, and his observed results and data!!**
  8. Describe the differences between **ALLELES** displaying codominance, incomplete dominance, or pleiotropy. What kinds of **altered Mendelian phenotypic ratios**, if any, might offspring of heterozygous parents display as a result of each of these types of interactions between alleles? Give an example of each.
  9. Compare and contrast the **GENE interactions** and results of epistasis, complementary genes, and multiple genes. What kinds of **altered Mendelian phenotypic ratios**, if any, might offspring of dihybrid parents display as a result of each of these types of interactions between genes? Give an example of each.
  10. Explain the uses of a **Dihybrid Test Cross**. What is a "Tester" strain? What can a dihybrid test cross tell you about the nature of two or more genes/traits being tracked in an organism? Give an example.
  11. Draw and explain the differences in **how sex is determined** in humans, fruit flies, and birds. Be sure to state which chromosome combination determines each sex/gender.

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12. **Practice gene-linkage map:** Diagram and give the distances and orders between the three fly genes, D, E and F. Of 1000 offspring from the cross DdEe (dihybrid) x ddee (homozygous recessive; "tester"), 347 were DdEd, 148 were Ddee, 152 were ddEe and 353 were ddee. Of 1000 offspring from the cross EeFf x eeff, 296 were EeFf, 197 were Eeff, 203 were eeFf, and 304 were eeff. Of 1000 offspring from the cross DdFf x ddff, 455 were DdFf, 45 were Ddff, 55 were ddFf and 445 were ddff.
- What are the distances and orders between the D, E and F loci in fruit flies?
  - How do you know, or **do** you know?, that these three genes are located on the same chromosome?

• **PRACTICE WELL:** Human pedigrees and patterns of inheritance; Linkage and chromosome mapping; and Chapter 12 (10) problems!! Also, know how to identify and describe differences between various stages of Mitosis and Meiosis.

## BIOL 230 (Final: Cumulative Portion) – Important Terms and Concepts 12/5/2011

2. Carbon, Hydrogen, Nitrogen, Oxygen, Phosphorus, Sulfur (**CHNOPS**). Electron shells; Protons, neutrons, atomic mass, atomic number, Octet Rule. Covalent bond – polar, nonpolar. **Hydrogen bond**; Ionic bond; **Van der Waals** forces; "hydrophobic interactions"; WATER: cohesion, adhesion; **pH buffer**, acid, base  
**Structure/shape → Function.**

3. **MACROMOLECULES**: Monomers, polymers, **Condensation reactions, Hydrolysis reactions**; Monosaccharide, polysaccharide, **Glycosidic** bonds.

**Lipids** – fatty acids, **triglycerides**, phospholipids, cholesterol; Saturated, unsaturated hydrocarbons; phospholipid bilayer  
Amino acids – polar, nonpolar, charged; **peptide** bonds

**Proteins**, Protein-structure: Primary, secondary (alpha helix, beta-pleated sheet), tertiary, and quaternary. Cysteine – **disulfides**

4. **Nucleic acids** – **DNA vs. RNA**; Adenine, Guanine, Cytosine, Thymine, Uracil; sugars Ribose, Deoxyribose; Single-stranded, double-stranded; Nucleotides, phosphodiester linkages  
**Base-pairing: A-T (A-U) [2 H-bonds], G-C [3-H bonds]**

5. **CELL THEORY**: **Prokaryotic vs. Eukaryotic** cells; Prok.: Plasma membrane, nucleoid, ribosomes, **Peptidoglycan** Cell Wall, Outer Membrane, Capsule, prokaryotic flagella, Pili;

**Plant vs. Animal cells; Nucleolus, Ribosomes, Mitochondria, Rough ER, Smooth ER, Golgi Apparatus, Cytoskeleton**; Nucleus – **nuclear envelope, nuclear pores, chromatin, chromosomes, nuclear lamina**; Endoplasmic Reticulum: **Rough, Smooth**; Golgi Apparatus – **cisternae, vesicles; cis, medial, trans regions; Lysosomes, phagocytosis, phagosomes, phagolysosomal fusion**

Mitochondria, Plastids – chloroplasts

**ENDOSYMBIOSIS THEORY; Cytoskeleton** – Microfilaments/actin filaments, G-actin; Microtubules, tubulin (alpha, beta), minus-end, plus-end; Microtubule organizing center, basal body, centrioles  
Flagella, Cilia; Plant cell wall – cellulose

6. **FLUID MOSAIC MODEL**: Simple diffusion; channel proteins (Passive transp.); Carrier proteins: Uniport, Coupled transport – symport, antiport. **Facilitated diffusion** – Passive transport; Primary and Secondary Active transport; Bulk Transport (active!); **Endocytosis** – Pinocytosis, Phagocytosis; Exocytosis.

8. **Enzymes & Metabolism** – **anabolic** and **catabolic** reactions. *Chemical reactions run both backward and forward; reversible!!*  
Chemical Equilibrium;  $-\Delta G = \text{spontaneous} = \text{exergonic}$   
 $+\Delta G = \text{nonspontaneous} = \text{endergonic}$   
**ATP (12 kcal/mol), energetic coupling**; Catalyst, **ENZYME**, Energy Barrier, **Activation Energy**  
Substrate, Product, **Active Site** – Lock and Key, Induced-Fit, **Enzymatic coupling**; Enzyme inhibitors – irreversible, reversible – competitive and noncompetitive  
**Allosteric enzymes – Branches in metabolic pathways**, Regulatory enzymes at branch-points, Feedback inhibition

9. **GLYCOLYSIS and RESPIRATION**: Glucose (6C), oxidative respiration, ATP (12 kcal/mol).

**Step-by-step packaging of free energy (G)**

**Oxidation-Reduction (redox) reactions**:  $\text{NAD}^+$ ,  **$\text{NADH} + \text{H}^+$  (52 kcal/mol)**; FAD,  **$\text{FADH}_2$** , **Hydride Ion ( $2e^- + \text{H}^+$ )**

**Glycolysis** – net 2ATP, 2NADH+H<sup>+</sup>, 2 Pyruvate (3C)

Glyceraldehyde-3-phosphate (3C), **Substrate-level**

**phosphorylation**; **Pyruvate Oxidation** (3C) → **Coenzyme A**, acetate (2C), 2 NADH+H<sup>+</sup>, 2 CO<sub>2</sub>;

**Citric Acid Cycle** – 2C (acetate) + 4C (oxaloacetate) → 6C (citrate) → 5C, → 4C; [+ 4 CO<sub>2</sub>, 2 ATP/GTP, 6 NADH+H<sup>+</sup>, 2 FADH<sub>2</sub>]

**Respiratory chain** – **Oxidative phosphorylation,**

**chemiosmosis, proton motive force, ATP Synthase,**

Ubiquinone/Q, Cytochrome C, Cytochrome Oxidase, **O<sub>2</sub> → H<sub>2</sub>O**

**3ATP/NADH+H<sup>+</sup>, 2ATP/FADH<sub>2</sub>**; Mitochondria – inner membrane, matrix; **Fermentation** – ethanol, lactate, NAD+

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13. **Griffith** – **transforming principle** (TP) is genetic material; S- & R-strains; **Avery/McLeod/McCarty** – TP = DNA!

**Hershey/Chase** – (bacteriophage, blender) DNA = genetic material;

**Watson/Crick**: DNA = double helix, sugar-phosphate backbone,

**Chargaff** (A=T, G=C), A(2)T and G(3)C base pairing;

**Franklin/Wilkins** X-Ray Crystallography, antiparallel strands;

Right-handed helix, uniform diameter, info in linear NT sequence

**DNA REPLICATION**: **semiconservative**, dispersive, conservative;

**Initiation, Elongation, Termination; DNA polymerase III**; **Origin of**

**replication (Ori, Ter)**, **Helicase, Primase** (RNA Primer, free 3'-

OH), **5' → 3'** synthesis; **DNA polymerase I, DNA Ligase**

14. The **Central Dogma**; messenger, adapter; Gene expression.

**TRANSCRIPTION** **Promoter**, RNA polymerase; Ribonucleoside

triphosphates; **Codons**: triplet "words", nonoverlapping,

degeneracy, "Wobble", Start, Stop

**TRANSLATION**, tRNA, methionine, AUG; Reading Frame;

**Ribosome** – large (peptidyl transferase) and small subunits,

Ribozyme; Amino (N) terminus, Carboxyl (C)- terminus;

**Aminoacyl tRNA synthetases** (activating enzyme); **N → C**

synthesis; A-site, P-site; **Release Factor**; Posttranslational

Regulation – delivery signals; Antibiotic regulation

Point mutations – **silent, missense, nonsense, frameshift**;

16. **Prokaryotic Genetics**: **Lytic vs. Lysogenic** Phage life cycles;

**Conjugation, Transformation, Transduction**;

**Operon, Operator, Promoter, Inducer, Repressor**

Positive control, Negative control; Inducible promoter, Constitutive promoter; cAMP, cAMP-repressor Protein (CRP)

**Lac Operon**; Inducer (lactose), **Trp Operon. Compare**

**Prokaryotic vs. Eukaryotic Genetics (see PartIV Review).**

## BIOL 230: Cell/Molecular Biology – FINAL: Cumulative Part (Fall '11): Study Questions

### Possible Short Essay Topics (be prepared to draw diagrams as well!):

1. List and explain 6 factors that distinguish life from non-life. Provide specific examples of each in the living world.
  2. Describe and compare **6 properties of DNA and RNA structure and synthesis** that are essential to their successful production, stability, and cellular function.
  3. **\*\* For each of the four major macromolecules, describe and diagram at least two specific examples of how its chemical structure determines its cellular function.**
  4. Use diagrams to describe and give specific examples of the levels of protein structure. Give a specific example that demonstrates how protein structure determines..... (You know!!).
  5. **\*\* Compare and contrast AT LEAST 10 characteristics that distinguish between Prokaryotic and Eukaryotic cells, including genomic structure and gene expression/regulation.**
  6. Using diagrams, name and describe the prevailing model of the structure of biological membranes. Be sure to include and define ALL relevant components of membranes *and their basic functions*.
  7. Using simple diagrams, compare and contrast the component monomers, general chemical structures, and shapes of each major type of macromolecule. Briefly explain how these structures directly contribute to the main cellular functions of each type of molecule.
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8. Describe five ways in which a metabolic (enzymatic) pathway can be regulated. Be sure to include physical properties of the protein enzymes themselves, especially those involved in branched pathways. (What is *allostery*? What is *feedback inhibition*? What are the effects of physical conditions?)
  9. Diagram and describe how ATP synthesis is coupled to electron transport in mitochondria and chloroplasts. Identify and describe the function of at least two proteins involved in energy conversions. Define *energetic coupling*, and identify what cellular molecules perform the coupling process in each case of energy conversion.
  10. Diagram and describe the flow of carbon atoms through glycolysis and the respiratory pathways. In what form (molecule) does carbon enter each process/stage, and in what form does it leave?
  11. Compare the pathways, and energy inputs and outputs of aerobic respiration and fermentation in living organisms. Include all processes/stages, electron carriers, and phosphorylated compounds.
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12. Describe the three processes involved in Heredity and “Gene Expression”, and the major enzymes and molecular polymers produced, that define the direction and flow of genetic information in living systems. What is the name of this fundamental theory voiced by Sir Francis Crick? *How does this theory explain the production of phenotype from hereditary genotype?*
  13. **\*\* Diagram and describe at least FOUR examples of allosteric control of protein activity in cellular metabolism, genetics/ gene regulation, and cell cycle control. Define allostery, and explain HOW and WHY it is such an efficient method of controlling cellular processes.**
  14. Distinguish between the starting sequences and ending sequences and enzymes used to initiate, polymerize (elongate), and terminate Replication, Transcription, and Translation. Define each process, including directions of synthesis, enzymes involved, nucleotide sequences recognized, and the type of molecule produced. Be sure to discuss main differences in numbers and directions of “bubbles” and “forks”.
  15. Compare and contrast regulation of the LAC Operon and the TRP Operon. When is each turned ON or OFF? ***Draw each operon in the PRESENCE of its own ligand (signal molecule)***. What controls the activity of the regulatory proteins involved (***both positive and negative regulation***)? ***Explain how each type of regulation is appropriate for an operon encoding catabolic or anabolic enzymes [HINT: How does each contribute to greater efficiency for a cell?, by conservation of energy and materials for the cell??]***
  16. Describe and DIAGRAM at least 8 ways that gene structure, transcription, and transcriptional and post-transcriptional regulation differ between Prokaryotes and Eukaryotes. What differences between prokaryotes and eukaryotes also exist in the translation of an mRNA transcript?

- ❖ ***Preparation notes:*** A good strategy for answering comparison and contrast questions is to make a TABLE with a column for each subject/topic to be compared. Then compare related characteristics in the listed rows below each topic. USE the TERMS and CONCEPTS on the first pages to help answer the short ESSAY questions!!
  - ❖ ***Remember:*** All questions are important study tools for the entire exam, though the questions in **BOLD** are the most likely questions to be asked in essay form (wording may be slightly altered) on the test.