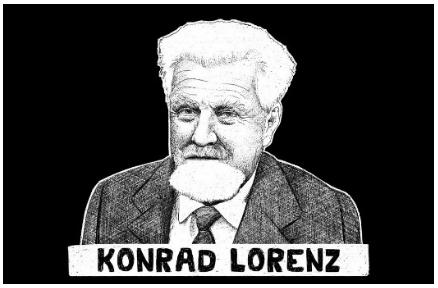
1.1 What is Ethology?

Ethology—from the Greek *ēthos* (character) and *logos* (study)—is the branch of zoology that studies animal behaviour under natural conditions. It asks how animals behave, why they behave as they do and how such behaviours evolve. Nikolaas Tinbergen (Dutch biologist and ornithologist) formalised this enquiry into four questions:

I. **Causation:** What causes behaviour? (What triggers it?)
II. **Development:** How does it change as the animal grows up?
III. **Function:** How does it help the animal survive or reproduce?
IV. **Evolution:** How did this behaviour arise over generations?

Understanding animal behaviour provides insights into biodiversity, conservation, domestication and even human psychology. For example, homing (knowing to come back home) pigeons inspire navigation systems; the waggle dance of honey bees reveals sophisticated non-verbal communication; and study on hormones and behaviour informs animal welfare and medicine.

Modern ethology emerged in the 20th century through the pioneering work of three scientists who shared the 1973 Nobel Prize in Physiology: Konrad Lorenz (Austrian zoologist and ornithologist, often called the father of modern ethology), Nikolaas Tinbergen, and Karl von Frisch. Lorenz's studies of imprinting in greylag geese and von Frisch's work on honey-bee communication highlighted the crucial interplay between innate mechanisms and learning in animal behaviour.



1.2. Fixed Action Pattern

Konrad Lorenz was instrumental in developing the core idea of an innate, unlearned, and stereotyped motor program. He stressed the **"fixed"** aspect, proposing that these behaviours were rigid, species-specific motor sequences driven by internal energy (action-specific energy) that was released by an external stimulus.

A **Fixed Action Pattern (FAP)** is an innate, instinctive behavioural sequence that animals perform in response to a specific trigger or stimulus. It is an unlearned, invariant, and complex behavioural response. The behaviour is common to generally all members of a species of the appropriate sex and/or age, suggesting a strong genetic basis (innate behaviour).

For example: the **wet-dog shake**.

- **Sign stimulus (signal trigger):** being wet; water clinging to the fur.
- **Fixed action pattern:** a stereotyped (typical) head-first twist that ripples down the spine to the body and tail, and once it starts it tends to complete (you can shout "stop," but the physiological program is already ongoing).
- **Function:** rapid water-ejection to stay warm and light; mammals from mice to bears do versions of it.

1.3 Scope and Methods of Ethology

Ethologists employ a toolkit of **naturalistic observation** (watching animals in the wild), **controlled experiments** (manipulating variables to test causal hypotheses) and **comparative methods** (examining similarities and differences across species). Modern ethology integrates molecular techniques (e.g., gene expression), neurobiology and endocrinology to link proximate mechanisms with ultimate functions.

1.4. Core Methodological Principles

i) Naturalistic Observation

The foundation of ethological research involves observing animals in their natural habitats with minimal interference. This approach allows researchers to understand behaviour as it has evolved and functions in real-world conditions.

a) **Ethogram Construction**

An ethogram is a complete catalogue (records) of all behaviours exhibited by a species. Creating an ethogram is often the first step in ethological studies.

Process:

- Identify discrete behavioural units (motor patterns)
- Define each behaviour operationally with clear category
- Record frequency, duration, and context of behaviours
- Create hierarchical organization of behaviour patterns

b) **Sampling Methods**

- **Ad Libitum Sampling**: Recording whatever is visible or seems interesting. Useful for preliminary observations but vulnerable to bias.
- **Focal Animal Sampling**: Observing one individual continuously for a predetermined period. Provides detailed behavioural sequences but limits sample size.
- **Scan Sampling**: Recording behaviour of entire group at predetermined intervals. Efficient for group studies but may miss brief behaviours.
- **Behaviour Sampling**: Recording each occurrence of specific behaviours across all visible individuals. Useful for studying particular behaviour patterns.

ii) Experimental Methods

a) **Field Experiments**

Manipulating variables in natural settings while maintaining ecological validity.

Examples:

- Playback experiments (presenting recorded vocalizations (sounds))
- Model presentations (dummy (toy) predators)
- Removal or addition experiments (altering group composition)
- Environmental manipulations (changing resource availability)

b) **Laboratory Studies**

Controlled studies in laboratories/controlled region allowing precise measurement and replication.

Applications:

- Isolating specific causal (trigger) factors
- Studying sensory capabilities
- Analysing neural mechanisms

- Developmental studies under controlled conditions

iii) Comparative Method

Ethologists compare behaviour across related species to infer evolutionary history and adaptive function.

Approach:

- Identify homologous behaviours (shared through common ancestry)
- Distinguish analogous behaviours (similar function, independent evolution)
- Construct phylogenetic trees of behavioural traits
- Map behavioural evolution onto known phylogenies

a) Descriptive Statistics:

Examining behaviours based on its frequency.

- Frequency: How often does behaviour occur?
- Duration: How long does behaviour last?
- Latency: Time from stimulus to response
- Intensity: Magnitude of response

b) Sequential Analysis

Examining the probability that one behaviour follows another, revealing behavioural chains and decision rules.

c) Time-Budget Analysis

Calculating proportion of time allocated to different activities (feeding, resting, social interaction, etc.).

Methods	**Description**
Naturalistic Observation	Recording behaviour in the animal's natural habitat without interference a) Ethogram b) Sampling method
Experimental methods	Manipulating variables to test causal hypotheses. a) Field Experiment b) Laboratory studies
Comparative methods	Comparing behaviour across species to infer evolutionary origins. a) Descriptive statistic b) Sequential analysis c) Time-budget analysis

Table 1: Methods used in Ethology

Practice Questions

1. Who is considered the founder of modern ethology?

A) B.F. Skinner
B) Konrad Lorenz
C) Ivan Pavlov
D) John Watson

2. Ethology is primarily defined as the study of:

A) Animal psychology in laboratory settings
B) Animal behaviour in natural environments
C) Human behaviour patterns
D) Domesticated animal training

3. Which of the following is NOT one of Tinbergen's Four Questions?

A) Causation
B) Development
C) Inheritance
D) Evolution

4. The term "fixed action pattern" refers to:

A) Learned behaviours that become automatic
B) Innate behavioural sequences triggered by specific stimuli
C) Random movements of animals
D) Flexible responses to environmental changes

5. Observational methods in ethology typically involve:

A) Only laboratory experiments
B) Studying animals in their natural habitat
C) Exclusively using questionnaires
D) Computer simulations only

Answers:

1. (B), 2. (B), 3. (C), 4. (B), 5. (B)

Common misconceptions about behaviour

1. **"Are all behaviours instinctive?"**

   No, most behaviours involve both genetic and learning.

2. **"Is motivation purely psychological?"**

   Not always. Motivation arises from physiological (body) needs (hunger, thirst) and are regulated by hormones and neural circuits.

3. **"Do all learning requires reinforcement (reward system)?"**

   No. Some learning (e.g., imprinting or insight) occurs without reward or punishment.

4. **"Do circadian rhythms only affect sleep?"**

   They also regulate hormone release, body temperature, feeding and many other physiological processes.

2.1. Behavioural Equipment

In the study of animal behaviour, or *ethology*, the concept of **behavioural equipment** refers to the innate physiological and neurological mechanisms that enable organisms to detect, process, and respond to environmental cues (signal). This "equipment" encompasses sensory systems, neural filters, and motor patterns that have evolved to promote survival and reproduction. At its core, behavioural equipment transforms environmental input (signals)—known as **stimuli**—into adaptive actions. However, not all stimuli are equal; animals must efficiently prioritize relevant signals amid a constant abundance of sensory noise.

2.2. Stimuli

A **stimulus** (plural: *stimuli*) is any detectable change or signal in the internal or external environment that can potentially elicit (cause) a behavioural response. Stimuli are the building blocks of perception and action, originating from diverse sources:

- **External stimuli**: Physical or chemical changes outside the organism, such as light patterns, sounds, odours, tactile (touch) pressures, or thermal (heat) gradients. For example, the rustle of leaves might signal approaching prey or a predator.
- **Internal stimuli**: Physiological (biological processes in the body) states within the organism, like hunger or hormonal surges, which motivate behaviours such as foraging (act of searching food) or mating.

2.3. Sign Stimuli

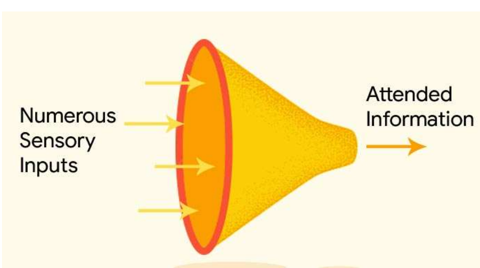
Sign Stimuli are highly specific, often simplified cues (signal) that initiate the fixed action patterns (FAPs): stereotyped, innate behaviours initiated by the nervous system.

Sign stimuli are evolutionarily refined to match the most reliable indicators of ecologically relevant events, such as danger, food, or mates. It uses the perceptual biases of the receiver, often exaggerating signals that stand out against background noise (a phenomenon termed **supernormal stimuli**).

Key Characteristics of Sign Stimuli:

- **Specificity**: They target particular sensory modalities (visual, auditory, smell, touch) and neural circuits.
- **Innate Recognition**: No learning is required; responses are reflexive, mediated by the **innate releasing mechanism (IRM)** (a hypothetical neural filter proposed by Lorenz (1935))

2.4. Stimulus Filtering



The nervous system does not passively relay all stimuli (signal); instead, it utilizes **stimulus filtering** to amplify relevant signals while suppressing irrelevant ones. This process prevents sensory overload and directs behavioural output toward survival priorities. Filtering occurs at multiple levels: peripheral sensory receptors, central neural pathways, and higher cognitive integration.

Mechanisms of Stimulus Filtering:

- **Sensory Adaptation**: Receptors habituate (gets-use-to) to constant stimuli (e.g., ignoring steady background noise) but remain sensitive to changes.
- **Neural Gating**: Specialized Neural circuits act as gates that lower response thresholds only for sign stimuli. Non-matching inputs are inhibited via lateral inhibition in the retina or auditory cortex.

- **Motivational Modulation**: Internal states (e.g., arousal or hormone levels) dynamically adjust filter sensitivity. E.g., A hungry animal filters for food-related odours.

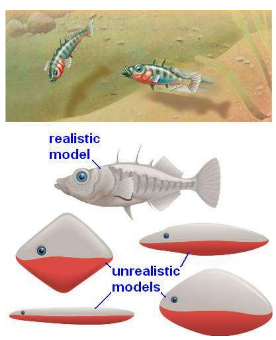
Feature	Sign Stimulus (Releaser / Key Stimulus)	Stimulus Filtering (Sensory Filtering)
Meaning	A specific stimulus (signal) that is necessary and sufficient to elicit a specific fixed action pattern (FAP) or instinctual behavioural sequence.	The process by which an animal's sensory systems and/or central nervous system selectively pay attention to a small, relevant part of the total sensory information available, and ignore the rest.
Role in Behaviour	Activates a particular, often innate behaviour (Fixed Action Pattern). It's the "key" that "unlocks" the response.	Limits the total amount of information that an animal processes, ensuring it only responds to the most relevant stimuli.
Location of Action	External environment, although its effect is due to the animal's internal processing mechanism (IRM).	Primarily in the sensory organs (peripheral filtering) and the Central Nervous System (CNS) (central filtering, or Innate Releasing Mechanism - IRM).
Example	The bright red colour of a rival male stickleback's belly triggers aggression in another male.  The red underside of an intruder causes the rival fish to attack it.	A frog's visual system is primarily sensitive to small, moving, dark objects (prey) and filters out large, stationary background objects.  The frog is able to focus on the target because of Stimulus Filtering which filtered out irrelevant signals (noise).
Relationship	The Sign Stimulus is the result of the Stimulus Filtering process. It is the particular feature that wasn't filtered out and successfully passes through the sensory and neural filters to trigger a response.	Stimulus Filtering is the mechanism that makes the Sign Stimulus possible by eliminating all the "noise" or irrelevant information (signals).

Table 2. Sign Stimulus and Stimulus Filtering

2.5 Patterns of Behaviour

Behavioural patterns refer to the consistent, recurring sequences of actions, responses, or interactions that individuals or groups exhibit in response to specific stimuli, environments, or internal states. In the field of behavioural science, patterns are studied through "classical and operant conditioning (Pavlov, 1927; Skinner, 1938), social learning theory (Bandura, 1977), and contemporary neuro-behavioural models" that integrate genetic and environmental influences.

Behavioural patterns serve adaptive functions, enabling organisms to navigate predictable aspects of their world efficiently. However, maladaptive patterns, such as compulsive behaviours in anxiety disorders, can impair functioning and require intervention.

Behavioural patterns can be categorised as follows:

i) **Orientation behaviours** – Movements that place an animal in a favourable environment.

a) **Kinesis** – An organism moving around more or less depending on how strong something in its environment is, but not in any particular direction. For e**xample,** Woodlice speed up and move around a lot when they're in a dry place. But when they find a humid/moist spot, they slow down and don't move as much. This helps them stay in the damp areas they prefer.

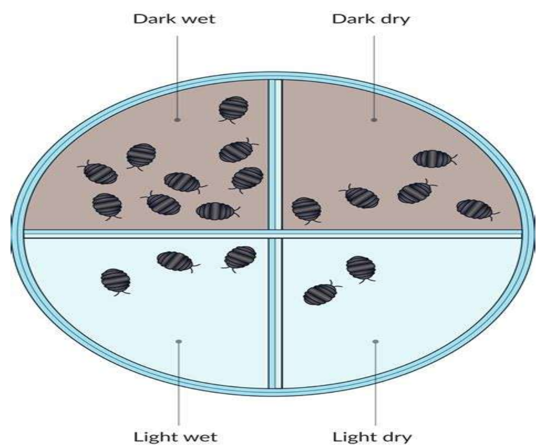


Fig: woodlice increase their rate of movement in dry areas

b) **Taxis** – Directional movement towards or away from a stimulus. For example, Phototaxis in moths (movement toward light) and chemotaxis in bacteria.

Fig: Moths moving towards and gathering around the light source (via phototaxi)

ii) **Fixed Action Patterns (FAPs)** – As discussed in the above sections, it is a stereotyped motor sequences triggered by sign stimuli, executed to completion once started; e.g., the wet-dog shake.

iii) **Reflexes** – Automatic, rapid responses to specific stimuli (knee-jerk reflex).

iv) **Learned behaviours** – Behaviours that are learned based on habituation, conditioning and insight.

Innate vs learned behaviour: Innate behaviours are typically inherited, fixed, species-specific and performed correctly without prior experience; learned behaviours result from interaction with the environment and can be modified by experience.

Characteristic	Innate Behaviour	Learned Behaviour
Meaning	Genetically programmed responses that are present from birth or develop without experience	Behaviours acquired through experience, practice, or interaction with the environment
Genetic Basis	Inherited through genes; controlled by DNA	Not directly inherited; develops through environmental interaction
Presence at Birth	Present at birth or emerges at specific developmental stages without prior experience	Absent at birth; develops over time through experience
Modification	Fixed and stereotyped; difficult or impossible to modify	Flexible and adaptable; can be modified with new experiences
Species Specificity	Generally uniform across all members of a species	Varies between individuals based on their unique experiences
Environmental Influence	Minimal environmental influence required for expression	Requires environmental stimuli and experiences to develop
Survival Value	Essential for immediate survival needs	Allows adaptation to changing or novel environments
Examples in Animals	Reflexes (blinking, suckling), migration patterns, web-spinning in spiders, bird song in some species	Tool use in primates, hunting techniques in predators, problem-solving, language acquisition
Examples in Humans	Rooting reflex, grasping reflex, crying, blinking	Reading, writing, riding a bicycle, playing musical instruments, speaking a specific language

Table 3: Innate Behaviour and Learned Behaviour

2.6. Individual Behaviour Pattern

Individual behavioural patterns refer to the consistent and unique ways an individual responds to various situations and challenges. These patterns represent the characteristic methods through which individuals handle both their internal experiences (thoughts and emotions) and external circumstances (events and environments). These patterns are shaped by many factors: genetic predispositions, early life experiences, neurochemical balances, and ongoing learning.

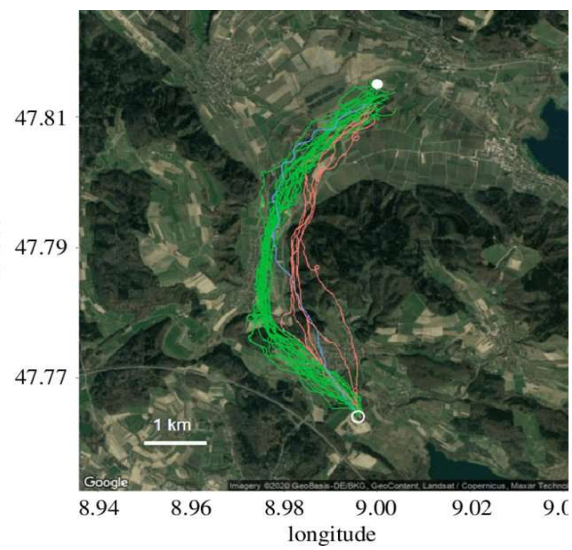
2.7.1 Homing Behaviour

Homing refers to an animal's ability to return to a specific location (e.g., nest, den or territory) after travelling elsewhere. It differs from **migration**, which is a long-distance, seasonal movement between habitats. Homing is common in central-place foragers such as bees and pigeons and depends on navigation mechanisms:

- **Path integration (egocentric information)** – The animal keeps track of the direction and distance travelled relative to its starting point using internal cues such as motor commands and sensory inputs. Honey bees use path integration during foraging and share this information via the waggle dance.
- **Map and compass senses (geocentric information)** – A map sense uses environmental cues (landmarks, odours, magnetic fields) to determine position; a compass sense uses a reference (sun position, stars or Earth's magnetic field) to maintain a direction. Pigeons maps location with signal from the relative sun position or magnetic compass to home accurately.

2.7.2. Homing in Pigeon

Homing pigeons demonstrate extraordinary navigational capabilities across impressive distances and under varied conditions. Pigeons can successfully locate home from distances exceeding 1,000 kilometres, traveling at average flight speeds of 60 to 80 kilometres per hour, with some exceptional individuals reaching speeds over 100 kilometres per hour. Experienced birds can pinpoint their loft location with remarkable precision, often landing directly at their home structure rather than simply arriving in the general vicinity. The success rate varies with distance, weather conditions, and individual experience, but well-trained birds typically show success rates exceeding 90 percent at moderate distances. These abilities make homing pigeons one of the most reliable natural navigation systems known to science.



Phases of Homing

i) **Initial Orientation**: The initial orientation phase occurs during the critical first few minutes after release, when the bird must determine the home direction from an unfamiliar location

ii) **Navigation**: Maintaining course over long distances. Utilises the Earth's magnetic field and the sun position.

iii) **Homing**: the homing phase involves the last few kilometres of the journey, when the bird recognizes the local area and uses familiar landmarks to locate the precise position of the loft.

Sensory Mechanisms and Navigation

i) Magnetic Compass

Pigeons possess magnetoreception, which is the ability to detect Earth's magnetic field and use it for orientation. Small magnetic particles called magnetite are found in the upper beak of pigeons, and experimental disruption of magnetic fields has been shown to impair their orientation abilities. Pigeons detect Earth's magnetic field via an inclination compass (angle relative to gravity), effective in low-light. The mechanism underlying this sense involves iron-rich cells in the beak that act as magnetic sensors, with the trigeminal nerve carrying magnetic information to the brain for processing. This magnetic sense function as a fundamental component of the pigeon's navigational toolkit, providing a reliable compass reference under most conditions.

ii) Sun Compass

Pigeons use the sun's position as a compass reference. This system is sophisticated that it must account for the sun's continuous movement across the sky throughout the day. This time-compensated sun compass requires an internal circadian clock that allows the bird to interpret the sun's position correctly depending on the time of day. Pigeons actively integrate temporal information with solar position to determine compass directions.

iii) Visual Landmarks

Visual landmarks play a crucial role in the final phase of homing, when birds approach and locate their specific loft. The recognition of familiar terrain features becomes particularly important within the last five to ten kilometres of the journey, allowing birds to transition from general navigation to pinpoint location finding. Pigeons demonstrate remarkable visual memory for landscape features, including buildings, roads, rivers, coastlines, and other prominent structures. During the final approach, birds often follow familiar routes that they have learned through repeated flights, suggesting that they maintain detailed visual memories of their local area. This landmark-based navigation provides the precision necessary for birds to land at their specific loft rather than simply arriving in the general neighbourhood.

Feature	Homing	Migration
Meaning	Return to a central place (nest, hive, den) after local foraging (Food search)	Seasonal movement between distant habitats
Distance	Generally short to moderate distance i.e., from foraging area to home	Often long-distance (hundreds to thousands of kilometres)
Signals used	Path integration, sun compass, magnetic fields, landmarks	Sun/star compass, magnetic fields, celestial patterns, wind patterns, memory of routes
Examples	Honey bees returning to hive; homing pigeons	Arctic tern migration; wildebeest migration

Table 4: Difference between Homing and Migration

__**2.8.1 Genetic Basis of Behaviour**__

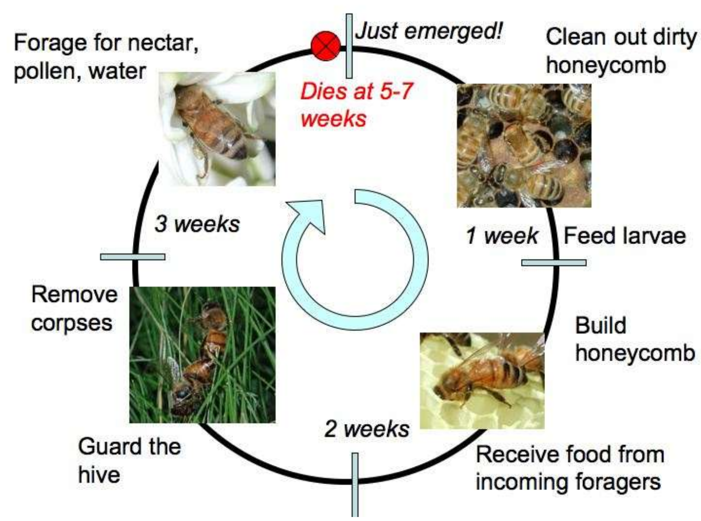
Genes provide a framework within which the environment shapes behaviour. They influence morphology and physiology, which in turn constrain behavioural possibilities. Early ethologists like Lorenz viewed behaviours as instinctive (innate, genetically "hard-wired"), but modern views recognize a continuum: genes provide the blueprint, while environments (e.g., social cues, predators) shape expression. No behaviour is completely determined by genes; instead, they set potentials modulated by experience.

All behaviour is a product of an interaction between an organism's **genotype** (its genetic code) and its **environment** (everything from the uterine environment to social interactions).

i) **Genes do not directly code for behaviour**; rather, they encode proteins that affect neural and hormonal pathways. Single gene changes can cause significant behavioural differences (e.g., hygienic behaviour in bees is influenced by multiple quantitative trait loci of the chromosomes).
ii) The physiological systems (e.g., a more sensitive amygdala, a less efficient serotonin system) are what influence an individual's *likelihood* to respond to an environmental stimulus in a particular way.
iii) Behaviour is a Phenotype: Behaviour is an observable trait (a phenotype), just like eye colour or height. However, it is an incredibly complex phenotype, resulting from the output of the entire nervous system in response to the environment.

Example of Genes (Expression level) shaping Behaviour in Honeybees (*Apis mellifera*):

- **Behaviour:** Bees exhibit **polyethism** (division of labour by age). Young bees are "nurses" (working in the hive), and older bees become "foragers" (collecting pollen/nectar outside).
- **Mechanism:** This is *not* a genetic polymorphism. *All* bees have the same *'for'* gene. Instead, the **level of gene expression** changes.
- **Result:** As bees age, the expression of the *'for'* gene in their brains *increases*, leading to higher PKG levels. This increase expression is correlated with the behavioural change from nursing to foraging.



2.8.2. Epigenetics: The Environment Modifying the Genome

Epigenetics is the study of changes in gene expression that occur without altering the DNA sequence. It's a primary mechanism for gene-environment interaction which can shapes behaviour.

- **Mechanism:** Environmental factors can cause **epigenetic marks** (like a **methyl group**, CH3) to be added to DNA.
- **Function:**
  - **High Methylation:** Tightly coils the DNA, "silencing" the gene (it cannot be read or expressed). No product (protein) from the gene. This absence of product in the physiology may cause a behavioural change (positive or negative) of the individual.
  - **Low Methylation:** Loosens the DNA, "activating" the gene (it can be read and expressed). Express product (Protein) from the gene. This presence of product in the physiology may cause a behavioural change (positive or negative) of the individual.

Example of Epigenetic in the Maternal Care in Rats

A study (experimented at "Douglas Hospital Research Centre" in 1997) showed how a mother's *behaviour* can epigenetically cause her pup's future stress response (behaviour).

- **Laboratory Environment:** The rat mothers are different naturally in their maternal care. Some are **High-Licking/Grooming (High-LG)**, and some are **Low-LG**.
- **Behavioural Outcome:**
  - Pups of High-LG (High Licking/Grooming) mothers grow up to be **less anxious**, less fearful, and have a mild response to stress.
  - Pups of Low-LG mothers grow up to be **highly anxious**, more fearful, and have an exaggerated stress response.

2.9.1 Neural and Hormonal Control of Behaviour

2.9.2 Nervous system

The nervous system is the highly complex part of an animal that coordinates its actions and sensory information by transmitting signals to and from different parts of its body. The nervous system mediates rapid and specific responses. **Sensory organs and central nervous structures act as stimulus filters**, preventing information overload by selecting biologically relevant signals. Information is processed by the brain and spinal cord, and motor commands produce behaviours.

The Key Components in Nervous System:

i) **Central Nervous System (CNS)**: It processes sensory input, integrates information, and generates outputs for behaviour. For example, the brain's amygdala detects fear and triggers avoidance behaviours.

ii) **Peripheral Nervous System (PNS)**: It includes the somatic system (voluntary actions like walking) and autonomic system (involuntary functions). The autonomic system has two branches:

a) Sympathetic: Activates "fight-or-flight" responses, increasing heart rate and alertness during stress.

b) Parasympathetic: Promotes "rest-and-digest," conserving energy post-stress.

Mechanisms: Neurons communicate via neurotransmitters (e.g., dopamine for reward-motivated behaviours) at synapses, allowing millisecond-speed adjustments. This enables immediate, localized control, such as pulling a hand from a hot surface.

2.9.3 Endocrine system

The endocrine system releases hormones—chemical messengers that travel through the bloodstream and act on distant target tissues. Hormones operate over longer timescales and regulate growth, metabolism and behavioural states. Two types of hormonal effects are recognised:

- **Organisational effects** occur during development, shaping neural circuits and sexual differentiation. For example, testosterone produced by male embryos organises reproductive tissues; absence of testosterone leads to female development.
- **Activational effects** are transient (or immediate) effects in response to external stimuli (signal). For example, Male fish change colour during territorial defence due to hormone release, and castration reduces aggression in male mammals because testosterone receptors in the brain are no longer stimulated.

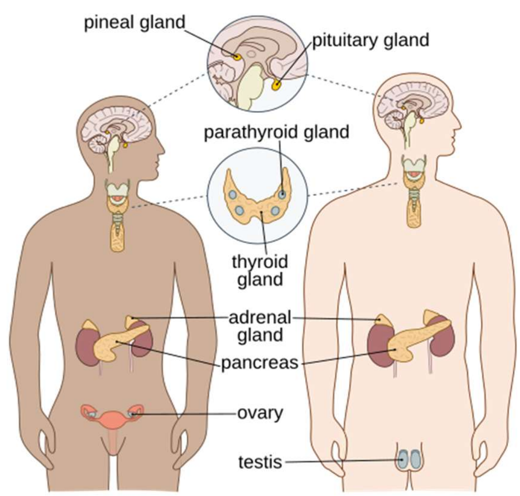


Fig: Major endocrine glands that release hormones which shapes behaviour

Hormones such as testosterone, oestrogens and progesterone modulate reproductive behaviours; oxytocin and vasopressin influence social bonding and parental care; and stress hormones like cortisol affect responses to threats.

Hormone	Source (Endocrine glands)	Behavioural roles/Primary result	Secondary result
Testosterone (androgens)	Testes (males), ovaries/adrenal glands (females)	Promotes aggression, courtship, territoriality; organisational role in male sexual differentiation	Excess reduces parental care in some species
Oestrogens (e.g., estradiol)	Ovaries, placenta, adrenal glands	Regulate female reproductive behaviours, maternal care	High levels during breeding season
Progesterone	Ovaries, placenta	Supports pregnancy, inhibits ovulation; involved in nest-building and maternal behaviour	Synergistic with oestrogens
Cortisol (glucocorticoids)	Adrenal cortex	Mediates stress responses; modulates learning and memory	Chronic (excessive) expression suppresses immunity
Oxytocin & vasopressin (peptide hormones)	Hypothalamus/pituitary	Promote social bonding, pair-bonding, parental care	Release stimulated by tactile contact
Thyroid hormones (T3, T4)	Thyroid gland	Regulate metabolism; influence locomotor activity	Hypothyroidism reduces activity

Table 5. Major hormones and behavioural roles.

2.9.4. Interactions Between Neural and Hormonal Systems

The hypothalamus acts as a master integrator, linking the two systems via the hypothalamic-pituitary-adrenal (HPA) axis. Neural inputs (e.g., from stress-sensing neurons) stimulate the pituitary to release hormones, which then feedback to the brain.

- **Bidirectional Feedback**: Behaviour influences hormones (e.g., winning a competition raises testosterone, boosting confidence), and hormones shape neural processing (e.g., estrogen enhances sensory sensitivity in females during ovulation).
- **Homeostasis Maintenance**: During stress, sympathetic nerves trigger cortisol release for sustained energy, while the brain monitors levels to prevent overload.
- **Developmental Effects**: Prenatal hormones organize brain sex differences, affecting lifelong behaviours like aggression or nurturing.

This coordination ensures behaviours align with physiological needs, from reproduction to survival.

Examples of Coordinated Neural and Hormonal (Endocrine gland) Control

- **Fight-or-Flight Response**: A threat activates sympathetic nerves for instant adrenaline surge (neural), followed by cortisol for prolonged vigilance (hormonal).

- **Maternal Behaviour**: In rodents, pregnancy hormones (progesterone) disinhibit neural circuits in the preoptic area (anterior of hypothalamus), enabling pup care; oxytocin reinforces bonding.
- **Human Aggression**: Testosterone amplifies amygdala (located in the brain) responses to provocation, but social context (neural integration) modulates the outcome.

Categories	Neurotransmitters/neuronal circuits	Steroid hormones (testosterone, estrogens)	Peptide hormones (oxytocin, vasopressin)	Stress axis (cortisol/ corticosterone)	Melatonin release rhythms
Latency (Result/onset upon trigger or signal)	Milliseconds.	Minutes to hours to onset due to genomic actions.	Seconds to minutes.	Minutes to onset after stress.	Secreted in darkness; onset within minutes; high at night.
Duration	Very brief (ms–s).	Hours to days.	Minutes to hours.	Hours; provides negative feedback (signal to lower hormone secretion) on hypothalamus/ pituitary.	Night-long.
Example behaviour	Acetylcholine release at neuromuscular junction during flight initiation.	Testosterone increasing territorial aggression; estradiol facilitating maternal care.	Oxytocin facilitating pair bonding; vasopressin influencing paternal care.	HPA axis activation during predator encounter resulting in cortisol release.	Regulates sleep–wake cycle and seasonal reproduction.

Table 6: Distinctive characteristics between Neuronal and different Hormonal Control

Practice Questions

1. The term “sign stimulus” (releaser) refers to:
   A. Any learned cue that triggers exploratory behaviour
   B. A specific external cue that reliably triggers a stereotyped response
   C. A hormone surge that primes a motor pattern
   D. A neural command that filters sensory input
2. A supernormal stimulus is:
   A. A cue that animals ignore under stress
   B. An exaggerated version of a sign stimulus that elicits an especially strong response
   C. A cue requiring prior learning to be effective
   D. A stimulus filtered out by higher brain centres
3. Which is the clearest example of stimulus filtering?
   A. A frog’s retina responding strongly to small moving “bug-like” objects
   B. A cat learning to open a door by trial and error
   C. A parrot mimicking human words after reinforcement
   D. A rat freezing after repeated shocks
4. A fixed action pattern (FAP) is typically:
   A. Variable and easily interrupted mid-sequence
   B. Highly stereotyped and runs to completion once started
   C. Always learned via imitation
   D. Dependent on circadian time only
5. In orientation, “taxis” differs from “kinesis” because taxis:
   A. Is random movement relative to a stimulus
   B. Is growth rather than movement
   C. Is directed movement toward/away from a stimulus
   D. Is movement only triggered by hormones
6. Cross-fostering that leaves offspring behaviour similar to their genetic parents suggests:
   A. Purely environmental control
   B. Heritable genetic influence
   C. Measurement error
   D. Maternal effects only
7. “Organizational” vs “activational” hormone effects differ in that organizational effects are:
   A. Short-lived and reversible in adults
   B. Long-lasting developmental effects that shapes neural circuits
   C. Restricted to peripheral tissues
   D. Only seen in insects
8. In vertebrates, the HPA axis chiefly coordinates:
   A. Acute stress and energy mobilization via glucocorticoids
   B. Thermoregulation via sweat glands
   C. Immediate reflex arcs
   D. Taste receptor adaptation

Answers:

1. B; 2. B; 3. A; 4. B; 5. C; 6. B; 7. B; 8. A;

Common Misconceptions:

1. **“Is Personality fixed for life?**”
   No. It’s **probabilistic** and can shift with development, hormones, experience, and ecology.

2. **“There’s a ‘gene for’ complex behaviours (deterministic).”**
   Not necessarily. Most behaviours are **polygenic** with **gene and environment** interplay; single-gene effects exist but are rare and context-dependent.

3. **“Hormones cause behaviours one-to-one (‘testosterone = aggression’).”**
   Not necessarily. Hormones **coordinate** via networks, receptors, and context; same hormone can produce different outcomes across situations/species.

4. **“Stress hormones are purely bad.”**
   No. Acute glucocorticoids **mobilize energy** and sharpen responses; chronic (excessive) dysregulation is the problem.