2. After reading the following excerpt from an article about the interrelationships among organisms in an oak forest, answer parts (a), (b), and (c), which follow.

Chain Reactions Linking Acorns to Gypsy Moth Outbreaks and Lyme Disease Risk

Oak trees (*Quercus* spp.) produce large autumnal acorn crops every two to five years, and produce few or no acorns during intervening years. Acorns are a critical food for white-footed mice (*Peromyscus leucopus*). Mice are important predators of the pupal stage of the gypsy moth (*Lymantria dispar*). This introduced insect periodically undergoes outbreaks that defoliate millions of hectares of oak forests, decreasing tree growth, survival, and acorn crop production. An abundance of acorns provides food for white-tailed deer (*Odocoileus virginianus*). Mice and deer are the primary hosts of the black-legged tick (*Ixodes scapularis*), which carries Lyme disease.

(a) In the space provided below, diagram a food web based on the interrelationships of the organisms identified in the excerpt.

(b) Design a controlled experiment that tests the relationship between acorn production and gypsy moth population. Include the hypothesis that the experiment tests.

(c) Briefly describe a strategy that uses integrated pest management for the control of the black-legged tick population.

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Question 2

2. (a) 4 points possible, 3 points internal maximum

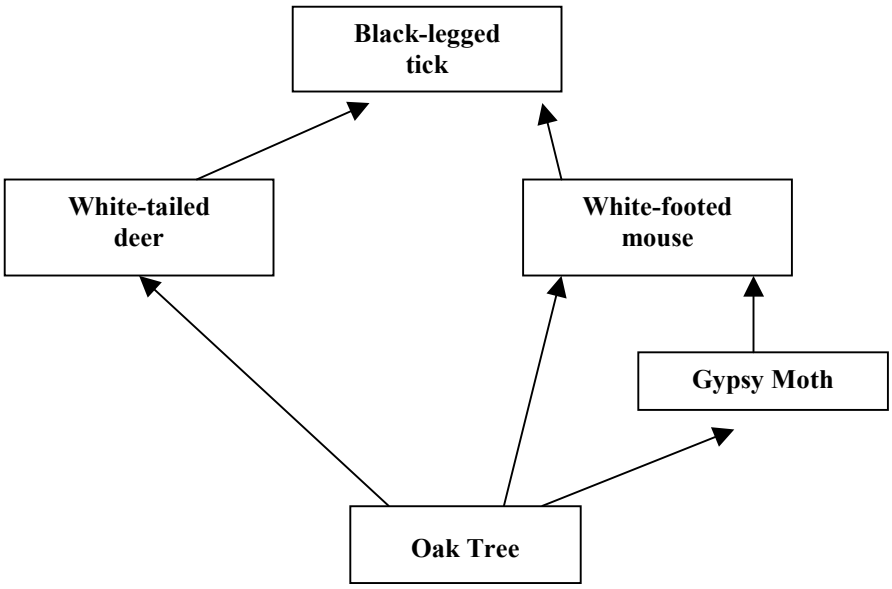
2 points for correctly identifying the five components (oak tree, gypsy moth, mice, deer, ticks) of the food web **AND** showing the proper connections (doesn't have to have arrows)

In this section, it is NOT acceptable to only specify "acorn" — gypsy moths do not eat acorns.

1 point each for the following:

- placing arrows in the direction of energy flow
- labeling trophic levels

Note: these points can be awarded even if the student missed one of the components or one of the connections in the food web.



The above is an example of a food web that would earn the student 3 points.

Question 2 (cont.)

2. (b) 4 points

1 point for the hypothesis IF the hypothesis is **connected to the question AND the experiment**, and is stated in a hypothesis format (i.e., can't just restate the question).

Since this hypothesis is supposed to be an answer to the question "How are acorn production and moth population related?", the student **must use the document** to formulate one of three hypothesis forms.

Note: these are general forms the hypothesis might take. In order to earn a point, the student must specify the direction of change, i.e., increasing or decreasing:

(1) change in moths → change in acorns (moths eat leaves and reduce acorn production)
(2) change in acorns → change in moths (this can only happen through the mouse connection, and this fact must be demonstrated in the hypothesis and/or the experiment in order to earn the hypothesis point)
(3) null hypothesis (i.e., there is no relationship)

Sample hypotheses:

- If the number of gypsy moths increase then the number of acorns will decrease (due to defoliation and stress on the oak trees)
- If there is a decrease in gypsy moths, there will be an increase in acorns
- An increase in acorns will lead to increased mouse population which will decrease the moth population
- If acorns increase, then mice will preferentially eat the acorns, leading to an increase in gypsy moth population

Student may also state their hypothesis as a NULL hypothesis, i.e.:

- The number of gypsy moths in an oak forest will have no impact on the number of acorns produced
- The number of acorns produced will have no impact on the mouse population, and thus no impact on the number of gypsy moths
- Mice have no preferential food, therefore the number of acorns produced will not impact the mice's feeding habits and thus have no impact on the number of gypsy moths

Question 2 (cont.)

Up to 3 points for an experiment that addresses the question (does not necessarily have to be linked to the hypothesis):

- **1 point** for experiment which clearly indicates measurement over a "reasonable" amount of time (not acceptable: days or a few months; for a controlled experiment at least one full cycle of the oak trees is needed)
- **1 point** for a clear indication of a control (see "Examples of Experiment Design" below for more detail)
- **1 elaboration point** available
    - e.g., discussion of testing for significant correlation between organisms
    - e.g., types of graphs they will produce with the data gathered
    - e.g., an in-depth discussion of the technique of counting species by capture and release

Examples of Experiment Design

Experimental — in this type the student is doing a more traditional type of experiment where there is at least one control site and one experimental site designated, and a variable is manipulated in the experimental site.

- Need at least two sites and a true experimental control (i.e., the absence of the variable to be tested) at one of the sites (control point)
- Manipulate moths (must have a count!) — either natural or in lab — count acorns; over at least one cycle (measurement point)
- Manipulate acorns (must have a count!) — natural sites only — count mice and moths; over at least one cycle (measurement point)

Observational — in this type of experiment the student is not manipulating a variable, but making long-term measurements and doing statistical analysis to determine if there is any significant correlation between the populations.

- May involve a single site or multiple sites over a long period of time
- Needs specification of a "reasonable" amount of time, i.e., multiple oak cycles (control point) **OR**
- Specification that measurements will be made over at least one oak cycle **AND** then compared to a baseline data set (control point)
- Must count all relevant species (measurement point)

An elaboration point is ONLY given if the student demonstrates an in-depth knowledge of the material. That is, the student must answer the basic question correctly. They can then get an elaboration point if they give ADDITIONAL information, demonstrating that they truly understand the subject matter.

Question 2 (cont.)

2. (c) 5 points possible; 4 points internal maximum

Up to 3 points for three different (acceptable) methods of control (see list below)

If students give at least two methods of control (indicating at least a basic understanding of IPM) they may earn:

1 elaboration point each (up to 2 points) for elaboration of a method of control

Integrated Pest Management

A combination of methods to control a pest. These may include limited and specific use of chemical, biological, and physical controls. The aim of IPM is long-term control (not eradication) of a pest, with minimal environmental impact.

Legitimate IPM control for ticks

PHYSICAL CONTROLS

Habitat management:

- Short grass, brush reduction (less than 6 inches in height)
- Rotation of pastures/ run areas
- Expose areas to more direct sunlight (higher soil temperature, lower soil moisture, lower humidity)
- Controlled burning (of brush)
- Introduce a tick-repellant plant

Question 2 (cont.)

BIOLOGICAL CONTROLS

- Introduce a tick predator (e.g., birds, wasps, ants)
- Introduce a disease that will affect only ticks
- Introduce a competitor to the tick
- Interrupt tick breeding cycle, e.g., sterile male; pheromones
- Control host population by reasonable means, including (but not necessarily limited to) the following:
  - Decrease mouse and/or deer population by introduction of a predator
  - Lengthen the hunting season for deer
  - Inoculate the host (only reasonable for deer)
  - Introduce a tick controlling substance to the host (NOT a pesticide); e.g., hormone disrupter or type of medicine on acorns that will be ingested by mice and deer
    - Simply stating "control host population" is not an acceptable answer. Student must include some (general) method of control.
    - Controlling the host population by a method such as increasing the gypsy moth population, which will defoliate trees, reducing the acorn population and thus limit mice and deer populations is NOT a reasonable technique.
    - Likewise, genetic engineering of oak trees, deer, and/or mice is not a reasonable technique.

CHEMICAL CONTROLS

Pesticide use:

- Must show an understanding of restricted or judicial use of pesticides in IPM (e.g., should give some indication of timing, place, type, or amounts of pesticide to be used)
- It is not necessary to name a specific pesticide

Herbicide use:

- Must show an understanding of restricted or judicial use of herbicides in IPM (e.g., should give some indication of timing, place, type, or amounts of herbicide to be used)