

One phenomenon studied by ecologists is the growth and regulation of populations. Population growth can be restricted when resources are limited. Competition for resources can also have an effect on population growth. Three experiments were conducted on various insects to test the validity of these statements. The table that follows is a summary of all three experiments.

Experiment 1

Two beetle species and caterpillars were studied: Six of each insect were grown in separate vials that contained adequate food supply. Beetle A and Beetle B feed on whole-wheat flour while the caterpillars feed on fresh leaves. Twenty identical vials were set up for each insect. After ten weeks, both species of beetles grew to an average population of five hundred in each vial. There was an average of twenty caterpillars in the vials that contained caterpillars.

Experiment 2

Six beetles from species A and six caterpillars were grown in the same vial containing whole-wheat flour and fresh leaves. Twenty identical vials were set up. After ten weeks, the average population of Beetle A was five hundred while there were an average of twenty caterpillars in each vial.

Experiment 3

Six beetles from each beetle species were placed in the same vial containing whole-wheat flour. Twenty identical vials were set up. After ten weeks, the average population of Beetle A was three hundred while the average population of Beetle B was one hundred.

	Experiment 1	Experiment 2	Experiment 3
Beetle A	500	500	300
Beetle B	500	—	100
Caterpillar	20	20	—

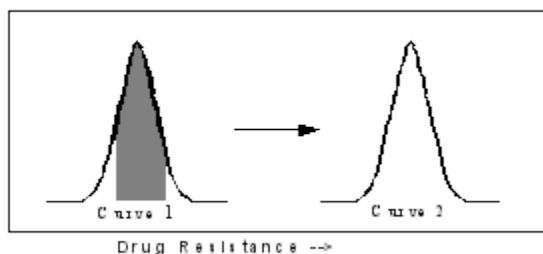
The table shows the average population of each insect that is involved in the experiments outlined.

1. Which of the following statements best describes why Experiment 1 is important?
 - a. Experiment 1 demonstrates that insects can thrive under the given conditions.
 - b. Experiment 1 establishes that both Beetle A and Beetle B eat whole-wheat flour.
 - c. Experiment 1 establishes the non-competitive total population of each insect.
 - d. Experiment 1 demonstrates that the caterpillar has a much slower growth rate than the beetles.

2. If Beetle A in Experiment 1 was left to grow indefinitely, one would initially observe an increase, followed by a brief plateau, and then a rapid decline in the population size. What would be the most likely cause of the final decline?
 - a. Other species of insects.
 - b. Limited supply of food.
 - c. Limited supply of minerals.
 - d. Long-term effects of confinement.
3. What would happen if, in Experiment 2, Beetle B and caterpillars were put in the same vial?
 - a. The caterpillars would die by Week 10 because of overpopulation by Beetle B.
 - b. The average population of Beetle B would reach 100 and the average population for caterpillars would reach 5 because of competition for food.
 - c. The average population of caterpillars would reach 50 while Beetle B would die because caterpillars are stronger competitors for food.
 - d. The average population of Beetle B would reach 500 while the average population of caterpillars would reach 20, as in Experiment 2.
4. Which of the following statements is true of Experiment 3?
 - a. Beetle B is the more dominant of the two beetle species.
 - b. Beetle A and Beetle B compete for space, food, or both.
 - c. The population size of beetle B is smaller than Beetle A due to migration.
 - d. The population size of Beetle B is smaller than Beetle A due to the absence of the caterpillars.
5. Suppose that, instead of starting with six of each species in Experiment 3, only three of each species were placed in the vial. After ten weeks, what percentage of the total population would the Beetle B species constitute?
 - a. 15%.
 - b. 25%.
 - c. 75%.
 - d. 85%.
6. Suppose another species of beetle, Beetle C, replaces Beetle A in Experiment 3. After ten weeks, only the Beetle C species can be found in the vial. Which of the following hypotheses does NOT explain the result in terms of competition?
 - a. The adult and larval Beetle C species ate the eggs and pupae of the Beetle B species.
 - b. The Beetle C species hoarded the food supply and defended it from the Beetle B species.
 - c. The Beetle B species was unable to reproduce due to a genetic mutation.
 - d. The Beetle C species secretes an enzyme on the food supply that can only be broken down by its own digestion system.

Ever since the discovery of penicillin by Alexander Fleming in 1928, antibiotics have served as a major weapon against pathogenic bacteria. However, the overuse of antibiotics has resulted in drug resistance - the ability of bacteria to resist the effects of a previously potent antibiotic. A distribution curve depicts the frequency of bacterial strains. The shaded area comprises the 95% of bacterial strains that can be treated by a specific antibiotic while the unshaded region comprises bacterial strains that are resistant to that antibiotic. For any given drug, a rightward shift from Curve 1 to Curve 2, as shown on the graph, occurs over time as the result of drug resistance – the percentage of existing bacterial strains which can resist the drug increases dramatically.

To test for drug resistance, biologists grow bacteria in special media containing specific antibiotics. The table below shows the effects of varying concentrations of a few antibiotics on the bacterium *Staphylococcus*. Each cell relates to the average of 3 flasks of media containing the indicated antibiotic with decreasing concentration moving from left to right.



Doxycycline	+++	+++	+++	+++
Sulfamethoxazole	+	++	+++	+++
Ethambutol	-	+	++	+++
Streptomycin	-	-	-	-
Kanamycin	-	+	++	+++

Decreasing concentration of antibiotics →
 - No growth, + Minimal growth, ++ Average growth, +++ Good growth

7. Which of the following scenarios definitively exemplifies drug resistance?
 - a. A specific antibiotic treats a broad spectrum of bacterial infections.
 - b. A specific antibiotic does not treat bacterial infections caused by *Staphylococcus*.
 - c. A specific antibiotic has become ineffective in treating bacterial infections from some strains of *Staphylococcus*.
 - d. A specific antibiotic treats bacterial infections from *Staphylococcus* but does not treat bacterial infections from the bacterium *Pseudomonas*.

8. Which statement is true of the given distribution curves?
- The unshaded region in Curve 1 represents 5% drug non-resistance.
 - Curve 2 represents 100% drug resistance.
 - Curve 1 represents 95% drug resistance.
 - Curve 2 is not related to drug resistance.
9. Which of the following conclusions is NOT consistent with the results of the experiment?
- Doxycycline had no effect on *Staphylococcus*.
 - Kanamycin and ethambutol were about equally effective on *Staphylococcus*.
 - Streptomycin was effective at all concentrations on *Staphylococcus*.
 - Sulfamethoxazole was effective only at low concentrations on *Staphylococcus*.
10. If the concentration of antibiotics used is to be kept at a minimum to prevent drug resistance, which of the antibiotics listed in the table would be the best choice for treatment of *Staphylococcus*?
- Kanamycin.
 - Ethambutol.
 - Streptomycin.
 - Sulfamethoxazole.
11. Suppose that a strain of bacteria arose which was resistant to streptomycin. Which of the following scenarios would you expect to occur in the course of time?
- The streptomycin-resistant strain would come to dominate the population of bacteria as the other strains died off after being exposed to antibiotics.
 - At least one of the other antibiotics would prove effective in treating the streptomycin-resistant bacteria.
 - The new strain of bacteria would become the source of a new family of antibiotics useful in treating previously intractable infections.
 - The distribution curves for bacteria treated with streptomycin would now include a substantial shaded region on the right-hand side.

Sedimentary rocks (which form from sediment) are thought to be deposited in cycles that occur in discrete packages called sequences. Each sequence constitutes a complete cycle. The cause for the cyclicity has been linked to sea level change, uplift of continents, climate change, and changes in earth's orbit. These packages are thought to have a duration ranging from 50,000 to 200 million years.

One theory states that the sequences that occur on a scale of every 200,000 to 10 million years are usually caused by changes in the global ice volume. As temperatures increase and glaciers melt, sea level rises and new marine sediment — which is typically coarser-grained than underlying sediments— is deposited along shorelines. As global temperatures decrease and glaciers build up, sea level falls and shoreline environments are eroded.

In order to test this theory, two studies were undertaken which enable us better to understand the relations between glaciations (periods of maximum cooling and glacier build-up) and marine sedimentary sequences.

Study 1

A 400m long core of sedimentary rock from an ancient shoreline in the U.S. was analyzed. The core represents marine sediments deposited over the last 20 million years. The researchers observed patterns of erosion and change in sediment size and determined that unique sequences occurred every 50,000, 100,000, 5 million, and 12 million years.

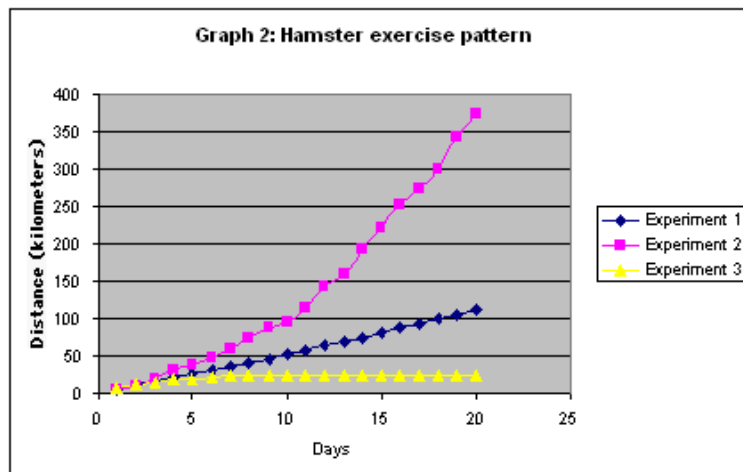
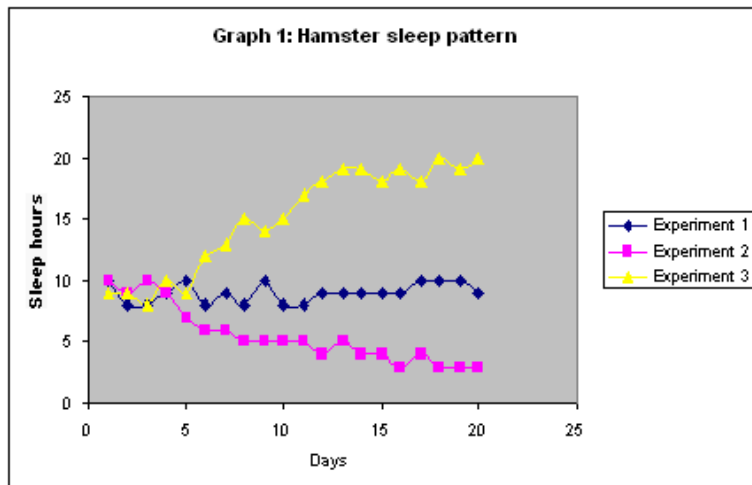
Study 2

At several sites beneath the Atlantic Ocean, a 50m core was removed from 500,000-year-old ocean-floor marine sediments. These sediments contained abundant microfossils that can be used in determining the nature of past climates. The researchers studied the abundance and taxonomy of these microfossils and deduced patterns of warming and cooling global temperatures. They found that periods of maximum cooling (peak glaciation) occurred 75,000, 175,000, 375,000, and 475,000 years ago.

12. The characteristics common to the studies is that both:
 - a. measured periods of maximum glaciations.
 - b. utilized ancient and modern sedimentary rocks.
 - c. analyzed data from marine sediments.
 - d. measured the depth of the cycles.
13. The two studies support the theory that marine depositional processes are:
 - a. controlled by microfossils and local climate changes.
 - b. unpredictable in nature.
 - c. most likely controlled by the cycling of glacial building and melting.
 - d. related to sequences of marine sediments.

14. Which of the following characteristics of a sequence of marine sediments or sedimentary rocks would make it unsuitable for a study such as this?
- I. an age of only 30,000 to 40,000 years
 - II. depth of ocean water
 - III. location away from the polar ice caps
- a. I only.
 - b. II and III only.
 - c. I, II, and III.
 - d. I and III only.
15. Each of the following is true EXCEPT:
- a. Both studies are compatible with the claim that major climate changes occur at intervals of 50,000 years or more.
 - b. Both studies provide support for the claim that cyclic climate changes caused changes in sediment patterns.
 - c. Sediment size was a central factor in the results of both studies.
 - d. Both studies concerned ancient marine sedimentary rocks.
16. According to the theory discussed in the passage, as glacial melting increases, the sediments along coastlines and microfossils within oceans should respectively show:
- a. more deposition and cooler global temperatures.
 - b. more erosion and cooler global temperatures.
 - c. more deposition and warmer global temperatures.
 - d. more erosion and warmer global temperatures.
17. Which of the following hypotheses was investigated in Study 1?
- a. Changes in sea level cause sequences of sediments.
 - b. Cycles occur every 50,000, 100,000, 5 million and 12 million years.
 - c. The sea level is currently rising.
 - d. Cyclicality in sediment deposition is the result of changes in global ice volume.

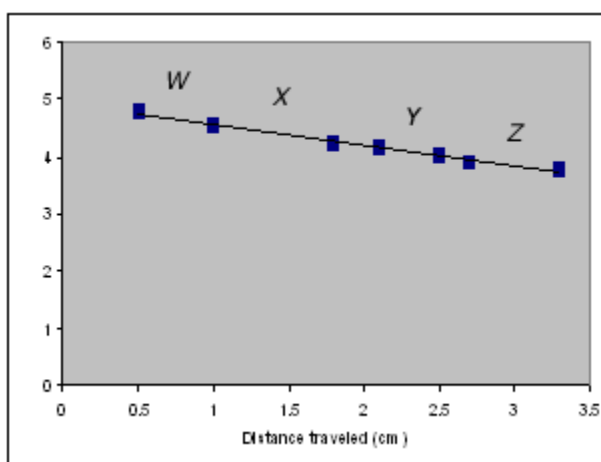
Many biological processes follow a 24-hour schedule. These cycles are called the circadian rhythms. These innate rhythms are governed by a biological clock located in the brain. The clock is strongly influenced by the daily change between sunlight and darkness, with morning sunlight promoting wakefulness and darkness setting the stage for sleep. A reversible upset in the exposure to light and darkness can affect sleep patterns in animals, which can subsequently cause behavioral changes. Researchers performed experiments to investigate the sleep pattern of hamsters. A total of 20 hamsters were used in each experiment, where the exposure of light varied. All the experiments lasted 20 days. In Experiment 1, the hamsters were exposed to 12 hours of light in a 24-hour period. In Experiment 2, the hamsters were exposed to 20 hours of light in a 24-hour period. In Experiment 3, the hamsters were exposed to 4 hours of light in a 24-hour period. Concurrent with changes in light exposure, the hamsters' exercise regime was also monitored. Odometers were attached to exercise wheels to measure total distances each group of hamsters traveled. The following graphs display the relationship between the number of hours spent sleeping (Graph 1) or the cumulative distance as measured on the odometer (Graph 2) with the exposure to light.



18. Which one of the following statements best describes why Experiment 1 is important?
- Experiment 1 shows that the hamsters need an average of 10 hours of sleep.
 - Experiment 1 is used as a basis of comparison by the other experiments.
 - Experiment 1 shows that hamsters exercise regularly.
 - Experiment 1 has no relation with the other experiments.
19. Which of following statements is NOT consistent with hamster sleep patterns?
- The greater the dark exposure in a 24-hour period, the less a hamster sleeps.
 - The length of light exposure affects a hamster's sleep pattern.
 - Under normal conditions, a hamster will sleep an average of 10 hours.
 - The greater the light exposure in a 24-hour period, the less a hamster sleeps.
20. What would one expect to observe at Day 3 if the hamsters were exposed to 15 hours of light?
- The hamsters would sleep and exercise less.
 - The hamsters would sleep and exercise more.
 - The hamsters would sleep less and exercise more.
 - No change from the normal would be observed.
21. Which of the following statements is true regarding hamster exercise patterns?
- Normal hamster sleep patterns lead to a steady decrease in the number of hours hamsters exercise a day.
 - Hamsters exercise more when more food is provided.
 - Hamsters deprived of light will eventually exercise very little or not at all.
 - Sleep deprivation and exercise are not related.
22. In view of the experimental results on hamsters, which of the following statements is a sound hypothesis regarding the behavior of mice exposed to light for abnormally long periods during 24-hour days?
- The mice will not react, either in sleep patterns or in exercise patterns, protracted exposure to light.
 - The mice will sleep more and exercise less than the hamsters when exposed to light for protracted periods.
 - The mice will exhibit a rapid increase in the number of exercise hours, reaching a cumulative distance of about 200 kilometers in 10 days.
 - The mice will react the same way as the hamsters to prolonged light exposure, but this reaction will not necessarily take place at the same rate.

23. If the hamsters in Experiment 3 were put under normal conditions again after Day 20, what would most likely be observed?
- a. No observable changes will occur as the hamsters have grown accustomed to sleeping in and not exercising.
 - b. No observable changes will occur as the hamsters' circadian rhythms were destroyed.
 - c. The hamsters will increasingly sleep less and exercise more to a point that matches Experiment 2.
 - d. The hamsters will increasingly sleep less and exercise more to a point that matches Experiment 1.

SDS-PAGE is a technique used by scientists to separate proteins according to their size. The compound SDS confers a uniform negative charge to individual proteins, causing these negatively charged proteins to travel toward the anode (positive end) when placed in an electric field. The migrating proteins are further placed in a uniform matrix (PAGE) in order to separate the different sizes. A bigger, heavier protein meets more resistance than a smaller, lighter one while traveling through the matrix, and hence migrates more slowly. The size of a protein is measured in Daltons (Da). The relationship between the logarithm values of the weights of 7 proteins and the distances they travel in the matrix in a given period of time is illustrated in the graph. A list of the discrete data point values for each protein, as well as the corresponding weight, is presented under the graph.



<u>Distance traveled (cm)</u>	<u>Log (Weight)</u>	<u>Weight (Da)</u>
0.5	4.81	65 000
1.0	4.55	35 000
1.8	4.23	17 000
2.1	4.16	14 000
2.5	4.02	11 000
2.7	3.91	8 000
3.3	3.79	6 000

24. Which statement characterizes the migration of SDS-associated proteins?
- Diffusion moves the proteins from a region of higher concentration to one of lower concentration.
 - An electric field causes negatively charged objects to migrate toward the anode (positive end).
 - The electrical resistance of negatively charged objects determines the speed of migration.
 - Osmosis of water indirectly causes the migration of the proteins.

25. A protein of weight 45 000 Da would be expected to migrate to the region on the graph marked?
- W.
 - X.
 - Y.
 - Z.
26. A protein essential for metabolism has just been discovered. SDS-PAGE reveals that this protein migrates a distance of 1.7 cm. Which statement best characterizes the new protein?
- The weight of the protein is somewhere between 6 000 Da and 11 000 Da.
 - The weight of the protein is somewhere between 11 000 Da and 17 000 Da.
 - The weight of the protein is somewhere between 14 000 Da and 17 000 Da.
 - The weight of the protein is somewhere between 17 000 Da and 35 000 Da.
27. Another essential protein in metabolism is made up of 2 units, each unit traveling a different distance from the other. The combined weight of the 2 units is approximately 50 000 Da. Referring to the regions W, X, Y and Z on the graph, which combination will NOT give the possible weight of each unit?
- X + Z.
 - Y + Z.
 - X + Y.
 - W + Y.
28. What would happen if an electric field were to be applied to SDS-PAGE for an indefinite length of time?
- Larger proteins will reach the anode before the smaller proteins.
 - All proteins will eventually reach a limiting resistance in the matrix, at which point they cease to migrate further.
 - Proteins associated with more SDS will reach the anode while proteins associated with less SDS will stop migrating due to resistance.
 - All proteins will eventually reach the anode.

All proteins consist of a string of amino acids linked together by peptide bonds. Because of its unique sequence of amino acids, every protein is distinct. Each protein folds into a specific conformation when manufactured by cells. All proteins must attain three-dimensional structures to properly function in the cell. While the peptide bonds between the amino acids are relatively rigid, all the other chemical bonds within a protein are flexible and can contort within certain limits. The ability of a protein to fold depends on the flexibility of these chemical bonds. A small protein of about 100 amino acids could undergo an astronomical number of trials and errors before assuming its final structure. This sampling of many conformations before attaining the right one would take far too long and so scientists hypothesize that there must be pathways which guide individual proteins to the right conformations, thereby eliminating total randomness in sampling. Three pathway models of protein folding have been proposed.

Diffusion-collision model

This model suggests that an amino acid within a protein can diffuse within its environment until it collides with its specific partner amino acid, to which it adheres. When all the amino acids are involved in favorable interactions, the protein ceases to diffuse and the proper conformation is attained.

Nucleation model

This model postulates that the acquisition of the proper fold within several amino acids would trigger the folding process. These amino acids act as nucleation centers and cause a domino effect in promoting protein folding. The protein can be imagined to sequentially acquire its proper conformation beginning from the nucleation centers.

Hydrophobic-collapse model

Out of the twenty different amino acids, some are hydrophobic. A hydrophobic amino acid is one that does not like to be associated with water but does like to be associated with others like itself. In the hydrophobic-collapse model, hydrophobic amino acids in the protein collapse into the center of the protein leaving the hydrophilic (water-loving) amino acids to surround them and interact with water.

29. The final three-dimensional structure of a protein, regardless of the folding pathway models, ultimately depends on:
 - a. how it is manufactured by the cell.
 - b. the flexibility of the peptide bonds.
 - c. the number of amino acids.
 - d. the sequence of the amino acids.
30. A mutation of an **important** amino acid affects the proper conformation of the protein. Which of the proposed models cannot account for this observation:
 - a. Diffusion-collision model.
 - b. Nucleation model.
 - c. Hydrophobic-collapse model.
 - d. None of the above.

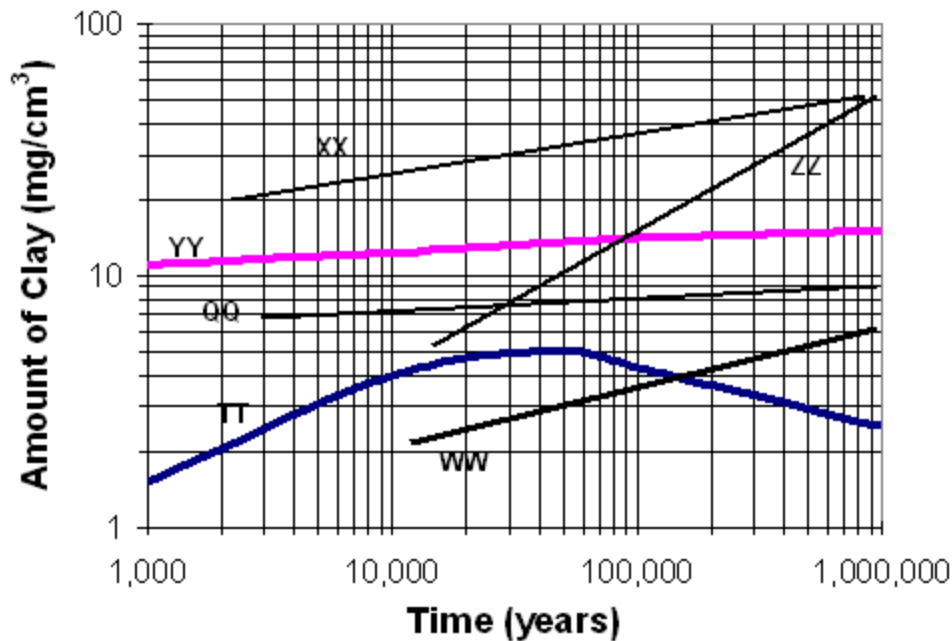
31. A certain mutation of an amino acid, which is thought to play a major role in **initiating** protein folding, does not affect the general structure of the protein. Which of the proposed models cannot account for this observation:
- Diffusion-collision model.
 - Nucleation model.
 - Hydrophobic-collapse model.
 - None of the above.
32. The nucleation model suggests that some amino acids are more important than others whereas the diffusion-collision model supposes that all amino acids are equally important. Which of the following statements is NOT true:
- A mutation in an important amino acid in the nucleation model will have no effect according to the diffusion-collision model.
 - A mutation in an amino acid, which is important in the nucleation model, will result in a wrong conformation.
 - A mutation in an amino acid might affect proper protein conformation according to the diffusion-collision model.
 - A mutation in a certain amino acid might have an effect according to both the nucleation model and the diffusion-collision model.
33. Implicit in the nucleation model is the assumption that:
- temperature is an important factor for a protein to attain the proper conformation.
 - the presence of salt promotes a protein in attaining the proper conformation.
 - the addition of a strong base will destroy the peptide bonds and thus the protein.
 - the time required to attain the proper conformation is dependent on the length of the protein.
34. A molecular chaperonin is a protein that aids small proteins in establishing their structures. The chaperonin has a barrel-like cavity that provides an unfolded protein an opportunity to fold. If the hydrophobic-collapse model can be used to explain this particular folding process, what can be said about the amino acids of the molecular chaperonin that come in contact with the unfolded protein?
- The amino acids in the molecular chaperonins are hydrophobic.
 - The amino acids in the molecular chaperonins are hydrophilic.
 - The amino acids in the molecular chaperonins are both hydrophobic and hydrophilic.
 - The amino acids in the molecular chaperonins are not involved in the folding process.

35. A fourth, all-inclusive view of protein folding is that **similar** proteins can fold via any of the three models. What cannot be said of proteins that conform to this all-inclusive model?
- a. The structure of a protein can be attained by any model.
 - b. The length of the protein does not influence the choice of a model.
 - c. The sequence of the protein determines the folding pathway.
 - d. A folding pathway that is hindered by a mutation can be compensated by another.

Amount of clay (g/cm^3) is one measure for development of a soil through time where a soil with no clay to low amounts of clay is considered *undeveloped* and a soil with high amounts of clay is considered *developed*.

The graph below shows changes over time in soils that began with no clay. Each letter stands for a group of soils in a particular climate. Absence of a line indicates an absence of clay at that particular time.

Note: X and Y axes are in logarithmic units.



36. Which of the following statements is supported by the data presented in the graph?
- Amount of clay depends on time only.
 - Amount of clay depends on time and climate.
 - Climate depends upon amount of clay only.
 - The graph does not support a relationship between climate, amount of clay, or time.
37. The graph indicates that after 100,000 years the greatest change in amount of clay (g/cm^3) has occurred in which climate?
- Climate XX.
 - Climate ZZ.
 - Climate TT.
 - Climate WW.

38. For any given climate, which of the following generalizations is supported by the graph?
- a. As time increases, the amount of clay present increases.
 - b. As time increases, the change in amount of clay decreases.
 - c. As the amount of clay increases, the change in the amount of clay decreases.
 - d. As time increases, the amount of clay present changes.
39. Based on the information in this graph, an extended graph including data up to 10,000,000 years would show the least change in amount of clay present in which climate?
- a. Climate ZZ.
 - b. Climate WW.
 - c. Climate TT.
 - d. Climate QQ.
40. A ranking of these soils from most developed to least developed changes significantly between 1,000-10,000 years and 10,000-100,000 years. If we extended this graph back to include data to 0 years, which of the following could be predicted to occur?
- a. Climate TT and YY would have equal ranking.
 - b. Climate YY would have the highest ranking.
 - c. All soils would have equal ranking.
 - d. Climate TT would have the highest ranking.