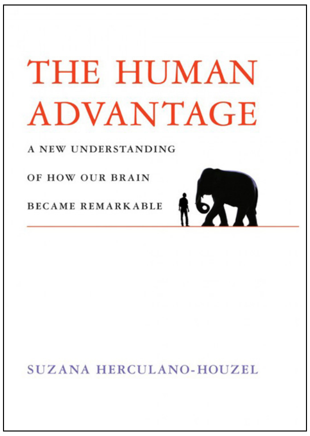


The Human Advantage: A New Understanding of How Our Brain Became Remarkable. Suzana Herculano-Houzel. The MIT Press, Cambridge, MA 02142, USA. 2016. 256 pages. Price: US$ 29.95.

This book by Suzana Herculano-Houzel provides a summary of her discoveries that have challenged the prevailing view that the human brain is an evolutionary outlier and is extraordinarily large for its body, which is considered to be the key reason behind its ability to perform extraordinarily complex cognitive tasks. Instead, she suggests that the human advantage lies in the sheer number of neurons in the cerebral cortex, made possible because of our ability to cook food.

The author first describes some popular beliefs about brain development, which have since been proven wrong. For example, Paul McLean proposed a 'triune brain', consisting of a reptilian complex (for basic functions), limbic system (emotional processing) and the neocortex (for complex cognitive functions), forming progressively. However, Herculano-Houzel discusses evidence against this and similar theories. She also discusses another popular belief that the human brain is larger than it should be, defined in terms of an 'encephalization quotient' (actual brain size relative to how large it 'should' be). Early studies by Harry Jerison showed that humans have an encephalization quotient of 7.5, with the next highest number being only around 2. However, the author argues that evidence of encephalization quotient being an indicator of cognitive capacity is not strong.

The key element of this book is the procedure developed by Herculano-Houzel to measure the number of neurons in the brain tissue, which, surprisingly, had not been done before. Some scientists had counted the cell density in small fixed tissue slices and then extrapolated, under the assumption that brains of different species were more or less scaled-up or scaled-down versions of the same material. A major problem in this approach is that different parts of the tissue may have different cell densities, which can be addressed by making the tissue homogeneous (i.e. by turning it into a 'soup'). Remarkably, this process was developed by Herculano-Houzel without having access to a proper laboratory, with instruments such as blenders/glass-homogenizers and standard dyes. Equally remarkable are her efforts to acquire brains of several species, including large apes, elephants and crocodiles.

Using this procedure, Herculano-Houzel first shows that non-human primate and non-primate (including rodents, insectivores, afrotherians, etc.) brains scale differently: brain mass scales much faster with growing number of neurons in non-primates compared to primates, suggesting that the latter diverged away from the ancestral scaling rule and found a way to pack more neurons in a similar volume. Indeed, the neuronal density decreases with the number of neurons in non-primates (neurons become larger), but remains the same for primates. Interestingly, human brains follow the same scaling law as other non-human primates. Quoting the author: 'human brain is just a scaled-up primate brain: remarkable, but not special'. What then allows greater cognitive abilities in humans?

To address this question, the author first discusses ways to compare cognitive abilities across species, and factors that correlate with them. Brain size/mass is not a strong indicator of cognitive abilities because elephants and whales have bigger brains than humans. Absolute number of neurons was found to be a better indicator by some scientists, but the author found that the number of neurons in the African elephant is about three times larger than humans. However, a disproportionately large fraction (98%) of the neurons was in a structure called cerebellum, potentially to deal with inputs coming from the trunk. If we leave that out and instead compare the total number of neurons in the cerebral cortex, the numbers match well with cognitive abilities, with humans leading the list with ~16 billion neurons, compared to ~6 billion in chimpanzee and ~5.6 billion in elephants. Thus, the author suggests that the number of neurons in the cerebral cortex is a more robust indicator of cognitive abilities.

Could greater cognitive abilities in humans be due to larger expansion of the cerebral cortex? Herculano-Houzel shows that the cerebral cortex expands at a faster rate than the rest of the brain and the rate of expansion is faster in primates than non-primates, such that the human cerebral cortex has the largest relative size (~80% of the brain), but without breaking the scaling rules for primates (in other words, without the human brains being 'special' or 'outliers'). Within the cerebral cortex, it has been proposed that the prefrontal cortex, thought to be involved in planning and reasoning, is particularly enlarged in humans. However, newer research shows this to be untrue – great apes have the same fraction of pre-frontal volume (~36%) as humans. The author's own research, in which she counted the number of neurons in the pre-frontal cortex, showed similar results: 8% of all cortical neurons are prefrontal neurons in humans as well as other primate species.

Herculano-Houzel next elaborates on the relationship between brain size and body size. Although brain size increases with body size, the increase is not linear but follows a power law with an exponent that is significantly less than one (brain mass increases slowly compared to body mass). The exponent is larger for primates: they have larger brains than body weight-matched non-primates. Importantly, humans are no exception when compared to other non-great ape primates. The outliers are actually the great apes (gorillas and orangutans): their bodies are too large for the number of neurons that they have. To explain this, the author first describes the metabolic costs required to run the brain. The popular beliefs that humans have 100 billion neurons and ten times more glial cells, which are thought to provide nutrition to the neurons and therefore related to the metabolic costs, are shown to be wrong. Herculano-Houzel reveals that there are ~86 billion neurons in humans and there is no obvious correlation between brain size and glial cells to neuron ratio, which is only ~1 for humans. The often-used numbers: 100 billion neurons in the human brain and 10 : 1 ratio of glial cells to neurons, are not based on careful experiments but a result of what she calls a 'game of telephone' among scientists. Remarkably, unlike neurons, glial cells follow a tight relationship with brain mass (almost linear), which is consistent across species and brain structures. More surprisingly, she found that neurons in the cerebral cortex, across species and irrespective of size, needed about the same amount of energy (~6 kcal/billion neurons/day), and therefore metabolic cost of the brain depended only on the number of neurons present. Running a human brain is costly just because it has so many neurons in the cerebral cortex.

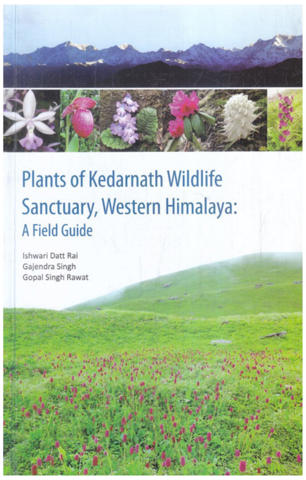
So, why are the brains of great apes too small for their size? The author suggests that a large body and large brain both need more energy, but caloric intake is limited by availability and quantity of food, as well as the capacity to take food through the mouth and produce saliva for swallowing. Caloric intake increases with body mass, but not as fast as the energy cost of larger body mass. Consequently, longer foraging hours are needed to meet daily energy requirements. Eventually, there is a trade-off between body weight, the number of neurons and foraging hours. It appears that great apes chose brawn over brains, while human ancestors went the other way. Even then, to have 86 billion neurons and a body weight of 70 kg, more than 9 h of foraging would have been required. The key difference is that human ancestors learned cooking about 1.5 million years ago, which increased caloric intake tremendously (an idea first put forth by Richard Wrangham; bipedality and endurance running are also discussed as other factors). Indeed, the brain size increased tremendously precisely after we learned to cook with fire, which made food easier to chew, swallow and subsequently digest.

Finally, the author discusses the difference between capacity versus ability. Modern humans have about the same number of neurons that their ancestors had 200,000 years ago (and hence presumably the same cognitive capacity), but have more cognitive ability, because abilities (for example, reading) change the way our brain works and bring improved technologies that expand the materials available, leading to an ascending, self-reinforcing spiral. Herculano-Houzel discusses technological revolutions such as making tools, controlling fire, agriculture and other path-breaking steps such as development of writing that allowed cultural transmission across generations. More recent advancements – the Industrial Revolution, and making automated machines to do physical and even mental work, have leapfrogged us to the forefront of cognitive and intellectual abilities, without having more neurons than our ancestors even a few 100,000 years ago.

Starting with a modest but important goal of counting the number of neurons in the brain, this book takes on fundamentally profound questions about our place in evolution and whether we (more specifically, our brains) are truly 'special'. Written with great style and excellent sense of humour that keeps the reader engaged throughout, Herculano-Houzel explains important scientific concepts and results in an accessible way without compromising scientific rigour. This book will be of great interest to anyone fascinated by the human brain and its wonderful cognitive abilities.

SUPRATIM RAY

Centre for Neuroscience,
Indian Institute of Science,
Bengaluru 560 012, India
e-mail: sray@iisc.ac.in



Plants of Kedarnath Wildlife Sanctuary, Western Himalaya: A Field Guide. Ishwari Datt Rai, Gajendra Singh and Gopal Singh Rawat. Bishen Singh Mahendra Pal Singh, Dehra Dun. 2017. 393 pages. Price: Rs 695. ISBN: 978-81-211-0959-8

Bio-resources in tropical countries are usually concentrated in designated protected areas. The managers of these protected areas habitually focus on conservation of some charismatic and appealing animals and their prey or fodder base but ignore all inclusive diversity and significance of plant wealth therein. Besides what does not occur to them is that plant wealth does amount to wildlife too. The scarcity of scientists and the situational disadvantages are often experienced by Botanical Survey of India in floral documentation of protected areas which are far away from its head quarters/regional centres. It was also believed that such studies by scientists from other institutes and university colleges can in fact speed up such documentation in all the designated protected areas. In this context, a field guide for the *Plants of Kedarnath Wildlife Sanctuary* is truly a crucial contribution from scientists of Wildlife Institute of India and Space Application Centre, Dehra Dun. Kedarnath, the holy shrine of Western Himalaya, receives a large number of devotees annually and many of them get attracted to the enchanting colourful flowering plants in its varied landscapes. The present publication serves as an excellent field guide and helps in identification of the plants of this sanctuary. This field guide contains an introduction, the details of holy place, landscapes and land use classes, vegetation types, people and resources utilization and management. Floristic analysis and recognized families are arranged following Bentham & Hooker's system of classification. A key to use this guide is provided. Serial numbered thumbnails of flowers grouped under different colours and families are provided. The alphabetical enumeration of species with currently accepted names (a few with synonyms), vernacular name/s, brief description, flowering and fruiting periods, habitat, distribution localities within the sanctuary and outside India/ global distribution and, uses if any are given. The photographs depicting landscapes and vegetation types are truly good. A flowering twig/or a whole plant and sometimes a close up of flower/s and fruits is given for species catalogued. The photographs of some are much reduced to correctly distinguish species that are closely allied. The photo inset showing vivipary on page 261 is interesting.

It is contextual to state that the floristic works published in recent years are generously photographed to make them user friendly. Thanks to the advanced