Keystone Review Packet Spring 2014

10th Grade Keystone Test Prep (Part II)

This packet contains information to help you prepare for the upcoming Biology Keystone exam on May 21st and 22nd. As you will see, this packet is broken down into several major themes that the Keystone Exam will cover. Please take the time to read through and complete each section with your best possible efforts. The preparation you put into this packet will benefit you in that scoring proficient on the spring Keystone will ensure that you do not have to take the exam again, nor will you have to participate in any intervention courses in the summer and/or next school year.

Major themes covered in this packet:

- Cell Reproduction (mitosis/meiosis)
- Genetics
- Protein Synthesis

Each section will have major vocabulary words that you should be familiar with, the major content anchors that you should be able to answer questions about, some questions that will refresh your memory and additional practice questions meant to be similar to exam questions.

Cell Reproduction & Genetics

Vocabulary

Allele
Cell cycle
Chromosomes
Cloning
Co-dominance
Crossing over
Cytokinesis
DNA replication
Dominant inheritance
Gamete
Gene
Gene splicing
Gene therapy
Gene recombination
Genetic engineering
Genetics
Incomplete dominance
Inheritance
Interphase
Meiosis
Mitosis
Multiple alleles
Nondisjunction
Polygenic trait
Recessive inheritance
Semiconservative replication
Sex-linked trait
Genetically modified organism
genotype
phenotype

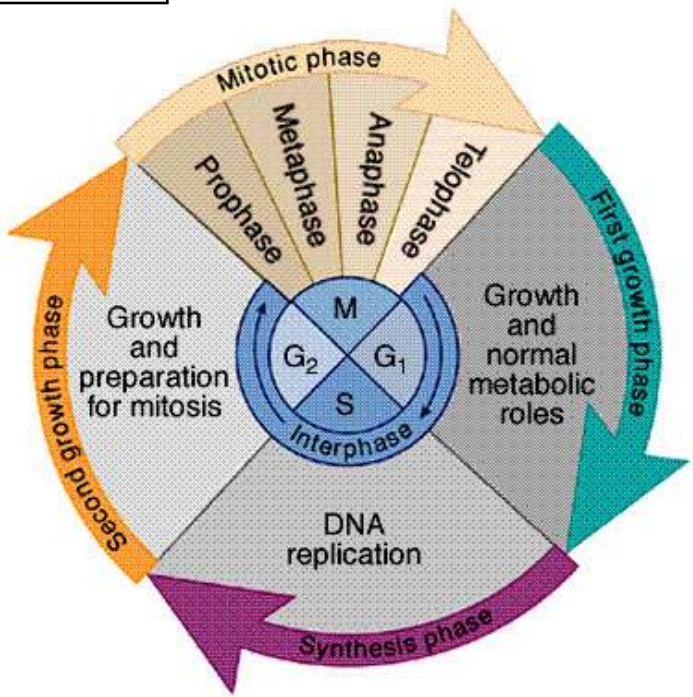
Concepts to Know

Main Concept #1: Describe the events that occur during the cell cycle: interphase, nuclear division (i.e. mitosis), cytokinesis.

- The Cell cycle – period of time from the beginning of one cell division to the beginning of the next
  - During the cell cycle, a cell grows, prepares for division, and divides to form two daughter cells, each of which then begins the cell cycle again
  - Consists of 4 phases
    - M phase – mitosis – the division of the cell nucleus and cytokinesis (includes PMAT) makes body cells
    - G1 – intense growth and activity
    - S phase – copying of chromosomes
    - G2 – intense growth and activity
      - G stands for gap

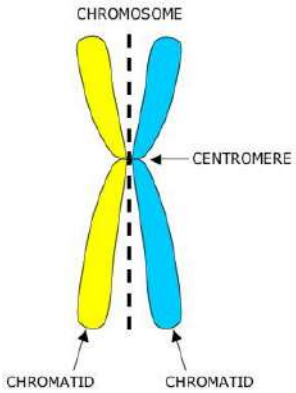
Interphase

- Interphase – time between two cell divisions (cell spends the most time in this phase)
  - Interphase can be broken into 3 phases: G1, S, G2
    - G1 → cells do most of their growing, increasing in size and synthesizing new proteins and organelles
    - S → DNA is replicated
      - Need to copy DNA so each new cell has a complete copy
    - G2 → usually shortest of 3 phases
      - Organelles and proteins required for cell division are produced
      - Cell enters M phase once complete



MITOSIS

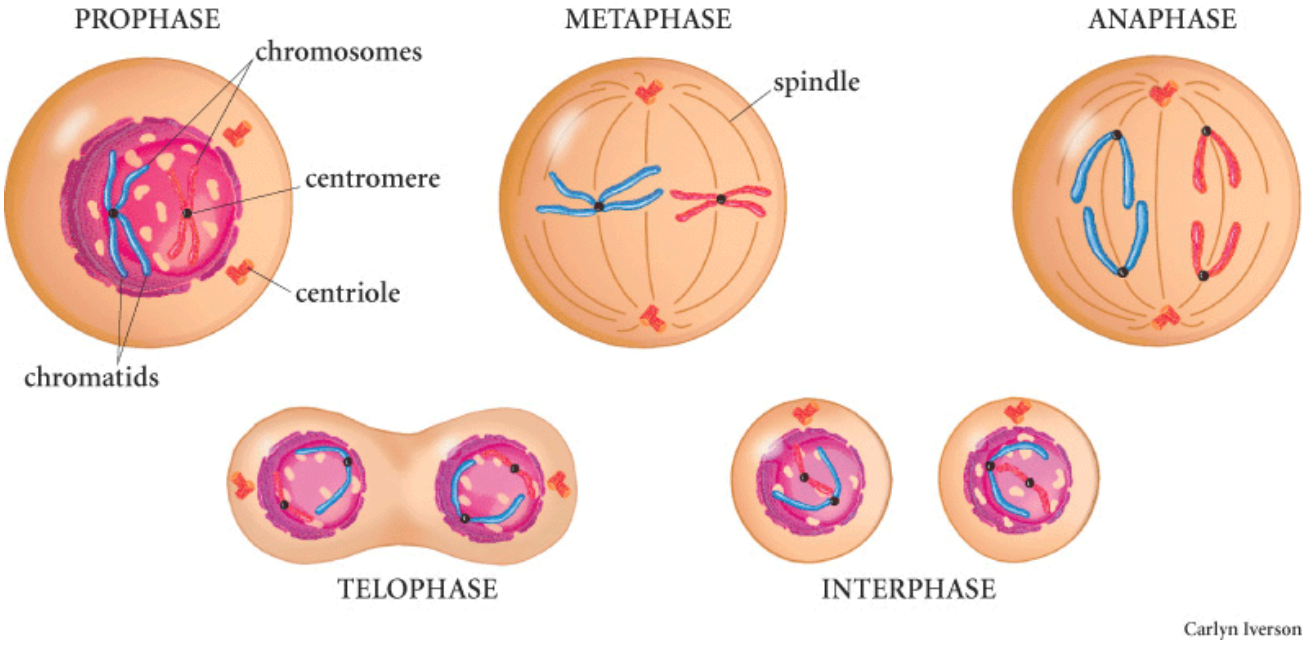
- Biologists divide the events of mitosis into 4 phases: prophase, metaphase, anaphase, and telophase
  1. prophase – 1st and longest phase of mitosis (50-60% of total time)
     - chromosomes become visible
     - centrioles separate and take up positions on opposite sides of the nucleus
       - focal point that helps organize spindle (fan-like microtubule structure that helps separate the chromosomes
       - chromosomes attach to spindle at the centromere
       - plants do not have centrioles
         - organize spindle from areas called centrosomes
     - nucleolus disappears
     - nuclear envelope breaks down



  2. metaphase – 2nd phase of mitosis
     - chromosomes line up along center of the cell
     - microtubules connect the centromere of each chromosome to the poles of the spindle

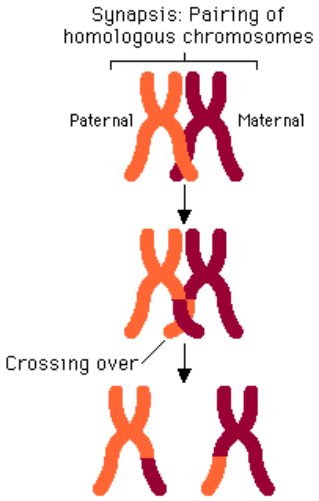
  3. anaphase – 3rd phase of mitosis
     - centromeres that join the sister chromatids split
     - chromatids separate and become individual chromosomes
     - chromatids get pulled apart, to the poles of the spindle
     - ends when they stop moving

  4. telophase – 4th phase of mitosis
     - chromosomes become loose and begin to disperse
     - nuclear envelope reforms
     - spindle breaks apart
     - a nucleolus reappears
     - cytokinesis – division of the cytoplasm
       - usually occurs at the same time as telophase
       - in animals, cell membrane pinches in at the middle
       - in plants, cell plate forms midway through the cell
         - beginning at the cell wall

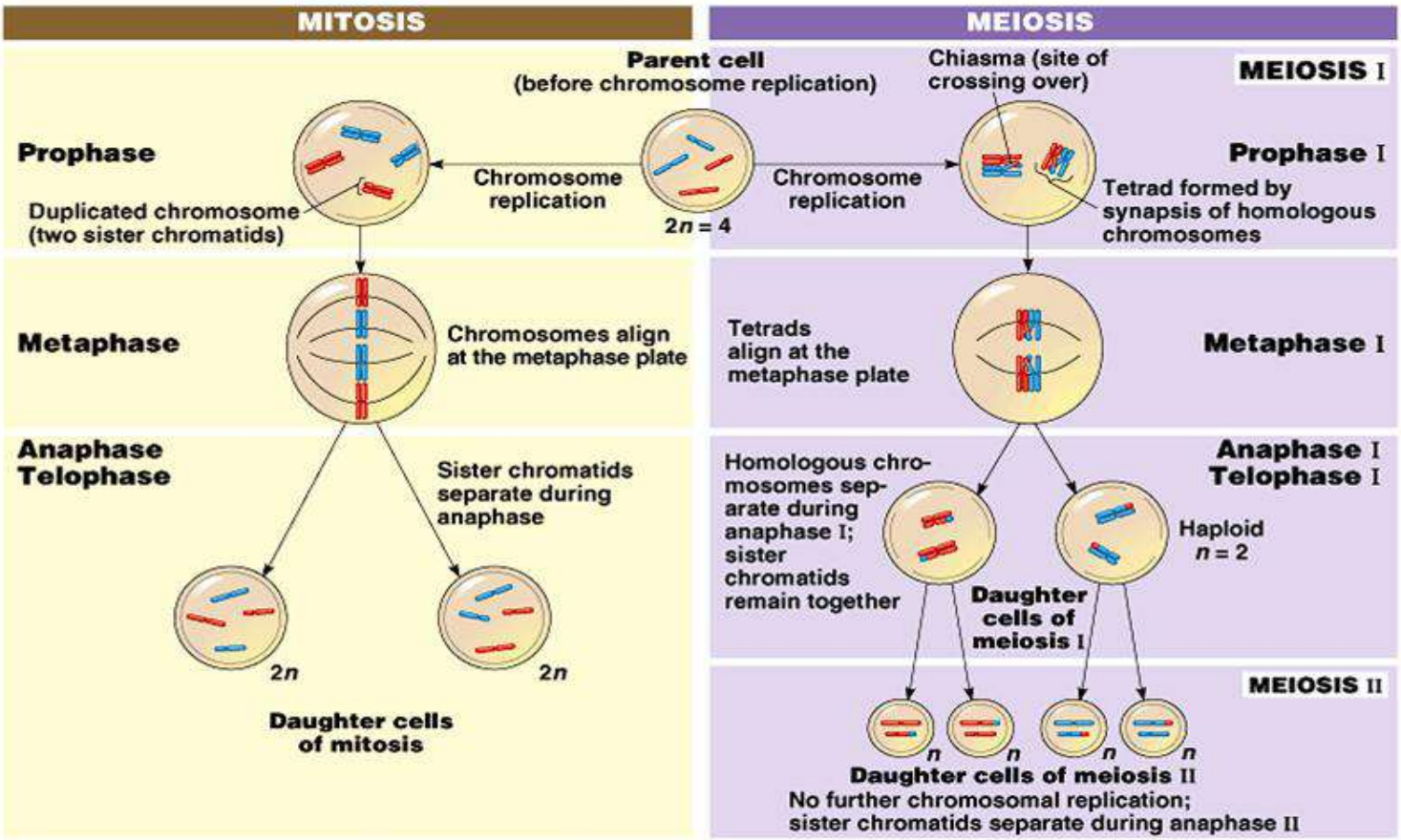


MEIOSIS

- meiosis is a process of reduction division in which the number of chromosomes per cell is cut in half and homologous chromosomes in a diploid cell are separated
    - involves two distinct stages: meiosis I and meiosis II
    - one diploid (full # of chromosomes) cell becomes 4 haploid (half # of chromosomes) cells
- homologous – two sets of chromosomes (one from mom and one from dad)
    - if a cell has both sets of chromosomes = diploid (2n)
        - 2 complete sets of chromosomes with 2 complete sets of genes
    - gametes with only one set of chromosomes = haploid (n)
        - contain only one set of genes
- **meiosis I** – prior to meiosis I, each chromosome is replicated
    - chromosomes line-up similar to mitosis, except the homologous chromosomes form a tetrad (4 chromatids)
        - occurs during prophase I
        - crossing over may occur – results in the exchange of alleles between homologous chromosomes and produces new combinations of alleles
    - homologous chromosomes separate and two new cells are formed
- **meiosis II** – cells from meiosis I enter meiosis II
    - cell does not undergo chromosome replication
    - anaphase II – chromatids separate instead of homologous pairs
    - Each resulting sex cell (gamete) has one copy of each gene



Main Concept #2: Compare the processes of mitotic and meiotic nuclear division.



In the table provided, check all of the parts of the cell cycle that apply to the description in the left column. In mitosis, meiosis I, and meiosis II columns – state whether it happens in prophase (P), metaphase (M), anaphase (A), or telophase (T)

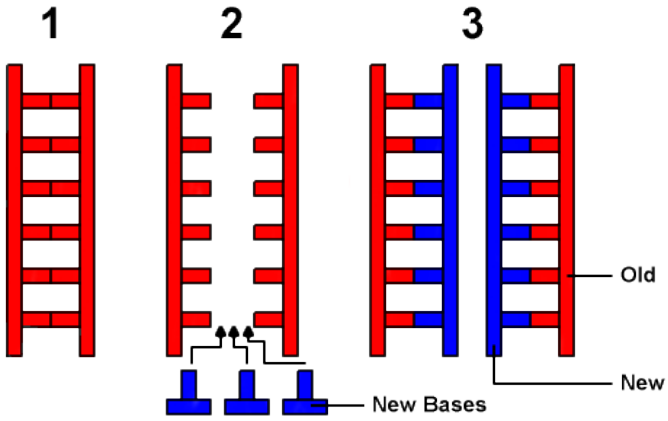
Description / Event	Interphase	Mitosis	Meiosis I	Meiosis II	Neither
Nuclear membrane breaks down		P	P	P	
Sex cells result				T	
Daughter cells are identical to parent		T			
Body cells result		T			
Chromatids line up single file during metaphase		M			
Final chromosome # is the same as the parent cell		T			
Diploid cells result at end		T			
Homologous chromosomes join			P		
Tetrads form			P		
DNA is replicated	S Phase				
Chromosomes are double file			P		
Cytokinesis begins		T	T	T	
Transcription / translation occur	G1, S, G2				
Spindle fibers form		P	P	P	
Haploid Cells Result				T	
Sister chromatids separate		A		A	
Crossing over happens			P		

- nondisjunction – failure of homologous chromosomes to separate during meiosis
    - if nondisjunction occurs, abnormal numbers of chromosomes may find their way into gametes, and a chromosome disorder may result (e.g. down syndrome, 3 chromosomes at 21st pair)

Remember this is likely to happen during anaphase of meiosis I. More serious effects in sex cells since non-disjunction will affect every cell in the new organism.

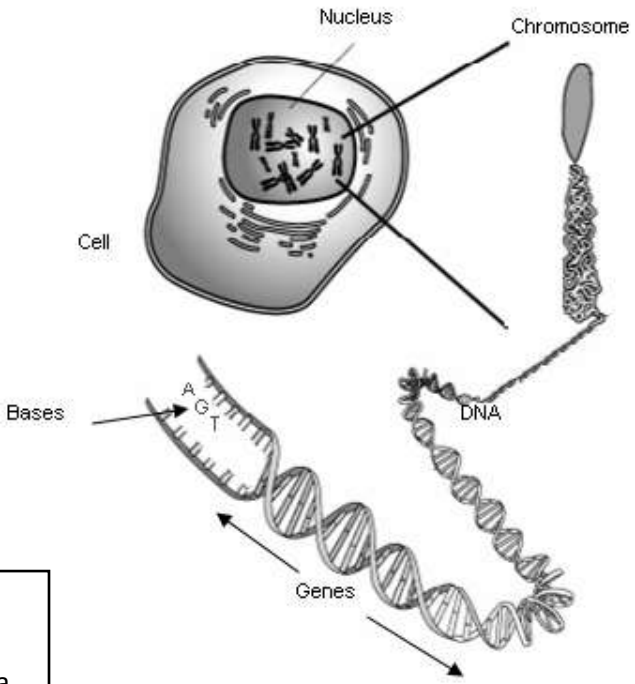
Main Concept #3: Describe how the process of DNA replication results in the transmission and/or conservation of genetic information.

- DNA Replication – copying of DNA
  - Ensures that each resulting cell will have a complete set of DNA molecules
  - During DNA replication, the DNA molecule separates into two strands, then produces two new complementary strands following the rules of base pairing. Each strand of the double helix of DNA serves as a template against which the new strand is made → called **semiconservative replication**



Main Concept #4: Explain the functional relationships between DNA, genes, alleles, and chromosomes and their roles in inheritance.

- Conclusions from Mendel's experiments with pea plants
  1. Inheritance is determined by "factors" that are passed from one generation to the next = **genes**
     - each gene controlled one trait with two contrasting characters
     - different forms of a gene = **alleles**
  2. Principle of dominance – states that some alleles are **dominant** and others are **recessive**
     - organism with dominant allele for a particular form of a trait will always have that form (ex. T=tall)
     - organism with two recessive alleles for a particular form of a trait will have that form only (tt = short)
  3. Segregation – separation of alleles
     a. During formation of gametes (sex cells) each allele is separated



DNA is a molecule that carries genetic codes which determine the sequence of amino acids in proteins

A **gene** is a specific segment of the DNA molecule that codes for a specific protein – EX: eye color

A **chromosome** is a whole bunch of genes linked together into an organized structure (eukaryotes it is linear / prokaryotes it is circular)

An **allele** is a form of a gene – meaning that it will continue to do what is asked (make eye color) but it has different information – blue eyes, brown eyes, hazel eyes…)
TT = alleles are alike

Tt = alleles are different

Main Concept #5: Describe and/or predict observed patterns of inheritance (ie. dominant, recessive, co-dominance, incomplete dominance, sex-linked, polygenic, and multiple alleles).

4. Probability – likelihood that a particular event will occur
    a. Probability of two events happening, you multiply the individual probabilities
        i. Past outcomes do not affect future ones
    b. The principles of probability can be used to predict the outcomes of genetic crosses
5. Punnett square – diagram that helps determine gene combinations that might result from a genetic cross
6. Capital letters represent dominant alleles; lower case letters represent lower case letters
7. Homozygous – have two identical alleles – true-breeding
8. Heterozygous – have two different alleles – hybrid – carrier
9. Phenotype – physical feature (attached or detached earlobes)
10. Gentoype – genetic make-up (EE or Ee or ee – represent genes)

11. for two genes, alleles segregate independently
    a. independent assortment – genes segregate independently and do not influence each other's inheritance
        i. the principle of independent assortment states that genes for different traits can segregate independently during the formation of gametes
12. some alleles are neither dominant nor recessive, and many traits are controlled by multiple alleles or multiple genes
    a. incomplete dominance (RedXWhite = pink) – one allele is not completely dominant over another
        i. heterozygous phenotype is somewhere between two homozygous phenotypes
    b. codominance (AB blood type, sickle cell) – both alleles contribute to the phenotype of the organism
        i. heterozygous phenotypes have some of both homozygous phenotypes
    c. multiple alleles (blood type – ABO) – genes that have more than 2 possible alleles
    d. sex linked traits (colorblindness, hemophilia) – traits from genes carried on X or Y chromosomes, genes on X usually occur at a higher rate in boys, females can be carriers and males cannot.
    e. polygenic traits (height, skin color, hair color) – traits that result from the interaction of many genes
        i. these traits are also greatly influenced by the environment

Monohybrid Cross

1. Two fish meet at the coral reef, fall in love, and get married that same night. They decide to make babies right away. The mom fish has a big fluffy tail (TT) while the dad has a very boring flat tail (tt). The dad is worried that he will pass his ugly tail down to his kids. What is the chance that the first child will have a flat tail?

T = fluffy tail t = flat tail Cross TT X tt

Tt	Tt
Tt	Tt

Genotypic Ratio: _____All alike_____ Phenotypic Ratio: ___All fluffy_____

Incomplete Dominance:

1. In Japanese four-o'clocks, the gene for red flower color (R) is incompletely dominant over the white flower color(r). For each of the following situations, predict the genotypic and phenotypic ratios of a red plant crossed with a white plant.

RR – Red

Cross = RR X R'R'

RR' = pink

Answer should be all pink (RR') when punnett is complete

R'R' = white

Codominance

1. The palomino horse is a hybrid (mix) showing a golden coat with a lighter mane and tail. A pair of codominant alleles, D1 and D2 is known to be involved in this trait. Horses with the D1D1 genotype are chestnut colored, horses with the D1D2 genotype are palomino, and horses with the D2D2 genotype are white in color.

   A. Two palomino horses mate by artificial insemination. What types of offspring could be produced?

D1D2 = palomino

D1D1 = Chestnut

Cross D1D2 X D1D2

D2D2 = white

Phenotypes = 2 palomino, 1 chestnut, 1 white

Sex-Linked Traits

1. White eyed fruit flies are the result of a sex-linked recessive gene. Show the results from a cross between a red-eyed (R) male and white-eyed (r) female fruit fly.

Cross = female X^rX^r x male X^RY

Two carrier females with Red eyes (X^RX^r)

Two male white eyed (X^rY)

Remember males inherit X's from mother and cannot be carriers.

Main Concept #6: Explain how genetic engineering has impacted the fields of medicine, forensics, and agriculture (e.g., selective breeding, gene splicing, cloning, genetically modified organisms, gene therapy).

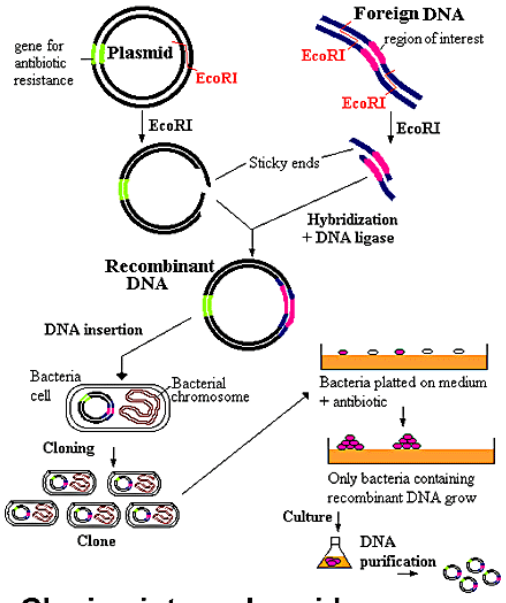
13. selective breeding – allowing only those animals with desired characteristics to produce the next generation

a. humans use selective breeding to pass desired traits on to the next generation of organisms (pure bred dogs, domestic livestock, etc.)

14. genetic engineering – making changes in the DNA code of living organisms
15. Cutting / Splicing DNA (recombinant)
    a. Restriction enzymes – cuts DNA at a specific sequence of nucleotides
    b. cutting and pasting
        i. recombinant DNA – taking DNA and "pasting" it to another organism's DNA (usually pasted into a plasmid from bacteria)

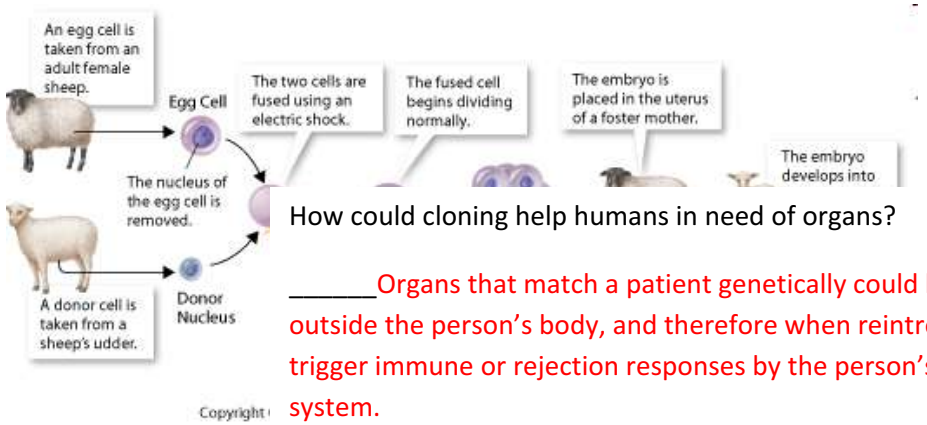
Why would scientists want to recombine a human gene for growth hormone or insulin with a plasmid? What benefit is provided?

_____Recombinant DNA provides a way to manufacture proteins like insulin or antibodies quickly and in large quantities so these proteins can be used to treat patients that can't manufacture the proteins on their own.



Cloning into a plasmid

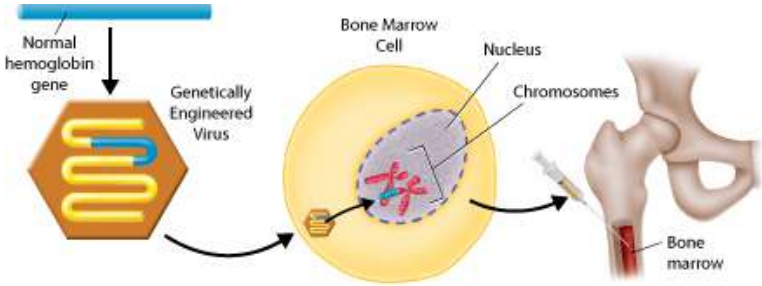
16. transgenic organisms /genetically modified organisms– organisms that contain genes from other organisms
    a. using the basic techniques of genetic engineering, a gene from one organism can be inserted into cells from another organism. These transformed cells can then be used to grow new organisms
17. clone –genetically identical organism or cells produced from a single cell



How could cloning help humans in need of organs?

_____Organs that match a patient genetically could be cloned outside the person's body, and therefore when reintroduced not trigger immune or rejection responses by the person's immune system.

18. gene therapy is the process of attempting to cure genetic disorders by placing copies of healthy genes into cells that lack them
19. DNA fingerprinting – Cutting and separating DNA so repeats in the genetic code that are unique to individuals can be compared for the purpose of identification



On the lines below, write T *next to an example of a transgenic organism, and* C *next to an example of a clone.*

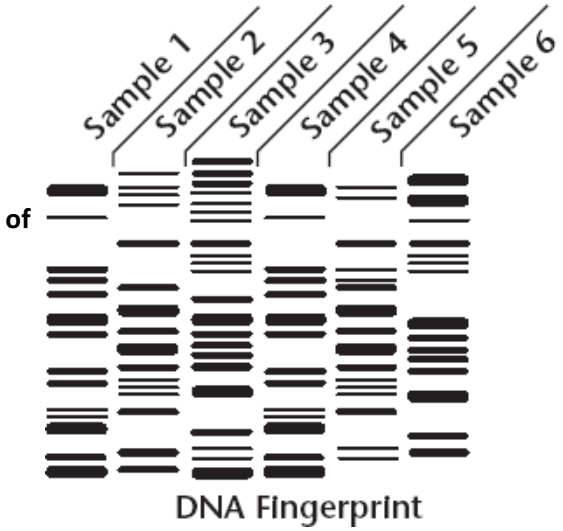
___T__1. A goat that produces spider's silk in its milk

___T__2. A plant that is grown from a cell into which *Agrobacterium* has incorporated recombinant DNA

___C__3. A lamb that is born with the same DNA as a donor cell

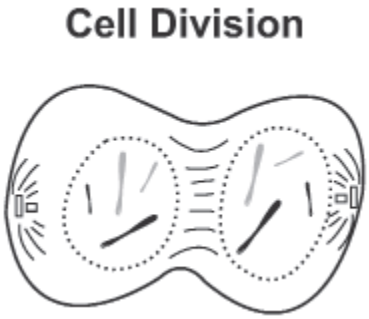
___C__4. A colony of bacteria that grows from one bacterium

___T__5. A bacterium that can produce human insulin



Which two samples might be from a set of identical twins? _____1 and 4_____

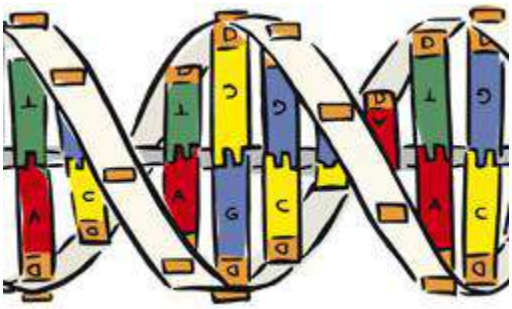
Practice Questions:



1. Which statement **best** describes the phase of the cell cycle shown?
   A. The cell is in prophase of mitosis because the number of chromosomes has doubled.
   B. The cell is in prophase I of meiosis because the number of chromosomes has doubled.
   C. The cell is in telophase of mitosis because the cell is separating and contains two copies of each chromosome.
   D. The cell is in telophase of meiosis because the cell is separating and contains two copies of each chromosome.

2. Mitosis and meiosis are processes by which animal and plant cells divide. Which statement **best** describes a difference between mitosis and meiosis?
   A. Meiosis is a multi-step process.
   B. Mitosis occurs only in eukaryotic cells.
   C. Meiosis is used in the repair of an organism.
   D. Mitosis produces genetically identical daughter cells.

Suppose that the central C-G base pair in the DNA molecule below is substituted by an A-T base pair.



3. What is the most likely result of this mutation?
   a. genetic variation
   b. genetic clones
   c. incomplete translation
   d. identical offspring

4. Hemophilia is an inheritable genetic disorder that prohibits the proper formation of blood clots. The recessive gene that causes hemophilia is located on the X-chromosome. Given this information, which of the following statements is true?
    a. In order for a male offspring to be a hemophiliac, his mother must be a hemophiliac.
    b. In order for a female offspring to be a hemophiliac, her father must be a hemophiliac.
    c. In order for a male offspring to be a hemophiliac, his father must be a hemophiliac.
    d. In order for a female offspring to be a hemophiliac, her mother must be a hemophiliac.

5. Which of the following statements is true?
    a. Mitosis results in the formation of two haploid gametes which can then combine to form a diploid daughter cell.
    b. During the process of meiosis, haploid cells are formed. After fertilization, the diploid number of chromosomes is restored.
    c. The process of meiosis forms daughter cells which are genetically identical to their parent cells.
    d. The daughter cells formed during mitosis are genetically similar to, though not identical to, their parent cell.

6. In a flowering plant species, red flower color is dominant over white flower color. What is the genotype of any red-flowering plant resulting from this species?
    A. red and white alleles present on one chromosome
    B. red and white alleles present on two chromosomes
    C. a red allele present on both homologous chromosomes
    D. a red allele present on at least one of two homologous chromosomes

7. Which of the following best describes the way that genes, chromosomes, and DNA are related?
    a. Chromosomes contain several genes, which are made up of sequences of DNA.
    b. Genes contain several chromosomes, which are made up of sequences of DNA.
    c. Genes contain several sequences of DNA, which are made up of chromosomes.
    d. Sequences of DNA contain several genes, which are made up of chromosomes.

8. If a cat has 38 chromosomes in each of its body cells, how many chromosomes will be in each daughter cell after mitosis?
    a. 19
    b. 76
    c. 11
    d. 38

9. Tom is going to buy two hamsters. He wants to breed them and sell the baby hamsters to a local pet store. The store owner tells him that his customers prefer dark brown hamsters with white bellies, long fur, black eyes, and long tails. Tom found a female hamster with all of those characteristics. Which male hamster should Tom buy in order to have the BEST chance of breeding baby hamsters with MOST of those characteristics?

Hamster W	**Hamster X**	**Hamster Y**	**Hamster Z**
Tan Fur Dark	Brown Fur	Tan Fur	Dark Brown Fur
White Belly	White Belly	White Belly	Dark Brown Belly
Long Fur	Long Fur	Short Fur	Long Fur
Long Tail	Long Tail	Long Tail	Short Tail
Brown Eyes	Brown Eyes	Black Eyes	Black Eyes

    a. W
    b. Z
    c. Y
    d. X

Use the table below to answer the question.

Blood Types

Genotypes	Phenotypes
ii	O
I^AI^A, I^Ai	A
I^BI^B, I^Bi	B
I^AI^B	AB

10. Blood type is inherited through multiple alleles, including I^A, I^B, and i. A child has type A blood. If the father has type AB blood, what are all the possible phenotypes of the mother?
    A. phenotypes O or A
    B. phenotypes A or AB
    C. phenotypes A, B, AB
    D. phenotypes O, A, B, AB

11. Genetic engineering has led to genetically modified plants that resist insect pests and bacterial and fungal infections. Which outcome would **most likely** be a reason why some scientists recommend caution in planting genetically modified plants?
    A. unplanned ecosystem interactions
    B. reduced pesticide and herbicide use
    C. improved agricultural yield and profit
    D. increased genetic variation and diversity

12. A cell in the process of cell division contains the normal chromosome number. Each chromosome consists of two identical sister chromatids. During which stages and processes can such a cell exist?
    A. telophase of mitosis, but no stage of meiosis
    B. metaphase of mitosis, but no stage of meiosis
    C. anaphase I of meiosis and anaphase of mitosis
    D. prophase I of meiosis and prophase of mitosis

13. Which statement correctly describes the alleles for any gene in a female cat's body cell?
    A. they have the same DNA sequence, but are located on separate chromosomes
    B. They have different DNA sequences, but are located on the same chromosome
    C. They may have the same or different DNA sequences, but are located on the same chromosome
    D. They may have the same or different DNA sequences, but are located on separate chromosomes

14. A child has type O blood. If the child's mother has type A blood, what are all the possible genotypes and phenotypes of the father?
    A. ii only
    B. ii and I^Ai
    C. ii, I^Ai, and I^Bi
    D. ii, I^Ai, I^AI^A, and I^Bi

15. The gene for seed shape in pea plants has two alleles, resulting in either smooth or wrinkled peas. A pea plant with one smooth allele and one wrinkled allele produces only smooth peas. Based on this information, which conclusion can be drawn?

A. both alleles are codominant
B. one allele is incompletely dominant
C. the allele for smooth seeds is recessive
D. the allele for wrinkled seeds is recessive

16. Fruit flies normally have red eyes. A recessive allele causes some fruit flies to have purple eyes. Which statement describes the purple-eyed offspring of a red-eyed parent and a purple-eyed parent?
    A. The offspring has two recessive alleles located on the same chromosome
    B. The offspring has two chromosomes with a recessive allele present on each.
    C. The offspring has one dominant and one recessive allele located on the same chromosome
    D. The offspring has one chromosome with a dominant allele and one chromosome with a recessive allele.

17. A scientist uses enzymes to splice genetic DNA into a plasmid, and then inserts the plasmid into a cell. Which of the following is most likely an application of this process?
    A. producing an exact genetic clone of prized racehorse
    B. producing a vaccine against the human papillomavirus
    C. determining which of several rice varieties should be crossed
    D. determining whether a suspect's blood was present at a crime scene

18. Which of the following is not an example of genetic engineering?
    A. An agricultural scientist creates a hybrid stain of rice by crossing two rice varieties.
    B. A biology student inserts plant DNA into bacteria to determine its role in the cell cycle.
    C. A vaccine manufacturer inserts a plasmid containing a gene forma a virus into yeast cells.
    D. A medical researcher isolates a functional copy of a muscular dystrophy gene for gene therapy.

Open-ended Question:

19. A cattle farmer genetically crosses a cow (female) with a white coat with a bull (male) with a red coat. The resulting calf (offspring) is roan, which means there are red and white hairs intermixed in the coat of the calf. The genes for coat color in cattle are co-dominant.

Part A: Although a farm has cattle in all three colors, the farmer prefers roan cattle over white or red cattle. Use the Punnett square to show a cross that would produce only roan offspring.

Cross RR (red) X WW (white) = all roan

RW = Roan

RW	RW	
RW	RW	

Part B: Explain how a roan calf results from one white- and one red-coated parent. In your explanation, use letters to represent genes. Be sure to indicate what colors the letters represent.

_____

_____When gametes form in both cows the Red allele R separates from the other red allele in the bull and the white allele, W separates from the other white allele in the cow. These alleles are segregated into gametes (sperm and egg). When fertilization occurs red R, and White W, alleles combine in the offspring. Since the coat color genes are codominant both red and white alleles are expressed in the phenotype of the calf causing red and white hairs

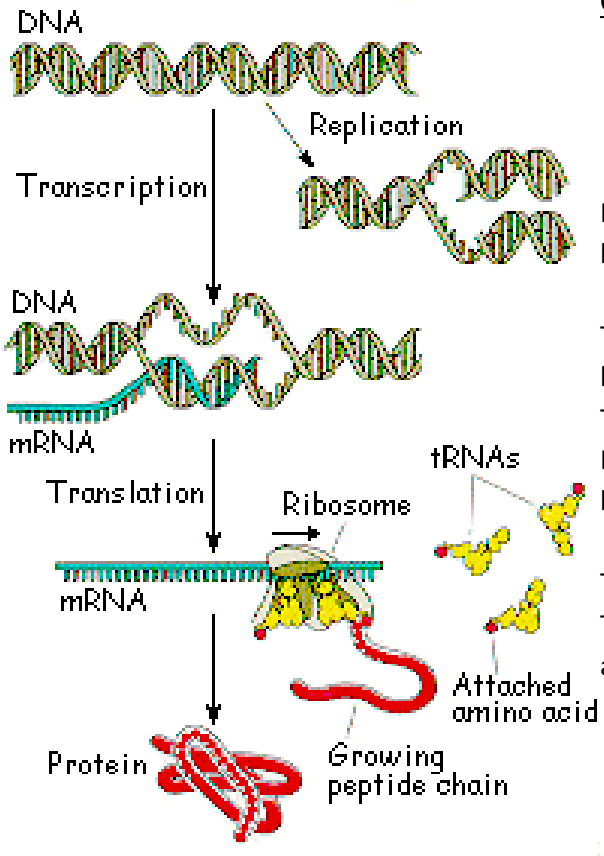
Part C: Predict the possible genotypes and phenotypes of the offspring produced from two roan cattle.

_____Cross RW X RW. The genotypes from this cross are RR, RW, and WW. Possible cow phenotypes will be red, roan and white.

Protein Synthesis

Vocabulary

Transcription
Translation
Translocation
Chromosomal mutation
Deoxyribonucleic acid
Frame-shift mutation
Gene expression
Mutation
Point mutation



Concepts to Know

The Central Dogma: How our DNA code makes our Phenotype
DNA → RNA → Protein

How are we so different? Why are we not identical to a plant? Or a bacterium? Or each other?

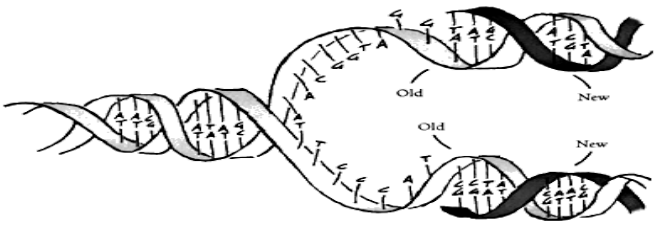
The DNA code is the same in all organisms but the sequence of the letters is different. All life uses A,C,T,G in double-stranded base pairs. This is the same concept that War and Peace is not identical to your IPod Warranty, but they're still written in English. DNA is just a language. A very, very, very important language.

This is why scientists can manipulate life in the laboratory so easily. This is also the key to understanding evolution from a single common ancestor.

DNA is the code of life –DNA is letters; codons are words; proteins are messages that make sense.

1st Idea: Life Contains DNA: it is a SELF-REPLICATING molecule.

DNA replicates itself (via DNA polymer**ase** and other enzymes) in ***a semi-conservative*** manner. This means that at the end of replication, each of the daughter molecules has one old strand, from the parent strand of DNA, and one strand that is newly synthesized. (see pic).

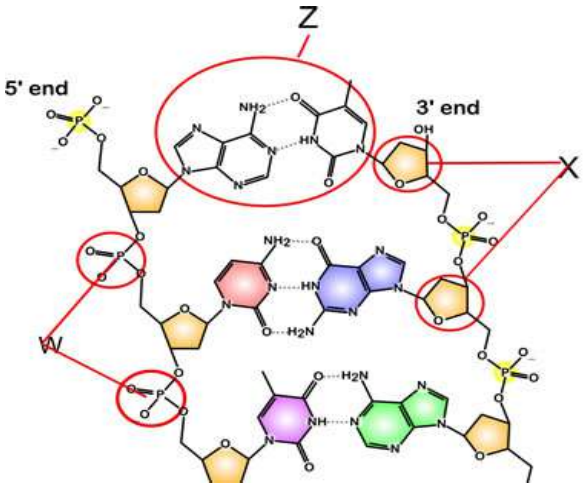


Adenine pairs with Thymine (A = T)
Guanine pairs with Cytosine (G = C)
The bonds between the base pairs are **hydrogen bonds**

If given the template strand of DNA below, what is the complementary sequence?

5' A T G T A T G C C A A T G C A 3'

3' T A C A T A C G G T T A C G T 5'

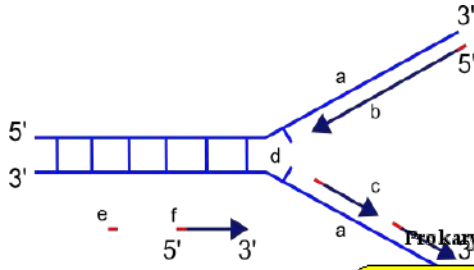


DNA STRUCTURE
Nucleic Acid (polymer) is made of nucleotides (monomer)

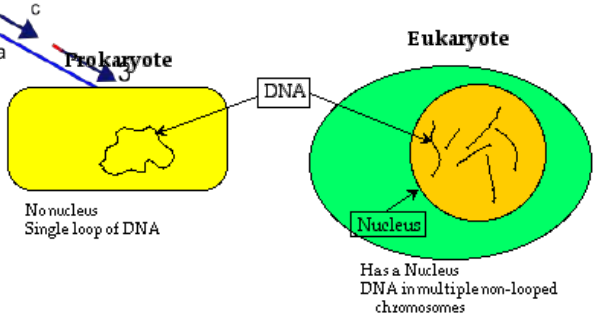
IDENTIFY EACH AS W, X, OR Z IN THE DIAGRAM
A nucleotide is made of: a. a sugar _X____,
b. a phosphate group__W___,
c. and a nitrogenous base __Z___.

I. DNA REPLICATION

DNA polymerase is an enzyme *(ends in –ase)*. **All enzymes have a specific active site.** The DNA in this example is the substrate and only can fit into the enzyme (DNA polymerase) a certain way. This is why DNA replication has a **leading** and a **lagging** strand when made. The enzyme can only fit onto DNA via the 3' hydroxyl side, not the 5' phosphate side.



What letter in this diagram represents the *continuous* leading strand? __b____
What letter represents the Okazaki *fragments* of the lagging strand? _c_____



EUKARYOTES

II. PROKARYOTES VS

Prokaryotes ("before nucleus") evolved before eukaryotes ("true nucleus") and have slight differences in their DNA structure.

2nd Idea: DNA is the source message but RNA is the working copy

MAJOR DIFFERENCES BETWEEN DNA AND RNA

DNA	RNA
deoxiribose sugar	ribose sugar
thymine	uracil
double helix	single strand (mRNA) or unit (tRNA)
permanent	temporary
in nucleus (some in mitochondria)	leaves nucleus, works in cytoplasm
one kind	many kinds (at least 3)

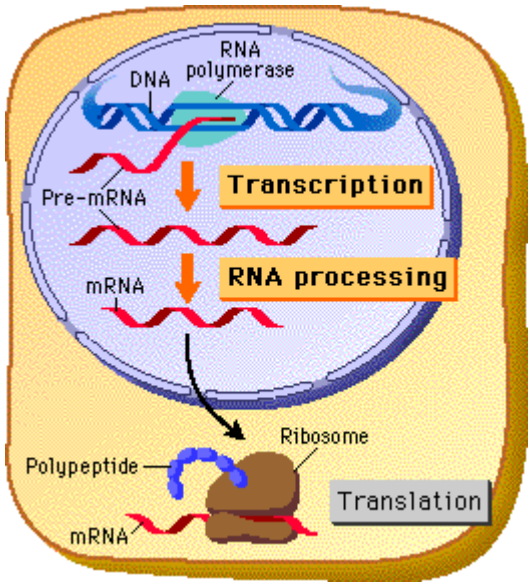
The DNA is like the encyclopedia you can never check out of the library. However, you are allowed to make copies of the information. That's what RNA is – a copied message of the important pages. Making copies ensures that you don't 'ruin' the original by taking it out of the nucleus (*this only applies to eukaryotes*), you can make copies in bulk, AND you only have to make copies of what you need. You wouldn't copy all 6000 pages of an encyclopedia would you? No! Only the 4-5 pages you might need for a report. In eukaryotes, we only code for ~ 2% of our DNA!

RNA (ribonucleic acid) is the intermediate between DNA and protein. It has slight differences to DNA.

TRANSCRIPTION is the process of making RNA from DNA (via the enzyme RNA polymer**ase**). This happens in the nucleus for eukaryotes, but would happen in cytoplasm for prokaryotes.

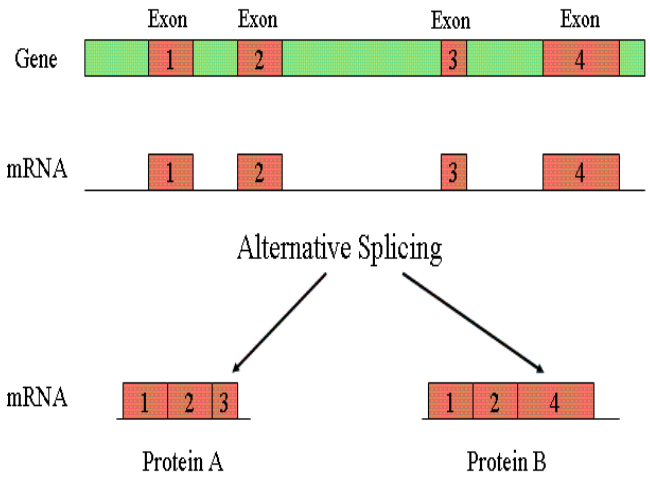
Can you complete this message?

T A C C C C T T T G G C A T A G A
A U G G G G A A_ A_ C_ C G_ U A U_C_ U__



Important Points about TRANSCRIPTION: **DNA → RNA** → Protein

- A single-stranded copy of RNA is made of the DNA gene, where **U is complementary to A instead of T.**
- **Transcription occurs in nucleus for eukaryotes.**
- Eukaryotic mRNA has **EXONS** (expressed message) and **INTRONS** (in-between message)
- Introns get spliced (cut out) of the mRNA to make the final mRNA.



3rd Idea: Translation is matching an amino acid to the mRNA in order to make the protein

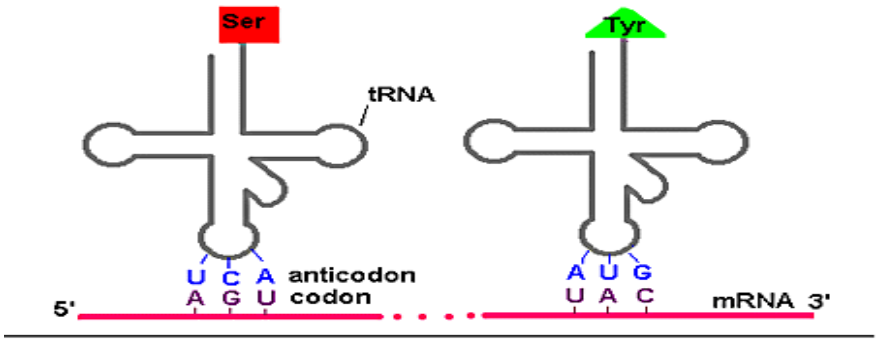
Important points about TRANSLATION

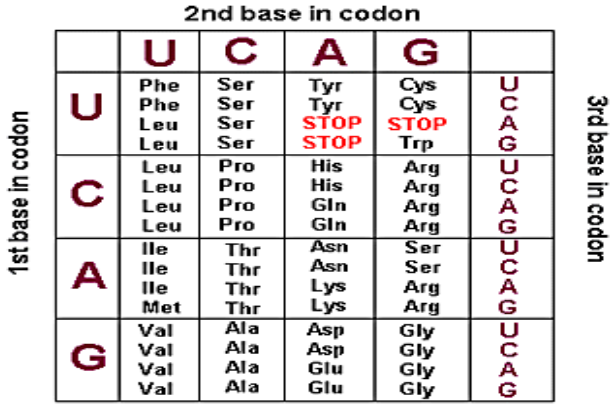
- The mRNA leaves the nucleus → cytoplasm *(in eukaryotes)*
- Message is read at the **ribosome**
- mRNA is read 3 letters at a time
- AUG is the start signal
- 1 Codon (3 letter message) is translated into 1 amino acid
- transferRNA molecule has one end (anticodon) that matches the mRNA . Each anticodon specifies an amino acid.
- There are 20 amino acids
- The amino acids are bonded together as peptide chains…which fold into proteins

If an mRNA transcript has 300 nucleotides, how many amino acids would that code for?

TRANSLATION :

DNA → **RNA → Protein**





The Genetic Code

Ex: the message AUGGGGCAAUAA codes for Met-Gly-Gln-*
(the * tells the ribosome to stop)

What does this message code for?

AUG CUU CCA GAG UGA

_ME_ _Leu_ Pro _Glu_ STOP___

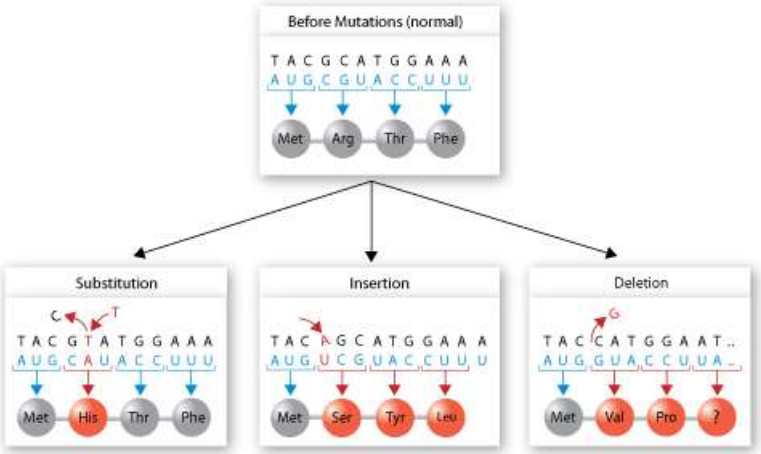
- After a polypeptide chain is made from amino acids (at a ribosome), it might be used right away in the cytoplasm, or it might be sent to the ER or Golgi apparatus to have more folding or carbohydrates added.
- Proteins made on free ribosomes will work in the cytoplasm
- Proteins made on the rough ER will go to the cell membrane or be excreted

4TH Idea: Mutations in the DNA or RNA sequence produce the wrong amino acid sequence.

*****The ultimate source of evolution is mutation*****

MUTATION : A change in DNA sequence

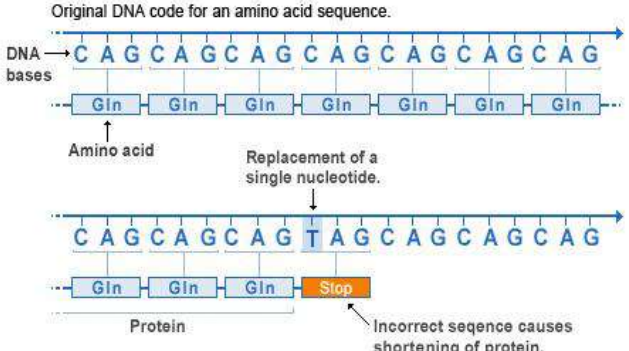
- **Point Mutations**: Change one or two base pairs
  - ➔ **Insertion, Deletion, Substitution**
    Deletion and insertion are "**frameshift mutations**" - that is, they change the codon reading frame.



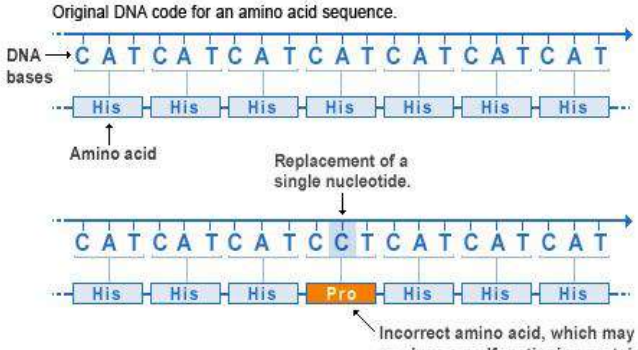
Other mutation vocabulary

- ➔ **Silent Mutation** - the mutation goes unnoticed – it does not change the amino acid sequence or is not in a coding region
- ➔ **Missense** – an insertion, deletion, or substitution that would make the message different
- ➔ **Nonsense** – really bad; a stop codon is created and the message stops prematurely

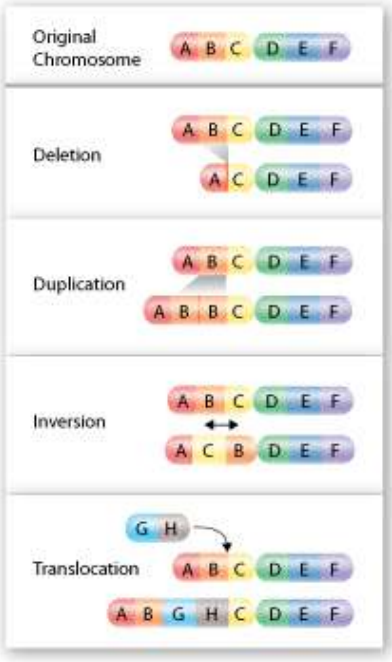
Nonsense mutation



Missense mutation



Chromosomal Mutations



- **Deletion:** The loss of all or part of a chromosome
- **Duplication:** A segment is repeated
- **Inversion:** part of the chromosome is reverse from its usual direction.
- **Translocation:** one chromosome breaks off an attaches to another chromosome.

Example: Remember that DNA and RNA are just a language. To emphasize the point of mutation, I am using English (an alphabet with 26 letters, not 4!) Imagine you have the following message:

THE CAT ATE THE RAT

Using the above bolded mutations, label the type of mutation each must be:

____Substitution_____ THE HAT ATE THE RAT

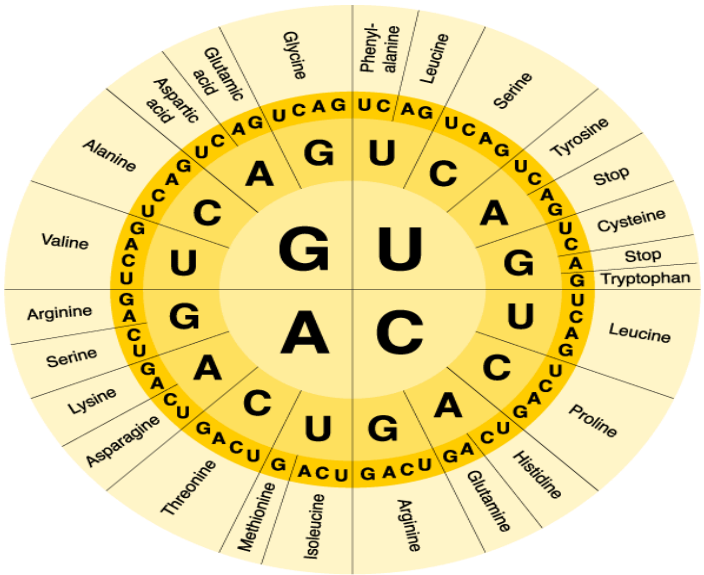
____Insertion_____ TTH EHA TAT ETH ERA T

____Deletion_____ THE ATA TET HER AT

The "Central Dogma of Biology" is summarized as:

___DNA_____ → ____RNA_____ → ___Protein_____

Fill in the chart:



DNA Triplet	mRNA Codon	tRNA Anticodon	Amino Acid
TAC	AUG	UAC	met
GGA	CCU	GGA	Pro
TTC	AAG	UUC	Lys
ATC	UAG	AUC	STOP

➔ ORDER THE FOLLOWING

__3___ Intron sequences are spliced out and exons are joined together

___7__ amino acids form peptide bonds as tRNA molecules match the mRNA

___2__ RNA polymerase reads the DNA and builds complimentary sequence

___5__ The mRNA attaches to the ribosome

__4___ The ends of the mRNA are protected before it leaves the nucleus

__1___ RNA polymerase finds the promoter sequence on DNA

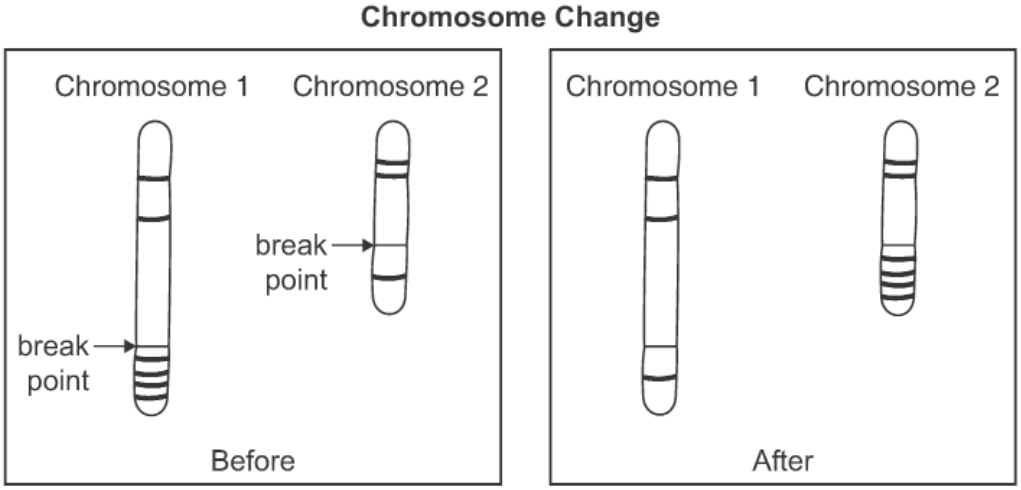
___6__ transfer RNA arrives at the ribosome and the anticodon complements to the mRNA codon

Practice Questions:

1. Which process helps to preserve the genetic information stored in DNA during DNA replication?
   A. the replacement of nitrogen base thymine with uracil
   B. enzymes quickly linking nitrogen bases with hydrogen bonds
   C. the synthesis of unique sugar and phosphate molecules for each nucleotide
   D. nucleotides lining up along the template strand according to base pairing rule

2. The endoplasmic reticulum is a network of membranes within the cell, and it is often classified as rough or smooth, depending on whether there are ribosomes on its surface. Which statement **best** describes the role of rough endoplasmic reticulum in the cell?
   A. It stores all proteins for later use.
   B. It provides an attachment site for larger organelles.
   C. It aids in the production of membrane and secretory proteins.
   D. It stores amino acids required for the production of all proteins.

Use the diagram below to answer the question.

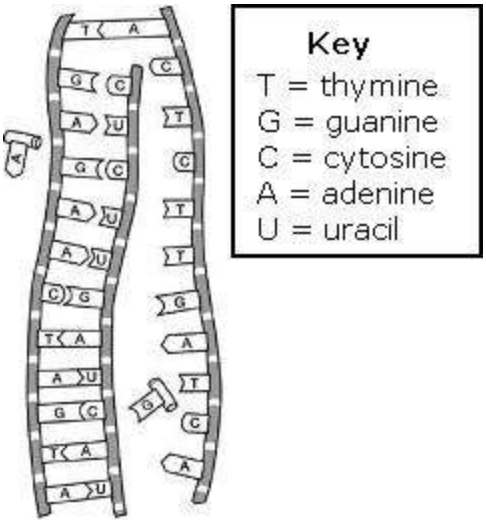


3. Which type of change in chromosome composition is illustrated in the diagram?
   A. deletion
   B. insertion
   C. inversion
   D. translocation

4. Which statement describes a cell process that is common to both eukaryotic and prokaryotic cells?
   A. Both cell types carry out transcription in the nucleus.
   B. Both cell types use ribosomes to carry out translation.
   C. Both cell types assemble amino acids to carry out transcription.
   D. Both cell types carry out translation in the endoplasmic reticulum.

5. A genetic mutation resulted in a change in the sequence of amino acids of a protein, but the function of the protein was not changed. Which statement **best** describes the genetic mutation?
   A. It was a silent mutation that caused a change in the DNA of the organism.
   B. It was a silent mutation that caused a change in the phenotype of the organism.
   C. It was a nonsense mutation that caused a change in the DNA of the organism.
   D. It was a nonsense mutation that caused a change in the phenotype of the organism.

6. Which of the following is primarily responsible for the coding of the amino acids used in the synthesis of cellular proteins?
   A. DNA
   B. transfer RNA
   C. ribosomes
   D. Golgi apparatus



7. Which statement describes the diagram above?
    a. DNA transcription is producing ribosomal RNA.
    b. DNA translation is producing messenger RNA.
    c. DNA transcription is producing messenger RNA.
    d. DNA translation is producing ribosomal RNA.

8. Which organelle is not involved in the synthesis and secretion of a protein from the cell?
    a. ribosome.
    b. Smooth ER.
    c. Golgi apparatus.
    d. Plasma membrane.

9. Which pair consists of terms that represent equivalent units of information?
    a. Codon : DNA
    b. Gene : polypeptide
    c. Chromosome : protein
    d. Nucleotide : amino acid

10. A tRNA molecule with which of the following anticodons would be able to bind to a molecule of lysine (has codons AAA or AAG)?
    a. TTT
    b. TTC
    c. AAA
    d. UUC

11. Suppose all of the ribosomes in a cell were destroyed. How would this most likely affect the process of gene expression?
    a. The DNA double strand would be unable to separate.
    b. The cell would be unable to form mRNA strands.
    c. The amino acids could not be joined to form a protein.
    d. The tRNA molecules would bind to the wrong amino acids.

Open-ended Question:

12. Consider the process of gene expression in a eukaryotic cell.

Part A: Describe two similarities between transcription and translation:

Could have any of the following four things:

Both transcription and translation involve the transfer of genetic information from one form to another

Bot involve enzymes that join monomers (nucleotides and amino acids) to form polymers (mRNA and protein).

Both rely on complementary base pairing (mRNA with DNA and tRNA with mRNA).

Bot rely on functions carried out by RNA (mRNA, rRNA and tRNA).

Part B: Describe two differences between transcription and translation

__Transcription takes place in the nucleus while translation takes place in the cytoplasm of a eukaryotic cell. Transcription produces mRNA from nucleotides while translation produces proteins or polypeptide chains from amino acids.

Part C: Identify one difference between the synthesis of proteins used within the cell and the synthesis of proteins that will be secreted from the cell.

_____Proteins that will be sued within the cell are synthesized by the loose ribosomes in the cytoplasm. Proteins that are to be secreted are synthesized by ribosomes bound to the rough ER.