

Glossary

The Idea Organ

Amino acids: Organic compounds that are the building blocks of **proteins** and participate in a number of processes such as neurotransmitter transport and biosynthesis. Amino acids are encoded by the **genome** as different three **nucleotide** codes.

Apes: A branch of "old world" primates characterized by the lack of a tail due to a mutation of the TBXT gene. Apes consist of the families, *Hylobatidae* ("lesser apes": gibbons and siamangs) and *Hominidae* ("**great apes**": orangutans, gorillas, chimpanzees, bonobos, and humans).

Archealization: A research approach in which genetic **variants** from extinct archaic human relatives (e.g., **Neanderthals** and **Denisovans**) are introduced into modern human cells to study how those ancient **genes** function and how they impact the function of those cells.

Artificial Intelligence (AI): A form of intelligence in which a machine system is able to make rational decisions based on perception of its environment.

Axon (nerve fiber): In invertebrates, a long, slender projection of a **neuron** that transmits information (as electrical impulses) to different neurons, muscles, and glands.

Axonal arbors: The tree-like branching patterns formed by the distal end of a **neuron's axon**.

Basal Ganglia (brain): Subcortical nuclei in the base of the forebrains of vertebrates, including humans, which are involved with a variety of functions, such as control of voluntary motor movements, procedural learning, and routine behaviors or "habits" (e.g., teeth grinding, eye movements, cognition, and emotion).

Bipedalism: The ability to walk upright on two legs, involving adaptations in the skeletal and muscular systems to support and propel the body using only the lower limbs.

Botanic age: A term used in paleoecology or forensic botany to describe the age of a site or specimen based on the growth rings of woody plants (dendrochronology) or the successional stage of local flora.

Brain asymmetry: The structural and functional differences between the left and right hemispheres of the brain.

Brain organoids: An artificially grown in vitro brain model used for investigating brain development and neurological disease. Brain organoids are clusters of brain-like cells that are derived from **induced pluripotent stem cells** and **embryonic stem cells**.

Broca's area (brain): A region in the **frontal lobe** of the dominant hemisphere (usually the left) of the human brain with functions linked to speech production.

Central nervous system (CNS): The majority of the **nervous system** that consists of the brain, spinal cord, retina, optic nerves, and olfactory epithelium. The CNS integrates sensory information and coordinates and influences the activity of the body in bilaterally symmetric animals (all multicellular animals except sponges and radially symmetric animals such

as jellyfish).

Cerebellum (brain): A part of the vertebrate hind brain that coordinates voluntary movements, maintain balance and posture, and control muscle tone. It also plays an important role in cognitive functions (e.g., attention, language, and emotional control). The cerebellum is located under the **cerebrum**.

Cerebral cortex (brain): The outer layer of the **cerebrum**, composed of folded gray matter, and plays an important role in consciousness.

Cerebrum (brain): The largest part of the brain that contains the **cerebral cortex**, **hippocampus**, **basal ganglia**, and **olfactory bulb**.

Chromatin: A complex of **DNA** and **proteins** (histone and adaptor proteins) forming **chromosomes**.

Chromosome: A discrete strand of tightly packaged **chromatin**.

Codon: A sequence of three **nucleotides** along a **DNA** or **RNA** chain encoding a single **amino acid**, and start or stop.

Cognition: The mental action or process of acquiring knowledge and understanding through thought, experience, and the senses.

Complex syntax: The linguistic ability to combine words into hierarchical structures, including the use of recursion, subordination, and long-distance dependencies to express intricate relationships. See **syntax**.

Cranial capacity: The volume of the interior of the cranium. Cranial capacity is used as a rough indicator of brain size and is typically measured in cubic centimeters (cc or cm³).

Culture: Behavior and norms that are shared, learned, and socially transmitted.

Cumulative culture: The process by which social learning allows for the accumulation of modifications over generations, leading to tools, beliefs, or behaviors that are more complex than any single individual could invent alone. See **culture**.

Denisovans: An extinct hominin population contemporary with **Neanderthals** that hybridized with ancient humans and Neanderthals. Knowledge of Denisovan morphology is limited to two small fossils found in Siberia, a jaw in Tibet, a skull in China, and a mandible in Taiwan.

Deoxyribonucleic acid (DNA): The molecule of inheritance, which consists of **sequences** of the four **nucleotide** bases: Adenine, Thymine, Guanine, and Cytosine.

DNA sequence: The specific order of the **nucleotide** bases along a strand of **DNA**.

Dopaminergic neurons: **Nerve** cells that synthesize and release dopamine, a neurotransmitter involved in movement, motivation, reward, learning, and emotional regulation.

Embryonic stem cell (ESC): The inner cell mass of the human blastocyst, the rapidly dividing fertilized egg at four to seven days post fertilization. ESCs are pluripotent, meaning they can differentiate into all cell types of the three embryonic tissue layers.

Endocasts: Internal casts of the cranial cavity (either natural fossilizations or synthetic molds/digital reconstructions) that provide a proxy for the size, shape, and surface anatomy of the brain in extinct species.

Enhancer: A non-coding DNA element that binds transcription factors to boost the expression of one or more target genes, regardless of its orientation or location relative to the gene.

Eukaryote: Organisms whose cells have a nucleus enclosed within membranes.

Evolutionary developmental biology (evo-devo): A field of biology that compares the developmental processes of different organisms to determine their ancestral relationships and how developmental changes lead to novel evolutionary traits.

Extended paleoneurological syntheses (EPS): An interdisciplinary framework that combines fossil endocast data with comparative neuroanatomy, genomics, and developmental biology to reconstruct the evolution of the brain and cognition.

External auditory rhythm: The perception and synchronization of motor movements to external periodic acoustic stimuli (often studied in the context of the evolution of music and speech).

Forkhead box P2 (FOXP2): A gene in humans that encodes for a transcription factor protein and is involved in the production of speech.

Frontal lobe (brain): The largest of the four major lobes of the brain in mammals, and is located at the front of each hemisphere. It is devoted to action such as skeletal movement, ocular movement, speech control, the expression of emotions. In humans, the largest part of the frontal lobe is the prefrontal cortex.

Frontotemporal dementia (FTD): A group of progressive brain diseases characterized by degeneration of the frontal and/or temporal lobes of the brain, leading to changes in behavior, personality, language, and executive function.

Gene: A DNA sequence which encodes a specific function.

Gene expression: The process by which the information contained within a gene (nucleotide sequence) is used to direct RNA and/or protein synthesis and dictate cell function. Nearly all of the cells in the body contain identical genes, but only a subset of this information is used or expressed at any time. The genes expressed in a cell determine what that cell can do.

Genome: The totality of DNA in a cell. Also refers to the DNA sequence that typifies an individual or species.

Genomics: The study of genome structure/function.

Glia (neuroglia): Non-neuronal cells in the central nervous system and the peripheral nervous system that do not produce electrical impulses. Their function is to ensure homeostasis, form myelin sheaths, and provide support and protection for neurons. Glia make up ~50% of our brain cells.

Great apes: A taxonomic family denoting the extant chimpanzees, bonobos, gorillas, and orangutans. This is biologically invalid grouping given that chimpanzees and bonobos are more closely related to humans than to gorillas or orangutans.

Gyrus (brain): A ridge on the cerebral cortex that, along with surrounding sulci (furrows) creates the folded appearance of the brain in humans and other mammals.

Hippocampus (brain): A part of the limbic system that plays important roles in the consolidation of information from short-term memory to long-term memory, and in spatial memory that enables navigation. Humans and other vertebrates have two hippocampi, one in each side of the brain. It is named after its resemblance to the shape of a sea horse (*hippocampus* in Latin).

Hominin: A classification of species comprising humans and our extinct relatives following the divergence from the common ancestor with chimpanzees.

Homo sapiens: The hominin species comprising all living humans. Meaning "wise man" in Latin, the name was introduced by Carl Linnaeus in 1758. The earliest fossil evidence of *Homo sapiens* appears in Africa around 300 kya (see **Jebel Irhoud Hominins**).

Human-Accelerated Region 123 (HAR123): A non-coding regulatory DNA element (an enhancer) that does not encode a protein but influences the activity of nearby genes involved in brain development. It has undergone rapid sequence change in humans compared with other mammals.

Human Accelerated Regions (HARs): Regions of the human genome that are conserved throughout vertebrate evolution but are strikingly different in humans. They are named according to their degree of difference between humans and chimpanzees. Some of these highly mutated areas may contribute to human-specific traits while others may represent "loss of function" mutations, possibly due to the action of biased gene conversion rather than adaptive evolution.

Human arcuate fasciculus: The specialized connections composed of axons linking Broca's area and Wernicke's area in the human brain and is a major anatomic feature supporting language function in humans.

Human brain expansion: Since the evolutionary split between the human lineage and other great apes (6–7 million years ago), the human brain more than tripled in volume and increased in complexity. While early hominins such as *Australopithecus afarensis* (3.9 to 2.9 million years ago) had brain volumes of roughly 400–500 cubic centimeters, similar to modern chimpanzees, it was with the emergence of genus *Homo* around 2–2.5 million years ago that brain size began to increase more rapidly. *Homo habilis* (2.4 to 1.4 million years ago) had a cranial capacity of about 600–700 cc and *Homo erectus* (1.9 million years ago to 110 thousand years ago) reached 900–1100 cc. In modern humans,

average brain volume is approximately 1,300–1,400 cc. This expansion involved disproportionate growth of the cerebral cortex, particularly regions associated with language, abstract reasoning, planning, and social cognition. Changes in brain organization, connectivity, and prolonged developmental periods (including extended childhood) were also crucial. Together, these evolutionary modifications supported increasingly complex tool use, symbolic thought, culture, and social structures.

Hypermethylated In Cancer 1 (HIC1): A *gene* that encodes a **transcription factor** involved in regulating cell growth, apoptosis (cell death), and DNA damage responses, and is frequently silenced or **hypermethylated** in various cancers.

Hypermethylation: The increase or abnormal addition of methyl groups (–CH₃) to **DNA**, typically at cytosine bases in CpG dinucleotides. This chemical modification is a key epigenetic mechanism that can influence **gene expression** without altering the underlying DNA sequence.

Immature oligodendrocytes: **Myelin sheath**-forming **glial** cells that have progressed from progenitor stages but have not yet fully differentiated or begun wrapping **axons** with insulating myelin sheaths.

Induced pluripotent stem cell (iPSC): Somatic (body) cells that are artificially reprogrammed to an **embryonic-like stem cell** state and differentiated into other types of cells.

Language (human): A structured system of communication that is generative (combine words/symbols to convey an infinite number of ideas), recursive (builds upon itself without limit), and has displaced reference (describe things not present).

Left anterior temporal degeneration: The progressive atrophy (shrinkage and loss of neurons) of the front (anterior) part of the left temporal lobe of the brain.

Lexical semantics: The subfield of linguistic semantics that studies how individual words convey meaning, the relationship between those meanings, and how the lexicon is structured in the mind.

Limbic system: Structures of the brain that deal with emotions and memory.

Lunate sulcus (brain): A prominent groove on the lateral surface of the occipital lobe that marks the anterior boundary of the primary visual cortex; its posterior displacement in human evolution is often cited as evidence for the expansion of parietal association areas.

Messenger RNA (mRNA): A type of **RNA** that conveys the genetic instructions from **DNA** in the nucleus to the ribosomes in the cytoplasm of the cell, where proteins are synthesized.

Mitochondria: Membrane-bound cell organelles that generate most of the chemical energy, adenosine triphosphate (ATP), needed to power the cell's biochemical reactions. Mitochondria are believed to be endosymbionts that were originally prokaryotic cells that became incorporated into eukaryotic organisms.

Molecules: A group of two or more atoms covalently bonded together to form the smallest fundamental unit of a chemical

compound that can take part in a chemical reaction.

Mutation: Change in a **DNA** or **RNA** sequence.

Myelin sheath: An insulating layer of fatty tissue (wrapped cell membrane) that protects **nerve** cells, especially their **axons**.

Neanderthals: An extinct Eurasian **hominin species** that existed from 500–30 kya and interbred with ancient humans and **Denisovans**.

Neocortex (brain): A part of the cerebral cortex concerned with sight, hearing, and touch in mammals, regarded as the most recently evolved part of the **cortex**.

Nerve: A bundle of fibers that transmits impulses of sensation to the brain or spinal cord, and impulses from these to the muscles and organs.

Nervous system: The network of nerve cells, fibers, and associated **glia** cells that transmits nerve impulses between parts of the body.

Neural cells: The specialized cells of the **nervous system** responsible for processing, transmitting, and responding to information in the form of electrical and chemical signals. They are the building blocks of the brain, spinal cord, and peripheral nerves.

Neural progenitor cell (NPC): Cells that are capable of dividing a limited number of times and have the capacity to differentiate into a restricted repertoire of **neuronal** and **glial** cell types.

Neurodegenerative disease: The progressive deterioration and loss of neurons in the central or peripheral nervous system, resulting in neurological dysfunction.

Neurodevelopment: The complex process by which the nervous system is formed, organized, and matured, spanning from early embryonic neurulation to the refinement of neural circuits through adulthood.

Neuron: A specialized cell that transmits nerve impulses and forms **synapses** with other cells.

Neuro-oncological ventral antigen 1 (NOVA1): A *gene* that encodes an **RNA-binding protein** primarily involved in regulating alternative splicing in **neurons**. NOVA1 is involved in early brain development and is implicated in autism and schizophrenia. Archaic variants of NOVA1 **archealized** into **human brain organoids** affect alternative splicing, synaptic protein interactions, and neural connectivity.

Nonsense-mediated RNA decay (NMD): A cellular quality-control mechanism in **eukaryotic** cells that identifies **mRNAs** with premature stop **codons** and selectively degrades them to maintain protein integrity and prevent cellular dysfunction.

Nucleic acid: One of the four classes of major biomolecules. The overall name for **DNA** and **RNA**, which are composed of **nucleotides**. DNA is double-stranded and more stable while RNA is single-stranded and less stable.

Nucleotides: **Molecular** building blocks for **DNA** and **RNA**. Specifically, they consist of three components: a 5-carbon sugar, a phosphate group, and a nitrogenous base. The type of sugar, either deoxyribose or ribose, determines if the resulting

nucleic acid is DNA or RNA.

Occipital lobe: The posterior (back) region of the brain that is primarily responsible for processing visual information.

Olfactory bulb (brain): A neural structure of the vertebrate forebrain involved in sense of smell.

Parietal lobes: A pair of regions located at the top-back of each hemisphere of the brain that receives and interprets sensory information and help coordinate spatial orientation, and contribute to attention and perception.

Parieto-occipital association cortices (brain): High-order cortical regions located at the junction of the parietal and occipital lobes that integrate multisensory information, particularly relating to spatial awareness, visual attention, and navigation.

Posterior visual networks: Cortical networks, primarily in the **occipital** and posterior **temporal/parietal lobes**, that receive and integrate visual input from the eyes to support perception, recognition, and spatial awareness.

Prefrontal cortex (brain): The **cerebral cortex** that covers the front part of the **frontal lobe** and is linked to complex cognitive behavior, personality, long and short-term memory, decision making, speech, language, and a person's will to live.

Primary motor control area (MI): The region of the **cerebral cortex** responsible for initiating and controlling voluntary movements of skeletal muscles.

Primary sensorimotor areas (brain): Regions of the **cerebral cortex** responsible for processing **sensorimotor control**, and is composed of the **primary somatosensory cortical area (SI)** and the **primary motor cortical area (MI)**. These areas manage sensory and motor functions related to the trunk, limbs, and orofacial regions.

Primary somatosensory cortical area (SI): The region of the **cerebral cortex** that receives and processes sensory information from the body, including touch, pressure, pain, temperature, and proprioception.

Primary visual cortex (brain): Located in the posterior pole of the occipital lobe, it is the first cortical area to receive and process visual information from the lateral geniculate nucleus of the **thalamus**.

Protein: One of the four classes of major biomolecules. Proteins are **molecules** encoded by **DNA sequences** and composed of **amino acids** connected by peptide bonds. These range in size from a few amino acids (short peptides) to large molecules (long polypeptides) comprised of thousands of amino acids.

Regulatory elements: Binding sites on **chromosomes** for **transcription factors**, which are involved in **gene** regulation.

Ribonucleic acid (RNA): A **molecule** essential in **gene** coding, decoding, regulation, and expression. RNA consists of **sequences** of the four **nucleotide** bases: Adenine, Uracil, Guanine, and Cytosine. Types of RNA include messenger RNA (mRNA), transfer RNA (tRNA), ribosomal RNA (rRNA), small nuclear RNA (snRNA), and other non-coding RNAs. Some viruses including Influenza A and SARS-CoV-2 have RNA

genomes.

Sensorimotor control: The process by which the **nervous system** integrates sensory information (from vision, touch, proprioception, etc.) with motor commands to produce coordinated, purposeful movement.

Sensorimotor-to-association (S-A) axis: The functional organization of the cerebral cortex in which information flows from **primary sensorimotor areas** to higher-order association areas for integration and complex processing.

Sequence: The linear order of the nucleotide building blocks, which encodes individual form and function.

Species: A population whose individuals can mate with one another to produce viable and fertile offspring. This is a debated definition and the concept is problematic for extinct fossil organisms for which **DNA** is not available. This definition is problematic in regard to bacteria as they can exchange genetic material across widely separate taxa.

Stem cell: An undifferentiated cell capable of giving rise to indefinitely more cells of the same type, and from which certain other kinds of cells arise by differentiation. See **embryonic stem cell (ESC)** and **induced pluripotent stem cell (iPSC)**.

Striatum (brain): A subcortical area of the brain that can be anatomically divided into ventral and dorsal regions. The dorsal region is comprised of the caudate and putamen striatal nuclei. The ventral striatum consists of the nucleus accumbens (NAc) and olfactory tubercle. The striatum mediates between emotions and actions, and plays an important role in reward-learning behaviors.

Sulcus (brain): A depression or groove in the **cerebral cortex** that, along with a **gyrus** (ridge), creates the folded appearance of the brain in humans and other mammals. The larger sulci are usually called fissures.

Syntax: The arrangement of words and phrases to create well-formed sentences in a language.

Temporal lobes: A pair of structures located on the sides of the brain that are responsible for hearing, speech comprehension, memory formation, and certain aspects of emotional and social processing.

Thalamic organoids: Three-dimensional, in vitro structures derived from pluripotent stem cells that recapitulate the cellular architecture, signaling, and development of the thalamus, the brain's primary sensory relay station.

Thalamus: A paired structure in the center of the brain that relays sensory information (touch, pain, temperature, vision, and taste, but excludes smell) to the appropriate areas of the cortex. The thalamus also processes motor signals between the **cortex**, **cerebellum**, and **basal ganglia**.

Theory of mind (ToM): The ability to attribute mental beliefs, desires, intentions, and perspectives, etc., to oneself and to others, and to understand that others have beliefs, desires, intentions, and perspectives that are similar or different from one's own. Related/Overlapping Terms: "Intentionality," "Attribution of Mental States," "Inter-subjectivity," "Mind-Reading," "Perspective taking," "Other-regarding Impulses," etc.

Transcription: The first step in **gene expression** during which the **nucleotide sequence** of **DNA** is transcribed into an **RNA molecule** that can ultimately be translated into **protein**.

Transcription factors: **Proteins** that initiate and regulate the **transcription** of **genes**. Transcription factors bind to specific sequences of **DNA** called **regulatory elements**, or other proteins that do so, and directly or indirectly affect the initiation of transcription. The activities of transcription factors determine where and when genes are expressed.

Transmodal association regions: Cortical areas that receive sensory and motor input and combine this information to enable complex processes such as reasoning, language, planning, and self-awareness.

Variant: DNA that differs among groups studied.

Wernicke's area: An important brain region involved in comprehension of written and spoken language.