Dr Yves Muscat Baron

Homo sapiens

Why did humans develop a large brain?

"Of all animals, man has the largest brain in proportion to his size" — Aristotle. **Dr Yves Muscat Baron** shares his theory on how humans evolved large brains. The theory outlines how gravity could have helped humans develop a large brain — the author has named the theory, 'The Gravitational Vascular Theory'.

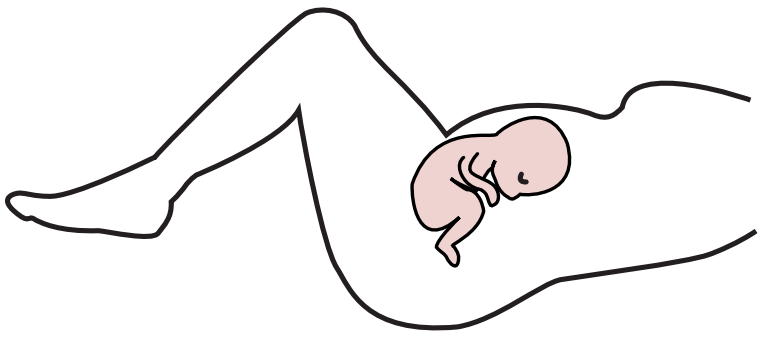
The tension in the second-stage delivery room is palpable.

"Now push Mrs X, push, puSH, PUSH", I urge on.

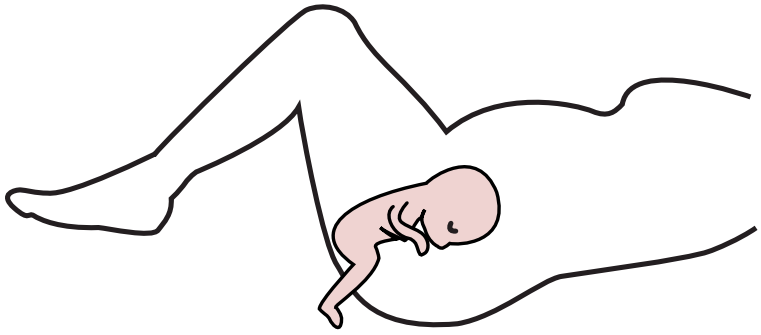
The baby's breech starts to appear and with every push it advances a little bit more out of the birth canal. It is a slow process. The foetal heart holds out, but a close eye and ear are kept on the baby's heart monitor. This is the worst time for the baby's heart rate to give out. At this point, it is crucial that the birth proceeds naturally. Intervention could disturb the natural manoeuvres the baby's body needs to make to negotiate and gain safe passage through the birth canal. The baby's breech slowly appears and slips out as I disengage its lower limbs. With another "PUSH", sluggishly the baby's body follows.

Thirty minutes after the mother started pushing, the tip of the shoulder blade emerges. At this moment, the baby's body is gently rotated in harmony with the mother's pushing. One shoulder is freed, delivering the upper limb and the whole process is gently repeated in the opposite direction to free the other shoulder and arm.

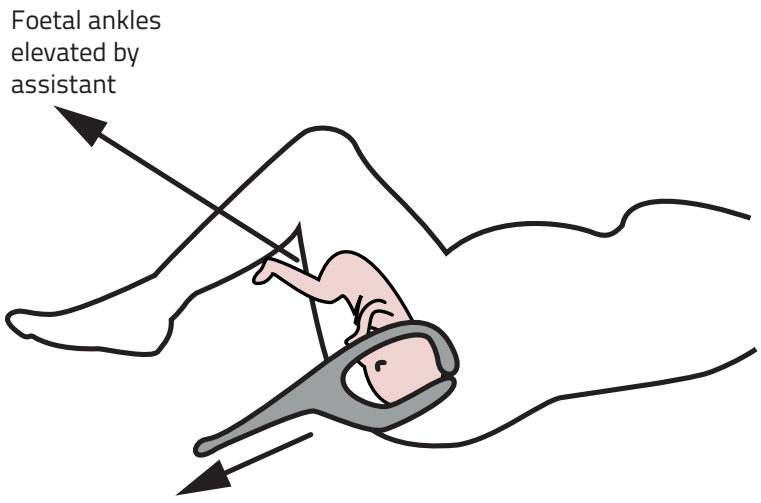
The tension in the delivery room rises a notch. Now the baby's head needs to be »



Breech Births: During pregnancy breech presentation at birth is when a baby's legs are delivered first, rather than the baby's head.



Delivery of foetal abdomen and thorax.



Obstetric forceps for the delivery of the foetal head.

delivered. An assistant takes hold of the foetal ankles and gently raises them. Carefully, I apply the Obstetric forceps (that resemble a pair of tongs; Image 3) parallel to the baby's head.

"Now give us a final PUSH", Mrs X is egged on and with gentle traction on the Obstetric forceps, the foetal head is gently delivered. A 3.8 kg baby girl (normal weight is around 3.2 kg) is born.

The paediatrician assesses the baby's condition and quickly tells us, "the baby is bradycardiac and pale" confirming that the baby's heart is slow and oxygen levels dwindling. The baby is at risk of brain damage or death. After sucking out fluid from the baby's mouth, the team supplies oxygen and a gentle heart massage to try and save her.

Silence pervades the delivery room and we all start to get a sinking feeling. My hands go through routine motions, I swallow hard and inwardly start to count. Then, after 15 long seconds, the baby tenses up and emits a shrill cry.

I carried out this breech delivery at 2.00am in a hospital in the U.K., way back in 1990. That same night a colleague of mine in a hospital 12 miles away also delivered a breech baby. The outcome was not favourable.

After the breech delivery, I staggered back to my rest room exhausted by the overwhelming, conflicting emotions of fear and elation. As I start to relax, I reflect on the whole sequence of events.

One thought swirls around my brain and gains speed like a beam of protons in a cyclotron. *Breech presentation at the end of a singleton pregnancy only constitutes 3% of all deliveries. Is it natural and moreover safe to deliver a baby in this manner?* The word *natural* directed my thoughts towards Darwin's mechanism for evolution – *Natural Selection*.

Charles Darwin in the final words of his "Descent of Man" (1871) said:

"[...] it seems to me, that man with all his noble qualities, with sympathy which feels for the most debased, with benevolence which extends not only to other men but to the humblest living creature, with his god-like intellect which has penetrated into the movements and constitution of the solar system — with all these exalted powers — Man still bears in his bodily frame the indelible stamp of his lowly origin."

The words *"god-like intellect"* worry an Obstetrician. Would a child delivered by breech still have a *"god-like intellect"*?

"...trying to give birth to a breech baby without the intervention of doctors has a much higher chance of complications, even death."

Ten years later, the results emerged from the much-awaited Term Breech Multi-Centre Trial in singleton pregnancies by Dr Mary E. Hannah and co-workers. The trial confirmed that it is safer for a breech baby to be delivered by Caesarean Section. Foetal death or serious damage could be prevented by a planned caesarean section rather than a normal birth (17 of 1039 Caesarean births [1.6%] versus 52 of 1039 normally deliv-

ered births [5.0%] suffered complications). For the mother, there were no large differences between the groups (41 of 1041 births [3.9%] versus 33 of 1042 births [3.2%]).

While reliving the events surrounding the breech delivery, I recalled my experience and the research I had read on breech births. In 2003, Dr Modupe O. Tunde-Bypass and co-workers from Sweden showed that breech presentation becomes progressively less common from the middle to later on in pregnancy.

After 40 weeks pregnancy, babies are delivered legs first only 3% of the time. There seems a clear link that the later a baby is born the more likely for the birth to be normal and born headfirst. It is very tempting to suggest that natural selection may have had a decisive role in this phenomenon.

As my personal experience suggests, trying to give birth to a breech baby without the intervention of doctors has a much higher chance of complications, even death. Natural selection would be ruthless in such cases, and that baby girl may not have survived in more primeval circumstances.

Following the breech delivery, I recalled three key words that may guide the hidden hand of natural selection and led to modern humans. Those factors are, *cephalic* (headfirst) births, *bipedalism* (the upright gait), and the high *encephalization quotient* (high brain to body ratio, or large brains). In the vast animal kingdom, all three are uniquely human, making them unlikely to be present by coincidence. These three qualities could easily have influenced the evolution of each other, fuelling human development.

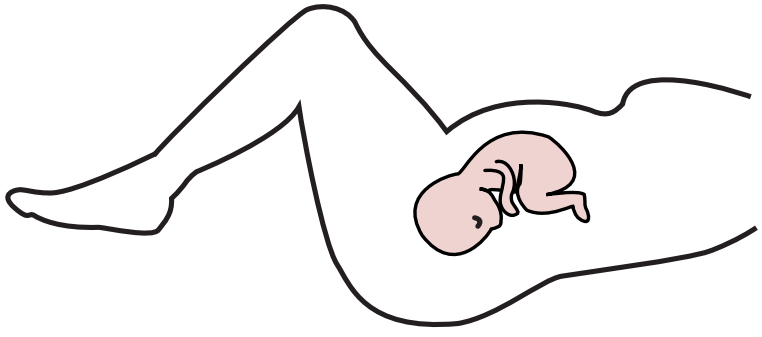
I continued to mull over the three key words trying to eek out any linkage. The solution to this puzzle could lie hidden within natural selection, with a sequence of events unravelling in humanity's evolution.

In human evolution walking upright was an important initial step. 'Our' descent from trees in the African savannah of Eastern Kenya was gradual but crucial in determining the particular direction human evolution would take. »

Age of foetus and relation to breech presentation

Gestational Age of Foetus	Breech Presentation %
21–24 weeks	33 %
25–28 weeks	28 %
29–32 weeks	14 %
33–36 weeks	9 %
37–40 weeks	7 %

Taken from Tunde-Byass et al (2003).



Cephalic presentation occurs in 97% of births.

POSSIBLE SEQUENCE IN THE EVOLUTION OF **HOMO SAPIENS**

BIPEDALISM

INCREASE IN BODY SIZE

INCREASE LENGTH OF PREGNANCY

CEPHALIC PRESENTATION

HIGH ENCEPHALISATION QUOTIENT

Anthropological studies show that our predecessors first walked upright then gained size and height. One of the first upright, bipedal primates named "Lucy" (*Australopithecus afarensis*), was only three feet tall. An improved diet, rich in high protein meat could have helped these hominids gain stature and a longer duration in the length of pregnancy. Subsequent hominids including the first Homo, *Homo habilis,* started getting taller. Coupled to height, brain size seems to have followed. It is unlikely that brain size grew before body weight and height since this would lead to a "top-heavy" species!

For the last three million years, brain size has been steadily increasing. Then, around 200,000 years ago, suddenly, abruptly, brain size shot up by 30%. Our predecessors had much smaller brain sizes, take *Homo erectus* with a brain volume of 909cc, and compare that to modern human brains at 1,350cc. Oxonian neurobiologist Colin Blakemore suggests that genetics had a role to play. He postulates that the intelligence of early hominids arises from a macromutation in a single human being 200,000 years ago. Human beings could have been a freakish genetic accident. Yet, scientific evidence does not support this theory, since no single genetic mutation linked to big brains has been found. More reasonable theories suggest that environmental influence such as diet could have switched on latent mutations. The interaction between genetic make-up and environmental factors is called epigenetics, and it could have kicked in leading to a jump in brain size.

Another possibility is that the increase in brain size is linked to a headfirst presentation at birth. As the physical size of the hominids increased, so did the length of pregnancy. As pregnancy increased in length, early delivery became rarer since it leads to death and birth defects, two factors which easily lead to natural selection. Moreover, breech births became rarer with a longer pregnancy.

Breech births at the end of singleton pregnancies, are linked with brain deficits. Studies from Denmark led by Dr Lone Krebs and his team, have shown how language problems are more frequent in breech births rather than normally delivered infants (10.6% versus 3.2%). Further studies by this team highlighted increased social and language disabilities in children born by breech. These abilities are intrinsic human traits, which may have been crucial in the process of natural selection.

As headfirst births became more common in hominids, another variable may have kicked in: gravity. Was it possible that headfirst births coupled to an upright gait increased blood supply, which supplemented more oxygen and nutrition to the head helping increase brain size? A clue may lie in the

Twin 1 is larger than twin 2 in the majority of multiple pregnancies, possibly due to gravity.

results of multiple pregnancy (twin) studies. Both body weight and brain volume in twin births are significantly larger in the lower, first-born twin, compared to the higher second born twin. Imaging studies of newborn brains by Dr Hulshoff and co-workers, suggest that second born twins have a smaller brain volume. In triplets a similar pattern is seen, with a progressive decrease in brain and body weight from the first to the third baby.

Gravity has a powerful effect on the body. Varicose veins appear in the legs of people as they age. Loss of gravity in space makes the facial veins of astronauts bulge. Their faces tend to become plump, while thinned out legs become "bird-like." Blood supply can also control organ size: the higher the blood flow, the larger the organ. A prime example is the kidney, with blood supply clearly correlating with size. The brain is no exception, the size of the left and right hemispheres are influenced by blood supply. In the frontal brain areas, greater blood flow in the right hemisphere enhances its size. The opposite applies to the posterior brain areas, with the left hemisphere becoming larger than the right. The size of the brain is linked to blood supply.

Once the human brain gains an edge at birth, the "head"-start is sufficient to outstrip all other species. Gravity's effects on brain blood supply have a part to play until at least the first year of life. At birth, the human brain weighs, on average, 450 grams. In contrast, newborn chimpanzees (*Pan troglodytes*) of a similar body weight have a brain weighing only 150 g. When a human infant is one year old its brain size doubles in weight to around 1 kg. The great leap could be linked to a baby's inability to walk upright. By six months, most human babies would just about be able to sit up. Spending more time lying prone could assist gravity in supplying more blood to the nutrient hungry brain. The enlarged human brain attains the largest brain volume to body size amongst all life forms.

My thoughts go back to those early hours in the delivery room, rekindling the emotions surrounding the breech delivery I had performed. Those thoughts and emotions in the early hours of the day may have shed light on the dawn of the greatest attribute in humanity's evolution — the human brain.

FURTHER READING

- Darwin C. 1871. The Descent of Man and Selection in Relation to Sex. London: John Murray.
- Hannah ME, Hannah WJ, Hewson SA, Hodnett ED, Saigal S, Willan AR. 2000
- Planned caesarean section versus planned vaginal birth for breech presentation at term: a randomised multicentre trial. Term Breech Trial Collaborative Group
- Lancet;35:1375-83.
- Tunde-Byass MO, Hannah ME. 2003 Breech vaginal delivery at or near term. Semin Perinatol. 27:34-45.
- Costandi M. 2010. Blakemore: Plasticity Made Us Human. DANA Foundation Report .
- Krebs L, Langhoff-Roos J, Thorngren-Jerneck K. 2001. Long-term outcome in term breech infants with low Apgar score — a population-based follow-up. Eur J Obstet Gynecol Reprod Biol. 100(1):5-8.
- Hulshoff Pol HE, Posthuma D, Baaré WF, De Geus EJ, Schnack HG, van Haren NE, van Oel CJ, Kahn RS, Boomsma DI. 2002. Twin-singleton differences in brain structure using structural equation modelling. Brain.; 125:384-90