Unit 8- Death
“Bodies, Bugs, & Bones”
The Autopsy: “to see with one’s own eyes”

- Not all deaths result in an autopsy - circumstances of death
- 2 Types of Autopsies: Forensic and Medical
### 2 Types of Autopsies:
#### Forensic Vs. Medical (Hospital)

<table>
<thead>
<tr>
<th>Forensic Autopsy</th>
<th>Medical Autopsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performed by a Medical Examiner (usually a Forensic Pathologist)</td>
<td>Performed by a Pathologist</td>
</tr>
<tr>
<td>Does not require family consent</td>
<td>Requires a family's consent</td>
</tr>
<tr>
<td>Performed in the following circumstances:</td>
<td>determine the extent of the disease / effects of therapy</td>
</tr>
<tr>
<td></td>
<td>the presence of any undiagnosed disease</td>
</tr>
<tr>
<td>- Sudden, unexpected death</td>
<td>fewer than 12% of “regular” deaths are autopsied.</td>
</tr>
<tr>
<td>- Violent death</td>
<td></td>
</tr>
<tr>
<td>- Unattended or suspicious death</td>
<td></td>
</tr>
</tbody>
</table>
Role of Forensic Pathologists

Medical doctors who perform autopsies & investigate:

- **Cause of Death** - Reason person died
  ex: shooting, heart attack

- **Mechanism of Death** - actual change in the body that leads to death (biology)
  ex: blood loss, asphyxia, sepsis (infection)

- **Manner of Death** (5)
  ex: - Natural (most common) - Accidental
  - Homicidal - Suicide - Unknown

- **Time of Death**

- **Identity** of the deceased
Famous Forensic Pathologists

Michael Baden (HBO)

Dr. G (Discovery Channel)
Training to Become a Forensic Pathologist

After high school you'll have to undertake:

➤ 4 years of college (BS)
➤ 4 years of medical school (MD)
➤ 4 or 5 years of residency (eligible to take the Board exams in pathology)
➤ 1 or 2 years of specialty forensic pathology fellowship (eligible to take Board exam in forensic pathology)
Determining Time of Death

- done most accurately if the body is found within the first 24 hours of death

- Early Indicators used:
  - Livor mortis
  - Algor mortis
  - Rigor mortis
  - Stomach contents
  - Potassium levels in eye fluids (vitreous humor)

- Late Indicators (after 1-2 days pass):
  - Decomposition/ putrefaction
  - Insect action (entomology)
Rigor Mortis: The rigidity of skeletal muscles after death

- Onset = as soon as 10 mins (high exertion) - 2 hours
- Small muscles (face) affected first, then spreads down the body
- Max. stiffness reached around 12-24 hours post mortem.
- The joints are stiff for 1-3 days then ions leak out causing muscles to relax
**Rigor Mortis - Biochemical Details**

- **Muscles contract when myosin & actin lock with the help of Ca ions.**
- **Muscles remain contracted until ATP (which requires $O_2$ to be made) attaches to the myosin and forces it to let go.**
- ATP also pumps Ca out of cell.
- No ATP upon death = muscles stay contracted -- hence rigor mortis.
- Rigor Mortis ends when **Autolysis** (cell break down) occurs.
- Enzymes leak out & muscles to break down.
**Livor Mortis**—settling of blood, resulting in red/purple color pattern ("color of death")

- As body decomposes, blood seeps through tissue & settles @ lowest point
- Begins about 2 hours after death
- Color becomes set between 8-12 hours after death.
- can indicate the position of the body after death or if they were moved.

Pressure points from ground, belts, etc. prevent blood from settling.
**Algor Mortis** = cooling rate of body after death (“Chill of Death”)

- At a crime scene, the body temperature is obtained through:
  - Rectal temperature
  - Liver temperature

- Generally, body cools 1.4 °F/hour (first 12 hours)

- After 12 hours body cools @ 0.7 °F/hour until it reaches the surrounding temperature.

- Influenced by: weather, amount of fat on individual, drugs in body, clothing
Example problem

1. What body temperature would you expect for someone who has been dead for 12 hours?

Step 1: \[ 12 \text{ hours} \times 1.4 \text{ F/hour} = \sim 16.8 \text{ F lost} \]
(unless other factors need to be considered)

Step 2: \[ 98.6 \text{ F} - 16.8 \text{ F} = 81.8 \text{ F} \]
Body’s been found with a temp of 67 F, approx. how long have they been dead?

Step 1: 98.6 F – 67 F = 31.6 F lost heat

Step 2: 12 hours x 1.4 F/hour

= 16.8 F lost in 1st 12 hours

Step 3: 31.6 F - 16.8 F = 14.8 F lost after 12 hours

Step 4: 14.8 F x 1 hr/0.7 F = 21.1 hours

Step 5: 21.1 hours + 12 hours = 33.1 hours dead
Stomach Contents

- Food breaks down at a fairly predictable rate
- Not very accurate b/c lots of variables (type of food, body's metabolizing rate, drugs, exercise.

Vitreous Humor

- Potassium levels increase in fluid after death
- relatively stable, less susceptible than other body fluids to rapid chemical changes and contamination
The Body Farm
the place where the dead teach the living

- The nickname of a two and a half acre research facility at University of Tennessee
- developed in 1980 by Bill Bass
- bodies are placed in various conditions and allowed to decompose.
- purpose = observe and understand the processes and timetable of postmortem decay.
Forensic Entomology (Study of insects) & Decomposition:

- 5 main stages of decay
- Most important environmental factors in corpse decay:*
  - Temperature
  - Access by insects
  - Depth of Burial
- Insects develop in predictable stages
- Insects arrive to the corpse like clockwork

* Based on study of decay rates of 150 human corpses at U. of Tenn
### Four Common Flies Used in Forensic Investigation

<table>
<thead>
<tr>
<th>House Fly Live Stages (eggs, larva, pupa, adult)</th>
<th>Blow Fly</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="House Fly Live Stages" /></td>
<td><img src="image2" alt="Blow Fly" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flesh Fly</th>
<th>Skipper Fly</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Flesh Fly" /></td>
<td><img src="image4" alt="Skipper Fly" /></td>
</tr>
</tbody>
</table>
The blow fly life cycle has six parts: the egg, three larval stages, the pupa, and adult.

- Eggs: 23 hours
- Larval stages: 22 hours, 27 hours, 130 hours
- Pupa: 143 hours; may not change size

At 70 degrees F, each stage in a blow fly's life takes a known amount of time to complete.
Stage 1: Fresh/Initial Decay
(0 to 3 days after death)

**Inside:**
- Bacteria & body's own digestive enzymes begin decay (autolysis)

**Outside:**
- flies attracted to corpse & lay eggs around wounds / natural body openings
- eggs hatch and move into the body
Stage 2: Bloat/ Putrefaction
(4 to 10 days after death)

Inside
- Swells due to gases produced by bacteria (putrefaction)

Outside
- Flies and maggots feeding in great quantity
Stage 3: Decay/ Black Putrefaction
(10 to 20 days after death)

**Inside**
- Skin breaks & gases escape
- Fluid leaking out
- Exposed parts are black in color

**Outside**
- Maggots are very large on body (and lots of them)
- Horrible odor
Stage 4: Post-Decay
(20 to 50 days after death)

Inside:
- mostly hair, skin, & bones

Outside:
- Most flies are gone (no soft food)
- Beetles feed on the skin and ligaments.

beetle
Stage 5: Dry/ skeletal
(50-365 days after death)

**Inside:**
- Body is dry
- all the hair disappears leaving the bones only.

**Outside:**
- Moths feeding on hair
Forensic Anthropology: Studying Bones

“There is a brief but very informative biography of an individual contained within the skeleton, if you know how to read it...”

—Clyde Snow, Forensic Anthropologist
Characteristics of Bones

Cartilage before Bone

- Cells called osteoblasts deposit minerals into center of cartilage and harden it
- Bones are constantly produced and broken down

Growing and Changing

- Babies have 450 bones & adults have 206 bones (they fuse)
- Bones get longer and thicker with age and use
- When cartilage growth plate fuses = no more growth
What We Learn from Bones

- Human or animal?
- Determination of Sex
  - Pelvis
  - Skull
- Determination of Race
  - Skull
- Approximate Age
  - Teeth
  - Cranial Sutures
  - Epiphyseal (growth plate) fusion
- Approximate Height
  - Length of long bones
- Injuries (Postmortem or antimortem)
Determination of Sex: Pelvis
(differences in childbirth adaptations)

**FEMALE pelvis**
- Anterior view: > 90°
- Superior view: Sacrum tilted back
- Inferior view: Big Pelvic Outlet, Ilia spread wider

**MALE pelvis**
- Anterior view: < 90°
- Superior view: Sacrum tilted forward
- Inferior view: Small Pelvic Outlet, Ilia closer together
1. females have wider subpubic angle
2. females have a flexible pubic symphysis
Determination of Sex: Skull

- more pronounced ridges & crests
- Forehead sloped
- Squared chins

Male

Female
Male Skull

Figure 3. Male skulls. (Source: Smithsonian Institution)
Female Skull

Figure 4. Female skulls. (Source: Smithsonian Institution)
difficult to determine especially since pure races are becoming uncommon.

An experienced forensic anthropologist can generally place skulls into one of 3 groups:

- **Caucasian**—European, Middle Eastern, and Indian descent (image A)
- **Negroid**—African, Aborigine, and Melanesian descent (B)
- **Mongoloid**—Asian, Native American and Polynesian descent (C)
Features of the Skull Used in Race Determination

- **Nasal index**: The ratio of the width: height of the nose, Nasal Spine

- **Prognathism**: extended lower jaw

- **Shape of eye orbits** (round or squarish)
General Shapes of the Eye Orbits

FIGURE 7.6 Different shapes of eye orbits for ancestral groups: (a) angular of Whites, (b) rectangular of Blacks, and (c) round of Asians.

Determination of Age from Bones

- Most accurate estimations from:
  - Teeth
  - Epiphyses (growth plates) fusion
  - Cranial sutures: 3 pieces when young

- Investigators use age range b/c people vary in how they age
  - Adults 25 -40 yrs are very hard to determine
  - Ages 40+: basically wear and tear on bones
Age Determination: Use of Teeth

Permanent Teeth

 Teeth waiting to come in

http://images.main.uab.edu/healthsys/ei_0017.gif

http://www.forensicdentistryonline.org/Forensic_pages_1/images/Lakars_5yo.jpg
Growth Plates - fuse at predictable time frames

Where new bone forms

growth plates are outlined in red
Epiphyseal (growth plate) Fusion: A General Guide

The commencement and completion of union takes several years. The table is only a guide for male subjects (female slightly earlier) in non-tropical climates; the two dates are partial and complete union (years).

<table>
<thead>
<tr>
<th>Bone</th>
<th>Partial Union</th>
<th>Complete Union</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head of femur</td>
<td>16–19</td>
<td>17–19</td>
</tr>
<tr>
<td>Greater trochanter</td>
<td>16–19</td>
<td>17–20</td>
</tr>
<tr>
<td>Lesser trochanter</td>
<td>16–19</td>
<td>17–19</td>
</tr>
<tr>
<td>Head of humerus</td>
<td>16–23</td>
<td>16–21</td>
</tr>
<tr>
<td>Distal humerus</td>
<td>13–16</td>
<td>16–19</td>
</tr>
<tr>
<td>Medial epicondyle</td>
<td>16–17</td>
<td>16–19</td>
</tr>
<tr>
<td>Proximal radius</td>
<td>14–17</td>
<td>15–17</td>
</tr>
<tr>
<td>Proximal ulna</td>
<td>14–17</td>
<td>18–22</td>
</tr>
<tr>
<td>Distal radius</td>
<td>18–21</td>
<td>14–16</td>
</tr>
<tr>
<td>Distal ulna</td>
<td>18–21</td>
<td>23–28</td>
</tr>
<tr>
<td>Metacarpals</td>
<td>14–17</td>
<td>18–21</td>
</tr>
<tr>
<td>Acromion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distal femur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal tibia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal fibula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distal tibia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distal fibula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metatarsals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iliac crest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary elements pelvis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sternal clavicle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acromial clavicle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Approximate dates (years) of epiphyseal union

Figure 12.3 A guide to the age of epiphyseal union in the major centres


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Age Determination Using Cranial Sutures

** not very accurate

- When you are born, skull is in several pieces that fuse together (soft spots) as you age.
- Lamboidal suture closed by 30 yrs (starts closing around 21 yrs)
- Sagittal suture closed by 35 yrs
- Coronal suture closed by 50 yrs
Other Information We Can Get From Bones:

- Evidence of trauma (here GSW to the head)
- Evidence of post mortem trauma (here the head of the femur was chewed off by a carnivore)
Body Proportions and Height
(intro to activity)

Leonard da Vinci’s “Canons of Proportions” in 1492 described what the ideal proportions of perfect man should be.

Some of the relationships described include:
- man’s height is 24 x’s the width of his palm.
- man’s height is 10 x’s length of the hand.
- man’s height is 8 x’s distance from the elbow to the armpit.
- man’s height is 2 x’s maximum width at the shoulders.
- man’s height is 8 x’s from the top of the head to the bottom of the chin.
- length of a man’s outstretched arms is equal to his height.
# Estimation of Height using Long Bones

(usually +/- 3.5 cm)

- Use equations below to estimate height (in cm)

<table>
<thead>
<tr>
<th>Bone</th>
<th>Race</th>
<th>Male Equation</th>
<th>Female Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femur</td>
<td>Caucasian</td>
<td>2.32 x Length + 65.53 cm</td>
<td>2.47 x Length + 54.13 cm</td>
</tr>
<tr>
<td></td>
<td>African-American</td>
<td>2.10 x Length + 72.22 cm</td>
<td>2.28 x Length + 59.76 cm</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>2.15 x Length + 72.57 cm</td>
<td>2.38 x Length + 56.93 cm</td>
</tr>
<tr>
<td>Tibia</td>
<td>Caucasian</td>
<td>2.42 x Length + 81.92 cm</td>
<td>2.90 x Length + 61.53 cm</td>
</tr>
<tr>
<td></td>
<td>African-American</td>
<td>2.19 x Length + 85.36 cm</td>
<td>2.45 x Length + 72.56 cm</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>2.39 x Length + 81.45 cm</td>
<td>2.68 x Length + 67.05 cm</td>
</tr>
<tr>
<td>Fibula</td>
<td>Caucasian</td>
<td>2.60 x Length + 75.50 cm</td>
<td>2.93 x Length + 59.61 cm</td>
</tr>
<tr>
<td></td>
<td>African-American</td>
<td>2.34 x Length + 80.07 cm</td>
<td>2.49 x Length + 70.90 cm</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>2.40 x Length + 80.56 cm</td>
<td>NA</td>
</tr>
<tr>
<td>Humerus</td>
<td>Caucasian</td>
<td>2.89 x Length + 78.10 cm</td>
<td>3.36 x Length + 57.97 cm</td>
</tr>
<tr>
<td></td>
<td>African-American</td>
<td>2.88 x Length + 75.48 cm</td>
<td>3.08 x Length + 64.67 cm</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>2.68 x Length + 83.19 cm</td>
<td>3.22 x Length + 61.32 cm</td>
</tr>
<tr>
<td>Ulna</td>
<td>Caucasian</td>
<td>3.76 x Length + 75.55 cm</td>
<td>4.27 x Length + 57.76 cm</td>
</tr>
<tr>
<td></td>
<td>African-American</td>
<td>3.20 x Length + 82.77 cm</td>
<td>3.31 x Length + 75.38 cm</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>3.48 x Length + 77.45 cm</td>
<td>NA</td>
</tr>
<tr>
<td>Radius</td>
<td>Caucasian</td>
<td>3.79 x Length + 79.42 cm</td>
<td>4.74 x Length + 54.93 cm</td>
</tr>
<tr>
<td></td>
<td>African-American</td>
<td>3.32 x Length + 85.43 cm</td>
<td>3.67 x Length + 71.79 cm</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>3.54 x Length + 82.00 cm</td>
<td>NA</td>
</tr>
</tbody>
</table>
Height Estimation Example

Asian female femur found measuring 45.5 cm.

Formula: \(2.38 \times \text{Length} + 56.93 \text{ cm}\)

Plug in: \(2.38 \times (45.5) + 56.93 \text{ cm} = \sim 165.22 \text{ cm}\)

(1 inch = 2.54 cm)

165 cm / 2.54 cm = 65 inches = \(\sim 5 \text{ ft 4 in}\)
Facial Restoration

After determining the sex, age, and race of an individual, facial features can be built upon a skull to assist in identification. Erasers are used to make tissue depths at various points on the skull. Clay is used to build around these markers and facial features are molded.

Read about the John List story
www.crimelibrary.com/notorious_murders/family/list/1.html
Animal Facial Restoration

Determining what T Rex looked like using the bone formation.

From this:  
To this:
Anthropologist at Work

This anthropologist is hard at work dusting away material from these imbedded bones.

Picture taken at Chicago’s Museum of Natural History
More Applications

Forensic experts may be called upon to give information on the life & death of humans and animals in unique circumstances, including:

- Mass Murder (Oklahoma bombing, plane crashes, World Trade)
- Earlier man (mummies, Iceman, Lindow man)
- Historical Significance (Holocaust, uncertain death of famous people)
- Prehistoric Animals (Dinosaurs)
Extra stuff on Race... not needed
Determining Race: Caucasian

<table>
<thead>
<tr>
<th>Trait</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal Index:</td>
<td>&lt;.48</td>
</tr>
<tr>
<td>Nasal Spine:</td>
<td>Prominent spine</td>
</tr>
<tr>
<td>Nasal Silling / Guttering:</td>
<td>Sharp ridge (silling)</td>
</tr>
<tr>
<td>Prognathism:</td>
<td>Straight</td>
</tr>
<tr>
<td>Shape of Orbital Openings:</td>
<td>Rounded, somewhat square</td>
</tr>
</tbody>
</table>
## Determination of Race: Asian (Asian decent and Native American decent)

<table>
<thead>
<tr>
<th>Trait</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal Index</td>
<td>0.48-0.53</td>
</tr>
<tr>
<td>Nasal Spine</td>
<td>Somewhat prominent spine</td>
</tr>
<tr>
<td>Nasal Silling/Guttering</td>
<td>Rounded ridge</td>
</tr>
<tr>
<td>Prognathism</td>
<td>Variable</td>
</tr>
<tr>
<td>Shape of Orbital Openings</td>
<td>Rounded, somewhat circular</td>
</tr>
</tbody>
</table>

Asian Orbital openings: Rounded, somewhat circular

Nasal spine: somewhat prominent

Progathism: variable

### Determination of Race: African: (African & West Indian decent)

<table>
<thead>
<tr>
<th>Trait</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal Index</td>
<td>&gt;.53</td>
</tr>
<tr>
<td>Nasal Spine</td>
<td>Very small spine</td>
</tr>
<tr>
<td>Nasal Silling/ Guttering</td>
<td>No ridge (guttering)</td>
</tr>
<tr>
<td>Prognathism</td>
<td>Prognathic</td>
</tr>
<tr>
<td>Shape of Orbital Openings</td>
<td>Rectangular or square</td>
</tr>
</tbody>
</table>

African

- Orbital openings: Rectangular or Square
- Nasal spine: Very small
- Prognathism: prognathic

[Image: http://upload.wikimedia.org/wikipedia/en/5/5e/Skullneg.gif]