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. Guppies are small fish that cannot survive if the water temperature becomes too warm. However, certain mutations can increase heat-resistance and thus improve individuals' ability to survive in warm water.

   Imagine two populations of guppy, one (#1) living in relatively cool water and the other (#2) living in an area where water temperatures are becoming warmer.

   In which population is heat-resistance most likely to increase, and why?

A. Population #2, because a heat-resistant mutation is more likely to occur in response to a warm environment.
B. Population #2, because any heat-resistant mutations that do occur will be favoured by selection in a warm environment.
C. Population #2, because both (a) and (b) contribute to increasing heat-resistance.
D. In either population, because a heat-resistant mutation is equally likely to occur and equally likely to be selectively favoured in either population.

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2. It is possible to stain chromosomes such that only the kinetochores are visible as bright red spots under the microscope.

   For an organism with 2n = 16, how many red spots would be present at anaphase of Meiosis II?

A. 8
B. 4
C. 32
D. 16

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3. As an important enzyme in DNA replication, ligase is strongly expressed during S phase of the cell cycle in insects.

   If you detected ligase activity in G_1 rather than S phase, which of the following activities would it likely be involved in?

   1. Excision repair of mismatches.
   2. Unequal crossing over.
   3. Non-homologous end joining of broken chromosomes.
   4. Photolyase repair of thymine dimers.

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

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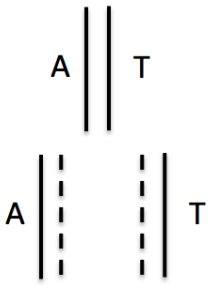
4. The sketch at right represents a typical AT base pair in DNA being replicated. During the first round of replication, imagine that a hypothetical purine, called shautamine, is incorporated into the growing DNA backbone as the original AT pair is replicated. During the second round of replication, shautamine undergoes a tautomeric shift and therefore attracts the "wrong" base.



Continuing the diagram in this pattern, which of the following SNPs will be present instead of the original AT pair following the third round of replication?

A. AT
B. GC
C. CG
D. TA

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5. Roughly one in every 1,000 girls is born with three copies of the X chromosome. Although the extra X chromosomes are inactivated in somatic cells, "triple X" females often exhibit lower IQ, motor coordination problems and delayed language development.

Assuming that the XXX karyotype results from a single error in chromosome partitioning, in which of the following stages of meiosis might the error occur?

1. Meiosis I in the mother.
2. Meiosis II in the father.
3. Meiosis II in the mother.
4. Meiosis I in the father.

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

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6. Mendel's careful analysis of controlled crosses was able to show the random segregation of the two alternative alleles of the seed colour gene, **Y** and **y**.

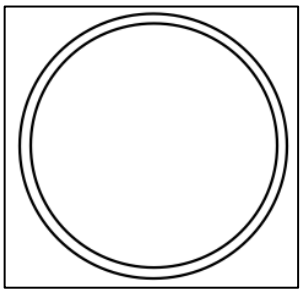
During which of the following stages of the life cycle of the pea plants did this random segregation take place?

A. spore
B. gametophyte
C. zygote
D. sporophyte

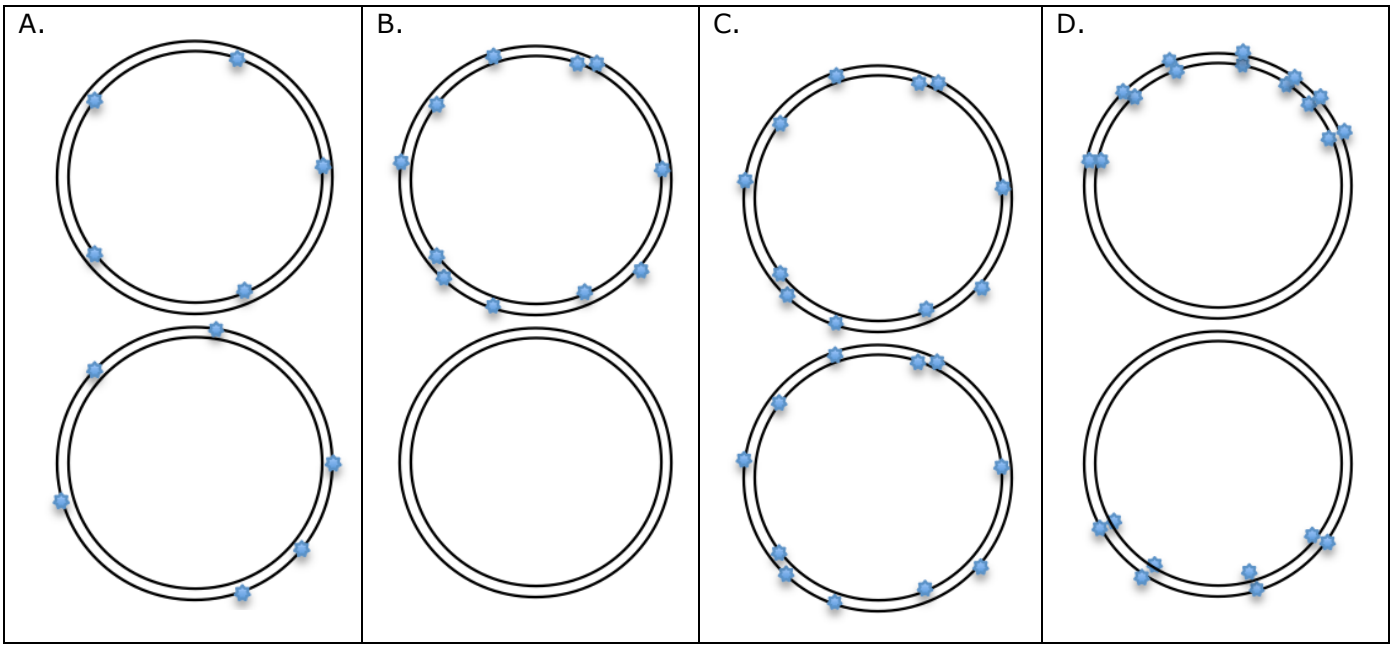
Use the information below to answer the following 2 questions.

Imagine that you have discovered a new species of very unusual unicellular eukaryote in which the nuclear genome is composed entirely of circular "ring" chromosomes. Subsequent analyses show that the ring chromosomes are simply linear chromosomes with their ends attached; the overall chemistry and replication of DNA is usual for eukaryotes. Telomerase activity is never expressed. The chromosomes attach to spindle tubules and segregate as expected during mitosis.

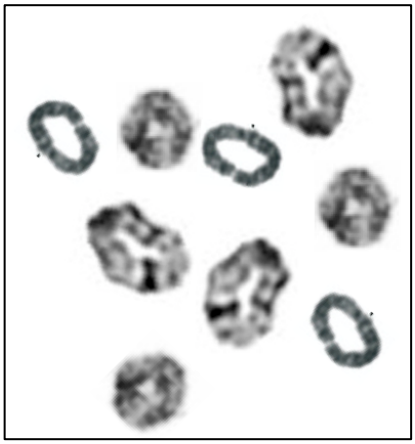
7. Each line in this sketch represents one backbone of the double helix of a ring chromosome in G_1 of the cell cycle. Imagine that you are able to add a fluorescent dye to thymine and then feed it to cycling cells in S phase.



Which of the following diagrams best conveys the relative location of the dyed thymine (stars) in the two ring chromosomes that would result from replication (ie. in G_2)?

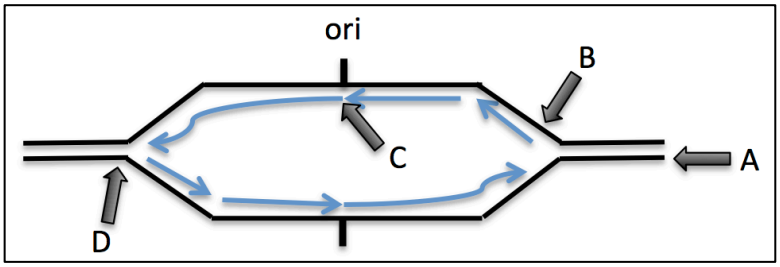


8. What is the likely ploidy level of this dividing cell?



A. 1n
B. 2n
C. 3n
D. 6n

9. The sketch at right shows a typical replication bubble near one end of a mouse chromosome.



Which of the following statements about this situation is correct?

1. The fork at Arrow D will proceed all the way to the other end of the chromosome.
2. The base indicated by Arrow C, the first DNA base to be added of this leading strand, was added by DNA polymerase III.
3. Arrow A identifies a 3'OH.
4. The strand indicated by Arrow B will be used as template DNA for replication of the entire chromosome.

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

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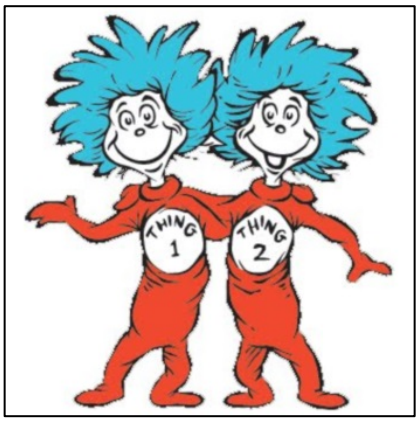
10. Identical twins arise when a single embryo splits into two independent embryos that develop into two independent offspring. Imagine twin male organisms, Thing One and Thing Two, who both carry the same novel SNP in their somatic genomes. However, neither of their parents carries this SNP in their respective somatic genome.



In which of the following cells did such a "*de novo*" mutation likely arise?

A. meiocyte of both parents
B. meiocyte of one parent
C. zygote giving rise to Thing One and Thing Two
D. each somatic cell of Thing One and Thing Two

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11. The diagram at right shows the relative location of the alleles of three genes along the maternal homologue of chromosome 9 in panda cells in G_1.

Which of the following statements is correct concerning a heterozygote (**Ee Bb Gg**)?

1. The organism would make 8 different gamete genotypes.
2. The **eBG** gamete would be rare, relative to **EBG**.
3. During G_2, the **b** allele would be on the paternal homolgue.
4. During meiosis I, this chromosome could align, and then disjoin, in three different combinations.

A. 1, 2 & 3 only
B. 1 & 3 only
C. 2 & 4 only
D. All of 1, 2, 3 and 4 are correct.

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12. *Ammophila brevigulata* is a species of diploid plant with a C-value of 480 Mb (million base pairs).

How much DNA would be in the nucleus of a spore cell in G2?

A. 240 Mb
B. 480 Mb
C. 960 Mb
D. 1920 Mb

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13. The concept of randomness comes up a lot in Biology, often with reference to situations in which alternative events are equally likely.

Which of the following statements describes two alternative events that are equally likely to occur?

1. Segregation of **H** vs. **h** into any given gamete in a (**Hh**) heterozygote.
2. Sons with red eyes vs. sons with white eyes from a heterozygous *Drosophila* mother.
3. Segregation of **HB** vs. **Hb** into any given gamete in a dihybrid (**HhBb**; with the two genes on separate chromosomes).
4. The appearance of a SNP at a particular location on Chromosome 3 vs. a particular location on Chromosome 6.

A. 1, 2 & 3 only
B. 1 & 3 only
C. 2 & 4 only
D. All of 1, 2, 3 and 4 are correct.

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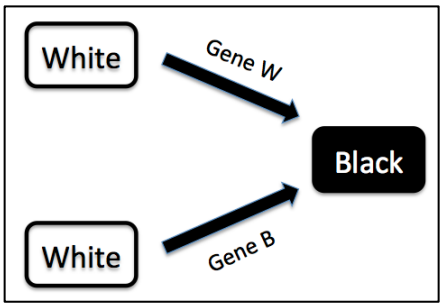
14. Recall that the **S** allele of the MC1R gene is responsible for black spotting as modeled in the Simutext module on pig pigmentation. Imagine that you use Mate-O-Matic to cross true breeding heavily spotted males with red females to create an F1 generation.

If you then cross these F1 animals together to create the F2 generation, which of the following phenotypes will not be expected?

A. black
B. heavily spotted
C. red
D. lightly spotted

15. The diagram at right shows two parallel biochemical pathways for the conversion of two different white compounds to a black compound. The action of the products of these two genes results in epistasis since the dominant alleles of either Gene B or Gene W will result in black phenotype. For both genes, the recessive alleles are not expressed at all.



Which of the following ratios would be expected among offspring from a dihybrid cross of **BbWw** x **BbWw**?

A. 4 Black: 12 White
B. 8 Black: 8 White
C. 15 Black: 1 White
D. 9 Black: 7 White

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16. In a hypothetical population of badgers, claw length is determined by the **C** locus. Badgers with genotype **CC** have long claws; badgers with genotype **Cc** have medium claws; and badgers with genotype **cc** have short claws.

In a colony of 50 badgers, 32 individuals have long claws (genotype **CC**), 16 have medium claws (**Cc**), and 2 have short claws (**cc**).

Which of the following processes is most likely to be occurring at this locus?

A. gene flow (the two **cc** individuals have probably immigrated from another colony)
B. heterozygote disadvantage
C. selection favouring the b allele
D. random mating

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17. In *Drosophila*, the *Notched* gene contributes to wing shape and neural development. Flies affected by this dominant mutation die as larvae at high temperatures. The *paralytic* gene is involved in nerve transmission such that flies lacking a dominant allele become reversibly paralyzed at elevated temperatures. The *Notched* gene is on Chromosome 3 while the *paralytic* gene is on the X chromosome.

If a dihybrid female (***NN*$^+$ *pp*$^+$***)*** is crossed at high temperatures to a homozygous wild type male (***N*$^+$*N*$^+$ *p*$^+$*Y***), which of the following fractions of their offspring would be phenotypically normal (ie. alive and not paralyzed)?

A. 1/8
B. 3/4
C. 1/2
D. 1/4

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18. The dominant allele at the "white" coat colour gene in domestic cats masks the effects of other pigmentation genes. That is, cats with at least one W allele are pure white, regardless of their ability to make pigment. White cats are also very likely to have blue eyes and to be deaf.

    Which of the following statements about this dominant allele (**W**) is likely correct?

    1. The **W** allele is more common than the **w** allele in wild cat populations.
    2. The **W** allele is pleiotropic.
    3. The **W** allele codes for a product that inhibits the product coded by the **w** allele.
    4. The **W** allele would cause deviation from 9:3:3:1 ratios that are usual among progeny from a dihybrid cross involving pigmentation.

A. 1, 2 & 3 only
B. 1 & 3 only
C. 2 & 4 only
D. All of 1, 2, 3 & 4 are correct.

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19. Which of the following processes results in adaptive evolution (ie. a population becoming better fit to its environment)?

    1. genetic drift
    2. inbreeding avoidance
    3. assortative mating
    4. selection favouring a recessive allele

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

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20. In a large population, the starting frequencies of alleles **A1** and **A2** are 0.8 and 0.2, respectively.

    Which of the following situations will result in allele **A1** going to fixation (i.e., completely replacing allele **A2**)?

    Assume that the population is so large that you can ignore the effects of genetic drift.

    1. wA1A1 = wA1A2 = wA2A2
    2. wA1A1 = wA2A2 > wA1A2
    3. wA1A1 = wA2A2 < wA1A2
    4. wA1A1 > wA1A2 > wA2A2

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