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The Journey from Life to Death: Biology of the Human Life Cycle and Our Attempt to Control It

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Abstract: Like most other many-celled animals, every mammal species has a characteristic life cycle, beginning with a sperm fertilizing an egg and ending with death. For mammals generally—including humans—major milestones are conception, birth, attainment of sexual maturity, and the end of life. Typically, before they die, individuals experience a period of physical decline in old age (senescence), which may be brief but is quite extensive in humans. And in each mammal species those principal life stages have typical durations, beginning with gestation in the mother's womb and then proceeding through infant and juvenile development into adult life. In every mammal species, the overall lifespan also has a typical duration. Death from natural causes is universal among mammals and its timing is fairly predictable for any particular species, given the existence of a species-specific maximum lifespan. Nevertheless, artificial extension of the lifespan—perhaps culminating in immortality—has long been a cherished goal in human societies. With the advent of modern medicine, it may seem as though long-term postponement of death has become a realistic prospect for the future. But this may well be a vain hope. The much-vaunted "improvement" in human longevity attributed to continued improvements in medical care may be an illusion. In the end, we all must learn to live with death. Content articles explore decay, immortality, and longevity in human societies.

Resumen: Como la mayoría de los animales multicelulares, cada especie de mamífero tiene un ciclo de vida característico, que comienza con un espermatozoide que fertiliza un óvulo y termina con la muerte. Para los mamíferos en general–incluidos los seres humanos–los principales hitos son la concepción, el nacimiento, el logro de la madurez sexual, y el final de la vida. Por lo general, antes de morir, las personas experimentan un período de deterioro físico en la vejez (senectud), el cual puede ser breve, pero es bastante extenso en los humanos. Y en cada especie de mamífero, esas etapas principales de la vida tienen duraciones típicas, comenzando con la gestación en el útero de la madre y luego avanzando a través del desarrollo infantil y juvenil hasta la vida adulta. En cada especie de mamífero, las etapas de vida en general también tienen una duración típica. La muerte por causas naturales es universal entre los mamíferos y su momento es bastante predecible para cualquier especie en particular, dada la existencia de una esperanza de vida máxima específica de la especie. Sin embargo, la extensión artificial de esta esperanza de vida, quizás culminando en la inmortalidad, ha sido durante mucho tiempo un objetivo preciado en las sociedades humanas. Con el advenimiento de la medicina moderna, puede parecer que el aplazamiento a largo plazo de la muerte se ha convertido en una perspectiva realista para el futuro. Pero esto bien puede ser una esperanza vana. La tan deseada "mejora" en la longevidad humana atribuida a las continuas mejoras en la atención médica puede ser una ilusión, y quizás una trampa. Al final, todos debemos aprender a vivir con la muerte. Los artículos contenidos en esta sección exploran la decadencia, la inmortalidad, y la longevidad en las sociedades humanas.

How different are human beings from other animal species? Is there something in our biology that makes us particularly distinctive from them? Each multicellular organism has a characteristic *lifecycle*, beginning when a sperm fertilizes an egg and ending with death. For mammals generally—including humans—major milestones are *conception*, *birth*, *attainment of sexual maturity,* and the *end of life* (Healy et al. 2014). Typically, before dying, mammals experience a period of physical decline in old age (*senescence*) (Finch 1990), which may be brief but, for some reason that will here be explored, can be more extensive in humans. And in each mammal species those principal life stages have typical durations, beginning with gestation in the mother's womb and then proceeding through infant and juvenile development into adult life (Charnov and Berrigan 1993). In humans, pregnancy (*gestation*) lasts nine months, physical maturity is typically reached by about 21 years of age (with sexual maturation somewhat earlier), and an individual can potentially live for over a century (Figure 2.1). However, in spite of the similitude, humans are the only mammals that have developed strategies to extend their natural lifecycles. This chapter will explicitly address biological aspects of human development; how our body progressively degenerates; how our lifecycles can be culturally manipulated; and the potential effects that such actions produce on our biology. Will the manipulation of our lifecycles prevent us from advancing toward our inexorable demise? Can we control all those variables that can potentially affect our chances of survival?

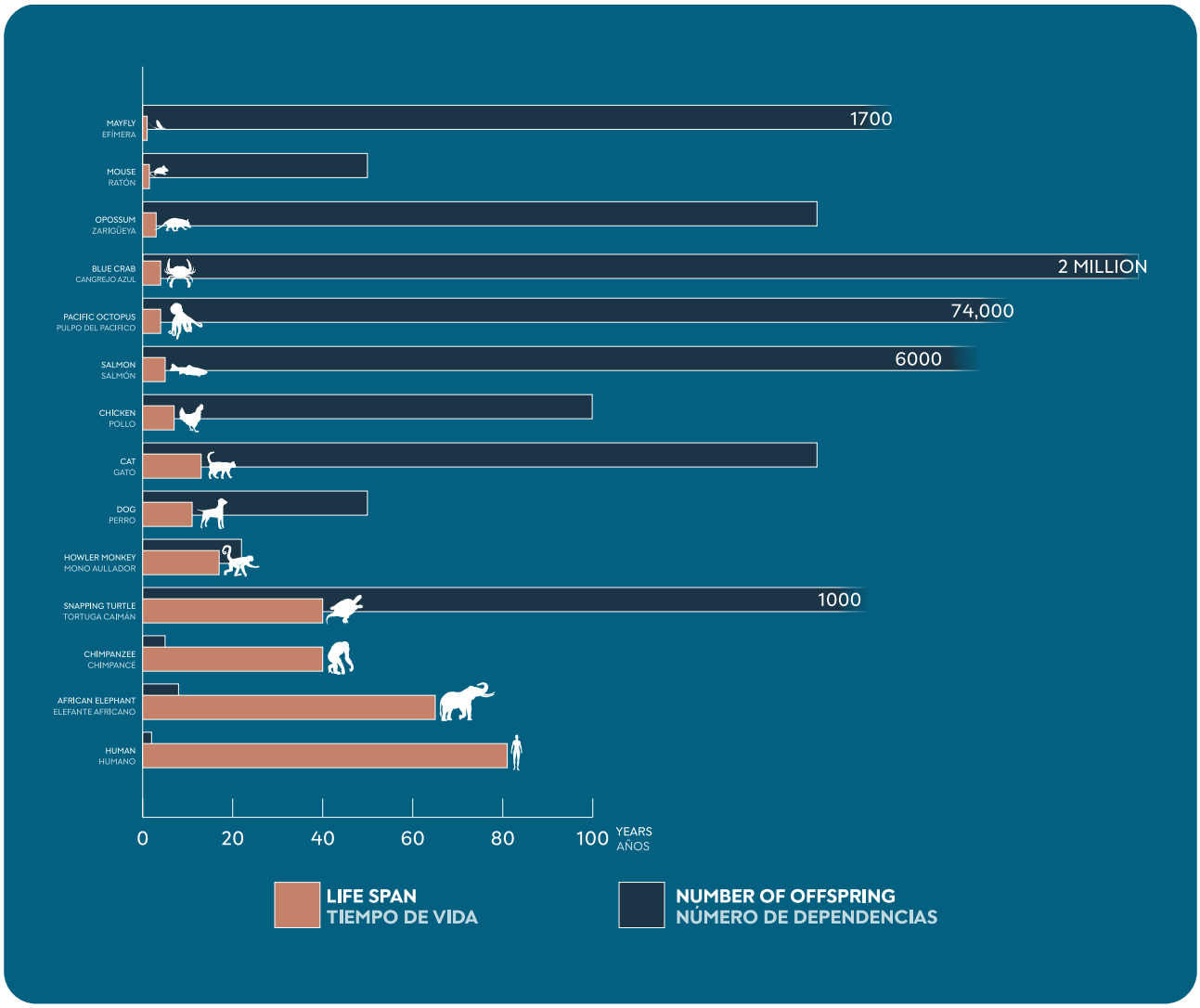

Figure 2.1. Comparative lifespans and offspring for humans and other species.

Overall, in every mammal species, lifespan has a typical duration (Smith 1993). Because of external influences—inadequate resources, accidents, predation and disease—longevity can vary quite widely between individuals of a species (Pokharel, Sharma, and Sukumar 2022). For this reason the *maximum* recorded lifespan (which is far more consistent for any given species) is used for comparisons between species. Across species the gestation period, time taken to reach sexual maturity, and maximum lifespan all tend to increase with increasing body size (Ellis et al. 2018). Typically, small-bodied mammals have short lifecycles, whereas those of large-bodied species are long. In short, some mammal species live in the "fast lane," while others (notably including primates) progress in the "slow lane." However, mammals of similar body size can have different durations of life stages (Lemaître et al. 2020). Among medium-sized mammals, for instance, the fast cycles typical of rodents and carnivores contrast with the slow cycles that characterize primates. In fact, at any given body size, tree-living mammals typically have longer maximum lifespans than mammals that live at ground level. Primates are essentially tree-living and long human lifespans have been retained and expanded from that biological heritage (Alberts et al. 2013; Alvarez 2000).

In contrast to humans, development after birth in other mammals has notably fewer stages. Many fast-breeding mammals are weaned and become sexually mature at about the same time, so they really have only two basic life stages: immaturity and adulthood. Other, more slowly breeding mammals such as nonhuman primates have a juvenile stage inserted between weaning and adulthood. However, and interestingly, humans have more life stages than other primates (Acscadi and Nemeskeri 1970; Carey 2003; Carey and Judge 2000). In particular, a new *childhood phase* intervenes before

the juvenile period, and a similarly novel *adolescent phase* follows. American anthropologist Barry Bogin (2009) convincingly argued that the developmental stage of childhood is unique to humans. Adolescence also seems to be more-or-less confined to our species. In other words, the undivided "juvenile period" seen in other mammals consists of three distinct phases in the human lifecycle. This increased complexity of human development before adulthood is associated with an extension of the period between birth and sexual maturity (Westendorp and Kirkwood 1998), and it can also be related to our prolonged period of senescence (see Austad 2015; Hamilton 1968).

With stages of development, as with many other aspects of human biology, comparisons with nonhuman primates yield a revealing perspective (Austad and Fischer 1992). These comparisons allow us to recognize ancient features of our primate origins or general mammalian heritage, and thus to identify more recent innovations that can be uniquely human. And here, valuable clues can be gleaned from the archaeological record, as interpretations of skeletal remains can expand our understanding of human life-histories, sometimes even back to fossil relatives. For instance, Barry Bogin and fellow American anthropologist Holly Smith inferred that the novel stages of childhood and adolescence in the human lifecycle may date back to the emergence of early members of the genus *Homo* around two million years ago, suggesting that these early stages of development could be unique features of the early hominids (Colchero et al. 2016).

It has long been widely accepted that the duration of the life stages is contingent on the development and progress of modern life (Barbi et al. 2018; Caspari and Lee 2006). In pre-industrial societies a typical human lifespan is "three score years and ten," or 70 years. With increasing advances in healthcare in industrialized nations, however, *average* life expectancy at birth has increased by about a decade—to 80 years—in the USA and Europe and other industrialized regions in Asia and Australasia (see Chernew et al. 2016; Olshansky 2008; Olshansky, Carnes, and Désesquelles 2001). Although, as Mutcherson (in this volume) demonstrates, other factors of social inequality in the USA can dramatically reduce life expectancy. As she cleverly asks, could we ever overcome the limitations of a deeply unequal life?

In general, it is usually expected that, accompanying progress in medical sciences, average longevity will continue to increase in future. But an important distinction must be noted. Thus far—although medical progress can substantially increase average human lifespans—it seems that there may be an upper limit (Dong, Milholland, and Vijg 2016; Olshansky, Carnes, and Cassel 1990). It is entirely possible that, while improvements in healthcare have enabled many individuals to survive longer than pre-industrial conditions allowed, there is a natural maximum age. All other mammal species have a recognizable maximum lifespan, so why should humans be any different? Under free-ranging conditions, because of fluctuation in resources, accidents, predation, and disease, individual mammals rarely attain the maximum lifespan (see Finch 2010; Flatt and Partridge 2018; Gavrilov and Gavrilova 1991). In captivity, however, average longevity may approach the species maximum more closely, although increasing signs of senescence become apparent with increasing age (Hawkes 2003; Hawkes and Coxworth 2013).

In fact, several lines of evidence indicate that the human species may have a maximum lifespan of about 125 years. This very long potential lifespan is substantially longer than in any nonhuman primate species. Indeed, it is longer than in any other mammal, not only relative to body size but also absolutely. For a medium-sized mammal, our extended lifespan is a striking outlier. Reliable sources indicate that no human has ever survived beyond the age of 125 years. The current record-holder (and even that has been questioned) is the French woman Jeanne Calment, who reportedly died during her one-hundred-and-twenty-third year in 1997.

Some researchers have concluded that maximal human longevity has actually increased over time, while others have inferred that no such increase is likely. In 2000, American demographer John Wilmoth and colleagues published an impressively detailed study of recent variation in the human lifespan. They reported that the maximum age at death in Sweden increased from about 101 years during the 1860s, in Darwin's heyday, to about 108 years during the 1990s. Over two thirds of that seven-year increase in maximum age at death can be attributed to reduced death rates for individuals more than 70 years old. Wilmoth and colleagues also noted that the rate of increase in maximum lifespan per decade accelerated after 1970. This faster increase in the maximum age reflected a more rapid decline in old-age mortality over the most recent three decades of the study. Wilmoth and colleagues (2000, 2368) concluded that "reductions in death rates at older ages … seem likely to continue and may gradually extend the limits of achieved human longevity even further." In other publications, the Wilmoth group has similarly argued that human maximum lifespan may continue to increase into the future.

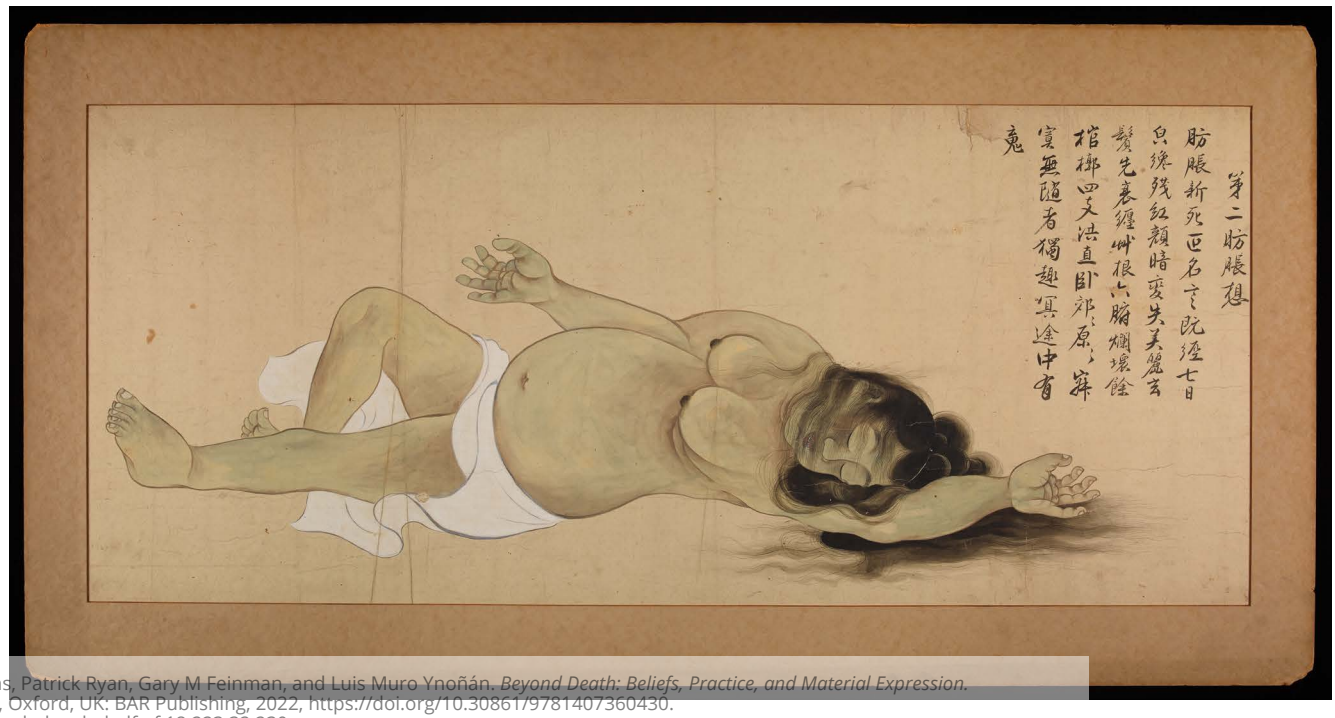

Figure 2.3. The fourth and fifth images of the *Kusōzu* series represent rupture of the body and exudation of blood (FM 125807.4,. 5-A115292d_009, 10).

Figure 2.2. *Kusōzu* watercolors representing a sequence of bodily decomposition: the first three images represent the living woman, the newly deceased, and the distension of the body (FM 125807.1, .2, .3-A115292d_003, 5, 6).

2A Sekishinsai Okada Tadaharu 赤心斎 岡田忠遥: *Nine Stages of Bodily Decay* (Kusōzu)

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The *Buddhacarita: In Praise of Buddha's Acts* tells the story of how Siddhartha was raised as a crown prince in a lavish palace. Having received a prophecy that the boy would become an ascetic, Siddhartha's father sheltered him from everything painful and unpleasant. At the age of 29, however, Siddhartha requested to see the outside world. Proceeding in one direction, he encountered an elderly person bowed with the pain and afflictions of old age; in another, a sick man; and in another, a funeral procession. He returned to the palace grief-stricken: "The world is very painful, ruined by old age, illness, and death," he reflected (Aśvaghoṣa 2009, 30). He eventually attained enlightenment after meditating under the bodhi tree and expounded the fourfold truth: all life is suffering; the cause of suffering is desire; the abandonment of all desire will bring liberation from suffering; the path to freedom is brought by the Middle Way, between the extremes of self-indulgence and self-abnegation. By abandoning desire and leaving his earthly body behind, the Buddha achieved *nirvana* and release from the cruel cycle of death and rebirth.

Buddhist scriptures portrayed the body in negative terms as the site of hunger, thirst, and sexual desire: Just as a man who "has lived painfully afflicted in a prison" despises the prison and "seeks only freedom," so, too, should people rid themselves of attachment to this present existence and focus on attaining Buddhahood. Just as sailors would toss a broken, leaking boat to the sand without giving that unseaworthy vessel a further thought, so, too, says the *Buddhavamsa,* should people cast off their impure bodies leaking from nine orifices and seek enlightenment (Horner 1975).

Since ancient times, Buddhist texts advocated meditating on a decaying corpse or on a skull in order to remind followers of the impermanence of the human body in contrast to the eternal nature of *nirvana*. Death's ability to transform even the most beautiful body into a putrid sight was taken as evidence not only of impermanence, but also of the fundamental impurity of the human body itself. Within the male-centered Buddhist worldview, female bodies were considered particularly unclean, both because patriarchal thought blamed them for leading men astray, and because karmic retribution for acts in a previous life were cited as the reason for being born a woman, whose social status at the time was inferior to that of men.

Accordingly, whereas the sight of a beautiful body was known to incite desire, meditating on a repulsive, decaying corpse was seen as an effective means of quelling sexual desire in devout believers, particularly those who had taken the tonsure. The *Discourses on Mahayana Meditation and Contemplation* is one of several Buddhist texts that recommends meditation on the stages of death and decay in this manner. It explains:

> Even a woman with graceful eyebrows, jadelike eyes, white teeth, and red lips is as if covered by a mixture of feces with fat powder, or as if a putrefied corpses were clothed with silk and twill …. [C]ontemplation [on a decaying corpse] is a golden remedy for sensual desire. (Translated and quoted in Kanda 2005, 61)

The stages of bodily decay were devised as an aid to meditation. Believers were encouraged to construct and reflect on detailed mental images of each of the following stages: newly deceased, distention, rupture, exudation of blood, putrefaction, consumption by animals, skeleton, and disjunction of the bones. Scholars have pointed out that beyond quelling sexual desire, the images might also help viewers mourn and come to terms with the loss of a loved one. In the eighth stage of the Field Museum version we see a skull, strands of hair, and a few bones amid flourishing autumn flowers and grass. The ninth stage features a stone stupa with scattered wooden grave tablets, autumn trees and grasses, and small birds. Despite having experienced a gruesome process of decomposition, the body of the deceased young woman ultimately returns to nature, which continues to flourish around the durable stone marker that is used to memorialize her.

The Field Museum *Nine Stages of Bodily Decay* was donated to the museum by Frederick Gookin in 1923 and may date from the nineteenth century (Figures 2.2–2.5). Deceased persons were usually cremated in Japan, and while the sutras taught that leaving corpses in the open for consumption by animals was an expression of compassion, centuries had passed since this practice was common. By contrast, the practice of making *Nine Stages* handscrolls, hanging scrolls, and large horizontal images such as this set remained well known. As in many medieval cases, the images are accompanied by named titles of each stage of bodily decay, accompanied by poetry in literary Chinese. While these poems have been attributed to the eleventh-century Chinese literary figure Su Shi (1037–1101), they were likely composed in medieval Japan and attributed to the Chinese thinker.

Nine Stages pictures often included an image of the deceased woman while still alive. The Field's images are distinctive in their portrayal of a woman in Chinese dress: many other *Nine Stages* paintings and prints depicted the subjects in courtly Japanese robes. The deceased was sometimes interpreted as Ono no Komachi, a courtly Japanese poetess renowned for her beauty and literary gifts. The medieval Japanese Noh drama *Sotoba Komachi* portrays Komachi as an impoverished old woman whose beauty has faded and who is found seated on a burial marker. The living woman in the Field's set of paintings bears an elaborate headpiece with designs of flowers and birds. It has been suggested that she may be Yang Guifei

(719–756), the Chinese beauty who is said to have so monopolized the attention of Tang Emperor Xuanzong as to bring about the downfall of his court. Xuanzong's ministers put Yang Guifei to death, but the epic poem by Bai Juyi (772–846) recounts that Xuanzong experienced everlasting sorrow at her passing. If Japanese viewers identified this elegantly attired Chinese lady as Yang Guifei, then the identification adds layers of moral and poetic sentiment onto the established genre of *Nine Stages of Bodily Decay*.

The Field Museum *Nine Stages* exhibits careful attention to anatomical details, such as to bones in the hands and feet. In the fifth stage, the skin is removed in an almost didactic manner to produce careful windows onto the veins, muscles, and bones below. Other aspects suggest the artist's limited anatomical experience: there seems to be uncertainty about whether a skeleton has a nose, for example, and details such as the number of ribs are incorrect.

The corpse is positioned in a manner that arouses sexual desire only to subsequently negate it. In the first stage, for example, the newly deceased pillows her head on her arm, which is raised to expose the breasts and willowy torso. In stages 2 and 3, the body continues to be depicted in a sensual manner despite the facts of bloating and decomposition: stage 3 clearly depicts the pubic area, which is just visible where the white cloth has fallen away. In stages 5 through 7, by contrast, the body and face appear gruesome, yet in the final two stages order is restored with the whiteness of the bones, the flourishing of nature, and the presence of the stupa.

Acknowledgments

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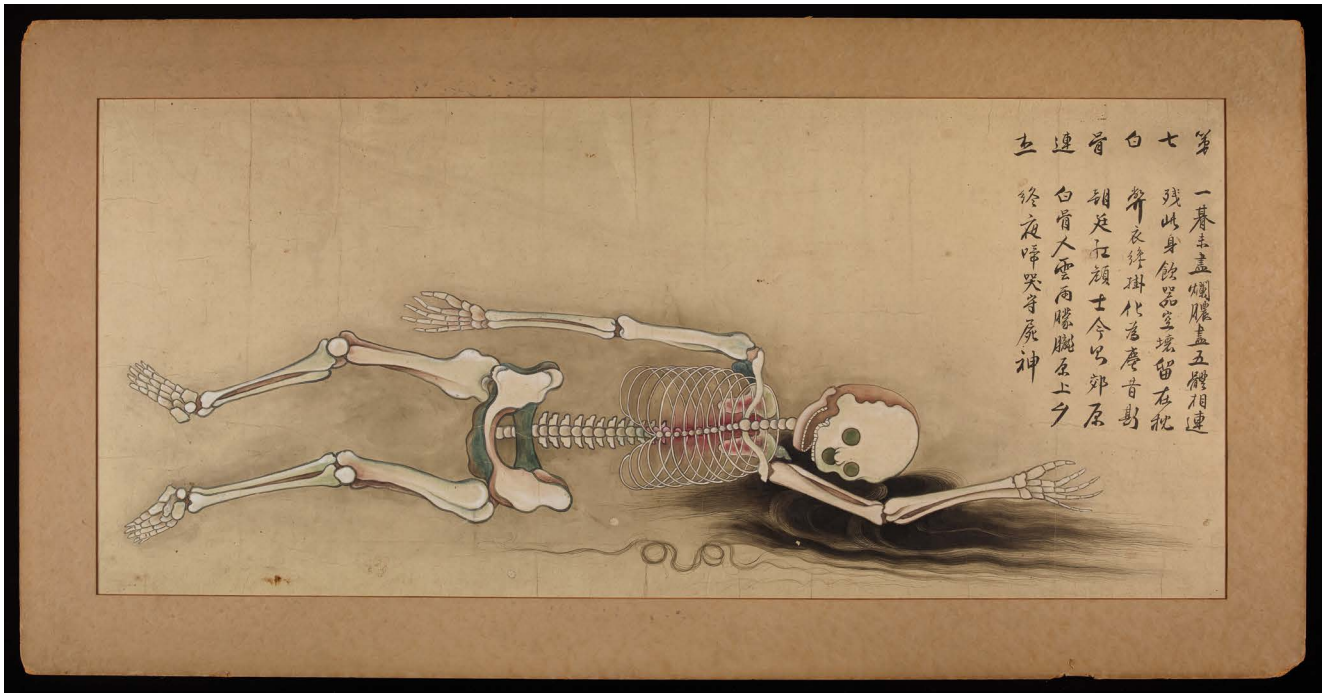
An opposing viewpoint—championed by American demographers Jay Olshansky and Bruce Carnes in their 2001 book *The Quest for Immortality: Science at the Frontiers of Aging*—is that the human lifespan has a fixed biological limit. Among other things, they suggest that our lives are subject to a certain inherent level of mortality that will remain even if we eliminate or at least drastically reduce all external and disease-driven causes of death. Confirming this interpretation, in a 2009 paper, Korean aging researchers Byung Mook Weon and Jung Ho Je reported results from a mathematical model designed to estimate the maximum possible human lifespan. Using life tables for Swedish women for the period between 1950 and 2005, they derived a figure of about 125 years. At the same time, they determined that the probability of survival is close to its upper limit in datasets for modern human populations in industrialized countries. Accordingly, the expectation is that maximum lifespan in human populations can increase to an upper limit of about 125 years but not beyond.

Moreover, there is now good reason to question the confident expectation that, enabled by medical advances, the average human lifespan will continue to expand into the future. In a 2005 paper, Olshansky and colleagues concluded that estimates of how long Americans are going to live in the twenty-first century could be incorrect because of current trends in obesity, to which we could add the emergence of new diseases and their varied impact on populations (see Wali in this volume, on responses to the pandemic). Kontis and colleagues' analysis of the effect of obesity on longevity indicates that the steady increase in life expectancy observed in industrialized populations over the past 200 years could soon go into reverse gear (Kontis et al. 2017). In a similar manner, the COVID-19 pandemic has demonstrated that the human immunological system provides differentiated levels of protection, leaving some more vulnerable than others, as well as more susceptible to dying because of the emergence of new infectious disease.

A key point concerning differences in interpretation on this issue is the crucial distinction between the maximum lifespan achieved in any human population at a particular time and the *maximum possible* lifespan that any individual, with full access to a good quality health service, can attain (Imai and Soneji 2007). In the oft-quoted words of English philosopher Thomas Hobbes, human life under original gathering-and-hunting conditions is generally perceived as "nasty, brutish and short." Although it is widely accepted that in industrialized societies average life expectancy has progressively increased thanks to a wide array of technological and medical advances, it is not at all clear whether the maximum possible length of the lifespan has also increased.

Figure 2.4. The putrefaction stage is followed by consumption by animals in the sixth and seventh images of the *Kusōzu* paintings (FM 125807.6, .7-A115292d_013, 4).

Figure 2.5. The final stages of the *Kusōzu* paintings represent the skeleton, the disjunction of the bones, and the final resting place of the body (FM 125807.8, .9, .10- A115292d_017, 8, 21).



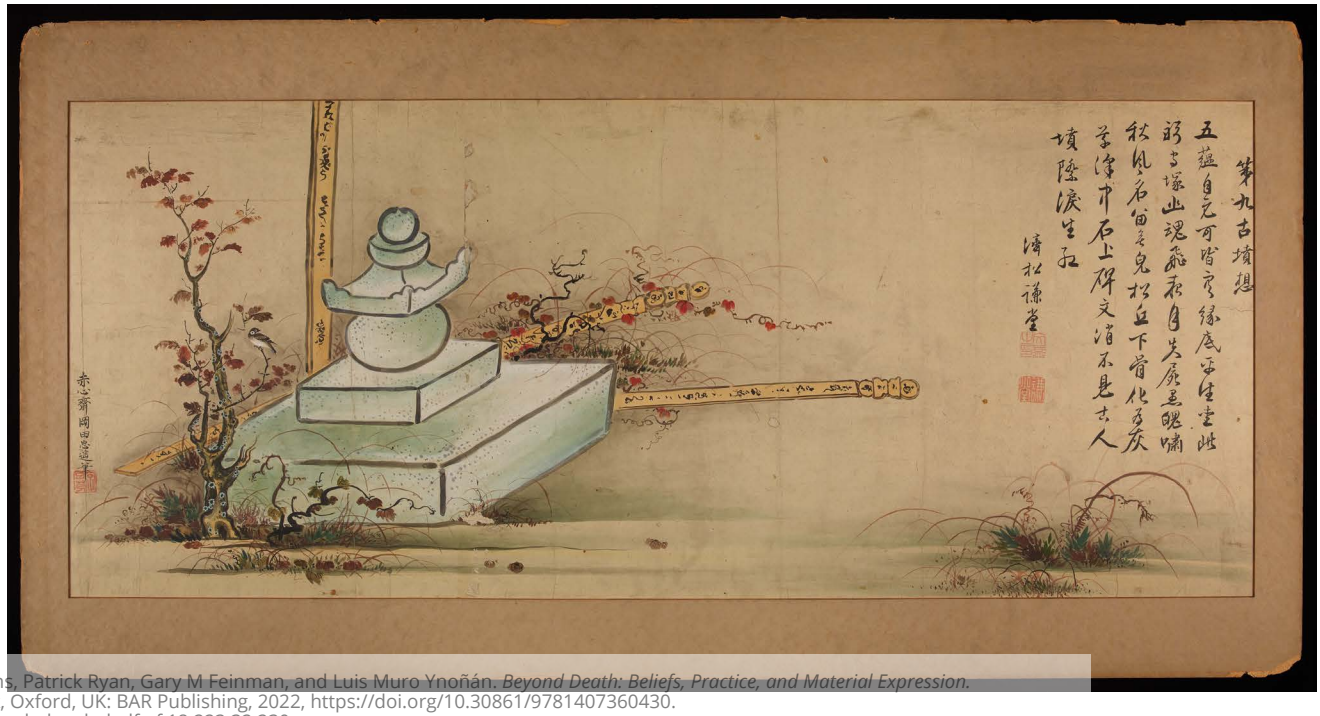


Figure 2.7. Lead pewter plate with brass rim design including examples of animals holding the *lingzhi* (fungus of immortality) in the mouth. Consuming the *lingzhi* was thought to convey energy and immortality (FM 110086).

Figure 2.6. Roman basin (reproduction) with representation of immortal gods Mars and Venus (FM 24010).

2B Daoist Immortals, the *Lingzhi* Fungus, and the Search for Immortality

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Field Museum

The search for immortality and the extension of the lifespan are often culturally linked, although in concept they represent two somewhat separate activities (Figure 2.6). The transition to immortality requires a transformation in the spiritual realm to free the spirit from the earthly manifestation of the body. Extension of lifespan is tied more directly to the physical body as it experiences aging and senescence. In both cases though, various mixtures of ingredients—elixirs—may play an important role. Almost always ingested either as food, liquid, or in some cases smoke or vapor, elixirs have an important role in mediating and affecting the transition from life to death to afterlife, and potentially the transition to immortality.

The ancient spiritual and ritual practices that coalesced in the later Han period (206 BCE–220 CE) into a more formalized set of religious and philosophical beliefs that became Daoism evolved over centuries (Copp 2018). There are legions of Daoist deities, sages, and wise adepts that inhabit various forms and live in sacred places such as mountains, blessed islands, and celestial places such as the moon. They have achieved immortality either through divine intervention or by extensive study or an extraordinary life or talent. An ancient example is the Queen Mother of the West who lives in the moon with many attendants in the form of animals, including a magical rabbit who pounds elixirs in a mortar and pestle. Many immortals are based on historical or legendary figures. Of later appearance in Daoist literature and practice, a core set of several individuals known collectively as the Eight Immortals is among the most well-known. Drawn from various walks of life and life histories, the Eight Immortals include four pairs of opposites: male and female, rich and poor, military and civilian, and young and old. They reinforce a central idea in Daoism that anyone can pursue mental cultivation.

The nature of beliefs and practices surrounding death and the interest in immortality was more prominent at certain times than at others. Nevertheless, Daoism does recognize a richly detailed and diverse set of beliefs regarding immortality and how it may be achieved (e.g., de Bary and Bloom 1999). Proper burial and the attentive care of one's descendants is important. Achieving immortality is difficult and requires many steps, such as mental cultivation, correct living, and a corresponding incorporation of, or surrender to, the Dao or the Way, a concept that loosely translates as the force and universality of energy that animates everything that happens, all of nature, and the cosmos (Ebrey 2010, 46–49; Watson 2007). Understanding the Dao is the work of several lifetimes, and perhaps truly unattainable, but key concepts include the embeddedness of all things in nature, the interdependence of opposite states, and a focus on yielding to the flow of nature and energy (Watson 2007).

The search for immortality can also include the use of elixirs (e.g., de Bary and Bloom 1999). There is a long history of alchemical attempts to develop elixirs to extend the lifespan, to achieve immortality, or to preserve the mortal remains of the body prior to burial. Many preparations made use of minerals and elements such as cinnabar, gold, sulphur, arsenic, and lead, often in deadly combinations. Many preparations used plant and animal ingredients, of which several are still in wide use such as the *lingzhi*, otherwise known as the fungus of immortality or the mushroom of immortality (Figures 2.7–2.9).

The *lingzhi*, *Ganoderma lucidum*, is also known as the reishi in Japanese. It is widely cultivated and has been a component of traditional Chinese medicine for centuries. It has a glossy brown surface appearance with a firm or woody texture; the exhibition includes a botanical specimen, now dried. All parts of the *lingzhi*, such as the spores or the fruiting body, have medicinal uses. Many health benefits are ascribed to *lingzhi*, including longevity and improvements in energy, as well as regulation of blood sugar, liver function, and other systems. As with many products from nature with traditional uses, it is being investigated today for the degree to which there are clinically measurable effects. It is widely available and marketed as a supplement for longevity and general health, including immune system support.

Given its long association with medicinal benefits of such power as to include immortality in the right preparations, the *lingzhi* is also potent symbolically. Hiding in plain sight in many artworks from East Asia, and especially China, is a stylized depiction of the *lingzhi*. Often depicted as an upside-down heart or kidney bean shape, the *lingzhi* is part of the rich visual vocabulary of Asian art. It is often used both as a symbol of longevity and, due to its similarity in shape to a wish-granting scepter known as a *ruyi*, as a visual rebus that expresses the desire that a wish be granted (Bartholomew 2006).

In the examples from the exhibition, the *lingzhi* appears in several configurations. The rhinoceros horn cup (Figure 2.8) employs motifs of the *lingzhi*, as well as bamboo. Rhinoceros horn libation cups were highly valued gifts made primarily for scholars, but the horn itself

Figure 2.8. Rhinoceros horn cup with stylized *lingzhi* fungus on the body of the cup (FM 110574).

was also considered by Daoists to have magical properties. The pewter tray (Figure 2.7) is surrounded by a border of auspicious motifs that include the *lingzhi* as a symbol of longevity. The ivory figure holds a fly whisk in one hand and a *lingzhi* in the other (Figure 2.9). In all these forms the *lingzhi* functions either as an auspicious symbol of longevity or as a visual rebus for the granting of a wish.

Daoism is certainly not alone in devoting energy and interest to the extension of life and the pursuit of immortality. The richness and detail with which Daoist practitioners have pursued these goals across centuries offers abundant evidence of our collective human desire to live on, to continue to experience the world, and to become a part of nature in a manner that transcends the body and escapes the boundaries of the human lifespan.

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The unusually long average and maximum lifespan of humans is undoubtedly linked, among many other factors, to the universal occurrence of *menopause* in women—the abrupt cessation of fertility at about 50 years of age. Until recently, menopause was regarded as a unique feature of the human lifecycle in comparison to all other mammals. However, new research has revealed that five whale species (Foster et al. 2012) and the Indian elephant (Lahdenperä and Lummaa 2014) also show abrupt cessation of fertility long before the average age at death. Nevertheless, the mammals concerned are all large-bodied, long-lived species whose lifespans are about as long as would be expected for their substantial size, so the human case stands out as being especially unusual.

Death from natural causes is universal among mammals and longevity is fairly predictable, given the existence of a species-specific maximum lifespan for any particular species. Nevertheless, artificial extension of the lifespan—perhaps culminating in *immortality*—has long been a cherished goal in human societies (see Bekken in this volume). Throughout human history, humans have obsessively sought mechanisms to extend life through the use of elixirs, sacred substance, and favors to the gods; and the emergence of religion in itself could be related to this human deep desire (Hall 2003).

Nowadays, with the advent of modern medicine, it may seem as though long-term postponement of death has become a realistic prospect for the future. But this may well be a vain hope. The much-vaunted "improvement" in human longevity attributed to continued improvements in medical care may be an illusion. Whereas it is undoubtedly true that *average human lifespan* has tended to increase in industrialized societies (see Tuljapurkar, Li, and Boe 2000), this may simply reflect the fact that more individuals are living longer and approaching the natural limit more closely. However, across the board, *average human lifespan* is still well below the inferred maximum of 125 years, and there is no reason to expect that even the best medical care, if accessible, will allow anyone to live longer than that. Furthermore, it is important to remember that artificial extension of human life is only worthwhile if the additional years are relatively free of health issues. The total period over which any person enjoys good health without any kind of physical handicap is now called the *healthspan*. It is surely more rewarding to seek ways of increasing human healthspans than to maximize lifespans.

The issue of whether there is an upper limit to human lifespan is directly linked to a key question that has long concerned biologists: Why do senescence and death occur at all? (see also Kirkwood and Rose 1991). The Bible, Shakespeare, and healthcare practitioners all portray aging and dying as inevitable facts of human existence. But why should this be so? Why are we not immortal? As proclaimed in the title of Peter Medawar's 1952 book *An Unsolved Problem of Biology*, this is a fundamental issue that has still not been definitively resolved. We know that various other organisms, notably viruses and bacteria, are potentially immortal, continuously propagating themselves. Individuals may succumb to lack of resources, accidents, predators, or disease, but they never die of old age. In principle, natural selection is expected to promote survival and continued reproduction of individuals. So it is not at all clear why humans and most multicellular animals have a relatively fixed maximum lifespan and do not simply survive indefinitely.

One simple view is that senescence is the unavoidable result of accumulated wear and tear and that we eventually die because we are well and truly burned out. As George Williams noted in a seminal paper in 1957, this view really stems from a simplistic analogy with disintegration of human artifacts. However, unlike a desktop computer or a washing machine, living organisms are equipped with an array of mechanisms for self-repair. So why should deterioration be inevitable? Williams proposed that senescence has actually been built into our genetic make-up through evolution so that we usually remain healthy throughout a standard period of active reproduction but then begin to decline and eventually die.

Numerous hypotheses have been proposed to explain the evolution of aging, but they generally fall into two categories (see Morley 1995). *Error theories* are based on the wear-and-tear notion of chance accumulation of damage to the body's tissues. This may be either environmental—including disruption of DNA and cumulative production of noxious chemical agents in cells—or internal, resulting from progressive failure of genetic systems for maintenance and repair (Stearns 1977). Other theories, by contrast, are founded on the idea that aging has been *pre-programmed by evolution* and is regulated by biological clocks across the lifespan (Szilard 1959). Such regulation is attributed to changes in expression of genes governing systems responsible for maintenance, repair, and defense. A key point is that natural selection should generally become weaker as an organism ages. It is suggested that aging may have evolved because external causes of mortality (resource depletion, predation, disease, accidental death)—which are likely to be largely random—gradually decrease

Figure 2.9. Daoist immortal holding a fly whisk and *lingzhi* fungus (FM 126823).

the probability that an organism will still be alive as age increases. Natural selection could hence favor developments leading to a higher reproductive rate at a young age and a shorter overall lifespan because the net outcome is a higher lifetime breeding success. This introduces the crucial notion, now well established in research into aging, that there is some kind of *trade-off*. It is proposed that aging occurs as a byproduct of investing in breeding rather than in upkeep of the body (Ossewaarde et al. 2005; Pavard, Metcalf, and Heyer 2008; Perls and Fretts 2001), because external causes of mortality will eventually kill an individual regardless of resources committed to maintenance of bodily functions (Harvey and Zammuto 1985).

In his "disposable soma" theory of aging (eloquently portrayed in his 1999 book *Time of Our Lives: The Science of Human Aging*), British biologist Tom Kirkwood proposed that pre-programmed mortality may have arisen as an energy-saving adaptation with reduced regulation of errors in body cells (also see Kirkwood 1999; Kirkwood and Austad 2000). He was particularly influenced by the observation that human fibroblast cells in culture have a finite lifespan, reflecting a constraint on the total number of divisions of any cell to about 60. Furthermore, the lifespan of cultured cells decreases with the age of the donor, indicating that a cellular clock of some kind has been ticking away.

Figure 2.10. Black Mamas Matter onesie that advocates for building awareness about Black maternal health, rights, and justice.

2C On Health Disparities and Motherless Children

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Serena Williams, one of the greatest athletes of all time, almost died while becoming a mother. Williams is a global superstar, one of the most dominant women to ever play in the WTA, who even won the 2017 Australian Open title while eight weeks pregnant. She is an entrepreneur, multi-millionaire, fashion designer, wife, sister, friend, daughter, and a mother. She is also a Black woman who, like far too many others in the United States, almost died because of her pregnancy. Williams delivered her daughter via an emergency C-section that initially seemed to go well. But the next day she began to feel short of breath, a worrying sign for a person with a history of blood clots and pulmonary embolisms. She assumed that the difficulty breathing indicated a coming pulmonary embolism. This world-class athlete, whose entire life has centered around being in tune with and control of her body, recognized worrying symptoms and immediately raised the alarm with a nearby nurse. Williams said that she needed a "CT scan with contrast and IV heparin (a blood thinner)" (Haskell 2018). The nurse suggested she was simply having a bad reaction to pain medication, but Williams did not back down. A physician at the hospital performed an ultrasound of her legs, not a CT scan, and found nothing. Still not satisfied, Williams insisted on the CT scan that she'd already requested. The medical team sent her for the CT scan, which revealed several small blood clots in Williams' lungs. She was soon given the drip that she'd asked for and lived to tell the tale.

Black women die or experience significant injury during pregnancy, childbirth, or in the immediate postpartum period far too frequently in the United States (Figure 2.10). The names of these women appear in numerous news reports as the crisis in maternal mortality for Black women has become a more mainstream discussion. Women like Dr. Shalon Irving, a CDC epidemiologist who studied health disparities, who died from complications related to high blood pressure three weeks after giving birth to her daughter (Martin and Montagne 2017). Or Sha-Asia Washington, who died after going into cardiac arrest while in labor (Dickson 2020). Or Dr. Chaniece Wallace, a pediatric chief-resident who died due to complications from preeclampsia two days after giving birth to her daughter (Burke 2020). So much preventable death at a time that should be full of wonder and happiness.

The US is one of the most dangerous countries for a woman who is pregnant or giving birth. In this country, 700 women die annually due to pregnancy or delivery complications. Unsurprisingly, there are significant racial disparities in the maternal mortality rate. According to the Commonwealth Fund, Black mothers in the United States have been more likely to die than white mothers for 100 years (Declercq and Zephyrin 2020). Black women and American Indian/Alaska Native Women are two to three times more likely to die from a pregnancy complication than are white women—a disparity that increases with age. Though higher education levels typically lead to better health outcomes, that is not so when it comes to maternal mortality. Black college-educated women are five times more likely to die from pregnancy-related complications than are white women with similar levels of education (Petersen et al. 2019). Thus, the data alarmingly reveals that education exacerbates the maternal mortality gap. Maternal deaths are more common among Black mothers with a college education than they are among white mothers with less than a high-school education (Declercq and Zephyrin 2020). Even where death does not result, research shows that Black and Latina women experience significantly higher risk of severe maternal morbidity, such as preeclampsia, which is much more common than maternal death (Artiga, Pham, and Orgera 2020). Despite advances in medicine, Black women continue to die at shocking rates because of pregnancy and childbirth, and efforts to combat this disparity have been sporadic and decidedly ineffectual (Declercq and Zephyrin 2020).

To be a Black woman in America is to live within a system that does not invest in your well-being. The historical line of mistreatment of Black women's bodies runs from the father of gynecology who experimented on enslaved women (Khabele et al. 2021), to the forced sterilizations of Black women across decades (Roberts 1999), to incarcerated women who have labored while chained to hospital beds (Goodwin 2020). The dignity of pregnancy and motherhood has frequently been denied to Black women, so it is no surprise to see persistent disparity in birth outcomes for Black women as compared to others.

Critically, it is racism, not race, that increases the risk of death for Black pregnant women. Research shows that the compounding effects of racism and the stress that it brings to the lives of Black women has a deleterious impact on health (Patterson, Becker, and Baluran 2022). Healthcare is an arena where Black women face deeply problematic interactions with clinicians who are blind to their own lack of cultural competence. One study found that, as compared with the white counterparts, Black women were more likely to report: unfair and disrespectful treatment from healthcare providers because of their race; being denied decisional autonomy during labor and delivery; and pressure to consent to a C-section. Low-income women on Medicaid, in contrast to women with private health insurance, were more likely to report no postpartum visit, a return to work within two months after the child's birth, less access to postpartum support (emotional and practical); a lack of decisional autonomy during labor and delivery, and unfair treatment and disrespect because of their insurance status.

As these findings illustrate, the experiences that women have with maternity care and childbirth differ significantly

across race, class, and insurance status. The maternal morbidity and mortality gap cannot be narrowed or eliminated without considering the root causes of racial disparities. Those causes can be related to health status (weight, chronic illnesses, nutrition), but the experiences that Black women have with the healthcare providers tasked with keeping them and their newborns safe is equally relevant and harder to quantify (Declercq and Zephyrin 2020).

There is no denying that the United States has a maternal morbidity and mortality crisis, and that crisis is even more pronounced in Black communities. Every pregnant woman or person deserves to have the tools to maximize their own health during pregnancy. As has been true for so much of the history of Black women in the United States, death presents itself in times that should be joyous. This will continue to be the case until there is a sustained commitment to identifying and weeding out bias in medicine, ensuring access to high-quality prenatal care for all pregnant people, providing community-based postpartum services and, most of all, valuing the lives of Black pregnant women as much as this country values those of other pregnant women.

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An alternative suggestion favored by Peter Medawar (1952), who won the Nobel Prize for major contributions to immunology, is that late-acting deleterious mutations may accumulate because there is only weak selection against them (Vijg and Dong 2020). Consider a population of otherwise immortal individuals whose fertility does not decrease over time. Some individuals will still be eliminated because of external factors such as lack of resources, predation, and disease. External risks of mortality are present throughout life, so their effects are cumulative and older age cohorts will contain fewer survivors. As a result, young cohorts make a greater contribution to the next generation than older ones. This is why selection against deleterious mutations that take effect late in life—affecting only a reduced number of older individuals—will be relatively weak. So such mutations may progressively become more prevalent over time.

One advantage of Medawar's hypothesis is that it yields a straightforward testable prediction: species that are subject to high external levels of mortality under natural conditions should age more quickly and have shorter lifespans (Peccei 2001). Testing the prediction is complicated by the fact that, as with most biological features, large-bodied mammals generally live longer

than small-bodied mammals. Once appropriate scaling analyses take body size into account, however, it emerges that the predicted inverse relationship between mortality rates and lifespan does indeed exist. Mammal species that are subject to heavy mortality have relatively short lifespans and vice versa. Moreover, analysis of data from field studies has revealed that the age at which sexual maturity is achieved decreases as natural mortality rates increase. So species that are exposed to heavy mortality begin to breed earlier. As already noted, compared to other mammals, primates have relatively long lifespans. Their typical arboreal habits are seemingly associated with lower mortality. However, the development of exceptionally long lifespans in ground-dwelling humans requires a different kind of explanation. Undoubtedly, in our case cultural innovations that reduced death from resource depletion, accidents, predation, and (eventually) diseases played an important part. In any case, according to Medawar's hypothesis the relatively long lifespan of humans indicates that humans are biologically adapted for relatively low mortality.

In 1957, George Williams proposed a somewhat different evolutionary aging hypothesis, based on the fact that a single gene may have a number of different effects (*antagonistic pleiotropy*). Williams suggested that certain effects that positively influence survival early in life might exert negative influences at a later stage. Because there are many more young individuals in a typical population, even quite limited positive effects of a given gene early in life can be subject to strong selection. By contrast, selection against large negative effects that emerge only later in life is likely to be weak. Williams offered an imaginary example in which a gene promoting calcium deposition in bones during development also promotes deleterious accumulation of calcium later in life. Once again, the concept of a trade-off is involved, but Williams' aging hypothesis suffers from the drawback that it is largely theoretical and that very few practical examples have been reported since it was originally proposed. Nevertheless, it is notable that Williams' hypothesis also predicts that—in species with high levels of externally caused mortality—individuals should age more quickly and have shorter lifespans.

A radically different perspective is presented in David Sinclair and Matthew LaPlante's 2019 book *Lifespan: Why We Age—and Why We Don't Have To*. This is based on his *Informational Theory of Aging*, developed over recent decades on the basis of extensive experimental studies at the molecular level conducted on organisms ranging from yeast to mice in his and many other laboratories. As in several other examples, Sinclair's hypothesis depends on a trade-off, in this case between resources needed for reproduction and repair of the fundamental genetic material. However, aging effects are attributed not to accumulating mutational errors in genes themselves but to increasing disruptions of *epigenetic* chemical tags that govern and guide their function. The *Informational Theory of Aging* differs from other proposals in that numerous experiments have indicated ways in which the effects of deleterious changes over time might be mitigated or even reversed. In sum, Sinclair argues persuasively that aging is not an unavoidable fact of life but a *disease* that can be cured (Gavrilov and Gavrilova 2018). The findings that he reports indicate that it should soon be possible to combat aging affects and add healthful decades to human lifespans. But it is not at all clear whether the treatments he envisages could extend the maximum lifespan beyond 125 years. Although Sinclair reports striking increases in age-at-death with experimental animals, there is as yet no evidence for survival beyond the maximum recorded lifespans for any of the species concerned. In a not-too-distant future, we may be enabled to live healthier, longer lives; but the long-sought goal of *immortality* will surely forever remain beyond our grasp.

This contrasts harshly with the way in which humans fantasize with the limits of their own existence and mortality. As this exhibit particularly shows, art has been a remarkable medium through which we express idealized notions of beauty, maturity, and the twilight of life. It is curious that when it comes to art produced to express such notions the number seven is a recurring theme. A superb illustration of this is the renowned painting *Seven Ages of Woman,* crafted in 1544 by the medieval German artist Hans Baldung Grien. This well-known masterpiece depicts seven female life-stages ranging from infancy through puberty and on into maturity and old age. An oft-quoted monologue from Shakespeare's play As *You Like It*, probably written in about 1599, provides a male counterpart. Jaques, a discontented nobleman, lists successive intervals, now widely known as the "seven ages of man": infant, schoolboy, lover, soldier, justice, pantaloon, and second childhood. (The word pantaloon here refers not to trousers but to a person showing signs of senility.) Interestingly, biology similarly leads us to distinguish seven key stages in the human lifespan too, though they are somewhat different: infancy, early childhood, later childhood, juvenile period, adolescence, adulthood, and old age. Similar parallels can be made with how the stages of death have been artistically represented by both ancient and modern cultures. A remarkable example is *the Nine Stages of Bodily Decay* depicted by Japanese Buddhist monks (see Foxwell in this volume). They reflected on the impermanence of the human body,

and, opposed to the aesthetic beauty of *nirvana*, envisioned death as a disgusting process of decay and evanescence of the body.

Returning to biology, investigation of longevity and human lifecycles, in general, has been particularly enriched through information derived from archaeological and bio-archaeological research. Human remains found in ancient cemeteries are sometimes preserved under excellent conditions, yielding a large proportion of available data when carefully examined in contexts (*archaeothanatology*). Through them, it is possible to study broad lifecycle characteristics (*palaeodemography*) in such population samples. However, it should not be forgotten that cemetery remains are death assemblages and do not provide a cross-sectional view of lives led in general populations.

Following the discovery of human skeletons at any given site, specialists are confronted with two practical tasks: inference of sex and estimation of age at death for the individuals represented. This information is of importance when trying to reconstruct life-history patterns for prehistoric populations. There is, in fact, a connection between sex and longevity because there is a certain tendency in human populations, other things being equal, for women to live longer than men, despite the challenges of childbirth (see also Mutcherson in this volume, on other factors affecting this tendency). In the USA, for example, the average life expectancy for women is currently around 81 years, whereas for men it is 77 years (Woolf, Masters, and Aron 2022; Woolf and Schoomaker 2019). In Europe, average lifespans are somewhat longer: 83 years for women and 78 years for men (United Nations Department of Economic and Social Affairs Population Division 2017). Information from archaeological sites may yield information about longevity from ancient populations. For example, age at death was estimated on skeletons recovered from graves at the Ukrainian locality of Sredny Stog, dated at about 7000 years ago. The results indicated that average life expectancy at birth was 44 years for women but only 36 years for men, a difference of eight years between the sexes (Wilmoth 1998). Eventually, analysis of information from a large number of well-documented archaeological sites may indicate whether the widely recognized sex difference in age at death in modern human populations dates back to antiquity. In fact, this seems highly likely as a large-scale survey of life histories of 101 wild mammal species has revealed a general tendency for females to live almost 20 percent longer than males, with relatively few exceptions (Lemaître et al. 2020).

Primary information regarding prehistoric life-history patterns comes from age-at-death estimations, derived from similar techniques to those used by forensic scientists today. For infant and sub-adult individuals, age estimation is based on developmental markers, such as the formation and eruption of the dentition, and patterns of long bone fusion. For adult individuals, age estimation is based on increasing signs of degradation of the skeleton, a prime example being tooth wear (*dental abrasion*). However, age estimation for any individual skeleton becomes increasingly unreliable as the lifecycle advances, especially because environmental factors exert effects. For instance, the degree of dental abrasion depends upon physical properties of the food that is masticated, including contamination with wind-borne sand.

Specialists face many more challenges when it comes to the age-at-death estimations, and even more so for identification of the causes of death. For the former, specialists draw on gradual degenerative changes that occur in the skeleton after attainment of physical maturity. Combining both developmental and degenerative aspects, one special example actually overlaps the transition to adulthood: the fusion of skeletal elements that are initially formed from separate centers of bone formation (*ossification*). In humans, the process of gradual ossification of cartilage regions of long bones is completed between ages of 16 and 21 years, depending on the skeletal element concerned. Eventually, bone formation in the skeleton is completed, although faint traces of fusion sites are still visible externally (and especially internally) for a while. With X-rays, traces of the fusion sites can be detected for several years after the attainment of adulthood.

Skeletal information derived from archaeological sites can also be used to study potential causes of disease and death (*palaeopathology*) and to investigate broad dietary habits (*palaeonutrition*) in prehistoric populations. Unfortunately—apart from healed fractures—only a limited number of pathological features are reflected by identifiable lesions or other changes in human skeletons. Notable examples are bone cancers, anaemia, and end-stage syphilis. Thankfully, modern molecular techniques permit direct identification of disease agents in samples from archaeological skeletons. For instance, recent work on genetic traces of the bacterium that causes syphilis has provided confident confirmation of the presence of the disease in certain individuals. Moreover, comparison between samples has permitted reconstruction of an evolutionary tree that throws new light on the origins of syphilis (Xirocostas et al. 2020). In a similar way, modern techniques have also permitted reliable inference about dietary habits in prehistoric populations, notably using assessment of stable isotopes.

2D Response to the Pandemic: Creativity in the Face of Precarity

Alaka Wali
Field Museum

Toward the end of 2019, people in the city of Wuhan, China, started to fall ill in large numbers, affected by a respiratory disease we all soon came to know as COVID-19. Caused by the SARS-CoV-2 virus, the illness spread quickly around the world, and in March 2020, the World Health Organization (WHO) declared COVID-19 a pandemic—a disease that was global in scope. In the United States, states and cities began to take measures to prevent the spread of the virus, shutting down public venues, requiring social distancing and masks, as the Centers for Disease Control (CDC) promoted national guidelines based on epidemiological investigation.

As museums began to recognize the enormity of the crisis, they began to implement programs to document the pandemic moment for the future. One of the earliest was the Victoria and Albert Museum in London, which started to make a collection there of pandemic-related material culture (Wainwright 2020).

The Field Museum also joined the effort and created a small task-force within the Science and Education Division to establish a collection of material culture that reflected the social and cultural responses to the COVID-19 pandemic. In part, this effort was spurred by the curiosity that there was virtually no representation of the material culture of previous pandemics, such as the 1918 influenza pandemic. In part, it was also part of a broader conversation in museums about future directions for collecting and representing practices (cf. Thorner 2022; Rotenberg and Wali 2014). By the early summer of 2020, it became clear that the pandemic was unfolding in tandem with other social and cultural events that represented significant shifts in the public manifestation of underlying tensions created by rising inequality (cf. Caduff 2020; Wahlberg, Burke, and Manderson 2021). The task force—social scientists from the Keller Science Action Center and the Negaunee Integrated Research Center (including scientific affiliates), together with anthropology collections staff—determined that the Field Museum collection should include documentation of the broader social circumstances.

Additionally, because scientific staff were working in venues across the world, the collection could reflect a global perspective on the pandemic. As of May 2022, the collection of objects numbers over 100 and includes: masks, visual art, song and poetry, educational materials, plant medicines, digital media, and more. The collection also includes over 60 interviews with cultural producers and community members. Our team is working with community partners in the Chicago, northwest Amazon, and south Philippines regions to identify creative cultural responses that give meaning to widespread suffering, and to support efforts to repair social well-being. From movements for racial, gender, medical, and environmental justice, to reflections on how to communicate with neighbors and strangers about the things that matter most, the stories and materials collected here demonstrate that even our most challenging moments invite us to connect and remake our world anew.

To find out more about the collection, please see the website: https://www.pandemic-collection.fieldmuseum.org.

One object in the current collection, displayed in the exhibition, encapsulates several themes emerging from the collection and ethnographic documentation. This is a textile made by Andrea Martinez, a life-long Chicagoan, and donated to the museum in 2021. Ms. Martinez is a neighbor of a Field Museum staff member, who happened to see the textile hanging from the fence in front of the house. It is a cotton fabric banner with hand-stitched letters cut out from other fabric scraps to spell out "Thank You Essential Workers." Ms. Martinez kindly donated the piece to the museum when she was contacted by the staff member. Subsequently, she agreed to be interviewed virtually (see Horton 2021 for an interesting perspective on doing remote ethnography during the pandemic) and narrated the story of the banner. She had been furloughed from her job and, with little to do, decided to sew the banner as her contribution to helping neighbors and family, some of whom were continuing to work. The banner stayed on the fence for several months, was photographed and shared on social media. Ms. Martinez was a self-taught seamstress, had a sewing machine, had saved fabric scraps, and obtained the blue cotton cloth for the banner from a neighborhood Facebook group set up as a barter site. The forced absence from her job inspired the creative response of making the banner. As stated in the interview, she "felt bad" that she couldn't do anything, that she wasn't "doing her part." Making the banner and hanging it connected her to her working relatives and friends. She also did a lot of baking and taking care of others. During the pandemic, she and her husband invited a close friend who lived alone to stay with them.

Ms. Martinez's account of her experience of the pandemic was similar to others we heard during ethnographic interviews. There were frustrations because plans had to be changed (her wedding was cancelled and instead became a small ceremony in her family's yard), but also the forging of closer connections to neighbors. Neighbors shared resources and, as the strict lockdowns faded, convened in their yards for shared meals. The experience of time also changed. To replace the routine of work, Ms. Martinez created a "to do" list every day that provided structure and prevented her from feeling idle. She brought a Kindle™ and read more than she had in years. Sewing also occupied her time. Ms. Martinez and her husband wanted to spend more time on their front porch so they could chat with neighbors and passers-by so they purchased outdoor

furniture and a heat lamp for cold weather. Neighbors they had not really known for the decade or so they had lived in their home became friends and have remained so. These types of creative responses to the pandemic are reflected in other collection items (cf. TallBear 2019 for an alternative approach to documentation of creativity).

In the ethnographic interview, we asked Ms. Martinez how she defined "essential workers." She included "grocery clerks, delivery people, teachers, healthcare workers" and all who had remained working during the lockdown. The concept of essential workers has emerged in the pandemic to make visible the working class who have largely been neglected in current public discourses. Media captured moments of recognition, such as people standing on their balconies clapping and banging pots as healthcare workers came home from long shifts. Grocery clerks, meat-packing-plant workers, and those who kept the infrastructure of social life going were more vulnerable to the disease and their plight shed light on the accumulated inequalities of late twentieth- and early twenty-first-century capitalism. The intersection of class and race also became more visible as the majority of essential workers are African American and Latinx.

Deeply embedded forms of societal structural racism also became the subject of public discourse as evidence grew that people of color were dying at disproportionally higher numbers. The systemic persecution of African Americans and other people of color by the police and other instruments of the state also became more visible, most notably after the murder of George Floyd by policemen in Minneapolis. Anti-Asian violence took hold as well, as former President Trump and other public officials vilified Chinese people and China as the origin of COVID-19. White nationalism and white supremacist ideologies, historically latent forces in American life, once again became more openly manifest in violent demonstrations and on social media. As with other historical moments when inequalities have disrupted the public square, people subjugated by the discriminatory practices of the intersection of stratifications have risen up to protest and respond. The disruptions are not confined to the United States, but are global. National protests against inequality are erupting in Europe, Asia, and Latin America. The Field Museum's documentation of the pandemic and its impact in this turbulent time continues.

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Use of advanced non-destructive visualization techniques has greatly facilitated investigation of prehistoric human skeletons, leading to notable advances in the study of causes of death and how ancient people dealt with death itself (see chapters 4 and 6 in this volume). Although classical X-rays have long been used to examine skeletal specimens, notably permitting more detailed examination of dentitions, the restriction to two dimensions limits their utility. The advent of CT scanners and three-dimensional reconstructions based on the information recorded, initially developed for medical diagnostics and subsequently applied to archaeological specimens, has literally transformed the study of preserved human remains and, with that, of human corporeality. The non-invasive nature of these techniques has been a particular advantage for renewed investigation of mummies. In this case, much can be learned about the procedures involved in natural or contrived mummification of human remains. Furthermore, much useful information can be extracted from the three-dimensional reconstructions obtained. In addition to permitting non-invasive inference of sex, age at death, and pathological conditions from the skeleton, such reconstructions yield additional information on non-skeletal features, such as preserved hair, wrappings, inclusion of artifacts, and the construction of a sarcophagus.

Mention of sarcophagus construction brings us to the issue of burial and associated funeral rites, as described

in other contributions in this book—undoubtedly a unique feature of human societies. They directly indicate that the death of an individual is a recognizable event that evokes strong responses from fellow members of a social group. Such recognition suggests, in turn, that individuals have become aware that they themselves are mortal and will die at some future time. As far as we know, such awareness of death is restricted to humans (see contribution by Martin et al. in this volume), although some primates occasionally show attachment to dead individuals. For instance, for chimpanzees and certain monkeys there have been sporadic reports of a mother carrying the body of a dead infant around for a while—usually just a few days—before abandoning it. As infant chimpanzees and monkeys can actively cling to their mothers from birth onward, carriage by a mother after death indicates her continued active attachment. However, nothing even vaguely similar to burial has been observed in any extant species other than *Homo sapiens*.

Archaeological evidence for human burial (*interment*) has become increasingly abundant since settled communities associated with domestication of plants and animals began to appear around 12,000 years ago (Gurven and Kaplan 2007). Indeed, over that period skeletal remains derived from archaeological sites have provided some of the most direct information that is available regarding past human life-histories, especially during prehistoric times. Deliberate burial accompanied by ritual is clearly evident over those ten millennia, although it is best documented after the end of the Neolithic era, starting at about 5000 years ago. Graves are often specially marked, notably with small and/or large stones, and bodies are often positioned in a special way. For instance, the legs are frequently bent, with the knees close to the chest in the well-known "fetal position," and the arms may be specially arranged. Moreover, recognizable grave goods such as stone tools or seashells and red ocher (the earliest documented natural earth pigment, often associated with burials) may be found on or near a skeleton. As a rule, a grave contains only one individual, but occasionally two or more individuals are buried together. In rare cases, for instance, an adult female skeleton is found buried with the fragile skeletal remains of a late-term or newborn baby, probably indicating the death of both during childbirth. The question that arises in this context is to what extent practices of burial among early groups were conditioned to a specific way of perceiving the physicality of the body, its progressive deterioration and aging, and its subsequent decay.

Given that burial practices are universal among human societies today, it is a reasonable inference that they are deeply rooted in our lineage. However, evidence older than 12,000 years is sparse. As far as *Homo sapiens* is concerned the earliest known potential examples are from the sites of Qafzeh and Skuhl in Israel, dated at about 100,000 years ago. At Qafzeh, two skeletons were found together in a single apparent burial—one from an individual in late adolescence and one from a young child. A more recent example is the skeleton of a human child found at the site of Taramsa 1 in Egypt, dated at around 55,000 years ago. The child's body was found in a sitting posture, with the legs and arms seemingly positioned specially. Several stone blades and flakes were found near the skeleton, but it is unclear whether they were intentionally deposited grave goods. More recently still, in a grave at the site of Nazlet Khater—also in Egypt and dated as about 30,000 years old—the body had evidently been placed on its back, with the knees bent, one arm resting on the pelvis and the other extended lengthwise, suggesting that a sense of orientartion and positionality of the body was already developed. A stone axe had been left in the grave close to the individual's head.

Humans shared a common ancestor with Neanderthals (our closest relatives in the hominid evolutionary tree) somewhere between 500,000 and a million years ago. So it is of particular interest to know whether Neanderthals also practiced deliberate burial (see Martin et al. in this volume, and also Monsó 2022). It has often been claimed that this was indeed the case, a prime example being a skeleton found in Kebara Cave, Israel, and dated as about 60,000 years old. Several feaures indicated that deliberate burial was involved. The skeleton was located in a shallow pit that showed signs of excavation and the body had been positioned on its back, pressed against the sides of the pit. The preserved bones of the fairly complete skeleton were still in their articulated positions and showed no signs of disturbance, indicating that the pit had been covered with vegetation and/or hides. Several Neanderthal skeletons discovered in a cluster of apparent graves in a cave in Shanidar in Iraq, dated at about 70,000 years old, provided additional indications of deliberate burial. One of the graves contained pollen from flowers that occur on a nearby mountain range, indicating carriage from some distance away.

Several other cases of apparent Neanderthal burials have been reported from Eurasia. Indeed, the relatively frequent discovery of fairly complete skeletons in anatomically appropriate configurations has been taken as an indication that protection by intentional burial had been provided. Examples of such burials are La Chapelle-aux-Saints, La Ferrassie, and Regourdou in France, and Teshik-Tash in Uzbekistan. Documentation of apparent burials began in 1908 with the renowned discovery of a skeleton in a cave in La Chapelle-aux-Saints (southwestern France), dated at around 50,000 years ago. The best-preserved Neanderthal skeleton ever

found was subsequently discovered at the French site of La Ferrassie, for which an approximate age of 40,000–70,000 years ago has been determined. Here, too, the bones of the skeleton were still in their articulated positions and it was concluded that all of the bodies at La Ferrassie had been intentionally buried.

It must be noted that *all* reports of deliberate burial at Neanderthal sites have been challenged, so it is still uncertain whether our sister species did indeed engage in this practice. Furthermore, the earliest proposed evidence for Neanderthal burials dates back only 70,000 years. This leaves a considerable gap lasting hundreds of thousands of years between the common ancestor of Neanderthals and modern humans and the earliest evidence for burials in either lineage. So, if late Neanderthals did actually bury the dead, we do not know whether this practice developed independently in the two sister lineages or whether it was already present at the common ancestral stage. Whatever the case may be, this leaves us with many intriguing questions about the origins of awareness of death and notions of an afterlife, as well as how perceptions of our own corporeality and our hope to avoid its progressive degeneration played a role in the emergence of an early funerary behavior. Aging is, ultimately, part of the natural process of life, of mammals and other animals, but the contradictory reactions and particular responses that it evokes in humans are perhaps what make us truly unique as species.

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3

Soul and Vital Force: Vibrant Life Matters and Mortuary Arts in Africana Religions and Beyond

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Abstract: Religious devotees all over the world pray for long and healthy life, one hopefully filled with prosperity and purpose. However, the search for immortality is not a universal quest of humankind. In African and African Diaspora religious communities, few rituals aim to prolong life indefinitely, as this would disrupt the cosmic flow of new and returning souls journeying to earth. Instead, African-derived communities emphasize the quality of a vibrant and well-balanced life, one lived with integrity and intention to fulfill the destiny of the soul(s). This thematic essay highlights core principles of longevity, livity, and the vibrancy of life within Black Atlantic religions. These insights ultimately reveal how life's vital force is sustained through balance, ritual, and the fortification of souls and divine energies. Case studies explore other religious traditions with similar characteristics in Latin America, Africa, and Asia.

Resumen: Los devotos religiosos de todo el mundo oran por una vida prolongada y saludable, llena de prosperidad y propósito. Sin embargo, la búsqueda de la inmortalidad no es una búsqueda universal de la humanidad. En las comunidades religiosas africanas y de la diáspora africana, pocos rituales tienen como objetivo prolongar la vida indefinidamente, pues esto interrumpiría el flujo cósmico de las nuevas almas y de aquellas almas viajeras que retornan a la tierra. Más bien, las comunidades de origen africano enfatizan la calidad de una "vida vibrante" y bien equilibrada, vivida con integridad, y con una intención de cumplir aquel destino del alma. Este ensayo destaca los principios fundamentales de la longevidad, la vitalidad, y el dinamismo de la vida dentro de las religiones del Atlántico Negro. Estas perspectivas, finalmente, revelan cómo la fuerza vital de la vida se sostiene a través del equilibrio, el ritual, y la fortificación de las almas y su energía divina. Los artículos que este ensayo contiene exploran otras tradiciones religiosas con características similares en América Latina, África y Asia.

Death as Initiation

Crouched comfortably before a black-and-white tombstone, the Haitian *lwa* (spirit) Gede Nibo balances on his heels in the cemetery and casts a knowing glance toward the viewer. While the spirit Bawon Samdi is officially regarded as Haiti's lord of the cemetery in the Vodou pantheon, all divinities hailing from the Gede and Bawon spiritual families reside between their spiritual home of Afrik-Ginen (an African realm of ancestors and spirits) and the liminal realm of the graveyard (Figures 3.1–3.4). Such is the case for Gede Nibo, a renowned healer and elder in the Gede family. A wide-brimmed purple hat with a tapered green ribbon dons the spirit's head, and against the backdrop of his full black beard, a curved tobacco pipe emerges from his lips. Ever the dapper dresser, Gede (Guede in French) sports a pressed white dress shirt with purple cufflinks, and a polka-dotted handkerchief peeking out from his breast pocket matches the pattern of his purple pantaloons. A diagonally striped tie incorporates all three of his primary colors—white, black, and purple—symbolizing his dominion over the various stages of life, death, and rebirth.

The tombstone that is often represented behind Gede Nibo in many drapo flags features a prominent black cross with white diamonds and an inverted heart in the very center, both emblems from the Haitian Vodou system of divination cards. While the cross is most commonly identified as the iconic symbol of Christianity in a nation such as Haiti colonized by French Catholics, the motif also has deep historical roots as *dikenga,* an Indigenous symbol of the ancient Kongo Kingdom. In Central Africa, the Kongo cross or *dikenga* signified the cosmic crossroads between mortal and spiritual realms, a cosmogram that represented dimensions of both time and space in the mystic encounter between worlds (Thompson and Cornet 1981; Martínez-Ruiz 2013). Kongolese citizens Africanized the Catholic tradition between the sixteenth and nineteenth centuries, and claimed the cross as their own religious symbol (Thornton [1992] 1998; Fromont 2014). Similarly today in Haiti, the cross represents the nation's plural religious realities, simultaneously embodying the presence of Jesus Christ for Christians as readily as the Gede spirits for Vodouizan, devotees of the African-derived tradition Vodou. And an analogous process of religious *mestizaje* becomes evident in other communities from the Caribbean and Central America (see Wali in this volume, on Guna Christianity).

In the same type of drapo flags, the silhouette of a white candle sits on the first step of the tombstone, an