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TECHNICAL NOTE

Refined Classification System for Thermally Damaged Human Remains by Body Segment

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ABSTRACT: This article provides a comprehensive regional approach to the classification of thermal damage of soft tissue and bone by assessing the body in segments, consisting of the head, torso, arms, and legs. The changes associated with each stage are generated from over 150 bodies over 12 years with the San Luis Obispo Fire Investigation Strike Team (SLO FIST), including photographs, video, and recorded statements. Each of the six stages represents a range and is bracketed from early to advanced phases. Each stage is presented with illustrations and descriptions that focus on the overall state of the remains at each stage and the features that define the transition from one stage to the next. As photographs make it difficult to discern the critical features, this system provides scientific illustrations with written descriptions. The system is also designed to be utilized by many in the death investigation field and can be used in the field and/or in the laboratory/morgue. Worksheets for recording burn damage have also been developed and facilitate recording on both soft tissues and bones.

KEYWORDS: forensic anthropology, fatal fire, burned human remains, classification

Introduction

Fire and heat degrade human remains, making identification and analysis of the circumstances of death difficult (Bohnert 2004; Bohnert et al. 1998; Bradtmiller & Buikstra 1984; Eckert et al. 1988). Forensic anthropological analysis of burned human remains is critical in mass fatality management, such as the 2018 California wildfires, and for forensic casework where the remains are burned (DeHaan and Icove 2012; DiMaio & DiMaio 1989; Dolinak et al. 2005; Fairgrieve 2008; Fanton et al. 2006; Gerling et al. 2001; Icove et al. 2013; Spitz 2020).

This article describes a comprehensive classification system—based on field observations of over 150 remains—on how human bodies burn and the heat-related changes of soft tissues, bones, and teeth throughout the fire's duration (Pope et al. 2020, 2021). This system allows for consistent, detailed reporting of burn damage and categorizes thermal changes so that a clear concept of the stage of damage can be easily communicated. The proposed system facilitates research by conveying damage levels in relation to the types of fuel sources and loads, fire environment, proximity to heat sources, duration of the fire, and other factors known to influence the level of damage. The proposed system also facilitates easy and detailed field reporting prior to transport, during which critical information may be lost. Abnormal burn patterns may result from the body's position, protection/restraint by fire debris, or traumatic injuries that produce deviations from the normal burn characteristics.

Classification systems for burned remains are already in use. Historically, the most commonly used is the Crow-Glassman Scale's (CGS) five-stage, overall-body format (Glassman & Crow 1996):

1. Burns typical in a smoke death with epidermal blistering and hair singeing.
2. Recognizable body form, but with varying degrees of charring. Elements of the hands and feet may be lost along with the genitalia and ears.
3. Major portions of the arms and/or legs no longer present; the head, while present, cannot be used in visual identification.
4. Extensive burning with skull fragmentation, which may be absent from the body; portions of the arms and legs may be attached to the charred torso.
5. Cremated remains with little or no tissue present.

This system was developed after the deadly 1993 Branch Davidian Compound fire in Waco, Texas, where the charred

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FIG. 1—*Exemplars of (a) singed skin (light pigmentation), (b) wet blisters, (c) dry blisters, (d) skin splits, (e) skin splits with oily appearance, (f) sloughing skin, (g) charred skeletal muscle, (h) bone color changes, (i) calcined pubic bones, (j) charred fractured enamel, (k) calcined teeth and roots, (l) vitrified humerus, (m) transverse and longitudinal fractures on long bone, (n) longitudinal fracture on radius, (o) curved heat fractures on a skull, (p) curved fractures on long bone, (q) crazed fracturing on a distal femur, (r) warped femur, (s) delaminated cranial vault, and (t) delaminated cranial fragment.*

remains of 76 victims were recovered. The classifications were derived from postmortem observations of bodies with varying degrees of heat damage, examined after the fire and within a clinical setting (Medical Examiner's Office). The CGS is utilized by forensic pathologists, anthropologists, and odontologists in fatal fire casework to communicate the overall condition of burned human remains. While useful, the CGS contains large gaps of information, offering a limited snapshot approach to thermal damage, limiting its effectiveness as a robust analytical method. Over the years, it has been modified/adapted for use in research or other mass fatality events (domestic/foreign) (Keough 2013; O'Donnell et al. 2011; Williams 2015, 2020).

Current research based on data generated by SLO FIST (Pope 2020, 2021) scenarios and tests using pig cadavers (Keyes 2019) reexamined the effectiveness of the CGS scale. In work by Pope et al. (2020, 2021), experimental fire research methods used cadavers throughout the burning process and for the final conditions of the body after the fire. Repeated observations confirmed several information gaps in the previously published studies:

1. Other significant heat-related characteristics are produced in soft and skeletal tissues as a sequence of changes during the fire (e.g., blisters, skin splits, muscle and bone exposure).
2. A multitude of heat-related changes can be observed for a single body, and body parts and individual bones can differ in their burn patterns.
3. Body movement occurs throughout the fire as muscles shrink, resulting in flexed joints (i.e., pugilistic posture). Local and specialized muscle anatomy in the head, arms, legs, and torso produces specific burn patterns and movements.
4. The body, environment, fuels, duration, and temperatures affect the final condition of burned human remains.
5. Common postfire alterations occur to fragile burned bones and body parts during search, recovery, handling, transportation to the Coroner's/Medical Examiner's Office, and forensic examination.

Knowing that the current classification systems of thermal damage to human remains lack the specificity from observation-based research over time in a wide range of settings, our system examines natural fire progression to the body's tissues. The proposed classification system documents relationships between body position pre-fire, body movement during the fire, and changes to soft tissue and skeletal elements. The system is organized by body segment and provides recording forms to document the information for use in the field and laboratory.

The Burning Process of Human Remains

The body burns in a sequence, with destructive changes occurring to soft tissues of the skin, subcutaneous fat, and muscles, followed by exposure of bones and teeth. Early heat-related changes occur to the hair and skin, which become singed, scorched, and tightened (Fig. 1a). Burned skin darkens with bands of red, tan, brown, and charred black that shrink and develops small circular/ovoid blisters (Fig. 1b and 1c) (Adelson 1954; Dolinak et al. 2005; Spitz 2020). These bands of discolored skin are easily visible on lightly pigmented individuals. With darker pigmented skin, the color changes are subtler and more present as a dry tightening of the skin and a darkened, mottled appearance. The blisters may be fluid-filled or dry, or as partially burned circular and stellate defects. Heat causes the skin to shrink and split into tapered, ovoid openings (Fig. 1d). Skin splits increase in size and multiply, exposing the underlying subcutaneous fat layers. Heated and rendered fat produces an oily surface/sheen on surrounding tissues that flows downward (Fig. 1e) (DeHaan et al. 1999; DeHaan & Nurbakhsh 2001). The palm of the hand and sole of the foot may slough (Bohnert & Pollak 2003). Heat dehydrates the underlying muscles, causing them to shrink and contract, resulting in flexion of the fingers, toes, hand, wrist, foot, ankle, elbow, knee, shoulder, and hip, in roughly that order. Smaller extension muscles also reposition the torso by causing arching in the neck and lumbar region.

Color and structural changes occur to bone during the burning process (Bradtmiller & Buikstra 1984; Buikstra & Swegle 1989; Fairgrieve 2008; Galeano & Garcia-Lorenzo 2014; Mayne Correia 1997; Nelson 1992; Pope 2007; Shipman et al. 1984; Symes et al. 2008, 2014; Thompson 2004; Walker et al. 2008). Bone is initially exposed where it is close to the surface. For a brief period after exposure, the bone appears as fresh (yellow), then transitions to brown/greasy

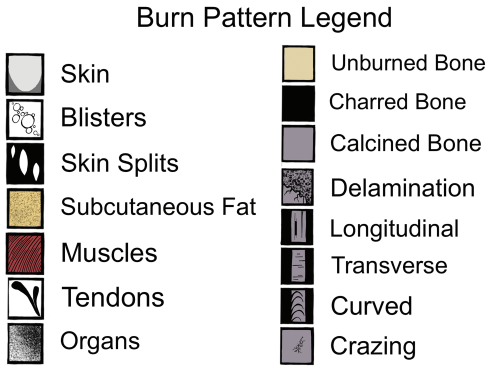

FIG. 2—*Burn pattern legend for illustrations in Figures 3 to 6.*

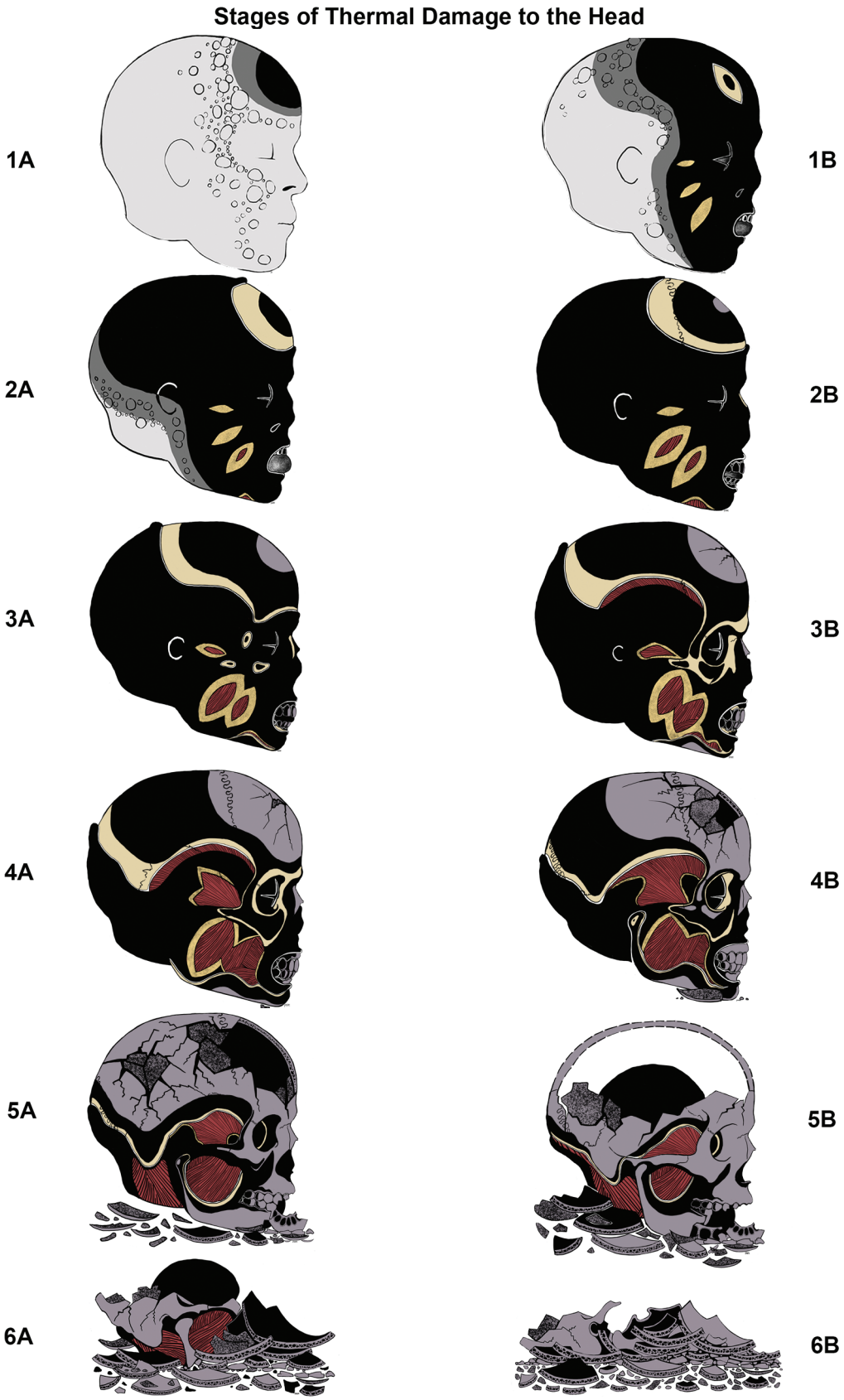

FIG. 3—*Illustrations of fire damage to the head for stages 1 to 6, demonstrating early and advanced phases for each stage.*

or off-white from denatured collagen and proteins, causing loss of bone strength (Todoh et al. 2009). Heat fractures develop in the bone's surface from shrinking and degradation of organic components from pyrolysis. Bone exposed longer transitions to brown/black charred bone, retaining its organic components with reduced strength (Fig. 1h). Finally, once the organic materials in bone pyrolyze, the structure transitions into brittle gray/white calcined bone (Fig. 1i). In teeth, mineralized enamel shrinks, fractures, separates from the root/dentin, and falls into the fire debris substrate (Fig. 1j and 1k) (Delattre 2000; Schmidt 2008). In rare instances, there may also be fusion of the hydroxyapatite crystals under prolonged/higher temperatures, producing a white porcelain appearance (Fig. 1l).

Transverse and longitudinal heat fractures in bone result from cortical surface shrinking (Fig. 1m and 1n) (Adelson 1954; Heglar 1984; Krogman & Iscan 1986; Pope 2007; Shipman et al. 1984; Symes et al. 2008). Curvilinear fractures result from shrinking muscles that produce surface tension, which stresses thermally weakened bone around large muscle attachments (posterior knee, nuchal area of the head and pelvis), articular joint surfaces, and long bones (Fig. 1o and 1p) (Gonçalves et al. 2015). There may also be "crazing," heat-induced checkering of fine hairline fractures on the surface of the bone (Fig. 1q) (Heglar 1984). Calcined bones with heat fractures may also appear significantly warped and deformed and, in some cases, with differential shrinking (Fig. 1r) (Heglar 1984). Smaller fragments will fall into the fire debris.

On the cranial vault, the most common heat fracture type is delamination (Fig. 1s and 1t), where the outer table shrinks and separates from the diploë and inner table (Pope et al. 2004; Pope & Smith 2004). Full-thickness fractures occur in later stages, exposing areas of the internal vault to heat (Bohnert et al. 1997).

The Classification System

The proposed classification system examines body segments (head, torso, upper and lower limbs) separately due to unique regional muscle anatomy. Roughly, the stages are as follows:

Stage 1: superficial burning
Stage 2: soft tissue charring and bone exposure
Stage 3: initiation of significant calcination
Stage 4: body segment loss due to heat fracturing
Stage 5: largely skeletonized/incomplete cremation
Stage 6: complete cremation

Individual cases will be affected by the body's proximity to fuels, direct/radiant heat sources, duration of exposure, fire environment, protective objects or coverings, position/exposure of the body, and other variables that may result in differential burning of remains and altered burn patterns.

Illustrations and descriptions of each stage provide early and late burn characteristics and serve as a guide for accurately describing levels of heat-related damage (Fig. 2). The progression of the stages and the descriptions they include are the natural progression for a body in the supine position, with the heat source greatest on the exposed anterior surfaces, and would need to be adjusted for a prone body, which limits the range of flexing limbs. The classification system is designed to maximize the understanding of differential burning while maintaining consistency in reporting. In many burn scenarios, body segment scores are closely aligned, for example, between stage 4a and 4b or 3b and 4a. However, when the classifications are more separated, it is important to consider how disparities in burning were produced. For example, if the legs are at stage 5b while the rest of the remains are at 3a–b, it may mean that the legs were closer to the source of the fire or that something protected the upper body.

Each body segment is presented in the following diagrams and their corresponding descriptive text, specific to different stages of thermal damage. The sequence of heat-related changes is demonstrated for the head (Fig. 3 and Table 1), the torso (Fig. 4 and Table 2), the upper limb (Fig. 5 and Table 3), and the lower limb (Fig. 6 and Table 4).

TABLE 1—*Description of changes to the head.*

STAGE	DESCRIPTION OF HEAD (FIGURE 3)
1	**Superficially scorched skin and singed hair**
A	• Burned and unburned skin • Scorched hair and skin • Bands of discolored skin (red, tan, brown to charred black depending on skin pigmentation) • Large and small blisters border discolored skin • Eyes, nose, and ears somewhat shrunken and deformed
B	• Skin darker brown to charred black • Blisters follow skin color changes

(*continued*)

TABLE 1—*Description of changes to the head (continued).*

STAGE	DESCRIPTION OF HEAD (FIGURE 3)
	• Skin splits closest to heat expose underlying subcutaneous fat, oily surfaces, rendered grease, possibly exposed cranial bone under scalp splits • Temporary shrinking/opening of eyelids, shrunken nose, and ears, lip retraction, swollen and protruding tongue • Anterior dentition exposed and possibly charred
2	**Deformed facial features and anterior cranial vault exposure**
A	• Charred, shrunken skin with multiple skin splits • Remnants of blisters • Exposed subcutaneous fat and rendered grease • Facial skeletal muscles exposed • Lower facial bones protected by subcutaneous fat and muscle • Facial features that are charred are unrecognizable • Anterior maxillary incisors charred labially • Exposed vault bone, usually frontal, with discoloration bands
B	• Charred and calcined bone, on the anterior cranial vault • Exposed charred anterior dentition and shrunken tongue • Nasal bones exposed
3	**Expansion of charring and calcination of vault and face**
A	• Scalp retraction exposes approximately one-fourth of vault (frontal, anterior parietals) • Charred surfaces of upper facial bones (nasal, maxilla, zygomatics) and inferior mandible • Calcined cranial bone with heat fractures • Neck extended • Anterior dentition (incisors) enamel charred and calcined and can have heat fractures with exposed dentine
B	• Skin splits expand on lower face • Cranial vault half exposed as charred and calcined bone • Heat fractures develop in external table with early delamination • Charred bone extends into upper face, around orbits, and inferior mandibular body • Calcination expands on the cranial vault and may appear on nasals, inferior mandibular body, and dentition
4	**Significant loss of tissue, especially on superior aspect**
A	• Charred and calcined bone on half of the head, including cranial vault and upper face • Eyes shrink into orbits • Delamination of outer table in calcined cranial bone • Heavily charred skin and skeletal muscles: masseter (cheeks), temporalis (sides of the head), and nuchal (neck) • Remaining scalp dense and shrunken mass above nuchal line • Dental charring/calcination extends to canines and premolars
B	• Increased calcination of cranial vault and face • Delamination includes external table flaking, deformation, and detachment • Delaminated fragments partially attached or separated in fire debris • Full-thickness cranial fractures present • Inferior mandible charred/calcined contour follows masseter muscle • Mandibular condylar process possibly visible • Incisors to premolars often calcined with fragmented enamel • Dentine/root sections in situ or separated in fire debris
5	**Incomplete cremation**
A	• Charred soft tissues on posterior head and neck (remnants of masseter, temporalis, and nuchal muscles) • Over three-fourths of vault and/or face charred and calcined • Skull remains either intact with heat fractures or fragmented • Delamination and full-thickness fractures into inner table • Dental charring and calcination to premolars and molars • Possible anterior dentition loss, including roots
B	• Increased cranial, facial, and dental heat fractures • Vault either appears intact or fragmented • Shrunken and charred brain mass in cranial base • Charred and carbonized muscles present under zygomatic arch and around cranial base
6	**Highly fragmented calcined bones**
A	• Cranium either "intact," though fractured, or calcined fragments • Carbonized tissues (cranial base muscles and brain)
B	• Complete cremation with skeletonized fragments or partially intact cranium with calcined fragments in fire debris

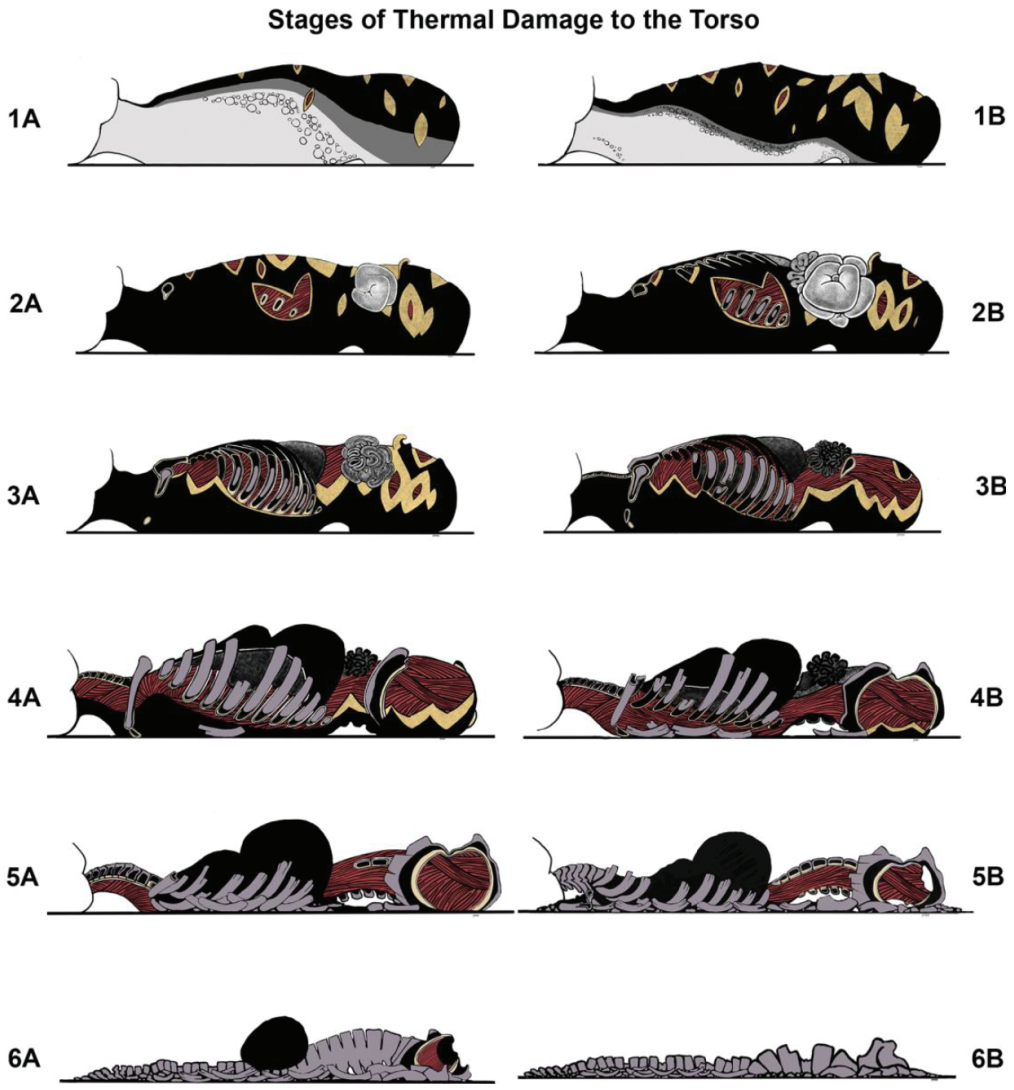

FIG. 4—*Illustrations of fire damage to the torso for stages 1 to 6, demonstrating early and advanced phases for each stage.*

TABLE 2—*Description of changes to the Torso.*

STAGE	DESCRIPTION OF TORSO (FIGURE 4)
1	**Superficial burning with skin discoloration, blistering, and skin splits**
A	• Unburned and burned skin with scorched hair and skin • Bands of discolored skin (unburned, red, tan, brown, and black, depending on normal pigmentation) • Shrunken and tightened skin • Bands of small and large blisters • Skin splits with exposed subcutaneous fat layers
B	• Larger skin splits closest to heat exposure • Skin discoloration and blistering expanded • Exposed and rendered subcutaneous fat and charred muscles with oily surfaces
2	**Charred skin surfaces, bony chest exposure, and abdominal organ protrusion**
A	• Larger skin splits prevalent closest to heat • Exposed and rendered subcutaneous fat • Charred chest skeletal muscle with delineated costal cartilage • Early exposure of lower abdominal organs protrude outside of torso, appear as burned and unburned intestinal loops • Anterior or lateral rib surfaces exposed

(*continued*)

TABLE 2—*Description of changes to the Torso (continued).*

STAGE	DESCRIPTION OF TORSO (FIGURE 4)
B	• Exposed upper chest skeletal muscles • Delineated and charred costal cartilage with anterior rib pattern visible • Surfaces of anterior/lateral ribs, medial clavicle, sternum, and manubrium charred and calcined • Internal organs protrude through lower abdomen • For larger individuals, fat rolls/sheets peel from abdomen • Early neck extension
3	**Chest wall isolation with burning/shrinkage of abdominal musculature**
A	• Sternum, costal cartilage, and medial clavicles charred with calcined surfaces • Exposed charred and calcined anterior/lateral ribs • Heart, lungs, and liver charred and shrunken, partially visible through ribs • Protruding abdominal organs charred and shrunken • Neck extends, moving head away from torso, and back extended slightly
B	• Chest wall exposed • Costal cartilage dehydrated, partially consumed • Ribs calcined laterally and anteriorly • Ribcage is “isolated” with space between ribs and interior chest interior • Internal thoracic organs visible • Anterior cervical vertebrae exposed and charred • Exposed liver, intestines, and stomach partially charred • Charred anterior iliac crest
4	**Reduction of the anterior ribcage**
A	• Ribs calcined with heat fractures and charred close to musculature • Sternal rib ends irregularly fragmented • Costal cartilage consumed • Calcined sternum and medial clavicles in chest/fire debris • Distal clavicles point downward into chest • Lateral scapulae exposed and charred • Thoracic and abdominal organs (lungs, heart, liver, stomach, intestines) charred and shrunken • Cervical vertebrae centra exposed and charred on extended neck • Iliac crest and anterior pubic surface charred • Lumbar spine extended, exposing charred spinous processes
B	• Charred muscles and organs (heart, liver, and abdominal organs) • Charred and calcined bones of lateral/posterior ribcage, anterior cervical spine, shoulders (lateral scapulae), iliac alae, and pubic bones • Ribs fragmented and calcined except near spinal muscles • Heart and liver large black masses within lower ribcage
5	**Reduction to blackened spine and pelvis**
A	• Partially skeletonized extended neck • Thoracic bodies protected by charred organs • Lumbar bodies protected by skeletal muscles • Carbonized posterior sacral surfaces • Small calcined rib segments protrude from spine • Heart and liver are black masses • Pelvic cavity contains shrunken muscles and internal organs • Calcination and fragmentation extend to ilial alae and pubic surfaces • Hip muscles charred masses
B	• Spine partially skeletonized, charred, and calcined with fragmented ribs, charred internal organs, and minimal charred muscles • Charred heart and liver masses • Pelvic area retains skeletal muscle and some internal organs • Pelvis exposed, charred, calcined, and often fragmented • Possible curved heat fractures on ilia
6	**Incomplete to complete cremation**
A	• Spine devoid of soft tissue except for lower back and pelvis • Blackened mass liver mass possibly present • Charred soft tissues around inner pelvis • Pelvic ring integrity lost • Vertebral bodies relatively intact while larger bones are fragmented
B	• Disarticulated, calcined bone and bone fragments, in rough anatomical position in fire debris

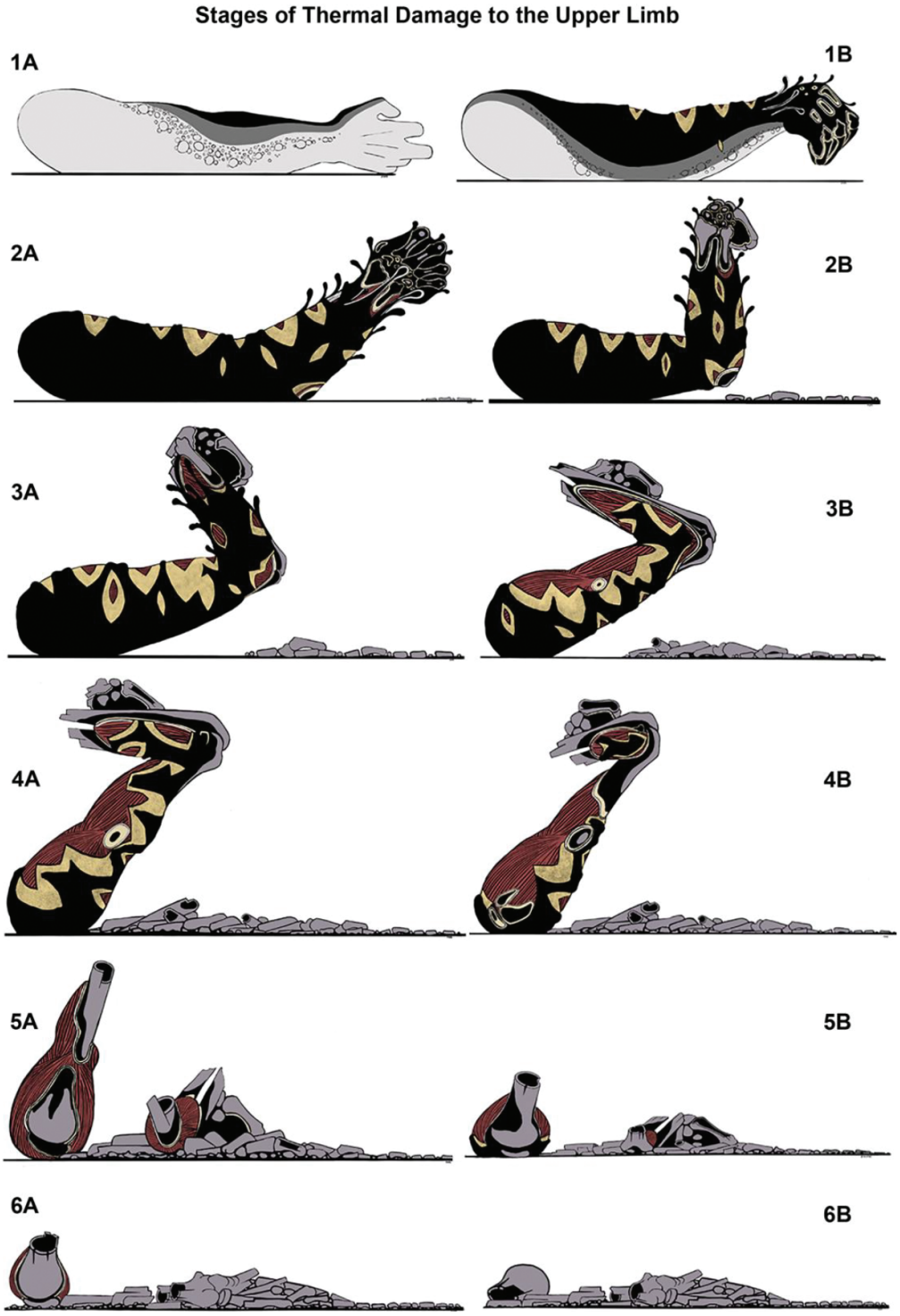

FIG. 5—*Illustrations of fire damage to the upper limb for stages 1 to 6, demonstrating early and advanced phases for each stage.*

TABLE 3—*Description of changes to the upper limb.*

STAGE	DESCRIPTION OF UPPER LIMB (FIGURE 5)
1	**Superficial burning with skin discoloration, blistering, and skin splits**
A	• Unburned and burned/discolored areas of skin • Scorched arm hair and skin • Small and large blisters • Skin splits usually confined to partially flexed finger joints and dorsal hand • Fingers splay and flex at interphalangeal joints • Wrists flex with palms medial
B	• Skin dark brown to charred black, shrunken and tightened • Blisters follow discolored skin • Skin splits expose subcutaneous fat • Rendered fat with oily surfaces • Fingers, hand flex • Elbow flexion raises lower arm above substrate • Superficial burning on dorsal hands with exposed skeletal muscles and charred bone • Phalanges at flexed joints, dorsal hand/wrist possibly exposed and charred with shrunken and detached extensor tendons • Exposed bone discolored and charred
2	**Arm movement with expansion of skin splits**
A	• Greasy charred skin with skin splits and blisters • Fingers, hand, wrist, and elbow are flexed, with forearm elevated from elbow • Exposed and charred skeletal muscles • Charred, shrunken, and detached extensor tendons on forearm • Charring with small, calcined surfaces on flexed fingers, dorsal hand, and wrist, distal radius and ulna, and proximal ulna (olecranon process)
B	• Skin splits on most of arm, charred skeletal muscle, ligaments, tendons, and charred/calcined bone • Bone exposure expanded to distal radius/ulna and proximal ulna • Elbow flexion more pronounced • Contracture of shoulder muscles lifts elbow off substrate (or beside torso) • Heat fractures on charred and calcined fingers, hand, wrist, distal radius, and ulna
3	**Distal forearm reduction, upper arm movement, and detachment of hand/wrist**
A	• Skin splits, rendered subcutaneous fat, charred skeletal muscle and tendons, exposed bone, and shrunken extensor tendons • Charred/calcined bone includes elbow (proximal ulna and distal humerus), distal forearm, wrists and hands • Heat fractures through distal radius and ulna separate hand and wrist from forearm • Arm raised around/above chest from early shoulder flexion
B	• Hand and wrist detached from heat fractures through distal radius/ulna or along natural wrist joint • Distal radius and ulna, wrist, hand and retained in shrunken skeletal muscles, pulling hand toward mid-forearm • Exposure of lateral ulnar midshaft • Deltoid tuberosity of humerus charred • Arms positioned around/above chest from shoulder flexion and internal rotation • Heat fractures in calcined bone with fragmentation
4	**Further reduction of forearm, elbow, hand, and wrist**
A	• Partial skeletonization from fingers to elbow • Widespread charred skin and muscles and rendered fat • Upper arm fully raised above floor and above/around chest • Detached hand positioned closer to mid-forearm • Calcined hand, wrist, and forearm bones fragmented • Humerus charred and calcined distally and charred at deltoid tuberosity • Calcined bone heat fractured and fragmented
B	• Charred musculature concentrated around flexed elbow and shoulder • Detached hand/wrist positioned within mid-forearm musculature charred • Upper arm raised above body at shoulder • Humerus charred, calcined, and heat fractured above elbow • Lateral aspect of proximal humerus and scapula charred
5	**Loss of upper arm, except around shoulder**
A	• Heat fracture through distal humerus (above elbow) separates elbow, lower arm, wrist, and hand from body • Charred skeletal muscle in upper arm and shoulder • Proximal humerus attached and anteriorly flexed • Charred and calcined humeral midshaft extends from shoulder

(*continued*)

TABLE 3—*Description of changes to the upper limb (continued).*

STAGE	DESCRIPTION OF UPPER LIMB (FIGURE 5)
B	• Distal humerus calcined and fragmented below midshaft with heat fractures, shrinkage, and warping • Proximal humerus in shoulder muscles with charred lateral surfaces
6	**Incomplete to complete cremation**
A	• Smaller charred shoulder muscles • Proximal humeral portion raised at shoulder
B	• Full skeletonization and cremation with charred and calcined fragments in debris

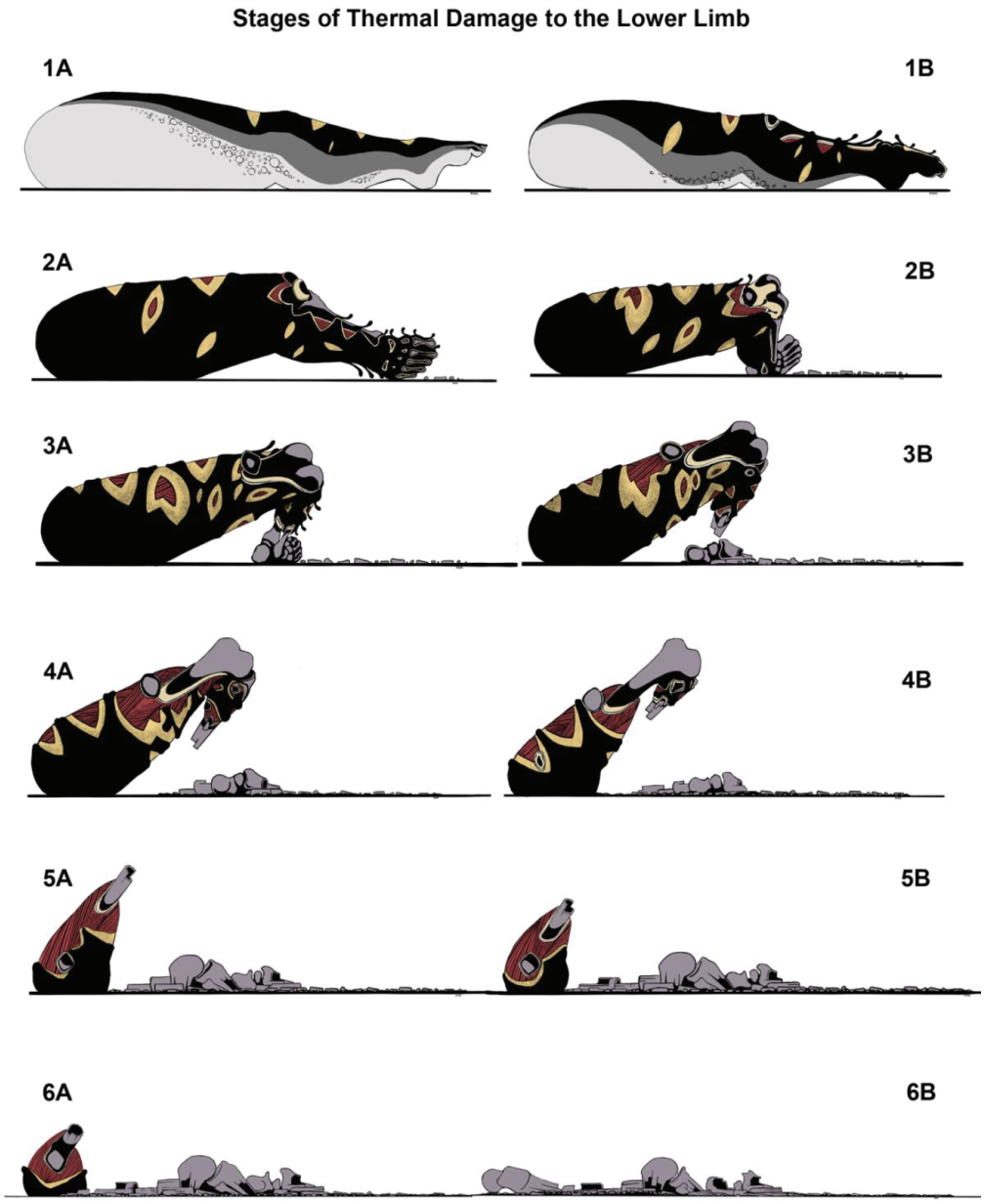

FIG. 6—*Illustrations of fire damage to the lower limb for stages 1 to 6, demonstrating early and advanced phases for each stage.*

TABLE 4—*Description of changes to the lower limb.*

STAGE	DESCRIPTION OF LOWER LIMB (FIGURE 6)
1	**Superficial burning with skin discoloration, blistering, and skin splits**
A	• Unburned and burned areas of skin • Scorched hair and skin • Skin shrunken, tightened, blistered, and discolored • Possible skin sloughing on sole • Toes splayed and joints flexed • Foot slightly flexed and pointed downward • Skin splits and possible bone exposure over flexed toe joints close to surface unless protected by footwear
B	• Skin darker brown to charred black, shrunken and tight with oily surfaces • Small and large blisters, skin splits, and exposure of subcutaneous fat • Flexed toes, with flexed foot inversion • Ankle extension with flexed foot pointing downward • Skin splits over toe joints, dorsal metatarsals, tarsals, and distal/anterior tibia • Exposed bones are discolored and charred
2	**Leg movement expansion with charred superficial soft tissue**
A	• Legs spread apart from knee flexion • Knees point laterally, flexed foot points downward, heels near midline • Skin charred with greasy/oily surfaces, skin splits, and blisters • Exposed musculature on lower leg and foot • Charring and calcination on anterior tibia • Bone exposure on toes, dorsal foot, ankle, anterior distal tibia, and around knee
B	• Flexed knees raised above ground/floor substrate • Thighs spread apart • Feet drawn toward torso midline • Skin charred and oily with skin splits • Exposed and rendered subcutaneous fat • Skeletal muscles, ligaments, tendons, and bone charred • Noticeable loss of body mass on lower leg, ankle, and foot • Charred and calcined bone extends to patella and distal femur
3	**Reduction of foot, ankle, and lower leg**
A	• Lower legs and thighs raised above substrate • Thighs charred with skin splits, rendered fat, charred muscles, tendons, and ligaments • Exposure, charred, calcined, and heat-fractured bone extends from toes to distal femur • Charred and calcined patella detached but retained in thigh muscles • Foot and ankle possibly detached by heat fracture through distal tibia/fibula or ankle joint
B	• Large thigh muscles present around femur and exposure of the knee • Knees flexed • Thighs spread wide apart and raised above substrate • Lower legs and heels closer to midline • Foot and ankle detached from heat fracture through distal tibia/fibula or ankle joint
4	**Heat fractures with fragmentation of tibia, fibula, and portions of distal femur**
A	• Widespread charring of thigh muscles with rendered fat • Charred calf muscle masses on posterior proximal tibia and fibula • Lower leg bones calcined with heat fractures • Thigh flexed at hip, tightly flexed at knee, and upper legs positioned outward
B	• Thigh mass reduced • Carbonized muscles around back of flexed knee • Exposure and charring of greater trochanter • Tibia/fibula shafts mostly charred and calcined bone fragments
5	**Mostly fragmentation at mid-thigh**
A	• Distal femur, knee, and lower leg detached from femoral midshaft and body as fragments in fire debris • Proximal femur protected in charred thigh muscles with charred greater trochanter • Charred and calcined femoral shaft extended at flexed hip
B	• Femoral midshaft, charred and calcined bone fragments are separated from body and with heat fractures, shrinkage, and warping
6	**Incomplete to complete cremation.**
A	• Skeletonized with carbonized tissues around hip and upper thigh • Proximal femur attached to torso
B	• Lower limbs skeletonized, calcined, and fragmented in fire debris

Conclusions and Application

This classification system standardizes descriptions of the extent of burning and provides means to identify normal burn patterns and any disparities by body segment. Differential burning may provide important information regarding scene context or body condition. Scene contexts that may cause differential burning include environmental factors, such as proximity and duration to heat sources, protection by various elements, or intentional acts that destroy certain aspects of the body such as the face. Restraint or perimortem trauma can affect burn patterns and, in some cases, body movement, which is an integral part of each classification stage. If the body movement is inconsistent with expectations for a stage, attention should be paid to scene circumstances.

The use of this classification system is best done during the examination of the burned remains at the scene as recovery and transportation can produce additional damage to burned bones. If examination at the scene is not possible, then the use of scene photographs along with examination at the morgue or laboratory will help separate fire damage from recovery and transportation damage. Documentation of burned remains should include clear overall photographs with scales for each body segment (head, torso, arms, and legs) with individual photos for the limbs of each side. If photographs alone are used, then familiarity with the system allows the anthropologist to request photographs be taken with the necessary level of detail.

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Supplementary Figures

INVESTIGATOR:_____ DATE:_____

CASE NO:_____ AGENCY:_____

TORSO STAGE _____
NOTES:

HEAD STAGE _____
NOTES:

RIGHT ARM STAGE
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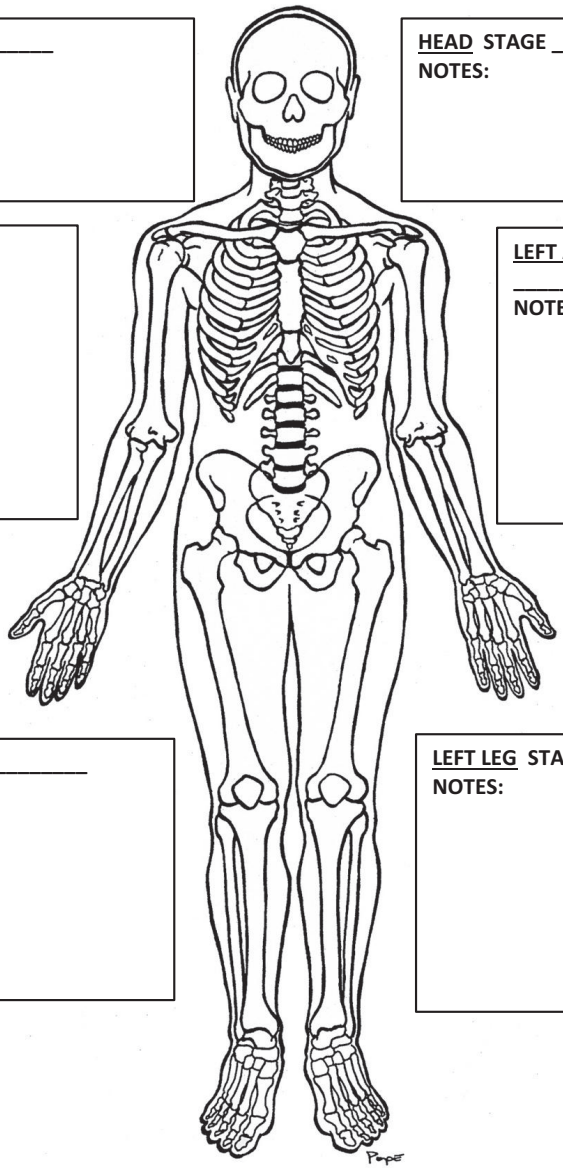
NOTES:



LEFT ARM STAGE
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NOTES:

RIGHT LEG STAGE _____
NOTES:

LEFT LEG STAGE _____
NOTES:

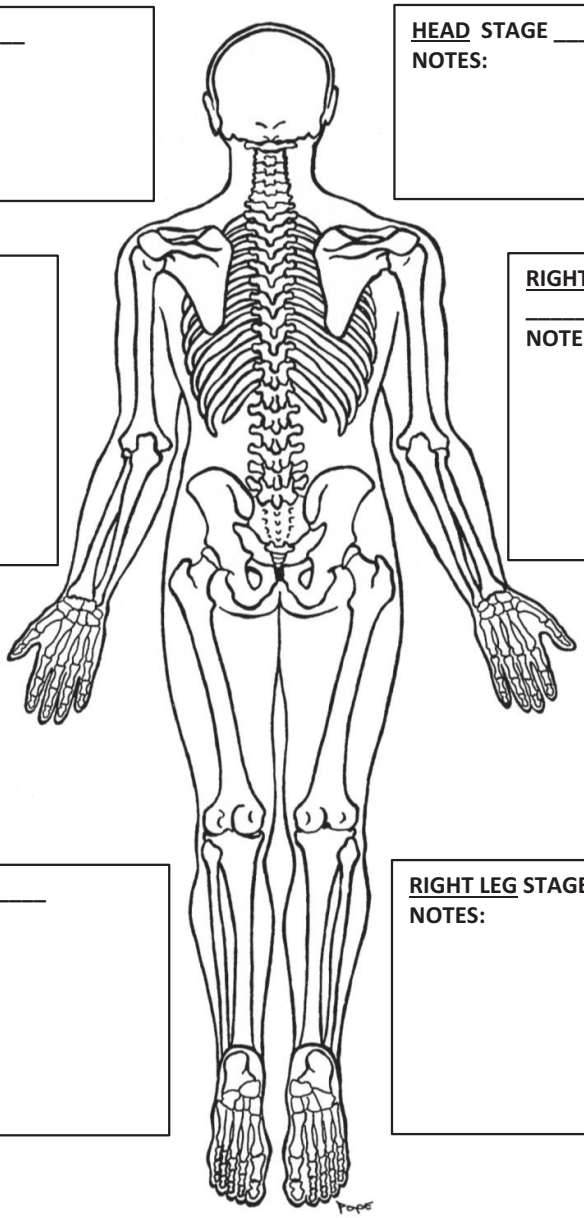
OVERALL STAGE AND NOTES:

INVESTIGATOR:_____ **DATE:**_____

CASE NO:_____ **AGENCY:**_____

TORSO STAGE _____
NOTES:

HEAD STAGE _____
NOTES:



LEFT ARM STAGE
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RIGHT ARM STAGE
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LEFT LEG STAGE _____
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RIGHT LEG STAGE _____
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OVERALL STAGE AND NOTES :