

Using the Instant Feedback (IFAT) scratch cards, scratch the covering off of answer choices for each question until you discover the correct answer indicated by a star.
Add up the remaining, unscratched, squares and record this total in the right column.
Be sure that everyone prints their name and signs the back of the scratch card.



1. Which of the following statements is part of the theory of evolution?

- A. Natural selection is the only source of adaptive traits.
 - B. All life on earth is related through descent from a common ancestor.
 - C. Over evolutionary time, populations become reproductively isolated from one another and become different species.
 - D. All of A, B and C are correct.**
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2. Medical researchers have designed several different drugs that interfere with replication of retroviruses such as HIV. Which of the following hypothetical drugs should have the LEAST severe side effects to its human host?

- A. One that interferes with RNA synthesis.
 - B. One that interferes with DNA replication.
 - C. One that interferes with reverse transcription.**
 - D. One that interferes with ribosome function.
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3. The use of antibiotic drugs to treat bacterial infections suffers from a paradox: the more we use them, the less effective they become. Why is this?

- A. Once an antibiotic-resistant mutation has occurred, antibiotics provide a selective environment in which this mutation should increase in frequency.**
 - B. Antibiotics influence the nature of mutations, making it more likely that the next mutation to occur will be one that improves resistance to that particular antibiotic.
 - C. Antibiotics increase bacterial mutation rates.
 - D. All of A, B and C contribute to the evolution of antibiotic resistance.
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4. Which of the following statements best describes the rationale for treating viral infections with multiple drugs at the same time ("drug cocktails")?

- A. Drug cocktails reduce viral mutation rates.
 - B. Drug cocktails increase the number of helpful mutations that must be present in the virus for it to successfully replicate.**
 - C. Drug cocktails reduce side effects to the human host.
 - D. Drug cocktails reduce selection pressure on the virus to evolve resistance.
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5. In a medical research trial, three people who have been infected with HIV are each prescribed a different course of treatment. Patient A is treated with AZT, patient B is treated with integrase inhibitors, and patient C is a control who receives no anti-viral drugs. Thus, the viral population in patient A (viral population A) is exposed to AZT, the viral population in patient B (viral population B) is exposed to integrase inhibitors, and viral population in patient C (viral population C) is not exposed to any anti-viral drugs.

In which viral population is a mutation that improves resistance to **integrase inhibitors** most likely to occur?

(Assume that viral replication rates and population sizes are the same across all three patients).

A. The mutation is equally likely to occur within any of the viral populations

- B. Viral population A, exposed to AZT
C. Viral population B, exposed to integrase inhibitors
D. Viral population C, exposed to no anti-viral drugs



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6. With reference to the previous question, imagine that a mutation improving **resistance to AZT** spontaneously occurs in each viral population (A, B and C). In which of these viral populations would you expect this new mutation to increase in frequency?

A. The mutation will increase in frequency in all three viral populations.

B. Viral population A, exposed to AZT

- C. Viral population B, exposed to integrase inhibitors
D. Viral population C, exposed to no anti-viral drugs

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7. Which of the following observations supports Darwin's concept of descent from a common ancestor?

A. The forelimbs of dolphins have the same arrangement of bones as the forelimbs of humans.

- B. Whales and fish have been evolving independently for many millions of years, but both groups have converged on similar body shapes that allow them to move smoothly through the water.
C. Cold-water fish have specialized molecules in their bloodstream that allows them to survive in their cold-water environment; fish that live in warm water do not produce these molecules.
D. Both B and C support the concept of descent from a common ancestor.

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8. Which of the following statements is falsifiable?

1. All whiptail lizards are female.
2. God exists.
3. Life does not exist on planets other than Earth.
4. Positive thinking can cure cancer, if you really try hard enough.

- A. 1, 2 & 3 only
B. 1 & 3 only
C. 2 & 4 only
D. 4 only

9. While dissecting a boa constrictor (a type of snake), you notice that although the animal has no externally visible legs, it does have tiny leg bones. How would evolutionary theory explain this observation?
- A. Having leg bones (even though they are very small) is an adaptive trait that improves the fitness of individuals in this species.
 - B. Future generations of snakes might benefit from having legs, so selection keeps them around in vestigial form.
 - C. Snakes are descended from an ancestral species of reptile that had legs.**
 - D. All of A, B and C are correct.
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10. How does natural selection differ from artificial selection?
- A. Natural selection requires heritable variation in the trait of interest. Artificial selection does not require heritable variation.
 - B. Under natural selection, individuals with traits that make them well adapted to their environment are the most likely to survive and produce offspring. Under artificial selection, humans select which individuals will produce offspring.**
 - C. Under natural selection, individuals change in response to their natural environment. Under artificial selection, individuals change in response to a controlled captive environment.
 - D. All of A, B and C are correct.
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11. Which of the following examples demonstrates evolution by natural selection?
- 1. After living at high altitude for several weeks, humans begin producing more red blood cells, a pattern which improves oxygen transport in this environment.
 - 2. During the Industrial Revolution, tree trunks became coated with soot, and exposure to these chemical pollutants caused white moths to mutate into black moths.
 - 3. The ancestors of modern-day giraffes stretched their necks by reaching for leaves on tall trees; these elongated necks were inherited by their offspring, such that neck length increased each generation.
 - 4. In cold environments, bears born with more body hair are more likely to survive and reproduce. These individuals produce offspring who are also relatively hairy.
- A. 1, 2 & 3 only
 - B. 1 & 3 only
 - C. 2 & 4 only
 - D. 4 only**
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12. The image at right shows all of the chromosomes in a dividing wing cell of an insect.

What is the coefficient of C for this cell?

- A. 12 C
- B. 6 C
- C. 4 C**
- D. 2 C



13. Many of the microscopic images of dividing cells shown in class were created by immunofluorescence techniques using antibodies that bind only to very specific proteins. These antibodies contain "tags" that give off coloured light, revealing the location of the target protein. In this way, different parts of a cell can be stained different colours.

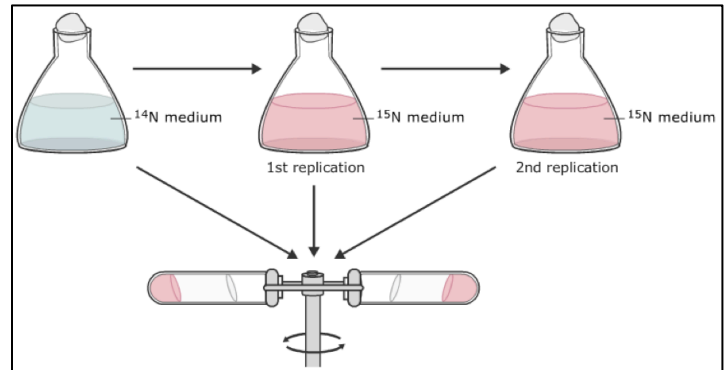
Imagine that you used immunofluorescence techniques to stain animal cells and plant cells with antibodies that bind only to actin, giving off red light.

If your cells were at the cytokinesis stage of mitosis, what would you likely see?

- A. The centrosomes would appear red, but only in animal cells.
- B. The nuclei would appear red in both plant and animal cells.
- C. There would be a red band encircling each cell, but only in animal cells.**
- D. The kinetochore motor proteins would appear red in both plant and animal cells.

14. Recall that, in their famous experiment on DNA replication in bacteria, Meselson and Stahl first grew cells in a medium containing only the heavy N isotope ¹⁵N, such that all of the initial parental DNA would contain only ¹⁵N. Then they allowed the cells to divide exactly twice in medium containing only the light isotope, ¹⁴N. Using ultracentrifugation, they then went on to determine how heavy the resulting DNA at each stage of the experiment. These data allowed them to distinguish between conservative, semi-conservative and dispersive models of DNA replication.

Now, suppose you want to conduct this same experiment, but in reverse. That is you grow cells in medium containing only light ¹⁴N and then allow them to divide exactly twice in medium containing only ¹⁵N. You subject a sample of the cells to ultracentrifugation after 0, 1 and 2 rounds of replication as shown at right.



The table below shows three possible results from your experiment.

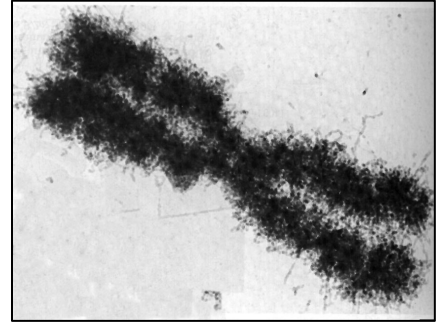
Which result would you expect to see if DNA replication followed the **dispersive** model?

Result B

| Parental strands grown in ¹⁴ N | After one replication in ¹⁵ N | After two replications in ¹⁵ N | |
|---|--|---|-----------------|
| | | | Result A |
| | | | Result B |
| | | | Result C |

15. Recall that the double helix of DNA is composed of two coiled strands of bases. The bases in each strand are held together through their sugar-phosphate backbones while hydrogen bonds hold one strand to the other.

How many such double-stranded DNA molecules make up the structure shown at right?



- A. The structure contains 2 double helices.**
B. The structure contains 1 double helix.
C. The structure contains 4 double helices.
D. The structure contains many hundreds of double helices.
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16. Imagine that you are a medical researcher trying to limit the spread of a newly discovered virus. How should you respond upon learning that you are dealing with a **retrovirus**?

- A. Good news! Retroviruses have unique stages in their life-cycle that human cells do not, and these stages can be targeted for drug development.
B. Bad news! Retroviruses have high mutation rates, meaning that they can quickly evolve resistance to anti-viral drugs.
C. Bad news! Retroviruses have high mutation rates, making it very difficult to design universally effective vaccines.
D. All of A, B, and C are correct.
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17. In 1999, the first polyploidy mammal was discovered, an Argentinian rat whose somatic cells contain four sets of chromosomes. If you imagine one of these cells dividing in the rat bone marrow, at which stage of the cell cycle would the coefficient of "C" be the same as the coefficient of "n" (ie. 1n AND 1C or 4n AND 4C etc.)?

- A. During G1, cells would be 4n and 4C.**
B. During G1, cells would be 2n and 2C.
C. During G2, cells would be 4n and 4C.
D. During G2, cells would be 8n and 8C.
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18. Imagine that you heard about a new drug that inhibits the growth of cancer tumors by inhibiting the action of kinetochore motor proteins. If you did a Google search for microscopic images comparing treated vs. untreated populations of cycling cells, what would you expect to see?

- A. In treated populations, there would be a decrease in the proportion of cells in anaphase.**
B. In treated populations, there would be a decrease in the proportion of moving cells.
C. In treated populations, there would be a decrease in the proportion of daughter cells that were abnormally large.
D. In treated populations, there would be a decrease in the proportion of cells blocked at the G₂/M checkpoint.
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19. One of the "rules" of DNA replication is that polymers grow by extending the 3'OH on a previously paired base.

Which of the following enzymes adds a DNA base to the 3'OH of a previously paired RNA base?

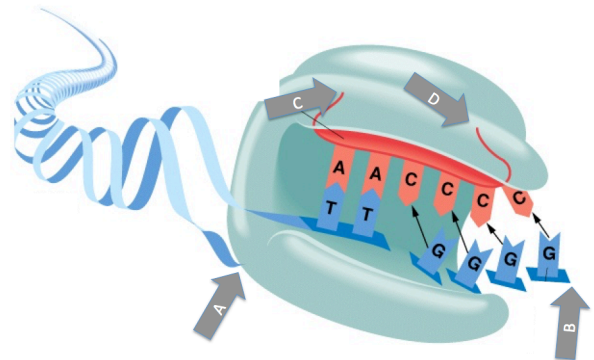
- A. telomerase
- B. primase
- C. DNA polymerase III**
- D. DNA polymerase I

20. Zebrafish are well known for their ability to regenerate fins that have been lost to predators. Regeneration involves stimulating nearby cells to begin cycling. How does this likely occur?

- A. Nearby cells that have been blocked at the mitosis checkpoint are released.
- B. Nearby cells fire all of their replication origins and enter S phase.
- C. Nearby cells in G₀ enter G₁ of the cell cycle.**
- D. Nearby cells enter the apoptosis pathway.

21. The image at right shows the action of telomerase. Which arrow indicates the 5' end of DNA?

- A. A**
- B. B
- C. C
- D. D



22. Chromosome 21 is the shortest human chromosome, containing about 50 million base pairs. One example of natural variation in human chromosome number is trisomy 21. In such cases, the individuals have three copies of chromosome 21 instead of the usual 2 copies like all of the other chromosomes.

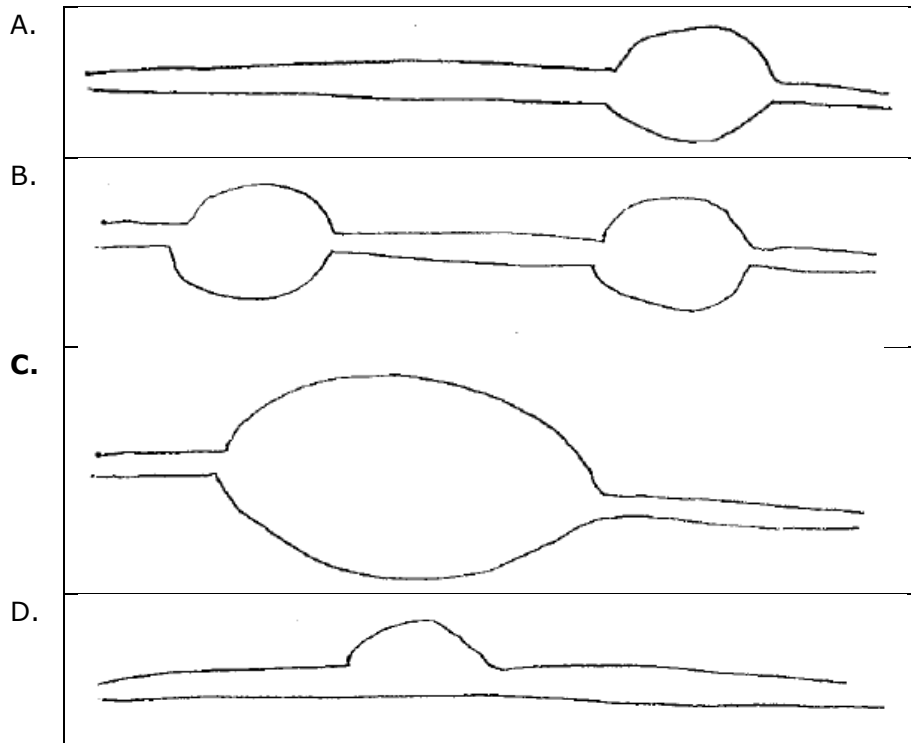
Which of the following statements about trisomy 21 is correct?

- A. During replication of chromosome 21, one strand will be "leading" and the other strand will be "lagging" for the entire chromosome.
- B. A karyotype from a person with Trisomy 21 would show 94 chromatids.**
- C. During metaphase in somatic cells, chromosome 21 would be composed of three chromatids.
- D. Somatic cells would be designated as $3n + 1$.

23. Imagine that Xiaoming and her friends were studying for this term test. Xiaoming draws this start of a replication bubble and challenges her friends, "What will happen next? What will this chromosome look like in a few minutes?"



Which of the following images drawn by Xiaoming's friends is the most appropriate response to her question?



24. ATP, produced by cellular respiration, is a ribonucleoside triphosphate; its sugar is ribose. Aside from its role as the "energy currency" of the cell, ATP is also an essential substrate for the replication of the nuclear genome during S phase.

Where would you expect to find this particular "A" base (derived from ATP) incorporated into the DNA of cells in G₂?



- A. On both old and new strands, at the replication origins.
- B. On the "new" DNA strands only, base-paired across the double helix from thymines.
- C. Nowhere; this base would not be present in the DNA of cells in G₂.**
- D. Only at the very tips of chromosomes (telomeres).

25. Synthesis of DNA requires the elongation of nucleic acid polymers by creating the covalent bonds that form the sugar-phosphate backbone. Which of the following components of the DNA replication machinery BREAKS the covalent bonds of the sugar phosphate backbone?



- A. DNA polymerase I
- B. Topoisomerase
- C. Helicase
- D. A and B are both correct.**