Glossary: *The Origin of Love*

Acetylation: A biochemical process in which an acetyl group (CH_3CO) is transferred to a molecule, typically a **protein**, from a donor molecule like acetyl-CoA. This modification usually occurs on the lysine residues of proteins, particularly **histones**, which are involved in DNA packaging. Acetylation can have significant effects on the structure and function of proteins, and it plays a critical role in regulating various biological processes, including **chromatin** remodeling.

Allele: Alternative **DNA sequence** at the same locus (location on the **chromosome**).

Allomaternal/alloparental care: Infant care provided by individuals other than the mother/parents.

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.

Attachment network (brain): A collection of brain regions and neural circuits that are involved in forming and maintaining emotional bonds, particularly in the context of social attachment. These networks are crucial for behaviors related to love, bonding, caregiving, and forming relationships with others.

Autism Spectrum Disorder (ASD): A range of conditions characterized by challenges with social skills, repetitive behaviors, speech, and nonverbal communication.

Autonomic nervous system (ANS): The part of the **nervous system** that operates mostly unconsciously to regulate bodily function (such as heart rate, respiratory rate, digestion, pupillary response, urination, and sexual arousal) and controls internal organs, smooth muscles, and glands.

Biobehavioral synchrony: The coordinated and mutually responsive interaction between individuals, where biological and behavioral rhythms align in a way that enhances communication and connection. This term is often used in the context of caregiver-infant interactions, where both parties' physiological responses (such as heart rate, breathing patterns, or hormonal levels) and behavioral cues (such as eye contact, facial expressions, or movements) are synchronized.

Biomarkers: Measurable indicators of a biological condition or process, often used in medicine and research to detect diseases, monitor health, or predict the outcome of treatments. They can be molecules, genes, proteins, or other substances found in blood, urine, tissues, or other bodily fluids, providing information about a person's health status or risk of disease.

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

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

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

Differently methylated region (DMR): A segment of **DNA** where the **methylation** pattern differs between two or more samples, conditions, or tissues. DMRs can be associated with gene silencing and epigenetic modifications.

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

Endocrine system: A hormonal system comprising internal glands, such as the hypothalamus, pituitary, thyroid, and adrenal, that produce, store, and release **hormones** into the circulatory system to regulate the body's healthy development and function.

Epigenetic: Biological information not encoded directly in **DNA**.

Epigenetic regulation: Processes that alter gene activity without changes to the underlying **DNA** sequence. Primary mechanisms of epigenetic regulation include DNA **methylation**, **histone modification**, and **non-coding RNA**. Epigenetic regulation is reversible and can be influence by environmental factors, lifestyle, and other external conditions.

Epigenetics: A term first coined in 1942 by the developmental biologist, Conrad Waddington, to explain how a singular **genotype** might produce variations in **phenotype** across development. He argued that some level of regulation must exists "above" or "over" genes to determine when and where they are expressed. Today the term refers to stable alterations in gene expression without changes to the underlying **DNA** sequence.

Estrogen: The category of **sex hormones** that includes estrone, estradiol, and estriol that are involved in the development and regulation of the female reproductive system and secondary sex characteristics. Estrogen is the precursor to **testosterone**.

Evolution: The process by which populations change over time through random variation and natural selection. Evolution occurs at the level of populations, not individuals, and involves genetic changes that are passed down through generations.

Father: A male parent, typically referring to the biological or legal male figure who contributes to the creation and/or upbringing of a child. The term "father" can also be used more broadly to describe a paternal figure in various cultural, religious, or metaphorical contexts, such as the "father" of a nation or a profession.

Father uncertainty: The lack of surety that a male is the biological father of a child. This uncertainty can arise in various social and biological contexts, especially when there are questions about sexual fidelity. Synonymous with **paternal confidence**.

Food abundance: A situation in which food is plentiful and easily available in a particular area, region, or society.

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.

Genetics: The study of **genes** and their inheritance.

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

Genotype: The two **alleles** at one or more diploid loci.

Genotyping: Characterizing genetic variants at one or more loci.

Glia: 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.

Glycans: One of the four classes of major biomolecules. Glycans consist of varying numbers of sugars (monosaccharides) attached to **proteins** or **lipids** or secreted as free glycans. Glycans are essential biomolecules whose functions can be divided into three broad categories: structural and modulatory properties (including nutrient storage and sequestration), specific recognition by other molecules, and molecular mimicry of host glycans.

Glycosylation: The process by which sugar molecules (**glycans**) are added to **proteins**, **lipids**, or other organic molecules. This post-translational modification plays a crucial role in the structure, stability, and function of many biomolecules.

Grandmother hypothesis: One of the explanations for the post-menopausal life stage of human females (and general long lives of humans), a life stage that does not exist in any non-human primate. It is hypothesized that the evolution of grandmothers is an advantage for humans. Grandmothers who invest energy into the offspring of their children reduce the reproductive cost of parenting through social kin-networking. This can further off-set the resource cost of childrearing and brain-building as parents are freed to provision for resources. An increase in resource procurement may reduce the inter-birth interval by allowing for earlier weening and more offspring production.

Histones: Chief **protein** components of **chromatin** and can be chemically modified as part of **epigenetics**.

Histone modification: A covalent, post-translational modification (PTM) of **histone proteins,** which includes **acetylation**, **glycosylation**, **methylation**, **phosphorylation**, **sumoylation**, **ubiquitylation**. The PTMs made to histones can impact gene expression by altering chromatin structure or recruiting histone modifiers.

Hormone: A signaling molecule in multicellular organisms that contributes to the regulation of physiology and behavior.

Immune system: The biological defense system of an organism that protects against disease.

Infant care: The practices and activities involved in ensuring the health, safety, and well-being of a newborn or young child, including feeding, hygiene, comfort, and emotional nurturing.

Lipids: One of the four classes of major biomolecules. A fatty or waxy organic compound involved in important cellular activities like storing energy, as a component of the cell membrane, and signaling within and between other cells.

Love: A complex physiological and psychological phenomenon driven by a combination of **hormonal**, neural, and biochemical processes. These processes involve several key brain regions and chemicals that influence attraction, bonding, and attachment between individuals. Love as a social concept is dependent on a variety of cultural, societal, and interpersonal dynamics.

Methylation: A biological process in which a methyl group (CH_3) is added to a molecule, typically to **DNA**, **proteins**, or other cellular structures. In the context of DNA, DNA methylation refers to the addition of a methyl group to the DNA molecule, usually at cytosine bases in a CpG dinucleotide. This modification can regulate gene expression by turning genes on or off without changing the underlying **DNA sequence**, and it plays a key role in processes like development, aging, and disease. Methylation patterns can be inherited or influenced by environmental factors and lifestyle.

Monogamy: A social or sexual practice where an individual has only one partner at a time. It can refer to both human relationships and the mating behavior of certain animal **species**.

Neuroendocrine: The interaction between the **nervous system** and the **endocrine system**, particularly how the brain regulates **hormone** production and secretion. The neuroendocrine system is responsible for regulating various physiological processes such as growth, metabolism, stress response, reproduction, and mood. It functions through a network of signals, where neurons release chemicals that influence hormone secretion, and hormones in turn affect brain function and behavior.

Neuropeptides: Small **protein**-like molecules that act as neurotransmitters or modulators in the brain and nervous system. They are involved in regulating a wide range of physiological processes, including pain, stress response, mood, appetite, and reproduction.

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

Non-coding RNA (ncRNA): **RNA** that is not translated into a **protein**. Important ncRNAs include transfer RNAs (tRNAs) and ribosomal RNAs (rRNAs), as well as small RNAs such as microRNAs, siRNAs, piRNAs, snoRNAs, snRNAs, exRNAs, scaRNAs and the long ncRNAs such as Xist and HOTAIR.

Novel treatments: New or innovative therapies, medications, or medical procedures that have been developed to address health conditions or diseases. These treatments are typically characterized by their uniqueness, often offering new mechanisms of action, improved effectiveness, or fewer side effects compared to existing options. Novel treatments may emerge from advancements in medical research, technology, or scientific understanding.

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.

Open chromatin: The state of **chromatin** when **DNA** is less tightly packed and accessible to **transcription factors**, RNA polymerase, and regulatory proteins, allowing for gene expression. Open chromatin is found in regions of the genome that are actively being transcribed or are ready to be transcribed in a cell-type specific pattern.

Orthologous genes: **Genes** that are found in different **species** that evolved from a common ancestral gene and typically retain the same function.

Owl monkey (genus *Aotus*): A New World monkey **species** found in Central and South America. Owl monkeys are nocturnal and have large, round eyes adapted for seeing in low-light conditions, giving them an "owl-like" appearance. Owl monkeys are social animals that typically live in small family groups and form strong **pair bonds**. They primarily feed on fruits, insects, and small vertebrates. Also known as the "night monkey" and "mirikina."

Oxytocin: A **peptide hormone** made by the hypothalamus and stored in the pituitary gland, from which it is released into the blood stream. Oxytocin has many physiological and behavioral functions. It is considered "the love hormone" due to its association with reproduction, social bonding, sexual behavior, childbirth, maternal bonding, and milk production. Oxytocin is also an anti-inflammatory and is associated with **sociostasis** and longevity.

Oxytocin receptor: A **protein** found on the surface of cells that binds to the **hormone** oxytocin, triggering various physiological responses. These receptors are primarily located in the uterus, mammary glands, brain, and other tissues involved in reproduction and social interactions. The activation of oxytocin receptors helps coordinate functions like labor, emotional bonding, and even responses to stress. The gene encoding the oxytocin receptor is called OXTR.

Pair bond: The formation of long-lasting bonds between two individuals.

Paternal investment: The parental effort of fathers.

Paternity: The state of being a **father** or the biological relationship between a father and his offspring.

Paternity confidence: A male's confidence in being the father of one or more offspring. Synonymous with **father uncertainty**.

Peptide: A short chain of **amino acids** linked by **peptide bonds**. A peptide is a short **protein**.

Peptide bond: A covalent chemical bond that forms between two **amino acids**, linking them together in a **peptide** or **protein** chain. It occurs when the carboxyl group (-COOH) of one amino acid reacts with the amino group (-NH2) of another amino acid, releasing a molecule of water (a process called dehydration or condensation).

Phenotype: Observable traits of an organism that result from interactions between **genes** and environment during development.

Phosphorylation: A biochemical process in which a phosphate group (PO_4^{3-}) is added to a molecule, typically a **protein**, by an enzyme called a kinase. This addition of a phosphate group often occurs at specific **amino acids** in the protein, such as serine, threonine, or tyrosine, and it can significantly change the protein's structure, function, or activity. Phosphorylation is a crucial mechanism of cellular regulation and plays a key role in controlling various cellular processes.

Prairie vole (*Microtus ochrogaster*): A small rodent found across central North America, particularly in prairies and grasslands where they feed on grasses, seeds, and roots. They play a significant role in the ecosystem by dispersing seeds and aerating the soil. Prairie voles are social, live in small colonies, and form strong, monogamous pair bonds with their mates.

Precuneus region: A region of the brain involved in self-reflection, spatial awareness, and episodic memory. The precuneus is implicated in several psychiatric and neurological conditions such as Alzheimer's disease, schizophrenia, and depression.

Primary motor cortex: A region of the brain located in the frontal lobe, specifically along the precentral gyrus. It is responsible for the initiation and control of voluntary movements by sending signals to muscles throughout the body, directing them to contract and execute movements.

Prolactin: A **protein hormone** primarily produced by the pituitary gland, located at the base of the brain. It plays a key role in stimulating milk production in females after childbirth. Prolactin also has other functions in both men and women, including regulating reproductive health, **immune system** function, and metabolism.

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.

Reproductive biology: The branch of biology that focuses on the processes, mechanisms, and systems involved in reproduction in living organisms. It studies how organisms produce offspring, including the biological, physiological, and **genetic** factors that govern sexual and asexual reproduction.

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**.

Seahorse (genus *Hippocampus*): A small marine fish known

for its distinct horse-like head and upright posture. They are typically found in shallow coastal waters, seagrass beds, coral reefs, and mangrove forests. Their bodies are covered in bony plates instead of scales, and they can change color to blend in with their surroundings. Seahorses are also notable for their reproductive behavior: in most seahorse **species**, the males carry the fertilized eggs in a brood pouch until they hatch, after which they "give birth" to live young.

Sex hormones: Steroid **hormones**, such as androgens (**testosterone**), **estrogens**, and progestogens, that interact with steroid hormone receptors.

Sexual selection theory: The selection of and competition for a reproductive partner. Inter-sexual mate selection of the opposite sex is contrasted with intra-sexual competition with same sex members for opposite sex mates.

Sociostasis: A recently evolved capacity to use sociality to anticipate and cope with a variety of challenges, and is necessary for mammalian survival and reproduction.

Spatial transcriptomics: A technique that combines **gene** expression analysis with tissue architecture mapping. It allows for the examination of how genes are expressed in specific locations within a tissue sample, preserving the spatial context of cells. This method provides a detailed, high-resolution view of where and how genes are active in different parts of a tissue, enabling the study of complex biological processes, cellular interactions, and disease mechanisms.

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.

Sumoylation: A post-translational modification in which a small **protein** called SUMO (Small Ubiquitin-like Modifier) is covalently attached to a target protein. This process is similar to **ubiquitylation**, but instead of marking proteins for degradation, sumoylation typically regulates the function, stability, or localization of target proteins.

Synteny: The conservation of relative **gene** order on **chromosomes** in different **species**. Synteny is valuable for understanding evolutionary relationships.

Testosterone: A primary male **sex hormone**, although it is also present in females in smaller amounts. It is produced primarily in the testes in men and in the ovaries in women, with small amounts produced by the adrenal glands in both sexes. Testosterone plays a crucial role in the development of male reproductive tissues, such as the testes and prostate, and is responsible for secondary sexual characteristics like facial hair, deepening of the voice, increased muscle mass, and bone density. In addition to its role in sexual development, testosterone is involved in regulating mood, energy levels, libido, and overall health. It also influences behaviors such as aggression and competitiveness. In both men and women, testosterone levels can fluctuate with age, and imbalances can lead to various health issues.

Titi monkey (genus *Callicebus*): A New World Monkey found across South America that is diurnal and arboreal. Titi monkeys are territorial and live in family groups (parents and offspring) of 2-7 members. They are often observed sitting or sleeping in pairs with tails wrapped around each other.

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.

Ubiquitylation: A biochemical process in which a small **protein** called ubiquitin is attached to a target protein. This attachment typically occurs on the lysine residues of the target protein and is facilitated by a series of enzymes known as the ubiquitin-proteasome system. Ubiquitylation serves as a signal for several key cellular processes.

Vasopressin (antidiuretic hormone): A **hormone** synthesized in the hypothalamus and then transported to the blood to regulate extracellular fluid volume in the blood vessels and kidneys. It also plays a role in vasoconstriction. Vasopressin and **oxytocin** consist of **9 amino acids** and evolved from a single primordial neurohypophyseal hormone called vasotocin, which is present in lower vertebrates. Vasopressin, oxytocin, and their receptors are involved in regulating mating systems in several mammals.