AP Biology Reading Guide
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Chapter 53: Population Ecology

1. What two pieces of data are needed to mathematically determine density?

D = M/V

2. What is the difference between density and dispersion?

The density of a population is the number of individuals per unit area or volume. Dispersion is the pattern of spacing among individuals within the boundaries of the population.

4. Explain the impact of immigration and emigration on population density.

Additions to populations occur through birth and immigration, the influx of new individuals from other areas. Death and emigration, the movement of individuals out of a population and into other locations, remove individuals from a population.

5. What do the dispersion patterns tell us about the population and its interactions?

Most populations show at least a tendency toward clumped distribution. Many animals group together where resources are abundant. Clumping may increase the effectiveness of predation or defense, and can also be associated with mating behavior. A uniform pattern of dispersion may result from direct interactions between individuals in the population. Some plants secrete chemicals that inhibit the germination and growth of nearby individuals that could compete for resources. Animals often exhibit uniform dispersion as a result of antagonistic social interactions, such as territoriality. In random dispersion, the position of each individual in a population is independent of other individuals. This pattern occurs in the absence of strong attractions or repulsions among individuals or where key physical or chemical factors are relatively constant across the study area.

6. In what population statistic do demographers have a particular interest? How is this data often presented?

Demography is the study of the vital statistics of populations and how they change over time. Life tables are age-specific summaries of the survival pattern of a population.

7. What is a cohort?

A cohort is a group of individuals of the same age.

8. Survivorship curves show patterns of survival. Label and explain the three idealized survivorship patterns.

A Type I curve is flat at the start, reflecting low death rates during early and middle life, then drops steeply as death rates increase among older-age groups. Many large mammals, including humans, that produce few offspring but provide them with good care exhibit Type I. In contrast, a Type III curve drops sharply at the start, reflecting very high death rates for the young, but flattens out as death rates decline for those few individuals that survive the early period of die-off. Type II is associated with organisms that produce very large numbers of offspring but provide little or no care, such as long-lived plants, many fishes, and most marine invertebrates. Type II curves are intermediate, with a constant death rate over the organism's life span. This kind of survivorship occurs in some rodents, various invertebrates, some lizards, and some annual plants.

9. Sketch the survivorship curve of an open nesting songbird (Type III for Year 1 and Type II for the rest of its lifespan).

10. What does a reproductive table show?

A reproductive table, or fertility schedule, is an age-specific summary of the reproductive rates in a population. It is constructed by measuring the reproductive output of a cohort from birth until death. For a sexual species, the reproductive table tallies the number of female offspring produced by each age-group. Reproductive output for sexual organisms is the product of the proportion of females of a given age that are breeding and the number of female offspring of those breeding females.

11. On what is the life history of an organism based?

The traits that affect an organism's schedule of reproduction and survival make up its life history.

12. What three variables form the life history of a species?

When reproduction begins, how often the organism reproduces, and how many offspring are produced per reproductive episode.

13. Explain the difference between semelparity (big-bang reproduction) and iteroparity (repeated reproduction).

Semelparity is a "one-shot" pattern of big-bang reproduction favored when the survival rate of offspring is low, typically in highly variable or unpredictable environments. Individuals typically die just after mass-producing eggs or sperm. In contrast, in iteroparity, organisms produce relatively few but large offspring each time they reproduce, and they provision the offspring better, a method that may be favored in more dependable environments, where adults are more likely to survive to breed again and competition for resources may be intense.

14. Explain how two critical factors influence whether a species will evolve toward semelparity or iteroparity.

No organism could produce as many offspring as a semelparous species and provision them as well as an iteroparous species. There is a trade-off between reproduction and survival. Plants and animals whose young are subject to high mortality rates often produce large numbers of relatively small offspring. Small seeds can be carried longer distances to a broader range of habitats. In other organisms, extra investment on the part of the parent greatly increases the offspring's chances of survival, especially in habitats with high population densities.

16. What is the advantage to using per capita birth and death rates rather than just raw numbers of births and deaths?

The per capita birth rate is the number of offspring produced per unit time by an average member of the population. If we know the annual per capita birth rate, we can calculate the number of births per year in a population of any size. Similarly, the per capita death rate allows us to calculate the expected number of deaths per unit time in a population of any size.

17. What will the per capita birth and death rates be if a population is demonstrating zero population growth?

Zero population growth (ZPG) occurs when the per capita birth and death rates are equal.

18. What is exponential population growth?

Population increase under ideal conditions in which the per capita rate of increase may assume the maximum rate for the species is called exponential or geometric population growth. The size of a population that is growing exponentially increases at a constant rate, resulting eventually in a J-shaped growth curve when population size is plotted over time.

19. Explain why the line with the value of 1.0 shows a steeper slope that reaches exponential growth more quickly. ✎

Increasing the value of the maximum rate for the species from 0.5 to 1.0 increases the rate of rise in population size over time because the population accumulates more new individuals per unit of time when the rate is large than when it is small.

20. What are two examples of conditions that might lead to exponential population growth in natural populations?

Exponential growth is characteristic of some populations that are introduced into a new environment or whose numbers have been drastically reduced by a catastrophic event and are rebounding.

21. What is carrying capacity?

Carrying capacity is the maximum population size that a particular environment can sustain.

22. What are six examples of limiting resources that can influence carrying capacity?

Energy, shelter, refuge from predators, nutrient availability, water, and suitable nesting sites can all be limiting factors.

23. What is the logistic population growth model?

In the logistic population growth model, the per capita rate of increase approaches zero as the carrying capacity is reached.

24. Explain why a large value for (K–N)/K predicts growth close to the maximum rate of increase for this population.

K (carrying capacity) – N (population size) is the number of additional individuals the environment can support, so $(K - N)/K$ is the fraction of K that is still available for population growth. When N is small compared to K, the term $(K - N)/K$ is close to 1, and the per capita rate of increase approaches the maximum rate of increase. But when N is large and resources are limiting, then $(K - N)/K$ is close to 0, and the per capita rate of increase is small. When $N = K$, the population stops growing.

25. Explain why the logistic model predicts a sigmoid (S-shaped) growth curve for this graph.

The rate of population growth decreases as population size (N) approaches the carrying capacity (K) of the environment. New individuals are added to the population most rapidly at intermediate population sizes, when there is not only a breeding population of substantial size, but also lots of available space and other resources in the environment.

26. Explain the ideas behind K-selection and r-selection.

Selection for traits that are sensitive to population density and are favored at high densities is known as *K*-selection, or density-dependent selection. In contrast, selection for traits that maximize reproductive success in low-density environments is called *r*-selection, or density-independent selection. *K*-selection is said to operate in populations living at a density near the limit imposed by their resources, where competition among individuals is stronger, while *r*-selection is said to maximize r, the per capita rate of increase, and occurs in environments in which population densities are well below carrying capacity or individuals face little competition. Such conditions are often found in disturbed habitats.

27. Compare and contrast density-independent and density-dependent regulation.

A birth rate or death rate that does not change with population density is said to be density independent. In contrast, a death rate that rises as population density rises is density dependent, as is a birth rate that falls with rising density.

28. Explain how negative feedback plays an essential role in the unifying theme of regulation of populations.

Without some type of negative feedback between population density and the rates of birth and death, a population would never stop growing. Density-dependent regulation provides that feedback, halting population growth through mechanisms that reduce birth rates or increase death rates.

29. Discuss methods of density-dependent population regulation.

negative feedback mechanism	*explanation*	*example*
competition for resources	increasing population density intensifies competition for nutrients and other resources, reducing reproductive rates	nutrient limitations on crop yield
territoriality	if space becomes the resource for which individuals compete	cheetahs use a chemical marker in urine to warn other cheetahs of their territorial boundaries
disease	if transmission rate depends on a certain level of crowding in a population	influenza infects a greater percentage of human populations in densely populated cities than in rural areas
predation	if predators capture more food as the population density of the prey increases or predators feed preferentially on the rapidly growing species	cutthroat trout concentrate for a few days on a particular insect species emerging from its aquatic larval stage, then switch to another prey species when it becomes more abundant
toxic wastes	individuals in the species die as their toxic waste builds up	alcohol content of wine is usually <13% because that is the maximum ethanol concentration most wine-producing yeast cells can tolerate
intrinsic factors	intrinsic physiological factors	aggressive interactions and hormonal changes in white-footed mice that delay sexual maturation and depress the immune system

30. Give both abiotic and biotic reasons for fluctuations over the last 50 years in the moose population on Isle Royale.

The first population collapse coincided with a peak in the number of predatory wolves from 1975 to 1980. The second collapse, around 1995, coincided with harsh winter weather, which increased the energy needs of the animals and made it harder for the moose to find food under the deep snow.

31. Explain the importance of immigration and emigration in metapopulations.

Immigration and emigration are particularly important when a number of local populations are linked, forming a metapopulation. Local populations in a metapopulation can be thought of as occupying discrete patches of suitable habitat in a sea of otherwise unsuitable habitat. Patches with many individuals can supply more emigrants to other patches.

32. Summarize human population growth since 1650.

The global human population has steadily grown almost continuously throughout history, but skyrocketed after the Industrial Revolution. The rate of population growth has slowed in recent decades, mainly as a result of decreased birth rates worldwide.

33. What is demographic transition? Explain the process in Sweden and Mexico.

The movement from high birth and death rates toward low birth and death rates which tends to accompany industrialization and improved living conditions is called the demographic transition. In Sweden, this transition took ~150 years, from 1810 to 1960, when birth rates finally approached death rates. In Mexico, where the human population is still growing rapidly, the transition is projected to take until at least 2050. Demographic transition is associated with an increase in the quality of healthcare and sanitation as well as improved access to education, especially for women.

34. Describe the key features for the three age-structure graphs and predict how the population of each country will grow.

country	*key features*	*predicted future growth*
Afghanistan	bottom-heavy, skewed toward young people who will perhaps sustain the explosive growth	continued growth
United States	relatively even until older, postreproductive ages, except for bulge corresponding to post-WWII “baby boom”; overall birth rate still exceeds death rate; current total reproductive rate 2.1 children per woman	slow growth through 2050 due to immigration
Italy	individuals younger than reproductive age relatively underrepresented in the population	population decrease

35. Why do infant mortality and life expectancy vary so greatly between certain countries?

These differences reflect the quality of life faced by children at birth and influence the reproductive choices parents make. If infant mortality is high, then parents are likely to have more children to ensure that some reach adulthood.

36. Can the world’s population sustain an ecological footprint that is currently the average American footprint?

The ecological footprint concept summarizes the aggregate land and water area required by each person, city, or nation to produce all the resources it consumes and to absorb all the waste it generates. One way to estimate the ecological footprint of the entire human population is to add up all the ecologically productive land on the planet and divide by the population. This calculation yields approximately 2 hectares (ha) per person. Reserving some land for parks and conservation means reducing this allotment to 1.7 ha per person – the benchmark for comparing actual ecological footprints. Anyone who consumes resources that require more than 1.7 ha to produce is said to be using an unsustainable share of Earth’s resources. A typical ecological footprint for a person in the United States is about 10 ha.