MEDICINE

CIRCA TUTORS

Human Visual Systems

Topics Required: No specific topics   **Difficulty:** 3/5

General comments

This interview is designed to be conducted with an interviewer, who should try to lead the candidate towards the correct answer using the hints provided. If they are still unable to answer, they should be told the solution to allow them to attempt subsequent questions.

A blank copy of figure 2 is required for each interview to allow annotation.

Questions marked with an asterisk (*) are considered more difficult.

Intro Questions [2 mins]

a) Why do humans have two eyes instead of one?

b) Why do humans have forward-facing eyes, but cows have sideways-facing eyes?

c*) If a cow's eyes don't point the same direction, how might they judge distance to objects?

Main Question [5-10 minutes]

Now look at figure 1 and figure 2.

Figure 1 shows a simplified version of the human visual pathway, as viewed from above. The blue and green lines represent nerves, which travel from the retina (at the back of the eyeball) to the visual cortex, where information is processed. The triangles at the top of the image represent light entering the patient's eyes.

Figure 2 represents the visual field of a healthy patient, with each circle representing input from one eye.

a) Using one of the blank visual field diagrams (*figure 2*), shade in the areas of the visual field which would be lost if the nerves at point 1 were cut.

Now draw what would happen if the nerves at point 3 were cut.

b) How would each of these injuries affect a patient's day-to-day life? What would be different in each scenario? What tasks that might be more difficult or dangerous for them?

c) The pituitary gland lies directly below the optic chiasm (location 2 in figure 1). What might happen to the visual field if a patient had a large tumour in their pituitary gland? Indicate this on one of the blank diagrams.

What might the patient complain of or have difficulty with?

d*) If a pituitary tumour grew slowly and initially only compressed the *lower* fibres at point 2, what might initially happen to the patient's visual field? Indicate this on one of the blank diagrams.

Extension Question [5-10 minutes]

Now look at figure 3. This diagram shows where rod and cone photoreceptor cells are found within the retina. Cone cells provide colour vision, but rod cells only provide greyscale vision.

a) Interpret this graph, describing the distribution of different photoreceptors within the retina.
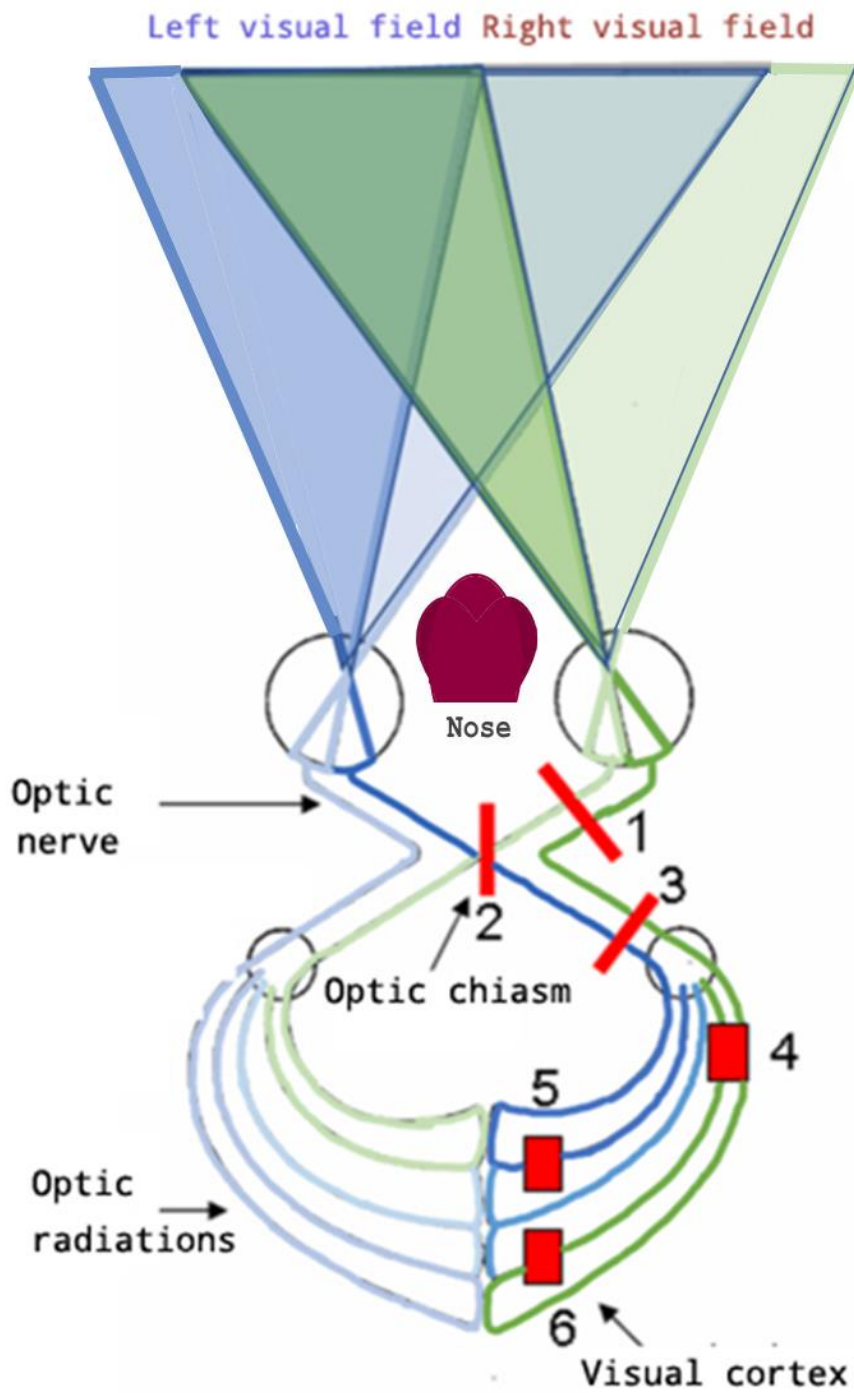
b) What happens at point B? Why do you think this is the case?

c) Why are cone cells only concentrated around point A? Why doesn't it matter that cones aren't as common elsewhere?

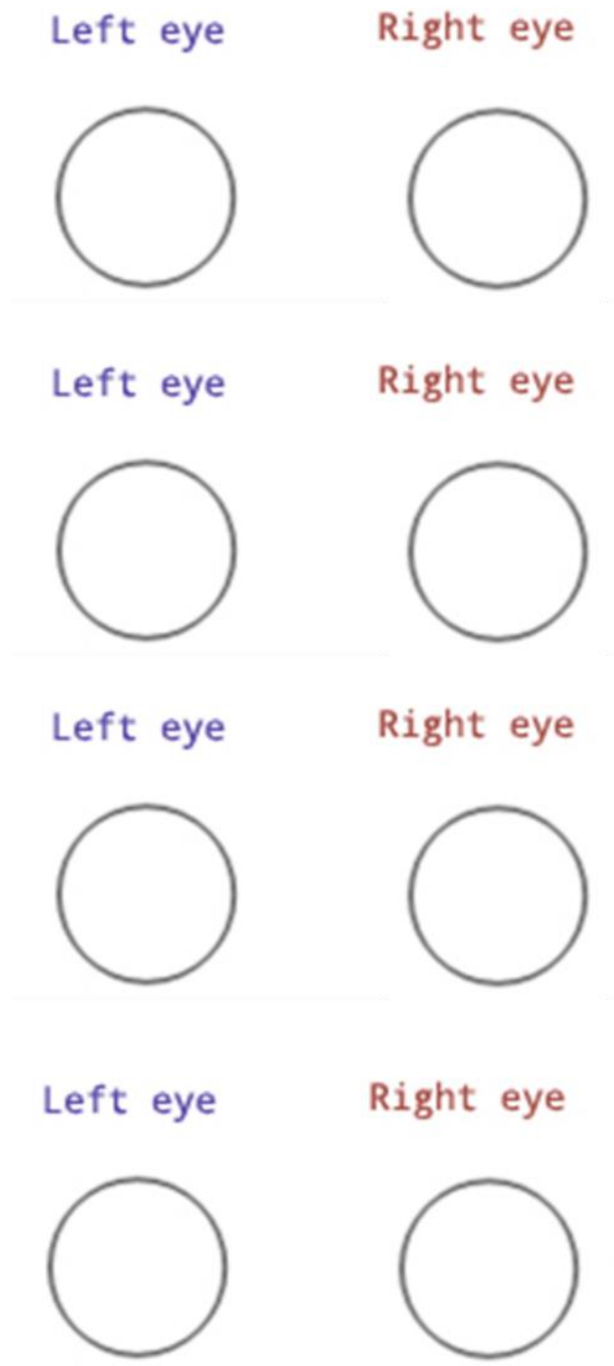d*) What do you notice about your colour vision in the dark? Why might this occur?

e*) Looking at the diagram, does your observation explain why it's harder to read a book or focus on fine detail in the dark? Are there other factors involved?

FIGURE 1

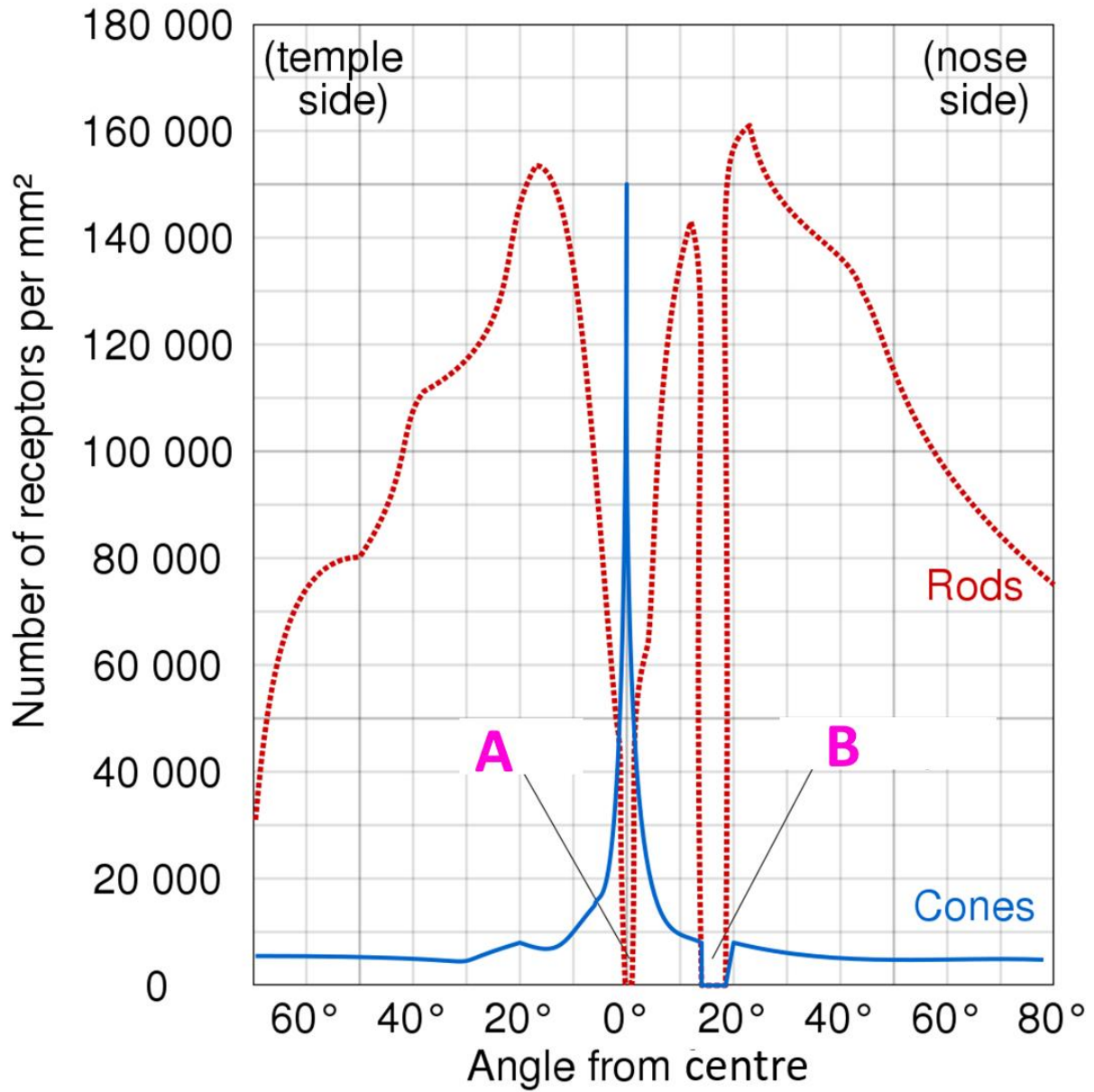
Left visual field   Right visual field

Nose

Optic nerve

1

3

2

Optic chiasm

4

5

Optic radiations

6

Visual cortex

FIGURE 2

Left eye   Right eye

Left eye   Right eye

Left eye   Right eye

Left eye   Right eye

FIGURE 3

Hints

Intro Question

b) When thinking about biology, always consider the evolutionary purpose of the feature in question. What do cows mainly use their eyes for? What do humans use their eyes for? Can you think of other examples of animals with forwards vs. sideways-facing eyes? What links each group animals?

c) If you were given a 2D photograph (the equivalent of the image from a single eye), how would you go about determining distance to the objects in it?

Main Question

a) Think about which part of the retina gives rise to each nerve. Consider how the light "changes sides" as it passes through the pupil of the eye.

c) Identify which nerves would be compressed, trace these back to the retina and work out which part of the visual field would be lost.

d*) Remember that the eye is 3 dimensional. Figure 1 only shows nerves from the left and right of each eyeball, but it would be fair to assume that nerves from the top and bottom of the retina follow similar rules.

Extension Question

a) Why isn't it possible to completely cover the eye with photoreceptors? What else does the eye need to work and communicate with the brain?

d*) Again, think about the evolutionary purpose of our eyes. How sensitive do our eyes need to be at different light levels? Would it be beneficial if rods and cones both operated at the same light levels, or if each system worked best at a different illumination?

e*) Which parts of your visual field are most highly detailed? Can you read a book in your peripheral vision? How does your observation in the previous question link to the data in the diagram?

Solutions

Intro Question

a) The primary advantage for humans is **depth perception** – each eye shows a slightly different image, allowing our brains to determine distance to an object.

- A weak candidate might only suggest "having a spare"

b) Most predatory mammals have forward-facing eyes to improve **depth/perception**, **hunting** and (in humans) manual **dexterity.** Most herbivorous animals have sideways-facing eyes to improve their **visual field** so that they can see **predators** approaching more easily.

c*) This is a difficult question – accept any reasonable responses. In fact, most mechanisms for judging distance in all animals require only one eye, so there are many correct answers:

- The degree of **focusing of the lens** within the eye
- **Moving** the head to change the viewing position
- **Prior knowledge** about the **size** or **shape** of objects
- **Overlap/shadows/reflections**
- Use of **other senses** (e.g. hearing, smell in some animals)
- Any other sensible suggestions

Main Question

a) A cut at 1 causes **blindness in one eye**, but a cut at 3 leads to **loss of the left side of the visual field**.
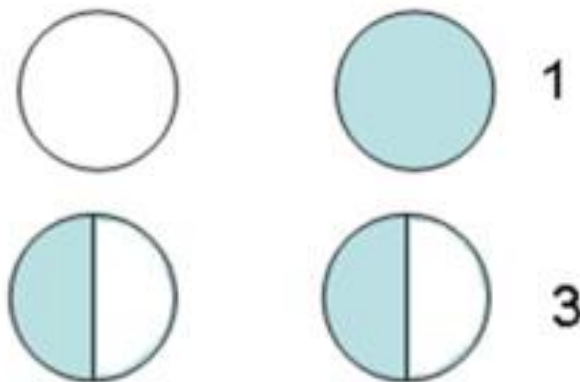
Below is a common mistake for cut 3. The candidate has the correct idea but has not recognised that light is **inverted** as it enters the pupil. Damage to nerves which connect with the **right side** of the retina leads to loss of the **left side** of the visual field.

b) A cut at **point 1** is equivalent to losing the right eye. The following are all sensible suggestions:

- The patient may struggle with **depth perception** or **judging distance** – might struggle with e.g. **ball sports, driving** or **moving furniture.**
- The patient may be less likely to notice things on their **right side** – could be dangerous **crossing roads** or **cycling.**
- A strong candidate might suggest **reduced night vision** because less light enters the eye overall.

A cut at **point 3** would cause the patient to lose their entire **left** visual field.

- Candidates might suggest that the patient will have better depth perception than for cut 1, as they can still use both eyes.
    - *This is not strictly correct (the patient will have difficulty focusing; see below) but should be given full credit.*
- Compared to cut 1, the patient cannot notice *anything* on their **left side** without turning their head – **driving, cycling, crossing roads** would all be very dangerous.
- The patient may bump into **obstacles**, be uncomfortable in **crowds** or have difficulty **moving around indoors**.
- A strong candidate might suggest **difficulty focusing** or **double vision,** because the centres of the images from each eye no longer align with the centre of the eye.
- A strong candidate might again suggest **reduced night vision.**

c) Pressure at the optic chiasm would only affect the nerve fibres which **cross the midline** (i.e. the fibres which correspond to the **outer** portions of the visual field).

- The patient would complain of **tunnel vision** (i.e. loss of **peripheral vision**)
- They may experience similar problems as above (bumping into obstacles, driving, crossing roads) but to a lesser degree, as they can still see to both sides.
- A strong candidate might again suggest **difficulty focusing, double vision** or **reduced night vision.**

d*) This is a difficult question. The candidate needs to work out that nerves from the **top** of the eye correspond to the **bottom** of the visual field. So, because the pituitary tumour is *below* point 2, the nerves corresponding to the *top* of the visual field will be affected first, causing loss of the **upper outer quarters** of the visual field in each eye.

Extension Question

a) This graph shows the **density** of rods and cones along a horizontal slice of the retina.

- There are no rods OR cones at **point B.**
- The density of **rods** increases towards the centre, but then drops to zero at the very centre (point A).
- The density of **cones** is low across most of the retina but **increases dramatically** near the centre – cones take over from rods.

b) There are **no rods or cones** at point B – this is the optic **blind spot**.

- The blind spot exists at the point where the **optic nerve** and **blood vessels** enter the eye – there isn't room for photoreceptors here.
- Other plausible but *incorrect* suggestions (give some credit) might include **injuries** or a **problem with the equipment** used to measure the data
- A weaker candidate may get confused and suggest that this blind spot results from light being blocked by the nose or the pupil of the eye (give no credit)

c) Humans only have good **colour vision** at the **centre** of their eye.

- Being aware of the **presence** of objects (e.g. a predator) in our **periphery** is much more important than knowing their colour, so cone cells here are unnecessary
- We can simply **shift our gaze** to focus on an object if we want to know its colour

- Candidates may also suggest that colour vision is more **resource-intensive**, so it would waste energy to have good colour vision across our entire eye.
- Accept any other sensible explanations

d) Humans **lose colour vision** when the light level becomes very low. In a dark room at night, all objects appear grey.

- Rod cells are **more sensitive** than cone cells, so can function at lower light levels
- Cone cells are **less sensitive** but provide **colour** and **greater detail.**
- This allows us to function at a **greater range** of light levels, allowing survival at night while providing more powerful vision during the day.

e) In dark conditions, we find it **harder to focus**, because **rods** (which function at lower light levels) are not found at the very centre of the eye.

- The **cones** at the centre **do not function properly in the dark**, meaning the very centre of the eye cannot be used for reading.
- The main other factor is simply a **reduction in total light** entering the eye, making detail harder to notice.

Introduction and Explanatory Notes

Interviews for medicine at Oxbridge vary considerably between different interviewers. To simulate this, I have provided questions which cover a broad range of topics and which vary in format. Some require drawing, most require analysis of diagrams, some are open-ended or philosophical. This should help candidates to identify their weakest areas.

A candidate could get most of the questions wrong but still perform very well if they explain their reasoning and justify their answers. I strongly recommend that the interviewer encourages candidates to explain their thought processes as they go along, and to challenge any statements which they do not think are justified or well-explained. Interviewers would benefit from reading the questions in advance and ensuring they understand the solutions, as this will make it easier to stimulate discussion with the candidate.

Most Oxbridge interviewers are experts in their field and are able to improvise questions and hints based on their assessment of a candidate's ability. Because they are interested in seeing how a candidate *thinks* rather than what they *know*, interviewers will lead candidates towards the correct answer if they are on the right track and will provide hints if candidates are stuck.

These questions are deliberately written for use by non-expert interviewers! I have provided detailed solutions and explanations of what I would expect candidates to say, as well as hints (usually in the form of questions) which can be used to help the candidate. Needing to use hints or be helped towards the answer is NOT the sign of a weak candidate! Many of these questions are challenging, some do not have "correct" answers and others are deliberately vague to encourage candidates to think. However, I would hope that good candidates are able to reach many of the answers with minimal help.

These questions are designed so they can be approached with minimal prior knowledge. Nevertheless, all candidates will benefit from general knowledge from independent reading (particularly on topics they have chosen to mention in their personal statement), and this should be encouraged as long as it does not interfere with schoolwork.

For students without an interviewer to help them, I would recommend the following approach: Look at the first question, covering up subsequent questions. Make brief notes on how you would answer. Then look at the hints (again covering up subsequent questions) and see if you wish to add anything to your answer. Now read the solution for this question and compare with your answers (cover up subsequent solutions). Repeat this process for each question. If you are completely stuck, it's okay to look at the solution, but make sure you understand how you would reach the solution in a similar question.

INTERVIEW SCORECARD

Candidate Name		Date	
Score/25		Question	

General Interview Notes

	Points to look for	Notes	Score /5
Explanation of ideas	How clear are the explanations, is the candidate explaining their thinking or are there long periods of silence? Is the candidate presenting their ideas in an organised manner both on paper and verbally?		
Problem solving ability	Has the candidate thought about the method that they are using or are they rushing into the solutions? Has the candidate tried to approach the problems using a few different methods?		
Response to new information	Does the candidate take a new approach to questions? Is the candidate ignoring hints or are they using them to inform their approach and solution?		
Creativity	Does the candidate suggest a few good quality ideas on questions which require this?		
Accuracy	Is the candidate able to check their mistakes and spot their errors?		

Question Specific Notes (Fill in as appropriate)

Question number	Notes
Introductory question	
Main Question 1	
Main Question 2	
Extension Question	