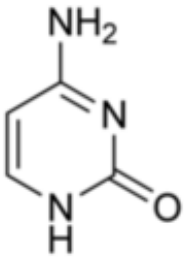
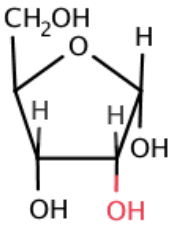
Introduction to Genetics
FALL 2024
EXAM I

1. The base shown at the right is



A) Adenine
B) Guanine
C) Uracil
D) Thymine
E) Cytosine

2. The sugar shown at the right is



A) Glucose
B) Ribose
C) Deoxyribose
D) Dihydroribose
E) DideoxyRibose

3. The sequence of one strand of DNA is 5'-GCTTTAG-3'. The sequence of the complementary strand would be

A) 5'-GCTTTAG-3'.
B) 5'-CTAAAGC-3'.
C) 5'-GATTTCG-3'.
D) 5'-ATGGGCA-3'.
E) 5'-CGAAATC-3'

Questions **4-5** refer to the biochemical pathway below.

In *Neurospora*, a linear biochemical pathway synthesizes amino acid Z, which is essential for growth.

$$W \xrightarrow{E1} X \xrightarrow{E2} Y \xrightarrow{E3} Z$$

4. Which compound(s) will be absent in null mutants lacking enzyme, E2?

A) W B) X C) Y D) Y and Z E) X, Y, and Z

5. Null mutants lacking enzyme E2 gene will grow on minimal medium supplemented with which of the following compounds?

A) W B) X C) W or X D) Y or Z E) X, Y, or Z

6. An unknown mutant lacks one of the enzymes above. All you know is that it fails to grow when X is added to the media. Which enzyme could it be missing?

A) E1 B) E2 C) E3 D) E1 or E2 E) E2 or E3

7. In a randomized DNA sequence, you would expect to encounter ATG sequence once every...

A) 8 bases B) 16 bases C) 64 bases D) 128 bases E) 256 bases

8. If a strand of DNA strand is 6 nucleotides long, how many different DNA sequences are possible?

A) 24 B) 216 C) 729 D) 1296 E) 4096

9. If a strand of DNA strand is 6 nucleotides long, but does not contain adenine, how many different DNA sequences are possible?

A) 18 B) 216 C) 729 D) 1296 E) 4096

10. The haploid human genome contains approximately 3100 megabases of DNA. Assuming all base pairs are randomized in the genome, what is the minimum length of DNA (in bases) needed to design a sequence NOT found in the human genome?

A) 8 B) 12 C) 16 D) 20 E) 24

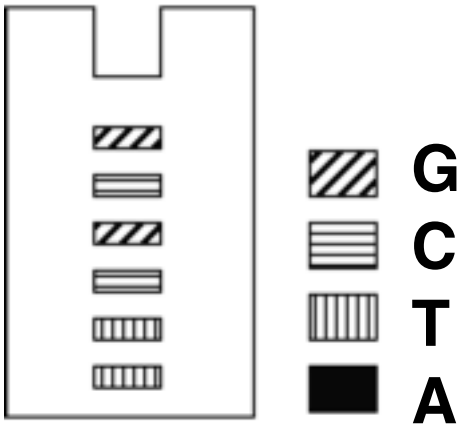
11. The replication machinery allows one error to slip through for each $1X10^{10}$ bases synthesized. The *E. coli* genome has 5 megabases of DNA. A 1ml culture of *E. coli* has $1X10^{9}$ cells. If you grow a 1ml culture of *E. coli* from a single cell, how many genetically distinct mutants are present in that culture?

A) 200 B) 2000 C) 20,000 D) 500,000 E) 2,000,000

12. A rapidly growing archaea has a circular genome that is 16 megabases in size and replicates using ***two bidirectional*** origins of replication. If a replication fork can replicate 100,000 bp/min, what is the minimum time needed for it to replicate its genome?

A) 10 min B) 20 min C) 40 min D) 80 min E) 320 min

13. A Sanger DNA sequencing reaction was loaded into the well at the top of the gel and electrophoresed.
The sequence in the gel shown to the right reads:



A) 5'-GCGCTT-3'
B) 5'-CGCGAA-3'
C) 5'-GCGCUU-3'
D) 5'-AAGCGC-3'
E) 5'-TTCGCG-3'

14. 5'- TGC___ - 3' is one half of a palindromic restriction site. What is the complete sequence?

A) 5'- TGCTGC- 3'
B) 5'- TGCCGT- 3'
C) 5'- TGCACG - 3'
D) 5'-TGCGCA - 3'
E) 5'- TGCGAA - 3'

15. The enzyme that catalyzes a covalent joining of a 5' phosphate with a 3' hydroxyl of two DNA fragments is called

A) Telomerase B) Ligase C) RNA Polymerase D) Primase E) Helicase

16. The enzyme that synthesizes the RNA used during lagging strand replication is called

A) Telomerase B) Ligase C) RNA Polymerase D) Primase E) Helicase

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17. Which pair of pentamer primers could be used to amplify the DNA sequence shown below?

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5'-TTTTTGATTACATCGGCATTACCGATTTAAAGCCCTGGGGG-3'
3'-AAAAACTAATGTAGCCGTAATGGCTAAATTTCGGGACCCCC-5'
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A) forward primer 5'-AAAAA-3' and reverse primer 5'-GGGGG-3'
B) forward primer 5'-TTTTT-3' and reverse primer 5'-CCCCC-3'
C) forward primer 5'-AAAAA-3' and reverse primer 5'-CCCCC-3'
D) forward primer 5'-TTTTT-3' and reverse primer 5'-GGGGG-3'
E) forward primer 5'-AAAAA-3' and reverse primer 5'-TTTTT-3'

18. Avery observed that a nonpathogenic strain of bacteria (**type R**) could be genetically transformed into a pathogenic strain if they took up a cellular component of a related pathogenic strain (**type S**).

To determine which substance was the transforming material, Avery treated a solution of the heat killed **type S** bacteria with the following enzyme solutions, then mixed this with the nonpathogenic **type R** bacteria and fed these mixtures to mice.

I) Nothing II) Proteinase III) DNase IV) RNase V) Proteinase, RNase, and DNase

Assuming that the presence of the pathogenic bacteria kill the mice, which of the following outcomes are consistent with the idea that DNA is the transforming material?

A) mice fed mixtures I and III both died
B) mice fed mixtures III and V both died
C) mice fed mixtures I, II, and IV died
D) mice fed mixture II, IV, and V died
E) only mice fed mixture I died

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Questions **19 - 21** refer to the following virus

A virus that infects armadillos is known to survive by frequently altering its capsid protein to evade its host's immune system. To do so, it has a DNA polymerase with a high error rate, so that new mutations are introduced into the capsid gene, changing its amino acid sequence. The virus's mutation rate is 1 error/10,000 bp replicated.

The viral genome is small (5000 bp) and contains only 3 genes, a capsid gene (1000 bp), a DNA polymerase gene (1000 bp), and a viral envelop gene (1000 bp).

Both the polymerase gene and envelop gene are essential for the virus to live. Suppose that ANY mutation in those genes results in a nonviable virus.

19. What fraction of viruses have a mutation each time they replicate?

A) 1/5 B) 3/5 C) 2/5 D) 1/10 E) 1/2

20. What fraction of viruses mutate their capsid gene each time they replicate?

A) 1/5 B) 3/5 C) 2/5 D) 1/10 E) 1/2

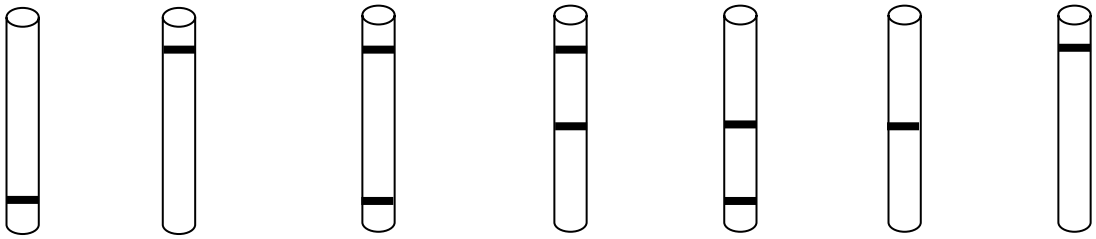
21. What fraction of viruses become inviable following replication?

A) 1/5 B) 2/5 C) 3/5 D) 1/10 E) 1/2

Questions 22 and 23 refer to the following experiment

To differentiate between potential mechanisms for how DNA is duplicated, Meselson-Stahl set up an experiment to differentially label the strands of the DNA during replication. For this experimental analysis, a culture of *E.coli* was grown in media containing heavy isotopes of nitrogen (^{15}N) for several generations. Cells from this culture were then transferred into media containing normal nitrogen (^{14}N) and then samples were prepared 1) after one generation in the normal media, and 2) after two generations of growth in the normal media.

The DNA was then prepared from each sample and its boyant density was determined by centrifugation CsCl gradients. The results of two control cultures grown in only heavy (^{15}N) media, and only light (^{15}N) media are shown, along with five potential outcomes, labeled A-E.



Control 1 heavy media | Control 2 normal media | A | B | C | D | E

22. Considering the controls, which samples would support the idea that DNA replicated conservatively?

A) D after one generation, E after two generations
B) C after one generation, D after two generations
C) D after one generation, A after two generations
D) A after one generation, A after two generations
E) D after one generation, B after two generations

23. Considering the controls, which samples would support the idea that DNA replicated semiconservatively?

A) D after one generation, E after two generations
B) C after one generation, D after two generations
C) D after one generation, A after two generations
D) A after one generation, A after two generations
E) D after one generation, B after two generations

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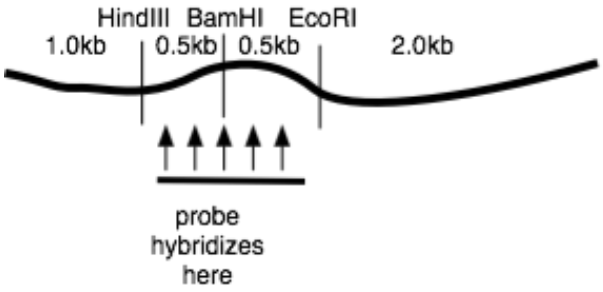
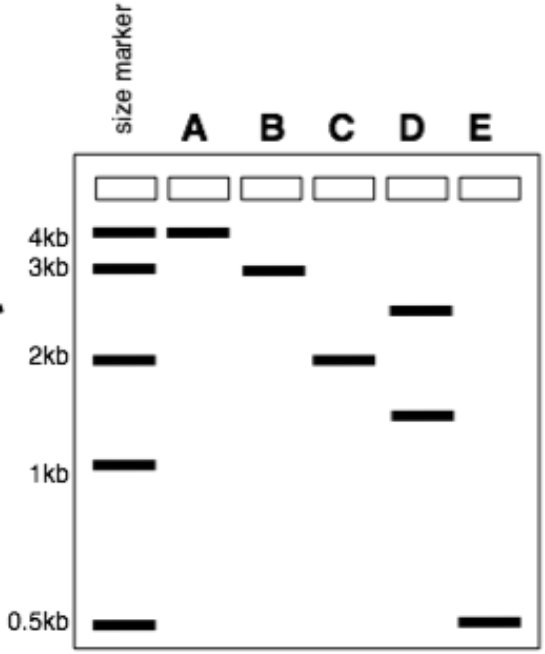
A 4kb linear double stranded DNA virus has the following restriction sites in its genome.





The solid bar represents a short PCR fragment that was amplified, radioactively labeled, and used as a probe for the Southern Blot shown to the right. The probe hybridizes only to the region shown above on the viral genome. In each lane, the viral DNA was digested with a restriction endonuclease, and run through an agarose gel. The gel was transferred onto a nylon membrane and probed with the PCR fragment shown above, and the probe was then visualized after exposing the southern blot to film.

24. Which lane was digested with BamHI?

A) A B) B C) C D) D E) E

25. Which lane was digested with HindIII?

A) A B) B C) C D) D E) E