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<tr>
<th>Date</th>
<th>Classwork</th>
<th>Homework</th>
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<tbody>
<tr>
<td>Mon. 12/14</td>
<td>Notes: Time of Death p.1, 4, 5</td>
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<td></td>
<td>CW: Rigor Mortis &amp; Algor Mortis p.2, 3, 5, 6</td>
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<td>Tues. 12/15</td>
<td>CW: Rigor &amp; Algor Mortis p.7-8</td>
<td>Logic Puzzle &amp; TV Analysis #15 due Fri. 12/18</td>
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<tr>
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<td>CSI NY: &quot;Heroes&quot; p.12</td>
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<tr>
<td>Wed. 12/16</td>
<td>Catching Killers: Insect Evidence</td>
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<td>Notes: Stages of Death &amp; Entomology p.22-24</td>
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<td>10 Ways Creepy-Crawlies Helped Solve Crimes p.13-20</td>
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<td>Thurs. 12/17</td>
<td>WebQuest: Crime Scene Creatures p.24 and</td>
<td>Logic Puzzle &amp; TV Analysis #15 due Fri. 12/18</td>
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<td>Research Worksheet p.25-26</td>
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<td>Fri. 12/18</td>
<td><strong>Early Release</strong></td>
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<td>CSI &quot;Sex, Lies &amp; Larvae&quot;</td>
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<td>CW: Forensic Entomology Review p.27-28</td>
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<td>CW: TOD Insect, Algor, Livor Mortis p.29-31</td>
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<td>Unit Assessment: Time of Death &amp; Entomology</td>
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## Rigor Mortis Reference Table

<table>
<thead>
<tr>
<th>Time after death</th>
<th>Event</th>
<th>Appearance</th>
<th>Circumstances</th>
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</thead>
<tbody>
<tr>
<td>2-6 hours</td>
<td>Rigor begins</td>
<td>Body becomes stiff and stiffness moves down body</td>
<td>Stiffness begins with the eyelids and jaw muscles after about three hours, then</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>center of body stiffens, then arms and legs</td>
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<tr>
<td>12 hours</td>
<td>Rigor complete</td>
<td>Peak rigor is exhibited</td>
<td>Entire body is rigid</td>
</tr>
<tr>
<td>15-36 hours</td>
<td>Slow loss of rigor</td>
<td>Loss of rigor in small muscle first followed by larger muscles.</td>
<td>Rigor lost first in head and neck and lastly in bigger leg muscles</td>
</tr>
<tr>
<td>36-48 hours</td>
<td>Rigor totally disappears</td>
<td>Muscle become flaccid</td>
<td>Many variables may extend some extend of rigor beyond the normal 36 hours</td>
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### Factors Affecting Rigor

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<thead>
<tr>
<th>Event</th>
<th>Effect</th>
<th>Circumstances</th>
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</thead>
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<tr>
<td>Cold temperature</td>
<td>Inhibits rigor</td>
<td>Slower onset and slower progression of rigor</td>
</tr>
<tr>
<td>Warm temperature</td>
<td>Accelerates rigor</td>
<td>Faster onset and faster progression of rigor</td>
</tr>
<tr>
<td>Aerobic exercise</td>
<td>Accelerates rigor</td>
<td>Lack of oxygen to muscle accelerates rigor</td>
</tr>
<tr>
<td>Sleep</td>
<td>Slows rigor</td>
<td>Muscles fully oxygenated will exhibit rigor more slowly</td>
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<tr>
<td>Obesity</td>
<td>Slows rigor</td>
<td>Fat stores oxygen</td>
</tr>
<tr>
<td>Thin</td>
<td>Accelerates rigor</td>
<td>Body loses oxygen quickly</td>
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CALULATING TIME OF DEATH – RIGOR MORTIS

NAME____________________

Directions: Use the Rigor Mortis reference table to help you estimate time of death in the following scenarios.

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.
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. After a run, 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 was found in a snow bank alongside a road. His body is rigid. How long has he been dead? Explain your answer, remembering the cold temperature.

12. 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.
CALCULATING TIME OF DEATH USING ALGOR MORTIS

- 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.
- Normal body temp is 37°C (98.6°F)

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

Example 2: Calculate the time of death if a person has been dead for less than 12 hours and the temperature of the body was determined to be 32.2°C.

Example 3: Is the time of death more than 12 hours or less than 12 hours?
- Recall that if a body has been dead for 12 hours or less, the body loses heat at a rate of 0.78°C per hour.

- If the body has been dead 12 hours, then 0.78°C/hr x 12 hrs = 9.36°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:

- Total loss of 7.9 °C:
- Total loss of 4.4 °C:
- Total loss of 11.7 °C:
- Total loss of 17.2 °C:
- 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.
- What if the body temp is 22.2°C (72°F)?

**Part A**
Determine the approximate time of death using evidence from algor mortis. Show your work.

1. Approximately how long has the victim been dead if his body temperature was 33.1°C?

2. A body found outside in the winter has a temperature of 33.1°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°C?
4. What is the approximate time of death if the body temperature was 15.6°C?

5. What is the approximate time of death if the body temperature was 10°C?

6. What is the approximate time of death if the body temperature was 29.4°C?

7. What is the approximate time of death if the body temperature was 24°C?

Part B
Describe the impact on time of death for each of the variables listed. 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:

8. Naked

9. Exposed to windy conditions

10. Suffering from an illness before death

11. Submerged in a lake
ALGOR MORTIS

1. What is a condition in which Algor Mortis cannot be used to determine time of death?

2. Describe conditions in which Algor Mortis is not a reliable measure of time of death?

3. What type of factors will increase the rate of temperature lost from the body?

4. What type of factors will decrease the rate of temperature lost from the body?

5. You find a body in an apartment building lying face down on the carpet....
   a. On what part of the body would you take their temperature?
   b. What is the next piece of information you would need to calculate time of death using algor mortis?

6. A body is found in a bathtub, the water’s temperature is around 70°F and the temperature of the room is 73°F. You take the temperature of the body and find that it is 81°F. At least how long has the body been dead?

5. A body is found in the backseat of a car off of Interstate 5. CSI investigators determine that the temperature inside of the car is 80°F and the body temperature is 87°F. At least how long has the body been dead?

6. A body is found in a cubicle 9C at 8945 Century Blvd, on the fourth floor office building, the body temperature was recorded at 74°F and the air in the office was measured at a crisp 67°F. At least how long has this body been dead?
RIGOR MORTIS

1. What is happening in the muscles that cause rigor mortis to occur in the body?

2. What part(s) of the body are the first to show signs of rigor mortis?

3. Why can a person continue to move after they have died? (Even after several hours?)

4. A body is found with an internal temperature of 89°F, ambient temperature of 71°F and showed some stiffening around the face and arms.
   a. At least how long has the body been dead based on rigor mortis?

   b. Now calculate time of death for Algor Mortis?

   c. Are these consistent with each other, if not which one do you think is more reliable?

5. A body was found in a hottub full of water that read 102°F. The body appeared warm, 99°F and it appeared to be in full rigor mortis. What is the approximate time range this person has been dead?
Notes: Calculating Time of Death using Algor Mortis

We can make some generalizations regarding temperature loss. For the first 12 hours after death, the body loses about 1.4°F per hour (0.78°C/hr). After the first 12 hours, the body loses about 0.7°F per hour (0.39°C/hr). These numbers are estimates and vary depending on surrounding temperatures and conditions. The body will lose heat faster in cooler temperatures. Excess body fat and presence of clothing will slow down heat loss. For the problems we complete in class, we will assume ideal conditions. Normal body temperature is 98.6°F (37°C).

1. What is normal body temperature? 
2. How many degrees are lost per hour in the first 12 hours after death? 
3. How many degrees are lost in the first 12 hours? 
4. How many degrees are lost per hour after the first 12 hours? 

Example 1:

Normal body temperature is 98.6°F
Temperature of dead body is 90°F. How long did it take the body to lose 8.6°F?

1. Calculate the degrees lost.

Normal Body Temperature – Current Body Temperature = Degrees lost

2. Then using our conversion factor calculate the number of hours this took.

°F °F hr °F

Example 2:

What temperature would you expect a body to have if it has been dead for 12 hours?

The total change in temperature of a body after 12 hours is.
Example 3:

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

a. total loss of 14.2°F  
b. total loss of 8°F  
c. total loss of 21°F  
d. total loss of 31°F  
e. total loss of 19°F

How many degrees will a person lose in 12 hours? ______ What will the body’s temperature be at 12 hours? ______

Example 4:

How do you perform calculations if the person was dead longer than 12 hours? Let’s say a corpse was found and its body temperature was 72°F.

- How many total degrees were lost? ________________
- Has the body been dead more than 12 hours? ______
- How do you know?

Step 1: Calculate how many degrees were lost after the first 12 hours.

Step 2: Now calculate how many hours past 12 hours the body has been dead.

Step 3: Solve for number of hours past the 12 hours.

Step 4: Add the answer from step 3 to 12 to get the total number of hours the corpse has been dead.
Solve the following problems.

1. Approximately how long has the victim been dead if his body temperature was 91.6° F?

2. If the body was found outside in the winter and had a temperature of 91.6° F, would you assume that the body has 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 78.6° F?

4. What temperature would you expect a body to be if the victim has been dead approximately 10 hours under normal conditions?

5. What temperature would you expect a body to be if the victim has been dead approximately 24 hours under normal conditions?

Adapted from Bennino Forensics, Obtained during Summer Institute provided by Humble ISD Education Foundation
1. Mac says the marine’s body temperature is 82.1F therefore he died 11 hours ago. Is this accurate? Show your work!

2. How did the medical examiner know the bruises weren’t inflicted on the marine at time of death?

3. What does the skull help them determine about the burned victim?

4. What was significant about the ear print found in the burned car?
Forensic entomology is the study of insect biology as it applies to criminal matters. Thanks to The Silence of the Lambs, we're all familiar with Agent Clarice Starling's visit to a museum's entomology department, where the two geeky scientists explain the now-famous death's-head hawk moth. Studying insect life on and around a cadaver to determine the time or place of death dates as far back as A.D. 1247. Let's take a look at 10 criminal cases where buggy evidence played a significant role.

The first documented case of insects used in a criminal investigation comes from China's Song Dynasty. Sung Tzu, a lawyer and death investigator, wrote The Washing Away of Wrongs in 1247. This book served as a guide for investigators and provided instructions for assessing a crime in a productive manner. The book mentions a murder case that Tzu solved using insect activity in 1235. The victim was murdered by slashing, and Tzu ordered the men of the village to lay their sickles on the ground. He found that flies were attracted to one specific sickle. He hypothesized that the flies were attracted to invisible matter on the sickle, and the murderer soon confessed.

Tzu's attention to detail and careful documentation of his investigations laid down the fundamentals for forensic entomology. The book was immensely popular, and it introduced to the general public the idea that insects could be used to solve crimes. Still translated and printed today, The Washing Away of Wrongs remains a treatise on forensic science.
Bergeret d’Arbois

In 1855, the mummified remains of an infant were found behind the wall of a Parisian apartment by the new owners. Investigators had no idea if the former owners had killed the infant and placed the body in the wall, or if the new owners were responsible. How long had the child been dead? That’s what French doctor Bergeret d’Arbois set out to discern. After studying the different insects present and the duration of their life cycles in the corpse, d’Arbois was able to estimate the period that had elapsed between the infant dying and the discovery of the body.

He determined that the accumulation of insects within the corpse pointed to a level of decay dating several years back. His analysis concluded that the baby had died in 1848, exonerating the new tenants. Based on testimony from the doctor, police deduced the logical suspects to be the occupants of the house in 1848, and they were subsequently arrested and convicted of the murder.

Buck Ruxton

The case of Buktyar Rustomji Ratanji Hakim, an Indian-born physician better known as Buck Ruxton, gripped the United Kingdom in 1935. In a fit of jealous rage, Ruxton murdered his wife, Isabella Kerr, and their maid, Mary Jane Rogerson. In an effort to hide his crime, Ruxton mutilated the bodies and scattered the parts. When the gruesome discovery of the remains was made, maggot specimens were collected and sent to Dr. AG Mearns at the University of Edinburgh.

Dr. Mearns, an expert on insects, was able to determine the date on which the body parts had been deposited in the countryside based on the presence of bluebottle larvae, better known as maggots.
The maggots helped pinpoint the date of death, and Ruxton’s alibi soon unraveled. This was the first time a maggot had been used in a court of law in the United Kingdom. Ruxton was found guilty and hanged in May 1936.

Kevin Neal

On July 9, 1997, Kevin Neal reported his step-children missing. Two months later, two small human skulls and badly decomposed remains were found in a nearby cemetery. By studying the locations on the bodies where blowflies had laid their eggs, it was determined that the children had likely been asphyxiated. The entomologists concluded that the egg-laying pattern would have been different had bullet or knife wounds been present.

Using climatological data and the life cycle of the blowflies on the children’s bodies, experts were able to calculate the earliest time the children had been dead. Neal, who had been imprisoned for an unrelated crime shortly after the children went missing, argued that he could not have been the murderer because he was in jail. But when the absence of other species of flies that prefer different states of decomposition were analyzed, it was determined that the children had died no earlier than July 9 and no later than July 14, well before Neal was incarcerated. The state of Ohio convicted Neal of murder. He is currently serving a life sentence.

Vincent Brothers

Vincent Brothers was suspected of killing his wife, mother-in-law, and three children in California in 2004. However, Brothers had a solid alibi: He claimed that he was visiting
family in Ohio during the time of the murders. Since he'd never left the state, there was no way he was responsible for the deaths of his family members. Or was there? FBI agents assigned to the case felt sure that Brothers was their man, but needed to disprove his alibi. The air filter and radiator from Brother's car were sent to UC Davis insect expert Lynn Kimsey.

Investigators hoped that Kimsey could identify the bugs in the radiator grill and ascertain where they came from. She testified that the species of dead bugs in Brother's rental car were from California and other locations strictly west of the Colorado Rocky Mountains. She said that there was no way the bugs could have been in Ohio. The time of year and the species of the insects present served as evidence that Brothers had driven the car to commit the murders and then gone back to Ohio. There were also no daytime insects on the car parts, indicating that the car had been driven mostly at night. In 2007, a California jury found Vincent Brothers guilty of five counts of first-degree murder. Brothers was sentenced to the death penalty.

Jonathan Blackwell went missing from his job at a Virginia Goodyear Plant in October 2004. In December 2006, his remains were discovered near a barn in North Carolina. But there was a problem: He had been missing for over two years, so how could the blowfly larvae that were found buried with his remains be only seven days old? Faced with that dilemma, an investigator on the case contacted Wes Watson, a professor of entomology at North Carolina State University.

Based on the presence of the fresh maggots, Watson determined that the shallow grave in which Blackwell was found had not been his first grave. He concluded that Blackwell's first burial must have preserved his body somewhat, leaving tissue for new blowflies to colonize after his killer dug him up. This is the first report of blowflies emerging from soil covering a corpse. If it hadn't been for the maggots, a crucial piece of evidence would have been overlooked: the fact that the body had been moved. The killer, a man named Stacy Maurice Webster, turned himself in to the authorities a few days later and was convicted of murder in 2010.
Kristine Switzer

The bullet-ridden body of Kristine Switzer was found in an abandoned house on May 4, 2004, in Beltzhoover, Pennsylvania. There were no witnesses and no evidence other than the mass of maggots crawling around the victim's body. Forensic entomologist William Todaro concluded that the murder of Stewart had taken place sometime between April 25 and April 27. The temperature in the vacant building provided the ideal climate for flies to lay eggs on the cadaver.

Though late April was still fairly cool, Todaro reported that flies usually became active above 45 degrees. He developed a timeline based on a comparison between the stages of fly development and the weather in the area during that time. A woman named Lenora Maiolo eventually came forward and admitted that she had spent April 26 smoking crack and driving around with Kristine Switzer and a man named Augustus Stewart. Stewart, a drug dealer, thought that Switzer had been snitching to police, so he shot her. Stewart was found guilty of first-degree homicide.

Steven Truscott

Steven Truscott was only 14 years old when he was sentenced to die in Canada for the murder of his childhood friend, Lynn Harper. Harper was last seen riding on the handlebars of Truscott's bike on the afternoon of June 9, 1958. Her body was found nearby two days later, raped and strangled. Witnesses testified that they had seen the children together at 7:00 PM,
but Truscott had been alone at 8:00 PM. Investigators were convinced based on evidence from Harper’s stomach contents that Truscott had managed to commit the crime during that lone hour, and the original coroner concluded that Harper had died at approximately 7:45 PM.

Truscott was convicted of murder in 1959 and sentenced to hang, but was spared because of his youth. Paroled in 1969, Truscott devoted his life to proving his wrongful conviction. Entomologist Richard Merritt of Michigan State University used original photographs and precise measurements of insects taken when the remains were discovered in 1958 to conclude that there was no way Harper died the evening of June 9. Based on maggot size, Merritt testified at Truscott’s appeal hearing that Lynn was most likely killed the morning of June 10. Forty-eight years after the original verdict, the court ruled that the conviction had to be set aside in light of new testimony.

David Westerfield

On the night of February 1, 2002, seven-year-old Danielle Van Dam disappeared from her bedroom in San Diego, California. Neighbor David Westerfield claimed to be driving around the desert and beach in his RV, but this alibi proved false when he was spotted barefoot and haggard at a local dry cleaners. Westerfield dropped off two comforters, two pillow covers, and a jacket that would later yield Danielle Van Dam’s blood. He was placed under 24-hour surveillance and the RV was impounded and searched.

It was later discovered that Danielle Van Dam had sold Girl Scout cookies to Westerfield on several occasions. When child pornography was found in his home, the noose began to tighten. He was arrested on February 22 after stains on his clothing and inside the RV proved to be Danielle’s blood. Searchers later found her body on February 26 in a remote area east of San Diego.

Entomology testimony figured heavily in Westerfield’s trial. The defense consulted three different entomologists, all of whom testified that flies first laid eggs on Danielle’s body sometime in mid-February, long after Westerfield was under surveillance. Eventually, under cross-examination by the prosecution, the scientists could not agree on an exact time of insect colonization, and Westerfield’s alibi fell apart. Westerfield was found guilty and sentenced to death.
Shafiea Ahmed

Shafiea Ahmed was a 17-year-old British Pakistani girl. She disappeared on September 11, 2003. Upon being absent from school for a week, her worried teachers informed police. A nationwide hunt was launched but failed to turn up any trace of Shafiea. Prior to her disappearance, Shafiea had visited Pakistan and turned down an arranged marriage proposal. In a bid to avoid the arranged marriage, Shafiea tried to kill herself by drinking a bottle of bleach. This incident left her throat badly scarred, but she lived.

When she failed to show up anywhere seeking treatment for her throat, investigators suspected foul play, although her parents claimed that she had run away with a boyfriend shortly after the arranged marriage fell through. Her body was found in February 2004. Entomologist Amoret Whitaker was called in to testify. Maggot evidence found on Shafiea’s body proved that the girl had died as soon as she had disappeared, disproving her parent’s suggestion that she had run off. Shafiea’s younger sister confessed to police that their parents had murdered Shafiea after she would not accept the arranged marriage. They felt that her refusal would bring shame to the family. Her parents were found guilty and sentenced to life in prison.
<table>
<thead>
<tr>
<th>Case / Person</th>
<th>Insect Evidence</th>
<th>How it was used</th>
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Kevin Neal, Convicted of Murder by Forensic Entomology

BY Mark Gribben

How Flies Tell Time

When he received the evidence at his home in Rensselaer, Indiana, where he was on staff as a professor of forensic entomology and biology at St. Joseph's College, Dr. Neal Haskell began his analysis by taking inventory of the shipment. At his direction following a conversation with detectives in Champaign County, Haskell was sent both live and preserved specimens of the insect fauna found at the body site, soil samples gathered at the scene and, equally important, from the body bags in which the cadavers were delivered to the medical examiner. He further instructed the detectives to send climatological data for the nearest National Weather Service station, which in this case was in Dayton, about 45 miles away from Nettle Creek Cemetery. Each of these components was necessary for Haskell to make an estimate of the minimum and maximum post-mortem interval.

Entomologists use a technique called Accumulated Degree Days to measure fly development on a corpse. One of the most common necrophilic fly species is the blow fly, known formally as Phormia regina. Over the years, P. regina has been studied under carefully controlled environmental conditions, so scientists know, when temperature is controlled, just how long the species takes to go from newly deposited egg to first instar, to second and third instar and through the pupal stage to adult.

"After the medicocriminal entomologist has calculated the degree-hours or degree-days available, this information can be applied to the template of known development of the species in question at a temperature regime similar to that recorded from the field," writes Larkin. "The result will give an estimate of the time required for that fly to progress from the stage produced by the female (and deposited on the corpse) to the stage collected. This, then, is the minimum PMI — all else being equal, the corpse must have been dead for at least that period or the developing flies would not have been able to get to the noted point of maturity." At a mean temperature of 20 degrees centigrade (68 degrees Fahrenheit), P. regina takes between 19 and 25 hours to hatch from a fresh egg. The average time for what entomologists call egg eclosion is 21.2 hours. To calculate Accumulated Degree Hours, an entomologist will multiply the number of degrees by the number of hours needed for eclosion. In other words, based on laboratory studies of P. regina, Haskell knew that on average, it takes 424 ADH (20 degrees C x 21.2 hours) for a blow fly to emerge from its egg. If the mean temperature at a crime scene is 25 degrees Celsius, the time for eclosion is simply calculated at 424 ADH divided by 25, or approximately 17 hours. Each stage of the blow fly's life cycle has been calculated and tabulated for entomologists, so when Haskell examined his preserved specimens and found 40 or 50 puparia that had hatched, he knew he could calculate the maximum post-mortem interval — the earliest time the children had been dead. The fact that no P. regina were still present on the bodies told Haskell that 'we had passed well beyond the time that the black blow fly would be active,' he would later testify. "It had done its thing at the early stage of decomposition, fed: They have done their thing and have long since been gone."
Four Stages of Decay

Stage One:

Stage Two:

Stage Three:

Stage Four:
1. What do they do?

Forensic __________________ apply their knowledge of entomology to provide information for criminal investigations.

A forensic entomologist’s job may include:
- Identification of insects at various stages of their ________ ________ , such as eggs, larva, pupa, and adults.
- Collection and preservation of insects as ________________.
- Determining an estimate for the postmortem interval or ________ (the time between death and the discovery of the body) using factors such as insect evidence, weather conditions, location and condition of the body, etc.
- ________________ in court to explain insect-related evidence found at a crime scene.

2. Insects as Evidence

Forensic entomologists use their knowledge of insects and their life cycles and ________________ to give them clues as about a crime.

Most insects used in investigations are in two major orders: ___________ (flies) and ___________ (beetles).

Species ________________ may also provide clues for investigators. Some species may to feed on a ___________ corpse, while another species may prefer to feed on one that has been dead for two weeks. Investigators will also find other insect species that ___________ on the insects feeding on the corpse.

3. Other Factors

________________ data is also an important tool in analyzing insect evidence from a corpse. Investigators will make note of the temperature of the ________ ground surface, the interface area between the body and the ground, and the ________ under the body as well as the temperature inside any ____________ masses. They will also collect weather data related to daily ________________ (highs/lows) and ________________ for a period of time before the body was discovered to the time the insect evidence was collected.

What are some other factors that could affect a forensic entomologist's estimate of PMI?

________________

________________

________________

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4. Blow Fly Life Cycle

Blow flies are attracted to dead bodies and often arrive within ______________ of the death of an animal. They have a _______________ life cycle that consists of egg, larva, pupa, and adult stages.

Label the life cycle diagram.

Fill in the blanks below.

1<sup>st</sup> - Adult flies lay eggs on the carcass.
2<sup>nd</sup> - Eggs hatch into larva (maggots) in ___:___ hours.
3<sup>rd</sup> - Larvae continue to grow and molt (shed their exoskeletons) as they pass through the various instar stages.
   1<sup>st</sup> Instar - 5 mm long after ____ days
   2<sup>nd</sup> Instar - 10 mm long after ____ days
   3<sup>rd</sup> Instar - 14-16 mm long after ____ days
4<sup>th</sup> - The larvae (17 mm) develop into pupa after burrowing in surrounding soil.
5<sup>th</sup> - Adult flies emerge from pupa cases after ____ days.

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CRIME SCENE CREATURES

#1 - What is the crime? ____________________________

#2 - Identify each tool by letter and then draw an line to connect it to its function.

___ Forceps  - Used to dig up soil samples
___ Ventilated jars - Used to store live species
___ Thermometer - Used to collect crawling insects
___ Hand net - Used to collect flying insects
___ Trowel - Used to collect & preserve specimens
___ Specimen Jars - Used to collect weather data
___ Weather Station - Used to take temperatures (air, soil, masses)

#3 - Which specimens did you take back to the lab? Circle the five that you chose.

Scorpion  - Small Maggots  - Spider
Beetle  - Empty Pupa Cases  - Fly Eggs
Large Maggots  - Adult Fly  - Fly (Crumpled Wings)

#4 - What was the correct PMI? _______________________

#5 - Which two specimens were most helpful in finding the correct answer? _______________________

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Using the websites, answer the following questions as completely as possible.

**Definition of Forensic Entomology**

1. What is the complete definition of forensic entomology?

2. In what three general areas can forensic entomology be used for legal investigations?

3. How might insects affect the interpretation of blood spatter pattern analysis?

**Estimating Time of Death**

1. What two insects usually arrive first to a dead body (or corpse)?

2. Where on the corpse will a blow fly female lay her eggs?

3. What is another term for “time of death?”

4. What is theory behind estimating PMI?

**You might want to remember this page as a good reference when examining evidence from your assigned case; it has specific information on the life cycle of a blow fly.**

**Life Cycle of a Blow Fly**

1. How long does it take the eggs of a female blow fly to hatch?

2. How can temperature affect the life cycle of a blow fly?
3. How long, from the time the eggs are laid, to the time an adult blow fly is ready to leave the corpse?

Other Information Provided by Insects

1. What facts about insects can help determine if a corpse has been moved after death (postmortem movement)?

2. Where can scientists recover DNA from a victim or a suspect?

3. Tests can be run on insects found on corpses to determine if any drugs are/were present in the corpse. Why is toxicological analysis successful?

A Case Study  

1. What circumstantial evidence pointed to the suspect?

2. What type of information was necessary for making an accurate prediction of time of death?

3. What was the final estimation of the postmortem interval?

4. What was the eventual result of the findings in the case? (Hint: What happened to the suspect?)
FORENSIC ENTOMOLOGY
UNIT REVIEW

Across
2. Third stage of a fly's life cycle
5. Third stage of decomposition; will have large maggot masses and noticeable odor
7. Type of animal that is often used to simulate a human body in forensic entomological experiments
8. The shedding of an exoskeleton that occurs as a larva or adult insect grows
9. Term that refers to the larval stage of a fly
12. Data related to the temperature and precipitation in an area where a crime scene is located
14. Order that includes beetles
15. Order that includes flies
17. Study of insects

Down
1. Female flies will lay their eggs near body openings or
2. The time between the death and the discovery of a body; called the postmortem interval
3. Last stage of a fly's life cycle
4. Second stage of a fly's life cycle
6. Last stage of decomposition in which most of the flesh is gone
10. Stage of decomposition that begins at the moment of death
11. Second stage of decomposition in which the body becomes inflated due to the production of gases from bacteria
13. Type of metamorphosis that has four stages
16. First stage of a fly's life cycle

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18. Label the life cycle diagram using the word list provided.

Egg
Adult
Pupa
1st Instar Larva
2nd Instar Larva
3rd Instar Larva

19. Use the charts on the Crime Solving Insects reference card to determine the age of the maggots listed in the chart.

<table>
<thead>
<tr>
<th>Species</th>
<th>Size (mm)</th>
<th>Average Temperature</th>
<th>Age (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blow fly maggot</td>
<td>30</td>
<td>85°</td>
<td></td>
</tr>
<tr>
<td>Skipper fly maggot</td>
<td>6</td>
<td>79°</td>
<td></td>
</tr>
<tr>
<td>House fly maggot</td>
<td>33</td>
<td>72°</td>
<td></td>
</tr>
<tr>
<td>Flesh fly maggot</td>
<td>12</td>
<td>64°</td>
<td></td>
</tr>
</tbody>
</table>

20. Explain how a forensic entomologist would use fly larva to estimate the PMI.
ESTIMATING THE TIME OF DEATH USING INSECT, ALGOR, AND LIVOR MORTIS EVIDENCE

Answer the following questions on your own paper.

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 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 cool to the touch. The thermometer gave a reading of 70°F. No rigor mortis was evident, but permanent 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 over four days. How is that possible?
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 Data Table.

![Life Cycle of Insects Collected from Dead Body](image)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Accumulated Time Since Egg Was Laid (Hours)</th>
<th>Accumulated Time Since Egg Was Laid (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>Egg laid minutes after death</td>
<td>0</td>
</tr>
<tr>
<td>Larva stage 1</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>Larva stage 2</td>
<td>60</td>
<td>2.5</td>
</tr>
<tr>
<td>Larva stage 3</td>
<td>96–120</td>
<td>4–5</td>
</tr>
<tr>
<td>Pupa</td>
<td>192–288</td>
<td>8–12</td>
</tr>
<tr>
<td>Adult</td>
<td>432–576</td>
<td>18–24</td>
</tr>
</tbody>
</table>

a. Record the estimated time since death if the insects recovered from the dead body were in each of the stages below:

egg—
larva 3—
larva 1—
pupa—
larva 2—
adult—

b. 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.
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.

<table>
<thead>
<tr>
<th>Insect</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blowfly</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Species A</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Species B</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Species C</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Species D</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

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

Recall that blowflies are attracted almost immediately to dead, warm bodies. They lay their eggs in the orifices on the body, and larva appears within 24 hours after death, often laying their eggs within minutes after death. Other flies are attracted because of smells produced by putrefaction and by the attraction of insect larvae.