Content: Multiple Choice Questions

1A

Which of the following statements about protein structure is NOT true?

a) Quaternary protein structure forms when two or more separate proteins interact and form a larger protein structure.

b) Primary protein structure is shaped like cork screws and zigzag bands of amino acids that form as soon as the protein is made.

c) Tertiary protein structure is formed when a single protein folds into its final shape.

d) Secondary structure forms due to hydrogen bonds and the amino acid side chains determine the shapes formed.

e) All of these statements are true and none of them are false.

1B

A good example of allosteric modulation of protein shape and function is

a) when a ligand binds to its receptor

b) when a kinase phosphorylates a protein.

c) when a phosphatase removes a phosphate from a protein.

d) when two proteins bind to each other.

e) only (a) and (d).

f) all of the above.

1C

Which of these statements does NOT describe common traits of signal transduction?

a) The original signal is amplified at every step in the multi-step pathway.

b) Signal transduction pathways always need mechanisms to activate and inactivate rapidly.

c) Signal transduction pathways can utilize covalent modulation, allosteric modulation or ion gradients.

d) Signal transduction moves information from the outside to the inside of a cell.

e) All of the statements above DO describe common traits of signal transduction.

1D

During a normal neuronal action potential, the depolarization phase occurs when

a) sodium and potassium ions move into the cell.

b) potassium ions move into the cell.

c) sodium ions move into the cell.

d) the sodium/potassium pump moves ions up their concentration gradients.

e) sodium ions diffuse down the axon to reach the secretory vesicles.

f) none of the above.

2A

Because of the anti-parallel nature of DNA,

a) one strand has an exposed 3' carbon on both ends, and the other strand has an exposed 5' carbon on both ends

b) DNA polymerization proceeds in opposite directions on the two template strands

c) synthesis of the leading strand during replication always ends with an exposed 3' carbon on the last nucleotide.

d) all of the above.

e) only answers (b) and (c) are correct.

2B

Consider a genetic character with two possible alleles, one dominant and one recessive. When a pair of heterozygotes mate and produce many progeny,

a) you expect the two phenotypes to occur in equal numbers in the progeny.

b) you expect progeny genotypes to be in a 3:1 ratio.

c) you expect recessive traits to be apparent in 75% of the progeny.

d) you expect progeny genotypes to be in a 1:2:1 ratio.

e) none of the above.

2C

In protein translation,

a) the ribosome consumes ATP every time a new amino acid is added.

b) energy is brought with each amino acid to the ribosome, which produces ADP as waste.

c) a protein polymerase covalently connects three amino acids into codons.

d) a signal moves across a membrane when a ligand binds to its receptor.

e) answers (a) and (b) are correct.

f) none of the above.

2D

Mitosis

a) includes cell division.

b) includes one round of DNA replication and two rounds of chromosome division.

c) results in diploid cells.

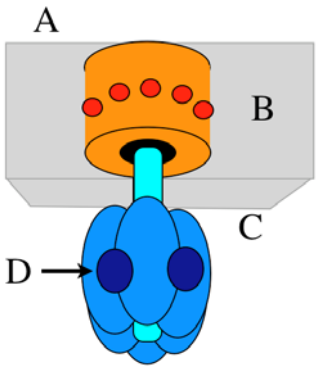
d) results in haploid cells.

e) is prone to crossing over (recombination).

f) none of the above.

3A

Chemiosmosis is the process of using H^+ ions to drive the production of ATP synthesis. Which statement most accurately describes the ion gradient if it were shown in the figure below?



a) H^+ ions accumulate on the A side of the membrane.

b) H^+ ions accumulate in the membrane as indicated by B.

c) H^+ ions accumulate on the C side of the membrane.

d) H^+ ions exit the ATP synthase through the pores labeled D.

e) both (b) and (d).

f) none of the above.

3B

During cellular respiration,

a) food molecules are gradually reduced to extract the energy.

b) food molecules are gradually oxidized to extract the energy.

c) electrons are added to metabolites at many steps.

d) the overall potential energy increases at nearly every step.

e) only (a) and (c).

f) none of the above.

3C

Carbon fixation

a) does not happen during photosynthesis.

b) is the reduction of carbon dioxide.

c) permits plants to make amino acids and fatty acids.

d) happens when plants repair damaged cells.

e) only (b) and (c).

f) none of the above.

3D

Many terms are used to describe energy. Which of the following is true?

a) Heat of the reaction is the difference in total energy (enthalpy) between reactants and products.

b) Free energy measures all the energy in a molecule that is available to do work.

c) Entropy is a form of energy that is used to increase chemical reactions.

d) The first law of thermodynamics states that energy is created when new covalent bonds are formed.

e) All of the statements above are correct.

f) Only (a) and (c) are correct.

g) Only (a) and (b) are correct.

4A

DNA mutations

a) may convert a recessive allele into a dominant allele.

b) may convert a dominant allele into a recessive allele.

c) may not have any effect on the gene's function.

d) are difficult to define since no two individuals have identical DNA.

e) all of the statements above are true.

f) none of the statements above are true.

4B

Alleles can be dominant or recessive. Which statement is true?

a) You cannot predict if a new allele is dominant or recessive by looking at the DNA sequence.

b) Unlike recessive alleles, dominant alleles must be inherited from the previous generation.

c) Recessive phenotypes are more common in girls than boys because girls have two X chromosomes.

d) Some dominant phenotypes can skip a generation if they are on the Y chromosome.

e) None of these statements are true.

4C

Some newly made proteins are transported to the surface of cells. Which statement is true?

a) Viral and host proteins are transported to the cell surface by different mechanisms.

b) Cell surface proteins are produced in the cytoplasm on ribosomes near the plasma membrane.

c) Cell surface proteins are produced by a unique type of ribosome that specializes in this class of proteins.

d) Secreted proteins and cell surface proteins are produced at two different subcellular locations.

e) All of the statements above are true.

f) None of the statements above are true.

4D

In order for a eukaryotic gene to be transcribed, the gene

a) must have at least one transcription factor bind to its promoter.

b) must contain at least one intron and two exons.

c) must be methylated on at least some of its cytosines.

d) cannot be linked to a mutant dominant allele.

e) cannot be longer than 100,000 base pairs in length.

f) only a and b are correct.

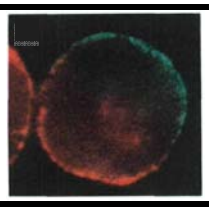
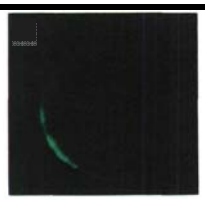
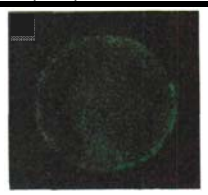
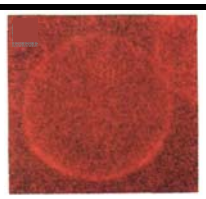
g) none of the statements above are correct.

Skills Assessment: Interpret/Analyze New Data

Quiz #1

Researchers in the 1960s and 70s wanted to know more about the characteristics of biological membranes, and, specifically, just how freely molecules in membranes are able to move laterally in the plane of the membrane (along its surface). This property of membranes is called fluidity.

These scientists tested membrane fluidity by fusing mouse cells with human cells to produce a hybrid cell called a heterokaryon. They then used two fluorescently labeled antibodies that each specifically bound to a particular plasma membrane protein. The antibody that specifically bound to a mouse protein emitted green light, and the antibody that specifically bound to a human protein emitted red light. After creating the heterokaryons and labeling them with the two antibodies, a number of heterokaryons were photographed at various timepoints at about 3,000x magnification.

	All heterokaryons were doubly labeled with antibodies for a mouse membrane protein (green) and a human membrane protein (red)				
					
Label Displayed	Green and Red	Green only	Red only	Green only	Red only
Time after fusion (min)	0	15		40	

[Adapted from Frye & Edidin (1970), *J. Cell Sci.* 7: 319-335.]

1. What can you conclude from the results in the figure above?
    a. The mouse protein spreads throughout the entire heterokaryon plasma membrane more rapidly than does the human protein.
    b. The human protein spreads throughout the entire heterokaryon plasma membrane more rapidly than does the mouse protein.
    c. The mouse and human proteins do not intermix in the heterokaryon plasma membrane.
    d. The heterokaryon plasma membrane is broken and discontinuous.
    e. The formation of a continuous, unbroken heterokaryon plasma membrane is only achieved at around 40 minutes after cell fusion.

ANSWER: b

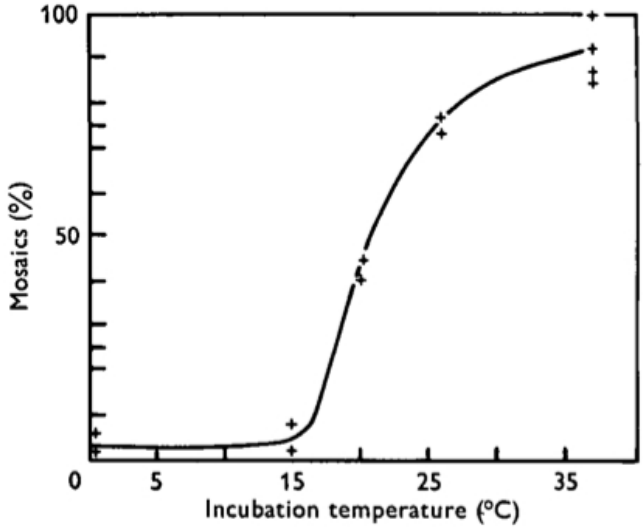


Fig. 2. Effect of temperature on the appearance of mosaic cells within 40 min of cell fusion.

[From Frye & Edidin (1970), *J. Cell Sci.* 7: 319-335.]

2. The figure above shows the fraction of heterokaryons with intermixed mouse and human protein at 40 minutes after fusion, as a function of temperature at which these cells were incubated. What conclusion(s) can be drawn from this figure?
   a. Essentially no membrane components (lipids, proteins, or carbohydrates) are freely moving in the plane of the membrane at 10°C or lower.
   b. Essentially no membrane components (lipids, proteins, or carbohydrates) are freely moving in the plane of the membrane at 37°C or higher.
   c. Judging by the slope of the curve, membrane proteins move most rapidly at about 20°C.
   d. Essentially no membrane proteins are freely moving in the plane of the membrane at 10°C or lower, but we can't be certain about other membrane molecules.
   e. Temperature strongly affects membrane fluidity, with the most fluid membrane occurring at the higher temperatures tested.

ANSWERS: d & e

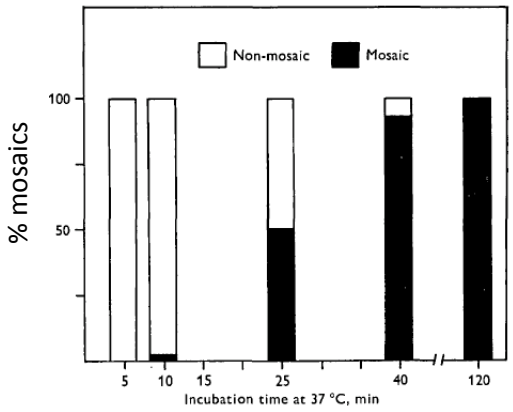


Figure 1: Effect of time on the appearance of mosaic cells, when incubated at 37°C.

[Adapted from Frye & Edidin (1970), *J. Cell Sci.* 7: 319-335.]

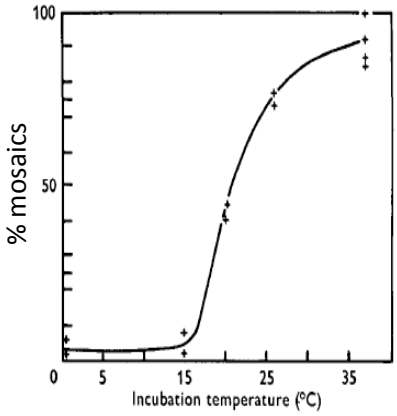


Figure 2: Effect of temperature on the appearance of mosaic cells within 40 minutes of cell fusion.

3. The investigators tested the effects of both time and temperature on membrane protein mobility, as measured by the percent of mosaic cells. Which of the following predictions or conclusions can be made from Figures 1 and 2?

   a. When cells are incubated at 25°C, the percent mosaics within 25 minutes would be less than 50%.
   b. When cells are incubated at 37°C, the percent mosaics within 30 minutes would be more than 50%.
   c. The area under the curve in Figure 2 is the value shown in Figure 1 for the 40-minute time point.
   d. During the first 40 minutes at 37°C, the rate of change in the percent mosaics is constant.
   e. The percent mosaics within 40 minutes increases logarithmically as the temperature increases from 0 to 20°C.
   f. The investigators probably chose to graph the data in Figure 1 with bars, rather than with a curve, because there is no variability in the data at each time point.
   g. The investigators probably chose to graph the data in Figure 1 with bars, rather than with a curve, because they did not test enough time points.
   h. There appears to be a statistically significant difference in membrane protein mobility between 30°C and 37°C.
   i. At 37°C, there appears to be a statistically significant difference in the percent mosaics between 40 minutes and 120 minutes.

ANSWERS: a, b, g

Quiz #2

In a landmark 1973 study, researchers engineered specific alterations in plasmid DNA using enzymes known as *Eco*RI (a restriction endonuclease) and DNA ligase. The investigators attempted to show that these enzymatically altered plasmids could be reinserted into the bacterium *Escherichia coli* (a process called bacterial transformation), where the plasmids might replicate and express their gene products, just as a natural plasmid or chromosome does.

A few notes about bacterial plasmids:
Bacterial expression of genes from plasmid DNA is essentially absent if the plasmid is linear (that is, if it is not an intact, closed loop). The plasmids used in this study were pSC101, which contains a tetracycline-resistance gene, and pSC102, which contains a kanamycin-resistance gene. Also, pSC101 contains only one site that gets cut by *Eco*RI, while pSC102 contains several such sites.

TABLE 1. *Transformation by covalently closed circular and EcoRI-treated plasmid DNA*

Plasmid DNA species		Transformed cells per μg DNA		
		Tetracycline	Kanamycin	Chloramphenicol
pSC101	Untreated	3×10^5	0	0
pSC101	*Eco*RI-treated	2.8×10^4	0	0

[Adapted from Cohen et al. (1973), *Proc. Nat. Acad. Sci.* 70: 3240-3244.]

4. Table 1, above, shows the results of separate transformations of *E. coli* by either intact or *Eco*RI-digested (but not ligase-treated) pSC101. What conclusion(s) can you draw from these results?
   a. Tetracycline resistance can be acquired spontaneously.
   b. Bacteria appear to take up plasmid DNA whether it is linear or circular.
   c. *Eco*RI treated DNA cannot confer resistance to kanamycin or chloramphenicol.
   d. Linear DNA can re-circularize inside bacterial cells.
   e. *Eco*RI treatment changes the tetracycline resistance gene to make it less effective.

ANSWERS: b & d

TABLE 2. *Transformation of E. coli with a mixture of pSC101 and pSC102 DNA*

Treatment of DNA	Transformation frequency for antibiotic resistance markers: Tetracycline	Kanamycin	Tetracycline + kanamycin
None	2×10^5	1×10^5	2×10^2
*Eco*RI	1×10^4	1.1×10^3	7×10^1
*Eco*RI+ ligase	1.2×10^4	1.3×10^3	5.7×10^2

Transformation frequency is shown as transformed cells per μg of DNA of each plasmid species in the mixture.

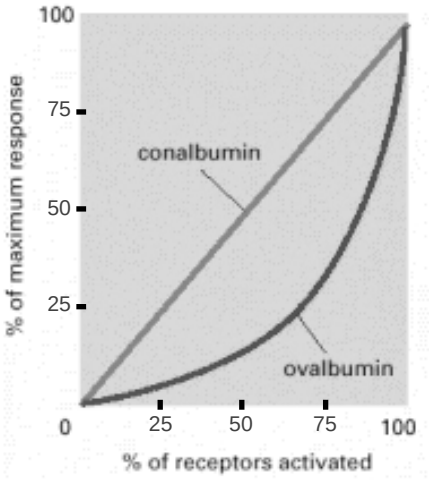
[Adapted from Cohen et al. (1973), *Proc. Nat. Acad. Sci.* 70: 3240-3244.]

5. Table 2, above, shows the transformation frequency of *E. coli* presented with an equal mixture of pSC101 and pSC102 DNA that has been subjected to enzymes as indicated. These results suggest:
   a. The frequency of co-transformation by two separate untreated plasmids is 500-1000 times lower than single transformation.
   b. The frequency of kanamycin-resistant bacteria in the *Eco*RI-only treatment is 100 times lower than in the untreated condition because it requires multiple DNA fragments to form a circular plasmid once inside the cells.
   c. Double antibiotic resistance is best achieved in the "*Eco*RI + DNA ligase" treatment, most likely *via* transformation by individual plasmids containing both resistance genes.
   d. Treating with DNA ligase improves the efficiency of transformation by the digested plasmids.
   e. Cut and reconstructed DNA plasmids are biologically functional when reinserted back into cells.

ANSWERS: a, b, c, d & e

Quiz #3

Researchers in the mid-1970s were interested in learning more about molecular and cellular responses to steroid hormones. One useful approach is to administer a steroid hormone to an animal or appropriate cell type, and then measure the expression level of genes that are regulated by that particular steroid hormone. This strategy was used to investigate the effects of estrogen on oviduct cells in chickens, using the particular estrogen molecule known as 17β-estradiol and looking at the response of two genes encoding the egg white proteins conalbumin and ovalbumin. An estrogen receptor molecule is considered activated when it is located in the nucleus, which is where it goes after binding to estrogen in the cytosol. Once in the nucleus, one or more activated receptors can bind DNA and regulate gene transcription.



[From Alberts et al. (2002), *Molecular Biology of the Cell*, 4th ed., Garland Science, as adapted from Mulvihill and Palmiter (1977), *J. Biol. Chem.* 252: 2060-2068.]

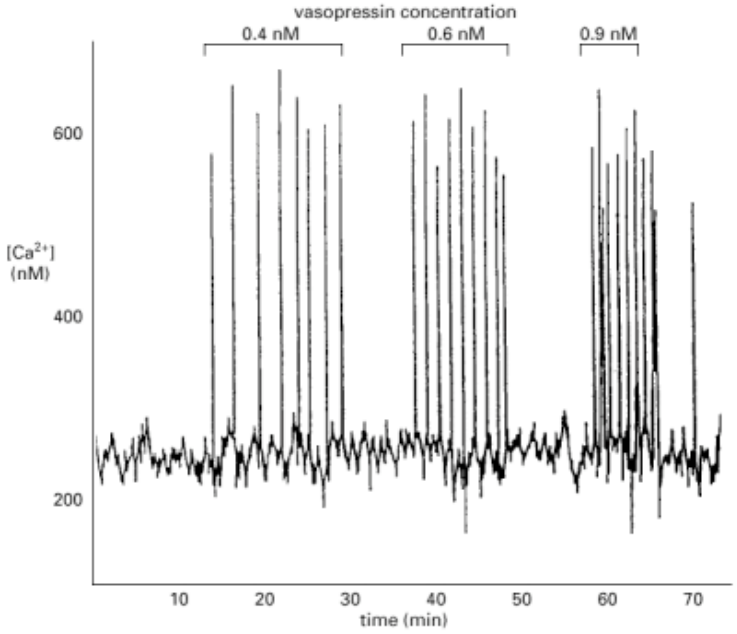
Female chicks were injected with different doses of 17β-estradiol, and eight hours later, specific gland cells in their oviducts were isolated. The curves in the figure above show the level of mRNA produced in these glands from the conalbumin and ovalbumin genes, as a function of the fraction of estrogen receptors activated by different doses of hormone (which was determined in a separate experiment).

6. What conclusion(s) can be drawn from the figure above?
    a. Conalbumin and ovalbumin are regulated by two different types of estrogen receptor.
    b. Transcription of the ovalbumin gene is slower than transcription of the conalbumin gene.
    c. More of the estrogen receptors present in a given cell must be active to produce a maximal conalbumin response than to produce a maximal ovalbumin response.
    d. More of the estrogen receptors present in a given cell must be active to produce a half-maximal ovalbumin response than to produce a half-maximal conalbumin response.
    e. 17β-estradiol always stimulates conalbumin expression, but may either inhibit or stimulate ovalbumin expression.
    f. Each individual activated estrogen receptor affects conalbumin transcription equally.
    g. Each individual activated estrogen receptor affects ovalbumin transcription equally.
    h. Multiple activated estrogen receptors may be simultaneously required to stimulate conalbumin expression.
    i. Multiple activated estrogen receptors may be simultaneously required to stimulate ovalbumin expression.

    ANSWERS: d, f & i

A change in cytosolic calcium concentration is a critical mediator of the physiological response to many stimuli. We can visualize the calcium response of cells by loading them with the luminescent Ca^{2+}-sensitive jellyfish protein, aequorin. Aequorin emits light in the presence of Ca^{2+} and can indicate changes in free Ca^{2+} concentration. Using this method, investigators have documented that changes in cytosolic Ca^{2+} concentrations occur as spikes of elevated Ca^{2+} in small regions of the cell, with these Ca^{2+} bursts sometimes repeating over time. Repeated transient elevations of calcium are called Ca^{2+} oscillations.

In the mid-1980s, biologists began to understand the complexity of intracellular Ca^{2+} signals. In the experiment shown below, liver cells were injected with aequorin and then exposed to increasing concentrations of the blood pressure-elevating hormone vasopressin. Vasopressin activates a G-protein coupled receptor to initiate a response in its target cell. The amount of light emitted by aequorin was quantified, converted to intracellular Ca^{2+} concentrations, and plotted on the graph below as a function of time.



[From Woods et al. (1986), *Nature* 319: 600-602, as adapted in Alberts et al. (2002), *Molecular Biology of the Cell*, 4th ed., Garland Science.]

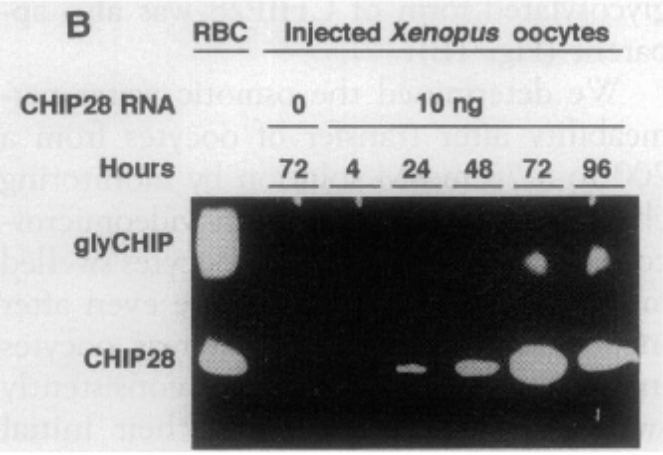
7. What do these results indicate about the Ca^{2+} response of liver cells to vasopressin?
    a. The higher the concentration of vasopressin, the more Ca^{2+} is released with each oscillation.
    b. The concentration of vasopressin does not affect the Ca^{2+} response.
    c. The intensity of the vasopressin signal is represented by the frequency of Ca^{2+} oscillations.
    d. Continued presence of vasopressin is required for repeated Ca^{2+} oscillations, regardless of the concentration.
    e. For a given concentration of vasopressin, Ca^{2+} oscillations become less frequent the longer the hormone exposure persists.
    f. The longer the vasopressin is present, the less intense each Ca^{2+} spike is.

    ANSWER: c

Quiz #4

In the early 1990s, a research group was studying a protein of unknown function called CHIP28. This protein was known to occur abundantly in red blood cells (RBC) and certain cells of the kidney that are partly responsible for concentrating urine. CHIP28 is a 28 kilodalton (kDa) protein whose sequence and structure is similar in many ways to other proteins known to be integral membrane channels.

The biologists decided to isolate the mammalian CHIP28 mRNA and inject this mRNA into oocytes (egg cells) from the frog *Xenopus laevis*. Unaltered *Xenopus* oocytes do not express CHIP28 under normal conditions.

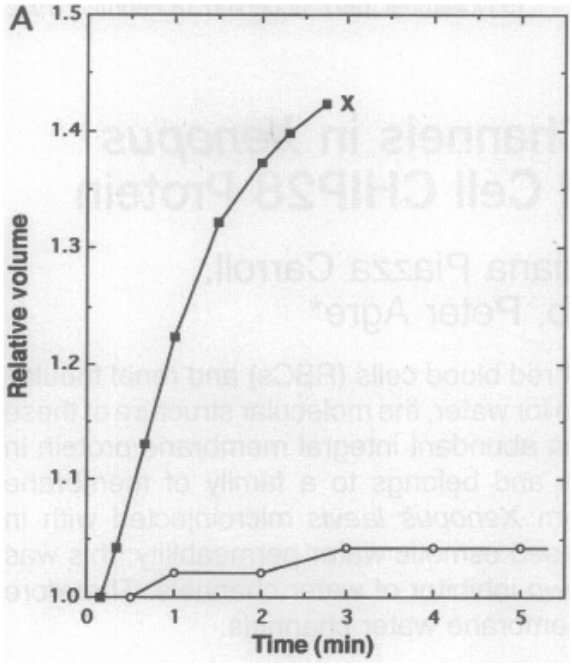


[From Preston et al. (1992), *Science* 256: 385-387.]

Above is a picture of a polyacrylamide gel (SDS-PAGE) that was labeled with an antibody which specifically recognizes CHIP28 and a glycosylated form of the protein called glyCHIP. (The presence of the antibody was detected by a radioactive probe that binds to the anti-CHIP28 antibody and produces the white shapes you see.) The proteins that were electrophoresed on this gel were either from RBC membranes (lane 1) or *Xenopus* oocytes homogenized (ground up) at the indicated time after injection with either RNA-free buffer or 10 ng of CHIP28 mRNA, as indicated (lanes 2-7).

8. What do these results indicate?
    a. More than 10 ng of mRNA is necessary for oocytes to express CHIP28 in 4 hours.
    b. To determine the function of CHIP28, future experiments with these oocytes should be performed at about 48 hours after mRNA injection.
    c. Oocyte expression of CHIP28 occurred independently of the presence of CHIP28 mRNA.
    d. The abundance of CHIP28 was independent of the time elapsed after injection with CHIP28 mRNA.
    e. RBCs were used as a positive control in this experiment because they efficiently express CHIP28 from the injected mRNA *via* translation, and they efficiently glycosylate it.

ANSWER: none of these



[From Preston et al. (1992), *Science* 256: 385-387.]

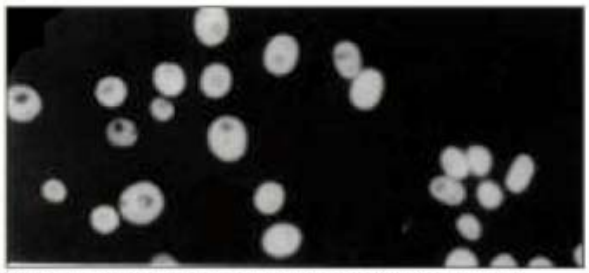
At an appropriate time after CHIP28 mRNA injection, *Xenopus* oocytes were placed in a hypotonic buffer and their volume was measured over the subsequent 5 minutes. Data from this experiment are shown in the graph above. (■ = oocytes injected with mRNA; o = oocytes injected with RNA-free buffer; X = time after which intact oocytes were no longer observed for the upper curve)

9. What conclusion(s) can you draw from the graph above?
    a. Oocyte volume increases about 10 times more rapidly in the mRNA-injected cells than in the control cells.
    b. Oocyte volume increases about 100 times more rapidly in the mRNA-injected cells than in the control cells.
    c. Oocyte volume increase requires CHIP28.
    d. Oocyte volume increase is facilitated by CHIP28.
    e. Osmotic swelling is not a potential problem for oocytes because they're already big cells.
    f. CHIP28 is probably a cytoskeletal protein forming a rigid structure just within the plasma membrane.
    g. CHIP28 is probably a channel protein that allows water to diffuse across the plasma membrane.

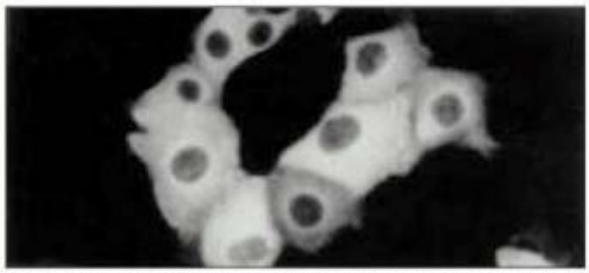
ANSWERS: a, d & g

Longitudinal Assessment of Data Interpretation Skills – April 2011, one semester later

A eukaryotic cell infected with a virus soon begins to express viral genes. One virus that infects mammalian cells is Simian Virus 40 (SV40). Researchers were using monkey cells in culture that had been injected with different versions of SV40 DNA to determine the subcellular location of one SV40 gene product called Large T-Antigen. They stained cells with a fluorescent antibody that specifically binds the T-antigen and observed these immunostained samples under a fluorescence microscope. Two of their immunofluorescence images are shown below. The images were taken at the same magnification.



Cells injected with wild type SV40 Large T-antigen and stained with a fluorescent T-antigen antibody. Fluorescing structures are nuclei.



Cells injected with mutant SV40 Large T-antigen and stained with a fluorescent T-antigen antibody. The mutation caused the lysine at position 128 in the protein to be changed to threonine.

[From Kalderon et al. (1984), *Cell* 39: 499-509.]

1. These results indicate that:
    a. Once the antibody enters the nucleus, it cannot leave.
    b. The antibody interaction with T-antigen is unstable in the cytosol.
    c. T-antigen is normally localized in the nucleus.
    d. T-antigen is normally localized in the cytosol.
    e. Part of the T-antigen amino acid sequence is responsible for targeting the protein to its proper location.
    f. A lysine must be present at position 128 in the T-antigen in order for the antibody to recognize the protein.
    g. A lysine must be present at position 128 in the T-antigen in order for the T-antigen to be synthesized in the nucleus and exported to the cytosol.

ANSWERS: c & e

The sequence of amino acids 126 to 132 in the wild type T-antigen is:
-Pro-Lys-Lys$_{128}$-Lys-Arg-Lys-Val-
The researchers engineered and inserted into cultured cells several genes that, when expressed, would have the above sequence of amino acids or slight alterations of this sequence fused to the amino terminus of the resulting proteins. They then performed immunostaining experiments similar to those shown above to determine the subcellular location of these engineered fusion proteins. The results are summarized in the table below.

	Normal Subcellular Location	**Subcellular Location of Fusion Protein (amino acids 126-132 of wild type T-antigen attached)**	**Subcellular Location of Fusion Protein (if any of the attached amino acids 126-132 from T-antigen are missing, or if Lys$_{128}$ is mutated to Thr)**
β-galactosidase	Cytosol, lysosomes, nucleus	Nucleus	Cytosol, lysosomes, nucleus
Pyruvate Kinase	Cytosol	Nucleus	Cytosol
Mutated SV40 Large T-antigen described above (Lys$_{128}$➔Thr)	Cytosol	Nucleus	Cytosol

2. Taken together, these results indicate:
    a. (-Pro-Lys-Lys-Lys-Arg-Lys-Val-) is a nuclear localization signal that directs proteins (of which it is a part) to the nucleus.
    b. (-Pro-Lys-Lys-Lys-Arg-Lys-Val-) directs proteins to the nucleus, regardless of the normal subcellular location of the protein.
    c. (-Pro-Lys-Lys-Lys-Arg-Lys-Val-) must be present for any protein to localize to the nucleus.
    d. any signal that directs a protein to the nucleus must be at least seven amino acids in length.
    e. (-Pro-Lys-Lys-Lys-Arg-Lys-Val-) can direct a protein to the nucleus even when located in different possible positions within that protein's sequence.
    f. the pyruvate kinase fusion protein with Lys$_{128}$ mutated to Thr in the N-terminal attachment probably started in the cytosol, translocated to the nucleus, and then relocated to the cytosol.
    g. normal β-galactosidase may have a nuclear localization signal of its own, but if so, the one in SV40 Large T-antigen must be more effective for directing proteins to the nucleus.

ANSWERS: a, b, e & g

Pre/Post Semester: Perceptions, Attitudes, and Self-Assessment
This survey was administered online via Checkbox.

1. Perceptions
    a. Self-assessment of specific abilities
        i. Please rate your own ability to do the following tasks, on a scale from 1(weak) to 5 (strong):
            1. Understand the most central concepts of biology
            2. Apply biological concepts to new problems and data
            3. Analyze biological data that I have not seen before
            4. Use math to explain biological concepts and examples
            5. Formulate a testable hypothesis in biology
            6. Remember facts about particular experiments and case studies
            7. Use examples and data to evaluate claims and observations about biology
            8. Formulate an opinion about a controversial topic in biology and defend my opinion with data
            9. Apply biological concepts to daily life outside the classroom
            10. Understand the historical foundations of biology
            11. Appreciate the social, legal, and ethical implications of biology research
    b. Perception of biology as a discipline
        i. How accurately does each of the following phrases describe the overall discipline of biology? Please rate each description on a scale ranging from 1 (not at all accurately) to 5 (extremely accurately).
            1. Biology is a set of definitions and processes to learn
            2. Biology is a discipline where all the big questions have already been answered
            3. Biology is a set of interrelated concepts and ideas
            4. Biologists investigate questions that have not been answered
            5. Biology consists of facts that are clearly and reliably true
            6. Biologists spend much of their time interpreting observations
            7. The division of biology into large (organismal, ecological, etc.) and small (molecular, cellular, etc.) fields of study accurately reflects the division in the natural world
        ii. How important are each of the following skills or characteristics for biologists to be successful? Please rate each skill or characteristic on a scale ranging from 1 (not at all important) to 5 (extremely important).
            1. Creativity
            2. Innovation
            3. Mathematical ability
            4. Memorization
            5. Interpretation
            6. Ethical awareness
    c. Relevance of biology for daily life

i. Can you think of an example where something that you've learned about biology was relevant for you personally over the last week? [YES, NO]
    1. [IF YES] Please explain. [OPEN ENDED]
ii. How important is biological knowledge for each of the following tasks? Rate the importance of each task on a scale ranging 1 (not at all important) to 5 (extremely important).
    1. Making personal decisions about your health care
    2. Buying a new car
    3. Understanding public debates about global warming
iii. How important is biological knowledge when facing ethical dilemmas?
    1. 1 (not at all important) to 5 (extremely important)
iv. How important is the study of ethics when studying biology?
    1. 1 (not at all important) to 5 (extremely important)
v. Imagine that you have a life-threatening illness. Also, imagine that your doctor offers to prescribe a new drug which has had some success in treating the disease, but with reports of harmful side effects for patients' livers. Which of the following would you do? Please check all that apply.
    1. Accept the physician's advice and take the drug.
    2. Research the types of side effects.
    3. Research the likelihood of side effects.
    4. Compare the likelihood of side effects to the likelihood of successful treatment.
    5. Refuse to take the drug.

d. Enrollment in biology courses
    i. What biology courses did you take in high school? Please check all that apply.
        1. Introductory Biology
        2. AP Biology
        3. IB Biology
        4. A course on a specific topic in biology
    ii. What biology courses have you taken so far in college? Please check all that apply.
        1. BIO 103 (Special Topics in Biology I)
        2. BIO 104 (Special Topics in Biology II)
        3. BIO 111 (Molecules, Genes, and Cells)
        4. BIO 112 (Organisms, Evolution, and Ecosystems)
        5. A course on a specific topic in biology
    iii. What is the likelihood that you will take more biology courses in the future?
        1. 1 (extremely unlikely) to 5 (extremely likely)
        2. IF ANSWERED 3 OR HIGHER: What biology courses might you take? [OPEN-ENDED]
    iv. Did this semester's biology course increase your interest in taking other biology courses, decrease your interest, or have no effect? [INCREASE INTEREST, DECREASE INTEREST, HAVE NO EFFECT]

v. Was this semester's biology course fundamentally different than previous biology courses you have had? [YES, NO] [ONLY ASK AT END OF SEMESTER]
    1. [IF YES] How? [OPEN ENDED]