

## Chapter Overview

Death can occur in many different ways. The reason someone dies is the cause of death, and the mechanism of death describes what has occurred in the body to cause death. Forensic examiners try to determine a time and a cause of death. Factors such as rigor mortis and the stages of decomposition of a corpse help a medical examiner determine the time of death. Insect evidence and environmental factors are also valuable when approximating the time of death.

## The Big Ideas

Death is a process rather than an instant event, so it is sometimes difficult to pinpoint the precise moment when someone dies. Forensic scientists have identified four ways a person can die: natural death, accidental death, suicidal death, and homicidal death (undetermined death is also sometimes listed on death certificates). When an autopsy is performed, a medical examiner is trying to determine the cause and time of death. (A coroner is an elected official who may or may not have a medical background. The coroner cannot perform autopsies unless he or she is also a forensic pathologist.) Livor mortis, rigor mortis, algor mortis, intestinal and stomach contents, changes in the eye following death, stages of decomposition, and presence and life stage of insects are all factors that help investigators determine the cause and time of death.

# CHAPTER 11

## Death: Meaning, Manner, Mechanism, Cause, and Time

### MYSTERIOUS DEATH AT THE FAIR

The Washington County Fairgrounds in upstate New York was the site of the 1999 annual county fair. Well water, the source of drinking water for the event, became contaminated by runoff from a nearby cattle barn after a recent storm. The cattle and their manure carried a type of the bacteria called *Escherichia coli*. *E. coli* is a natural, and necessary, inhabitant of our digestive systems, but one strain carried by cattle produces a powerful toxin. The cattle that carry this strain of *E. coli* are unharmed, but humans can become very sick and die from an infection. Two of the 127 confirmed cases of *E. coli* poisoning from the fair died from the infection. As is often the case with *E. coli* poisoning, the deaths were from among the youngest and eldest of the group infected, a 79-year-old man and a 3-year-old girl. Manner of death—accidental; cause of death—food poisoning/water contamination; mechanism of death—kidney failure.

*Escherichia coli* is a leading cause of food-borne illness. Scientists estimate there are 73,000 cases of infection and 61 deaths in the United States each year. In addition to eating undercooked meat, people can become infected in a variety of ways. People have



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*E. coli* bacteria.

become ill from eating contaminated bean sprouts or fresh leafy vegetables, or through person-to-person contact in families and child care centers. Infection also can result from drinking raw milk or swimming in or drinking sewage-contaminated water.

### SCENARIO

Write this sentence from the scenario on the board: Manner of death—accidental; cause of death—food poisoning/water contamination; mechanism of death—kidney failure. Organize students into groups of two, have them read the scenario, and answer the following questions: How would you define manner of death, cause of death, and mechanism of death? What other descriptions or adjectives could be used for manner of death, cause of death, and mechanism of death?

## KEY SCIENCE CONCEPTS

**Biology:** medical definition of death; cause of rigor mortis; insect life cycle; factors affecting decomposition; autolysis of tissue

### OBJECTIVES

By the end of this chapter you will be able to

- 11.1 Discuss the definition of death.
- 11.2 Distinguish between four manners of death: natural, accidental, suicidal, and homicidal.
- 11.3 Distinguish between cause, manner, and mechanisms of death.
- 11.4 Explain how the development of rigor, algor, and livor mortis occurs following death.
- 11.5 Use evidence of rigor, algor, and livor mortis to calculate the approximate time of death.
- 11.6 Describe the stages of decomposition of a corpse.
- 11.7 Use evidence from the autopsy's report on stomach contents to estimate time of death.
- 11.8 Explain how time of death can be estimated using insect evidence.
- 11.9 Provide an example of the succession of different types of insects that are found on a body as it decomposes.
- 11.10 Given insect evidence, livor, rigor, and algor mortis data, be able to estimate time of death.
- 11.11 Describe how various environmental factors may influence the estimated time of death.

### VOCABULARY

**algor mortis** the cooling of the body after death

**autolysis** the spontaneous breakdown of cells as they self-digest

**cause of death** the immediate reason for a person's death (such as heart attack, kidney failure)

**death** the cessation, or end, of life

**decomposition** the process of rotting and breaking down

**forensic entomology** the study of insects as they pertain to legal issues

**instar** one of the three larval stages of insect development

**larva** (plural **larvae**) immature form of an animal that undergoes metamorphosis (for example, a maggot)

**livor mortis** the pooling of the blood in tissues after death resulting in a reddish color to the skin

**manner of death** one of four means by which someone dies (i.e., natural, accidental, suicidal, or homicidal)

**mechanism of death** the specific body failure that leads to death

**pupa** (plural **pupae**) the stage in an insect's life cycle when the larva forms a capsule around itself and changes into its adult form

**rigor mortis** the stiffening of the skeletal muscles after death

### TOPICAL SCIENCES KEY



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## Teaching Resources

- Instructor's Resource CD-ROM includes:
  - PowerPoint Presentation
  - Lesson Plan and extended Objective Sheets
  - Teacher Notes and Activities
  - Activity Forms
  - Rubric
- ExamView CD-ROM
- E-book on CD-ROM

Web site: [school.cengage.com/forensicscience](http://school.cengage.com/forensicscience)





## Engage

Before students read the Introduction, make a two-column chart on an overhead or chalkboard. Label one column “alive” and one column “dead.” Ask students how they know someone is alive or dead. Write their answers in the appropriate column and discuss. After the discussion, ask students to read the Introduction.

## Explore

Not only is the phrase “saved by the bell” associated with being buried with a bell, but the phrase “dead ringer” is also associated with this behavior.

## Evaluate

You may want to bring in newspaper, magazine, and Internet articles that report the facts of the case of Terri Schiavo. Search the Gale Forensic Science eCollection at [school.cengage.com/forensicscience](http://school.cengage.com/forensicscience) for additional articles. After students have read the articles, lead the class in a discussion of one or both of the following topics:

- Who is responsible for making decisions regarding a person’s health if he or she is not able to do so? Ask students to research living wills.
- Morally and legally, when is someone considered “dead,” or at the “point of no return?”



To avoid burying people before they were dead, “waiting mortuaries” were established in the 17th century. Those people thought to be dead were placed on cots and observed until the body began to rot. Only then was the person declared dead.

In the 17th century, before the stethoscope was invented, anyone in a coma or with a weak heartbeat was presumed dead and was buried. The fear of being buried alive led to the fad of placing a bell in the coffin. If someone was buried by mistake and awoke, he or she could ring the bell to get someone’s attention. This is how the phrase “saved by the bell” might have originated.

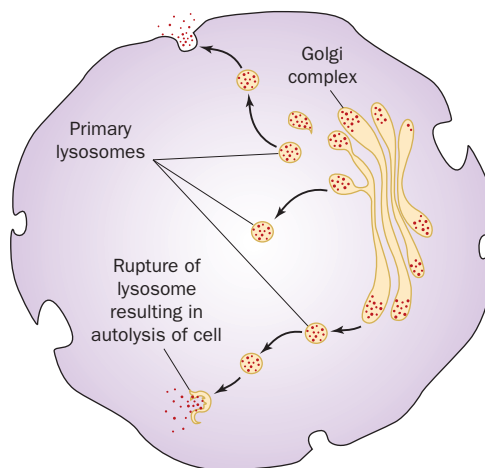
Today, people no longer fear being buried alive. It is, however, sometimes difficult to tell if a person is dead or not. The outward signs of death, such as being cold to the touch and comatose, can be present even though a person is still alive. One definition of **death** is the cessation, or end, of life. To be more precise, death is sometimes defined as the “irreversible cessation of circulation of blood.” In other words, the heart stops beating and cannot be restarted. Death might also be defined as the cessation of all brain activity. Even this definition is not perfect. Experts cannot agree on a single definition for death. Is a person with a heartbeat alive even if there is no brain activity? This is not an easy question to answer.

It remains difficult to precisely pinpoint the moment that someone dies. For one thing, death is a process rather than an instant event. The moment of death is usually considered the point of no return. According to physiologists, when the heart stops beating, the cells of the body begin to die because they no longer receive a fresh supply of oxygen. As oxygen levels drop, the basic processes of the body fail to occur. Nerves, muscles, organs, and the brain stop working. This is the first stage of death—stoppage.

When a cell dies, it breaks down. Once enough cells begin to break down, life cannot be restarted. Cell breakdown is called **autolysis** (Figure 11-1). When the cell membrane dissolves, enzymes and other cell contents spill out and digest surrounding tissues.

In cases of suspicious or unnatural deaths, a medical doctor called a forensic pathologist conducts an examination on the deceased. This examination is called an *autopsy*. The autopsy is conducted to determine the manner, cause, and mechanism of death, described in the following sections.

**Figure 11-1.** Autolysis occurs when cells break down.



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## Science

### Biology

The definition of death relates to the cessation of the circulation of blood and brain activity. When the heart stops beating, the cells of the body begin to die, because they no longer receive a fresh supply of oxygen.



## Science

### Biology

In order for cells to make enough ATP (energy useful to the body) to support all bodily functions, oxygen must be present. Once a person stops breathing, there is insufficient oxygen, and thus insufficient energy to support life.



## THE MANNER OF DEATH

Obj. 11.2

There are four ways a person can die, referred to in official terms as the **manner of death**: natural death, accidental death, suicidal death, and homicidal death. A fifth manner of death, undetermined, perhaps should be added because it is occasionally the official cause recorded on a death certificate. Natural death is caused by interruption and failure of body functions resulting from age or disease. This is the most common manner of death. Accidental death is caused by unplanned events, such as a car accident or falling from a ladder. Suicide occurs when a person purposefully kills oneself, whether by hanging, drug overdose, gunshot, or some other method. A homicide is the death of one person caused by another person.

Sometimes it is difficult to determine if the manner of death was a suicide or an accidental death. Did the person deliberately take an overdose of pills, or was it an accident? Did a person mean to shoot himself, or was it a mistake? In some cases, the coroner cannot make this determination and marks the manner of death as unknown on the death certificate.

Consider the following two examples. How would you categorize the manner of death?

- A man with a heart condition is attacked and dies from a heart attack during the assault. Is the manner of death accident or homicide?
- An elderly woman dies after being kept from receiving proper health care by her son. Is the manner of death natural or homicide?

In both cases, homicide would be the manner of death. Proving in court that the manner of death was a homicide, however, may be difficult.

## CAUSE AND MECHANISM OF DEATH

Obj. 11.3

**Figure 11-2.** Cause of death describes the event that led to a person's death (e.g., hanging).



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The reason someone dies is called the **cause of death** (Figure 11-2). Disease, physical injury, stroke, and heart attack can all cause death. Examples of causes of death by homicide include bludgeoning, shooting, burning, drowning, strangulation, hanging, and suffocation. Have you ever heard the term “proximate cause of death”? It refers to an underlying cause of death, as opposed to the final cause. If someone is exposed to large amounts of radiation and then develops cancer, the proximate cause of death is the radiation exposure.

**Mechanism of death** describes the specific change in the body that brought about the cessation of life. For example, if the cause of death is shooting, the mechanism of death might be loss of blood, exsanguination, or it might be the cessation of brain function. If the cause of death is a heart attack, the mechanism of death is the heart stopping to beat or pulmonary arrest.

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## Teaching Tip

The fifth manner of death, undetermined death, is stated on a death certificate if the official cause cannot be determined. Explain to students that writing this on a death certificate leaves room for further investigation without prejudice.

## Evaluate

In pairs, ask students to write short scenarios that include information about cause, manner, and mechanism of death, without labeling them as such. Have them exchange their scenarios with another pair, who then identifies the cause, manner, and mechanism of death in the scenario.

## Explore

The movies *Erin Brockovich* and *A Civil Action* both tell stories of lawyers fighting big companies over dumping toxic waste, which eventually leads to the illnesses and deaths of many people. Either of these movies would be good examples of proximate cause of death. Students can watch the entire movie, or just portions, and discuss the difficulty in proving proximate cause of death. (Note: The ratings on these movies might prevent their classroom use.)

## Differentiated Learning

### Teaching At-Risk Students

Students tend to engage in subjects they know about or with which they feel a connection. Stories such as the Terri Schiavo case, Dr. Kevorkian, and others that are current and in the news create relevancy and allow students to voice their opinions.



## Explore

Ask students about the variables affecting time of death calculations, such as temperature, location of body (e.g., in the shade, sun, trunk of car, buried), clothed or unclothed, and so forth. They should detail how each variable affects time of death calculations.

## Teaching Tip

Information obtained by homicide detectives or investigators can also aid in the estimation of time since death. Because so many factors influence rigor, livor, and algor mortis, information such as who saw the person last is often most useful in estimating the time a person died.

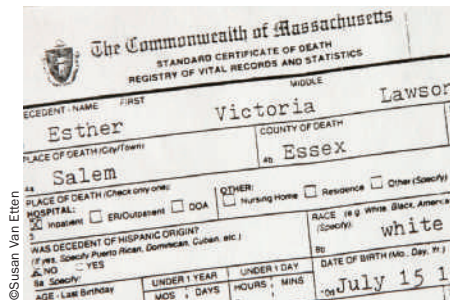
## Teaching Tip

Explain to students that the adjective “livid” means bluish or dark, and it is used to describe how people look when angry. Also point out that lividity will not be present where clothing or accessories, such as belts and watches, restrict the flow of blood.

## Evaluate

Ask students how a criminal might be able to disguise the time of death by controlling the ambient conditions that affect livor mortis.

**Figure 11-3.** The official death certificate lists the cause and sometimes the mechanism of death.



A forensic pathologist’s report may indicate the cause and mechanisms of death in a single statement (as do some death certificates, Figure 11-3). For example, someone killed in a car accident may be said to have died from “massive trauma to the body leading to pulmonary arrest.” Trauma to the body is the cause of death; respiratory arrest is the mechanism of death.

## TIME OF DEATH Obj. 11.4, 11.5, and 11.11

During an autopsy, the forensic examiner wants to determine when the person died. By establishing the time of death, a suspect may be proved innocent simply because he or she was not in the same place as the victim at the time of death. On the other hand, the suspect may remain a person of interest if he or she was in the same area at the time a person died. Many factors are used to approximate the time of death. These factors are discussed in more detail in the following sections.

## LIVOR MORTIS

**Livor mortis** means, roughly, death color. As a body begins to decompose, blood seeps down through the tissues and settles into the lower parts of the body. The red blood cells begin to break down, spilling their contents. Hemoglobin, the substance in red blood cells that carries oxygen and gives blood its red color, turns purple when it spills out of the cells. This purplish color is visible on parts of the skin wherever the blood pools. The process of livor mortis takes time.

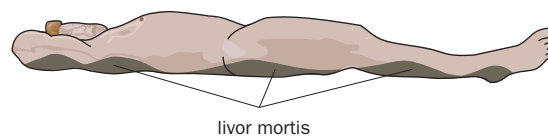
Pooling of blood in the body, known as *lividity*, provides a clue as to how long the person has been dead. Lividity first begins about two hours after death. The discoloration becomes permanent after eight hours. If death occurred between two and eight hours, lividity will be present, but if the skin is pressed, the color will disappear. After eight hours, if the skin is pressed, the lividity will remain. The ambient temperature at which a person dies impacts the time it takes for lividity to set in. If the corpse is left outside on a hot, summer day, livor mortis takes place at a faster rate. If the body is left in a cool room, livor mortis is slower. This is why it is so important to record the environmental conditions surrounding a dead body. The extent of livor mortis is also affected by anything impeding the flow of blood, such as tight wristwatches or belts.

Besides providing an approximate time of death, livor mortis can provide other important clues. Because gravity pulls the blood toward the ground, lividity can reveal the position of a corpse during the first eight hours (Figure 11-4). If the corpse were face down in a flat position, blood would pool along the face, chest, abdomen, and portions of the arms and legs close to the floor. If the corpse were positioned on its back, blood would

pool along the back, the buttocks, head, and the parts of the arms and legs close to the floor. If the corpse were wedged in a standing position, the blood would collect in the lower legs and feet and the lower arms and hands.

Lividity also can reveal if a body has been moved. For example, if the person

**Figure 11-4.** The location of livor mortis can reveal the position of the body during the first eight hours after death.



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## Differentiated Learning

### Teaching English-Language Learners

There are many scientific terms in this chapter. When students are asked to work in groups, assign the groups instead of allowing students to choose their own groups. This way you can place English learners with native speakers in the same group. The native speakers should assist the non-native speakers.



died sitting in a chair, lividity would appear on the back of the thighs, buttocks, and the bottom of the feet. If the corpse were then moved so that the body was lying face down on the floor, lividity would also be found on the face, chest, abdomen, and front surface of the legs. Dual lividity could occur if the body was kept in one position two hours after death and then moved to a second position before the lividity became permanent. This is not uncommon if a murder victim is killed in one place and then transported somewhere else.

## RIGOR MORTIS

Have you ever seen a dead animal in the road? Were all four of its legs stiff and sticking straight up in the air (Figure 11-5)? If the animal was still there a few days later, you may have noticed that the animal was no longer stiff. **Rigor mortis** means, roughly, death stiffness. It is temporary and can be very useful in determining the time of death.

Rigor mortis starts within two hours after death. The stiffness starts in the head and gradually works its way down to the legs. After 12 hours, the body is at its most rigid state. The stiffness gradually disappears after 36 hours. Sometimes, depending on body weight and temperature in the area, rigor may remain for 48 hours. If a body shows no visible rigor, it has probably been dead less than two hours or more than 48 hours. If a body is very rigid, then the body has been dead for about 12 hours. If the body exhibits rigor only in the face and neck, then rigor has just started, and the time of death is just over two hours. If there is some rigor throughout the body, but a lack of rigor in the face, then the body is likely to be losing rigor, and the death occurred more than 15 hours ago.

The stiffness occurs because the skeletal muscles are unable to relax and remain contracted and hard. In life, the flexing and relaxing of muscles happens as the muscle fibers slide back and forth. Whenever muscles contract, they release calcium. In healthy, live muscles, the calcium molecules are removed from the cells. This requires energy, and for cells to get energy, they need oxygen. After death without circulation, oxygen flow to the cells ceases, and calcium accumulates in the muscle tissue. In the presence of the extra calcium, the muscle fibers remain in the contracted, rigid position (Figure 11-6). Because the muscles control the movement of bones, the joints appear to be rigid as do the muscles. The muscles eventually begin to relax as the cells and muscle fibers begin to dissolve by autolysis.

Many factors affect when rigor mortis sets in and how long it lasts. When trying to estimate the time of death, these factors need to be taken into account:

1. **Ambient temperature.** The cooler the body, the slower the onset of rigor. The warmer the body, the onset of rigor is faster because chemical reactions happen more quickly at higher temperatures.



If a body needs to be transported when rigor is at its peak, it might be necessary to break bones to change the position of the body.

**Figure 11-5.** During the first 48 hours of death, the skeletal muscles are stiff—a condition known as rigor mortis.



©AP Photo/Damian Dovarganes

## Teaching Tip

Students might think that muscles actually move and contract after death. Explain that muscles do not contract, but rather, the muscle filaments (actin and myosin) chemically bond to form rigid muscle tissue. Eventually, as cells die, rigor will be lost and muscles will become limp (flaccid).

### Science



#### Biology

Rigor mortis (death stiffness) occurs because the skeletal muscles are unable to relax. Instead, they remain contracted and rigid as a result of calcium buildup.

### Science



#### Biology

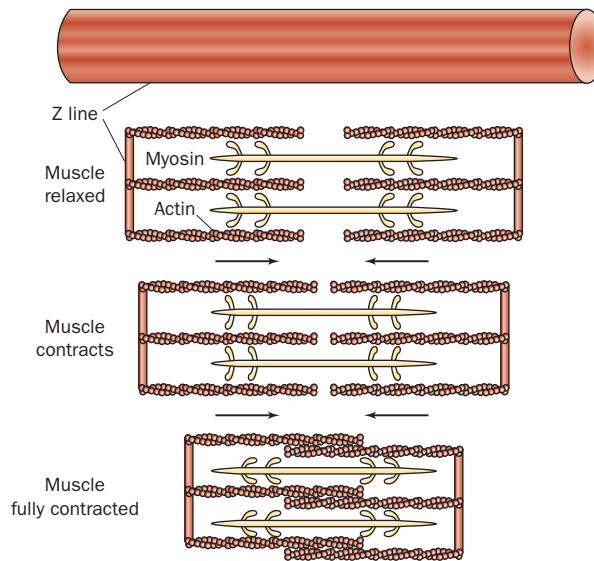
In the living, calcium ions are actively transported to the outside of the muscle cells. After death (postmortem), there is no energy (ATP) to continue the process, and the calcium builds up inside the cells. The calcium promotes cross-bridge attachment of the muscle fibers actin and myosin, causing stiffness or rigor. Rigor remains until the muscles begin to decompose. You might want to review muscle function with students. The How Stuff Works Web site (<http://health.howstuffworks.com/muscle2.htm>) has an easy-to-understand model.



## Teaching Tip

Ask students to flex an arm and notice the effect on the biceps. As the biceps contract, the muscle fibers slide into a higher stack and the biceps becomes thicker. The triceps is now relaxed. When the arm is straightened, the triceps contract and the biceps relax as the fibers slide apart. What would happen if a person dies and the biceps is flexed? The muscle would lock in that position for a time and become rigid (rigor).

**Figure 11-6.** Live muscle fibers slide back and forth; in the first 48 hours of death, the muscle fibers become locked in a flexed position.



**Figure 11-7.** Body weight and physical activity affect the timing of rigor mortis.



**Figure 11-8.** Progression of rigor mortis.

| Time After Death | Event                    | Appearance  | Circumstances  |
|------------------|--------------------------|---|--|
| 2 to 6 hours     | Rigor begins             | Body becomes stiff and stiffness moves down body.               | Stiffness begins with the eyelids and jaw muscles after about two hours, then center of body stiffens, then arms and legs. |
| 12 hours         | Rigor complete           | Peak rigor is exhibited.  | Entire body is rigid.  |
| 15 to 36 hours   | Slow loss of rigor       | Loss of rigor in small muscles first followed by larger muscles | Rigor lost first in head and neck and last in bigger leg muscles.  |
| 36 to 48 hours   | Rigor totally disappears | Muscles become relaxed.   | Many variables may extend rigor beyond the normal 36 hours.  |

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2. *A person's weight.* Body fat stores extra oxygen and will slow down rigor mortis. A person with less oxygen stored in the body experiences rigor faster (Figure 11-7).
3. *The type of clothing.* Because clothing helps keep a body warm, the presence of clothes accelerates rigor mortis. A naked body cools faster, which slows down the onset of rigor mortis.
4. *Illness.* If a person dies with a fever, the body temperature will be higher, and rigor mortis will set in faster. If a person experiences hypothermia, the onset of rigor will be slower.
5. *Level of physical activity shortly before death.* If a person was exercising or struggling before death, then rigor will progress faster. This is true for several reasons, including the fact that exercise increases body temperature and decreases oxygen availability to the cells in the body and increases lactic acid levels.
6. *Sun exposure.* A body exposed to direct sunlight will be warmer, and rigor mortis would occur faster.

Because so many variables can affect how fast rigor mortis progresses, a precise time of death cannot be determined, it can only be estimated. However, when rigor mortis is combined with other factors, a more accurate time of death can be established (Figures 11-8 and 11-9).

## Differentiated Learning

### Teaching At-Risk Students

Help students understand the six variables that can affect how fast rigor mortis progresses. Identify a factor and have students tell whether it speeds or slows the process and why.



Figure 11-9. Factors Affecting Rigor Mortis.

| Factors Affecting Rigor | Event            | Effect            | Circumstances  |
|-------------------------|------------------|-------------------|--|
| Temperature             | Cold temperature | Inhibits rigor    | Slower onset and slower progression of rigor   |
|                         | Warm temperature | Accelerates rigor | Faster onset and faster progression of rigor   |
| Activity before death   | Aerobic exercise | Accelerates rigor | Lack of oxygen to muscle, the build up of lactic acid, and higher body temperature accelerates rigor |
|                         | Sleep            | Slows rigor       | Muscles fully oxygenated will exhibit rigor more slowly  |
| Body weight             | Obese            | Slows rigor       | Fat stores oxygen  |
|                         | Thin             | Accelerates rigor | Body loses oxygen quickly and body heats faster  |

## ALGOR MORTIS

**Algor mortis** means, roughly, death heat and describes the temperature loss in a corpse. When a person is alive, the body maintains a constant temperature. To keep our temperature within a normal range, many parts of our body work together, including the circulatory, respiratory, and nervous systems. In death, the body no longer generates heat and begins to cool down.

To take a corpse's temperature, forensic investigators insert a thermometer into the liver. Having a standard location for taking body temperature ensures that investigators can compare their results.

How fast a corpse loses heat has been measured, and investigators can determine how long ago death occurred by its temperature. Approximately one hour after death, the body cools at a rate of 0.78°C (1.4°F) per hour. After the first 12 hours, the body loses about 0.39°C (0.7°F) per hour until the body reaches the same temperature as the surroundings. This is just an estimate and will vary depending on surrounding temperature and conditions. In cooler environments, the body will lose heat faster than in hotter environments. If it is windy, heat loss will occur faster. The surrounding air temperature and other environmental factors are noted when a body is found, because the environment will affect the rate at which the body loses heat. The excess body fat and the presence of clothing will slow down heat loss. Time of death determined by body temperature calculations is always expressed as a range of time because it cannot be calculated exactly; however, a rule of thumb is to expect a heat loss of approximately 1 degree F per hour.

## STOMACH AND INTESTINAL CONTENTS

Obj. 11.7

Medical examiners help determine the time of death by studying the corpse's stomach contents. In general, it takes four to six hours for the stomach to empty its contents into the small intestine and another 12 hours for the food to leave the small intestine (Figure 11-10). It takes approximately 24 hours from when a meal was eaten until all undigested food is released from the large intestines. From this, it can be concluded that:

1. If undigested stomach contents are present, then death occurred zero to two hours after the last meal.

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## Explore

Ask students to look over the Factors Affecting Rigor Mortis Reference Table and propose a set of conditions that would cause rigor mortis to proceed the quickest and the slowest and why.

## Evaluate

Ask the students what part of the body they think might be the last to completely cool during algor mortis and why.

## Teaching Tip

A common misconception about blood is that venous blood is blue until it is exposed to oxygen and turns red. Blood is never blue. Red blood cells (RBCs) make up nearly half of the liquid part of our blood. RBCs are always red because of a protein called hemoglobin, which contains iron. The iron in the hemoglobin is more stable when bound to oxygen, and the iron-oxygen combination is red, thus giving our blood a red color. Veins are close to the surface of our skin and they appear bluish, which is why some people think venous blood is blue. Blood traveling in our veins is not without oxygen; it has a decreased amount of oxygen and appears a lighter shade of red. Point out to students that when blood is drawn into a vacuum tube, it is red, and there is no oxygen present.

## Teaching Tip

To illustrate examining stomach contents, you may want to show a clip from *CSI Miami* in which the stomach contents of a shark are examined to see if that shark is the one that attacked a swimmer. (The movie *Jaws* has a similar scene.)

## Differentiated Learning

### Teaching At-Risk Students

Students might have trouble calculating temperatures using the decimals. Give them several scenarios so they can practice the calculations.





## Explore

Tell students that digestion is both a mechanical and a chemical process. Biting, tearing, and chewing our food, breaking it down into smaller and smaller pieces, is the mechanical process of digestion. Food is broken down through the use of chemicals found in our mouth and stomach. For example, our bodies cannot use an apple in its original state. They must break down the apple, mechanically and chemically, into a usable form. Our digestive system begins with the mouth and moves on to the esophagus, stomach, small intestines, and then large intestines.

## Teaching Tip

Explain to students that the film that develops over the eyes minutes after death (if the eyes are open) is a transparent coating of the eye, or corneal film. It covers the iris and pupil as they dry up from exposure to air. When a person is alive, the cornea is constantly being lubricated as a result of blinking.

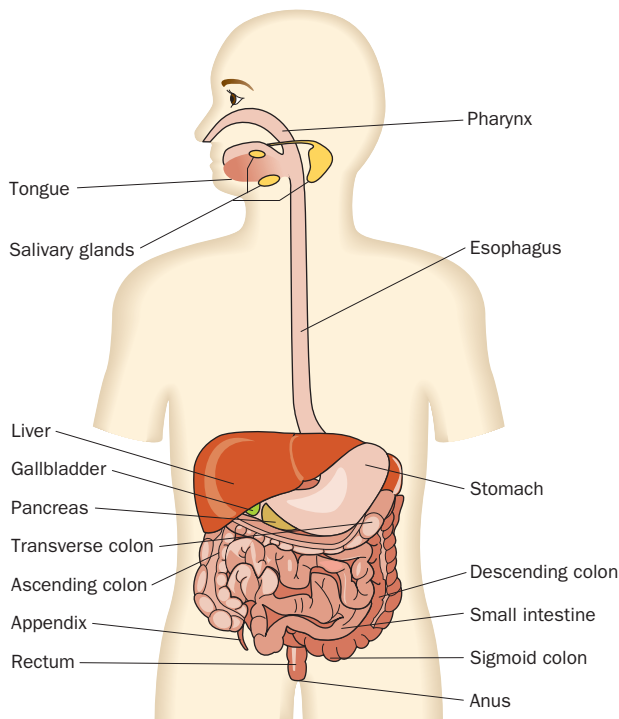
## Teaching Tip

Point out to students that within two days, the green and purplish staining from blood decomposition looks similar to a healing bruise.

## Evaluate

At six to ten days, the corpse bloats with carbon dioxide as bacteria continue to feed on tissues. Ask students if these bacteria are aerobic or anaerobic. Where did these bacteria come from?

**Figure 11-10.** The state of food digestion provides a clue to the time of death.



2. If the stomach is empty but food is found in the small intestine, then death occurred at least four to six hours after a meal.
3. If the small intestine is empty and wastes are found in the large intestine, then death probably occurred 12 or more hours after a meal.

## CHANGES OF THE EYE FOLLOWING DEATH

In life, the surface of the eye is kept moist by blinking. Following death, the surface of the eye dries out. A thin film is observed within two to three hours if the eyes were open at death and within 24 hours if the eyes were covered at death.

Following death, potassium accumulates inside the vitreous humor. Because decomposition progresses at a predictable rate, the buildup of potassium may be used to estimate the time of death. This method is still being refined and is not yet used as an accurate measure of time of death.

### Obj. 11.6 STAGES OF DECOMPOSITION

A corpse decomposes in predictable ways over time that can help examiners judge when death occurred:

1. Within two days after death:
  - Cell autolysis begins following death.
  - Green and purplish staining occurs from blood decomposition.
  - The skin takes on a marbled appearance.
  - The face becomes discolored.
2. After four days:
  - The skin blisters.
  - The abdomen swells with the gas carbon dioxide that is released by bacteria living in the intestines.
3. Within six to ten days:
  - The corpse bloats with carbon dioxide as bacteria continue to feed on tissues. Eventually, the gas causes the chest and abdominal cavities to burst and collapse.

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## Differentiated Learning

### Teaching English-Language Learners

Non-native speakers will have different names for the parts of the digestive system. Have them name the parts in their native language and then identify the English word for it.



- Fluids begin to leak from the body openings as cell membranes rupture.
- Eyeballs and other tissues liquefy.
- The skin sloughs off.

Figure 11-11 provides more information about the stages of decomposition.

**Figure 11-11.** The stages of decomposition provide information about time of death.

| Stage                | What Happens During Decomposition  |
|----------------------|--|
| Initial Decay        | Corpse appears normal on the outside, but is starting to decompose from the actions of bacteria and autolysis. |
| Putrefaction         | Odor of decaying flesh is present and the corpse appears swollen.  |
| Black Putrefaction   | Very strong odor. Parts of the flesh appear black. Gases escape and the corpse collapses.                      |
| Butyric Fermentation | Corpse is beginning to dry out. Most of the flesh is gone.   |
| Dry Decay            | Corpse is almost dry. Further decay is very slow from lack of moisture.  |

Ultimately, this leads to the **decomposition**, or rotting, of all tissues and organs. Bacteria and other microorganisms also help decompose a human body, just as they decompose plants and animals in the environment.

The speed of decomposition depends on the person's age, size of the body, and the nature of death. Sick individuals decompose faster than healthy people. The young decompose faster than the elderly. Overweight people with rich deposits of fat and body fluids break down faster than people of normal weight.

Just as environmental conditions affect rigor, they also influence decomposition. Naked bodies decompose faster than clothed bodies. Bodies decompose fastest in the 21–37°C (70–99°F) temperature range. Higher temperatures tend to dry out corpses, preserving them. Lower temperatures tend to prevent bacterial growth and slow down decomposition. Moist environments rich in oxygen speed up decomposition. Bodies decompose most quickly in air and slower in water or if buried.

## INSECTS *Obj. 11.8, 11.9, and 11.10*

Insects can provide detailed information about time of death in several ways. In fact, insects are so useful in crime investigation that there is an entire field dedicated to this study and practice called **forensic entomology** (Figure 11-12). A forensic entomologist at a crime scene observes and records data

### Digging Deeper

with Forensic Science e-Collection

The science of forensics is always looking to improve its techniques or invent new ones to uncover the truth with greater accuracy. The article "A study of volatile organic compounds evolved from the decaying human body" explores a new technique for gathering information from a corpse. Search the Gale Forensic Sciences eCollection on [school.cengage.com/forensicscience](http://school.cengage.com/forensicscience) for the article. From what you have learned about the nature of tissue decomposition, evaluate this new technique and give a one-page argument about how this technique will be useful or not. Support your answer with information found in this textbook or other reputable sources.

Source: M. Statheropoulos, C. Spiliopoulou, and A. Agapiou, "A study of volatile organic compounds evolved from the decaying human body," *Forensic Science International* 153.2–3 (Oct 29, 2005): pp. 147(9). From *Forensic Science Journals*.



**Figure 11-12.** Insects can provide information about time of death.



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## Explore

Sometimes when the body of a pregnant woman is not found for several days after she has died, the fetus is found outside of the mother's body. Some medical professionals believe this happened in the case of Laci Peterson. This phenomenon is called coffin birth, when the fetus is expelled from the mother because of a buildup of gases inside the body after death. You might want to outline the Peterson case for students. In December 2002, during her eighth month of pregnancy, Laci Peterson disappeared. After her body was found and an investigation completed, it was determined that she was murdered by her husband Scott. He is currently on death row in San Quentin prison. For more information on the Peterson case, go to the Gale Forensic Science eCollection at [school.cengage.com/forensic-science](http://school.cengage.com/forensic-science).

## Explore

Tell students that dogs can be trained to find dead bodies. These dogs are called cadaver dogs. Their noses are sensitive enough to pick up the trace gases given off by bodies undergoing decay. These dogs have been used to find mass graves, missing persons, and victims of natural disasters, such as after Hurricane Katrina. Have students search the Gale Forensic Science eCollection at [school.cengage.com/forensic-science](http://school.cengage.com/forensic-science).

## Differentiated Learning

### Teaching Gifted Students

Have students research the method a forensic dentist uses to help identify a dead body. Typically, a dentist will receive a radiograph image of the teeth and jaw from the medical examiner's office. This postmortem radiograph is then compared to a database of antemortem radiograph images to determine the identity of the deceased. Students might contact the city or county forensic dentist, CSI, or field investigators for information.



## Digging Deeper

Forensic dentistry is another way to gather information from a corpse. Dentists keep records of all their patients. For this reason, and the fact that teeth are unique and nearly indestructible, people can be identified using their dental records.

## Digging Deeper

Explain to students that bleeding is a loss of blood from the body, and the term “hemorrhage” is the technical or medical term for bleeding profusely.

### Explore

Forensic entomologists can also help in identifying a suspect's whereabouts using objects that were in the suspect's possession. Most typically, entomologists can identify insects found on a car's bumper or windshield and match them to the insects found at the crime scene.

### Evaluate

Ask students to what specific parts of the body insects might be most attracted. Also, ask how a knife or gunshot wound might affect the decay process.

### Evaluate

Have students discuss how a body found indoors, in a sealed car or trunk, or wrapped in a thick blanket might affect insect activity.

## Digging Deeper

With Forensic Science e-Collection

Petechial hemorrhages are a common forensic tool that can provide evidence of time of death as well as some clues about the cause of death. Search the Gale Forensic Sciences eCollection on [school.cengage.com/forensicscience](http://school.cengage.com/forensicscience) for the article “Factors and circumstances influencing the development of hemorrhages in livor mortis.” Read the article and then research the topic online. In 500 words or less, describe and characterize petechial hemorrhages: what they are, what they look like, what causes them, how forensic scientists use them, and how reliable they are as a tool for determining time of death.

Source: Britta Bockholdt, H. Maxeiner, and W. Hegenbarth, “Factors and circumstances influencing the development of hemorrhages in livor mortis,” *Forensic Science International* 149.2–3 (May 10, 2005): pp. 133(5). From *Forensic Science Journals*.



### Did You Know?

To establish how different environmental conditions affect the appearance and rate of development of insects, University of Tennessee professor William Bass established the Body Farm in 1980. This has helped forensic experts interpret the evidence about the time of death much more accurately.

about the environmental conditions, including temperature, moisture, and wind, around the body as well as below it. The forensic entomologist collects insect evidence from on, above, and below the victim's body as well as insect evidence from the immediate area around the victim.

Within minutes of a death, certain insects arrive to lay their eggs on the warm body, attracted by the smell of the first stages of decomposition. The eggs will hatch and feed on the nutritious decomposing tissues. Blowflies are a common example. Blowflies are attracted to two gases of decomposition that have only recently been discovered by scientists, called putrescine and cadaverene. As a corpse progresses through the stages of decomposition, other kinds of insects will arrive. Tiny wasps come to lay their eggs on maggots already present on the body. Wasp larvae live as parasites inside the maggots, feeding on their flesh. The cheese skippers arrive once putrefaction is underway; they are attracted by the seepage of body fluids (Figure 11-13). The last groups of insects to arrive are those that favor drier conditions, such as the mites and beetles that feed on dry tissues and hair as shown in Figures 11-14, 11-15, and 11-16.

Blowflies are one of the first insects to arrive at a dead body and are very useful in determining the time of death. Like other insects, blowflies exhibit different stages as they develop from egg, larva stages (also known as instars), pupa, to adult. Refer to the blowfly life cycle table for more information (Figure 11-17).

Figure 11-13. Cheese skipper.



©A. Skonieczny/Peter Arnold, Inc.

Figure 11-14. Rove beetles feeding on fly larva.



©Nature's Images/Photo Researchers, Inc.

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## Differentiated Learning

### Teaching Gifted Students

If students are interested, try getting them to shadow a medical examiner in your area. You will also need written permission from the students' parents or guardians. Another option might be the cadaver lab of nearby colleges.





Because scientists know how long it takes for the various stages of development at given temperatures, forensic entomologists can determine when the blowflies arrive by studying the insects on the corpse. More importantly, it is quite easy to identify the stage of blowfly development by noting the change in size, color, mobility, presence or absence of a crop, and number of spiracle slits (Figure 11-18). The stages of blowfly larva can be determined by the number of spiracle slits at their posterior end.

**Figure 11-15.** Adult dermestid beetle.



©Cengage Learning

**Figure 11-16.** Dermestid beetle larva.

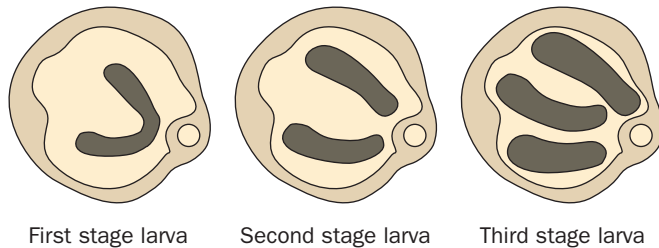


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**Figure 11-17.** Blowfly Life Cycle (times are approximations).

| Stage               | Size (mm) | Color                                | When first appears | Duration in phase | Characteristics  | Sketch (not to scale) |
|---------------------|-----------|--------------------------------------|--------------------|-------------------|--|-----------------------|
| Egg                 | 2         | white                                | Soon after death   | 8 hours           | Found in moist, warm areas of body<br>Mouth, eyes, ears, anus  |                       |
| Larva 1 (instar 1)  | 5         | white                                | 1.8 days           | 20 hours          | Black mouth hooks visible (anterior)<br>Thin body<br>One spiracle slit near anus   |                       |
| Larva 2 (instar 2)  | 10        | white                                | 2.5 days           | 15–20 hours       | Black mouth hooks (anterior)<br>Dark crop seen on anterior dorsal side<br>Actively feeding<br>Two spiracle slits near anus             |                       |
| Larva 3 (instar 3)  | 17        | white                                | 4–5 days           | 36–56 hours       | Black mouth hooks<br>Crop not visible, covered by fat deposits<br>Fat body<br>Three spiracle slits near anus                           |                       |
| Pre-Pupa            | 9         |                                      | 8–12 days          | 86–180 hours      | Larva migrates away from body to a dry area  |                       |
| Early and late Pupa | 9         | Light brown<br>Changes to dark brown | 18–24 days         | 6–12 days         | Immobile, does not feed<br>Changes to dark brown with age<br>Filled air “balloon” to help split open pupa case prior to adult emerging |                       |
| Adult               | Varies    | Black or green                       | 21–24 days         | Several weeks     | Incapable of flight for first few hours  |                       |

**Figure 11-18.** Spiracle slits for larva stages Larva 1, Larva 2, Larva 3.



First stage larva

Second stage larva

Third stage larva

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## Teaching Tip

Point out that dermestid beetles, or flesh beetles, like the dry tissue that clings to bone in the last stages of decay. Coffin flies are another type of insect that can be involved in the decay process. These flies can actually burrow underground and access decaying material.

## Teaching Tip

Explain to students that environmental conditions affect living organisms. Ecological succession is a gradual change in the environment. As an ecosystem changes, an organism living in it must either adapt or die. Insects that are more suited for the altered environment will enter it. Each species adapts to survive and thrive under a certain set of environmental conditions. When these conditions change, the species either adapt or die.

## Teaching Tip

Spiracles on larva can be easily observed under a stereomicroscope. Larvae shown in Figure 11-17 are not drawn to scale.

## Teaching Tip

Encourage students to find pictures of the mentioned insects associated with death. Have them share the pictures with the class and display them in the classroom.



Maggots can help detect if a dead person had poison or drugs in the body at the time of death. When the maggots feed on tissues, any toxins or drugs they eat will be built into their own bodies. A “maggot milkshake” is prepared by a forensic entomologist, which is then analyzed for the presence of poisons or drugs.

First-stage larva has one V-shaped slit (1.8 days old); second-stage larva has two slits (2.5 days old); third-stage larva has three slits (4 to 5 days old). For example:

1. If a corpse contains blowfly eggs, then the approximate time of death would be 24 hours or less.
2. If a corpse contains third-stage larvae, then the time of death is approximately four to five days.
3. If a corpse contains pupae, then the time of death would be approximately 18 to 24 days.

Many factors affect insect development, including temperature, moisture, wind, time of day, season, exposure to the elements, and variations among individual insects. Because life cycles are affected by fluctuations in the daily environmental conditions, insects cannot provide an exact time of death, only a close estimate. Insects collected at the crime scene and then raised in the laboratory under the same environmental conditions as those found at the crime scene. This process can provide a more accurate estimate of time of death (Figure 11-19). The process is called Accumulated Degree Hours (ADH). Here is how this is done:

1. Immediately preserve some insects from the crime scene so you know exactly how old they are at the time of discovery of the body.
2. At the crime lab, raise some of the insects from the crime scene in the same conditions as those found at the crime scene.
3. Record the length of time for development under the specific conditions found at the crime scene.
4. Compare the insects raised at the crime lab to those found at the crime scene.

**Figure 11-19.** Insects from the crime scene are raised in a laboratory to determine the time of their life cycle.



Forensic entomology includes more than an estimation of time of death. If insects from another region are found on a corpse, then it suggests that the corpse may have been moved.

Whatever the cause, mechanism, and time of death, reconstructing a detailed picture surrounding a fatality is critical to any forensic investigation.

## SUMMARY

- There are several definitions of death, or the end of life, including the cessation of the heartbeat and the cessation of brain function. Upon death, cells break down and release their contents, resulting in decomposition.
- The manner of death refers to how the death occurs: by suicide, homicide, natural causes, or accident. If one of these four causes cannot be determined, the manner of death may be ruled undetermined.
- The cause of death refers to what led to the death and includes causes such as heart attack, gunshot wound, or cancer.
- The mechanism of death refers to the specific bodily function resulting in death. A heart attack might lead to the heart ceasing to beat, whereas a gunshot wound might lead to loss of blood or the ceasing of brain function that results in death.
- It is often important to determine the time of death in a forensic investigation. There are several means of doing this. Livor mortis, rigor mortis, and algor mortis are changes that happen to a body after it dies. Stomach contents and the condition of the eyes also provide clues. The states of decomposition of a corpse, as well as the insects on the body, provide further evidence of time of death.

## CASE STUDIES

### The Baby in the Box

In March 1944, the dead body of a newborn child was found wrapped in a blanket and newspaper in a cardboard box. The body had been placed in a pit dug in the forest floor and was covered with leaves. The forensic investigator who examined the body thought it had been abandoned for only a few hours because of the condition of the baby's body. The discovery of more than 20 beetles in the wrappings around the baby demonstrated that the time of death had to be much earlier than this. Recent cold weather had kept the body preserved and had disguised the real time of death.

### Beetles on a Ski Mask Lead to the Conviction of a Rapist

A woman was attacked during the summer outside her apartment building in Chicago. The attacker, wearing a ski mask, leapt at her from the shrubs. He escaped. The police began to suspect a man in the building where the woman lived. A search warrant was obtained, and a ski mask was found in the suspect's apartment. The man claimed he had not used the ski mask since the previous winter.

The victim identified the man in a voice lineup, but this evidence was not sufficient for a conviction. On microscopic examination, fragments of a plant that matched a plant at the crime scene were found stuck to the ski mask. Live larvae of a beetle called a weevil were found in the bushes. The species of weevil survives the winter every year as adults, and larvae are found only during the summer months. The weevil larvae were also

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## Close

Organize students into five groups and assign each group one of the following topics: meaning, manner, mechanism, cause, and time of death. Have each group prepare a summary of the chapter information about their topic and present it to the class.

## Evaluate

Ask students what evidence other than the beetles found with the baby in "The Baby in the Box" could provide investigators with information.

## Differentiated Learning

### Teaching At-Risk Students

Some students, especially visual learners, might find flash cards of insects helpful. They simplify identification of insects.





## Evaluate

Ask students what they think might have happened to delay the flies from accessing the bodies.

found on the ski mask. The presence of the weevil larvae on the ski mask proved the suspect was lying. The ski mask had been in contact with the plant at the crime scene that summer. The insect evidence was enough to convince the jury of the suspect's guilt.

### When Insect Evidence Fails

In response to a 911 call by a relative, a family of three was found dead in a cabin. Their bodies were decomposing, and maggots were found on their flesh. A shocked relative, Mike Rubenstein, found the bodies. He stated he was the last person at the cabin in mid-November. The insect evidence placed the time of death well after this period, providing Mr. Rubenstein with an alibi, but police were suspicious when he quickly applied for the insurance money. A second look at the bodies by Bill Bass revealed that the stage of decomposition did not match that of the insect evidence. It appeared that the flies did not gain entry to the cabin until weeks after the family was killed. Decomposition evidence placed the time of death in mid-November, at the same time Mike Rubenstein says he was there. Eventually, he was convicted of the triple murder.



**Think Critically** Review the Case Studies and the information on insect evidence in the chapter. Then state in your own words how insect evidence impacts a case.

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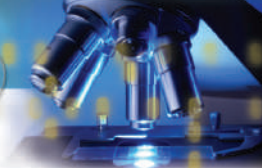
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## Differentiated Learning

### Teaching At-Risk Students

Some students, especially visual learners, might find flash cards of insects helpful. They simplify identification of insects.





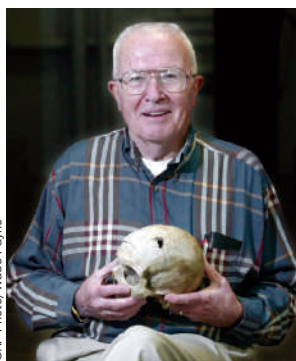
## CAREERS

Discuss with students how this facility is invaluable for research, but it is limited to data collected under the climatic conditions of Tennessee. Ask them how much of the information would or would not be useful for investigating deaths that occur in the desert or in much colder climates. What other kind of mammal might be a good replacement for decay studies if for some reason the use of human bodies was strictly forbidden?

### William Bass

William Bass was studying psychology. For fun, he enrolled in an elective anthropology course studying the behavior and culture of humans. His professor, a specialist in skeletal remains, was asked to come to the scene of a terrible accident. A collision on the highway resulted in a fire. Three people had died, and one body was burned so badly that identification was difficult and the professor was asked to help. The professor asked Bill for a ride to the crime scene and asked the young psychology student to join him. Bill decided right then and there to switch his studies and his career from psychology to anthropology. He learned all about the human body, skeletal remains, and what they can tell us about the life and death of a person.

While at the University of Tennessee, Bill spent many years examining bodies as a forensic expert assisting in solving crimes. In particular he specialized in digging up skeletal remains and learning their secrets, to answer a question of utmost importance in forensic cases, “How long ago did they die?” When Bill started, little information existed to link the physical characteristics of a rotting corpse to a specific time of death. Bill saw a need—and a solution—and in 1971 he approached his university to ask for a small piece of land to do research on decomposition of the human body. His request was granted, and his research on dead bodies has never stopped. Today it is one of the few facilities dedicated to human decomposition. At first, the questions Bill and his team asked were pretty simple, such as, “How long does it take for a limb to fall off of a corpse?” Since then the depth and breadth of the questions being explored has exploded.



©AP Photo/Wade Payne

William Bass at the Anthropology Research Facility.

At any given time, there are about 40 dead bodies on the three acres of the Anthropology Research Facility. They are rotting away in different circumstances, such as in water, in the shade, in the sun, in shallow burials, and in the trunks of cars. All changes in decomposition are carefully recorded over time. The researchers ask all types of specific questions about the chemical changes in different parts of the body during decomposition, as well as the details of insect growth and development under specific conditions. After the decomposition process is completed, the skeletons are catalogued. The collection of

skeletons is, in fact, the largest of its kind in the world and is used to provide a vast array of information about a person from his or her remains. For example, from skeletal comparisons, it is possible to use the length of the thighbone to determine the person’s gender, race, and height. The research facility is also used to train FBI personnel. Bodies are buried with evidence planted, and the FBI is sent in to find the body and recover the evidence.

In 1994, Patricia Cornwell, a mystery novel author, wrote a book based on the research facility. She called her book *The Body Farm*. The name has stuck. The bodies on the body farm are not grown, however. Most bodies are donated, either by families of the dead or given in a will. Hundreds of people have given their remains to the cause of improving forensic science.

Bill Bass, the body farmer, is now retired, but he is still involved in his facility and spends a lot of time communicating forensic science to the public. His work and the body farm are featured in documentaries and books, including *Death’s Acre*, which Bass wrote.



#### Learn More About It

To learn more about the work of forensic entomologists, go to [school.cengage.com/forensicscience](http://school.cengage.com/forensicscience).

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## Differentiated Learning

### Teaching Gifted Students

Dr. Bass is not the first person to try to determine the time of death using insect evidence. Have interested students research some earlier work.



True or False

- 1. True
- 2. False
- 3. True
- 4. True
- 5. False
- 6. True
- 7. False
- 8. True
- 9. True
- 10. False

Short Answer

(For more complete answers see the Instructor's Resource CD.)

- 1. a. Manner of death and cause of death are similar because they both involve a description of death. However, cause of death is the reason someone dies, and manner of death is how he or she died. Manner of death is the overall reason for death (natural, accidental, suicidal, or homicidal), while cause of death is the specific reason for death, such as blunt force trauma, stabbing, disease, stroke, or a heart attack.
- b. Cause of death is the reason someone dies, and mechanism of death describes the specific change in the body that brought about the cessation of life. For example, the cause of death is suffocation and the mechanism would be lack of oxygen to the brain. For each cause of death, there is a mechanism.
- c. Both larvae and pupae

True or False

- 1. Many factors affect rigor mortis, such as the type of clothing the person was wearing. *Obj. 11.4*
- 2. Experts from different sciences agree that the definition of death is the end of life. *Obj. 11.1*
- 3. Blowflies are one of the first insects to arrive at a dead body and are very useful in determining the time of death. *Obj. 11.8*
- 4. Livor mortis refers to the color of a dead body. *Obj. 11.4*
- 5. The only two manners of death are natural death and homicidal death. *Obj. 11.2*
- 6. Mechanism of death describes what has occurred in the body to cause death. *Obj. 11.3*
- 7. The presence of drugs in a corpse cannot be determined by a chemical analysis of larvae found feeding on the body. *Obj. 11.10*
- 8. In the first 12 hours, a dead body cools about 1 degree F per hour. *Obj. 11.4*
- 9. Within minutes of a death, certain insects are attracted by the smell of the first stages of decomposition. *Obj. 11.9*
- 10. *The Body Farm* is a fictional account of the work of a country coroner. *Obj. 11.1*

Short Answer

- 1. Explain the similarities and differences of the following terms: *Obj. 11.2, 11.3, 11.4, 11.6, and 11.9*

a. manner of death and cause of death

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b. cause of death and mechanism of death

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c. larva and pupa

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are stages in certain insect life cycles. The pupal stage follows the larval stage. During the pupal stage, the insect forms a cocoon and grows the adult structures that the insect did not have during the larval stage. A larva moves, eats, and grows. The pupa is a "resting" stage when the insect changes into the adult form.



d. rigor mortis and livor mortis

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---

e. autolysis and decomposition

---

---

2. As you drive along a roadside, you and your friend notice a dead deer that apparently was struck by a car. Your friend comments that she has never seen such a fat deer. "Did you see the size of its abdomen? It was huge!" As a student of forensics, how would you explain to your friend why the abdominal region of the dead deer was so large? *Obj. 11.4 and 11.6*

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3. The forensic examiner tells the detective that he thinks the body was killed in the country before it was later found in an alley in New York City. What type of evidence could be present on the body to lead the forensic examiner to that conclusion? *Obj. 11.4 and 11.5*

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4. A body is found with rigor mortis present in the face, neck, and upper torso. The young crime-scene investigator claims that the time of death must be at least 15 hours previous to the discovery of the body. The first-responding officer still at the crime scene asks what led her to that conclusion. The crime-scene investigator states that rigor mortis peaks at 12 hours and then gradually fades. Because there was no rigor in the legs, rigor mortis must be disappearing and is now only evident in the face, neck, and upper torso. Do you agree with this time estimation? Provide reasons for your answer. *Obj. 11.4 and 11.5*

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5. Provide an example of the possible succession of insects that would be found on the body of a dead squirrel. Include in your answer: Which insect is usually the first to arrive on the dead body? Explain your reasoning. Which insects are usually the last to arrive on the dead body? Explain your reasoning. *Obj. 11.9*

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4. Sample answer: Rigor mortis starts within two hours after death. The stiffness starts in the head and gradually works its way down to the legs. After 12 hours, the body is at its most rigid state. The stiffness gradually disappears after 36 hours. Because the body was found and rigor mortis was in the face and upper torso, rigor mortis was just beginning, and therefore death occurred more than two hours but less than 12 hours prior.

5. Blowflies would be one of the first insects to arrive at the squirrel's body and lay its eggs. These eggs would hatch and feed on the tissue. Tiny wasps then come to lay their eggs on maggots that are already present on the body. Their larvae live as parasites inside the maggots, feeding on their flesh. The cheese skippers arrive once putrefaction is under way. They are attracted by the seepage of body fluids. The last groups of insects to arrive are those that favor drier conditions, such as the mites and beetles that feed on dry tissues and hair.

d. Livor mortis is the pooling of blood after death that causes discoloration. Livor mortis begins about two hours after death and becomes permanent after about eight hours. Rigor mortis is body stiffness which occurs about two hours after death and lasts for up to 48 hours. Both are factors that can help determine the time of death.

e. Autolysis is the dying or breakdown of cells. Decomposition refers to the entire body breaking down. Therefore, autolysis is a breakdown at the cellular level, while decomposition is breakdown on a larger scale. Autolysis occurs when the body begins to self-destruct using its own enzymes. Decomposition occurs as outside factors invade the body and cause its destruction.

2. The abdominal region of the deer is so large because of gasses emitted by anaerobic bacteria inside the animal's gut. Within six to ten days after death, the animal bloats with carbon dioxide given off by the bacteria as they feed on the tissue.

3. Sample answer: Lividity can reveal if a body has been moved. For example, if the person died sitting in a chair, lividity would appear on the backs of the thighs, buttocks, and the bottoms of the feet. Dual lividity could occur if the body was kept in one position for two hours after death and then moved to a second position before the lividity became permanent. This is not uncommon if a murder victim is killed in one place, then transported somewhere else. Insect evidence may point to movement of a body—city insects and country insects also vary!

## ACTIVITY 11-1

### Background

In this activity, students work in pairs to analyze scenarios in which they must estimate the time of death based on rigor mortis evidence.

### Safety Precautions

There are no safety precautions for this activity.

### Procedures

1. Make sure students read all directions *before* beginning the activity.
2. Review the Rigor Mortis Reference Table with students before beginning this activity.
3. Remind students to include as much detail as possible in their answers.

### Answers

(For more complete answers, see the Instructor's Resource CD.)

#### Part A

1. There is not enough information to determine a time of death. The person could have just died and rigor had not yet begun, or the person may have died 36 hours ago and has now lost all signs of rigor.
2. Peak rigor is usually noted 12 hours after someone dies.
3. It appears that rigor is just in its early stages. The time of death is at least 2 hours earlier because rigor begins in the face. Because rigor is also found in the chest, arms, and neck, more than two hours has passed. The legs have not yet started to undergo rigor, therefore the approximate time of death is between four and nine hours.



## ACTIVITY 11-1 Ch. Obj. 11.5

### CALCULATING TIME OF DEATH USING RIGOR MORTIS

#### Background:

In old detective movies, a dead body was often referred to as a “stiff.” The term refers to the onset of rigor mortis that follows soon after death. In this activity, you will estimate the approximate time of death by analyzing the degree of rigor of the deceased body.

#### Objective:

*By the end of this activity, you will be able to:*  
Estimate the time of death using rigor mortis evidence.

#### Materials:

paper  
pen or pencil  
calculator (optional)

#### Safety Precautions:

None

#### Procedure:

In pairs, answer the following questions dealing with approximating the time of death based on rigor mortis evidence. Refer to the Rigor Mortis Reference Table in your textbook (Figures 11-8 and 11-9).

#### Questions:

##### Part A

Estimate the approximate time of death for the following situations. Explain each of your answers:

1. A body was found with no evidence of rigor.
2. A body was found exhibiting rigor throughout the entire body.
3. A body was found exhibiting rigor in the chest, arms, face, and neck.
4. A body was discovered with rigor present in the legs, but no rigor in the upper torso.
5. A body was discovered with most muscles relaxed, except for the face.
6. A body was discovered in the weight room of a gym. A man had been doing “arm curls” with heavy weights. The only place rigor was present was in his arms.

4. Because no rigor is evident in the upper body, it might be assumed that peak rigor has already occurred and rigor is slowly moving out of the body. The legs tend to be the last place on the body where rigor is present. Peak rigor occurs at 12 hours, and rigor is usually gone by 36 hours. Time of death is estimated to be 24 to 30 hours.
5. Because rigor begins in the face and works its way down to the legs, it is possible that rigor is just commencing. This would put the time of death around two hours previous to the discovery of the body.

6. This form of exercise would result in lactic acid buildup in his biceps and not in other parts of his body. Rigor usually begins in the face and neck and works its way down to the arms. It appears rigor has not begun in his face, which would put the estimated time of death to be less than two hours. Arms exhibiting rigor before any other body part are due to the high level of lactic acid in the arms at the time of death.

## Part B

Estimate the time of death based on the following information:

7. A frail, elderly woman's body was found in her apartment on a hot summer's evening. Her body exhibited advanced rigor in all places except her face and neck.
8. A body was discovered in the woods. The man had been missing for two days. The average temperature the past 48 hours was 50 degrees Fahrenheit. When the body was discovered, it was at peak rigor.
9. An obese man was discovered in his air-conditioned hotel room sitting in a chair in front of the television. The air conditioner was set for 65 degrees Fahrenheit. When the coroner arrived, the man's body exhibited rigor in his upper body only.
10. While jogging, a young woman was attacked and killed. The perpetrator hid the body in the trunk of a car and fled. When the woman's body was discovered, rigor was noticed in her thighs only.
11. The victim's body is not rigid. How long has she been dead? Explain your answer.
12. The body is completely stiff. How long has he been dead? Explain your answer.
13. The victim was found in a snowbank alongside a road. His body is rigid. How long has he been dead? Explain your answer, remembering the cold temperature.
14. The body of the runner was found in the park one early, hot summer morning. Her body shows rigor in her face, neck, arms, and torso. How long has she been dead? Explain your answer.



## Part B

7. This woman seems to be recently past the peak 12 hours of rigor and is just starting to lose rigor. Based on this information, her estimated time of death would be approximately 15 hours. However, it is also noted that the woman is frail. This usually accelerates rigor. This might bring her time of death closer to 12 hours. Finally, another situation must be considered: The apartment was hot. High ambient temperature would also accelerate rigor mortis. This might make her time of death closer to nine hours.
8. Because the body was outside in 10°C (50°F) temperatures, rigor may be delayed. This could make the time of death closer to 24 hours.
9. Rigor is not complete. Rigor has not yet progressed to the man's thighs. This would put the time of death at approximately six hours since he died. However, the air conditioning in the room would have slowed down the onset of rigor, making the time of death closer to nine hours. Time of death could be approximated sometime between 8 to 12 hours.
10. If rigor was noted only in the thighs, it would appear that rigor was already being lost. The legs are usually the last area of the body to demonstrate rigor. Because rigor is exhibited only in the legs, that would put the time of death at approximately 24 to 30 hours. Another variable to be considered was that the woman was running. This would build up lactic acid and would tend to accelerate the onset and disappearance of rigor. This could move the time of death to be sooner, or 18 to 24 hours. Finally, a major consideration is that the woman's body was left in

the trunk of the car during the hot summer months. This would definitely accelerate rigor's onset and disappearance because chemical reactions happen faster in warmer temperatures. Time of death might be much sooner than the originally estimated time of 24 to 30 hours. If insect evidence were collected along with rigor evidence, the time of death could be better approximated. This situation demonstrates a need for the body farm. Variables such as temperature and other environmental conditions, as well as the effect of exercise before death, could be duplicated to better establish a time of death.

11. Two possibilities—dead less than two hours or more than 36 hours—check body temperature for an additional clue.
12. Peak rigor ~ 12hours
13. Time of death is more than 12 hours—onset of rigor might be delayed by cold temperature.
14. Time of death is between one and three hours. Hot, dry weather accelerates rigor.

## ACTIVITY 11-2

### Background

In this activity, students work in pairs to estimate the time of death using algor mortis measurements.

### Safety Precautions

There are no safety precautions for this activity.

### Procedures

1. Make sure students read all directions *before* beginning the activity.
2. Read through the activity examples as a class to make sure students understand what is expected of them.



## ACTIVITY 11-2 Ch. Obj. 11.5 CALCULATING TIME OF DEATH USING ALGOR MORTIS

### Objective:

*By the end of this activity, you will be able to:*  
Estimate the time of death using algor mortis measurements.

### Materials:

paper  
pen or pencil  
calculator  
Rigor Algor Reference Table

### Safety Precautions:

None

### Procedure:

Working in pairs, answer the following questions using this information:

- For the first 12 hours, the body loses 0.78°C (1.4°F) per hour.
- After the first 12 hours, the body loses about 0.39°C (0.7°F) per hour.

**Example 1:** What is the temperature loss for someone who has been dead for 12 hours?

$$\text{Temperature loss} = (0.78^{\circ}\text{C}/\text{hour}) \times 12 \text{ hours} = 9.36^{\circ}\text{C}$$

**Example 2:** Calculate the time of death if a person has been dead for less than 12 hours.

If temperature loss is less than 12 hours (or less than 9.36°C), then you use the rate of 0.78°C per hour to estimate the time of death.

Temperature of dead body is 32.2°C (90°F).

Normal body temperature is 37°C. (98.6°F)

$37^{\circ}\text{C} - 32.2^{\circ}\text{C} = 4.8^{\circ}\text{C}$  lost since death.

How long did it take to lose 4.8°C ?

$$0.78 \text{ (}^{\circ}\text{C}/\text{hour}) \times (\text{unknown number of hours}) = \text{degrees lost}$$

$$0.78 \text{ (}^{\circ}\text{C}/\text{hour}) \times (\text{unknown number of hours}) = 4.8^{\circ}\text{C lost by body}$$

Solve for the unknown number of hours since death occurred:

$$\text{Number of hours} = 4.8^{\circ}\text{C} \div 0.78 \text{ (}^{\circ}\text{C}/\text{hour})$$

$$\text{Number of hours} = 6.1 \text{ hours}$$

Convert 0.1 hours into minutes:

$$0.1 \text{ hour ( } 60 \text{ (min}/\text{hour}) = 6 \text{ minutes}$$

$$\text{Hours since death} = 6.1 \text{ hours or } 6 \text{ hours and } 6 \text{ minutes}$$

**Example 3:** Is the time of death more than 12 hours or less than 12 hours?

Recall that if a body has been dead 12 hours or less, the body loses heat at rate of .78°C per hour. If the body has been dead 12 hours, then  
 $.78^{\circ}\text{C}/\text{hour} \times 12 \text{ hours} = 9.36^{\circ}\text{C}$ .



If a body loses 9.36°C, then the person has been dead for 12 hours.

If a body loses more than 9.36°C, then the person has been dead for more than 12 hours.

If they lose less than 9.36°C, then the body has been dead for less than 12 hours.

For each of the following, state if the body had been dead for more than or less than 12 hours based on the number of degrees lost:

1. total loss of 7.9°C
2. total loss of 4.4°C
3. total loss of 11.7°C
4. total loss of 17.2°C
5. total loss of 10.6°C

**Example 4:** Calculate the time of death if the person was dead for more than 12 hours.

If the body has lost more than 9.36°C, then you know that the victim has been dead for more than 12 hours. Recall that after 12 hours, the body loses heat at a rate of 0.39°C per hour. You need to calculate how many hours beyond the 12 hours that someone died and add it to the 12 hours. Body temperature was given as 22.2°C (72°F).

1. How many total degrees were lost from the time of death until the body was found?

$$37^{\circ}\text{C} - 22.2^{\circ}\text{C} = 14.8^{\circ}\text{C}$$

2. Since 14.8°C is more than 9.36°C, you know that the body was dead longer than 12 hours. How much longer?

$$37^{\circ}\text{C} - 22.2^{\circ}\text{C} = \text{total loss of } 14.8^{\circ}\text{C} \text{ since death}$$

$$9.36^{\circ}\text{C} \text{ were lost in the first 12 hours}$$

$$14.8^{\circ}\text{C} \text{ lost since death} - 9.36^{\circ}\text{C} \text{ lost the first 12 hours} =$$

$$5.44^{\circ}\text{C} \text{ lost after the first 12 hours}$$

3. Recall that the rate of heat lost after 12 hours is 0.39°C per hour.

You need to determine how many hours it took to lose that 5.44°C.

$$(0.39^{\circ}\text{C}/\text{hour}) \times (\text{unknown \# of hours}) = \text{degrees lost after 12 hours}$$

$$(0.39^{\circ}\text{C}/\text{hours}) \times (\text{unknown \# of hours}) = 5.44^{\circ}\text{C} \text{ lost after the initial 12 hours}$$

Solve for unknown number of hours:

$$\text{unknown \# of hours (x)} = 5.44^{\circ}\text{C} \div (0.39^{\circ}\text{C}/\text{hour})$$

$$= 13.9 \text{ hours total time to lose } 13.9^{\circ}\text{C} \text{ or approximate time of death}$$

4. First 12 hours there was a loss of 9.36 degrees C 9.36°C

Next 13.9 hours there was an additional loss of 5.44° C= 5.44°C

Therefore, the victim has been dead about 25.9 hours. (or approximately 26 hours)

$$.8 \text{ hours} \times 60 \text{ min/hr} = 48 \text{ minutes}$$

### Questions:

#### Part A

1. Determine the approximate time of death using evidence from algor mortis. Show your work. Approximately how long has the victim been dead if his body temperature was 33.1°C (91.6°F)?

4. (Note a body temperature of 15.6°C = 60°F )

$$37^{\circ}\text{C} - 15.6^{\circ}\text{C} = 21.4^{\circ}\text{C} \text{ lost since time of death}$$

$$9.4^{\circ}\text{C} \text{ lost in the first 12 hours}$$

$$21.4^{\circ}\text{C} - 9.4^{\circ}\text{C} = 12^{\circ}\text{C} \text{ lost after 12 hours}$$

$$(0.39^{\circ}\text{C}/\text{hour}) \times \text{unknown number of hours} = 12^{\circ}\text{C}$$

$$\text{unknown number of hours} = 12^{\circ}\text{C} / (0.39^{\circ}\text{C}/\text{hour})$$

$$= 30.8 \text{ hours or } 30 \text{ hours } 48 \text{ minutes}$$

$$(0.39 \text{ hours} \times 60 \text{ min}/\text{hour}) = 48 \text{ minutes}$$

$$12 \text{ hours} + 45 \text{ minutes} = 57 \text{ hours } 6 \text{ minutes (approximately) before discovery of the body}$$



## Answers

### Example 3

1. Less
2. Less
3. More
4. More
5. More (about 26 hours)

Note: Answers are always approximate, and they are based on differing conditions.

### Part A

1. k

$$37^{\circ}\text{C} - 33.1^{\circ}\text{C} = 3.9^{\circ}\text{C}$$

$$.78^{\circ}\text{C}/\text{hour} \times \text{unknown hours} = 3.9^{\circ}\text{C}$$

$$\text{unknown hours} = 3.9^{\circ}\text{C} / .78^{\circ}\text{C}$$

$$\text{unknown hours} = 5 \text{ hours}$$

2. The person died in less than 5 hours since the body would have lost heat at a faster rate being outside in the winter. If the body was found outside in the winter, the rate of body heat lost would be much greater than the calculated .78°C (1.4 degrees °F) per hour.

3.  $37^{\circ}\text{C} - 25.9^{\circ}\text{C} = 11.1^{\circ}\text{C}$  lost since death

$$9.4^{\circ}\text{C} \text{ would be lost in the first 12 hours}$$

$$11.1^{\circ}\text{C} - 9.4^{\circ}\text{C} = 1.7^{\circ}\text{C}$$

$$\text{lost after 12 hours}$$

$$(0.39^{\circ}\text{C}/\text{hour}) \times (\text{unknown hours}) = 1.7^{\circ}\text{C}$$

$$\text{unknown hours} = 1.7^{\circ}\text{C} / .39^{\circ}\text{C}$$

$$\text{unknown hours} = 4.36 \text{ hours or } 4 \text{ hours and } 22 \text{ min.}$$

$$(.36 \text{ hours} \times 60 \text{ min}/1 \text{ hr} = 22 \text{ min})$$

$$\text{total time dead} = \text{initial 12 hours plus } 4 \text{ hours and } 22 \text{ minutes} = 16 \text{ hours } 22 \text{ minutes (approximately)}$$

5. (Note a body temperature of  $10^{\circ}\text{C} = 50^{\circ}\text{F}$ )

$37^{\circ}\text{C} - 10^{\circ}\text{C} = 27^{\circ}\text{C}$  lost since time of death

$27^{\circ}\text{C} - 9.4^{\circ}\text{C} = 17.6^{\circ}\text{C}$

lost in first 12 hours

$(0.39^{\circ}\text{C}/\text{hour}) \times \text{unknown}$

# of hours =  $17.6^{\circ}\text{C}$

unknown # of hours =

$17.6^{\circ}\text{C} \times (0.39^{\circ}\text{C} / \text{hour})$

= 45.1 hours or 45

hours 6 minutes

0.1 hours ( 60 min/hr) = 6

minutes

Approximate time of death:

12 hours + 45 hours should

be 6 minutes not 24) 6min-

utes = 57 hours 6 minutes

before discovery of the body

6. (Note a body temperature of  $29.4^{\circ}\text{C} = 85^{\circ}\text{F}$ )

$37^{\circ}\text{C} - 29.4^{\circ}\text{C} = 7.6^{\circ}\text{C}$

lost. (Note: less than 12 hours since time of death)

$(0.78^{\circ}\text{C} / \text{hour}) \times \text{unknown}$

hours =  $7.6^{\circ}\text{C}$

unknown hours =  $7.6^{\circ}\text{C}$  (

$0.78^{\circ}\text{C}/\text{hour}$ )

= 9.7 hours or 9 hours

42 minutes

0.7 min  $\times$  (60 min/hour) =

42 minutes

Approximate time of death:

9 hours and 42 minutes

before discovery of the body

7. (Note a body temperature of  $24^{\circ}\text{C} = 75.2^{\circ}\text{F}$ )

$37^{\circ}\text{C} - 24^{\circ}\text{C} = 13^{\circ}\text{C}$  lost

$13^{\circ}\text{C} - 9.4^{\circ}\text{C} = 3.6^{\circ}\text{C}$  lost

after first 12 hours

$.39^{\circ}\text{C} \times \text{unknown \# hours} =$

$3.6^{\circ}\text{C}$

unknown hours =  $7.6^{\circ}\text{C}$

$7.6^{\circ}\text{C}$  divided by  $(0.78^{\circ}\text{C}/\text{hour})$

unknown hours =  $3.6^{\circ}\text{C}$

divided by  $(0.39^{\circ}\text{C}/\text{hour})$

$(0.2 \text{ hours} \times (60 \text{ min/hr}) =$

12 minutes)

Approximate time of death:

12 hours + 9 hours and 12

minutes = 21 hours and 12

minutes before discovery of

the body



2. A body found outside in the winter has a temperature of  $33.1^{\circ}\text{C}$ . Has the body been dead a longer or shorter time than in problem 1? Explain your answer.
3. Approximately how long has the victim been dead if his body temperature was  $25.9^{\circ}\text{C}$  ( $85.2^{\circ}\text{F}$ )?
4. What is the approximate time of death if the body temperature was  $15.6^{\circ}\text{C}$  ( $60.8^{\circ}\text{F}$ )?
5. What is the approximate time of death if the body temperature was  $10^{\circ}\text{C}$  ( $50^{\circ}\text{F}$ )?
6. What is the approximate time of death if the body temperature was  $29.4^{\circ}\text{C}$  ( $84.9^{\circ}\text{F}$ )?
7. What is the approximate time of death if the body temperature was  $24^{\circ}\text{C}$  ( $75^{\circ}\text{F}$ )?

#### Part B

Describe the impact on time of death for each of the variables listed below. If you based your time of death estimates strictly on temperature loss to be 10 hours earlier, would you reduce your 10-hour estimate or increase your 10-hour estimate if the body had been:

1. Naked
2. Exposed to windy conditions
3. Suffering from an illness prior to death
4. Submerged in a lake

#### Further Study:

1. Investigate the procedures used by crime-scene investigators to take accurate body temperature readings.
2. What is the significance of determining the time of death? Why is it so important to crime-scene investigators to take the temperature of the deceased body if the person is already known to be dead?

#### Part B

1. Reduce time of death estimate.
2. Reduce time of death estimate.
3. Increase time of death estimate if they had a fever.
4. Probably reduce the time of death estimate because most lakes are much cooler than body temperature.

## ACTIVITY 11-3 *Ch. Obj. 11.8, 11.9, and 11.10*

### INSECT STUDY



#### Objective:

By the end of this activity, you will be able to:  
Study the behavior and life cycles of insects associated with decomposition.

#### Introduction:

The blowfly is often the first insect to reach a corpse and lay its eggs. Use Figures 11-17 and 11-18 as references in your study of blowfly development.

#### Materials:

Data Table: Insect Study  
1 lb. cottage cheese or pudding containers  
raw calf liver (1 lb.)  
sharp knife  
warm (or hot) day (but not windy or too hot!)  
thermometer  
plastic kitchen-sized garbage can with a flip top  
plastic garbage bag liner  
another cardboard box to cut up into smaller pieces  
small cardboard box large enough to hold the plastic cottage cheese container and fit inside a garbage can  
digital camera (optional)

#### Safety Precautions:

Wash your hands after handling the flies.

#### Procedure:

##### Part A: Setting up the Fly Incubator

1. Line a plastic kitchen-sized flip-top or swinging-lid garbage can with a plastic liner.
2. Cut up a cardboard box and fold the cardboard pieces in half so that the pieces of cardboard don't lie flat.
3. Add the folded cardboard to the bottom of the kitchen garbage bag so that the garbage bag is one-third full. This is important because, during the last stage, the larvae will migrate away from the food to a dry area. If you have ample cardboard pieces available, the larvae will have many areas to hide. (Depending on the size of your garbage can, you might want to add an empty box on top of the cardboard pieces to elevate your fly assembly so that you will have easier access to the fly dish shown on the next page.

##### Part B: Preparing Your Liver Dish

1. Add raw liver in a plastic cottage cheese container.
2. Cut some slices into the surface of the liver to make gashes within the liver to resemble an open wound.

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## ACTIVITY 11-3

### Background

In this activity, students work in groups to study the behavior and life cycles of insects associated with decomposition. A review of the blowfly life cycle might be helpful.

### Safety Precautions

1. Remind students to wash their hands after handling the flies.
2. Expect some odor from this fly setup. To reduce the odor, place the liver dishes in plastic garbage cans as described.

### Procedures

1. Make sure students read all directions before beginning the activity.
2. Collecting the flies and larvae does not need to be a challenge.
3. You are going to get more than just blowflies on this chunk of liver because of the succession of insects that progress during decomposition. Some insects prey upon larva. Be sure to maintain a culture of larva away from the possibility of contamination.
4. The larvae and adults can be stored and preserved in 70 percent rubbing alcohol in small vials. These vials can later be arranged in order, representing the incremental stages of the blowfly life cycle. If saved, they can be used in subsequent years as examples for students to identify the stages. Wrap the lid of each jar with paraffin to eliminate evaporation.

5. Not being able to see and collect data around the clock is a limitation that cannot be avoided. If a class meets from 1 p.m. to 2 p.m., students will only see data for one hour a day. If possible, have volunteers collect and observe at different times of the day and night.
6. Discuss with students what a good presentation, diary, and scrapbook will contain so students have an idea what you will be looking for when you grade them. Provide students with a rubric to make sure they know what is expected.

## Answers

Check students' data tables, PowerPoint presentations, diaries, and scrapbooks.



### Part C: Obtaining Flies

1. Leave your open liver container in an area where you want to collect flies. The odor of the liver should attract flies within minutes.
2. Collect flies on a warm day. If it is too cold or too windy, flies will not lay their eggs. Avoid taking fly collections on very windy days or very hot days.
3. Leave the liver container in the open area for at least one hour. Place the dish in an area that will not be disturbed by dogs or cats.
4. Look for very small, white clusters of fly eggs on top of the liver.

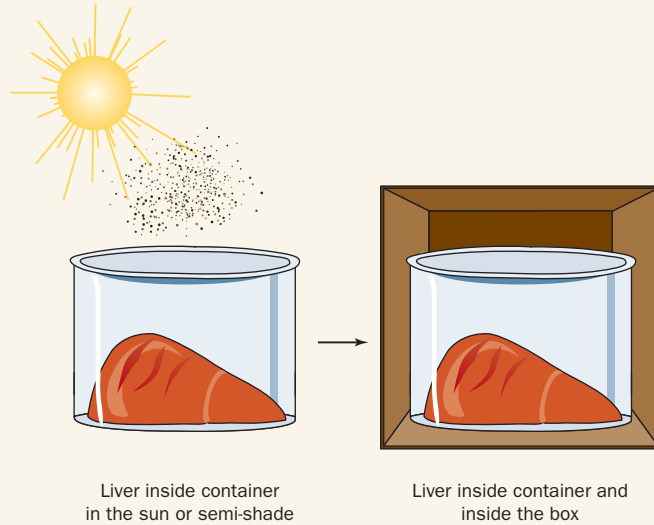
### Part D: Incubation of Fly Eggs

1. Place the liver container and fly eggs into a small cardboard box. Be sure the cardboard box and the plastic liver dish will fit in the garbage can.
2. Allow the flip-top cover of the garbage can to close. This will still allow other insects to enter the dish while keeping some of the odor inside the garbage can.
3. Keep the garbage can in an area that is not in direct sunlight. Because some odor will be given off, place the garbage can in an area where the odor will not present a problem to others.

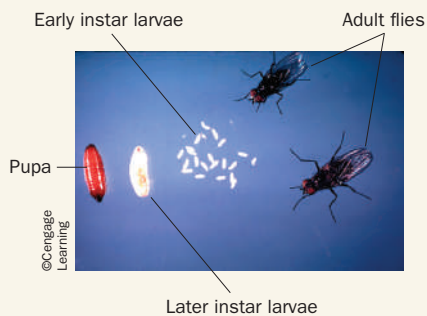
### Part E: Observations and Data Collection

1. Make observations each day and record on your data table until adult flies have emerged.
2. Take a digital photo of the liver container and any organisms near or on the container. Note: Larvae tend to move away from light, so be ready to quickly take pictures when you view your liver dish.
3. Complete the data table as you make your daily observations. Record the date and time of your daily collections. Record the

*Insect study setup.*







temperature inside the fly incubator (garbage can). Make other observations such as the color, size, and behavior of your insects.



#### Part F: Report

##### Option 1

1. Create a PowerPoint presentation of the insects collected on the liver. Include your digital photos taken of the different stages of the insects you observed. If you do not have a digital camera, obtain pictures of the insects from the Internet.
2. Include the name of all insects and correctly identify their stage of development. Indicate the preferred food source for each of the insects.
3. Do not place too many words on each frame.

##### Option 2

Write an autobiography from the viewpoint of the fly as it develops from an egg into adulthood. Include in your diary:

- Physical description of the insect at different stages of development
- Physical description of the insect's environment
- Descriptions of when the insect feeds or does not feed
- Description of the type of food it is eating
- Descriptions of any "travels" or migrations and movements of the insect
- Photos from your digital pictures taken during the study

Your information should be scientifically correct, but feel free to be creative in your insect diary!

##### Option 3

Prepare a scrapbook from the viewpoint of the insect as it progresses through its different stages. Use the photos from your study. Add notations indicating the:

- Physical descriptions of the insect at the different stages of development
- Physical descriptions of the insect's environment
- Descriptions or comments on the insect's source of food at different stages
- Descriptions of any "travels" or migrations of the insect

Your information should be scientifically correct, but feel free to be creative with this scrapbook!

### Further Research and Extensions

Encourage students to research insects associated with death on the Internet. Another resource is the Wards "Critters on Cadavers" lab activity.

Save projects to share with your classes in the coming years or for parent/teacher conferences or open houses. Have students design a project to study the variables affecting insect development. This might include varying the temperature or the exposure of cultures to light.

## ACTIVITY 11-4

### Background

In this activity, students work in pairs to estimate the time of death using insect, algor, and livor mortis evidence. Students need to be reminded to first estimate the time of death based solely on temperature change and then factor in the variables. Time of death is not exact, but can be estimated by examining all the evidence from insects, algor, rigor, and livor mortis.

### Safety Precautions

There are no safety precautions for this activity.

### Procedures

1. Print, copy, and distribute Activity Sheets for Activity 11-4 from the IRCD.
2. Make sure students read all directions *before* beginning the activity.
3. Review the Blowfly Life Cycle table before beginning this activity.
4. Review temperature loss after death.

### Answers

(For complete answers see the Instructor's Resource CD.)

1. a. Death occurred approximately 2 hours earlier, around 6 AM.  
b. Based on algor mortis evidence:  
3.3 hours or 3 hours and 18 minutes  
(0.3 hours  $\times$  60 minutes/hour) = 18 minutes  
Time since death based on algor mortis:  
3 hours and 18 minutes  
Based on livor mortis: time of death less than 2 hours, no evidence of lividity  
Based on rigor mortis: limited rigor suggesting time of death more than 2 hours.



## ACTIVITY 11-4 Ch. Obj. 11.5, 11.8, 11.9, and 11.10 ESTIMATING TIME OF DEATH USING INSECT, ALGOR, AND LIVOR MORTIS EVIDENCE

### Objective:

By the end of this activity, you will be able to:  
Estimate the time of death using insect, algor, and livor mortis evidence.

### Materials:

paper  
pen or pencil  
calculator  
Rigor Mortis Reference Table: Refer to the tables distributed by your teacher (Figures 11-8 and 11-9)  
Insect Reference table: Refer to the table distributed by your teacher (Figure 11-7).

### Safety Precautions:

None

### Procedure:

Working in pairs, answer the following questions.

### Questions

1. A naked, male corpse was found at 8 a.m. on Tuesday, July 9. The air temperature was already 26.7°C (81°F). The body exhibited some stiffness in the face and eyelids and had a body temperature of 34.4°C (93.9°F). Livor mortis was not evident.
  - a. Approximately how long ago did the man die?
  - b. Justify your answer.
  - c. Would clothing on the body have made a difference in determining the actual time of death? Why or why not?
2. At noon, a female corpse was found partially submerged on the shore of a lake. The air temperature was 26.7°C (81°F), and the water temperature was about 15.6°C (61°F). Rigor mortis was not evident, and the body's temperature was 15.6°C. Livor mortis showed a noticeable reddening on the victim's back that did not disappear when pressed. Bacterial activity was not significantly increased, and the lungs were filled with water.
  - a. Approximately how long ago did the woman die?
  - b. Justify your answer.
3. The body felt cold to the touch. The thermometer gave a reading of 21.1°C (70°F) for the body temperature. No rigor mortis was evident, but livor mortis had set in with blood pooling along the back. There was no noticeable increase in bloating or bacterial activity in the digestive system and no putrefaction. The man had been dead for more than 48 hours. How is that possible?

Variables: cooler temperatures and naked body would cause the body to cool at a faster rate. Therefore the 3 hours and 18 minutes could have been actually less time.

- c. A lack of clothing would cause the body to lose body heat faster.
2. a. 36 to 43 hours before the discovery of the body, or between 9 p.m. on May 18 to 5 a.m. on May 19  
b. Based on algor mortis evidence:  
or 31 hours 36 minutes  
Time since death based on algor mortis:  
43 hours 36 minutes since death.

Based on livor mortis evidence:

Permanent livor mortis indicates that death occurred at least eight hours earlier.

Based on rigor mortis evidence:

No rigor is evident, which is consistent with the time of death being more than 36 hours.

Bacterial evidence:

There is not much evidence of bacterial decomposition.

Variables to consider:

When bodies are submerged in water or partially submerged in water, it is difficult to accurately determine the time of death.

4. The dead body contained evidence of blowfly infestation. The larvae were collected and reared in a lab in an environment similar to the conditions surrounding the dead body. Adult flies mated and laid eggs. Data was collected, noting the time required to progress from one stage to the other and recorded in the following Data Table.



| Stage         | Accumulated Time Since Egg Was Laid (Hours) | Accumulated Time Since Egg Was Laid (Days) |
|---------------|---|--|
| Egg           | Egg laid minutes after death                | 0  |
| Larva stage 1 | 24  | 1  |
| Larva stage 2 | 60  | 2.5  |
| Larva stage 3 | 96–120                                      | 4–5  |
| Pupa          | 192–288                                     | 8–12                                       |
| Adult         | 432–576                                     | 18–24                                      |

- Record the estimated time since death if the insects recovered from the dead body were in each of the stages below: egg, larva 1, larva 2, larva 3, pupa, adult.
  - Record the estimated time since death if insects were in the following stages: Some eggs and some larva stage 1, some adults and some pupae, some larva found in stage 2 and stage 3.
5. A dead body of an elderly gentleman was discovered in an abandoned building. Blowfly pupae were found on the body. A missing person's report was filed for an elderly gentleman who had wandered away from home just two days before. The body found was similar in age, height, and weight to the missing person. Could this possibly be the same person as the person described in the missing person's report? Explain your answer.
6. The police received a report about a body found in the woods behind the local shopping center. The forensic investigator collected 5 different types of living insects on the man's body. It's important to stress that investigators found all 5 insects alive on the body at the same time. The insects were sent to the forensic entomology lab, where they were raised under similar conditions to those found around the dead body. The following chart describes the life cycles of each of the five different types of insects found on the dead body. How long has the man been dead? Justify your answer.

| Insect    | Day |   |   |   |   |   |   |   |   |    |
|-----------|-----|---|---|---|---|---|---|---|---|----|
|           | 1   | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Blowfly   | 1   | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0  |
| Species A | 0   | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1  |
| Species B | 0   | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0  |
| Species C | 0   | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1  |
| Species D | 0   | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1  |

0 = no evidence of fly species; 1 = evidence of egg, larva (maggot) or pupa

The water temperature was cool at 15.6°C (60°F), which could slow down body decomposition while accelerating the rate of heat loss.

Combined effects:

Time of death seems to be within a range of 36 hours to 43 hours..

3. Sample answer: It appears that the body might have been refrigerated sometime after death, slowing down heat loss as well as reducing bacterial decomposition.

Algor mortis evidence:

28 hours and 42 minutes since death.

**Livor mortis evidence:**

Permanent pooling of blood indicates that death occurred at least eight hours before the discovery of the body.

**Rigor mortis evidence:**

No evidence of rigor indicates either that rigor has not started (which seems unlikely if the body was known to be dead for at least four days) or that rigor has already disappeared and left the muscles in a flaccid state. It appears that rigor has gone and that the body has been dead at least 36 hours.

**Bacterial evidence:** Lack of significant bacterial evidence seems to indicate that the body was kept refrigerated. This would also explain how the body temperature had cooled to less than 21.1°C (70°F) over 2 days' time.

- Within the past 24 hours; at least 24 hours; at least 2.5 days; at least 4 to 5 days; at least 8 to 12 days; at least 18 to 24 days.
- At least 24 hours; at least 18 to 24 hours; at least 4 to 5 days.

### Further Research and Extensions

As an alternative, students can answer these questions using a PowerPoint or poster presentation.

- The insect evidence of pupa cases indicates that the body found in the abandoned building had been there at least 8 to 12 days. The missing person's report indicated that the man they were looking for was missing only two days. Therefore, based on insect evidence, the man in the abandoned building could not be the same man who was reported missing.
- The person has been dead for 9 days.

## ACTIVITY 11-5

### Background

In this activity, students observe and record the heat loss each hour of a simulated human body, “Tommy the Tub,” over a 24-hour period. Then they compare that heat loss to the projected heat loss of a human corpse.

### Safety Precautions

There are no safety precautions for this activity, however avoid getting water on the computer.

### Procedures

1. Print, copy, and distribute Activity Sheet 11-5 from the IRCD.
2. Make sure students read all directions *before* beginning the activity.
3. Make sure the tub is set up on a cart so it can be easily moved at the end of the activity.

### Teaching Tip

Probes are optional. A regular thermometer used at several intervals during the investigation will work.



## ACTIVITY 11-5 TOMMY THE TUB

Ch. Obj. 11.6 and 11.11

### Background:

Whether you are playing volleyball on a hot beach in August or snowboarding down a mountain on a cold, windy day in January, your body is constantly working to maintain a normal body temperature. Living organisms are equipped with mechanisms that maintain this balance (homeostasis). However, if a person becomes ill or dies, the mechanisms fail.

### Objectives:

*By the end of this activity, you will be able to:*

1. Observe and record the heat loss each hour of a simulated human body, “Tommy the Tub,” over a 24-hour period.
2. Compare that heat loss to the projected heat loss of a human corpse.

In this activity, you will create a simulation of a human body and record the heat loss over a 24-hour time period. Because the body is mostly water, you will substitute a tub of approximately the same volume of water as a human body. You are to compare the heat loss of Tommy the Tub to the projected heat loss of 0.78°C (1.4°F) for the first 12 hours and 0.39°C (0.7°F) for the next 12 hours.

### Materials:

Activity Sheet for Activity 11-5  
66-L plastic tub (with drawing of body, optional)  
probe ware interface and two temperature probes or two thermometers  
computer or TI-83 calculator (or better)  
cart for transporting the tub  
graph paper

### Safety Precautions:

None

### Time Required to Complete Activity:

two consecutive days (30 minutes per day)

### Procedure:

1. Fill a tub with approximately 66 liters of hot water, adjusting the temperature to about 37°C (98.6°F).
2. Connect two temperature probes to a computer or TI-83 calculator to record temperature readings over an extended period. One probe should record the ambient air temperature. The second probe should be submerged in the tub to record the “body temperature.”
3. Set the probe to measure temperature at one-hour intervals for a 24-hour period.
4. Record tub temperatures on the data table.
5. From the probe ware data or your data table, determine the average air temperature over the 24-hour period.  
Average air temperature = \_\_\_\_\_°C



- From the probe ware data or your data table, determine the average loss of tub water temperature for the first 12 hours \_\_\_\_\_°C, average loss of tub water temperature for hours 13 to 24 \_\_\_\_\_°C, and average loss of tub temperature for hours 1 to 24 \_\_\_\_\_°C.
- Prepare a best-fit graph of Tommy's heat loss over a 24-hour period. Include in your graph:
  - Title of graph
  - Appropriate scale for x and y axis
  - Labeled x and y axis
  - Units on x and y scale
  - Draw the best-fit line (This line is approximated. It will be a straight line that will pass through some of the points but not necessarily all of them. There will be some points on either side of the line and not on the line.)



| Time (hrs.) | Tommy Tub Temp. (°C) | Ambient Temp (°C) | Time (hrs.)           | Tommy Tub Temp. (°C) | Ambient Temp (°C) |
|-------------|----------------------|-------------------|-----------------------|----------------------|-------------------|
| 0           |                      |                   | 13                    |                      |                   |
| 1           |                      |                   | 14                    |                      |                   |
| 2           |                      |                   | 15                    |                      |                   |
| 3           |                      |                   | 16                    |                      |                   |
| 4           |                      |                   | 17                    |                      |                   |
| 5           |                      |                   | 18                    |                      |                   |
| 6           |                      |                   | 19                    |                      |                   |
| 7           |                      |                   | 20                    |                      |                   |
| 8           |                      |                   | 21                    |                      |                   |
| 9           |                      |                   | 22                    |                      |                   |
| 10          |                      |                   | 23                    |                      |                   |
| 11          |                      |                   | 24                    |                      |                   |
| 12          |                      |                   | Average loss per hour |                      |                   |

### Questions:

- How does Tommy the Tub's temperature loss over the first 12 hours compare with that of a real human corpse? Explain your answer. Include data from your graph or data table to support your answer.
- How does Tommy the Tub's temperature loss over the next 12 hours (hours 13 to 24) compare with the expected heat loss of a real human corpse? Explain your answer. Include data from your graph or data table to support your answer.
- Explain some of the limitations of using Tommy the Tub as an appropriate model for a human body.
- How could you design a more realistic model of a human corpse to be used in this experiment?
- Did the ambient temperature change over the 24-hour period? If the ambient temperature did change, describe its possible impact on the loss of temperature noted on Tommy the Tub.
- List some variables affecting the rate of heat loss from a human corpse.

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## Answers

- Check students' data tables and graphs.
- Over a 24-hour period, the results should be somewhat similar. Student answers should include specific data regarding the average loss of temperature over the first 12 hours.
- Estimated loss of body temperature is 0.78°C per hour for the first 12 hours and 0.39°C per hour for the next 12 hours. Students should use data from their data table to compare Tommy the Tub's heat loss over the next 12 hours to the above estimates. Some of the limitations include: (1) the tub is not made of cells; (2) the tub does not have variable thicknesses as those found in a human body; and (3) the tub does not contain any insulating materials such as human fat.
- Students' answers will vary. Sample answer: A pig would present a more realistic model for this experiment.
- Answers will vary. If the temperature in the room changed, this would affect the loss of temperature of Tommy the Tub. Students should compare temperature loss when the ambient temperature changes, compared to the temperature loss when the ambient temperature is more stable.
- Answers might include ambient temperature, body weight, if the body is naked or clothed, and if the body is in water.

### Further Research and Extensions

You may want to set up other variables and investigate them simultaneously or subsequently after the main trial. Other variables could include: different body size (smaller/larger tubs), wearing clothes (wrap a tub with a jacket), or ambient temperature (under a lamp to mildly increase temperature).