AP® Biology
2002 Sample Student Responses

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3. The complexity of structure and function varies widely across the animal kingdom. Despite this variation, animals exhibit common processes. These include the following.

- transport of materials
- response to stimuli
- gas exchange
- locomotion

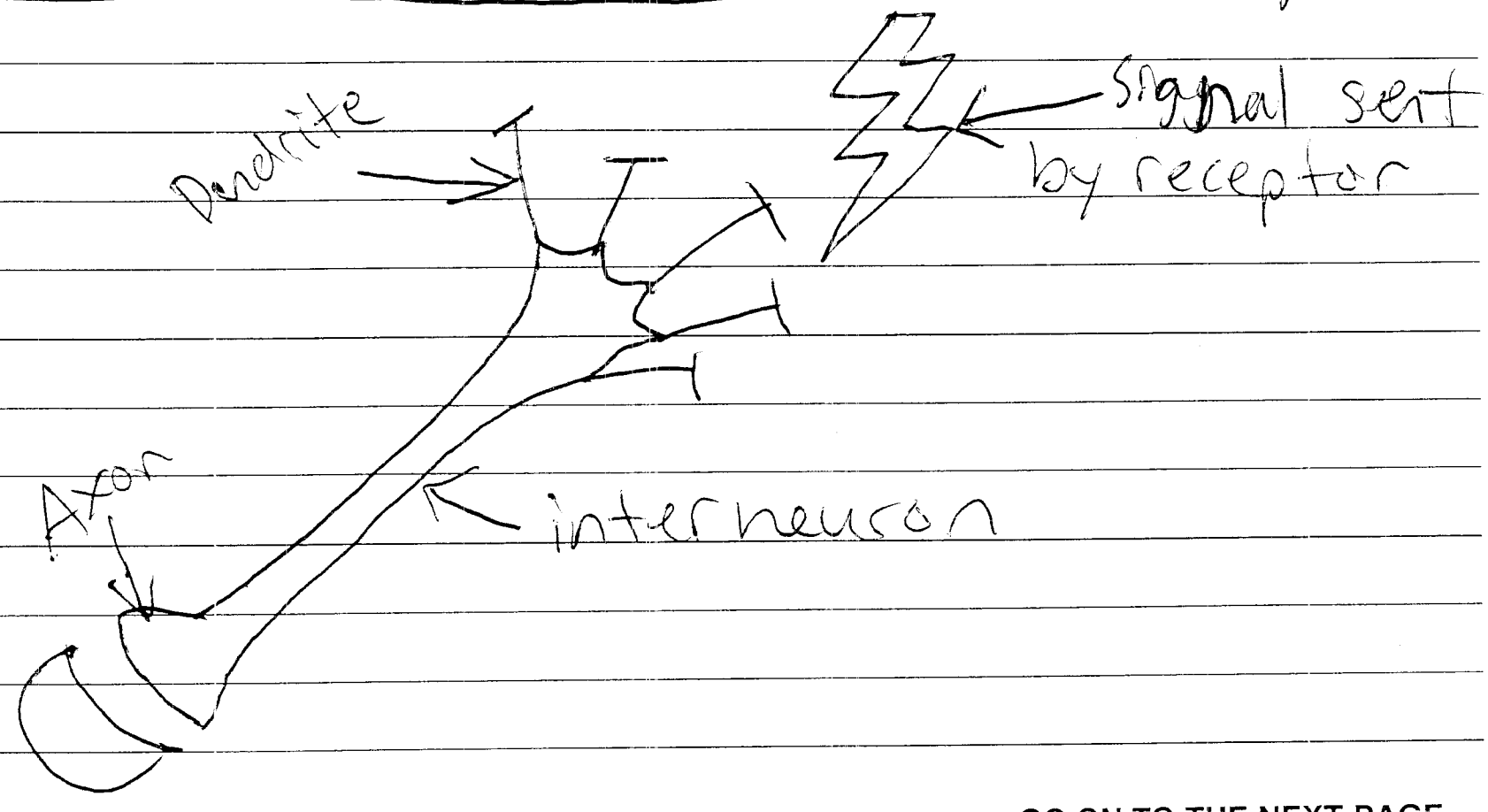
(a) Choose **two** of the processes above and for each, describe the relevant structures and how they function to accomplish the process in the following phyla.

Cnidaria (e.g., hydra, jellyfish)
Annelida (e.g., earthworm)
Chordata (e.g., mouse)

(b) Explain the adaptive (evolutionary) value(s) of the structural examples you described in part a.

a)

• The structure that responds to a stimuli includes receptors, sensory neurons, associated neurons, motor neurons, and ~~recep~~ effectors. The long nerve cells have feelers called dendrites on one end and axons on the other. These are to recieve and pass the message sent by the receptor. The nerve cells are a long chain that passes electrical currents to initiate responses.



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- In Cnidaria the tentacle have receptors that pick up something touching it. Immediately the jelly fish would respond by sending a poisonous sting through the stingers of the tentacles
- In Annelida, such as an earthworm, they have bristles that contain receptors and neurons and when something comes in contact with it the message is sent to the brain by nerves and is interpreted and sent back down with a response on how to react depending on pleasure or pain stimulus.
- In a Chordata, such as a human, receptors pick up a stimulus and carries it either to the brain or the spinal cord. The message is sent back to either interpretted or not but depending on pain or pleasure the response would be to move away or get closer to the stimulus.
- The structure for locomotion differs in Cnidaria, Annelida, and chordata. For a Cnidarian such as a jelly fish, water is used to propell them through the water. They contract their two levels of tissue to force a jetstream of water out of their ventral opening
- In an Annelida, suchas an earthworm, the

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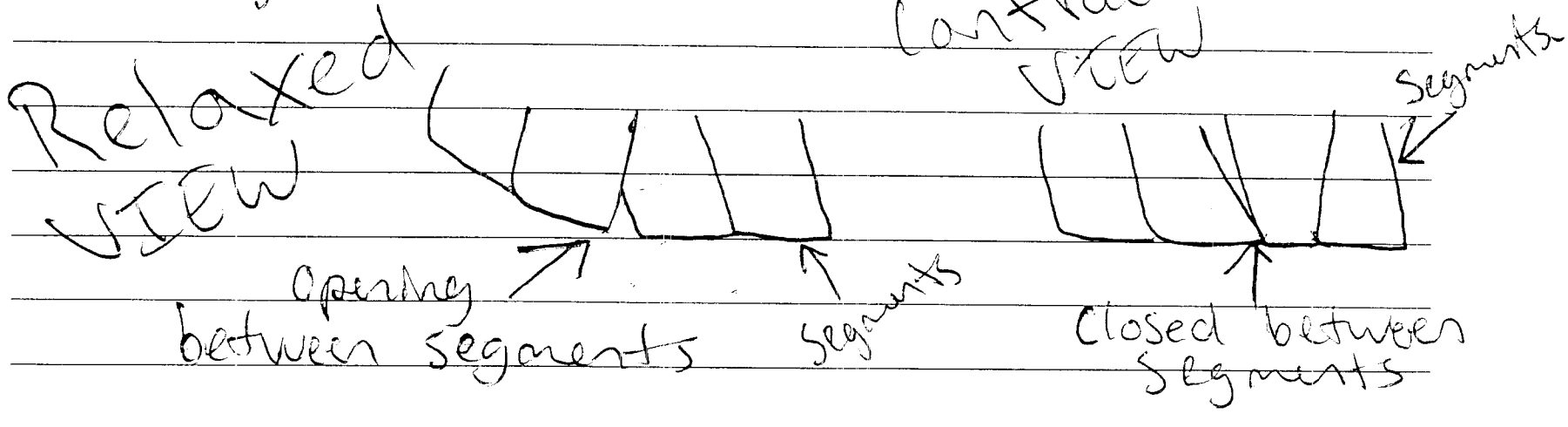
body segments and bristles are used to pull the worm along the surface. Inside the segments muscle is lined to contract the segments.



The opening consumes surface area and as the segments contract, the pulling together of segments pulls the worm across the ground.

In a chordata, such as a human, Muscles, ligaments, tendons, and bone are used for locomotion. Humans have bone to which tendons attach to it and to muscle. Ligaments attach muscle to muscle. Muscles contract pulling bone, which is linked by joints

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(a) Gas exchange is common throughout ~~Cnidaria~~ Annelida and Chordata in that they all require oxygen to carry out oxidative respiration. In Cnidaria, which are all aquatic animals, gas exchange takes place directly between the water and the outer epithelia or body tissues of the animals. This process is similar to that in ~~the platyhelminthes~~ annelida. ~~The earthworm~~ In the earthworm, gas ~~is~~ is exchanged through the ~~skin~~ epidermis and outer epithelium. Phylum Chordata however, exhibits a wide variety of gas exchange. Fish for instance exchange gas through their gills which through counter-current flow and diffusion, ~~take~~ take up ~~oxygen~~ oxygen dissolved in the water. Certain Amphibians such as frogs, ~~have~~ have lungs as well as the ability to carry out gas exchange through their skin. Other chordates rely solely on lungs for gas exchange including all mammals and more specialized in birds, Lungs are sacs

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comprised of alveoli through which oxygen can diffuse into surrounding ~~blood~~ capillaries and gases such as carbon dioxide can diffuse from the blood out into the lungs and into open atmosphere.

Locomotion, like gas exchange, is also characteristic of Cnidaria, Annelida, ~~Chor~~ and Chordata. Cnidaria are least specialized in this aspect. Mostly carried by the currents of the ocean, some however, such as the medusa form of the jellyfish, can propel themselves through water through a contraction of their parachute shaped bodies. Annelida, such as the earthworm are able to move by muscle contractions. ~~and~~ The earthworm in addition has specialized bristles, or Setae, which help it move through dirt and grip to surfaces. In phylum Chordata, there is the widest variety of ways in which ~~members of the phylum move~~ animals move. The defining characteristic however of animals in phylum chordata is the implementation of a muscle-skeletal system in which ~~the animals~~ most of the animals have a skeletal system to which muscles are attached. Through contraction and relaxation, these muscles move the bones and therefore move the animal. This basic form however is manifested in a number of ways such as ~~through~~ the flight of birds, swimming of fish, and walking of humans.

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(b) In gas exchange, the evolutionary examples are more striking in the phylum Chordata. ~~Lungs the alveoli of lungs~~ The gills of fish are the most efficient of all animal structures in facilitating gas exchange ~~through counter current flow through counter current flow~~ through because of their counter-current flow. The alveoli of the lungs help to increase the surface area through which gases can be exchanged between the air and capillaries. Likewise they reduce the amount of moisture lost to the atmosphere by internalizing the gas exchange process.

In locomotion there is a progression that can be seen in structural complexity and evolutionary advantage between Cnidaria, Annelida, and Chordata. The movement of Cnidaria is controlled mainly by water currents so they do not move efficiently to areas where there is food. Annelids are slightly more advanced in that they control their own movement through muscles. The setae also aid in their movement. Chordates are most specialized in movement and are the most apt at finding their food. Birds are able to fly with wings and are able to move quickly to catch and avoid prey. Cheetahs, for example, are able to move quickly with their legs and are more able to find prey than a slower animal.

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Chordates in general have more complex sensory systems which allow them to utilize their abilities for locomotion more efficiently.

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(b) Explain the adaptive (evolutionary) value(s) of the structural examples you described in part a.

a) Cnidaria achieve transport of material through their gastrovascular cavities, body openings in which foods and nutrients are taken up and absorbed and wastes are expelled, all through the same orifice. Those needed materials can then be distributed to the cnidarian's cells by diffusion, since their body walls can be only two cells thick. The high amount of surface area exposed to the environment and the thinness of the body streamline the transport process, obviating the need for highly specialized structures when much useful work can be done simply by diffusion.

Annelids like the earthworm possess closed circulatory systems that run throughout their segments in ring-like structures that distribute materials throughout the circumference of each segment. The blood is propelled by a dorsal heart, and carries both nutrients and oxygen, which are taken up by their destination cells through diffuse across the walls of the blood vessels and through the interstitial fluid. The epidermis itself acts as a respiratory surface, its thin, moist epithelium facilitating the direct ~~diffusion~~ diffusion of CO_2 out of the blood vessels and O_2 into the blood vessels. The surface vessels then carry their oxygenated ~~payload~~ payload throughout the body cells. The vessels are ~~the~~ thus the structure

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upon which both gas exchange and materials transport depend, though gas exchange is also dependent upon the epithelium of the skin.

Chordata also transport materials throughout their bodies using closed circulatory systems, but their hearts are more structurally sophisticated, separating blood reception to the atria and blood pumping to the ventricles. The vessel system is necessarily more complex, owing to the greater body size of many chordates. In chordates, unlike cnidarians and annelids, gas exchange is more thoroughly decoupled from materials transport. Lungs or gills pass oxygenated air or water over a thin, moist epithelium, which allows diffusion into the interstitial space and then into the blood vessels, a similar high-level mechanism as in the other phyla but one more dependent on the surface area and specialized structures of unique respiratory organs.

b) The gastrovascular cavity that facilitates both gas exchange and materials transport in cnidarians is an adaption cnidarians' aquatic environment. When needed nutrients, food sources, and gases are readily available present in dissolved form in the environment, it makes little sense to evolve complex transport and exchange systems. Simply maximizing surface area with a thin-walled body and large, two-sided cavity allows for the most efficient absorption and excretion.

Annelids require more specialized, closed circulatory systems for materials transport because they are terrestrial. Not constantly bathed in aqueous solution where many substances are in dissolved form, they cannot rely solely on diffusion to move materials throughout their bodies. A circulatory system must take on the function of transport - diffusion

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alone would be prohibitively slow, and the body's extremities would essentially starve from the inefficiency. However, since annelids still have relatively high surface area-to-volume ratios, ~~the~~ their skin still suffices as a gas exchange organ and is efficient enough to not require separate respiratory structures. The circulatory system is ~~a~~ a valuable adaptation because it insures proper materials distribution throughout the body in the absence of an aqueous environment, but the skin is adaptive in the sense that further specialization would be a waste of scarce resources. The relatively unspecialized skin suffices in gas exchange as adaptation enough.

Chordates, however, have far-lower surface-area-to-volume ratios than annelids, and therefore their skins are not extensive enough to service the entire body in gas exchange. Thus the lungs and gills evolved, with their complexly branched/folded alveoli and lammellae, which allow for ~~in~~ the maximization of surface area & as a platform for gas exchange that the skin cannot provide. By evolving specialized structures for gas exchange, chordates could free themselves from tube-like, high-surface-area body plans and gain the body volume necessary for greater complexity. This complexity and specialization in turn allowed them to better exploit their environs. Meanwhile, the continued to ~~sup~~ advance and improve upon the type of circulatory system found in annelids, insuring that materials would find their way through all regions of the body and that the new, larger, more complex body plans could nutritionally and metabolically sustain themselves.