Section A: Summary Content Notes

- Receptors are specialised cells that detect stimuli and convert them into nerve impulses.
- Receptors sense changes in the internal and external environment.
- The brain will interpret the impulses and give rise to a sensation.
- A concentration of receptors with the same function forms a sense organ.
- Different stimuli are detected by receptors:
  - Light
  - Sound
  - Temperature
  - Pressure
  - Pain
  - Chemicals (smell and taste)

The Human Eye – Light Receptor/Photoreceptor

The best way to study the eye is an annotated diagram. Draw the eye and put the functions. An example is on the next page.
The eyes are organs that make it possible for us to see. How do we see?

- Light rays pass from an object to the eye, through the transparent **convex cornea, aqueous humour**, the biconvex **lens** and **vitreous humour**.
- As the light rays pass through the curved surfaces (the cornea and the lens), **light is refracted** (bent).
- The lens refracts the light rays and forms an **inverted** (upside-down) image on the retina, bringing the image into focus by making fine adjustments.
- The **rod and cone cells** (photoreceptors) are stimulated by the light rays, and convert the stimulus into impulses.
- These impulses are transmitted along the **optic nerve** across the optic chiasma (cross-over) so that impulses enter the **lower visual centres** on opposite sides of the mid-brain at the **occipital lobes**.
- Here, the upright images are interpreted for size, shape and colour of the object that was seen.

**Accommodation**

Seeing with two eyes = **binocular vision** (bi=two and ocular = eye) helps us to focus on one object with both eyes, and allows for a greater field of vision. A sharp image falls on each retina. The image from the left eye is always slightly different to the image from the right eye. The two images join in the brain at the occipital lobes and results in **stereoscopic vision**. This helps with **judging distance, depth and size of objects**. The eyes can change the convex curve of the lens and this changes the focal length. This process is termed **accommodation**.
Near Vision (lens is round) | Distant Vision (lens is long and at rest)
---|---
Object is less than 6 m | Object is further than 6 m
Ciliary muscles **contract** (causing the ciliary body to move closer to the lens) | Ciliary muscles **relax** (causing the ciliary body to pull away from the lens)
Suspensory ligaments **slacken** | Suspensory ligaments become **taut**
Tension on the lens decreases | Tension on the lens increases
Lens becomes more convex and **rounded** | Lens is pulled to a **longer** and thinner shape (less convex)
Increasing the **refractive power** of the lens | Decreasing the **refractive power** of the lens
Focal length **decreases**, bringing the object into focus onto the yellow spot of the retina (clear image formed) | Focal length increases, bringing the object into focus onto the yellow spot of the retina. (clear image is formed)

**Pupillary Mechanism (Reflex Action)**
Too much light into the eye will cause damage to the retina and the photoreceptors (rod and cone cells). The **iris** controls the amount of light that enters the eye. The iris contains **circular and radial** muscle fibres that regulate the size of the **pupil**. Make sure that you learn the diagrams.

**Iris = bright light**
- Circular muscles contract – causing pupil to constrict
- Radial muscles relax
- Less light is allowed into the eye

**Iris = dull light/dark**
- Circular muscles relax – causing the pupil to dilate
- Radial muscles contract
- More light is allowed into the eye
Visual Defects

Short-sightedness: also called myopia or nearsightedness. It is a refractive defect where the image focuses in front of the retina because the cornea is too rounded or the ability of the lens to become flat. Distant objects are seen as blurred. Glasses and contact lenses that are concave are prescribed to reduce refraction.

Long-sightedness: also called hypermetropia or farsightedness. This is a refractive defect where the image focuses behind the retina. The person will not be able to see objects when they are close by, as the images are blurred. This condition is caused by the following:

- An eyeball that is too short (genetic): This is corrected with prescription eyeglasses or contact lenses which assist to increase refraction of light by using convex lenses

- When the lens cannot become round enough during accommodation: This may be genetic or it may be as a result of aging. As one ages, the ciliary muscles are unable to contract enough to cause the lens to become rounder. Eyeglasses or contact lenses are prescribed to assist to increase refraction of light by using convex lenses
Astigmatism: is an optical defect that results in blurred vision. It is caused by an irregular curvature of the cornea or the lens so the eye has different focal points that occur in different planes. Glasses and hard contact lenses correct the irregular focal points.

Cataracts: is the clouding of the lens when the lens cortex liquefies to form a milky white fluid. Cataracts progress over time and may result from long-term exposure to ultra-violet light, radiation, diabetes, hypertension, old age and physical trauma. Genetically, people may have a predisposition to cataracts. Cataracts must be removed surgically.

Section B: Practice Questions

Question 1

The diagram below represents a section through part of the human eye.
Question 1

1.1. Supply labels for the parts numbered 1, 3 and 5. (3)

1.2. Supply the number and the name of the part that controls the amount of light that enters the eye. (2)

1.3. Mention the changes that the part named in Question 1.2 will undergo when exposed to bright light. (4)

1.4. List one function for each of parts 4 and 7. (2)

1.5. Supply the number/s and the name/s of the part/s that is/are responsible for the accommodation of the eye. (3)

1.6. Explain the changes that will take place when a person views an object closer that 6m. (5)

Question 2

Study the diagram below showing a longitudinal section through an eye.

2.1. Label parts 2, 3, 4 and 5 respectively. (4)

2.2. Name and describe the process that causes part 1 to dilate. (6)

2.3. State how the following defects can be treated to improve vision:
   a. Long-sightedness
   b. Astigmatism
   c. Cataract
   d. Short-sightedness (4)

Question 3

When a person moves from bright light into almost total darkness, he is temporarily blinded. After a few minutes, the rod cells in each retina respond and he can see fairly well. His eyes are now dark-adapted. When he returns to bright light he cannot see clearly for a short period until the cone cells in each retina respond. Then he can see properly again and his eyes are now light-adapted.

The degree of sharpness of detail seen by an eye is called its visual acuity. The graph below shows the visual acuity of a dark-adapted and light adapted eye...
3.1 Explain the difference between a light-adapted and a dark-adapted eye. (2)

3.2 In which type of eye is the relative acuity (sharpness) of vision the greatest at the:
   a. Yellow spot (2)
   b. Side of the eye at point Y

3.3 Identify region X on the graph. (2)

3.4 Give the reason why the acuity of vision for both types of eye is zero at region X on the retina. (1)

**Question 4**

Study Diagrams I and II that illustrate the lens and parts of one layer of the human eye, as well as the graph below, and answer the questions that follow.
4.1 Explain the significance of the elastic nature of the lens. (3)

4.2 Identify parts A and B.
   (i) Which Diagram (I or II) shows part of the eye… (2)
   (ii) where the ciliary muscles are contracted (1)
   (ii) under dim light conditions (1)

4.3 Explain your answer in QUESTION 4.2 (i). (2)

4.4 Which letter on the graph indicates each of the following:
   (i) The eye looking at a nearby stationary object (1)
   (ii) The eye looking at an object moving towards the viewer (1)

4.5 Explain the significance of the elastic nature of the lens. (3)

**Question 5**

Study the diagram that shows the anterior and longitudinal section of the human eye and answer the questions that follow.

5.1 Identify parts numbered 1 – 3 (3)

5.2 Give the function of structure numbered 3. (1)

5.3 Name the condition responsible for:
   a) the size of structure 1 in the diagram (2)
   b) the shape of the lens in the diagram
A person in a darkened room is asked to cover one eye. A dim electric bulb, positioned at varying distances from the person (not all measurements were at different distances), is switched on at one-minute intervals for a period of 10 seconds. During this period the diameter of the pupil of the eye is measured. The results obtained are shown in the table below.

<table>
<thead>
<tr>
<th>Time intervals in minutes</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of pupil in mm</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

5.4 Provide an appropriate title for this table.

5.5 Which structure in the eye controls the size of the pupil?

5.6 Plot a line graph of the results in the table above.

5.7 Between which two measurements did the following change in the diameter of the pupil occur: largest decrease?

5.8 Why did the diameter of the pupil remain the same during the third and the fourth time intervals?

Section C: Solutions

Question 1

1.1. 1 = cornea ✓ 2 = pupil ✓ 3 = suspensory ligaments ✓  

1.2. Number 2 ✓, the iris ✓

1.3. The radial muscles of the iris relax ✓ the circular muscles contract ✓ this will cause the pupil to constrict ✓ allowing less light to enter into the eye ✓

1.4. Part 4 = the lens focuses the light rays onto the retina at the back of the eye ✓ Part 7 = the viterous body/vitreous humor is part of the refracting medium of the eye and helps to maintain the shape of the eyeball ✓

1.5. Number 6 = the ciliary muscles in the ciliary body ✓ 5 - suspensory ligament ✓ 4- lens ✓

1.6. Ciliary muscle contract towards the lens - Releasing the tension on the suspensory ligaments so they become relaxed ✓ The tension on the elastic lens becomes less ✓ The lens becomes rounder/more convex ✓ This increases the refraction of light through the lens so that the image focuses on the retina ✓
Question 2

2.1. 2 – cornea✓
      3 – lens✓
      4 – suspensory ligaments ✓
      5 – ciliary muscles✓/body

2.2. Pupillary mechanism ✓/Pupil reflex
      The radial muscles ✓ of the iris contracts ✓ and the circular muscles ✓ relax ✓
      The pupil ✓ dilates and more light enters the eye ✓

2.3. (a) Wear spectacles with convex ✓ lenses/use convex contact lenses/using lasers during surgery to reshape the cornea
      (b) Wear spectacles with lenses which are unevenly ground ✓ to compensate for the uneven cornea/lens/surgery
      (c) Cataracts surgically ✓ removed/lens replacement
      (d) Wear spectacles with concave ✓ lenses/use concave contact lenses/using lasers during surgery to reshape the cornea

Question 3

3.1 In light-adapted eyes the cone cells respond ✓ in bright light
      While in dark-adapted eyes the rod cells respond ✓ in low light conditions
      OR
      In light-adapted eyes the pupil is constricted ✓
      In dark-adapted eyes the pupil is dilated ✓

3.2 (a) Light-adapted ✓ ✓
      (b) Dark-adapted ✓ ✓

3.3 Blind spot ✓

3.4 Rods and cones/photoreceptors are absent ✓ at X

Question 4

4.1 (i) A: Ciliary body/Ciliary muscle ✓
      B: Suspensory ligament ✓

4.2 (i) Diagram 2 ✓
      (ii) Diagram 1 ✓

4.3 Suspensory ligament ✓ slackens ✓

4.4 (i) D ✓
      (ii) F ✓

4.5 Can change its shape ✓
      to focus image onto the yellow spot ✓
      irrespective of the distance from the eye ✓
      OR for near or distant vision ✓ OR for accommodation ✓
Question 5

5.1 1 = pupil
     2 = iris
     3 = ciliary body

5.2 contracts or relaxes to focus the image using the lens

5.3 a) amount of light present
     b) distance of object from eye/ focus

5.4 Table showing the diameter of the pupil after increasing time intervals.

5.5 iris

5.6

[Line graph showing changes in pupil diameter over time]

Heading  2
Time on x axis  1
Both axes labelled  1
Scaling of both axes  1
Line graph  1
Pts  2

5.7 Between 6 and 7 min ✓ (no units, no marks)  (1)

5.8 Light source was the same ✓ distance ✓ from the person (2)