AP Biology Review Part 3: Genetics & DNA and Protein Synthesis

3A1- DNA, and in some cases RNA, is the primary source of heritable information

3A3: The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parents to offspring.

3A4: The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.

3C1: Changes in genotype can result in changes in phenotype.

1. **DNA (genetic info is passed down through DNA and RNA)**
2. Discovery
3. Avery-MacLeod- Marty- 1944 isolated DNA from Griffith’s transformation experiment
4. Hershey-Chase- 1952 elegant experiment with virus and bacteria showing DNA was injected not protein
5. Watson, Crick, Wilkins, and Franklin- 1953 W and C published work showing structure of DNA (used Wilkins and Franklins work to do so)
6. Structure of DNA
7. Deoxyribose nucleic acid
8. Double helix (two twisted stsrands) made of nucleotides (monomers)
9. Nucleotide = phosphate + 5C deoxyribose sugar + nitrogen base
10. Antiparallel strands- one runs 3’ to 5’ the other runs 5’ to 3’,sides of phosphates and sugars (backbone), rungs of paired bases with hydrogen bonds in between
11. Purines (adenine,guanine; double rings) pair with Pyrimidines (cytosine, uracil, thymine; single ring)
12. A - T- double H bond
13. C – G- triple H bond
14. Location
15. In eukaryotes DNA is found in nucleus on multiple linear chromosomes (a chromosome IS a strand of DNA with proteins etc. associated).
16. In prokaryotes DNA is not in a nucleus and is usually a single circular chromosome
17. Prokaryotes, viruses, and eukaryotes (yeast) can contain plasmids (small extra-chromosomal DNA that is double stranded DNA)
18. **DNA replication**
19. Process of making exact copies of DNA (i.e. for mitosis or meiosis)
20. Process is semi conservative (original strand is copied)
21. Steps
22. Enzyme (helicase) unzip strands by breaking hydrogen bonds
23. “Spare” nucleotides are added bidirectionally to bond complementarily with use of DNA polymerases (DNA pol)
24. DNA pol only can add to the 3’ to 5’ side and new DNA is made in the 5’ to 3’direction
25. Replication bubbles open up and a replication fork is created because bubble is in half and it has one side 3/5 and one 5/3
26. RNA primers must be laid down to start process (RNA primase makes primers)
27. Leading strand makes DNA continuously (3/5)
28. Lagging strand makes DNA discontinuously (5/3), Okazaki fragments
29. Lagging strand requires enzyme (ligase) to fuse fragments

**3. RNA**

1. Ribonucleic acid
2. Single stranded, different sugar called ribose, different base called uracil INSTEAD of thymine
3. Base pair rules in RNA, A-U and C-G
4. messenger RNA or mRNA carries information from DNA to the ribosome
5. transfer RNA or tRNA bind amino acids and are used in translation at ribosome
6. ribosomal RNA or rRNA are part of ribosomes that have catalytic function
7. RNAi are molecules that are used for regulation of gene expression (turn on or off)

**4. Transcription**

1. making mRNA in nucleus
2. enzyme RNA pol reads the DNA in 3’ to 5’ direction and synthesizes complementary mRNA
3. Ex. 3’ to 5’ DNA is ATG CAT then the 5’ to 3’ mRNA made will be UAC GUA
4. Steps
5. TATA Box where RNA pol binds and begins
6. Transcription Factors (proteins that enhance transcription and help RNA pol into correct shape)
7. Elongation (adding of RNA nucleotides- does not stay attached to DNA)
8. Termination, ends when RNA pol reaches a termination sequence

**5. mRNA editing**

1. introns are excised (cut out)
2. exons are left and spliced together using spliceosomes (snRNP’s)
3. add polyA tail to 3’
4. add GTP cap to 5’
5. each 3 are called a codon
6. go to ribosome (free or in RER)

**6. Translation**

1. mRNA code is read and matched with tRNA (brings amino acids) to construct a polypeptide using the ribosome
2. Ex. mRNA codon is AAA then tRNA anticodon will be UUU and will have a corresponding amino acid for that codon of mRNA
3. Initiation: 5’ end of mRNA attaches to small ribosome, tRNA with anticodon UAC attaches to start codon AUG ; large ribosomal subunit binds and tRNA is in P site
4. Elongation: new tRNA enters A site; peptide bond forms when a.a. is transferred from tRNA in P site to A site; translocation occurs and tRNA in A site moves to P
5. Termination: Ribosome encounters stop codon (UAA, UAG, UGA)
6. If in ER then: polypeptide is released into ER, then to Golgi complex, vesicle to cell membrane, then exocytosis (may be given signals for exit/destination)
7. Free ribosomes typically make products for the cell and are not exported

**7. Mutations**

1. any change of DNA sequence, can be inheritable if it is in egg or sperm
2. point mutations- one nucleotide error; substitutions (i.e. A instead of G)
3. frame shift mutations- one or more bases deleted or inserted
4. silent mutations can occur, i.e. substitution codes for same a.a. or deletion/insertion is of three nucleotides
5. Missense mutation- means that new letter codes for a new amino acid, i.e. sickle cell; can be extensive with frameshift mutations
6. Nonsense mutation- means that a stop codon is coded for too early and results in short polypeptide
7. Single gene mutations in humans caused by DNA mutations
8. PKU- recessive; phenylketonuria, enzyme deficiency
9. Sickle cell- recessive; primarily of African descent, carriers resistant to malaria
10. Cystic fibrosis- recessive; primarily of European descent, protein in channel misshaped; thick mucus
11. Huntington’s- dominant; nervous disorder at age 40 or so; fatal

**8. Heredity**

1. Mendel’s Laws (remember he laid groundwork for genetics but these rules can all be broken looking at chromosome theory and molecular genetics)
2. Law of Dominance- one allele will be expressed over another (ex. Aa – if big A is purple it will be seen over little a which is white)
3. Law of Segregation- alleles pairs separate from each other during meiosis
4. Law of Independent Assortment- alleles assort independently during meiosis IF they are on separate chromosomes (i.e. AaBb can make gametes AB, Ab, aB or ab)
5. Terms to know
6. dominant
7. recessive
8. genotype
9. phenotype
10. allele
11. homozygous
12. heterozygous
13. testcross

1. Probability,Patterns and Exceptions to Mendel’s Rules
2. product rule- multiply chance of one event happening by the chance of another event happening to get the chance of both events occurring together
3. Inheritance patterns
4. autosomal vs. sex-linked (on the X or Y chromosome)
5. monohybrid cross; one trait; 3:1 (Aa x Aa); 1:1 (Aa x aa) or 4:1 (AA x\_), (aa x aa)
6. dihybrid cross; 9:3:3:1 genotype (AaBb x AaBb) or test cross 1:1:1:1(AaBb x aabb)
7. Thomas Hunt Morgan- fruit flies, X- linked traits
8. male- heterozygous XY; Y chromosome is very small in mammals and fruit flies with few genes
9. female- homozygous XX
10. not for all living things sometime sex is determined by haploid/diploid or temperature or it is reversed in birds, moths, butterflies (XX is boy)
11. single gene mutations on X chromosome cause disease such as hemophilia or colorblindness
12. sex limited traits are dependent on sex of individual like milk production or male patterned baldness
13. incomplete dominance- red X white 🡪 pink; both protein product are expressed and blended
14. codominance- red x white 🡪 red and white; both protein products are equally expressed ex.AB blood types
15. multiple alleles- blood types- ABO
16. epistasis- one gene affects expression of another
17. linked genes- genes on same chromosome that are inherited together (can be unlinked by crossing over); recombination frequency calculated by recombinants/total; used for chromosome mapping; genes further apart cross over more often
18. gene/environment- phenotypes affect by environment, Siamese cat, flower color with soil pH, seasonal color in arctic animals, human height and weight
19. polygenic- continuous variation, many genes affect one trait- height, color
20. Chloroplasts and mitochondria (come from egg in mammals)are randomly assorted in cell division so they do not follow Mendelian rules.
21. Human Genetics
22. karyotype- 22 pair autosomes & 1 pair sex chromosomes + 46 total chromosomes
23. Chromosomal Mutations (occur during gamete formation- usually denovo)
24. deletion, inversion, addition of genes as a result of crossing over mistakes, ex. Prader Willi
25. chromosomal number abnormalities
26. nondisjunction- failure of chromosomes to separate at anaphase of meiosis
27. monosomy- 45 chromosomes- Turner’s- XO
28. trisomy- Down’s- trisomy 21; Kleinfelters- XXY
29. amniocentesis- for prenatal diagnosis

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Overview: Three crosses were performed by different groups (one trait, two trait and sexlinked) by allowing F1 fruit flies to mate and then counting F2 generation. Chi Square analysis was used to determine if offspring were as expected.

IV: Fruit flies

DV: Traits in Offspring

Equations: See Chi-Square Analysis

**Laws of Probability**

If A and B are mutually exclusive, then P (A or B) = P(A) + P(B)

If A and B are independent, then P (A and B) = P(A) x P(B)

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**DNA**

amino acids

anticodon

base-pairing rules

cell differentiation

coding strand

codon

DNA

DNA ligase

DNA polymerase

DNA replication

exons

genetic code

helicase

hydrogen bonding

inducible genes

introns

lagging strand

leading strand

micro RNA (miRNA)

mutation

nucleic acids

nucleotides

Okazaki fragments

protein

replication fork

repressor

RNA (mRNA, rRNA, tRNA

RNAi

start codon/stop codon

template strand

transcription

transcription factors

translation

**Genetics**

allele

autosome

back cross

cline

codominance

continuous variation

cross

dihybrid cross

discontinuous variation

dominant

F1/F2 Generation

genetic counseling

genomic imprinting

genotype

heterozygous

homozygous

incomplete dominance

independent assortment

lethal allele

linkage

monohybrid cross

multiple alleles

non-disjunction

non-nuclear inheritance

pedigree analysis

phenotype

phenotypic plasticity

polygenetic inheritance

Punnett square

pure-breeding (aka

true-breeding)

recessive

segregation

sex chromosome

sex-limited traits

sex linked gene

test cross

trait

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Questions and Practice

1. How is genetic information organized in the eukaryotic chromosome?
2. How does this organization contribute to both continuity of and variability in the genetic information?
3. How did Mendel’s work lay the foundation of modern genetics?
4. What are the principal patterns of inheritance?
5. How do the structures of nucleic acids relate to their functions of information storage and protein synthesis?
6. What are the similarities and differences between prokaryotic and eukaryotic genomes?
7. What is one way genetic information can be altered?
8. What problems can it cause?
9. What are the differences and similarities between protein synthesis in prokaryotes and eukaryotes?
10. Draw a picture to show the relationship between chromosome, DNA, gene, allele, nucleotide, base, and a trait.