AP BIOLOGY · UNIT 8 · TOPIC 8.5

Community Ecology

Learning objective 8.5.A Describe the structure of a community according to its species composition and diversity, and 8.5.B explain how interactions within and among populations influence community structure.

Name: Date: Period:

Use the tool **Who Eats Whom, and What It Costs**. Parts 1 and 2 use **Counting is not enough**, Part 3 uses **Two signs**, Part 4 uses **The chase**, Part 5 uses **Down the chain**, and Parts 6 and 7 use **Sharing a resource**. A community is a set of populations whose numbers depend on each other. This topic is about what happens to the others when one population changes. In three places the result differs from the answer that is often memorized, so work each one out from the numbers.

Part 1 · Two communities, five species each

Both communities below contain **one hundred individuals** of **five species**. Calculate Simpson's Diversity Index for each: $1 - \Sigma(n/N)^2$. Square each proportion before you add, and keep four decimal places, because Part 2 uses them. Check each index in the tool by clicking Even, five species and Dominated, five species.

Community	Counts	$\Sigma(n/N)^2$	Index = $1 - \Sigma(n/N)^2$
Even, five species	20, 20, 20, 20, 20		
Dominated, five species	96, 1, 1, 1, 1		

1. (a) Describe a community.

(b) Identify the two characteristics used to describe the structure of a community.

2. (a) Identify the formula for Simpson's Diversity Index.

(b) Describe what each symbol in the formula represents.

3. Both communities in the Part 1 table contain exactly five species.
(a) Explain how the two communities can have such different diversity indices.

(b) Describe what this result shows about using the number of species alone to measure diversity.

Part 2 · What the square is for

Take the dominated community (**96, 1, 1, 1, 1**) and fill in the table one species at a time, checking each value against the Term by term table in the tool with Dominated, five species selected. In the last column, write each proportion again without squaring it.

Species	n	n/N	$(n/N)^2$	n/N without the square
Species A	96			
Species B	1			
Species C	1			
Species D	1			
Species E	1			

4. (a) Calculate 1 minus the sum of the $(n/N)^2$ column of the Part 2 table.

(b) Calculate 1 minus the sum of the n/N without the square column.

5. (a) Explain how squaring each proportion makes the index sensitive to dominance by one species.

(b) Explain why the index would be 0 for every community if the square were left out.

6. A five-species community can never have an index above 0.8, and a ten-species community can never have an index above 0.9.
(a) Determine the highest index that a community of S species can have.

(b) Explain why the highest index has this form.

Part 3 · Every interaction is a pair of signs

For each interaction, mark what it does to each partner: **+** for benefit, **–** for harm, **0** for no effect. Check each row against the tool's table. Then look down the Signs column and find the two rows with the same pair of signs.

Interaction	Effect on A	Effect on B	Signs	One example
Mutualism				
Commensalism				
Predation				
Parasitism				
Competition				
Amensalism				

7. Identify the three types of symbiosis and the pair of effects for each.

8. Two rows of the Part 3 table have the same pair of signs.
(a) Identify the two interactions.

(b) Describe one difference between the two interactions that the signs do not show.

Part 4 · The chase, at two amplitudes

The tool runs the same predator-prey model twice, changing nothing but where the run starts. Click Small oscillation and Large oscillation in turn and record both rows. The predicted period is $2\pi/\sqrt{(r \cdot m)} = \mathbf{16.22}$, and the lag is usually quoted as a quarter of a cycle. Check both claims against both runs before you answer question 10.

Run	Measured period	Predicted period	Lag as a share of a cycle
Small oscillation		16.22	
Large oscillation		16.22	

9. Explain why predator and prey populations cycle rather than settling at fixed numbers.

10. The predator peak is often said to lag the prey peak by a quarter of a cycle. (a) Using the Part 4 table, describe the condition under which this statement is true.

(b) Describe how the period and the lag change when this condition is not met.

11. In the tool's model, the prey equilibrium is 75 = m/(b·a) and the predator equilibrium is 25 = r/a. Here r is the prey's growth rate, a is the predation rate, b is the predator's conversion efficiency and m is the predator's death rate. (a) Identify the population whose growth rate determines the predator equilibrium.

(b) Predict the effect of an increase in the predator's death rate, m, on the prey equilibrium and on the predator equilibrium. Justify your prediction.

Part 5 · Down the chain, twice

The tool removes the top predator from a four-level chain and from a three-level one, using **identical rules**. Click Four levels and Three levels in turn and record which way each level moves. Then compare the plants in the two chains.

Links below the removal	Four-level chain: level	Direction	Three-level chain: level	Direction
0 (removed)	Top predator	removed	Predator	removed
1	Mesopredator		Herbivore	
2	Herbivore		Plants	
3	Plants		—	—

12. (a) Describe a trophic cascade.

(b) Explain why the effects of removing a top predator alternate in direction down a food chain.

13. Removing the top predator raises the plants in one chain of the Part 5 table and lowers them in the other. Describe a rule, based only on the number of links between the removed predator and the plants, that predicts the direction of the change in the plants.

Part 6 · Two advantages

Two species compete for one resource, which they use in **exactly the same way**. In the first run species A grows **2%** faster. In the second it tolerates **10%** more crowding. The tool shows both results at once, so write your prediction for each before you look at the panel, then record the results.

Advantage held by A	Your prediction	Species A ends at	Species B ends at
Grows 2% faster			
Tolerates 10% more crowding			

14. Describe the competitive exclusion principle.

15. (a) Identify the advantage in the Part 6 table that led to the exclusion of species B.

(b) Explain why, in the model, growing 2 percent faster did not exclude species B.

Part 7 · Then separate the niches

The same pair, the same crowding advantage, run at four degrees of niche overlap. Overlap **`1.0`** means the two species are using the resource identically; **`0.3`** means they mostly are not competing at all. Click each overlap in turn and record both species, whether both persist, and the total the tool gives for the two of them together.

Niche overlap	Species A	Species B	Both persist?	A + B
1.0				
0.9				
0.6				
0.3				

16. Explain how niche partitioning allows two competing species to coexist.

17. In the Part 7 table, the two species together reach 1,615 individuals at an overlap of 0.3, but the single winner reaches only 1,100 at an overlap of 1.0. Explain why the partitioned community supports more individuals in total.

18. An ecologist observes two similar bird species sharing a woodland for 30 years with no sign that either species is declining. Explain why this observation is not evidence against the competitive exclusion principle.

What the model simplifies

Simpson's Diversity Index is one of several diversity indices and it is the one the 2025 CED gives. It weights common species heavily and is comparatively insensitive to rare ones: a community's index barely moves when a species making up a thousandth of it disappears. Other indices weight rarity more.

The communities contain exactly a hundred individuals, which makes the arithmetic legible and hides a real difficulty. In the field the true proportions are not known: a sample is taken, and rare species are often missed. A sample of the dominated community could easily miss one or more of its rare species.

The predator-prey model is the Lotka–Volterra pair integrated in small steps. It leaves out everything except birth, predation, conversion and death: no carrying capacity for the prey, no handling time for the predator, no other species, no environment. Its cycles are neutral, meaning the amplitude is fixed by where the run started and never grows or shrinks. Real cycles are damped or driven and do not behave that way.

The quarter-cycle lag is not a general result. Running the identical model near equilibrium and far from it gives lags of 24.3% and 14.5% of a cycle and periods of 16.23 and 18.02 against a predicted 16.22. The familiar figures are small-oscillation approximations, and this tool shows both runs rather than quietly showing the one that agrees with the textbook.

The trophic cascade model is a schematic in which each level is pushed toward an abundance set by its food supply and the pressure from above. It is not fitted to any real food web, and real food webs are webs rather than chains: most organisms eat at more than one level, which blurs the alternation. What is asserted is the structural claim, that the effects alternate, and its consequence, that the effect on the plants depends on the parity of the chain length.

The competition model is discrete Lotka–Volterra competition. The crowding advantage is given as a higher ceiling for species A, standing in for the real mechanism: being able to persist at a lower level of the remaining resource. The growth-rate advantage genuinely produces no exclusion in this model, which is a property of the model as much as of the world, but it is the right lesson, because the species that draws a resource down furthest is the one that wins, not the one that gets there first.

The 2025 CED's exclusion statements for this topic place the specific mechanisms of individual interactions beyond the scope of the exam. What is in scope is the classification by effect, the fact that interactions shape community structure, and the named examples: predator/prey, cooperation, trophic cascades, niche partitioning, competition, predation and the symbioses.