Western UNIVERSITY · CANADA

111

BIOLOGY 1002B

Term Test March 14, 2015 Time: 80 minutes

Student No. _____ Name: _____ Test Room _____

This is a 2-stage test: you will have 1 hr and 20 minutes to complete this individual portion. Then you submit this paper and gather with your team to do the group bonus portion in 30 minutes.

INSTRUCTIONS - FOLLOW THE CHECK LIST!

(√)	On your Scantron sheet		Fill the bubbles completely • Use **HB pencil only** • No stray marks or doodles • Make all erasures complete **Yes** - Calculators are permitted (non-programmable only) **No** – Borrowing is not allowed
	Print name	Print clearly	
	Signature	Do your best	
	Instructor	Haffie	
	Course	Bio 1002B	
	Student number	Print clearly/ Bubble neatly	
	Exam Code	**111 – Very important**	
	Section	Leave it blank	
	Answer Sheet	Leave it blank	

(√)	On this Test Book		Your Scantron answers and feedback will be uploaded to OWL after about a week.
	Student number	Write clearly.	
	Name	Write clearly.	
	Test Room	The room you're in right now	
	Indicate your answers in the test book. Leave no questions blank.		

1) Please place your ID prominently on your desk and sign the attendance sheet when it comes to you.
2) There are 35 questions in this test. Check your paper carefully.
3) There is only **one** fully correct option for each question. Part marks may be awarded. **Answer all questions**.
4) Indicate your answers in **both** the test paper **and** on the Scantron.
5) It is your responsibility to transfer all answers from the test paper to the Scantron sheet **within the 80 min. test period.**
6) When finished, **please stay seated** and raise your hand. We will collect both your test paper and your Scantron sheet.

Warning	The Scantron marking program has a cheating analysis feature that compares answer patterns for all papers. It alerts us to similarities. We then check seating arrangements.

Clarifications: Please defend your arguments **on this page only**. Comments will not be accepted after the test.

Q #	Ans	Clarification	Alt Ans
50	*D*	*However, if you mean "green with envy" rather than "green in colour" . . .*	*B*

Circle the best single letter choice for each of the following questions before transferring your answers to your computer sheet. Note: *Questions may have 3, 4 or 5 choices.*

1. Endosymbiosis is now a strongly established theory to explain at least part of the evolution of complex cells on Earth.

   Which of the following observations supports the theory of endosymbiosis?

   1. Many proteins are required to be imported into the mitochondria to maintain its function.
   2. Chloroplasts have their own tRNA genes.
   3. Golgi vesicles are membrane bound.
   4. Chloroplasts divide using the same mechanism as photosynthetic bacteria.

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

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2. The development of genome asymmetry was a significant factor in the evolution of early life.

   Which of the following statements is the best illustration or definition of genome asymmetry?

A. The development of eukaryotic genomes that were larger than prokaryotic genomes.
B. The different genomes found in a single cell are not the same size.
C. Two genes that code for the same protein are of different sizes.
D. The number of genes found in a genome does not equal the number of proteins coded.

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3. Which of the following relationships between genome size (or DNA content) vs. ATP generation is correct?

A. *Epulopiscium* has fewer copies of its genome than *E.coli* but generates more ATP.
B. *E. coli* contains less DNA than a mitochondrion but generates more ATP.
C. *Thiomargarita* has a larger haploid genome than *E. coli* but generates less ATP.
D. *Epulopiscium* contains more DNA than a human cell but generates less ATP.

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4. The bacterium *Epulopiscium* seems to have solved the problem of bacteria having to be small — in fact, it's as large as many eukaryotic cells.

   So 100 million years in the future, would you expect it to become complex like many eukaryotes?

A. No. What is required is a very rare interaction that may never occur.
B. No. A fundamental requirement for complexity is something *Epulopiscium* lacks, oxidative phosphorylation.
C. Yes. Evolution of eukaryotes is inevitable given enough time.
D. Yes. The biggest hurdle was size and now that that has been overcome, complexity will rapidly develop.

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5. The evolution of plants, fungi and animals can be linked to the earlier development of a class of bacteria called cyanobacteria.

   Which of the following features made cyanobacteria particularly important in the evolution of more complex life forms?

A. Cyanobacteria had a very small genome.
B. Cyanobacteria produced oxygen.
C. Cyanobacteria were aerobic.
D. Cyanobacteria could harvest light energy for growth.

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6. Although related to photosynthetic "green" algae like *Chlamydomonas*, *Polytomella* is unusual in that it is entirely heterotrophic, having lost the ability to do photosynthesis. *Polytomella* cells contain the evolutionary remnants of a chloroplast, now called simply a "plastid". Modern plastids are the site of biosynthetic pathways for carbohydrates, lipids and other essential compounds. Dr. David Smith, in Western's biology department, thinks that these plastids have no genes left in them at all. That is, they have no "plastome".

   Is it reasonable to argue that plastids have lost ALL of their genes?

A. No. There are still proteins (enzymes) needed inside the plastid.
B. No. The algal cells would still need the ability to express prokaryotic genes.
C. Yes. Without photosynthesis, there would be no need to maintain a plastome.
D. Yes. All genes could be lost, leaving the only remaining DNA coding for an origin of replication.

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7. Lateral gene transfer (LGT) has not stopped — it continues to occur over evolutionary time. For example, the gene *rbcS* is found in the chloroplast of one species of the plant *Arabidopsis* but the same gene is found in the nucleus of a closely related *Arabidopsis* species.

   In which of the following ways is the *rbcS* gene found in the nucleus of a plant cell most likely different from the *rbcS* gene found in the chloroplast of a plant cell?

A. The nuclear version of *rbcS,* like the *cpn60* gene in *Giardia*, is not functional.
B. The nuclear version of *rbcS* has a new function - not related to the chloroplast.
C. The nuclear version of *rbcS* has an SD box.
D. The nuclear version of *rbcS* contains a target peptide.

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8. The mitochondrial genome of *Chlamydomonas* contains the lowest number of genes, 12, of all the species of green algae. However, only 7 proteins are produced inside these mitochondria.

   Which of the following statements is the best explanation for why only 7 proteins are made from the 12 genes in *Chlamydomonas* mitochondria?

A. Five of the genes are redundant; another copy is expressed from the nuclear genome.
B. Five of the genes are nonfunctional "pseudogenes".
C. Five of the genes are transcribed, but not translated.
D. Five of the genes are coding for proteins that are translated in the cytoplasm.

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9. PCR was used to specifically amplify a single gene. One strand of the DNA is shown below (the specific gene is shown by the thick line).

Using this single strand of DNA as the template, which of the following images best represents the product of the first cycle of PCR?

A. 

B. 

C. 

D. 

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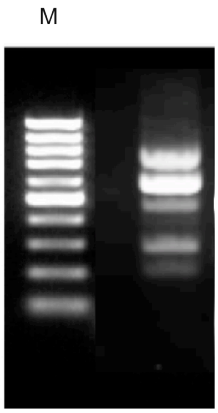
10. A PCR reaction was set up to amplify a 600 bp portion of a single gene. The template was total human genomic DNA. After the PCR reaction was complete, the products were separated on an agarose gel and compared to a DNA ladder (M).



Which of the following explanations best accounts for the result shown in the right lane of the gel?

A. Primers were probably too short.
B. DNA sample contained some RNA.
C. DNA was probably degraded.
D. Reaction did not contain enough polymerase.

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11. Primer annealing is an important aspect of PCR. The annealing step of the cycle usually takes place at around 45-55°C and lasts for only 20-30 seconds.

Which of the following statements best explains why the annealing time has to be so brief?

A. A longer annealing time would prevent primers binding to specific sites.
B. The short time frame prevents primers from binding to each other.
C. If the time were any longer, DNA polymerase would begin to denature.
D. The short time frame minimizes complementary template strands base pairing with each other.

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12. A recent paper published in the journal *Nature* was titled *"A metagenome study of intestinal bacteria in adults with type 2 Diabetes"*.

    Which of the following findings could have come from such a metagenomic study?

1. Discovery of a gene previously only found in a bacterium from goats.
2. Genes involved in insulin metabolism are more strongly transcribed in microbes from adults with type 2 Diabetes.
3. Detection of many copies of similar DNA sequences, all coding for the enzyme hexokinase.
4. That susceptibility to type 2 Diabetes is linked to a mutation in a mitochondrial gene.

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

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13. Imagine that you have sequenced a metagenome from a polluted lake and have identified a gene that you would like to use in a synthetic biology project. The gene sequence is over 3200 bases long and is shown below as a single strand of DNA, 5' to 3' on the non-template strand.

    That is, the sequence given is the same as the mRNA for this gene, except there is "t" where the mRNA would have "u". Only the first 120, and the last 153, bases are shown to save space. The boxed codons are "start" and "stop" respectively.

```
   1 aaggagagcc gaagggtctt gctggaagca aaaacggacg aggagctact ggtcacttgg
  61 ctcaatgaac tcgtttacct ctttgacaca gaggggcttc ttttcaggat ttacgatgtc

3241 tgaggtccaa tggcgacaca aaatgatgcg agacctggcc cgattcatct gttaatcaat
3301 ccttttttcgg cagcgagggc ggtcagagag gccacgttgt ggaggccgag tttctccatg
3361 aggttagcgc gatgtttttc aaccgttttg acg
```

You want to precisely amplify only the coding region of this gene using PCR, so you make the primer `atgaactcgtttacc`.

Which of the following additional primers would you also need to make? (Draw this out!)

A. `aattgtctacttagc`
B. `attagttaggaaaaa`
C. `augaacucguuuacc`
D. `ttaacagatgaatcg`

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14. The creation of nucleic acid polymers usually requires: i) a polymerase enzyme, ii) nucleotide triphosphates (ATP, GTP, CTP and GTP for DNA; UTP for RNA), and iii) a template.

    Which of the following processes does NOT require all three of the above components?

A. creation of polyA tails on mRNA
B. extending primers during PCR
C. transcription of tRNA genes

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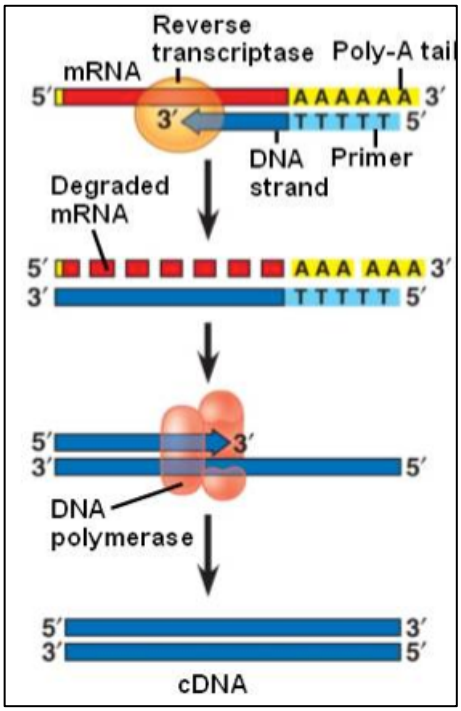
15. One aspect of synthetic biology that we did not discuss in class is the creation of "complementary DNA" (cDNA).

    The Figure at right shows cDNA being created when reverse transcriptase makes a single-stranded DNA version of a gene, using mRNA as a template. DNA polymerase then creates double-stranded cDNA.

    Which of the following signals would you expect to be present in genes created as cDNA from eukaryotic mRNA isolated from the cytoplasm?

    1. 5′ UTR
    2. introns
    3. stop codons
    4. promoters



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

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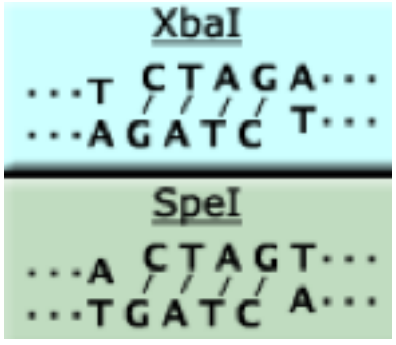
16. Synthetic biology regularly exploits the ability of restriction endonucleases to cut double stranded DNA. The figure at right shows the cut sites for two enzymes, *XbaI* and *SpeI*.

    If you digested a vector with *XbaI*, and digested your gene of choice with *SpeI*, the resulting sticky ends would be complementary. If you ligated these ends together, you would create a "hybrid" restriction site on your vector.

    Which enzyme could cut the new hybrid site?



A. *XbaI*
B. *SpeI*
C. Both enzymes
D. Neither enzyme

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17. Which of the following characteristics of *Taq* polymerase makes it especially well suited for use in PCR reactions?

A. It does not need a 3'OH in order to extend DNA strands.
B. It can recognize and amplify only specified gene sequences.
C. It does not need a template like "regular" polymerases.
D. It remains functional at high temperatures.

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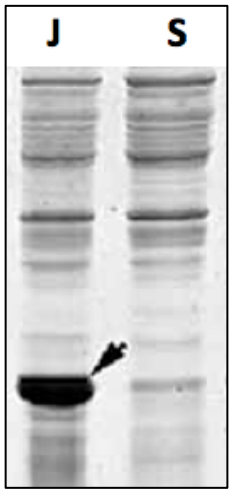
18. In a synthetic biology project to create bacteria that are attracted to cancer cells, both Jamil and Sheshi amplified the same gene by PCR from a cancer metagenome. They then transformed this gene into host cells using vectors that they had each designed.



The gel at right shows the result of electrophoresis of proteins from the same number of host cells from both experiments. The arrow shows the location of the desired protein product.

Which of the following explanations best accounts for the difference in results between the Jamil and Sheshi lanes of the gel?

A. Jamil included the proper target sequence on his vector to get the protein inserted into the bacterial membrane.
B. Sheshi forgot to add an "ori" region to his vector.
C. Sheshi used a more effective terminator sequence on his vector.
D. Jamil used a more attractive promoter on his vector.

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19. There are many operons in bacteria. One, called the *lux* operon, enables cells to "glow" by bioluminescence. In *lux*, when a certain chemical signal accumulates to a high concentration in the environment, it inactivates a DNA-binding repressor such that the *lux* genes are then induced.

Is this an example of negative or positive control?

A. Negative
B. Positive
C. Can't tell; need more information about the structure of the operon.

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20. X-gal is a substrate with a β-galactoside bond that, when cut by β-galactosidease, turns the cell blue. X-gal is transported across the cell membrane the same way that lactose is but it does not bind to lac repressor.

Assume you have a mutant strain of *E. coli* that is deleted for the entire lac operator site.

What colour will your mutant be if you grow it in the presence of X-gal and lactose?

A. White (no blue)
B. Light blue.
C. Dark blue.

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21. The DNA sequence of the lac operon enables *E. coli* metabolism to regulate the production of enzymes needed to use lactose in the environment as a carbon and energy source.

    If you discover a mutant strain of E. coli that grows poorly when only lactose is available as a source of reduced carbon, where might the mutation be?

    1. lacZ coding region; reduced lactose binding
    2. CAP binding site; no CAP binding
    3. lacY coding region; reduced lactose transport
    4. lacI promoter; reduced polymerase binding

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

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22. Which of the following characteristics of cells would be on a list titled "Things that are the same in prokaryotic cells and eukaryotic cells"?

A. power per gene
B. translation termination
C. promoter sequence
D. snRNA genes

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23. Which of the following components of gene expression would be most likely to contain a "helix-turn-helix" domain?

A. cyclic AMP (cAMP)
B. translation release factor
C. lacI gene product
D. enhancer region

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24. DNA codes for many different types of information that is, in turn, understood at many different stages of gene expression.

    Which of the following types of information is understood by a protein binding to a specific sequence of nucleic acid?

    1. stop codon
    2. enhancer
    3. prokaryotic 5'UTR
    4. operator

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

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25. One of the places in the universe that the genetic code is **not** strictly universal is in human mitochondria; the codon GUG means "Start" and calls for the amino acid Methionine (Met) instead of Val.

	U	C	A	G
U	UUU Phe UUC UUA Leu UUG	UCU UCC UCA Ser UCG	UAU Tyr UAC UAA Stop UAG	UGU Cys UGC UGA Stop UGG Trp
C	CUU CUC CUA Leu CUG	CCU CCC CCA Pro CCG	CAU His CAC CAA Gln CAG	CGU CGC CGA Arg CGG
A	AUU AUC Ile AUA AUG Met	ACU ACC ACA Thr ACG	AAU Asn AAC AAA Lys AAG	AGU Ser AGC AGA Arg AGG
G	GUU GUC GUA Val GUG	GCU GCC GCA Ala GCG	GAU Asp GAC GAA Glu GAG	GGU GGC GGA Gly GGG

In the double-stranded sequence below, find the beginning of the coding region of a mitochondrial gene. Use the standard genetic code at right to predict the first three amino acids of this protein.

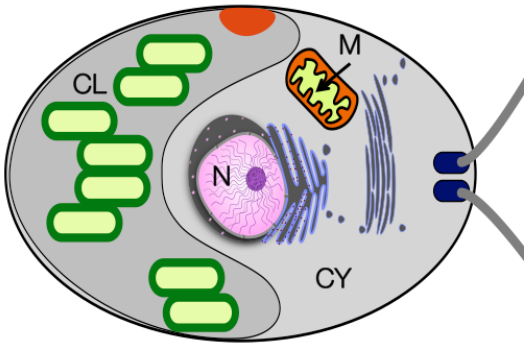
GUGGGTCCCGGGTTAACGTGGCCTTAGGGCTTAA

CACCCAGGGCCCAATTGCACCGGAATCCCGAATT

A. met – pro - gly
B. met – gly - pro
C. met – glu - asn
D. met – gln - ser

Use this diagram of a *Chlamydomonas* cell for the following 2 questions.

CL is chloroplast, CY is cytoplasm,
M is mitochondrion, N is nucleus.



26. Which of the following locations is a likely site for transcription of genes responsible for oxidative phosphorylation?

A. CL, M & N
B. CL & M
C. M & N
D. CL & N
E. N only

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27. Which of the following locations is a likely site for a single mRNA being translated by several ribosomes at the same time?

A. CY only
B. CL & M
C. CL, M & N
D. CL, CY, & M
E. N only

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28. Recall that cytosolic ribosomes are composed of structural proteins and catalytic RNAs. Genes coding for both of these components reside in the nuclear genome.

    Which of the following features of gene structure would be associated with BOTH the genes coding for ribosomal proteins AND the genes coding for ribosomal RNAs?

    1. start codon
    2. cytoplasm target peptide
    3. 3' UTR
    4. promoter

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

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29. Recall that ribosomes are present in both the cell cytoplasm and in the mitochondria of eukaryotic cells. Genes coding for the cytoplasmic ribosomal proteins are found in the nuclear genome while genes coding for mitochondrial ribosomal proteins are found in the mitochondrial genome.

    Which of the following features of gene expression would be associated with BOTH the nuclear and mitochondrial genes coding for ribosomal proteins?

    1. intron
    2. 5' UTR
    3. mitochondrial target sequence
    4. promoter

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

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30. Which of the following must cross the nuclear membrane to get from where it is synthesized to where it is functional?

    1. RNA polymerase II
    2. 5' cap
    3. snurp proteins
    4. chloroplast target peptide

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

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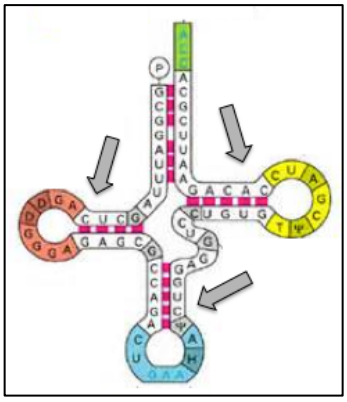
31. The figure at right shows the structure of a typical tRNA. Arrows indicate three "loops".



Recall also that a kind of "loop" is also involved in enhancer bending, intron splicing, lac repressor binding and transcription termination.

Which of the following statements accurately contrasts tRNA loops with these other types of loops?

A. Both a tRNA loop and a terminator hairpin loop are transcribed but not translated.
B. Both a tRNA loop and the loop created by lac repressor binding occur exclusively in prokaryotes.
C. Both a tRNA loop and the loop created by bending enhancers depend on protein binding.
D. Both a tRNA loop and the "lariat" resulting from splicing are formed by complementary base pairing.

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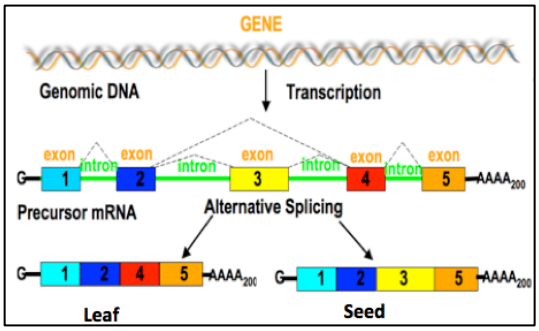
32. The diagram at right shows the result of alternative splicing of a given precursor mRNA in two different plant tissues: leaf and seed.



Which of the following statements about this situation is correct?

1. One gene can code for two different proteins.
2. The protein products of this gene could function in the chloroplast of leaf, but in the cytoplasm of seed.
3. Mature mRNA is longer in seed than leaf.
4. A single base pair substitution in the middle of exon 3 would affect seed but not leaf.

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

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33. Why is the *Elyssia/Vaucheria*, system, known as the "solar slug", so interesting to scientists?

A. The *Elyssia* slug maintains chloroplasts, suggesting that it had a recent evolutionary ancestor that was a plant.
B. The *Vaucheria* algae give up its chloroplasts, suggesting that an alga has an endosymbiotic relationship with an animal.
C. The *Elyssia* slug maintains chloroplasts, suggesting that an animal has the ability to be photoautotrophic.
D. The *Vaucheria* algae give up its chloroplasts to an animal, suggesting that this alga is a "missing link" between plants and animals.

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34. In any chromatography experiment, where does the least soluble pigment migrate relative to the others?

A. The least soluble pigment travels either the furthest, or the shortest distance, depending on its charge.
B. The least soluble pigment travels with the solvent front.
C. The least soluble pigment travels the furthest distance.
D. The least soluble pigment travels the shortest distance.

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35. Which of the following features of yeast made this organism appropriate for Lab 2?

A. Yeast is capable of photosynthesis under light.
B. Yeast is only capable of aerobic respiration reactions.
C. Yeast is capable of alcoholic fermentation reactions.
D. Yeast is capable of releasing oxygen under anaerobic conditions.
