Timberlane High School Science Summer Reading Assignment:

Course: Anatomy & Physiology

Instructions

- Please read the following selection(s) from the book A Short History of Nearly Everything by Bill Bryson.
- Please provide written answers (short essay style) to the questions at the end of the reading

  •Questions adapted from Random House Publishing Inc. https://www.randomhouse.com/catalog/teachers_guides/9780767908184.pdf
- The written assignment is to be turned into your teacher by **Thursday, September 5th and Friday, September 6th**, for potential full credit. Accepted until Sept 12th with 10% deduction in grade per day. Not accepted after Sept 12th.
- This is a graded assignment worth up to 3% of your quarter 1 grade.

Grading Rubric:

The writing will be assessed on the following 0 to 3 scales

- Each answer should be in a short essay style (minimum one paragraph).
  - 1: most answers are short one word answers.
  - 3: complete thoughts and sentences that fully convey the answers.
- Each answer should demonstrate evidence of reading to comprehension.
  - 1: answers indicate that the reading was not completed ○ 3: answers show clear comprehension of the reading
- Each answer should be correct, relevant to the topic, should strive for detail and completeness.
  - 1: answers are not relative to question or reading ○ 3: Answers demonstrate clear relevancy to passage and get to the heart of the rationale for question in relation to subject area.
- Each answer should refer to a specific statement or include a quote from the reading.
  - 1: the writing is vague, incomplete and contains little detail ○ 3: writing is detailed, complete and references specific statements or quotes from the reading passage.
- Each answer should be original (no plagiarism)

Tips on how to read science text for comprehension:

Break the reading into more than one session (2 to 4 pages per day). This should take about 15 minutes each time. Read slowly! Understand each sentence before reading the next. Be sure to examine unfamiliar words and concepts; try to determine meaning from the reading (or look them up). Make notes on each paragraph! It is OK to reread as you go or even reread the entire text. Read to understand, think about the ideas as you read and relate to what you already know, and what you may want to find out.

28 THE MYSTERIOUS BIPED

JUST BEFORE CHRISTMAS 1887, a young Dutch doctor with an un-Dutch name, Marie Eugène François Thomas Dubois, arrived in Sumatra, in the Dutch East Indies, with the intention of finding the earliest human remains on Earth.[1]

Several things were extraordinary about this. To begin with, no one had ever gone looking for ancient human bones before. Everything that had been found to this point had been found accidentally, and nothing in Dubois's background suggested that he was the ideal candidate to make the process intentional. He was an anatomist by training with no background in paleontology. Nor was there any special reason to suppose that the East Indies would hold early human remains. Logic dictated that if ancient people were to be found at all, it would be on a large and long-populated landmass, not in the comparative fastness of an archipelago. Dubois was driven to the East Indies on nothing stronger than a hunch, the availability of employment, and the knowledge that Sumatra was full of caves, the environment in which most of the important hominid fossils had so far been found. What is most extraordinary in all this—nearly miraculous, really—is that he found what he was looking for.

At the time Dubois conceived his plan to search for a missing link, the human fossil record consisted of very little: five incomplete Neandertal skeletons, one partial jawbone of uncertain provenance, and a half-dozen ice-age humans recently found by railway workers in a cave at a cliff called Cro-Magnon near Les Eyzies, France. Of the Neandertal specimens, the best preserved was sitting unremarked on a shelf in London. It had been found by workers blasting rock from a quarry in Gibraltar in 1848, so its preservation was a wonder, but unfortunately no one yet appreciated what it was. After being briefly described at a meeting of the Gibraltar Scientific Society, it had been sent to the Hunterian Museum in London, where it remained undisturbed but for an occasional light dusting for over half a century. The first formal description of it wasn't written until 1907, and then by a geologist named William Sollas "with only a passing competency in anatomy."

So instead the name and credit for the discovery of the first early humans went to the Neander Valley in Germany—not unfittingly, as it happens, for by uncanny coincidence Neander in Greek means "new man." There in 1856 workmen at another quarry, in a cliff face overlooking the Düssel River, found some curious-looking bones, which they passed to a local schoolteacher, knowing he had an interest in all things natural. To his great credit the teacher, Johann Karl Fuhlrott, saw that he had some new type of human, though quite what it was, and how special, would be matters of dispute for some time.

Many people refused to accept that the Neandertal bones were ancient at all. August Mayer, a professor at the University of Bonn and a man of influence, insisted that the bones were

[1] Though Dutch, Dubois was from Eijsden, a town bordering the French-speaking part of Belgium.

merely those of a Mongolian Cossack soldier who had been wounded while fighting in Germany in 1814 and had crawled into the cave to die. Hearing of this, T. H. Huxley in England drily observed how remarkable it was that the soldier, though mortally wounded, had climbed sixty feet up a cliff, divested himself of his clothing and personal effects, sealed the cave opening, and buried himself under two feet of soil. Another anthropologist, puzzling over the Neandertal's heavy brow ridge, suggested that it was the result of long-term frowning arising from a poorly healed forearm fracture. (In their eagerness to reject the idea of earlier humans, authorities were often willing to embrace the most singular possibilities. At about the time that Dubois was setting out for Sumatra, a skeleton found in Périgueux was confidently declared to be that of an Eskimo. Quite what an ancient Eskimo was doing in southwest France was never comfortably explained. It was actually an early Cro-Magnon.)

It was against this background that Dubois began his search for ancient human bones. He did no digging himself, but instead used fifty convicts lent by the Dutch authorities. For a year they worked on Sumatra, then transferred to Java. And there in 1891, Dubois—or rather his team, for Dubois himself seldom visited the sites—found a section of ancient human cranium now known as the Trinil skullcap. Though only part of a skull, it showed that the owner had had distinctly nonhuman features but a much larger brain than any ape. Dubois called it Anthropithecus erectus (later changed for technical reasons to Pithecanthropus erectus) and declared it the missing link between apes and humans. It quickly became popularized as "Java Man." Today we know it as Homo erectus.

The next year Dubois's workers found a virtually complete thighbone that looked surprisingly modern. In fact, many anthropologists think itis modern, and has nothing to do with Java Man. If it is an erectus bone, it is unlike any other found since. Nonetheless Dubois used the thighbone to deduce—correctly, as it turned out—that Pithecanthropus walked upright. He also produced, with nothing but a scrap of cranium and one tooth, a model of the complete skull, which also proved uncannily accurate.

In 1895, Dubois returned to Europe, expecting a triumphal reception. In fact, he met nearly the opposite reaction. Most scientists disliked both his conclusions and the arrogant manner in which he presented them. The skullcap, they said, was that of an ape, probably a gibbon, and not of any early human. Hoping to bolster his case, in 1897 Dubois allowed a respected anatomist from the University of Strasbourg, Gustav Schwalbe, to make a cast of the skullcap. To Dubois's dismay, Schwalbe thereupon produced a monograph that received far more sympathetic attention than anything Dubois had written and followed with a lecture tour in which he was celebrated nearly as warmly as if he had dug up the skull himself. Appalled and embittered, Dubois withdrew into an undistinguished position as a professor of geology at the University of Amsterdam and for the next two decades refused to let anyone examine his precious fossils again. He died in 1940 an unhappy man.

Meanwhile, and half a world away, in late 1924 Raymond Dart, the Australian-born head of anatomy at the University of the Witwatersrand in Johannesburg, was sent a small but remarkably complete skull of a child, with an intact face, a lower jaw, and what is known as an endocast—a natural cast of the brain—from a limestone quarry on the edge of the Kalahari Desert at a dusty spot called Taung. Dart could see at once that the Taung skull was not of a Homo erectus like Dubois's Java Man, but from an earlier, more apelike creature. He placed its age at two million years and dubbed it Australopithecus africanus, or "southern ape man of Africa." In a report to Nature, Dart called the Taung remains "amazingly human" and

suggested the need for an entirely new family, Homo simiadae ("the man-apes"), to accommodate the find.

The authorities were even less favorably disposed to Dart than they had been to Dubois. Nearly everything about his theory—indeed, nearly everything about Dart, it appears—annoyed them. First he had proved himself lamentably presumptuous by conducting the analysis himself rather than calling on the help of more worldly experts in Europe. Even his chosen name, Australopithecus, showed a lack of scholarly application, combining as it did Greek and Latin roots. Above all, his conclusions flew in the face of accepted wisdom. Humans and apes, it was agreed, had split apart at least fifteen million years ago in Asia. If humans had arisen in Africa, why, that would make us Negroid, for goodness sake. It was rather as if someone working today were to announce that he had found the ancestral bones of humans in, say, Missouri. It just didn't fit with what was known.

Dart's sole supporter of note was Robert Broom, a Scottish-born physician and paleontologist of considerable intellect and cherishably eccentric nature. It was Broom's habit, for instance, to do his fieldwork naked when the weather was warm, which was often. He was also known for conducting dubious anatomical experiments on his poorer and more tractable patients. When the patients died, which was also often, he would sometimes bury their bodies in his back garden to dig up for study later.

Broom was an accomplished paleontologist, and since he was also resident in South Africa he was able to examine the Taung skull at first hand. He could see at once that it was as important as Dart supposed and spoke out vigorously on Dart's behalf, but to no effect. For the next fifty years the received wisdom was that the Taung child was an ape and nothing more. Most textbooks didn't even mention it. Dart spent five years working up a monograph, but could find no one to publish it. Eventually he gave up the quest to publish altogether (though he did continue hunting for fossils). For years, the skull—today recognized as one of the supreme treasures of anthropology—sat as a paperweight on a colleague's desk.

At the time Dart made his announcement in 1924, only four categories of ancient hominid were known—Homo heidelbergensis, Homo rhodesiensis, Neandertals, and Dubois's Java Man—but all that was about to change in a very big way.

First, in China, a gifted Canadian amateur named Davidson Black began to poke around at a place, Dragon Bone Hill, that was locally famous as a hunting ground for old bones. Unfortunately, rather than preserving the bones for study, the Chinese ground them up to make medicines. We can only guess how many priceless Homo erectus bones ended up as a sort of Chinese equivalent of bicarbonate of soda. The site had been much denuded by the time Black arrived, but he found a single fossilized molar and on the basis of that alone quite brilliantly announced the discovery of Sinanthropus pekinensis, which quickly became known as Peking Man.

At Black's urging, more determined excavations were undertaken and many other bones found. Unfortunately all were lost the day after the Japanese attack on Pearl Harbor in 1941 when a contingent of U.S. Marines, trying to spirit the bones (and themselves) out of the country, was intercepted by the Japanese and imprisoned. Seeing that their crates held nothing but bones, the Japanese soldiers left them at the roadside. It was the last that was ever seen of them.

In the meantime, back on Dubois's old turf of Java, a team led by Ralph von Koenigswald had found another group of early humans, which became known as the Solo People from the site of their discovery on the Solo River at Ngandong. Koenigswald's discoveries might have been more impressive still but for a tactical error that was realized too late. He had offered locals ten cents for every piece of hominid bone they could come up with, then discovered to his horror that they had been enthusiastically smashing large pieces into small ones to maximize their income.

In the following years as more bones were found and identified there came a flood of new names—Homo aurignacensis, Australopithecus transvaalensis, Paranthropus crassidens, Zinjanthropus boisei,and scores of others, nearly all involving a new genus type as well as a new species. By the 1950s, the number of named hominid types had risen to comfortably over a hundred. To add to the confusion, individual forms often went by a succession of different names as paleoanthropologists refined, reworked, and squabbled over classifications. Solo People were known variously as Homo soloensis, Homo primigenius asiaticus, Homo neanderthalensis soloensis, Homo sapiens soloensis, Homo erectus erectus, and, finally, plain Homo erectus .

In an attempt to introduce some order, in 1960 F. Clark Howell of the University of Chicago, following the suggestions of Ernst Mayr and others the previous decade, proposed cutting the number of genera to just two—Australopithecus and Homo —and rationalizing many of the species. The Java and Peking men both became Homo erectus. For a time order prevailed in the world of the hominids.[2] It didn't last.

After about a decade of comparative calm, paleoanthropology embarked on another period of swift and prolific discovery, which hasn't abated yet. The 1960s produced Homo habilis, thought by some to be the missing link between apes and humans, but thought by others not to be a separate species at all. Then came (among many others) Homo ergaster, Homo louisleakeyi, Homo rudolfensis, Homo microcranus, and Homo antecessor, as well as a raft of australopithecines: A.afarensis, A. praegens, A. ramidus, A. walkeri, A. anamensis, and still others. Altogether, some twenty types of hominid are recognized in the literature today. Unfortunately, almost no two experts recognize the same twenty.

Some continue to observe the two hominid genera suggested by Howell in 1960, but others place some of the australopithecines in a separate genus called Paranthropus , and still others add an earlier group called Ardipithecus. Some put praegens into Australopithecus and some into a new classification, Homo antiquus, but most don't recognize praegens as a separate species at all. There is no central authority that rules on these things. The only way a name becomes accepted is by consensus, and there is often very little of that.

A big part of the problem, paradoxically, is a shortage of evidence. Since the dawn of time, several billion human (or humanlike) beings have lived, each contributing a little genetic variability to the total human stock. Out of this vast number, the whole of our understanding of human prehistory is based on the remains, often exceedingly fragmentary, of perhaps five thousand individuals. "You could fit it all into the back of a pickup truck if you didn't mind

[2] Humans are put in the lamely Homimdae. Its members, traditionally called hominids, include any creatures (including extinct ones) that are more closely related to us than to any surviving chimpanzees. The apes, meanwhile, are lumped together in a family called Pongidae. Many authorities believe that chimps, gorillas, and orangutans should also be included in this family, with humans and chimps in a subfamily called Homininae. The upshot is that the creatures traditionally called hominids become, under this arrangement, hominins. (Leakey and others insist on that designation.) Hominoidea is the name of the aue sunerfamily which includes us.

how much you jumbled everything up," Ian Tattersall, the bearded and friendly curator of anthropology at the American Museum of Natural History in New York, replied when I asked him the size of the total world archive of hominid and early human bones.

The shortage wouldn't be so bad if the bones were distributed evenly through time and space, but of course they are not. They appear randomly, often in the most tantalizing fashion. Homo erectus walked the Earth for well over a million years and inhabited territory from the Atlantic edge of Europe to the Pacific side of China, yet if you brought back to life every Homo erectus individual whose existence we can vouch for, they wouldn't fill a school bus. Homo habilis consists of even less: just two partial skeletons and a number of isolated limb bones. Something as short-lived as our own civilization would almost certainly not be known from the fossil record at all.

"In Europe," Tattersall offers by way of illustration, "you've got hominid skulls in Georgia dated to about 1.7 million years ago, but then you have a gap of almost a million years before the next remains turn up in Spain, right on the other side of the continent, and then you've got another 300,000-year gap before you get a Homo heidelbergensis in Germany—and none of them looks terribly much like any of the others." He smiled. "It's from these kinds of fragmentary pieces that you're trying to work out the histories of entire species. It's quite a tall order. We really have very little idea of the relationships between many ancient species—which led to us and which were evolutionary dead ends. Some probably don't deserve to be regarded as separate species at all."

It is the patchiness of the record that makes each new find look so sudden and distinct from all the others. If we had tens of thousands of skeletons distributed at regular intervals through the historical record, there would be appreciably more degrees of shading. Whole new species don't emerge instantaneously, as the fossil record implies, but gradually out of other, existing species. The closer you go back to a point of divergence, the closer the similarities are, so that it becomes exceedingly difficult, and sometimes impossible, to distinguish a late Homo erectus from an early Homo sapiens, since it is likely to be both and neither. Similar disagreements can often arise over questions of identification from fragmentary remains—deciding, for instance, whether a particular bone represents a female Australopithecus boisei or a male Homo habilis.

With so little to be certain about, scientists often have to make assumptions based on other objects found nearby, and these may be little more than valiant guesses. As Alan Walker and Pat Shipman have drily observed, if you correlate tool discovery with the species of creature most often found nearby, you would have to conclude that early hand tools were mostly made by antelopes.

Perhaps nothing better typifies the confusion than the fragmentary bundle of contradictions that was Homo habilis. Simply put, habilis bones make no sense. When arranged in sequence, they show males and females evolving at different rates and in different directions—the males becoming less apelike and more human with time, while females from the same period appear to be moving away from humanness toward greater apeness. Some authorities don't believe habilis is a valid category at all. Tattersall and his colleague Jeffrey Schwartz dismiss it as a mere "wastebasket species"—one into which unrelated fossils "could be conveniently swept." Even those who see habilis as an independent species don't agree on whether it is of the same genus as us or is from a side branch that never came to anything.

Finally, but perhaps above all, human nature is a factor in all this. Scientists have a natural tendency to interpret finds in the way that most flatters their stature. It is a rare paleontologist indeed who announces that he has found a cache of bones but that they are nothing to get excited about. Or as John Reader understatedly observes in the book Missing Links, "It is remarkable how often the first interpretations of new evidence have confirmed the preconceptions of its discoverer."

All this leaves ample room for arguments, of course, and nobody likes to argue more than paleoanthropologists. "And of all the disciplines in science, paleoanthropology boasts perhaps the largest share of egos," say the authors of the recent Java Man —a book, it may be noted, that itself devotes long, wonderfully unselfconscious passages to attacks on the inadequacies of others, in particular the authors' former close colleague Donald Johanson. Here is a small sampling:

In our years of collaboration at the institute he [Johanson] developed a well-deserved, if unfortunate, reputation for unpredictable and high-decibel personal verbal assaults, sometimes accompanied by the tossing around of books or whatever else came conveniently to hand.

So, bearing in mind that there is little you can say about human prehistory that won't be disputed by someone somewhere, other than that we most certainly had one, what we think we know about who we are and where we come from is roughly this:

For the first 99.99999 percent of our history as organisms, we were in the same ancestral line as chimpanzees. Virtually nothing is known about the prehistory of chimpanzees, but whatever they were, we were. Then about seven million years ago something major happened. A group of new beings emerged from the tropical forests of Africa and began to move about on the open savanna.

These were the australopithecines, and for the next five million years they would be the world's dominant hominid species. (Austral is from the Latin for "southern" and has no connection in this context to Australia.) Australopithecines came in several varieties, some slender and gracile, like Raymond Dart's Taung child, others more sturdy and robust, but all were capable of walking upright. Some of these species existed for well over a million years, others for a more modest few hundred thousand, but it is worth bearing in mind that even the least successful had histories many times longer than we have yet achieved.

The most famous hominid remains in the world are those of a 3.18-million-year-old australopithecine found at Hadar in Ethiopia in 1974 by a team led by Donald Johanson. Formally known as A.L. (for "Afar Locality") 288–1, the skeleton became more familiarly known as Lucy, after the Beatles song "Lucy in the Sky with Diamonds." Johanson has never doubted her importance. "She is our earliest ancestor, the missing link between ape and human," he has said.

Lucy was tiny—just three and a half feet tall. She could walk, though how well is a matter of some dispute. She was evidently a good climber, too. Much else is unknown. Her skull was almost entirely missing, so little could be said with confidence about her brain size, though skull fragments suggested it was small. Most books describe Lucy's skeleton as being 40 percent complete, though some put it closer to half, and one produced by the American Museum of Natural History describes Lucy as two-thirds complete. The BBC television series

Ape Man actually called it "a complete skeleton," even while showing that it was anything but.

A human body has 206 bones, but many of these are repeated. If you have the left femur from a specimen, you don't need the right to know its dimensions. Strip out all the redundant bones, and the total you are left with is 120—what is called a half skeleton. Even by this fairly accommodating standard, and even counting the slightest fragment as a full bone, Lucy constituted only 28 percent of a half skeleton (and only about 20 percent of a full one).

In The Wisdom of the Bones, Alan Walker recounts how he once asked Johanson how he had come up with a figure of 40 percent. Johanson breezily replied that he had discounted the 106 bones of the hands and feet—more than half the body's total, and a fairly important half, too, one would have thought, since Lucy's principal defining attribute was the use of those hands and feet to deal with a changing world. At all events, rather less is known about Lucy than is generally supposed. It isn't even actually known that she was a female. Her sex is merely presumed from her diminutive size.

Two years after Lucy's discovery, at Laetoli in Tanzania Mary Leakey found footprints left by two individuals from—it is thought—the same family of hominids. The prints had been made when two australopithecines had walked through muddy ash following a volcanic eruption. The ash had later hardened, preserving the impressions of their feet for a distance of over twenty-three meters.

The American Museum of Natural History in New York has an absorbing diorama that records the moment of their passing. It depicts life-sized re-creations of a male and a female walking side by side across the ancient African plain. They are hairy and chimplike in dimensions, but have a bearing and gait that suggest humanness. The most striking feature of the display is that the male holds his left arm protectively around the female's shoulder. It is a tender and affecting gesture, suggestive of close bonding.

The tableau is done with such conviction that it is easy to overlook the consideration that virtually everything above the footprints is imaginary. Almost every external aspect of the two figures—degree of hairiness, facial appendages (whether they had human noses or chimp noses), expressions, skin color, size and shape of the female's breasts—is necessarily suppositional. We can't even say that they were a couple. The female figure may in fact have been a child. Nor can we be certain that they were australopithecines. They are assumed to be australopithecines because there are no other known candidates.

I had been told that they were posed like that because during the building of the diorama the female figure kept toppling over, but Ian Tattersall insists with a laugh that the story is untrue. "Obviously we don't know whether the male had his arm around the female or not, but we do know from the stride measurements that they were walking side by side and close together—close enough to be touching. It was quite an exposed area, so they were probably feeling vulnerable. That's why we tried to give them slightly worried expressions."

I asked him if he was troubled about the amount of license that was taken in reconstructing the figures. "It's always a problem in making re-creations," he agreed readily enough. "You wouldn't believe how much discussion can go into deciding details like whether Neandertals had eyebrows or not. It was just the same for the Laetoli figures. We simply can't know the details of what they looked like, but we can convey their size and posture and make some reasonable assumptions about their probable appearance. If I had it to do again, I think I might

have made them just slightly more apelike and less human. These creatures weren't humans. They were bipedal apes."

Until very recently it was assumed that we were descended from Lucy and the Laetoli creatures, but now many authorities aren't so sure. Although certain physical features (the teeth, for instance) suggest a possible link between us, other parts of the australopithecine anatomy are more troubling. In their book Extinct Humans, Tattersall and Schwartz point out that the upper portion of the human femur is very like that of the apes but not of the australopithecines; so if Lucy is in a direct line between apes and modern humans, it means we must have adopted an australopithecine femur for a million years or so, then gone back to an ape femur when we moved on to the next phase of our development. They believe, in fact, that not only was Lucy not our ancestor, she wasn't even much of a walker.

"Lucy and her kind did not locomote in anything like the modern human fashion," insists Tattersall. "Only when these hominids had to travel between arboreal habitats would they find themselves walking bipedally, 'forced' to do so by their own anatomies." Johanson doesn't accept this. "Lucy's hips and the muscular arrangement of her pelvis," he has written, "would have made it as hard for her to climb trees as it is for modern humans."

Matters grew murkier still in 2001 and 2002 when four exceptional new specimens were found. One, discovered by Meave Leakey of the famous fossil-hunting family at Lake Turkana in Kenya and called Kenyanthropus platyops ("Kenyan flat-face"), is from about the same time as Lucy and raises the possibility that it was our ancestor and Lucy was an unsuccessful side branch. Also found in 2001 were Ardipithecus ramidus kadabba, dated at between 5.2 million and 5.8 million years old, and Orrorin tugenensis, thought to be 6 million years old, making it the oldest hominid yet found—but only for a brief while. In the summer of 2002 a French team working in the Djurab Desert of Chad (an area that had never before yielded ancient bones) found a hominid almost 7 million years old, which they labeled Sahelanthropus tchadensis. (Some critics believe that it was not human, but an early ape and therefore should be called Sahelpithecus.) All these were early creatures and quite primitive but they walked upright, and they were doing so far earlier than previously thought.

Bipedalism is a demanding and risky strategy. It means refashioning the pelvis into a full load-bearing instrument. To preserve the required strength, the birth canal must be comparatively narrow. This has two very significant immediate consequences and one longer-term one. First, it means a lot of pain for any birthing mother and a greatly increased danger of fatality to mother and baby both. Moreover to get the baby's head through such a tight space it must be born while its brain is still small—and while the baby, therefore, is still helpless. This means long-term infant care, which in turn implies solid male–female bonding.

All this is problematic enough when you are the intellectual master of the planet, but when you are a small, vulnerable australopithecine, with a brain about the size of an orange,[3] the risk must have been enormous.

[3] Absolute brain size does not tell you everything-or possibly sometimes even much. Elephants and whales both have brains larger than ours, but you wouldn't have much trouble outwitting them in contract negotiations. It is relative size that matters, a point that is often overlooked. As Gould notes, A. africanus had a brain of only 450 cubic centimeters, smaller than that of a gorilla. But a typical africanus male weighed less than a hundred pounds, and a female much less still, whereas gorillas can easily top out at 600 pounds (Gould pp. 181-83).

So why did Lucy and her kind come down from the trees and out of the forests? Probably they had no choice. The slow rise of the Isthmus of Panama had cut the flow of waters from the Pacific into the Atlantic, diverting warming currents away from the Arctic and leading to the onset of an exceedingly sharp ice age in northern latitudes. In Africa, this would have produced seasonal drying and cooling, gradually turning jungle into savanna. "It was not so much that Lucy and her like left the forests," John Gribbin has written, "but that the forests left them."

But stepping out onto the open savanna also clearly left the early hominids much more exposed. An upright hominid could see better, but could also be seen better. Even now as a species, we are almost preposterously vulnerable in the wild. Nearly every large animal you can care to name is stronger, faster, and toothier than us. Faced with attack, modern humans have only two advantages. We have a good brain, with which we can devise strategies, and we have hands with which we can fling or brandish hurtful objects. We are the only creature that can harm at a distance. We can thus afford to be physically vulnerable.

All the elements would appear to have been in place for the rapid evolution of a potent brain, and yet that seems not to have happened. For over three million years, Lucy and her fellow australopithecines scarcely changed at all. Their brain didn't grow and there is no sign that they used even the simplest tools. What is stranger still is that we now know that for about a million years they lived alongside other early hominids who did use tools, yet the australopithecines never took advantage of this useful technology that was all around them.

At one point between three and two million years ago, it appears there may have been as many as six hominid types coexisting in Africa. Only one, however, was fated to last: Homo, which emerged from the mists beginning about two million years ago. No one knows quite what the relationship was between australopithecines and Homo, but what is known is that they coexisted for something over a million years before all the australopithecines, robust and gracile alike, vanished mysteriously, and possibly abruptly, over a million years ago. No one knows why they disappeared. "Perhaps," suggests Matt Ridley, "we ate them."

Conventionally, the Homo line begins with Homo habilis, a creature about whom we know almost nothing, and concludes with us, Homo sapiens (literally "man the thinker"). In between, and depending on which opinions you value, there have been half a dozen other Homo species: Homo ergaster, Homo neanderthalensis, Homo rudolfensis, Homo heidelbergensis, Homo erectus, and Homo antecessor.

Homo habilis ("handy man") was named by Louis Leakey and colleagues in 1964 and was so called because it was the first hominid to use tools, albeit very simple ones. It was a fairly primitive creature, much more chimpanzee than human, but its brain was about 50 percent larger than that of Lucy in gross terms and not much less large proportionally, so it was the Einstein of its day. No persuasive reason has ever been adduced for why hominid brains suddenly began to grow two million years ago. For a long time it was assumed that big brains and upright walking were directly related—that the movement out of the forests necessitated cunning new strategies that fed off of or promoted braininess—so it was something of a surprise, after the repeated discoveries of so many bipedal dullards, to realize that there was no apparent connection between them at all.

"There is simply no compelling reason we know of to explain why human brains got large," says Tattersall. Huge brains are demanding organs: they make up only 2 percent of the body's mass, but devour 20 percent of its energy. They are also comparatively picky in what

they use as fuel. If you never ate another morsel of fat, your brain would not complain because it won't touch the stuff. It wants glucose instead, and lots of it, even if it means short-changing other organs. As Guy Brown notes: "The body is in constant danger of being depleted by a greedy brain, but cannot afford to let the brain go hungry as that would rapidly lead to death." A big brain needs more food and more food means increased risk.

Tattersall thinks the rise of a big brain may simply have been an evolutionary accident. He believes with Stephen Jay Gould that if you replayed the tape of life—even if you ran it back only a relatively short way to the dawn of hominids—the chances are "quite unlikely" that modern humans or anything like them would be here now.

"One of the hardest ideas for humans to accept," he says, "is that we are not the culmination of anything. There is nothing inevitable about our being here. It is part of our vanity as humans that we tend to think of evolution as a process that, in effect, was programmed to produce us. Even anthropologists tended to think this way right up until the 1970s." Indeed, as recently as 1991, in the popular textbook The Stages of Evolution, C. Loring Brace stuck doggedly to the linear concept, acknowledging just one evolutionary dead end, the robust australopithecines. Everything else represented a straightforward progression—each species of hominid carrying the baton of development so far, then handing it on to a younger, fresher runner. Now, however, it seems certain that many of these early forms followed side trails that didn't come to anything.

Luckily for us, one did—a group of tool users, which seemed to arise from out of nowhere and overlapped with the shadowy and much disputed Homo habilis. This is Homo erectus, the species discovered by Eugène Dubois in Java in 1891. Depending on which sources you consult, it existed from about 1.8 million years ago to possibly as recently as twenty thousand or so years ago.

According to the Java Man authors, Homo erectus is the dividing line: everything that came before him was apelike in character; everything that came after was humanlike. Homo erectus was the first to hunt, the first to use fire, the first to fashion complex tools, the first to leave evidence of campsites, the first to look after the weak and frail. Compared with all that had gone before, Homo erectus was extremely human in form as well as behavior, its members long-limbed and lean, very strong (much stronger than modern humans), and with the drive and intelligence to spread successfully over huge areas. To other hominids, Homo erectus must have seemed terrifyingly powerful, fleet, and gifted.

Erectus was "the velociraptor of its day," according to Alan Walker of Penn State University and one of the world's leading authorities. If you were to look one in the eyes, it might appear superficially to be human, but "you wouldn't connect. You'd be prey." According to Walker, it had the body of an adult human but the brain of a baby.

Although erectus had been known about for almost a century it was known only from scattered fragments—not enough to come even close to making one full skeleton. So it wasn't until an extraordinary discovery in Africa in the 1980s that its importance—or, at the very least, possible importance—as a precursor species for modern humans was fully appreciated. The remote valley of Lake Turkana (formerly Lake Rudolf) in Kenya is now one of the world's most productive sites for early human remains, but for a very long time no one had thought to look there. It was only because Richard Leakey was on a flight that was diverted over the valley that he realized it might be more promising than had been thought. A team was dispatched to investigate, but at first found nothing. Then late one afternoon Kamoya

Kimeu, Leakey's most renowned fossil hunter, found a small piece of hominid brow on a hill well away from the lake. Such a site was unlikely to yield much, but they dug anyway out of respect for Kimeu's instincts and to their astonishment found a nearly complete Homo erectus skeleton. It was from a boy aged between about nine and twelve who had died 1.54 million years ago. The skeleton had "an entirely modern body structure," says Tattersall, in a way that was without precedent. The Turkana boy was "very emphatically one of us."

Also found at Lake Turkana by Kimeu was KNM-ER 1808, a female 1.7 million years old, which gave scientists their first clue that Homo erectus was more interesting and complex than previously thought. The woman's bones were deformed and covered in coarse growths, the result of an agonizing condition called hypervitaminosis A, which can come only from eating the liver of a carnivore. This told us first of all that Homo erectus was eating meat. Even more surprising was that the amount of growth showed that she had lived weeks or even months with the disease. Someone had looked after her. It was the first sign of tenderness in hominid evolution.

It was also discovered that Homo erectus skulls contained (or, in the view of some, possibly contained) a Broca's area, a region of the frontal lobe of the brain associated with speech. Chimps don't have such a feature. Alan Walker thinks the spinal canal didn't have the size and complexity to enable speech, that they probably would have communicated about as well as modern chimps. Others, notably Richard Leakey, are convinced they could speak.

For a time, it appears, Homo erectus was the only hominid species on Earth. It was hugely adventurous and spread across the globe with what seems to have been breathtaking rapidity. The fossil evidence, if taken literally, suggests that some members of the species reached Java at about the same time as, or even slightly before, they left Africa. This has led some hopeful scientists to suggest that perhaps modern people arose not in Africa at all, but in Asia—which would be remarkable, not to say miraculous, as no possible precursor species have ever been found anywhere outside Africa. The Asian hominids would have had to appear, as it were, spontaneously. And anyway an Asian beginning would merely reverse the problem of their spread; you would still have to explain how the Java people then got to Africa so quickly.

There are several more plausible alternative explanations for how Homo erectus managed to turn up in Asia so soon after its first appearance in Africa. First, a lot of plus-or-minusing goes into the dating of early human remains. If the actual age of the African bones is at the higher end of the range of estimates or the Javan ones at the lower end, or both, then there is plenty of time for African erects to find their way to Asia. It is also entirely possible that older erectus bones await discovery in Africa. In addition, the Javan dates could be wrong altogether.

Now for the doubts. Some authorities don't believe that the Turkana finds are Homo erectus at all. The snag, ironically, was that although the Turkana skeletons were admirably extensive, all othererectus fossils are inconclusively fragmentary. As Tattersall and Jeffrey Schwartz note in Extinct Humans, most of the Turkana skeleton "couldn't be compared with anything else closely related to it because the comparable parts weren't known!" The Turkana skeletons, they say, look nothing like any Asian Homo erectus and would never have been considered the same species except that they were contemporaries. Some authorities insist on calling the Turkana specimens (and any others from the same period) Homo ergaster. Tattersall and Schwartz don't believe that goes nearly far enough. They believe it wasergaster "or a reasonably close relative" that spread to Asia from Africa, evolved intoHomo erectus, and then died out.

What is certain is that sometime well over a million years ago, some new, comparatively modern, upright beings left Africa and boldly spread out across much of the globe. They possibly did so quite rapidly, increasing their range by as much as twenty-five miles a year on average, all while dealing with mountain ranges, rivers, deserts, and other impediments and adapting to differences in climate and food sources. A particular mystery is how they passed along the west side of the Red Sea, an area of famously punishing aridity now, but even drier in the past. It is a curious irony that the conditions that prompted them to leave Africa would have made it much more difficult to do so. Yet somehow they managed to find their way around every barrier and to thrive in the lands beyond.

And that, I'm afraid, is where all agreement ends. What happened next in the history of human development is a matter of long and rancorous debate, as we shall see in the next chapter.

But it is worth remembering, before we move on, that all of these evolutionary jostlings over five million years, from distant, puzzled australopithecine to fully modern human, produced a creature that is still 98.4 percent genetically indistinguishable from the modern chimpanzee. There is more difference between a zebra and a horse, or between a dolphin and a porpoise, than there is between you and the furry creatures your distant ancestors left behind when they set out to take over the world.

Chapter 28

Discussion Questions:

1.Where did "humans" come from? What do we know about human ancestry?

2.Why does Bryson say, "Did you have a good ice age?"

3.How did the ice age influence human development?

4.Where and how were the first human fossils found?

5.Bryson states, "In their eagerness to reject the idea of earlier humans, authorities were willing to embrace the most singular possibilities." What are some examples?

6.Who were "Java man" and "Neanderthal man" and "Peking Man"?

7.Who was Dart and what was the "Taung child"?

8.Why was there such confusion of human fossils and identification in the 1950s?

9.What are the classifications of human fossils?

10.What are some of the problems with identifying human fossils?

11.How was (and is) human fossil identification another example of "Fitting the evidence to our preconceptions."

12.Who was "Lucy?" Is she a human ancestor?

13.What were some of the "risks" in human development?

14.Why does Bryson say bipedalism and large brains are "risky?"

15.What is the current knowledge of human history?