

# AP<sup>®</sup> BIOLOGY

## 2012 SCORING GUIDELINES

### Question 1

*Note:* At least 1 point must be earned from each of parts (a), (b), (c), and (d) in order to earn a maximum score of 10.

The ability to reproduce is a characteristic of life.

- (a) **Describe** the process of embryological development in a typical vertebrate embryo, beginning with a fertilized egg and ending with the development of three tissue layers.  
(4 points maximum)

| Embryological process                   | Description of embryological process (1 point per box)  |
|---|---|
| Fertilization                           | <ul style="list-style-type: none"> <li>• Egg is fertilized by <b>sperm</b>.</li> <li>• Zygote is formed.</li> <li>• Polyspermy is blocked.</li> <li>• Diploid number of chromosomes is restored.</li> <li>• Nuclei of egg and sperm fuse.</li> <li>• Sex of offspring is determined.</li> <li>• Polarity is determined.</li> </ul>          |
| Cleavage<br>(can occur in other stages) | <ul style="list-style-type: none"> <li>• Rapid cell divisions.</li> <li>• Cell divisions without cell growth.</li> <li>• Cleavage divisions form a small, <b>solid</b> ball of cells (morula).</li> <li>• Rapid DNA replications and mitotic divisions occur.</li> <li>• Cells get smaller in early cleavage with each division.</li> </ul> |
| Blastulation                            | <ul style="list-style-type: none"> <li>• Cleavage divisions form a <b>hollow</b> ball of cells surrounding a fluid-filled cavity.</li> <li>• Room for germ layers is developed.</li> </ul>  |
| Gastrulation                            | <ul style="list-style-type: none"> <li>• Germ cell layers (ectoderm, endoderm, and mesoderm) are established.</li> <li>• Opening called a blastopore forms.</li> <li>• Cells near the surface of the blastula reorganize and move to an interior location.</li> <li>• Primitive digestive gut (archenteron) forms.</li> </ul>               |

- (b) **Identify** the developmental origin of TWO of the following tissues in vertebrates:

- central nervous system
- digestive system
- muscle

(2 points maximum)

| Tissue                 | Identification of developmental origin (1 point per box)   |
|------------------------|--|
| Central nervous system | <ul style="list-style-type: none"> <li>• Ectoderm / outer germ layer</li> </ul>  |
| Digestive system       | <ul style="list-style-type: none"> <li>• Endoderm / inner germ layer (lining)</li> <li>• Mesoderm / middle germ layer (other layers of digestive tract)</li> </ul> |
| Muscle                 | <ul style="list-style-type: none"> <li>• Mesoderm / middle germ layer</li> </ul>   |

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**Question 1 (continued)**

- (c) **Identify** and **explain** THREE differences between the embryological development of protostomes and the embryological development of deuterostomes.  
(3 points maximum)

| <b>Developmental differences:<br/>protostomes vs. deuterostomes</b> | <b>Explanation (1 point per box)</b>   |
|---|--|
| Pattern of cleavage   | <ul style="list-style-type: none"> <li>• Patterns of cleavage occur along different planes.</li> <li>• Spiral (diagonal planes in protostomes).</li> <li>• Radial (parallel/perpendicular in deuterostomes).</li> </ul>                                      |
| Determination of cell fate  | <ul style="list-style-type: none"> <li>• Determination of cell fate occurs in different developmental stages.</li> <li>• Early determination in protostomes (determinate).</li> <li>• Late determination in deuterostomes (indeterminate).</li> </ul>        |
| Blastopore fate   | <ul style="list-style-type: none"> <li>• Blastopore fate differs.</li> <li>• Mouth forms first; anus forms second in protostomes.</li> <li>• Anus forms first; mouth forms second in deuterostomes.</li> </ul>   |
| Coelom formation  | <ul style="list-style-type: none"> <li>• Coelom formation from mesoderm occurs by different processes.</li> <li>• Coelom forms from splitting of mesoderm in protostomes.</li> <li>• Coelom forms from outpocketing of mesoderm in deuterostomes.</li> </ul> |

- (d) **Explain** TWO unique properties of human embryonic stem cells that distinguish them from other human cell types. **Describe** a current medical application of human stem cell research.  
(3 points maximum)

| <b>Unique properties</b> | <b>Explanation (1 point per box; 2 points maximum)</b>   |
|--------------------------|--|
|                          | <ul style="list-style-type: none"> <li>• Totipotent: can become any type of cell, tissue, organ, or entire organism.</li> <li>• Pluripotent: can become many types of cells, tissues, or organs.</li> <li>• Undifferentiated: has the ability to follow any <b>differentiation</b> pathway.</li> </ul> |
|                          | <ul style="list-style-type: none"> <li>• Unspecialized: can give rise to <b>specialized</b> cell types.</li> </ul>   |
|                          | <ul style="list-style-type: none"> <li>• Infinite reproduction: no restriction on cell types.</li> </ul>   |
|                          |  |

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**Question 1 (continued)**

**Description of a current medical application (1 point maximum)**

Acceptable responses include, but are not limited to, the following:

- Repair of brain and spinal tissues.
- Treatment of diseases such as leukemia, stroke, Alzheimer's, Parkinson's, diabetes, cystic fibrosis.
- Therapeutic cloning of human cells, tissues, and certain organs (e.g., bone, cartilage, muscle).
- Reprogramming of diseased cells.
- Testing of new drugs.
- Storage of umbilical cord stem cells.

**BIOLOGY**  
**SECTION II**  
**Time—1 hour and 30 minutes**

1A1

**Directions:** Answer all questions.

Answers must be in essay form. Outline form is not acceptable. Labeled diagrams may be used to supplement discussion, but in no case will a diagram alone suffice. It is important that you read each question completely before you begin to write. Write all your answers on the pages following the questions in this booklet.

1. The ability to reproduce is a characteristic of life.

- (a) **Describe** the process of embryological development in a typical vertebrate embryo, beginning with a fertilized egg and ending with the development of three tissue layers.
- (b) **Identify** the developmental origin of TWO of the following tissues in vertebrates:
- central nervous system *ectoderm*
  - digestive system *endoderm?*
  - muscle *mesoderm?*
- (c) **Identify and explain** THREE differences between the embryological development of protostomes and the embryological development of deuterostomes.
- (d) **Explain** TWO unique properties of human embryonic stem cells that distinguish them from other human cell types. **Describe** a current medical application of human stem cell research.

a) A fertilized egg, or zygote, results from the fusion of a male and female gamete. The zygote is diploid. After fertilization, the zygote undergoes a series of mitotic divisions in a stage called cleavage. After cleavage, the group of cells becomes a hollow ball known as a blastula. During gastrulation, the group of cells fold in on each other to make the gastrula. At this stage, the gastrula forms the three tissue layers: ectoderm, mesoderm, and endoderm.

b) The central nervous system (CNS) is derived from the ectoderm, along w/ skin and eyes. The digestive system mainly develops from the endoderm, while muscles, bones,

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and almost everything else derive from the mesoderm.

c) In protostomes, cleavage ~~forms~~ occurs in a spiral-like formation. Early in development, the cells of a protostome are already determined, meaning they can only give rise to cells that are destined to be a certain part of the body. In protostomes, the mesoderm splits and forms two ~~masses on opposite~~ distinct masses in early development. Deuterostomes differ in that cleavage occurs and forms an equally distributed mass of cells, unlike a spiral. The cells of a deuterostome in development are not determined early on, meaning that any cell can give rise to a complete organism. And instead of the mesoderm splitting in protostome development, the mesoderm does not split in deuterostome development.

d) Human embryonic stem cells are undetermined, so they can become any type of cell the body needs. This also means that early on ~~in~~ in embryonic development a cell that is removed from the embryonic group can result in a complete organism, like mentioned above w/ deuterostomes. A current medical application of human stem cell research is using bone marrow cells to help leukemia patients. Bone marrow cells can give rise to any type of erythrocyte, leukocyte,

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1A3

or lymphocyte. This is very helpful for people w/ leukemia who have cancerous bone marrow. Stem cells from healthy bone marrow are being placed in the bone marrow of leukemia patients to see if this helps with their condition.

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**BIOLOGY**  
**SECTION II**  
Time—1 hour and 30 minutes

1 B<sub>1</sub>

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- (a) **Describe** the process of embryological development in a typical vertebrate embryo, beginning with a fertilized egg and ending with the development of three tissue layers.
- (b) **Identify** the developmental origin of TWO of the following tissues in vertebrates:
- central nervous system
  - digestive system
  - muscle
- (c) **Identify** and **explain** THREE differences between the embryological development of protostomes and the embryological development of deuterostomes.
- (d) **Explain** TWO unique properties of human embryonic stem cells that distinguish them from other human cell types. **Describe** a current medical application of human stem cell research.

a. In embryological development first comes a fertilized egg. That fertilized egg then undergoes mitosis and continues to divide into a blastula. The blastula then keeps dividing and forms a gastrula. In the gastrula stage three tissue layers are formed. These tissue layers are the endoderm, mesoderm, and ectoderm. The endoderm is the most inner tissue layer, the mesoderm is in the middle, while the ectoderm is the outer tissue layer.

b. The digestive system is eventually formed from the endoderm. Muscles form from the middle tissue layer, the mesoderm.

c. Protostomes and deuterostomes have a few differences in their embryological development. First, the indent that begins to form in the blastula stage becomes the mouth in protostomes, while in deuterostomes it becomes the anus. Second, protostome cells begin specializing much earlier than deuterostome cells do. Finally, protostomes normally don't take as long to

develop as deuterostomes do.

d. Human embryonic stem cells have their own unique properties and are much different than other cells. First of all, they divide much faster than regular human cells. Secondly, embryonic stem cells are not specialized. This means they can develop into any type of cell. This is helpful in the medical world because stem cells can be used to replace brain cells, since brain cells are unable to divide.

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**BIOLOGY**  
**SECTION II**  
Time—1 hour and 30 minutes

1 C<sub>1</sub>

**Directions:** Answer all questions.

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- central nervous system
  - digestive system
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- (c) **Identify and explain** THREE differences between the embryological development of protostomes and the embryological development of deuterostomes.
- (d) **Explain** TWO unique properties of human embryonic stem cells that distinguish them from other human cell types. **Describe** a current medical application of human stem cell research.

After an egg is fertilized ~~and~~ it starts to develop as an embryo. The embryo begins to grow and receive nutrients from the amniotic sac. Three types of tissue ~~begin~~ <sup>begin</sup> to develop. The mesoderm, the ectoderm, and the endoderm. The mesoderm become muscle tissue. The ectoderm becomes the central nervous system. Human stem cells are cells that haven't received a job for what function they are to ~~perform~~ perform yet. These make the cells unique in a way that ~~the~~ certain genes can be turned on in them and the cells can adapt to become any type of cell. A current medical application of human stem cell research is to use the cells ~~from embryos~~ human stem cells from human embryos and using them to help rebuild damaged tissue.

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## 2012 SCORING COMMENTARY

### Question 1

#### Overview

This question focused on reproduction and examined students' knowledge of the embryological development aspect of the reproductive process. Part (a) asked students to describe the processes involved in the embryological development of a typical vertebrate embryo as it develops from a fertilized egg to the stage where the three embryonic tissue layers are formed. Part (b) asked them to identify, from a list of three tissues, the developmental origins of two of those tissues. In part (c) students were required to identify and explain three differences between the embryological development of protostomes and the embryological development of deuterostomes. In part (d) they had to explain two unique properties of human embryonic stem cells that distinguish them from other human cell types. Students were also asked to describe a current medical application of human stem cell research (not just human *embryonic* stem cell research).

#### Sample: 1A Score: 10

In part (a) 1 point was earned for describing how fertilization “results from the fusion of a male and female gamete.” One point was earned for describing cleavage as “a series of mitotic divisions.” Another point was earned for a description of blastulation: “After cleavage, the group of cells becomes a hollow ball known as a blastula.” One more point was earned for describing how the gastrula forms three tissue layers called ectoderm, mesoderm, and endoderm. In part (b) 1 point was earned for identifying the ectoderm as the developmental origin of the central nervous system. One point was earned for identifying the endoderm as the developmental origin of the digestive system. In part (c) 1 point was earned for identifying and explaining that protostome cleavage differs from deuterostome cleavage because protostome cleavage “occurs in a spiral-like formation.” One point was earned for stating that “[e]arly in development, the cells of a protostome are already determined, meaning they can only give rise to cells that are destined to be a certain part of the body.” Another point was earned for explaining that in protostome development “the mesoderm splits and forms two distinct masses” but does not split in deuterostome development. In part (d) 1 point was earned for explaining that a unique property of human embryonic stem cells is that they “are undetermined, so they can become any type of cell.” More points could have been earned, but the question had a maximum of 10 points. The overall response earned the maximum of 10 points because at least 1 point was earned in each section.

#### Sample: 1B Score: 8

In part (a) 1 point was earned for describing how the process of cleavage occurs when the “egg ... undergoes mitosis and continues to divide.” One point was earned for describing the process of gastrulation as occurring when a gastrula forms the three germ layers: the endoderm, mesoderm, and ectoderm. In part (b) 1 point was earned for identifying the developmental origin of the digestive system as the endoderm. One point was earned for identifying the developmental origin of muscles as the mesoderm. In part (c) 1 point was earned for identifying and explaining that a difference between protostomes and deuterostomes occurs in the blastula stage, where an indentation becomes the mouth in protostomes and the anus in deuterostomes. One point was earned for indicating that a difference between protostomes and deuterostomes is that the determination of cell fate begins much earlier in protostomes than in deuterostomes. In part (d) 1 point was earned for explaining that a unique property of embryonic stem cells is that they “are not specialized. This means they can develop into any type of cell.” One point was earned for describing a current medical application for the use of human stem cells to replace brain cells.

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**2012 SCORING COMMENTARY**

**Question 1 (continued)**

**Sample: 1C**

**Score: 6**

In part (a) 1 point was earned for describing the embryological process of gastrulation, which occurs when “[t]hree types of tissue begin to develop. The mesoderm, the ectoderm, and the endoderm.” In part (b) 1 point was earned for identifying the developmental origin of muscle as the mesoderm. One point was earned for identifying the developmental origin of the central nervous tissue as the ectoderm. No points were earned in part (c). In part (d) 1 point was earned for explaining that human stem cells “haven’t recieved [*sic*] a job for what function they are to perform yet.” One point was earned for explaining that human stem cells “can adapt to become any type of cell.” Another point was earned for describing a current medical application of human stem cell research in rebuilding damaged tissue.