AP® Biology
2003 Scoring Guidelines

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Question 1

In fruit flies, the phenotype for eye color is determined by a certain locus. ***E*** indicates the dominant allele and ***e*** indicates the recessive allele. The cross between a male wild-type fruit fly and a female white-eyed fruit fly produced the following offspring.

	Wild-type Male	Wild-type Female	White-eyed Male	White-eyed Female	Brown-eyed Female
F1	0	45	55	0	1

The wild-type and white-eyed individuals from the F1 generation were then crossed to produce the following offspring.

F2	23	31	22	24	0

(a) Determine the genotypes of the original parents (P generation) and explain your reasoning. You may use Punnett squares to enhance your description, but the results from the Punnett squares must be discussed in your answer.

(b) Use a Chi-squared test on the F2 generation data to analyze your prediction of the parental genotypes. Show all your work and explain the importance of your final answer.

(c) The brown-eyed female in the F1 generation resulted from a mutational change. Explain what a mutation is, and discuss two types of mutations that might have produced the brown-eyed female in the F1 generation.

Critical Values of the Chi-Squared Distribution

Probability (p)	Degrees of Freedom (df)				
	1	2	3	4	5
0.05	3.84	5.99	7.82	9.49	11.1

The formula for Chi-squared is:

$$X^2 - \sum \left[\frac{(o-e)^2}{e} \right]$$

where o = **observed** number of individuals

e = **expected** number of individuals

$\sum$ = the **sum of the values** (in this case, the differences, squared, divided by the number expected)

Question 1 (continued)

(a) Maximum 4 points

1 pt Genotypes of the parents (words or symbols) X^EY (or X^+Y) and X^eX^e
1 pt Discuss/show how these resulted in this F1 (may be annotated Punnett)
1 pt Explain that it is a sex-linked (X-linked) gene (not just the word)
1 pt How you know which type is dominant
1 pt F2 results (may be annotated Punnett square)

(b) Maximum 4 points

1 pt Correct F2 hypothesis (1:1:1:1; or 25/genotype)
1 pt Show work (components): o e o-e $(o-e)^2$ $(o-e)^2/e$
(or correct numbers (4/25 + 36/25 + 1/ 25 + 9/25 = 50/25 = 2; or at least the last term)
1 pt Sum: correct chi-square result ~ 2.0 or 1.85
1 pt degrees of freedom = 3 (critical value is 7.82)
1 pt correct interpretation of chi-square in terms of p
p = probability that the difference between the observed and the expected value is due to chance alone.
This p value shows we accept our hypothesis.
The null hypothesis is supported in this case.
(alternative: 2 X^2 tests of white *vs.* red males and white *vs.* red females)

(c) Maximum 4 points

1 pt Explain what a mutation is: (heritable) change in the DNA (code)
1-2 pts Discuss 2 types of mutations
May be: Point mutation, frameshift (deletion/duplication), insertion, transposition, break, inversion within gene, base substitution, nonsense/stop, missense)
May NOT be: chromosomal aberration, nondisjunction, silent/neutral, transcription or translation or processing error
1 pt Molecular or biochemical elaboration beyond the explanation required

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Question 2

Regulatory (control) mechanisms in organisms are necessary for survival. Choose **THREE** of the following examples and explain how each is **regulated**.

(i) Flowering in plants

(ii) Water balance in plants

(iii) Water balance in terrestrial vertebrates

(iv) Body temperature in terrestrial vertebrates

(i) Maximum 4 points

(each box represents an independent 1 point each)

change in photocycle/photoperiod	long day (short night) plants flower only if night is shorter than a critical duration - - - or - - - short day (long night) plants flower only if night exceeds a critical duration	phytochromes
		$P_r \Leftrightarrow P_{fr}$ (night) (day)
		unknown "florigen" converts
		shoot-meristem to floral-meristem
		or breaks bud dormancy
		leaf is photoreceptor organ
		gibberellins → ↑flowering
		auxins, ethylene, or abscisic acid→ ↓flowering
change in temperature pattern (vernalization)	specific duration of cold exposure - - - or - - - specified sequence of temperature changes initiate flowering	can be independent of (day neutral) or dependent on photocycle changes
		unknown "florigen" transitions shoot meristem to floral meristem or break bud dormancy
		gibberellins → ↑flowering
		auxins, ethylene, or abscisic acid→ ↓flowering
nutritional status	plant has enough nutritional resources to support flowering	can be independent (day neutral) or co-dependent of photocycle changes
		unknown "florigen" transitions shoot meristem to floral meristem
		or break bud dormancy
		gibberellins → ↑flowering
		auxins, ethylene, or abscisic acid→
		↓flowering

Question 2 (continued)

(ii) Maximum 4 points

Regulatory mechanism (must earn one "explanation point" before awarding a second "mechanism point")	**Explain how the regulatory mechanism affects water balance:** (2nd point must come from explanation before 3rd point can be awarded)	**Elaboration** (max 1 point)
- stomates/guard cells	closed ≈ ↓water loss (evap/transpir) open ≈ ↑water loss (evap/transpir)	ion, water influx/efflux from guard cells; turgid/flaccid (stomates: open/closed)
- altered stomate location or "sunken stomates"	stomates more abundant in more humid, cooler regions of the plant	
- cuticle thickening	↓water loss (evap/transpir)	waxy polymers resist water movements, cutin
- increased succulence	water storage	
- smaller leaves	↓water loss (evap/transpir)	
- drop leaves	↓water loss (evap/transpir)	abscisic acid
- altered leaf angle	↓water loss (evap/transpir)	less surface area directly exposed to sun's heat
- water potential in roots lower than that of soil	permits water uptake, even in saline soils	production of organic osmolytes in roots
- deeper root growth	reach deeper water	
- altered metabolic pattern (e.g., CAM)	stomates open only at night: ↓water loss (evap/transpir)	cooler, more humid conditions during the night
- increase cellular turgidity	opposes osmotic force	cell wall resists influx until pressure gradient offsets osmotic pressure

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Question 2 (continued)

(iii) Maximum 4 points

Hypothalamus is water-regulation center (1 point max)		*Hypothalamus regulates neural circuits in behavior of thirst (1 point max)*
Regulatory mechanism/ detector/ signal (must earn one "explanation point" before awarding a second "mechanism point")	**Explain how the regulatory mechanism affects water balance.** (2nd point must come from explanation before 3rd point can be awarded)	**Elaboration** (1 point max)
Hyperosmotic conditions result in increased secretion of **Vasopressin (a.k.a. Anti-Diuretic Hormone = ADH)** from the hypothalamus/ (posterior) pituitary (gland) [[hyposmotic opposite]]	reduces water loss in urine [[hyposmotic opposite]]	↑ water permeability in descending limb of loop of Henle, distal tubule, or collecting duct causes greater reabsorption of water [[hyposmotic opposite]]
Hypovolemic conditions activate RAAS system (renin angiotensin activating system), especially **Ang II** from kidney/blood	Ang II increases (Na^+) and water reabsorption in proximal tubule; less urine	decreased renal blood pressure and filtrate flow increase renin release; renin activates angiotensinogen to Ang I, which is readily converted to Ang II juxtaglomerular apparatus (JGA)
Hypovolemic/ RAAS active Ang II stimulates **hypothalamic thirst** center	Ang II increases thirst	"dry mouth" perception
Hypovolemic/ RAAS active Ang II stimulates secretion of **aldosterone** from adrenal (cortex) gland	Aldosterone increases (Na^+) and water reabsorption (& K^+ secretion) in distal tubule	
Hypervolemic conditions (excess blood volume) cause increased secretion of **Atrial Natriuretic Peptide (ANP)**	decreases (Na^+) and water reabsorption in distal tubule	inhibits renin and aldosterone release; causes vasodilation of afferent arterioles
EVOLUTION		
- loop of Henle	loop length α urine osmolarity	
- type of nitrogenous waste	use less water in excretion	compare ammonia, urea, and uric acid for water solubility or toxicity
- development of specialized transport epithelia, e.g., salt glands	less water loss in osmoregulation	
- cloaca development	use less water in excretion	
- large intestine/ colon	greater surface area for water and ion absorption	
- water-resistant body surface	decrease water loss from body surface	
- behavioral avoidance of dessicating conditions	nocturnal habits reduce water loss due to heat	

Question 2 (continued)

(iv) Maximum 4 points

Hypothalamus is thermostat *(1 point max)*	*Thermostat reset by different conditions; autonomic/other neural outputs influence body temperature (1 point max)*	*Fever, hypothermia (1 point max)*
1 Regulatory mechanism (must earn one "explanation point" before awarding a second "mechanism point")	**Explain how the regulatory mechanism affects temperature regulation.** (2nd point must come from explanation before 3rd point can be awarded)	**Elaboration** (1 point max)
- move to a location that is: cooler if hot (e.g., shade), or warmer if cold (e.g., bask)	 ↑heat loss from body ↓heat loss from body	
- sweat/ perspire when hot	↑ evaporative cooling	
- lick body surface when hot	↑evaporative cooling	
- pant when hot	↑evaporative cooling	
- alter insulation (fur, feathers): flat when hot . . . . . . or erect when cold	 ↑heat loss ↓heat loss	 ↓boundary layer ↑boundary layer
- ↑ peripheral: vasodilation when hot, or vasoconstriction when cold	 blood at periphery to ↑heat loss blood kept in core of body	
- ↑shivering when cold	↑heat production	contraction/relaxation cycling in skeletal muscles
- ↑non-shivering thermogenesis when cold	↑heat production	metabolism of brown fat
- ↑activity when cold	↑metabolic heat production	
- activate heat-shock proteins when hot	intracelluar protection of protein structure	HSPs are chaperones that guide protein folding
- torpor estivate when hot	↓ activity & ↓ metabolism → ↓ metabolic heat	sometimes triggered by changes in day length
or hibernate when cold	↓activity and slower metabolism ↓ heat loss during cold winter	sometimes triggered by changes in day length
- ↑ surface area (e.g., big ears) - ↓ surface area	↑heat loss ↓heat loss	
- ↓body fat	↑heat loss	
- shed insulation when hot - grow insulation when cold	↑heat loss ↓heat loss	↑boundary layer
- ↑metabolic rate when cold - ↓metabolic rate when hot	↑heat production ↓heat production	↑thyroid hormones ↓thyroid hormones
- ↓surface area:volume	↓heat loss	
- counter-current heat exchange/blood flow	↓heat loss by keeping core warmer than periphery	heat transferred from arterial to venous vessels

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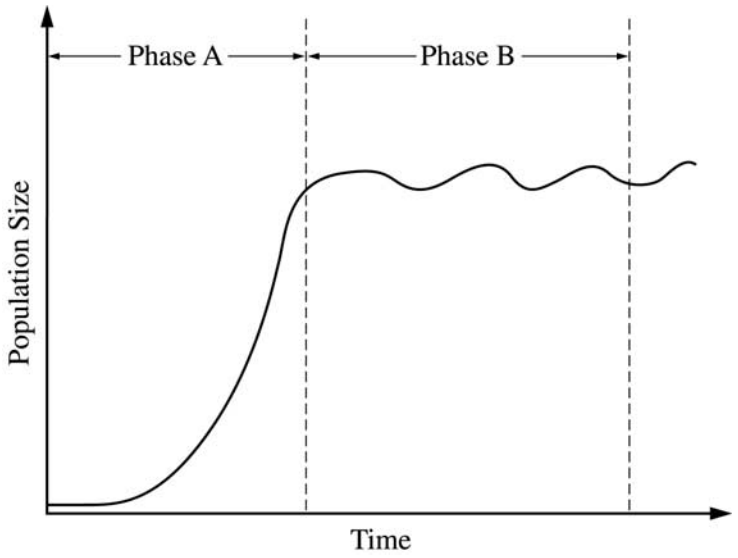
Question 3

Many populations exhibit the following growth curve:



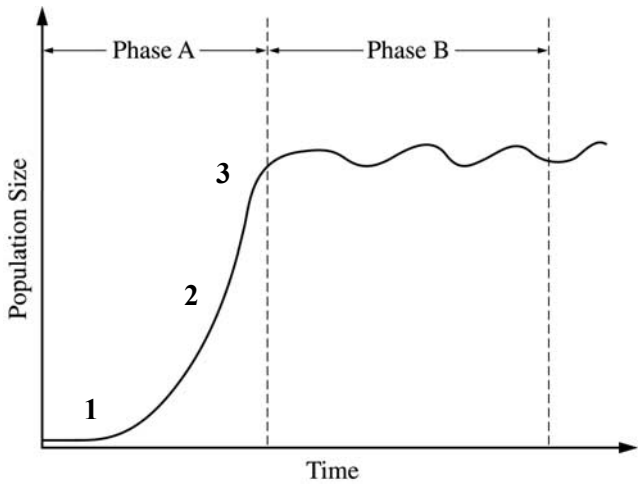
(a) Describe what is occurring in the population during phase A.

(b) Discuss **THREE** factors that might cause the fluctuations shown in phase B.

(c) Organisms demonstrate exponential (*r*) or logistic (*K*) reproductive strategies. Explain these two strategies and discuss how they affect population size over time.

****Global point; 1 point**: Carrying capacity definition: The number of individuals of a particular species that an environment can support; determined by the availability of resources. Point can be earned in any section.

(a) Maximum 3 points



1 point for each part of curve

#3 population growth slows as population approaches the carrying capacity; deceleration. No point for stating that population reaches carrying capacity — must indicate rate change (slows) or levels off.

#2 exponential growth; log phase; period of rapid growth; dramatically or rapidly increasing

#1 establishment period or lag phase: population grows slowly or does not grow. No credit for small population size, must indicate slow growth rate

Question 3 (continued)

(b) Maximum 4 points

3 points: Three biologically sound factors that discuss the rise or fall of population size. Only the first three factors discussed will be scored. Commonly used density-dependent factors include limited resources, predation (predator/prey cycles), disease, and reproduction. Density-independent factors must reflect the periodic nature of the curve and cannot include cataclysmic events such as earthquakes, volcanoes, etc.

For each example to be legitimate, it must
- have a biologically sound explanation/discussion
- have a cause and an effect
- fit the graph in phase B

1 point for explanation of a complete cycle (rise and fall of population size.)

(c) Maximum 4 points

Explanation: 2 points (1 each for *r* and for *K*) Each explanation must have at least **two** characteristics from the table

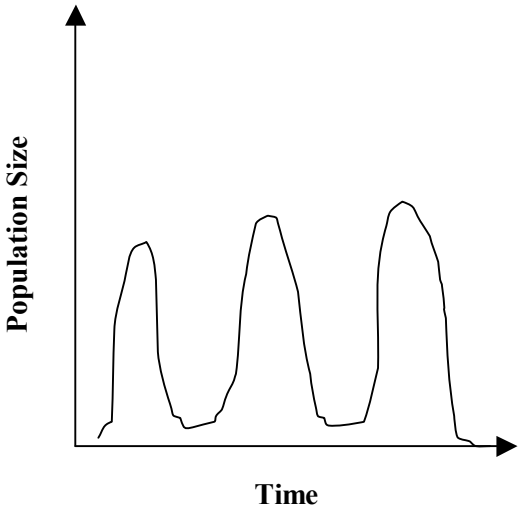
***r*-strategists**	***K*-strategists**
Many young	Few young
Little energy investment in each	High energy investment in each
Small young	Large young
Rapid sexual maturation	Slow sexual maturation
Higher incidence of asexual reproduction	Higher incidence of sexual reproduction
Brief reproductive life span	Long reproductive life span
Little or no parental care	Lots of parental care
"Big bang" (semelparous) reproduction	Many reproductive events (iteroparous)
Unpredictable environment	Predictable environment
Population control by density-independent factors	Population control by density-dependent factors
Short life span	Long life span
Type III survivorship curve; few offspring survive	Type I survivorship curve; many offspring survive
Not prone to extinction	Prone to extinction
Higher reproductive capacity	Lower reproductive capacity

Question 3 (continued)

Discussion: 2 points (1 point each) Note: No points for a graph without an explanation

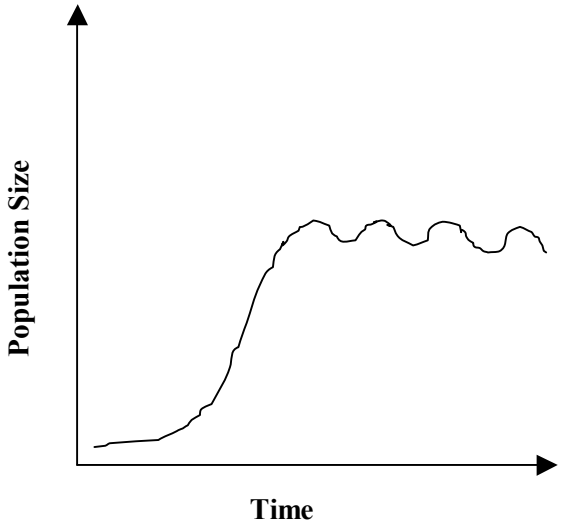
***r*-strategists**

boom/bust (great fluctuations) in population size



***K*-strategists**

population *stabilizes* around K (carrying capacity)



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Question 4

Death is a natural and necessary part of life cycles at all levels of organization.
(a) Discuss **TWO** examples of how cell death affects the development and functioning of a multicellular organism.
(b) Discuss **ONE** example of how substances are degraded and reused in cells.
(c) Discuss the evolutionary significance of death.

(a) Maximum 6 points (3 points per example)

- 1 pt. Example of cell death leading to a change in development
- 1 pt. Example of cell death leading to a change in function
- 1 pt. Discussion of ***how*** cell death occurs or an extension of cell death significance

Examples (categories) of cell death
- elimination of cells, tissues, and organs
- tissue remodeling / reconstruction
- destruction that poses a threat to the survival of the organism
- repair / maintenance
- cell death as a result of severe injury
- cell death as a result of exposure to toxins / altered chemical balance
- cell death as a result of aging

(b) Maximum 3 points

1 pt. Substance: ***how*** degraded to product
1 pt. Product: ***how*** reused in cells
1 pt. Discussion / elaboration on process to degrade or reuse

***** "Energy" is not a substance in this response.

(c) Maximum 3 points

Relate evolution to death:
- change in allele or phenotype frequency / removal of individuals from a population based on phenotype / differential reproduction
- selection based on variation
- competition (struggle, resource availability, overpopulation) having an effect on reproductive success
- speciation / mass extinction / adaptive radiation
- genetic drift
- cell death genes preserved early in evolution
- **mechanism** of apoptosis (changes that occur within the cell)
- activation / inhibition of cell death genes
- effect on embryonic development