AP® BIOLOGY
2008 SCORING GUIDELINES (Form B)

Question 2

2. Many biological structures are composed of smaller units assembled into more complex structures having functions based on their structural organization.

   For THREE of the following complex structures, describe the smaller units, their assembly into the larger structures, and one major function of these larger, organized structures.

   For each:

Unit Structure (with description)	**Organization/Assembly**	**Function/Benefit**
1 point	**2 points maximum* (*1 may be general, second specific to larger structure)**	**1 point maximum**

Structures → Emergent properties **(4 points maximum each, only grade first 3)**

(a) A eukaryotic chromosome

Unit Structure—Organization/Assembly (must demonstrate organization to a chromosome):

- Describe nucleotides (or later structure in the sequence)
  → DNA → nucleosomes* → chromosome
  *around histones (non-DNA)
- Describe levels of folding
  → heterochromatin → condensed chromosome
- Describe DNA (or later structure in the sequence)
  → functional sequences (introns/exons/spacers) → genes → regulatory elements → chromosome

Function/Benefit:

- Package DNA
- Make for efficient cell division
- Juxtaposition of coding elements
- Gene regulation
- Storage/protection of genetic information

(b) A mature angiosperm root

Unit Structure—Organization/Assembly (must demonstrate organization to a functional root):

- Describe organelles (or later structure in the sequence)
  → cells → tissues→ layer → root

Function/Benefit:

- Storage
- Transport H_2O (absorption only via root hairs)
- Symbiotic relationships
- Secondary growth

Question 2 (continued)

- Anchorage
- Mineral uptake

(c) A colony of bees

Unit Structure—Organization/Assembly (must demonstrate organization to a colony):
- Individual bee (or component later in sequence) (this is usually the unit)
- → organization into castes (workers, drones, queen) → colony
- Elaboration on roles of castes

Function/Benefit:
- Survival of colony—specialization maintains colonial "homeostasis"
- Preservation of genetic makeup through altruism
- Communication for food/enemies
- Role in ecosystem, e.g., pollination

(d) An inner membrane of a mitochondrion

Unit Structure—Organization/Assembly (must demonstrate organization to inner membrane):
- Phospholipids and proteins (or component later in sequence)—describe at least one
- → organization of proteins (specific respiratory molecules together) → folding → membrane (cristae must be uniquely mitochondrial)

Function/Benefit:
- Impermeable to H+ forming gradient
- Proximity of Kreb's Cycle to the membrane
- Electron transport

(e) An enzyme

Unit Structure—Organization/Assembly (must demonstrate organization to enzyme):
- Amino acid (or component later in the sequence) described
- → polypep (1° structure, etc.) → protein + modification
- Uniquely enzymatic modifications: cofactor/coenzyme/prosthetic group/allosteric modulators

Function/Benefit:
- R-group interactions forming active site
- Lowers activation energy
- Increases reaction rate (cannot simply say "catalyzes reactions")

2. Many biological structures are composed of smaller units assembled into more complex structures having functions based on their structural organization. 2A1

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(b) A mature angiosperm root

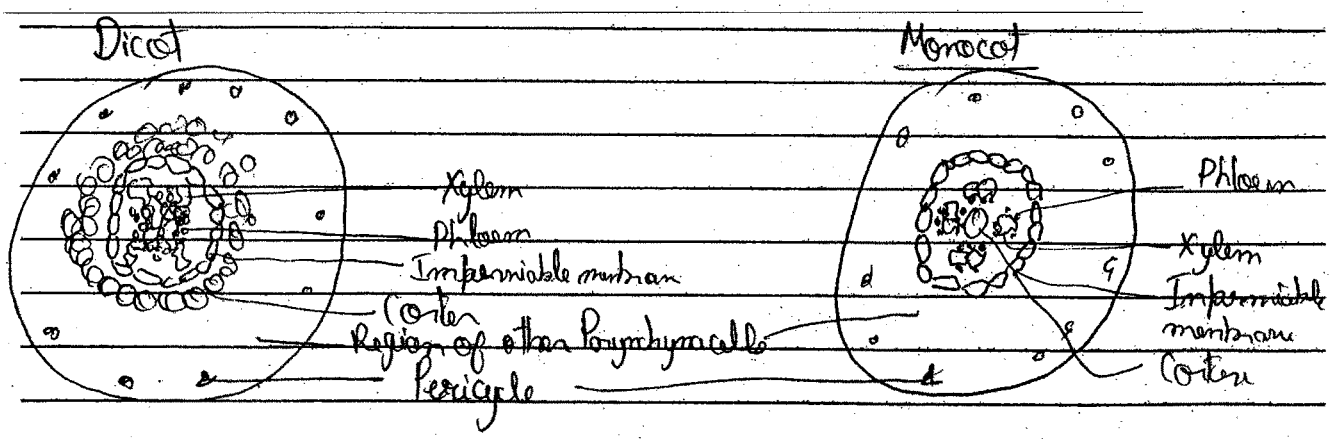
(c) A colony of bees

(d) An inner membrane of a mitochondrion

(e) An enzyme

b) A mature angiosperm root:

Angiosperms can either be dicots or monocots. Their root differes in both kinds, but they are primarily made of same ~~complex~~ smaller units. The root contains phloem, xylem, epidermis cells, a water impermiable membrane, cortex and parenchyma cells. The xylem is made up of tracheids and vessels which take part in the transport of water and minerals from the root to the plant. The phloem consists of sieve-tubes and companion cells and are responsible for the transport of food molecules like starch. Since it is the root it will have more xylem functioning. Root hairs absorb the water and can send to the xylem through apoplast or symplast and the transpiration of water helps in pulling it upward. The xylem cells are dead cells.



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d) An inner membrane of mitochondria

The inner membrane is made up of phospholipids and filled with many proteins making the cytochrome complexes for the electron transport chain which leads to the production of ATP. The phospholipids are made of two non-polar lipid tails and a polar hydrophyllic phosphate head. The form a structure like ⁂. They have two layers giving it the name bilayer. These phospholipids are semi permeable and form membranes of the mitochondria. The phopholipid contains of many other proteins such as ATP synthase. This helps in production of ATP when $2H^+$ join $\frac{1}{2} O_2$ to form H_2O. The large surface area of the membrane of mitochondria also help keep the proton gradient and a long electron transport chain.

e) An enzyme

They are made of long polypeptide chains of amino acids. Their smaller units are amino acids. AA's sequences on the DNA store all genetic information. The AA is made of a carboxyl group, an "R" group, a central carbon atom and an amine group (NH_2). The undergo condensation / dehydration reaction to form a bond between another amino acid forming a peptide bond. Long chains of these are called polypeptide chains or proteins. Enzymes are a kind of proteins which act as catalyst and speed up chemical reaction without actually taking part in the reaction. They have a binding side called the active site where the substrate binds and the enzyme carries out the reaction faster than it would naturally occur.

2. Many biological structures are composed of smaller units assembled into more complex structures having functions based on their structural organization.

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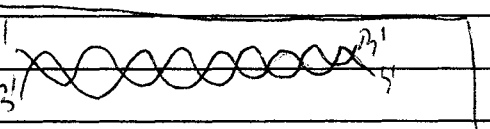
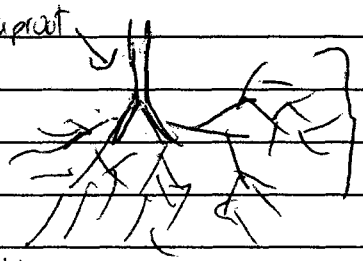
A eukaryotic chromosome is a highly compressed strand of DNA. ~~During~~ Before cell division (mitosis) the DNA is folded and compressed into chromosomes to maximize efficiency. DNA is made out of a very long sequence of nucleotides. There are 4 nucleotides: A, C, T and G. A strand of DNA has two ends 5' and 3'. DNA is double stranded, meaning two threads are intertwined, these are complementary. 5' is complementary to 3' and A and C are complementary to T and G respectively.

e.g. 5'-AGTACCTAG-3' ⇒ 3'  3' 5'
3'-TCATGGATC-5' 5'

DNA contains coding for proteins produced in the body. All of these can have effects on body build, hair color, metabolism, character, ... It determines the genetic build up of a being.

A mature root of an angiosperm (flowering plant) has one large main root, the taproot and many smaller branches.



The surface of the root is covered by tiny, almost hair like

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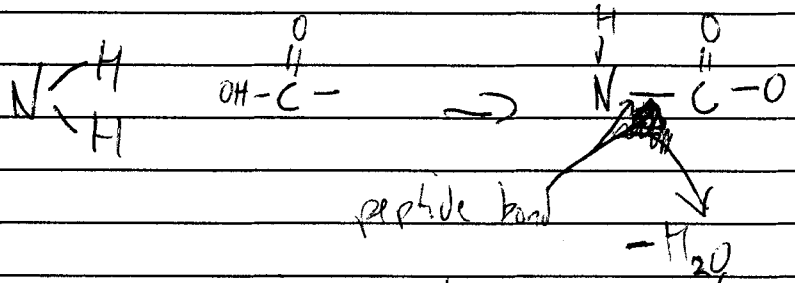
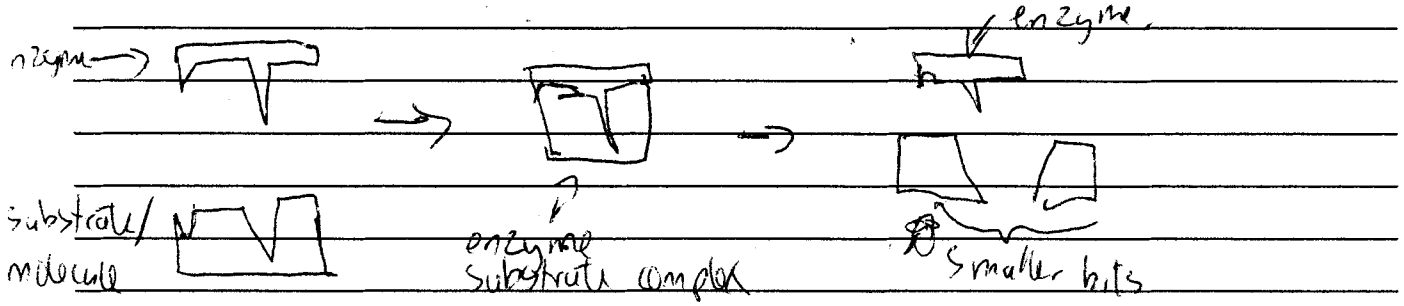
ADDITIONAL PAGE FOR ANSWERING QUESTION 2

coverings. These maximize the surface area so that more water and nutrients can be absorbed. Sometimes fungi and plants form mycorrhizae. This is when a fungus covers the roots of a plant, improving its ability to absorb water and nutrients, in return the fungus takes some photosynthetic products from the plant.

An enzyme is built up from proteins, which are built out of amino acids. Amino acids have two ends one containing a $-NH_2$ group and one containing a $-COOH$ group. They can be bonded together through a peptide bond. In the process one molecule of water is produced.



A protein is a polypeptide, a large chain of amino acids. It can contain any number and order of the 20 amino acids, ~~an almost endless~~ there is an almost endless amount of possibilities. Enzymes are special proteins that have a catalytic function to break down other molecules. They bind with other molecules forming an enzyme substrate complex, break the bond and break down the molecule into smaller bits.



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   (d) An inner membrane of a mitochondrion

   (e) An enzyme

a) A eukaryotic chromosone: ~~Smaller unit: Chromatid~~

~~Smaller unit: 2 sister chromatid~~

Their smaller units are sister chromatids and they assemble into the genetic information of DNA (deoxyribose nucleic acid) and ~~their function: to contain the genetic material for the cell's DNA~~. the function of DNA is to house the genetic material for the cell.

e) An enzyme:

An example of an enzyme is one that is found in the saliva, that breaks down starch into Amylase

2C2

~~e) An enzyme's~~

~~Their shape~~

~~They assemble into the enzyme amylase, which breaks~~

e

AP® BIOLOGY
2008 SCORING COMMENTARY (Form B)

Question 2

Sample: 2A
Score: 10

Part (b) earned 3 of 4 possible points. The student identifies and describes smaller units and also correctly describes the function of the whole root in "transport of water and minerals from the roots to the plant." The description of xylem tracheids and vessels weakly earned an organization/assembly point for connecting different levels of organization. The diagram would have earned the organization point if the student had referred to the diagram within the text or explained rather than just labeling it. Standalone diagrams cannot earn points.

Part (d) earned all 4 possible points. The student initially defines the smaller unit, "phospholipids," and later describes that unit as "made of two non-polar lipid tails." The student earned the organization point by describing membrane proteins of the electron transport chain. The student earned the other organization/assembly point by describing the ATP synthase and the emergent property of the proton gradient produced by the membrane. The student earned the function point for correctly describing production of ATP.

Part (e) earned 3 of 4 possible points. The smaller unit is described as "chains of amino acids." The organization/assembly point was earned through the description of the chemical construction of an amino acid. The description of the active site is not sufficient for the second organization point without a correct description of allosteric modulation or competitive/noncompetitive modulators, which would be considered an elaboration point. The function point was earned for the phrase "act as [a] catalyst and speed up chemical reactions." Using the term catalyst was not sufficient to earn that point, but the addition of increasing reaction rate and lowering activation energy required for reactions was acceptable.

Sample: 2B
Score: 5

Part (a) earned 3 of 4 possible points. The student identifies a smaller unit of a chromosome as DNA and describes it as a "compressed strand," earning the unit point. The student describes strands of DNA, earning the organization point, and correctly describes a function of a chromosome as "contains coding for proteins."

Part (b) earned 1 of 4 possible points. The function of "water and nutrients can be absorbed" is sufficient for the function of the entire root. The student does not address multiple levels of organization within the root.

Part (e) earned 1 point for describing the smaller unit of the protein, the amino acid. The student did not earn the function point because the explanation of "catalytic function to break down other molecules" is not correct.

Sample: 2C
Score: 1

Part (a) earned 1 of 4 possible points for correctly identifying the function of a chromosome as housing genetic material. The student identifies the smaller unit of the chromosome but does not describe that smaller unit.

No points were earned in part (c) because the question did not ask for examples of enzymes.