The Ultimate AP® Biology Unit 8 Cheat Sheet

8.1 Responses to the Environment

Behavior Basics

Behavior = response to internal or external stimuli; shaped by natural selection → ↑ survival & reproduction.
Innate: genetic, fixed (fixed action pattern: goose rolls egg back). **Learned**: modified by experience over time.

Behavior	Example
Taxis	Moth flies toward light
Kinesis	Pill bugs speed up in dry
Imprinting	Goslings follow mom
Classical cond.	Pavlov's dog
Operant cond.	Rat presses lever → food
Habituation	Ignore harmless stimulus

Taxis = directed movement toward/away from a stimulus.
Kinesis = random; only speed or turning rate Δ.

Communication

Signals: visual (courtship display), auditory (bird song), chemical (**pheromones**), tactile (bee waggle dance).
Waggle dance: angle of the run vs vertical = direction to food relative to the sun; length of waggle = distance.
Cooperation: herds, flocks, pack hunting → ↓ risk of predation, ↑ success finding food & mates for each member.
Altruism: helps others at own cost (alarm calls); **kin selection** → helps shared genes survive.

Physiological Responses

Plants: phototropism (auxin), photoperiodism (flowering set by night length), closing stomata in drought.
Animals: hibernation, estivation, migration, circadian rhythms; timing often tied to the seasons.

⚠ Taxis has a direction; kinesis is random. Pill-bug choice chambers can show kinesis + taxis in the same trial.

✓ FRQ: link the behavior to how it increases the organism's survival or reproduction (its fitness) directly.

8.2 Energy Flow Through Ecosystems

Trophic Levels

Producers (autotrophs) → **primary consumers** (herbivores) → **secondary** → **tertiary**. **Decomposers** recycle all levels.
Energy flows one way (sun → heat); **matter cycles**.
~10% rule: only ~10% of energy passes to the next level; ~90% lost as heat (resp.), waste, uneaten parts.
Worked: 10,000 kcal in producers → 1,000 primary → 100 secondary → 10 kcal in tertiary consumers.
Few top predators b/c little energy reaches high levels. Food chains rarely have more than 4–5 links in total.
Food web = linked food chains; arrows point from eaten → eater (in the direction energy flows through it).
Chemosynthesis: deep-sea vent bacteria fix carbon using chemical energy (e.g., H_2S), not light.

Productivity

GPP = total energy fixed by photosynthesis. **NPP** = GPP − R (producer respiration) = energy available to consumers.
Highest NPP: tropical rainforest, estuaries, coral reefs. Open ocean is low per area but huge in total (it's vast).

Metabolism & Energy

	Endotherm	Ectotherm
Heat source	Metabolism	Environment
Energy need	High	Low
Example	Birds, mammals	Reptiles, fish

Smaller endotherms: higher metabolic rate per gram (high SA:V → lose heat fast; see Unit 2) → eat more per gram.
Energy deficit → body mass ↓ → eventually death. Energy surplus → growth, storage, reproduction.
Detritivores & decomposers return nutrients to the soil for producers to reuse, but not the energy.

⚠ Energy is lost as HEAT at each level, not "used up". Matter is recycled; energy is never recycled.

✓ Energy pyramid math: multiply by 0.1 per level going up; divide by 0.1 (× 10) per level going down.

8.2 Biogeochemical Cycles

Carbon Cycle

In: photosynthesis takes CO_2 from air. **Out**: respiration, decomposition, burning fossil fuels → CO_2.
Reservoirs: atmosphere, oceans (dissolved CO_2), living biomass, soil, fossil fuels, limestone rock.
Human impact: fossil fuels + deforestation → atmospheric CO_2 ↑ → climate change, ocean acidification.
Ocean absorbs ~¼ of emitted CO_2 → forms carbonic acid → pH ↓ → shells & coral skeletons dissolve.

Nitrogen Cycle

Step	Change	Who
Fixation	$N_2 \rightarrow NH_3$	Bacteria (legumes)
Nitrification	$NH_4^+ \rightarrow NO_3^-$	Soil bacteria
Assimilation	$NO_3^- \rightarrow$ proteins	Plants
Ammonification	Waste → NH_4^+	Decomposers
Denitrification	$NO_3^- \rightarrow N_2$	Bacteria

N_2 is 78% of air but unusable by most organisms → must be fixed. Needed for proteins & nucleic acids.
Lightning & Haber process (fertilizer factories) also fix N.

Phosphorus & Water

Phosphorus: no gas phase; rock weathering → soil/water → organisms. Needed for DNA, ATP, phospholipids.
Water: evaporation, transpiration (from plants), condensation, precipitation, runoff, groundwater flow.
Why cycles matter: C, H, O, N, P, S build all 4 classes of macromolecules (see Unit 1) in every cell.
Fertilizer runoff (N, P) → **eutrophication**: algal bloom → die → decomposers use O_2 → dead zone.

⚠ Phosphorus has NO atmospheric (gas) step. Nitrogen does: N_2 gas makes up about 78% of the air.

✓ Cycle Q: name the molecule, the process, and the organism (or human activity) doing it.

8.3 Population Ecology

Population Basics

Population = same species, same area. Described by size (N), density, dispersion, age structure.
Dispersion: clumped (resources patchy; most common), uniform (territorial animals), random (rare).

Growth (Formula Sheet)

Population growth: dN/dt = B − D (births − deaths, ignoring immigration & emigration). Units: individuals/time.
Exponential: dN/dt = $r_{max}N$. Unlimited resources → **J-curve**.
r = per capita growth rate = (B − D)/N. If r > 0, the pop. grows; if r = 0, stable; if r < 0, it shrinks.
Worked: N = 500, B = 60, D = 10 per year → dN/dt = 60 − 10 = 50 individuals/yr; r = 50/500 = 0.1 per yr.
Exponential seen: new habitat, after a disaster, invasive species, bacteria in a fresh flask of medium.
Doubling: same % growth each gen. → numbers explode (bacteria: 1 → 2 → 4 → 8 → 16 → 32 → …).

Survivorship & Life History

Curve	Pattern	Example
Type I	Most die old	Humans
Type II	Constant death	Birds, lizards
Type III	Most die young	Fish, oysters

r-selected: many small offspring, little care, unstable env. **K-selected**: few large offspring, lots of care, stable env.
Age structure pyramid: wide base → rapid growth; even sides → stable; narrow base → pop. shrinking.
Human population: grew exponentially after agriculture & modern medicine, as technology kept raising K.

⚠ Exponential growth needs unlimited resources. It never lasts for long in nature; limits on K stop it.

✓ Show the formula, plug in the numbers, and include units (e.g., individuals per year) in the answer.

8.4 Effect of Density on Populations

Logistic Growth

Logistic: dN/dt = $r_{max}N((K - N)/K)$. Growth slows as N nears **K** → **S-curve** (sigmoid shape) that levels off.
Carrying capacity (K): the max pop. size an environment can support long term w/ its food, space & water.
Fastest growth at N = K/2. At N = K → growth = 0.
Term (K − N)/K = fraction of K still "open": near 1 when N is small (≈ exponential), 0 when N = K (no growth).
Worked: r_{max} = 0.2, N = 400, K = 1,000 → 0.2 × 400 × (600/1,000) = **48 individuals/yr** added.
Overshoot: N > K → deaths ↑ → oscillates around K.

Limiting Factors

Density-dependent	Density-independent
Competition	Fire
Predation	Flood, drought
Disease, parasites	Extreme cold/heat
Waste buildup	Volcano, hurricane

Density-dependent: effect ↑ as the pop. gets denser (more crowded) → acts as negative feedback toward K.
Density-independent: same % killed regardless of density.
Feedback: density-dependent factors work like negative feedback (Unit 4) → stabilize the pop. near K.

Predator-Prey Cycles

Lynx & hare: prey ↑ → predators ↑ (lag) → prey ↓ → predators ↓. Food supply also matters.
K can change: more food, habitat or tech (humans) → K ↑.
Allee effect: too few individuals → hard to find mates or defend the group → small pops can crash toward 0.
Real data often wobble around K, not a smooth S.

⚠ Logistic growth rate is NOT highest at K (it's 0 there). It's highest at half of K, i.e., where N = K/2.

✓ Graph Q: J-curve = exponential; S-curve leveling off at K = logistic. Label K & K/2 on the graph.

8.5 Community Ecology

Species Interactions

Interaction	Sp. 1	Sp. 2	Example
Competition	−	−	Lions, hyenas
Predation	+	−	Wolf, deer
Herbivory	+	−	Deer, plants
Parasitism	+	−	Tick, dog
Mutualism	+	+	Bee, flower
Commensalism	+	0	Barnacle, whale

Niches & Competition

Niche = role: resources used, conditions tolerated.
Competitive exclusion: 2 spp. can't share the exact same niche long term; one outcompetes the other.
Resource partitioning: spp. split a niche (warblers feed at diff. tree heights) → they can coexist long term.
Character displacement: competing spp. evolve diff. traits where they overlap (e.g., Galápagos finch beaks).

Structure & Diversity

Simpson's Diversity Index (on formula sheet): D = 1 − $\Sigma(n/N)^2$. Closer to 1 = a more diverse community.
Worked: 3 spp. w/ 50, 30, 20 of 100 total → 1 − (0.5^2 + 0.3^2 + 0.2^2) = 1 − (0.25 + 0.09 + 0.04) = **0.62**.
Diversity = richness (# of spp. present) + evenness (how equal the counts are across those spp.).
Defenses: camouflage, warning coloration, mimicry (Batesian: a harmless sp. copies a harmful one; Müllerian: 2+ harmful spp. look alike, e.g., bees & wasps).
Succession: primary (bare rock, lichens & mosses first) vs secondary (soil left after a fire, flood or farming).

⚠ Parasites usually don't kill the host quickly; they live off it for a long time. Predators kill and eat their prey.

✓ Interaction Q: write +, − or 0 for each of the 2 species first, then name the relationship from the pattern.

8.6 Biodiversity

Why Diversity Matters

Biodiversity: genetic, species & ecosystem diversity. More diversity → more **resilience** to disturbance.
Redundancy: several spp. doing the same job → losing one of them doesn't collapse the whole system.
Genetic diversity within a species → some individuals survive disease or climate change (see Unit 7).

Key Species

Type	Role	Example
Keystone	Big effect vs abundance	Sea otter, starfish
Foundation	Builds habitat	Coral, kelp
Ecosystem eng.	Alters habitat	Beaver
Indicator	Shows env. health	Frogs, lichens

Keystone removal: sea otters gone → urchins ↑ → kelp forests destroyed → many other spp. lost.
***Pisaster* starfish** removed from tide pools → mussels take over the rocks → species diversity ↓ sharply.

Trophic Cascades

Top-down control: predators regulate lower levels (Yellowstone wolves → elk ↓ → willows ↑ → beavers ↑).
Bottom-up control: nutrients/producers limit higher levels.
Ecosystem services: pollination, clean water, soil formation, flood control, medicines, food for people.
Higher diversity index (e.g., 0.8 vs 0.4) → usually a more stable, resilient community after disturbance.

⚠ Keystone species are often NOT the most abundant in the community. Their impact ≫ their numbers.

✓ Predict Q: remove a species → trace the effects both up AND down the food web, one level at a time.

8.7 Disruptions & Exam Strategy

Human & Natural Disruptions

Invasive species: no natural predators → outcompete natives (cane toads, kudzu, zebra mussels, Burmese pythons).
Habitat loss & fragmentation: #1 cause of extinction today.
Climate change: CO_2 ↑ → warming, ocean acidification → coral bleaching, range shifts, mismatched timing.
Pollution: eutrophication, **biomagnification** (DDT, mercury get more concentrated at each higher level).
Natural events: El Niño, volcanoes, hurricanes, fires → sudden Δ; ecosystems recover via succession.
Overharvesting: overfishing, poaching → population crash (e.g., the Atlantic cod fishery collapse in the 1990s).

Adaptation vs Disruption

Rapid Δ outpaces evolution → spp. w/ short generations & high genetic diversity are the ones that adapt best.
Conservation tools: protected areas, corridors, removing invasives, reintroductions (e.g., wolves).

Exam Moves

Calc (formula sheet)	Key step
Exponential	dN/dt = $r_{max}N$
Logistic	× (K − N)/K
Simpson's D	1 − $\Sigma(n/N)^2$
10% rule	× 0.1 per level

Data Qs: identify IV & DV, describe the trend, predict the effect of removing or adding a species.
Links: Unit 3 photosynthesis & respiration → energy flow; Unit 7 natural selection → adaptations to change.
Claim-evidence-reasoning: state the effect (claim), cite the data (evidence), then explain the mechanism.

⚠ Biomagnification = toxin concentration ↑ up the food chain. Top predators are hit the hardest.

✓ Every ecology answer: name the interaction, the direction of change, and explain why it happens.