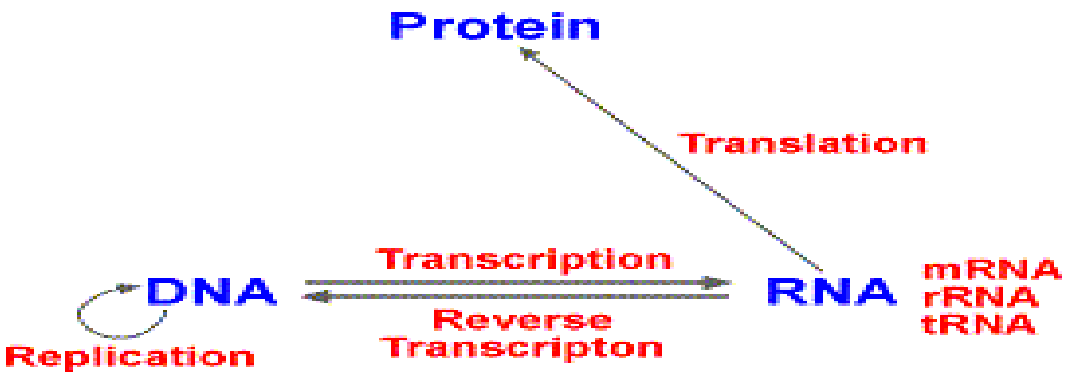
DESIGNER GENES: PRACTICE –MOLECULAR-GENETIC GENETICS

CENTRAL DOGMA OF MOLECULAR GENETICS



1. Where is DNA housed in Eukaryotic Cells?

2. What two cytoplasmic organelles in Eukaryotic cells have their own DNA?

3. How does this organelle DNA differ from the nuclear DNA on the chromosomes?

4. What is the process which produces new DNA?

5. What is a gene?

6. What is the normal sequence of events that allows the genetic code of DNA to be used in producing a protein?

7. What is the name of this sequence of events which results in the production of a protein?

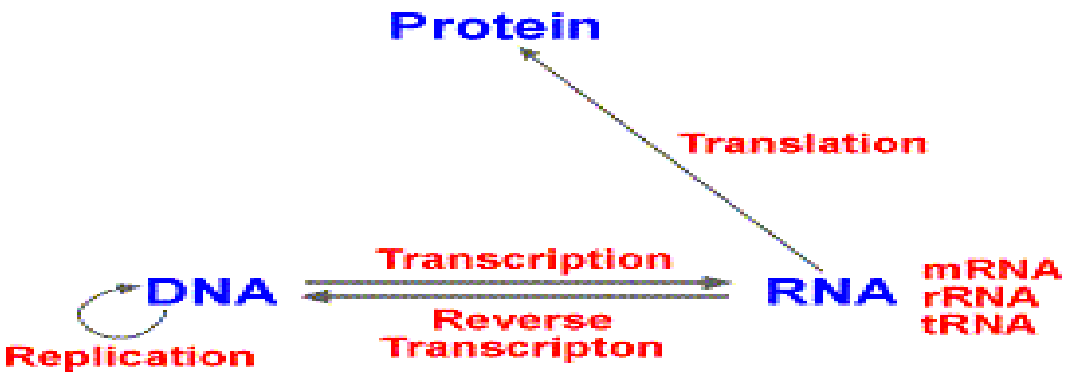
8. What is Reverse Transcription?

9. When does Reverse Transcription occur?

10. How can Reverse Transcription be used in Biotechnology?

DESIGNER GENES: PRACTICE –MOLECULAR-GENETIC GENETICS

CENTRAL DOGMA OF MOLECULAR GENETICS



1. Where is DNA housed in Eukaryotic Cells?
   most is stored in the nucleus on the chromosomes, also in 2 cytoplasmic organelles
2. What two cytoplasmic organelles in Eukaryotic cells have their own DNA?
   mitochondria and chloroplast
3. How does this organelle DNA differ from the nuclear DNA on the chromosomes?
   nuclear DNA is linear while the organelle DNA is circular (like Prokaryotes)
4. What is the process which produces new DNA?
   replication
5. What is a gene?
   a segment of DNA that contains the blueprint to produce a protein or segment of a protein or RNA
6. What is the **normal** sequence of events that allows the genetic code of DNA to be used in producing a protein?
   DNA → transcription of RNA → transcription of protein (central dogma of molecular biology states that all genetic information flows in one direction: from DNA to RNA through the process of transcription, and then from RNA to protein through the process of translation
7. What is the name of this sequence of events which results in the production of a protein?
   transcription
8. What is Reverse Transcription?
   where RNA is used as the coding template for making new DNA
9. When does Reverse Transcription occur?
   with certain viruses as retroviruses – some eukaryotic cells retrotransposons utilize reverse transcriptase or RNA-dependent DNA polymerase to move from one position to another in the genome via an RNA intermediate
10. How can Reverse Transcription be used in Biotechnology?
    It is used to Clone Expressed Genes in Association with PCR

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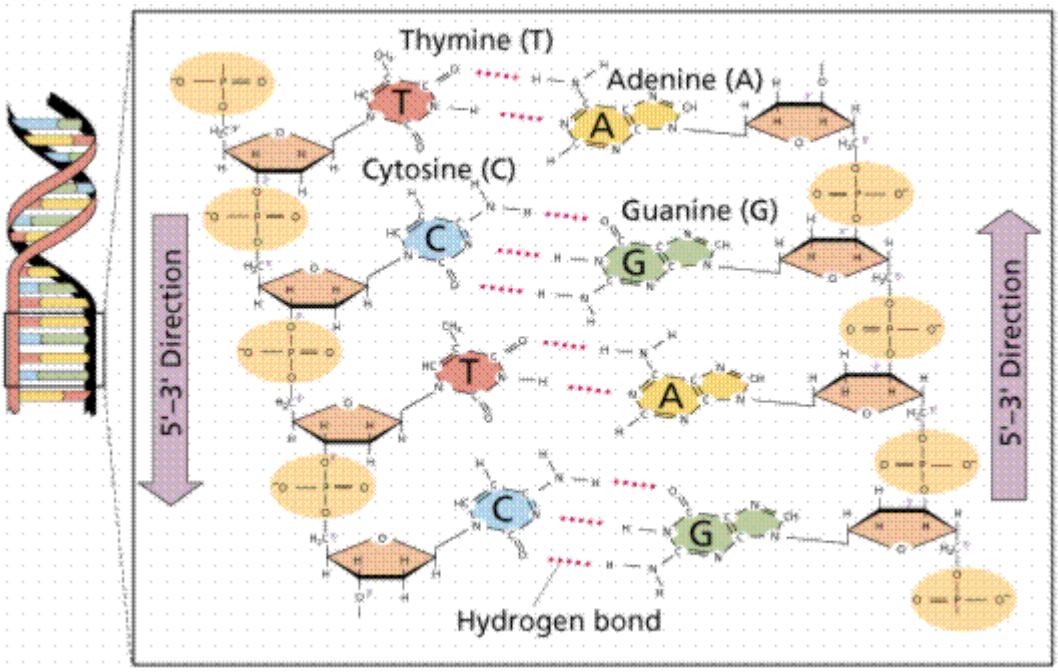
DNA STRUCTURE



1. What is the shape of the DNA molecule?

2. What makes up the backbone of the DNA molecule?

3. What makes up the step of the staircase?

4. What are the four bases of DNA?

5. What is a purine base? Which are the purines bases?

6. What is a pyrimidine base? Which are the pyrimidines bases?

7. What bonds with Adenine?

8. What always bonds with Cytosine?

9. What type of bonds hold the nitrogen bases together?

10. The DNA molecule is called antiparallel. What does this mean?

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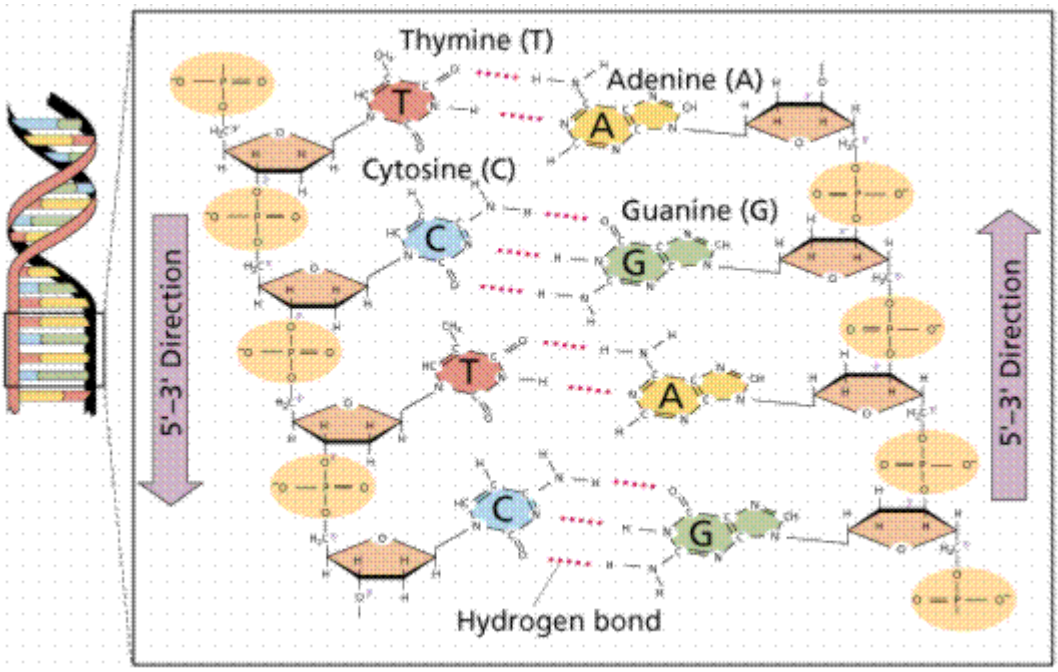
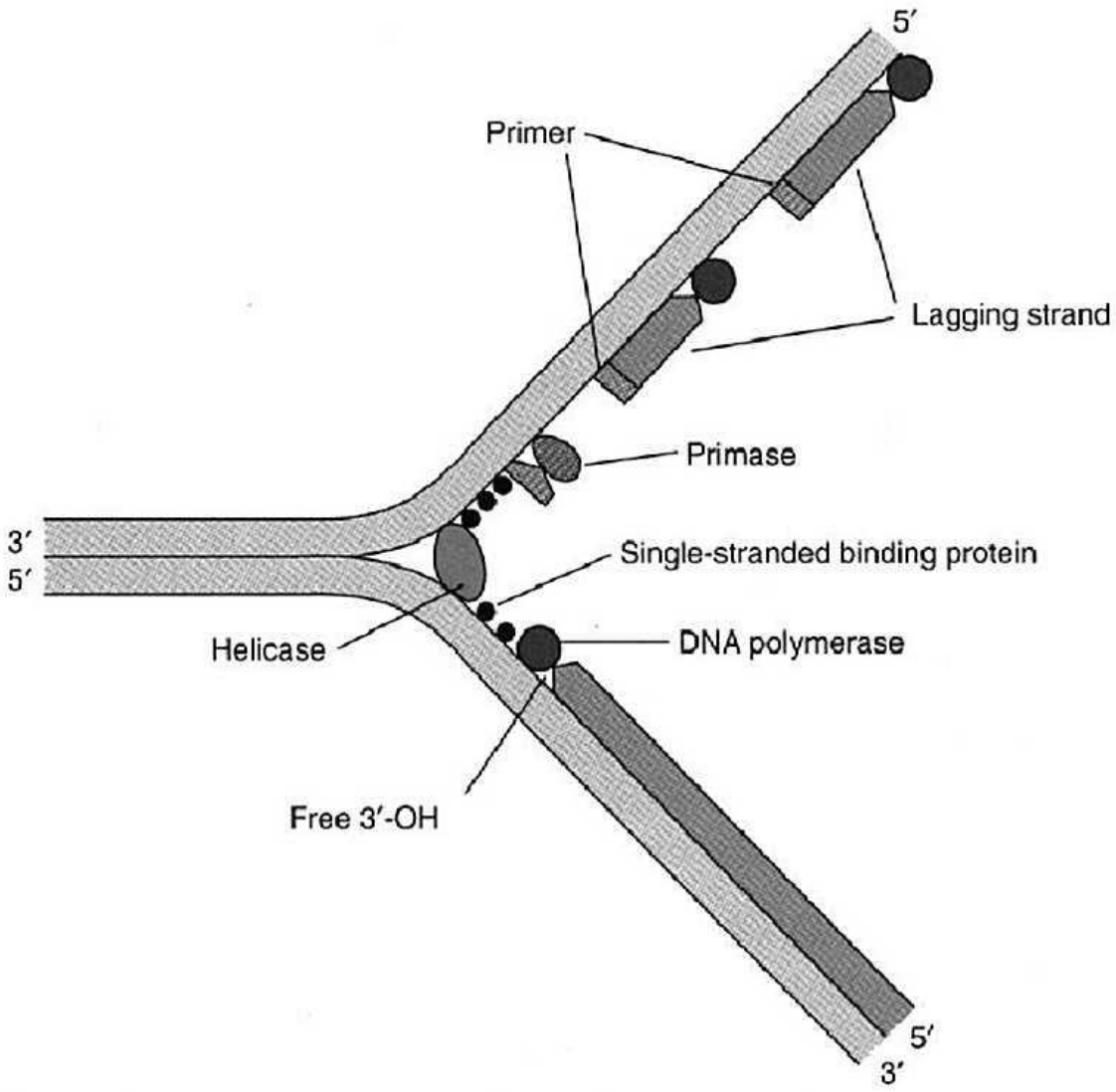
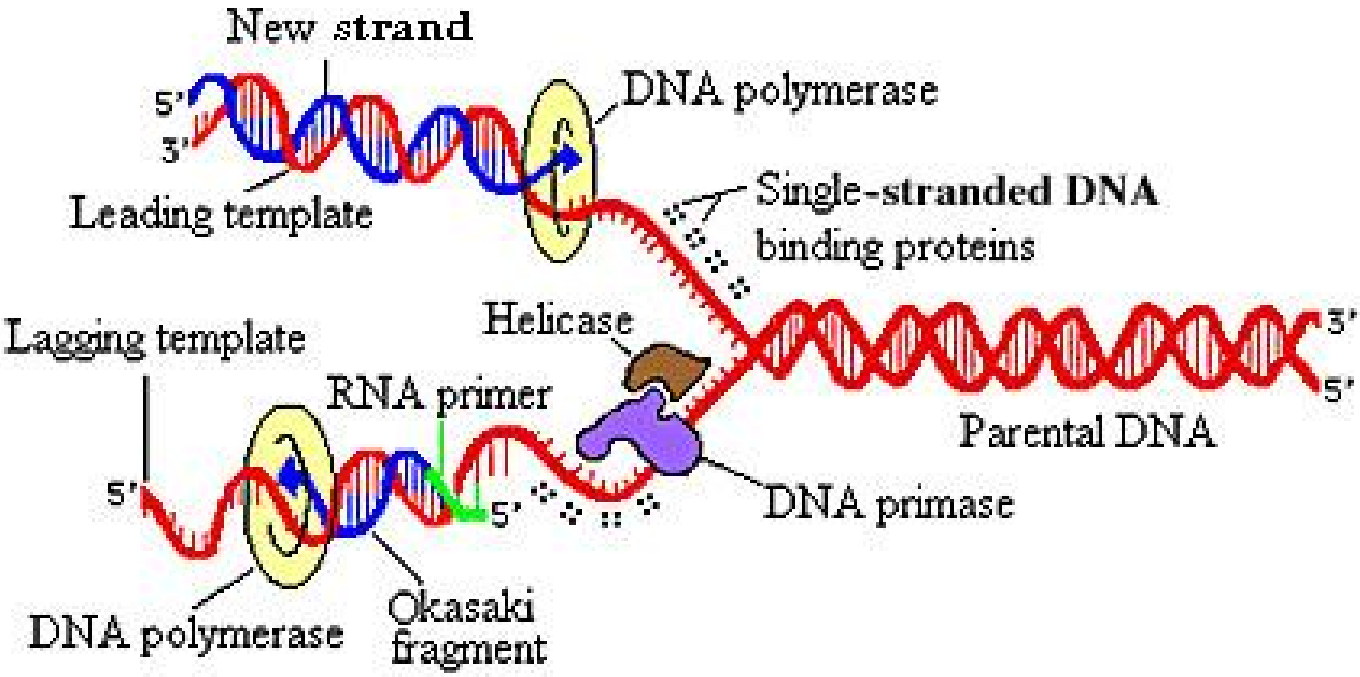
DNA STRUCTURE



1. What is the shape of the DNA molecule?
   double helix
2. What makes up the backbone of the DNA molecule?
   alternating molecules of the 5 carbon sugar *deoxyribose* and phosphate
3. What makes up the step of the staircase?
   nitrogen base pairs
4. What are the four bases of DNA?
   adenine, thymine, guanine, and cytosine
5. What is a purine base? Which are the purines bases?
   nitrogen bases that have 2 nitrogen containing rings adenine and guanine
6. What is a pyrimidine base? Which are the pyrimidines bases?
   nitrogen bases that have 1 nitrogen containing ring thymine and cytosine
7. What bonds with Adenine?
   Thymine always bonds with Adenine T-A
8. What always bonds with Cytosine?
   Guanine always bonds with Cytosine G-C
9. What type of bonds hold the nitrogen bases together?
   hydrogen bonds A-T pair is held together by 2 hydrogen bonds,
   G-C pair is held together by 3 hydrogen bonds
10. The DNA molecule is called antiparallel. What does this mean?
    The two strands of DNA have opposite chemical polarity which means that their sugar- phosphate backbones run in opposite directions –
    one is 3' to 5' and the other is 5' to 3' (5' specifies the 5th carbon in the ribose ring, counting clockwise from the oxygen molecule, and 3' specifies the 3rd carbon in the ring)

DNA REPLICATION





Collaboration of Proteins at the Replication Fork

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DNA REPLICATION

1. What are the enzymes involved in DNA replication and what do they do?

2. Explain the process of DNA replication

3. A section of the template is 3ô ATACATGACCCCGGTAGCATT 5ô
   List the sequence for the complementary strand which will be produced?

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DNA REPLICATION

1. What are the enzymes involved in DNA replication and what do they do? **(see DIAGRAMS)**

   - ***Topoisomerase*** **is responsible for initiation of the unwinding of the DNA by eliminating the supercoiling.**
   - ***Helicase*** **accomplishes unwinding of the original double strand, once supercoiling has been eliminated by the topoisomerase.**
   - ***DNA polymerase*** **proceeds along a single-stranded molecule of DNA, recruiting free dNTP's (deoxy-nucleotide-triphosphates) to hydrogen bond with their appropriate complementary dNTP on the single strand (A with T and G with C), and to form a covalent phosphodiester bond with the previous nucleotide of the same strand -- DNA polymerases cannot start synthesizing de novo on a bare single strand. It needs a primer with a 3'OH group onto which it can attach a dNTP. DNA polymerase also has proofreading activities, so that it can make sure that it inserted the right base, and nuclease (excision of nucleotides) activities so that it can cut away any mistakes it might have made.**
   - ***Primase*** **attaches a small RNA primer to the single-stranded DNA to act as a substitute 3'OH for DNA polymerase to begin synthesizing from. This RNA primer is eventually removed and the gap is filled in by DNA polymerase (I).**
   - ***Ligase*** **can catalyze the formation of a phosphodiester bond given an unattached but adjacent 3'OH and 5'phosphate. This can fill in the unattached gap left when the RNA primer is removed and filled in.**
   - ***Single-stranded binding proteins*** **are important to maintain the stability of the replication fork. Single-stranded DNA is very labile, or unstable, so these proteins bind to it while it remains single stranded and keep it from being degraded**.

2. Explain the process of DNA replication
   - **DNA uncoils and splits**
   - **template strand is read 3' to 5'**
   - **new complementary strand must add new nucleotides to the 3' end – leading strand (continuous) while lagging strand is fragments (Okazaki fragments) latter attached with the enzyme ligase**

3. A section of the template is 5ô ATACATGACCCCGGTAGCATT 3ô
   List the sequence for the complementary strand which will be produced?

   3' TATGTACTGGGGCCATCGTAA 5'

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DNA & RNA

1. List the major differences between DNA & RNA

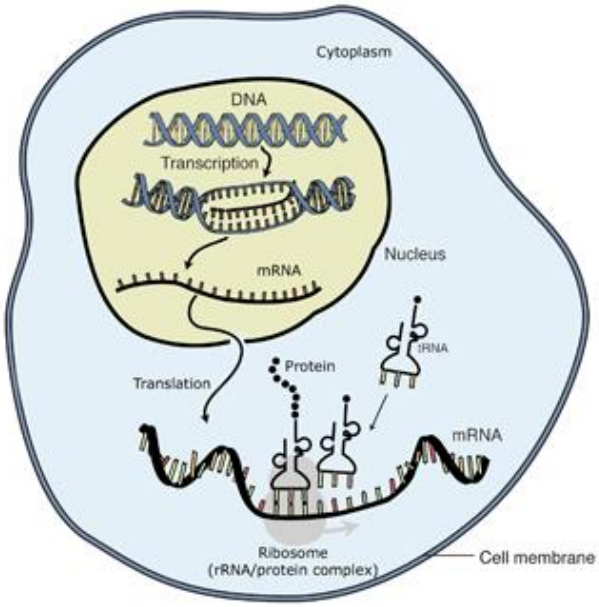

Image adapted from: National Human Genome Research Institute.

2. Where is DNA produced and what is the name of the process which produces new DNA?

3. Where is RNA produced and what is the name of the process which produces RNA from DNA?

4. What are the three types of RNA and what do they do?

5. Where do the three types of RNA function in the production of proteins and what is the process called ?

DESIGNER GENES: PRACTICE –MOLECULAR-GENETIC GENETICS

DNA & RNA

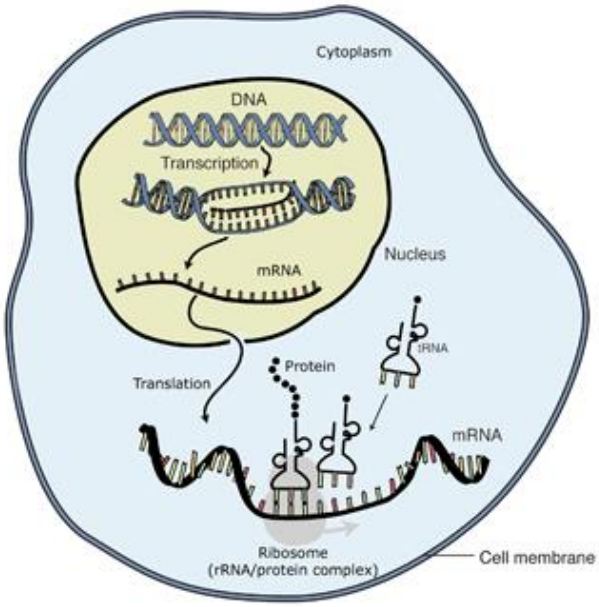

Image adapted from: National Human Genome Research Institute.

1. List the major differences between DNA & RNA

   - **RNA is single strand - DNA is double strand**
   - **RNA has Ribose – DNA has Deoxyribose**
   - **RNA has Uracil – DNA has Thymine**

2. Where is DNA produced and what is the name of the process which produces new DNA?

   DNA is produced in the nucleus by Replication

3. Where is RNA produced and what is the name of the process which produces RNA from DNA?

   RNA is produced in the nucleus by using the template from DNA by Transcription

4. What are the three types of RNA and what do they do?

   - **Messenger RNA (m-RNA)** ï carries genetic code from DNA into cytoplasm
   - **Transfer RNA (t-RNA)** ï brings the amino acids for building of protein to be attached according to the genetic code of the M-RNA
   - **Ribosomal RNA (r-RNA)** ï make up the ribosome and reads the code of M-RNA and allow T-RNA to attach and connect amino acids

5. Where do the three types of RNA function in the production of proteins and what is the process called ?

   In the cytoplasm during the process of translation when proteins are produced

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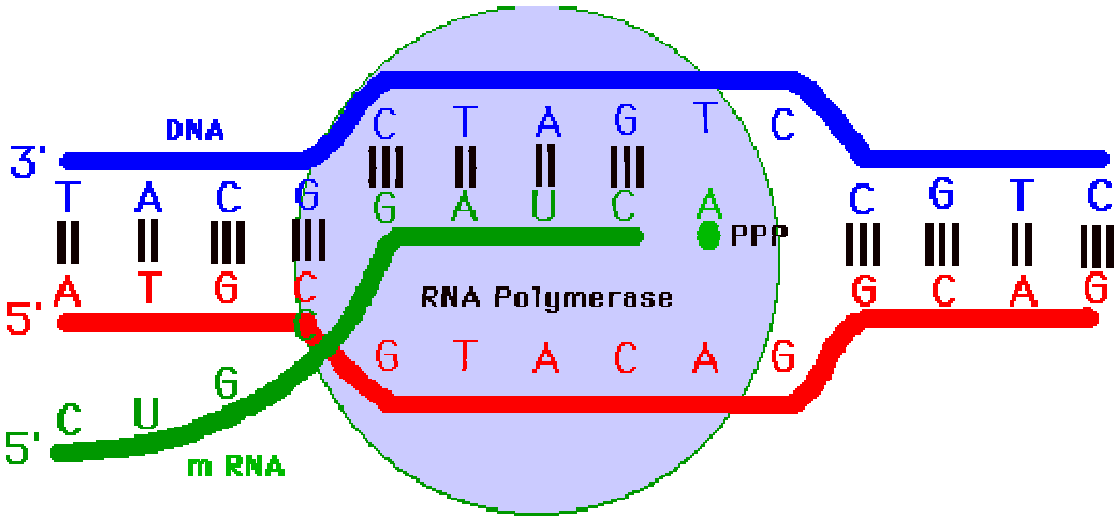
RNA TRANSCRIPTION



1. Explain the process of RNA production by DNA via transcription**.**

2. For the DNA template of 3ô ATACATGAGCCCGGTAGCATT 5ô, what m-RNA sequence will be produced?

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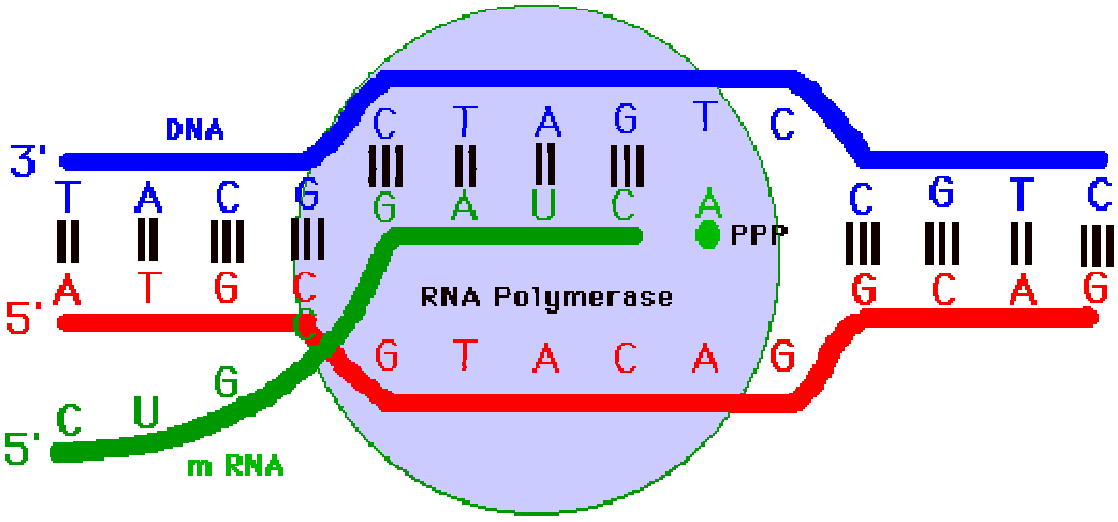
RNA TRANSCRIPTION



1. Explain the process of RNA production by DNA via transcription.

- **a section of DNA double helix is uncoiled**
- **only one of the DNA strands serves as a template for RNA polymerase enzyme to guide the synthesis of RNA**
- **The DNA template is read 3' to 5' and the RNA strand is produced 5' to 3'**
- **The RNA nucleotides being assembled will also have Ribose instead of Deoxyribose along with the phosphate s in the backbone of the RNA**
- **One major difference is that the adenine, on DNA codes for the incorporation of uracil in RNA rather than thymine as in DNA.**
- **After the synthesis is complete, the RNA separates from the DNA and the DNA recoils into its helix.**
- **The RNA will remain a single strand**

2. For the DNA template of 3ô ATACATGAGCCCGGTAGCATT 5ô, what m-RNA sequence will be produced?

5'UAUGUAUCGGGCCAUCGUAA 3'

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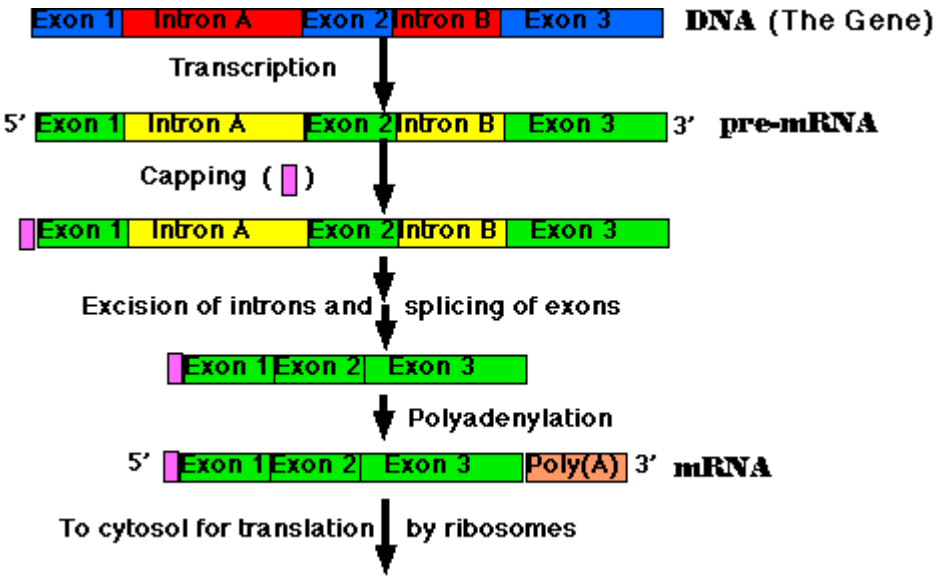
POST-TRANSCRIPTION MODIFICATION OF RNA



Explain the modifications taking place with RNA in the above diagram.

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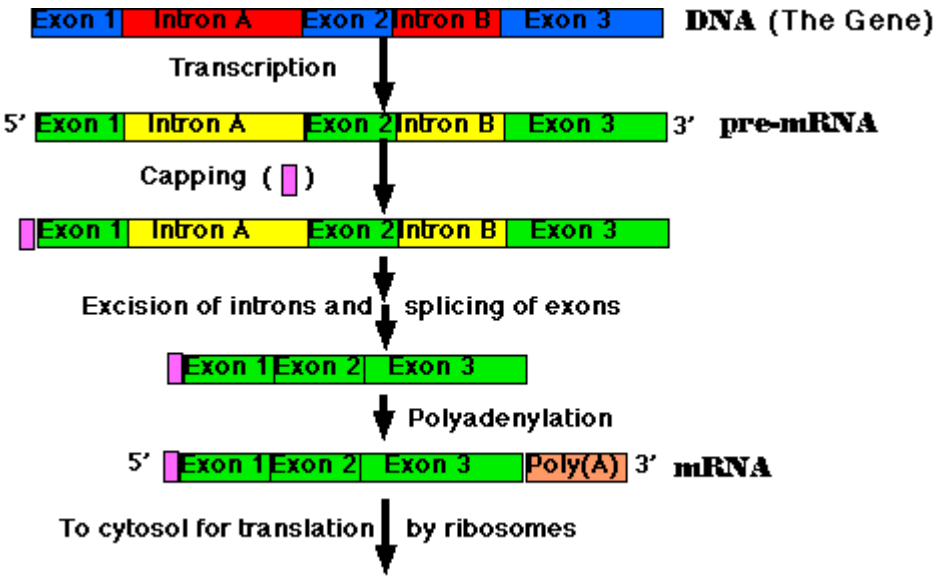
POST-TRANSCRIPTION MODIFICATION OF RNA



Explain the modifications taking place with RNA in the above diagram.

- **In eukaryotes, RNA polymerase produces a "primary transcript", an exact RNA copy of the gene.**
- **A cap is put on the 5' end.**
- **The RNA is terminated and poly-A is added to the 3' end.**
- **All introns are spliced out.**
- **At this point, the RNA can be called messenger RNA. It is then transported out of the nucleus into the cytoplasm, where it is translated.**

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UNIVERSAL CODE:

First position (5' end)	U	C	A	G	Third position (3' end)
U	UUU Phe UUC Phe UUA Leu UUG Leu	UCU Ser UCC Ser UCA Ser UCG Ser	UAU Tyr UAC Tyr UAA Stop UAG Stop	UGU Cys UGC Cys UGA Stop UGG Trp	U C A G
C	CUU Leu CUC Leu CUA Leu CUG Leu	CCU Pro CCC Pro CCA Pro CCG Pro	CAU His CAC His CAA Gln CAG Gln	CGU Arg CGC Arg CGA Arg CGG Arg	U C A G
A	AUU Ile AUC Ile AUA Ile AUG	ACU Thr ACC Thr ACA Thr ACG Thr	AAU Asn AAC Asn AAA Lys AAG Lys	AGU Ser AGC Ser AGA Arg AGG Arg	U C A G
G	GUU Val GUC Val GUA Val GUG Val	GCU Ala GCC Ala GCA Ala GCG Ala	GAU Asp GAC Asp GAA Glu GAG Glu	GGU Gly GGC Gly GGA Gly GGG Gly	U C A G

Amino acid names:

Ala = alanine	Gln = glutamine	Leu = leucine	Ser = serine
Arg = arginine	Glu = glutamate	Lys = lysine	Thr = threonine
Asn = asparagine	Gly = glycine	Met = methionine	Trp = tryptophan
Asp = aspartate	His = histidine	Phe = phenylalanine	Tyr = Tyrosine
Cys = cysteine	Ile = Isolevcine	Pro = proline	Val = valine

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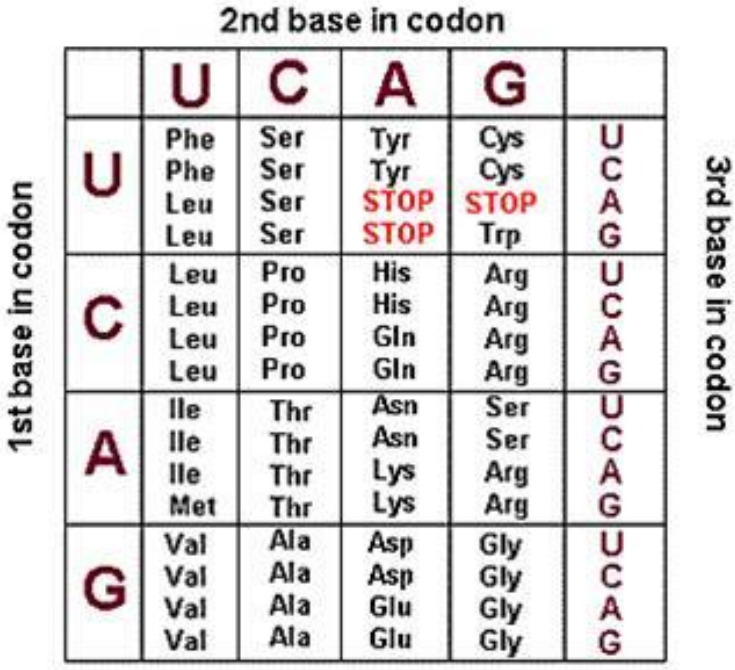
UNIVERSAL CODE



1st base	U	C	A	G	3rd base
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

1. The three base template on DNA is called what?

2. The three base template on m-RNA is called what?

3. The three base template on t-RNA is called what?

4. The Universal Code is for which type of nucleic acid template?

5. How many 3 letter templates are possible using 3 bases as a coding mechanism?

6. How many of these 3 letter templates actually serve as a coding mechanism for an amino acid?

7. Which of the codons serve as stop codes?

8. What would be the Stop Codes on DNA which produced these mRNA codons?

9. These codons serve as a coding mechanism for how many amino acids

10. For the m-RNA sequence **5' UAUGUAUCGGGCCAUCGUAAA 3'** list the sequence of amino acids along the peptide chain. (I have underlined every other codon to make it easier for your to read the codons)

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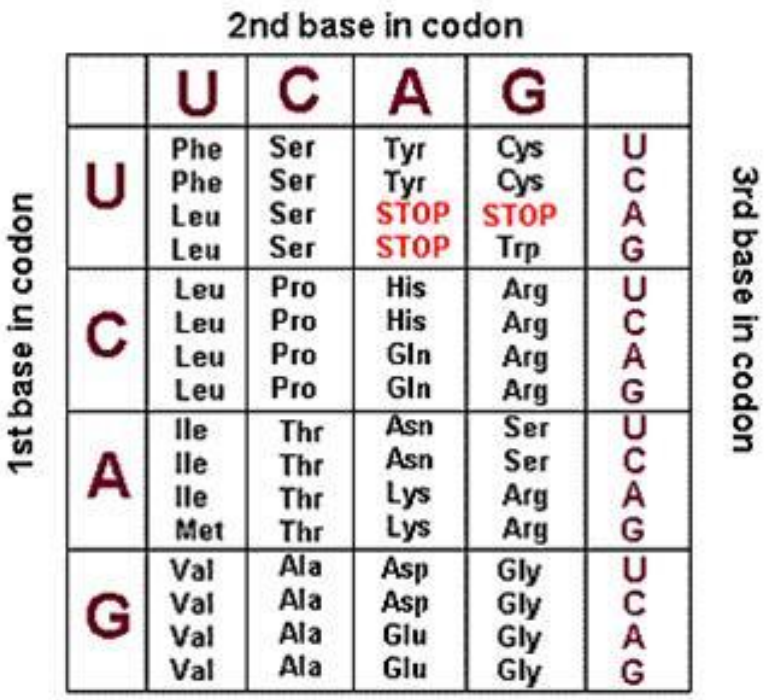
UNIVERSAL CODE

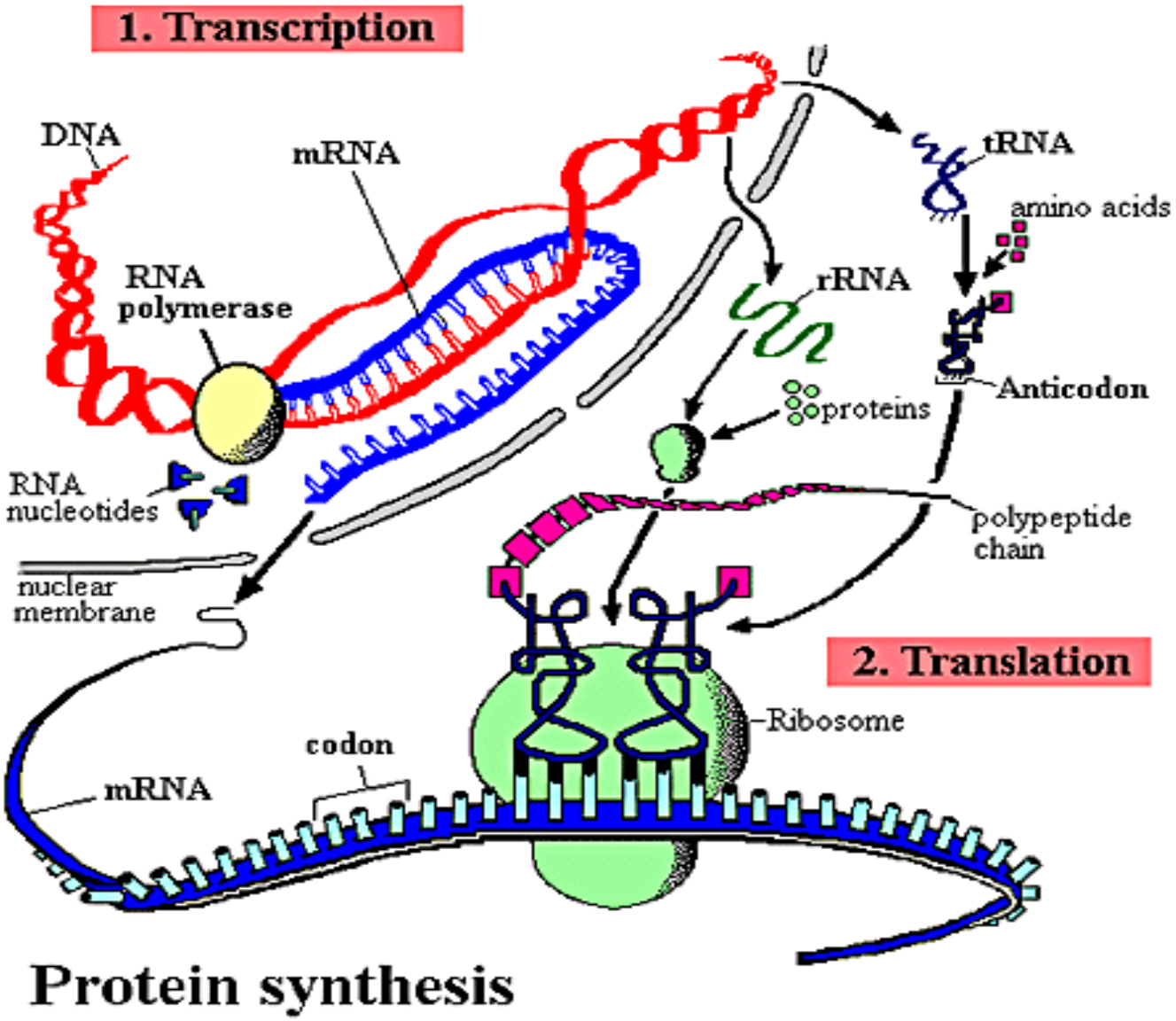


	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

1. The three base template on DNA is called what?
   code
2. The three base template on m-RNA is called what?
   codon
3. The three base template on t-RNA is called what?
   anticodon
4. The Universal Code is for which type of three base template?
   m-RNA
5. How many 3 letter templates are possible using 3 bases as a coding mechanism?
   64
6. How many of these 3 letter templates actually serve as a coding mechanism for an amino acid?
   61
7. Which of the codons serve as stop codes?
   UAA, UAG, UGA
8. What would be the Stop Codes on DNA which produced these mRNA codons?
   ATT, ATC, ACT
9. These m-RNA codons serve as a coding mechanism for how many amino acids
   20
10. For the m-RNA sequence **5' UAUGUAUCGGGCCAUCGUAAA 3'** list the sequence of amino acids along the peptide chain. (I have underlined every other codon to make it easier for your to read the codons)

    Tyr, Val, Ser, Gly, His, Arg, Lys
    tyrosine valine serine glycine histidine arginine lysine

TRANSLATION or PROTEIN SYNTHESIS



Protein synthesis

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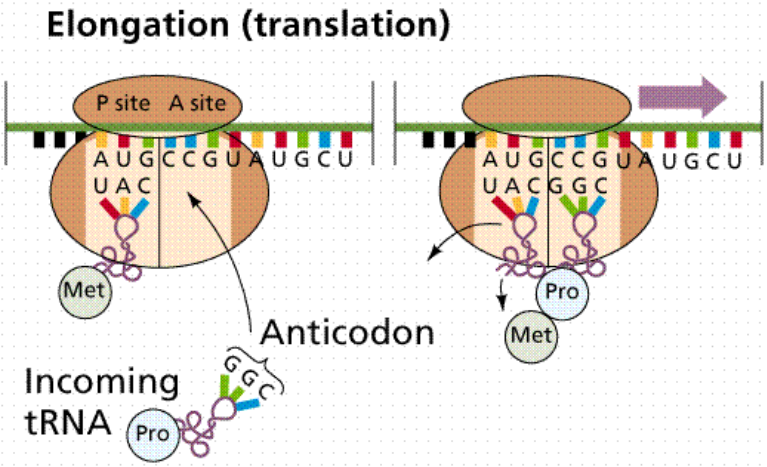
TRANSLATION or PROTEIN SYNTHESIS



Explain the three steps that take place during Translation or Protein Synthesis

1. Initiation

2. Elongation

3. Termination

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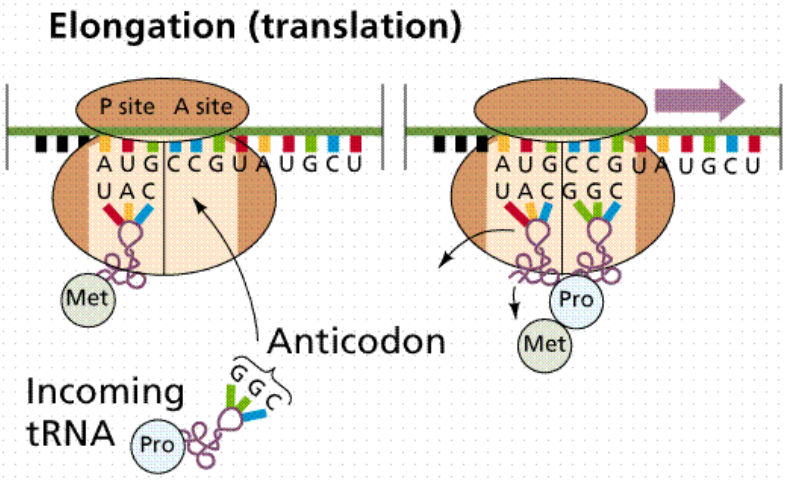
TRANSLATION or PROTEIN SYNTHESIS



Explain the three steps that take place during Translation or Protein Synthesis

1. **Initiation: a mRNA enters the cytoplasm and becomes associated with ribosomes (rRNA + proteins) and tRNAs, each carrying a specific amino acid, pair up with the mRNA codons inside the ribosomes. The base pairing (A-U, G-C) between mRNA codons and tRNA anticodons determines the order of amino acids in a protein.**

2. **Elongation: involves the addition of amino acids one-by-one: As the ribosome moves along the mRNA, each tRNA transfers its amino acid to the growing protein chain, producing the protein**

3. **Termination: when the ribosomes hits a stop codon - UAA, UGA, or UAG – no tRNA with its amino acid can be added so the ribosome falls apart and the process ends. The amino acid sequence is finished. The same mRNA may be used hundreds of times during translation by many ribosomes before it is degraded (broken down) by the cell.**

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CONTROL OF GENE EXPRESSION AND MUTATIONS

1. What 5 types of things control gene expression

2. What is a gene?

3. What is a mutation?

4. What are some of the agents which cause mutations?

5. What is the difference between a **gene mutation** and a **chromosomal mutation**?

6. What is the difference between a **point mutation** and a **frameshift mutation**?

7. What is nondisjunction?

8. What are trinucleotide repeats?

9. What is crossover?

10. What are defective genes?

DESIGNER GENES: PRACTICE –MOLECULAR-GENETIC GENETICS

CONTROL OF GENE EXPRESSION AND MUTATIONS

1. What 5 types of things control gene expression
   - **Transcriptional Control**
   - **Post transcriptional Control – assembling proteins**
   - **Cell differentiation and specialization**
   - **Turning genes "on" and "off"**
   - **Chemical Signals – Hormones**
   - **Chemical Modifications**
   - **Relocation of DNA – transposons**
   - **Abnormal Expression of Genes**

2. What is a gene?
   section of DNA with carries the blueprint for making a peptide strand or RNA

3. What is a mutation?
   changes in genetic code (DNA blueprint) of genes or chromosomes and causes changes in expression in the for making protein or RNA

4. What are some of the agents which cause mutations?
   radiation, chemicals, excess heat , viruses

5. What is the difference between a **gene mutation** and a **chromosomal mutation**?
   gene mutation affects just one gene on the chromosome while a chromosomal mutation affects the whole chromosome

6. What is the difference between a **point mutation** and a **frameshift mutation**?
   in a point mutation, one base is replaced by another base and in a frameshift mutation one or more bases is added or deleted resulting in the wrong codons being produced in the mRNA for protein synthesis

7. What is nondisjunction?
   the chromatids do not separate correctly during meiosis resulting in a gamete with a missing chromosome or an extra chromosome – this causes the individual to have an extra chromosome (triosomy) or a chromosome missing (monosomy)

8. What are trinucleotide repeats?
   sequences of 3 nucleotides is repeated, often several times in a gene, when too many repeats are formed – cause genetic disorders

9. What is crossover?
   during the tetrad formation in Prophase I of meiosis, as the chromatids are twisted together in synapse, pieces of chromosomes trade places and end up on a different chromosome This will affect gene frequency

10. What are defective genes? **genes that do not produce correct protein due to mutation**

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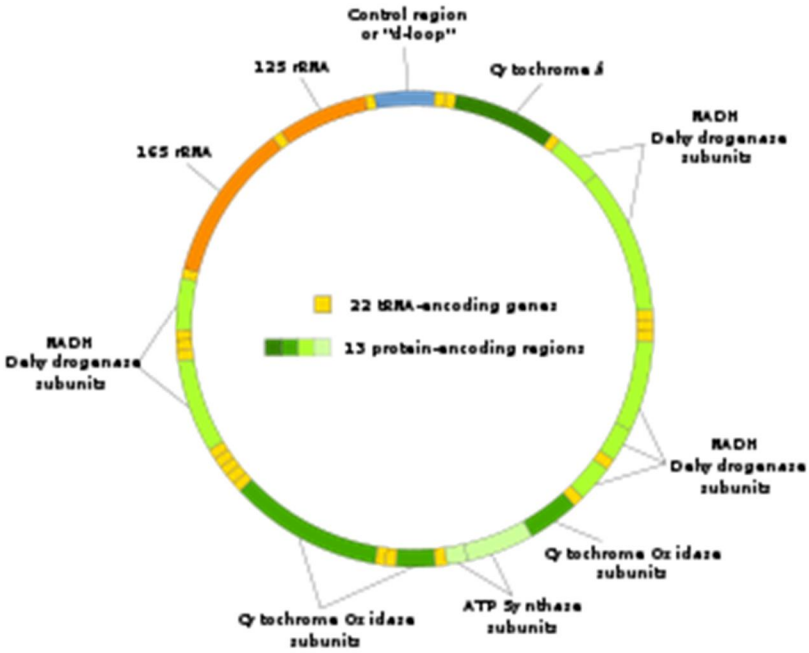
MITOCHONDRIAL INHERITANCE



1. What is the difference between chromosomal DNA and mitochondrial DNA?

2. Which parent provides the mitochondrial DNA or mtDNA?

3. What does the mitochondria do for the cell?

4. What is the advantage of the mitochondria having its own DNA?

5. Can mitochondrial disease be in either a male or a female?

4. If a person has a mitochondrial disease, from which parent is it inherited?

5. What are mitochondrial myopathies?

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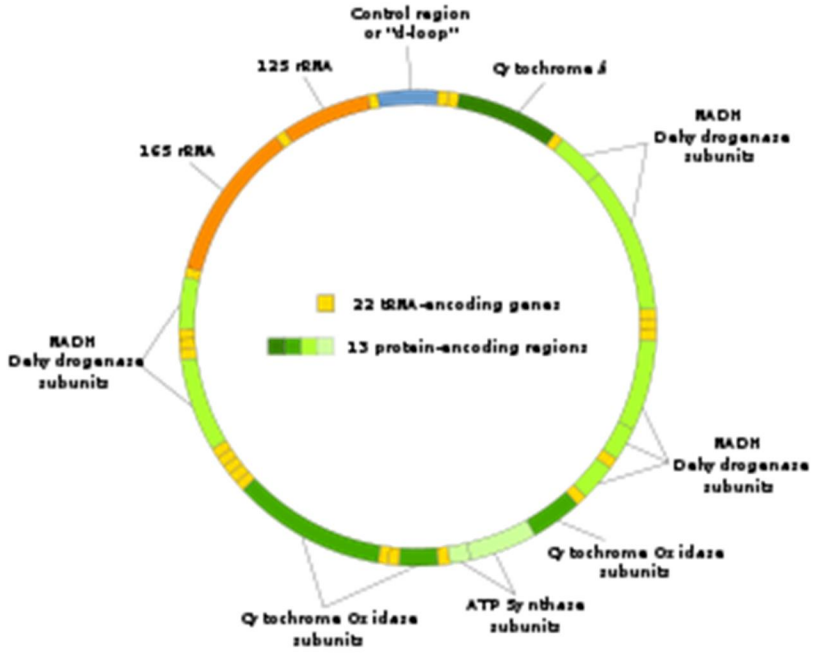
MITOCHONDRIAL INHERITANCE



1. What is the difference between chromosomal DNA and mitochondrial DNA?
   chromosomal DNA is linear with protein
   mitochondrial DNA is circular and resembles prokaryotic DNA

2. Which parent provides the mitochondrial DNA or mtDNA?
   mother

3. What does the mitochondria do for the cell?
   it is responsible energy production or is the powerhouse

4. What is the advantage of the mitochondria having its own DNA?
   the cell can produce more mitochondria without the whole cell reproducing

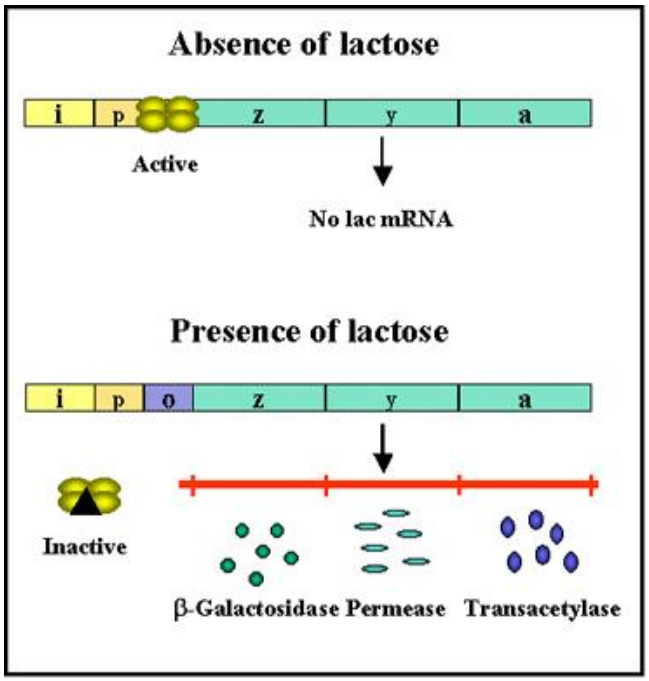
5. Can mitochondrial disease be in either a male or a female?
   yes, because both males and females inherit the mitochondrial genome

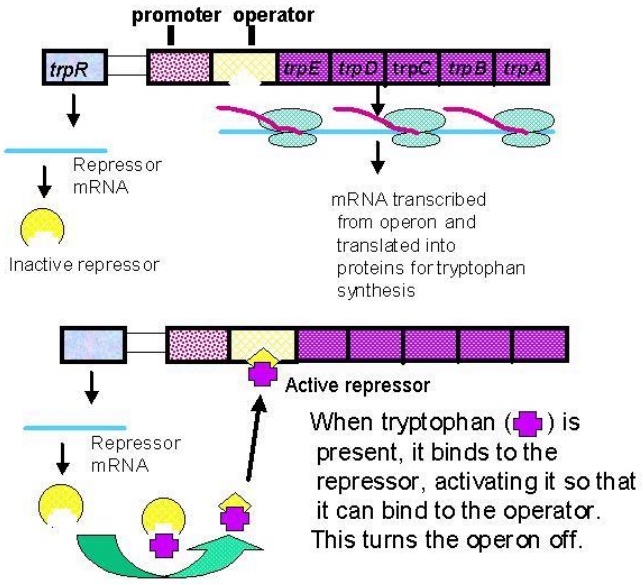
4. If a person has a mitochondrial disease, from which parent is it inherited?
   the mother because she provides the mitochondrial genome to the child

5. What are mitochondrial myopathies?
   a group of neuromuscular diseases caused by damage to the mitochondria-small, energy-producing structures that serve as the cells' "power plants."

DESIGNER GENES: PRACTICE –MOLECULAR-GENETIC GENETICS

OPERONS

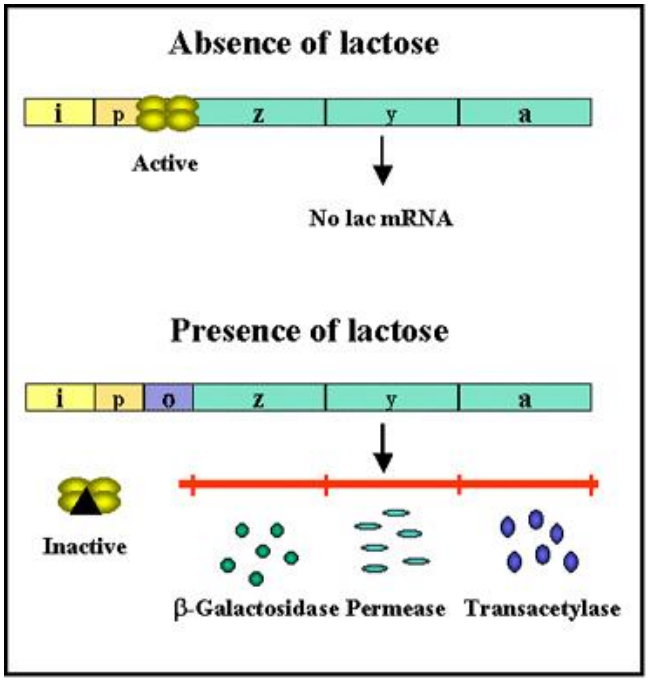


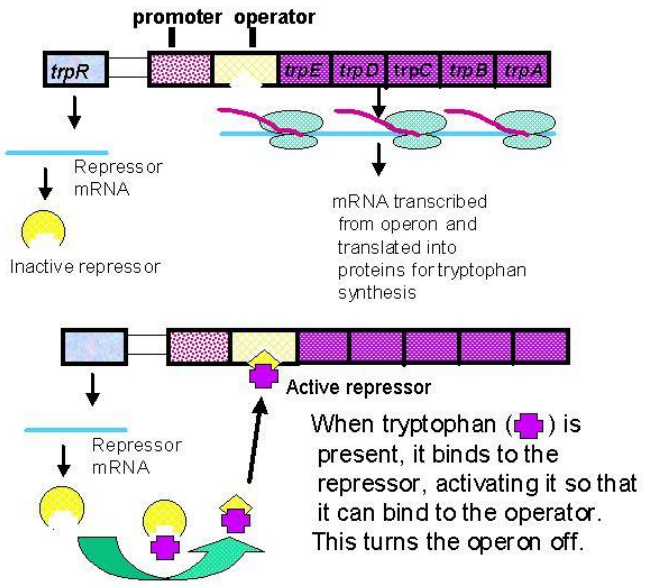


1. What is an operon?
2. What type of genes use an operon?
3. Which of the above operon systems is controlled by the presence of a sugar?
4. What is the name of the sugar?
5. Is this operon turned on by the ñpresenceò or the ñabsenceò of the sugar?
6. What is this type of operon called?
7. Which type of operon is controlled by a specific amino acid?
8. What is the name of this amino acid?
9. Is the operon turned on by the ñpresenceò or the ñabsenceò of this amino acid?
10. What is this type of operon called?

DESIGNER GENES: PRACTICE –MOLECULAR-GENETIC GENETICS

OPERONS





1. What is an operon?
   The genes that code for the enzymes to control a gene are clustered on the same chromosome
2. What type of genes use an operon?
   prokaryotic genes as in the bacterium E coli
3. Which of the above operon systems is controlled by the presence of a sugar?
   Lac Operon
4. What is the name of the sugar?
   lactose
5. Is this operon turned on by the ñpresenceò or the ñabsenceò of the sugar?
   presence
6. What is this type of operon called?
   inducible operon
7. Which type of operon is controlled by a specific amino acid?
   Trp Operon
8. What is the name of this amino acid?
   tryptophan
9. Is the operon turned on by the ñpresenceò or the ñabsenceò of this amino acid?
   absence
10. What is this type of operon called?
    repressible operon where genes are expressed in the absence of a substance and the presence of the substance shuts off the gene