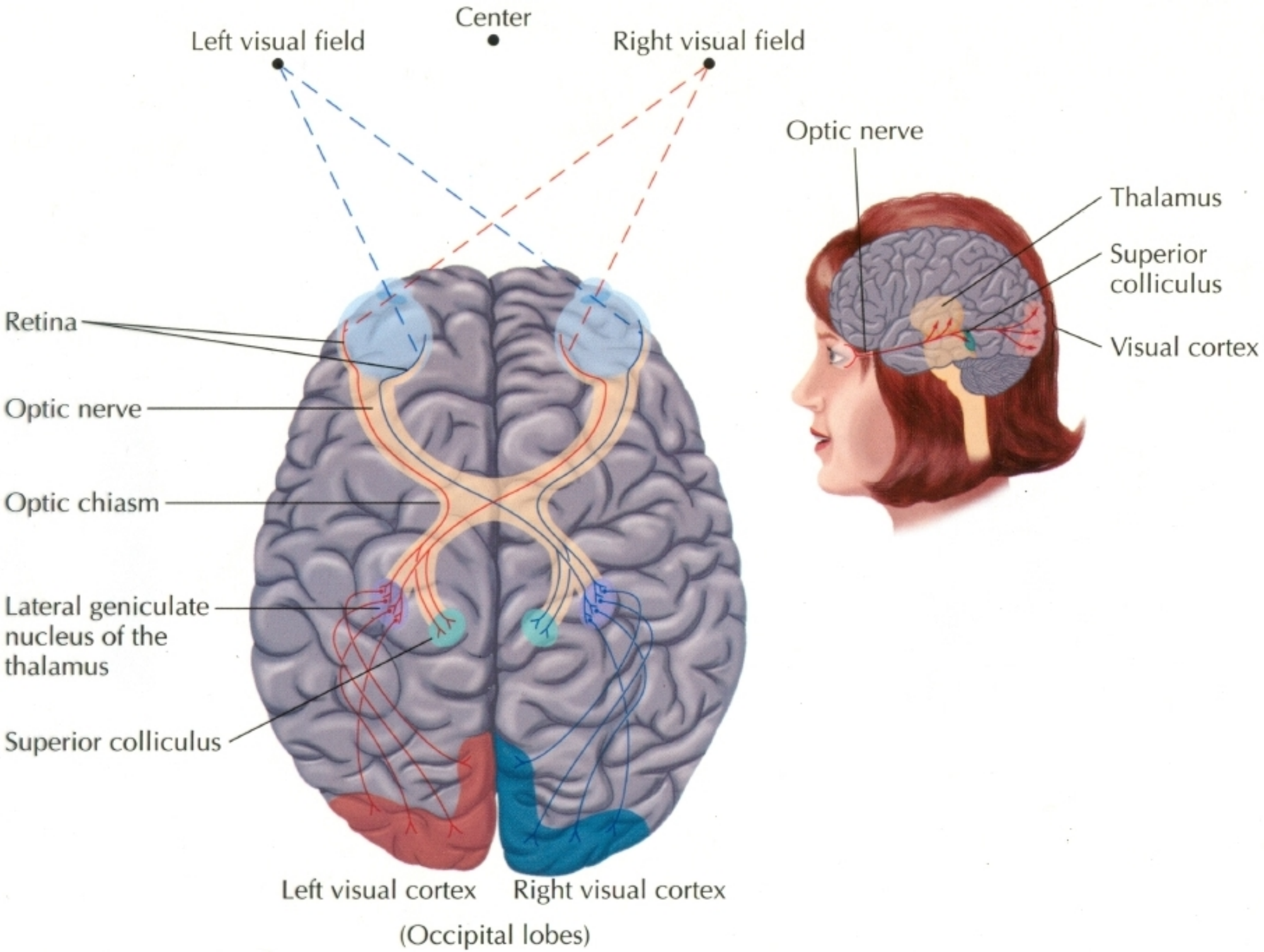
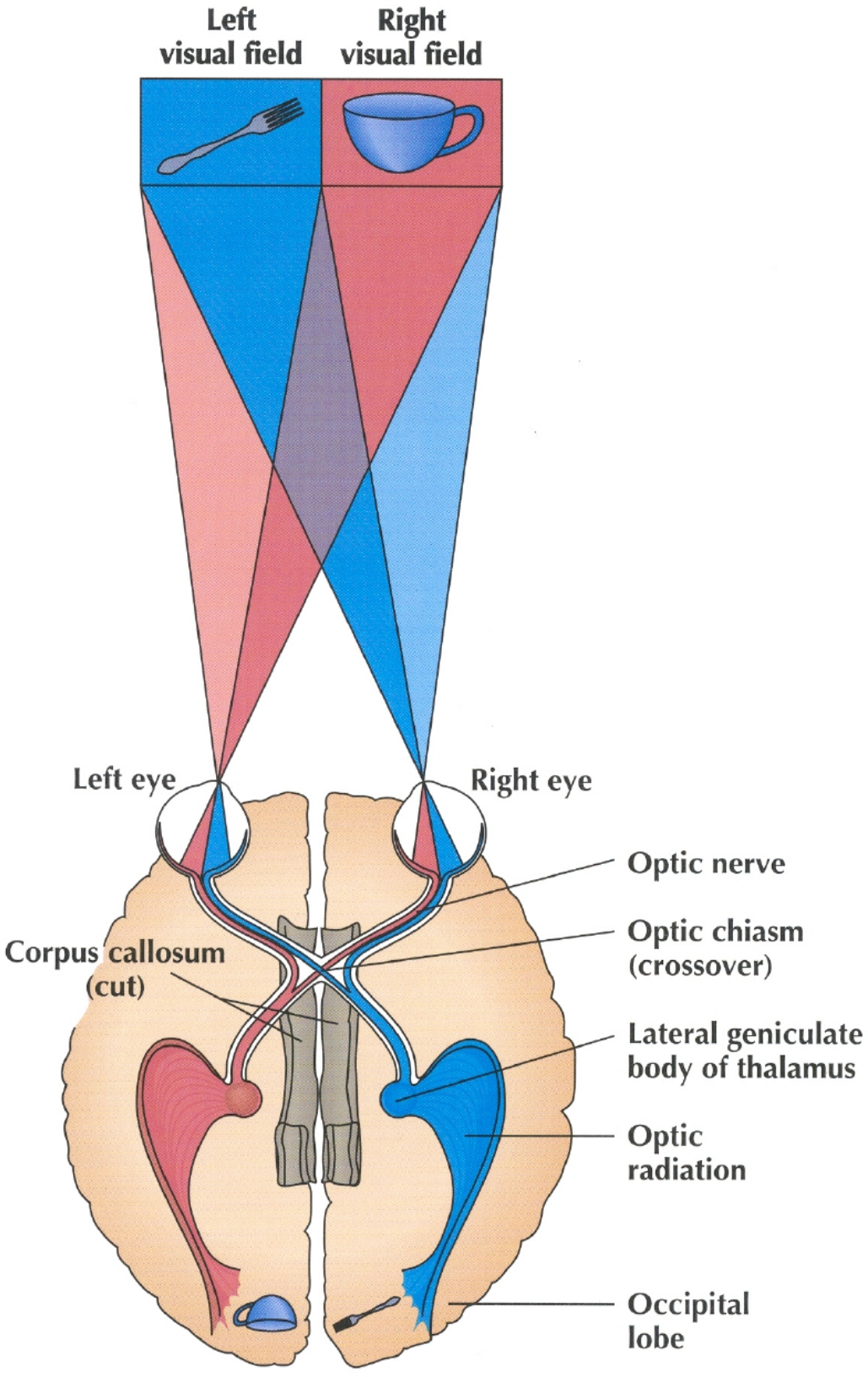
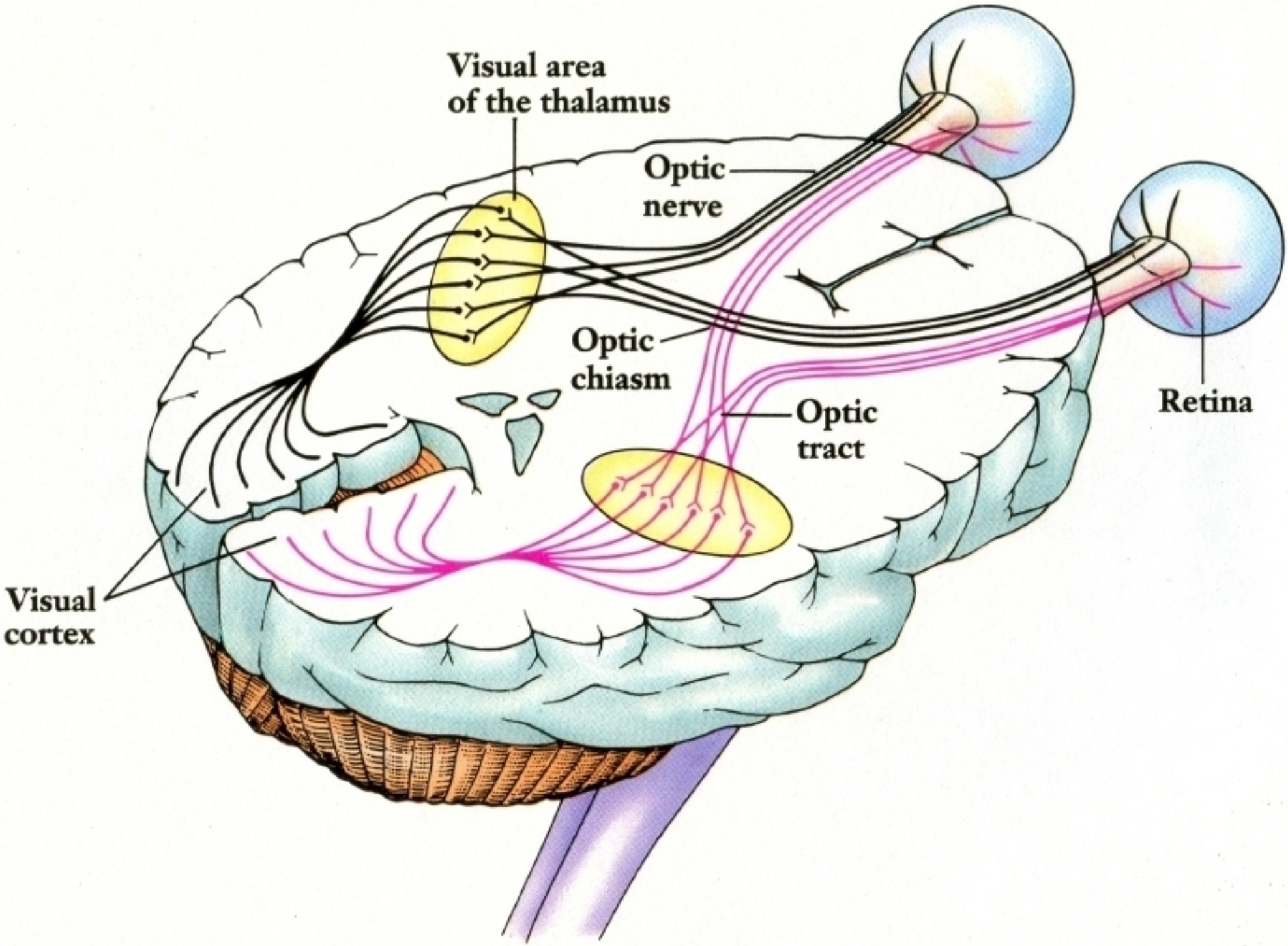
The Visual Pathway




Left visual field
Right visual field
Left eye
Right eye
Optic nerve
Optic chiasm (crossover)
Corpus callosum (cut)
Lateral geniculate body of thalamus
Optic radiation
Occipital lobe

The Visual Pathway

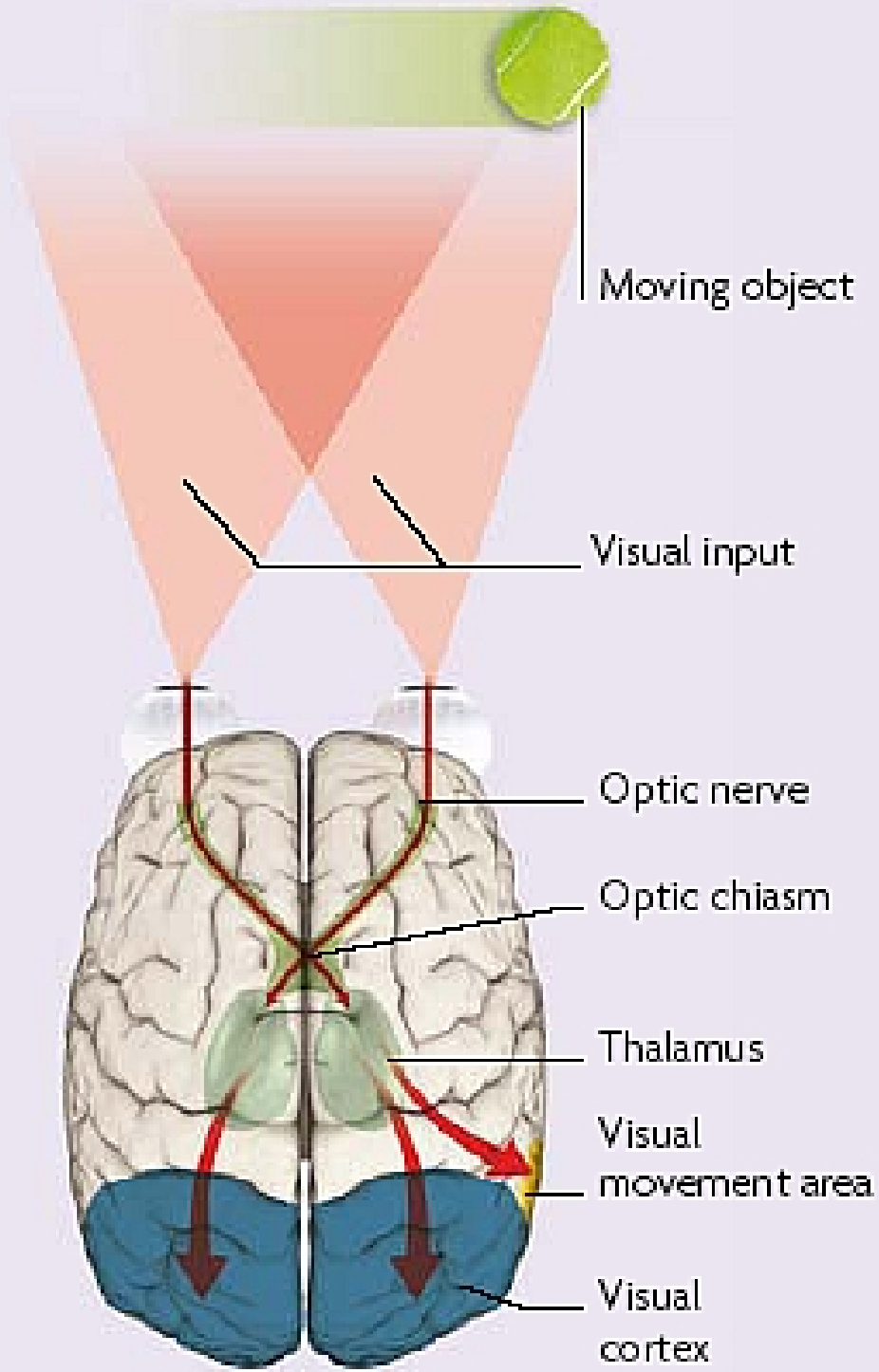


BLINDSIGHT

Blindsight gives visual knowledge without conscious vision. It is likely that we all have it, but it is most easily measured in people who are blind due to cortical damage. Such people cannot knowingly see, but if something is put in front of them they can correctly "guess" what it looks like, without knowing how. Most blindsight studies use moving objects. The subjects say they can't see the objects, but can usually "guess" the direction of movement correctly.

"GUESSING" MOVEMENT

Blindsight for movement is probably due to information from the eyes stimulating the visual movement area directly via an unconscious route. Conscious vision depends on activation in the primary visual cortex, stimulated via another pathway.



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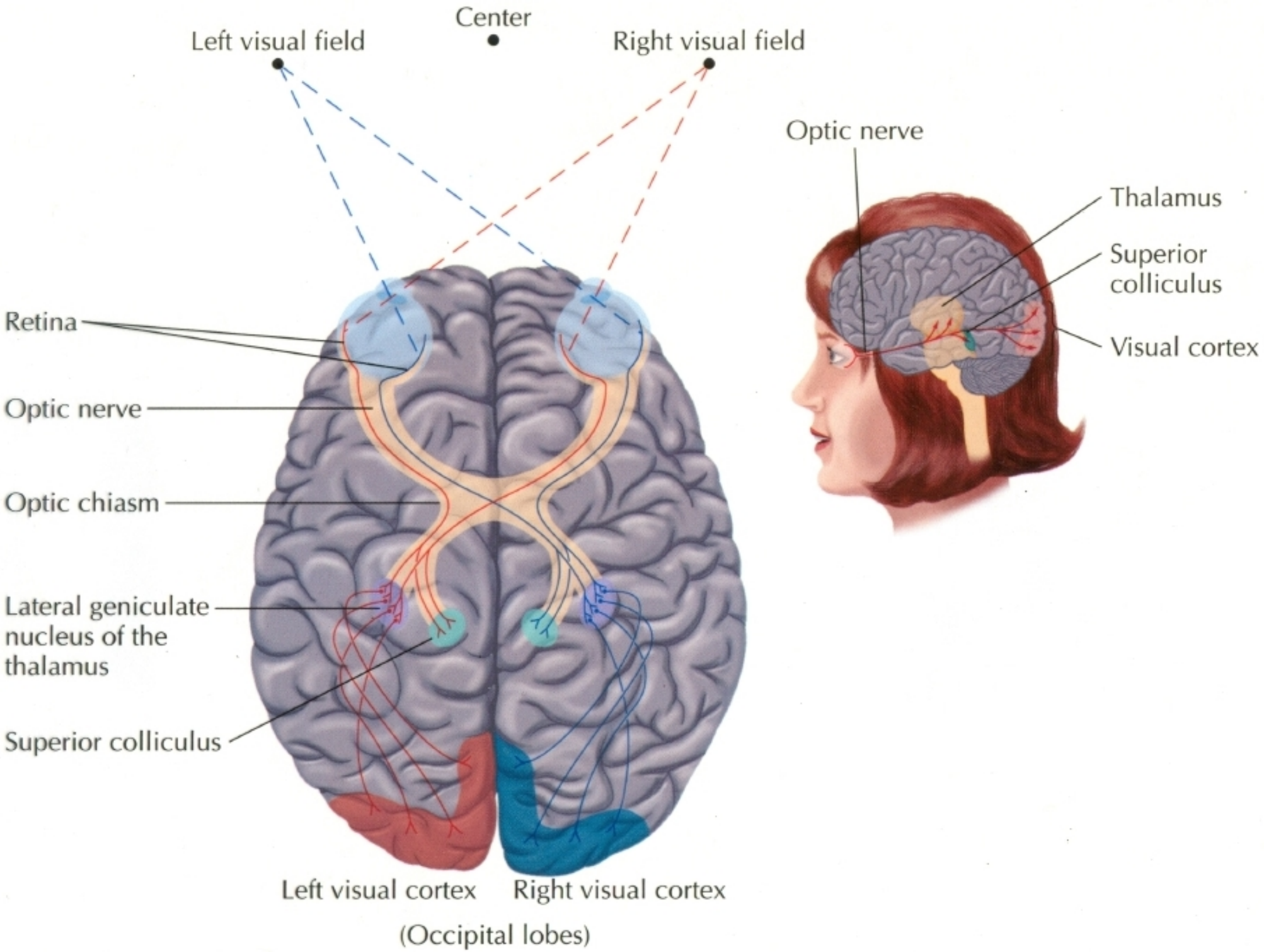


5 THE DORSAL ROUTE

Information from the eyes is registered by the primary visual cortex and then sent forward along two pathways for further processing. The dorsal route takes it up through areas that are concerned with charting the location of the target object in relation to the viewer. Along this route, neuronal activity encodes the object's position, movement, and some aspects of its size and shape. The dorsal route ends in the parietal areas, which construct action plans relative to the viewed object. This process occurs unconsciously.

Motion
Movement is processed along the dorsal pathway. It is an essential component of any "action plan" (see p.119), and the brain not only notes current motion, but also predicts where an object will be in a split second. This ensures that any action plan is well timed.

Depth
In order to calculate the depth of an object, the brain combines visual signals from both eyes—each of which has a slightly different view (see p.81)—along with information about how the shape of the image alters as the eyes move.

DORSAL

6 THE VENTRAL ROUTE

The ventral route carries information from the primary visual cortex down through the temporal lobes, where the neural activity identifies the sights and "clothes" them with meaning. A face, for example, is distinguished and recognized here (see p.82), and information about it such as the name of the person is recalled from memory (see p.161). Information traveling along the ventral path is brought together with that from the dorsal path in the frontal lobes—resulting in conscious perception rather than action.

Form
The brain has many different ways of "seeing" form. These include registering the orientation of light waves hitting an object and processing information about the way the waves reflect from its surfaces or outlines.

Color
Color discrimination begins in the retinal cells, some of which are tuned to fire in response to specific light wavelengths. Color processing continues in the brain, especially in an area known as V4 (see pp.80–81), which contains the majority of color-sensing neurons.

VENTRAL

SEEING

SEEING SEEMS TO BE INSTANTANEOUS AND EFFORTLESS, AND VISUAL IMAGES ALWAYS APPEAR FULLY FORMED. UNCONSCIOUSLY, HOWEVER, THE BRAIN IS CONSTANTLY UNDERTAKING A MAJOR FEAT OF CONSTRUCTION TO PRESENT US WITH OUR VIEW OF THE WORLD.

VISUAL PERCEPTION

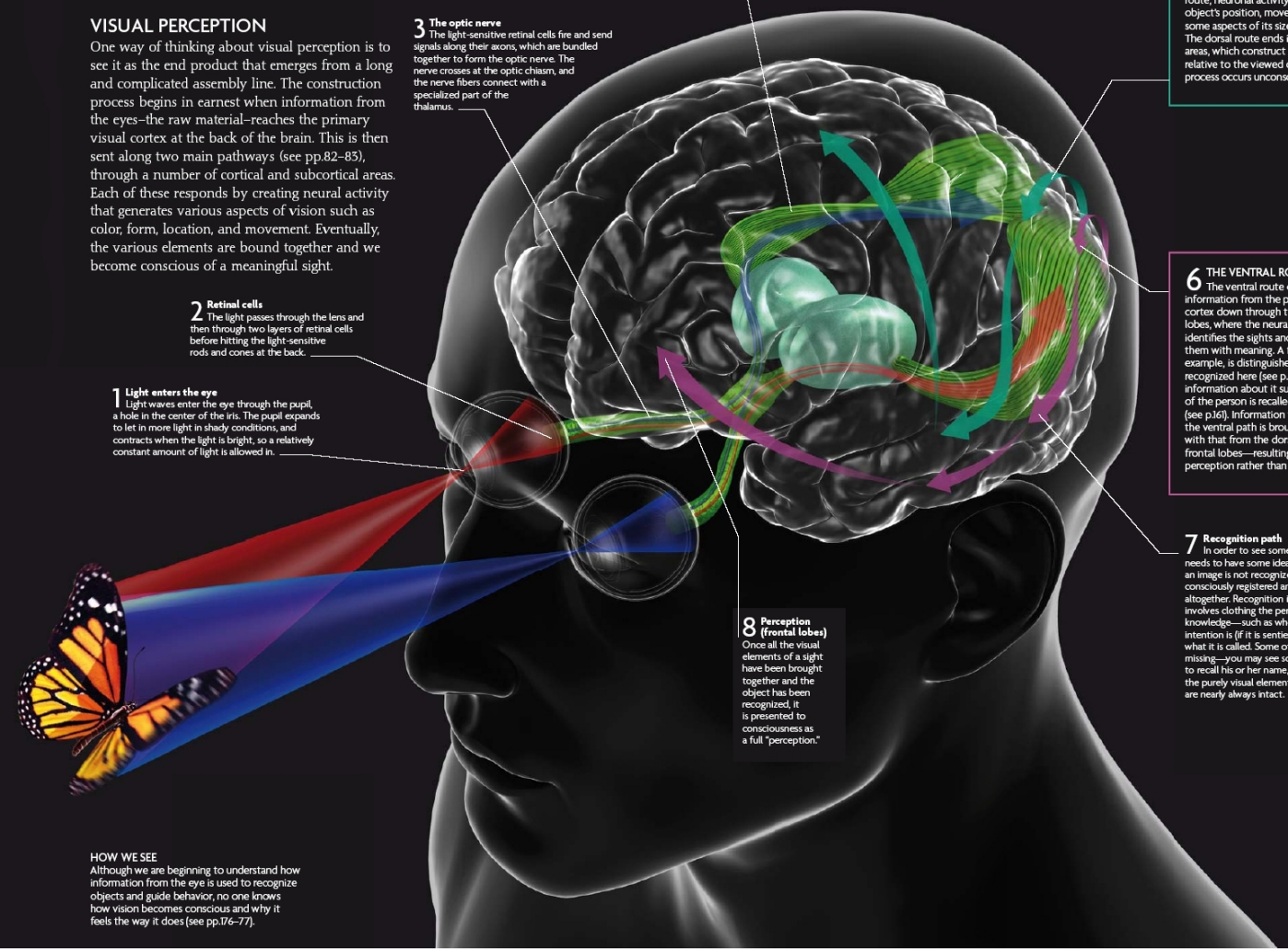
One way of thinking about visual perception is to see it as the end product that emerges from a long and complicated assembly line. The construction process begins in earnest when information from the eyes–the raw material–reaches the primary visual cortex at the back of the brain. This is then sent along two main pathways (see pp.82–83), through a number of cortical and subcortical areas. Each of these responds by creating neural activity that generates various aspects of vision such as color, form, location, and movement. Eventually, the various elements are bound together and we become conscious of a meaningful sight.

1 Light enters the eye
Light waves enter the eye through the pupil, a hole in the center of the iris. The pupil expands to let in more light in shady conditions, and contracts when the light is bright, so a relatively constant amount of light is allowed in.

2 Retinal cells
The light passes through the lens and then through two layers of retinal cells before hitting the light-sensitive rods and cones at the back.

3 The optic nerve
The light-sensitive retinal cells fire and send signals along their axons, which are bundled together to form the optic nerve. The nerve crosses at the optic chiasm, and the nerve fibers connect with a specialized part of the thalamus.

4 The optic radiation
The signals are then sent from the thalamus on to the visual cortex via a thick band of tissue known as the optic radiation.



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VENTRAL

7 Recognition path
In order to see something properly, a person needs to have some idea of what is being seen. If an image is not recognized, it is less likely to be consciously registered and may be overlooked altogether. Recognition is not purely visual, but involves clothing the perception with knowledge—such as who or what it is, what its intention is (if it is sentient), why it is there, and what it is called. Some of these elements may be missing—you may see someone you know but fail to recall his or her name, for example. By contrast, the purely visual elements of a perception are nearly always intact.

8 Perception (frontal lobes)
Once all the visual elements of a sight have been brought together and the object has been recognized, it is presented to consciousness as a full "perception."

HOW WE SEE
Although we are beginning to understand how information from the eye is used to recognize objects and guide behavior, no one knows how vision becomes conscious and why it feels the way it does (see pp.176–77).

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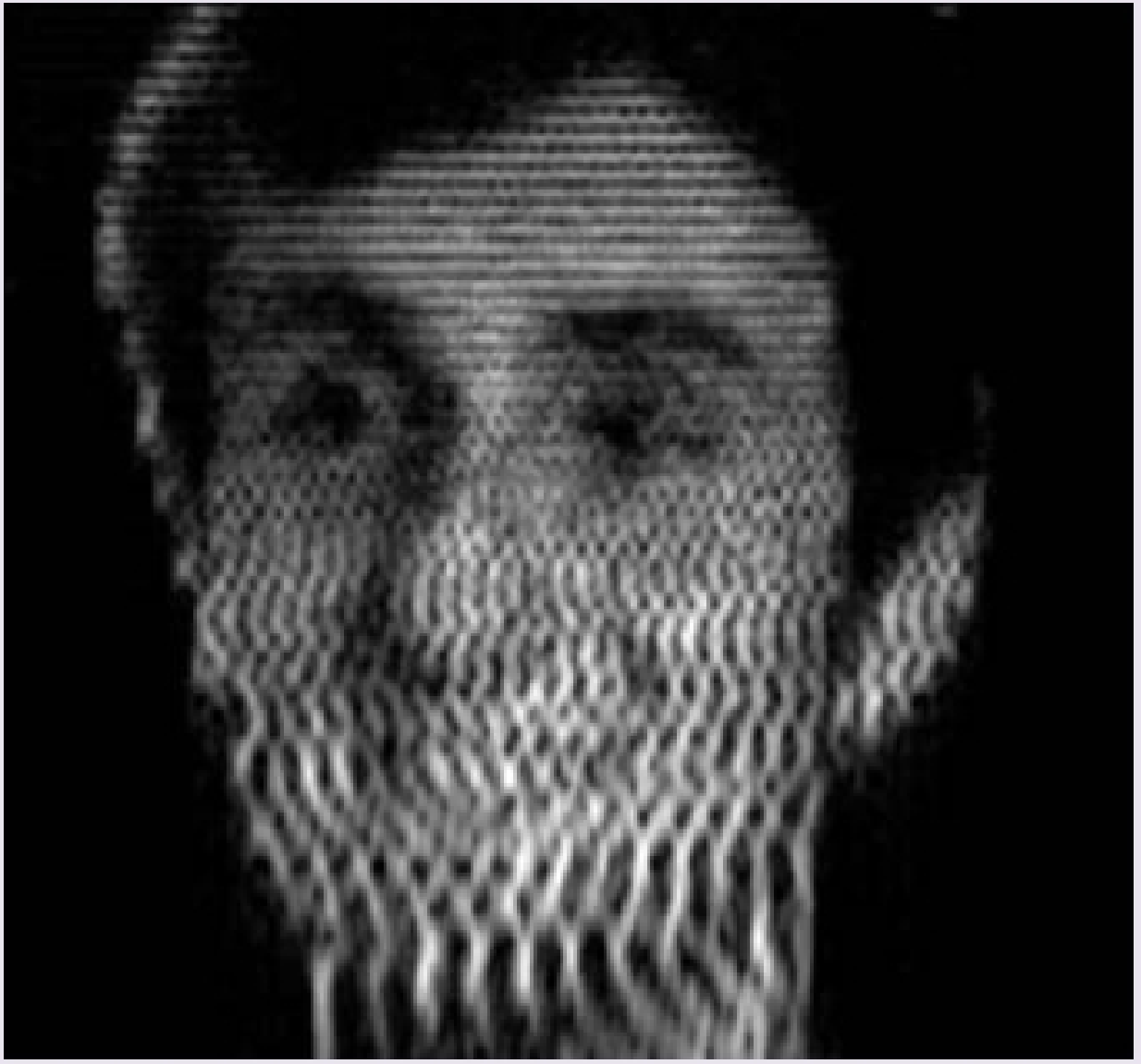
SEEING WITH SOUND?

A device that turns visual information into sound has been reported to create visual experience in at least one user, who is otherwise blind. The device involves mounting a small camera on a person's head, which captures a moment-by-moment view of what would normally be the person's visual field. This information is then turned into a "soundscape" that is played into the user's ears. As the person learns to recognize the physical qualities matching the sounds—for example, that a single high-pitched tone signifies a vertical surface—they seem to cease to hear it as a noise and instead experience it much like normal vision. One woman claims that her experience of "hearing" the environment is sometimes indistinguishable from seeing it.



SOUNDSCAPE
This image is a computer reconstruction of one second of sound, as "seen" by the system that builds soundscapes from camera images.