

# Study Guide- Final Exam

## Study Guide- Comprehensive Part

- 28 questions will be taken from previous exams (14 multiple choice, 14 half short answers).
- These questions may be reworded; **DO NOT** try to memorize old answers.
- The way to study for the comprehensive part of final is to understand why original answer was correct, **AND** why the other choices were wrong.

## Study Guide- Part 4 (covers 4.1 through 4.6)

### Class 4.1---04/12/07: Exceptions to the Fundamentals of Molecular Biology

#### Know the following terms:

Ribozymes, Group I introns, Group II introns, L19 catalytic RNA, riboswitch, maturases, viroids, virusoids, hammerhead structures, RNA editing, deaminase enzymes, terminal uridylyltransferase (TUTase), RNA ligase, guide RNAs, exteins, inteins.

#### Understand the Following Concepts:

1. Know how a guanine nucleotide acts as a cofactor for the splicing of Group I introns.
2. Know the types of genes that contain Group I introns.
3. Know the mechanism for splicing of the 26S rRNA in *Tetrahymena*.
4. Know how the secondary structure of Group I introns leads to self splicing.
5. Know how the L19 RNA generated from a Group I intron can catalyze the addition of nucleotides onto small RNAs.
6. Understand the mechanism by which a ligand can activate a riboswitch.
7. Know that some Group I and II introns contain ORFs. Know what kinds of proteins these ORFs produce and how they are related to the mechanism of intron spreading and intron homing.
8. Understand how viroids and virusoids can be infectious.
9. Know how ribozymes can be engineered to be tools for silencing specific genes.
10. Know how RNA editing can produce different proteins without affecting the sequence of the gene.
11. Understand the mechanisms by which RNA editing can change the RNA sequence.
12. Know the composition of the RNA editing complex.
13. Know the 4 stages of RNA editing using a guide RNA.
14. Know the relationship between inteins, exteins, and protein splicing.

### Class 4.2---04/17/07: Chromosomes

#### Terms:

Capsid, terminase enzyme, nucliod, free supercoiling, restrained supercoiling, metaphase chromosome, chromatin, euchromatin, constitutive heterochromatin, facultative heterochromatin, karyotype, giemsa staining, G-banding, lampbrush chromosomes, polytene chromosomes, centromere, C-banding, kenetochore, microtubule organizing center (MTOC), *CEN* fragment, CDE-1, CDE-II, CDE-III, telomere, telomerase complex.

Concepts:

1. Know the two different ways that nucleic acids are packaged in viruses or phages.
2. Know how translocation and condensation are related to the stages of the packaging in viruses.
3. Know how bacterial chromosomes are packaged.
4. Know the difference between free and restrained supercoiling.
5. Understand the structure and function of matrix attachment regions (MAR).
6. Know the difference between euchromatin and heterochromatin.
7. Know the difference between constitutive and facultative heterochromatin.
8. Know the five characteristics that make heterochromatin inactive.
9. Know three molecular characteristics that define inactive chromatin.
10. Know the physical basis for banding patterns that are seen when mitotic chromosomes are stained.
11. Know the circumstances for how lampbrush chromosomes are formed.
12. Know the circumstances for how polytene chromosomes are formed.
13. Be able to define a centromere in terms of structure and DNA sequence.
14. Know the difference between a centromere and a kenetochore.
15. Know the role of a microtubule organizing center (MTOC).
16. Be able to describe the structure of a yeast centromere: Know the 3 types of DNA sequence elements and their organization.
17. Know the general structure for the protein complex that connects the centromere to the spindle.
18. Know the characteristics of telomeres and their general DNA structures.
19. Recall the general problems with replicating linear DNA molecules and how the telomerase system overcomes this problem.
20. Know the difference between telomeres and telomerases: Know the general composition of telomerases.

**Class 4.3---04/19/07: Nucleosomes**

Terms:

Nucleosomes, H2A, H2B, H3, H4, histones, core particle, octomer, H1, micrococcal nuclease, DNase I, DNase II, linking number paradox, 10 nm fiber, 30 nm fiber, solenoid, CAF-1, H3.3, translational positioning, rotational positioning, DNase hypersensitive site, insulator.

Concepts:

1. Know the structure and composition of the core histone particle or octomer.
2. Know the role of H1 histone in the nucleosome.

3. Know the relationship between the 200, 165, and 146 bp DNA fragments resulting from micrococcal nuclease of isolated chromatin.
4. Know why micrococcal, DNaseI, DNaseII enzymes are used to define nucleosome positioning.
5. Understand how winding around nucleosomes leads to supercoiling of the DNA.
6. Know all the levels of higher order chromatin packaging: DNA helix, 10 nm fiber, 30 nm fiber, looped domains, interphase chromosome, metaphase chromosome.
7. Know how the H3-H4 tetramer and the H2A-H2B dimers fit into the nucleosome core particle.
8. Know that the N-terminal tails of the histone proteins stick out of the core particle to interact with other proteins.
9. Know how chromatin replicates and how core particles are disassembled and reassembled on daughter strands. Know the role of CAF-1 in the process.
10. Know how the replication-coupled pathway of histone synthesis is tied to the cell cycle.
11. Know the relationship between histone H3.3 and differentiated cells.
12. Know the two types of nucleosomal positioning and how this can affect the binding of transcription factors.
13. Know what happens to nucleosomes as RNA polymerase moves down a template DNA. Know the role of FACT in repositioning nucleosome as genes are being expressed.
14. Know how micrococcal nuclease is used to gauge the degree of nucleosome phasing on a promoter region.
15. Know how DNase hypersensitive sites correlate with nucleosome positioning on the chromatin.
16. Know what insulators are and how they work in terms of the action of enhancers and promoters.

#### **Class 4.4--04/24/07: Chromatin Structure**

##### Terms:

Equilibrium model of gene expression, discontinuous-change-of-state model of gene expression, remodeling complexes, SWI/SNF, ISWI, histone methylation, histone acetylation, histone phosphorylation, histone acetyl transferase (HATs), histone deacetylases (HDACs), position-effect variegation (PEV), Su(var) gene, E(var) gene, chromo-domain, bromo-domain, HP-1 protein.

##### Concepts:

1. Know the relationship between chromatin remodeling and heterochromatin.
2. Understand how the equilibrium model of gene expression explains transcription regulatory mechanisms in prokaryotes.
3. Understand how the discontinuous change-of-stage (dynamic model) explains mechanisms of gene expression in eukaryotes.
4. Know the 3 types of chromatin remodeling that can give transcription factors access to DNA.
5. Know the 2 general types of chromatin remodeling complexes and how they work using ATP.

6. Know the mechanism of how chromatin remodeling can change the access of binding sites to transcription factors. Be familiar with the specific example involving steroid receptor binding and the blocking or unblocking of downstream response elements.
7. Know the 3 types of histone modifications; the proteins and amino acid residues that are modified; and how these modifications affect chromatin structure and gene expression in general.
8. Know what histone acetyl transferases (HAT) enzymes are, how they work, and that they are sometimes found as separate domains in other proteins. Know their relationship to activator proteins as coactivators.
9. Know what histone deacetylases (HDACs) are, how they work, and that they are sometimes found as separated domains in other proteins. Know their relationship to repressor proteins as corepressors.
10. Know the differences and the different consequences between histone methylation and DNA methylation.
11. Know the 3 major differences between an active and inactive promoter at the chromatin level.
12. Know the stages involved in promoter activation.
13. Know the relationship between position effect variegation and heterochromatin.
14. Be able to predict the phenotype relative to PEV of a Su(var) or E(var) mutation. Be able to predict what type of molecule may be encoded by a Su(var) and/or E(var) gene.
15. Be able to predict what happens to chromatin and histone modification during the generation and/or spreading of heterochromatin.
16. Know the role of HP1 in packaging chromatin into heterochromatin.

#### **Class 4.5---04/26/07: Epigenetic Effects**

##### Terms:

Epigenetic effects, telomeric silencing, Polycomb, Pc-G proteins, PRE elements, PRC1, ESC-E(z) complex, methyltransferases, trithorax group proteins (trxG), dosage compensation, X-inactivation, Bar body, genetic mosaic, *Xic*, *Xist*, *De novo* methylases, maintenance methylases, imprinting, imprinting control region (ICR), prions, [psi-] phenotype, [PSI+] phenotype, scrapie, mad cow disease, kuru, Crutzfeld-Jakob disease (CDJ), PrP<sup>C</sup>, PrP<sup>Sc</sup>.

##### Concepts:

1. Know the difference between true genetic effects and epigenetic effects.
2. Recall how DNA is methylated on CpG sites and why and how that leads to gene inactivation.
3. Know the mechanism by which heterochromatin is perpetuated, and that it can sometimes spread up or down the chromosome.
4. Know the 2 stages by which heterochromatin is formed (as suggested by PEV).
5. Know the relationship between PEV and telomeric silencing.
6. Know what Polycomb-group proteins are, how they recognize PREs, and how they repress chromatin structure.
7. Be familiar with the types of proteins that are found in Pc-G complexes.

8. Know what dosage compensation is, and how it is affected in mammals, flies, and worms.
9. Know that female mammals are mosaics for genes on the X chromosome. Understand the consequences of this mosaicism if the female is heterozygous (has different alleles) for an X-linked gene.
10. Know the difference between the *Xic* region and the *Xist* gene. Know what *Xist* encodes.
11. Know the mechanism for how *Xist* expression and stabilization leads to X-chromosome inactivation.
12. Know the difference between *De novo* and maintenance methylases, and know the substrates that they recognize.
13. Be able to define and give an example of imprinting. Know that this is an epigenetic effect that it is manifested during development.
14. Know the molecular details and the epigenetic consequences for a locus that is imprinted.
15. Understand how methylation at an Imprinting Control Region (ICR) can lead to a gene being inactivated or activated by mechanisms that can include preventing an insulator from functioning.
16. Know what prions are.
17. Know how the [psi] phenotype of yeast can result from different structural conformations of the Sup35 protein.
18. Know the relationship between the PrP<sup>C</sup> and Prp<sup>Sc</sup> protein conformations and neurodegenerative disorders in mammals.

#### **Class 4.6---05/01/07: Genetic Engineering**

##### Terms:

Recombinant DNA, genetic engineering, gene cloning, polymerase chain reaction (PCR), restriction enzyme, recognition site, compatible ends, origin of replication (*ori*), green fluorescent protein (GFP), transfection, liposomes, microinjection, T-DNA infection, transient transfection, stable transfection, electroporation, tandem array of DNA, transgenic organisms, position effect, knock out, knock in, embryonic stem (ES) cells, totipotent.

##### Concepts:

1. Know three areas that are encompassed by genetic engineering.
2. Be able to define gene cloning.
3. Know how PCR works to amplify a DNA fragment.
4. Be able to describe the two major tools for recombinant DNA: Restriction enzymes and vectors.
5. Be able to describe how restriction enzymes are used to put 2 different DNA molecules together.
6. Know three key considerations for engineering a vector for recombinant DNA.
7. Know four different types of specialized vectors and how they are used to accomplish different goals.
8. Know what Green Fluorescent Protein (GFP) is and why it is such a powerful reporter gene.
9. Know how GFP is used to tag endogenous proteins.
10. Know the types of considerations that would be needed to express a mammalian gene in a bacterial cell.

11. Know the four general ways that DNA can be introduced into eukaryotic cells.
12. Know the difference between transient and stable transfections of mammalian cells. What are the strengths and weaknesses of each technique.
13. Know that DNA is inserted into the genome of a cell as a tandem array after a transfection protocol.
14. Know the difference between a transgenic mouse and a knock-out mouse.
15. Be able to propose models for position effects = why some genes are expressed in transgenic animals at one level and why the same genes may be expressed in a different transgenic animal at a different level.
16. What are the advantages of transgenic organisms. Be able to name some current uses of transgenic animals and/or plants.
17. Know the difference between a knock out and a knock in mouse.
18. Know how ES cell lines are generated.
19. Know some of the diseases that could be cured by ES cells.