**Forensic Pathology**

*Forensic pathology* is a sub-specialty area of pathology that focuses on determining the cause of death of a corpse. An autopsy is performed by a medical examiner to gather information for criminal investigation and in some cases civil litigation.

**Defining Death**

In order to define death, one must understand what characteristics define a living thing.

According to the biological definition, a living thing is any organism or living form that has the characteristics of life.

* An organized structure composed of one or more \_\_\_\_\_\_\_\_\_
* Requires \_\_\_\_\_\_\_\_\_\_to sustain existence or survivie
* Has the ability to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Has the ability to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Has the ability to metabolize
* Responds to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Has the ability to adapt to the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Mobility or movement
* Ability to respire

(<http://www.biology-online.org/dictionary/Living_thing>)

In a medical sense, when the end or cessation of life occurs when the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_stops beating and all body functions \_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. In a hospital setting this is usually evidenced by the heart monitor displaying a flat line.

**Manners of Death**

*Natural death:* the body ceases to function on its own. There may be factors that contribute to natural death such as \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_or heart disease for example.

*Accidental death:* not due to natural causes but a result of some\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or risk taken by a individual. Example: car accident

*Suicidal:* deliberate taking of one’s\_\_\_\_\_\_\_\_\_\_\_\_life.

*Homidical:* deliberate taking of\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_ life (murder or manslaughter)

**Cause, Manner and Mechanism of Death**

*Cause of death:* the immediate reason for a person’s death (this is usually determined at autopsy if not already evident) Examples: aneurysm, heart attack, gunshot wound

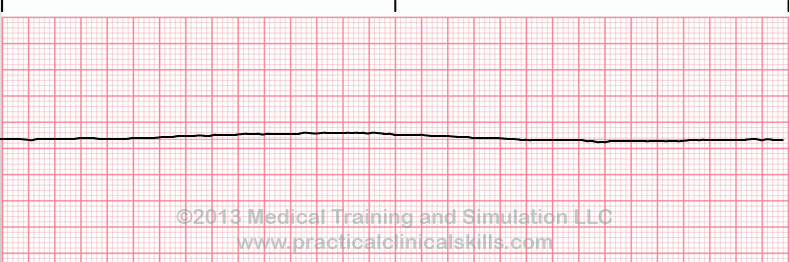
*Manner:* the means by which someone dies (natural, accidental, suicide, homicide)

*Mechanism:* the specific body or organ failure that leads to death

**Determining the Time of Death**

If there is another person present, it is usually easier to determine the time of death. This is not always the case.

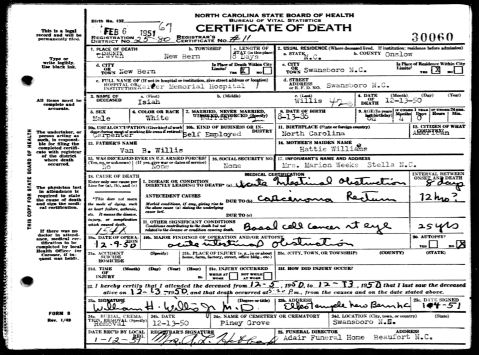
*Physiological time of death:* the time at which the deceased person ceases to function: heartbeat stops and vital organs shut down.



*Estimated time of death:* a best \_\_\_\_\_\_\_\_\_\_\_\_\_\_or estimate based on available information.

* When was person last seen or heard from
* Who was the last person to have contact with the deceased
* Medical illnesses, age, circumstances

*Legal time of death:*  the time when the body was discovered or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_dead by another person usually medical personnel or law enforcement. This is the official time of death that is recorded on the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.



**Examining the Corpse to Determine Estimated Time of Death**

*Rigor Mortis:* natural \_\_\_\_\_\_\_\_\_\_\_\_\_\_ and relaxation of the skeletal muscles after death due to chemical changes and loss of Adenosine triphosphate

* Begins in the smaller muscles of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_and spreads to larger muscles throughout the body
* Signs usually appear within the first \_\_\_\_\_\_\_\_\_hours after death and can last anywhere from \_\_\_\_\_\_\_\_ to \_\_\_\_\_\_\_\_\_\_\_ hours
* Can be used to approximate time of death because rigor occurs within the first 36 to 48 hours after death so the time of death can be narrowed to within 2 days if the muscles are still stiff.
* Eventually there will be a relaxation of the limbs because the tissues are decaying within.

*Livor Mortis or lividity:* a purple or discolored look to the body; may be a marbled or bruised look

* occurs when the blood stops moving in the body because the heart has stopped pumping
* Remaining blood settles due to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_to the lowest position.
* Begins within \_\_\_\_\_\_\_\_\_\_\_\_\_\_of death and lasts for up to \_\_\_\_\_\_\_\_\_\_\_hours
* Within the first 6 hours after death, livor mortis can be altered or re-distributed if the body is moved
* After 6 hours, livor mortis becomes fixed because the blood vessels have begun to break down.

*Algor mortis:* cooling of the body

* Body temperature begins to drop after death and skin becomes less \_\_\_\_\_\_\_\_\_\_\_\_\_\_
* A corpse of average weight in an air temperature of 20 degrees Celsius would drop approximately \_\_\_\_\_\_\_\_\_⁰F per hour.
* In a thin or malnourished corpse, the temperature change will be faster. If the air temperature is lower or there are windy conditions the temperature will also change quicker.
* Slower temperature changes occur if the corpse is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or has a fever at the time of death or if the air temperature is higher.

**Measuring Core Body Temperature**

Human body temperature varies but on the average is 98⁰F or 37⁰C. Person’s with higher metabolism usually have a slightly \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_body temperature.

Locations to take temperature:

1. Mouth
2. Armpit
3. Rectum

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_-temperature is closest to core body temperature.

**Stages of Decomposition**

*Initial Decay: sometimes called the “fresh stage’*

* Corpse appears \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_-on the outside
* Internally decomposition is occurring; This process is called autolysis (self-digestion)
* “Human cells use enzymes to cleave molecules, breaking compounds down into things they can use. While a person is alive, the cells keep these enzymes in check, preventing them from breaking down the cells’ own walls. After death, the enzymes operate unchecked and begin eating through the cell structure, allowing liquid inside to leak out.” (Mary Roach, *Stiff*)
* The liquid seeps under the skin and causes the skin to loosen. This is known as skin slippage or gloving. (Roach).

*Putrefaction:*

* An \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_of decaying flesh is present
* Corpse appears \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_due to gases produced during internal decomposition, a condition known as bloat. It is most noticeable in the abdomen , mouth, tongue and genitalia.
* The bacteria inside the body in the gastrointestinal tract, lungs and skin which were considered normal flora when the body was alive now begin multiply in the nutrient rich liquid released from the cells. Bacteria produce gas as a by-product of digestion. (Roach)

*Black putrefaction:*

* Very strong \_\_\_\_\_\_\_\_\_\_\_\_\_\_-
* Parts of flesh appear \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Gases escape and corpse \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* The body is “literally” melting or dissolving itself.

*Butyric fermentation:*

* Corpse begins to dry out; most of the flesh is gone

*Dry decay:*

* Corpse is almost completely dry: further decay is \_\_\_\_\_\_\_\_\_\_\_\_\_ due to lack of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Factors that Affect Decomposition**

* Warm, wet weather speeds up decay
* Cold, dry weather slows down decay
* A large larval mass feeding on the corpse increases the temperature and speeds up decay

Note: Embalming fluid used by funeral homes is a preservative that is pumped into the blood vessels to slow down the autolysis process and slow decay.

(<http://autstralianmuseus.net/au/Stages-of-Decomposition>)

**Examination of the Eyes**

Studies of the vitreous humor of the eye have show a linear increase in potassium level up to 24 hours post mortem. After 24 hours there is no significant increase.

(Agrawal R L, Gupta P C, Bhasin S, Nagar C K. Determination of the time of death by estimating potassium level in the cadaver vitreous humour. Indian J Ophthalmol [serial online] 1983 [cited 2015 Feb 9];31:528-31. Available from: <http://www.ijo.in/text.asp?1983/31/5/528/29537>)

**Autopsy**

In some cases the cause of death may not be apparent or the death may be a legal investigation. A medical examiner can provide additional information by performing an autopsy.

* Gather information about the deceased:
  + Age,Weight,Height
  + Sex
  + Ethnicity
* Do an external examination of the body
  + Photographs if needed
  + Marks
  + Scars
  + Tattoos
  + Piercings
  + Bruises
  + Wounds
* Recover and store trace evidence found during the external exam
* Do internal examination
  + Cut a Y-shaped incision and remove chest plate
  + Collect blood and urine samples for toxicology studies
  + Collect stomach contents for toxicology and other tests
  + Remove, weigh and examine major organs; obtain photographs and tissue samples if necessary
  + Open skull and examine brain. Take samples and photographs.
  + Return the bodily contents and stitch up skull, chest and abdomen.
  + Write report and conclusions.

**Entomological Data**

Forensic entomology: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

If a body has been dead for more than 3 days, investigators and scientists can examine insect larvae to determine an estimate of the time of death or the post mortem interval. Flies lay eggs on the corpse at points of entry such as nostrils, mouth, ears, eyes, open wounds and genitalia. The eggs, called maggots, feed on the subcutaneous fat. Some species of beetles also inhabit the corpse.

**Early Cases: Using Insects as an Investigative Tool**

***Judge Sung Tz’u:*** Used the attraction of flies to fresh blood to identify a murder suspect; victim was murdered with a scythe and so he ordered all villagers to bring their scythes for inspection. When blowflies swarmed on a single scythe coated with microscopic traces of blood, the suspect and weapon was revealed.

***Dr. Bergeret d’Arbois (Swiss entomologist):*** Used entomology in 1855 to solve a murder in Paris. The body of an infant was found concealed behind the mantle in a house that had been plastered 5 years previous preventing further insects to have contact with the body. He determined that *Sarcophaga carnaria* had laid eggs which developed into maggots when the corpse was fresh. Mites had laid eggs on the corpse when the corpse was dry. He estimated that the drying process had taken about a year so the mites were date from 1849 and maggots from 1848. A search for the occupant of the house during 1848 was done and the suspect located and arrested for the murder.

**Duties of a forensic entomologist**

* Collect and prepare insects for identification
* Provide accurate identifications
* Make references on the age of larval stages based on the size and stage of larvae in the sample from a crime scene
* Work with experts in other disciplines to test the insects in a corpse for toxins

Forensic entomology rarely links a particular suspect with a crime or location. It provides data used to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_the time that elapsed between actual death and when the body was first discovered. This is known as the PMI or \_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_.

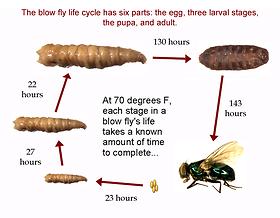
**Life cycle of the insect**

* **Adult:** hard body; segmented; six legs; one or two pairs of wings; three distinct body regions: \_\_\_\_\_\_\_\_\_\_\_\_\_-, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* **Larval forms:** soft body; often legless; segmented; worm-like

Insects are one of the most numerous and diverse groups of organisms on earth with approximately \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_million species described and named.

The insects of forensic interest are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Two groups of flies, the blow fly and the flesh fly, live on carrions or carcasses. They are usually the first insects to arrive on the scene. The adult blowfly can be differentiated from the flesh fly by its iridescent blue, green, copper or black body. The flesh fly is gray with three distinct longitudinal dark stripes on the dorsal thorax. Some species of beetles will also occupy the carrion but they are less common and usually arrive later than the flies. Some fly species prefer the fresh corpse while others prefer the bloated or dry corpse. The ordered series of insects attracted to the decomposing body is called a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Databases are kept of this information for different geographic regions.



Carrion flies arrive to the dead body within minutes of death. They lay **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**in open, moist surfaces of the body: eyes, ears, mouth, tongue, nostrils, genitalia and open wounds. The eggs are laid in a single batch but the female may return to lay eggs several times during her reproductive life (2-3 weeks). The eggs hatch into \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_,( small, 2mm long in about 12-24 hours) which can become so numerous that they speed up decomposition. The larvae grow and molt. Each stage of growth followed by a molting is called an \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. There are 3 Instar stage: first, second, third feeding and third migrating. The last Instar stage called the migrating Instar actually leaves the body to burrow in the soil where the outer skin hardens and it becomes a\_\_\_\_\_\_\_\_\_\_\_\_\_. After 6-8 days, the adult fly emerges.

**Factors that Affect Fly activity:**

* if the body is protected from fly activity by enclosure in a container (car trunk)
* large larval mass causing increased rate of decomposition
* two or more species colonizing the same body may change the pattern of development than when they colonize individually
* flies are generally inactive at night and during periods of rain
* time of year: some species are active in the early spring, some in the fall, and others continuous

**Essential Vocabulary**

* Algor mortis
* Rigor mortis
* Livor mortis
* Autloysis
* Autopsy
* Cause of death
* Death
* Decomposition
* Forensic entomology
* Manner of death
* Mechanism of death
* Egg
* Larva
* Instar
* Pupa
* succession

**Essential Questions**

1. What are the 4 manners of death and how are they identified?
2. How is the mechanism of death defined?
3. What are the stages of decomposition and how are they identified?
4. What is the difference between a medical examiner and a coroner?
5. What is post mortem interval?
6. How is core body temperature used to establish time of death?
7. Describe the steps in an autopsy.
8. How is the development and life cycle of insects used as part of a forensic investigation?