# 1 The decay process

**Chapter outline**

The stages of decomposition: fresh; bloat; putrefaction; putrid dry remains

Factors affecting the speed of decay: burial underground; burial underwater; time of year and temperature; exposure to sunlight; burning; geographical location

**Objectives**

Compare the chemical and physical characteristics of the different stages of decomposition.

Explain how a body's rate of decomposition is affected by the way in which death occurred and the environment in which it is placed.

Compare the conditions that promote the formation of adipocere and of mummification and how these processes preserve body tissues.



## The stages of decomposition

After a person dies, their body undergoes dramatic changes in its chemical and physical composition. These changes can provide an indication of how long a person has been dead (Dix, 2000) but they also influence the body's attractiveness to detritivores – organisms that consume dead organic matter. An understanding of the decay process and the factors that influence it is therefore helpful in the study of animals, plants and microbes associated with dead bodies. The stages of decomposition in terrestrial environments can be loosely divided into four stages: fresh, bloat, putrefaction and putrid dry remains. However, these stages merge into one another and it is impossible to separate them into discrete entities.

There are a number of specialist terms that are used in association with the study of human remains. If there is a desire to know more about the causes of

*Essential Forensic Biology*, Alan Gunn

a person's death then the body is subjected to an 'autopsy' or 'postmortem examination', although in the majority of deaths there are no suspicious circumstances so no autopsy takes place. Some doctors have expressed concern about this because it is estimated that 20–30% of death certificates incorrectly state the cause of death (Davies *et al.*, 2004). However, all bodies discovered in suspicious circumstances are subjected to an autopsy and doctors who have received advanced training in pathology perform these. Pathology is the study of changes to tissues and organs caused by disease, trauma and toxins, etc. and forensic pathologists specialize in cases in which death has occurred in suspicious circumstances. The study of what happens to human remains after a person dies is known as 'taphonomy' and the factors that affect the remains are known as 'taphonomic processes'. Thus, temperature, maggot feeding and cannibalistic practices are all examples of taphonomic processes and they are of interest to both forensic pathologists and to archaeologists uncovering the graves of persons who died many hundreds of years ago.

When investigating any death it is essential to keep an open mind as to the possible causes. For example, if the partially clothed body of a woman is found on an isolated moor, there are many explanations other than she was murdered following a sexual assault. First of all, she may have lost some of her clothes after death through them decaying and blowing away or from them being ripped off by scavengers (see Chapter 8). Secondly, she may have been a keen rambler who liked the open countryside. Most people die of natural causes and she may have suffered from a medical condition that predisposed her to a heart attack, stroke or similar potentially fatal condition whilst out on one of her walks. Another possibility is that she may have committed suicide: persons with suicidal intent will sometimes choose an isolated spot in which to die. For example, when Dr Richard Stevens, a consultant haematologist at the Royal Manchester Children's Hospital in Pendlebury, disappeared from work in July 2003 he sparked a nationwide hunt that lasted for many months. There were several false sightings but ultimately his body was discovered by accident many miles away at the back of a walk-in mineshaft on a remote mountainside in Cumbria. Here, he had committed suicide by injecting himself with a combination of two drugs that resulted in his death. Another explanation for the woman's death would be that she had suffered an accident, such as tripping over a stone, landing badly and receiving a fatal blow to her head. And, finally, it is possible that she was murdered. All of these scenarios must be considered in the light of the evidence provided by the scene and the body.

## Fresh

When someone's heart stops pumping blood around their body, the tissues and cells are deprived of oxygen and rapidly begin to die. Different cells die at different rates, so, for example, brain cells die within 3–7 minutes while skin cells can be taken from a dead body for up to 24 hours after death and still grow in a laboratory culture. Contrary to folklore, human hair and fingernails do not continue to grow after death, although shrinkage of the skin can make it seem as though they do. It is important to bear in mind that as the joints and muscles relax following death, a person's height may increase by as much as 3 cm.

Once cells start to die and decay their DNA begins to be degraded into ever-smaller fragments: this presents both potential opportunities and problems for the forensic scientist. The opportunity comes from the observation by DiNunno *et al.* (2002) that within liver cells there is an almost linear correlation between the degree of degradation of the DNA and the time since death. This would therefore suggest a means of estimating how long a person had been dead, although more work is required to confirm how susceptible the technique is to interference by environmental factors and underlying medical conditions such as liver disease. An accurate knowledge of the time since death is often crucial to a homicide or suspicious death investigation but all current methods for its estimation have their drawbacks. It is therefore always helpful if at least two or three different methods are employed so as to increase confidence in the results. The problems of DNA degradation are much more important because once this occurs its usefulness as an identifier of either the victim or the culprit of a crime can be compromised. DNA degrades more quickly in some tissues than in others and as a rule it is best extracted from the bones of the femur or ribs or from the molar teeth.

Between 20 and 120 minutes after death, *livor mortis* (also called hypostasis, and postmortem lividity) is usually seen – it can be found in all bodies but may be difficult to observe. *Livor mortis* is a purple or reddish purple discoloration of the skin caused by the blood settling in the veins and capillaries of the dependent parts of the body. It starts as a series of blotches that then spread and deepen in colour with time. Initially the blood remains in the blood vessels but with time the blood cells haemolyse (break down and rupture) and the pigment diffuses out into the surrounding tissues, where it may be metabolized to sulphaemaglobin that gives rise to a greenish discoloration. Sulphaemoglobin is not present in normal blood although it may be formed after exposure to drugs such as sulphonamides. This emphasizes the need to be aware that normal decomposition processes may mimic those that are induced before death or by the action that induced death.

Blood remains liquid within the circulatory system after death, rather than coagulating, because of the release of fibrinolysins from the capillary walls. These chemicals destroy fibrinogen and therefore prevent clots from forming. However, wounds that are caused after death do not bleed profusely because the heart is no longer beating and blood pressure is not maintained. Blood from even a deeply incised wound therefore trickles out as a consequence of gravity rather than being spurted out, as it might if inflicted during life. In the past, a suspected murderer would sometimes be compelled to touch the wounds on the body of his victim: if the wounds bled, then he was considered guilty. Clearly, because the blood does not clot after death, it would be difficult for a person to touch a wound without staining his hands. Unlike the situation on land, in the case of drowning or a dead body disposed of in a lake or river there may be a considerable loss of blood from wounds. After initially sinking, a dead body tends to rise to the surface, owing to the accumulation of gas from the decay process, and then floats face downwards. Consequently, the blood pools in the facial and dorsal regions and wounds affecting these areas after death may bleed profusely.

After about 10–12 hours of a body remaining in a set position, the discoloration caused by *livor mortis* becomes fixed (Figure 1.1). If the body is then moved and left in a different position a second area of discoloration forms. Two or more distinct patterns of discoloration therefore indicate movement of the body. Pressure, whether from tight-fitting clothes such as belts and bra straps, a ligature around the neck, ropes used to bind hands together or corrugations in the surface on which the body is resting, will prevent the underlying blood vessels from filling with blood and therefore these regions will appear paler than their surroundings – this is known as 'pressure pallor' or 'contact pallor'. Whilst the body is fresh, it is possible to distinguish between *livor mortis* and bruising because in the former the blood is restricted to the dilated blood vessels whilst a bruise results from the leaking of blood into the surrounding tissues, and the formation of clots, during life. However, as the body decays it becomes more difficult to distinguish between the two.

The rate of development of *livor mortis* varies from body to body and is also influenced by underlying medical conditions, such as circulatory disease. Consequently, there is some variation in the literature about when events begin, when they reach their maximal effect and when *livor mortis* becomes 'fixed' (DiMaio and DiMaio, 2001; http://www.dundee.ac.uk/forensicmedicine/Iib/

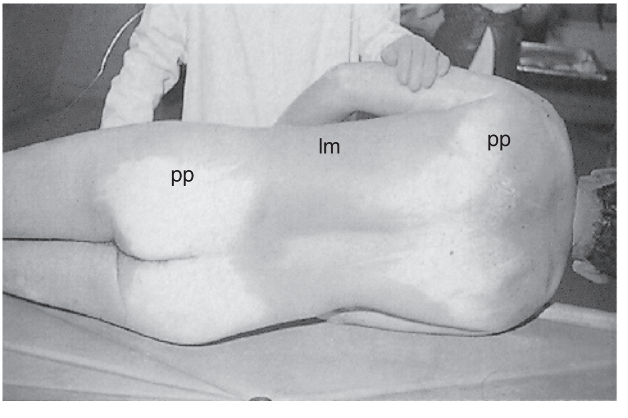


**Figure 1.1** Characteristic pattern of *livor mortis* (lm) and pressure pallor (pp) resulting from a dead body lying on its back. The reddening results from the settling of blood in the veins whilst the pale regions are where the pressure of the body against the underlying substrate has constricted the vessels. (Reproduced from Shepherd, 2003, with permission from Arnold)

timedeath.htm). Therefore, on its own, *livor mortis* has limited usefulness in determining the time since death.

Approximately 3–4 hours after death, *rigor mortis* (the stiffening of muscles and limbs) sets in and the whole body becomes rigid by about 12 hours. The condition can, however, be broken by pulling forcefully on the affected limbs. Rigor commences with the small muscles and those being used most actively prior to death. It is brought about by the rise in the intracellular concentration of calcium ions in muscle cells that follows death, as the membranes around the sarcoplasmic reticulum and the cell surface become leaky and calcium ions are therefore able to move down their concentration gradient into the sarcoplasm. This rise causes the regulatory proteins troponin and tropomyosin to move aside, thereby permitting the muscle filaments actin and myosin to bind together and form cross-bridges. This is possible because the head of the myosin molecule would already be charged with ATP before death. However, actin and myosin once bound, are unable to detach from one another because this process requires the presence of ATP – and this is no longer being formed. Thus, the actin and myosin filaments remain linked together by the immobilized cross-bridges, resulting in the stiffened condition of dead muscles. Subsequently, *rigor mortis* gradually subsides as the proteins begin to degrade and it disappears after about 36 hours. *Rigor mortis* is prolonged at low temperatures and at a constant 4°C may last for at least 16 days with partial stiffening still detectable up until 28 days after death (Varetto and Curto, 2004). The extent and degree of *rigor mortis* is therefore not an especially accurate measure of time since death.

Unlike *rigor mortis*, 'cadeveric rigidity' sets in immediately after death. It is rare and is said to be associated with individuals who were extremely stressed, emotionally and physically, immediately before they died (Shepherd, 2003). One would have thought that this would include most murder victims and also many who die of painful medical conditions, so there must be other factors, possibly genetic, to explain the rarity. The physiological basis of this form of rigidity is not known.

## Bloat

The intestines are packed with bacteria and these do not die with the person. These micro-organisms start to break down the dead cells of the intestines, while some, especially the *Clostridia* and the *coliforms*, start to invade the other body parts. At the same time, the body undergoes its own intrinsic breakdown, known as autolysis, that results from the release of enzymes from the lysosomes (subcellular organelles that contain digestive enzymes), thereby causing cells to digest themselves and chemicals, such as the stomach acids, from the dead cells and tissues. The pancreas, for example, is packed with digestive enzymes, and so rapidly digests itself. Autolysis may also occur on a more restricted scale in a living person as a consequence of certain pathological processes.

The decomposing tissues release green substances and gas that make the skin discoloured and blistered, starting on the abdomen in the area above the caecum (Figure 1.2). The front of the body swells, the tongue may protrude and fluid from the lungs oozes out of the mouth and nostrils. This is accompanied by a terrible smell because gases such as hydrogen sulphide and mercaptans (sulphur-containing organic molecules) are produced as end products of bacterial metabolism. Methane (which does not smell) is also produced in large quantities and contributes to the swelling of the body. In the UK, this stage is reached after about 4–6 days during spring and summer but would take longer during colder winter weather.

Blowflies and other detritivores are attracted by the odour of decomposition (Figure 1.3), and as the smell changes during the decomposition process so does the species of invertebrate that is attracted. Therefore, species that are attracted to 'fresh corpses' are often different to those that are attracted to corpses in an advanced state of decay (Table 1.1). Blowflies do not lay their eggs on corpses once these have passed a certain state of decomposition or they have become dry or mummified. By contrast, dermestid beetles do not colonize corpses until these have started to dry out (for more details see Chapters 6 and 7).

## Putrefaction

Some authors distinguish several stages of putrefaction (decay) but the usefulness of this is uncertain. Different parts of the same body may decay at different rates and decay itself is a gradual process rather than a series of discrete

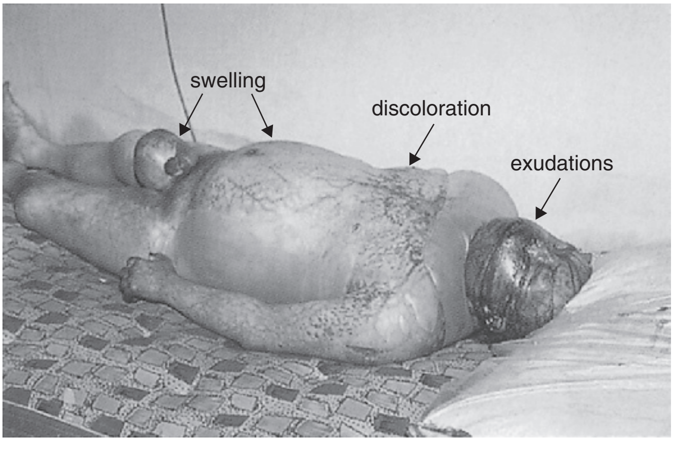


**Figure 1.2** Late bloat stage of decomposition. The body is about 7 days old and exhibits pronounced swelling owing to accumulation of gas. Note discoloration of the skin and exudates from the mouth and nose. (Reproduced from Shepherd, 2003, with permission from Arnold)

**Figure 1.3** Blowfly maggots developing upon a human corpse. Note how mature maggots can be seen crawling over the surface and the discoloration of the skin. (Reproduced from Klotzbach *et al.*, 2004, with permission from Elsevier)

events. As the body enters the bloat stage, it can be said to be 'actively decaying' and during this time the soft body parts rapidly disappear as a result of autolysis and microbial, insect and other animal activity. The body then collapses in on itself as gases are no longer retained by the skin. At this point, the body is said to enter a stage of 'advanced decay' and, unless the body has been mummified, much of the skin will now be lost. Obese people tend to decay faster than those of average weight and this is said to be due to the 'greater amount of liquid in the tissues whose succulence favours the development and dissemination of bacteria' (Campobasso *et al.*, 2001). At first sight, this appears surprising because fat has a lower water content than other body tissues and obese individuals therefore have a lower than normal water content. However, fat can act as a 'waterproofing', preventing the evaporation of water and therefore the drying out of the corpse whilst its metabolism yields large amounts of water.

Adipocere (grave wax) may be formed during the decay process if the conditions are suitable and this is capable of influencing the future course of decay (Fiedler and Graw, 2003; Forbes *et al.*, 2004). It is a fatty substance that is variously described as being whitish, greyish or yellowish and with a consistency ranging from paste-like to crumbly. Once formed, it acts to inhibit further decomposition and the body can remain virtually uncorrupted for many years (Figure 1.4). Adipocere formation is therefore a nuisance in municipal

**Table 1.1** The sequence in which insects arrive to colonize a corpse during the decomposition process. The stages of decay merge into one another and the insects may arrive or leave sooner or later than is indicated in the table, depending upon the individual circumstances (for more details see Chapters 6 and 7)

| Stage of decomposition | Insect |
|---|---|
| Fresh | Blowfly eggs and 1st instar larvae<br>Fleshfly 1st instar larvae<br>Burying beetle adults |
| Bloat | Blowfly eggs + 1st, 2nd, 3rd instar larvae<br>Fleshfly 1st, 2nd, 3rd instar larvae<br>Burying beetle adults and larvae<br>Histerid beetle adults and larvae |
| Putrefaction | No blowfly eggs once advanced putrefaction<br>Blowfly 2nd, 3rd instar larvae<br>Fleshfly 2nd, 3rd instar larvae<br>Blowfly and fleshfly larvae leaving corpse for pupation site<br>Histerid beetle adults and larvae<br>Eristalid fly larvae (liquified regions)<br>Phorid fly larvae (later stages of putrefaction)<br>Piophilid fly larvae (later stages of putrefaction) |
| Putrid dry remains | No blowfly larvae<br>Stratiomyid fly larvae<br>Dermestid beetle adults and larvae<br>Tineid moth larvae<br>Pyralid moth larvae |

**Figure 1.4** The formation of adipocere has preserved the body of this child despite it being buried for about 3 years. (Reproduced from Shepherd, 2003, with permission from Arnold)

graveyards because it prevents the authorities from recycling grave plots but it is very useful to forensic scientists and archaeologists who wish to autopsy long-dead bodies.

The term adipocere refers to a complex of chemicals rather than a single chemical compound and it results from the breakdown of body lipids. As soon as a person dies, autolysis and bacterial decomposition of triglycerides, which make up the majority of the body's lipid stores, results in the production of glycerol and free fatty acids. The free fatty acids are comprised of a mixture of both saturated and unsaturated forms, but as adipocere formation progresses the saturated forms become predominant. The formation of these fatty acids lowers the surrounding pH and thereby reduces microbial activity and further decomposition. The formation of adipocere also brings about a characteristic odour, the nature of which changes with time and has been used to train cadaver dogs to detect dead bodies. Extensive adipocere formation can result in the body swelling and consequently the pattern of clothing, binding ropes or ligatures can become imprinted on the body surface whilst incised or puncture wounds may be closed and difficult to detect. Adipocere formation is not exclusive to human decomposition (Forbes *et al.*, 2005d) and this should be borne in mind if there is a possibility that human and animal remains have become mixed together. For example, the bodies of animals are often found at the bottom of disused mine shafts, having stumbled in or been thrown in by a farmer looking for a quick means of disposing of dead livestock. Murderers will also make use of such facilities.

Adipocere formation has been described from bodies recovered from a wide variety of conditions, including fresh water, seawater and peatbogs, shallow and deep graves or tightly sealed containers, and in bodies buried but not enclosed at all (e.g. Evershed, 1992; Mellen *et al.*, 1993). Some authors mention that warm conditions may speed its formation but adipocere has been recorded from bodies recovered from seawater at a temperature of 10–12°C and from icy glaciers (Ambach *et al.*, 1992; Kahana *et al.*, 1999) – the preservation of the 5300-year-old 'Iceman' found in the Tyrol region appears to be at least partly a consequence of the formation of adipocere (Bereuter *et al.*, 1997; Sharp, 1997). A wide variety of times have also been cited for the time taken for adipocere formation to become extensive, ranging from weeks to months to over a year. Obviously, the time will be heavily dependent upon the local conditions and it is not yet possible to use the formation of adipocere as an estimate of the time since death. However, adipocere does leak out of the body and into the surrounding soil and therefore its presence might be useful in determining if a body had been stored in a particular location but then moved or if the extent of adipocere formation in the body matches that which might be expected in the surrounding soil if the body had been there since death. Forbes *et al.* (2005a, b, c) conducted an extensive series of experiments on the physical and chemical factors promoting the formation of adipocere. They found that adipocere would form in soil types ranging from sandy to clayey, provided that the soils were kept moist, and also in sterile soil that had been heated at 200°C for 12 hours to remove the normal soil microbial flora. 'Bodies' buried directly in the ground tended to form adipocere more rapidly than those contained in a coffin. Interestingly, placing the 'body' in a plastic bag retarded the formation of adipocere but if the 'body' was clothed and then placed in the plastic bag adipocere formation was promoted. They suggested that this was owing to the clothing absorbing glycerol and other decay products that would otherwise inhibit the pathways through which adipocere is formed. Polyester clothing was deemed to be the most effective, probably as a consequence of its ability to retain water and, compared to cotton clothing, resistance to decay.

Another means by which a body might become naturally preserved is through mummification. This occurs when it is exposed to dry conditions coupled with extreme heat or cold, especially if there is also a strong air current to encourage the evaporation of water. It is typically seen in persons who have died in deserts, such as the hot Sahara and the cold Tibetan plateau. It is also found in murder victims who have been bricked up in chimneys or persons who have died in well-sealed centrally heated rooms. Size is important, and dead babies, owing to their large surface area to volume ratio, will lose water more rapidly than an adult. Newly born babies lack an active gut microbial flora and therefore not only will they lose water quickly but they also may dehydrate before microbial decomposition can cause major destruction of tissues.

### Putrid dry remains

After the skin and soft tissues are removed, the body is reduced to the hard skeleton and those structures that are more difficult to break down, such as the tendons, ligaments, fingernails and hair. Organs such as the uterus and prostate glands are also fairly resistant to decay and may last for several months if the body is kept in a well-sealed container. Because there are still traces of dead organic matter being broken down by bacteria and fungi, a skeletonized body still smells of decay.

Once the skin and the soft tissues have been lost, it can be difficult to detect death that results from penetrating wounds, such as those caused by stabbing with a knife or screwdriver. However, in about half of such cases there is usually associated damage to the bones and cartilage (Banasr *et al.*, 2003) so it is important that these tissues are examined very carefully.

For a summary of the decomposition stages and their characteristics, see Table 1.2.

## Factors affecting the speed of decay

The speed with which a body decays depends upon many factors (see Table 1.3).

**Table 1.2** Summary of stages of decomposition and their characteristics

| Stage of decomposition | Characteristics |
|---|---|
| Fresh | Body starts to cool and autolysis begins. *Livor mortis* and *rigor mortis* may be seen |
| Bloat | Discoloration of skin surface, body swells from accumulation of gases. Tongue protrudes, fluid expelled from orifices. Soft tissues visibly decaying. Rapid decay owing to intense microbial and invertebrate activity |
| Putrefaction | Progressive loss of skin and soft tissues. Body deflates as decomposition gases escape. Decay owing to invertebrate and microbial activity starts to slow down once soft tissues removed and body starts to dry out |
| Putrid dry remains | Skin and soft tissues lost. Decay proceeds more slowly. Progressive loss of uterus/prostate gland, tendons, cartilage, fingernails, hair. Skeleton may become disarticulated through environmental and biological processes |

## Burial underground

Some species of blowflies and fleshflies will lay their eggs on a corpse within minutes of a person dying and will travel long distances to do so. The rapidity and extent to which a corpse is colonized by the larvae of these flies, along with the activities of other invertebrates, microbes and vertebrates such as dogs and birds, heavily influences the speed with which a body decays. Consequently, those factors that restrict their access or reduce their activity, such as lack of oxygen or the temperature being too low or too high, reduce the rate of decomposition enormously. For example, buried corpses decay approximately four times slower than those left on the surface, and the deeper they are buried, the longer they are preserved, provided that the ground is not waterlogged (Dent *et al*., 2004). Even a shallow covering of soil will exclude blowflies from colonizing a body and hence reduce the rate of decomposition, although some fly species, such as the coffin fly (*Conicera tibialis*), are able to locate bodies a metre or more below ground. Sealing a body within an airtight container also reduces its rate of decay because of the reduced oxygen level and the inability of invertebrates to gain access to it. Bodies that are encased in concrete will also be preserved, although there are few experimental data on how the body's chemistry changes with time under these conditions. A body that is left hanging may decay more slowly than one that is lying on the surface of the ground (Wyss and Cherix, 2004). This is probably because when a body is suspended in mid air there would not be a moist, dark, under-surface where flies could lay their eggs,

**Table 1.3** Summary of factors promoting or delaying the rate of decay

| Factors promoting decay | Factors delaying decay |
|---|---|
| Oxygen supply not restricted | Oxygen supply restricted |
| Warm temperature (15–37°C) | Cold temperatures (<10°C; decay will cease below 0°C) |
| Humid atmosphere | Dry atmosphere |
| Presence of invertebrate detritivores (e.g. blowfly larvae) | Absence of invertebrate detritivores |
| Wasp, ant and other invertebrate predators feeding on corpse | Wasp, ant and other invertebrate predators feeding on detritivores |
| Wounds permitting invertebrates easier access to internal body tissues | Inability of detritivores to gain access to all or part of the corpse |
| Surface burning causing skin to crack and thereby allowing easier access of invertebrates and oxygen to internal tissues | Intense burning resulting in tissues carbonized and drying out. |
| Obesity | |
| Suffering from septicaemia or myiasis before death | |
| Body exposed to the environment above ground | Burial on land or underwater (rate of decay declines with increasing depth) |
| Body resting on soil | Body suspended above ground (e.g. hanging) |
| | Formation of adipocere |
| | Mummification |

the circulation of air would promote drying out and many maggots would fall off whilst crawling around or be washed off by the rain.

## Burial underwater

Decomposition underwater is typically twice as slow as when the body is exposed to air and the underwater rate is even slower at low temperatures and oxygen levels. Under deep-sea conditions, decomposition may be prolonged and fish, crabs, starfish and other benthic (i.e. those living on or close to the sea bed) invertebrates may be more important than microbial decomposition. Bodies that float on the surface of ponds, lakes and rivers can still be colonized by blowfly larvae and this, along with the exposure to higher temperature and oxygen levels, increases the rate of decomposition.

## Time of year and temperature

Many invertebrates show distinct patterns of seasonal activity. For example, in the UK, many blowfly species are not active during the winter months and consequently a body tends to decay more slowly during this time. Temperatures that are too high or too low will also restrict the activity of invertebrates and microbes and thereby reduce the rate of decay.

## Burning

Murderers often attempt to dispose of their victim's body by burning the corpse. However, they are seldom completely successful owing to the extremely high temperatures required – identifiable human remains may still be found among the ashes produced by a crematorium, which typically operates at over 1000°C. Badly burnt bodies are also a common feature of victims of explosions and traffic and aircraft accidents. Some factors associated with burning may reduce the rate of decomposition whilst others promote it, so it is difficult to generalize. For example, burning sterilizes the skin surface and dries the underlying tissues, making them unsuitable for the growth of microbes and blowfly maggots but it also causes cracks through which they may invade the deeper tissues that are less affected. Similarly, although the skin surface may be charred, the temperature may not have been high enough to affect the gut microbial flora, so decomposition may commence here as normal. Burning induces chemical changes in proteins, carbohydrates, lipids and other organic molecules that may affect their suitability to support microbial and maggot growth, but there is little published information on this. Some workers have found that burnt corpses retain their attractiveness to blowflies whilst others have found that it reduces their likelihood to lay eggs on the body (Catts and Goff, 1992; Avila and Goff, 1998). Obviously, a great deal depends on the degree of burning and the individual circumstances.

## Exposure to sunlight

Many invertebrates avoid laying their eggs on and colonizing regions of a corpse that are exposed to the full summer sun. This is because it would cause their delicate eggs and young larvae to be killed by a combination of desiccation and exposure to UV light. However, eggs may still be laid on the under-surfaces and if the body is clothed or similarly covered then the covered regions will be protected from the sun and have a more humid microenvironment. This can provide a more suitable environment for microbes and maggots to grow and consequently they may decay more rapidly than exposed body parts. Loosely fitting clothing will facilitate the entry of invertebrates and the circulation of air and therefore enhance the rate of decay, whereas tight-fitting clothing may delay it.

## Geographical location

The abundance and species composition of the invertebrate fauna vary considerably between regions and this can affect the speed with which a body is located, colonized and decomposed. For example, because cities offer warm microclimates, some blowfly species may remain active throughout the winter period whereas they would be inactive in the surrounding countryside. In both cities and the countryside, the adults of some blowfly species enter buildings during the autumn period and will attempt to overwinter indoors. Should a body be placed within a building where they occur and the temperature is high enough for them to be active, then colonization of the corpse will commence even in the depths of winter. Decay proceeds much faster in the tropics, where conditions are both hot and humid, and slower in cold or dry conditions. In the tropics, a corpse can become a moving mass of maggots within 24 hours but in the UK it would take several days to reach this stage, even during the summer.

---

## Quick quiz

1. Distinguish between *livor mortis* and *rigor mortis*.
2. What is meant by the term ‘taphonomic process’? State two examples of taphonomic processes.
3. What causes the ‘bloat’ stage of decomposition?
4. What is adipocere and what is its forensic relevance?
5. Why do newly born babies mummify more readily than older children and adults?
6. Why does a buried body decay more slowly than one lying on the surface of the ground?
7. Why does a hanging body decay more slowly than one lying on the surface of the ground?
8. During winter, why might an exposed body decay faster if left in the centre of a city than in the outlying countryside?
9. State one means by which burning can reduce the rate of decay of a corpse and one means by which its rate of decay might be increased.

---

## Project work

### *Title*

The effect of freezing on the rate of decay.

### *Rationale*

Murderers sometimes store their victim's body in a freezer before disposing of it. Freezing will cause tissue damage so once the body has thawed does it decay at the same rate as an unfrozen body?

### *Method*

Bodies or tissues can be frozen for varying lengths of time and then placed above or below ground and the rate of decay, speed of colonization by invertebrates, etc. can be compared to a control unfrozen body. If a thermocouple is placed on the frozen body when it is exposed, it would be possible to determine whether blowflies are deterred from laying until the surface temperature has risen to near-ambient levels. Histological changes could also be assessed, along with biochemical assays to determine the speed with which autolysis begins.

### *Title*

The effect of burying in concrete on the rate of decay.

### *Rationale*

Bodies are sometimes disposed of in the concrete foundations of buildings or bridges.

### *Method*

Bodies or tissues, which may or may not be wrapped in clothes, would be encased in concrete and then left at varying temperatures. After varying times the body would be retrieved from the concrete and its state of decay compared to control bodies that were not placed in concrete. The ability to extract DNA from the bodies would be assessed and structural changes to the surrounding concrete determined.