One type of wound is a contact wound.[161] If the muzzle is against the surface when the weapon discharges, the flame and gas emitted from the muzzle scorch hair and skin in the area. This scorching is usually termed singeing. In some cases, when the muzzle was pressed firmly against the skin, there will also be an imprint or profile of the muzzle. The abrasion ring is round if the shot was head-on but oval if the bullet struck at an angle (although rings with these shapes are not confined to contact wounds). In many cases involving contact wounds of the scalp, the entrance wound is stellate or star-shaped in appearance. In this type of contact wound, the gasses initially blow into the wound; but there is then a backlash, deflecting the gasses back and tearing the edge of the wound. In other instances, though, the hole is circular. First, if the weapon was .22 caliber, the firearm discharges so little gas that there may be no tearing. Second, when the contact occurred over a cavity such as the chest or abdomen, the gasses blow in; but there is little or no backlash. The edges of the hole frequently bevel inward and are often burned. Inside the hole the pathologist should find soot and powder; like the gasses, these materials enter the wound. Many contact wounds have a pinkish tint. The tint results from the presence of carboxyhemoglobin and carboxymyoglobin, created by the mixture of hemoglobin (or myoglobin) and carbon monoxide. Gunsmoke has a high carbon monoxide content, creating a cherry-red discoloration in the wound. This carbon monoxide can also be seen in some close (but not contact) wounds. It also may be seen at the exit wound. Further, there may be backspatter in a contact or close-range wound.[162]

Another type of gunshot wound is a close-range wound, up to perhaps six inches from the skin surface. A key difference between a contact and a close-range wound is the final resting place of the soot. In a contact wound the soot comes to rest inside the wound. In a close-range wound, the soot deposits around the wound. This soot deposit is variously called blackening, fouling, or smudging.

A third kind of gunshot wound is an intermediate range shot, potentially up to 3½ to 4 feet from the skin surface. At this intermediate distance, there would be no soot on the skin surface. Since they have greater mass than the soot, particles of powder carry farther and imbed in the skin. This phenomenon is termed peppering, stippling, or tattooing. Most handguns using flake powder rarely cause stippling beyond 18 inches. Ball powder can stipple the body up to approximately 3½ to 4 feet.

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161. Bucklin, *supra* note 58, at 204.

162. Burnett, "Detection of Bone and Bone-Plus-Bullet Particles in Backspatter from Close-Range Shots to Heads," 36 J. Forensic Sci. 1745 (1991).

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The last type of wound is a distant shot. Once the distance exceeds that at which stippling occurs, it is difficult to estimate the distance; a shot from six feet may appear the same as a shot from 30 feet. In a distant shot, the hole tends to be circular or oval with a smooth abrasion rim. Because the skin is somewhat elastic, the size of the hole in the skin bears no constant relationship to the caliber of the bullet. In attempting to characterize the wound, the pathologist considers the damage done by the expanding gasses, the bullet, and debris — both on the bullet and in the air which the bullet travels through.[163] In a contact wound, all three types of damage are present. In a near contact wound, the gasses dissipate; and, hence, the damage is caused by the bullet and the debris. In a distant wound, the damage is done by the bullet.

The above paragraphs describe typical wounds. However, atypical wounds are sometimes encountered.[164] The possible causes of such wounds include intermediate targets (such as clothing that the bullet passes through), ricochets, inappropriate weapon/ammunition combinations, poor weapon construction, and the use of misaligned silencers.[165] In addition, if the bullet strikes a bone, most notably the skull, the grazing effect can create an atypical defect in the bone — sometimes called a keyhole lesion.[166]

Shotgun entrance wounds also pose special problems. The number of projectiles in a shotgun shell can vary markedly. If the firer uses 00 buckshot, there may be only nine to 15 projectiles. However, if the person uses #9 birdshot, there could be 270 projectiles. If the shot is at short range — up to three or four feet, there will be a single hole or defect; and the wadding enters the wound together with the shot. Just beyond four feet, the group of shot begins to separate. Hence, in a medium range shot, there is still a single defect; but the hole has an irregular margin similar to a cookie cutter edging. At longer distances, the group of shot has separated, there will be multiple wounds, and the wadding may create a separate defect. The choke of the shotgun has a significant effect on the shot pattern at a given distance. If the shooter

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163. Jachimczyk, Violent Death Investigation and Pathology (unpublished manuscript on file with the National College of District Attorneys, Bates College of Law, University of Houston, Houston, Texas).

164. Donoghue, Kaleklar, Richmond & Teas, "Atypical Gunshot Wounds of Entrance: An Empirical Study," 29 J. Forensic Sci. 379 (1984).

165. *Id.*; Stone & Petty, "Interpretation of Unusual Wounds Caused by Firearms," 36 J. Forensic Sci. 736 (1991) (interposed targets such as clothing, windows, and body parts can cause confusing patterns and can lead to misidentification of the points of entrance and exit).

166. Dixon, "Keyhole Lesions in Gunshot Wounds of the Skull and Direction of Fire," 27 J. Forensic Sci. 555 (1982).

simultaneously discharges both shots from a double-barrel shotgun, externally the wound may simulate a wound made by the discharge of a single barrel.[167]

Exit wounds. In an exit wound, there is no powder stippling or charring around the wound; there should be no powder or gas to impact the skin surface. Typically, there is no rim of abrasion. However, there may be a misleading marginal abrasion if the exit wound was "shored," that is, if the skin was up against a firm material such as concrete, metal or even certain tight garments when the bullet exited. As the skin is pressed between the exiting bullet and the supporting material, a pressure abrasion can be created which sometimes resembles an entry abrasion rim. In an exit wound, the hole in the skull bevels outward.[168] The exit hole tends to be larger than an entrance hole. Moreover, the shape of the hole is very variable. As the bullet passes through the body, the bullet may tumble and leave the body sideways. If the bullet fragmented bone, the bone fragments may exit separately, creating secondary exit wounds. The bullet itself may break up into several particles, or the jacket may separate from the bullet in the body; the bullet fragments and the jacket could leave secondary exit wounds.

In shotgun killings, exit wounds are rare. Unless the firer used very large shot or the shot struck a thin portion of the body (e.g., arm), the shot probably will not have enough energy to pass through the body.

Analysis of Gunshot Wounds

An examination of the gunshot wound will assist in reaching several determinations.

Characterizing the wound as contact, close, intermediate, or distant will aid in determining the range of fire, the muzzle-to-target distance. In addition to studying the characteristics of the wound, the pathologist may rely on certain rules of thumb. Some experts believe that "between three and 10 yards the dispersion of shot is about one inch per yard for a fully choked barrel and between one and two inches per yard for a cylindrical barrel," while others follow the rule that "[t]he

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167. Medich, Cohle, Burritt & Davison, "Single Wound Produced by Simultaneous Discharge of Both Shells from a Double-Barrel Shotgun," 35 J. Forensic Sci. 473 (1990).

168. *But see* Peterson, "External Beveling of Cranial Gunshot Entrance Wounds," 36 J. Forensic Sci. 1592 (1991) (although entrance gunshot wounds generally have internal beveling, external beveling can occur; and consequently, an entrance wound can sometimes be mischaracterized as an exit wound; however, our reviewer states that the wound should not be mischaracterized if the examiner identifies the dominant beveling).

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diameter of the pellet pattern in inches equals the muzzle distance from the target in yards."[169] Since factors other than range[170] will affect the dispersion of pellets, test firings of the weapon to compare the dispersion found on the body should be conducted if possible. Test firing is one of the firearms identification techniques discussed in Chapter 14.

The pathologist can also estimate the direction or angle of the shot.[171] If the bullet entered the body perpendicularly, the abrasion collar around the hole is circular and of equal width all around the hole.[172] In an angular shot, the abrasion is oval — the greater the angle, the wider the abrasion margin.[173] The pathologist can also examine the body's internal organs to determine whether the bullet struck them; the bullet track inside the body helps confirm the angle of entrance. This analysis, however, determines only the anatomic position of the track within the body; the body may not have been upright when the bullet entered the body. Graze wounds of skin or internal organs can indicate the direction the bullet was travelling when it created the wound.[174]

The pathologist can sometimes venture an opinion as to the type of firearm that caused the wound. In a contact wound, the muzzle may have left an impression on the skin. In addition, firearms differ in their

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169. Breitenecker, "Shotgun Wound Patterns," 52 Am. J. Clin. Path. 258 (1969); J. Mason, *Forensic Medicine for Lawyers* 106 (1978).

170. Even, Bergman, Springer & Klein, "The Effects of Water Soaking on Firing Distance Estimations," 33 J. Forensic Sci. 319 (1988) (soaking of the target by water or blood can affect the gunshot residue and thereby the distance estimation); Zaki & Hanzlick, "Gunshot Wound with Asphalt Related Pseudo-Soot, Pseudo-Tattooing, and Pseudo-Scorching," 32 J. Forensic Sci. 1136 (1987) (contact between the body and an asphalt surface produced artifacts which mimicked the tattooing and soot deposition of a close-range gunshot wound).

171. Bucklin, *supra* note 58, at 206; Suwanjutha, "Direction, Site and the Muzzle to Target Distance of Bullet in the Head and Neck at Close Range as an Indication of Suicide or Homicide," 37 Forensic Sci. Int'l 223 (1988) ("For suicide, the direction of the bullet should be at an angle of elevation in the majority of cases. The position of the handgun in relation to the head in suicide was most often in tight contact and near contact. For homicide, the direction of the bullet should be horizontal in most cases. The bullet was at close range in the majority of cases;" however, our reviewer disagrees with the preceding two sentences); Smith, Berryman & Lahren, "Cranial Fracture Patterns and Estimate of Direction from Low Velocity Gunshot Wounds," 32 J. Forensic Sci. 1416 (1987).

172. W. Spitz & R. Fisher, *The Medicolegal Investigation of Death* 204 (1972).

173. *Id.* at 204-05.

174. Dixon, "Determination of Direction of Fire from Graze Gunshot Wounds of Internal Organs," 29 J. Forensic Sci. 331 (1984); Dixon, "Determination of Direction of Fire from Graze Gunshot Wounds," 25 J. Forensic Sci. 272 (1980).

capacity to cause damage to body organs.[175] High velocity weapons such as .30-06 and .30-30 hunting rifles can cause massive organ destruction that low velocity firearms of .38, .357, and .45 caliber are incapable of causing. Hence, the extent of damage may be indicative of the kind of weapon used.

Similarly, on occasion the pathologist may be able to surmise the type of ammunition used. Bullets differ in their composition. By carefully removing residue from around and within the wound and subjecting the residue to instrumental analysis such as atomic absorption or neutron activation analysis, the pathologist can sometimes single out the type of ammunition. However, our reviewer states that this technique is "controversial."

Moreover, the pathologist may be able to determine the number and sequence of shots. A careful examination of the exit and entrance wounds, internal wound tracks, and the projectiles remaining in the body should permit the pathologist to fix the number of shots striking the body. If while passing through the body the bullets fractured bone, the pathologist may be able to reconstruct the sequence of shots. Fracture lines caused by later shots will stop at fracture lines caused by earlier shots.[176]

§ 19-5(D). Drowning.

Drowning is one of the most difficult causes of death to diagnose. There are actually several questions that must be considered in any suspected case of drowning.

One question is whether the victim died before entering the water. A killer may attempt to disguise a homicide as an accidental drowning. In resolving this question, some pathologists rely on an examination of the gastrointestinal system. Some pathologists believe that the presence of water in the duodenum (the first part of the small intestine) is evidence that the victim was alive when he or she entered the water.

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175. Klatt, Tschirhart & Noguchi, "Wounding Characteristics of .38 Caliber Revolver Cartridges," 34 J. Forensic Sci. 1387 (1989); Ragsdale & Sohn, "Comparison of the Terminal Ballistics of Full Metal Jacket 7.62-mm M80 (NATO) and 5.56-mm M193 Military Bullets: A Study in Ordnance Gelatin," 33 J. Forensic Sci. 676, 677 (1988) (the researchers investigate the generalization that the 5.56-mm round creates more severe tissue wounds and conclude that the generalization "is incomplete. Relative wounding potential should be catalogued by specific bullet species and impact velocities rather than weapon type ...."); Jauhari & Bandyopadhyay, "Wound Ballistics: Motion of 9MM, Ball MK2Z, Bullet in Gel," 5 J. Police Sci. & Admin. 197 (1977).

176. Dixon, "Pattern of Intersecting Fractures and Direction of Fire," 29 J. Forensic Sci. 651 (1984).

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However, other pathologists believe that water in the gastrointestinal tract is not a useful criterion, since water can reach there after death.

If the person was alive upon entry, the next question that arises is whether the cause of the person's death while in the water was drowning. Several tests may aid in answering this question. One test is an ultrasonic[177] or microscopic[178] study for the presence of diatoms, unicellular algae, in the victim's bone marrow. Although in the past some experts claimed that this is a conclusive test for drowning, the current consensus is that the test is nonspecific.[179] Some believe that the procedure is characteristic, but not conclusive.[180] Another test analyzes the heart blood to determine whether small cells known as macrophages normally found in the lungs are present.[181] The theory underlying this test is that when the victim drowns, water enters the lungs and causes the air cells or alveoli in the lungs to burst. The rupture of the alveoli permits the rushing water to wash the macrophages from the lungs into the bloodstream. This test is also not specific for drowning. Still another technique is examining the body externally to determine whether there is a mushroom or cone of froth in the mouth and nose and froth in the lower airways. The froth supports a finding of a drowning death.[182] Still another new technique is testing the level of serum strontium.[183] Egyptian researchers recently reported their findings, indicating that the serum strontium level can help differentiate between deaths due to drowning and postmortem immersion of a victim. Other techniques for diagnosing drowning are now under study.[184]

A final issue is whether the drowning occurred in fresh or sea water. In the view of some pathologists, the resolution of this question

177. Fukui, Hata, Takahashi & Matsubara, "A New Method of Detecting Diatoms in Human Organs," 14 Forensic Sci. Int'l 67 (1980).

178. Funayama, Aoki, Sebetan & Sagisaka, "Detection of Diatoms in Blood by a Combination of Membrance Filtering and Chemical Digestion," 34 Forensic Sci. Int'l 175 (1987); Bucklin, *supra* note 58, at 220.

179. *Id.*

180. Fukui, Hata, Takahashi & Matsubara, *supra* note 177, at 67.

181. Karkola & Neittaanmaki, "Diagnosis of Drowning by Investigation of Left Heart Blood," 18 Forensic Sci. Int'l 149 (1981).

182. Bucklin, *supra* note 58, at 219-20.

183. Abdallah, Hassan, Kabil & Ghanim, "Serum Strontium Estimation as a Diagnostic Criterion of the Type of Drowning Water," 28 Forensic Sci. Int'l 47 (1985).

184. Jeanmonod, Staub & Mermillod, "The Reliability of Cardiac Haemodilution as a Diagnostic Test of Drowning," 52 Forensic Sci. Int'l 171 (1992); Lorente, Hernandez-Cueto, Villanueva & Luna, "The Usefulness of Long Surfactant Phospholipids (LSPs) in the Diagnosis of Drowning," 35 J. Forensic Sci. 1367 (1990); Yu-Chuan, Zhao-Ke & Jia-Zhen, "The Significance of Detecting Serum Fluorine Level in the Diagnosis of Drowning," 46 J. Forensic Sci. 289 (1990).

ordinarily requires sampling the blood on the right and left sides of the heart.[185] These pathologists believe that in a fresh water drowning, the level of chloride is often lower in the left heart. In sea water drownings, the reverse is true. To be significant, the difference in chloride levels should exceed 18 milli-equivalents.[186] However, perhaps the majority of pathologists believe that there is no single, simple test.

§ 19-5(E). Hyperthermia, Fire Deaths, and Hypothermia.

Exposure to extremes of heat and cold can result in death. Hyperthermia is an abnormal elevation of the body temperature, usually above 106 degrees F. It has many causes. Various natural disease processes can affect the brain's thermoregulatory center and result in elevated temperature. Hyperthermia can also result from exposure to high environmental temperature and humidity (heat stroke). Fire deaths should be distinguished from hyperthermia deaths.

Deaths occurring in fires may not always be due to actual burning. Suppose, for example, that a person dies during a fire. The thermal burns could have led to death, but there may be a cause other than the burning; for instance, fires create smoke, smoke contains carbon monoxide, and the victim could have died of carbon monoxide poisoning.

When a person has been severely burned, the body's skin may exhibit linear, sharp-edged lesions similar to cuts.[187] These lesions develop because the heat splits the skin and underlying tissue. In addition, the heat causes the body's muscles to shorten, often leaving the body in a pugilistic position.[188] Fire can also fracture bones, including the skull.[189] The heat may cause the content in the cranium to expand, literally bursting the skull open. Dry heat may also singe the hair. These heat effects must not be confused with pre-existing injuries.

One of the determinations that a pathologist attempts to make is whether the victim was alive when the fire was in progress. For example, it is important to uncover a fire set by a killer in an attempt to conceal a murder by burning the house with the body in it. Although there are certain exceptions such as flash fire, individuals who were alive during the fire will have soot within the lower airway and will have elevated levels of carbon monoxide. The body should also be

185. Bucklin, *supra* note 58, at 219-20.

186. *Id.*

187. *Id.* at 216; Parks, Noguchi & Klatt, "The Epidemiology of Fatal Burn Injuries," 34 J. Forensic Sci. 399 (1989).

188. Bucklin, *supra* note 58, at 216.

189. *Id.*

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examined for the presence of injuries such as gunshots and stabs that are unrelated to the fire.

Other types of heat produce different types of lesions. For example, wet heat scalds the skin.[190] Or if the burning was caused by electrical current passing through the body, there may be deep scars and yellow-gray, elevated areas of skin.[191] When the current passes through the heart area, death may be due to ventricular fibrillation, in which the heart muscle fibers contract irregularly.[192] Current passing through the brainstem can also cause death.

It is customary to differentiate among several degrees of burns. In first-degree burns such as sunburn, the skin takes on a red color. In second-degree burns, blistering occurs. Elevated, often circular vesicles form on the superficial skin surface. In third-degree burns, the burn affects the entire thickness of the skin. Finally, in fourth-degree burns, charring and loss of body parts can occur.

Like extreme heat, severe cold can cause death. In these cases, the cause of death is hypothermia. Hypothermia is abnormally low body temperature, usually under 95 degrees F.[193] The time lapse preceding death by hypothermia in an exposure victim is affected by such factors as the victim's clothing, the victim's prior state of health and activity, body habitus, and the nature of the exposure (dry cold vs. cold water immersion).

§ 19-5(F). Asphyxia.

Asphyxia is a broad term encompassing numerous conditions in which there is a mechanical or chemical interference with the uptake or utilization of oxygen. Asphyxia can occur in several ways.[194]

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190. United States v. Vretta, 790 F.2d 651, 660-61 (7th Cir.) (the pathologist testified that detached skin was caused by scalding), *cert. denied*, 479 U.S. 851 (1986); McConnel v. Commonwealth, 33 K.L.S. 15 (Ky., Nov. 14, 1986) (expert testified that child appeared to have been held in scalding water).

191. Bucklin, *supra* note 58, at 216-17.

192. Hahson, "Electrocution by Low-Voltage," 9 Forensic Sci. Dig. 85 (1983).

193. J. Weston & V. McCarty, *supra* note 63, at 305; Hirvonen, Huttunen & Hiltunen, "Creatine Phosphokinase in Serum and Cerebrospinal Fluid, and Microscopic Findings in Brain and Heart in Hypothermic Rabbits," 39 Forensic Sci. Int'l 271, 278 (1988) (based on research with rabbits, the authors suggest that an assay for CPK may be "an additional method of supporting the diagnosis of hypothermia;" however, our reviewer states that postmortem CPK is not a worthwhile test because it is difficult to interpret).

194. Wecht, *supra* note 19, at 25-72; Tamaki & Katsumata, "Enzyme-Linked Immunoabsorbent Assay for Plasma Thyroglobulin Following Compression of the Neck," 44 Forensic Sci. Int'l 193 (1990) (the results suggest that "Tg was released by mechanical force on the thyroid gland added at the agonal stage;" the elevated Tg level may therefore be diagnostic for external compression of the neck; our reviewer adds

One way is hanging. Judicial hangings should be distinguished from other types of hangings. In judicial hangings as a method of administering the death penalty, the sudden drop snaps the cervical vertebra.[195] In suicidal hangings, in contrast, death usually results from compression of the blood vessels in the neck, thus preventing blood from getting to or draining from the brain. The object used to compress the neck often leaves a furrow or mark on the neck.[196] In addition, there may be minute hemorrhagic spots (petechial hemorrhages) on the victim's face and eyelids.[197] A non-judicial hanging rarely may be accidental rather than suicidal. Various asphyxial modalities which decrease the supply of oxygen to the brain (hypoxia) apparently heighten sexual gratification.[198] Accidental deaths during autoerotic asphyxial episodes are generally due to hanging and occur almost exclusively in males. If a person engaging in such activity becomes unconscious, he is unable to relieve the pressure on the neck; and death will ensue.[199]

Asphyxia can also be caused by strangulation. If the strangler uses a ligature such as a rope, it typically leaves furrows on the victim's neck.[200] Or the strangulation may be manual throttling. Throttling leaves bruises and occasionally fingernail marks on the neck. More so than ligature strangulation, throttling can cause fractures in the neck area, particularly of the larynx and the hyoid bone, which is located at the base of the tongue.[201]

Finally, the lack of oxygen may be caused by smothering and choking. Smothering and choking entail an obstruction to the passage of air. The obstruction can occur externally (smothering) or internally (choking). Externally, a killer might place a pillow over the airways, including the mouth and nose. Internally, foreign material might be

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that this suggestion is not generally accepted); Ito & Kimura, "Histological Examination of the Temporal Bone in Medicolegal Cases of Asphyxia," 44 Forensic Sci. Int'l 135 (1990) (an examination of the temporal bone can help the pathologist determine whether the cause of the asphyxia was drowning, strangulation by ligature, or manual strangulation; however, our reviewer states that he would not rest such a determination on the examination of the temporal bone).

195. Bucklin, *supra* note 58, at 212.

196. *Id.* at 213.

197. *Id.*

198. Wecht, *supra* note 19, at 25-76.

199. Bucklin, *supra* note 58, at 214; Garza-Leal & Landron, "Autoerotic Asphyxial Death Initially Misinterpreted as Suicide and a Review of the Literature," 36 J. Forensic Sci. 1753 (1991); Byard, Hucker & Hazelwood, "A Comparison of Typical Death Scene Features in Cases of Fatal Male and Female Autoerotic Asphyxia with a Review of the Literature," 48 Forensic Sci. Int'l 113 (1990).

200. Wenyou, Junzhu & Xinman/Mau, "A New Staining Method for Constriction Marks in Skin," 50 Forensic Sci. Int'l 147 (1991).

201. Bucklin, *supra* note 58, at 214.

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aspirated into the respiratory passage. A "cafe coronary" occurs when a bolus of food blocks the airway, usually lodging at the opening to the larynx.

The previously described occurrences are types of mechanical asphyxia. Various chemicals can also cause asphyxia. Examples of these are carbon monoxide[202] and cyanide.

§ 19-6. Mechanism of Death.

The previous section surveyed some of the leading causes of death. The cause of death differs from the mechanism of death. The cause of death is the injury or disease which initiates the chain of events leading to death. The mechanism of death is the "biochemical or physiologic abnormality produced by the cause of death which [is] incompatible with life."[203] The mechanisms of sudden death fall into three broad categories: exsanguination, sudden heart stoppage, and slow heart stoppage.[204] In exsanguination, the victim bleeds to death. Death in which the heart stops suddenly is often due to conditions in which the lethal physiologic disruption involves the heart directly. Examples include electrocution and sudden coronary artery death. Interference with the respiratory control centers (for example, barbiturate overdose) features the cessation of breathing followed shortly by the cessation of cardiac activity. The recognition of the mechanism which is operative in a given case steers the pathologist to certain groups of causes of death.

§ 19-7. Manner or Mode of Death.

The questions of the cause and mechanism of death lie within medical expertise. However, the forensic pathologist must deal with another question, the manner or mode of death. This issue requires medicolegal expertise and is often the most subtle issue facing the pathologist.

In some cases, the indicators of the manner of death are so equivocal that the pathologist must report the manner as "undetermined." However, in the overwhelming majority of cases, the pathologist will

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202. Yoshida, Adachi, Watabiki, Tatsuno & Ishida, "A Study on House Fire Victims: Age, Carboxyhemoglobin, Hydrogen Cyanide and Hemolysis," 52 Forensic Sci. Int'l 13 (1991).

203. Wright, Forensic Pathology 5 (unpublished manuscript on file with the National College of District Attorneys, Bates College of Law, University of Houston, Houston, Texas).

204. *Id. See also* W. Curran, A. McGarry & C. Petty, *Modern Legal Medicine, Psychiatry and Forensic Science* 252-53 (1980).

be able to assign the death to one of the categories in the "NASH" classification: natural causes — accidental — suicidal — homicidal.[205]

A natural death is one resulting from the inevitable failure of a vital body function due solely to a natural disease process. Most deaths encountered by both hospital and forensic pathologists fall into this classification.[206] If it was clear from the outset that the death was due to a recognized natural disease, it is unlikely that the death would have been reported to the medical examiner, unless the death was sudden and unexpected or fell into one of the other categories of reportable diseases set forth in the particular statute in effect in that medical examiner system.

In accidental death, death is due to trauma but the trauma was not intentionally applied to the body. Even a death caused by a gunshot wound could be accidental. For example, although rare, a person might have inadvertently discharged a firearm while cleaning it.

Death is suicidal if the trauma is intentionally self-induced.[207] If a person commits suicide with a knife, hesitation wounds are often present.[208] Hesitation wounds are typically superficial and are frequently located in the same general area as the fatal wound. The hesitation marks often parallel the fatal wound. Some hesitation wounds are created as trial wounds to find out what the contemplated lethal wound will feel like — the "courage" factor. Other victims desire to suffer some pain before death, possibly to atone for feelings of guilt. If a clever killer used a knife, the killer might make additional wounds in the same vicinity as the fatal thrust to give the appearance of

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205. 3B M. Houts & I. Haut, *Courtroom Medicine* § 23.01 (1984).

206. DiMaio & DiMaio, "Natural Death as Viewed by the Medical Examiner: A Review of 1000 Consecutive Autopsies of Individuals Dying of Natural Disease," 36 J. Forensic Sci. 17 (1991) ("One of the most common misconceptions ... in regard to medical examiner offices is that the cases handled by these offices are exclusively traumatic in origin. In fact, the largest category of deaths seen in medical examiners' offices are natural deaths").

207. Jobes, Casey, Berman & Wright, "Empirical Criteria for the Determination of Suicide Manner of Death," 36 J. Forensic Sci. 244 (1991) (in 126 cases, the Empirical Criteria for the Determination of Suicide (ECDS) "predicted 100% of the suicides and 83% of the accidents, thus correctly identifying 92% of all cases"); Little & Sparks, "Brain Markers and Suicide: Can A Relationship Be Found?," 35 J. Forensic Sci. 1393, 1400 (1990) (although some have suggested that "some persons who commit suicide have altered neurochemistry in their brains," "neurochemical methods for detecting suicide cannot be considered forensically useful" at present); Rosenberg, Davidson, Smith, Berman, Buzbee, Gantner, Gay, Moore-Lewis, Mills, Murray, O'Carroll & Jobes, "Operational Criteria for the Determination of Suicide," 33 J. Forensic Sci. 1445, 1450-51 (1988) (a working group of coroners, medical examiners, statisticians, and public health officials developed a list of criteria related to the decedent's intent).

208. Wecht, *supra* note 19, at 25-46.

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hesitation wounds. These wounds can usually be distinguished from true hesitation wounds, since they will generally have the appearance of wounds inflicted after death or when the blood pressure is low or absent.

Lastly, death can be homicidal. Here a third party intentionally causes the injuries leading to death. This definition is broad enough to include cases in which the third party is lawfully exercising a right of self-defense or defense of others. Accordingly, a homicidal death is not necessarily an unlawful killing.

In knife deaths, one important type of evidence of the death's homicidal character is the presence of defense wounds. The victim often sustains these cuts on his extremities (such as hands and forearms) as he tries to parry the killer's thrusts and perhaps grab the knife away from the killer. In some suicides, in order to conceal the suicide and ensure that surviving relatives collect insurance proceeds, decedents have feigned defense wounds before killing themselves.

As a practical matter, in the investigation of manner of death, forensic pathologists sometimes use presumptions.[209] For example, many pathologists follow the rule of thumb that deaths caused by firearms are usually intentional, that is, either homicidal or suicidal.[210] The presumption is rebuttable in the pathologist's mind.[211] For example, the location of the wound, the presence of a gun cleaning kit nearby, and traces of gun cleaning chemicals on the decedent's hands might rebut the presumption and lead the pathologist to characterize the death as accidental. However, it should be recognized that in determining manner of death, pathologists rely on their past experience. If that experience has been that a certain type of death is almost always accidental or nearly always homicidal, the past experience may influence the pathologist's judgment.

§ 19-8. Time of Death.

The determination of time of death (TOD) is unfortunately an inexact science.[212] In the words of one expert, the science remains in the "dark ages."[213] Even the best trained and most experienced pathologist cannot positively pinpoint a time of death.[214] In most cases, only a gross estimate can be ventured.[215] Moreover, the estimate

209. Wright, *supra* note 203, at 5.
210. *Id.*
211. *Id.*
212. Houts, "Time of Death: Still the Dark Ages of Proof," 10 Trauma 7 (Aug. 1968).
213. *Id.* at 1.
214. *Id.* at 7.
215. *Id.* at 3-4.

becomes progressively less reliable as the time frame between death and the autopsy — the postmortem interval — increases. The longer the time lapse, the greater is the margin of error.

The immediate consequences of death occur within five to 10 minutes. They include, *inter alia:* cessation of breathing and circulation, changes in the appearance of the eyes, loss of natural muscle tone (primary flaccidity), and pallor of the skin. The cessation of circulation causes the pallor of the skin; as the blood stops circulating, it drains from the capillaries and venules of the skin.

These immediate consequences lead to two other sets of consequences: the early or short-term changes and the late or long-term changes.[216] Together these changes serve as a postmortem clock which allows the pathologist to gauge the time of death within very broad parameters. Each sign of death, whether early or late, can vary with the conditions prevailing at the time of death.[217] Moreover, on many of the signs, even the leading experts disagree over the correct chronology.[218]

This section describes the various techniques pathologists rely on to estimate time of death. In a given case, the pathologist may employ several techniques. By using multiple techniques, the pathologist can improve the reliability of the estimate;[219] but the pathologist's opinion remains merely an estimate.

§ 19-8(A). Short-Term Signs.

As previously stated, the shorter the postmortem interval, the more trustworthy the estimate of time of death is likely to be. Consequently, time estimates based on early signs of death have smaller margins of error than estimates based on the late changes. However, even when the pathologist relies exclusively on the early signs, he cannot pinpoint a given hour as the time of death.[220] Like the long-term changes, the short-term signs are subject to numerous variables; and an opinion based on the short-term signs is at best an approximation. Some

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216. For charts listing these changes, *see* Wecht, *supra* note 19, at 25-20, 25-22-23.

217. Burton, "Fallacies in the Signs of Death," 19 J. Forensic Sci. 529 (1974).

218. *Id.*

219. Schoenly, Griest & Rhine, "An Experimental Field Protocol for Investigating Postmortem Interval Using Multidisciplinary Indicators," 36 J. Forensic Sci. 1395 (1991); Henssge, Madea & Gallenkemper, "Death Time Estimation in Case Work. II. Integration of Different Methods," 39 Forensic Sci. Int'l 39 (1988) ("it is possible to narrow down a reliable time period for a stated death by means of the lower and upper limits of different criteria").

220. Camps, "Time of Death," 10 Trauma 9 (Aug. 1968).

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experts assert that estimates based on the early signs are subject to a margin of error of two to four hours.[221]

The three leading short-term signs are livor mortis, rigor mortis, and algor mortis — sometimes referred to as the triad of death.[222]

Livor Mortis

Livor mortis, lividity, or hypostasis is the postmortem discoloration of the body. When the person dies, circulation ceases. Gravity draws the blood into the lower or dependent regions of the body, where the blood pools. When the blood sinks to the lower areas, those areas take on a red-purple coloration. Although the stain may superficially resemble a bruise, there is a fundamental difference. In lividity, the blood remains in the vessels. In contrast, when the coloration is due to a bruise, the blood hemorrhages into the tissue.

The onset of the process begins immediately at death, but lividity usually becomes apparent between one and two hours after death.[223] Livor exhibits wide variability. In some severely debilitated individuals it may begin before death. Its appearance may be delayed in anemic persons, and it may never be perceived in some dark-skinned decedents.[224] In its early stage, the coloration is moveable or only partly fixed. If someone presses his finger against the discolored area of skin, the area will blanch or turn white.

In the next stage, the lividity becomes "fixed," maximal, or permanent. In this stage, the color no longer blanches under finger pressure. The experts differ on the time lapse needed for fixation. The most frequent estimates are between six and twelve hours.

Like the other signs, livor mortis can be influenced by several variables. For example, if the decedent were anemic, the lividity might be difficult to detect. High temperatures tend to accelerate the disappearance of lividity.[225]

Rigor Mortis

Rigor mortis is the postmortem rigidity or stiffening of the body. When death occurs, the body immediately loses natural muscle tone — primary flaccidity. At the time of death, a complex series of biochemical alterations take place. The muscles begin to develop an acid condition and energy-dependent processes cease. This acid condition is

221. A. Fatteh, *Handbook of Forensic Pathology* 20-29 (1973).
222. Burton, *supra* note 217, at 529.
223. Wecht, *supra* note 19, at 25-20.
224. *See also id.*
225. *Id.*

due to a chemical change; the body begins to develop lactic acid. The appearance of rigor is variable. The chemical processes culminating in perceptible rigor begin immediately upon death. In most cases, rigor becomes apparent two to four hours after death.[226] The condition may occur within 15 minutes after death or as late as six hours after death.[227] The rigidity first becomes apparent in the eyelids and face and then appears to work its way down the body to the jaw, arms, trunk and legs. The step-wise appearance of rigor from the top of the body to the bottom is only an apparent phenomenon. The process of rigor actually begins in all body muscles at the same time. However, rigor becomes perceptible in the smaller muscles before it does in the larger ones. This accounts for the apparent sequence of the onset and disappearance of rigor mortis. Rigor becomes complete within 12 or 16 hours after death.[228]

However, the condition is merely temporary. As decomposition sets in, the rigor starts to disappear. Rigor ordinarily appears to leave in the apparent order of appearance; it departs first in the face area and works downward. In the body's lower extremities, rigor may persist for between three and five days.[229] If the surrounding temperature is high, rigor may begin to disappear in 24 hours after death; but in most cases, disappearance begins in 36 or 48 hours after death.[230] When the rigor has disappeared, the body is said to be in secondary flaccidity.

Rigor is similar to lividity in that rigor is subject to many factors and, for that reason, "gross variation."[231] Intense emotion or physical activity can hasten the onset of rigor. In fact, if death occurred quickly and the victim realized the impending death, rigor may occur almost instantaneously. This phenomenon is termed cadaveric spasm or cataleptic rigidity. In these cases, the decedent's hand is sometimes found firmly grasping a weapon such as a gun or knife. However, cases of this phenomenon are rare. Some pathologists have never encountered the spasm. High temperatures can cause rigor to appear and disappear earlier than normal.[232] If someone forcibly breaks the rigor, rigor will not return and reestablish itself. If the pathologist does not

226. *Id.*
227. *Id.*
228. *Id.*
229. *Id.*
230. *Id.*
231. Camps, *supra* note 220, at 13.
232. Krompecher, "Experimental Evaluation of Rigor Mortis. V. Effect of Various Temperatures on the Evolution of Rigor Mortis," 17 Forensic Sci. Int'l 19 (1981). *See also* Krompecher & Bergerioux, "Experimental Evaluation of Rigor Mortis. VII. Effect of Anteand Post-Mortem Electrocution on the Evolution of Rigor Mortis," 38 Forensic Sci. Int'l 27 (1988) (electrocution hastens both the onset and passing of rigor mortis).

discover that rigor was broken, he might mistake the broken rigor for its natural disappearance and reach an erroneous conclusion about the time of death. Cold temperatures retard rigor mortis.

Algor Mortis

Algor mortis is the cooling of the body after death. The phenomenon is sometimes colorfully referred to as the chill of death. After death, the body tends to reach thermal equilibrium with the environment; that is, the body temperature declines until it reaches a plateau equaling the ambient temperature.[233]

Over the years experts have advanced several different formulae for calculating the fall of body temperature.[234] At first it was assumed that body cooling followed Newton's Law of Cooling that the rate of heat loss from a warm object cooling in air is directly proportional to the excess of the object's temperature over its surroundings.[235] Researchers subsequently discovered that body cooling does not follow that norm. Many experts now believe that the curve of cooling is a sigmoid or reverse-S shaped curve such as Figure 19-4.[236]

As Figure 19-4 indicates, there is an initial period of slow cooling. Temperature then drops rapidly — practically in a straight line.[237] As the body temperature nears the environmental temperature, the rate slows again.[238] During this last period of slow temperature fall, the rate of decline seems to follow Newton's Law. Over the entire period of decline, the average loss per hour is approximately 1.5°F.[239] However, the range of temperature loss is wide. Two English researchers recently proposed an amendment to Newton's Law to develop a formula — the time dependent Z equation (TDZE) — to estimate postmortem interval based on body temperature data.[240] The TDZE method requires taking two rectal temperatures, approximately an hour apart.

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233. Wecht, *supra* note 19, at 25-17.
234. Camps, *supra* note 220, at 9.
235. Sharpe, "The Rate of Cooling as an Index of the Time of Death," 10 Trauma 19 (Aug. 1968).
236. *Id.*; Sopher, The Law Enforcement Officer and the Determination of the Time of Death, F.B.I. Law Enf. Bull. Reprint, Oct. 1973, at 4. Reprinted with the permission of the Federal Bureau of Investigation.
237. Sharpe, *supra* note 235, at 19.
238. *Id.* at 19-20.
239. Sopher, *supra* note 236, at 4.
240. Green & Wright, "Postmortem Interval Estimates from Body Temperature Data Only," 28 Forensic Sci. Int'l 35 (1985); Green & Wright, "The Theoretical Aspects of the Time Dependent Z Equation as a Means of Postmortem Interval Estimation Using Body Temperature Data Only," 28 Forensic Sci. Int'l 53 (1985).

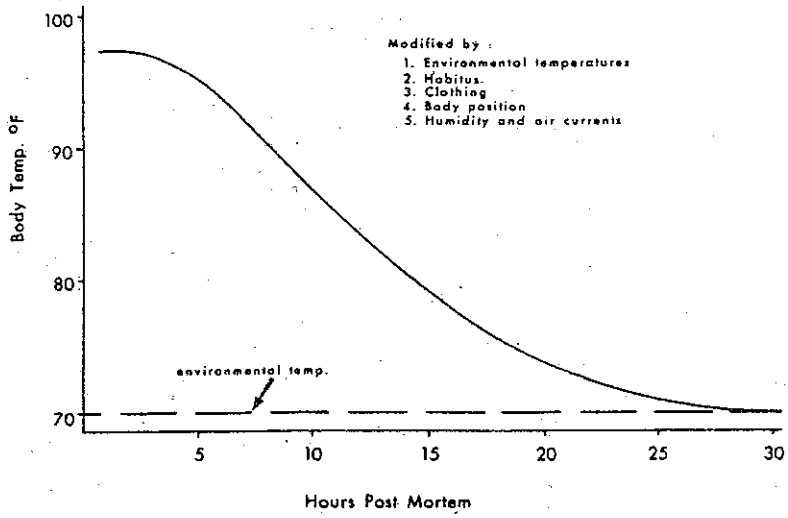

Figure 19-4

Like the other signs in the triad of death, algor mortis is subject to many variables.[241] The state of ventilation of the location of the body can affect the rate of fall. Although the pathologist will usually assume that the body temperature was the normal 98.4°F at the time of death, the assumption may be false; the temperature at that time might have been higher due to an infection or lower if the person was gradually dying for some time.[242] The site at which the pathologist inserts the thermometer can have an effect. The body surface cools before the interior, and there is usually a 1° difference between temperature measured in the mouth and temperature in the rectum.[243] Many European pathologists now insert the thermometer into the brain.[244] Most American pathologists use liver temperatures because of the ease of obtaining measurements. The physical state of the body can have an effect. If the body is fat or heavily clothed, the temperature decline will

241. Camps, *supra* note 220, at 9; Knight, "The Evolution of Methods for Estimating the Time of Death from Body Temperature," 36 Forensic Sci. Int'l 47, 53 (1988) ("the level of accuracy remains low, even in the artificial venue of a controlled environment").

242. Camps, *supra* note 220, at 10.

243. Henssge, "Death Time Estimation in Case Work. I. The Rectal Temperature Time of Death Nomogram," 38 Forensic Sci. Int'l 209 (1988) (the nomogram is based on a single measurement of the rectal temperature).

244. Burton, *supra* note 217, at 530.

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be slower. Other pathologists favor using a series of measurements at a number of body sites.[245]

Although pathologists rely heavily on livor, rigor, and algor mortis, there are other early signs that they can evaluate in estimating time of death. Those other signs include the following.

Stomach Contents

The state of the stomach can be indicative of the time of death.[246] Some experts estimate that a small meal empties in between one and two hours, a medium-sized meal in three to four hours, and a large meal in six hours. Other experts prefer to state that the stomach should empty in between two and four hours.[247]

Many factors can affect the rate of stomach emptying. Abnormal medical conditions such as a drug overdose or head injury can slow or even temporarily stop the digestive process.[248] Fear or excitement can inhibit digestion.[249] The type of food eaten also can influence the rate of digestion.[250]

Age of Bodily Injuries

The age of an injury on the body differs from the time of death. The victim may have suffered the injuries hours before the time of death. However, if the wound would normally be immediately fatal, a determination of the age of the injury is persuasive evidence of the time of death. Many types of injuries follow a normal chronology of color changes.[251] For example, a black eye typically follows this sequence: an initial bluish-red color; changing to dark violet; turning yellow or yellow-green within a day or two; becoming brown on the fourth or fifth day; and finally disappearing.[252] The injured cells under the discolored area also follow a regular sequence of disintegration and

245. Morgan, Nokes, Williams & Knight, "Estimation of the Post Mortem Period by Multiple-Site Temperature Measurements and the Use of a New Algorithm," 39 Forensic Sci. Int'l 89 (1988).

246. J. Bock, M. Lane & D. Morris, Identifying Plant Food Cells in Gastric Contents for Use in Forensic Investigations — A Laboratory Manual (1988); Suzuki, "Experimental Studies on the Presumption of the Time After Food Intake from Stomach Contents," 34 Forensic Sci. Int'l 83 (1987); Camps, *supra* note 220, at 14.

247. *Id.* at 15.

248. *Id.*

249. *Id.*

250. *Id.*

251. Wecht, *supra* note 19, at 25-24. *See also* Langlois & Gresham, "The Ageing of Bruises: A Review and Study of the Colour Changes With Time," 50 Forensic Sci. Int'l 227 (1991).

252. Wecht, *supra* note 19, at 25-24.

repair. The pathologist can examine the tissues in a microscopic study.[253] The pathologist can also use microscopy to detect healing changes between 24 and 36 hours after a fracture. Within five to seven days after a fracture, calcification can be seen microscopically. It must be remembered that there is wide variation in the rate of resolution of various wounds. The presence of certain markers such as cathespin D can help the pathologist distinguish between a vital wound and one inflicted postmortem.[254] The measurement of other chemical changes such as fluctuations in elemental concentrations can help the pathologist determine the time of the infliction of an injury.[255]

Eye Chemistry

Vitreous humor is a fluid in one of the regions of the eye. After death, the glucose and potassium levels, among others, in the vitreous humor change.[256] There has been some research attempting to correlate the changes with the lapse of time postmortem,[257] but many experts remain skeptical of the strength of the correlation.[258] There also has been some research into the phenomenon of corneal haziness.[259] Corneal hazing which occurs within 10 minutes of death is due to atmospheric drying of the surface of the eye and can be reversed by

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253. *Id.* at 25-25.

254. Girela, Hernandez-Cueto, Lorente & Villanueva, "Postmortem Stability of Some Markers of Intra-Vital Wounds," 40 Forensic Sci. Int'l 123 (1989).

255. Zhong & Zhen, "Localization and Quantification of Histamine in Injured Skin as Parameters for the Timing of Wounds," 51 Forensic Sci. Int'l 163 (1991); Njau, Epivatianos, Tsoukali-Papadopoulou, Psaroulis & Stratis, "Magnesium, Calcium and Zinc Fluctuations on Skin Induced Injuries in Correlation With Time of Induction," 50 Forensic Sci. Int'l 67 (1991).

256. Madea, Herrmann & Henbge, "Precision of Estimating the Time Since Death by Vitreous Potassium — Comparison of Two Different Equations," 46 Forensic Sci. Int'l 277, 283 (1990) ("equations with a steeper slope than that reported by Sturner should be preferred to avoid systematic overestimations of the time since death"); Coe, "Vitreous Potassium as a Measure of the Postmortem Interval: An Historical Overview and Critical Evaluation," 42 Forensic Sci. Int'l 201 (1989); Madea, Henssge, Honig & Gerbracht, "References for Determining the Time of Death by Potassium in Vitreous Humor," 40 Forensic Sci. Int'l 231 (1989); Stephens & Richards, "Vitreous Humor Chemistry: The Use of Potassium Concentration for the Prediction of the Postmortem Interval," 32 J. Forensic Sci. 503 (1987); Bray, "The Eye as a Chemical Indicator of Environmental Temperature at the Time of Death," 29 J. Forensic Sci. 396 (1984); Bray, Luke & Blackbourne, "Vitreous Humor Chemistry in Deaths Associated with Rapid Chilling and Prolonged Freshwater Immersion," 28 J. Forensic Sci. 588 (1983).

257. Wroblewski, "Estimation of Time of Death by Eye Changes," 2 Forensic Sci. 201 (1973).

258. M. Houts, *Courtroom* [illegible] § 1A.04 (1977).

259. Gradwohl, *Legal Medicine* [illegible] 94 (F. Camps ed. 3d ed.).

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wetting the eye with water. However, irreversible deeper clouding occurs 10-12 hours after death whether or not the eyes are open.

Enzyme Activities in Muscles

Other researchers have attempted to document that after death, the level of the activity of certain enzymes (protease and creatine phosphokinase) changes.[260] The researchers have attempted to correlate the changes in enzyme activity with the lapse of time postmortem.[261] To date the research has been restricted to rats, but the researchers are hopeful that the technique will also prove applicable to humans.[262]

Migration of Bacteria Within Body

After death, bacteria normally located in one part of the body may migrate to another area.[263] For example, microbiota typically found in the small intestine may travel to other areas of the body. Researchers are now using the scanning electron microscope (SEM) to study the migration in an attempt to correlate the extent of the migration with the length of the postmortem interval.[264]

Retardation of Plant Life Under the Body

If the body comes to rest on ground with plant life, the body may retard the growth of the plants under the body. A consulting botanist may be able to estimate the period of time the body has been resting on top of the plant life by studying the state of retardation of the plants. Alternatively, perennial plants may have begun to grow around the

260. Mayer & Neufeld, "Post-Mortem Changes in Skeletal Muscle Protease and Creatine Phosphokinase Activity — A Possible Marker for Determination of Time of Death," 15 Forensic Sci. Int'l 197 (1980). *See also* Kominato, Kumada, Yamazaki & Misawa, "Estimation of Postmortem Interval Using Kinetic Analysis of the Third Component of Complement (C3) Cleavage," 34 J. Forensic Sci. 207 (1989); Kominato, Harada, Yamazaki & Misawa, "Estimation of Postmortem Interval Based on the Third Component of Complement (C3) Cleavage," 33 J. Forensic Sci. 404 (1988); Perry, Bass, Riggsby & Sirotkin, "The Autodegradation of Deoxyribonucleic Acid (DNA) in Human Rib Bone and Its Relationship to the Time Interval Since Death," 33 J. Forensic Sci. 144 (1988); Gallois-Montbrun, Barres & Durigon, "Postmortem Interval Estimation by Biochemical Determination in Birds Muscle," 37 Forensic Sci. Int'l 189 (1988).

261. Mayer & Neufeld, *supra* note 260.

262. *Id.*

263. Melvin, Cronholm, Simson & Isaacs, "Bacterial Transmigration as an Indicator of Time of Death," 29 J. Forensic Sci. 412 (1984).

264. *Id.*

remains of the body. Dendochronology (the study of annual growt rings) may help a botanist estimate the time of death.[265]

Infestation of Insects On and Around the Body

After death, insects tend to colonize the body in a particula sequence.[266] Thus, the state of insect infestation at the time of th body's discovery is a clue to the time of death.[267] A forensic entomolc gist may be of great aid to the pathologist in evaluating the insec infestation on the body.[268]

There are a number of caveats. The most obvious is that thi research is still in its early stages. However, even at this point, there are several identifiable dangers. One is that the sequence of infestatior probably depends on the geographic region.[269] Furthermore, the body may have been deposited at its final resting place some time after

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265. Willey & Heilman, "Estimating Time Since Death Using Plant Roots and Stems," 32 J. Forensic Sci. 1264, 1265 (1987).

266. Lord, "Collection and Preservation of Forensically Important Entomological Materials," 28 J. Forensic Sci. 936 (1983). *See* Goff, Brown, Hewadikaram & Omori, "Effect of Heroin in Decomposing Tissues on the Development Rate of Boettscherisca peregrina (Diptea, Sarcophagidae) and Implications of This Effect on Estimation of Postmortem Intervals Using Arthropod Development Patterns," 36 J. Forensic Sci. 537 (1991) ("The time required for pupation was significantly greater for colonies fed on tissues from heroin-dosed" specimens); Goff & Flynn, "Determination of Postmortem Interval by Arthropod Succession: A Case Study from the Hawaiian Islands," 36 J. Forensic Sci. 607 (1991); Introna, Suman & Smialek, "Sarcosaprophagous Fly Activity in Maryland," 36 J. Forensic Sci. 238 (1991); Erzinclioglu, "On the Interpretation of Maggot Evidence in Forensic Cases," 30 Med. Sci. Law 65 (1990) (in the past, entomologists have often estimated the interval based on the largest maggot present on the corpse; this estimate rests on a misconception about the biology of flies because the first egg may begin to develop even before it is laid on the corpse); Haskell, McShaffrey, Hawley, Williams & Pless, "Use of Aquatic Insects in Determining Submersion Interval," 34 J. Forensic Sci. 622 (1989); Kashyap & Pillay, "Efficacy of Entomological Method in Estimation of Postmortem Interval: A Comparative Analysis," 40 Forensic Sci. Int'l 245 (1989) ("Sixteen insect-infested cadavers were examined and analysed to evaluate the reliability of the entomological method in estimation of time elapsed since death, in relation to other medicolegal approaches. The entomological method was found statistically more reliable and superior ...."); Introna, Altamura, Dell'Erba & Dattoli, "Time Since Death Definition by Experimental Reproduction of Lucilla Sericata Cycles in Growth Cabinet," 34 J. Forensic Sci. 478 (1989); Scott v. Commonwealth, 685 S.W.2d 184, 185 (Ky. 1984) ("The time of death, the summer of 1982, was determined by insect larvae, which are present only in the summer").

267. Schrof, "Murder, they chirped: Insect detectives are the latest scientific tool in criminal investigations," 111 U.S. News & World Rep., Oct. 14, 1991, at 67.

268. *See* State v. Needs, 99 Idaho 883, 591 P.2d 130 (1979).

269. Rodriguez & Bass, "Insect Activity and Its Relationship to Decay Rates in Human Cadavers in East Tennessee," 28 J. Forensic Sci. 423 (1983).

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death. If the entomologist does not realize this, he may underestimate the postmortem interval.[270] Or the insects in question may have gone through more than one growth cycle before the body's discovery. If the entomologist erroneously assumes that there was only one life cycle, again the entomologist may underestimate the interval. When the victim is a baby and the cadaver is found with a diaper containing fecal material, the entomologist might overestimate the interval; the insects may have begun in the fecal material before death, and their maturity might mislead the entomologist.[271]

Other researchers are using an analogous technique, estimating the postmortem interval based on the amount of animal damage to the skeleton.[272]

Other Techniques

Although the above techniques are the leading ones in most widespread use, there is an enormous amount of research into other techniques for estimating postmortem interval.[273]

270. Sopher, *supra* note 236, at 6.

271. Goff, Charbonneau & Sullivan, "Presence of Fecal Material in Diapers as a Potential Source of Error in Estimations of Postmortem Interval Using Arthropod Development Rates," 36 J. Forensic Sci. 1603 (1991).

272. Willey & Snyder, "Canid Modification of Human Remains: Implications for Time-Since-Death Estimations," 34 J. Forensic Sci. 894 (1989); Haglund, Reay & Swindler, "Canid Scavenging/Disarticulation Sequence of Human Remains in the Pacific Northwest," 34 J. Forensic Sci. 587 (1989) (the researchers identify five sequential steps of animal scavenging of human remains); Haglund, Reay & Swindler, "Tooth Mark Artifacts and Survival of Bones in Animal Scavenged Human Skeletons," 33 J. Forensic Sci. 985 (1988).

273. Brion, Marc, Launay, Gailledreau & Durigon, "Postmortem Interval Estimation by Creatinine Levels in Human Psoas Muscle," 52 Forensic Sci. Int'l 113 (1991); Vanezis, "Assessing Hypostasis by Colorimetry," 52 Forensic Sci. Int'l 1 (1991); Rognum, Hauge, Oyasaeter & Saugstad, "A New Biochemical Method for Estimation of Postmortem Time," 51 Forensic Sci. Int'l 139 (1991); Querido, "In Vitro Loss of Potassium from Erythrocytes During the 0-108 h Postmortem Period in Rats: Relationship Between Potassium Loss and Postmortem Interval," 51 Forensic Sci. Int'l 111 (1991); Nokes, Daniel, Flint & Barasi, "Investigations into the Analysis of the Rate of Decay of the Compound Action Potentials Recorded from the Rat Sciatic Nerve After Death: Significance for the Prediction of the Post-Mortem Period," 50 Forensic Sci. Int'l 75 (1991); Madea & Henssge, "Electrical Excitability of Skeletal Muscle Postmortem in Casework," 47 Forensic Sci. Int'l 207 (1990); Querido, "Linearization of the Relationship Between Postmortem Plasma Chloride Concentration and Postmortem Interval in Rats;" 45 Forensic Sci. Int'l 117 (1990); Fneschi, Picchi, Tassini, Valensin & Vivi, "H-NMR Studies of Postmortem Biochemical Changes in Rat Skeletal Muscle," 44 Forensic Sci. Int'l 225 (1990) (changes in perchloric acid extracts); Querido, "Double Logarithmic, Linear Relationship Between Plasma Sodium/Potassium Concentration Ratio and Postmortem Interval During the 6-96-H

§ 19-8(B). Long-Term Signs.

The second group of postmortem changes sets in at a later stage t the signs mentioned in the last subsection.

In a normal environment, the long-term change is the proces decomposition which includes autolysis and putrefaction. There numerous contributing causes to decomposition, including bacte activity within the body (putrefaction). Environmental temperatu the single most important factor in determining the rate of decomp tion. High temperatures accelerate the putrefaction process while temperatures slow the process. Doctor Wecht, a prominent fore pathologist, has outlined a chronology for decomposition:[274]

Sign	*Time of appearance*
Green discoloration of skin, abdomen, trunk	2 to 3 days 4 to 7 days
Visible purplish-brown color in subcutaneous veins	5 to 7 days
Skin blisters	5 to 7 days

Postmortem Period in Rats," 44 Forensic Sci. Int'l 125 (1990); Endo, Hara, Kuriiv Kano, "Postmortem Changes in the Levels of Monoamine Metabolites in Hu Cerebrospinal Fluid," 44 Forensic Sci. Int'l 61 (1990); Nagata, Kage, Kimura, Ku Noda, "Sulfide Concentrations in Postmortem Mammalian Tissues," 35 J. Forensic 706 (1990) (concentrations increased in blood, liver, and kidneys, but there was litt no change in the lung, brain, and muscle); Sparks, Oeltgen, Kryscio & Hunsa "Comparison of Chemical Methods for Determining Postmortem Interval," 3 Forensic Sci. 197 (1989) (the accumulation or clearance of the dopaminergic metab 3-methoxytyramine (3-MT) in the patamen of the brain); Sarkioja, Yla-Hertta Solakivi, Nikkari & Hirvonen, "Stability of Plasma Total Cholesterol, Tricylcer and Apolipoproteins B and A-1 During the Early Postmortem Period," 33 J. Fore Sci. 1432 (1988); Sawyer, Steup, Martin & Forney, "Cardiac Blood pH as a Pos Indicator of Postmortem Interval," 33 J. Forensic Sci. 1439 (1988).

274. Wecht, *supra* note 19, at 25-22. *See also* Yoshino, Kimijima, Sato & S "Microscopical Study on Estimation of Time Since Death in Skeletal Remains, Forensic Sci. Int'l 143 (1991) ("Microradiographic examination revealed no morph ical changes in [compact] bonds left in the open air for long periods, except one c years since death. In bones left in the soil, vacuoles of 5-10 mm diameter, w contained a honeycomb-like structure formed by small vacuoles of 0.5-1 mm diam were found in the peripheral zone of the substantia compacta approximately 5 y since death .... In bones left in the sea for 4-5 years, vacuoles of 5-10 mm diam were observed in the outer peripheral zone of the substantia compacta"); Mann, Ba Meadows, "Time Since Death and Decomposition of the Human Body: Variables Observations in Case and Experimental Field Studies," 35 J. Forensic Sci. 103, (1990) ("the rate of bodily decay is quite variable"); Galloway, Birkby, Jones, Hen Parks, "Decay Rates of Human Remains in an Arid Environment," 34 J. Forensic 607 (1989); Rodriguez & Bass, "Decomposition of Buried Bodies and Methods That Aid in Their Location," 30 J. Forensic Sci. 836 (1985). Bass has been one of the lea researchers in this field, and his articles are especially worth reading.

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Formation of gas (gastrointestinal tract and tissues)	7 to 9 days
Wet, peeling skin	7 to 9 days
Greenish-purple, swollen face and body	1 to 4 weeks
Easily detached hair and nails	3 to 4 weeks

Suppose that a body is left in water or on very moist soil. The likelihood is that the long-term change will take the form of saponification. In saponification, adipocere forms on the body; acids formed by the body fat give the skin a yellowish color and make the skin waxy or soapy to the touch. Adipocere which is apparent to the naked eye may be seen in as soon as three months after death. The process is usually not developed before five or six months after death.[275] The more warm and moist the environment, the faster will be the process.

Lastly, assume that the body is left in a dry, warm environment. This environment will dry out the body and make the skin taut and leathery. Peripheral mummification involving the hands and feet can be found in people dead two or three days. The process of generalized mummification can begin in one month after death and require a full year for completion. However, in most cases, the process is complete between three and a half and six months after death.[276]

§ 19-9. Place of Death.

The forensic pathologist is often asked to determine the place of death as well as the time of death.[277] The place of death can have critical legal importance. As a preliminary matter, the place of death may determine whether the trial court has jurisdiction and venue over the case. The place of death can also be a hotly contested issue on the historical merits of the case.

In some instances, the forensic pathologist can determine only that the death did not occur where the body was found. Livor and rigor mortis occasionally enable the pathologist to reach this conclusion. Assume, for example, that the pathologist discerns two areas of lividity or that the location of the lividity is inconsistent with the position of the body when the body was discovered.[278] The police may have found the body in a typical, suicidal hanging position; but rather than discovering lividity in the body's lower extremities, the pathologist

275. W. Spitz & R. Fisher, *The Medicolegal Investigation of Death* 23 (2d ed. 1980).
276. Wecht, *supra* note 19, at 25-23.
277. Berryman, Bass, Symes & Smith, "Recognition of Cemetery Remains in the Forensic Setting," 36 J. Forensic Sci. 230 (1991).
278. Burton, *supra* note 217, at 531.

notes lividity in the chest area. Inconsistent or multiple lividity strongly suggests that the body was moved after death. In the same fashion, the posture of the body's rigor may be inconsistent with the position in which it was found. In the hanging example, assume that the police find the body with the arms flexed rather than hanging straight down. The posture of the rigor will prompt the pathologist to suspect that the decedent died elsewhere and was later moved to the place and into the position in which the police discovered the body.

In other cases, the forensic pathologist and allied experts may be able to affirmatively determine the place of death. The pathologist may request that police laboratory criminalists analyze the trace evidence on the body (fiber, glass, and soil). Chapter 24 describes the various techniques for analyzing trace evidence. Or the pathologist may ask a forensic entomologist for assistance.[279] There are different species of flies in urban and rural areas.[280] The presence of a particular species of insect on the body may give a clue to the place of death.

§ 19-10. Pathological Evidence.

§ 19-10(A). Necessity for Pathological Testimony.

Although a forensic pathologist's expertise makes him the best qualified witness on numerous topics, in most jurisdictions other witnesses may also testify on these topics.

In some cases, the courts do not require any expert testimony even to establish cause of death.[281] For example, if a gunshot wound is obviously mortal, even a lay juror can infer that the wound caused death. In one federal case, there was a detailed description of a gunshot wound that passed through the victim's brain and no other signs of injury.[282] On these facts, the court held that expert testimony was unnecessary to establish causation. In a clear-cut case, the inference can be deemed a matter of common knowledge.

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279. Goff, "Comparison of Insect Species Associated with Decomposing Remains Recovered Inside Dwellings and Outdoors on the Island of Oahu, Hawaii," 36 J. Forensic Sci. 748 (1991); Hawley, Haskell, McShaffrey, Williams & Pless, "Identification of a Red Fiber: Chironomid Larvae," 34 J. Forensic Sci. 617 (1989) (the pathologist discovered the larva of a common freshwater midge on the body; the discovery indicated the submersion of the body); Prichard, Kossoris, Leibovitch, Robertson & Lovell, "Implications of Trombiculid Mite Bites: Report of a Case and Submission of Evidence in a Murder Trial," 31 J. Forensic Sci. 301 (1986) (some insects have a discrete geographic distribution); Middleton, "Tale Told by a Fly," 69 A.B.A.J. 571 (1973).

280. *Id.*

281. Annot., 65 A.L.R.3d 283 (1975); Annot., 31 A.L.R.2d 693 (1953). *E.g.*, Parten v. State, 672 S.W.2d 251 (Tex. App. 1984.)

282. Rife v. Blankenship, 721 F.2d 983 (4th Cir. 1983).

In other cases, courts accept testimony from lesser experts, such as police officers, morticians, coroners and physicians not expert in this area. Sheriffs have sometimes qualified as experts based on limited training and practical experience in investigating homicides.[283] Even when the witness lacked medical training, many courts have allowed coroners, morticians, embalmers, and chemistry professors to opine on cause of death.[284] The courts have not been at all reluctant to allow physicians[285] and hospital pathologists[286] to testify on such topics as cause[287] and time[288] of death. The courts have even allowed investigators to testify on such subjects as the manner and sequence of the gunshot wounds causing the victim's death.[289]

Although in the past many courts have liberally admitted nonexpert testimony and testimony by minimally qualified experts, more and more courts are embracing the view that testimony on subjects such as cause of death requires at least some medical training.[290] In a growing number of cases, courts have barred testimony by coroners and morticians.[291] Moreover, even in jurisdictions allowing nonpathologists to testify to cause of death, some trial courts take the position that manner of death is such a subtle, evaluative judgment that only qualified pathologists can testify on that subject.

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283. Brown v. State, 140 Ga. App. 160, 230 S.E.2d 128 (1976), *cert. denied,* 434 U.S. 819 (1977).

284. Annot., 71 A.L.R.3d 1265 (1976); Jackson v. State, 412 So. 2d 302, 305 (Ala. Crim. App. 1982); Woodard v. State, 401 So. 2d 300, 303 (Ala. Crim. App. 1981); Smoot v. State, 381 So. 2d 668, 670-71 (Ala. Crim. App. 1980); State v. Miller, 429 N.W.2d 26 (S.D. 1988) (a forensic pathologist testified about the type of instrument used to inflict certain head wounds on the murder victim).

285. Martin v. Industrial Comm'n, 75 Ariz. 403, 257 P.2d 596 (1953); State v. Vincent, 785 S.W.2d 805 (Mo. App. 1990) (gunshot wounds and injuries); Barber v. State, 628 S.W.2d 104, 108 (Tex. App. 1981), *cert. denied,* 459 U.S. 874 (1982).

286. Annot., 56 A.L.R.2d 1447 (1957).

287. Barber v. State, 628 S.W.2d 104, 108 (Tex. App. 1981), *cert. denied,* 459 U.S. 874 (1982).

288. Martin v. Industrial Comm'n, 75 Ariz. 403, 257 P.2d 596 (1953).

289. State v. Beuke, 38 Ohio St. 3d 29, 526 N.E.2d 274 (1988), *cert. denied,* 489 U.S. 1071 (1989).

290. Annot., 71 A.L.R.3d 1265, 1268 (1976); Evans v. Twin Falls County, 118 Idaho 210, —, 796 P.2d 87, 91 (1990) (citing Am. Jur. 2d, the court states that "[a] majority of states which have addressed this matter have held that ... [w]here the subject matter regarding the cause of disease, injury, or death of a person is wholly scientific or so far removed from the usual and ordinary experience of the average person that expert knowledge is essential to the formation of an intelligent opinion, only an expert can competently give opinion evidence ...."), *cert. denied,* 111 S. Ct. 960, 112 L. Ed. 2d 1048 (1991).

291. *Id.*

§ 19-10(B). Permissible Subjects for Expert Opinions.

Identity of Decedent

As previously stated, the forensic pathologist must often grapple with the question of the decedent's identity. The pathologist may ask a fingerprint examiner or forensic odontologist to assist in the identification. Chapters 13 and 16 note that fingerprint and dental identification is admissible. Chapter 18 discusses DNA typing. Several jurisdictions have also accepted evidence of radiological identification.[292] In one case, the court admitted the evidence and rejected a *Frye* challenge even though the radiologist conceded that there were only three or four American experts experienced in radiologic identification.[293]

There is little case law dealing with the anthropological techniques used to narrow the class of persons the decedent might belong to. One of the few reported cases is *State v. Needs,*[294] in which an anthropologist estimated the decedent's age and stature.[295] The witness based the age estimate on an analysis of the decedent's femur bone and pubic symphysis. However, the testimony was evidently admitted without objection. Consequently, the appellate court did not have occasion to reach the question of whether these anthropological techniques satisfy the *Frye* test. In *State v. Klindt,*[296] it was unnecessary for the court to discuss the question because the case arose in Iowa, a jurisdiction which has abandoned *Frye*. However, in the course of sustaining the admission of expert anthropological testimony about the victim's stature, the court stressed that forensic anthropology is "a recognized scientific discipline."[297]

Cause and Manner of Death

Forensic pathologists sometimes find themselves in disagreement over a decedent's cause or manner of death.[298] However, possibility of

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292. Coleman v. State, 423 So. 2d 276, 278 (Ala. Crim. App. 1982); Commonwealth v. Gilbert, 366 Mass. 18, 24, 314 N.E.2d 111, 115 (1974); Commonwealth v. Devlin, 365 Mass. 149, 310 N.E.2d 353 (1974).

293. Commonwealth v. Devlin, 365 Mass. 149, 310 N.E.2d 353 (1974). However, our reviewer adds that today there are many radiologists qualified to make such identifications.

294. 99 Idaho 883, 591 P.2d 130 (1979).

295. *Id.* at 886, 591 P.2d at 133. *See also* United States v. Ferri, 778 F.2d 985 (3d Cir. 1985), *cert. denied,* 479 U.S. 831 (1986).

296. 389 N.W.2d 670 (Iowa 1986).

297. *Id.* at 673. *See also* People v. Knights, 166 Cal. App. 3d 46, 212 Cal. Rptr. 307 (1985); State v. Bullard, 312 N.C. 129, 322 S.E.2d 370 (1984).

298. *E.g.,* People v. Kent, 111 Ill. App. 3d 733, 67 Ill. Dec. 334, 444 N.E.2d 570 (1982); People v. Ellison, 100 Ill. App. 3d 282, 426 N.E.2d 1058 (1981); Estate of Moran,

disagreement has not discouraged the courts from routinely admitting pathologists' opinions on cause, mechanism, and manner of injury and death.

The courts allow pathologists to testify on the nature, cause, and effects of wounds and injuries.[299] For example, a pathologist may testify that the pattern of bruises on an alleged rape victim's labia majora and minora is consistent with forcible insertion of a penis.[300] A pathologist is also permitted to testify on the cause of illnesses such as conditions that may be caused by poisoning.[301] Similarly, a pathologist may testify about the effects of the use of illicit drugs such as cocaine.[302] The pathologist's opinions about a decedent's cause of death are also admissible. Pathologists have been permitted to testify to deaths caused by, inter alia: blunt trauma,[303] sharp-edged instruments,[304]

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67 Ill. App. 3d 576, 24 Ill. Dec. 312, 385 N.E.2d 79 (1978), *aff'd,* 77 Ill. 2d 147, 32 Ill. Dec. 349, 395 N.E.2d 579 (1979).

299. Bishop v. Kelso, 914 F.2d 1468 (11th Cir. 1990); Bell v. State, 435 So. 2d 772, 775 (Ala. Crim. App. 1983).

300. People v Chambers, 136 Cal. App. 3d 444, 186 Cal. Rptr. 306 (1982). *See also* United States v. Weeson, 779 F.2d 1443 (9th Cir. 1986) (expert testimony that the victim's injuries were inconsistent with consensual intercourse); Pegg v. State, 183 Ga. App. 668, 359 S.E.3d 678 (1987) (forcible penile entry); People v. Byrd, 206 Ill. App. 3d 996, 565 N.E.2d 176, 151 Ill. Dec. 905 (1990) (the vaginal injuries sustained by the complainant resulted from nonconsensual intercourse), *appeal denied,* 137 Ill. 2d 667, 571 N.E.2d 150, 156 Ill. Dec. 563 (1991); State v. Everett, 98 N.C. App. 23, 390 S.E.2d 160 (1990) (the witness, a pediatrician, not only testified that there had been penetration but also opined as to the number of times sexual penetration had occurred).

301. State v. Jones, 54 N.C. App. 482, 283 S.E.2d 546 (1981).

302. Bright v. State, 191 Ga. App. 655, 382 S.E.2d 426 (1989); State v. Rangitsch, 40 Wash. App. 771, 700 P.2d 382 (1985).

303. Guam v. Reyes, 879 F.2d 646 (9th Cir. 1989) (a pathologist was permitted to testify that a bruise on the victim's chest was "most likely" caused by pressure from the tip of a gun); Mitchell v. State, 18 Ala. App. 471, 93 So. 46, *cert. denied,* 208 Ala. 699, 93 So. 923 (1922); People v. Stout, 122 Ill. App. 3d 254, 77 Ill. Dec. 641, 460 N.E.2d 1205 (1984); People v. Gray, 121 Ill. App. 3d 867, 77 Ill. Dec. 298, 460 N.E.2d 354 (1984); People v. Mifflin, 120 Ill. App. 3d 1072, 458 N.E.2d 1343 (1984); People v. Franklin, 119 Ill. App. 3d 899, 75 Ill. Dec. 563, 457 N.E.2d 1005 (1983); People v. Martin, 112 Ill. App. 3d 486, 65 Ill. Dec. 151, 445 N.E.2d 795 (1983); People v. Schreiber, 104 Ill. App. 3d 618, 60 Ill. Dec. 417, 432 N.E.2d 1316 (1982), *cert. denied,* 459 U.S. 1214 (1983).

304. People v. Perez, 100 Ill. App. 3d 901, 56 Ill. Dec. 149, 427 N.E.2d 229 (1981); People v. Paschall, 91 A.D.2d 645, 456 N.Y.S.2d 828 (1982) (but the court forbade the expert from characterizing particular injuries as "defense wounds"); Commonwealth v. Henry, 524 Pa. 135, 569 A.2d 929 (1990) (multiple transverse cuts on the front of the victim's neck were the type generally attributable to threatening or at-bay situations), *cert. denied,* 111 S. Ct. 1338, 113 L. Ed. 2d 269 (1991).

gunshot wounds,[305] burns,[306] asphyxia,[307] and poisons[308] including arsenic,[309] carbon monoxide,[310] cyanide,[311] and Darvon.[312]

The courts allow forensic pathologists to venture beyond the medical questions of cause and mechanism to testify directly on the medicolegal question of manner or mode of death.[313] For example, pathologists have testified that the manner of death was homicidal[314] or acciden-

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305. United States v. Lebron-Gonzalez, 816 F.2d 823 (1st Cir.) (the direction of a fatal shot), *cert. denied*, 484 U.S. 843 (1987); Bryant v. State, 428 So. 2d 641 (Ala. Crim. App. 1982), *cert denied*, 428 So. 2d 646 (Ala. 1983); Portis v. State, 418 So. 2d 924 (Ala. Crim. App.), *cert. denied*, 418 So. 2d 927 (Ala. 1982); Bright v. State, 191 Ga. App. 655, 382 S.E.2d 426 (1989) (the path of a bullet through the body); People v. Reyes, 102 Ill. App. 3d 820, 57 Ill. Dec. 914, 429 N.E.2d 1277 (1981) (distance determinations); Wissman v. State, 540 N.E.2d 1209 (Ind. 1989) (the angle of entry); State v. Moran, 495 So. 2d 338 (La. App. 1986) (distance from which gun fired); May v. State, 524 So. 2d 957 (Miss. 1988) (the victim's gunshot wound was not a contact wound); People v. Bonilla, 95 A.D.2d 396, 467 N.Y.S.2d 599 (1983), *aff'd sub nom.* People v. Eulo, 63 N.Y.2d 341, 472 N.E.2d 286, 482 N.Y.S.2d 436 (1984); Smith v. Commonwealth, 239 Va. 243, 389 S.E.2d 871 (the presence of gunpowder debris in the back of the victim's head was consistent with a "close gunshot wound"), *cert. denied*, 111 S. Ct. 221, 112 L. Ed. 2d 177 (1990); Annot., 86 A.L.R.2d 611 (1962) (muzzle-to-target determinations).

306. People v. McNeeley, 77 A.D.2d 205, 433 N.Y.S.2d 293 (1980); State v. Setzer, 42 N.C. App. 98, 256 S.E.2d 485, *cert. denied*, 298 N.C. 571, 261 S.E.2d 127 (1979).

307. Commonwealth v. Pikul, 400 Mass. 550, 511 N.E.2d 336 (1987) (expert testimony that a child's death was due to traumatic sexual asphyxia).

308. Sheriff, Clark County v. Morris, 99 Nev. 109, 659 P.2d 852 (1983) (lethal dose); O'Bryan v. State, 591 S.W.2d 464 (Tex. Crim. App. 1979) (fatal dose), *cert. denied*, 446 U.S. 988 (1980).

309. Vaughn v. State, 249 Ga. 803, 294 S.E.2d 504 (1982); State v. Jones, 54 N.C. App. 482, 283 S.E.2d 546 (1981); State v. Barfield, 298 N.C. 306, 259 S.E.2d 510 (1979), *cert. denied*, 448 U.S. 907 (1980); State v. Hunt, 297 N.C. 258, 254 S.E.2d 591 (1979).

310. Manigan v. State, 402 So.2d 1063 (Ala. Crim. App.), *cert. denied*, 402 So. 2d 1072 (Ala. 1981); Williams v. State, 250 Ga. 553, 300 S.E.2d 301, *cert. denied*, 462 U.S. 1124 (1983); Clifton v. Nardi, 65 Ill. App. 3d 344, 22 Ill. Dec. 194, 382 N.E.2d 514 (1978); State v. Setzer, 42 N.C. App. 98, 256 S.E.2d 485, *cert. denied*, 298 N.C. 571, 261 S.E.2d 127 (1979).

311. O'Bryan v. State, 591 S.W.2d 464 (Tex. Crim. App. 1979), *cert. denied*, 446 U.S. 988 (1980); State v. Hoffman, 106 Wis. 2d 185, 316 N.W.2d 143 (1982).

312. People v. Ellison, 100 Ill. App. 3d 282, 55 Ill. Dec. 733, 426 N.E.2d 1058 (1981).

313. State v. Dietz, 390 S.E.2d 15, 23-24 (W. Va. 1990) ("the manner and mode of death").

314. People v. Franklin, 119 Ill. App. 3d 899, 75 Ill. Dec. 563, 457 N.E.2d 1005 (1983). *But see* State v. Pinero, 70 Haw. 509, ___, 778 P.2d 704, 712 (1989) (the pathologist should not have been permitted to testify that the death was "a homicide;" "The [witness' answers were] plainly beyond the intendment of ... [R]ule 704; the questions were conclusionary, and the answers told the jury what result to reach. Moreover, the opinions were 'phrased in terms of inadequately explored ... criteria' related to criminal homicide. Haw. R. Evid. 704, Commentary").

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tal.[315] To establish the homicidal character of a death, a pathologist may testify that most suicides shoot themselves in areas of the body other than the area where the decedent's wound was located.[316] Similarly, there is substantial authority permitting experts to characterize injuries as "defensive wound[s]."[317] Many courts, including the United States Supreme Court, have already accepted battered child syndrome evidence and allowed pathologists to testify that the decedent child's wound pattern suggests homicide rather than accident.[318] One court even allowed a pathologist to characterize a set of wounds as not being the result of a "maniacal attack."[319] However, other courts have held that even a forensic pathologist may not describe injuries as "defense wounds"[320] or a killing as "murder."[321] In these cases, the courts believed that the pathologist overstepped proper bounds by using terms with specialized legal meanings. In still another case, the appellate court held that the trial judge erred in permitting a physician to testify about the age of a healed cervical tear.[322] The court

315. State v. Jones, 801 P.2d 263, 267 (Wash. App. 1990) (the doctors "were better qualified than jurors to adjudge ... whether the fatal blow was accidental or inflicted. Opinion evidence on these issues is commonly allowed in homicide cases").

316. May v. State, 524 So. 2d 957 (Miss. 1988).

317. Floyd v. State, 569 So. 2d 1225, 1232 (Fla. 1990).

318. Estelle v. McGuire, 116 L. Ed. 2d 385, 112 S. Ct. 475 (1991); United States v. Bowers, 660 F.2d 527, 529 (5th Cir. 1981) ("Testimony describing the battered child syndrome has been approved in several state jurisdictions"); Eslava v. State, 473 So. 2d 1143 (Ala. Crim. App. 1985); Bell v. State, 435 So. 2d 772, 776 (Ala. Crim. App. 1983); Boone v. State, 282 Ark. 274, 668 S.W.2d 17 (1984); Carpenter v. Commonwealth, 771 S.W.2d 822 (Ky. 1989) (a child's injuries were intentionally caused rather than accidental); State v. Durfee, 322 N.W.2d 778 (Minn. 1982); People v. McNeeley, 77 A.D.2d 205, 433 N.Y.S.2d 293 (1980); People v. Kinder, 75 A.D.2d 34, 428 N.Y.S.2d 375 (1980); Commonwealth v. Rodgers, 364 Pa. Super. 477, 528 A.2d 610 (1987), *appeal denied*, 518 Pa. 638, 542 A.2d 1368 (1988); State v. Toennis, 52 Wash. App. 176, 758 P.2d 539 ("The Battered Child Syndrome is a well-recognized medical diagnosis ..."), *review denied*, 111 Wash. 2d 1026 (1988). *See generally* E. Imwinkelried, *Uncharged Misconduct Evidence* § 4.06 (1984); Orfinger, "Battered Child Syndrome: Evidence of Prior Acts in Disguise," 41 Fla. L. Rev. 345, 347 (1989) ("Expert testimony as to battered child syndrome has hardly been a point of judicial contention; every jurisdiction considering such evidence has held it admissible").

319. People v. Smith, 59 N.Y. 156, 451 N.E.2d 157, 464 N.Y.S.2d 399 (1983). *See also* Hernandez v. State, 772 S.W.2d 274 (Tex. App. 1989) (a pathologist was allowed to testify that a wound was a "deliberate cutting type of wound"); State v. Dietz, 390 S.E.2d 15 (W. Va. 1990) (a pathologist was permitted to testify that the homicide was "of a psychosexual type").

320. West v. State, 485 So. 2d 681 (Miss. 1985), *cert. denied*, 479 U.S. 983 (1986); People v. Paschall, 91 A.D.2d 645, 456 N.Y.S.2d 828 (1982).

321. Bell v. State, 435 So. 2d 772, 778 (Ala. Crim. App. 1983) (error not prejudicial).

322. Brown v. Commonwealth, 812 S.W.2d 502 (Ky. 1991).

declared that the opinion embraced the ultimate question of whether the complainant had been abused when she was 10 years old.

Time of Death

The courts recognize that the determination of time of death is an inexact science.[323] Some courts even give the jury a cautionary instruction to that effect.[324] In light of the imprecision inherent in any estimate of time of death, it is not surprising that forensic pathologists occasionally disagree over time of death in the reported cases.[325] However, although the courts realize the fallibility of opinions of time of death, they are also aware that pathologists' opinions on the subject can be helpful to a jury. Consequently, the courts admit pathologists' opinions on time of death,[326] age of injuries,[327] and the sequence of multiple deaths.[328] The pathologist may testify on the basis of short-term signs such as stomach contents[329] and rigor[330] as well as long-term changes such as decomposition.[331] However, in one case, the court held that a forensic pathologist's estimate based on insect larvae was

323. Gruzen v. State, 276 Ark. 149, 634 S.W.2d 92, *cert. denied,* 459 U.S. 1020 (1982).

324. *Id.*

325. *E.g.,* People v. Trolia, 107 Ill. App. 3d 487, 63 Ill. Dec. 155, 437 N.E.2d 804, (1982), *cert. denied,* 460 U.S. 1044 (1983); People v. Cable, 96 A.D.2d 251, 468 N.Y.S.2d 470 (1983).

326. United States v. Maravilla, 907 F.2d 216 (1st Cir. 1990) (Federal Rule of Evidence 403, permitting the trial judge to balance probative value against probative danger, does not require the exclusion of a forensic pathologist's testimony about the approximate time of death); Gruzen v. State, 276 Ark. 149, 634 S.W.2d 92, *cert. denied,* 459 U.S. 1020 (1982); State v. Needs, 99 Idaho 883, 591 P.2d 130 (1979); People v. Hendricks, 145 Ill. App. 3d 71, 99 Ill. Dec. 20, 495 N.E.2d 85 (1986) (the court rejected the defense argument that time of death estimates are so unreliable that the prosecution's reliance on the estimate necessarily creates a reasonable doubt about the defendant's guilt), *aff'd,* 1988 Ill. LEXIS 194 (1988), *different results reached on reh'g,* 137 Ill. 2d 31, 148 Ill. Dec. 213, 560 N.E.2d 611 (1990); People v. Kent, 111 Ill. App. 3d 733, 67 Ill. Dec. 334, 444 N.E.2d 570 (1982); People v. Trolia, 107 Ill. App. 3d 487, 63 Ill. Dec. 155, 437 N.E.2d 804 (1982), *cert. denied,* 460 U.S. 1044 (1983); State v. Garrett, 627 S.W.2d 635, 642 (Mo.), *cert. denied,* 459 U.S. 906 (1982).

327. People v. Washington, 197 Cal. App. 3d 488, 891, 232 Cal. Rptr. 190, 194 (1986) (abrasions), *superseded,* 235 Cal. Rptr. 302, 733 P.2d 624 (1987); People v. Cable, 96 A.D.2d 251, 468 N.Y.S.2d 470 (1983), *rev'd,* 63 N.Y.2d 270, 471 N.E.2d 447, 481 N.Y.S.2d 675 (1984). *But see* Brown v. Commonwealth, 812 S.W.2d 502 (Ky. 1991) (the age of a healed cervical tear).

328. Hitchcock v. Key, 163 Ga. App. 901, 296 S.E.2d 625 (1982); Estate of Moran, 67 Ill. App. 3d 576, 24 Ill. Dec. 312, 385 N.E.2d 79 (1978), *aff'd,* 77 Ill. 2d 147, 32 Ill. Dec. 349, 395 N.E.2d 579 (1979).

329. State v. Pridgen, 313 N.C. 80, 326 S.E.2d 618 (1985).

330. State v. Garrett, 627 S.W.2d 635, 642 (Mo.), *cert. denied,* 459 U.S. 906 (1982).

331. State v. Needs, 99 Idaho 883, 591 P.2d 130 (1979).

inadmissible because the expert conceded that "his methodology is completely untested by other scientists ...."[332]

Place of Death

In most instances, the prosecutor must use trace evidence — fiber, hair, and soil — to determine the place of death. The admissibility of trace evidence is discussed in Chapter 24.

Position of the Body

The expert may also express an opinion on the position of the victim's body when the victim was shot.[333]

§ 19-10(C). Admissibility of Autopsy Reports.

As noted in Chapter 6, courts often admit forensic reports as business entries or public records even when the scientist who prepared the report does not testify at trial. The courts have applied this view to autopsy reports prepared by pathologists; autopsy reports have qualified as business entries[334] and public records.[335] Since the reports fall within well-recognized hearsay exceptions, most courts hold that their admission does not deny the defendant the right of confrontation.[336] The report is admissible even without sponsoring testimony by the pathologist who authored the report,[337] at least when the record contains foundational evidence that the report's author had the expert qualifications to form the opinions stated in the report.[338]

Moreover, as part of the basis for an expert opinion, one pathologist may rely on a report prepared by a medical examiner's investigator[339]

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332. State v. Miller, 429 N.W.2d 26, 39 (S.D. 1988).

333. Guam v. Reyes, 879 F.2d 646 (9th Cir. 1989); State v. Jones, 749 S.W.2d 356 (Mo.), *cert. denied*, 488 U.S. 871 (1988); State v. Torres, 99 N.C. App. 364, 393 S.E.2d 585 (1990) (one of the shots fired at the murder victim could have entered the victim's body while the victim was lying on the floor).

334. Wiley v. State, 389 So. 2d 604 (Ala. Crim. App. 1980). *But see* Segrest v. Gillette, 96 N.C. App. 435, 386 S.E.2d 88 (1989) (a laboratory report describing a test did not fall within the business entry hearsay exception because it was prepared two years and nine months after the test).

335. People v. Wardlow, 118 Cal. App. 3d 375, 173 Cal. Rptr. 500 (1981).

336. Wiley v. State, 389 So. 2d 604 (Ala. Crim. App. 1980). *But see* Manocchio v. Moran, 708 F. Supp. 473 (D.R.I. 1989) (the admission of a medical examiner's report on the cause of death violated the confrontation clause because the prosecution did not make a good faith effort to produce the examiner at trial), *rev'd*, 919 F.2d 770 (1st Cir. 1990), *cert. denied*, 111 S. Ct. 1695, 114 L. Ed. 2d 89 (1991).

337. People v. Wardlow, 118 Cal. App. 3d 375, 173 Cal. Rptr. 500 (1981).

338. *Id.*

339. United States v. Scarfo, 711 F. Supp. 1315 (E.D. Pa. 1989), *aff'd sub nom.* United States v. Pungitore, 910 F.2d 1084 (3d Cir. 1990), *cert. denied*, 111 S. Ct. 2009, 114 L. Ed. 2d 98 (1991).

or an autopsy report written by another pathologist.[340] However, the pathologist does not have carte blanche to select the bases for his or her opinion. Under Federal Rule of Evidence 703, the pathologist may rely on hearsay which is not independently admissible only if it is reasonable to do so.[341] In one case the court ruled that it was error for the pathologist to recite that none of his colleagues had given him a persuasive reason to change his opinion.[342] The court found that there had been no showing that it was a reasonable practice for the witness to rely on other experts' concurrence in his opinion.

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AFYB-CG

02 DEC 2004

MEMORANDUM FOR Staff Judge Advocate, 4th Infantry Division, Fort Hood, Texas 76544

SUBJECT: Request for Employment of Expert Consultant in the Case of *U.S. v. 1LT Jack M. Saville*

The request for Dr. Cyril Wecht as an expert consultant in the case of *U.S. v. 1LT Jack M. Saville,* is:

[ ] Approved.

[X] Denied.

[ ] Other.

JAMES D. THURMAN
Major General, USA
Commanding

2 Encls
1. SJA Recommendation
2. Defense Request

APPELLATE EXHIBIT VIII

AFYB-JA (27-10e)

MEMORANDUM FOR Commander, 4th Infantry Division, Fort Hood, Texas 76544

SUBJECT: Request for Employment of Expert Consultant in the Case of *U.S. v. 1LT Jack M. Saville*

1. Purpose. To consider whether to approve the request for employment of an expert consultant.

2. Recommendation. That you disapprove the request for employment of the expert consultant.

3. Discussion.

a. In accordance with *Ake v. Oklahoma,* 470 U.S. 68 (1985), and *U.S. v. Ndayni,* 45 M.J. 315 (CAAF 1996), the defense is entitled to receive expert assistance to prepare for the court-martial. The defense is not entitled to a specific expert. The government may provide an adequate substitute.

b. The defense specifically requested Dr. Cyril H. Wecht as an expert consultant to assist in the preparation of the accused's defense. Dr. Wecht lives and works in Pittsburgh, Pennsylvania.

c. The defense has not met the burden of showing the necessity for expert assistance under the provision of Rule for Court Martial (RCM) 703(d). The expert consultant would testify and consult about forensic evidence and autopsy procedure relating to the death of Zaydun Mamoun. Currently there is no scientific evidence being presented at this court martial by the government relating to the cause of death of Zaydun Mamoun. Furthermore, it is unlikely that an autopsy, at this time, would yield any forensic evidence. The government does not intend to rely on expert testimony to prove its case relating to the manslaughter charge. I recommend that you disapprove the request.

Tracy A. Barnes

TRACY A. BARNES
LTC, JA
Staff Judge Advocate

1 Dec 04

2 Encls
1. Decision Document (TAB A)
2. Defense Request (TAB B)

Request for Trial Before Military Judge Alone

(Article 16, UCMJ)

United States
v.
1LT Jack M. Saville

1. ACCUSED

I have been informed that Colonel Theodore E. Dixon is the military judge detailed to the court-martial to which the charges and specifications pending against me have been referred for trial. After consulting with my defense counsel, I hereby request that the court be composed of the military judge alone. I make this request with full knowledge of my right to be tried by a court-martial composed of officers and, if I so request, enlisted personnel.

a. Typed Name (Last, First, Middle initial)	b. Rank	c. Signature	d. Date Signed
SAVILLE, JACK M.	1LT	Jack M Saville	14 MAR 05

2. DEFENSE COUNSEL

Prior to the signing of the foregoing request, I fully advised the above accused of his right to trial before a court-martial composed of officers[1] and of his right to have such court consist of at least one-third enlisted members[2] not of his unit, upon his request.

a. Typed Name (Last, First, Middle initial)	b. Rank	c. Signature	d. Date Signed
DRAKE, DAVID H	CPT	David H. Drake	14 March 05

3. TRIAL COUNSEL

Argument is (not) requested.

a. Typed Name (Last, First, Middle initial)	b. Rank	c. Signature	d. Date Signed
SCHIFFER, THOMAS E.	CPT	Thomas E Schiffer	14 MAR 05

4. MILITARY JUDGE

The foregoing request for trial before me alone is hereby: (x one) ☑ approved ☐ disapproved [3]

a. Typed Name (Last, First, Middle initial)	b. Rank	c. Signature	d. Date Signed
DIXON, THEODORE E.	COL	Theodore E. Dixon	14 Mar 05

1. Not applicable when accused is a warrant officer or enlisted member.
2. Not applicable when accused is a commissioned officer or warrant officer.
3. When request is disapproved, the basis for the denial must be put on the record. (See MCM, 1984, RCM 903(c))

DD Form 1722, OCT 84, Replaces Edition of 1 Oct 69, which may be used until supply is exhausted

APPELLATE EXHIBIT IX

UNITED STATES	)	
	)	
v.	)	PRETRIAL OFFER AND AGREEMENT
	)	
SAVILLE, Jack M.	)	
1LT, U.S. Army,	)	
Headquarters and Headquarters Company	)	
3d Brigade Combat Team	)	3 March 2005
4th Infantry Division (Mechanized)	)	
Fort Carson, Colorado, 80613	)	

1. I, First Lieutenant (O-2) Jack M. Saville, the Accused in the court-martial case now pending, having had an opportunity to examine the charges preferred against me, and all statements and documents attached thereto, and after consulting with my defense counsel, Mr. Frank Spinner and CPT David H. Drake, and being fully advised that I have a legal and moral right to plead not guilty, offer to plead as follows:

To Charge I and its specification: **Not Guilty**.

To Charge II and its specification: **Not Guilty**.

To Charge III and its specification: **Not Guilty**.

To Charge IV and its specification: **Guilty**.

To Charge V and its specification: **Guilty**.

To Additional Charge I and its specification: **Not Guilty**.

To Additional Charge II and its specification: **Guilty**.

To Additional Charge III and its specification: **Guilty**.

2. I also agree to enter into a written stipulation of fact with the Government concerning the facts and circumstances surrounding the offenses to which I am pleading guilty. This stipulation is to be used only to inform the military judge alone of certain matters pertinent to an appropriate sentence and in determining the providence of my pleas.

3. I understand my rights under Article 32(b) and R.C.M. 405(f), UCMJ, regarding Additional Charges II and III. After consulting with my defense counsel, I hereby agree to unconditionally waive my right to any Article 32(b), UCMJ, pretrial investigation of Additional Charges II and III, and their joinder under RCM 601(e)(2), in this case.

APPELLATE EXHIBIT X

4. If granted testimonial immunity and ordered to testify, I agree to cooperate truthfully and fully concerning my knowledge of any fact in the investigations and in any courts-martial or other proceedings involving CPT Cunningham, SSG Werst, or any other accused relating to offenses occurring on 2-3 January 2004.

5. This offer to plead guilty originated with me. No person or persons have made any attempt to force or coerce me into making this offer or to plead guilty.

6. I understand that I may withdraw my pleas at any time before my pleas are accepted. I also understand that after the acceptance of my pleas, but before the sentence is announced, the military judge, may, as a matter of discretion, permit withdrawal of my pleas.

7. This agreement shall not be affected by the dismissal of any charges or specifications by the military judge or the Convening Authority.

8. I understand this offer and agreement and the fact that I have agreed to enter into the Stipulation of Fact as set out above. If my pleas are not accepted, this offer to stipulate is null and void and the Stipulation of Fact may not be used against me in any subsequent proceeding or court-martial.

9. I further understand that this agreement will be automatically canceled at the discretion of the military judge and/or the Government upon the happening of any of the following events:

a. Failure to agree with the Government on the contents of the Stipulation of Fact;

b. The changing of my pleas by anyone during the trial from Guilty to Not Guilty; or,

c. The refusal of the military judge to accept my pleas of Guilty.

10. Additionally, I understand that the convening authority may withdraw from the pretrial agreement at any time upon the happening of any of the following events:

a. Before I begin performance of the promises contained in my pretrial agreement;

b. Upon my failure to fulfill any material promise or condition in the agreement;

c. When inquiry by the military judge discloses a disagreement as to a material term in the agreement;

d. If findings are set-aside because a plea of guilty entered pursuant to the agreement is held improvident on appellate review.

11. I understand that this writing, including the Appendix A (Quantum), embodies the entire pretrial agreement and contains all the promises made to me or by me concerning my pleas of guilty. There are no terms or conditions placed upon my offer to plead guilty which are not contained in this agreement.

JACK M. SAVILLE
1LT, IN
Accused

David H. Drake
DAVID H. DRAKE
CPT, JA
Defense Counsel

DATE: 8 MAR 05

The foregoing is (accepted) ~~(not accepted)~~.

DATE: 11 March 2005

JAMES D. THURMAN
Major General, USA
Commanding

UNITED STATES	)	
	)	
v.	)	APPENDIX A (QUANTUM) TO
	)	PRETRIAL OFFER AND AGREEMENT
SAVILLE, Jack M.	)	
1LT, U.S. Army, .	)	
Headquarters and Headquarters Company	)	
3d Brigade Combat Team	)	3 March 2005
4th Infantry Division (Mechanized)	)	
Fort Carson, Colorado, 80613	)	

1. I, First Lieutenant (O-2) Jack M. Saville, offer to plead guilty and abide by the other terms and conditions set forth in the Pretrial Offer and Agreement, provided the Convening Authority will:

a. Disapprove any confinement over 15 months

2. Except as limited above, any other lawful punishments can be approved.

JACK M. SAVILLE
1LT, IN
Accused

DAVID H. DRAKE
CPT, JA
Defense Counsel

DATE: 3 MARCH 05

The foregoing is (accepted) ~~(not accepted)~~.

DATE: 11 March 05

JAMES D. THURMAN
Major General, USA
Commanding

APPELLATE EXHIBIT XI

UNITED STATES	)	
	)	ORDER FOR EXHUMATION
v.	)	
	)	AND EXAMINATION
Saville, Jack M.	)	
1LT, U.S. Army	)	14 December 2004
HHC, 3rd Bde, 4th Inf Div (Mech)	)	
Fort Carson, CO 80913	)	

1. The Defense has requested, and the military judge hereby ORDERS the Government to exhume, and conduct a comprehensive medical examination of, the remains purportedly to be those of Fadhil, Zaydun Ma'Mun. The examination will consist of medically reliable methods to corroborate or refute that the remains are those of Fadhil, Zaydun Ma'Mun.

2. Time is of the essence. Accordingly, the Government will comply with this order and ensure a final written report of the examination findings is prepared NLT 1700 1 March 2005.

THEODORE E. DIXON
COL, JA
Military Judge

APPELLATE EXHIBIT XIII