

## NOTES ON SOURCES

The following is intended as a quick guide for those who wish to check a fact or do further reading. Where a fact is commonly known or widely reported – the functions of the liver, for instance – I have not cited the source. On the whole, sources are listed only where assertions are specific, arguable, or otherwise distinctively notable.

### CHAPTER 1: HOW TO BUILD A HUMAN

- 9 **Altogether, according to RSC calculations:** The information on the cost of building a replica Benedict Cumberbatch was supplied by Karen Ogilvie of the Royal Society of Chemistry, London.
- 9 **We need, for instance, just twenty atoms:** Emsley, *Nature's Building Blocks*, p. 4.
- 11 **We now know that selenium makes two vital enzymes:** Ibid., pp. 379–80.
- 11 **you can irremediably poison your liver:** *Scientific American*, July 2015, p. 31.
- 12 **in 2012 *Nova*, the long-running science programme on the TV network PBS:** 'Hunting the Elements', *Nova*, 4 April 2012.
- 13 **Well, you blink fourteen thousand times a day:** McNeill, *Face*, p. 27.

- 14 **The length of all your blood vessels:** West, *Scale*, p. 152.
- 14 **if you formed all the DNA in your body:** Pollack, *Signs of Life*, p. 19.
- 15 **You would need twenty billion strands of DNA:** Ibid.
- 18 **Its chemical name is 189,819 letters long:** Ball, *Stories of the Invisible*, p. 48.
- 18 **Nobody knows how many types of protein:** Challoner, *Cell*, p. 38.
- 18 **All humans share 99.9 per cent of their DNA:** *Nature*, 26 June 2014, p. 463.
- 18 **My DNA and your DNA will differ:** Arney, *Herdning Hemingway's Cats*, p. 184.
- 18 **about a hundred personal mutations:** *New Scientist*, 15 Sept. 2012, pp. 30–33.
- 18 **One particular short sequence, called an Alu element:** Mukherjee, *Gene*, p. 322; Ben-Barak, *Invisible Kingdom*, p. 174.
- 20 **Five out of every six smokers:** *Nature*, 24 March 2011, p. S2.
- 20 **between one and five of your cells turns cancerous:** Samuel Cheshier, neurosurgeon and Stanford professor, quoted on *Naked Scientist* podcast, 21 March 2017.
- 20 **Our bodies are a universe of 37.2 trillion cells:** 'An Estimation of the Number of Cells in the Human Body', *Annals of Human Biology*, Nov.–Dec. 2013.
- 20 **There are thousands of things that can kill us:** *New Yorker*, 7 April 2014, pp. 38–39.
- 21 **We undertake every part of the process:** Hafer, *Not-So- Intelligent Designer*, p. 132.

## CHAPTER 2 : THE OUTSIDE: SKIN AND HAIR

- 25 **'Our seams don't burst':** Jablonski interview, State College, Pa., 29 Feb. 2016.

- 25 **We shed skin copiously, almost carelessly:** Andrews, *Life That Lives on Man*, p. 31.
- 25 **We each trail behind us:** Ibid., p. 166.
- 26 **acne, a word of very uncertain derivation:** *Oxford English Dictionary*.
- 27 **They detect light touch:** Ackerman, *Natural History of the Senses*, p. 83.
- 27 **if you sink a spade into gravel or sand:** Linden, *Touch*, p. 46.
- 27 **Curiously we don't have any receptors for wetness:** 'The Magic of Touch', *The Uncommon Senses*, BBC Radio 4, 27 March 2017.
- 27 **Women are much better than men at tactile sensitivity:** Linden, *Touch*, p. 73.
- 29 **skin gets its colour from a variety of pigments:** Jablonski interview.
- 29 **Its production slows dramatically as we age:** Challoner, *Cell*, p. 170.
- 29 **'Melanin is a superb natural sunscreen':** Jablonski interview.
- 29 **Melanin often responds to sunlight:** Jablonski, *Living Color*, p. 14.
- 30 **The red of sunburn:** Jablonski, *Skin*, p. 17.
- 31 **The formal name for sunburn is erythema:** Smith, *Body*, p. 410.
- 31 **The process is known as melasma:** Jablonski, *Skin*, p. 90.
- 31 **some 50 per cent of people globally:** *Journal of Pharmacology and Pharmacotherapeutics*, April/June 2012; *New Scientist*, 9 Aug. 2014, pp. 34–37.
- 31 **As people evolved lighter skin:** University College London press release, 'Natural Selection Has Altered the Appearance of Europeans over the Past 5000 Years', 11 March 2014.

- 32 **Skin colour has been changing:** Jablonski, *Living Color*, p. 24.
- 32 **Indigenous populations in South America:** Jablonski, *Skin*, p. 91.
- 32 **Rather harder to explain have been the KhoeSan people:** ‘Rapid Evolution of a Skin-Lightening Allele in Southern African KhoeSan,’ *Proceedings of the National Academy of Sciences*, 26 Dec. 2018.
- 33 **Cheddar Man had had ‘dark to black’ skin:** ‘First Modern Britons Had ‘Dark to Black’ Skin’, *Guardian*, 7 Feb., 2018.
- 33 **suggested that the DNA was too degraded:** *New Scientist*, 3 March 2018, p. 12.
- 33 **We are actually as hairy as our cousins the apes:** Jablonski, *Skin*, p. 19.
- 33 **Altogether we are estimated to have five million hairs:** Linden, *Touch*, p. 216.
- 34 **it provides warmth, cushioning, and camouflage:** ‘The Naked Truth’, *Scientific American*, Feb. 2010.
- 34 **In furry mammals, it adds a useful layer:** Ashcroft, *Life at the Extremes*, p. 157.
- 34 **Horripilation also makes mammalian hair stand up:** *Baylor University Medical Center Proceedings*, July 2012, p. 305.
- 34 **it is known from genetic studies that dark pigmentation:** ‘Why Are Humans So Hairy?’, *New Scientist*, 17 Oct. 2017.
- 34 **‘because it increases the thickness of the space’:** Jablonski interview.
- 34 **humans don’t seem to have pheromones:** ‘Do Human Pheromones Actually Exist?’, *Science News*, 7 March 2017.
- 36 **secondary hair is for display:** Bainbridge, *Teenagers*, pp. 44–45.
- 36 **We each grow about eight metres of hair:** *The Curious Cases of Rutherford and Fry*, BBC Radio 4, 22 Aug. 2016.

- 36 **The system introduced the concept of the mugshot:** Cole, *Suspect Identities*, p. 49.
- 39 **The uniqueness of fingerprints was first established:** Smith, *Body*, p. 409.
- 39 **They are assumed to aid in gripping:** Linden, *Touch*, p. 37.
- 39 **why our fingers wrinkle when we have long baths:** ‘Why Do We Get Prune Fingers?’, Smithsonian.com, 6 Aug. 2015.
- 39 **a condition known as adermatoglyphia:** ‘Adermatoglyphia: The Genetic Disorder of People Born Without Fingerprints’, *Smithsonian*, 14 Jan. 2014.
- 40 **Most quadrupeds cool by panting:** Daniel E. Lieberman, ‘Human Locomotion and Heat Loss: An Evolutionary Perspective’, *Comprehensive Physiology* 5, no. 1 (Jan. 2015).
- 40 **‘The loss of most of our body hair’:** Jablonski, *Living Color*, p. 26.
- 40 **a man who weighs 70kg:** Stark, *Last Breath*, pp. 283–85.
- 41 **Although salt is only a tiny part:** Ashcroft, *Life at the Extremes*, p. 139.
- 41 **Sweating is activated by the release of adrenaline:** *Ibid.*, p. 122.
- 41 **Emotional sweating is what is measured:** Tallis, *Kingdom of Infinite Space*, p. 23.
- 41 **The two chemicals that account for the odour:** Bainbridge, *Teenagers*, p. 48.
- 41 **the number of bacteria on you:** Andrews, *Life That Lives on Man*, p. 11.
- 41 **To make one’s hands safely clean:** Gawande, *Better*, pp. 14–15; ‘What Is the Right Way to Wash Your Hands?’, *Atlantic*, 23 Jan. 2017.
- 42 **One volunteer harboured a microbe:** National Geographic News, 14 Nov. 2012.

- 42 **The problem with antibacterial soaps:** Blaser, *Missing Microbes*, p. 200.
- 43 **They have lived with us for so long:** David Shultz, 'What the Mites on Your Face Say About Where You Came From', *Science*, 14 Dec. 2015, [www.sciencemag.org](http://www.sciencemag.org).
- 43 **Studies of scratching showed:** Linden, *Touch*, p. 185.
- 45 **the most extraordinary case of unappeasable suffering:** Ibid., pp. 187–89.
- 45 **We each have about 100,000:** Andrews, *Life That Lives on Man*, pp. 38–39.
- 45 **a hormone called dihydrotestosterone:** Baylor University Medical Center Proceedings, July 2012, p. 305.
- 45 **considering how easily some of us lose it:** Andrews, *Life That Lives on Man*, p. 42.

### CHAPTER 3: MICROBIAL YOU

- 49 **For nitrogen to be useful to us:** Ben-Barak, *Invisible Kingdom*, p. 58.
- 49 **Humans produce twenty digestive enzymes:**  
Interview with Professor Christopher Gardner of Stanford University, Palo Alto, 29 Jan. 2018.
- 49 **the average bacterium weighs about one trillionth:**  
*Baylor University Medical Center Proceedings*, July 2014; West, *Scale*, p. 1.
- 49 **But bacteria can swap genes:** Crawford, *Invisible Enemy*, p. 14.
- 49 **A single parent bacterium could in theory:** Lane, *Power, Sex, Suicide*, p. 114.
- 50 **In three days, its progeny:** Maddox, *What Remains to Be Discovered*, p. 170.
- 50 **If you put all the Earth's microbes in one heap:**  
Crawford, *Invisible Enemy*, p. 13.
- 50 **you are likely to have some forty thousand species:**  
'Learning About Who We Are', *Nature*, 14 June 2012;

- ‘Molecular-Phylogenetic Characterization of Microbial Community Imbalances in Human Inflammatory Bowel Diseases’, *Proceedings of the National Academy of Sciences*, 15 Aug. 2007.
- 50 **Altogether your private load of microbes:** Blaser, *Missing Microbes*, p. 25; Ben-Barak, *Invisible Kingdom*, p. 13.
- 51 **In 2016 researchers from Israel and Canada:** *Nature*, 8 June 2016.
- 52 **Microbial communities can be surprisingly specific:** ‘The Inside Story’, *Nature*, 28 May 2008.
- 52 **just 1,415 are known to cause disease in humans:** Crawford, *Invisible Enemy*, pp. 15–16; Pasternak, *Molecules Within Us*, p. 143.
- 53 **all these microbes have almost nothing in common:** ‘The Microbes Within,’ *Nature*, 25 Feb. 2015.
- 53 **The herpes virus has endured:** ‘They Reproduce, but They Don’t Eat, Breathe, or Excrete’, *London Review of Books*, 9 March 2001.
- 53 **If you blew one up to the size of a tennis ball:** Ben-Barak, *Invisible Kingdom*, p. 4.
- 53 **he called the mysterious agent *contagium vivum fluidum*:** Roossinck, *Virus*, p. 13.
- 54 **Of the hundreds of thousands of viruses:** *Economist*, 24 June 2017, p. 76.
- 54 **Proctor found that the average litre of seawater:** Zimmer, *Planet of Viruses*, pp. 42–44.
- 54 **ocean viruses alone if laid end to end:** Crawford, *Deadly Companions*, p. 13.
- 55 **Colds unquestionably are more frequent in winter:** ‘Cold Comfort’, *New Yorker*, 11 March 2002, p. 42.
- 55 **The common cold is not a single illness:** ‘Unraveling the Key to a Cold Virus’s Effectiveness’, *New York Times*, 8 Jan. 2015.

- 55 **In one, a volunteer was fitted with a device:** ‘Cold Comfort’, p. 45.
- 57 **In a similar study at the University of Arizona:** *Baylor University Medical Center Proceedings*, Jan. 2017, p. 127.
- 57 **In the real world, such infestations:** ‘Germs Thrive at Work, Too’, *Wall Street Journal*, 30 Sept. 2014.
- 57 **Where microbes thrive is in the fabrics:** *Nature*, 25 June 2015, p. 400.
- 58 ***Cryptococcus gattii* was for decades:** *Scientific American*, Dec. 2013, p. 47.
- 61 **A most arresting illustration of that:** ‘Giant Viruses’, *American Scientist*, July–Aug. 2011; Zimmer, *Planet of Viruses*, pp. 89–91; ‘The Discovery and Characterization of Mimivirus, the Largest Known Virus and Putative Pneumonia Agent’, *Emerging Infections*, 21 May 2007; ‘Ironmonger Who Found a Unique Colony’, *Daily Telegraph*, 15 Oct. 2004; *Bradford Telegraph and Argus*, 15 Oct. 2014; ‘Out on a Limb’, *Nature*, 4 Aug. 2011.
- 63 **Max von Pettenkofer was so vehemently offended:** Le Fanu, *Rise and Fall of Modern Medicine*, p. 179.
- 64 **Salvarsan was effective against only a few things:** *Journal of Antimicrobial Chemotherapy* 71 (2016).
- 66 **The principal investigator at Oxford:** Lax, *Mould in Dr Florey’s Coat*, pp. 77–79.
- 68 **By early 1941, they had just enough to trial the drug:** Le Fanu, *Rise and Fall of Modern Medicine*, pp. 3–12; *Economist*, 21 May 2016, p. 19.
- 68 **a lab assistant in Peoria named Mary Hunt:** ‘Penicillin Comes to Peoria’, *Historynet*, 2 June 2014.
- 68 **Every bit of penicillin made since that day:** Blaser, *Missing Microbes*, p. 60; ‘The Real Story Behind Penicillin’, *PBS NewsHour* website, 27 Sept. 2013.
- 68 **The British discoverers found to their chagrin:** *Oxford Dictionary of National Biography*, s.v. ‘Florey, Howard Walter’.



- 69 **Chain, despite sharing the Nobel Prize:** *Oxford Dictionary of National Biography*, s.v. 'Chain, Sir Ernst Boris'.
- 70 **By attacking a broad spectrum of bacteria:** *New Yorker*, 22 Oct. 2012, p. 36.
- 70 **Grant ended up in Yale New Haven Hospital:** Interview with Michael Kinch, Washington University of St Louis, 18 April 2018.
- 71 **antibiotics are prescribed for 70 per cent of acute bronchitis cases:** 'Superbug: An Epidemic Begins', *Harvard Magazine*, May–June 2014.
- 72 **most Americans consume second-hand antibiotics:** Blaser, *Missing Microbes*, p. 85; *Baylor University Medical Center Proceedings*, July 2012, p. 306.
- 72 Sweden banned the agricultural use of antibiotics: Blaser, *Missing Microbes*, p. 84.
- 72 **In 1977, the US Food and Drug Administration:** *Baylor University Medical Center Proceedings*, July 2012, p. 306.
- 72 **In consequence, the death rate:** Bakalar, *Where the Germs Are*, pp. 5–6.
- 72 **They have not only grown steadily more resistant:** 'Don't Pick Your Nose', *London Review of Books*, July 2004.
- 73 **methicillin-resistant *Staphylococcus aureus*:** 'World Super Germ Born in Guildford', *Daily Telegraph*, 26 Aug. 2001; 'Squashing Superbugs', *Scientific American*, July 2009.
- 73 **Today, MRSA and its cousins kill:** 'A Dearth in Innovation for Key Drugs', *New York Times*, 22 July 2014.
- 73 **CRE kills about half of all those it sickens:** *Nature*, 25 July 2013, p. 394.
- 73 **'It's just too expensive for them':** Kinch interview; 'Resistance Is Futile', *Atlantic*, 15 Oct. 2011.
- 73 **all but two of the eighteen largest:** 'Antibiotic Resistance Is Worrisome, but Not Hopeless', *New York Times*, 8 March 2016.

- 75 **At the current rate of spread:** *BBC Inside Science*, BBC Radio 4, 9 June 2016; *Chemistry World*, March 2018, p. 51.
- 75 **produce quorum-sensing drugs:** *New Scientist*, 14 Dec. 2013, p. 36.
- 75 **the most abundant bioparticles on Earth:** 'Reengineering Life', *Discovery*, BBC Radio 4, 8 May 2017.

#### CHAPTER 4: THE BRAIN

- 79 **The consistency of the brain:** 'Thanks for the Memory', *New York Review of Books*, 5 Oct. 2006; Lieberman, *Evolution of the Human Head*, p. 211.
- 79 **Altogether, the human brain is estimated to hold:** 'Solving the Brain', *Nature Neuroscience*, 17 July 2013.
- 80 **It makes up just 2 per cent of our body weight:** Allen, *Lives of the Brain*, p. 188.
- 80 **the brain is by far the most expensive of our organs:** Bribiescas, *Men*, p. 42.
- 80 **The most efficient brains:** Winston, *Human Mind*, p. 210.
- 80 **the number is more like eighty-six billion:** 'Myths That Will Not Die', *Nature*, 17 Dec. 2015.
- 82 **'in a single cubic centimetre of brain tissue':** Eagleman, *Incognito*, p. 2.
- 82 **It is divided into two hemispheres:** Ashcroft, *Spark of Life*, p. 227; Allen, *Lives of the Brain*, p. 19.
- 82 **six patches on the temporal lobe:** 'How Your Brain Recognizes All Those Faces', *Smithsonian.com*, 6 June 2017.
- 83 **Although the cerebellum occupies just 10 per cent:** Allen, *Lives of the Brain*, p. 14; Zeman, *Consciousness*, p. 57; Ashcroft, *Spark of Life*, pp. 228–29.
- 85 **how slowly or rapidly we age:** 'A Tiny Part of the Brain Appears to Orchestrate the Whole Body's Aging', *Stat*, 26 July 2017.
- 85 **People whose amygdalae are destroyed:** O'Sullivan, *Brainstorm*, p. 91.

- 85 **Your nightmares may simply be:** ‘What Are Dreams?’, *Nova*, PBS, 24 Nov. 2009.
- 86 **The eyes send a hundred billion signals:** ‘Attention’, *New Yorker*, 1 Oct. 2014.
- 86 **only about 10 per cent of the information:** *Nature*, 20 April 2017, p. 296.
- 87 **‘while we have the overwhelming impression’:** Le Fanu, *Why Us?*, p. 199.
- 88 **implant entirely false memories in people’s heads:** *Guardian*, 4 Dec. 2003, p. 8.
- 89 **One year later the psychologists asked:** *New Scientist*, 14 May 2011, p. 39.
- 90 **The mind breaks each memory:** Bainbridge, *Beyond the Zonules of Zinn*, p. 287.
- 90 **A single fleeting thought:** Lieberman, *Evolution of the Human Head*, p. 183.
- 90 **these fragments of memory:** Le Fanu, *Why Us?*, p. 213; Winston, *Human Mind*, p. 82.
- 90 **‘It’s a little more like a Wikipedia page’:** *The Why Factor*, BBC World Service, 6 Sept. 2013.
- 91 **the United States has a national memory championship:** *Nature*, 7 April 2011, p. 33.
- 91 **The idea arose principally from a series:** Draaisma, *Forgetting*, pp. 163–70; ‘Memory’, *National Geographic*, Nov. 2007.
- 93 **The person from whom we learned:** ‘The Man Who Couldn’t Remember’, *Nova*, PBS, 1 June 2009; ‘How Memory Speaks’, *New York Review of Books*, 22 May 2014; *New Scientist*, 28 Nov. 2015, p. 36.
- 94 **‘Rarely in the history of neuroscience’:** *Nature Neuroscience*, Feb. 2010, p. 139.
- 94 **Brodmann was repeatedly overlooked:** *Neurosurgery*, Jan. 2011, pp. 6–11.

- 94 **Both white matter and grey matter:** Ashcroft, *Spark of Life*, p. 229.
- 95 **the idea that we use only 10 per cent:** *Scientific American*, Aug. 2011, p. 35.
- 96 **a teenager's brain is only:** 'Get Knitting', *London Review of Books*, 18 Aug. 2005.
- 96 **The leading cause of deaths among teenagers:** *New Yorker*, 31 Aug. 2015, p. 85.
- 97 **The difficulty is that there is no certain way:** 'Human Brains Make New Nerve Cells', *Science News*, 5 April 2018; *All Things Considered* transcript, National Public Radio, 17 March 2018.
- 97 **The remaining third of his brain:** Le Fanu, *Why Us?*, p. 192.
- 98 **'If you were designing an organic machine':** 'The Mystery of Consciousness', *New York Review of Books*, 2 Nov. 1995.
- 98 **In the 1880s, in a series of operations:** Dittrich, *Patient H.M.*, p. 79.
- 99 **Moniz provided an almost perfect demonstration:** 'Unkind Cuts', *New York Review of Books*, 24 April 1986.
- 101 **The procedure was so crude:** 'The Lobotomy Files: One Doctor's Legacy', *Wall Street Journal*, 12 Dec. 2013.
- 102 **Freeman was a psychiatrist with no surgical certification:** El-Hai, *Lobotomist*, p. 209.
- 102 **About two-thirds of Freeman's subjects:** *Ibid.*, p. 171.
- 102 **His most notorious failure was Rosemary Kennedy:** *Ibid.*, pp. 173–74.
- 103 **the very fact that the brain is so snugly encased:** Sanghavi, *Map of the Child*, p. 107; Bainbridge, *Beyond the Zonules of Zinn*, pp. 233–35.
- 103 **known as contrecoup injuries:** Lieberman, *Evolution of the Human Head*, p. 217.

- 104 **In Britain, epilepsy remained on the statute books:** *Literary Review*, Aug. 2016, p. 36.
- 104 **‘The history of epilepsy can be summarised’:** *British Medical Journal* 315 (1997).
- 106 **Capgras syndrome is a condition:** ‘Can the Brain Explain Your Mind?’, *New York Review of Books*, 24 March 2011.
- 106 **In Klüver-Bucy syndrome the victim develops:** ‘Urge’, *New York Review of Books*, 24 Sept. 2015.
- 106 **Perhaps the most bizarre of all:** Sternberg, *NeuroLogic*, p. 133.
- 106 **Locked-in syndrome is different again:** Owen, *Into the Grey Zone*, p. 4.
- 106 **No one knows how many:** ‘The Mind Reader’, *Nature Neuroscience*, 13 June 2014.
- 107 **It may be simply that a less robust:** Lieberman, *Evolution of the Human Head*, p. 556; ‘If Modern Humans Are So Smart, Why Are Our Brains Shrinking?’, *Discover*, 20 Jan. 2011.

## CHAPTER 5: THE HEAD

- 111 **Mary, Queen of Scots, needed three hearty whacks:** Larson, *Severed*, p. 13.
- 111 **Charlotte Corday, guillotined in 1793:** Ibid., p. 246.
- 113 **Davis became so celebrated:** *Australian Indigenous Law Review*, no. 92 (2007); *New Literatures Review*, University of Melbourne, Oct. 2004.
- 113 **He was convinced that a person’s intellect:** *Anthropological Review*, Oct. 1868, pp. 386–94.
- 113 **he referred to it as ‘Mongolism’:** Blakelaw and Jennett, *Oxford Companion to the Body*, p. 249; *Oxford Dictionary of National Biography*.
- 114 **In one case, cited by Stephen Jay Gould:** Gould, *Mismeasure of Man*, p. 138.

- 114 **In 1861, during an autopsy on a stroke victim:** Le Fanu, *Why Us?*, p. 180; ‘The Inferiority Complex’, *New York Review of Books*, 22 Oct. 1981.
- 115 **No two authorities seem to agree:** See McNeill, *Face*, p. 180; Perrett, *In Your Face*, p. 21; ‘A Conversation with Paul Ekman’, *New York Times*, 5 Aug. 2003.
- 116 **Babies fresh from the womb:** McNeill, *Face*, p. 4.
- 116 **Although the change was too slight:** *Ibid.*, p. 26.
- 117 **the French anatomist G.-B. Duchenne de Boulogne:** *New Yorker*, 12 Jan. 2015, p. 35.
- 117 **we all indulge in ‘microexpressions’:** ‘Conversation with Paul Ekman’.
- 118 **in favour of our small, active eyebrows:** ‘Scientists Have an Intriguing New Theory About Our Eyebrows and Foreheads’, *Vox*, 9 April 2018.
- 118 **One of the reasons the *Mona Lisa*:** Perrett, *In Your Face*, p. 18.
- 118 **external nose and intricate sinuses:** Lieberman, *Evolution of the Human Head*, p. 312.
- 119 **we have as many as thirty-three systems:** *The Uncommon Senses*, BBC Radio 4, 20 March 2017.
- 119 **your own white blood cells:** ‘Blue Sky Sprites’, *Naked Scientists*, podcast, 17 May 2016; ‘Evolution of the Human Eye’, *Scientific American*, July 2011, p. 53.
- 120 ***muscae volitantes*, or ‘hovering flies’:** ‘Meet the Culprits Behind Bright Lights and Strange Floaters in Your Vision’, *Smithsonian.com*, 24 Dec. 2014.
- 120 **If you held a human eyeball:** McNeill, *Face*, p. 24.
- 121 **The lens, which gets all the credit:** Davies, *Life Unfolding*, p. 231.
- 122 **Tears not only keep our eyelids:** Lutz, *Crying*, pp. 67–68.
- 122 **you produce about five to ten ounces of tears:** *Ibid.*, p. 69.

- 124 **Our sclerae are unique:** Lieberman, *Evolution of the Human Head*, p. 388.
- 124 **Their main problem isn't that their world is pallid:** 'Outcasts of the Islands', *New York Review of Books*, 6 March 1997.
- 125 **Much later, primates re-evolved the ability:** *National Geographic*, Feb. 2016, p. 56.
- 125 **The movements of the eye are called saccades:** *New Scientist*, 14 May 2011, p. 356; Eagleman, *Brain*, p. 60.
- 125 **Victorian naturalists sometimes cited this:** Blakelaw and Jennett, *Oxford Companion to the Body*, p. 82; Roberts, *Incredible Unlikelihood of Being*, p. 114; Eagleman, *Incognito*, p. 32.
- 127 **They were jaw bones in our ancient ancestors:** Shubin, *Your Inner Fish*, pp. 160–62.
- 128 **A pressure wave that moves the eardrum:** Goldsmith, *Discord*, pp. 6–7.
- 128 **From the quietest detectable sound to the loudest:** *Ibid.*, p. 161.
- 129 **This means that all sound waves:** Bathurst, *Sound*, pp. 28–29.
- 129 **The term was coined by Colonel Sir Thomas Fortune Purves:** *Ibid.*, p. 124.
- 130 **The reason we feel dizzy:** Bainbridge, *Beyond the Zonules of Zinn*, p. 110.
- 130 **When loss of balance is prolonged:** Francis, *Adventures in Human Being*, p. 63.
- 131 **half of people under the age of thirty:** 'World Without Scent', *Atlantic*, 12 Sept. 2015.
- 132 **'Smell is something of an orphan science':** Interview with Gary Beauchamp, Monell Chemical Senses Center, Philadelphia, 2016.
- 132 **the receptors are activated:** Al-Khalili and McFadden, *Life on the Edge*, pp. 158–59.

- 133 **A banana, for example, contains three hundred volatiles:** Shepherd, *Neurogastronomy*, pp. 34–37.
- 133 **Tomatoes have four hundred:** Gilbert, *What the Nose Knows*, p. 45.
- 133 **The smell of burned almonds:** Brooks, *At the Edge of Uncertainty*, p. 149.
- 133 **The smell of liquorice:** ‘Secret of Liquorice Smell Unravelling’, *Chemistry World*, Jan. 2017.
- 134 **it was first suggested way back in 1927:** Holmes, *Flavor*, p. 49.
- 134 **In 2014, researchers at the Pierre and Marie Curie University:** *Science*, 21 March 2014.
- 134 **‘These claims have no basis’:** ‘Sniffing Out Answers: A Conversation with Markus Meister’, Caltech press release, 8 July 2015. (<https://www.caltech.edu/about/news/sniffing-out-answers-conversation-markus-meister-47229>).
- 134 **why certain odours are so powerfully evocative of memories:** Monell website, ‘Olfaction Primer: How Smell Works’.
- 134 **researchers at the University of California:** ‘Mechanisms of Scent-Tracking in Humans’, *Nature*, 4 Jan. 2007.
- 135 **For five of fifteen smells tested:** Holmes, *Flavor*, p. 63.
- 135 **Babies and mothers are similarly skilful:** Gilbert, *What the Nose Knows*, p. 63.
- 135 **One of the early symptoms of Alzheimer’s:** Platoni, *We Have the Technology*, p. 39.
- 135 **Ninety per cent of people who lose smell:** Blodgett, *Remembering Smell*, p. 19.

## CHAPTER 6: DOWN THE HATCH: THE MOUTH AND THROAT

- 139 **Midway through the entertainment:** ‘Profiles’, *New Yorker*, 9 Sept. 1953; Vaughan, *Isambard Kingdom Brunel*, pp. 196–97.



- 141 **he was the person who first postulated:** Birkhead, *Most Perfect Thing*, p. 150.
- 141 **The anatomist's word for swallowing:** Collis, *Living with a Stranger*, p. 20.
- 142 **choking is the fourth most common:** Lieberman, *Evolution of the Human Head*, p. 297.
- 143 **Henry Heimlich was something of a showman:** 'The Choke Artist', *New Republic*, 23 April 2007; *New York Times* obituary, 23 April 2007.
- 144 **2,374 imprudently ingested items:** Cappello, *Swallow*, pp. 4–6; *New York Times*, 11 Jan. 2011.
- 145 **Jackson was a cold and friendless man:** *Annals of Thoracic Surgery* 57 (1994), pp. 502–5.
- 146 **A typical adult secretes:** 'Gut Health May Begin in the Mouth', *Harvard Magazine*, 20 Oct. 2017.
- 146 **we secrete about thirty thousand litres:** Tallis, *Kingdom of Infinite Space*, p. 25.
- 147 **a powerful painkiller called opiorphin:** 'Natural Painkiller Found in Human Spit', *Nature*, 13 Nov. 2006.
- 147 **We produce very little saliva while we sleep:** Enders, *Gut*, p. 22.
- 147 **150 different chemical compounds:** *Scientific American*, May 2013, p. 20.
- 147 **Altogether, about a thousand species of bacteria:** Ibid.
- 147 **Dawson's team found that candle-blowing:** Clemson University press release, 'A True Food Myth Buster', 13 Dec. 2011.
- 149 **teeth have been called 'ready-made fossils':** Ungar, *Evolution's Bite*, p. 5.
- 149 **if you are a typical adult male:** Lieberman, *Evolution of the Human Head*, p. 226.
- 149 **the most regenerative of all cells in the body:** *New Scientist*, 16 March 2013, p. 45.

- 149 **In fact, that is a myth, traced to a textbook:** *Nature*, 21 June 2012, p. S2.
- 149 **the body has taste receptors in the gut and throat:** Roach, *Gulp*, p. 46.
- 150 **Taste receptors have also been found:** *New Scientist*, 8 Aug. 2015, pp. 40–41.
- 150 **These contain a poison called tetrodotoxin:** Ashcroft, *Life at the Extremes*, p. 54; ‘Last Supper?’, *Guardian*, 5 Aug. 2016.
- 151 **the British author Nicholas Evans:** ‘I Wanted to Die. It Was So Grim’, *Daily Telegraph*, 2 Aug. 2011.
- 151 **We have about ten thousand taste receptors:** ‘A Matter of Taste?’, *Chemistry World*, Feb. 2017; Holmes, *Flavor*, p. 83; ‘Fire-Eaters’, *New Yorker*, 4 Nov. 2013.
- 152 **A purified version of a Moroccan species:** Holmes, *Flavor*, p. 85.
- 153 **Chinese adults who consumed a lot of capsaicin:** *Baylor University Medical Center Proceedings*, Jan. 2016, p. 47.
- 153 **Some authorities believe we also have:** *New Scientist*, 8 Aug. 2015, pp. 40–41.
- 154 **Today Ajinomoto is a behemoth:** Mouritsen and Styrbæk, *Umami*, p. 28.
- 155 **Smell is said to account for:** Holmes, *Flavor*, p. 21.
- 156 **The students without exception listed:** *BMC Neuroscience*, 18 Sept. 2007.
- 156 **if an orange-flavoured drink is coloured red:** *Scientific American*, Jan. 2013, p. 69.
- 156 **‘are perhaps more extensively debated’:** Lieberman, *Evolution of the Human Head*, p. 315.
- 158 **Within and around it are nine cartilages:** *Ibid.*, p. 284.
- 160 **Johann Dieffenbach, one of Germany’s most eminent surgeons:** ‘The Paralysis of Stuttering’, *New York Review of Books*, 26 April 2012.

## CHAPTER 7: THE HEART AND BLOOD

- 163 **‘Stopped’:** Quoted in ‘In the Hands of Any Fool’, *London Review of Books*, 3 July 1997.
- 165 **That symbol first appeared:** Peto, *Heart*, p. 30.
- 165 **Every hour your heart dispenses:** Nuland, *How We Die*, p. 22.
- 165 **It has been calculated:** Morris, *Bodywatching*, p. 11.
- 166 **Of all the blood pumped out:** Blakelaw and Jennett, *Oxford Companion to the Body*, pp. 88–89.
- 166 **Every time you stand up:** *The Curious Cases of Rutherford and Fry*, BBC Radio 4, 13 Sept. 2016.
- 168 **Much of the early research on blood pressure:** Amidon and Amidon, *Sublime Engine*, p. 116; *Oxford Dictionary of National Biography*, s.v. ‘Hales, Stephen’.
- 169 **Well into the twentieth century:** ‘Why So Many of Us Die of Heart Disease’, *Atlantic*, 6 March 2018.
- 169 **in 2017 the American Heart Association:** ‘New Blood Pressure Guidelines Put Half of US Adults in Unhealthy Range’, *Science News*, 13 Nov. 2017.
- 169 **At least 50 million Americans:** Amidon and Amidon, *Sublime Engine*, p. 227.
- 169 **In the United States alone:** Health, United States, 2016, DHSS Publication No. 2017-1232, May 2017.
- 170 **A heart attack and a cardiac arrest:** Wolpert, *You’re Looking Very Well*, p. 18; ‘Don’t Try This at Home’, *London Review of Books*, 29 Aug. 2013.
- 171 **For about a quarter of victims:** *Baylor University Medical Center Proceedings*, April 2017, p. 240.
- 171 **A woman is more likely to experience:** Brooks, *At the Edge of Uncertainty*, pp. 104–5.
- 171 **the Hmong people of Southeast Asia:** Amidon and Amidon, *Sublime Engine*, pp. 191–92.

- 172 **Hypertrophic cardiomyopathy is the condition:** ‘When Genetic Autopsies Go Awry’, *Atlantic*, 11 Oct. 2016.
- 172 **The triggering event for public awareness:** Pearson, *Life Project*, pp. 101–3.
- 173 **the Framingham study recruited five thousand local adults:** Ibid.; [framinghamheartstudy.org](http://framinghamheartstudy.org).
- 174 **he fed a catheter into an artery in his arm:** Nourse, *Body*, p. 85.
- 175 **build a machine that could oxygenate blood artificially:** Le Fanu, *Rise and Fall of Modern Medicine*, p. 95; National Academy of Sciences, biographical memoir by Harris B. Schumacher Jr, Washington, DC, 1982.
- 176 **In 1958, a Swedish engineer named Rune Elmqvist:** Ashcroft, *Spark of Life*, pp. 152–53.
- 178 **in 2000 he killed himself:** *New York Times* obituary, 21 Aug. 2000; ‘Interview: Dr. Steven E. Nissen’, *Take One Step*, PBS, Aug. 2006, [www.pbs.org](http://www.pbs.org).
- 178 **To remove a beating heart:** *Baylor University Medical Center Proceedings*, Oct. 2017, p. 476.
- 179 **Frey’s sample contained a fungus:** Ibid., p. 247.
- 179 **success rates of 80 per cent:** Le Fanu, *Rise and Fall of Modern Medicine*, p. 102.
- 179 **Today some four to five thousand heart transplants:** Amidon and Amidon, *Sublime Engine*, pp. 198–99.
- 179 **The young woman’s parents argue:** *Economist*, 28 April 2018, p. 56.
- 180 **‘heart disease kills about the same number’:** Kinch, *Prescription for Change*, p. 112.
- 181 **By 2000, a million precautionary angioplasties:** Welch, *Less Medicine, More Health*, pp. 34–36.
- 181 **‘This is really American medicine at its worst’:** Ibid., p. 38.

- 183 **A newborn baby contains only about half a pint:** Collis, *Living with a Stranger*, p. 28.
- 183 **25,000 miles of blood vessels:** Pasternak, *Molecules Within Us*, p. 58.
- 183 **a single drop of blood:** Hill, *Blood*, pp. 14–15.
- 183 **In the United States, plasma sales:** *Economist*, 12 May 2018, p. 12.
- 184 **Haemoglobin has one strange and dangerous quirk:** Annals of Medicine, *New Yorker*, 31 Jan. 1970.
- 184 **Each will be shot around your body:** Blakelaw and Jennett, *Oxford Companion to the Body*, p. 85.
- 185 **In severe bleeding, the body:** Miller, *Body in Question*, pp. 121–22.
- 186 **They also play important roles in immune response:** *Nature*, 28 Sept. 2017, p. S13.
- 187 **Nearly all Harvey's peers thought him:** Zimmer, *Soul Made Flesh*, p. 74.
- 187 **Harvey couldn't explain how blood circulating:** Wootton, *Bad Medicine*, pp. 95–98.
- 187 **Lower transfused about half a pint:** 'An Account of the Experiment of Transfusion, Practised upon a Man in London', *Proceedings of the Royal Society of London*, 9 Dec. 1667.
- 190 **'cools and ventilates the blood':** Zimmer, *Soul Made Flesh*, p. 152.
- 192 **'I have observed the most speedy convalescence':** 'Politics of Yellow Fever in Alexander Hamilton's America,' US National Library of Medicine, undated. (<https://www.nlm.nih.gov/exhibition/politicsofyellowfever/collection-transcript14.html>).
- 192 **William Osler, author of *The Principles and Practice of Medicine*:** 'An Autopsy of Dr. Osler', *New York Review of Books*, 25 May 2000.
- 192 **Although everybody reads and pronounces:** Nourse, *Body*, p. 184.

- 193 **There are some four hundred kinds of antigens:** Sanghavi, *Map of the Child*, p. 64
- 195 **'Blood is a living tissue':** Dr Allan Doctor interview, Oxford, 18 Sept. 2018.
- 197 **For more than fifty years:** 'The Quest for One of Science's Holy Grails: Artificial Blood', *Stat*, 27 Feb. 2017; 'Red Blood Cell Substitutes', *Chemistry World*, 16 Feb. 2018.
- 197 **a \$1.6 million saving in costs:** 'Save Blood, Save Lives', *Nature*, 2 April 2015.

## CHAPTER 8: THE CHEMISTRY DEPARTMENT

- 201 **One twelve-year-old boy was left so hungry:** Bliss, *Discovery of Insulin*, p. 37.
- 202 **'wrongly conceived, wrongly conducted':** Ibid., pp. 12–13.
- 202 **'The discovery of insulin':** 'The Pissing Evile', *London Review of Books*, 1 Dec. 1983.
- 204 **Others have suggested an imbalance:** 'Cause and Effect', *Nature*, 17 May 2012.
- 204 **Between 1980 and 2014, the number of adults:** *Nature*, 26 May 2016, p. 460.
- 205 **That means that insulin levels:** 'The Edmonton Protocol', *New Yorker*, 10 Feb. 2003.
- 206 **'I love hormones':** Interviews with Dr John Wass, Oxford, 21 March and 17 Sept. 2018.
- 210 **Starling coined the term 'hormone':** Sengoopta, *Most Secret Quintessence of Life*, p. 4.
- 211 **History's most famous sufferer:** *Journal of Clinical Endocrinology and Metabolism*, 1 Dec. 2006, pp. 4849–53; 'The Medical Ordeals of JFK', *Atlantic*, Dec. 2002.
- 214 **Yet in tests where oxytocin:** *Nature*, 25 June 2015, pp. 410–12.
- 216 **Perhaps no one has better understood:** *Biographical Memoirs of Fellows of the Royal Society*, London, Nov. 1998; *New York Times* obituary, 19 Jan. 1995.

- 217 **In what way exactly testosterone might shorten:**  
Bribiescas, *Men*, p. 202.
- 217 **there is much greater evidence:** *New Scientist*, 16 May 2015, p. 32.
- 218 **Non-alcoholic fatty liver disease:** *Nature*, 23 Nov. 2017, p. S85; *Annals of Internal Medicine*, 6 Nov. 2018.
- 224 **Each day they process about 180 litres:** Pasternak, *Molecules Within Us*, p. 60.
- 225 **As we age, the bladder loses elasticity:** Nuland, *How We Die*, p. 55.
- 225 **the urinary world is at least somewhat microbial:**  
*Nature*, 9 Nov. 2017, p. S40.
- 228 **Probably history's most famous lithotomy:** Tomalin, *Samuel Pepys*, pp. 60–65.
- 229 **Pepys for his part marked the anniversary:** 'Samuel Pepys and His Stones', *Annals of the Royal College of Surgeons* 59 (1977).

## CHAPTER 9 : IN THE DISSECTING ROOM: THE SKELETON

- 233 **'Feel this,' Dr Ben Ollivere is saying to me:** Dr Ben Ollivere interview, Nottingham, 23–24 June 2017.
- 236 **there was a brief scandal in America:** 'Yale Students and Dental Professor Took Selfie with Severed Heads', *Guardian*, 5 Feb. 2018.
- 237 **When the great anatomist Andreas Vesalius:**  
Wootton, *Bad Medicine*, p. 74.
- 237 William Harvey, in England, was so desperate: Larson, *Severed*, p. 217.
- 239 **Fallopippo and the criminal together:** Wootton, *Bad Medicine*, p. 91.
- 240 **All of his illustrations had to be drawn:** *Baylor University Medical Center Proceedings*, Oct. 2009, pp. 342–45.

- 243 **regular exercise helps to stave off Alzheimer's:** 'Do Our Bones Influence Our Minds?', *New Yorker*, 1 Nov. 2013.
- 245 **It takes one hundred muscles:** Collis, *Living with a Stranger*, p. 56.
- 246 **Studies by NASA have shown:** NASA information sheet, 'Muscle Atrophy'.
- 247 **Sir Charles Bell, the great:** *Oxford Dictionary of National Biography*, s.v. 'Bell, Sir Charles'.
- 247 **What we do have in our thumbs:** Roberts, *Incredible Unlikelihood of Being*, pp. 333–35.
- 248 **A good deal of what we know:** Francis, *Adventures in Human Being*, pp. 126–27.
- 249 **The average human walks at a pace:** 'Gait Analysis: Principles and Applications', *American Academy of Orthopaedic Surgeons*, Oct. 1995.
- 250 **ostriches have eliminated this problem:** Taylor, *Body by Darwin*, p. 85.
- 250 **'as early as the eighteenth year':** Medawar, *Uniqueness of the Individual*, p. 109.
- 250 **An estimated 60 per cent of adults:** Wall, *Pain*, pp. 100–101.
- 251 **surgeons perform over 800,000 joint replacements:** 'The Coming Revolution in Knee Repair', *Scientific American*, March 2015.
- 253 **Almost no one has heard of Charnley:** Le Fanu, *Rise and Fall of Modern Medicine*, pp. 104–8.
- 253 **three-quarters of men and half of women:** Wolpert, *You're Looking Very Well*, p. 21.

## CHAPTER 10: ON THE MOVE: BIPEDALISM AND EXERCISE

- 257 **In 2016 anthropologists at the University of Texas:** 'Perimortem Fractures in Lucy Suggest Mortality from Fall Out of Tall Tree', *Nature*, 22 Sept. 2016.



- 258 **A chimpanzee uses four times:** Lieberman, *Story of the Human Body*, p. 42.
- 260 **Fossil evidence suggests that early hominins:** ‘The Evolution of Marathon Running’, *Sports Medicine* 37, no. 4–5 (2007); ‘Elastic Energy Storage in the Shoulder and the Evolution of High-Speed Throwing in Homo’, *Nature*, 27 June 2013.
- 262 **Jeremy Morris, became convinced:** Jeremy Morris obituary, *New York Times*, 7 Nov. 2009.
- 263 **Going for regular walks reduces the risk:** *New Yorker*, 20 May 2013, p. 46.
- 263 **Being active for an hour or more:** *Scientific American*, Aug. 2013, p. 71; ‘Is Exercise Really Medicine? An Evolutionary Perspective’, *Current Sports Medicine Reports*, July–Aug. 2015.
- 263 **The ten-thousand-step idea:** ‘Watch Your Step’, *Guardian*, 3 Sept. 2018.
- 264 **Only about 20 per cent of people:** ‘Is Exercise Really Medicine?’
- 264 **Today the average American walks:** Lieberman, *Story of the Human Body*, pp. 217–18.
- 264 **‘Some workers have reportedly’:** *Economist*, 5 Jan. 2019, p. 50.
- 264 **Modern hunter-gatherers, by contrast:** ‘Is Exercise Really Medicine?’
- 264 **‘If you want to understand the human body’:** Lieberman interview.
- 265 **If everybody else in the world:** ‘Eating Disorder’, *Economist*, 19 June 2012.
- 265 **A bodybuilder and a couch potato:** ‘The Fat Advantage’, *Nature*, 15 Sept. 2016.
- 265 **the average woman in the United States:** *Baylor University Medical Center Proceedings*, Jan. 2016.
- 266 **more than half of today’s children:** ‘Interest in Ketogenic Diet Grows for Weight Loss and Type 2

- Diabetes', *Journal of the American Medical Association*, 16 Jan. 2018.
- 266 **The current generation of young people:** Zuk, *Paleofantasy*, p. 5.
- 266 **The British are among the tubbiest:** *Economist*, 31 March 2018, p. 30.
- 266 **The global figure for obesity is 13 per cent:** *Economist*, 6 Jan. 2018, p. 20.
- 266 **According to one calculation, you must walk:** 'The Bear's Best Friend', *New York Review of Books*, 12 May 2016.
- 266 **people overestimated the number:** 'Exercise in Futility', *Atlantic*, April 2016.
- 266 **a worker on a factory floor:** Lieberman, *Story of the Human Body*, p. 217.
- 267 **People who sit a lot:** 'Are You Sitting Comfortably? Well, Don't', *New Scientist*, 26 June 2013.
- 267 **If you spend an evening:** 'Our Amazingly Plastic Brains', *Wall Street Journal*, 6 Feb. 2015; 'The Futility of the Workout-Sit Cycle', *Atlantic*, 16 Aug. 2016.
- 267 **James Levine, an obesity expert:** 'Killer Chairs: How Desk Jobs Ruin Your Health', *Scientific American*, Nov. 2014.
- 267 **That alone burned sixty-five extra calories an hour:** *New Scientist*, 25 Aug. 2012, p. 41.
- 269 **'a pile of rubbish':** 'The Big Fat Truth', *Nature*, 23 May 2013.

## CHAPTER 11: EQUILIBRIUM

- 273 **little creatures have to produce heat:** Blumberg, *Body Heat*, pp. 35–38.
- 273 **One area where animals are curiously:** West, *Scale*, p. 197.
- 273 **A typical mammal uses about thirty times:** Lane, *Power, Sex, Suicide*, p. 179.

- 274 **To stray more than a very few degrees:** Blumberg, *Body Heat*, p. 206.
- 274 **That experiment largely recalled:** Royal Society, 'Experiments and Observations in an Heated Room by Charles Blagden, 1774'.
- 275 **Curiously, no one knows quite why this happens:** Ashcroft, *Life at the Extremes*, pp. 133–34; Blumberg, *Body Heat*, pp. 146–47.
- 275 **An increase of only a degree or so:** Davis, *Beautiful Cure*, p. 113.
- 277 **The idea, incidentally, that we lose most of our heat:** 'Myth: We Lose Most Heat from Our Heads', *Naked Scientists* podcast, 24 Oct. 2016.
- 277 **The man who coined the term:** *Obituary Notices of Fellows of the Royal Society* 5, no. 15 (Feb. 1947): pp. 407–23; *American National Biography*, s.v. 'Cannon, Walter Bradford'.
- 278 **paper on the practice of voodoo:** '“Voodoo” Death', *American Anthropologist*, April–June 1942.
- 279 **Every day you produce and use:** West, *Scale*, p. 100.
- 279 **you have only 60 grams:** Lane, *Vital Question*, p. 63.
- 280 **The person who discovered:** *Biographical Memoirs*, Royal Society, London.
- 280 **'I was your first wife':** *Biochemistry and Biology Molecular Education* 32, no. 1 (2004): pp. 62–66.
- 281 **A child half your height:** 'Size and Shape', *Natural History*, Jan. 1974.
- 281 **a British airman in the Second World War:** 'The Indestructible Alkemade', RAF Museum website, posted 24 Dec. 2014.
- 283 **Consider the case of little Erika Nordby:** *Edmonton Sun*, 28 Aug. 2014.
- 284 **Between 1998 and August 2018, almost eight hundred children:** Full details can be found at the website [noheatstroke.org](http://noheatstroke.org).

- 284 **The highest permanent settlements in the world:** Ashcroft, *Life at the Extremes*, p. 8.
- 284 **Tenzing Norgay and Raymond Lambert:** Ibid., p. 26.
- 285 **At sea level, about 40 per cent of your blood volume:** Ibid., p. 341.
- 286 **Ashcroft notes the case of a pilot:** Ibid., p. 19.
- 287 **In Nazi Germany, healthy prisoners:** Annas and Grodin, *Nazi Doctors and the Nuremberg Code*, pp. 25–26.
- 289 **In a typical experiment, Chinese prisoners:** Williams and Wallace, *Unit 731*, p. 42.
- 289 **Some, for unfathomable reasons, were dissected:** ‘Blood and Money’, *New York Review of Books*, 4 Feb. 1999.
- 289 **When pregnant women or young children:** Lax, *Toxin*, p. 123.
- 289 **a student from Keio University in Tokyo:** Williams and Wallace, *Unit 731*.

## CHAPTER 12 : THE IMMUNE SYSTEM

- 293 **we have some three hundred different types of immune cell:** ‘Ambitious Human Cell Atlas Aims to Catalog Every Type of Cell in the Body’, National Public Radio, 13 Aug. 2018.
- 293 **‘A dendritic cell in the skin’:** Interview with Professor Daniel Davis, University of Manchester, 30 Nov. 2018.
- 293 **If you are stressed or exhausted:** ‘Department of Defense’, *New York Review of Books*, 8 Oct. 1987.
- 294 **Altogether about 5 per cent of us suffer:** Davis, *Beautiful Cure*, p. 149.
- 294 **‘just about the cleverest little cells’:** Bainbridge, *Visitor Within*, p. 185.
- 295 **the thymus is a nursery for T-cells:** Davis, *Compatibility Gene*, p. 38.
- 296 **‘the last person to identify the function’:** *Lancet*, 8 Oct. 2011, p. 1290.

- 298 **Faulty inflammation has been linked:** ‘Inflamed’, *New Yorker*, 30 Nov. 2015.
- 298 **‘the immune system gets so ramped up’:** Kinch interview.
- 300 **‘vivacious, sociable, debonair, brilliant in conversation’:** ‘High on Science’, *New York Review of Books*, 16 Aug. 1990.
- 300 **‘For all the clinical good will’:** Medawar, *Uniqueness of the Individual*, p. 132.
- 301 **Richard Herrick of Marlborough:** Le Fanu, *Rise and Fall of Modern Medicine*, pp. 121–23; ‘A Transplant Makes History’, *Harvard Gazette*, 22 Sept. 2011.
- 302 **As of late 2018, 114,000 people:** ‘The Disturbing Reason Behind the Spike in Organ Donations’, *Washington Post*, 17 April 2018.
- 303 **People on dialysis live an extra eight years:** *Baylor University Medical Center Proceedings*, April 2014.
- 304 **One possible solution would be to use animal transplants:** ‘Genetically Engineering Pigs to Grow Organs for People’, *Atlantic*, 10 Aug. 2017.
- 304 **Altogether humans are afflicted by some fifty types:** Davis, *Beautiful Cure*, p. 149.
- 304 **Before 1932, when Burrill Crohn:** Blaser, *Missing Microbes*, p. 177.
- 304 **Lieberman suggests that the overuse:** Lieberman, *Story of the Human Body*, p. 178.
- 305 **autoimmune diseases are grossly sexist:** Bainbridge, *X in Sex*, p. 157; Martin, *Sickening Mind*, p. 72.
- 305 **The word’s first appearance in English:** *Oxford English Dictionary*.
- 305 **Roughly 50 per cent of people claim:** ‘Skin: Into the Breach’, *Nature*, 23 Nov. 2011.
- 306 **one child on an aeroplane:** Pasternak, *Molecules Within Us*, p. 174.

- 307 **America's National Institute of Allergy and Infectious Diseases:** 'Feed Your Kids Peanuts, Early and Often, New Guidelines Urge', *New York Times*, 5 Jan. 2017.
- 307 **the well-known 'hygiene hypothesis':** 'Lifestyle: When Allergies Go West', *Nature*, 24 Nov. 2011; Yong, *I Contain Multitudes*, p. 122; 'Eat Dirt?', *Natural History*, n.d.

### CHAPTER 13: DEEP BREATH: THE LUNGS AND BREATHING

- 313 **Every time you breathe, you exhale:** *Chemistry World*, Feb. 2018, p. 66.
- 313 **about 20 per cent of all antibiotic prescriptions:** *Scientific American*, Feb. 2016, p. 32.
- 314 **sneeze droplets can travel up to eight metres:** 'Where Sneezes Go', *Nature*, 2 June 2016; 'Why Do We Sneeze?', *Smithsonian*, 29 Dec. 2015.
- 317 **Our lungs can hold about six litres:** 'Breathe Deep', *Scientific American*, Aug. 2012.
- 317 **If you are an averagely sized adult:** West, *Scale*, p. 152.
- 318 **Before opening his mail:** Carter, *Marcel Proust*, p. 72.
- 318 **Wherever he was in the world:** *Ibid.*, p. 224.
- 319 **It is the fourth leading cause:** Jackson, *Asthma*, p. 159.
- 320 **Japan, for instance, has not seen a great increase:** 'Lifestyle: When Allergies Go West', *Nature*, 24 Nov. 2011.
- 320 **'You probably think asthma is caused':** Interview with Professor Neil Pearce, London School of Hygiene and Tropical Medicine, 28 Nov. 2018.
- 321 **In an asthma attack, the airways narrow:** 'Asthma: Breathing New Life into Research', *Nature*, 24 Nov. 2011.
- 323 **In what way exactly Western lifestyles:** 'Lifestyle: When Allergies Go West'; 'Asthma and the Westernization "Package"', *International Journal of Epidemiology* 31 (2002), pp. 1098–102.

- 323 **'We now have a population':** 'Lifestyle: When Allergies Go West', *Nature*, 24 Nov. 2011.
- 323 **A person who smokes cigarettes regularly:** 'Getting Away with Murder', *New York Review of Books*, 19 July 2007.
- 326 **When Britain's Minister of Health, Iain Macleod:** Wootton, *Bad Medicine*, p. 263.
- 326 **'No one has established that cigarette smoke':** 'Getting Away with Murder'.
- 326 **the average American adult was smoking:** 'A Reporter at Large', *New Yorker*, 30 Nov. 1963.
- 328 **The number of cigarettes smoked:** Smith, *Body*, p. 329.
- 328 **one of the board members:** 'Cancer: Malignant Maneuvers', *New York Review of Books*, 6 March 2008.
- 328 **As late as 1973 Nature ran an editorial:** 'Get the Placentas', *London Review of Books*, 2 June 2016.
- 328 **The world record for hiccups:** *Sioux City Journal*, 4 Jan. 2015.

#### CHAPTER 14: FOOD, GLORIOUS FOOD

- 333 **Americans today consume about 25 per cent:** *Baylor University Medical Center Proceedings*, Jan. 2017, p. 134.
- 333 **The father of caloric measurement:** *American National Biography*, s.v. 'Atwater, Wilbur Olin'; USDA Agricultural Research Service website; Wesleyan University website.
- 335 **we should eat a lot of meat:** McGee, *On Food and Cooking*, p. 534.
- 336 **You may eat 170 calories' worth of almonds:** 'Everything You Know About Calories Is Wrong', *Scientific American*, Sept. 2013.
- 336 **'You can't possibly have a large brain':** Interview with Professor Daniel Lieberman, London, 22 Oct. 2018.
- 338 **'a figment of the imagination':** Gratzner, *Terrors of the Table*, p. 170.

- 341 **‘such a poorly done paper’:** ‘Nutrition: Vitamins on Trial’, *Nature*, 25 June 2014.
- 341 **Americans can choose from among:** ‘How Did We Get Hooked on Vitamins?’, *The Inquiry*, BBC World Service, 31 Dec. 2018.
- 341 **He took up to 40,000mg of vitamin C:** ‘The Dark Side of Linus Pauling’s Legacy’, quackwatch.org, 14 Sept. 2014.
- 342 **Proteins are complicated molecules:** Smith, *Body*, p. 429.
- 342 **Why evolution has wedded us:** Challoner, *Cell*, p. 38.
- 343 **most traditional diets in the world:** McGee, *On Food and Cooking*, p. 534.
- 344 **Virtually all carbohydrates in the diet:** Ibid., p. 803.
- 344 **a 150g serving of white rice:** *New Scientist*, 11 June 2016, p. 32.
- 347 **For complex chemical reasons:** Lieberman, *Story of the Human Body*, p. 255.
- 347 **an avocado has five times as much saturated fat:** *New Scientist*, 2 Aug. 2014, p. 35.
- 347 **Not until 2004 did the American Heart Association:** Kummerow obituary, *New York Times*, 1 June 2017.
- 348 **The idea has been traced to a 1945 paper:** *More or Less*, BBC Radio 4, 6 Jan. 2017.
- 348 **People allowed to drink all the water:** Roach, *Grunt*, p. 133.
- 348 **Drinking too much water:** ‘Can You Drink Too Much Water?’, *New York Times*, 19 June 2015; ‘Strange but True: Drinking Too Much Water Can Kill’, *Scientific American*, 21 June 2007.
- 348 **Over a lifetime we eat about sixty tons of food:** Zimmer, *Microcosm*, p. 56.
- 349 **far more people suffer from obesity:** *Nature*, 2 Feb. 2012, p. 27.



- 349 **One chocolate chip cookie a week:** *New Scientist*, 18 July 2009, p. 32.
- 349 **The person most responsible:** Keys obituary, *Washington Post*, 2 Nov. 2004; Keys obituary, *New York Times*, 23 Nov. 2004; *Journal of Health and Human Behavior* (Winter 1963): pp. 291–93; *American Journal of Clinical Nutrition* (March 2010).
- 350 **Keys embarked on what became known as the Minnesota Starvation Experiment:** ‘They Starved So That Others Be Better Fed: Remembering Ancel Keys and the Minnesota Experiment’, *Journal of Nutrition* 135, no. 6, June 2005.
- 353 **One-fifth of all young people in America:** ‘What Not to Eat’, *New York Times*, 2 Jan. 2017; ‘How Much Harm Can Sugar Do?’, *New Yorker*, 8 Sept. 2015.
- 354 **The fruits that Shakespeare ate:** Lieberman, *Story of the Human Body*, p. 265; ‘Best Before?’, *New Scientist*, 17 Oct. 2015.
- 355 **the most popular vegetable in America:** *Baylor University Medical Center Proceedings*, April 2011, p. 158.
- 356 **the average American about 3,400mg:** ‘Clearing Up the Confusion About Salt’, *New York Times*, 20 Nov. 2017.
- 357 **A meta-analysis at McMaster University:** *Chemistry World*, Sept. 2016, p. 50.
- 357 **‘We found that the published literature’:** *International Journal of Epidemiology*, 17 Feb. 2016.
- 357 **‘Well, actually originally it was to impress a girl’:** Interview with Professor Christopher Gardner, Palo Alto, Calif., 29 Jan. 2018.
- 359 **Roughly 40 per cent of people with diabetes:** *Nature*, 2 Feb. 2012, p. 27.
- 359 **‘fifty per cent genetic and fifty per cent cheeseburger’:** *National Geographic*, Feb. 2007, p. 49.

## CHAPTER 15: THE GUTS

- 363 **The surface area of all that tubing:** Vogel, *Life's Devices*, p. 42.
- 363 **Food lingers inside a woman:** Blakelaw and Jennett, *Oxford Companion to the Body*, p. 19.
- 363 **That's why you are constantly told:** 'Fiber Is Good for You. Now Scientists May Know Why', *New York Times*, 1 Jan. 2018.
- 363 **The rumblings of your gut:** Enders, *Gut*, p. 83.
- 364 **Every year three thousand people:** 'A Bug in the System', *New Yorker*, 2 Feb. 2015, p. 30.
- 364 **'but had decided that cooking them':** *Food Safety News*, 27 Dec. 2017.
- 365 **According to a study by the United States:** 'Bug in the System', p. 30.
- 366 **'People tend to blame the last thing they ate':** 'What to Blame for Your Stomach Bug? Not Always the Last Thing You Ate', *New York Times*, 29 June 2017.
- 368 **After drifting around for a few years:** 'Men and Books', *Canadian Medical Association Journal*, June 1959.
- 370 **about 250,000 people are hospitalized:** 'The Global Incidence of Appendicitis: A Systematic Review of Population- Based Studies', *Annals of Surgery*, Aug. 2017.
- 370 **The incidence of acute appendicitis:** Blakelaw and Jennett, *Oxford Companion to the Body*, p. 43.
- 371 **Lipes's bedside manner was not:** *New York Times* obituary, 20 April 2005.
- 372 **People flocked to him from all around the world:** 'Killing Cures', *New York Review of Books*, 11 Aug. 2005.
- 373 **Every gram of faeces you produce:** Money, *Amoeba in the Room*, p. 144.
- 373 **Even samples taken from two ends:** *Nature*, 21 Aug. 2014, p. 247.

- 374 **Two strains of *E. coli***: Zimmer, *Microcosm*, p. 20; Lane, *Power, Sex, Suicide*, p. 119.
- 374 ***E. coli* wasn't named for him until 1918**: *Clinical Infectious Diseases*, 15 Oct. 2007, pp. 1025–29.
- 374 **'the olfactory nerves become paralyzed'**: Roach, *Gulp*, p. 253.
- 375 **'many recorded examples of explosion'**: 'Fatal Colonic Explosion During Colonoscopic Polypectomy', *Gastroenterology* 77, no. 6 (1979).

## CHAPTER 16: SLEEP

- 379 **In 1989, in an experiment**: 'Sleep Deprivation in the Rat', *Sleep* 12, no. 1 (1989).
- 379 **People with early signs of hypertension**: *Nature*, 23 May 2013, p. S7.
- 381 **'If sleep does not serve'**: *Scientific American*, Oct. 2015, p. 42.
- 381 **Even quite simple creatures like nematodes**: *New Scientist*, 2 Feb 2013, pp. 38–39.
- 382 **Aserinsky's volunteer subject for the first night's test**: 'The Stubborn Scientist Who Unraveled a Mystery of the Night', *Smithsonian*, Sept. 2003; 'Rapid Eye Movement Sleep: Regulation and Function', *Journal of Clinical Sleep Medicine*, 15 June 2013.
- 382 **Sleep is so shallow in these first two stages**: Martin, *Counting Sheep*, p. 98.
- 384 **Typically a man will be erect**: Ibid., pp. 133–39; 'Cerebral Hygiene', *London Review of Books*, 29 June 2017.
- 384 **The average person turns over**: Martin, *Counting Sheep*, p. 104.
- 385 **when a dozen airline pilots on long-haul flights**: Ibid., pp. 39–40.

- 385 **That may explain why we:** Burnett, *Idiot Brain*, p. 25; Sternberg, *NeuroLogic*, pp. 13–14.
- 386 **One member of an audience shouted:** Davis, *Beautiful Cure*, p. 133.
- 386 **‘They struggled to accept that something’:** Interview with Professor Russell Foster, Brasenose College, Oxford, 17 Oct. 2018.
- 388 **‘The pineal is not our soul’:** Bainbridge, *Beyond the Zonules of Zinn*, p. 200.
- 388 **When asked to estimate the passage:** Shubin, *Universe Within*, pp. 55–67.
- 389 **‘Around half of these bestselling drugs’:** Davis, *Beautiful Cure*, p. 37.
- 390 **Later start times have been shown:** ‘Let Teenagers Sleep In’, *New York Times*, 20 Sept. 2018.
- 392 **Insomnia has been linked to diabetes:** ‘In Search of Forty Winks’, *New Yorker*, 8–15 Feb. 2016.
- 392 **women who regularly worked night shifts:** ‘Of Owls, Larks, and Alarm Clocks’, *Nature*, 11 March 2009.
- 393 **About 50 per cent of people who snore:** ‘Snoring: What to Do When a Punch in the Shoulder Fails’, *New York Times*, 11 Dec. 2010.
- 393 **The most extreme and horrifying form:** Zeman, *Consciousness*, pp. 46–47; ‘The Family That Couldn’t Sleep’, *New York Times*, 2 Sept. 2006.
- 393 **Some authorities think prions may also:** *Nature*, 10 April 2014, p. 181.
- 394 **four million people globally:** ‘The Wild Frontiers of Slumber’, *Nature*, 1 March 2018; Zeman, *Consciousness*, pp. 106–9.
- 394 **‘I remember when I woke up’:** *Morning Edition*, National Public Radio, 27 Dec. 2017.
- 395 **Yawning doesn’t even correlate reliably:** Martin, *Counting Sheep*, p. 140.

## CHAPTER 17: INTO THE NETHER REGIONS

- 397 **'On a Presidential visit to a farm':** The story is of course apocryphal.
- 400 **Nettie Stevens deserves to be better known:** 'Nettie M. Stevens and the Discovery of Sex Determination by Chromosomes', *Isis*, June 1978; *American National Biography*.
- 401 **It is just an extraordinary coincidence:** Bainbridge, *X in Sex*, p. 66.
- 401 **'literally waited at the foot of the gallows':** 'The Chromosome Number in Humans: A Brief History', *Nature Reviews Genetics*, 1 Aug. 2006.
- 401 **That number stuck, universally unquestioned:** Ridley, *Genome*, pp. 23–24.
- 402 **After countless generations of making:** 'Vive la Difference', *New York Review of Books*, 12 May 2005.
- 402 **At its current rate of deterioration:** 'Sorry, Guys: Your Y Chromosome May Be Doomed', *Smithsonian*, 19 Jan. 2018.
- 403 **humans don't actually reproduce:** Mukherjee, *Gene*, p. 357.
- 404 **How many people are unfaithful:** 'Infidels', *New Yorker*, 18–25 Dec. 2017.
- 404 **In one study, the number of sexual partners:** Spiegelhalter, *Sex by Numbers*, p. 35.
- 404 **Because of funding problems, only 3,432 people:** *American Journal of Public Health*, July 1996, pp. 1037–40; 'What, How Often, and with Whom?', *London Review of Books*, 3 Aug. 1995.
- 405 **leaving Spiegelhalter to wonder what exactly:** Spiegelhalter, *Sex by Numbers*, p. 2.
- 407 **the median time for sex:** Ibid., pp. 218–20.
- 407 **A chimpanzee and a human:** 'Bonobos Join Chimps as Closest Human Relatives', *Science News*, 13 June 2012.

- 408 **They are more vulnerable to infection:** Bribiescas, *Men*, pp. 174–76.
- 410 **‘vaginal secretions [were] the only bodily fluid’:** Roach, *Bonk*, p. 12.
- 411 **It is named for Ernst Gräfenberg:** *American Journal of Obstetrics and Gynecology*, Aug. 2001, p. 359.
- 413 **Until the early 1900s, ‘clitoris’:** *Oxford English Dictionary*.
- 413 **The uterus normally weighs two ounces:** Cassidy, *Birth*, p. 80.
- 414 **many mammals get along perfectly well:** Bainbridge, *Teenagers*, pp. 254–55.
- 415 **There is also a great deal of uncertainty:** ‘Skin Deep’, *New York Review of Books*, 7 Oct. 1999.
- 415 **Authorities seem to be universally agreed:** Morris, *Bodywatching*, p. 216; Spiegelhalter, *Sex by Numbers*, pp. 216–17.

## CHAPTER 18: IN THE BEGINNING: CONCEPTION AND BIRTH

- 419 **The chances of a successful fertilization:** ‘Not from Venus, Not from Mars’, *New York Times*, 25–26 Feb. 2017, international edition.
- 419 **A meta-analysis in the journal:** ‘Yes, Sperm Counts Have Been Steadily Declining’, *Smithsonian.com*, 26 July 2017.
- 419 **‘a common class of endocrine disruptors’:** ‘Are Your Sperm in Trouble?’, *New York Times*, 11 March 2017.
- 420 **The number of spermatozoa produced:** Lents, *Human Errors*, p. 100.
- 421 **by the age of thirty-five a woman’s stock of eggs:** ‘The Divorce of Coitus from Reproduction’, *New York Review of Books*, 25 Sept. 2014.
- 423 **Without this, the rate of birth defects:** Roberts, *Incredible Unlikelihood of Being*, p. 344.

- 425 **About 80 per cent of mothers-to-be:** ‘What Causes Morning Sickness?’, *New York Times*, 3 Aug. 2018.
- 427 **The only truly reliable test:** Oakley, *Captured Womb*, p. 17.
- 427 **Medical students in England weren’t required:** Epstein, *Get Me Out*, p. 38.
- 427 **Women were sometimes bled:** Oakley, *Captured Womb*, p. 22.
- 427 **In 1906, an estimated 150,000 American women:** Sengoopta, *Most Secret Quintessence of Life*, pp. 16–18.
- 428 **‘God knows the number of women’:** Cassidy, *Birth*, p. 60.
- 429 **sterilize the air around patients:** ‘The Gruesome, Bloody World of Victorian Surgery’, *Atlantic*, 22 Oct. 2017.
- 429 **As late as 1932, one mother in every 238 died:** Oakley, *Captured Womb*, p. 62.
- 429 **It was the rise of penicillin:** Cassidy, *Birth*, p. 61.
- 430 **Yet American women are 70 per cent:** *Economist*, 18 July 2015, p. 41.
- 431 **‘the least understood organ in the human body’:** *Scientific American*, Oct. 2017, p. 38.
- 434 **‘women in labour have pretty much’:** *Nature*, 14 July 2016, p. S6.
- 434 **people born by C-section:** ‘The Cesarean-Industrial Complex’, *Atlantic*, Sept. 2014.
- 434 **more than 60 per cent of Caesareans are done:** ‘Stemming the Global Caesarean Section Epidemic’, *Lancet*, 13 Oct. 2018.
- 435 **the rush to clean up babies:** Blaser, *Missing Microbes*, p. 95.
- 435 ***Bifidobacterium infantis*, an important microbe:** Yong, *I Contain Multitudes*, p. 130.
- 436 **by the age of one the average baby:** *New Yorker*, 22 Oct. 2012, p. 33.
- 436 **There is some evidence that a nursing mother:** Ben-Barak, *Why Aren’t We Dead Yet?*, p. 68.

- 437 **'fighting to protect women's abilities':** 'Opposition to Breast-Feeding Resolution by U.S. Stuns World Health Officials', *New York Times*, 8 July 2018.

## CHAPTER 19: NERVES AND PAIN

- 444 **Repeat the experiences and the patterns:** 'Show Me Where It Hurts', *Nature*, 14 July 2016.
- 444 **'Pain only emerges when the brain':** Interview with Professor Irene Tracey, John Radcliffe Hospital, Oxford, 18 Sept. 2018.
- 447 **The person who first identified nociceptors:** *Oxford Dictionary of National Biography*, s.v. 'Sherrington, Sir Charles Scott'; *Nature Neuroscience*, June 2010, pp. 429–30.
- 451 **More than half of spinal cord injuries:** *Annals of Medicine*, *New Yorker*, 25 Jan. 2016.
- 451 **Pain, like the nervous system itself:** 'A Name for Their Pain', *Nature*, 14 July 2016; Foreman, *Nation in Pain*, pp. 22–24.
- 455 **the word is a corruption of the French *demi-craine*:** 'Headache', *American Journal of Medicine*, Jan. 2018; 'Why Migraines Strike', *Scientific American*, Aug. 2008; 'A General Feeling of Disorder', *New York Review of Books*, 23 April 2015.
- 455 **'Donnerwetter, so it has':** Dormandy, *Worst of Evils*, p. 483.
- 456 **But equally pain is decreased:** *Nature Neuroscience*, April 2008, p. 314.
- 456 **Just having a sympathetic and loving partner:** Wolf, *Body Quantum*, p. vii.
- 456 **when subjects in pain received morphine:** *Nature Neuroscience*, April 2008, p. 314.
- 456 **about 40 per cent of adult Americans:** Foreman, *Nation in Pain*, p. 3.
- 456 **Altogether chronic pain affects more people:** 'The Neuroscience of Pain', *New Yorker*, 2 July 2018.



- 456 **‘deaf and blind to other people’**: Daudet, *In the Land of Pain*, p. 15.
- 456 **‘The drugs we have relieve 50 per cent’**: ‘Name for Their Pain’.
- 457 **Between 1999 and 2014, by one estimate**: *Chemistry World*, July 2017, p. 28; *Economist*, 28 Oct. 2017, p. 41; ‘Opioid Nation’, *New York Review of Books*, 6 Dec. 2018.
- 457 **opioid fatalities have led to a rise in organ donations**: ‘The Disturbing Reasons Behind the Spike in Organ Donations’, *Washington Post*, 17 April 2018.
- 458 **one doctor got good results**: ‘Feel the Burn’, *London Review of Books*, 30 Sept. 1999.
- 459 **Even so, 59 per cent of those tested**: ‘Honest Fakery’, *Nature*, 14 July 2016.
- 459 **Placebos don’t shrink tumours**: Marchant, *Cure*, p. 22.

## CHAPTER 20: WHEN THINGS GO WRONG: DISEASES

- 463 **In the autumn of 1948, people in the small city**: ‘The Post-viral Syndrome: A Review’, *Journal of the Royal College of General Practitioners*, May 1987; ‘A Disease Epidemic in Iceland Simulating Poliomyelitis’, *American Journal of Epidemiology* 2 (1950); ‘Early Outbreaks of “Epidemic Neuromyasthenia”’, *Postgraduate Medical Journal*, Nov. 1978; *Annals of Medicine*, *New Yorker*, 27 Nov. 1965.
- 463 **in 1970, after several years of quiescence**: ‘Epidemic Neuromyasthenia: A Syndrome or a Disease?’, *Journal of the American Medical Association*, 13 March 1972.
- 464 **West Nile virus surfaced in New York**: Crawford, *Deadly Companions*, p. 18.
- 464 **Two hundred years later a very similar illness**: ‘Two Spots and a Bubo’, *London Review of Books*, 21 April 2005.
- 465 **Bourbon virus, as it became known**: Centers for Disease Control and Prevention, *Emerging Infectious Diseases*

- Journal*, May 2015; ‘Researchers Reveal That Killer “Bourbon Virus” Is of the Rare Thogotovirus Genus’, *Science Times*, 22 Feb. 2015; ‘Mysterious Virus That Killed a Farmer in Kansas Is Identified’, *New York Times*, 23 Dec. 2014.
- 466 **‘Unless doctors are doing laboratory tests’**: ‘Deadly Heartland Virus Is Much More Common Than Scientists Thought’, National Public Radio, 16 Sept. 2015.
- 467 **‘Within a few days, thirty-four were dead’**: ‘In Philadelphia 30 Years Ago, an Eruption of Illness and Fear’, *New York Times*, 1 Aug. 2006.
- 468 ***Legionella* is widely distributed in soil**: ‘Coping with Legionella’, *Public Health*, 14 Nov. 2000.
- 468 **Much the same thing happened**: ‘Early Outbreaks of ‘Epidemic Neuromyasthenia’.
- 468 **Whether or not a disease becomes epidemic**: *New Scientist*, 9 May 2015, pp. 30–33.
- 468 **A successful virus is one**: ‘Ebola Wars’, *New Yorker*, 27 Oct. 2014.
- 469 **the number of viruses in birds and mammals**: ‘The Next Plague Is Coming. Is America Ready?’, *Atlantic*, July–Aug. 2018.
- 470 **‘a catastrophe from which we’**: ‘Stone Soup’, *New Yorker*, 28 July 2014.
- 471 **a shadowy cook and housekeeper**: Grove, *Tapeworms, Lice, and Prions*, pp. 334–35; *New Yorker*, 26 Jan. 1935; *American National Biography*, s.v. ‘Mallon, Mary’.
- 473 **The United States has an estimated 5,750 cases each year**: CDC figures.
- 473 **The death toll in the twentieth century**: ‘The Awful Diseases on the Way’, *New York Review of Books*, 9 June 2016.
- 473 **enough to infect seventeen others**: ‘Bugs Without Borders’, *New York Review of Books*, 16 Jan. 2003.
- 475 **In 2014, someone looking through a storage area**: US Centers for Disease Control and Prevention, ‘Media

- Statement on Newly Discovered Smallpox Specimens', 8 July 2014.
- 476 **Inmates were given pickaxes:** 'Phrenic Crush', *London Review of Books*, Oct. 2003.
- 476 **she and other inmates were allowed visits:** MacDonald, *Plague and I*, p. 45.
- 477 **Some boroughs of London now have rates:** 'Killer of the Poor Now Threatens the Wealthy', *Financial Times*, 24 March 2014.
- 477 **The only treatment, even now:** *Economist*, 22 April 2017, p. 54.
- 478 **Bilharz bandaged the pupae of cercaria worms:** Kaplan, *What's Eating You?*, p. ix.
- 480 **a protein called huntingtin:** Mukherjee, *Gene*, pp. 280–86.
- 480 **At least forty have been linked to Type 2 diabetes:** *Nature*, 17 May 2012, p. S10.
- 480 **'Why a temperate climate':** Bainbridge, *Beyond the Zonules of Zinn*, pp. 77–78.
- 481 **Only about two hundred cases of the disorder:** Davies, *Life Unfolding*, p. 197.
- 481 **For 90 per cent of rare diseases:** *MIT Technology Review*, Nov.–Dec. 2018, p. 44.
- 482 **'You are most likely going to die':** Lieberman, *Story of the Human Body*, p. 351.
- 483 **only 36 per cent less likely to get flu:** 'The Ghost of Influenza Past and the Hunt for a Universal Vaccine', *Nature*, 8 Aug. 2018.

## CHAPTER 21: WHEN THINGS GO VERY WRONG: CANCER

- 487 **Diphtheria, smallpox and tuberculosis:** Bourke, *Fear*, pp. 298–99.

- 487 **‘The early history of cancer’:** Mukherjee, *Emperor of All Maladies*, pp. 44–45.
- 487 **Half of men over sixty:** Welch, *Less Medicine, More Health*, p. 71.
- 488 **A survey of physicians in America:** ‘What to Tell Cancer Patients’, *Journal of the American Medical Association* 175, no. 13 (1961).
- 488 **Surveys in Britain at about the same time:** Smith, *Body*, p. 330.
- 488 **‘That’s why cancers aren’t contagious’:** Interview with Dr Josef Vormoor, Princess Máxima Center, Utrecht, the Netherlands, 18–19 Jan. 2019.
- 490 **Between birth and forty:** Herold, *Stem Cell Wars*, p. 10.
- 490 **More than half of cases:** *Nature*, 24 March 2011, p. S16.
- 491 **How exactly weight tips the balance:** ‘The Fat Advantage’, *Nature*, 15 Sept. 2016; ‘The Link Between Cancer and Obesity’, *Lancet*, 14 Oct. 2017.
- 491 **The first person to notice a connection:** *British Journal of Industrial Medicine*, Jan. 1957, pp. 68–70; ‘Percivall Pott, Chimney Sweeps, and Cancer’, *Education in Chemistry*, 11 March 2006.
- 492 **More than eighty thousand chemicals:** ‘Toxicology for the 21st Century’, *Nature*, 8 July 2009.
- 492 **Although no one can say to what extent:** ‘Cancer Prevention’, *Nature*, 24 March 2011, pp. S22–S23.
- 493 **In the face of opposition:** Armstrong, p. 53; *The Gene That Cracked the Cancer Code*, pp. 27–29.
- 493 **Altogether, it has been estimated, pathogens:** ‘The Awful Diseases on the Way’, *New York Review of Books*, 9 June 2016.
- 493 **About 10 per cent of men:** Timmermann, *History of Lung Cancer*, pp. 6–7.
- 498 **There is some evidence that his wife:** *Baylor University Medical Center Proceedings*, Jan. 2012.

- 499 **the concept of the radical mastectomy:** *American National Biography*, s.v. 'Halsted, William Stewart'; 'A Very Wide and Deep Dissection', *New York Review of Books*, 20 Sept. 2001; Beckhard and Crane, *Cancer, Cocaine, and Courage*, pp. 111–12.
- 500 **He lost most of his jaw and parts of his skull:** Jorgensen, *Strange Glow*, p. 94.
- 500 **In 1920, four million radium watches:** Ibid., pp. 87–88.
- 501 **'he was so badly disfigured':** Ibid., p. 123.
- 502 **Mrs Lawrence's cancer went into remission:** Goodman, McElligott, and Marks, *Useful Bodies*, p. 81–82.
- 502 **It was subsequently discovered:** *American National Biography*, s.v. 'Lawrence, John Hundale'.
- 503 **From this, it was realized:** Armstrong, p. 53; *The Gene That Cracked the Cancer Code*, pp. 253–54; *Nature*, 12 Jan. 2017, p. 154.
- 504 **The breakthrough moment was in 1968:** 'Childhood Leukemia Was Practically Untreatable Until Don Pinkel and St. Jude Hospital Found a Cure', *Smithsonian*, July 2016.
- 505 **A significant fraction of childhood cancer deaths:** *Nature*, 30 March 2017, pp. 608–9.
- 505 **2.4 million fewer people have died:** 'We're Making Real Progress Against Cancer. But You May Not Know It if You're Poor', *Vox*, 2 Feb. 2018.
- 505 **no more than 2 to 3 per cent of cancer research money:** *Nature*, 24 March 2011, p. S4.

## CHAPTER 22 : MEDICINE GOOD AND BAD

- 509 **whatever he learned about soil fertility:** 'The White Plague', *New York Review of Books*, 26 May 1994.
- 510 **Selman Waksman was awarded the Nobel Prize:** *Literary Review*, Oct. 2012, pp. 47–48; *Guardian*, 2 Nov. 2002.

- 510 **By one reckoning, life expectancy on Earth:** *Economist*, 29 April 2017, p. 53.
- 514 **‘Somewhere between 1900 and 1912’:** *Nature*, 24 March 2011, p. 446.
- 515 a British epidemiologist named Thomas McKeown: Wootton, *Bad Medicine*, pp. 270–71.
- 516 **McKeown’s thesis attracted a good deal:** *American Journal of Public Health*, May 2002, pp. 725–29; ‘White Plague’; Le Fanu, *Rise and Fall of Modern Medicine*, pp. 314–15.
- 516 **males in the East End of Glasgow:** ‘Between Victoria and Vauxhall,’ *London Review of Books*, 1 June 2017.
- 519 **For every 400 middle-aged Americans:** *Economist*, 25 March 2017, p. 76.
- 519 **Among rich countries, America is at or near:** ‘Why America Is Losing the Health Race’, *New Yorker*, 11 June 2014.
- 520 **Even sufferers of cystic fibrosis:** ‘Stunning Gap: Canadians with Cystic Fibrosis Outlive Americans by a Decade’, *Stat*, 13 March 2017.
- 520 **One-fifth of all the money:** ‘The US Spends More on Health Care than Any Other Country’, *Washington Post*, 27 Dec. 2016.
- 520 **‘Even wealthy Americans are not isolated’:** ‘Why America Is Losing the Health Race’.
- 520 **A US teenager is twice as likely to be killed:** ‘American Kids Are 70% More Likely to Die Before Adulthood than Kids in Other Rich Countries’, *Vox*, 8 Jan. 2018.
- 521 **A helmeted rider is 70 per cent:** Insurance Institute for Highway Safety figures.
- 521 **An angiogram, a survey by the *New York Times* found:** ‘The \$2.7 Trillion Medical Bill’, *New York Times*, 1 June 2013.
- 522 **One commonly accepted yardstick:** ‘Health Spending’, OECD Data, [data.oecd.org](http://data.oecd.org).

- 524 **when 160 gynaecologists were asked:** Jorgensen, *Strange Glow*, p. 298.
- 526 **‘One person’s overtreatment’:** ‘The State of the Nation’s Health’, *Dartmouth Medicine*, Spring 2007.
- 526 **‘most doctors take money or gifts’:** ‘Drug Companies and Doctors: A Story of Corruption’, *New York Review of Books*, 15 Jan. 2009.
- 527 **‘they just had better blood-pressure numbers’:** ‘When Evidence Says No but Doctors Say Yes’, *Atlantic*, 22 Feb. 2017.
- 528 **But when the same drugs were tried on humans:** ‘Frustrated Alzheimer’s Researchers Seek Better Lab Mice’, *Nature*, 21 Nov. 2018.
- 529 **So for most people there is:** ‘Aspirin to Prevent a First Heart Attack or Stroke’, NNT, Jan. 8, 2015, [www.thennt.com](http://www.thennt.com).
- 529 **low-dose aspirin is not effective:** National Institute for Health Research press release, 16 July 2018.

## CHAPTER 23: THE END

- 533 **more people globally died:** *Nature*, 2 Feb. 2012, p. 27.
- 533 **‘Nearly a third of Americans who die’:** *Economist*, 29 April 2017, p. 11.
- 533 **In 1940, that probability was reached:** ‘Special Report on Aging’, *Economist*, 8 July 2017.
- 533 **if we found a cure for all cancers tomorrow:** *Economist*, 13 Aug. 2016, p. 14.
- 533 **Of nothing is that more true:** Hayflick interview, *Nautilus*, 24 Nov. 2016.
- 533 **‘For every year of added life’:** Lieberman, *Story of the Human Body*, p. 242.
- 533 In the United States, the elderly constitute: Davis, *Beautiful Cure*, p. 139.

- 534 **Zhores Medvedev, a Russian biogerontologist:** 'Rethinking Modern Theories of Ageing and Their Classification', *Anthropological Review* 80, no. 3 (2017).
- 535 **Hayflick discovered that cultured human stem cells:** 'The Disparity Between Human Cell Senescence In Vitro and Lifelong Replication In Vivo', *Nature Biotechnology*, 1 July 2002.
- 535 **A study by geneticists at the University of Utah:** University of Utah Genetic Science Learning Center report, 'Are Telomeres the Key to Aging and Cancer?'.  
 537 **'If all aging was due to telomeres':** 'You May Have More Control over Aging than You Think . . .', *Stat*, 3 Jan. 2017.
- 537 **Most of us would almost certainly:** Harman obituary, *New York Times*, 28 Nov. 2014.
- 537 **'It is a massive racket':** 'Myths That Will Not Die', *Nature*, 17 Dec. 2015; 'No Truth to the Fountain of Youth', *Scientific American*, 29 Dec. 2008.
- 538 **'antioxidant supplementation did not lower':** 'The Free Radical Theory of Aging Revisited', *Antioxidants and Redox Signaling* 19, no. 8 (2013).
- 539 **After the age of forty, the volume of blood:** Nuland, *How We Die*, p. 53.
- 539 **At least two species of whale:** *Naked Scientists*, podcast, 7 Feb. 2017.
- 540 **Two principal theories have been advanced:** Bainbridge, *Middle Age*, pp. 208–11.
- 540 **It is a myth, incidentally, that menopause:** Ibid., p. 199.
- 540 **A study by the Albert Einstein College of Medicine:** *Scientific American*, Sept. 2016, p. 58.
- 541 **only about one person in ten thousand:** 'The Patient Talks Back', *New York Review of Books*, 23 Oct. 2008.
- 541 **The Gerontology Research Group:** 'Keeping Track of the Oldest People in the World', *Smithsonian*, 8 July 2014.



- 543 **Costa Ricans have only about one-fifth:** Marchant, *Cure*, pp. 206–11.
- 544 **she may not have been suffering:** *Literary Review*, Aug. 2016, p. 35.
- 545 **about 30 per cent of elderly people:** ‘Tau Protein—Not Amyloid—May Be Key Driver of Alzheimer’s Symptoms’, *Science*, 11 May 2016.
- 546 **Virtuous living doesn’t eliminate:** ‘Our Amazingly Plastic Brains’, *Wall Street Journal*, 6 Feb. 2015.
- 547 **In Britain, dementias cost the National Health Service:** *Inside Science*, BBC Radio 4, 1 Dec. 2016.
- 547 **Alzheimer’s drugs have a 99.6 per cent failure rate:** *Chemistry World*, Aug. 2014, p. 8.
- 548 **Every day, around the world 160,000 people die:** World Health Organization statistics.
- 548 **A separate study found evidence:** *Journal of Palliative Medicine* 17, no. 3 (2014).
- 548 **Most dying people lose any desire:** ‘What It Feels Like to Die’, *Atlantic*, 9 Sept. 2016.
- 548 **Agonal breathing, in which the sufferer:** ‘The Agony of Agonal Respiration: Is the Last Gasp Necessary?’, *Journal of Medical Ethics*, June 2002.
- 549 **cancer sufferers receiving palliative care:** *Economist*, 29 April 2017, p. 55.
- 549 **‘One review found that’:** Hatch, *Snowball in a Blizzard*, p. 7.
- 549 **‘A man’s corpse looks as though’:** Nuland, *How We Die*, p. 122.
- 549 **Some organs function longer than others:** ‘Rotting Reactions’, *Chemistry World*, Sept. 2016.
- 550 **decomposition in a sealed coffin:** ‘What’s Your Dust Worth?’, *London Review of Books*, 14 April 2011.
- 550 **The average grave is visited:** *Literary Review*, May 2013, p. 43.
- 550 **A century ago only about one person in a hundred:** ‘What’s Your Dust Worth?’.