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The Hairless Mutation Hypothesis Explains Not Only the Origin of Humanization from the Human/Ape Common Ancestor but also Immature Baby Delivery

Shizuyo Sutou*

School of Pharmacy, Shujitsu University, 1-6-1 Nishigawara, Naka-ku, Okayama 703-8516, Japan

Abstract

Molecular and paleontological dating indicates human appearance 6 million years ago. Early hominin fossils show that they were bipeds. Three salient characteristics distinguish humans from other primates: bipedality, practical nakedness, and the family reproductive unit. Once a hairless mutation was initially introduced, the three characteristics became separately inexplicable. All primates except humans can carry their babies without using their hands. A hairless mother would be forced to stand and walk upright to hold a baby. Her activities would be markedly limited. The male partner would have to collect food and carry it to her to keep their baby from starving; irresponsible and selfish males could not have left their offspring. The mother would have sexually accepted her partner at any time as a reward for food. Sexual relations irrespective of estrus cycles might have strengthened the pair bond. Consequently, hairless and upright pairs would have established strong families. Early hominins had the opposable hallux and remained as arboreal denizens. Climate changes probably forced them to terrestrial life, but the ground was full of danger and trees were indispensable for refuge and nesting. Consequently, archaic hominins had mosaic characteristics of the upper body adapted for arboreal life and the lower body for terrestrial life, for which a larger brain became advantageous. Alternative strategies became possible: development of a large pelvis with a big birth canal through which a baby with a big head could pass, or delivery of an immature baby, with rearing after birth. The former was physically incompatible with an upright posture, and structurally unfavorable for swift movement. The latter was unavailable to primates, the babies of which had to cling to the mother; upright hominins were able to hold the immature baby with hands and raise it after birth.

Keywords: Bipedalism, Bipedality, Family formation, Hairlessness, Hominin, Human evolution, Immature baby, *Tyrannosaurus rex*

Abbreviations: CLCA: Chimpanzee/Human Last Common Ancestor; Ma: Million years ago

Dominators of the Earth

Unique *Homo sapiens*

More than 7 billion individuals of a single species, *Homo sapiens*, reside on spaceship Earth now. If each one weighed 60 kg, that would make up 42 million tons of flesh. We *H. sapiens* occupy a unique position in the whole evolutional history in that one species of one genus has reached this huge population, sustained not only by natural products but also by foods produced independently. Our prosperity has been blessed by the development of science and technology, which have been achieved using the dexterous hands and the big brain that have been in turn attained as the result of upright bipedalism.

Tyrannosaurus rex the tyrant

Tyrannosaurus rex was a biped, but it did not stand upright as we do. How many *T. rex* swaggered around at its peak period of dominance? Seven billion people are equal to 70 million *T. rex* if one 6-ton *T. rex* is equivalent to a hundred 60-kg people. Even if *T. rex* had been an apex predator at the top of their food chain, such a large number must have been impossible to achieve because a large territory was necessary for a single animal to maintain its huge carnivorous body. As the largest carnivore, *T. rex* reigned on earth until their sudden extinction by the collision of an asteroid 65 million years ago (Ma) [1]. How did they become tyrants? *T. rex* had a T-shape body structure that required a balance between the top and the tail so that both a big head and powerful hands at the top part were not compatible. The strategy they adopted was the development of the big head as a weapon at the expense of forelimb development. This strategy was successful; the forelimbs became so small that they were nearly vestigial, useful only as toothpicks. The head was equipped with tremendously powerful jaws with the long teeth, with the big, forward pointing eyes giving it stereoscopic vision, and probably with the nose with a fine olfactory function. Consequently, the head became a powerful weapon beyond comparison. This carnivore must have been truly dreadful. Targeted creatures must have found it difficult to escape. *T. rex* might have had a refined brain, but its function must have been specialized to catch game. No matter how elaborate *T. rex* might be as a killer, its brain could not be used to create things as we humans do because the brain was not oriented for creation. Moreover, the forelimbs, not with nails but with claws, were not useful for manipulating things and realizing ideas if they had even had any. Therefore, *T. rex* was successful only in a sense that it occupied the top of the ecosystem at their time. Avoiding many dinosaurs including *T. rex* on the ground and pterosaurs, winged dinosaurs, in the air, small mammalian ancestors seemed to live mainly nocturnal lives. After the extinction of dinosaurs, mammalian species showed adaptive radiation. Among them, we biped humans with regressing small jaws without fangs and with slender hands without

***Corresponding author:** Shizuyo Sutou, School of Pharmacy, Shujitsu University, 1-6-1 Nishigawara, Naka-ku, Okayama 703-8516, Japan, Tel/Fax: +81-86-271-8357; E-mail: sutou@shujitsu.ac.jp

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claws came to dominate the whole earth, as if strength had come from weakness.

Major Three Human Characteristics

Upright bipedalism

H. sapiens is a unique creature that shows many characteristics separating it from other primates such as upright bipedality, practical hairlessness, a family as a reproductive and social unit, a large brain and neocortex, small canine teeth, use and manufacture of tools, use of fire, communication by language, food production by cultivating plants and domesticating animals, creation of culture and civilization, and formation of society and states. Especially, the first three are regarded as constituting basic key factors of the origin of humans. Other important characteristics such as the use of tools, fire, and language are regarded as being achieved after the establishment of upright bipedalism, which had liberated hands from walking and which had removed limitations impeding brain enlargement. Therefore, the attainment of bipedalism is regarded as the key factor of humanization. This has been accepted as common knowledge. The origin of bipedalism, however, has remained a matter of interest for over a century. Many hypotheses and ideas have been advanced to explain the origin of bipedalism, but no common understanding has been established. Some of these ideas include that upright posture and bipedal gait were useful for vigilance against predators, that hominins were scavengers, that bipedalism was a necessary adaptation for sufficient food, and that bipedal walking was less costly than quadrupedalism energetically. I put forward the hypothesis that bipedalism is explainable by a single hairless mutation that worked as a driving force of upright walking while holding a baby with both hands [2].

Practical hairlessness

Taking bipedalism as the first issue of humanity, the second issue is hairlessness, which is related inseparably to bipedalism according to my hypothesis [2]. Hairlessness distinguishes humans from other primates. Lack of availability of skin or hair fossils must be the major reason for the scarcity of hypotheses about human nakedness in contrast to the number and variety of those for bipedalism. The body-cooling hypothesis, which was most persuasive to explain human hairlessness, holds that the reduction in body hair provided a thermoregulatory advantage to hominins with a large brain, which is vulnerable to thermal damage [3,4]. However, hairlessness is disadvantageous at lower ambient temperatures. The naked skin is vulnerable to injuries. The big brain was attained after bipedalism in the later stage of human evolution. The body-cooling hypothesis was based on the savanna environment, although humanization was not achieved in the savanna. For that reason, this hypothesis has been criticized bitterly [5]. Another hypothesis is that humans, who were able to regulate their environment using fire, shelter, and clothing, shed their fur to rid their bodies of diseases spreading ectoparasites such as lice [6]. This is inapplicable to early hominins, who had no ability to use fire, shelter, or clothing. Indeed, a molecular clock analysis shows that human body lice originated approximately 72 000 years ago and suggests that clothing is a recent innovation in human evolution [7]. My hypothesis is that a single hairless mutation triggered the very start of human evolution [2]. Hair is useful to maintain body temperature and to avoid injuries, but the major raison d'etre of hair in primates is its role as a grip for babies. A hairless mother had to hold her baby with a hand or more safely with both hands, forcing her to walk upright. The hairless gene might soon be shared by males if the gene was dominant or semi-dominant where homozygotes are lethal. Inversely, a male might be a proband of hairlessness. Here, let me draw the reader's attention to a phenotype called canine ectodermal dysplasia (CED), by which affected dogs are hairless but have hair on the head. A frame shift mutation in a forkhead box transcription factor family (FOXI3) gene was identified as the responsible gene for CED [8]. Mexican hairless dogs have hair on the terminal area of the tail. Chinese crested dogs have long hair not only on the head but also on the tail and the lower part of the legs.

Family as a Reproductive and Social Unit

Unique human family: At first glance, it is easily understandable that bipedalism and hairlessness are *sine qua nons* of humanity, but the extremely important third issue of the family as a reproductive and social unit in human society is often overlooked. The uniqueness of human families can be understood when other primate societies are examined. The social organization of orangutans is a loose community, with a typical reproductive unit consisting of one male and one or more female clusters. Single male and multi-male groups exist among gorillas. Chimpanzees form a closed reproductive unit consisting usually of 20-80 males and females who are promiscuous. Consequently, the primarily monogamous nature of a human family is unique among primates. The importance of human families can be understood by thinking of ourselves, who were raised by extensive cooperative efforts of parents, and frequently, of family members. I am deeply impressed by seeing a baby rely and depend completely on parents, especially on the mother, and by her devotion to her baby. Consequently, I think that the three major basic characteristics, i.e., bipedalism, hairlessness, and a family as a reproductive and social unit, must share the same root at the origin and be associated intrinsically and inseparably with the origin of human development [2].

Hairless mutation and family formation: The hairless mutation hypothesis explains the formation of a human family as follows: All primates except humans can carry their babies without using their hands. Once hairless, mutation occurred, a hairless mother had to hold her baby with both hands. In doing so, she devoted her attention incessantly to the baby, strengthening mother–baby bonding. However, she had to stand and walk upright, and her activities were thereby greatly limited. She found difficulty in moving from branch to branch and from tree to tree, in climbing trees, in collecting fruits and nuts, and so on. The male partner's assistance was indispensable. He would have to collect food and carry it to her to keep her and their baby from starving. Irresponsible and selfish males could not have left their offspring. The mother would have sexually accepted him at any time as a reward for food. She might have also desired his return to their nest. Sexual relations irrespective of estrus cycles might have strengthened the pair bond. Her reluctance to move frequently helped to let their nest on a tree be used as long as possible. Sexual relations in the nest occurring with a face-to-face posture, which stimulated the clitoris irrespective of the estrus cycle, might have strengthened the pair bond. Skin-to-skin contact without intervening fur might have let the pair feel deeper contact. Season less copulation must have caused consecutive conceptions, continuous breeding seasons, and families with members consisting of parents, a suckling baby, and junior and senior children if several years were necessary for babies to grow up. The hairless condition was fatally disadvantageous. Therefore, cooperative maintenance of a family by its members must have been crucially important. Consequently, the unique sexual and reproductive behavior of monomorphic humans, including monogamous and season less mating, lack of an externally recognizable estrous cycle, continual receptivity, and the large penis are explainable inseparably as a result of hairlessness.

Family bond to human bonding: An early hominin, *Ardipithecus*

ramidus, had a reduced canine/premolar complex [9] and showed no sexual dimorphism in body size [10], indicating less male-to-male conflict and social aggression, and implying its monogamous family system. This cooperative family as the basic unit of human society seems to have been transferred to the descendant hominins. An archaic *Australopithecus afarensis* was likely to be principally monogamous, as we *Homo sapiens* are [11]. Morris [12] wrote that we *H. sapiens* have lived in a culturally developed society to date, but the basic unit of the society remains the family, as was true in the early hunting and gathering days. In addition to the family structure, the mentality of family bonding manifested by a sympathetic mindset trying to help and support each other substantially and mentally, is apparently expanded to human communities as human bonding. In this context, it is interesting to learn that 2–3-year-old human children understand collaboration and sharing, although chimpanzees do not [13].

Hominins were Bipeds from the Start

Early hominins were bipeds

It is commonly accepted that we *H. sapiens* separated from CLCA between 5 and 7 Ma. A very early fossil of the human lineage close to CLCA is *Sahelanthropus tchadensis*, which was found in the Djurab Desert of northern Chad [14] (Table 1). Associated fauna suggest that the fossils are 6–7 Ma and that the hominins lived close to a lake but not far from a sandy desert. Analysis of the basicranium suggests that *S. tchadensis* was an upright biped [15]. The femoral morphology of *Orrorin tugenensis* 6 Ma from Kenya, the second oldest hominin, exhibits bipedalism [16,17]. The third old hominin *Ar. kadabba* from the Middle Awash area of Ethiopia was dated to 5.2–5.8 Ma; it was associated with a wooded pale environment. The proximal foot phalanx is consistent with bipedalism [18]. Consequently, different parts of fossils from different genera imply that early hominins were bipeds. Based on the similarity of dentition of these three early hominins, the possibility that the three might be involved in a single genus has been suggested [19]. If so, collectively, then bipedalism of early hominins can be confirmed more strongly. Even though they were likely to walk upright habitually, they were thought to be arboreal denizens.

Ardi the *Ar. ramidus* was a biped

Ar. ramidus might have lived ca. 6–4 Ma. Ardi was an *Ar. ramidus* woman who lived in the Afar Rift region of northern Ethiopia 4.4 Ma [20]. She was found with most of her skull, pelvis, teeth, hands, feet, and other parts along with many other *Ar. ramidus* specimens. The markedly well preserved and reconstructed skeleton of Ardi provides reliable information related to early human evolution. She is estimated to have stood approximately 120 cm tall and to have weighed 50 kg. Her face was small; her brain was also small (300-350 cm^3), similar to that of a present-day bonobo or a present-day female chimpanzee. She was a denizen of woodlands with small patches of forest, as animal and plant fossils around her show. She was probably omnivorous and ate

Hominin	Species	Time (Ma)	Height (m)	Weight (kg)	Brain (cc)
Early	*Sahelanthropus tchadensis*	6-7	150		320-380
	Orrorin tugenensis	6.1-5.8			
	Ardipithecus kadabba	5.6			
	Ar. ramidus	4.4	120	50	300-350
Archaic	*Australopithecus anamensis*	4.2-3.9		33-51	
	Au. afarensis	3.9-.9	107-152	29-45	380-430
	Au. bahrelghazali	3.5-3			
	Au. africanus	3.03-2.04	115-138	30-41	420-500
	Au. garhi	3-2			450
	Au. sediba	1.78-1.95	130		420
	Kenyanthropus platyops	3.5-3.2			350
Megadont	*Paranthropus aethiopicus*	2.6-2.3			410
archaic	*P. boisei*	2.1-1.1	124-137	34-49	530
	P. robustus	2-1.5	110-132	32-40	530
Transitional	*H. rudolfensis*	2.4-1.6	150-160	51-60	790
	H. habilis	2.4-1.5	100-131	32-37	500-800
	H. georgicus	1.8	150		600-780
pre-modern	*H. ergaster*	1.8-1.3	160-180	56-66	700-1,100
	H. electus	1.9-0.14	179		950-1,100
	Homo antecessor	1.2-0.8	160-180	90	1,000-1,150
	H. heidelbergensis	0.5-0.2	175	62	1100-1400
	Denisova hominins	- 0.04			
	H. neanderthalensis	0.23-0.024	157-165	80	1450
	H. floresiensis	- 0.017	106	25	426
Modern	*H. sapiens*	0.2 -	170	70	1350

Table 1: More than two hominin species had been usually coexisted. All are bipeds.

nuts, insects, snails, and small animals found among the trees and on the ground, and did not feed much in the open grassland. Importantly, she was apparently a biped, showing that our ancestors walked upright before they evolved a larger brain. She had no characteristics of the suspension, vertical climbing, and knuckle-walking that present great apes have [10]. She had the opposable hallux, indicating that she was bipedal when moving on the ground, but quadrupedal when moving about in tree branches. She shows that more than two million years passed from the quadrupedal CLCA age to the bipedal Ardi's age. The bones consist of many parts and are closely mutually associated. To shift from quadrapedalism to bipedalism, not only bones but muscles and nerves must be changed coordinatively. This must be one reason to require a long time span to evolve.

Archaic hominins were bipeds

The age of the early hominin *Ar. ramidus* was followed by archaic hominins (4.2–1.4 Ma) such as *Au. anamensis*, *Au. afarensis*, *Au. africanus*, and later *Au. sediba*. *Ar. Ramidus* and *Au. anamensis* [21] were separated temporally by only ca. 0.2 million years, but this period separates the two groups discretely. Especially, early hominins had the opposable hallux, but archaic hominins had the more adducted great toe in line with other four lateral toes. By transformation from an ape-like foot to a human-like one, the foot is modified to act as a propulsive lever rather than a grasping tool. Abundant fossils of *Au. afarensis* are available. Lucy, the common name of AL 288-1, was a female *Au. afarensis* who lived 3.18 Ma. She was discovered in 1974 at Hadar in the Awash Valley of Ethiopia. Over 40% of Lucy's skeleton was recovered, making her one of the most complete fossil hominins. Her foot was not recovered, but her pelvic structure clearly indicates that Lucy was a biped. Her brain size is deduced as less than 400 cc. Consequently, Lucy showed that bipedalism outstripped enlargement of the brain. Another markedly well-preserved skeleton of Selam or Dikika Baby, a 3-year-old *Au. afarensis* girl who lived 3.32 Ma and whose brain size was 330 cc, also supports bipedal walking before brain enlargement [22]. Bipedalism of *Au. afarensis* was demonstrated directly by 3.6 Ma hominin footprint fossils at Laetoli in Tanzania [23]. The Laetoli hominins walked with weight transfer most similar to the economical extended limb bipedalism of humans, which is more ergonomically efficient than ape-like bipedalism [24]. Although Lucy seemed to have flat feet, some archaic hominins had arched feet [25]. The StW 573 specimen called 'Little Foot' was found in Sterkfontein, near Johannesburg, South Africa, belongs to neither *Au. afarensis* nor *Au. africanus*, but to an *Australopithecus* species [26]. Little Foot might have lived 3.5 Ma, but the date has not been firmly fixed, varying from 4, 3.3, and 2.2 Ma. Whereas the great toe is medially diverged (varus) and mobile, the foot is adapted manifestly for bipedalism [27]. These fossils reflect that Australopithecines were adapted to bipedal locomotion if not perfect.

Au. sediba's odd gait

We *H. sapiens* are bipeds. Pre-modern hominins such as *Homo antecessor*, *H. heidelbergensis*, and *H. neanderthalensis* were also fully bipedal. *H. ergaster*, one of the early members of the genus *Homo* 1.8 Ma, was thought to be a fully developed biped. The OH8 *H. habilis* foot 1.8 Ma seemed to show a full bipedal adaptation at first, but it has been argued that it retains evidence of an arboreal adaptation [28]. Consequently, full bipedalism of these early *Homo* species is not always accepted. Very recently, results of precise analyses of *Au. sediba* fossils of ca. 2 Ma, which was discovered in 2008 at the site of the Malapa cave, South Africa, have been reported [29]. The remarkably well-reserved older female skeleton of *Au. sediba* is interesting from several perspectives. 1) This archaic hominin *Au. sediba* and early *Homo* species that appeared first 2.4 Ma coexisted. 2) Two million years passed between the appearance of *Au. anamensis* and this *Au. sedaba*, both of which show mosaic characteristics of an ape-like upper body and human-like lower body [29]. The long, strong arms show adaptation for climbing trees. The pelvis and femurs show that they stood on two legs and regularly walked upright. Their adaptations for living both in the trees and on the ground were apparently necessary for their survival. No basic changes were allowed to them for two million years. 3) The skull is a mosaic of ape-like small brain size (420–450 cm^3) with a human-like lower jaw with small canine teeth like all other hominins, which presents a contrast with *Au. afarensis* that had ape-like face proportions of a flat nose and a strongly projecting lower jaw. 4) The bottom of the heel bone is too small to allow the transmission of body weight to the foot directly so that the outside of its mid-foot was used to share the weight with the small heel bone. Consequently, she must have pronated the foot at each step, rolling it markedly inwards. Was this rather odd gait common to all australopithecines? The answer might be 'no' because hominin footprint fossils at Laetoli in Tanzania 3.6 Ma indicates that at least some australopithecines were bipeds [23]. There must be different evolutional stages of the foot. There are also many variations among species and individuals [25]. The odd gait might not be specific to all *Au. sediba*, but she might be exceptional, for example, because of an accidental injury when she was young, and finally fell into the Malapa cave to her death. She shows spinal curvature, a hallmark of upright walking, and the human-like pelvis and leg structure, implying that *Au. sediba* generally walked similarly to a human.

Split of Upper and Lower Bodies

Early hominins were arboreal denizens

As discussed above, probably as a result of a hairless mutation, hominins were bipeds from the start. Early hominins represented by Ardi had long arms with long fingers and feet with an opposable hallux, indicating that they were arboreal denizens and were good at climbing trees and walking on branches rather than walking on the ground. Because a hairless mutation has nothing to do with bone morphology, their body structure must have been at first the same as CCLA with only a single exception: hairlessness. Fortunately, the movement of CCLA on trees was conducted using four limbs as if they were half bipedal and half quadrupedal. Therefore, they must have been able to endure the hairless life on trees. Both the upper and lower bodies of early hominins were primitive and ape-like. Given that the earliest hominin appeared 7 Ma, there were more than 2 million years from the start of humanization to the age of Ardi, 4.4 Ma, which resembled a standing ape. Why did they remain primitive for such a long period? There must not have been any reasons to leave the arboreal territory and arboreal principles must not have allowed them to evolve further. They were probably able to live, so to speak, happily in trees. Once Dr. Motoo Kimura, who was famous for the neutral theory of molecular evolution, invited Prof. Linus Pauling to the National Institute of Genetics in Japan. After his lecture, I asked him why humans cannot synthesize vitamin C. He answered that our ancestors probably lived in fruit-rich valleys.

Archaic hominin's split body

Archaic hominin *Au. anamensis* appeared 4.2 Ma (Table 1). A span of only 0.2 million years separates its time from the days of Ardi. Another archaic hominin, *Au. afarensis*, represented by Lucy, had a mosaic structure of the upper and lower body: the upper body, with a small head and long arms with long fingers, is primitive and ape-like, but the lower body is apparently bipedal. Footprint fossils at Laetoli in

Tanzania assigned to *Au. afarensis* show no sign of an adducted hallux and clearly show that they were human-like bipeds. *Au. sediba* 2 Ma also shows the split features of upper and lower bodies. Therefore, evolution from early hominins to archaic ones was applied mostly to the lower body, and the upper body remained rather primitive. The reason for the split evolution between the two parts is the selective pressure from their lifestyle. Early hominins probably spent most of their lives in trees and were sometimes forced to walk on the ground to move from tree to tree and collect nuts, berries, snails, insects, and so on. Archaic hominins must not have been allowed to live mainly in trees because of arboreal regression associated with climate change. Then they had to collect a fairly large fraction of their diet on the ground. In addition to collecting traditional foods such as nuts and berries, they must catch vivid insects and small animals. Moreover, they might scavenge from kills made by more efficient predators such as large cats and dogs, from which they would have had to flee quickly and frequently to trees nearby. Therefore, trees must have provided them with refuge and places to make nests where young were reared. Effective walking and running was becoming a major selective pressure for archaic hominins to evolve human-like bipedalism according to the terrestrial principles, whereas the upper body remained ape-like according to the arboreal principles. Gathering and collecting life would not require a big brain. However, the terrestrial life forced them to attain a big brain gradually. However, they were unable to afford to invest in many raw materials of bones to a big brain case because they had to keep the long upper limbs with the massive and limber shoulder girdles, which made them able to brachiate if necessary. Most importantly, they did have insufficient tools and power or ability to get nutrition sufficient to support a large brain.

Hairlessness Helped Immature Baby Delivery

A big pelvis for a big baby is not sufficient

Babies of herbivores such as horses, cows, goats, and sheep are so mature that they can stand, walk, and run less than one hour after birth. Although the gestation period of cattle is approximately 280 days, which comparable to that of humans, cattle show great differences in neonatal maturity. Fetuses would be pulled down gravitationally and would have difficulty remaining in the abdominal cavity if the cattle gait were upright. In most mammals, brain growth occurs mainly in the fetal stage. In chimpanzees, for example, the brain and the cerebral part of the skull grow little after birth, although the human brain continues to grow significantly for the first few years after birth. Therefore, human babies are delivered immaturely and take a longer period to become adults than do other species of comparable body size. Inversely, if hominins try to deliver a mature neonate with a big head, they must have a pelvis sufficiently wide and long from front to back to provide a large birth canal through which a baby with the big head can pass. The peritoneal space of an upright body can be compared to an inverted bag with an opening at the bottom. When the opening is large, it must be difficult to retain internal organs including digestive and urogenital organs inside. Hernias and anal and vaginal prolapse would readily occur. Walking and running add a downward gravitational pressure and maintenance of gestation might be difficult. Moreover, a wide pelvis to the outside of which the femurs are connected would necessitate a kind of bowleggedness that would prevent swift walking and running. Therefore, a big pelvis for a mature child with a big head must be selected against.

Only bipedal hominins can rear an immature baby

Apes must deliver a baby that is sufficiently mature to cling to its mother for itself. The head of archaic hominins was as small as that of a chimpanzee. Therefore, mothers with a small birth canal were able to give birth to such babies. Climate change might have compelled archaic and later hominins to shift their major life from arboreal to terrestrial, i.e., from woody lands to more savanna-like openly lands. Terrestrial life was full of dangers; they had to be vigilant for the approach of predators. Escaping from predators must have been the greatest concern of hominins. They must not have been hunters; rather they were hunted. To walk and run fast, a slender body structure was necessary and a wide and big pelvis was not favored, as discussed above. Families would have formed communities for mutual cooperation to avoid dangers as early as possible. Families with developed communication capability and methods would be advantageous over a solitary family. Vocal communications must be useful to convey warnings about predators. Immediately after receiving an alert signal, they had to escape to nearby trees by running. A larger brain was favored for speedy walking, running, vocal communications, and so forth in terrestrial life. To have a larger brain, a nutritional supply was indispensable. Foods rich in lipids and proteins, such as meat, were favored. With a vegetarian life supported by collecting and gathering nuts and berries, it must be difficult to support a big brain. To get meat, they had to catch insects actively, in addition to catching small animals for themselves, scavenging remains left by predators, and hunting game. Scavenging must have been competitive and dangerous. Hunting was much more difficult and dangerous. Archaic hominins with their primitive upper bodies could not have been good hunters, and were probably not successful in obtaining a big brain during 2 million years (Table 1). Later, *Homo* people who developed weapons such as stone tools were able to become group hunters with communication ability. They were ready to get a big brain. There were two strategies to do so: one was to widen the birth canal and the other was to deliver an immature baby and rear it after birth. As discussed above, the first strategy could not be accepted by bipedal hominins to keep a slender body with swift movement. Quadrupedal apes cannot adopt the second strategy because immature babies cannot cling to the mother. Only bipedal hominins were able to adopt the second strategy because mothers would be able to hold an immature baby with both hands.

Delivery is laborious

The human pelvis has a more ovoid form accompanied by an expansion of the birth canal than the archaic hominin's pelvis. The human newborn's cranium is flexible to some extent and is helpful for a baby to pass through the birth canal. Upright bipedalism would not allow a wide pelvis with a big birth canal. However, needs for a big brain have required a wide pelvis with a big birth canal. This conflict forced women to deliver a baby only through difficult labor. The newborns are so immature that her family's help, in particular that of her partner, is indispensable. Immature conditions of human babies leave much room for further development depending on their nurturing after birth.

Are *Homo Sapiens* Successful?

Were it not for that accidental asteroid collision, *T. rex* could have persisted longer as tyrants because they lived in the realm of the ecosystem and would not have hunted needlessly when their stomachs were full. Humans would not have had a chance to evolve if there were no such collision. By accident, we are here. Throughout the history of human evolution, except for the very beginning, two or more hominin species coexisted. For example, several *Australopithecus* species coexisted 2-4 Ma (Table 1). *Australopithecus* and *Homo* species coexisted 2 Ma. *Paranthropus* and *Homo* species coexisted 2-1 Ma. Surprisingly, *H. sapiens* lived together with Denisova hominins, *H. neanderthalensis,*

and *H. floresiensis* until very recently, 40,000, 30,000, and 20,000 years ago, respectively. *H. sapiens* and *H. neanderthalensis* mated 45,000-80,000 years ago, giving modern humans *H. neanderthalensis*' genes by 1–4% [30]. Did we terminate these people, for example, as we did the Dodo in the island of Mauritius? It is probable [31]. Were mammoths our victims, too? Our recent ancestors must have been killing animals and humans directly, or indirectly restricting their territories to send them to extinction as a result. It is said that the rate of extinction in the twentieth century was 50 times greater than the average for the past 100,000 years. One fourth of mammalian species are on the verge of extinction [32]. This rapid extinction must be mainly a result of habitat destruction caused by human cultural changes and overpopulation. For example, current rates of consumption of fossil fuels, which started during the Industrial Revolution only 250 years ago, are so high that waste carbon dioxide is apparently causing the ambient temperature to increase sufficiently to alter the world climate. Extremely hot and cold temperatures, ferocious and large tornadoes, torrential rains and floods, and shifts of the temperate zones to semi-tropical zones must be alarms from fate and destiny. Environmental pollution, the cutting down of trees in forests, and other human activities have endangered entire ecosystems. Of the many crises in the history of life on Earth, the impact of one species, *H. sapiens*, is the greatest and potentially the most devastating. Earth's capacity to sustain life is reaching its limit. We are changing the world faster than many species can adapt. Can our large brains resolve the crisis which our brains have produced and in which we are inextricably involved?

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