Understanding Biology 2026 Release 1st edition Mason Solutions Manual

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Answers to Inquiry & Analysis Questions

Chapter 1 "Does the Presence of One Species Limit the Population Size of Others?"

1a. The dependent variable is "Number of captures of other rodents" and is plotted on the y axis. The "number of captures of other rodents" is the variable *not* being manipulated in the experiment and as such it is the dependent variable.

1b. The enclosure indicated by the red points and red line maintained the highest populations of rodents. These are enclosures in which the kangaroo rats were removed.

2a. In 1988, when the kangaroo rats were removed, the two sets of enclosures were approximately the same with 7-8 small rodents captured on average. After one year, 15 small rodents on average were captured from the enclosures with kangaroo rats removed, and 10 small rodents were captured on average from the enclosures with kangaroo rats present. After two years, 10 small rodents on average were captured from the enclosures with kangaroo rats removed, and 3 small rodents on average were captured from the enclosures with kangaroo rats present.

2b. Three months into 1989 showed the greatest difference between the two kinds of enclosures, with a difference of 9 small rodents captured on average (14 in enclosures with kangaroo rats removed versus 5 in enclosures with kangaroo rats present).

3a. Kangaroo rats impact the population size of smaller rodents by reducing their overall numbers.

3b. Although the magnitude of the differences between the two types of enclosures varies, there is an overall trend. The average difference of number of rodents captured between the two types of enclosures is about 5.5, but peaks in differences (9 or 8) are not maintained and tend to be followed by drops in differences. Also, larger magnitude differences occurred during the first three months of 1989 and 1990.

4. Yes, the results do support the hypothesis that kangaroo rats compete with other rodents, thereby limiting their population sizes. For each measurement taken, the population sizes of other rodents in enclosures that contained kangaroo rats were always smaller than the populations of other rodents in the enclosures in which the kangaroo rats were removed.

5a. The population sizes of other rodents could be smaller in the enclosures that contained kangaroo rats because kangaroo rats could be preying on the other rodents. By placing kangaroo rats in a confined enclosure with other rodents, researchers could monitor if the kangaroo rats were attacking the other rodents. The enclosures could also be examined for the remains of dead rodents. Other explanations are also possible and may be provided as answers.

5b. Yes, the populations in the two types of enclosures do change in synchrony over the course of a year. Both types of enclosures show the populations peaking at the beginning of the year and decreasing toward the middle of the year. This could be explained by

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weather-related conditions. These are desert rodents, and the hot summer months in North America could be adversely affecting the food and water supply. This hypothesis could be tested by supplementing some of the enclosures of each type with food and water, which would reduce fluctuations in those resources. Or the heat itself could limit the population size. A laboratory experiment, on a smaller scale, where conditions could be maintained relatively constant could eliminate that variable.

Chapter 2 "Using Radioactive Decay to Date the Iceman"

1. The text states that the proportion of ^{14}C still in his body is 0.435 or a little under 50%.

2. The point, just under 0.500, corresponds to a little over one half-life.

3. If he were a recent corpse, the ratio of ^{14}C to ^{12}C would be the same as that found in my body, or 1.000.

4. According to the radioisotope dating he is just over one half-life old, or just over 5,730 years old. That would mean that Otzi died around 3,700 BC.

Chapter 3 "How Does pH Affect a Protein's Function?"

1. The pH value of 7.2 represents the highest concentration of hydrogen ions. This is more acidic than the other two pH values of 7.4 and 7.6. No, the relationship between hemoglobin saturation and oxygen concentration is not linear.

2. The percent hemoglobin bound to O_2 at saturation for all three pH values is about 98%. At an oxygen level of 20 mm Hg, the percent of bound hemoglobin for a pH of 7.6 is 50%, for 7.4 is 36%, and for 7.2 is 25%. At an oxygen level of 40 mm Hg, the percent of bound hemoglobin for a pH of 7.6 is 82%, for 7.4 is 75%, and for 7.2 is 64%. At an oxygen level of 60 mm Hg, the percent of bound hemoglobin for a pH of 7.6 is 92%, for 7.4 is 89%, and for 7.2 is 82%.

3. At an oxygen level of 40 mm Hg, more oxygen is bound to hemoglobin at a pH of 7.6 compared to 7.0.

4. Hemoglobin binds oxygen less tightly at lower pH levels and so when the pH is lower, more oxygen will be released from hemoglobin.

Chapter 4 "Control of Endosome Formation"

1a. The dependent variable is "Number of LDL vesicles taken up" and is presented along the y axis. The "Number of LDL vesicles taken up" is the variable *not* being manipulated in the experiment and as such it is the dependent variable.

1b. Yes, it is important that investigators sample equal numbers of control and Rab5 KD cells because the dependent variable is a count of the number of LDL vesicles taken up, rather than some kind of indicator value. For example, if 20 control cells were monitored and only two Rab5 KD cells, then the difference in numbers of LDL vesicles taken up could be due just to the different numbers of cells.

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2a. The number of LDL particles taken up Rab5 KD cells is first very low, but then slowly increases in the last half of the hour.

2b. The number of LDL particles taken up by control cells increases steeply at first and then continues to increase though not as fast.

2c. At 20 minutes into the experiment, about 1,750 LDL particles had been taken up by the control cells and around 50 had been taken up by the Rab5 KD cells.

3. During the first twenty minutes of the experiment, Rab5 KD cells take up very few LDL vesicles, whereas uptake in control cells in much higher.

4a. Yes, silencing of the Rab5 gene by RNA interference disrupted the ability of the endosomes to carry out endocytosis of LDL particles.

4b. Endosomes are continually being made and are very active organelles. Cells replace endosomes on a regular basis or encode proteins that can activate endosomes.

5. Levels of serum LDL in cells with RNAi treatment would be much higher than levels in control animals because in the treatment cells, LDL is not being taken up from the serum.

Chapter 5 "How Hemorrhagic *E. coli* Resists the Acid Environment of the Stomach"

1a. The dependent variable is "Substrate accumulation" and is presented along the y axis. The "Substrate accumulation" is the variable *not* being manipulated in the experiment and as such it is the dependent variable.

1b. A substrate is a molecule on which an enzyme or transport protein acts. In this investigation, the substrates that are accumulating in this experiment are glutamate for GadC and arginine for AdiC.

1c. A pH of 5 has an H^+ concentration of $10^{-5}\,\text{mol}/\text{L}$, and a pH of 7 has an H^+ concentration of $10^{-7}\,\text{mol}/\text{L}$. A pH of 5 is 100 times more acidic than a pH of 7 because the pH scale is logarithmic: a pH change of 1 represents a 10-fold change in the concentration of hydrogen ions.

2a. Yes, the amount of amino acid transported (substrate accumulation) varies with pH for AdiC. The amount of amino acid transported also varies with pH for GadC.

2b. About 20% of the low pH activity of AdiC is observed at the higher pH.

2c. About 0% of the low pH activity of GadC is observed at the higher pH.

3. No, the GadC antiporter does not exhibit the same pH dependence as the AdiC anitporter. The GadC antiporter is less active at nonacid pHs.

4. No, the Glutamate-GABA antiporter GadC is not active at nonacidic pH levels.

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5. If the transport of glutamine by the GadC antiporter involved hydrogen ions, then it might play a role in combating low pH environments. A way to test this is to monitor glutamine accumulation by GadC at a variety of pHs.

Chapter 6 "Do Enzymes Physically Attach to Their Substrates?"

1. Yes, as *S* increases, *V* increases. However, this increase is not linear. *V* does not increase steadily. At lower values of *S, V* increases by a larger amount than it does at larger values of *S*. As *S* reaches about 200, *V* begins to increase by only very small amounts. Yes, there seems to be a maximum reaction rate at about $V = 48$.

2. Yes, this result supports the hypothesis that an enzyme binds physically to its substrate. The fact that the reaction rate levels off indicates a saturation of the enzyme by the substrate. This means that all of the enzymes are bound to the substrate, such that increasing the concentration of the substrate has no further affect on the reaction rate. If the enzymes didn't physically bind the substrate, we wouldn't expect to see a saturation of the reaction, and the data would instead show a linear response that continues to increase in rate as the concentration of substrate increased.

3. Yes, the graph of the reciprocal plot is a straight line, which supports the hypothesis that the enzyme physically binds to the substrate and that as fewer unoccupied enzymes are available, the reaction rate levels off.

Chapter 7 "How Do Swimming Fish Avoid Low Blood pH?"

1a. The dependent variable is "Relative lactic acid levels in blood" and is plotted on the y axis. The level of lactic acid is the variable *not* being manipulated in the experiment and as such it is the dependent variable.

1b. Along the x-axis, the swimming data are presented in minutes, and the recovery data are presented in hours.

2a. Exercise causes the level of lactic acid to increase in the trout's blood.

2b. After exercising stops, the level of lactic acid changes. It continues to increase in the trout's blood for up to 2 hours, and then it slowly decreases.

3. The majority of lactic acid is released after exercise stops. The amount of lactic acid doubles two hours after exercise stops and decreases over the rest of the day. About 24 hours after the exercise stops, lactic acid levels return to pre-exercise amounts.

4. Yes, the results support the hypothesis that fish control blood pH levels by delaying the release of lactic acid from the muscles into the bloodstream. Only a portion of lactic acid is released during exercise and then it takes a full two hours before the maximum levels of blood lactic acid are reached, dropping back to preexercise levels over a 24-hour period. By delaying the release of lactic acid into the blood, the fish has time to neutralize the acid and keep the pH in the blood from dropping too low.

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Chapter 8 "Testing the Great Iron Dump Hypothesis"

1. The dependent variable in both graphs is "Concentration," that is, concentration of organic carbon for the top graph and concentration of chlorophyll in the bottom graph. These are the variable *not* being manipulated in the experiment, and as such they are the dependent variables.

2a. Yes, the concentrations of both organic carbon and chlorophyll change in the weeks after Fe fertilization.

2b. Yes, over the course of the first four weeks after fertilization, the change in both organic carbon and chlorophyll is consistent.

2c. Over the last two weeks, the change in both organic carbon and chlorophyll is different compared to the first four weeks. During the last two weeks, the concentration of organic carbon drops to levels seen before fertilization, and the concentration of chlorophyll drops by about 50%.

3. Yes, from these results it would be reasonable to infer that the Fe fertilization resulted in an algal bloom at 100 meters ocean depth. No, this effect does not persist after four weeks.

4a. Yes, these results do support the claim that iron is limiting the growth of phytoplankton, and thus of photosynthesis, in some areas of the oceans.

4b. Yes, Martin's ocean dump hypothesis is verified.

5. An experiment could be set up to monitor levels of organic matter at the ocean's bottom both before and after Fe fertilization of areas of the ocean. Monitoring of the organic matter would have to take place at least 4 weeks after Fe fertilization, when the die off seems to begin, and then extended for several weeks. The fact that diatoms are involved means that experiments should take place in areas of the ocean that have sufficient supplies of silicon ions that are used in the construction of diatom shells. But if silicon ions are not limiting, diatoms should be able to flourish and will sink after they die.

Chapter 9 "Why Measles Is a Respiratory Disease"

1a. The dependent variable in the left graph is "Relative nectin-4 mRNA expression," and the dependent variable in the right graph is "Number of infectious centers." These are the variable *not* being manipulated in the experiment, and as such they are the dependent variables.

1b. Nectin-4 mRNA expression is measured in the left graph relative to the expression that would be seen in a cell without nectin-4 siRNA, such as the control cell.

2a. Yes, the relative amount of mRNA transcribed from the nectin-4 gene is affected by nectin-4-specific siRNA. An approximate 80% decrease in nectin-4 mRNA expression is observed when nectin-4 siRNA is present.

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2b. The average number of infectious centers in cells treated with control siRNA was about 4.3. The average number of infectious centers in cells treated with nectin-4 siRNA was 0.

3a. Yes, you can infer that treatment of respiratory epithelium cells with nectin-4 siRNA shuts off the nectin-4 gene.

3b. Yes, you can infer that nectin-4 siRNA inhibits measles virus infection of respiratory cells in culture.

4a. Yes, silencing of the nectin-4 gene blocks infection of respiratory epithelium cells by the measles virus.

4b. The removal of nectin-4 does prevent infection of cells by the measles virus. The simplest way to explain this is that the nectin-4 cell surface receptor provided a route for the measles virus across the respiratory epithelium.

5. An experiment could be set up in which cells with nectin-4 receptors and cells without nectin-4 receptors or with disabled nectin-4 receptors are exposed to the measles virus and infection levels of the cells then monitored. Experiments could also be carried out in which the viruses are radioactively or fluorescently labeled and then presence of the label measured within cells that possess nectin-4 receptors. Multiple other answers are possible.

Chapter 10 "Do We Possess an Enzyme That Facilitates Cancer Growth?"

1a. The dependent variable is "Tumor volume." This is the variable *not* being manipulated in the experiment, and as such it is the dependent variable.

1b. Error bars represent the variability of the data and give a general idea of how accurate a data value is. The fact that the error bars of the two sets of data do *not* overlap shows that even with variability in the data, the two sets of data are different. If the error bars of the two sets of data *did* overlap, then there may not be a significant difference between the two sets of data.

2a. Yes, the control human tumor increases in size over the course of 35 days. The change is not continuous; at first, control tumors increase in size slowly, then after about 15 days, their growth rate increases rapidly.

2b. Yes, the S7KD tumor increases in size over the course of 35 days. The change is not continuous; at first, S7KD tumors increase in size, then the amount of change decreases to almost none.

3. No, control and S7KD tumors did not grow at the same rate over the 35 days of the experiment. The control tumors grew more rapidly. The rate of cancerous growth speeds up for control tumors and slows down for S7KD tumors.

4a. Yes, depletion of SIRT-7 activity in the S7KD tumors decreases the rate of tumor growth.

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4b. Yes, it is reasonable to conclude that SIRT-7 acts to unleash cancerous growth.

5. In faster growing or larger tumors, SIRT-7 activity would likely be upregulated. SIRT-7 activity would be even more upregulated in aggressively growing tumors.

Chapter 11 "How Meiotic Recombination Matches Homologue Sequences in Crossing Over"

1a. The dependent variable is "Fraction of homologously paired molecules." This is the variable *not* being manipulated in the experiment, and as such it is the dependent variable.

1b. ssDNA is pairing with dsDNA where one strand is complementary to the ssDNA. This takes place in the context of a nucleoprotein filament formed by RecA protein.

2. The fraction of ssDNA bound to dsDNA does not increase with time for 162 nucleotide ssDNA molecules, but it does increase with time for 430 and 1762 nucleotide ssDNA molecules.

3a. The 1762 nucleotide ssDNA achieves homologous pairing more rapidly.

3b. No, the 162 nucleotide ssDNA never achieves 50% homologue binding.

4a. Yes, it is fair to conclude that successful homologue binding requires an ssDNA strand longer than 162 nucleotides.

4b. Yes, it is fair to conclude that the ability of the ssDNA to form loops is critical to its successful homologue binding.

5. An experiment could be designed in which >430 nucleotide ssDNA is prevented from forming loops and then its ability to bind homologous dsDNA measured. Other answers are also possible. To determine if the length of the dsDNA sequence affects successful homologue binding, the length of the ssDNA on the RecA-ssDNA filament could be kept constant (and >430), and the length of the homologous dsDNA varied, keeping the length of the region that is complementary to the ssRNA constant. Other answers are possible.

Chapter 12 "How Can Two Genes on the Same Chromosome Segregate in a Cross"

1a. The dependent variable is "Observed percent recombination." This is the variable *not* being manipulated in the experiment, and as such it is the dependent variable.

1b. The highest frequency of recombination observed is 50%.

2a. Yes, the frequency of recombination increases as the distance between genes increases.

2b. The relationship between frequency of recombination and distance between genes is not linear.

3. Yes, for genes that are far apart, more recombination events are observed. The % recombination is observed to increase, first in a roughly linear fashion, then leveling off and reaching a plateau of 50%. This is because as the number of recombination events

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observed increases, these events will also produce parental gametes. Odd numbers of events will produce recombinant gametes, but even numbers of events will produce parental gametes. At longer distances, these will be roughly equal, and produce an observed % recombination of 50%. This is also the expectation for genes that are on different chromosomes, which we call independent assortment. Recombination values higher than 50% could not be observed because increasing or decreasing the likelihood of recombination will not affect this relationship of odd numbers of events producing recombinant gametes, and even numbers producing parental gametes.

4. Mendel's flower color and seed color genes are located approximately on opposite ends of the chromosome, with about 98% of the chromosome located between them.

Chapter 13 "Why Woolly Hair Runs in Families"

1. There are a total of 129 individuals in the pedigree. They are related by blood except for spouses.

2a. The trait appears in both females and males, but the trait is more prevalent in females compared to males, with a 64% to 36% ratio.

2b. Yes, every woolly-haired child has a woolly-haired parent.

2c. The percentage of woolly-haired offspring of a woolly-haired parent is about 43%.

3a. The woolly-hair trait is autosomal. It would appear more in males and rarely in females if it were sex-linked, but that is not the case so it is autosomal.

3b. The woolly-hair trait is dominant because every woolly-haired child has a woolly-haired parent.

3c. The woolly-hair trait is determined by a single gene. If more than one gene were involved, you would not see the reliable pattern of inheritance that is apparent in this pedigree.

4a. A person needs to have only one copy of the woolly-hair allele to express the trait and have woolly hair.

4b. If an individual was homozygous for the dominant woolly-hair trait, then all of their offspring would have the trait and both parents would have the trait. No family shows either of these patterns, so no woolly-haired individuals are homozygous dominant.

Chapter 14 "Are Mutations Random or Directed by the Environment?"

1. The dependent variable, the variable that is *not* being manipulated, is the number of T1 resistant colonies found.

2. The mean number of T1 resistant bacteria in the 20 cultures is 11.35.

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3a. No, the cultures do not exhibit similar numbers of T1 resistant bacteria. The number of T1-resistant colonies shows small variation in many cultures, but very large variation in 3 cultures.

3b. The "(b)" outcome is more similar to the results obtained by Luria and Delbruck in their experiment.

4. These data are not consistent with the hypothesis that mutations for T1 resistance among *E. coli* are caused by exposure to T1 viruses. The prediction made by that hypothesis is that resistance to T1 would be more evenly distributed among the different cultures, not clustered as we see in these results. These results instead support the hypothesis that the mutation to T1 resistance is random and may have been present in the population at very low levels at the start of the experiment.

Chapter 15 "Building Proteins in a Test Tube"

Experiment A

1. The dependent variable in experiment A is "Amount of leucine bound to RNA." The amount of bound leucine is the variable *not* being manipulated in the experiment and as such it is the dependent variable, plotted on the y axis.

2. Yes, the more leucine that is added (indicated on the x axis), the greater the amount of leucine that is bound to small RNA (shown on the y axis).

3. Yes, the amount of leucine bound to small RNA is proportional to the amount of leucine added to the mixture.

4. Yes, it is reasonable, based on these results, to conclude that the leucine added to the mixture is binding to the small RNA.

Experiment B

1. The dependent variable in experiment B is the "Radioactivity" (in radioactive leucine bound to small RNA) measured. The amount of radioactivity is the variable not being manipulated in the experiment and as such it is the dependent variable plotted on the y axis.

2a. The level of radioactivity in the small RNA decreases in the 20 minutes following the addition of the radioactive leucine-small RNA complex.

2b. The level of radioactivity in the newly made protein increases in the 20 minutes following the addition of the radioactive leucine-small RNA complex.

3. Yes, the decrease in radioactivity in the small RNA is relatively equivalent to the increase in radioactivity in the newly made protein.

4a. Yes, the results of these experiments support the conclusion that the small RNA (now known to be the tRNA in the cell) is donating its amino acid (the radioactive leucine in this experiment) to the growing protein.

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4b. The radioactively-labeled amino acids in the newly made proteins would all be leucine. Leucine was the only amino acid radioactively tagged, and so only leucine would carry the radioactivity in the newly made proteins.

Chapter 16 "How Do Transcription Factors Find Specific Regulatory Sites on DNA?"

1. The dependent variable is "Association rate," a measure of the rate of repressor binding to operator sites. Association rate is the variable *not* being manipulated in the experiment, and as such it is the dependent variable.

2a. Yes, the discovery time is affected by the distance between operators.

2b. Below about 50 bp (base pairs) separation between operator sites, binding by the repressor protein becomes less effective, decreasing rapidly from 75% to 50% of the maximal rate.

3a. Yes, the observation that the distance between operators affects how quickly an operator site is bound by repressor does imply that the repressor is moving along the DNA. This is true because if repressors begin to slide along the DNA to find binding sites, it is more likely that more of them will be able to slide and associate with binding sites if the sites are located farther apart. The farther sites are apart, the more surface area there is for sliding and binding, and the less likely that binding of one repressor will interfere with the sliding and binding of another repressor.

3b. When two operator sites are located closer together, the binding of one repressor likely interferes with the sliding and binding of another repressor. If two sites overlapped, the binding of one repressor would physically prevent the binding of a second repressor to the second site.

4. Yes, it is reasonable to conclude from these results that the *lac* repressor protein is sliding along bacterial DNA.

5. Yes, reduction in repressor binding observed when TetR is bound is consistent with *lac* repressor sliding.

Chapter 17 "Does Bt Cotton Promote Biological Forms of Pest Control?"

1a. The dependent variable is "Predators per 100 plants." This is the variable *not* being manipulated in the experiment.

1b. When the vertical or horizontal error bars of two points overlap, it means that the variation in the data obtained for one point overlaps with the variation in the data obtained for the second point. This suggests that the results between the two points (two experimental fields) are not significantly different if the two sample sizes are the same. When the error bars do not overlap, it is possible, but not absolutely certain that there is a significant difference between the two data points.

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2a. As the frequency of sprayings increased, there was a directly correlated reduction in the number of predators per 100 plants.

2b. A result can be made to be 'statistically significant' by the p value the scientist selects as a cut-off. If the p value for statistical test was 0.04 and the conclusion of statistical significance was made on $p<0.05$, then the identical test yielding 0.04 would be statistically not significant if $p<0.01$ was used.

3. A tripling of insecticide applied leads to a 50% decrease in predator numbers. It is hard to know how confident of this decrease in predator numbers for a three-fold increase in spraying frequency we should be. Lines of best fit like the one shown here (a 'least squares' regression analysis) should be shown with an r-value that indicates how confident we are that the line is an accurate representation of any trend it purports to show. Given the variance around many of the data points, it may not be that reliable as an indicator of a trend.

4. Yes, it is reasonable to conclude from these results that a decrease in spraying of cotton bollworm insecticide leads to an increase in population numbers of generalized predator insects. We must always be critical of the data and ask for more information whenever possible and meaningful, however. For example, we might want to know about the trend line r-value.

5. An experiment could be set up in which numbers of pest insects were monitored on neighboring noncotton crops near fields sprayed with bollworm insecticide at varying numbers of sprays per season.

Chapter 18 "Recombination Is Directed Away from the Functional Mouse Genome"

1a. The dependent variable is "Percent of double-stranded breaks." This is the variable *not* being manipulated in the experiment, and as such it is the dependent variable. It is the variable being measured.

1b. A value of 75 represents 75% of the total number of double-stranded breaks analyzed in the study.

2a. Yes, there is a difference: among knockout mice lacking PRDM9 activity, about 62% of recombination occurred at TSS sites and about 38% of recombination occurred at sites away from TSSs.

2b. Yes, there is a large difference: among wild-type mice with PRDM9 activity, about 5% of recombination occurred at TSS sites and about 95% of recombination occurred at sties away from TSSs.

3a. Among knockout mice lacking PRDM9 activity, about 62% of recombination affects the transcribed (functional) genome.

3b. Among wild-type mice with PRDM9 activity, about 5% of recombination affects the transcribed (functional) genome.

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4. Yes, it is reasonable to conclude that in mice, the gene *PRDM9* acts to direct the enzyme initiating meiotic recombination away from the functional genome.

5. Researchers might sequence the sites, locate them on chromosomes, or characterize the state of the DNA in which these sites occur. Researchers could also determine if there are any differences produced in cells with and without recombination occurring at these sites. These sites likely are not evolutionarily important because if recombination occurs so frequently at these sites, any gene combinations at these sites would be changed frequently.

Chapter 19 "Does Natural Selection Act on Enzyme Polymorphism?"

1a. These data are obtained by observation and not an experiment where variables can be controlled. In this case, the study looks at how allele frequency varies with latitude. Thus, the allele frequency of the (*a*) allele, plotted on the Y-axis, is the dependent variable.

1b. According to the graph, the frequency of the *a* allele at 35˚ N is about 0.1 or 10%. Recall that the pie charts on the map show data only for 20 populations, whereas the graph is showing data for 41 populations, with an "average" indicated by the best-fit line. Therefore, data read from the graph will be more accurate.

1c. The fish sampled from the colder, more northern latitude of 44˚ N had a much higher frequency of the *a* allele (over 0.95 or 95%) compared with those sampled at the warmer latitude of 31˚ N (around 0.03 or 3%). In general, fish from lower latitudes have lower frequencies of allele *a.*

2. The fish sampled around 41˚ N latitude exhibit the greatest variability in frequency of the *a* allele, the frequency ranging from 30% to 60%.

3a. Neither of the populations of fish in the extreme latitudes, 44˚ N or 31˚ N, would be likely to exhibit many heterozygotes. At 44˚ N, allele *a* and homozygous *aa* individuals would be favored, and at 31˚ N, allele *b* and *bb* homozygotes would be favored.

3b. The highest frequency of heterozygotes would be around 40˚ N latitude. This is where the frequency of the *a* allele is around 50%, meaning that the *b* allele is just as likely to be present as is the *a* allele. With these allele frequencies, you would tend to see more heterozygotes.

4. Yes, the differences in the frequencies of allele *a* support the hypothesis that natural selection is acting on the alleles encoding this enzyme. The fact that the *a* allele, which produces an enzyme that functions better at lower temperatures, is present in higher frequencies in the colder waters of the northern latitudes supports the hypothesis that fish containing this allele survive better in these colder conditions and go on to produce more offspring that are carrying this allele.

5. Very few fish captured from the warmer waters found at 32˚ N will be carrying the *a* allele and so when they are released into the colder waters at 44˚ N, few will probably survive. The influx of the *b* allele from the fish released from the warmer waters will have little impact on the total population such that over several generations, the allele

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