

Student name (Last, First):

Corrected Exam

Student number: _____

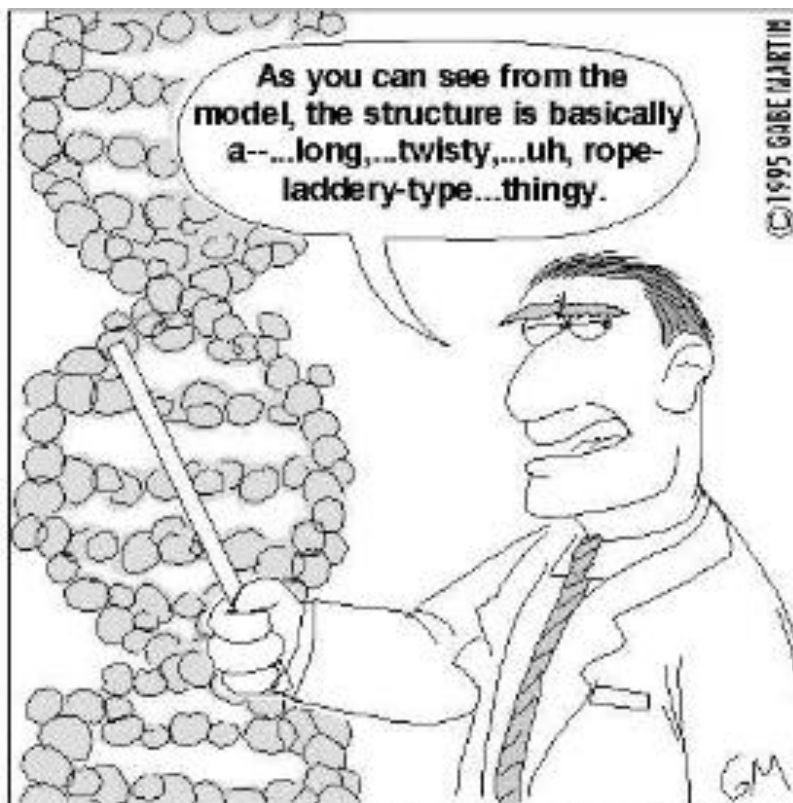
Instructions:

- Calculator permitted (Faculty approved or any other kind)
- Molecular model kits are permitted

Cellular phones, unauthorized electronic devices or course notes (unless an open-book exam) are not allowed during this exam. Phones and devices must be turned off and put away in your bag. Do not keep them in your possession, such as in your pockets. If caught with such a device or document, the following may occur: academic fraud allegations will be filed which may result in your obtaining a **0** (zero) for the exam.

By signing below, you acknowledge that you have ensured that you are complying with the above statement.

Sign here: _____



1953: The structure of the DNA molecule is first described.

Guidelines for Exam Correction**TRUE/FALSE SECTION**

Point distribution: 3 pts per question for a total of 15 pts for the section.

- For a T/F question that is true: 3 pts are allocated to the question
- For a T/F question that is false: 1 pt allocated for indicating that it is false and 2pts are allocated for the explanation

MULTIPLE CHOICE SECTION

Point distribution: 3 pts per question for a total of 60 pts for the section.

The student receives the full 3pts per question if:

- All the correct statement(s) for a given question are selected

The student receives 1.5pts/3pts per question if:

- Not all of the correct statement(s) are selected for a given question OR;
- All the correct statement(s) are selected for a given question AND an incorrect statement(s) is/are selected OR;
- Not of the correct statement(s) are selected for a given question AND an incorrect statement(s) is/are selected

The student receives 0pts/3pts per question if:

- All the statement(s) for a given question are selected OR;
- None of the statement(s) for a given question are selected

LONG ANSWER QUESTION:

Refer to the marking scheme to see how the marks are allocated

TRUE/FALSE SECTION

Point distribution: 3 pts per question for a total of 15 pts for the section. You receive 1 pt for correctly selecting true or false and 2pts for the explanation. If an explanation is not necessary, 3 pts is allocated to correctly selecting true or false.

In DNA polymerase, the divalent magnesium ion is a Lewis base, which increases the pKa of water.

The melting temperature of double-stranded DNA (dsDNA) decreases with increasing concentration of salt.

In a DNA double helix, the C-4 carbonyl of thymine forms a hydrogen bond with the N-6 amino group on adenine.

In 454 sequencing, a monophosphate is released upon nucleobase incorporation and is subsequently used to form ATP.

In a spontaneous chemical reaction, the Gibbs free energy should be greater than zero.

MULTIPLE CHOICE SECTION

Point distribution: 3 pts per question for a total of 60 pts for the section. You will receive the full 3 pts for each question if you select ALL the statements that correctly apply to a given question. You will receive NO POINTS if you select a statement that does not apply to the question, you select just one of the correct statements (assuming more than 1 statement applies to the question), if you select all the statements in a given question, and/or if you do not select any statements in a given question.

- When an amphipathic biomolecule is added to water, the biomolecule will spontaneously fold. Which of the following statement(s) describes this process?
 - Since it is spontaneous, it is an endergonic transformation
 - The sum of the entropy of the system (ΔS_{system}) and the surroundings ($\Delta S_{\text{surroundings}}$) will be greater than zero
 - Hydrophobic collapse will decrease the ΔS_{system} but will increase the $\Delta S_{\text{surroundings}}$.
 - The enthalpy (ΔH) of spontaneous biomolecular folding contributes negatively ($+\Delta H$) to folding
- Which of the following statements(s) describes the hypothesis of the Urey-Miller experiment?
 - That life on earth evolved from innate chemicals
 - That complex organic molecules can form spontaneously under conditions that probably existed on early Earth
 - That RNA can act as a catalyze for the formation of other biomolecules
 - That primordial earth had a reducing atmosphere and no complex molecules
- DNA replication in prokaryotic organisms is undertake principally by DNA polymerase I (Pol I) and DNA polymerase III (Pol III). Which of the following statement(s) best describes the role of these two polymerases?
 - Pol I has a bidirectional exonuclease activity which is used to simultaneous remove a nucleotide from the RNA primer and add a dNTP to the growing ssDNA daughter strand
 - Pol III has both a 5'-3' exonuclease and a 3'-5' exonuclease, which is used for "proofreading" DNA
 - Pol III ensures that dNTPs that bind to the insertion site have Watson-Crick base pair complementarity
 - Both DNA pol I and pol III displace ssDNA binding proteins (ssDNA) during replication
 - Only DNA pol I requires divalent magnesium ions in DNA replication
- Which of the following statements best describes structure of a double-stranded DNA (dsDNA) helix?
 - The most commonly occurring dsDNA helix is a B-form DNA (B-DNA)
 - In cellular DNA, the number of adenosines is always equal to the number of thymidine residues
 - In a dsDNA helix, the cytosine nuclear base is generally in the "syn" conformation relative to the ribose sugar
 - The helical width of a B-DNA is approximately 20 Å
- There are three known dsDNA helices: A-form, B-form, and Z-form. Which of the following statement(s) explicitly describe the A- and B-form of dsDNA?
 - B-DNA has a helical width of 20 Å and the A-form has a helical width of 26 Å
 - The B-form has a left-handed helical sense and the A-form has a right-handed helical sense
 - Both the A- form and the B-form dsDNA are not found in eukaryotic organisms
 - The A-form dsDNA is favored in solutions that lack water.

6. Illumina (or reversible terminator) and 454 sequencing are two automated DNA sequencing methods that are used to characterize the nucleotide sequence of organisms. Which of the following statement(s) best describe these two methods?
- The 454 sequencing method “pulses” unaltered dNTPs one-at-a-time on the reacting surface, permitting the incorporation of complementary dNTPs onto the DNA strand. This incorporation ultimately results the visualization of a flash of light.
 - Illumina sequencing harnesses the use of apyrase to degrade excess dNTPs added to the reacting surface
 - Illumina sequencing requires the use of dNTPs with appended fluorophores to visualize Watson-Crick base pairing.
 - 454 sequencing prefers approximately 700 nucleotides reads and Illumina sequencing prefers read lengths of between 30-300 nucleotides
7. An undergraduate student has isolated and carefully heated DNA to about 80°C and then prepared the sample for electron microscopy. She observed several small open loops of DNA. What conclusion(s) can she make from her observation?
- The open loops contain DNA mutation, such as cyclobutene dimers and deaminations
 - The denature DNA is the site of genes, of coding region, and the annealed DNA is the site of non-coding DNA
 - The open loops contain DNA with a high A-T content
 - The open loops contain denatured DNA that is being transcribed
 - The open loops are plasmids, and the annealed DNA is genomic
8. Select the following statement(s) that describe RNA polymerase (RNAP) in prokaryotic organism:
- Binds tightly to a region of DNA thousands of base pairs away from the DNA to be transcribed
 - Can synthesize RNA transcripts without a primer
 - Has a subunit called lambda (λ) that acts as a proof-reading ribonuclease
 - RNAP separates DNA strands throughout a long region of DNA, up to 100 base pairs, then copies one of them
 - Synthesizes RNA transcripts in the 5' → 3' direction
9. Select the following statement(s) that correctly describe the differences between RNA molecules of prokaryotic and eukaryotic organisms:
- Precursor RNA transcripts in prokaryotic organisms have a 7-methylguanosine cap at the 3' end of the strand
 - Precursor RNA transcripts in eukaryotic organisms have a polyadenylated tail that protects the transcript from endonucleases and supports translocation to the cytoplasm
 - Precursor RNA transcripts in eukaryotic organisms undergo RNA processing to remove introns and form a mature RNA molecule.
 - The half-life for a prokaryotic RNA transcript is measured in minutes and the half-life for eukaryotic RNA transcripts is measured in days.
10. Nucleic acids form the backbone of DNA and RNA molecules. Which of the following statement(s) describes the chemical characteristics of nucleic acids?
- They absorb UV light maximally at 280nm
 - They are all the same size
 - They are hydrophobic molecules
 - They are roughly planar molecules
 - They can all base pair with one another

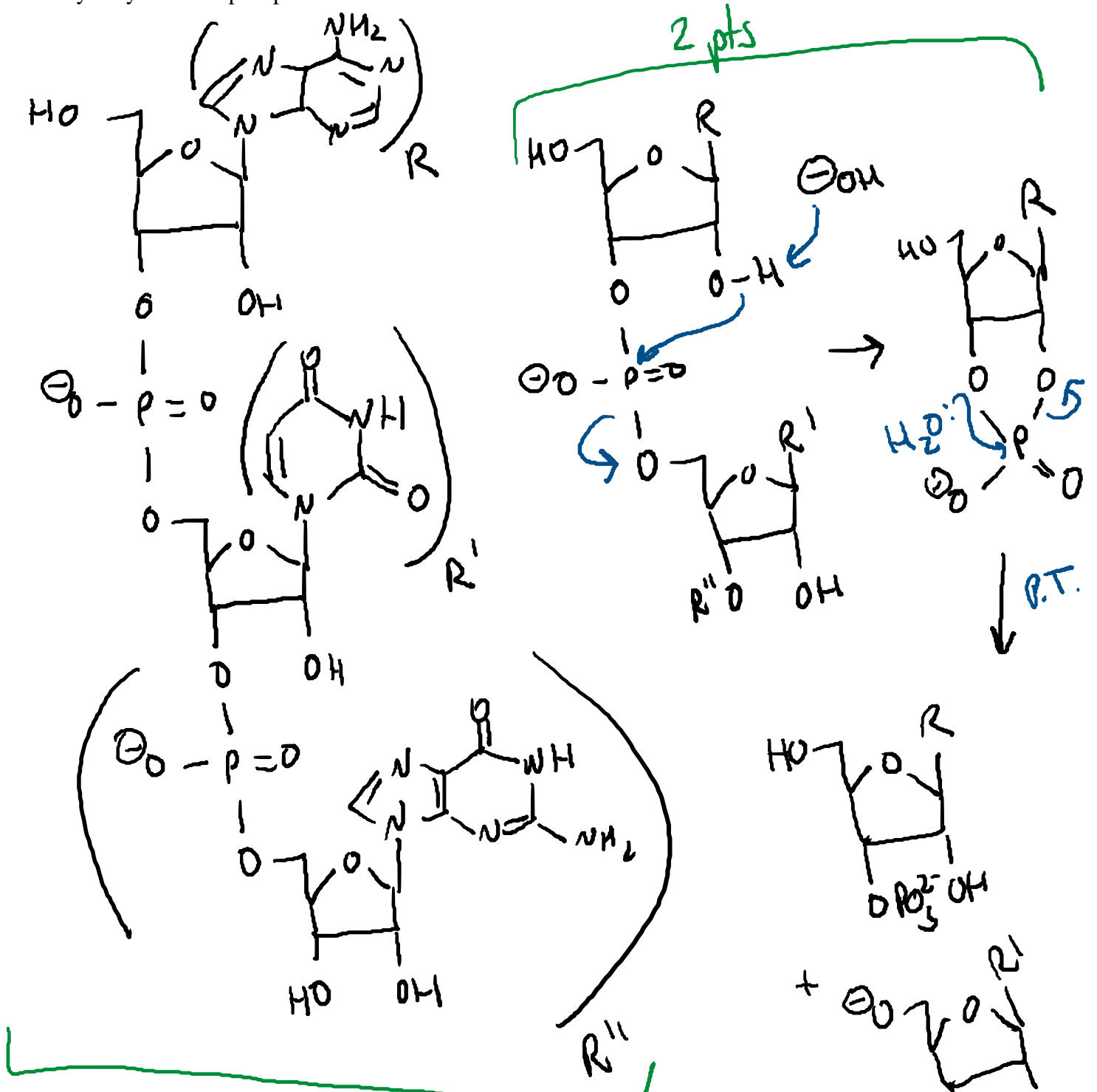
11. Which of the following single-stranded nucleic acid strands could form a hairpin structure in solution?
- 5'-TTTGGCGATACTCATCGCATT-3'
 - 5'-TTTGGCGATACTCACGCTATT-3'
 - 5'-TTTGGCGATACTCTGCGATTT-3'
 - All the answers are correct
 - All the answers are incorrect
12. According to the sense strand (read left-to-right) below, which of the following primers would be the best forward primer to use of the gene of interest? Note: the gene of interest is underlined.
- GGTTTGAATC AAATGGCTGA CGAAAAAGAA ATGACTGATA CTGCTATTGA
ATCCTTGGCT GGTGAGTCGG TTCAATTCGTA AGCAGCCAGT CGTAGGAATT
- 5'-GGTTTGAATCAAATGGCTGA-3'
 - 5'-ATGACTGATACATCATCCTC-3'
 - 5'-ATGACTGATACATCATCCTC-3'
 - 5'-GAGGATGATGTATCAGTCAT-3'
 - 3'-GAGGATGATGTATCAGTCAT-5'
13. What would happen if blocking tags were not used in Illumina sequencing?
- The DNA fragments to sequence/read would be too large
 - More than one dNTP could be incorporated to the same growing nucleotide chain during a single cycle
 - The flow cell could not immobilized DNA fragments
 - Multiple fluorescent colors could be observed across the flow call at the same time
14. Certain restriction enzymes generate cohesive ends. Which of the following statement(s) apply to cohesive ends?
- Cut both DNA strands at the same base pair
 - Cut in regions of high GC content, leaving ends that can form more hydrogen bonds than ends of high AT content
 - Make a staggered double-stranded cut, leaving ends with a few nucleotides of single-stranded DNA protruding
 - Make ends that can anneal to cohesive ends generated by a restriction enzyme that recognizes the same palindromic sequence
 - Stick tightly to the ends of the DNA they cut
15. Which of the following statement(s) about polymerase chain reaction (PCR) are false?
- DNA amplified by PCR are cloned
 - DNA amplification is linear in magnitude
 - Newly synthesized DNA must be heat-denatured before the next round of DNA synthesis begins
 - The boundaries of the amplified DNA segment are determined by the synthetic oligonucleotides used to prime DNA synthesis
 - The technique is sufficiently sensitive that DNA sequence can be amplified from a single animal or human hair
16. A 0.6 M solution of a weak acid has a pH of 5.8. What is the pKa of the solution?
- 11.3
 - 10.5
 - 8.2
 - 5.7
 - 2.9

17. The Henderson-Hasselbach equation:
- Allows the graphic determination of the molecular weight of a weak acid from its pH alone
 - Does not explain the behavior of di- and tri- basic weak acids
 - Employs the same value for pK_a for all weak acids
 - Is equally useful with solutions of weak acid and of hydrochloric acid
 - Relates the pH of a solution to the pK_a and the concentrations of acid and conjugate base
18. An operon contains a cluster of gene sequences, a promotor, and an additional regulatory sequence. The *lac* operon codes for three genes: β -galactosidase (Z), galactoside permease (Y), and thiogalactoside transacetylase (A). Allolactose binding to the regulatory sequence is an example of what?
- Transcriptional activation by reducing repressor binding
 - Transcriptional inhibition by increasing repressor binding
 - Transcriptional activation by increasing activator binding
 - Transcriptional inhibition by decreasing activator binding
19. Which of the following statements is not true about the formation of early organisms?
- The first organisms were anaerobic because the atmosphere was devoid of oxygen
 - The original electron donor for photosynthetic processes was probably H_2S
 - Oxygen, a powerful oxidant, was probably welcomed by anaerobic organisms as a preferable choice for metabolic reactions
 - The transfer of electrons to O_2 releases more energy than transferring electrons to SO_4^{2-}
 - Cyanobacteria are modern descendants of early photosynthetic oxygen-producers
20. In a bacterial cell, the DNA is in the:
- Cell envelope
 - Cell membrane
 - Nucleoid
 - Nucleus
 - Ribosomes

LONG ANSWER QUESTIONS

This question is from a previous exam.

21. (8 pts; partial marks are allocated) Ribonucleic acids (RNA) are less stable than deoxynucleic acids (DNA), which ultimately makes RNA more challenging to work with experimentally. Draw the complete structure of the RNA oligonucleotide 5'-AUG-3' and propose a mechanism for the alkaline hydrolysis of the phosphodiester bond between A and U.



6 pts : 1.5 pts / base
1.5 pts for phosphodiester

→ This question is a variation of Q2.25 from text.

22. (7 pts, partial marks are allocated) To ascertain the pH of a given solution, pH meters convert the concentration of hydrogen ions to a proportional electrical response. To ensure the pH meters are correctly calibrated, a standard solution of known hydronium ion concentration is used. Determine the weight in grams of sodium dihydrogen phosphate ($\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$; MW 138) and disodium hydrogen phosphate (Na_2HPO_4 ; MW 142) needed to prepare 800 mL of a standard buffer solution with $\text{pH}=7$ and with a total phosphate concentration of 0.120 M. (pK_a for $\text{H}_2\text{PO}_4^- = 6.86$).

① Need to determine the ratio of acid to base because we are working with a buffer:

$$\text{pH} = \text{pK}_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

$\text{A}^- = \text{HPO}_4^{2-}$
 $\text{HA} = \text{H}_2\text{PO}_4^-$

$$7 = 6.86 + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

2 pts.

$$10^{0.14} = \frac{[\text{A}^-]}{[\text{HA}]} = \frac{1.38}{1} \text{ or } \frac{7}{5} \text{ ratio } \frac{[\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]}$$

② Now barren the values in the question

$$[\text{HPO}_4^{2-}] + [\text{H}_2\text{PO}_4^-] = 0.120 \text{ M}$$

$$[\text{H}_2\text{PO}_4^-] = 0.120 \text{ M} - [\text{HPO}_4^{2-}]$$

substitute
2 pts.

$$\frac{[\text{HPO}_4^{2-}]}{0.120 \text{ M} - [\text{HPO}_4^{2-}]} = 1.38 \Rightarrow \frac{0.1656 \text{ M}}{2.38} \Rightarrow 0.0696 \text{ M}$$

$$[\text{H}_2\text{PO}_4^-] = 0.120 \text{ M} - 0.0696 \text{ M} \Rightarrow 0.0504 \text{ M}$$



SCRAP PAPER

③ Calculate the mass of each required:

$$[\text{HPO}_4^{2-}] = 0.0696 \frac{\text{Mol}}{\text{L}} \times 0.800\text{L} = 0.05568 \text{ mol} \times 142 \frac{\text{g}}{\text{mol}}$$

↳ 7.90 g (1.5 pts)

$$[\text{H}_2\text{PO}_4^-] = 0.0504 \frac{\text{Mol}}{\text{L}} \times 0.800\text{L} = 0.04032 \text{ mol} \times 132 \frac{\text{g}}{\text{mol}}$$

↳ 5.56 g (1.5 pts)