Without adaptive behaviors, animals would not survive.

(a) **Describe** what innate and learned behaviors are. **Explain** the adaptive value of each of these two categories of behavior to an individual animal.

**One point for each of the following explanations/identifications (4 points maximum):**
- Description or definition of innate behavior
- Description or definition of learned behavior (change with experience/trial and error)
- Explanation of how innate behavior is adaptive
- Explanation of how learned behavior is adaptive

(b) During mating season, male snakes exhibit tracking behavior when they follow chemical pheromone trails deposited on the ground by females. **Design** a controlled experiment to determine whether a male garter snake will track only a female of his species or will also follow the female of a related species.

**One point for each of the following explanations/identifications (7 points maximum):**
- Hypothesis/prediction of results
- Description of the independent variable (female of same species and female of different species)
- Description of how to measure movement (e.g., sensors, observation)
- Description of how to measure male’s choice (e.g., Y-maze, *in situ* observation)
- Verification of results (e.g., repetitions, number of snakes)
- Statistical analysis
- Control group (no female snakes)
- Control of at least one variable (e.g., sexually mature snakes, temperature, light, mating season)
The defenses of the human body to the entry and establishment of a pathogen (disease-causing organism) can be divided into nonspecific responses and specific responses.

(a) **Explain** how THREE types of nonspecific defenses can prevent the entry and/or establishment of a pathogen in a person’s body.

**One point for each of the following explanations/identifications (3 points maximum):**

- Barrier (skin)
- Traps (mucous membranes, cilia, hair, ear wax)
- Phagocytosis (white blood cells)
- Elimination (coughing, sneezing, urination)
- Unfavorable pH (stomach acid, sweat, saliva, urine)
- Unfavorable environment (normal flora, fatty acids, enzymes)
- Cell destruction (complement, natural killer cells)
- Interference with viral replication (interferon)
- Lysozyme action (tears, sweat)
- Inflammatory response (increase in body temperature, capillary permeability, attraction of macrophages, histamine release, vasodilation)

(b) **Discuss** how the immune system responds to an initial pathogenic exposure, and how this initial exposure can lead to a quicker response following a second exposure to the same pathogen.

**One point for each of the following explanations/identifications (6 points maximum):**

- APCs (macrophages, dendritic cells, B cells) present antigen
- B cells/plasma cells produce/secrete antibodies
- Helper T cells activate B cells, cytotoxic T cells, and/or macrophages
- Cytotoxic T cells cause cell death (apoptosis)
- Ag presented on MHC
- Explanation of how antibodies destroy the pathogen
- Secretion of cytokines (or interleukins) to signal or activate
- Memory cells produced in primary response speed up secondary response

(c) **Explain** the biological mechanisms that lead to the rejection of transplanted organs.

**One point for each of the following explanations/identifications (3 points maximum):**

- Cell-mediated response or explanation of cytotoxic T, CD8, killer T cells, or natural killer cells
- Concept of nonself (foreign) or MHC incompatibility
- Explanation of the role of cell death or apoptosis or cell lysis

*Note: To obtain a score of 10, the student must earn the memory cell point in part (b).*
A molecule of messenger RNA (mRNA) has just been synthesized in the nucleus of a human cell.

(a) What type of modifications may occur to this RNA before it leaves the nucleus?

One point for each of the following explanations/identifications (3 points maximum):
- Difference between introns and exons
- Description of splicing
- 5′ cap added or description of function
- 3′ poly A tail added or description of function

(b) Once in the cytoplasm, how is the mRNA translated to a protein?

One point for each of the following explanations/identifications (6 points maximum):
- Description of the role of tRNA in the transport of amino acids
- Description of the ribosome/tRNA
- Peptide bond formation (or the connecting of amino acids into a polypeptide chain)
- Concept of codon-anticodon binding
- Concept of the role of the genetic code (e.g., mRNA bases determine the sequence of amino acids)
- Description of stages (initiation, elongation, and termination)
- Elaboration point for a detailed explanation—examples of acceptable answers include, but are not limited to, the following:
  - Description of 40S and 60S ribosomal subunits
  - Role of aminoacyl-tRNA synthetase
  - Structure of tRNA
  - Use of GTP as energy source

(c) If the cell is a secretory cell, how is the protein from part (b) eventually targeted, packaged, and secreted to the exterior of the cell?

One point for each of the following explanations/identifications (3 points maximum):
- Role of chaperones in folding a polypeptide into the protein
- Modification of the protein or addition of sugars and/or phosphate
- Concept of the endomembrane system (description of protein moving from ER to Golgi to vesicles)
- Exocytosis through the fusion of the vesicle with the cell membrane
The energy flow in ecosystems is based on the primary productivity of autotrophs.

(a) **Discuss** the energy flow through an ecosystem and the relative efficiency with which it occurs.

**One point for each of the following explanations/identifications (6 points maximum):**
- Conversion of light (or inorganic chemical) energy to cellular chemical energy
- Explanation that conversion is the result of photosynthesis or chemosynthesis
- Concept that energy moves from one trophic level to another
- Understanding that there is a dramatic decrease in the amount of energy transferred from one trophic level to the next
- Energy loss is the result of metabolic activity/heat loss from one trophic level to the next
- Explanation of the concept of primary productivity

(b) **Discuss** the impact of the following on energy flow on a global scale.
- Deforestation
- Global climate change

**One point for each of the following explanations/identifications (6 points maximum):**

<table>
<thead>
<tr>
<th>Deforestation (3 points)</th>
<th>Global climate change (3 points)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impact</strong></td>
<td><strong>Definition</strong></td>
</tr>
<tr>
<td>Loss of energy</td>
<td>Alternation of climate/global warming or cooling</td>
</tr>
<tr>
<td>Removal of primary producers</td>
<td></td>
</tr>
<tr>
<td>Destruction of habitat decreases food supply</td>
<td></td>
</tr>
<tr>
<td>Disruption of ecosystem</td>
<td>Impact</td>
</tr>
<tr>
<td>Natural succession—NO change in energy flow</td>
<td>Increase or decrease in numbers of producers</td>
</tr>
<tr>
<td>Clear-cutting for agriculture increases primary productivity</td>
<td>Increase or decrease in energy</td>
</tr>
<tr>
<td>Clear-cutting for development decreases primary productivity</td>
<td>Increase or decrease in metabolism/energy</td>
</tr>
<tr>
<td></td>
<td>Changes in respiratory heat depending on the ecosystem</td>
</tr>
<tr>
<td></td>
<td>Replacement of productive ecosystems with less productive ones (desertification, tundrification)</td>
</tr>
</tbody>
</table>