

Science League Biology II January 2013

Choose the answer that best completes the statements or questions below and fill in the appropriate response on the scan-tron. If you change your answer be sure to completely erase your first choice, please **PRINT** your name, school, area, and which test you are taking on the scan-tron. This exam is for AP level students.

1. Suppose we have a population of fruit flies. In this population 180 individuals are homozygous for normal wings (wild type: VV), 220 individuals are heterozygous (Vv), and 100 individuals express vestigial wings (vv). What is the frequency of the V allele?

- a. 0.29 b. 0.36 c. 0.40 d. 0.58 e. 0.80

2. What is the frequency of the recessive allele (v) in this population?

- a. 0.20 b. 0.42 c. 0.58 d. 0.64 e. 0.84

As a consequence of volcanic activity a new island formed. Over many years this island underwent a succession of natural processes and it was able to sustain life. By accident a small raft of vegetation dislodged from the mainland arrived on the island. It carried 5 rats, 2 males and 3 females, which survived the voyage. All 5 rats were dark in coat color (black/brown = B) but one male carried the recessive allele for yellow coat (b).

3. What are the frequencies of allele B and allele b in the initial rat population of this island?

- a. $B=0.95$ & $b=0.05$ b. $B=0.90$ & $b=0.10$ c. $B=0.10$ & $b=0.90$ d. $B=0.20$ & $b=0.80$

4. If we assume a Hardy-Weinberg equilibrium for the coat color alleles, how many rats can we expect to have yellow fur when the island population reaches 20,000?

- a. 0 b. 20 c. 100 d. 200 e. 2,000

5. Suppose that when the rat population reaches 20,000 there are 100 times as many yellow rats as predicted by Hardy-Weinberg. Which of the processes described below best accounts for this discrepancy?

- a. The island's volcanic origins favors the dark colored rats over the light colored rats.
b. Divine intervention
c. Preferential predation of yellow rats
d. Genetic drift
e. Because dark rats are better swimmers they were able to swim away from the island in greater numbers than yellow rats.

6. In order for a phenotype to be favored in the Darwinian sense, it must

- a. be expressed in the majority of the individuals in the population.
b. be heritable.
c. exist in many other related species.
d. increase opportunities for mating.
e. be easily observed by scientists.

7. The Basque people, a tribe from the Pyrenees Mountains that form the border between Spain and France, are all Rh negative (Rh^-). Pure Peruvian Incas from the Andes Mountains all have blood type O. Neither blood type O nor Rh^- seems to impart superiority for high altitude existence. Which scenario below best explains the distribution of blood type alleles in these populations?

- a. The founding populations were, by chance, heavy in Rh^- and O alleles respectively.
b. Women preferred to mate with men who had the blood types in question.
c. Babies with other blood types were sacrificed.
d. Low oxygen partial pressure gave a selective advantage to these blood types.
e. In general, individuals with blood types other than the ones in question had fewer offspring.

8. Ellis-van Creveld syndrome (EvC - a.k.a. “six-fingered dwarfism”) is a rare autosomal recessive genetic disorder that affects bone growth and results in very short stature (dwarfism characterized by particularly short forearms and lower legs and a narrow chest with short ribs). Most individuals also have extra fingers and toes (polydactyly), unusually formed nails and teeth, and heart defects. The highest rate of the condition is seen among the Old Order Amish population of Lancaster County, Pennsylvania. It is fairly rare in the general population. It is known that at least one and possibly two of the men who founded this agrarian community carried the allele for this condition. Which of the scenarios below best explains the prevalence of EvC syndrome in this population?

- a. Manual labor and farm work selected for individuals with extra digits.
- b. The Founder Effect combined with inbreeding increased the chances of the disorder manifesting itself.
- c. Dwarfism is considered a desirable attribute among the Amish and therefore individuals expressing EvC mated more frequently than others.
- d. Exposure to teratogenic agricultural chemicals, such as pesticides and herbicides, caused additional mutations of the EcV locus.

9. Because natural populations seldom meet Hardy-Weinberg conditions

- a. evolution is improbable.
- b. the frequency of alleles in a given population does not change over generational time.
- c. rare genetic conditions tend to stay rare.
- d. there is a large probability that gene frequencies will change over generational time.

10. In *D. melanogaster*, there is a recessive allele that in the homozygous condition produces ebony body color. Ebony flies are not as viable as wild flies, but in cool, dry environments, heterozygotes have a slight viability advantage over either homozygous genotype, i.e. “Aa” outperforms “AA” or “aa.” This example of heterozygote advantage is similar to that seen in

- a. color blindness in humans, wherein heterozygotes have an advantage during times of famine.
- b. sickle cell anemia in humans, wherein heterozygotes have an advantage in malaria infested areas.
- c. roan coat color in cattle, wherein heterozygous cattle better survive harsh winters.
- d. seed color in garden peas, wherein heterozygous plants better survive dry conditions.
- e. wing size in fruit flies, wherein heterozygous flies better survive in laboratory cultures.

QUESTIONS 11-14 ARE BASED A STUDY OF GUPPY POPULATIONS IN A STREAM IN TRINIDAD.

Scientists have studied the distribution of coloration in male guppy populations. The data table below summarizes population samples from three separate naturally occurring pools.

POOL #	# of guppies	Avg. male coloration	Numbers of Predators
1	75	Brightly multi-colored w/ large spots	Pike cichlids = 0 Blue acara = 0 Rivulus = 12
2	83	Medium coloration on body and tail, medium sized spots	Pike cichlids = 0 Blue acara = 7 Rivulus = 15
3	110	Drab coloration w/ very small spots concentrated near the tail	Pike cichlids = 17 Blue acara = 20 Rivulus = 5

11. What would be a reasonable explanation for the high incidence of brightly colored males in pool 1?

- a. Predators belonging to the *Rivulus* group prefer to eat brightly colored males.
- b. The absence of significant predation favors brightly colored males because they mate more successfully than drab males.
- c. The absence of cichlids and acara favors brightly colored males because they blend in better with the bright, multi-colored streambed than do the drab males.
- d. Predators belonging to the *Rivulus* group prefer to eat drab males.

12. The presence of aggressive predators such as acara and cichlids
- increases the selection pressure on brightly colored males
 - allows the few brightly colored males to mate more frequently than drab males
 - selects against drab males
 - significantly reduces guppy populations
13. If in an experiment we stocked a new pool with 100 mostly drab guppies and about 30 *Rivulus*, after 14 guppy generations (about 8 years) what will the guppy population most likely look like?
- All the male guppies will be drab.
 - Most of the guppies will be drab, with an occasional brightly colored male.
 - There will be a 50/50 split between drab male guppies and brightly colored ones.
 - Most of the males will be brightly colored.
14. Why do brightly colored males exist in the first place?
- Random genetic variation in the species.
 - Females prefer mating with them.
 - The absence of predators stimulates males to become more brightly colored.
 - Some males prefer to be gaudy colored.
 - Bright coloration provides cryptic coloration in freshwater streams.
15. Which of the scenarios below best exemplifies convergent evolution?
- South American maras are rodents that look and behave very much like rabbits do in Europe, even though they are not very closely related.
 - As a result of continental drift an island becomes separated from the mainland. A small population of a mainland species is isolated on the island. Over time this isolated population becomes a separate species from the large mainland population.
 - On the island of Madagascar one can find many species of small, monkey-like animals called LEMURS. Each species is specially adapted to fulfill a specific niche, yet all of them are thought to have evolved from a few ancestral species when Madagascar first separated from the African continent many millions of years ago.
 - An antibiotic that kills bacteria was added to a dish in which bacteria were grown. A few bacteria were able to grow and reproduce even in the presence of the antibiotic.
16. Probably the best way to determine potential common ancestry among different species is to
- compare and contrast external morphological features
 - try to create hybrids between the species in question
 - look for common analogous structures
 - compare and contrast DNA base sequences of common genes
17. Data suggest that there is greater genetic diversity among the human tribes of sub-Saharan Africa than there is among all of the other races in the rest of the world. What best explains the greater genetic diversity among Africans?
- There was more frequent interbreeding between ancient Africans and Neanderthals than between Neanderthals and non-African humans.
 - Humans in Europe, Asia and the Americas evolved from a small population that migrated out of Africa.
 - Humans in Africa were subject to greater selection pressure than humans elsewhere.
 - All Africans diverged from a small group of humans that migrated to Africa from the Middle East.
18. The presence of gill slits in vertebrate embryos of all taxonomic Classes is a possible indication that vertebrates of all Classes
- may have had a common ancestor.
 - are all actually fish.
 - breathe through these gills before birth.
 - prefer an aquatic existence over a terrestrial one.
19. The theory of evolution by natural selection supports the idea that
- humans evolved from monkeys
 - giraffe necks will get longer over generational time
 - inbreeding produces mutants
 - environmental conditions favor certain phenotypes

20. The Australian hammer orchid produces flowers that look very much like female Thynnid wasps, to the extent that a male Thynnid will attempt to copulate with the flower. Although this may frustrate the male wasp, it helps the orchid because
- the male wasp aids in pollination
 - the male wasp aids in seed dispersal
 - the orchid flowers are insectivorous and eat the wasps
 - the wasps protect the orchid from insects that may harm it

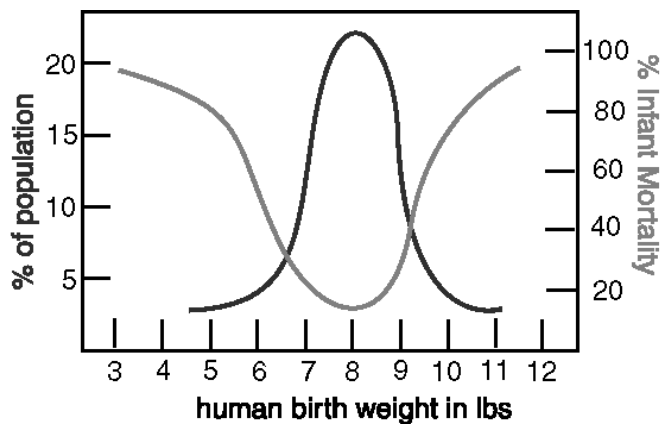
21. Ostensibly, the selection pressure that drove the evolution of orchid-wasp mimicry was
- increased wasp reproductive success
 - selective predation by wasps of insect pests
 - enhanced orchid reproductive success
 - better use of limited resources by orchids and wasps alike

The table below shows data from an investigation on a specific viral protein sampled over time. The numbers show how many DNA base substitutions, either synonymous or non-synonymous, occurred in selected codons.

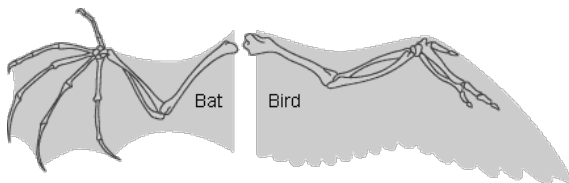
CODON POSITION	NUMBER OF SYNONYMOUS SUBSTITUTIONS IN CODON	NUMBER OF NON-SYNONYMOUS SUBSTITUTIONS IN CODON
11	0	6
16	2	8
59	0	11
75	6	0
130	11	1
162	30	2
201	4	3

22. Which codon position most likely encodes an amino acid that has changed because of positive selection?
- 59
 - 75
 - 130
 - 162
 - 201

23. Which codon position most likely encodes an amino acid that has changed because of purifying selection?
- 11
 - 16
 - 59
 - 162
 - 201



24. The data in the graph above offer evidence for
- disruptive selection
 - directional selection
 - stabilizing selection
 - speciation

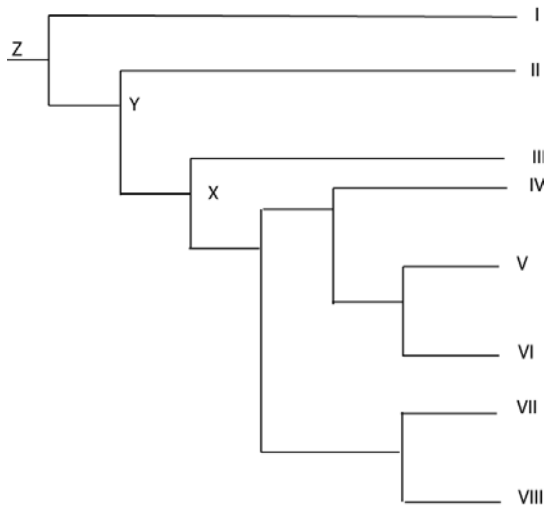


25. Birds and bats have independently evolved the ability to fly, and do so using their respective forelimbs. Therefore bird wings and bat wings represent
- analogous (homoplastic) structures only
 - homologous structures only
 - vestigial structures only
 - both analogous (homoplastic) and homologous structures
 - both homologous and vestigial structures

Eight vertebrates & the Presence or Absence of Selected Shared Derived Characteristics

TAXON NAME	JAWS	LUNGS	CLAWS/NAILS	GIZZARD	FEATHERS	FUR	MAMMARY GLANDS	SCALES OF KERATIN
Hagfish	-	-	-	-	-	-	-	-
Sunfish	+	-	-	-	-	-	-	-
Salamander	+	+	-	-	-	-	-	-
Lizard	+	+	+	-	-	-	-	+
Alligator	+	+	+	+	-	-	-	+
Pigeon	+	+	+	+	+	-	-	+
Mouse	+	+	+	-	-	+	+	-
Chimp	+	+	+	-	-	+	+	-

26. What shared derived trait distinguishes alligators and pigeons into their own clade?
- feathers
 - absence of fur
 - claws
 - gizzard
 - keratinized scales



27. Assume that the cladogram shown above has been constructed using the data from the table above. If "Z" is the common ancestor, then species I is most likely
- the chimp
 - the hagfish
 - the alligator
 - the mouse
 - Cannot be determined
28. What shared derived trait does junction "X" represent?
- absence/presence of claws/nails
 - absence/presence of lungs
 - absence/presence of jaws
 - absence/presence of fur
 - absence/presence of gizzard
29. Which of the traits in this data table is highly likely to be homoplastic?
- feathers
 - fur
 - claws
 - gizzard
 - None of them is homoplastic

30. If “V” represents the alligator, then “VI” is most likely the
 a. chimp b. pigeon c. mouse d. lizard e. sunfish

31. Although phylogenies have been constructed primarily from morphological data, these nascent phylogenies are best affirmed or modified based on data from
 a. embryology b. fossil studies c. behavioral analyses d. comparative DNA sequence analysis

TRAITS IN SELECTED LAND PLANTS

TAXON	PROTECTED EMBRYOS	TRUE ROOTS	SPOROPHYTE PREDOMINANTLY GREEN	VASCULAR TISSUE	STOMATA	TRUE LEAVES	SEEDS
STONEWORT	-	-	-	-	-	-	-
LIVERWORT	+	-	-	-	-	-	-
PINE TREE	+	+	+	+	+	+	+
BRACKEN FERN	+	+	+	+	+	+	-
CLUB MOSS	+	+	+	+	+	-	-
SPHAGNUM MOSS	+	-	-	-	+	-	-
HORNWORT	+	-	+	-	+	-	-
DAISY	+	+	+	+	+	+	+

32. Based on the data in the table above, the two taxa that are most closely related are
 a. stonewort and liverwort d. pine tree and daisy
 b. club moss and sphagnum moss e. pine tree and bracken fern
 c. hornwort and liverwort

33. Selecting from the taxa given in the table above, which one is the sister group to plants that produce seeds?
 a. pine tree b. bracken fern c. club moss d. hornwort e. sphagnum moss

34. Which two traits most likely evolved along the same phylogenetic branch?
 a. seeds and leaves
 b. protected embryos and true roots
 c. true roots and stomata
 d. true roots and green sporophyte

35. What trait is most likely homoplastic?
 a. protected embryos b. seeds c. leaves d. vascular tissue e. stomata

36. Reconstruction of phylogenies based on fossil evidence is limited to
 a. embryological data
 b. morphological features
 c. behavioral studies
 d. comparative amino acid sequence analysis

37. Because all life on earth uses nucleic acids to store and transmit genetic data we can assume that
 a. life arose spontaneously more than once.
 b. extraterrestrial molecules most likely “seeded” planet Earth for life.
 c. all living things are related to one another.
 d. the same system will be present in extraterrestrial life, should it ever be discovered.

Data on the number of differences in the amino acid sequence of Cytochrome C in 9 species

	Horse	Donkey	Whale	Chicken	Penguin	Snake	Moth	Yeast	Wheat
Horse	0	1	5	11	13	21	29	45	46
Donkey		0	4	10	12	20	28	46	45
Whale			0	9	10	18	27	45	44
Chicken				0	3	18	29	46	46
Penguin					0	17	27	45	46
Snake						0	29	46	46
Moth							0	48	45
Yeast								0	47
Wheat									0

38. Given the data in the table above, what would be a reasonable prediction regarding the range of differences we could expect in amino acid sequences in cytochrome c for a horse and a zebra?
a. 0-2 b. 9-11 c. 17-21 d. 45-47
39. Since the cytochrome c sequence for chickens and penguins differs by just 3 amino acids, we can assume that
a. they would probably be able to successfully interbreed
b. the chicken cytochrome c gene would work well if transplanted into a penguin
c. chickens and penguins are more closely related to whales than to one another
d. chickens and penguins shared a fairly recent common ancestor
40. Suppose we were to add data on turkey cytochrome c to the table. These data would most likely show that turkeys are most closely related to
a. snakes b. horses c. wheat d. chickens e. whales
41. Suppose there exist three related species, A, B, and C. Species A and species B have long tails, whereas species C have short tails. Which of the following pieces of evidence would best support the hypothesis that "long tail" is a synapomorphy (shared derived trait)?
a. Fossil evidence showing that the common ancestor of species A, B, and C had long tails
b. Fossil evidence showing that the common ancestor of species A, B, and C had short tails
c. DNA evidence showing that species A and C are sister species
d. DNA evidence showing that species B and C are sister species
e. Evidence showing that species A and B live in an environment that favors long tails, whereas species C lives in an environment that favors short tails
42. The most critical attribute that differentiates two groups of closely related organisms into separate species is
a. morphological differences c. differences in migration patterns
b. habitat preference d. reproductive isolation

43. Island populations often undergo rapid evolutionary divergence from mainland relatives because of

- geographic isolation
- polyploidy
- significant migration away from the island
- forced inbreeding

44. Horses and donkeys are related but separate species. Even though the two mate to produce robust mules, a mule is unable to carry out normal meiosis. In this case the reproductive barrier that separates horses and mules

- is prezygotic resulting in inviable hybrids
- is postzygotic resulting in sterile hybrids
- is prezygotic resulting in sterile hybrids
- is postzygotic resulting in inviable hybrids

45. Humans have successfully crossbred captive lions and tigers to produce fertile tiglon and ligers. Even though they produce viable, fertile hybrids, lions and tigers are considered to be members of two separate species because

- in nature lions tend to eat tigers rather than mate with them
- tigers and lions are separated geographically
- their ranges overlap in only two places
- differences in sizes among wild tigers and lions prevent the males of one species from successfully mounting the females of the other species.

*In eastern North America, prior to the mid-1800's, the apple maggot fly (*Rhagoletta pomonella*) deposited eggs only on hawthorn fruits. After Europeans brought apple trees to America, the flies began laying eggs on apples as well. Today there are two populations of *Rhagoletta*, those that reproduce on apples and those that reproduce on hawthorn fruits. They seldom interbreed and they seem to be evolving towards separate species.*

46. What other conditions must exist in order for this speciation to occur?

- the preference for apples or hawthorns must have a genetic basis
- apple trees and hawthorn trees must be isolated from one another
- one of the populations must undergo autopolyploidy
- one population must be nocturnal whereas the other diurnal

47. What can we assume is true about the two populations of *Rhagoletta*?

- males from one population can't copulate with females from the other
- flies that prefer hawthorn fruit look very different from flies that prefer apple.
- flies that prefer hawthorn fruit mate at different times of the year than flies that prefer apple.
- flies from either population have the same chromosome number

48. Which example below is evidence that evolution is currently taking place?

- Humans have successfully created new strains of dog through selective breeding.
- Some *Staphylococcus aureus* bacteria resist all but one antibiotic drug.
- Monsanto has developed "Roundup Ready" corn that resists the effects of the herbicide Glyphosate.
- Human embryos possess pharyngeal gill pouches.

From geologic, fossil and other evidence scientists estimated the following data on the Galapagos Islands.

TIME (mya)	# OF ISLANDS	# OF FINCH SPECIES
0.25	18	14
0.50	18	9
0.75	9	7
1.00	6	5
2.00	4	3
3.00	4	1
4.00	3	0

49. These data seem to support the idea that
- evolution occurs in “fits and starts” over short time intervals rather than slowly over long stretches of time
 - natural selection favors the survival of the fittest
 - finches with large beaks for crushing large seeds outcompeted small-billed finches on most islands
 - isolation of populations on newly formed islands is related to speciation
50. In frogs, among species of the genus *Rana*, if species exist allopatrically, their respective breeding seasons overlap. However, where different species exist sympatrically, overlap of breeding seasons is greatly reduced or eliminated. How do these conditions contribute to sustained speciation?
- They represent pre-zygotic, temporal reproductive isolation.
 - Whether allopatric or sympatric, the breeding season preference eventually leads to geographic isolation
 - Sympatric species of the genus *Rana* prey on one another, so it pays to breed at different times.
 - Any hybrids that may result from chance cross-species mating always prefer one breeding season over another.
51. The best evidence for periodic mass extinctions in the history of life on earth comes from
- comparative DNA studies
 - the fossil record
 - the study of homologies
 - the presence of vestigial structures in modern species.
52. The evolution of large eukaryotic species could not be possible if it weren't for
- the transition of life from aquatic to terrestrial forms
 - large deposits of biomass matter during the carboniferous
 - the evolution of photosynthesis
 - the extinction of the dinosaurs
53. The history of life on earth is dominated by
- Humans
 - Dinosaurs
 - Insects
 - Viruses
 - Bacteria
54. The first forms of life on earth were most likely
- photosynthetic bacteria
 - chemosynthetic bacteria
 - aerobic bacteria
 - parasitic bacteria
55. Although life on earth today stores and transmits genetic information through DNA, in the primordial conditions that led to the evolution of life, RNA probably acted as the first genetic material because
- RNA is more complex than DNA
 - RNA is more stable than DNA
 - RNA can self-edit its own code
 - RNA can make DNA but DNA can't make RNA

56. Imagine that part of a population of African swallows is blown by a storm onto an island far offshore and manages to survive and reproduce there for a period of 20,000 years. However, climate change has caused sea levels to drop and the island became reconnected to the mainland. Members of the formerly isolated island population can now interact freely with members of the original mainland population. Which of the following observations would lead you to conclude that the island population had evolved into a distinct biological species?

- The island birds all have black tails, but the mainland birds have only grey tails.
- Individuals from the different populations sometimes mate with each other, but all of the resulting offspring are sterile.
- Individuals from the different populations seem to mate freely with each other, and the resulting offspring mate freely with either island birds or mainland birds.
- Individuals from the different populations feed on the same kinds of insects in the same habitats and frequently direct courtship behavior toward members of the other population.
- Hybrid offspring produced by pairs of individuals from the two different populations do not look like either parent.

Two species of cichlid fishes were isolated from one another in separate lakes for tens of thousands of years. However, the two were inadvertently allowed to colonize a new man-made pond designed for fish culture. Local biologists collected samples of fish over the course of first breeding cycle. They discovered that the once separated species did mate to produce hybrids. Here are their data.

LIFE STAGE	SPECIES A	SPECIES B	F1 HYBRIDS
Recent hatchlings	185	144	225
Early juveniles	66	72	81
Late Juveniles	45	50	21
Adults	18	22	1

57. What isolating mechanism best explains the data?

- post-zygotic hybrid sterility
- pre-zygotic gamete incompatibility
- low hybrid juvenile vigor
- hybrid inviability

58. If the two species of cichlids are allowed to co-exist in this pond, over time we can expect

- a sustained genetic isolation of the two species
- the fusion of the two into one indistinguishable species
- that eventually the hybrid population will be larger than the respective populations of the original species
- a lack of crossbreeding between species A and species B

59. The Miller-Urey experiments helped us understand that

- the primordial earth could have spontaneously produced the molecules necessary for life
- the primordial earth was seeded with organic molecules from an extraterrestrial source
- in order for life on earth to get started, there had to be a high level of oxygen present in the atmosphere
- one can create life in a glass container

60. If *E. coli* bacteria are grown in a culture medium that contains the antibiotic Ampicillin most cells will die, but a few will survive. What best explains the existence of the resistant bacteria?

- The bacteria develop a resistance while growing in the dish.
- The bacteria acquire resistant genes from the antibiotic.
- The surviving cells already had the resistant genes.
- The antibiotic stimulates the formation of new genes in the surviving bacteria.
- While the bacteria were growing in the dish, some mutated to become resistant

NEW JERSEY SCIENCE LEAGUE
Biology II Answer Key
January 2013

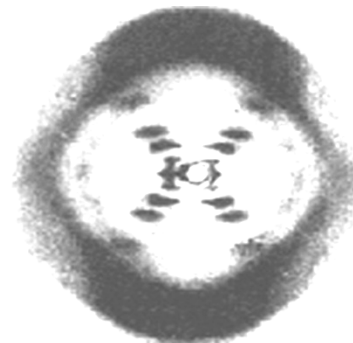
1	D	17	B	33	B	49	D
2	B	18	A	34	A	50	A
3	B	19	D	35	E	51	B
4	D	20	A	36	B	52	C
5	D	21	C	37	C	53	E
6	B	22	C	38	A	54	B
7	A	23	D	39	D	55	C
8	B	24	C	40	D	56	B
9	D	25	D	41	B	57	D
10	B	26	D	42	D	58	A
11	B	27	B	43	A	59	A
12	A	28	A	44	B	60	C
13	D	29	E	45	B		
14	A	30	B	46	A		
15	A	31	D	47	D		
16	D	32	D	48	B		

Science League Biology II March 2013

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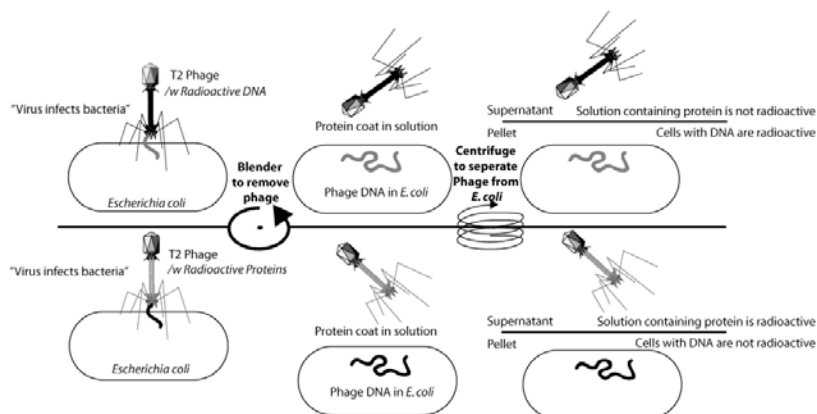
FIGURE 1

- The image shown in Figure 1
 - was produced by James Watson and allowed him and Francis Crick to elucidate the structure of DNA.
 - was produced by Maurice Wilkins and allowed Rosalind Franklin, James Watson, and Francis Crick to determine that DNA was a double helix.
 - was produced by Rosalind Franklin and allowed James Watson and Francis Crick to determine the structure of DNA.
 - was produced by Linus Pauling and caused Watson and Crick to build a bad model of DNA.
 - was made by Rosalind Franklin, stolen by Linus Pauling and so allowed him to build a model of DNA before Watson and Crick.



- What critical information did the image shown in Figure 1 provide?
 - That a DNA molecule is composed of two helices.
 - That the backbone of the molecule is made of phosphates and sugars.
 - That the nitrogen bases must be paired.
 - That the sequence of bases in a DNA molecule is unique.
- In human DNA, the four bases Adenine (A), Thymine (T), Cytosine (C), and Guanine (G) are present in these percentages: A= 30.9% and T= 29.4%; G=19.9% and C=19.8%. Data such as these provided by Erwin Chargaff helped Watson and Crick to
 - determine that the nitrogen bases are on the inside of the helix and the phosphates and sugars are on the outside.
 - organize bases in pairs.
 - determine that the double helix was antiparallel in nature.
 - solve the genetic code.
 - determine that the DNA helix repeats itself every 3.4 Nanometers.

FIGURE 2. – Summary of the Hershey and Chase experiment



- How did the results of the Hershey and Chase experiment shown in Figure 2 help Watson and Crick?
 - They learned that viruses could infect bacteria.
 - They discovered that a blender is a useful scientific instrument.
 - They learned how to make proteins and DNA radioactive.
 - They had evidence to support the idea that DNA is the genetic material.
 - They used the same techniques to determine the structure of DNA.

5. According to the experiment shown in Figure 2, if radioactive sulfur (S^{35}) is used in the culture medium of bacteria that harbor phage viruses, it will most likely appear in
- phage DNA
 - bacterial RNA
 - viral coats
 - viral RNA
 - bacterial cell wall

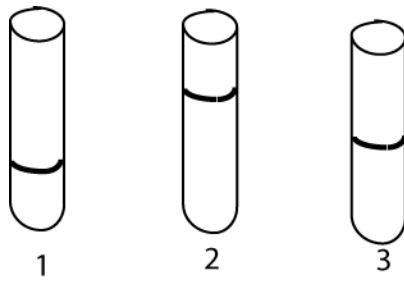


FIGURE 3

Recall the Meselson and Stahl experiment on DNA replication. The band in centrifuge tube 1 represents DNA isolated from bacteria grown in medium containing heavy nitrogen (^{15}N) and then separated in a cesium chloride gradient. Tube 2 contains DNA isolated from bacteria grown in medium containing normal nitrogen (^{14}N). Tube 3 shows hybrid DNA from bacteria that were first grown in ^{15}N medium and then allowed to reproduce in ^{14}N medium.

6. The DNA in tube 3 is partially radioactive (i.e. contains a mix of ^{14}N and ^{15}N DNA). If DNA replication is semiconservative what is the arrangement of heavy DNA and normal DNA in the DNA molecules in tube 3?
- Both DNA strands of the double helix are partially radioactive and partially normal. Each strand is a mix of heavy and normal DNA.
 - One strand of the double helix is heavy and contains ^{15}N . The other contains ^{14}N .
 - 50% of the DNA molecules are composed of two strands of heavy DNA (both sides of the helix contain ^{15}N). The other 50% of the DNA molecules contain only ^{14}N .
 - ONE molecule of DNA in tube 3 is composed of two strands of heavy DNA (both sides of the helix contain ^{15}N). All of the other molecules of DNA contain only ^{14}N .
7. Meselson and Stahl saved some of the bacteria that yielded the DNA in tube three. These bacteria were allowed to reproduce in medium containing only ^{14}N . If DNA from these progeny is isolated and separated as in Figure 3, what would the tube look like?
- We could expect a hybrid band and a normal band.
 - We could expect a heavy band and a hybrid band.
 - We would see only more hybrid DNA.
 - There would be a heavy band and a normal band

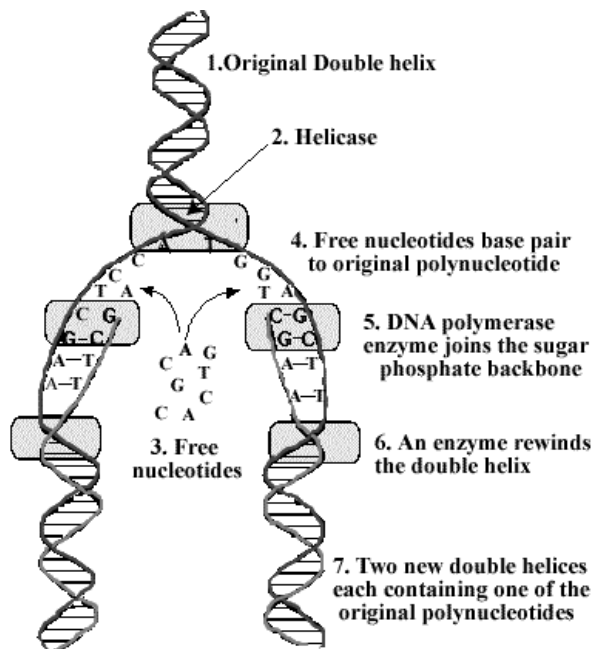


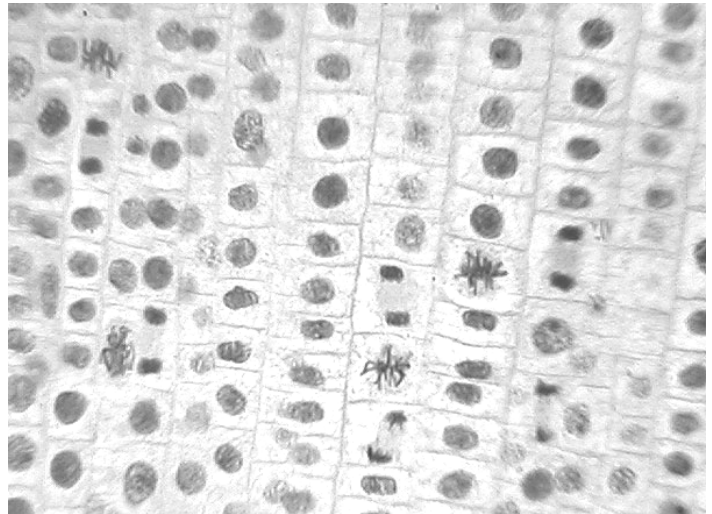
FIGURE 4

A student sketched his impression of the process of DNA replication.

8. Analyze the sketch in figure 4. Is the student's representation correct or incorrect?
- It is correct as shown.
 - It is correct except for the names and labels of the enzymes.
 - It is incorrect because the newly synthesized DNA does not take on a double helix shape until the entire molecule has been replicated.
 - It is incorrect because it fails to take into account a DNA strand's directionality.
9. Suppose a cell successfully completes replication of all of its DNA. For what cell process is the cell most likely preparing?
- mitosis
 - interphase
 - transcription to mRNA
 - translation of mRNA

10. Removal of the terminal RNA primer for the last Okazaki fragment is problematic because
- it causes unnatural lengthening of the DNA molecule, leading to mutations.
 - it leaves a small bit of unpaired single stranded DNA that may be cleaved by repair enzymes, leading to progressive DNA loss.
 - the primer RNA may be used as a template to make DNA by parasitic retroviruses.
 - the DNA to which the RNA primer had been attached folds back on itself and can no longer be transcribed
11. Telomeres are repeated sequences of DNA (e.g. TTAGG) that protect the ends of chromosomes much like the plastic tips of shoelaces protect the laces from fraying. Repeated rounds of cell division eventually eat away at the telomeres. This can result in
- apoptosis
 - cancer
 - meiosis
 - premature differentiation
 - crossing over

FIGURE 5



12. In Figure 5 most of the cells
- are undergoing cytokinesis
 - are in some stage of mitosis
 - have recently completed mitosis.
 - are not dividing
13. To what tissue do the cells in figure 5 most likely belong?
- plant meristem
 - leaf mesophyll
 - human bone growth plate
 - cervical cancer tissue culture

14. The drug cytochalasin B blocks assembly and function of microfilaments. Animal cells treated with this drug after telophase but before cytokinesis would most likely result in
- cancer
 - polyploidy
 - a cell with two nuclei
 - cell death

15. Human cells grown in culture can normally undergo a finite number of cell divisions (about 50 population doublings – the Hayflick Limit) before they stop dividing. Cells that are transformed with an active telomerase gene often
- reach the Hayflick limit sooner (after fewer divisions)
 - stop dividing immediately
 - increase the pace of the cell cycle
 - experience a higher Hayflick limit

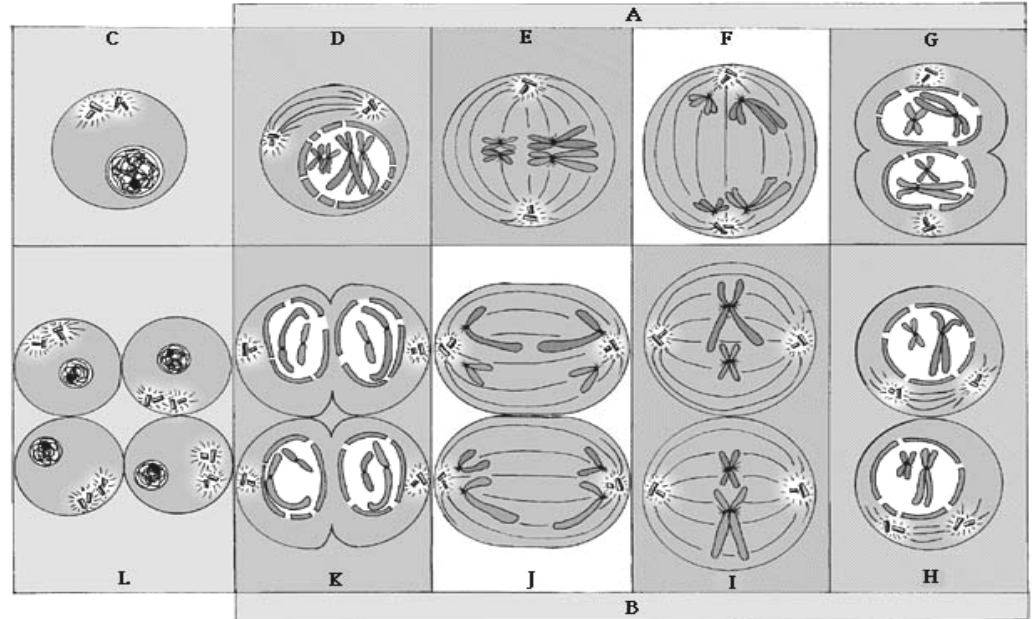
Scientists fused cells in S phase with cells in G1 phase, producing a cell with two nuclei. Using radioactive labeling and microscopy, they compared DNA synthesis in these fused S-G1 cells with unfused G1 cells and unfused S cells.

The data from that experiment show the number of cells that took up radioactive DNA during DNA synthesis as a fraction of the total cells.

TYPE OF CELLS	CELLS WITH LABELED NUCLEI/TOTAL CELLS
Unfused G1 cells	5/291
Unfused S cells	394/450
Fused S-G1 cells	20/23 (both nuclei labeled)

16. What do the data indicate regarding the control of the cell cycle?
- A G1 cell produces a substance that can stimulate an S cell to synthesize DNA.
 - A G1 cell produces a substance that can inhibit an S cell so it does not divide.
 - An S cell produces a substance that can stimulate a G1 cell to synthesize DNA.
 - Fused S-G1 cells are better at making DNA than unfused G1 cells or unfused S cells.

FIGURE 6



17. In panel H of Figure 6, how many chromosomes are there in each cell and how many chromatids are there in each chromosome?

- There are $2N$ chromosomes and each chromosome is composed of one chromatid.
- There are N chromosomes and each chromosome is composed of one chromatid.
- There are $2N$ chromosomes and each chromosome is composed of two chromatids.
- There are N chromosomes and each chromosome is composed of two chromatids.

18. Where would you expect to find cells that undergo the process illustrated in Figure 6?

- In skin cells because they are constantly dividing to produce more skin
- In a testis because this is where spermatozoa are produced
- In a tumor because its cells demonstrate aberrant reproduction, yielding 4 instead of 2 daughter cells in each cycle of cell division
- In cells infected by a virus that stimulates aberrant reproduction

19. What is an important benefit of the process shown in Figure 6?

- The cells that are produced by this process exhibit genetic variability.
- It produces a clone of identical cells that are quickly able to fill available space.
- It produces cells that are no longer able to divide.
- The cells produced by this process can differentiate into many different kinds of cells.

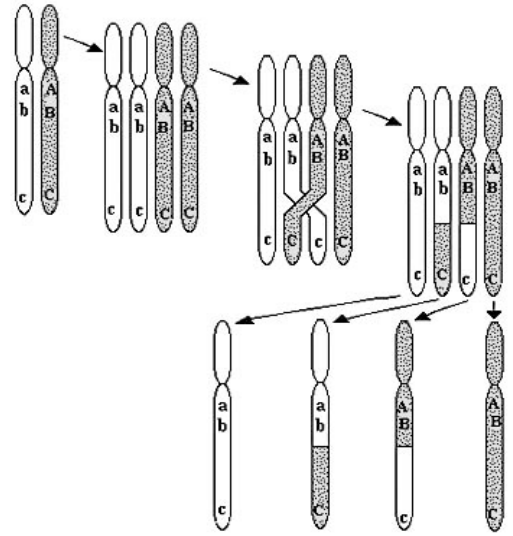
FIGURE 7

20. Study Figure 7 and compare it to Figure 6. In which panel of figure 6 does the process shown in Figure 7 occur?

- a. panel K
- b. panel D
- c. panel G
- d. panel F
- e. panel H

21. Scientists can take advantage of the process shown in Figure 7 to

- a. sequence DNA
- b. isolate genes responsible for specific genetic disorders
- c. determine the relative positions of loci on a chromosome
- d. predict how often a specific gene will be passed on from generation to the next



3' TACACGATGAAG... 5' (A)
 5' ATGTGCTACTTC... 3' (B)

FIGURE 8 – an abbreviated DNA sequence of the first three amino acids of the polypeptide Vasopressin

22. How many codons are there in the sequence shown in Figure 8?

- a. can't be determined from the information given
- b. there are 3 codons because there are 3 of vasopressin amino acids coded for in the sequence
- c. there are 12 codons, one for each base
- d. the sequence contains 4 codons

23. When transcribed and translated, the DNA sequence shown in Figure 8 produces the following amino acid sequence: *methionine-cysteine-tyrosine-phenylalanine*. In mRNA methionine is represented by the sequence AUG. Therefore, which strand (A) or (B), is the coding strand and why?

- a. The coding strand is (A) because it contains 3' TAC 5', which yields the start signal for translation.
- b. The coding strand is (B) because it contains 5' ATG 3', which yields the start signal for translation.
- c. The coding strand is (A) because its 3' end is on the left and this sets the directionality for RNA polymerase.
- d. The coding strand is (B) because its 5' end is on the left and this sets the directionality for RNA polymerase.

24. Suppose strand (A) in Figure 8 was mutated to yield the following sequence 3' **A**ACACGATGAAG... 5'. What might be a reasonable consequence in a cell that harbors this mutation? (*The mutation is highlighted*)

- a. It would produce a mutant protein with one amino acid different.
- b. It would produce a shorter protein, missing one amino acid.
- c. The polypeptide would be the same because this is a silent mutation.
- d. There would be no protein made.

FIGURE 9 –The genetic code

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

25. You will need Figure 9 to answer this question. Look at the 3 highlighted bases in the following sequence, 3' TACACGATGAAG... 5' [this is the same sequence as (A) in Figure 8]. Which mutation below would have the least impact on the amino acid sequence that can be produced?

- Change the A to T.
- Change the A to C.
- Change the C to G.
- Change the G to C.
- Change the G to A.

26. Which of the following amino acids can tolerate the greatest number of base substitutions in a representative codon (before the mutation causes the insertion of a different amino acid)?

- Leucine
- Cysteine
- Phenylalanine
- Glycine
- Methionine

27. Why is a base insertion (addition) mutation usually more disruptive than a base substitution?

- A base substitution may result in an amino acid substitution, but a base insertion results in one additional amino acid inserted in the polypeptide.
- A base insertion may result, perversely, in the loss of a single amino acid.
- A base insertion disrupts the subsequent reading frame.
- A base insertion will terminate the amino acid sequence at the point of insertion.

28. Suppose a point mutation occurs as follows in a codon of the DNA coding strand; ACA → ACT. What might be the impact on the resulting polypeptide?

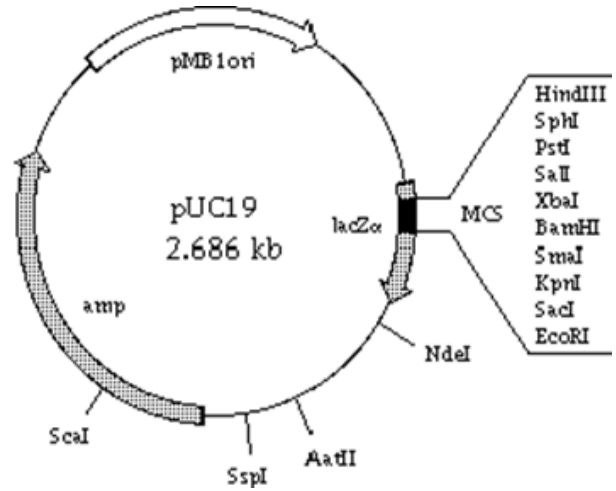
- None. This is a silent mutation.
- The polypeptide would be shorter than normal.
- There would be a single amino acid substitution.
- This would result in a significantly different amino acid sequence downstream from the mutation.

29. How might a mutation in the gene for the rRNA of the small ribosomal subunit impact protein synthesis?

- There would be a reduction in the rate of gene transcription.
- Polypeptide products would contain mutant amino acid sequences.
- Translation of mRNA to a polypeptide chain would be compromised.
- Polypeptide chains would all be longer than usual.

FIGURE 10 – map of plasmid pUC19

30. The plasmid pUC19 is a commonly used cloning vector (see Figure 10). Assume a gene of interest is successfully inserted in the MCS (Multiple Cloning Site) thus disrupting the *lacZ* gene yielding a recombinant plasmid. Undisrupted *lacZ* allows *E. coli* cells that harbor this gene to convert X-gal substrate into a bright blue product. Plasmid pUC19 also contains a gene that confers resistance to the antibiotic ampicillin (*amp*). *E. coli* cells that have no other functional *lacZ* genes and that are sensitive to Ampicillin are made competent and exposed to recombinant plasmid. By chance, some cells take up the recombinant DNA, other cells take up native pUC19 (no insert), and some do not take up any plasmid. Cells of all three varieties are grown on media as shown in the data tables. Which data table best corresponds to the expected outcomes?



a.

MEDIUM	CELLS W/ NO PLASMID	CELLS WITH NONRECOMBINANT pUC19	CELLS WITH RECOMBINANT pUC19
Plain nutrient agar (N.A.)	No growth	Growth	Growth
N.A. + ampicillin	No growth	Growth	Growth
N.A. + ampicillin + Xgal	No growth	No growth	White colonies
N.A. + Xgal	No growth	Blue colonies	White colonies

b.

MEDIUM	CELLS W/ NO PLASMID	CELLS WITH NONRECOMBINANT pUC19	CELLS WITH RECOMBINANT pUC19
Plain nutrient agar (N.A.)	Growth	Growth	Growth
N.A. + ampicillin	Growth	Growth	Growth
N.A. + ampicillin + Xgal	Growth	No growth	White colonies
N.A. + Xgal	Blue colonies	Blue colonies	White colonies

c.

MEDIUM	CELLS W/ NO PLASMID	CELLS WITH NONRECOMBINANT pUC19	CELLS WITH RECOMBINANT pUC19
Plain nutrient agar (N.A.)	Growth	Growth	Growth
N.A. + ampicillin	No Growth	Growth	Growth
N.A. + ampicillin + Xgal	No Growth	Blue colonies	Blue colonies
N.A. + Xgal	Blue colonies	Blue colonies	White colonies

d.

MEDIUM	CELLS W/ NO PLASMID	CELLS WITH NONRECOMBINANT pUC19	CELLS WITH RECOMBINANT pUC19
Plain nutrient agar (N.A.)	Growth	Growth	Growth
N.A. + ampicillin	No Growth	Growth	Growth
N.A. + ampicillin + Xgal	No Growth	Blue colonies	White colonies
N.A. + Xgal	White colonies	Blue colonies	White colonies

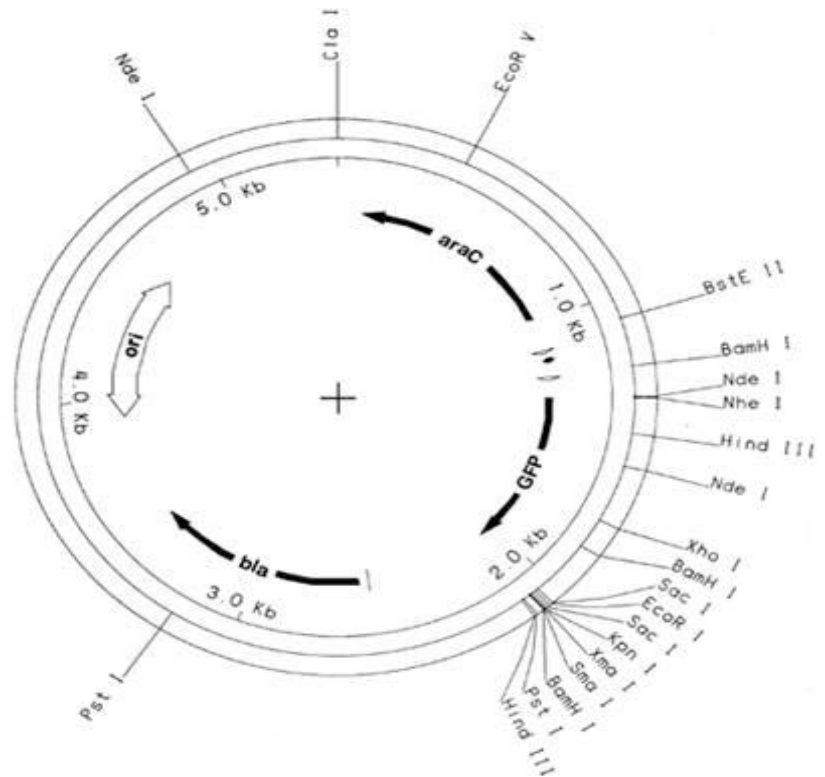
31. *BCL2* is a gene that when activated produces a protein that blocks apoptosis. In some forms of cancer this gene is inadvertently turned on, conferring cell line immortality and leading to tumors. Oblimersen sodium (G3139, Genasense; Genta Inc., Berkeley Heights, NJ) is an antisense oligonucleotide compound designed to specifically bind to the first six codons of the human *BCL2* mRNA sequence. Therefore Oblimersen's anticancer potential depends on...

- the ability of RNA to catalyze its own destruction
- the preventing of *BCL2* mRNA translation
- its ability to stick to the *BCL2* gene, thus turning it off
- its ability to home on the specific *bcl2* protein and destroy it

32. The synthetic antisense oligonucleotide described in question 31 was most likely produced through

- PCR
- reverse transcription
- restriction endonuclease digestion
- homologous recombination

FIGURE 11 – Restriction map of plasmid pGLO. *AraC* is a promoter that in the presence of Arabinose will turn on the GFP gene. Expression of GFP produces a protein that fluoresces green under UV light. The *bla* gene confers ampicillin resistance.



33. Assume we used the restriction enzyme *Xho* I to insert an additional piece of DNA that was about 1.0 kb long. Suppose we successfully inserted this new recombinant plasmid into *E. coli* HB101 (this strain contains no plasmids and no genes for ampicillin resistance). What phenotypic expression could we expect when the cells are grown on medium containing ampicillin and arabinose?

- The recombinant cells would be resistant to ampicillin and would glow under UV.
- The recombinant cells would be resistant to ampicillin and would not glow under UV.
- The recombinant cells would not be resistant to ampicillin and would glow under UV.
- The recombinant cells would not be resistant to ampicillin and would not glow under UV.

34. Suppose we digested native plasmid pGLO with *Pst* I. If the successfully digested DNA is then subjected to gel electrophoresis, how many bands should we see and about how big are the DNA molecules in these respective bands?

- We should see 4 bands, each about 1000 base pairs long.
- There would be three bands. One about 1 kb, and two each at 2 kb.
- We would see only one band of about 5 kb because *Pst* I would linearize the plasmid.
- There would be two bands. One about 1 kb long and the other about 4 kb long.

35. Expression of GFP in bacteria containing plasmid pGLO that are grown in the presence of arabinose is an example of

- a. gene induction
- b. gene repression
- c. gene de-repression
- d. gene elimination

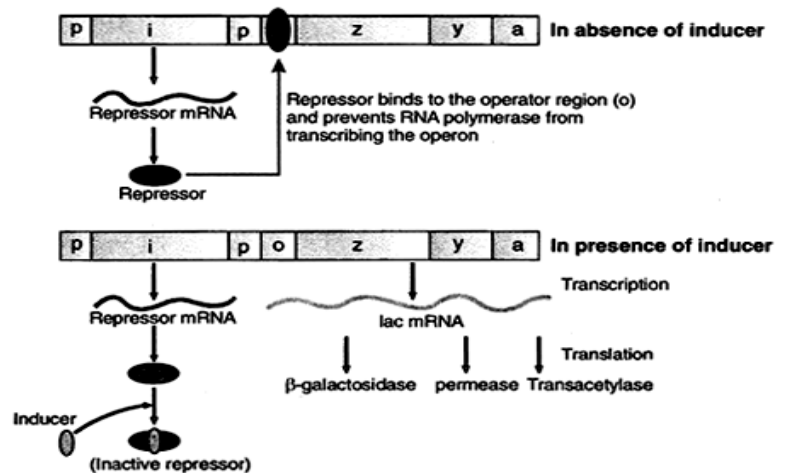
Scientists can use transposon insertions (a.k.a. transposon mutagenesis) to inactivate genes and so determine which genes are really essential for survival. The data table below shows data from an experiment wherein transposons were inserted into genes (intragenic regions) and into non-coding regions (intergenic) of the bacterium *Mycoplasma genitalium*. The data show the number of bacterial strains that were able to grow in culture medium as compared to the number of genes or regions that were mutated by transposon insertion.

TYPE OF INSERTION	# OF DIFFERENT GENES/REGIONS	# THAT GREW
Intragenic	482	100
Intergenic	199	184

36. Interestingly some of the insertions in non-coding (intergenic) regions blocked growth. Which statement below best accounts for this observation?

- a. The insertions interfered with base pairing thereby denaturing the DNA
- b. The insertions occurred in introns, thereby accidentally making them into exons
- c. The insertions disrupted regulatory regions such as promoters
- d. The transposon knocked out an rRNA region

FIGURE 12- The lac operon



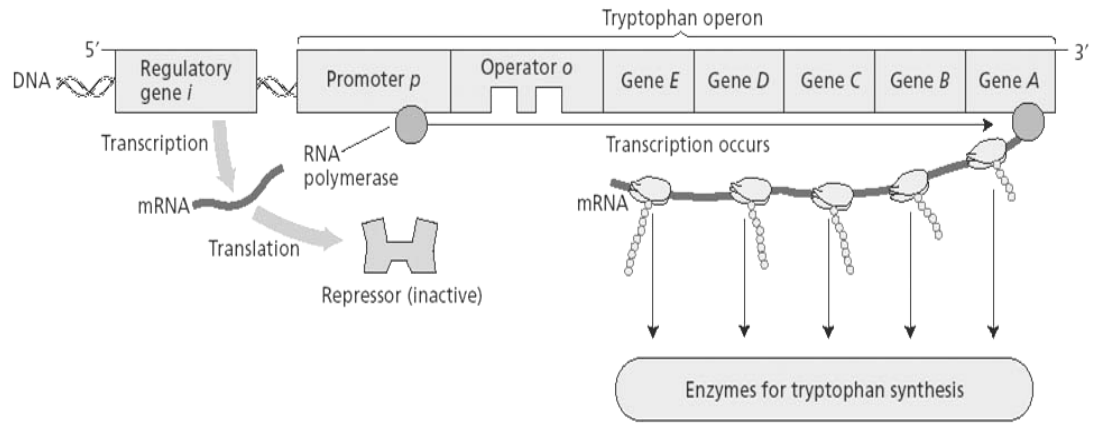
37. Study Figure 12. When there is no or very low transcription of the three structural genes (z,y and a) the repressor protein binds to the operator and interferes with

- a. DNA transcriptase
- b. reverse transcriptase
- c. RNA polymerase
- d. the binding of ribosomes

38. As the products of genes z,y and a accumulate these genes will be repressed again because

- a. the products will facilitate the digestion of lactose, which acts as the inducer
- b. the products will themselves act as repressors of their own synthesis in a negative feedback loop
- c. the products will induce a conformational change in the operator region, thereby preventing transcription
- d. the products will stimulate the synthesis of more repressor proteins

FIGURE 13.
The
tryptophan
synthetase
operon



39. Study Figure 13. The repressor is inactive because
- the repressor has the wrong shape
 - the operator needs to be activated to receive the repressor
 - RNA polymerase is blocking access to the DNA
 - there is too much tryptophan in the cell
40. Which scenario best explains how this operon is normally turned off?
- The mRNA that codes for repressor protein is modified after transcription to yield a repressor protein that better attaches to the operator.
 - The co-repressor Tryptophan binds allosterically to the repressor, changing its shape so it fits in the operator.
 - The repressor binds to RNA polymerase so that it can't attach to the promoter.
 - Tryptophan induces a mutation in the operator to allow it to accept the repressor.
41. Suppose regulatory gene *i* is mutated so that it produces a mutant repressor. Which scenario below is LEAST likely to happen as a consequence of a mutant repressor?
- The mutant repressor is a form of RNA polymerase and enhances transcription of the trp operon structural genes
 - The mutant repressor can no longer accept the co-repressor so that repression is very unlikely to happen even if a surplus of tryptophan builds up.
 - The mutant repressor's shape changes so that it can bind to the operator in the absence of co-repressor.
 - The mutant repressor's shape changes so that, even if it successfully accepts the co-repressor, it has difficulty binding to the operator.
- Ellen is phenotypically normal but her family displays their share of x-linked traits. Her husband Bobby has the x-linked dominant allele for brown spotted teeth. Her brother Paul has hemophilia but has normal color vision, and her father Simon is colorblind but does not suffer from hemophilia. When her son, Little Al, was born he was immediately diagnosed with hemophilia, but he was otherwise healthy. It wasn't until he took his school physical, however, that it was discovered that Al was also colorblind.***
42. Which scenario best accounts for Al's phenotype?
- Al inherited colorblindness from Bobby.
 - Nondisjunction occurred in one of Bobby's spermatocytes and it was the one that contributed Al's paternal genetic complement.
 - Al is missing a chromosome.
 - The X-chromosomes in one Ellen's oocytes underwent crossing-over.
43. Ellen and Bobby are expecting another child. They know it will be a girl. What are the chances that their daughter will have brown spotted teeth?
- 100%
 - 0%
 - 50%
 - 25%
 - can't be determined

44. Should Ellen and Bobby ever have another son, what are the chances the kid will be colorblind?
 a. 100% b. 0% c. 50% d. 25% e. can't be determined

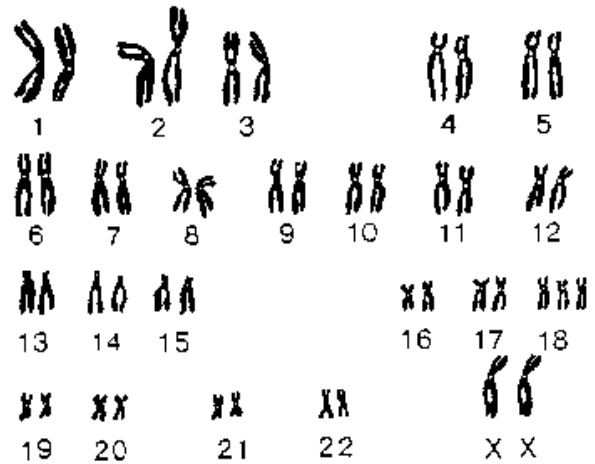
Crossing a strain of snapdragons that has regular (bilaterally symmetrical) white flowers with another strain that has peloric (radially symmetrical) red flowers produces an F₁ generation that has 100% regular pink flowers. In an experiment the F₁ progeny were crossed to each other and they produced an F₂ generation shown in the table below.

Regular pink	95	Peloric pink	29
Regular red	44	Peloric red	16
Regular white	42	Peloric white	14

45. For the observed total of 240 F₂ progeny, what is the expected number of peloric pink individuals?
 a. 25 b. 30 c. 35 d. 15 e. 29
46. Why do observed outcomes often not equate to expected outcomes?
 a. The differences can be attributed to normal error in procedure by the scientist(s).
 b. The interbreeding among the F₁ can't be controlled carefully enough.
 c. Expected outcomes are never possible because they are too perfect.
 d. The difference between observed outcomes and expected outcomes is due to chance.
47. Flower color in snapdragons is most likely inherited through
 a. incomplete dominance b. simple dominance c. x-linkage d. multiple allelism

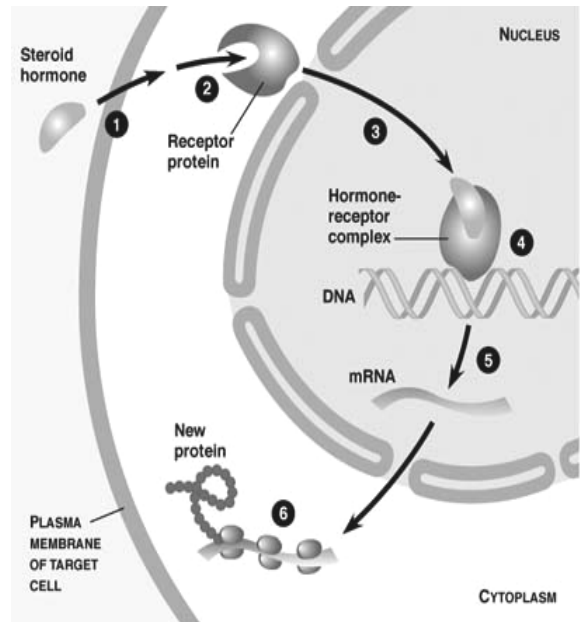
FIGURE 14

48. From Figure 14 we can conclude that the individual who donated this karyotype
 a. suffers from Down syndrome
 b. is a human female
 c. is missing a chromosome
 d. has Klinefelter syndrome
 e. All of the above are correct.



49. What process or phenomenon is most likely responsible for the chromosomal anomaly shown in Figure 14?
 a. translocation between two non-homologous chromosomes
 b. crossing over between homologous chromosomes
 c. mitotic nondisjunction
 d. meiotic nondisjunction

FIGURE 15



50. What hormone has a mode of action as illustrated in Figure 15?
 a. testosterone b. insulin c. human growth hormone
 d. thyroid hormone e. adrenalin

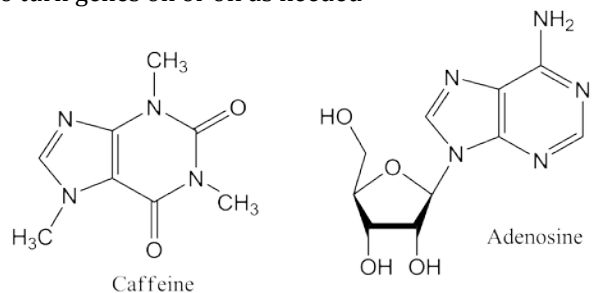
51. The hormone-receptor complex in figure 15 most likely impacts the target cell by
 a. increasing the rate of mutation of target DNA
 b. altering post transcriptional editing of mRNA
 c. binding to regulatory regions of specific genes
 d. combining with the translational product and altering its tertiary conformation

Scientists at Princeton University have discovered that bacteria can communicate with one another through chemical mediators. Using chemical signals bacteria are able to “know” when a critical number of them are in one place in order to do something together, such as make light or secrete toxins. This phenomenon is called “quorum sensing.”

52. In their mode of action quorum sensing molecules resemble
 a. enzymes b. animal hormones c. trans-membrane proteins d. hormone receptors
53. Recently the EPA began a screening program to identify chemicals in pesticides that may disrupt endocrine function in humans and other animals. Many of the chemicals impact the development or proper functioning of male reproductive organs. Therefore, these chemicals most likely interfere with
 a. androgens b. insulin c. growth hormone d. epinephrine e. calcitonin

54. A common feature shared by Ca^{++} -mediated and cyclic AMP-mediated intracellular second messengers is that both
 a. depend on cell surface receptors to interact with external signal proteins
 b. require the activation of adenynyl cyclase enzyme
 c. require the activation of phospholipase c enzyme
 d. both Ca^{++} and cyclic AMP migrate directly into the nucleus to turn genes on or off as needed

FIGURE 16 - In the brain adenosine binds to receptors on the cell surface of certain cells. This may cause drowsiness.



55. Caffeine can increase alertness and decrease drowsiness. How?
 a. caffeine binds to the adenosine receptors and sets off an intracellular cascade of antagonistic responses
 b. caffeine acts as a competitive inhibitor of adenosine
 c. caffeine binds to adenosine so it can no longer fit in the receptor

d. because it resembles adenosine, caffeine stimulates an enzyme that digests adenosine

Glycogen phosphorylase is activated in liver cells after epinephrine binds to the membrane. Liver tissue was homogenized and separated into membrane and cytoplasm fractions. The hormone epinephrine (adrenalin) was added to whole homogenate, cytoplasm alone, membranes alone and a mix of both. Results were compared to controls to which no epinephrine was added. Here are the results.

CONDITION	Glycogen phosphorylase ENZYME ACTIVITY (units)
(1) Homogenate	0.4
(2) Homogenate + epinephrine	2.5
(3) Cytoplasm fraction	0.2
(4) Cytoplasm + epinephrine	0.4
(5) Membrane fraction + epinephrine	0.4
(6) Cytoplasm + Membranes + epinephrine	2.0

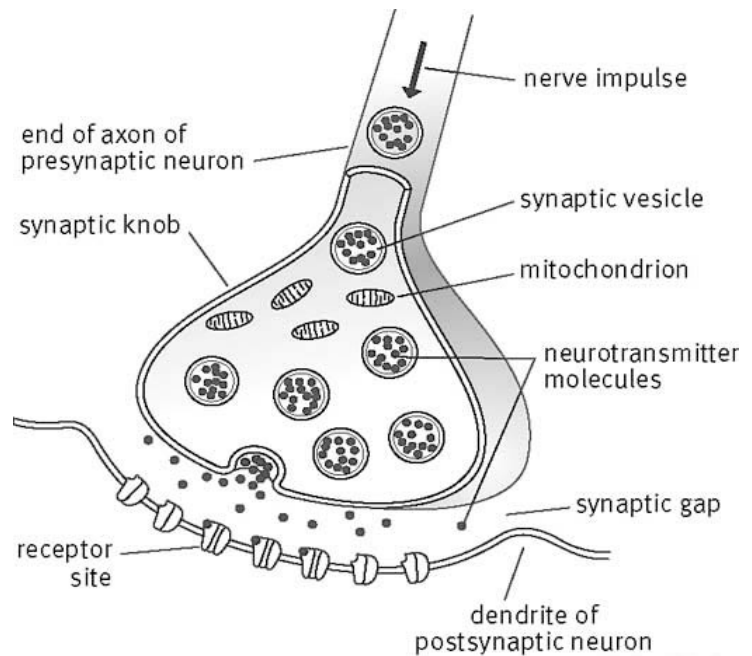
56. What do these data show?

- a. Epinephrine needs cell membranes and cytoplasm in order for it to work.
- b. Epinephrine can't work on homogenate.
- c. Epinephrine binds to nuclear DNA as well as it binds to cell membranes.
- d. Epinephrine can keep you awake.

57. If cAMP can replace the membrane fraction and the hormone treatment, which condition in the table above would be the best target for such an experiment?

- a. (2) b. (4) c. (5) d. (6)

FIGURE 17



58. Study Figure 17. In order for the

postsynaptic signal to be stopped or mitigated, the neurotransmitter molecules

- a. can dislodge themselves from the receptor sites and wait for the arrival of another impulse
- b. will be engulfed by the postsynaptic membrane and subjected to phagocytosis
- c. must be reabsorbed by the presynaptic membrane
- d. must slowly disintegrate over time

59. Suppose a drug exists that could stimulate the postsynaptic membrane even though no nerve impulse has arrived at the presynaptic membrane. This drug would most likely

- a. have a similar molecular shape to the neurotransmitter
- b. be made by the presynaptic neuron
- c. destroy the native neurotransmitter
- d. hyperpolarize the postsynaptic membrane

60. Suppose the synapse shown in Figure 17 is an inhibitory synapse. What effect might the neurotransmitter molecules have on the postsynaptic membrane?

- a. They will induce a very rapid depolarization
- b. They will cause a rapid influx of sodium ions into the postsynaptic neuron
- c. They will hyperpolarize the postsynaptic membrane
- d. They will cause the postsynaptic neuron to release an inhibitory transmitter that will migrate back across to the presynaptic membrane and block the message

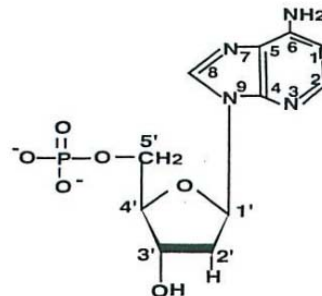
NEW JERSEY SCIENCE LEAGUE White Test
Biology II Answer Key
MARCH 2013

1	C	16	C	31	B	46	D
2	A	17	D	32	A	47	A
3	B	18	B	33	B	48	B
4	D	19	A	34	D	49	D
5	C	20	B	35	A	50	A
6	B	21	C	36	C	51	C
7	A	22	D	37	C	52	B
8	D	23	B	38	A	53	A
9	A	24	D	39	A	54	A
10	B	25	E	40	B	55	B
11	A	26	A	41	A	56	A
12	D	27	C	42	D	57	D
13	A	28	A	43	A	58	C
14	C	29	C	44	C	59	A
15	D	30	D	45	B	60	C

Science League Biology II April 2013

Choose the answer that best completes the statements or questions below and fill in the appropriate response on the scan-tron. If you change your answer be sure to completely erase your first choice, please **PRINT** your name, school, area, and which test you are taking on the scan-tron. This exam is for AP level students.

FIGURE 1 (used in questions 1-3)



1. Assume the nitrogen-containing double ring structure is adenine. Which description most accurately fits the molecule shown in Figure 1?

- a. This is a nucleotide often found in RNA.
- b. This molecule is commonly referred to as cAMP.
- c. This molecule is commonly incorporated into a DNA molecule.
- d. Adding two more phosphate molecules would make this molecule ATP.

2. Suppose the OH group at the 3' position was replaced with a hydrogen atom (just like what can be seen at the 2' position). How might this structural change impact this molecule's function?

- a. This molecule's 3' terminus can no longer participate in dehydration synthesis.
- b. The impact would be minimal. The molecule's shape has not changed enough to alter its function.
- c. The molecule would no longer be able to pair with a nucleotide that contains thymine.
- d. The molecule would no longer be able to pair with a nucleotide that contains uracil.

3. What description best characterizes this molecule's central pentagon structure (the one whose carbons are labeled 1'-5')?

- a. This is the 6-carbon sugar glucose.
- b. This is the 5-carbon sugar deoxyribose.
- c. This is the 5-carbon sugar ribose.
- d. This is the 5-carbon sugar ribulose.
- e. This is adenosine monophosphate.

(sequence A)	Cys-Tyr-Phe-Gln-Asn-Cys-Pro-Arg-Gly-NH ₂
(sequence B)	Cys-Tyr-Ile-Gln-Asn-Cys-Pro-Leu-Gly-NH ₂

FIGURE 2 - Two sequences of amino acids (the three-letter abbreviations of the names are used)

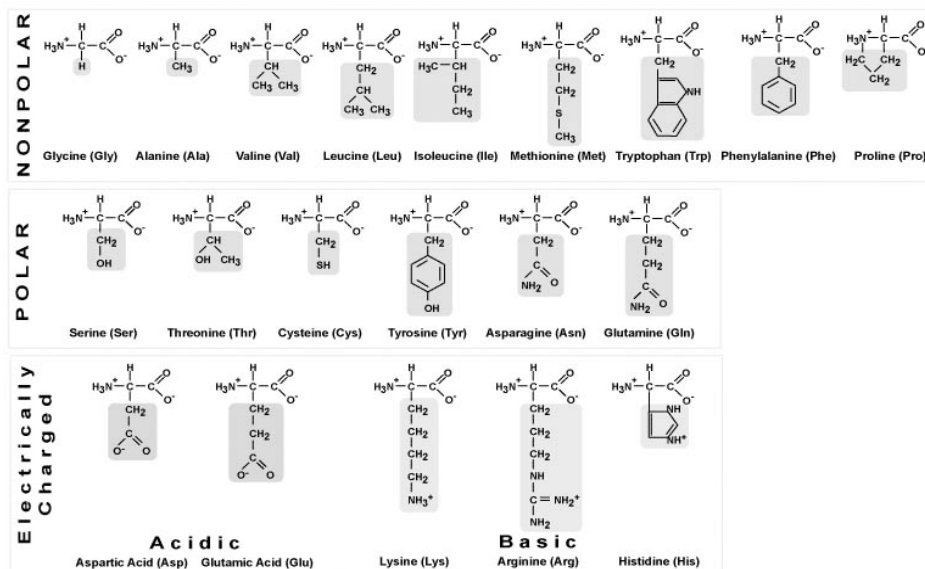
4. In Figure 2 each sequence ends on the right side with a -NH₂ terminus, as shown. What functional group best characterizes the other terminus (not shown)?

- a. phosphate
- b. hydroxyl
- c. sulfhydryl
- d. carboxyl

5. The cysteine molecules present in each sequence will have the greatest influence on

- a. the ability of the chain to fold into an alpha helix
- b. the final tertiary configuration the chain will take
- c. the protein's tendency to denature at neutral pH
- d. the tendency for the chain to polymerize with other chains like it

FIGURE 3 – list of amino acids



6. Use Figure 3 to evaluate the two amino acid sequences shown in Figure 2. Although the two sequences are similar, what would most likely account for differences in the tertiary configuration of the two respective proteins?

- The presence of a leucine in sequence B in place of an arginine in sequence A
- The presence of a isoleucine in sequence B in place of a phenylalanine in sequence A
- The presence of two cysteines in each sequence
- Sequence B appears slightly shorter than sequence A.

7. Suppose a particular protein was composed primarily of amino acids from the first row in Figure 3 (the “nonpolar” group). Based on this knowledge, what prediction can we make about the structure/behavior of such a protein?

- The protein would be very soluble in water
- The protein would tend to be hydrophobic
- The protein would be rich in disulfide bonds
- The protein would readily denature when exposed to water

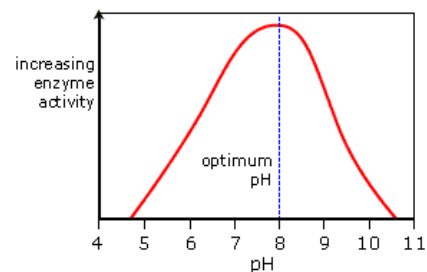
8. Which of the substitutions below would most likely have the least impact on the tertiary structure of a protein?

- proline for histidine
- methionine for cysteine
- glycine for lysine
- aspartic acid for glutamic acid

FIGURE 4

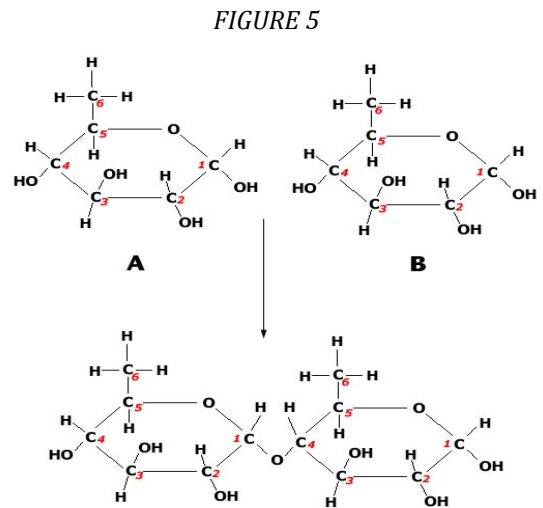
9. In Figure 4, what explanation best accounts for the drop in enzyme activity at pH 5?

- Reduced hydrogen ion concentration prevents formation of alpha helices.
- Acid is “eating away” at the protein molecules.
- High levels of OH⁻ ions disrupt stability of disulfide bridges.
- Hydrogen ions interfere with intra-molecular ionic interactions.



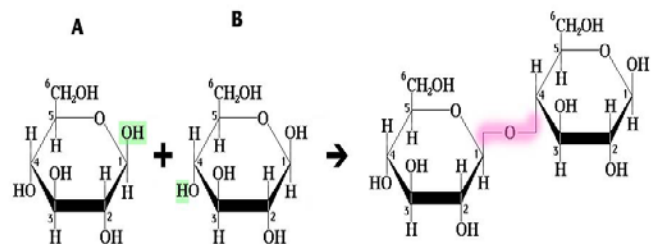
10. Looking at Figure 4, what can we say about the enzyme at pH 8?
- Its three-dimensional shape has a crevice that is well suited to fitting the substrate.
 - The rate of collisions between enzyme and substrate is at its maximum.
 - The protein is most denatured at this pH.
 - The protein at this pH will contain slightly more basic amino acids than acidic ones.
11. In what setting could we expect to find an enzyme such as the one illustrated in Figure 4?
- In acidophilic bacteria such as *Lactobacillus acidophilus*, the bacterial strain used to make yogurt
 - In the human stomach
 - In the human small intestine
 - In bacteria that thrive in acid hot springs

12. Which statement best describes the reaction shown in Figure 5?
- This is a hydrolysis reaction that would also yield a molecule of water.
 - This is a dehydration synthesis that would also yield a molecule of water.
 - In this reaction two amino acids are joined to form a dipeptide by condensation.
 - In this reaction two simple sugars are joined through hydrolysis.



13. Where would we most likely find the enzyme that catalyzes the reaction shown in Figure 5?
- In human small intestine
 - In mitochondria of animal cells
 - In a young seed growing on a plant
 - In yeast cells active in rising bread dough
14. Polymerizing reactants A and B in Figure 5 would possibly yield
- amylose
 - a polypeptide
 - a large lipid
 - DNA
 - cellulose

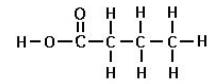
15. The enzyme that catalyzes the reaction shown in Figure 6
- is the same as the one that catalyzes the reaction shown in Figure 5.
 - can be isolated from the mitochondria of animal cells.
 - is active in human liver cells.
 - is active in plant meristem.



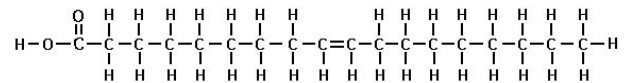
16. Polymers of reactants A and B in Figure 6
- contribute to the fluid nature of cell membranes.
 - can't be digested by humans.
 - form the major storage compound in fat cells.
 - produce the complex 3-dimensional globular shapes of enzymes.

17. In comparing the reactions shown in Figure 5 and Figure 6, we can say that
- they both produce water as a product, even though this is not shown.
 - they use identical monomers.
 - they both release energy, even though this is not shown.
 - they both need an input of ATP, even though this is not shown.

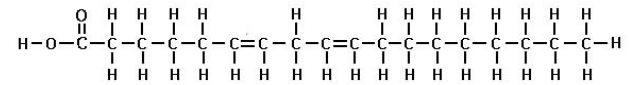
FIGURE 7



Butyric Acid



Oleic Acid



Linoleic Acid

18. Which of these fatty acids when incorporated into a triglyceride is likely to produce a substance that is solid at room temperature?

- All are equally likely.
- Only oleic and linoleic will do so.
- Only butyric acid will do so.
- Only linoleic acid will do so.

19. Linoleic acid is best described as

- | | |
|--------------------|-------------------|
| a. polyunsaturated | c. saturated |
| b. monounsaturated | b. supersaturated |

20. Judging from their respective molecular structures, for what roles are the molecules in Figure 7 well suited?

- They would make for good information storage compounds.
- They would be good energy storage compounds.
- They would be good for providing structural strength to cell walls.
- They would make good enzymes.

Cultured liver cells were exposed to radioactive amino acids for 3 minutes. During this time all of the proteins manufactured by the cell became radioactive. The radioactive amino acids were then removed, and at 5-minute intervals thereafter, portions of cells were broken open, fractionated and treated with anti-lipase antibody. This allowed the lipase to be distinguished from all other proteins present. In the table below are data that show the percentage of radioactively labeled lipase in several cell compartments over time.

TIME (MIN)	ER LUMEN	GOLGI	LYSOSOMES	RIBOSOMES
5	5	0	0	95
10	25	10	0	65
15	75	20	5	0
20	25	55	20	0
25	0	65	35	0
30	0	25	75	0
35	0	0	100	0

21. Based on the data above, what is the most likely pathway of lipase through the liver cells?

- ER → Golgi → Lysosomes → Ribosomes
- Ribosomes → Lysosomes → Golgi → ER
- Ribosomes → ER → Golgi → Lysosomes
- Ribosomes → ER → Lysosomes → Golgi

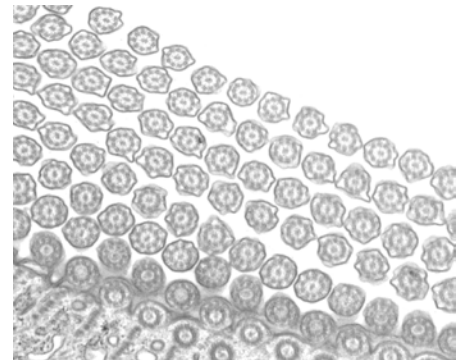
22. How do lysosomal storage diseases such as Tay-Sachs impact effected patients?

- a. Patients fail to make enough ATP and so are frequently fatigued.
- b. The activity of certain enzymes is well below normal levels.
- c. Critical mRNA molecules are not effectively translated.
- d. Cell motility is compromised due to defective microtubules.

23. Taxol (a.k.a. paclitaxel) is a compound derived from plants of the genus Taxus (the yews). Taxol molecules inhibit microtubule elongation. Therefore they can disrupt

- a. cell metabolism
- b. protein synthesis
- c. cell membrane integrity
- d. mitosis

FIGURE 8 – electron micrograph (EM)



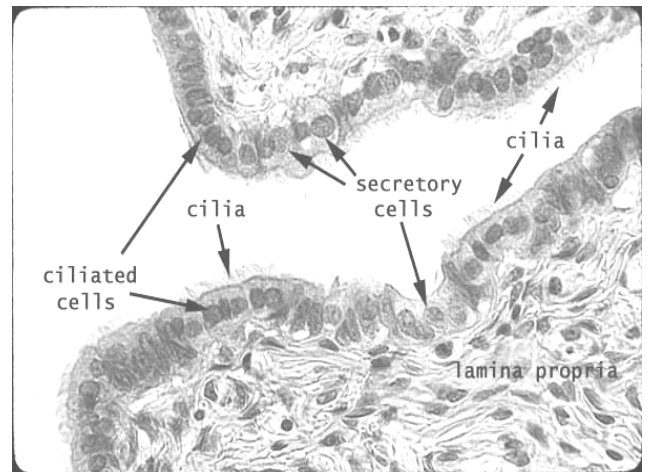
24. From which tissue did the cell in the EM in Figure 8 most likely come?

- a. nervous
- b. skeletal muscle
- c. blood
- d. liver
- e. ciliated epithelium

25. One drawback to using the electron microscope for studying cells is that

- a. cells must be dead
- b. cells that move are hard to track
- c. cells can't be stained and so are hard to see
- d. many cells are still too small to visualize

FIGURE 9 – a light micrograph of the lining of the trachea



26. The dark circles inside the cells labeled “secretory cells” are most likely

- a. chloroplasts
- b. mitochondria
- c. lysosomes
- d. nuclei

STRUCTURE	SIZE
Chloroplast	5-10 micrometers
Lysosome	200 nanometers
Microtubule	25 nanometers
Mitochondrion	0.5-10 micrometers
Nucleus	3-10 micrometers
Ribosome	20 nanometers

FIGURE 10 – sizes of cell structures

27. Visible light ranges in wavelength from 380-750 nanometers. Looking at Figure 10 we can tell that no matter how much we magnify cells using a light microscope we will never be able to see

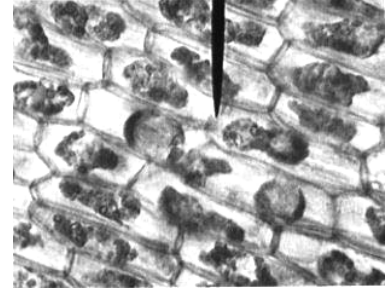
- a. chloroplasts
- b. mitochondria
- c. nuclei
- d. ribosomes

28. Intracellular digestion as a part of phagocytosis depends largely on the fusion of the phagosome (a.k.a. phagocytic vesicle) with a

- a. lysosome
- b. ribosome
- c. Golgi body
- d. vacuole

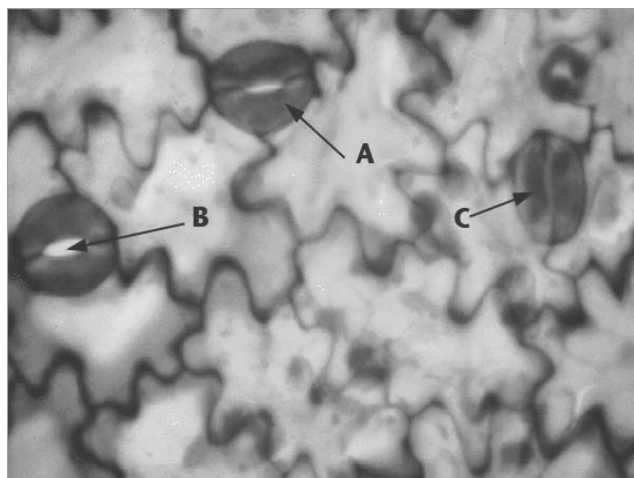
29. Heart cells can communicate rapidly with one another because
- the membranes of contiguous cells are tightly bound by tight junctions.
 - the membranes of contiguous cells are perforated by gap junctions.
 - microtubules run continuously from cell-to-cell through their membranes.
 - they share nuclei

FIGURE 11 – Light micrograph of plasmolysed *Elodea* leaf, whole mount



30. The tip of the black pointer in Figure 11 most likely points to
- the nucleus
 - chloroplasts
 - cell membrane
 - cell wall
31. In the cells shown in Figure 11, which structure has collapsed?
- vacuole
 - lysosome
 - cell wall
 - chloroplast
32. What features do mitochondrial cristae and chloroplast grana share?
- They both harbor electron transport systems.
 - They both have ribosomes attached to them.
 - They both possess pores through which macromolecules pass in and out.
 - They both contain light-absorbing pigments.
33. Homeotic genes such as the *Antennapedia* and *Ultrabithorax* genes in *Drosophila*, share a common 180 bp sequence called the homeobox that produces a protein containing the same 60 amino acid sequence. Mutant *Antennapedia* produces legs instead of antennae whereas mutant *Ultrabithorax* produces an extra pair of wings in place of tiny halteres. What does this information tell us about the homeobox and homeotic genes?
- The proteins produced by these genes control expression of the same trait.
 - The homeobox is evolutionarily conserved.
 - Homeotic genes remain active in the adult.
 - The mutant protein works as well as the wild protein.
34. In mammals, pluripotent stem cells
- can be isolated only from pre-blastocyst embryos
 - can be made by inducing adult skin cells to de-differentiate
 - can only produce a limited variety of tissues
 - can develop into complete adult organisms
35. In vascular plants, water and nutrients absorbed by root hairs travel through the cortex on their way to the vascular stele. Whether by symplast or apoplast, all water and ions must pass through the _____ before reaching the xylem.
- Casparian strip
 - phloem
 - endodermis
 - the stomata
36. In order for water to move from the environment into a root hair, the water potential in the root hair must be
- positive in comparison to the environment
 - negative in comparison to the environment
 - equal in comparison to the environment
37. Adding solutes to water
- lowers the water potential
 - increases the water potential
 - has no impact on water potential
 - usually adds to the pressure potential

FIGURE 12 – light micrograph of leaf tissue



38. What does Figure 12 show?

- A typical leaf cross-section with three vascular bundles
- Several spongy mesophyll cells with three air spaces
- One large mesophyll cell with three chloroplasts
- Leaf epidermis cells with three stomata

39. In Figure 12, the white oval labeled “B” is partially visible next to structure “A” but NOT visible next to “C.” Why is this so?

- The water potential of “A” is lower than that of its surroundings.
- The water potential of “C” is lower than that of its surroundings.
- “C” is more turgid than “A.”
- More protons have been pumped out of “C” than out of “A”.

40. Under what conditions would “B” appear as shown in figure 12?

- At night, when the leaf is no longer illuminated by the sun.
- When the leaf is illuminated.
- When it’s raining so as to allow water to enter.
- When the ambient air temperature approaches the freezing point of water.

Water Temp (°C)	O ₂ content of H ₂ O (ML/L)	Inactive fish – metabolic rate (ML O ₂ /KG/Hr)	Active fish – metabolic rate (ML O ₂ /KG/Hr)
5	9.0	8	30
15	7.0	50	110
20	5.8	140	255
25	5.0	225	285

Oxygen consumption by active and inactive fish at various water temperatures as compared to the relative concentration of oxygen in water over the same temperature range

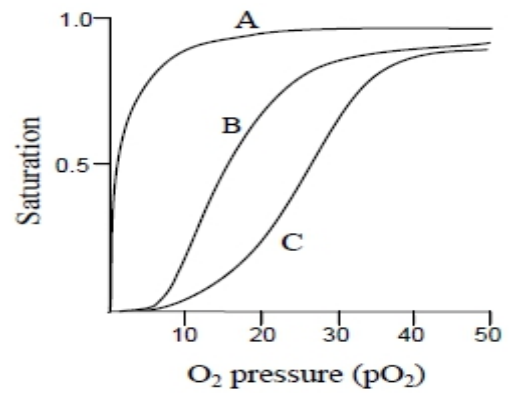
41. What can we infer from the table above?

- Fish that are actively feeding have lower oxygen demands.
- Oxygen availability is a limiting factor for fish metabolism in warm water.
- At high water temperatures fish are more active.
- The colder the water the more active the fish.

42. Suppose a power plant dumps heated water into an estuary. What might be an impact on the fish that live in the estuary?

- The estuary can sustain fewer active fish.
- Warm water will support more algae and provide more food for fish.
- Warm water will stimulate fish to be more active.
- Fish population should increase because fish mate more frequently at higher temperatures.

FIGURE 13 – Graph of oxygen binding capacities of three proteins.



43. In an individual, three distinct proteins bind oxygen depending on the location and development stage. Hemoglobin is the major oxygen-binding protein in adult blood. Skeletal muscle tissue uses myoglobin to bind oxygen. A fetus uses fetal hemoglobin as the major oxygen-binding protein. In Figure 13, match the respective curves (A,B,C) with the hemoglobin varieties.

- a. hemoglobin, fetal hemoglobin and myoglobin, respectively
- b. hemoglobin, myoglobin and fetal hemoglobin, respectively
- c. fetal hemoglobin, hemoglobin and myoglobin, respectively
- d. myoglobin, fetal hemoglobin and hemoglobin, respectively

44. Assume the curve for hemoglobin in Figure 13 came from data taken at pH 7.4. How might the oxygen-binding curve for hemoglobin differ if the data came from blood at pH 7.2?

- a. The curve would shift to the left.
- b. The curve would shift to the right.
- c. The curve would not shift because oxygen binding by hemoglobin is not sensitive to pH.
- d. The curve would flatten at a higher saturation level.

45. Increased physical activity raises the level of a metabolite called BPG (2,3 Bi-phospho-glyceric acid). BPG reversibly combines with hemoglobin and lowers its affinity for O₂. In this scenario BPG acts as

- a. an enzyme
- b. a co-enzyme
- c. a co-factor
- d. an allosteric regulator

46. Without insulin treatment a diabetic will metabolize fats and produce an excess of acidic products, thus lowering the blood's pH (a condition known as acidosis). How might acidosis impact the patient's breathing?

- a. The patient's breathing rate would decrease because at lower pH hemoglobin will release more oxygen.
- b. The patient's breathing rate would increase because at lower pH hemoglobin will bind more oxygen.
- c. The patient's breathing rate would increase because at lower pH hemoglobin will bind less oxygen.
- d. The patient's breathing rate would decrease because at lower pH hemoglobin will bind more oxygen.

47. Bruce is a New Zealand sheep farmer who thinks that raising red deer is more profitable. Before committing to raising deer he needs to know how well they will do on his land. He buys 100 pregnant females that were previously inseminated and places 10 of them in a pasture previously occupied by sheep. He monitors this sample of 10 over the course of a year. Here are his data.

FEMALE #	ALIVE AT END OF YEAR	NUMBER OF CALVES
1	yes	1
2	yes	1
3	NO	0
4	yes	0
5	yes	0
6	NO	0
7	yes	1
8	yes	1
9	yes	0
10	yes	1

Based on this sample, what is the size of Bruce's entire deer herd at the end of the first year?

- a. less than 100 but greater than 75
- b. around 130 deer
- c. more than 100 but less than 120
- d. around 200 deer
- e. around 50 deer

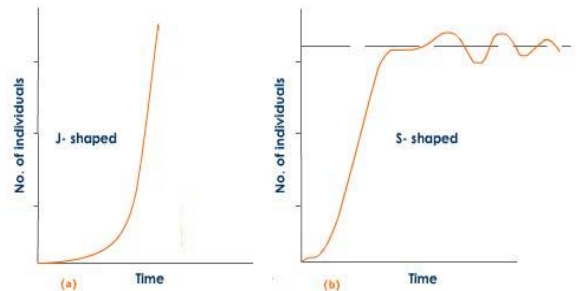
48. What is the estimated per capita growth birth rate of Bruce's deer herd?
 a. 0.5 b. 0.2 c. 5.0 d. 3.0 e. 0.3

Life table for 1978 cohort of 210 cactus ground finches of the species *Geospiza scandens* on Isla Daphne of the Galapagos Islands

YEAR	AGE OF BIRD (YEARS)	SURVIVORSHIP (as a proportion of original population)	FECUNDITY (avg. # of young fledged per female)
1978	0	1.00	0.00
1979	1	0.43	0.05
1980	2	0.37	0.67
1981	3	0.33	1.50
1982	4	0.31	0.66
1983	5	0.30	5.50
1984	6	0.20	0.69
1985	7	0.11	0.00
1986	8	0.07	0.00
1987	9	0.07	2.20
1988	10	0.05	0.00
1989	11	0.05	0.00

49. What may account for the increased fecundity in years 1983 and 1987?
 a. a gender distribution that favors males over females c. above average rainfall
 b. increased survivorship d. below average rainfall
50. What factor would NOT account for lack of fecundity in years 10 and 11?
 a. age c. limited food supply
 b. disproportionate number of males d. absence of predators

FIGURE 14 – two population growth curves



51. Natural populations follow curve (b) rather than (a) because
 a. in species that have separate males and females, the females can only produce one offspring per year.
 b. eventually many individuals migrate away from the original population.
 c. of competition for limited resources.
 d. as population density increases over time, fecundity also increases.
52. Which graph does the population of humans on Earth resemble and why?
 a. Human population growth is like graph (b) because our population has reached Earth's carrying capacity.
 b. Human population growth is like graph (a) because it will never reach Earth's carrying capacity.
 c. Human population growth is like graph (b) because the high birth rate in developing countries is balanced by a high death rate.
 d. Human population growth is like graph (a) because resources, like food, are highly subsidized by fossil fuels.

53. How can we best describe the point labeled “K” in the graph above?
- At this point density dependent factors limit population growth rate.
 - At this point the birth rate is less than the death rate.
 - Population densities greater than the value at point “K” will not occur.
 - Once a population density has reached the value at point “K” it can no longer be less than that.

54. If the diagonal line in Figure 15 shifts to the left this means that
- the population will experience a burst of growth
 - the population will never reach carrying capacity
 - the carrying capacity of the system has decreased
 - it will take longer for a population in this system to reach carrying capacity

FIGURE 15

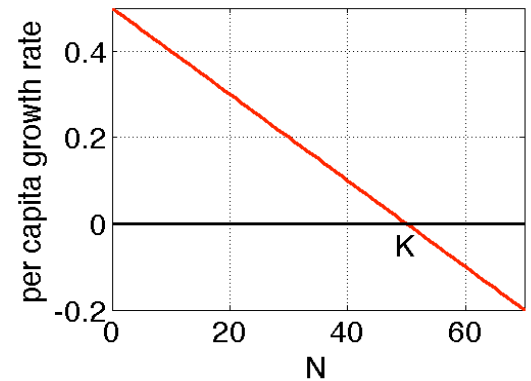


FIGURE 16 – plant biomass and species diversity

55. The data in Figure 16 support the idea that
- species diversity has limited impact on primary productivity
 - productivity increases when a greater number of species is present
 - productivity as measured by plant biomass is independent of functional diversity
 - a monoculture will produce as much biomass as a diverse plant community

56. According to the data in Figure 16, the greatest productivity should be found in
- temperate grasslands
 - temperate deciduous forests
 - tropical rain forest
 - sugar cane fields

57. Foods high in folic acid are known to methylate DNA, especially in CpG islands abundant in promoters. Therefore, folic acid can help to
- turn genes off
 - bind RNA polymerase
 - turn genes on
 - mutate DNA

58. Which of the populations below is least susceptible to disease that may spread quickly and threaten many individuals?

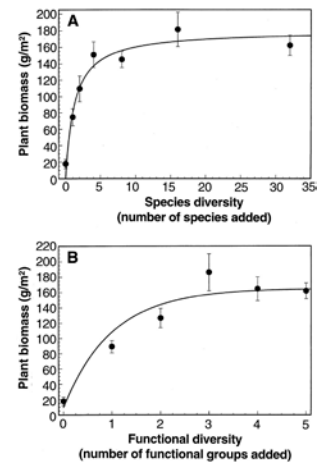
- A field of corn in Iowa
- An isolated, inbred island population
- A species in danger of extinction (such as the California condor)
- A meadow of wild Lupines (a kind of wildflower)

59. In Yellowstone National Park, the wolf is considered a keystone species. Which of the observations below provides the best evidence for designation?

- Wolves are social animals that live in groups (packs).
- When wolves were removed from the Park in 1926, the population of young Aspen trees dropped, as did the population of beavers.
- Wolves are carnivorous.
- The removal of wolves from Yellowstone in 1926 had no appreciable impact on tourism.

60. In 1980, a team of researchers led by Nobel prize-winning physicist Luis Alvarez, his son geologist Walter Alvarez and chemists Frank Asaro and Helen Michels discovered that sedimentary layers found all over the world at the Cretaceous–Paleogene boundary (Cretaceous–Tertiary boundary or K–T boundary) contain a concentration of iridium hundreds of times greater than normal. For what geologic event did this discovery provide evidence?

- The extinction of trilobites
- The evolution of hominids
- The break up of Pangea
- The extinction of the dinosaurs



NEW JERSEY SCIENCE LEAGUE **White Test**

Biology II Answer Key

APRIL 2013

1	C	16	B	31	A	46	C
2	A	17	A	32	A	47	B
3	B	18	C	33	B	48	E
4	D	19	A	34	B	49	C
5	B	20	B	35	C	50	D
6	A	21	C	36	B	51	C
7	B	22	B	37	A	52	D
8	C	23	D	38	D	53	A
9	D	24	E	39	A	54	C
10	A	25	A	40	B	55	B
11	C	26	D	41	B	56	C
12	B	27	D	42	A	57	A
13	C	28	A	43	D	58	D
14	A	29	B	44	B	59	B
15	D	30	D	45	D	60	D