Communication

Communication is the successful transfer of a message from one organism to another.

The ability to detect and respond to stimuli is essential for survival. By detecting changes in the external environment, humans and other animals are able to respond appropriately.

Receptors & Stimuli

- A stimulus is anything that can provoke action. Receptors are **transducers** that detect stimuli. Our environments contain many stimuli and we have many specialised receptors to detect them: e.g.
  - **Photo**receptors (eye) - Detect light
  - **Mechano**receptors - Detect vibrations in the ear, also, pressure and touch (skin)
  - **Thermo**receptors - detect temperature e.g. in the skin
  - **Chem**oreceptors - detect chemical signals. E.g. odors (nose) and taste (tongue).

- To initiate a response the receptor must send information to the bodies control centre (brain) where an response is organised and carried out.

<table>
<thead>
<tr>
<th>Sense Involved</th>
<th>Human Communication</th>
<th>Animal Communication</th>
<th>Sensing the Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sight</strong></td>
<td>Hand-signals</td>
<td>Body colours/patterns and “display” behaviours for finding mates &amp; establishing territories are very common</td>
<td>Virtually all animals have some ability to see their surroundings. Some snakes “see” the infra-red warmth from their prey.</td>
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<tr>
<td></td>
<td>Facial expressions</td>
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<td></td>
<td>Body Language</td>
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<tr>
<td><strong>Hearing</strong></td>
<td>Spoken language</td>
<td>Mating calls (e.g., frogs)</td>
<td>Most animals have some ability to hear sounds. Many insects “hear” sound vibrations with their feet. Bats &amp; dolphins use SONAR for navigation in the dark/water.</td>
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<td></td>
<td></td>
<td>Territorial calls</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(e.g., kookaburra)</td>
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<tr>
<td><strong>Touch</strong></td>
<td>Many emotions are</td>
<td>Grooming each other is important among apes &amp; monkeys to establish relationships, and positions within the group.</td>
<td>Spiders feel the vibrations in their web when prey has been caught. Mice, cats, etc have whiskers to feel the width of burrows, etc.</td>
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<tr>
<td></td>
<td>shown with a hug a</td>
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<tr>
<td></td>
<td>pat on the back.</td>
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<td>by holding hands,</td>
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<td></td>
<td>etc.</td>
<td></td>
<td></td>
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<tr>
<td><strong>Smell</strong></td>
<td>Not very important.</td>
<td>Insects release pheromones to attract mates by odour. Many mammals “mark” their territory with smelly musk or urine.</td>
<td>Smell is vital for many animals to find their food. Flower perfumes attract some pollinating insects.</td>
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<tr>
<td></td>
<td>Use of perfumes to</td>
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<tr>
<td></td>
<td>enhance attractiveness.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Taste</strong></td>
<td>Not used</td>
<td>Bees allow others to taste gathered nectar, so they’ll know what to search for.</td>
<td>Snakes “taste” the air by collecting samples on their tongue (this is really their way of smelling) to detect prey or enemies.</td>
</tr>
<tr>
<td><strong>Electrical</strong></td>
<td>Not detectable</td>
<td>Platyypus can detect (with their bill) electrical field from animals’ nerves. They use this sense to hunt prey.</td>
<td></td>
</tr>
<tr>
<td><strong>Fields</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Magnetic</strong></td>
<td>Not detectable</td>
<td>Some migrating birds are guided by the Earth’s magnetic field which they can detect.</td>
<td></td>
</tr>
<tr>
<td><strong>Fields</strong></td>
<td></td>
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</tbody>
</table>
Practical Work: Dissection Observations

- **The Sclera is very tough** - great job of protecting eyeball.
- The Cornea, Aqueous humor, Lens and Vitreous Humor are all **perfectly transparent**.
- **Lens** - Can refract light very well - like a magnifying glass
- **The pupil is not a physical structure** - but an opening - the size of which is controlled by iris.

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### Anatomy of the Human Eye

**Part** | **Description** | **Function**
--- | --- | ---
conjunctiva | A delicate membrane that covers the surface of the eye and the inside of the eyelids. | Protects the front part of the eye. |
cornea | The front part of the eyeball. It is transparent and relatively thick. | Bends (refracts) light rays as they pass through it. |
sclera | Continuous with the cornea but not transparent, it forms the tough, white outer back part of the eyeball. | Protects the eye and helps maintain its shape. |
choroid | Lies on the inside of the sclera. It is a thin, black-pigmented layer containing blood vessels. | The pigment absorbs stray light, preventing false images. |
retina | The innermost layer of the eye. It lines the back of the eyeball and contains the light-sensitive cells or photoreceptors and nerve fibres. | Receives the light and changes it into electrical impulses that travel via the optic nerve to the brain. |
iris | The coloured part at the front of the eye, composed of muscles. | Regulates the opening size of the pupil. |

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>pupil</td>
<td>A circular opening in the centre of the iris. The size of the pupil is controlled by the action of the iris muscles.</td>
<td>Controls the amount of light entering the eye.</td>
</tr>
<tr>
<td>lens</td>
<td>A transparent, biconvex protein disc behind the pupil.</td>
<td>Focuses light rays onto the retina.</td>
</tr>
<tr>
<td>aqueous and vitreous humour</td>
<td>Aqueous humour is a viscous liquid that fills the front chamber of the eye. Vitreous humour is jelly-like and fills the larger back chamber of the eye.</td>
<td>Help keep the eyeball in shape and also bend (refract) the rays of light as they pass through.</td>
</tr>
<tr>
<td>ciliary body</td>
<td>Connects the choroid with the lens. It contains the suspensory ligaments and the ciliary muscles.</td>
<td>The ligaments hold the lens in position and the ciliary muscles alter the shape of the lens.</td>
</tr>
<tr>
<td>optic nerve</td>
<td>Connects the eye to the brain. The region where the optic nerve leaves each eye is known as the blind spot because it has no photoreceptors and thus cannot produce an image.</td>
<td>Carries nervous signals from the retina to the visual cortex of the brain, which interprets them as images.</td>
</tr>
</tbody>
</table>
The Electromagnetic Spectrum

The “wavelength” is the distance from one crest of a wave to the next. For all light waves this is a very small distance, so the unit commonly used is the nanometre (nm).

**Infra-red (above 700)**

**Ultra-Violet (UV) (below 400)**

The Rattle Snake

450 - 850nm

This is in the infra-red range.
- Equipped with special sensory pits between eyes and nostrils that detect infra-red radiation.
- Hot objects emit heat radiation (infra-red waves) e.g. warm body of a mouse
- Snakes use this to hunt.

The Honey Bee

300 - 700nm

This is in the ultraviolet range.
- Bee’s navigate using the sun
- Also markings on flowers which are in UV wavelengths.

Human eye

400 - 700nm

Refraction of Light

- The Refraction of light is the bending of light rays. This occurs when light rays pass from one medium into another medium that has a different density. E.g. Light traveling through air (less dense) into water (more dense). Also, The light must enter the alternate substrate at an angle other than 90° (the normal) for it to be diffracted.

The Cornea, Aqueous Humour, Lens and Vitreous Humour are structures in the eye composed of materials with different densities. Therefore they are all refractive media that help to focus the image on the retina. However, only the lens is able to change its shape:

A “Thicker” Lens has a shorter Focal Length

A “Thinner” Lens has a longer Focal Length
Accommodation

Modeling Accommodation:

- The lens of the eye is made of a flexible, and transparent protein material.
- The muscles of the Ciliary Body can pull the lens causing it to become thicker.
- The muscles of the Ciliary body can relax and allow the lens to become thinner.

Changing the shape of the lens is called Accommodation. Accommodation is very important in order to obtain clear images. If the rays of light where to converge in front or behind of the retina, the image would appear blurry. This happens to people who have vision problems like long/short-sightedness. Also wouldn’t be able to focus on both near and far objects!

![Diagram of Accommodation](image)

The “fatter” the lens, the more refractive power it has to bend the light rays. (i.e. shorter focal length)

Depth Perception

- Human have eyes that face forward. Both eyes focus on the same object, but from slightly different angles. - This is called “Stereoscopic” or “Binocular” vision.
- This means the brain receives 2 images. The brain combines these two images in such a way that we are able to perceive 3-dimensional images.
- Beyond 50 or so metres, binocular vision does not improve depth perception significantly because the difference between the two images is too small to be significant.
Myopia - Short-Sightedness
Close objects can be seen
- distant objects cannot

Hyperopia - Long-Sightedness
Distant object can be seen
- close objects cannot.

- These problems generally caused by:
  - Lens is unable to change shape enough to alternate between either close / far away objects and becomes ‘stuck’ in one position. (usually caused by old age)
  - OR, The eyeball itself is too long or too short, so that the focus position of an image is either in front or behind the retina, instead of right on it.

Cataract Blindness & Treatment
 “Cataracts” are a condition where the lens of the eye loses its opacity and becomes “cloudy”. Usually associated with the elderly, this condition can also develop in tropical Asia or Africa where nutrition may be poor and UV strong.

Using local anesthetic, a surgeon can remove the cloudy lens material via a small incision through the cornea and replace with a flexible plastic one.

Due to the Professor Fred Hollows Foundation, many suffers in Africa and Asia have had sight restored. These people are able to lead full, productive lives again. Rather than facing poverty and starvation, they can continue to farm or fish, or work and aren’t a burden on their families.
- The Fred Hollows foundation also trains local medical staff, helping to continue treatment.
Photoreceptor Cells

Rods and cones are photoreceptor cells. They are modified nerve cells that contain light sensitive pigments which convert light into **electrochemical signals** which the brain can interpret.

**Rods**

- Very sensitive to light - allow for images in semi-darkness “Night-Vision”
- Rod’s cannot detect colour
- The images that are processed lacks fine detail but *shows* shapes and detects movement very well. This is why you often notice things “out of the corner of your eye”

**Cones**

- Three types: sensitive to either red, green or blue.
- (different to Rhodopsin in Rods - they contain Photopsin that is sensitive to different wavelengths of light - corresponding to r, g, or b)
- Do not work well in low light conditions.

Distribution of Rods & Cones

- There are about 125 Million rod cells, but only about 6 million cone cells.
- **All** of the cone cells are densely packed in the Fovea region of the retina. In good light, whatever you stare at directly will be focused on the Fovea in full detail & colour.
- The rest of the retina is less densely packed, and is entirely rod cells.
- The blind spot is where the optic nerve leaves the eyeball. there are no photoreceptors here.

Rhodopsin

The actual chemical which absorbs the light in a rod cell is a complex molecule called “Rhodopsin”. When light is absorbed by the molecule it undergoes a chemical change, splitting into two components. This change, results in a nerve message being produced. The two components are then reassembled by enzymes and the process repeats.

Colour Blindness

Complete inability to distinguish colours is rare (no cone cells). More common is the inability to distinguish between certain shades of red & green - “Red-Green Colour Blindness”. This disorder is sex-linked, and results from one or more of the cone types being absent or not working. e.g. no green, or no red. This is called Dichromatism. Very rarely does a person only have a single type of cone, which is single colour vision. This is called monochromatism.
Colour For Communication

**Sticklebacks**
A small freshwater fish, which usually has a silverly colouring. In the breeding season - develop bright red colouring - to attract females and to warn other males to stay away.

**Monarch Butterfly**
In some cases, bright colours of orange / yellow or red indicate to predators that an insect is poisonous or bad tasting. The monarch butterfly has a very nasty taste!

**Photoreceptor Cells in Different Organisms**

- **Insects - The Common Fly**
Insects have a “**Compound Eye**” - each eye is made of thousands of visual units called **ommatidia**. Each ommatidia is in effect, a self contained eye, with its own cornea, lens and receptor cells.

  The image formed by each covers very small area but each is aimed in a slightly different direction. The insect’s brain forming a mosaic image - which gives it a large field of vision.

  The overall image is more blurred and has less visual acuity than the human eye, yet it is much better at detecting and responding to movement.

- **The Flatworm**
Their “Eyes” nothing more than cup-shaped depressions that are lines with photoreceptors. No lens, no cornea, and no image is formed! Each eye, merely informs the brain of light or darkness. -- The brain responding by guiding the animal to the safety of darker soil and leaves.

**Sound**

Sound = a very versatile means of communication - as can convey very complex messages because it has many features that can be varied; Esp. The Pitch (frequency), loudness, speed, and length of each sound. also, not affected by whether it is night or day, and is much easier to produced by an organism than light.
The Nature of Sound

- Unlike light, sound cannot travel through a vacuum. They must have a medium to carry the vibrations.
- Sound is produced by vibrating objects, e.g. feel the speaker of a radio, or look at a guitar string vibrate. Whatever the rate of vibration of the object - the sound wave will vibrate at the same rate. The rate of vibration is called the Wave Frequency and is measured in Hz (hertz) -- the amount of waves that pass a given point per second. This determines the pitch.

\[\text{Wave Frequency} = \frac{1}{\text{Wavelength}}\]

- The greater the amplitude (measurement from bottom to top of wave) the greater the loudness.

Note: Low frequency sounds travel further than high frequency sounds.

How Humans Make Sound

- In humans sound is produced in the Larynx, or “voicebox”. This is at the top of the trachea (wind pipe).
- At base of Larynx are vocal chords; 2 flaps of tissue which can vibrate the air-flow as you exhale.

<table>
<thead>
<tr>
<th>Pulled tight</th>
<th>High pitch sound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relaxed slightly</td>
<td>Low pitched sound</td>
</tr>
<tr>
<td>Totally relaxed</td>
<td>No sound</td>
</tr>
</tbody>
</table>

- The open space above V Chords - acts as a resonance chamber - amplifying the sounds.

Final sound modified by position of lips, teeth & tongue, and by the shape of mouth (which is changed by the soft palate - roof of the mouth), as-well as by the nasal cavity.
How Other Animals **Make Sound**

No other animals have such a complex language of sounds as humans - but still use to communicate.

**Fish**
- **Swim Bladder;** a gas filled sac that regulates buoyancy; many fish can vibrate the muscles of the bladder (and gas in it resonates) - to produce sounds.
- or **Clicking Sounds** with gills or fins.

**Insects**
- **Crickets and grasshoppers** make sounds by rubbing legs / wings together to cause body structures to vibrate.

How Other Animals **Detect Sound**

**Fish**
- Do not have external ears. Instead have **internal ears** located near the brain. The internal ear is comprised of many canals, that contain special bones that oscillate when detecting sound. As they move, many thousands of hair cells (similar to those in our own ears) detect and interpret the movement.
- **Lateral Line System**; along the sides of their body - lateral line which allows fish to ‘hear’ small pressure changes in the water, such as a predator approaching or to follow the movement of other. This system also contains small hair cells, and is similar to our ear. *Water flowing through the system bends hair cells, producing nervous impulses that are sent to the brain.*

**Insects**
- Male Mosquito’s **have hair on their antenna** that detect a particular frequency of sound. The frequency is *that of the wing beats of a female mosquito.* - helps with mating.
- Some insects have tiny organs called **tympanic organs.** They are special structures consisting of a membrane stretched over an air chamber (rather like a mini eardrum!). Sound vibrates the membrane and is detected.

**Detection & Range of Frequency**

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Description</th>
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<tbody>
<tr>
<td>20Hz - 20,000Hz</td>
<td><strong>Human</strong> most sensitive to freq. 2,000 - 4,000 (These are the freq. of speech)</td>
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</tbody>
</table>

**Dolphins and Bats** are able to detect very **high frequencies** (e.g. 150,000Hz) They produce a sound and then bounce it off objects around them - using it as navigation or to detect prey. This is called ‘echolocation’.

**Humpback Whales** communicate over very long distances by listening and singing in **very low frequencies.** Low frequency sounds - travel very long distances, and in a vast ocean this is a useful feature to have.
The Human Ear

When the eardrum vibrates, the ossicles vibrate in turn. Hammer: Malleus Anvil: Incus stirrups: Stapes.

Eustachian Tube
- The Eustachian tube connects the middle ear with the throat. Usually this opening is kept closed, but it opens when we swallow or yawn. It keeps the pressure on either side of the tympanic membrane equal.

The Organ of Corti
- The hair cells located in different regions of the Organ of Corti detect different frequencies. Those nearest the oval window vibrate in response to high frequencies (short hairs). These waves die out fairly soon, but low frequency waves can continue to travel. Long hairs toward the end of the membrane respond to low frequencies.
Pathway & Energy Transformations of Sound Waves in the Ear

- Sound energy is a form of kinetic energy. Sound is a decompression and compression of air particles.

### The Sound Shadow

- Unless sound comes from directly in front / behind our heads casts a ‘sound shadow’ which partially blocks sound energy from reaching the ear on one side.

- The small differences in sound that each ear collects due to the sound shadow - can be processed by the brain to discover the direction of the sound.

### Hearing Aids

- Hearing aids are used when the hair receptors in the Cochlea lose sensitivity. They still work but require a louder sound to reach the “threshold” at which they respond. This is usually due to aging but could be due to noise strain, illness, injury, infection, or head trauma.

- Consist of a microphone and amplifier system. Sound > Electrical Energy > Amplified Sound. Battery powered - channels sound directly into ear canal.

- Modern hearing aids are specifically sensitive to the frequencies of speech.

- Limitations:
  - Does not restore normal hearing
  - If the hair cells of the Cochlea are not responsive at all, and deafness is total -- no amount of amplification will help.

### Cochlear Implants

- If the hair cells of the Cochlear are completely dead; hearing aid cannot help. A Cochlear Implant involves, an electronic device which bypasses the damaged parts of inner ear & electronically stimulates the auditory nerve itself.

- Sounds are picked up by a microphone, and processed using an external unit.

- This technology provides the patient with a basic auditory sense of the environment. It is not like normal hearing - the patient must learn to interpret the new sensations being heard. (extremely difficult)


Limitations:
- Very expensive
- Rehabilitation depends heavily upon when the person became deaf.
- May require years of training and therapy.
Nerve Fibers

- A single nerve cell is called a Neuron.
- Three types: Sensory Neuron, Interneurons and Motor Neurons.
- “Neuronal Fibers” are a series of neurons joined end-to-end, forming a single pathway for signals to be carried.
- A nerve is a bundle of many neuronal fibers.

How Messages are Transmitted

- Nerve signals are carried by a “wave of depolarisation”.

Polarised State
- An electrical difference is maintained. Outside the nerve cell is positive, and inside the nerve cells is negative.

Depolarised State
- Nerve cells can be described as Excitable Cells. They generate changes in their membrane in response to a stimulus. When the neuron fires, a region of the membrane becomes permeable to the sodium ions. They flood inwards, depolarising that part of the cell. If the stimulus is great enough (above the threshold), additional Sodium Channels will open resulting in a chain reaction, that travels all the way down the membrane. This is the action potential, or nerve impulse.

Must know this graph

**Action Potential**

noun Physiology

the change in electrical potential associated with the passage of an impulse along the membrane of a muscle cell or nerve cell.

The “Threshold Potential”

A neuron will not “fire” unless it receives a minimum stimulus. This prevents insignificant events or accidental stimuli from affecting the system.
The Brain

The Cerebrum (all of the coloured below) is separated into right & left halves. The left controls the right side of the body, and the right side controls the left.

**Frontal Lobe**
*(Cognition)* Reasoning, Planning, Speech, Movement, Emotions, Problem Solving

**Parietal Lobe**
Movement, Orientation, Recognition, Perception of Stimuli

**Occipital Lobe**
*(Includes Visual Cortex)* Visual Perception

**Temporal Lobe**
*(Includes Auditory Cortex)* Perception and Recognition of Auditory Stimuli, Memory, and Speech

**Cerebellum**
The “hind-brain” - associated mainly with co-ordination.

**Spinal Chord**

**Medulla Oblongata**
Responsible for the co-ordination of many unconscious functions - e.g. breathing, heart beat.

**Pons**
Connect the Right and Left sides of the brain, and allows for communication between the two.

The Importance of Correct Interpretation

Receiving information from the receptors is just the first step. For the information to be of any value, the brain must interpret it correctly.

**E.g. Eagle and Rabbit**
- The rabbit receives a loud sound of the eagles wings, as well as the image of it approaching very quickly.
- The rabbit must respond very quickly in order to survive.
- The rabbit may have learnt from past experience, how to deal with the eagle.
- However, it may also be an inherited survival instinct in the rabbit.
- Whichever it may be, the brain is able to use this to make sense of the information it is receiving.

**E.g. Parkinson’s Disease**
- The *importance* of the brain in the coordination of animal behavior is highlighted when parts of it are damaged. The shaking movements of people with Parkinson’s disease, is a sign of damage to the brain. In people with this conditions, muscular contractions are no longer coordinated by the brain.