



## AP<sup>®</sup> Biology 2002 Scoring Guidelines

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**Question 1**

1. (a) • **Maximum 4 points for this part of the question (1 point earned for each bullet below, up to 4)**

**(Maximum 3 points, 1 for each bullet)**

**Describe** the use of **plasmid for cloning/sequencing** a human gene

- Cut plasmid with “restriction” enzyme
- Cut/isolate human sequence with the corresponding “restriction” enzyme
- Mix/anneal/ligate
- Introduce recombinant plasmid into bacteria
- Select recombinant bacteria (e.g., antibiotic resistance, fluorescence, reporter gene, etc.)
- Bacterial reproduction used to amplify the sequence
- Describe either degradative (Maxam-Gilbert) or dideoxy (Sanger) method to generate fragments
- Electrophoresis to separate fragments
- Read the sequence (automated method is OK)

**(Maximum 3 points, 1 for each bullet)**

**Explain** the contribution of this procedure

- Source of the DNA is immaterial to cloning
- Used to produce transgenic organisms
- Used to make human proteins (e.g., insulin, HGH)
- Understanding gene structure/regulation
- Comparative genomics
- Development of gene therapies
- Making gene library
- Amplifying a particular sequence

- **Maximum 4 points for this part of the question (1 point earned for each bullet below, up to 4)**

**(Maximum 3 points, 1 for each bullet)**

**Describe** PCR

- Heat to separate strands
- Add primers
- Cool to anneal
- Add polymerase and/or nucleotides
- Specification of heat stable (Taq) polymerase
- Description of thermocycling process
- Repetition of process

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**Question 1 (cont'd.)**

**(Maximum 3 points, 1 for each bullet)**

**Explain** the contribution of this procedure

- Allows amplification of very small samples
- Replicates/amplifies a defined region
- Can be automated to allow for faster expansion of knowledge
- Can be used for forensics
- Can be used for diagnosis
- Evolutionary applications
- Other

- **Maximum 4 points for this part of the question (1 point earned for each bullet below, up to 4)**

**(Maximum 3 points, 1 for each bullet)**

**Describe** RFLP analysis

- DNA sample cut with “restriction” enzyme(s)
- Separation of fragments (electrophoresis)
- Description/elaboration of electrophoresis (charge/size/apparatus)
- Visualize fragments (probes, dyes, blots)
- Compare fragment sizes/mobility
- Compare single and double digests (two or more restriction enzymes)
- Compare individuals/species/organisms/tissue samples

**(Maximum 3 points, one for each bullet)**

**Explain** the contribution of RFLP analysis

- Trace RFLPs as genetic markers in families
- Diagnose disease/carriers/prenatal samples
- Prepare fingerprints (for forensics, etc.)
- Order fragments for physical mapping
- Compare genomes of different species/evolutionary relationships
- Locate the flanking regions of the gene/sequence
- Find mutations
- Individual bands can be used for further analysis
- Can determine presence of sequence without knowing its function

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**Question 1 (cont'd.)**

1. (b) **Maximum 4 points — Explain the contradiction**

Sources of difference in DNA fingerprint

- Variation in non-coding material (introns, spacers, minisatellites, “junk,” transposable elements)
- Point mutations, small deletions, SNPs (single NT polymorphisms)
- Variable number of tandem repeats (VNTRs/STRs)

Recognition of differences

- A small percentage difference of a very large genome results in a large number of nucleotide differences
- PCR-based fingerprinting: differences found by where primers anneal
- Variation in restriction enzyme cutting sites

Similarities among proteins

- Redundancy in the code for amino acids
- Neutral/silent mutation does not alter the function of the protein

**Caution:** No explanation points in (a) without an attempted description of procedure  
Order of procedure points is not important if they are logical and accurate  
No credit for mutations leading to new phenotypes  
Codons specify amino acids (not proteins)

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**Question 2**

2. (a) **A maximum of 5 points**

**Description of the cycle of activity (1 point)**

A student could earn a point if he/she accurately summarized the graph. A simplistic statement such as, “Bombats are active during the day and quiet at night” which ignored the shape and obvious peaks and valleys of the graph did not receive the point. To earn this point, the student had to identify the peak of activity at “noon,” “midday,” or “12:00 p.m.,” AND indicate a lower activity at “night.” The student could also be specific about the lowest activity being at “midnight,” or “12:00 a.m.” The description had to be clearly distinguishable from the rest of the answer and not simply implied in another part of the response.

**Discussion of how THREE factors might affect the physiology and/or behavior resulting in the cyclic activity pattern (1 point each)**

To earn points here, each of the descriptions had to (a) be biologically plausible and consistent with typical mammalian behavior and physiology (no fictional biology); (b) indicate a cause and effect relationship beyond a simple restatement of the question. This had to include at least a very brief indication of how or why the factor had any effect at all on the bombat — or in some cases its prey; and finally, the discussion could not be inconsistent with the part of the curve described or time of day referenced in the explanation.

**Elaboration on any one of the three factors (1 point)**

Here the readers were looking for exemplary descriptions of physiology and/or behavior that reflected an unusual depth of understanding and clarity of expression. With special regard to temperature, a student who demonstrated an understanding that the activity curve was different from a temperature curve or that mammal physiology, unlike that of ectotherms, is typically insensitive to temperature could earn an elaboration point.

2. (b) **A maximum of 7 points**

**Hypothesis (1 point)**

The student was required to indicate that a CHANGE in the light (intensity, duration, wavelength) causes a CHANGE in the cycle of activity or biorhythm. There also could be a prediction of a change of light having no effect on the cycle of activity. Like the description of the curve above, the hypothesis statement had to be clearly distinguishable from the rest of the answer and not simply implied in another part of the response. The student may have failed to earn this point if the experiment he/she designed below clearly used a different light characteristic (independent variable), and/or produces a different result (dependent variable) from the ones indicated in his/her hypothesis.

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**Question 2 (cont'd.)**

**Experimental Design (5 points maximum)**

If the experimental design used a factor other than light for the independent variable, AND it satisfies AT LEAST THREE of the following standards, the answer was still allowed to earn 1 point total for this and the “Description of Results” section combined.

- 1 point** Specified an appropriate control group for comparison. In this control, the environmental conditions had to be very similar to the natural conditions in which you find the bombat population, and not simply placing them into the dark, etc.
- 1 point** Indicated that the independent variable (light) was manipulated. This was usually a change in light intensity or photoperiod.
- 1 point** Held confounding variables constant or indicated that all variables other than the independent variable are held constant. To earn the point for listing the variables being held constant, the student had to list at least two.
- 1 point** Verified results with reasonable sample size (at least two bombats in each group), and/or repeated trials. With repeated trials, the point was not awarded if the same bombat was used over and over.
- 1 point** “Measured,” “recorded,” etc. (using quantitative terminology) bombat activity levels (dependent variable). If the student used the verb “observe,” then some measurement activity had to be specified.
- 1 point** Included a mathematical and/or statistical comparison of control and experimental groups, or of observed and expected results. A specific kind of inferential statistic (chi square, t-test, etc.) did not need to be mentioned. A comparison of slopes of curves on a graph was also acceptable.

**Description of results (1 point)**

If the student had earned AT LEAST 3 POINTS in the *Experimental Design* section above, he/she became eligible for 1 point earned for a graph, data table and/or description of results **consistent** with the experimental design.

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**Question 3**

Points can be awarded for three categories: Structure/function, Description, and Adaptive value.

- 1 point awarded for correct structure **linked** to its function. Maximum is 6 points with only 1 point given per phylum per process.
- 1 point awarded for elaborate description of the structure if the related structure/function is correct and appropriate. This cannot be a **single word**. Maximum is 3 points.
- 1 point awarded for adaptive value **linked** to structure. This value should clearly establish a selective advantage. Maximum is 3 points.

**1 point maximum may be awarded** for natural selection being used throughout all phyla but it must still be coupled to a correct structure.

	<b>Process I</b>	<b>Process II</b>	<b>Elaborate</b>	<b>Adaptive Value</b>
			Description (I or II) <b>(3 points maximum)</b>	<b>(3 points maximum)</b>
<b>Cnidaria</b>	<b>1 point</b> Structure + Function	<b>1 point</b> Structure + Function	<b>1 point</b> (only with 1 point proper structure 1 point + function link)	<b>1 point</b> (only when 1 point linked with 1 point proper structure)
<b>Annelida</b>	<b>1 point</b> Structure + Function	<b>1 point</b> Structure + Function		
<b>Chordata</b>	<b>1 point</b> Structure + Function	<b>1 point</b> Structure + Function		

**TRANSPORT OF MATERIALS**

**(has to be a mover of nutrients, oxygen, wastes, hormones, gametes, chemicals)**

**Cnidarians**

<b>Structure</b>	<b>Function</b>	<b>Description</b>	<b>Adaptive Value</b> (tied to structure)
Molecular level Amebocytes/ gastrodermal cell	Undergo phagocytosis	Mobile cells found in mesoglea	Nutrient transport to body surface
GVC	Circulates water and nutrients	Fluid-filled/extends into tentacle/hollow cavity/digestive sac with one opening	* Importance of material transport
Circulatory canal	Connects all branches of canals, circulates gametes		* Maintain optimal concentration gradients, permits for larger body size and complexity
Cilia	Keeps fluids moving	Tiny hairs	

\* This represents an answer that can be connected to any structure(s) option.

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**Question 3 (cont'd)**

**Annelids**

<b>Structure</b>	<b>Function</b>	<b>Description</b>	<b>Adaptive Value (tied to structure)</b>
Molecular level Membranes – nephridia, typhlosole, capillary	Method of transport needs to be specific (diffusion/ facilitated/active)	Semi-permeable, transport proteins, elaborate description of structure	* Importance of material transport
System level – (mover must be named) circulatory digestive reproductive respiratory* <i>not to include same examples as in gas exchange</i>	Tissue or organ must have function related to material being transported Examples: aortic arch/pseudoheart, muscular activity, muscular contraction	Tissue or organ must be described to show how structure relates to function. Example, dorsal, ventral, segmental, conducting tubes, muscular, five pairs	* Maintain optimal concentration gradients, permits for larger body size and complexity

**Chordates**

<b>Structure</b>	<b>Function</b>	<b>Description</b>	<b>Adaptive Value (tied to structure)</b>
Molecular level Membranes – nephron, villi, capillary	Method of transport needs to be specific (diffusion/ facilitated/active)	Semi-permeable, transport proteins, elaborate description of structure	* Importance of material transport
System level- (mover must be named) circulatory digestive reproductive respiratory* <i>not to include same examples as in gas exchange</i> lymphatic excretory	Tissue or organ must have function related to material being transported Examples: pumping heart, peristalsis by muscular activity, diaphragm contracting, gular movement in frogs, uterine contractions, muscle contraction	Tissue or organ must be described to demonstrate how structure relates to function.	* Maintain optimal concentration gradients, permits for larger body size and complexity

\* This represents an answer that can be connected to any structure(s) option.

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**Question 3 (cont'd)**

**RESPONSE TO STIMULI**

**(detection, transmission, and/or effector) Two of these must be present.**

**Cnidarians**

<b>Structure</b>	<b>Function</b>	<b>Description</b>	<b>Adaptive Value</b>
Receptor	Detects stimulus and transmits	Must demonstrate how structure relates to function	Radial symmetry allows for multidirectional response/coordinated response
Nerve net/ ring	Detects stimulus and transmits or transmits + responds		
Contractile fiber/cell	Tentacle movement /body contraction		*Prey capture and defense
Nematocyte Cnidocyte Cnidoblast Nematocyst Stinging cell stinging tentacle	} Stings prey/toxic or poisonous, defense		

**Annelids**

<b>Structure</b>	<b>Function</b>	<b>Description</b>	<b>Adaptive Value</b>
Sensory receptor	Detects stimulus and transmits	Photo, tactile, chemo	*More complex behavior
Special segments	Integration/ transmission	Cephalized, anterior, or paired bundles of nerves	*Directed response
Ganglia/brain	Integration/ transmission	Rudimentary/primitive	Complex locomotion
Nerve cord	Segmental control	Ventral or paired bundles of nerves/segmented nerves	
Effector organ/ structure (gland, muscle, setae, reproductive)	Contraction/ movement/secretion	Proper description	

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**Question 3 (cont'd)**

**Chordates**

Structure	Function	Description	Adaptive Value
Sensory receptor	Detects stimulus and transmits	Photo, chemo, auditory, equilibrium, touch, tactile, olfactory	*Improved homeostasis
Spinal/nerve cord	Integration/transmission	Dorsal/hollow	*More complex behavior
Brain	Integration/transmission	Specialized regions/complex	*Directed response
Effectors	Contraction, movement, secretion	Proper description	

**GAS EXCHANGE (diffusion of oxygen and carbon dioxide)**

**Cnidarians**

Structure	Function	Description	Adaptive Value
Body wall/outer epithelium/epidermis or gastrovascular cavity (GVC)	Diffusion of O <sub>2</sub> and CO <sub>2</sub> / moving toward [ ↓ ]	2 layers thick Fluid-filled, continuous with outside water	*Increased surface area *Increased rate of exchange

**Annelids**

Structure	Function	Description	Adaptive Value
Skin/integument/epidermis/epithelium	Diffusion of O <sub>2</sub> and CO <sub>2</sub> / moving toward [ ↓ ]	Moist, thin, vascularized — <b>(MUST HAVE TWO)</b>	*Increased surface area
Parapodia	Diffusion of O <sub>2</sub> and CO <sub>2</sub> / moving toward [ ↓ ]	Must demonstrate understanding of how structure relates to function	*Increased oxygen/carbon dioxide exchange efficiency/rate of exchange
Gills	Diffusion of O <sub>2</sub> and CO <sub>2</sub> / moving toward [ ↓ ]	Must demonstrate understanding of how structure relates to function	
Hemoglobin/other respiratory pigment	Carries oxygen/carbon dioxide	Respiratory pigment/transport protein	

\* This represents an answer that can be connected to any structure(s) option.

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**Question 3 (cont'd)**

**Chordates**

<b>Structure</b>	<b>Function</b>	<b>Description</b>	<b>Adaptive Value</b>
Gills/ lamellae	Diffusion of O <sub>2</sub> +CO <sub>2</sub> / moving toward [ ↓ ] Countercurrent exchange	Must demonstrate understanding of how structure relates to function (example, sheet-like, flat, vascularized )	*Increased surface area
Modified swim bladder	Diffusion of O <sub>2</sub> +CO <sub>2</sub> / moving toward [ ↓ ]	Examples: sac pouch connected to pharynx	*Internalization to avoid dehydration/ damage
Skin (amphibian)	Diffusion of O <sub>2</sub> +CO <sub>2</sub> / moving toward [ ↓ ]	Examples: moist and vascularized	*Increased oxygen/ carbon dioxide exchange efficiency/ rate of exchange
Lung/alveoli	Diffusion of O <sub>2</sub> +CO <sub>2</sub> / moving toward [ ↓ ]	Examples: compartmentalized lung/ vascularized alveoli/ alveolar sacs/ membranous sac	
Avian supplemental air sacs	Diffusion/ moving toward [ ↓ ]		
Hemoglobin/ RBC	Carries oxygen/ carbon dioxide	Respiratory pigment/ transport protein	

\* This represents an answer that can be connected to any structure(s) option.

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**Question 3 (cont'd)**

**LOCOMOTION (move organism from point A to point B)**

**Cnidarians**

Structure	Function	Description	Adaptive Value
Hydrostatic skeleton with contractile fibers (muscles)	Contractile fibers/muscle acting on hydrostatic skeleton to move organism	Concept of hydrostatic	*Expands food gathering options, avoidance, promotes gene flow
GVC	Contractile fibers/muscle acting on hydrostatic skeleton to move organism	Fluid-filled cavity	
Contractile fibers/muscle	Tumbling, somersaulting, looping, floating (with explanation)		
Cilia on larvae (planulae)	Swimming	Tiny hair-like	Dispersion

**Annelids**

Structure	Function	Description	Adaptive Value
Hydrostatic skeletal/coelom with muscles <b>OR</b> muscles + fluid-filled cavity	Contractions allow for shortening/lengthening of body Directed movement	Concept of hydrostatic Longitudinal, circular, segmental	*Oriented response
Skin	Mucous aids in movement	Mucous used as a lubricant	*Food gathering, improved mobility
Suckers	Anchoring		
Setae, Parapodia, lateral flaps	Pushing, burrowing, anchoring, acting against resistance	Bristles, flap-like, paddle-like	
Cilia on larva (trochophore)	Swimming	Tiny hair-like	Dispersion, predator avoidance

\* This represents an answer that can be connected to any structure(s) option.

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**Question 3 (cont'd)**

**Chordates**

<b>Structure</b>	<b>Function</b>	<b>Description</b>	<b>Adaptive Value</b>
Skeleton and muscles	Movement associated with muscle contraction	Muscles attached to bone/endoskeleton, cartilage	*Efficient, predator/prey interaction, food gathering  *Promotes gene flow, sexual selection, habitat selection

\* This represents an answer that can be connected to any structure(s) option.

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**Question 4**

4. (a) **3 points maximum**

- 1 point** correct orientation with dependent variable (concentration) on y (vertical) axis and independent variable (time) on x (horizontal) axis
- 1 point** correct axes labels with units **and** scaling for 5% line on axes provided
- 1 point** correct plotting of all data points including zero (0,0); line is not necessary but if drawn must not extend beyond last data point; dashing line beyond last data point is okay; arrow at end of line is okay

4. (b) **4 points maximum**

- 1 point** correct prediction and legend (or label) for 0%, 1%, **and** 10% lines (0% line flat, 1% line below 5% line, 10% line above 5% line)

*Explanation points*

- 1 point** correct explanation for 0% line (e.g., since there is no NaCl in the bag no Na<sup>+</sup>Cl<sup>-</sup> can diffuse into the water in the beaker)
- 1 point** correct explanation for 1% line — must include a discussion of rate; connects concentration of NaCl with diffusion rate
- 1 point** correct explanation for 10% line — must include a discussion of rate; connects concentration of NaCl with diffusion rate

**or**

- 1 point** general explanation that solute concentration affects the rate of diffusion; answers that attempt to explain the 0%, 1% or 10 % NaCl lines are not eligible to receive this point

4. (c) **4 points maximum**

- 1 point** statement that water will leave the plant **and** description of effect this has on plant cell (e.g., loss of turgor, plasmolysis, decrease in cell volume, decrease in central vacuole volume)
- 1 point** concept of osmosis (e.g., movement of water across a selectively permeable membrane (cell or cell membrane) from solution with lower solute concentration (hypotonic) to solution with higher solute concentration (hypertonic))
- 1 point** explanation that water moves from solution with higher (more positive/less negative) water potential ( $\psi$ ) to solution with lower (more negative) water potential ( $\psi$ )
- 1 point** explanation of how water loss can cause decreased crop production (e.g., stomates close, transpiration stops, photosynthesis stops, decreased metabolism)