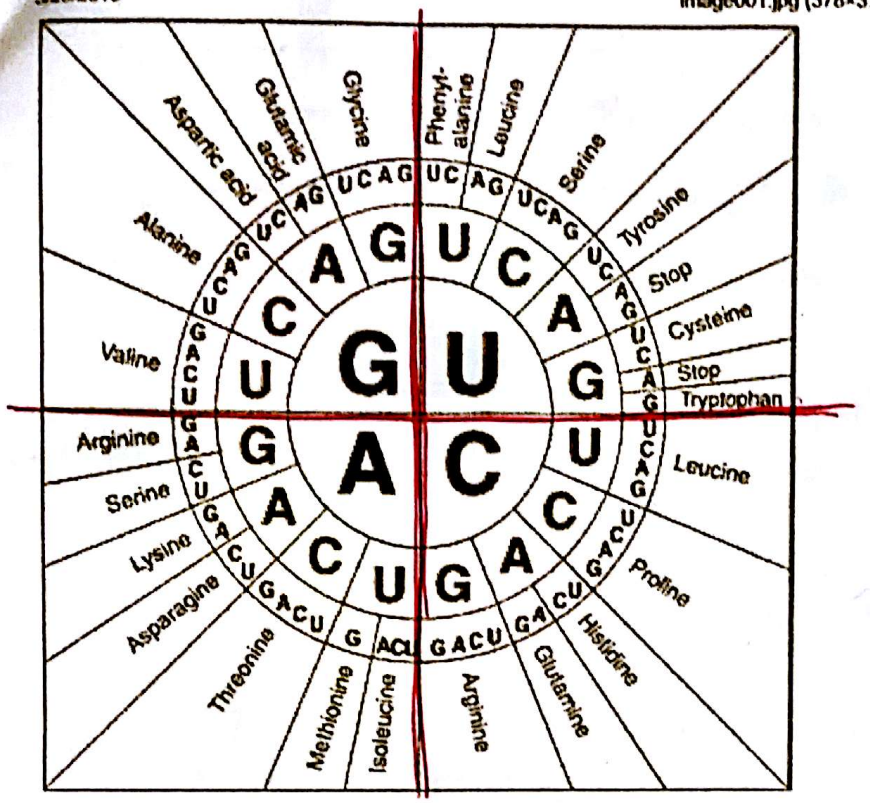
ANSWER KEY



Name _____

Date _____

Protein Synthesis

1. Using the amino acid chart, fill in the amino acid that corresponds to the given mRNA codon.

mRNA codon	Amino Acid
UGG	Tryptophan
GUA	valine
UGA	stop
CAC	Histidine

2. Given the DNA code, fill in the complementary mRNA codon and the corresponding amino acid.

DNA code	mRNA codon	Amino Acid
CGT	GCA	alanine
AAC	UUG	Leucine
ACT	UGA	stop

3. All codons are 3 bases long.

4. What is the base sequence for the mRNA "start codon"? AUG

5. All proteins begin with which amino acid? Methionine (Met)

6. Where in the cell does translation take place? ribosome

7. tRNA has an anti-codon at one end that complements the mRNA codon and an amino acid at the other end.

8. There are 22 different kinds of amino acids.

9. Amino acids are held together by peptide bonds.

10. Translation ends when the ribosome reaches a stop codon.

BIOLOGY ACTIVITY

Gene Mutations and Proteins **Names:** _____

Objective: To demonstrate how gene mutations affect the production of proteins?

Procedure:

1. Use the following base sequence of one strand of an imaginary DNA molecule:
   AATGTG AAC ACA TGC GCC C.
2. Write the base sequence for an mRNA strand that would be transcribed from the given DNA sequence. Place your results in the table below.
3. Use the table on page 2 to determine the sequence of amino acids in the resulting protein fragment. Place your results in the table below.
4. If the ~~fifth~~ base in the original DNA strand were changed from G to C, how would this affect the resulting protein fragment? Write the new protein fragment in the table below.
5. If G were added to the original DNA strand after the third base, what would the resulting mRNA look like? How would this addition affect the protein? Show your results in the table below.

Data:

mRNA from Step 2	UUA CAC UUG UGU ACG UGG G
Protein Sequence from Step 3	Leu-His-Leu-Cys-Thr-Arg
Protein Sequence from Step 4	Leu-Asp-Leu-Cys-Thr-Arg
MRNA from Step 5	UUA-CCA-CUU-GUG-UAC-GCG-GG
Protein Sequence from Step 5	Leu-Pro-Leu-Val-Tyr-Ala-Gly

Conclusions:

1. Which change in DNA was a point mutation? Which was a frameshift mutation?
   insertion, substitution — guess → insertion
2. In what way did the ~~point mutation~~ substitution affect the protein?
   only changed ONE amino acid
3. How did the frameshift mutation affect the protein?
   changed almost all of the amino acids

Name: _____

How DNA Controls the Workings of the Cell

Below are two partial sequences of DNA bases (shown for only one strand of DNA) Sequence 1 is from a human and sequence 2 is from a cow. In both humans and cows, this sequence is part of a set of instructions for controlling a bodily function. In this case, the sequence contains the gene to make the protein insulin. Insulin is necessary for the uptake of sugar from the blood. Without insulin, a person cannot use digest sugars the same way others can, and they have a disease called diabetes.

Instructions:

1 Using the DNA sequence, make a complimentary RNA strand from both the human and the cow. Write the RNA directly below the DNA strand (remember to substitute U's for T's in RNA)

2. Use the codon table in your book to determine what amino acids are assembled to make the insulin protein in both the cow and the human. Write your amino acid chain directly below the RNA sequence.

Sequence 1 - Human

C C A T A G C A C G T T A C A A C G T G A A G G T A A

RNA : GG U/A U C/G U G/C AA/UG U/U G C/AC U/U CC/A U U

Amino Acids: Gly - Iso - Val - Glu - Cys - Cys - Thr - Ser - Iso

Sequence 2 - Cow

C C G T A G C A T G T T A C A A C G C G A A G G C A C

RNA: GG C/A U C/G U A/C A A/U G U/U G C/AC U/U C C/G U G

Amino Acids: Gly - Iso - Val - Glu - Cys - Cys - Ala - Ser - Val

Analysis

1. Comparing the human gene to the cow gene, how many of the codons are exactly the same? 5

2. How many of the amino acids in the sequence are exactly the same? 7

3. Could two humans (or two cows) have some differences in their DNA sequences for insulin, yet still make the exact same insulin proteins? Explain. Yes. Multiple codons can code for the same amino acids.

4. Find ALL of the codons that can code for the amino acid leucine and list them.

UUA, UUG, CUA, CUU, CUC, CUG

5. Diabetes is a disease characterized by the inability to break down sugars. Often a person with diabetes has a defective DNA sequence that codes for the making of the insulin protein.

Suppose a person has a mutation in their DNA and the first triplet for the insulin gene reads T A T. The normal gene reads T A G. What amino acid does the mutant DNA and the normal DNA code for and will the person with this mutation be diabetic?

DNA TAT → mRNA AUA → prot. Iso

TAG → AUC → Iso

Same amino acid so no change in insulin

6. Another mutation changes the insulin gene to read T C T (instead of the normal T A G). Will this person be diabetic? Explain. DNA TCT TAG
MRNA AGA AUC
protein Arg Iso
protein structure is different affecting the function of insulin

7. DNA sequences are often used to determine relationships between organisms. DNA sequences that code for a particularly gencan vary, though organisms that are closely related will have very similar sequences. This table shows the amino acid sequences of 4 organisms.

Human: CCA TAG CAC CTA	Chimpanzee: CCA TAA CAC CTA
Pig: CCA TGT AAA CGA	Cricket: CCT AAA GGG ACG

Based on these sequences, which two organisms are most closely related? Human & chimp

8. An unknown organism is found in the forest and the gene is sequenced as follows:

Unknown: C C A T G G A A T C G A

What kind of an animal do you think this is? Pig

DNA

Name: _____ Row: _____

Date: _____ Period: _____

Gene Mutations Worksheet

There are two types of mutations, small-scale gene mutations and large-scale chromosomal mutations. You will do gene (point) mutations in this handout. Since mRNA is read in threes (codons), an addition or deletion of a base changes the reading frame of the sequence.

FRAMESHIFT MUTATIONS

DNA Sentence THE BOY CUT HIS LIP AND ATE THE HOT DOG

Insertion Example THE BOY CUT HIS SLI PAN DAT ETH EHO TDO

Insert a base

Delete a base

DNA Sentence THE BOY CUT HIS LIP AND ATE THE HOT DOG

Deletion Example THE BOY CUT HIS LIP ANA TET HEH OTD OG

The insertion shifts the reading frame to the right. The deletion frame shifts the reading frame to the left. *Insert a letter C for the two insertion questions. For the deletion questions, delete the H or one base letter.*

Write each codon per line.

DNA Sentence THE BOY CUT HIS LIP AND ATE THE HOT DOG

Insertion THE BOY CVC THI SLI PAN DAT ETH EHO IDO G

Deletion THE BOY CUT ISL IPA NDA TET HEH OTD OG

Now use real DNA code and translate it into the correct amino acids. Decide where in the original DNA code to cause a mutation on the rest of the questions. Please use the codon table on the last page to find the corresponding amino acids.

Write each codon per line and circle the mutated DNA base where the mutation took place.

Original DNA TAC GGA CGA TCT CAG GAG CCT ATA ATC

Insertion DNA TAC CGG ACG ATC TCA GGA GCC TAT AAT C

Mutated mRNA AUG GCC UGC UAG AGU CCU CGG AUA UUA G

Mutated Amino Acids Met Ala Cys stop ____ ____ ____ ____ ____

Original Amino Acid Met Pro Ala Arg Val Leu Gly Tyr STOP

Write each codon per line and circle the mutated DNA base where the mutation took place.

Original DNA TAG GGA CGA TCT CAG GAG CCT ATA ATC

Deletion DNA TAG GAC GAT CTC AGG AGC CTA TAA TC

Mutated mRNA AUC CUG CUA GAG UCC UCG GAU AUU AG

Mutated Amino Acids Iso Leu Leu Glu Ser Ser Asp Iso

Original Amino Acid Met Pro Ala Arg Val Leu Gly Tyr STOP

Usually a frame shift mutation results in the synthesis of a nonfunctional protein.
Why do you think your mutated proteins might not be functional?

None of the amino acids are the same. Protein function is dependent on its structure.

BASE SUBSTITUTION MUTATIONS

For simplicity, change only one base for all of the following base substitution mutations.

Base substitution is a different type of gene mutation. It is the simplest type of mutation where a nucleotide pair is replaced with a different nucleotide pair.

Base Substitution GAC → GGC

One type of base substitution is called *transversion mutation*. Transversion mutation happens when one purine (A, G) is swapped with a pyrimidine (C, T).

Purine → Pyrimidine GAC → TAC
Pyrimidine → Purine GAC → GAG

Use the DNA code below to demonstrate a purine → pyrimidine transversion mutation. All you have to do is change one DNA base.

Write each codon per line and circle the mutated amino acid.

Original DNA TAG CAT GCA GAT CTG GCC CAG TTC ATC

Transversion DNA TAG CAT GCA GAT CTG GCC CAG TTC ATC

Mutated mRNA AUC GUA CGU CUA GAC CGG GUC AAG UAG

Mutated Amino Acid Iso Val Arg Leu Asp Arg Val Lys Stop

Original Amino Acid Met Val Arg Leu Asp Arg Val Lys STOP

The opposite of transversion mutations are *transition mutations*. A transition mutation happens when one purine is swapped with the other purine or a pyrimidine with pyrimidine.

Purine → Purine	GAC → AAC
Pyrimidine → Pyrimidine	GAC → GAT

Use the DNA code below to demonstrate a purine → purine transition mutation. All you have to do is change one DNA base.

Write each codon per line and circle the mutated amino acid.

Original DNA	TAC	GTC	GCT	CAA	CGG	GAC	CTG	ACC	ACT
Transition DNA	TGC	GTC	GCT	CAA	CGG	GAC	CTG	ACC	ACT
Mutated mRNA	ACG	CAG	CGA	GUU	GCC	CUG	GAC	UGG	UGA
Mutated Amino Acid	Thr	Gln	Arg	Val	Ala	Leu	Asp	Trp	Stop
Original Amino Acid	Met	Gln	Arg	Val	Ala	Leu	Asp	Trp	STOP

A third type of base substitution is called *silent mutation*. Silent mutation happens when one base in a codon is changed, but both code for the same amino acid.

DNA	CTT → CTG
Amino Acid	Leu → Leu

Use the DNA code below to demonstrate a silent mutation. All you have to do is change one DNA base but the amino acid stays the same.

Write each codon per line and circle the mutated DNA base.

Original DNA	TAC	CAT	TCT	CGG	TGT	AAA	AGG	GCG	ATT
Silent DNA	TAC	CAA	TCT	CGA	TGT	AAA	AGA	GCG	ATT
Mutated mRNA	AUG	GUU	AGA	GUC	ACA	UUU	UCC	CGC	UAA
Mutated Amino Acid	Met	Val	Arg	Ala	Thr	Phe	Ser	Arg	Stop
Original Amino Acid	Met	Val	Arg	Ala	Thr	Phe	Ser	Arg	STOP

A base mutation that creates a new stop codon in place of an amino acid is called a *nonsense mutation.*

DNA TGT → TGA

Amino Acid Cys → STOP

Use the DNA code below to demonstrate a nonsense mutation. All you have to do is change one DNA base to create a new stop codon.

Write each codon per line and circle the mutated amino acid.

Original DNA	TAC	GGT	AAT	CAA	ATA	GAA	CCT	GAG	ACT
Nonsense DNA	TAC	GGT	ATT	CAA	ATA	GAA	CCT	GAG	ACT
Mutated mRNA	AUG	CCA	UAA						
Mutated Amino Acid	Met	Pro	Stop						
Original Amino Acid	Met	Pro	Leu	Val	Tyr	Leu	Gly	Leu	STOP

Please explain the difference between a frame shift mutation and a base substitution mutation.

A base substitution only changes a single codon.
A frameshift mutation changes all codons after the mutation.

Codon Table

1st Base	2nd Base: U	2nd Base: C	2nd Base: A	2nd Base: 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

UAA UGA UAG

ATT ACT ATC

Section 12–3 RNA and Protein Synthesis

(pages 300–306)

Key Concepts

- What are the three main types of RNA?
- What is transcription?
- What is translation?

The Structure of RNA (page 300)

1. List the three main differences between RNA and DNA.
   a. DNA is double-stranded; RNA is single-stranded
   b. DNA has deoxyribose; RNA has ribose
   c. DNA has thymine; RNA has uracil
2. What is the importance of the cell's ability to copy a single DNA sequence into RNA?
   that's transcription; RNA preserves DNA

Types of RNA (pages 300–301)

3. What is the one job in which most RNA molecules are involved? making proteins during translation
4. Complete the table about the types of RNA.

TYPES OF RNA

Type	Function
messenger RNA	Carries copies of the instructions for assembling amino acids from DNA to the rest of the cell
Ribosomal RNA	makes up ribosomes
transfer RNA	Transfers each amino acid to the ribosome to help assemble proteins

Transcription (page 301)

5. Circle the letter of each sentence that is true about transcription.
   a. During transcription, DNA polymerase binds to RNA and separates the DNA strands.
   b. RNA polymerase uses one strand of DNA as a template to assemble nucleotides into a strand of RNA.
   c. RNA polymerase binds only to DNA promoters, which have specific base sequences.
   d. Promoters are signals in RNA that indicate to RNA polymerase when to begin transcription.

RNA Editing (page 302)

6. Many RNA molecules from eukaryotic genes have sections, called ~~introns~~ in trans, edited out of them before they become functional. The remaining pieces, called exons, are spliced together.
7. Is the following sentence true or false? RNA editing occurs in the cytoplasm of the cell.
8. What are two explanations for why some RNA molecules are cut and spliced?
   a.
   b.

The Genetic Code (pages 302–303)

9. Proteins are made by joining amino acids into long chains called polypeptides.
10. How can only four bases in RNA carry instructions for 20 different amino acids?
    They are read in groups of 3
11. What is a codon? a group of 3 bases in mRNA or DNA
12. Circle the letter of the number of possible three-base codons.
    a. 4 b. 12 c. 64 d. 128
13. Is the following sentence true or false? All amino acids are specified by only one codon. False
14. Circle the letter of the codon that serves as the "start" codon for protein synthesis.
    a. UGA b. UAA c. UAG d. AUG

Translation (pages 303–305)

15. What occurs during the process of translation? mRNA is read & protein is made
16. Where does translation take place? the ribosome

17. Circle the letter of each sentence that is true about translation.
   a. Before translation occurs, messenger RNA is transcribed from DNA in the nucleus.
   b. Translation occurs in the nucleus.
   c. It is the job of transfer RNA to bring the proper amino acid into the ribosome to be attached to the growing peptide chain.
   d. When the ribosome reaches a stop codon, it releases the newly formed polypeptide and the mRNA molecule.

18. What is an anticodon? a complementary codon on a tRNA

The Roles of RNA and DNA (page 306)

Match the roles with the molecules. Molecules may be used more than once.

	Roles	Molecules
A	19. Master plan	a. DNA
B	20. Goes to the ribosomes in the cytoplasm	b. RNA
A	21. Blueprint	
A	22. Remains in the nucleus	

Genes and Proteins (page 306)

23. Many proteins are enzymes, which catalyze and regulate chemical reactions.
24. Is the following sentence true or false? Genes are the keys to almost everything that living cells do. ~~true~~

Reading Skill Practice

A flowchart is useful for organizing the steps in a process. Make a flowchart that shows the steps in the process of translation. Look at Figure 12–18 on pages 304–305 for help. For more information about flowcharts, see Appendix A. Do your work on a separate sheet of paper.

6. Circle the letter of each sentence that is true about gene mutations.
   a. Point mutations affect just one nucleotide.
   b. The substitution of one nucleotide for another in the gene never affects the function of the protein.
   c. Point mutations that involve the insertion or deletion of a nucleotide change the reading frame of the genetic message.
   d. Frameshift mutations affect every amino acid that follows the point of the mutation.

Significance of Mutations (page 308)

7. Mutations that cause dramatic changes in protein structure are often bad.
8. Mutations are a source of diversity in a species.
9. What is polyploidy?

Section 12–4 Mutations (pages 307–308)

Key Concept
- What are mutations?

Introduction (page 307)

1. What are mutations? changes in gene sequence
2. Is the following sentence true or false? Chromosomal mutations result from changes in a single gene. false

Kinds of Mutations (pages 307–308)

3. Mutations that occur at a single point in the DNA sequence are point mutations.
4. A mutation involving the insertion or deletion of a nucleotide is a(an) frameshift mutation.
5. Complete the table of types of chromosomal mutations.

CHROMOSOMAL MUTATIONS

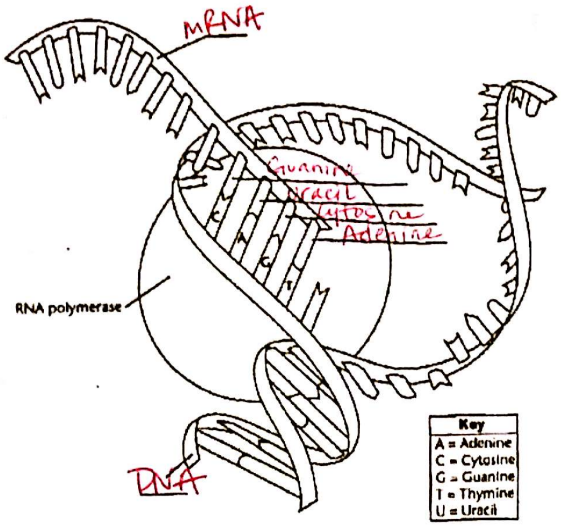
Type	Description	Examples
		ABC•DEF → AC•DEF
Duplication		
	Part of a chromosome becomes oriented in the reverse of its usual direction	
Translocation		

Name_____ Class_____ Date_____

Transcription

In transcription, RNA polymerase splits the two halves of a strand of DNA. RNA then uses one half as a template to make a copy of the other half. RNA contains the nucleotide uracil instead of the nucleotide thymine.

Label the DNA and RNA. Then, label the missing nucleotides marked on the diagram.



Use the diagram to answer the question. Circle the correct answer.

1. In RNA, which nucleotide is always paired with uracil?

adenine guanine

Name_____ Class_____ Date_____

Comparing DNA Replication and Transcription

DNA replication is the process by which a cell copies its DNA. During replication, both strands of the double helix are used as templates to make complementary, or matching, strands of DNA. DNA transcription is the process by which a single strand of DNA is used as a template to generate a strand of mRNA.

Fill in the missing information. One row has been completed for you.

Template DNA	Complementary DNA	Messenger RNA (mRNA)
TTACG	AATGC	AAUGC
CCGCC	GGCGG	GGCGG
TGCATCG	ACGTAGC	ACGUAGC
AGACTC	TGTGAG	UCUGAG
CTATTCT	GATAAGA	GAUAAGA
GACCCAUG	CTGGGTAC	CUGGGUAC

Use the table to answer the question.

1. Give another example of a template DNA code that is at least four base pairs long. Then give its matching complementary DNA and mRNA codes.

DNA template CGAT
mRNA Complementary GCTA
GCUA

Week 10 List of Prefixes, Suffixes and Roots

Suffix, Root, Prefix	Definition	Example
Pelv(i)-, pelvi(o)-	Hip bone	Pelvis
Peo-	Of or pertaining to the penis	Peotomy
-pexy	Fixation	Nephropexy
Phaco-	Lens-shaped	Phacolysis
Phon(o)-	Sound	Phonograph
Post-	Denotes something as 'after' or 'behind' another	Postoperation, postmortem
Pre-	Denotes something as 'before' another	Premature birth
Presby(o)-	Old age	Presbyopia
Psor-	Itching	Psoriasis
Quadr(i)-	Four	Quadriceps
Radio-	Radiation	Radiowave
Re-	Again, backward	Relapse
Rhabd(o)-	Rod shaped, striated	Rhabdomyolysis
Rhod(o)-	Denoting a rose-red color	Rhodophyte
-rrhagia	Rapid flow of blood	Menorrhagia
Salping(o)-	Of or pertaining to tubes e.g. fallopian tubes	Salpingectomy
Schiz(o)-	Denoting something 'split' or 'double-sided'	Schizophrenia
Semi-	One-half, partly	Semiconscious
Thely-	Denoting something as 'relating to a woman, feminine'	thelygenous