BIOL 230 (Part IV): Major Terms & Concepts (this is NOT an exhaustive list!!) 12/2/2019

11. Ch. 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 (Cyclin-Dependent Kinases)**

- ***Mitosis or Meiosis = NUCLEAR division!!***

P53 activates expression of p21, which blocks expression of G1 cyclins. If p21 activity is inhibited, cyclin-CDK complexes phosphorylate RB protein, inactivating RB, and allowing the cell cycle to progress. Mutations in p53, RB, and/or p21 are associated with many types of cancer.

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. 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.

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. **T.H. Morgan, A. Sturtevant.**

Recombinant Gametes in Prophase I, Crossing Over.

BIOL 230 f'19: Cell & Molecular Biology – Final Exam, part IV: Study Questions

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

1. **DIAGRAM and 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] 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 5μm 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 hypotheses, 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 DdEe, 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 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 12/2/2019

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;** Carbohydrates**:** 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-standed, 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.

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8. Enzymes & Metabolism – **anabolic** and **catabolic** reactions.
Chemical reactions run both backward and forward; ***reversible****!!*
Chemical Equilibrium; **-ΔG = spontaneous = exergonic**
+ΔG = nonspontaneous = 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: NAD^+, **NADH + H^+ (52 kcal/mol);** FAD, **$FADH_2$, Hydride Ion (2e- + H^+)**
Glycolysis – net 2ATP, 2NADH+H^+, 2 Pyruvate (3C) Glyceraldehyde-3-phosphate (3C), **Substrate-level phosphorylation; Pyruvate Oxidation** (3C)→ **Coenzyme A**, acetate (2C), 2 NADH+H^+, 2 CO_2;
Citric Acid Cycle – 2C (acetate) + 4C (oxaloacetate) → 6C (citrate) → 5C, → 4C; [+ 4 CO_2, 2 ATP/GTP, 6 NADH+H^+, 2 $FADH_2$]
Respiratory chain – **Oxidative phosphorylation**, ***chemiosmosis*, proton motive force, ATP Synthase**, Ubiquinone/Q, Cytochrome C, Cytochrome Oxidase, **O_2→H_2O**
3ATP/ NADH+H^+, 2ATP/ $FADH_2$; 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 '19): 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. ** For each of the four major macromolecules, describe and diagram at least two specific examples of how its chemical structure determines its cellular function. Compare structures of monomers for each polymer.

3. Use diagrams to describe each level of protein structure. Include the types of molecular bonding/interactions that are important at each level, and provide specific examples to show how each _____ determines its _____. ……. *(You know!! ☺)*
4. **Using diagrams, explain 3 differences between simple diffusion, and primary and secondary active transport across a biological membrane. Also, what are three properties of a transported substance that strongly affect its rate of diffusion across a membrane?**
5. **Describe energetic coupling within a living cell, and give an example. Use diagrams if helpful.**
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 associated functions.**
7. **Describe and explain three ways in which an enzyme can interact with a substrate in order to speed up a chemical reaction. Be sure to explain the effect of an enzyme on ΔG, E_a, and the state of equilibrium of a reaction.**

8. ** Compare and contrast AT LEAST 10 characteristics that distinguish between Prokaryotic and Eukaryotic cells, *including genomic/chromosome structure, gene structure, and gene expression/regulation*.

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9. Describe five ways (physical and chemical) by 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?)
10. **Diagram and describe the flow of all six carbon atoms in glucose through glycolysis and each stage of the respiratory pathways. In what form (molecule) does carbon enter each process/stage, and in what form does it leave? *WHERE does each process occur?* What type of energy is the major type extracted from these carbon compounds/sugars?**
11. **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, and describe two important processes, involved in energy conversions. Define *energetic coupling*, and identify what cellular molecules perform the coupling process in each case of energy conversion.**

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12. ** 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. What MAJOR biological/biochemical concept does this demonstrate??

13. Describe 5 main pieces of evidence that lead Watson and Crick to solve the structure of DNA. Describe 5 main characteristics of the structure of DNA, and explain how each contributes to its functions.
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. *DEFINE what an operon is.* 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?**
17. Describe and Diagram the interactions between 6 protein and DNA factors involved in ONLY Eukaryotic gene regulation. How does coordinate gene regulation differ between Prokaryotes and eukaryotes?

❖ ***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.*