

Stephen F. Austin High School

CAPTAINS EXCHANGE 2019-2020

Names: _____

Team: _____ #: C-_____

Score: _____/217



Rules:

- You have 50 minutes.
- Allowed: 1 page of notes, 2 calculators (non-programmable/graphing)
- Always show work and express your answer in decimal form, rounded to **THREE DECIMAL PLACES** (if necessary)
 - Writing must be legible for it to be scored.
 - No penalty for guessing.

Good Luck 😊

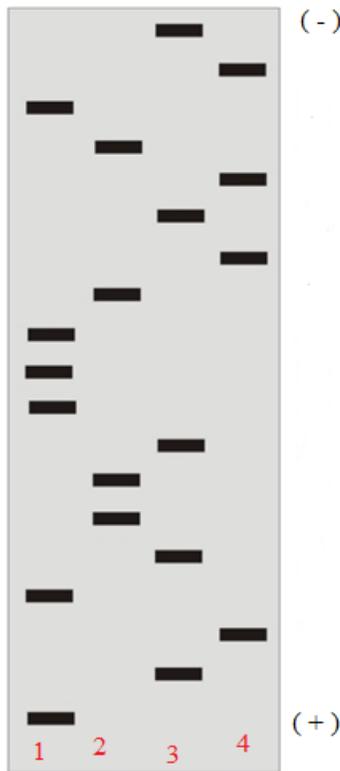
Section I. Multiple Choice. _____/61

Choose the best answer for each question. Point values assigned.

- (3pts) In humans, blood type is determined by alleles A, B, and O. Another factor is Rh. Troy has blood type A-, but his father was type O+. Georgia has blood type AB+, and he is heterozygous for the Rh factor. If Troy and Georgia incubate a child together, what percent of their offspring would have B-blood?
A. 0% D. 37.5%
B. 12.5% E. 50%
C. 25% F. None of the options (A-E are correct).
- (2pts) Cytosine makes up 38% of the DNA sample. Is Thymine a purine or a pyrimidine, and what percent of this sample is Thymine?
A. Pyrimidine; 12% of sample C. Purine; 38% of sample E. None of the above
B. Purine; 31% of sample D. Pyrimidine; 24% of sample
- (2pts) Why is analyzing mtDNA (mitochondrial DNA) useful for determining ancestry among species?
A. mtDNA is maternally inherited
B. mtDNA has a high mutation rate
C. mtDNA have circular chromosomes
D. mtDNA encodes important proteins and RNAs such as ATP Synthase
E. mtDNA is not found in the nucleus and replicates independently
- (2pts) How many total possible different gametes can be made from selfing AaBbccDDEeFfggHH?
A. 4 D. 256
B. 16 E. 32
C. 64
- (2pts) Y-linked genes are also called:
A. Holandric C. Yelic
B. Heterotic D. Heteroandric
- (2pts) Which of the following does NOT occur during mitosis?
A. Spindle formation D. Separation of Sister Chromatids
B. Chromosomes condensation E. All of the above occur during mitosis
C. Replication of DNA
- (2pts) Cell A has half as much DNA as cells B, C, and D in a mitotically active tissue. Cell A is most likely in-
A. G2 phase of interphase
B. Anaphase
C. Prophase
D. G1 phase of interphase
- (2pts) The decline of MPF activity (maturation-promoting factor) in the cell cycle indicates that-
A. The cell is about to enter the G2 phase
B. The cell is peaking in cyclin concentration
C. The cell is about to undergo apoptosis
D. The cell is declining in cyclin concentration
- (2pts) Alice is phenotypically female, but when Doctor Ito took a look at her interphase somatic nuclei, there were no Barr bodies. What statement is likely true?
A. Turner's Syndrome D. Patau Syndrome
B. Klinefelter's Syndrome E. Edward's Syndrome
C. Down Syndrome
- (2pts) Female calico cats can be very colorful. They have fur color genes on their X chromosomes, and parts of their body can be black, parts orange, and parts white. This is an example of-
A. Co-dominance
B. Incomplete dominance
C. Both
D. Neither

11. (2pts) In which substage of prophase I does crossing over occur?
- A. Leptotene D. Diplotene
 B. Zygotene E. Diakinesis
 C. Pachytene
12. (3pts) The antibiotic trimethoprim inactivates a bacterial enzyme in folate metabolism that converts DHF into THF, making deficient the THF derivative necessary for the enzyme ThyA to generate deoxythymidine- P_i from deoxyuridine- P_i . Which of the following can bacteria potentially scavenge from their medium to overcome the effects of trimethoprim?
- A. RNA nucleotides D. DNA Nucleotides
 B. ThyA E. ATP
 C. DHF
13. (1pt) What is the function of modified nucleotides in Sanger Sequencing?
- A. To enhance polymerase fidelity
 B. To increase polymerase processivity
 C. To initiate/prime replication
 D. To terminate replication

Use this diagram to answer questions 14-15:



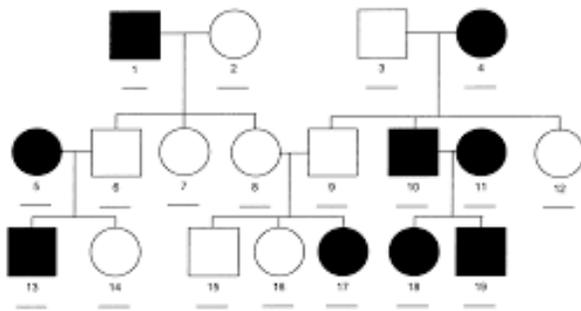
14. (2pts) Using standard Sanger Sequencing dye colors for the four DNA nucleotides, it can be determined that the columns representing pyrimidine nucleotides are found in columns-
- A. 1 and 2
 B. 2 and 3
 C. 3 and 4
 D. 2 and 4
 E. 1 and 3
15. (2pts) Using standard Sanger Sequencing dye colors for the four DNA nucleotides, it can be determined that in the first five nucleotides synthesized after the primer, all the nucleotides are present EXCEPT-
- A. Adenine
 B. Cytosine
 C. Guanine
 D. Thymine
 E. All of them are present

16. (2pts) Very Vibrant Vincent and Loser Leslie are crossed in a lab by Dr. Ken Ito to test the Ear Shape Gene, which is X-linked. E is dominant and represents normal ear shape, and e is deformed and inverted. Very Vibrant Vincent had a homozygous dominant mother and a diseased father. Loser Leslie had a normal father and a diseased mother. Which of the following is true about their offspring?
- A. All offspring will be diseased
 B. No offspring will be diseased
 C. All male offspring will be diseased
 D. All male offspring will be normal
 E. No female offspring will be diseased

17. (1pt) Which general transcription factor recognizes the TATA Box?

- A. TFIIA
- B. TFIIB
- C. TFIID
- D. TFIIE
- E. TFIITATA

18. (2pts) Analyze this pedigree:



How is this disease inherited?

- A. Autosomal dominant
- B. Autosomal recessive
- C. Sex-linked Dominant
- D. Sex-linked Recessive
- E. Y-linked

19. (3pts) What's the genotype of Individual-16, if G is dominant and g is recessive?

- A. GG
- B. Gg
- C. More likely to be GG than Gg, but can't say for sure
- D. Less likely to be GG than Gg, but can't say for sure
- E. gg

20. (2pts) Which of the following is true regarding DNA replication?

- A. Helicase and Topoisomerase are responsible for synthesis of primers and DNA separation
- B. DNA Polymerase I and III are primarily responsible for eukaryotic DNA replication
- C. DNA Primase removes primers and allows DNA Polymerase to initiate replication
- D. Okazaki fragments form on the lagging strand and are typically longer in eukaryotes
- E. Uracil is a nucleotide which is used in DNA Replication

21. (3pts) You should do all of the following if you want to insert plasmid clones into bacteria except-

- A. Remove introns via reverse transcription, creating cDNA
- B. Use restriction enzymes that cut the plasmid in at least two places, not on the Origin of Replication
- C. Put a genetic marker such as amp^r to identify those who took up the plasmid
- D. Expose the bacteria to high concentrations of $CaCl_2$ to induce uptake
- E. Add polylinkers to add a variety of possible restriction enzymes to use

22. (2pts) The two strands of DNA are _____; replication is _____.

- A. Antiparallel and complementary; semi-conservative
- B. Parallel and complementary; conservative
- C. Antiparallel and identical; dispersive
- D. Parallel and identical; semi-conservative
- E. Antiparallel and complementary; conservative

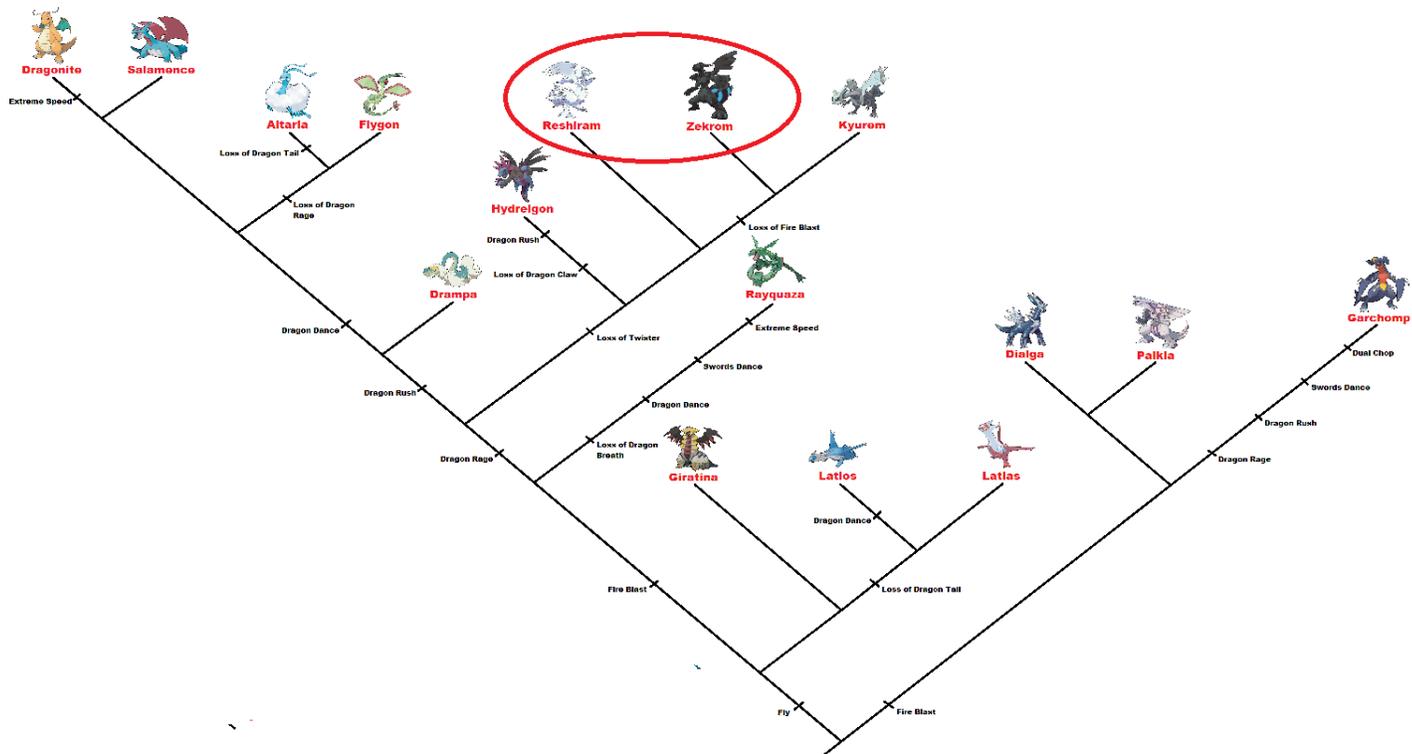
23. (3pts) Of the three major forms of DNA present in cells, _____ is left-handed, while _____ has the greatest diameter.

- A. A-DNA; Z-DNA
- B. B-DNA; C-DNA
- C. B-DNA; A-DNA
- D. Z-DNA; A-DNA
- E. Z-DNA; B-DNA

24. (2pts) When the ribosome reaches a stop codon in the mRNA, what molecule is added to the polypeptide to terminate translation?

- A. Polyadenine tail
- B. 7-Methylguanosine cap
- C. The terminator Amino Acid
- D. Water
- E. A ddNTP which ceases extension
- F. None of the above

Use this diagram to answer the following questions:



25. (2pts) All of the following have adapted Dragon Rage EXCEPT-
- A. Salamence
 - B. Drampa
 - C. Garchomp
 - D. Kyurem
 - E. Flygon
 - F. All of the above have that rage
26. (2pts) The red circle of Unova's Reshiram and Zekrom represent what kind of group?
- A. Paraphyletic
 - B. Monophyletic
 - C. Polyphyletic
 - D. Holophyletic
 - E. Sister Taxa
27. (2pts) Which of the following is false?
- A. Garchomp has many derived traits that Palkia and Dialga do not
 - B. The latest common ancestor of Dragonite and Flygon knew how to use Dragon Dance
 - C. Rayquaza and Dagonite both have the ability to zoom zoom (extreme speed) that was not present in their common ancestor
 - D. Zekrom is more closely related to Reshiram than Kyurem
 - E. Dialga and Palkia are sister taxa
-
28. (2pts) The half-life for newly synthesized mRNA (ie the time it takes for 1/2 of it to degrade) is greater/longer in _____ because of _____.
- A. Eukaryotes; the fact that newly synthesized mRNA is protected in the nucleus
 - B. Prokaryotes; the fact that prokaryotes need mRNA for a greater period of time
 - C. Eukaryotes; processing such as 7-methylguanosine caps and polyadenine tails
 - D. Prokaryotes; the fact that prokaryotic mRNA is fundamentally different from eukaryotic mRNA
 - E. There is no difference
29. (2pts) A chromosome has 12 genes, of which at least one is responsible for eye color. Dr. Ken Ito fires intense UV rays at multiple cats with this chromosome, noting which specific gene(s) were mutated and observing the effects. Is this random or targeted mutagenesis, and why?
- A. Random; any of the 12 genes can be affected
 - B. Targeted; it is specifically targeting that chromosome
 - C. Random; it is inducing random, non-specific mutations
 - D. Targeted; Dr. Ken Ito is targeting the genes of the cats
 - E. Not enough information

Section II. Short-Answer. _____/120

30. (5pts) *LacI* is the repressor of *E. Coli*'s *lac* operon. Match one or more possible *lac* operon genotype(s) to each of the following *E. Coli* phenotypes (all in the absence of glucose):

- a) _____ *lac* expression only in absence of lactose
- b) _____ *lac* expression only in presence of lactose
- c) _____ *lac* expression both in the presence and absence of lactose
- d) _____ *lac* expression in no condition

- A. Mutation in LacI-binding operator that makes it constitutively bind
- B. Mutation in the LacI-binding operator (*lacO*) that makes it never bind
- C. Mutation in LacI that makes it a corepressor, binding the operator upon induction
- D. Nonsense mutation early in *lacI*
- E. Wild-type, no mutations

31. (4pts) For a given type of alien, hot (H) is dominant to ugly (h), and sexy (S) is dominant to unsexy (s). 2 aliens of unknown genotype are crossed, producing 300 offspring. Of these offspring, 110 have ugly yet sexy appearance, while 39 have hot yet unsexy appearance. What is the MOST LIKELY the genotypes of the parents, assuming independent assortment?

_____ & _____

32. (4pts) Dr. Ken Ito is analyzing the cross between two birds, Hot Hoe and Jank Joe. In this species of bird, wing color is determined by two traits, gene X and Y. Gene X determines the color of the front of the wing and has two alleles, B (dominant) for Blue and b (recessive) for brown. Gene Y determines the color of the back of the wing and exhibits incomplete dominance between alleles R for Red and Y for yellow. Hot Hoe has genotypes Bb and RY, but he is albino (aa). Jank Joe is orange for the back of the wing, brown for the front of the wing, and heterozygous for the Albino trait (Aa). If Dr. Ken Ito crosses Hot Hoe and Jank Joe, what percent of their offspring will be Blue (front wing) and Red (back wing)?

_____ %

33. Analyze this karyotype:

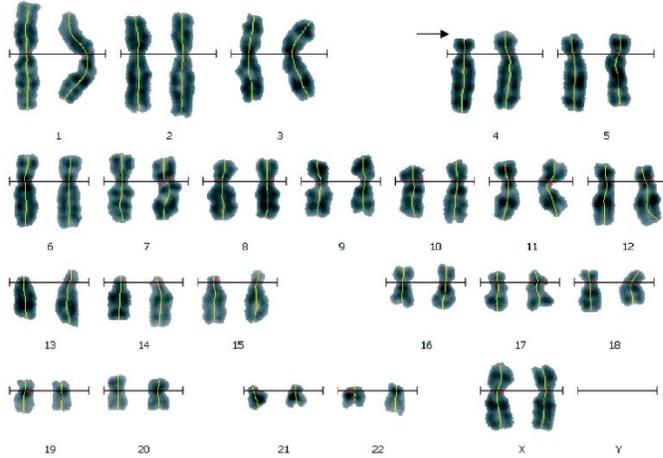


- a) (1) Identify the disorder.
- b) (1) Identify the gender.

c) (2) At what phase of mitosis was this karyotype taken?

d) (2) This image was taken through a process known as G-banding. What does the G stand for?

34. Analyze this karyotype:



a) (3) Identify the disorder.

b) (4) Assuming fertility and that the disorder does not affect the gonads, does one expect this patient to form polar bodies during meiosis? Why or why not?

35. Acronym Nation! What do the following acronyms stand for? (2pts each)

a) F1 generation (identify what “F1” stands for)

b) CpG Island (identify what “CpG” stands for)

c) A & P sites of a ribosome (identify what “A” & “P” stand for)

d) cpDNA

e) RFLP

f) VNTR

g) PCR

h) CRISPR

i) ddNTPs

j) WTSS

k) Tn-Seq

l) shRNA

m) ssBp

36. Stages Sensation!!! Identify the three phases/steps/stages of each of the following processes: (+3 each)

a) PCR

b) CRISPR-Cas9 (as an immune system in prokaryotes)

c) Interphase

d) Transcription

37. Mad Scientist Baby!!! BRIEFLY describe the contributions of the following scientists (+2 each):

a) Meselson & Stahl

b) Sir Alec Jeffreys

c) Elizabeth Blackburn

d) Kary Nullis

e) Friedrich Miescher

f) Francis Crick

g) Herb Boyer & Stanley N. Cohen

h) Francisco Mojica

38. (4pts) Recently, there has been some controversy because He Jian Kui, a scientist in China, actually used CRISPR Cas9 on human embryos. This raises many bioethical concerns. What gene did he disable, and what was the stated purpose of this gene inactivation?

39. (4pts) Why can't you determine the exact sequence of a gene (order of nucleotides) based on its corresponding polypeptide sequence? Give two reasons.

40. Dr. Ken Ito is performing a microarray.

- a) (3pts) Thicc Dev has cancer. Dr. Ken Ito takes a biopsy of both cancer and normal cells. He extracts Dev's mRNA, synthesizes cDNA from this transcript, and prepares the microarray filled with short synthetic, unmodified oligonucleotides representing all the genes in the genome. He then mixes the two cDNA samples with the microarray. However, nothing shows up on the X-Ray film!!! What mistake did Dr. Ito make?
- b) (3pts) Quickly realizing his stupidity, Dr. Ito fixes his mistake. He finds that the normal cell microarray DNA sample is brighter on the microarray than the cancer cells. Is this expected, and why?

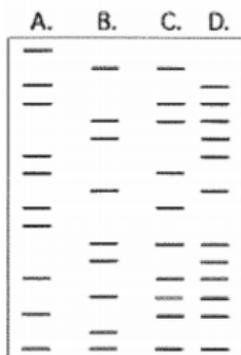
41. (5pts) Do prokaryotes or eukaryotes have higher gene density? Identify TWO reasons to justify your answer.

42. (3pts) How many codons are there that code for amino acids? How come there are not as many types of tRNA?

43. (4pts) Why do scientists use *Taq Polymerase* for PCR? Name an application for PCR's capabilities.

44. (4pts) What is the ribosomal binding site in bacterial mRNA known as? What does the AUG sequence (of which the binding site is upstream of) code for in bacteria?

45. Dr. Ken Ito does a RFLP on Four Individuals, A- Hoe Joe, B- Thicc Nic, C- Hot Lot, and D- the child.



a) (1pt) Dr. Ken Ito has a sample of DNA and he wants it to somehow move slower across the gel electrophoresis. Name one way he can accomplish this.

b) (2pts) Identify the probable parents.

46. (3pts) Cool Juul acts like he's all cool and all smoking and stuff, but he doesn't realize that his smoking tendencies could actually impact his future unborn offspring, making them less healthy and sicker!!! Other than mutations, how is this possible!?!?
47. (4pts) Are the functions/effects of Histone Acetyltransferase (HAT) and DNA Methyltransferase fundamentally different or the same? If same, what's the similarity? If different, what's the difference?

Section III. Free-Response (long answer). ____/36

48. In the tongue sole fish, sex is determined by a combination of genetics and environmental temperature. Genetically male fish have two Z chromosomes (ZZ), and genetically female fish are heterozygous (ZW). When fish are raised at 22 degrees Celsius, ZZ fish develop into phenotype males and ZW fish develop into phenotypic females. However, when fish are raised at 28 degrees Celsius, the Z chromosome is modified (denoted to Z*). Z*W develop as phenotype males that are fertile and can pass the Z* chromosome to their offspring even when the offspring are raised as 22 degrees Celsius.
- a) (3pts) Predict the percent of phenotypic males among the F1 offspring of the cross between a ZW female and a Z*Z male if the offspring are raised at 22 degrees Celsius.
- _____ %
- b) (7pts) At least one Z or Z* chromosome is necessary for survival of the fish. A researcher crossed two fish and observed a 2:1 ratio of males to females among the offspring. Based on the information, identify the genotypes of the parents in the cross. Describe ONE fitness cost so the female of mating with this particular male.
49. Doctor Ito is studying genetic traits in dogs. He sees that Black (B) is dominant to brown (b) when it comes to fur, and that Cuteness (C) is dominant to ugliness (c). He is trying to determine whether or not these genes are linked.
- a) (2pts) Write a null hypothesis for this experiment.
- b) (4pts) Dr. Ito crosses Bad Boy, BbCc, and Cute Coy, BbCc. If they have 32 offspring, write the expected number of offspring with each phenotype (assuming null hypothesis is true)?

- c) (5pts) Alas, the real number of offspring are below:
 23 Black, Cute Dogs
 2 Black, ugly Dogs
 1 brown, Cute Dog
 6 brown, ugly Dogs
 Calculate the chi square for this result. Round to two decimal places.

- d) Look at the following:

df	Probability level (alpha)					
	0.5	0.10	0.05	0.02	0.01	0.001
1	0.455	2.706	3.841	5.412	6.635	10.827
2	1.386	4.605	5.991	7.824	9.210	13.815
3	2.366	6.251	7.815	9.837	11.345	16.268
4	3.357	7.779	9.488	11.668	13.277	18.465
5	4.351	9.236	11.070	13.388	15.086	20.517

(4pts) Are the genes linked or not? Justify your answer.

50. An original strand of DNA reads: 3' → TAC GAA TCA ACG → 5'

It was exposed to mutagens and now: 3' → TAU GAT ATC AAC G → 5'

- a) What kinds of mutations occurred? Choose multiple. ALL OR NOTHING. (3)
 A. Point Mutations C. Insertion E. Frameshift G. Missense
 B. Substitutions D. Deletion F. Silent H. Nonsense
- b) What's the name of the process that led to the formation of the Uracil in the DNA? What happens in this process? (3)
- c) A common way of writing mutations is like this: "Pro250Arg." Look at the first codon of this gene, TAC. It mutated to TAU. Write the TAC→TAU mutation in the same way as "Pro250Arg." (3)
- d) Based on your knowledge of Designer Genes, would an insertion/deletion be more harmful earlier on or later on in the DNA segment? (2)