

Big Data: Does Size Matter

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She has contributed to several publications, including BBC Science Focus magazine and The Daily Telegraph, and authored the book Big Data: Does Size Matter?. Harkness has co-written and performed comedy shows related to science and mathematics, including collaborations with her mother Linda Cotterill and comedian Matt Parker. Since 2016, she has chaired the Data Debate series for the Alan Turing Institute and the British Library. She is a Fellow of the Royal Statistical Society and a visiting fellow at the University of Winchester's Centre for Information Rights.

Human penis size

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Human penis size varies on a number of measures, including length and circumference when flaccid and erect. Besides the natural variability of human penises in general, there are factors that lead to minor variations in a particular male, such as the level of arousal, time of day, ambient temperature, anxiety level, physical activity, and frequency of sexual activity. Compared to other primates, including large examples such as the gorilla, the human penis is thickest, both in absolute terms and relative to the rest of the body. Most human penis growth occurs in two stages: the first between infancy and the age of five; and then between about one year after the onset of puberty and, at the latest, approximately 17 years of age.

Measurements vary, with studies that rely on self-measurement reporting a significantly higher average than those with a health professional measuring. A 2015 systematic review measured by health professionals rather than self-reporting, found an average erect length of 13.12 cm (5.17 in), and average erect circumference of 11.66 cm (4.59 in). A 1996 study of flaccid length found a mean of 8.8 cm (3.5 in) when measured by staff. Flaccid penis length can sometimes be a poor predictor of erect length. An adult penis that is abnormally small but otherwise normally formed is referred to in medicine as a micropenis.

Limited to no statistically significant correlation between penis size and the size of other body parts has been found in research. Some environmental factors in addition to genetics, such as the presence of endocrine disruptors, can affect penis growth.

Big Bang

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The Big Bang is a physical theory that describes how the universe expanded from an initial state of high density and temperature. Various cosmological models based on the Big Bang concept explain a broad range of phenomena, including the abundance of light elements, the cosmic microwave background (CMB) radiation, and large-scale structure. The uniformity of the universe, known as the horizon and flatness problems, is explained through cosmic inflation: a phase of accelerated expansion during the earliest stages. Detailed measurements of the expansion rate of the universe place the Big Bang singularity at an estimated 13.787 ± 0.02 billion years ago, which is considered the age of the universe. A wide range of empirical

evidence strongly favors the Big Bang event, which is now widely accepted.

Extrapolating this cosmic expansion backward in time using the known laws of physics, the models describe an extraordinarily hot and dense primordial universe. Physics lacks a widely accepted theory that can model the earliest conditions of the Big Bang. As the universe expanded, it cooled sufficiently to allow the formation of subatomic particles, and later atoms. These primordial elements—mostly hydrogen, with some helium and lithium—then coalesced under the force of gravity aided by dark matter, forming early stars and galaxies. Measurements of the redshifts of supernovae indicate that the expansion of the universe is accelerating, an observation attributed to a concept called dark energy.

The concept of an expanding universe was introduced by the physicist Alexander Friedmann in 1922 with the mathematical derivation of the Friedmann equations. The earliest empirical observation of an expanding universe is known as Hubble's law, published in work by physicist Edwin Hubble in 1929, which discerned that galaxies are moving away from Earth at a rate that accelerates proportionally with distance. Independent of Friedmann's work, and independent of Hubble's observations, in 1931 physicist Georges Lemaître proposed that the universe emerged from a "primeval atom," introducing the modern notion of the Big Bang. In 1964, the CMB was discovered. Over the next few years measurements showed this radiation to be uniform over directions in the sky and the shape of the energy versus intensity curve, both consistent with the Big Bang models of high temperatures and densities in the distant past. By the late 1960s most cosmologists were convinced that competing steady-state model of cosmic evolution was incorrect.

There remain aspects of the observed universe that are not yet adequately explained by the Big Bang models. These include the unequal abundances of matter and antimatter known as baryon asymmetry, the detailed nature of dark matter surrounding galaxies, and the origin of dark energy.

Brain size

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The size of the brain is a frequent topic of study within the fields of anatomy, biological anthropology, animal science and evolution. Measuring brain size and cranial capacity is relevant both to humans and other animals, and can be done by weight or volume via MRI scans, by skull volume, or by neuroimaging intelligence testing.

The relationship between brain size and intelligence has been a controversial and frequently investigated question. In 2021 scientists from Stony Brook University and the Max Planck Institute of Animal Behavior published findings showing that the brain size to body size ratio of different species has changed over time in response to a variety of conditions and events.

As Kamran Safi, researcher at the Max Planck Institute of Animal Behavior and the study's senior author writes:

“Sometimes, relatively big brains can be the end result of a gradual decrease in body size to suit a new habitat or way of moving—in other words, nothing to do with intelligence at all.”

Universe

beginning and has been expanding since then. According to the Big Bang theory, the energy and matter initially present have become less dense as the universe

The universe is all of space and time and their contents. It comprises all of existence, any fundamental interaction, physical process and physical constant, and therefore all forms of matter and energy, and the structures they form, from sub-atomic particles to entire galactic filaments. Since the early 20th century, the

field of cosmology establishes that space and time emerged together at the Big Bang 13.787 ± 0.020 billion years ago and that the universe has been expanding since then. The portion of the universe that can be seen by humans is approximately 93 billion light-years in diameter at present, but the total size of the universe is not known.

Some of the earliest cosmological models of the universe were developed by ancient Greek and Indian philosophers and were geocentric, placing Earth at the center. Over the centuries, more precise astronomical observations led Nicolaus Copernicus to develop the heliocentric model with the Sun at the center of the Solar System. In developing the law of universal gravitation, Isaac Newton built upon Copernicus's work as well as Johannes Kepler's laws of planetary motion and observations by Tycho Brahe.

Further observational improvements led to the realization that the Sun is one of a few hundred billion stars in the Milky Way, which is one of a few hundred billion galaxies in the observable universe. Many of the stars in a galaxy have planets. At the largest scale, galaxies are distributed uniformly and the same in all directions, meaning that the universe has neither an edge nor a center. At smaller scales, galaxies are distributed in clusters and superclusters which form immense filaments and voids in space, creating a vast foam-like structure. Discoveries in the early 20th century have suggested that the universe had a beginning and has been expanding since then.

According to the Big Bang theory, the energy and matter initially present have become less dense as the universe expanded. After an initial accelerated expansion called the inflation at around 10^{-32} seconds, and the separation of the four known fundamental forces, the universe gradually cooled and continued to expand, allowing the first subatomic particles and simple atoms to form. Giant clouds of hydrogen and helium were gradually drawn to the places where matter was most dense, forming the first galaxies, stars, and everything else seen today.

From studying the effects of gravity on both matter and light, it has been discovered that the universe contains much more matter than is accounted for by visible objects; stars, galaxies, nebulae and interstellar gas. This unseen matter is known as dark matter. In the widely accepted Λ CDM cosmological model, dark matter accounts for about $25.8\% \pm 1.1\%$ of the mass and energy in the universe while about $69.2\% \pm 1.2\%$ is dark energy, a mysterious form of energy responsible for the acceleration of the expansion of the universe. Ordinary ('baryonic') matter therefore composes only $4.84\% \pm 0.1\%$ of the universe. Stars, planets, and visible gas clouds only form about 6% of this ordinary matter.

There are many competing hypotheses about the ultimate fate of the universe and about what, if anything, preceded the Big Bang, while other physicists and philosophers refuse to speculate, doubting that information about prior states will ever be accessible. Some physicists have suggested various multiverse hypotheses, in which the universe might be one among many.

Big data

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Big data primarily refers to data sets that are too large or complex to be dealt with by traditional data-processing software. Data with many entries (rows) offer greater statistical power, while data with higher complexity (more attributes or columns) may lead to a higher false discovery rate.

Big data analysis challenges include capturing data, data storage, data analysis, search, sharing, transfer, visualization, querying, updating, information privacy, and data source. Big data was originally associated with three key concepts: volume, variety, and velocity. The analysis of big data presents challenges in sampling, and thus previously allowing for only observations and sampling. Thus a fourth concept, veracity, refers to the quality or insightfulness of the data. Without sufficient investment in expertise for big data veracity, the volume and variety of data can produce costs and risks that exceed an organization's capacity to

create and capture value from big data.

Current usage of the term big data tends to refer to the use of predictive analytics, user behavior analytics, or certain other advanced data analytics methods that extract value from big data, and seldom to a particular size of data set. "There is little doubt that the quantities of data now available are indeed large, but that's not the most relevant characteristic of this new data ecosystem."

Analysis of data sets can find new correlations to "spot business trends, prevent diseases, combat crime and so on". Scientists, business executives, medical practitioners, advertising and governments alike regularly meet difficulties with large data-sets in areas including Internet searches, fintech, healthcare analytics, geographic information systems, urban informatics, and business informatics. Scientists encounter limitations in e-Science work, including meteorology, genomics, connectomics, complex physics simulations, biology, and environmental research.

The size and number of available data sets have grown rapidly as data is collected by devices such as mobile devices, cheap and numerous information-sensing Internet of things devices, aerial (remote sensing) equipment, software logs, cameras, microphones, radio-frequency identification (RFID) readers and wireless sensor networks. The world's technological per-capita capacity to store information has roughly doubled every 40 months since the 1980s; as of 2012, every day 2.5 exabytes (2.17×260 bytes) of data are generated. Based on an IDC report prediction, the global data volume was predicted to grow exponentially from 4.4 zettabytes to 44 zettabytes between 2013 and 2020. By 2025, IDC predicts there will be 163 zettabytes of data. According to IDC, global spending on big data and business analytics (BDA) solutions is estimated to reach \$215.7 billion in 2021. Statista reported that the global big data market is forecasted to grow to \$103 billion by 2027. In 2011 McKinsey & Company reported, if US healthcare were to use big data creatively and effectively to drive efficiency and quality, the sector could create more than \$300 billion in value every year. In the developed economies of Europe, government administrators could save more than €100 billion (\$149 billion) in operational efficiency improvements alone by using big data. And users of services enabled by personal-location data could capture \$600 billion in consumer surplus. One question for large enterprises is determining who should own big-data initiatives that affect the entire organization.

Relational database management systems and desktop statistical software packages used to visualize data often have difficulty processing and analyzing big data. The processing and analysis of big data may require "massively parallel software running on tens, hundreds, or even thousands of servers". What qualifies as "big data" varies depending on the capabilities of those analyzing it and their tools. Furthermore, expanding capabilities make big data a moving target. "For some organizations, facing hundreds of gigabytes of data for the first time may trigger a need to reconsider data management options. For others, it may take tens or hundreds of terabytes before data size becomes a significant consideration."

Matter

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In classical physics and general chemistry, matter is any substance that has mass and takes up space by having volume. All everyday objects that can be touched are ultimately composed of atoms, which are made up of interacting subatomic particles. In everyday as well as scientific usage, matter generally includes atoms and anything made up of them, and any particles (or combination of particles) that act as if they have both rest mass and volume. However it does not include massless particles such as photons, or other energy phenomena or waves such as light or heat. Matter exists in various states (also known as phases). These include classical everyday phases such as solid, liquid, and gas – for example water exists as ice, liquid water, and gaseous steam – but other states are possible, including plasma, Bose–Einstein condensates, fermionic condensates, and quark–gluon plasma.

Usually atoms can be imagined as a nucleus of protons and neutrons, and a surrounding "cloud" of orbiting electrons which "take up space". However, this is only somewhat correct because subatomic particles and their properties are governed by their quantum nature, which means they do not act as everyday objects appear to act – they can act like waves as well as particles, and they do not have well-defined sizes or positions. In the Standard Model of particle physics, matter is not a fundamental concept because the elementary constituents of atoms are quantum entities which do not have an inherent "size" or "volume" in any everyday sense of the word. Due to the exclusion principle and other fundamental interactions, some "point particles" known as fermions (quarks, leptons), and many composites and atoms, are effectively forced to keep a distance from other particles under everyday conditions; this creates the property of matter which appears to us as matter taking up space.

For much of the history of the natural sciences, people have contemplated the exact nature of matter. The idea that matter was built of discrete building blocks, the so-called particulate theory of matter, appeared in both ancient Greece and ancient India. Early philosophers who proposed the particulate theory of matter include the Indian philosopher Kaṇva (c. 6th century BCE), and the pre-Socratic Greek philosophers Leucippus (c. 490 BCE) and Democritus (c. 470–380 BCE).

Neuroscience and intelligence

polygynandrous statue correlates to brain size. Intelligence in chimpanzees has been found to be related to brain size, grey matter volume, and cortical thickness

Neuroscience and intelligence refers to the various neurological factors that are partly responsible for the variation of intelligence within species or between different species. A large amount of research in this area has been focused on the neural basis of human intelligence. Historic approaches to studying the neuroscience of intelligence consisted of correlating external head parameters, for example head circumference, to intelligence. Post-mortem measures of brain weight and brain volume have also been used. More recent methodologies focus on examining correlates of intelligence within the living brain using techniques such as magnetic resonance imaging (MRI), functional MRI (fMRI), electroencephalography (EEG), positron emission tomography and other non-invasive measures of brain structure and activity.

Researchers have been able to identify correlates of intelligence within the brain and its functioning. These include overall brain volume, grey matter volume, white matter volume, white matter integrity, cortical thickness and neural efficiency.

Analyses of the parameters of intellectual systems, patterns of their emergence and evolution, distinctive features, and the constants and limits of their structures and functions made it possible to measure and compare the capacity of communications (~100 m/s), to quantify the number of components in intellectual systems (~10¹¹ neurons), and to calculate the number of successful links responsible for cooperation (~10¹⁴ synapses).

Although the evidence base for our understanding of the neural basis of human intelligence has increased greatly over the past 30 years, even more research is needed to fully understand it.

The neural basis of intelligence has also been examined in animals such as primates, cetaceans, and rodents.

Big Rip

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In physical cosmology, the Big Rip is a hypothetical cosmological model concerning the ultimate fate of the universe, in which the matter of the universe, from stars and galaxies to atoms and subatomic particles, is progressively torn apart by the gravitational influence of the dark energy at a certain time in the future, until

distances between particles will infinitely increase.

According to the standard model of cosmology, the scale factor of the universe is accelerating, and, in the future era of cosmological constant dominance, will increase exponentially. But this expansion is similar for every moment of time (hence the exponential law—the expansion of a local volume is the same number of times over the same time interval), and is characterized by an unchanging, small Hubble constant, effectively ignored by any bound material structures. By contrast, in the Big Rip scenario the Hubble constant increases to infinity in a finite time. According to recent studies, the universe is set for a constant expansion and heat death, because the equation of state parameter $w = -1$.

The Big Rip is only possible if the universe contains phantom energy, a hypothetical form of dark energy with implausible physical properties.

Dark matter

invisible and hypothetical form of matter that does not interact with light or other electromagnetic radiation. Dark matter is implied by gravitational effects

In astronomy and cosmology, dark matter is an invisible and hypothetical form of matter that does not interact with light or other electromagnetic radiation. Dark matter is implied by gravitational effects that cannot be explained by general relativity unless more matter is present than can be observed. Such effects occur in the context of formation and evolution of galaxies, gravitational lensing, the observable universe's current structure, mass position in galactic collisions, the motion of galaxies within galaxy clusters, and cosmic microwave background anisotropies. Dark matter is thought to serve as gravitational scaffolding for cosmic structures.

After the Big Bang, dark matter clumped into blobs along narrow filaments with superclusters of galaxies forming a cosmic web at scales on which entire galaxies appear like tiny particles.

In the standard Lambda-CDM model of cosmology, the mass–energy content of the universe is 5% ordinary matter, 26.8% dark matter, and 68.2% a form of energy known as dark energy. Thus, dark matter constitutes 85% of the total mass, while dark energy and dark matter constitute 95% of the total mass–energy content. While the density of dark matter is significant in the halo around a galaxy, its local density in the Solar System is much less than normal matter. The total of all the dark matter out to the orbit of Neptune would add up about 10¹⁷ kg, the same as a large asteroid.

Dark matter is not known to interact with ordinary baryonic matter and radiation except through gravity, making it difficult to detect in the laboratory. The most prevalent explanation is that dark matter is some as-yet-undiscovered subatomic particle, such as either weakly interacting massive particles (WIMPs) or axions. The other main possibility is that dark matter is composed of primordial black holes.

Dark matter is classified as "cold", "warm", or "hot" according to velocity (more precisely, its free streaming length). Recent models have favored a cold dark matter scenario, in which structures emerge by the gradual accumulation of particles.

Although the astrophysics community generally accepts the existence of dark matter, a minority of astrophysicists, intrigued by specific observations that are not well explained by ordinary dark matter, argue for various modifications of the standard laws of general relativity. These include modified Newtonian dynamics, tensor–vector–scalar gravity, or entropic gravity. So far none of the proposed modified gravity theories can describe every piece of observational evidence at the same time, suggesting that even if gravity has to be modified, some form of dark matter will still be required.

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