**Chapter 1: Humans, and other animals, are able to detect a range of stimuli from the external environment, some of which are useful for communication.**

1. **Identify the role of receptors in detecting stimuli.**
   - **Stimulus:** any piece of information that is detected by a living organism to make it aware of a change in the environment. E.g. light, sound, smell etc.
   - **Receptor:** a specialised cell that can detect a stimulus, resulting in either a nerve signal being generated or a hormone being produced (i.e. a message is sent to the nervous system).
     - Includes rods and cones in the eyes that detect light.
   - The role of receptors is to detect changes in the environment and send information about the conditions to the control centres.

2. **Explain that the response to a stimulus involves; stimulus, receptor, messenger, effector and response.**
   - In order that a stimulus may produce a response, a receptor must detect the stimulus. A message must then be passed to a messenger, which may be a nerve or a hormone. The messenger then passes information to an effector, which may be a gland or a muscle, which responds to the information.

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stimulus</strong></td>
<td>A change in the internal or external environment, which and organism can detect and bring about a response/</td>
<td>Heat from hotplate</td>
</tr>
<tr>
<td><strong>Receptor</strong></td>
<td>A specialized cell that can detect changes in the environment (specific type of stimuli).</td>
<td>Sensory receptor in skin</td>
</tr>
<tr>
<td><strong>Messenger/CNS</strong></td>
<td>A nerve impulse (electric nature) takes the message to the brain which interprets the message and sends message to the effector.</td>
<td>Sensory neuron sends electrochemical message to CNS to brain and at the same time a reflex arc may connect to a motor neuron</td>
</tr>
<tr>
<td><strong>Effector</strong></td>
<td>The organ of the body (muscle or gland) that receives a message from a neuron and carries out a response.</td>
<td>Muscle in arm</td>
</tr>
<tr>
<td><strong>Response</strong></td>
<td>A reaction to the stimulus</td>
<td>Hand moves away from hotplate</td>
</tr>
</tbody>
</table>
3. Identify data sources, gather and process information from secondary sources to identify the range of senses involved in communication.

<table>
<thead>
<tr>
<th>Senses</th>
<th>Definition</th>
<th>Human examples</th>
<th>Other animal examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sight</td>
<td>Very common and useful for communication. Visual signals can be given between animals and sometimes sight provides the majority of information about the environment. Animals that have sight have photoreceptors to detect light stimuli.</td>
<td>Facial expression signals include emotions including aggression.</td>
<td>Bioluminescence in fireflies to attract mates, female chimpanzees have a coloured rump to show when they are ready for mating, Blue-ringed octopus signal an intention to attack by glowing blue rings on their bodies.</td>
</tr>
<tr>
<td>smell</td>
<td>Chemoreceptors in the nasal passages detect different chemicals that we interpret as different odours.</td>
<td>Not so important in humans, human females may change their menstrual cycle because of olfactory information</td>
<td>Animals release pheromones to make their presence known; male mice will mate immediately after they smell a receptive female.</td>
</tr>
<tr>
<td>Hearing</td>
<td>Some animals use sound to communicate, but many species cannot detect a wide range of sound frequencies</td>
<td>Language used extensively to convey information, used as a warning signal.</td>
<td>Crickets use sound as a warning and to attract mates, some moths can hear the ultrasonic calls of bats and can avoid being eaten, frogs use sound for mating calls, dolphins use echolocation.</td>
</tr>
<tr>
<td>Touch</td>
<td>Many species rely on tactile information to communicate and find out about their environment. Mechanoreceptors detect mechanical energy, e.g. touch, pressure, gravity or bending and stretching caused by movement.</td>
<td>Used in group bonding and in mating. Also used aggressively.</td>
<td>Seagull chicks get their mothers to release food by pecking on their beaks. Bees dance to communicate the location of food.</td>
</tr>
<tr>
<td>Taste</td>
<td>Chemoreceptors detect different chemicals. In the tongue they detect sweet, sour, salty and bitter tastes.</td>
<td></td>
<td>Some butterflies such as the Monarch butterfly have a bitter taste to communicate that they are poisonous</td>
</tr>
</tbody>
</table>
Chapter 2: Visual communication involves the eye registering changes in the immediate environment.

1. Describe the anatomy and function of the human eye, including the; conjunctiva, cornea, sclera, choroid, retina, iris, lens, aqueous and vitreous humour, ciliary body, optic nerve.

<table>
<thead>
<tr>
<th>Part of Eye</th>
<th>Anatomy</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conjunctiva</td>
<td>Mucous membrane that covers the eye</td>
<td>Protects the eye, keeps eye moist with mucus</td>
</tr>
<tr>
<td>Cornea</td>
<td>Transparent, dome-shaped window covering the front part of the eye</td>
<td>Refracts (bends) light passing through the retina, protects eye</td>
</tr>
<tr>
<td>Sclera</td>
<td>Tough outer coating of the eye (white part of the eye)</td>
<td>Protects the eye</td>
</tr>
<tr>
<td>Choroid</td>
<td>Dark pigment layer, inside sclera containing many blood vessels</td>
<td>Absorbs and prevents light scattering to prevent false images forming on the retina</td>
</tr>
<tr>
<td>Retina</td>
<td>Inner layer of eye, contains photoreceptors (rod &amp; cones)</td>
<td>Changes light into nerve pulses</td>
</tr>
<tr>
<td>Iris</td>
<td>Coloured part of eye, pigment tissue that contains muscle to adjust opening of pupil</td>
<td>Controls the amount of light entering the eye, by adjusting the size</td>
</tr>
<tr>
<td>Lens</td>
<td>Transparent protein disk, behind pupil</td>
<td>Focuses light into retina</td>
</tr>
<tr>
<td>Aqueous and vitreous humour</td>
<td>Watery liquid found between cornea and lens</td>
<td>Refracts light, gives eyeball shape</td>
</tr>
<tr>
<td>Ciliary body</td>
<td>Front extension of choroid</td>
<td>Attaches to suspensory ligaments to hold lens in place.</td>
</tr>
<tr>
<td>Optic nerve</td>
<td>Neurons that go from back of the eye to brain</td>
<td>Transmits electrical impulses from the retina to the brain.</td>
</tr>
</tbody>
</table>

---

[Diagram of the human eye showing its parts]
2. Identify the limited range of wavelengths of the electromagnetic spectrum detected by humans and compare this range with those of other vertebrates and invertebrates.

- The electromagnetic spectrum consists of waves of varying wavelengths. These waves include visible light, infra-red radiation and UV radiation. Blue-green light (500 nm) is the most effective wavelengths for humans.
- Either side of this wavelength in the red or ultraviolet areas are less effective in humans but are used by other organisms.
- Visible light is the part of the electromagnetic spectrum visible to humans, including the wavelengths (400-700 nm).
- Snakes can see visible light with their eyes and can also see infrared with ‘pit organs’ which lie between their eyes and their nostrils. This enables them to ‘see’ warm blooded prey, even at night or when they’re hiding.
- Sharks have almost no colour vision and only see in black and white.
- Bees have three-colour vision, including UV radiation. This allows the bees to navigate using the position of the sun in the sky, since UV light can penetrate clouds. Thus, they can accurately ‘see’ the sun even on cloudy days, helping them find their way accurately from hive to flowers and back again.

3. Plan, choose equipment or resources and perform a first-hand investigation of a mammalian eye to gather first-hand data to relate structures to functions.

   **PRAC INVESTIGATION**

4. Use available evidence to suggest reasons for the differences in range of electromagnetic radiation detected by humans and other animals.

- Certain types of snakes, such as rattlesnakes, can detect infra-red radiation using a pit organ on their body. This means that they will hunt during the night or move into dark burrows and still be able to see and detect particular endotherms, for example the detection of mice, so this infra-red vision allows them to hunt and detect nearby food. They can detect prey by using both their eyes and the pit organ. Humans have very different means of hunting these types of food sources for example if we are looking for a food source in the dark we tend to take torches or some form of light emitting substance with us like a glow stick that allows us to see the visible spectrum that our eyes can detect, therefore allowing us to see as clear as daylight and expose the food we may be hunting for in the dark.
- Insects like the honey bee can detect UV radiation, and as many flowers have patterns of UV light rays as they are exposed to them throughout the day, as a source of food for the honey bees this can be detected easily through the use of their UV radiation, directing them to the nectar helping in the pollination progress as well. Human are not able to see these particular wavelengths, but for good reason, as we are not a prime pollinator in natural ecosystems, so it is good that honey bees have it for their purpose of pollination, a food source and survival.

<table>
<thead>
<tr>
<th>Type of animal</th>
<th>Name of animal</th>
<th>Electromagnetic spectrum used</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vertebrate</strong></td>
<td>Human</td>
<td>Visible</td>
<td>Active during the day uses colour for perception of objects</td>
</tr>
<tr>
<td></td>
<td>Rattlesnake</td>
<td>Infra-red and visible</td>
<td>Active at night hunts in dark burrows</td>
</tr>
<tr>
<td></td>
<td>Hummingbird</td>
<td>Visible</td>
<td>Can detect flowers from over a kilometre away</td>
</tr>
<tr>
<td><strong>Invertebrate</strong></td>
<td>Honeybee</td>
<td>Ultraviolet and visible</td>
<td>Can detect ultraviolet markings on flowers and uses polarised light for navigation</td>
</tr>
<tr>
<td></td>
<td>Mantis shrimp</td>
<td>Ultraviolet and visible</td>
<td>Can perceive many more colours and escape predation in the well-lit waters were it lives.</td>
</tr>
</tbody>
</table>
Chapter 3: The clarity of the signal transferred can affect interpretation of the intended visual communication.

1. Identify the conditions under which refraction of light occurs.
   - Refraction of light occurs when there is a change in speed as the light ray passes from one transparent medium to another, for example, from water to air, causing it to change direction, or ‘bend’. The bending of light is called refraction.
   - However, if light strikes the surface at 90 degrees, the ray will travel straight through without changing direction.

   ![Refraction of light](image)

2. Identify the cornea, aqueous humour, lens and vitreous humour as refractive media.
   - Any part of the eye that is transparent or clear will allow light to pass through, and can be considered to be a refractive medium.
   - The aqueous and vitreous humours, along with the cornea and the lens are all refractive mediums as each part has a different density, causing light to be refracted as it passes from one medium into the next. The end result is an image focused on the retina.
   - Light rays that are reflected from an object six metres or more away are almost parallel to each other. The lens refracts these rays so that they fall on the fovea, the part of the retina where vision is sharpest. If an object is closer than six metres the light rays reflected from it will be diverging rather than parallel. To bend these light rays so that they fall on the fovea the lens must become more rounded.
   - The cornea causes most of the refraction.
3. Identify accommodation as the focusing on objects at different distances, describe its achievement through the change in curvature of the lens and explain its importance.

- Accommodation is the ability to change focus to see objects at different distances from the eye.
- If the lens becomes more rounded (greater curvature) it refracts light to a greater extent and close objects can be focused.
- If the lens becomes less rounded (less curvature) it refracts light less and distant objects can be focused.
- The ciliary muscles are responsible for adjusting the shape of the lens. When they relax, the lens is less rounded. When they contract, the lens becomes more rounded.
- Accommodation enables the organism to see very close objects and then focus on distant objects - assists the organism in detecting predators, food sources etc.

4. Compare the change in the refractive power of the lens from rest to maximum accommodation.

<table>
<thead>
<tr>
<th>DISTANT OBJECT</th>
<th>CLOSE OBJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light reaches eye in parallel rays.</td>
<td>Light reaches eye as diverging rays.</td>
</tr>
<tr>
<td>Lens is quite flat/elongated and at resting state. Ciliary muscles relax.</td>
<td>Lens becomes convex, that is bulging out. This is due to the ciliary muscle contracting.</td>
</tr>
<tr>
<td>Low refractive power. This means that there is very little to low levels of refraction occurring.</td>
<td>High refractive power. This means that there is a high level of refraction occurring.</td>
</tr>
</tbody>
</table>

5. Distinguish between myopia and hyperopia and outline how technologies can be used to correct these conditions.

- Myopia is short-sightedness. A person with myopia sees objects that are close clearly but objects in the distance are out of focus. Rays from distant objects are focused in front of the retina rather than on the retina. The usual cause of myopia is that the eyeball is too long.
  - Technologies used to correct these conditions include eyeglasses or spectacles, contact lenses or surgery. Myopia can be corrected with concave lenses worn for distance viewing. These lenses cause parallel rays to diverge slightly before they enter the eye so that the lens can focus them on the retina.
- Hyperopia is long-sightedness. A person with hyperopia sees objects that are in the distance clearly but close objects are out of focus. Rays from distant objects are focused behind the retina rather than on the retina. The usual cause of hyperopia is that the eyeball is too short or that the lens gradually hardens with age, reducing its power of accommodation.
  - Hyperopia can be corrected with convex lenses worn for viewing close objects. These lenses cause parallel light rays to converge slightly before entering the eye so that the lens can then converge the rays to a point on the retina.
### Table: Myopia vs Hyperopia

<table>
<thead>
<tr>
<th>Feature</th>
<th>Myopia</th>
<th>Hyperopia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common name</strong></td>
<td>Short-sightedness</td>
<td>Long-sightedness</td>
</tr>
<tr>
<td><strong>Cause of condition</strong></td>
<td>Eyeball is too elongated or lens is too curved</td>
<td>Eyeball is too shallow or lens is too flat</td>
</tr>
<tr>
<td><strong>Where image focuses unaided</strong></td>
<td>In front of the retina</td>
<td>Behind the retina</td>
</tr>
<tr>
<td><strong>Which objects focus correctly</strong></td>
<td>Correctly focuses on near objects</td>
<td>Correctly focuses on distant objects</td>
</tr>
<tr>
<td><strong>Spectacles</strong></td>
<td>Concave lenses cause light rays to diverge and extend the focal point</td>
<td>Convex lenses cause light rays to converge and decrease the focal length</td>
</tr>
</tbody>
</table>

![Diagram of lens used in spectacles](image)

6. **Explain how the production of two different images of a view can result in depth perception.**
   - Stereoscopic vision is vision in three dimensions – you perceive distance, depth, height and width of vision.
   - Binocular vision occurs when both eyes are focused on the same visual field.
   - Each eye captures its own image of the view and sends the message to the brain.
   - Where the images from each eye overlap, the brain matches similarities, notes differences and the combined picture is a three dimensional, stereo picture of the view – giving depth perception (the ability to accurately judge the distance of an object)

7. **Plan, choose equipment or resources and perform a first-hand investigation to model the process of accommodation by passing rays of light through convex lenses of different focal lengths.**
   - **PRAC Investigation**
   - We used a light, a screen and a lens on a track to model accommodation.
   - Distance between lens and screen remains constant to model the distance between the lens and the retina in the eye. By using convex lenses of different thicknesses we were able to see how the different lenses focused things that were different distances away. In this experiment the lens represents the lens in our eye, the distance from the lens to the screen represents the focal length and the screen represents our retina.
   - The image on the screen was a small round white dot. As it was a perfect circle it did not matter if it was inverted.
   - If we had an image in front of the light it would have produced a shadow, which could have been our object. If this occurred the shadow should have appeared upside down on the screen of paper. This relates to our eye as when we first look at an image it is shown upside down on our retina. Our brain turns the image the right way around.
   - A thin lens gives a clear focus on a far object. This is illustrated by the results as the lens was 28cm away from the screen, compared to the thick lens which was 13cm. This indicates that a thinner lens accommodates best when focusing on a distant object.
• A thick lens gives a clear focus on a near object. This is illustrated by the results as the lens was 13cm away from the screen, compared to the thin lens which was 28cm. This indicates that a thick lens accommodates best when focusing on a near object.

• Through this experiment links can be drawn between the results and how the human eye works. Through accommodation the human eye is able to see distant and near objects with precision. This is largely due to that fact that the lens is able to change shape or accommodate according to the distance of the object it is looking at. When we look at a distant object our ciliary muscles relax and lens becomes thinner, this was also illustrated by the experiment and our results. When we look at near objects the ciliary muscles contract causing the lens to bulge and become more convex, this was also illustrated by our results.

• This model differs from the eye in the following ways. The focal length in the human eye will be a lot shorter. The size of the lens is controlled by ciliary muscles in the eye. The human eye contains other refractive media such as the cornea, aqueous humor and vitreous humor which also affects the amount of refraction.

• This model is similar to what happens in the eye in the way the lens refracts the light to a central point. In this experiment the light was refracted to one point on the screen while in the human eye light is refracted to the retina.

• Models help to explain key concepts in science on a larger scale. Their disadvantage is that they cannot include all relevant data and concepts.

• CONCLUSION: In this experiment we were able to model the concept of accommodation. This was evident in the refraction taken out by the different sized lenses and their focal lengths on the screens.

8. Analyse information from secondary sources to describe changes in the shape of the eye’s lens when focusing on near and far objects.

• When focusing on near objects the lens gets shorter and thicker. When focusing on objects which are further away the lens becomes longer and flatter.

9. Process and analyse information from secondary sources to describe cataracts and the technology that can be used to prevent blindness from cataracts and discuss the implications of this technology for society.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
</table>
| Cause of cataracts | • Injury to eye  
• Severe inflammatory disease of the eye  
• Drug reaction or radiation  
• Sun exposure  
• Disease such as glaucoma or diabetes  
• Smoking or congenital  
Most develop late in life due to ageing. |
| Appearance of the lens | • Older people the lens becomes yellowish and loses its transparency.  
• It becomes cloudy |
| How cataracts affect the individual | • Visual clarity fades  
• Images appear as though you are looking through a waterfall (cataract).  
• Individual needs brighter reading lights. |
| When blindness occurs | • If the lens becomes completely opaque the individual will become blind, even though the photoreceptors are functional. |
| Cure | • Surgery removes the opaque damages lens and replaces it with a plastic intraocular lens. |
| Implication of the technology for society (consequence) | • Estimated that 1 in 5 the people in the world are blind due to cataracts  
• Majority of these people live in developing countries, their blindness has a great impact on their society.  
• Organisations such as World Cataract Foundation and Fred Hollows Foundation decrease blindness  
• The people can then fulfil other roles in society |

- Cataracts is a medical condition in which the lens of the eye becomes progressively opaque, resulting in blurred vision.
Chapter 4: The light signal reaching the retina is transformed into an electrical impulse.

1. Identify photoreceptor cells as those containing light sensitive pigments and explain that these cells convert light images into electrochemical signals that the brain can interpret.

   - Photoreceptor cells contain light-sensitive pigments in the retina such as rhodopsin and photopsin.
   - Photoreceptors convert light images into electrochemical signals that the brain can interpret.

   Steps in transforming a light image to an image in the brain:
   1. Light image strikes the retina and is absorbed by photosensitive pigments in rods and cones.
   2. An electrical impulse is generated due to a photochemical change in the rods and cones.
   3. Bipolar cells in the retina receive the impulse.
   4. Bipolar cells stimulate ganglion cells.
   5. Axons of ganglion cells form the optic nerve and transmit message to the brain.

2. Describe the differences in distribution, structure and function of the photoreceptor cells in the human eye.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Rods</th>
<th>Cones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution</td>
<td>Distributed across most of retina, absent from fovea and form a broad band around edge.</td>
<td>Distributed in groups, few around periphery, most concentrated in macula lutea and its central part, called the fovea.</td>
</tr>
<tr>
<td>Structure</td>
<td>Outer segment is a rod-shaped and contains light-sensitive pigments in stacks of folded membrane or discs. Each disc is a separate entity. Rods have a cell body containing the nucleus and a foot.</td>
<td>Outer segment is cone-shaped and contains light-sensitive pigments in stacks of folded membrane or discs. Discs are infolding of cell membrane. Cones have a cell body containing the nucleus and a foot.</td>
</tr>
<tr>
<td>Diagram</td>
<td><img src="image1.png" alt="Rod Diagram" /></td>
<td><img src="image2.png" alt="Cone Diagram" /></td>
</tr>
<tr>
<td>Function</td>
<td>Dim light vision that responds to low light intensities, e.g. night vision and detecting light and shadow contrasts.</td>
<td>Responsible for colour vision, vision in bright light and seeing detail. There are red cones, green cones, and blue cones and colour vision is a combination of these three colours.</td>
</tr>
<tr>
<td>Amount</td>
<td>125 rod cells in each eye</td>
<td>7 million cone cells in each eye</td>
</tr>
</tbody>
</table>
3. Outline the role of rhodopsin in rods.
   - Rhodopsin: The photosensitive pigment that absorbs light waves in the rods.
   - Rhodopsin is a broad-spectrum pigment found in vertebrates, arthropods and molluscs
     - It consists of opsin and retinal, which is a derivative of Vitamin A.
     - The rhodopsin in rods is sensitive to blue-green light with peak sensitivity around 500nm.
     - When rhodopsin absorbs light it changes shape and begins a series of chemical reactions.
     - These reactions produce a generator potential that starts a nervous impulse. Following this sequence, more rhodopsin can be resynthesised using ATP

4. Identify that there are three types of cones, each containing a separate pigment sensitive to either blue, red or green light.
   - There are three different types of cones in the human eye – each sensitive to a different colour – green, red or blue and its corresponding region of the visible light spectrum.
   - Long-wavelength cones detect red, middle-wavelength cones detect green and short-wavelength cones detect blue.
   - Each type of cones contains a different light sensitive pigment, e.g. red cones contain erythrolabe, green cones contain chlorolable, and blue cones contain cyanolable.
   - To see in colour, impulses from red, blue and green cones are sent to the brain. The brain interprets signals from the cones as colour perception so that all colours we see are combinations of these colours.
   - Rods allow you to see grey, black or white.

5. Explain that colour blindness in humans results from the lack of one or more of the colour-sensitive pigments in the cones.
   - Colour blindness means that the person is unable to see certain colours and is colour-vision deficient rather than ‘blind’.
   - There is a range of colour blindness conditions ranging from only a slight difficulty distinguishing different shades of the same colour to the rare inability to distinguish any colours.
   - Colour blindness can occur in several ways, e.g. one or more types of cones do not function correctly, or they may be absent.
   - Inability to function could be an inability to manufacture the required visual pigment or the pigment is defective.
   - Red-green colour blindness is a recessive gene on the X chromosome and thus more men are red-green colour blind than women. People with the condition perceive red and green as the same colour, because either red or green cones are missing or not functional.
   - To determine colour blindness there are several test that can be carried out, e.g. Ishihara’s test for colour blindness that has a series of dots in different colours.
   - Colour blindness and colour deficiency can limit a person’s ability to perform certain tasks, e.g. interpreting test strips that use a colour change to show a reaction has occurred.
6. Process and analyse information from secondary sources to compare and describe the nature and functioning of photoreceptor cells in mammals, insects and in one other animal.

<table>
<thead>
<tr>
<th>Example Type of photoreceptor</th>
<th>Mammal</th>
<th>Insect</th>
<th>Flatworm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>Single lens eye</td>
<td>Common eye – many ommatidia</td>
<td>Image if formed is unclear and not inverted – gives information about light intensity and direction</td>
</tr>
<tr>
<td>Bee</td>
<td>Mosaic image of visual field</td>
<td>Detects light</td>
<td>Eyecup</td>
</tr>
<tr>
<td>Planaria</td>
<td>Detects light</td>
<td>Has higher resolving power and greater visual acuity.</td>
<td>Has fewer photoreceptor cells than insect or mammal and has poor visual acuity.</td>
</tr>
<tr>
<td>Flatworm</td>
<td>Detects light</td>
<td>Has many ommatidia, can detect colour but fewer than rods and cones in mammals. More efficient at detecting movement compared with mammals.</td>
<td></td>
</tr>
</tbody>
</table>

7. Process and analyse information from secondary sources to describe and analyse the use of colour for communication in animals and relate this to the occurrence of colour vision in animals.

- Animals that use colours to communicate include fish, amphibians, reptiles and birds.
- Animals use colour communication for a variety of reasons including: To signal their availability to mate and other kinds of reproductive behaviour like courtship, To warn off predators, Protective coloration and camouflage
- Examples of colour communication:
  - Camouflage - hiding by blending into the environment. Some animals can change the colour of their skins to match wherever they are - e.g. chameleons and the octopus
  - Sexual dimorphism - different appearance between the sexes. Males and females can be distinguished by their colours or sizes - e.g. only male lion develops the mane, in birds often male is brightly coloured while female is plain
  - Warning colours - some animals change colours to give warning that they are about to attack - e.g. blue ringed octopus when threatened blue rings appear all over the surface of the skin
  - Breeding colours - many birds take on different colours during breeding season - e.g. male puffin during breeding season the bands on the beak are bright while outside the season the bands fade.
Chapter 5: Sound is also a very important communication medium for humans and other animals.

1. Explain why sound is a useful and versatile form of communication.
   - All animals live in environments that transmit sound, i.e. sound can travel through air, water and solids, and using sound is a useful way for animals to communicate.
   - They do not have to be within sight of each other to communicate by sound. Can be in dark environments.
   - Sound can be used for hunting and navigation (location detection) as well as communication.
   - Sound is easily produced by most organisms, and different sounds can provide different information.
   - The speed of sound in water (1400 m/s) is much faster than in air (340 m/s).

2. Explain that sound is produced by vibrating objects and that the frequency of the sound is the same as the frequency of the vibration of the source of the sound.
   - Sound is a form of energy produced by an object that vibrates, moving backwards and forwards. The vibrating object causes nearby air molecules to vibrate back and forth, and these molecules cause others to vibrate.
   - This results in a compression wave travelling through the air.
   - The frequency of the vibration of air molecules is the same as the frequency of the vibrating object.

3. Outline the structure of the human larynx and the associated structures that assist the production of sound.
   - Human Larynx:
     - The human larynx (voice box) is a hollow structure with the vocal chords stretched across the tube, and is used to produce sound.
     - The larynx consists of nine cartilages, membranes and ligaments. There is a mucous lining on the larynx.
     - As air passes over the vocal chords they vibrate and produce a particular sound. The diameter, length and tension in the vocal chords determine the pitch of the sound.
     - Together, the larynx, tongue and hard and soft palate make speech possible. When air passes over the vocal cords in the larynx, they produce sounds that can be altered by the tongue, together with the hard and soft palate, the teeth and the lips.
   - Associated Structures:
     - The subglottal system, which consists of the lungs and its associated muscles, controls the loudness of the sound. Louder sounds are made by using more energy to expel air from the lungs.
     - The supralaryngeal airway produces speech. The palate determines the direction of airflow to either the mouth or nasal cavity and the movement of the lips, tongue and jaw help form different sounds.
     - Phonation is the production of speech and intelligent sounds.
4. Plan and perform a first-hand investigation to gather data to identify the relationship between wavelength, frequency and pitch of a sound.

Materials

- Cathode ray oscilloscope (CRO)
- Audio oscillator/amplifier
- Selection of tuning forks of different pitch
- Microphone
- Sounding boxes to suit the forks

Method

1) Play a pure note repeatedly on a musical instrument into the microphone attached to the CRO and you should be able to produce a simple waveform. (control)
2) Make a labelled pencil drawing of this wave and identify the wavelength, frequency and pitch.
3) Play different notes on your instrument until you find one that changes just the wavelength of the control note.
4) Find a note that changes just the frequency of the control note.
5) Find a note that changes just the pitch of the control note.

5. Gather and process information from secondary sources to outline and compare some of the structures used by animals other than humans to produce sound.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Description of structure used to produce sound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bats</td>
<td>Ultrasonic signals from the bat’s larynx</td>
</tr>
<tr>
<td>Grasshoppers</td>
<td>Friction of the back legs or rubs the veins on the wings together (stridulating)</td>
</tr>
<tr>
<td>Frogs</td>
<td>Male frogs vocalise by squeezing their lungs while shutting their nostrils and mouth, air flows over their vocal cords and into their vocal sacs</td>
</tr>
<tr>
<td>Fish</td>
<td>Some fish vibrate their swim bladders to create sound</td>
</tr>
</tbody>
</table>
Chapter 6: Animals that produce vibrations also have organs to detect vibrations.

1. Outline and compare the detection of vibrations by insects, fish and mammals.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Fish, e.g. carp</th>
<th>Mammal, e.g. human</th>
<th>Insect, e.g. Cricket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of vibration detected</td>
<td>Pressure waves</td>
<td>Soundwaves</td>
<td>Soundwaves</td>
</tr>
<tr>
<td>Structure that detects vibration</td>
<td>Lateral Line</td>
<td>Ear</td>
<td>Tympanum</td>
</tr>
<tr>
<td>How it works</td>
<td>Mechanoreceptors with hair cells in a cupula detect changes in water pressure. This causes an impulse to the brain. Bony fish also have an inner ear with hair cells. This ear does not open to the outside and sound waves travel from the water through the bone in the skull to the inner ear.</td>
<td>Have an outer, middle and inner ear. There is a tympanic membrane between the outer and middle ears and it converts the sound wave into mechanical vibrations. The inner ear has the cochlea which has hair cells that generate an impulse. The impulse is sent to the brain.</td>
<td>Tympanum is an internal air chamber enclosed by a tympanic membrane (eardrum). Sound waves cause the tympanic membrane to vibrate and attached nerve fibres are generated and travel to the brain.</td>
</tr>
</tbody>
</table>

- **Similarity**: Receptors detect vibration. Nerve fibres send the information to the brain.

- **Difference**: Lateral line provides the fish information about changes in direction and speed of water movement. Bony fish do not have a cochlea and the ear does not open to the outside. Ear provides information about changes in direction and pitch of sounds. Has a cochlea and ear opens to the outside. Has a tympanic membrane which detects sound vibrations. Tympanum provides information about the changes in direction of sounds and detects certain pitch. Does not have a cochlea. Has a tympanic membrane exposed to the air that detects sound vibration.

2. Describe the anatomy and function of the human ear, including: pinna, tympanic membrane, ear ossicles, oval window, round window, cochlea, organ of Corti and auditory nerve.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Description of Anatomy</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinna</td>
<td>Large fleshy external part of the ear</td>
<td>Collects sound and channels it into the ear</td>
</tr>
<tr>
<td>Tympanic membrane</td>
<td>The eardrum - a membrane that stretches across the ear canal</td>
<td>Vibrates when sound waves reaches it and transfers mechanical energy into the middle ear</td>
</tr>
<tr>
<td>Ear ossicles</td>
<td>Three tiny bones, the hammer, anvil and stirrup</td>
<td>Amplify the vibrations from the tympanic membrane</td>
</tr>
<tr>
<td>Oval window</td>
<td>Region that links the ossicles of the middle ear with the cochlea in the inner ear</td>
<td>Picks up the vibrations from the ossicles and passes them onto the fluid in the cochlea</td>
</tr>
<tr>
<td>Round window</td>
<td>Membrane between cochlea and middle ear</td>
<td>Bulges outward to allow pressure differences in the cochlea</td>
</tr>
<tr>
<td>Cochlea</td>
<td>Circular fluid filled chamber</td>
<td>Changes mechanical energy into electrochemical</td>
</tr>
<tr>
<td>Organ of Corti</td>
<td>A structure within the cochlea</td>
<td>Location of the hair cells that transfer vibrations into electrochemical signals</td>
</tr>
<tr>
<td>Auditory nerve</td>
<td>The nerve that travels from the ear to the brain</td>
<td>Transmits electrochemical signals to the brain</td>
</tr>
</tbody>
</table>
3. **Outline the role of the Eustachian tube.**
   - The Eustachian tube connects the pharynx (throat) to the middle ear. This opening is usually kept close, but opens when we yawn or swallow.
   - Its role is to allow air pressure to equalize between the outside atmosphere and inside the middle ear.

4. **Outline the path of a sound wave through the external, middle and inner ear and identify the energy transformations that occur.**
   - **Path of a sound wave through the ear**
     - Sound waves are collected by the pinna and travel down the auditory canal to the tympanic membrane, which vibrates at the same frequency as the sound.
     - The first of the ossicles is attached to the tympanic membrane, and this bone begins to vibrate, amplifies the vibration and then passes the vibration on to the other two ossicles, which also amplify the vibration.
     - The last ossicle is attached to the oval window, which begins to vibrate and causes the fluid in the cochlea to vibrate.
     - The hair cells of the organ of Corti detect the vibration and pass a message to the brain via the auditory nerve.
     - Different sounds move the hair cells in different ways, thus allowing the brain to distinguish various sounds.
       - **External:**
         - Auditory canal → outer layer of tympanic membrane
       - **Middle ear:**
         - Tympanic membrane → malleus → incus → stapes
       - **Inner ear:**
         - Oval window → upper canal → Reissner’s membrane → middle canal → basilar membrane → lowest canal → round window
   - **Energy transformation**
     - **External:** Sound energy
     - **Middle ear:** Mechanical energy (Kinetic energy)
     - **Inner ear:** Electrochemical energy

5. **Describe the relationship between the distribution of hair cells in the organ of Corti and the detection of sounds of different frequencies.**
   - The organ of Corti is part of the cochlea, in the middle canal.
   - It consists of hearing receptor hair cells.
   - High-frequency sounds cause vibrations in the organ or Corti near the oval window. Low-frequency sounds stimulate hair cells at the other end of the cochlea.
   - The basilar membrane of the organ Corti has receptor sensory hair cells that act like microphones to pick up vibrations.
   - Vibrations cause the hair cells to bend and release chemicals that stimulate adjacent sensory neurons. The electrochemical signal is sent to the brain.
6. Outline the role of the sound shadow cast by the head in the location of sound.

- The sonic (sound) shadow is the region that does not receive the direct sound as the head is blocking the vibration.
- Animals use the sonic shadow to determine the direction of the source of the sound. The difference in loudness and time of arrival of the sound at each ear can be interpreted by the brain to determine location.
- Many humans will turn their head when trying to determine the source of the sound. Turning the head increases the difference in time of arrival at each ear and increases the ability to determine location.

7. Gather, process and analyse information from secondary sources on the structure of a mammalian ear to relate structures to functions.

- See point 2.

8. Process information from secondary sources to outline the range of frequencies detected by humans as sound and compare this range with two other mammals, discussing possible reasons for the differences identified.

<table>
<thead>
<tr>
<th>Mammal</th>
<th>Range of frequencies detected</th>
<th>Reasons for the differences identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humans</td>
<td>20 – 20,000 Hz</td>
<td>Communicating and warning.</td>
</tr>
<tr>
<td>Bats</td>
<td>100,000 – 120,000 Hz</td>
<td>Very high sounds allow for precise echolocation.</td>
</tr>
<tr>
<td>Marine mammals</td>
<td>Whales: can hear sounds as low as 20 Hz</td>
<td>Marine mammals need to communicate over large distances.</td>
</tr>
<tr>
<td></td>
<td>Dolphins: can hear sounds as high as 150,000 Hz</td>
<td>Very low sounds (with low frequency) travel a long way under water.</td>
</tr>
<tr>
<td></td>
<td>Porpoise: 50 – 150,000 Hz</td>
<td>Very high sounds allow for precise echolocation.</td>
</tr>
</tbody>
</table>
9. Process information from secondary sources to evaluate a hearing aid and a cochlear implant in terms of; the position and type of energy transfer occurring, conditions under which the technology will assist hearing and limitations of each technology.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Hearing Aid</th>
<th>Cochlear Implant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diagram of aid</strong></td>
<td><img src="image1.png" alt="Diagram of hearing aid" /></td>
<td><img src="image2.png" alt="Diagram of cochlear implant" /></td>
</tr>
<tr>
<td><strong>Description of aid</strong></td>
<td>Electronic device with microphone and amplifier that increases loudness of sounds</td>
<td>External microphone and speech processor with electrodes embedded in cochlea to stimulate auditory nerve.</td>
</tr>
<tr>
<td><strong>Position of aid</strong></td>
<td>Aid is worn in a chassis or shell behind or inside the ear or in frames or spectacles.</td>
<td>Headset is worn externally and implant is surgically placed inside skull.</td>
</tr>
<tr>
<td><strong>Type of energy transfer occurring</strong></td>
<td>Uses a microphone to convert sound energy to electrical energy, an amplifier amplifies electrical energy, earphone converts amplified electrical energy back into sound energy of greater intensity than original sound.</td>
<td>Microphone in ear picks up sound signals and sends them to a microprocessor that converts them into electrical signals. These are sent to a transmitter, then a receiver implanted beneath the skin of the skull. Signals are sent to the cochlea where the stimulate auditory nerve endings</td>
</tr>
<tr>
<td><strong>Conditions under which the technology will assist hearing</strong></td>
<td>People with some hearing loss or impairment but are not completely deaf.</td>
<td>People who are profoundly deaf, with functional auditory nerve.</td>
</tr>
</tbody>
</table>
| **Limitations of each technology**           | - Hearing aids can be somewhat expensive to buy and maintain depending on the patients economic status.  
- Hearing aids can be uncomfortable to wear.  
- The voice of the person using the device may seem a lot louder to them than usual.  
- Hearing aid users may get feedback from their device such as a whistling noise.  
- Hearing aid may pick up background noise which may give the patient some difficulty in distinguishing between people and sounds within a room or area.  
- Some hearing aid users may get a buzzing noise when they use a mobile phone. | - Surgery and the cost of a cochlear implant may be somewhat expensive depending on the patient’s economic status.  
- The device as a whole can be uncomfortable.  
- A person who has not developed speech will be at a far greater disadvantage than a patient who becomes deaf at a later date in their life.  
- Sound in noisy areas can be somewhat hard to distinguish.  
- Sound can be unclear.  
- Full hearing potential is not reached with a cochlear implant. |
Chapter 7: Signals from the eye and ear are transmitted as electro-chemical changes in the membranes of the optic and auditory nerves.

1. Identify that a nerve is a bundle of neuronal fibres.
   - A nerve is a bundle of axons or neuronal fibres bound together like wires in a cable.
   - A neuron is a nerve cell. A typical neuron consists of a cell body, dendrites and an axon covered by an insulating myelin sheath.

2. Identify neurones as nerve cells that are the transmitters of signals by electro-chemical changes in their membranes.
   - A neuron is a nerve cell that transmits a signal or impulse from one part of the body to another.
   - A nerve impulse is an electrochemical message that travels along a neuron and is passed to the next neuron by neurotransmitters.
   - A nerve impulse can be detected as a change in voltage. The impulse is transmitted as a wave of electrical changes that travel along the cell membrane of the neuron.
   - The electrical changes are caused as sodium ions move into the neuron. Thus the signal is described as an electrochemical impulse.
   - After the signal has been transmitted, potassium ions move to the outside of the cell to restore the original charge of the neuron.

3. Define the term ‘threshold’ and explain why not all stimuli generate an action potential.
   - The ‘threshold’ is the amount of positive change in membrane potential which is required before an action potential is produced.
   - The depolarization must reach a threshold, which is at least 15 mV. No action potential is produced if the depolarization is below this level. This is one of the reasons why not all stimuli generate an action potential.
   - The point of excitation that causes the neurone to fire is called the threshold of reaction.
   - Each stimulus produces either a full action potential or none at all, each action potential is a separate event.
   - A cell cannot produce another action potential until the previous one is complete.

4. Identify those areas of the cerebrum involved in the perception and interpretation of light and sound.
   - Cerebrum: a mass of wrinkled tissue that makes up 90 per cent of the brain. It is responsible for complex thoughts, the senses, muscle control, memory and thinking.
   - Cerebellum: the ‘base’ of the brain. It controls complex muscular movements like cycling, walking and running.
   - Medulla: the ‘stem’ of the brain. It controls vital activities that do not require conscious thought, like breathing and heartbeat.
   - Spinal cord: a bundle of nerves running the length of the spine. They transmit messages between the brain and the PNS, and control some actions that do not require thinking.
5. Explain, using specific examples, the importance of correct interpretation of sensory signals by the brain for the coordination of animal behaviour.

- Reasons why there can be incorrect sensory signals:
  - There can be damage to brain cells, e.g. due to ageing, chemicals both legal and illegal, or physical damage such as head injury causing concussion
  - There are many diseases that affect sensory signals. These diseases can be congenital, autoimmune or caused by pathogens
  - There can be incorrect sensory signals such as damage or problems with the sensory organs, e.g. cataracts in the eyes, damage to the eardrum.
  - There are many chemicals and drugs that can influence perception, e.g. alcohol influences the brain and changes the ability of a person to react to different stimuli, reducing reaction times and coordination and the ability to feel physical injury. Alcohol also causes slurred speech and blurred vision.
  - E.g. Parkinson’s disease – caused by an imbalance of the chemical dopamine in the brain. The imbalance prevents the brain from coordinating sensory signals properly. They have difficulty with motor coordination.

6. Perform a first-hand investigation using stained prepared slides and/or electron micrographs to gather information about the structure of neurones and nerves.
We examined electron micrograph pictures in order to learn about the structure of neurons. Dendrites are the first part of the neuron. They have a large surface area for the collection of signals from other neurons by receptor cells. Dendrites lead in to the cell body which is a large area containing a nucleus and organelles. It is where metabolism occurs. Axons lead out of the cell body and convey signals along the neuron to the synapse (labelled on the diagram as axon terminals). The axon is coated by a myelin sheath. We also examined electron micrographs of nerves and discovered that they were bundles of neurons.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dendrites</td>
<td>Receives the signal from the previous neuron</td>
</tr>
<tr>
<td>Cell Body</td>
<td>Largest part of the cell, contains organelles such as Golgi body</td>
</tr>
<tr>
<td>Axon</td>
<td>Long protection that conducts the electrical signals away from cell body</td>
</tr>
<tr>
<td>Myelin Sheath</td>
<td>Insulates the axons so that the electrical signal can be transported quicker along the neuron</td>
</tr>
<tr>
<td>Axon Terminals</td>
<td>Line up next to the dendrites of the next neuron</td>
</tr>
</tbody>
</table>

7. Perform a first-hand investigation to examine an appropriate mammalian brain or model of a human brain to gather information to distinguish the cerebrum, cerebellum and medulla oblongata and locate the regions involved in speech, sight and sound perception.

**Materials**
- Sheep brain
- Scalpel
- Dissecting needle and board
- Tweezers
- Rubber gloves

**Method**
1) Examine the sheep brain externally noting the appearance and location of the cerebrum, cerebellum and medulla oblongata
2) Make a biological drawing of the external parts of the brain and labelling the parts.
3) Cut the brain in half lengthways and identify the areas for speech, sight and sound perception.
4) Make a biological drawing of the cross-section labelling that you can identify for speech, sight and sound perception.

**Safety**
- There is a hazard using the scalpels. The blades are extremely sharp and may cause injury. Risk management: using extreme care when handling the scalpel blades.
- Organic remains should be wrapped in newspaper and then given to the laboratory technician for safe disposal.

<table>
<thead>
<tr>
<th>Major Structure</th>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebrum</td>
<td>Frontal lobe</td>
<td>Learning, thoughts, memory and speech</td>
</tr>
<tr>
<td></td>
<td>Parietal lobe</td>
<td>Processes speech in Wernicke’s area</td>
</tr>
<tr>
<td></td>
<td>Occipital lobe</td>
<td>Processes visual signals where sight and vision is perceived</td>
</tr>
<tr>
<td></td>
<td>Temporal lobe</td>
<td>Processes auditory information, where hearing is perceived</td>
</tr>
<tr>
<td>Cerebellum</td>
<td></td>
<td>Coordinates sensory signals and helps with balance, movements, coordination and processing language</td>
</tr>
<tr>
<td>Medulla Oblongata</td>
<td></td>
<td>Relays signals between the brain and the spinal chord</td>
</tr>
</tbody>
</table>
• We dissected a mammalian brain using a scalpel and we identified the medulla oblongata (hollow cord like structure leading to the cerebrum and cerebellum), the cerebrum (the main part of the brain, divides in two hemispheres) and the cerebellum (lying on top of the medulla oblongata). Using a diagram such as the one above we also then located the regions involved in coordinating speech, sight and sound.

8. **Present information from secondary sources to graphically represent a typical action potential.**

• Action potential: nerve impulse, a large temporary depolarizing even which occurs along the membrane of a nerve fibre or a muscle cell.
• The action potential of a neuron can be graphically represented by the graph to the right.