

8/8/20 Biology Bowl Seeding Pretest

Total: Out of 135 points

Problem 1 *(15 points)*

You are carrying out experiments with unicorns again. After noticing that the length of unicorn's horns varies considerably across the population, you decide to try and determine the genetic basis. You travel the land, searching far and wide to find all of the possible horn lengths; at the end of your expeditions, you have kidnapped a unicorn with the longest possible horn length trait, and a unicorn that has no horn at all. After crossing these unicorns, all of the 1000 offspring that are produced have the same horn length intermediate that of their parents. However, interbreeding these offspring produces a wide spectrum of horn lengths, which you document in the table below:

No horn	17
Short horn	92
Medium-short horn	235
Medium-length horn	312
Medium-long horn	234
Long horn	96
Longest Horn	14

What is the most likely mode of inheritance? *(0.5 point)*

How many pairs of genes are involved in determining horn length? *(0.5 points)*

What will be the phenotypic distribution of the offspring for each of the following cases? (Give your answer as a ratio)

- The medium length horned unicorns from the second cross are interbred: *(6 points)*
- The long horned unicorns from the second cross are interbred: *(2 points)*
- The medium-short horned unicorns from the second cross are interbred: *(6 points)*

Problem 2 (20 points)

Nondisjunctions are the cause of many spontaneous diseases, including Down Syndrome and Turner Syndrome in humans. By experimenting with human eggs and sperm, you determine that for sex chromosomes, the probability of nondisjunction of a pair of homologous chromosomes during meiosis I is 1% in both males and females, and the probability of nondisjunction of a pair of sister chromatids during meiosis II is 2% in both males and females.

What is the probability of obtaining each of the following GAMETES through spermatogenesis? Round to the nearest hundredth percent.

- a. Only one X unduplicated chromosome?
- b. Only one Y unduplicated chromosome?
- c. 2 X unduplicated chromosome?
- d. Only one X unduplicated chromosome and only one Y unduplicated chromosome?

What is the probability of obtaining each of the following GAMETES through oogenesis? Round to the nearest hundredth percent.

- a. 4 X unduplicated chromosome?
- b. 3 X unduplicated chromosome?

Each correct answer is worth 3 points (18 total)

You notice that zygotes with YY have developmental disabilities (in real life, humans with YY karyotypes are unviable, but allow us to pretend...). After further investigation, you realize that the gene for normal development is only expressed on one copy of the X chromosome in normal humans. In females, the other copy of the X chromosome is inactivated.

What is this type of inheritance called? (1 points)

What is the name of the process in which 2 copies of a chromosome are inherited from the same parent (it led to the YY karyotype)? (1 points)

Problem 3 *(10 points)*

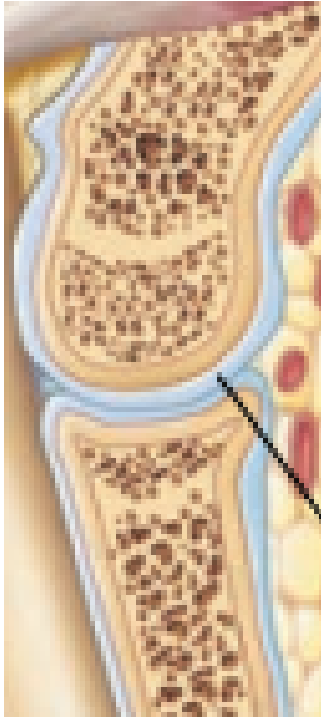


This is a human chromosome spread with polyploidy.

- a) What phase of mitosis is this chromosome spread arrested in? *(1 point)*
- b) What drug is most commonly used to arrest mitosis? *(2 points)*
- c) Name 3 distinct organs/tissues where a cell with polyploidy would be found commonly naturally occurring in humans? *(6 points)*
- d) In which kingdom of life is polyploidy considered as a major driving force for evolution?
(1 point)

Problem 4 (10 points)

This is the inside of an animal leg.



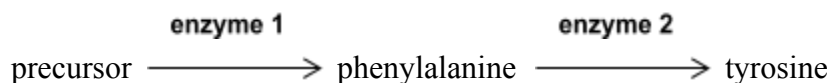
1. What is the general name of the structure pointed to by the black line? (1 point)
2. What is the name of the protein-carbohydrate complex that makes up the above structure, and what fibers are embedded within this complex? (2 and 1 points respectively)
3. How does the structure from question 1 receive nutrients and oxygen and why does it need to receive nutrients this way? (1 and 2 points respectively)
4. As one gets older, what happens to this structure overall throughout the entire body and what larger effect does this have on the individual? (1 and 2 points respectively)

Problem 5 *(10 points)*

- a) State the alternate vitamin letter-number combination of the following vitamins:
- Retinol *(1 point)*
 - Folic acid *(1 point)*
 - Riboflavin *(1 point)*
- b) Which of the 4 major types of feeding mechanisms do brachiopods utilize in general? *(4 points)*
- c) Would a tiger or cow have a longer alimentary canal, and why (be specific)? *(1 and 2 points respectively)*

Problem 6 (15 points)

	Sample I x Sample II	Sample II x Sample III	Sample I x Sample IV	Sample II x Sample IV	Sample III x Sample IV
Minimal medium (MM)	No growth	Growth	Growth	No growth	Growth
MM + phenylalanine + tyrosine	Growth	Growth	Growth	Growth	Growth
MM + phenylalanine	No growth	Growth	Growth	Growth	Growth
MM + tyrosine	Growth	Growth	Growth	No growth	Growth



The lack of enzyme 1 in an imaginary microbe called blurb is caused by a recessive gene. The lack of enzyme 2 is caused by a different recessive gene located on a different chromosome. Phenylalanine and tyrosine are both essential amino acids for blurbs. The minimal medium contains the precursor to tyrosine and phenylalanine along with other essential nutrients for blurbs. Samples I-IV are strains of blurbs that may be missing enzymes in the above pathway for tyrosine and phenylalanine synthesis. The above table shows crosses between the different samples, which were spread on petri dishes. Assume all samples contain blurbs homozygous in the genes that may cause enzyme 1 and 2 deficiency. Assume the above pathway is the only pathway for phenylalanine and tyrosine synthesis.

- What enzyme(s), if any, are each of the four samples deficient in? (4 points)
- What would change about the crossing results if all homozygous dominant samples were heterozygous instead? (4 point)
- What would be the crossing results if the lack of enzymes 1 and 2 was due to a dominant gene instead? Assume previous condition of all samples being homozygous. (7 points)

Problem 7 *(15 points)*

As a general surgeon in Beverly Hills, California. You are approached by one of your residents, Alex, about a new case. John Smith, a 21 year old college student, was treated for a uncategorized bacterial infection with a 2 week course of oral clindamycin. He successfully overcame the infection. He came back 1 week later complaining of diarrhea, bloating, and pain in his abdomen and after examination he was found to have a fever and blood in his stool. He was given 3 courses of oral vancomycin. However, they were found to have no effect on John. You suspect John's gut microbiome was wiped out by the first course of antibiotics and was taken over by a hardy, resistant pathogen.

a.) What pathogen do you suspect John is infected with? *(3 points)*

Samuel Billingsly, being the rockstar surgeon of the department, suggests performing a new procedure on John: a fecal transplant. In this procedure, he introduces stool from a healthy donor into the bowel of a patient with this infection is believed to restore the gut's natural mix of Microbes.

b.) What is the medical or scientific term for the "gut's natural mix of microbes?" *(2 points)*

Samuel looks to Alex and decides this is a great learning opportunity for him and asks him to name possible deliveries of the stool. He suggests three other methods to introduce stool from a healthy donor into the bowel of a patient with an infection. (Hint: none of them are actually surgically opening up the gut and injecting stool into it.)

c.) What is one possible method Alex suggested? (extra points for all three) *(6 points)*

Samuel condescends to compliment Alex on his knowledge and decide to let him scrub in on the surgery. You go interview John about his infection.

d.) Suggest a route of transmission for John to have gotten this infection in the first place. *(2 points)*

Samuel and Alex work together to perform the surgery... and it's a success!!
You, Samuel and Alex decide to get Burgers to celebrate. Alex asks you about another application of fecal transplants.

e.) How would Samuel respond, other than telling Alex he's disgusting? (2 points)

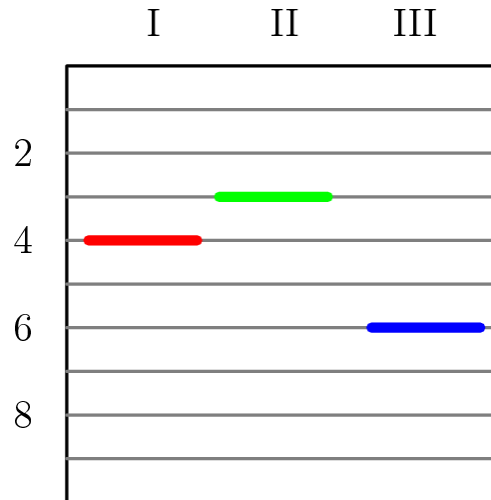
Problem 8 (15 points)

JELLO

(contrary to the title of this question, you should not eat the gel in a gel electrophoresis experiment if it has already been used)

Amino Acid	α -COOH pKa	α -NH ₃ pKa	Side Chain pKa
Arginine	2.1	8.9	12.5
Cysteine	1.7	10.4	8.3
Tyrosine	2.2	9.1	10.1

- a) Why don't uncharged proteins move in a gel electrophoresis experiment? (1 point)
- b) You are running a gel electrophoresis experiment with purified samples of three amino acids. For each of the following amino acids, identify the *exact* (no rounding!) pH you would have to set the gel to in order for the amino acid to stay stationary: 1) arginine, 2) cysteine, 3) tyrosine. Assume the pKa's in the table are exact. (2 points each)
- c) PAGE is a type of gel electrophoresis that uses a medium of polyacrylamide (hence the acronym PolyAcrylamide Gel Electrophoresis). There are two main types of PAGE: native PAGE, which is just standard gel electrophoresis on polyacrylamide, and SDS-PAGE.
- Explain how SDS-PAGE differs from native PAGE in terms of laboratory setup. (2 points)
 - Two identical samples of assorted proteins are collected and one is run in a native PAGE experiment, while the other is run in an SDS-PAGE experiment. Assuming that all other aspects of the experiments are the same (current, time run, etc.), explain any discrepancies that would appear between the native PAGE and SDS-PAGE data. (3 points)



d) The drawing above shows a gel electrophoresis experiment with 3 different DNA samples. On the left, the distance from the wells is measured in cm. If the DNA in well I has strands of length 100bp and the DNA in well II has strands of length 500bp, calculate the strand length for the DNA in well III to the nearest bp. Use the approximation $\log(2) = 0.3$. (*3 points*)

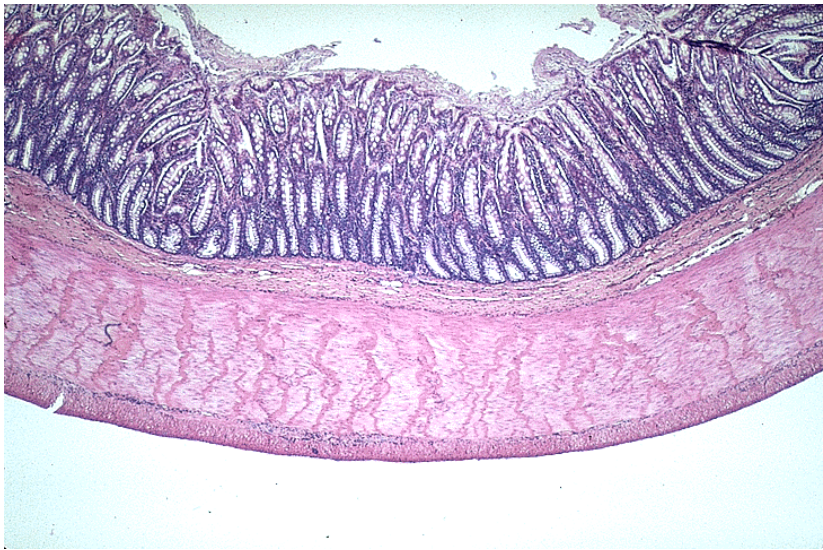
Problem 9 (12 points)

YAY HISTO, WE STAN HISTO

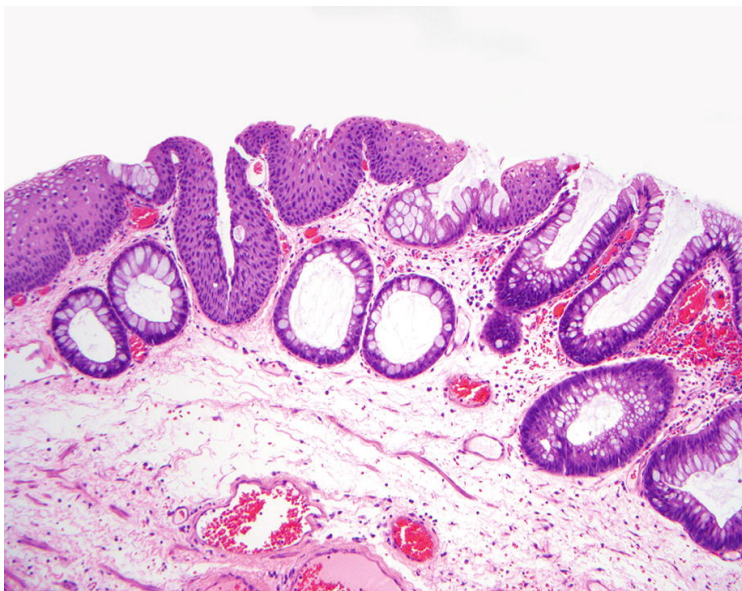
Look familiar?

Word Bank: (yeet there is no word bank)(dw it's not that bad 😊)(wait...pinecone?)

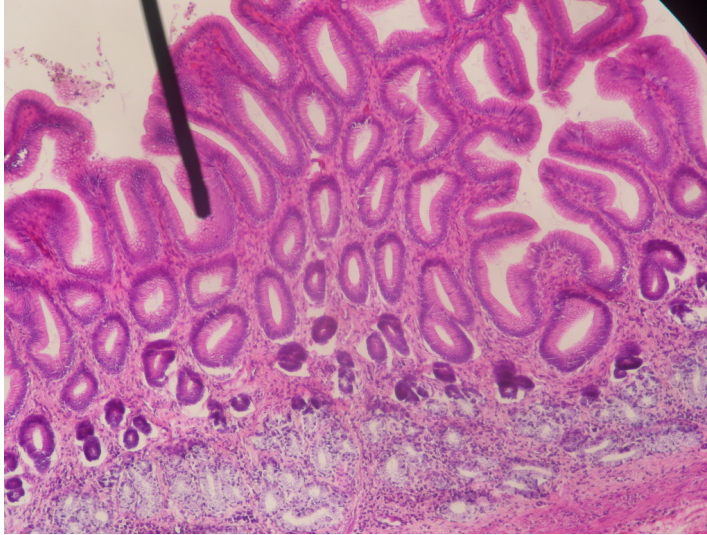
PART A: PLEASE IDENTIFY THE ORGAN: (12 points)



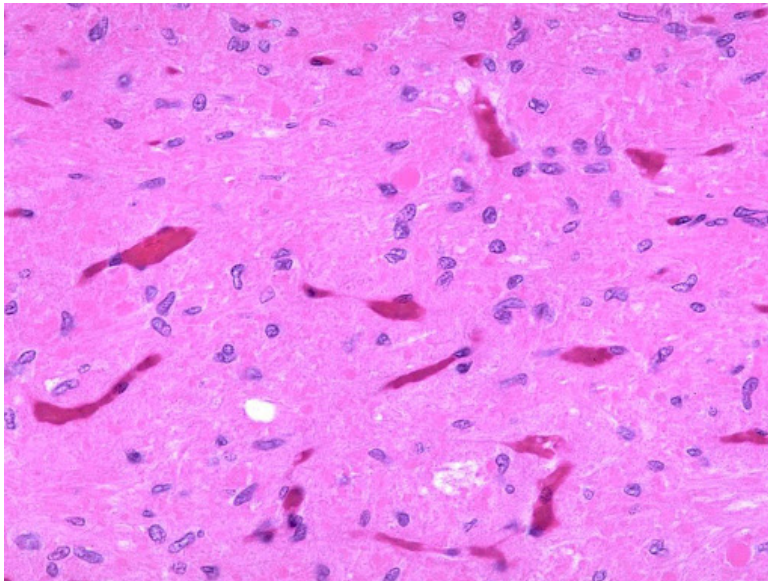
1)



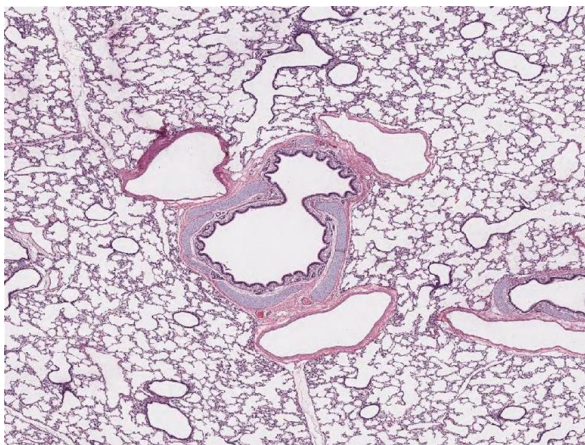
2)



3)



4)

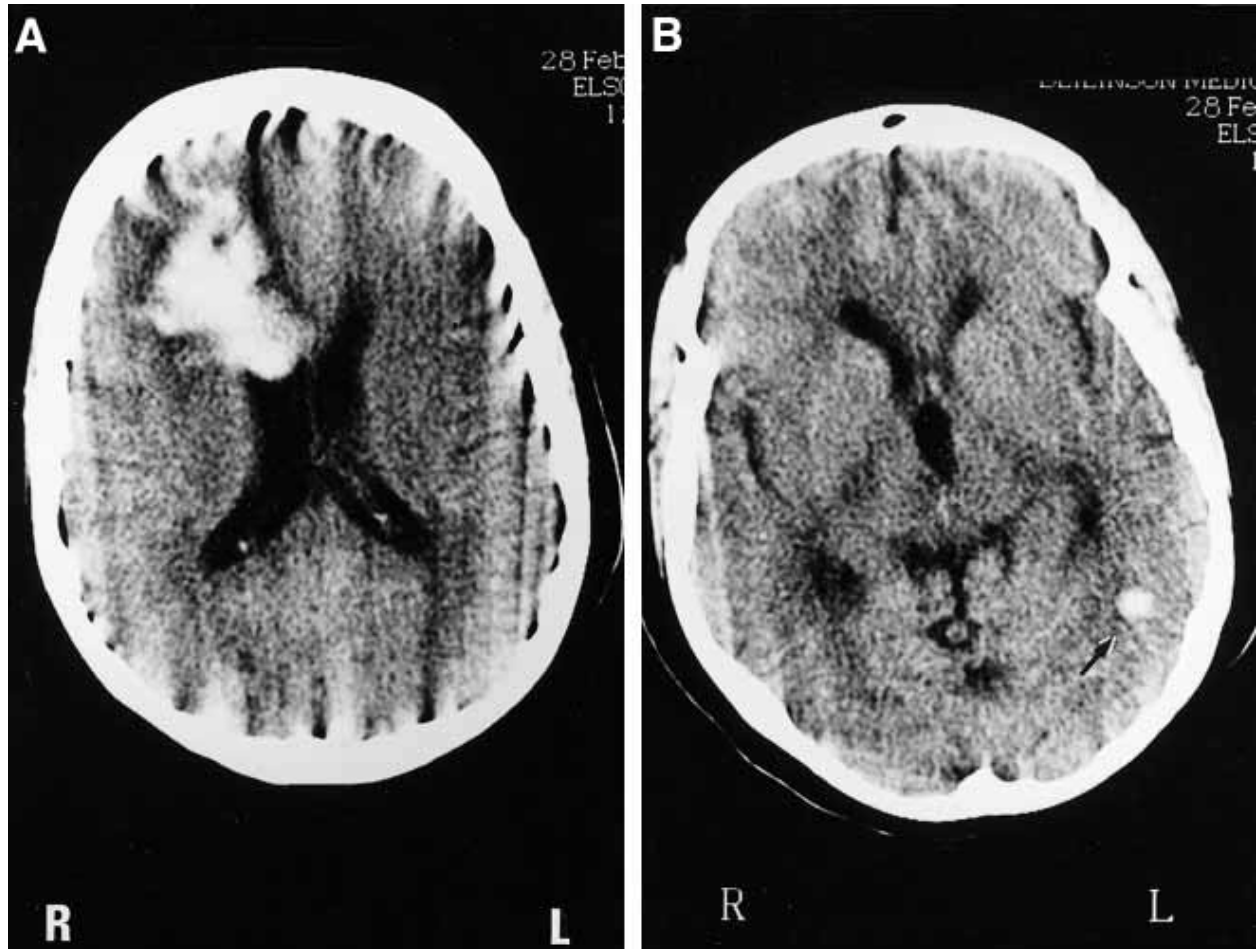


5)

Problem 10 (13 points)

PART B: ARE WE DUNE YET?

Your friend Chris went surfing on some gnarly waves in the Sahara desert. Sadly, he fell and got buried under a sand dune. Bad things happened. *Magic hand wave motions* Now he is unresponsive and under critical condition. Please find out what's wrong with him.



More hand waving

You find this picture of Chris's head. Being an equal to House M.D., you instantly analyze this picture and come to a sound conclusion. Sadly, I, the grader, am not as smart. Please thoroughly tell me what you diagnose.

- 1) What imaging technique was used to create these images? (1 points)
- 2) What does the white patch on the left side of the left image depict? Be as specific as possible (hint: what it is and where it is). (4 points)

- 3) Give one possible reason for the origin of the white patch? *(2 points)*

Miraculously, Chris wakes up. However, Chris is very different now. Before the accident, Chris was the OG, a true alpha male. Now, he is a surly, aggressive drunkard who is unable to hold down a job.

- 4) Based on the images above, Chris's injury, and your doctor skills, please explain why Chris's "change" is reasonable and not completely unexpected? *(6 points)*