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Name: _____

7.016 EXAM 1
Oct 3, 2018

TA: _____

Recitation: _____

The Exam starts at 10.05 AM and ends at 10.55 AM.

Write your name on this page and your initials on all the other pages in the space provided. This exam has 7 pages including the coversheet. Check that you have all the pages **1-7**.

NOTE: You can detach Page 7.

Only writing on the **FRONT** of every page will be graded. You may use the backs of the pages, but only as scratch paper.

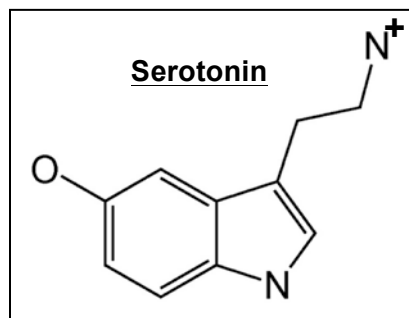
| Questions | Points | Score |
|------------------|---------------|--------------|
| 1 | 8 | |
| 2 | 16 | |
| 3 | 22 | |
| 4 | 14 | |
| 5 | 22 | |
| 6 | 18 | |
| TOTAL | 100 | |

Name: _____

Question 1 (8 points)

Serotonin is a neurotransmitter that regulates mood. Low levels of serotonin result in depression and high levels cause anxiety. The following is a partial “line-angle” drawing of serotonin.

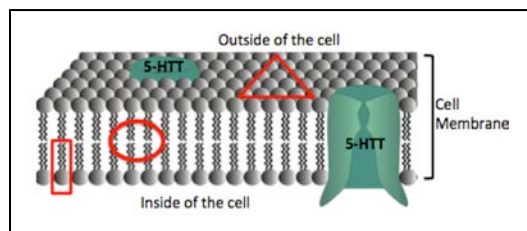
Note: The hydrogen (H) atoms bonded to carbon (C) and other atoms are not shown but implied.



- Show **ALL** of the C and H atoms on the line angle drawing.
- Circle **ALL** groups on the schematic that could participate in condensation reactions.
- Show the lone pair(s) of electrons on the appropriate electronegative elements taking into consideration the charged states.

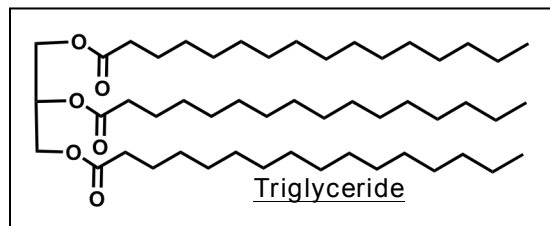
Question 2 (16 points)

The serotonin transporter protein (5-HTT) is located in the membrane of serotonin-secreting cells as shown below.



- Which elements would predominate in the indicated triangular region but **NOT** in circled region of cell membrane and **why**: C/ H/ N/ O/ P/ S?

- The following is the structure of a triglyceride.



- Circle an ester linkage on the structure.

- Box **one** fatty acid chain in the triglyceride and identify it as **saturated** or **unsaturated**.

iii. Your friend says that the triglyceride shown above is a monomer in the boxed area of the cell membrane shown in part (a) above. You are skeptical and rightfully so. **Explain why.**

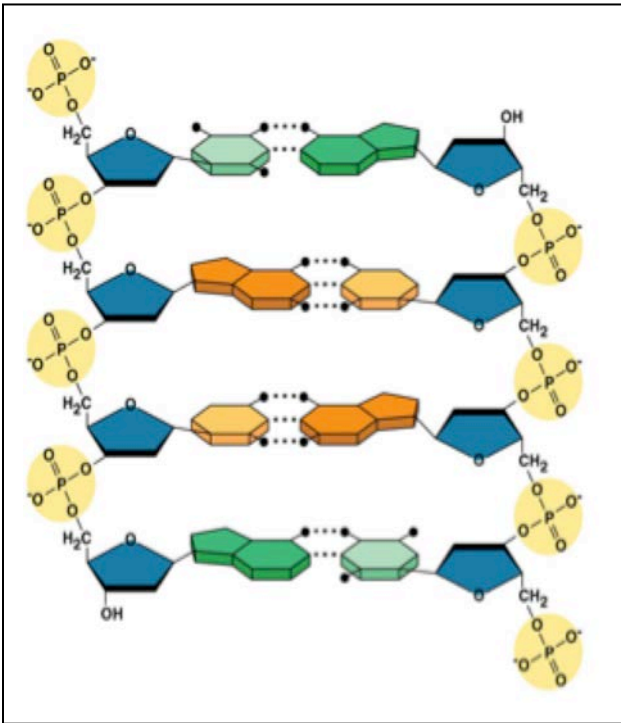
c) Functional 5-HTT includes two polypeptide chains. What is the highest order of the structure of each polypeptide chain of 5-HTT: **Primary/ Secondary/ Tertiary/ Quaternary?**

d) Secreted serotonin binds to the 5-HTT protein. This causes serotonin reuptake into the cell so that serotonin can no longer act on its target cell. You design a novel competitive inhibitor that covalently binds to 5-HTT. Does increasing the concentration of serotonin reverse the effect of the inhibitor on 5-HTT? **Why or why not?**

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Question 3 (22 points)

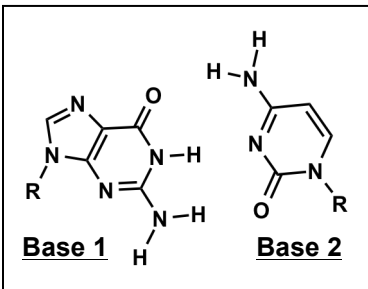
The following is a schematic of a part of the SLC6A4 gene that encodes the 5-HTT receptor protein.



- a) Label the 5' and 3' ends of BOTH DNA strands.
- b) Show the direction of synthesis of **each strand** by drawing arrows.
- c) Which end of a growing strand of DNA would receive an incoming nucleotide: **3' or 5'**?
- d) What is the type of interaction between two **adjacent bases** on the **same** DNA strand: **ionic/ covalent/ hydrogen-bonding/ hydrophobic**?
- e) Chromosomes are made up of DNA and one other class of macromolecule. Which one: **Lipids/ Carbohydrates/ Proteins**?
- f) **Explain** why it is important for the DNA in a cell to be more stable than RNA and how is this achieved.

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g) The following schematic represents a nucleotide base pair in the SLC6A4 gene that encodes the 5-HTT.

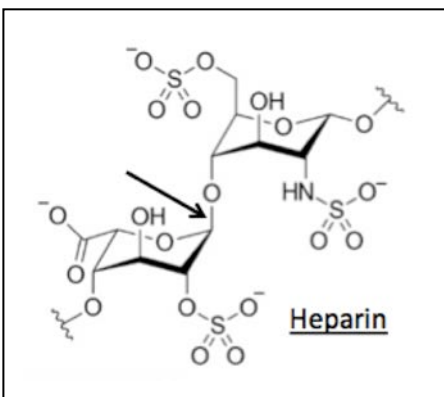


i. Identify the two bases as purine or pyrimidine.

Base 1: _____ **Base 2:** _____

ii. On the schematic, label the hydrogen-bond donors by writing a “D” and hydrogen-bond acceptors by writing an “A” for each hydrogen bond.

h) The following is the close up view of the molecular structure of heparin.



i. Which class of macromolecules is heparin an example of: **carbohydrates/ lipids/ nucleic acids/ proteins**.

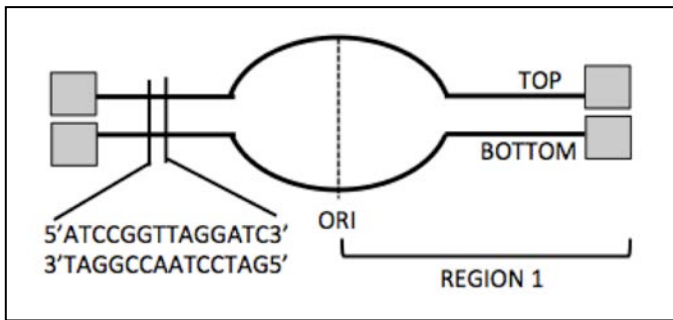
ii. Name the covalent bond that is indicated by the arrow.

iii. Heparin can be used to purify transcription factors (TFs) that usually bind to DNA. What structural similarity between heparin and DNA makes heparin bind well to a TF?

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Question 4 (14 points)

Shown below is a segment of replicating DNA. A small part of the DNA sequence is magnified.



a) Label the **5' and 3' ends** by filling in the shaded boxes and show the **direction of movement of replication forks** by an arrow (→)

b) Which strand in Region 1 is the template for the leading strand: **Top/ Bottom**?

c) Draw the primer for the leading strand **in Region 1** and label its 5' and 3' ends.

d) You isolate cells from a normal healthy individual and grow them in the following plates.

- Plate 1 has TAT-2, a compound known to activate telomerase.
- Plate 2 has ciprofloxacin, a compound that inhibits topoisomerase.

In which plate would DNA replication be inhibited and **why**?

e) You identify a mutant cell that shows an increased error rate during replication.

- Which enzyme **REMOVES** the incorrect nucleotide during replication and **what activity** of the enzyme allows it to do so?
- Which enzyme **ADDS** the correct nucleotide to the growing strand of DNA during replication and **what activity** of the enzyme allows it to do so?
- DNA ligase** is required in all the processes listed below except one.

Circle this process: **Replication/ Proof-reading/ Base excision repair/ Nucleotide excision repair.**

Name: _____

Question 5 (22 points)

The following is the DNA sequence of the transcription initiation region of the **SLC6A4** gene. **Note:** **Promoter sequence** is boxed. **Transcription begins at and includes** the bold and underlined **T/A** base pair.

| | | | | | | |
|-----------------|-------------------|---------|--|------|----|---------------|
| 5' | -TGGACTGCTATAAAAG | CAGTACT | TGCAGAGATGAGGAAAATACGGCCATGGTTCTTAAAGT | ---- | 3' | TOP |
| 3' | -ACCTGACGATATTTTC | GTCATG | <u>A</u>CGTCTCTACTCCTTTTATGCCGGTACCAAGAATTTCA | ---- | 5' | BOTTOM |
| Promoter | | | | | | |

- a) Which DNA strand serves as the template strand for transcription and **why: Top or Bottom?**

- b) Give the first **10 nucleotides** of the **newly transcribed** mRNA transcript and **BOX** the part of the sequence that will be the **start codon** for translation: **5'** _____ **3'**

- c) Give the sequence of the anticodon and the amino acid corresponding to the 2nd codon on the mRNA transcript: **Anticodon: 5'** _____ **3'** **Amino acid: _____**

- d) Which type of RNA is the anticodon a part of: **messenger RNA/ transfer RNA/ ribosomal RNA?**

- e) You analyze five mutations where the A/T base pair (bold and shaded) at positions **1, 2, 3, 4** or **5**, as marked in the sequence below is substituted by a T/A base pair.

| | | | | | | | | | | |
|-----------------|-------------------|----------|--|----------|----------|---------------|----------|----------|--|--|
| | | 1 | | 2 | 3 | | 4 | 5 | | |
| 5' | -TGGACTGCTATAAAAG | CAGTACT | TGCAGAGATGAGGAAAATACGGCCATGGTTCTTAAAGT | ---- | 3' | TOP | | | | |
| 3' | -ACCTGACGATATTTTC | GTCATG | <u>A</u>CGTCTCTACTCCTTTTATGCCGGTACCAAGAATTTCA | ---- | 5' | BOTTOM | | | | |
| Promoter | | | | | | | | | | |

Which of these substitutions will:

- i. Change the sequence of the **SLC6A4** gene but **NOT** the **SLC6A4** mRNA transcript and **why:**
1/ 2/ 3/ 4/ 5?

- ii. Change the sequence of the **SLC6A4** mRNA transcript but **NOT** the 5-HTT protein and **why:**
1/ 2/ 3/ 4/ 5?

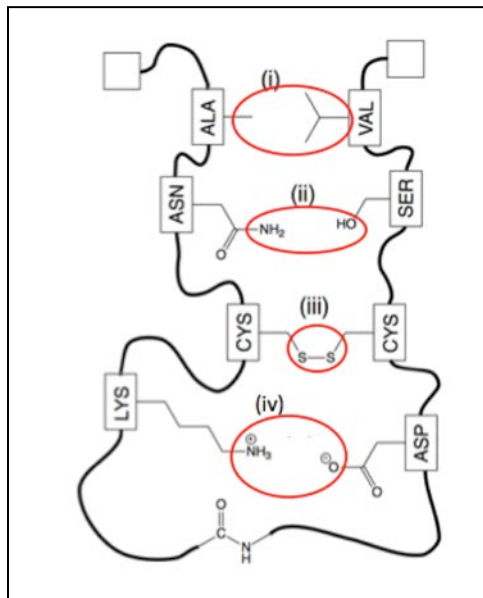
- iii. Decrease the responsiveness of 5-HTT to serotonin resulting in depression and **why:**
1/ 2/ 3/ 4/ 5?

f) You observe that SLC6A4 gene can encode three different proteins in three different cell types. **Explain** in 2-3 sentences how one gene can encode multiple proteins in eukaryotes and **why** this adds to their evolutionary complexity (compared to prokaryotes such as bacteria).

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Question 6 (18 points)

The following are some intra-molecular interactions that are critical for the folding of 5-HTT.



a) Name the **strongest covalent or non-covalent interaction** at the each of the circled positions, (i)–(iv).

- **Position (i):** _____
- **Position (ii):** _____
- **Position (iii):** _____
- **Position (iv):** _____

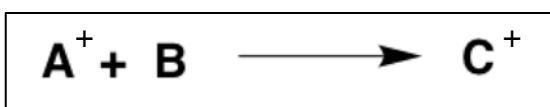
b) Label the amino (N) and carboxyl (C) ends of 5-HTT in the boxes.

c) You treat purified 5-HTT with a protease, which hydrolyzes all of the peptide bonds with a $\Delta G = (-) 5 \text{ kcal/mole}$ per peptide bond.

- Circle all of the correct options. The hydrolysis of peptide bonds is an example of: **Catabolic/ Anabolic / Exergonic / Endergonic** reaction.
- Show the energy diagram for the hydrolysis of a peptide bond and label the: **axes of the plot (including units), ΔG , Energy of activation (E_{act}), substrate energy level (S), and product energy level (P).**



iii. **Explain** how the structure of an enzyme that catalyzes the reaction below might contribute to enzyme catalysis.



Name: _____

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CODON CHART

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

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7.016 Introductory Biology
Fall 2018

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