- Behaviour:

The expression of coordinated vital activities by which an animal integrates with its environment.

It is the externally observable muscular activity triggered by some stimulus, or what an animal does when interacting with its natural environment.

It shows a vast array of specializations, each species exhibiting a particular repertoire of activities which fits it for its particular niche in nature.

- Few of the behavioural adaptations of animals are known, most of these relate to:

✓ the reproductive activity,

✓ means of obtaining food,

✓ protection

The animals adopt ‘alarm’ or other defensive behaviours.

Most of these records were obtained from artificial laboratory experiments conducted under artificial conditions.

(Observe animals)

Contributors to behaviour

- The ‘father’ of animal behavior is Charles Darwin who published the first book on the subject in 1872 titled:

‘The expression of the Emotions in Man and Animals’

Other leading scholars in study of behaviour and the animals they studied include the following:

L. Lorenz ----------Dog, Goose

N. Tinbergen ----- Gulls

K. von Frisch------- Bees

J. Goodall ---------- Chimps

J. Emlen ---------- Birds, Mice

R. Penny ----------Penguins

G. Schaller --------- Gorilla, Tiger, Lion

H. Harlow ---------- Monkeys

P. Johnsgard ------- Waterfowl

Methods and problems

- Completeness and objectivity are very necessary in the study of animal behaviour.
- Records must be taken with an open and unprejudiced mind.
- The researcher should stay as far away as possible from the animal being studied. The behaviour of the animal may be modified by the presence of the researcher.
- Records should be taken for extended periods of time.
- Records on stimulus and environment are very important.

- Limitations include the imperfect nature of human (researcher's) sense organs. One may not see, hear or smell everything, language for correct description of observed behavior.
- Small sizes of some animals.
- Rapid movements of animals.
- Difficulty to differentiate between certain similar movements

Questions about behaviour

Two fundamentally different categories of questions in the study of behaviour:

- ***"How questions"*** about **proximate** mechanisms inside the organism that causes the behaviour. These questions ask ***how*** an individual manages to carry out an activity. How an animal's internal mechanisms developed; how they then cause the animal to behave in a certain way is expected to be explained in the response to the question.

- What is your response to this question?.

Why do birds sit on eggs?

- ***"Why questions"*** about **ultimate** or evolutionary reasons for the behaviour.
- A full understanding of the **ultimate** causes of an animal's behaviour requires investigation into the initial form and subsequent evolution of the behaviour, as well as processes responsible for the changes.

NB: The two causes of behaviour are complementary and not mutually exclusive. Full analysis of any behaviour involves answering both proximate and ultimate questions.

- **Think about this question and provide an answer when emphasis is on only one of the underlined words:**

<u>Why</u> do <u>birds</u> <u>sit</u> on <u>eggs</u>?

Reasons for experimenting on animals.

- *Experimentation on humans is often very difficult and sometimes impossible.*
- *Reward or punishment is usually essential. Animals are often deprived of food for a day or more prior to the experiment and a food reward is given for a correct answer to the problem and perhaps a mild electric shock for a wrong/ incorrect answer. Such deprivation or punishment would be unacceptable in human experimental work.*

- *Also the effects of administration of drugs or of the alterations to the nervous system can be studied in animal experiments with much less foreknowledge of the consequences than are acceptable for human studies.*

- *General studies are much more feasible with animals than humans. Most animals have relatively short life-cycles which allow many generations to be studied.*

- Problems associated with the study of animal behaviour in an attempt to understand human behaviour relates mainly to the extent to which extrapolation from knowledge of animal behaviour to hypothesis about human behaviour is possible.
- It has been suggested that in attempting to assess the extent to which behavioural studies of animals are relevant to human behaviour, it is important to consider the phylogenetic relationship between man and the animal concerned.

- Also the extent to which the behaviour in question is specialized.

Study of Animal behaviour

- The three main approaches to behavioural studies are the **vitalistic, mechanistic** and **ethological approaches.**

- **Vitalistic approach** seeks to account for behavioural activities in terms of what animals are seen to do.
- It attempts to relate this to changes in the environment.
- It involves the total rejection of any study of the animal outside its natural environment.
- The technique has its foundations in natural history and has provided a lot of data. It is however, non- scientific because all the observations relate to past events which cannot be tested experimentally.

- **Mechanistic Approach** is an experimental approach and involves the study of particular aspects of behaviour **under controlled conditions in the laboratory**. The technique has been used extensively in psychology and was pioneered by Pavlov. This approach may be criticized on the following grounds:
- artificiality of the experimental situation
- the nature of the behaviour activities
- the way in which the results are interpreted.

The Ethological Approach

- The ethological approach which has been defined as **biological approach** to the study of behaviour was pioneered by **Lorenz, von Frisch and Tibergen**. It involves studying animals in **natural conditions** (**in the field**) in order to ask useful questions about their behaviour and obtaining answers to the questions.

Characteristics of Ethological / Biological Approach

- First step involves a careful systematic observation of the animal as it encounters various problems of its existence. It requires attentiveness, patience and ingenuity. These are basic to the one studying the animal. It should start with a period of unobtrusive but precise and careful observation of the animal.
- It is believed that many questions about behaviour can be answered without experimental interference. Experiments should be kept simple and, wherever possible, carried out in the field.

- Ethology is characterized by the way data are collected. A description of what the animals does in terms of relatively simple components of behaviour, such as movements and posture and to give these descriptive rather than interpretative labels.
- The early ethological investigations aimed at producing inventories of such actions (**ethograms**) for a range of animal species.

- **NB:** Care must be taken to avoid putting oneself in the place of animal (**anthropocentrism**)
- Or interpreting what is observed in terms of human experience. Here we attribute behavior or characteristics of non human organisms or objects to those of human. Eg. Saying fast flowing river is “ angry” or running cow is “mad” (**anthropomorphism**)
- Or interpreting the cause of the observation in terms of outcome, end, goal or function (**teleology**)

The strengths of Ethological Approach.

- The chances of overlooking rare but important behaviour patterns are reduced because of the patient observation of the animals under natural conditions.

- The approach highlights biologically important questions and is a fruitful source of hypotheses, especially where questions about the functions of behaviour are concerned.

- Furthermore, the straightforward description of the movements that animals make, as free as possible from preconceived interpretation as to their significance, encourages an open mind about how behaviour is organized and what it is for.

- With careful description of movements concerned this method of recording behaviour should facilitate replication.
- Makes it possible to look for general principles about animal behaviour, although zoological experience indicates that extrapolation should be done cautiously.

Weaknesses of Ethological Approach

- Observation of simple movements tends to overemphasize the importance of discrete, stereotyped actions, which can be seen or heard and to underemphasize the importance of more variable movements and the production of scents.
- Ethological research therefore has concentrated on behaviour of animals such as insects, fish and birds which use predominantly visual and auditory signals.

- Description of behavour in terms of form alone often stated as an ideal of ethological research may result in important aspects of behaviour being ignored.
- For example it may be useful to distinguish pecking at food from pecking at nest material which introduces something about the behaviour’s relationship to the environment into the description.

- The ideal of an open minded observer faithfully reporting all an animal does is not realistic in practice. Because one can never record everything, decisions must be made about what to include in a behavioural study and the process by which this is done depends on the observer's interests and preconceptions about what is important.

- There is the danger of collecting large masses of difficult to use data which are of little interest, simply because these are there to be collected. This tendency to record everything sometimes results in overemphasis of techniques of data collection and analysis at the expense of ideas.
- Simplicity and naturalness in experiments could lead to some weakness in experimental design.

- **NB:** The Ethological Approach is the contemporary approach to behavioural investigations. However, whatever the approach and techniques used in the investigation of behaviour, the fundamental explanation of behaviour activity must begin with a stimulus, end with a response and include all the stages occurring at various levels of organization within the body linking ***cause*** and ***effect.***

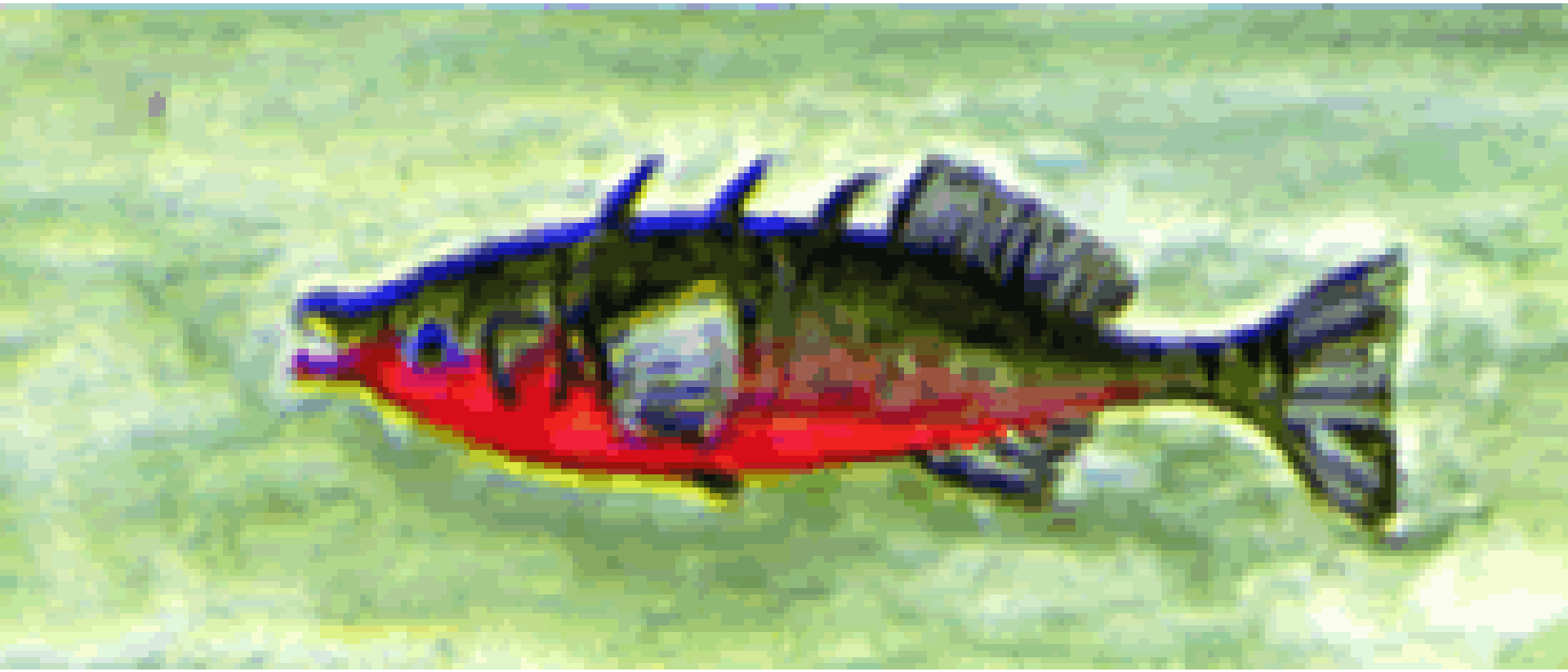
Outline of classical Ethological theory

According to classical ethological theory, an animal's behaviour consists of a series of regularly repeated, stereotyped movements or combinations of movements which are as characteristic of the species concerned as any of its structural features. These are called ***fixed action patterns*** and are elicited by one or a few key aspects of the environment or ***sign stimuli.***

- In a study by Tinbergen (1953) he found out that the male three-spined sticklebacks (*Gasterosteus aculeatus*) developed red bellies in the breeding season and that they preferentially attack conspecifics (species in the same group). His experiment was to determine what elicits this response.
- <u>Experiment:</u> He presented male fish with a series of stimuli ranging from an entire dead, non-breeding stickleback to very crude models of various shapes, with or without a red spot.

- Results: All the sticklebacks attacked most strongly those models with red on their lower surface, **regardless of shape**.
- He concluded that in the male sticklebacks the fighting response was critically dependent on the stimulus "red belly underneath" He only designed his experiment around natural behaviour of the animals and since males generally go red in the breeding season he did not investigate their response to other colours.

- It could be deduced from the experiment that the red belly of a rival elicits the fixed action patterns used in attack by breeding male sticklebacks.
- The stimulus could be simple or complex, configurational affairs.
- In Tinbergen's experiment, the red only elicits attack if it is underneath.



Where more than one sign stimulus triggers a response, their effects were believed to combine additively (a property which is summarized in the *Law of Heterogenous Summation*).

For example a male stickleback with a red belly and in a head down posture elicits more attack than one in a horizontal position.

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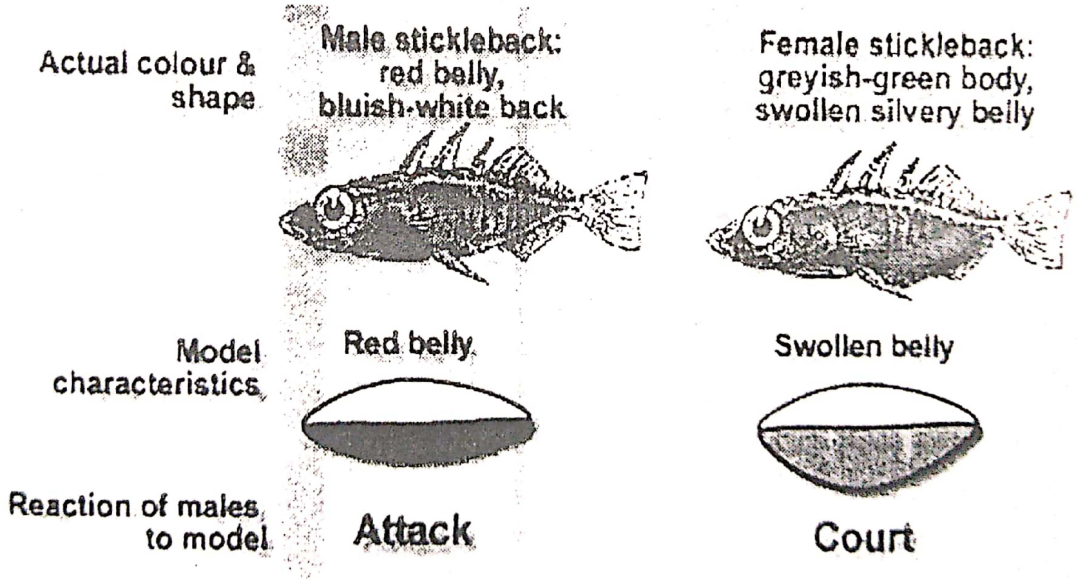


- The specificity with which a fixed action pattern can be released by the appropriate sign stimulus was seen as the result of mechanisms in the central nervous system specific to the response in question.
- This detects the presence of a particular configuration of stimuli and activate the appropriate response.
- These mechanisms were called ***Innate Releasing Mechanisms***.

Motivation/drive

- When animals are undisturbed, a given stimulus does not always elicit the same response.
- Male sticklebacks do not attack red models outside the breeding season. As such an animal's internal state or ***motivation*** is extremely important in determining what behaviour it shows and is made up of a variety of factors which may be internal or external.

- Presenting food to a starved animal will produce a different response from that shown by an animal that has been fed.
- Many behavioural responses associated with reproduction have motivational element. For example, many female mammals are only responsive to mating attempts by males at certain times of the year.
- These times coincide with the period of oestrus and have the adaptive significance of ensuring that mating coincides with the optimum time for fertilization and therefore the production of offspring at the most favourable time of the year.
- These behavioural patterns are known as ***biological rythms.***

- In many species the degree of motivation, or ***drive*** coincide in males and females, but in other species some system of communication between the sexes is essential to express the degree of motivation.
- Drives represents an accumulation of action specific energy and at any given time the animal will display fixed action patterns controlled by that drive whose action specific energy is at the highest level.

Development of fixed action patterns

- From classical ethological theory, fixed action patterns are inherited, genetically determined and do not require specific environmental contingencies for their final expression.

<u>Basis for theory</u>

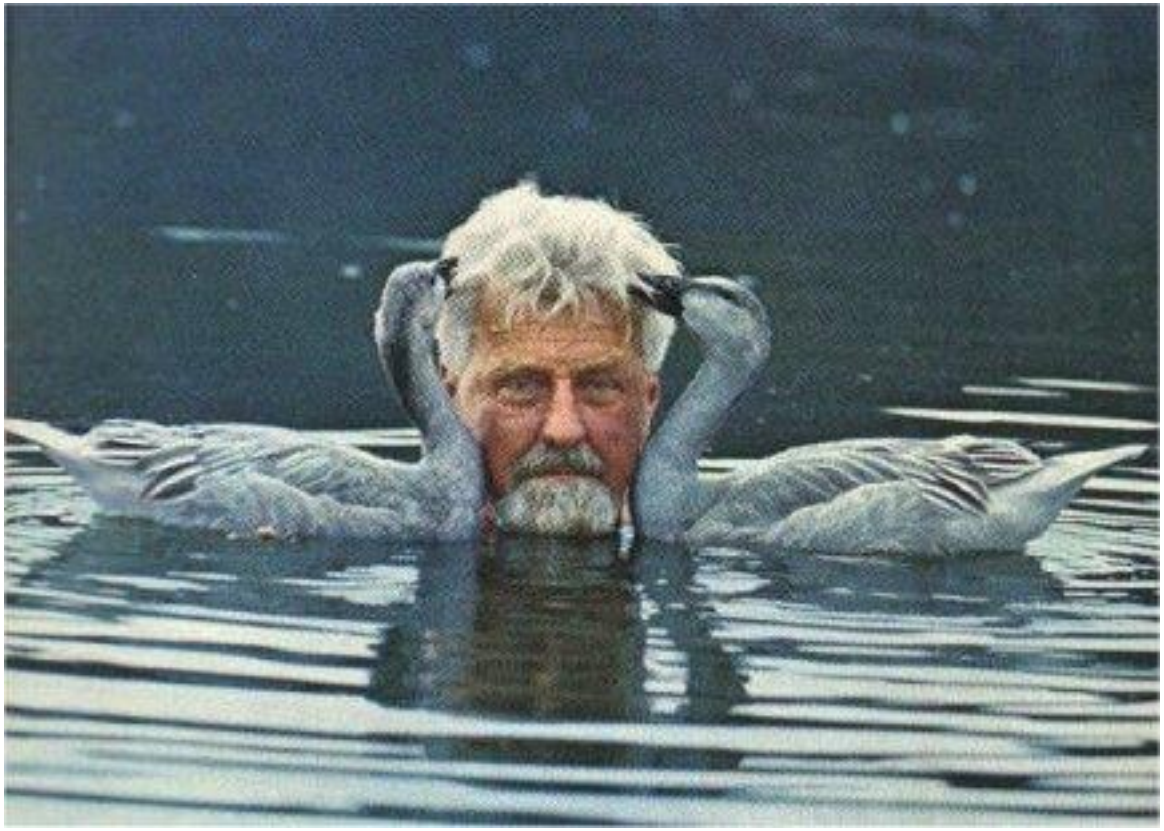
This theory was based on observation that animals tend to perform the fixed action patterns typical of their species.

- The more closely related two species are, the more similar their behaviour tends to be.

Behaviour often appears to be clearly adapted by natural selection to animals needs and it may appear fully formed at the first performance in the absence of any opportunity for learning.

Effect of experience on behaviour (fixed action patterns)

- The development of fixed action patterns is independent of environmental influence but classical ethologists accepted that it could be modified by experience.
- Lorenz showed that newly hatched geese follow the first moving object that they encounter - usually their mother.
- Hand reared birds followed him (Lorenz).
- The long - term social and sexual preferences are formed at a critical stage in development in the absence of any conventional reinforcement by a process called ***imprinting:*** This is learning that is limited to a specific time period in an animal's life and that is irreversible.



Learning

It is to acquire knowledge or skills through study, experience or being taught. It is a lifelong process, most prominent in humans.

- Importance: Helps individuals to acquire the necessary skills so that set goals may be achieved.

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Principles of learning

- Participation
- Repetition
- Relevance
- Transference
- Feedback

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Types of learning

- Restricted learning:

Genes exert constraints on learning.

Some learning may take place only at a certain sensitive period in early life.

Some things may be learned readily but others cannot be learned at all.

Usually related to performance of some behaviors characteristic of the whole population

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or species which are particularly vital for the survival or successful reproduction.

- Imprinting is a form of restricted learning which can take place only during limited sensitive period, often in early life.

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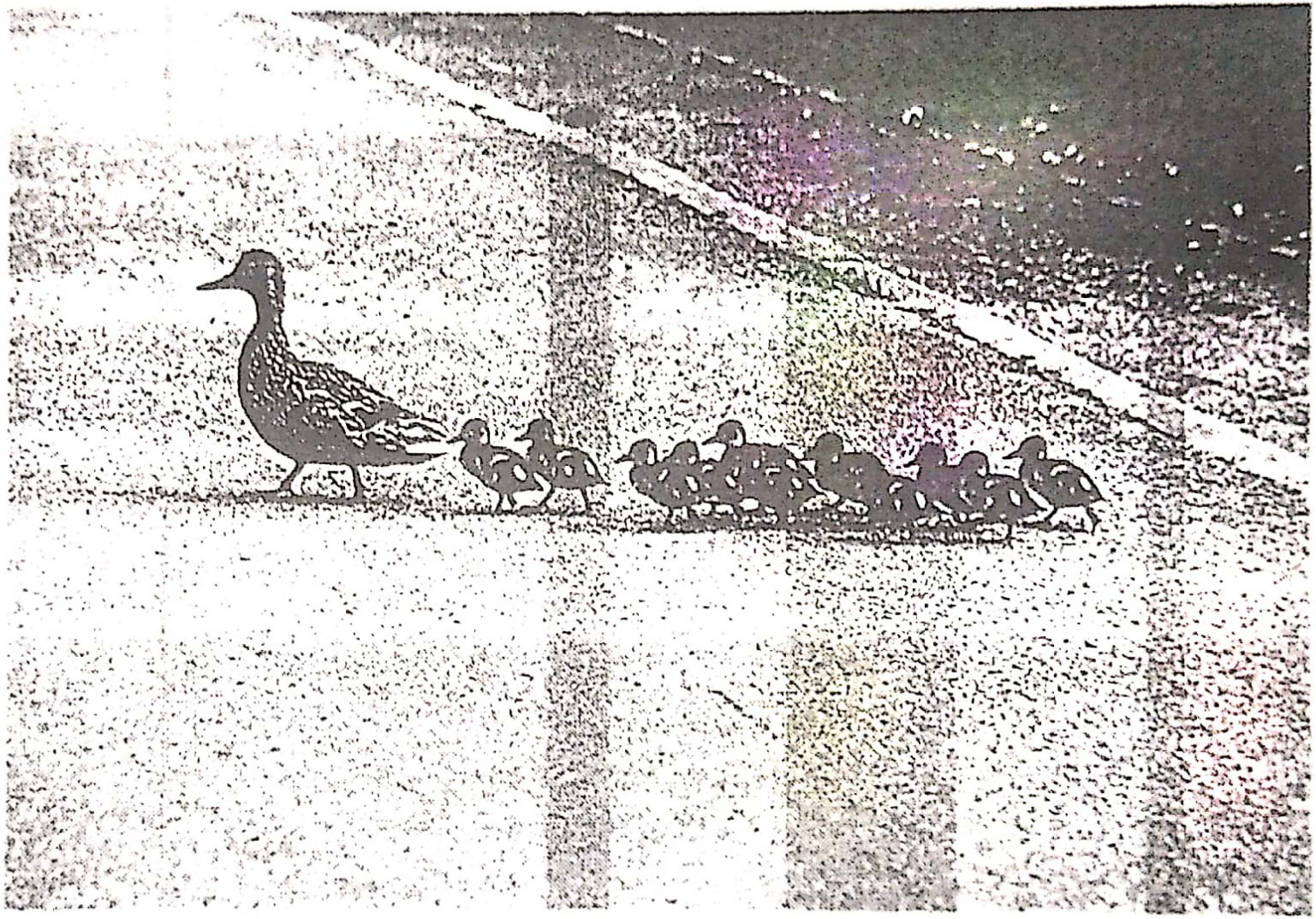

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Classical conditioning/Associative Learning

- Takes place when a secondary or conditional stimulus comes to elicit response because it has occurred along with a natural or unconditional stimulus often enough for an association to be established.
- Eg Pavelov's conditioning.

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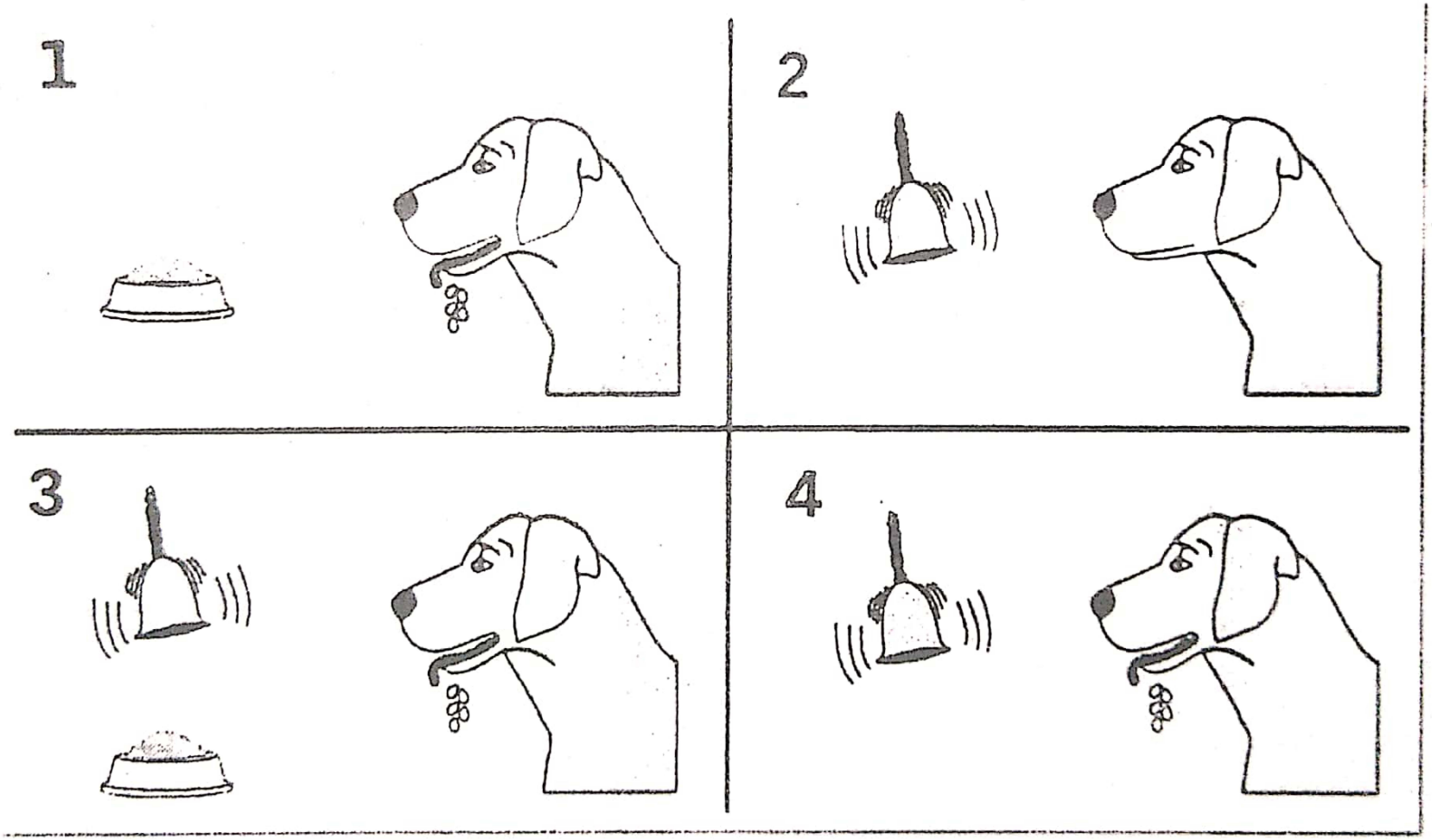
Pavlovian Conditioning



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Instrumental learning/ Trial and error learning

- Involves the determination of behavior by its consequences.
- Positively reinforced behavior (rewarded/ successful)is repeated.
- Negatively reinforced (punished)is abolished.
- A positively rewarded behavior which ceases to be reinforced will eventually not be performed.

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- Habituation is similar to instrumental learning.
- It is the abolishing of a response that is not reinforced at all.
- The situation becomes ignored as meaningless.

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Allelomimetic learning/aping

- The tendency of many vertebrates behaving as others of their kind.
- A rat which is caged close to another rat which knows how to press a button and receive food, soon learns this behavior and faster than one which is alone.

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Importance of behaviour

- Observations and experiments on animals in their natural habitats suggested that behaviour serves a variety of functions including the following:

  - avoiding predators

  - obtaining food

  - attracting mates

  - rearing young

MODERN STUDY OF BEHAVIOUR

- The most obvious difference between the research of the early ethologists and that of the modern students of animal behaviour includes the following:
- the enormous increase in the complexity of the exercise,
- techniques of data collection which has become much more sophisticated,
- multichannel event recording systems instead of use of pencil and paper only,
- analysis of large blocks of multivariate data in modern study of the subject,
- development of highly complex body of theory.

Procedures:

During the study of animals in the field care is taken to ensure that the presence of the researcher does not disturb the animals.

- The field worker often constructs a small viewing tent - a hide. It may be camouflaged with pieces of vegetation and has one or more slits through which the animals are observed.

Most animals become accustomed to the presence of such a structure and after a while continue their normal behaviour.

It is usual for the observer to be accompanied to the hide by another person who then departs.

In most cases as the animals see someone arriving and leaving the hide, they quickly settle down after the initial disturbance.

- Modern cine cameras and tape recorders are an invaluable aid to field workers.
- On the film there is a complete and permanent record of the behaviour which was observed.
- Slowing down the film allows analysis of the components of behaviour patterns which normally occur too quickly for the eye to follow and may involve social interactions.
- Recording call of birds provides a permanent record which is available for further analysis.

- Sound spectrographs, which give a precise physical description of a sound, have been useful for comparing the vocalizations of closely related species.
- It has been possible to distinguish between calls made by starlings resident in Washington and those in New York.
- Washington starlings were not frightened by the alarm calls of their New York types which were broadcast in an attempt to scare them off the city buildings. This shows that only the birds can tell the difference of the various calls.

Sensory processes and perception

- It is important for animals to respond to changes in the external environment and the ability to do that depends on sensory processes designed to detect such changes.

the ability to detect changes in the environment depends on the sensory process designed to detect such changes

- The changes range from simple discrimination of differences in temperature or light intensity, to the recognition of complex patterns.
- Sensory processes can be divided into different modalities, each having characteristic sense organs. However, the sensation perceived depends upon the part of the nervous system that is activated and not the type of sense organ stimulated.

Categories of sensory reception:

- 1. **Chemoreception and thermoreception**

The capability of identifying chemical substances and their concentrations.

Virtually all nerve cells are chemoreceptors because they react to substances released by other nerve cells.

Chemoreceptors may be exteroceptors detecting the presence of chemicals in the external environment or interoceptors detecting substances circulating in the body fluids such as hormones and carbon dioxide. Both taste and smell depend on chemoreceptors.

- Pheromone is a chemical or mixture of chemicals that is released into the environment by an organism that causes specific behavioural or physiological reaction in a receiving organism of the same species.
- These are involved probably in one of the most primitive form of communication.

- The first chemically defined sex pheromone was that of the silkworm (***Bombyx mori***) moth which is secreted by an abdominal gland of the female, and by this means females can attract males over a distance of several kilometers.
- The behavioural response of male silkworm moth is to fly upwind upon detecting the pheromone **(bombykol)** and when he finds the female he couples with her.

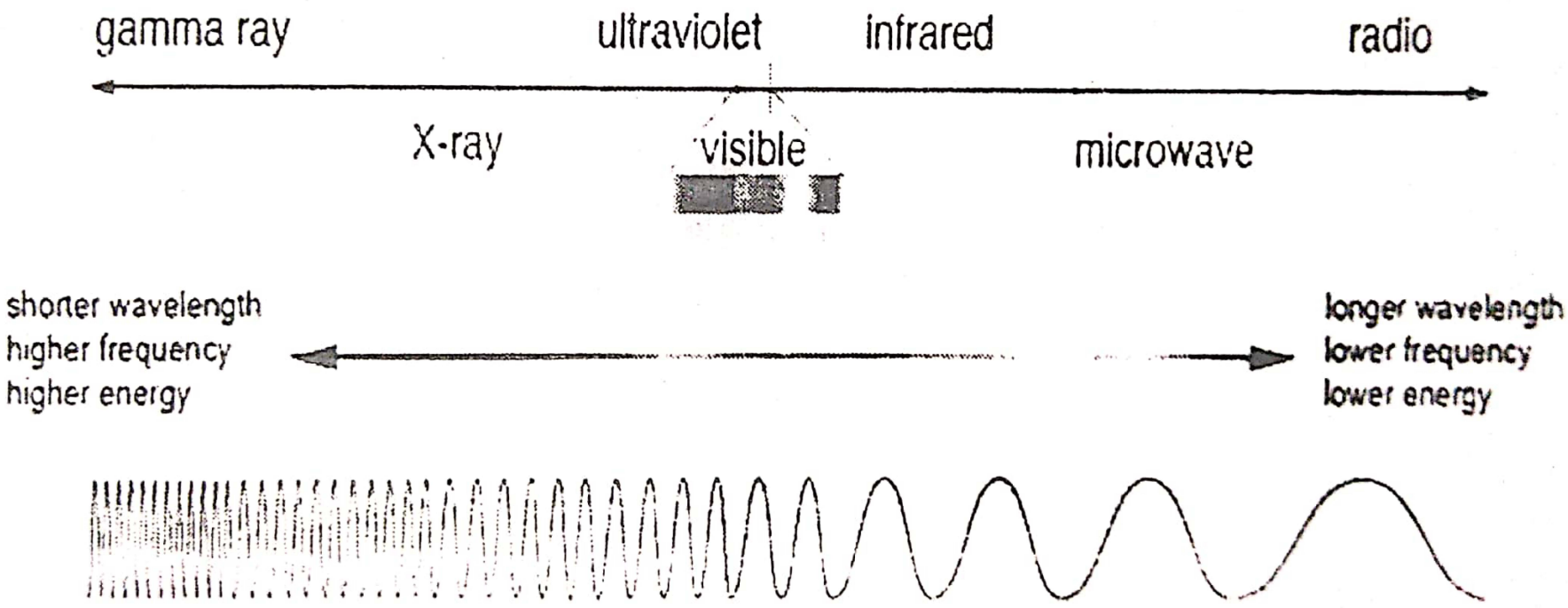
- Thermoreception occurs in most animals but not studied to any appreciable extent. In mammals distinct heat and cold receptors are distributed in the skin, heat receptors usually are deeper than cold.
- Cockroaches have thermoreceptors on the legs which perceive ground temperatures and some on antennae. Fish – skin, lateral line, and brain.
- Birds – few on skin

2. **Mechanoreceptors and hearing**

- Sound results from minute changes in pressure that originates from a vibrating source within a medium such as water and air.
- The receptors that detect sound are basically mechanoreceptors that show rapid adaptation and that are thus sensitive to vibration.
- Hearing is a form of mechanoreception designed to pick up vibrations. It may be based on a simple mechanism involving few neurons, eg. The special-purpose ears of moths, or it may involve a complex mechanism, as in the sophisticated hearing of humans.

3. **Vision**

- Vision ranges from simple discrimination of light and dark to the formation and resolution of images.
- It is based on the detection of electromagnetic radiation.
- The visual spectrum is a very small proportion of the electromagnetic spectrum which covers a very wide span.
- Photoreceptor cells may be scattered over the body surface as in the earthworm (*Lumbricus*) but they are usually gathered together in clusters.
- Vision is widespread in the animal kingdom but species vary enormously in the type of eye and visual capability. The eyes of vertebrates. eg. human eye, conform to a single basic plan.


gamma ray
ultraviolet
infrared
radio
X-ray
visible
microwave
shorter wavelength
higher frequency
higher energy
longer wavelength
lower frequency
lower energy

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- S**ensory capacities** of animals have been measured in several experiments. For example the conditioned discrimination method by Pavlov.
- After training to one particular stimulus such as colour, brightness, shape, texture, sound, smell, weight etc. the animal is tested to see how far it can discriminate this stimulus from others.
- It is presented with another stimulus of the same type and reward only the responses to the former, and giving slight punishment for incorrect responses.

- The two stimuli are made increasingly similar until there comes a point beyond which the animal can no longer learn to discriminate between them.
- This marks the limit of its sensory capacity as measured by its behavior.
- This method was used by von Frisch (1967) in his studies of the colour vision of bees, for examining the touch sensitivity of the octopus and the chemical senses of fish.

MOTOR CODES

- At some high level in the brain, actions are coded not as a sequence of detailed commands to muscles, but as movements specified in a spatial and temporal coordinates so that at this level the form of the motor code is compatible with the way in which the external environment is represented within the brain.
- How a translation is made from what perhaps a special representation of a movement to detailed command to muscles remains an unanswered question.

Limitation of sensory equipment

- No organism is equipped with sense organs suitable for detecting all possible physical changes in the environment.
- Sensory capacities diverge so widely that the characteristics of an object to which an animal responds may be quite different from those by which humans recognize the object.

- Recording from single fibers indicate that many sensory cells are normally sensitive to more than one form of energy.
- For example, single units in the cat's lingual nerve can be activated by mechanical or thermal stimuli to the tongue and single units in the lobster statocysts are sensitive to both position and acceleration.
- At the other extreme, some receptor cells have a highly specific sensitivity.

- Even if physical techniques indicate that the sense organ itself is responsible to a certain dimension of stimulus, one cannot be certain that variation in that feature can influence behaviour.
- Even when we know the general nature of the stimuli to which an organism responds, we may not be able to specify the dimensions along which these stimuli should be assessed.

Effects of hormones on behaviour

- The endocrine (hormonal) system is a parallel system of feedback to the nervous system and controls behaviour in animals.
- Hormones are chemicals (usually peptides and steroids) which are produced by endocrine glands and released into blood.
- Each hormone has specific functions and often affects specific target organs.
- Secretions from endocrine glands are turned on and off at appropriate times.
- Hormones circulate in very small amounts but most hormone molecules have a lifespan of less than one hour in the blood.

- They have to be secreted continuously if their presence is to be effective.

Effects of hormones on behaviour

- **They can influence effectors, such as special structures involved in behaviour**.

Eg. mating behavoiur of the African clawed toad (*Xenopus laevis*), during the breeding season the male develops special nuptial pads on the forelimbs. It is made up of a thick mass of small spines set into the skin, which enables the male to grip the smooth and slippery pelvic area of the female during mating.

- The appearance of the pad depends on the hormone testosterone which is released from the testes at appropriate time. At the end of the breeding season testosterone production ceases and the pads disappear.

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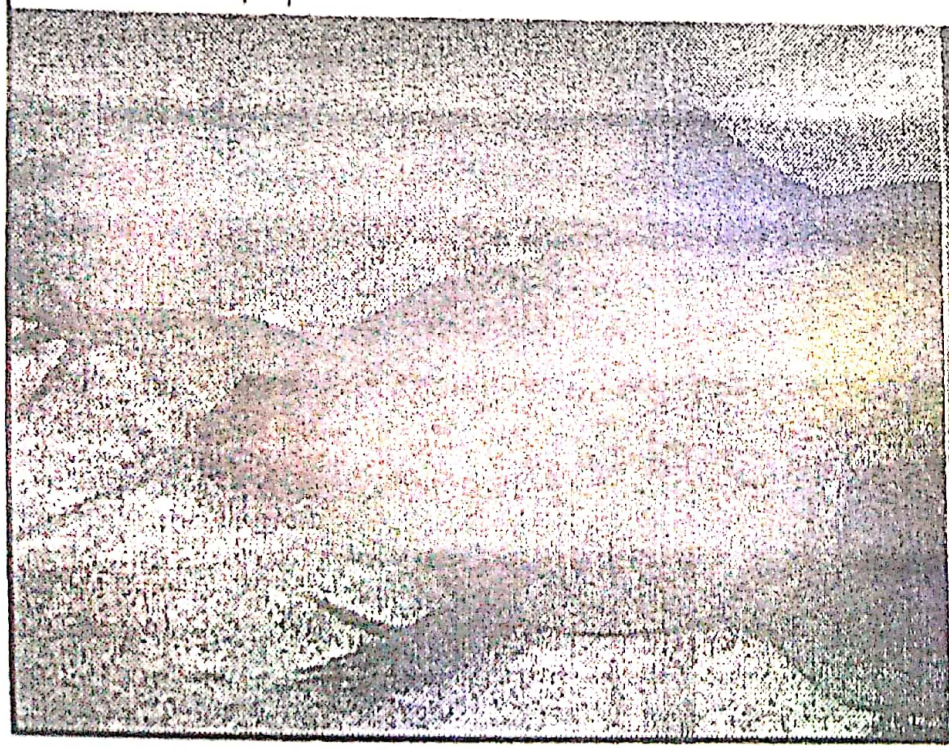

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- **They can influence peripheral sensory receptors and bring about a modification of the input to the brain.**
- The courtship of the male doves influences the female hormonal system to release gonadotrophin, which stimulates the ovaries.
- These produce oestrogen which stimulate the female to start building a nest. When the nest is built the female lays two eggs.
- The nest building process induces release of progesterone in both male and female and this hormone facilitate incubation behaviour.

- **They can influence/affect the brain directly.**
- This is the most important mode of hormonal influence on behaviour.
- Implantation of minute quantities of artificial oestrogen into certain regions of the brain of cats could induce sexual behaviour, even though the level of oestrogen in the blood was well below the level normally required for such behaviour.

- Most studies on the influence of hormones on behaviour has been concerned with reproductive behaviour. Evidence of hormonal influence on the reproductive activities of vertebrates is of three main types:
- The occurrence of reproductive activities is correlated with enlargement or secretary activity of the endocrine glands. In many seasonally breeding animals the gonads are enlarged and certain gonadal cells show secretary activity only during the period in which reproductive activity are most common.

- The frequency or intensity of sexual behaviour is reduced after gonadectomy. The rapidity of this decrease, however, varies considerably between species.
- Injection or implantation of certain hormone preparations increases the frequency of reproductive responsiveness.

- Generally, male sexual behaviour of higher vertebrates is induced by androgens, while female sexual behaviour is induced by oestrogen and progesterone alone or in combination.
- It is not always easy to define clear-cut differences between their actions since they are steroids of similar chemical constitution.

Courtship and mating

- Courtship is a complex behaviour pattern designed to stimulate organisms to sexual activity.
- It is associated with pair formation in those species where both parents are involved in the rearing of offspring or gregarious mixed-sex groups such as baboons.
- During mating, the behavioural activities are initiated by releasing stimuli and ended by terminating stimuli associated with the release of gametes by the male.

- **Releaser** is either a simple stimulus or a sequence of stimuli produced by a member of a species which evokes a behavioural response in another member of the same species.
- **Terminating stimuli** complete the behavioural response and may be external or internal.
- For example the external visual stimuli of a successfully completed nest will terminate nest building in birds.

- The motivational stimuli for courtship in most species are external, such as photoperiod, and leads to rising levels of reproductive hormones and the maturation of the gonads.
- In most animals this gives rise to changes in the secondary sexual characteristics and other behavioural activities including colouration changes, as in the development of red belly in male stickleback, increases in size of body parts as in plumage of birds, postural displays and the use of chemical sex attractants, as in butterflies and moths.
- Sight, sound and smell play important roles as signals used in courtship to attract members of opposite sex.

Mating systems

- This describes the social and sexual context in which mating occurs. The main types include the following:
- Monogamy: both male and female mate with just one partner. Found among foxes and some crustaceans.
- Polygamy: mating system in which an individual of one sex has exclusive for mating to several members of the opposite sex. This is **polygyny** if a male is shared between several females eg. Elephant, seals, zebra; and **polyandry** if a female is shared between several males.

Sub-divisions of Polygamy:

- - **Resource based polygamy**- a situation in which individuals monopolize resources necessary to members of opposite sex. Those which control most resources get many mates.
- -**Harem defense polygamy** – individuals of one sex directly control access to potential mates by aggressively deterring rivals. Eg. elephant seals.
- -**Dominance polygyny/polyandry** – mating priority determined by dominance status without reference to resources or coercion. The highest status animals attract many mates.

Reproductive cannibalism and sexual suicide

- Courtship and mating in some animals is accompanied by conflict behaviour on the part of one or both sexes. This could result in the death of a partner.
- For example the head of a male praying mantis is naturally chopped off by the female during such struggle. However, the male can still copulate. Headless, its leg carry what is left of it in a circular path until its body touches the female's, at which point the male climbs onto the female's back and copulates with the female.

- Another extreme type of behaviour is found in the **redback spider.** The male that is transferring sperm to a female performs a somersault that throws his body into the jaws of the female (partner).The female devours the male.

- NB
- For the vast majority of animal species the context within which mating occurs is not known especially small inconspicuous animals which are difficult to observe.

Rhythms of Behaviour

- The behaviour of many animals undergo regular cycles which have periods ranging from hours to several years.
- For example voles (*Microtus arvalis*) show cycles of feeding with a period of two hours whilst some cicadas emerge from their eggs at regular intervals of about fifteen to seventeen years. The study of *Drosophila melanogaster* show that for their emergence from the pupae, even though the process occurs at different times of the day there is a clear peak in the early morning.

- Most of these cycles are corresponds to geophysical cycles such as the earth's rotation on its own axis. Others fit in with the moon's movements. An example is the shore crab, *Carcinus maenus,* which show tidal rhythms of activity, emerging regularly from hiding at high tide. That is, a period of about 12 hours.
- Lunar cycles of activity with a period of about 29 days are also common. For example the ant lion (*Myrmeleon obscurus*) shows a rhythm of pit building with peak activity at full moon.

- Rhythms have also been described which fit in with the earths annual cycle of movement around the sun. The golden mantled ground squirrel (*Citellus lateralis*) shows an annual activity rhythm, hibernating in winter and emerging each spring.

- One species of animal may be subject to several rhythms of different periodicity. For example shore crabs show both diurnal and tidal rhythms.
- In many cases these rhythms have been shown to persist under constant conditions. *Drosophilla melanogaster* still shows peak levels of eclosion at 24 hr intervals in constant darkness.
- Some rhythms however, disappear after a few cycles in constant conditions. The rhythm shown by Drosophilla may persist for hundreds of cycles but its period changes slightly from 24 hrs under normal light conditions to a period of 25 hrs 5min in constant light.
- For this reason the pattern is called a circadian rhythm having a period of about a day.

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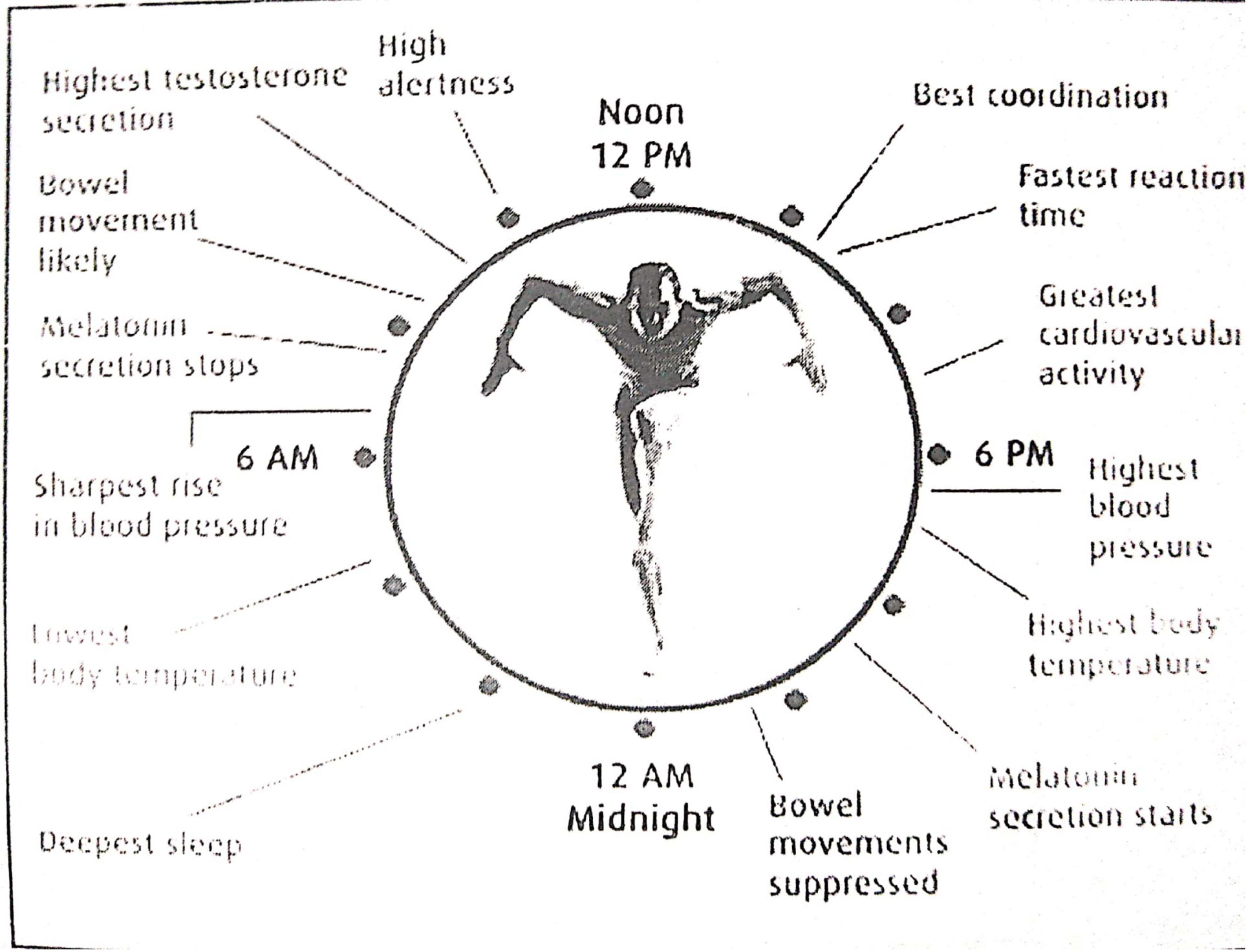
Highest testosterone secretion
High alertness
Noon
12 PM
Best coordination
Fastest reaction time
Bowel movement likely
Melatonin secretion stops
Greatest cardiovascular activity
6 AM
Sharpest rise in blood pressure
6 PM
Highest blood pressure
Lowest body temperature
Highest body temperature
12 AM
Midnight
Bowel movements suppressed
Melatonin secretion starts
Deepest sleep

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- Activity rhythms which are not dependent on the existence of regularly occurring environmental events must depend on some factor within the animal and are therefore called **endogenous rhythms.** The structure(s) which control these types of cycles are not yet know but are often referred to as **biological clocks.**

Adaptive significance of behavioural rhythmicity

- Results for most endogenous rhythms indicate that they represent inherited characteristics of the animals concerned.
- Also the potential for showing rhythmicity and the period of the cycles including the eclosion of *Drosophilla melanogaster* can be modified by genetic change.

- Populations of Drosophilla respond to artificial selection for early and late eclosion while mutants exist in these flies whose eclosion rhythm is lost or its period altered. These indicate that different patterns depends of rhythmicity may depend on genetic and are therefore potentially subject to natural selection.

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Reasons for showing rhythmic behaviour

- Animals must be active during the most suitable time.
- One factor shaping the temporal patterning of an animal's activity is the need to avoid desiccation. For example, *Drosophilla* which emerge from pupae in dry conditions often fail to survive, suggesting that the rhythm ensures that eclosion occurs at the correct humidity. *Drosophilla* species living in subtropical forest where humidity is high have more flexible activity rhythms than those found in open country.

- Rhythmic activity can also be an adaptation to biotic factors. The timing of the cycle is adjusted to the metabolic needs of the animal concerned, although food intake and digestion are not necessary for the rhythm to manifest itself.

- The process may also be an anti-predator device.
- Where two species which are closely related and with similar courtship behaviour, mate at different times of the day, there is a reduced chance of hybridization between them.
- Very different pattern of activity of two species which are closely related may also serve to reduce competition although it may also be related to a difference in vulnerability to predation.

Importance/function of self – sustaining, endogenous rhythms

- Rhythms of behaviour which are internally controlled rather than a direct response to environmental changes are expected when it is necessary to prepare in advance for some regularly occurring event such as the laying down of fat prior to hibernation.
- This is especially necessary if information about important environmental changes is not immediately available to the animal or if such information is not sufficiently precise and reliable to ensure that an animal does the right thing at the right time.

- Animals at some times require a clock which they can consult continuously in order to predict and interpret changes in the environment.
- Bees which visit different types of flower at different times of day need a clock to meet an open flower and this is provided by their self – sustaining, endogenous rhythms.

Ontogeny of behaviour

- The behavioural pattern of any animal is the result of complex interactions of external stimuli and internal conditions.
- The internal information processing systems are established during the course of development of the animal from the fertilized egg, to the embryo, to the adult animal. This process is known as **ontogeny**.

- The development of the individual from embryo to adult involves a continual interaction between the animal's genetic make-up and its environment.
- The interaction is one in which each phase of development sets the stage for the next.
- The process is known as epigenesis.

- The basic material which compose animals are alike or the same. The differences that are seen between different animals are the result of differences in the ways in which these basic materials are put together.
- Genes control development by producing proteins which regulate the complex organization of embryological process.

- The regulatory proteins are only effective in so far as the developing organism is sensitive to the messages they convey.
- The regulator becomes functional under certain range of environmental conditions. The information provided by genes for the development of behaviour cannot be separated from that provided by the environment.
- Even the levels to which these factors contribute may not be easily determined. However, in the study of ontogeny emphasis have been placed on studying the variety of ways in which patterns of behaviour develop.

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- There appear to be a spectrum of processes, ranging from those that appear to be relatively uninfluenced by environmental factors to those that are heavily dependent on experience.

- During the early stages of development the environmental component consists mainly of biochemical factors that surround the early embryo.
- At a latter stage of development the environmental component may consist of post – hatching environment.
- After hatching or birth an animal's environment includes information taken in by its sense organs as well as biochemical conditions based upon feeding level etc.
- Learning can then take place and influence the animals behavioural phenotype permanently.

- Comparing very young birds of **precocial** and **altricial** species one can determine which behaviours are learned and innate or non-learned behaviours.

- Precocial = species in which hatching occurs late in development
- Altricial = species in which hatching occurs early

- Eg domestic fowl - precocial and Vulture-altricial

  Rat /mouse/ rabbit(altricial) and goat/sheep(precocial)

- By the time the precocial bird hatches, the altricial juvenile has had the opportunity to learn a great deal while the precocial juvenile has not yet begun to learn.
- It has however been shown that certain behaviours that are learned by altricial birds are innate in some precocial species

APPLIED ETHOLOGY

- Ethology may be said to be different from other approaches to the study of animal behavour because in ethology emphasis is placed on detailed observation of the movements of unconstrained animals, preferably in their natural habitats.
- Ethological research has addressed questions about the causes, development, function and evolution of behaviour.

- It brings understanding of behaviour in non-human animals.
- This approach has provided part of the knowledge and theory which is now referred to as **behavioural ecology** or **sociobiology.**

- **Applied** implies that it is a piece of research which is used in an attempt to solve one of a number of kinds of problem.
- These could be of economic or medicinal importance. For example ethological research could be used in pest control and in enhancing the productivity of commercially important animals.
- There are aesthetic or moral problems to address such as those deserving rational conservation programmes and ensuring the wellbeing of the animals which humans exploit.

- The ethological research which results in the understanding of human behaviour is also considered as applied whether or not its results have any direct medicinal, sociological or economic benefit.

Application of ethology in solving practical problems.

Direct application of the results of ethological research.

- The actual fact which ethologists discover is put to work. For example the observations made on starlings (*Sternus vulgaris*).
- It was realized that when these birds made a particular call when disturbed by a predator, the flock moved to a new feeding area. Taking advantage of this, tape recordings of alarm calls have been played to flocks of starlings to prevent their feeding where they are not wanted.

Using the ideas and concepts of ethology.

- The ideas and principles resulting from ethological research can be used to suggest possible solutions to practical problems although there is no simple distinction between extrapolating facts and using ideas.
- For example, the idea that strong and lasting social bonds can form during a sensitive period with no conventional rewards (imprinting) has been used in an attempt to understand effects in humans of early disruption of parent –child relationship.

Using ethological techniques

- The techniques of observing and analyzing the movements of unconstrained animals have been applied to practical problems.
- Description of simple movements and sequential relationships between mothers and their babies have been used to pinpoint differences in behavioural development between normal and retarded children.

- NB: there are several applications of ethological research in areas such as pest control, productivity of commercially important animals, animal welfare, conservation and other knowledge and understanding of human behavoiur.

Pest control

- Use of pheromones to eliminate harmful insects.
- Release of sterile males to mate with females. Each female that mates with a sterile male is removed from the breeding population while still using up food and egg sites.

- **Increasing Productivity**-
- What commercially important animals eat has been intensively studied and applied to maximize yield.

Animal welfare-

- Ethological research seeks to identify and quantify the signs of suffering in animals that humans exploit, in determining the conditions which induce this state and in finding ways of reducing or removing it.

Conservation-

- A knowledge of ethological principles and information about the behaviour of animals and ways in which this influences and is influenced by environmental conditions is also of value.
- Breeding in zoos with subsequent release into suitable environments has a major role to play in the conservation of species which have been brought to the edge of extinction.
- Such programmes often fail through lack of detailed information about the behaviour of the species concerned, and especially about their social organization.