Cognitive Neuroscience of Language: 7: Visual information processing and the brain

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Goals

Look at how the brain represents visual information

Look at some of the implications for the processing of orthography (and the visual aspects of speech processing).

Reading for this lecture

Lavidor M., & Walsh, V. (2004). The nature of foveal representation. Nature *Reviews Neuroscience*, *5*, 729–735.

Juan, ,C-H., Walsh, V. (2002). Feedback to V1: a reverse hierarchy in vision. *Exp Brain Res*, *150*, 259–263.

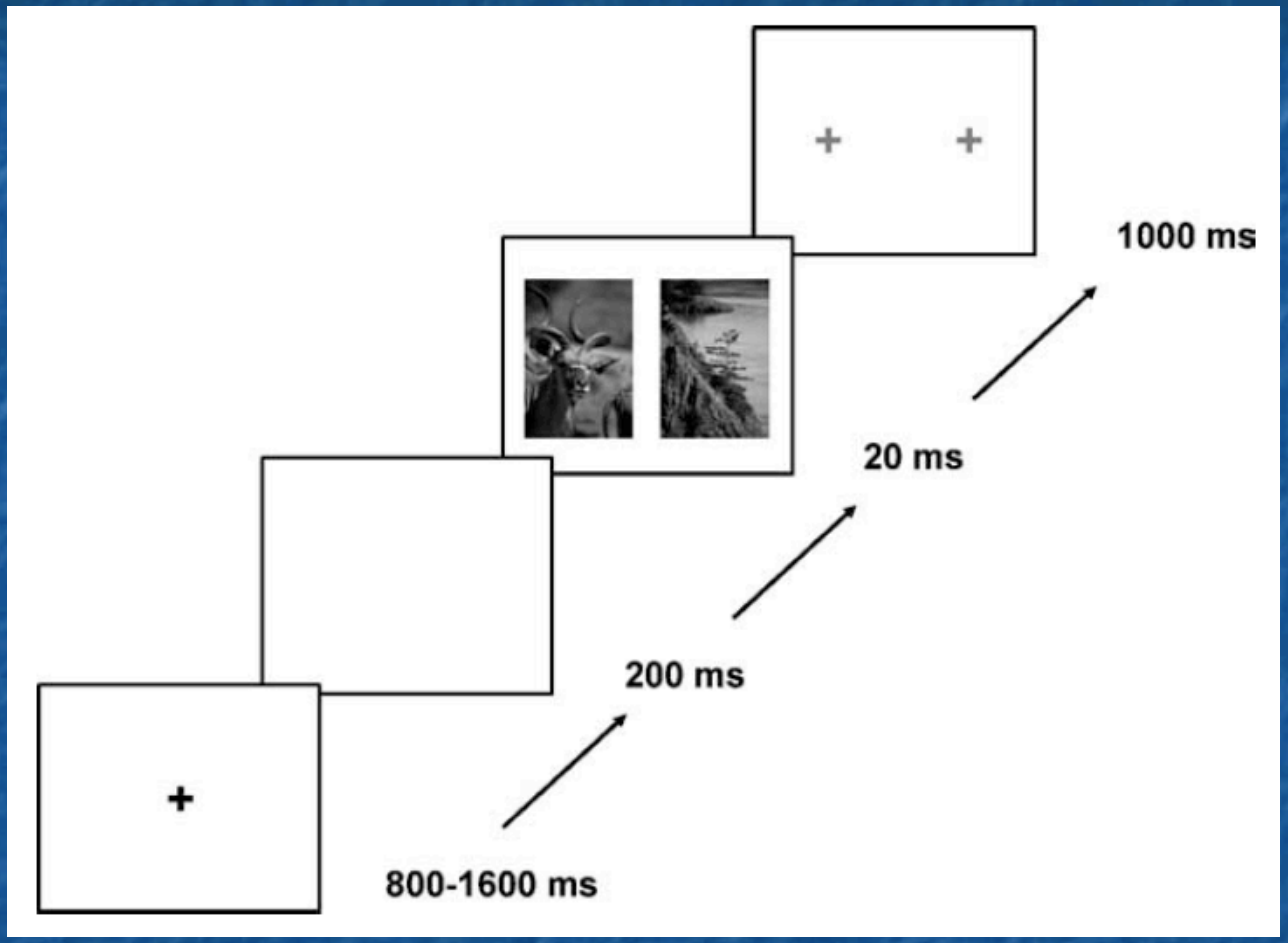
Functional requirements: crossmodal

The McGurk Effect (McGurk & MacDonald, 1976): visual and auditory information are fused in speech perception

Functional requirements: crossmodal

The McGurk Effect (McGurk & MacDonald, 1976): visual and auditory information are fused in speech perception

Functional requirements: speed



Ultra-rapid responding (120 msec) using a saccade to a high-level hemifield target (Kirchner & Thorpe, 2005)

Functional requirements: speed

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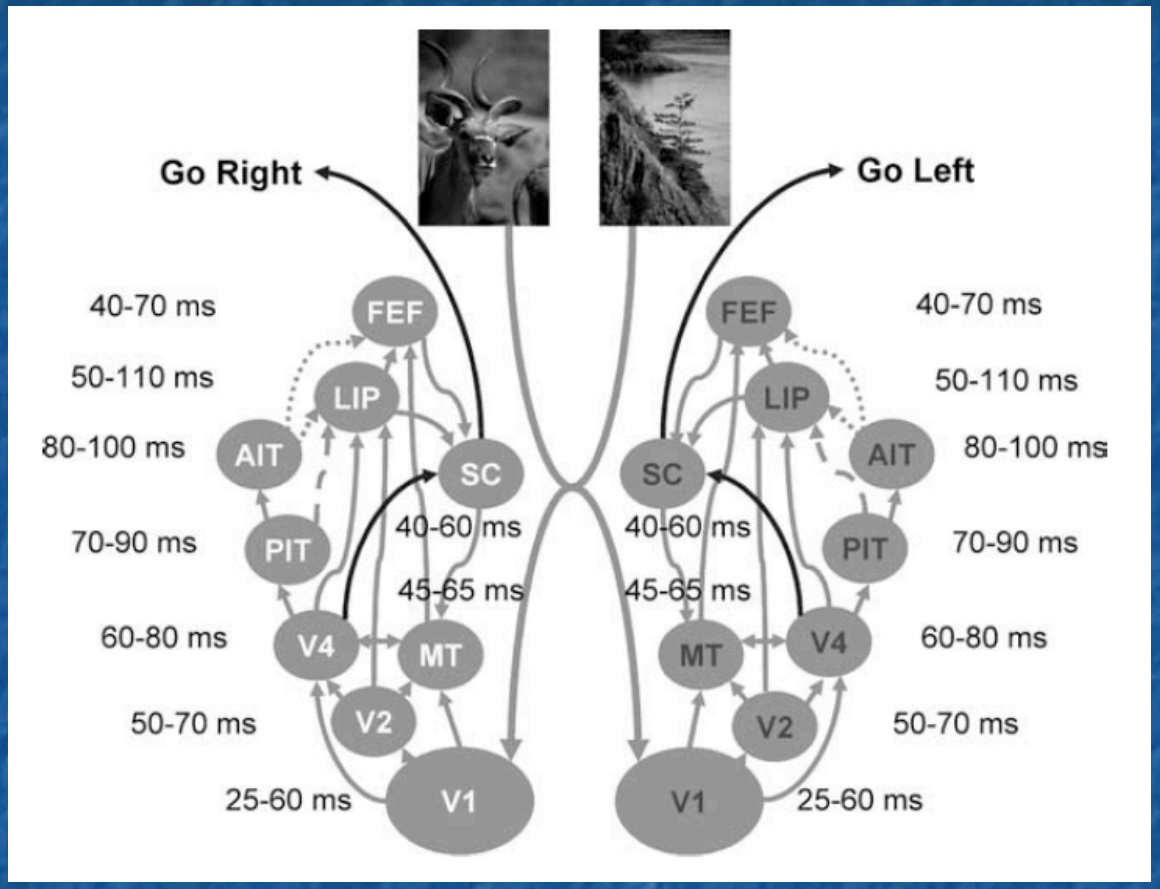
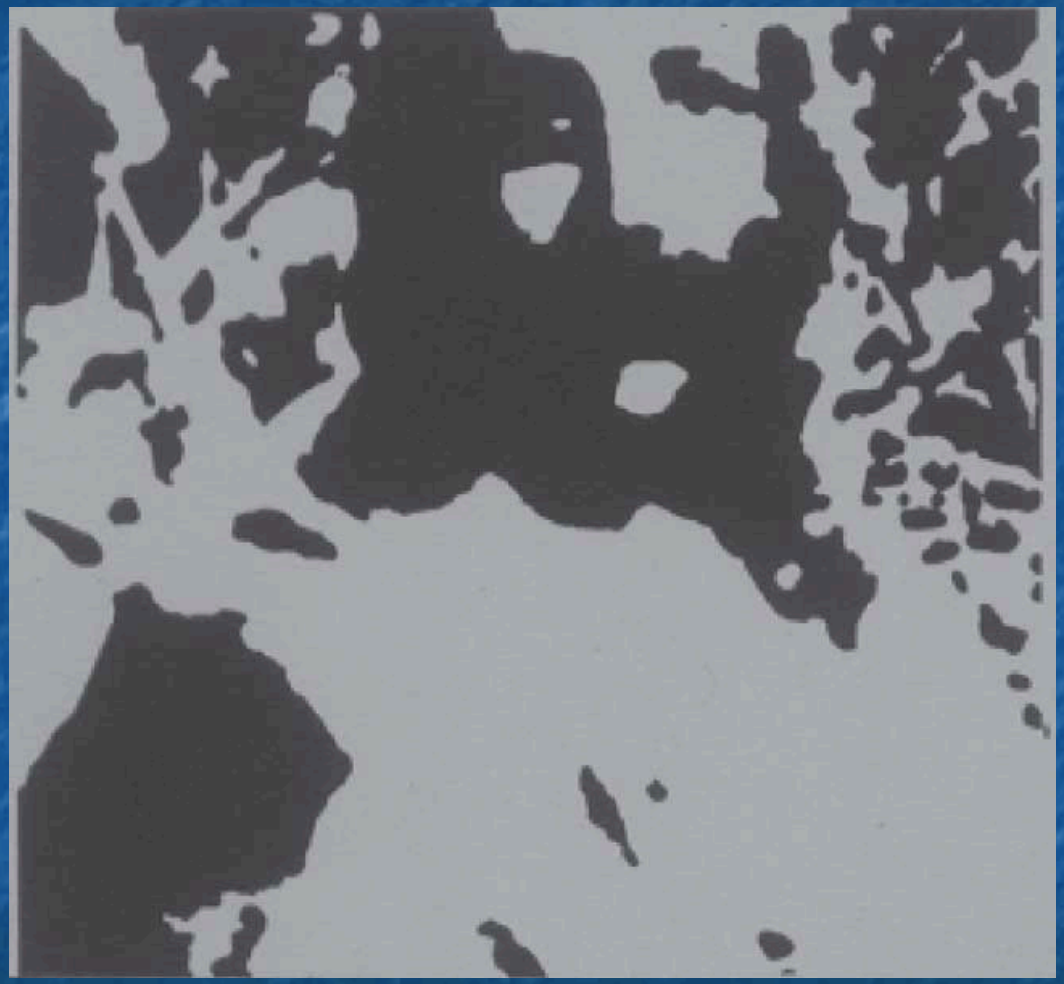
Functional requirements: speed



Rate coding may be too slow for such responding (Van Rullen & Thorpe, 2001)

Functional requirements: learning



One-shot learning is often extraordinary resilient

Functional requirements: learning

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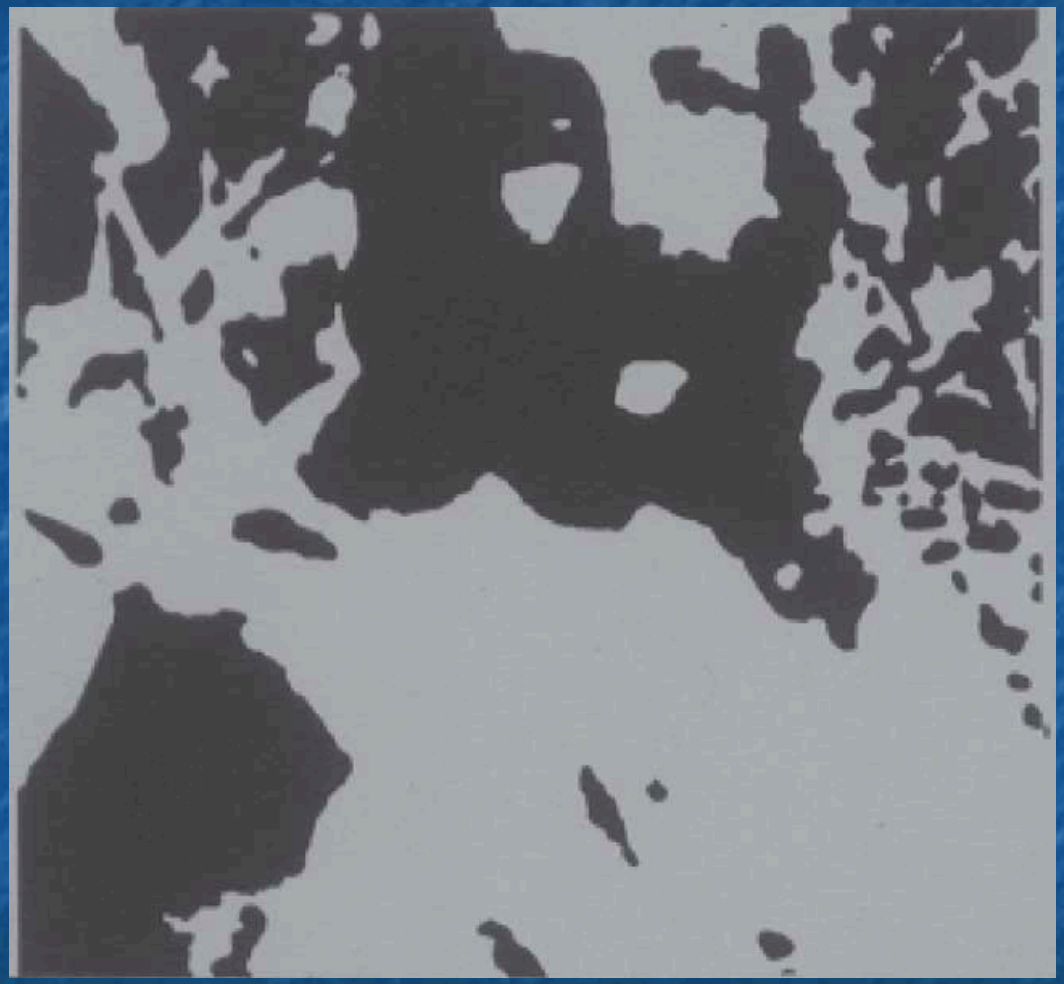
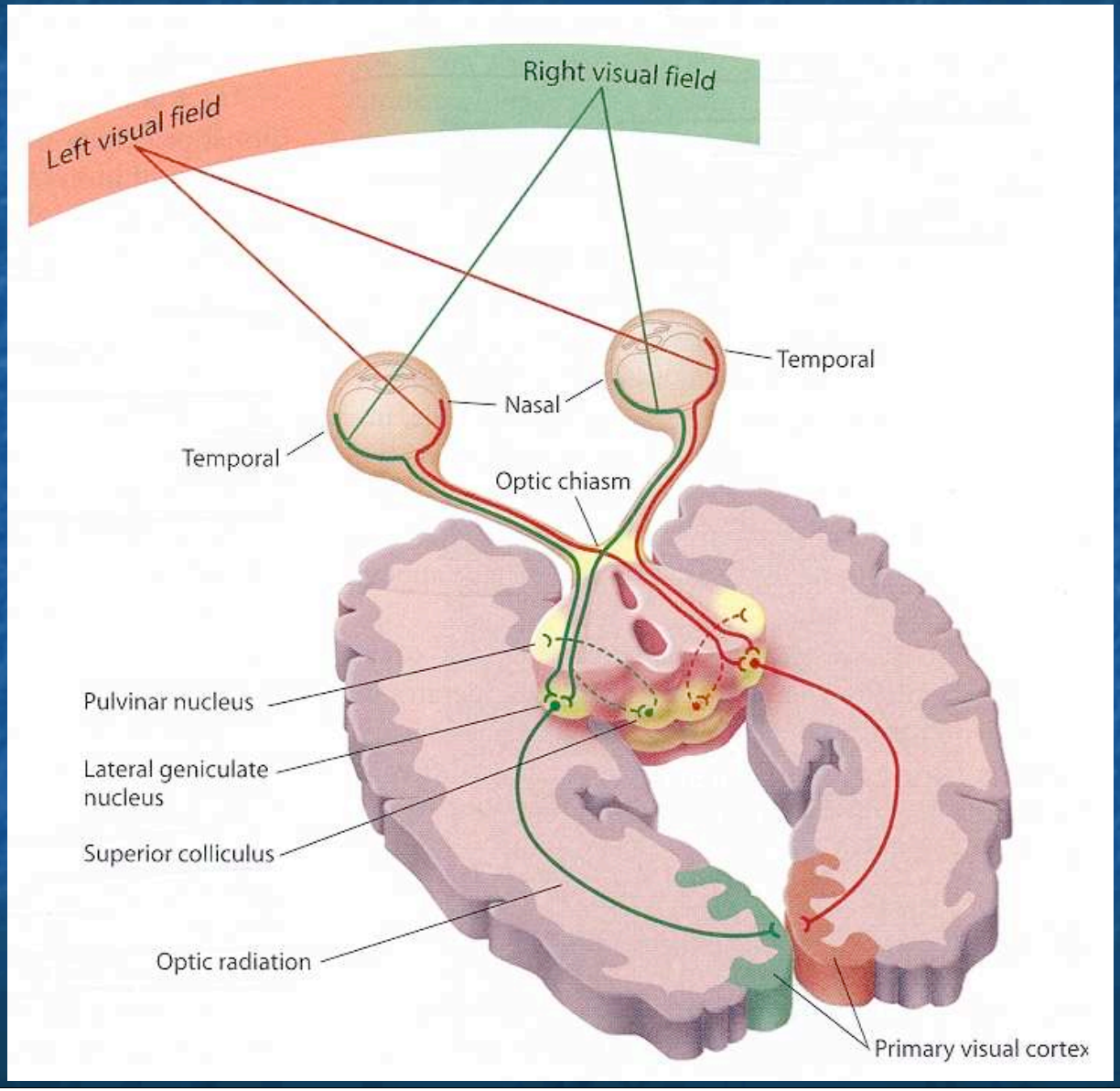


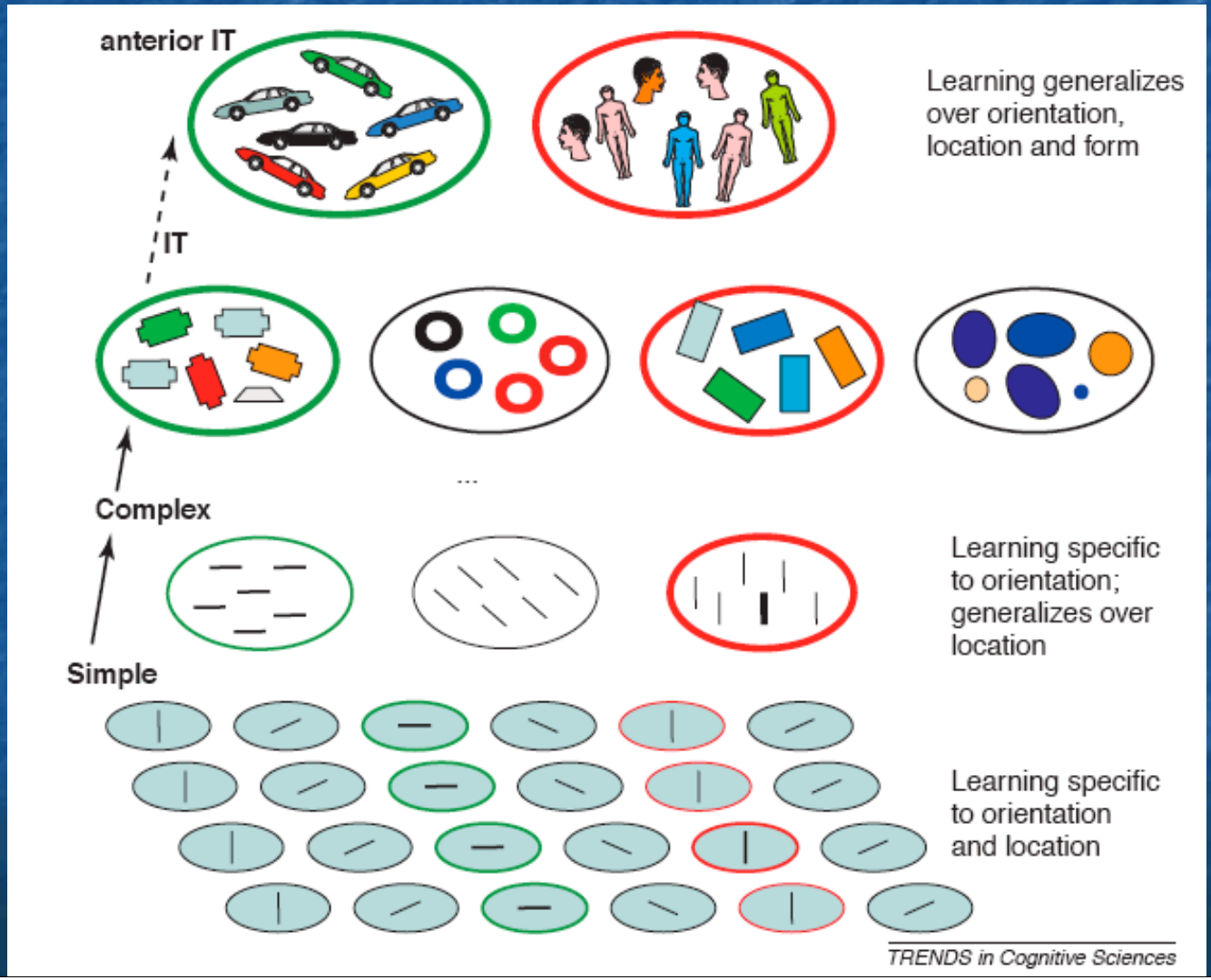
One-shot learning is often extraordinary resilient

The whole pathway



Functional requirements: learning

Ahissar & Hochstein (2004)



Functional requirements: learning

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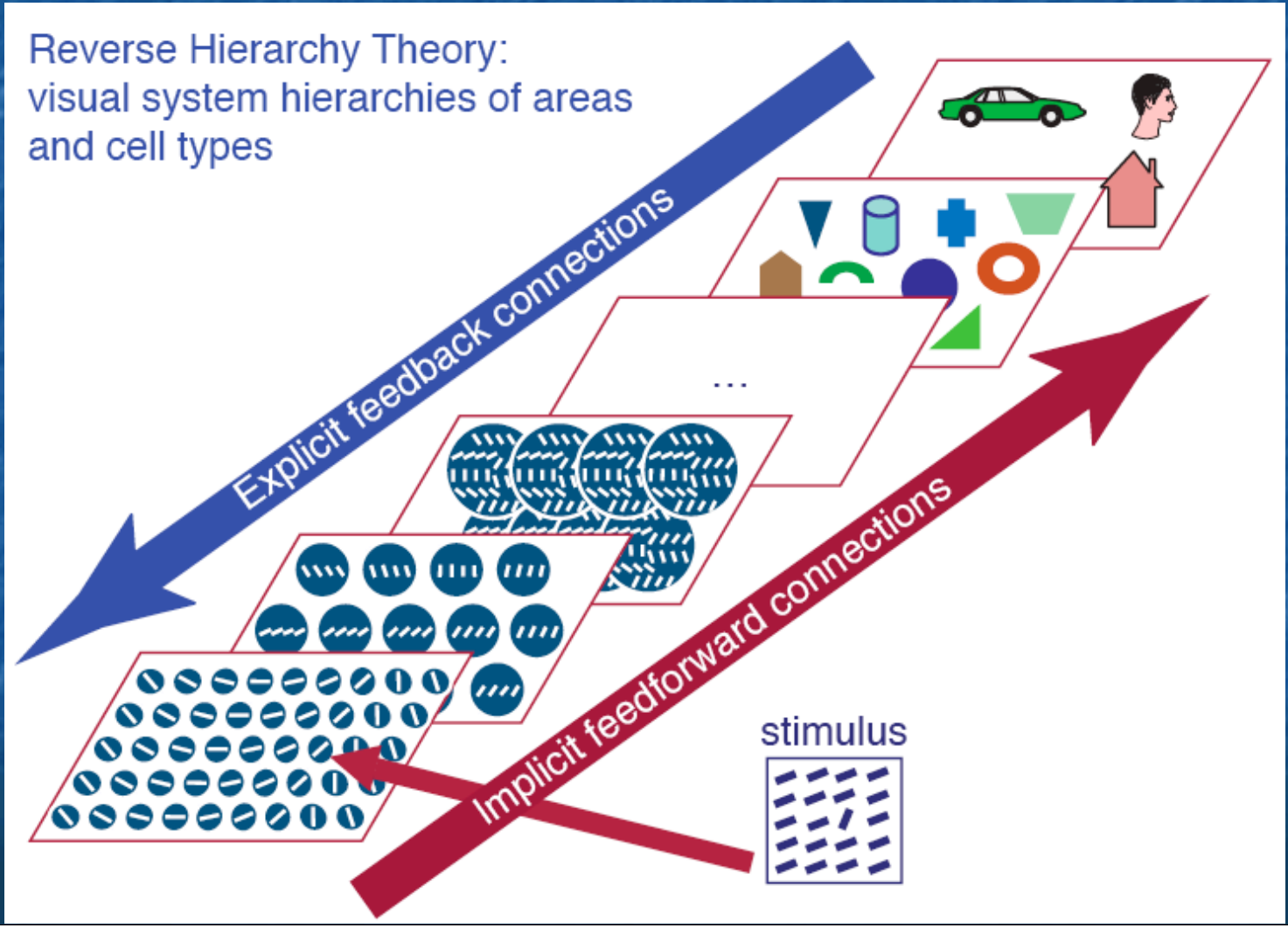


Functional requirements: learning

Ahissar & Hochstein (2004)

High-level representations are necessarily noisy and tolerant of deviation, but they are fast and reflect real-world categories

Attention is (possibly) necessary to increase the weighting of lower-level processing so as to make finer discriminations

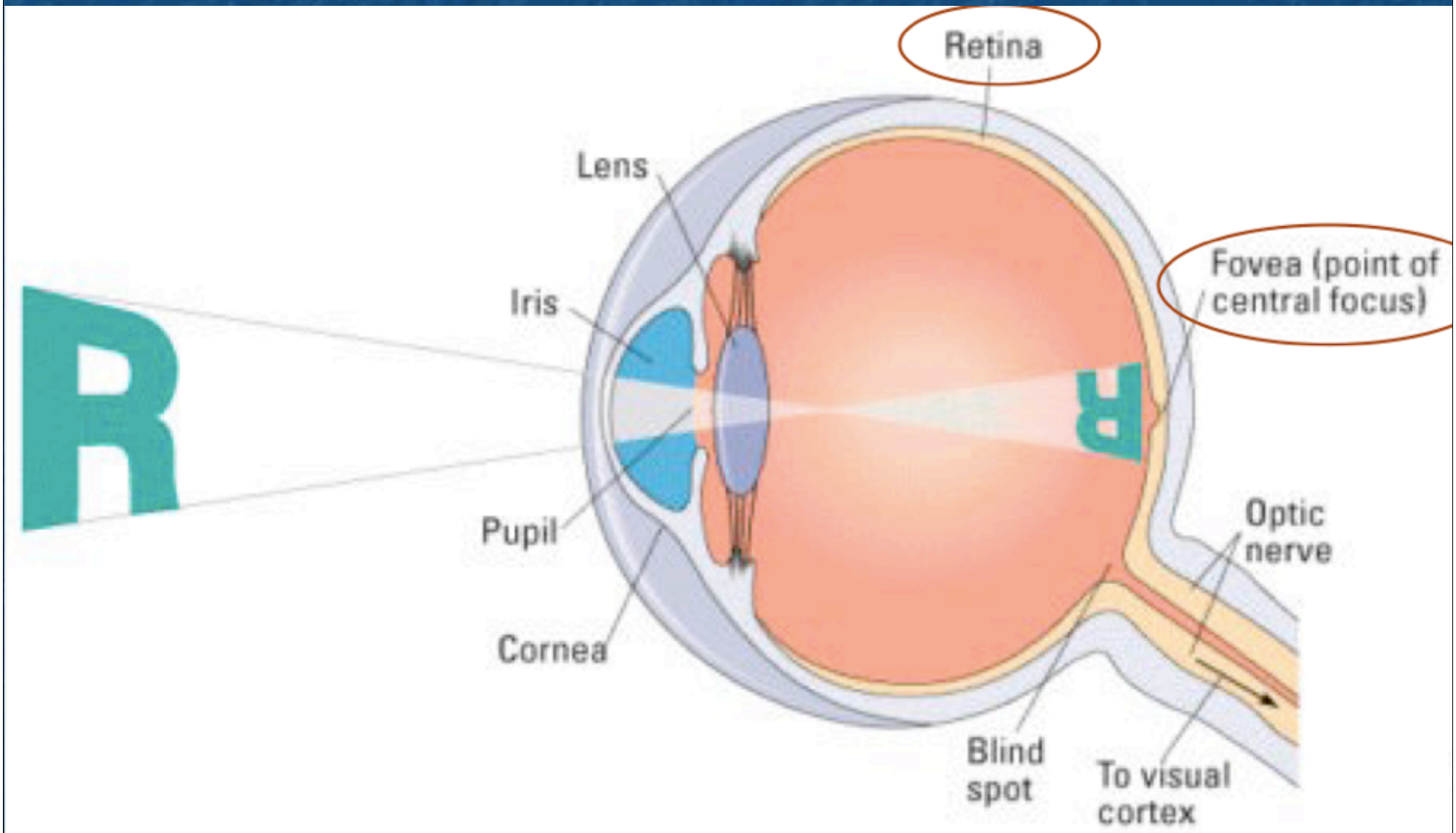
Population coding is assumed

Functional requirements: features

Pelli, Farrell & Moore (2003)

There is an argument that visual word recognition always proceeds by features, not whole words

Within the eyes



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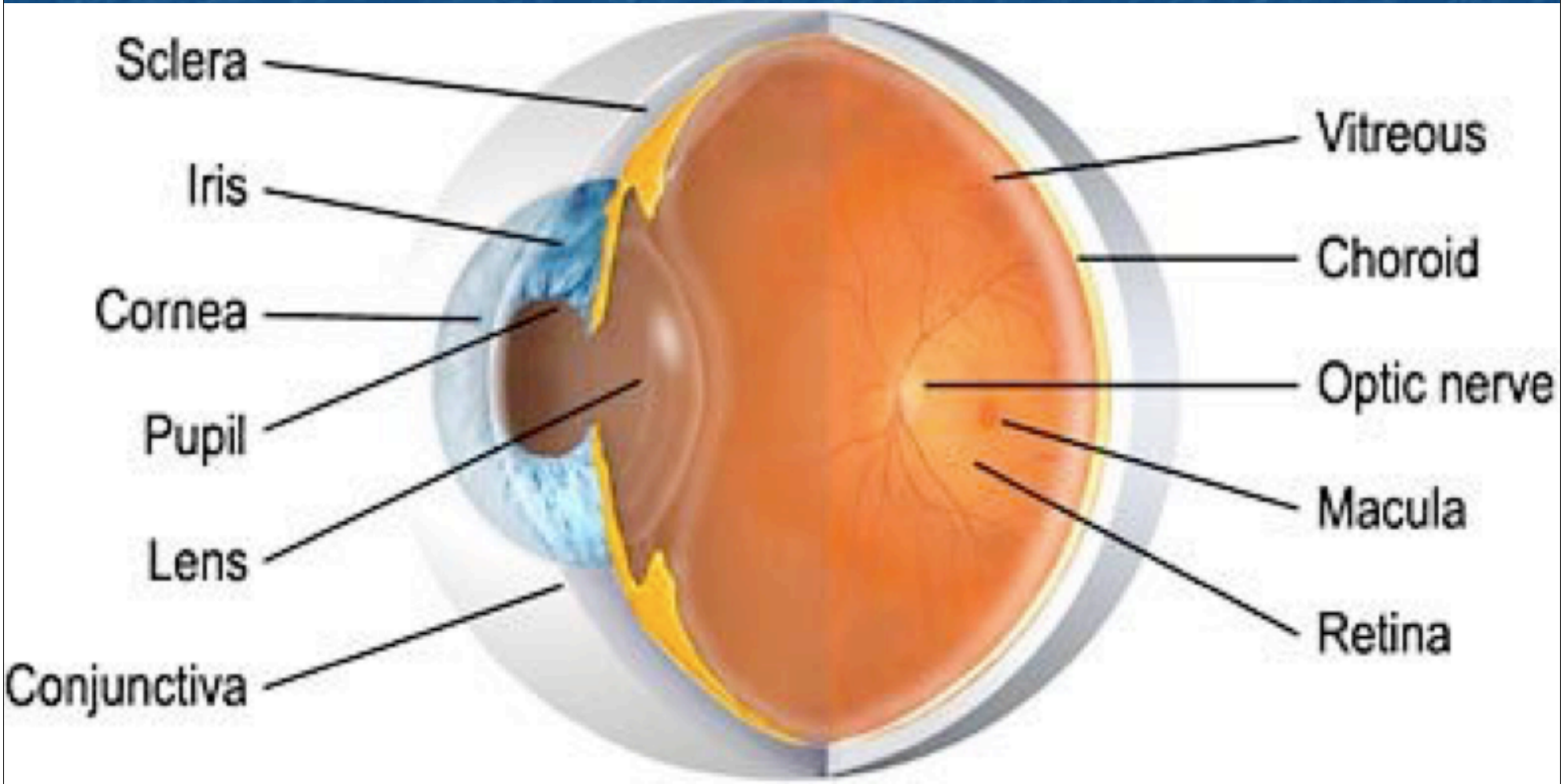

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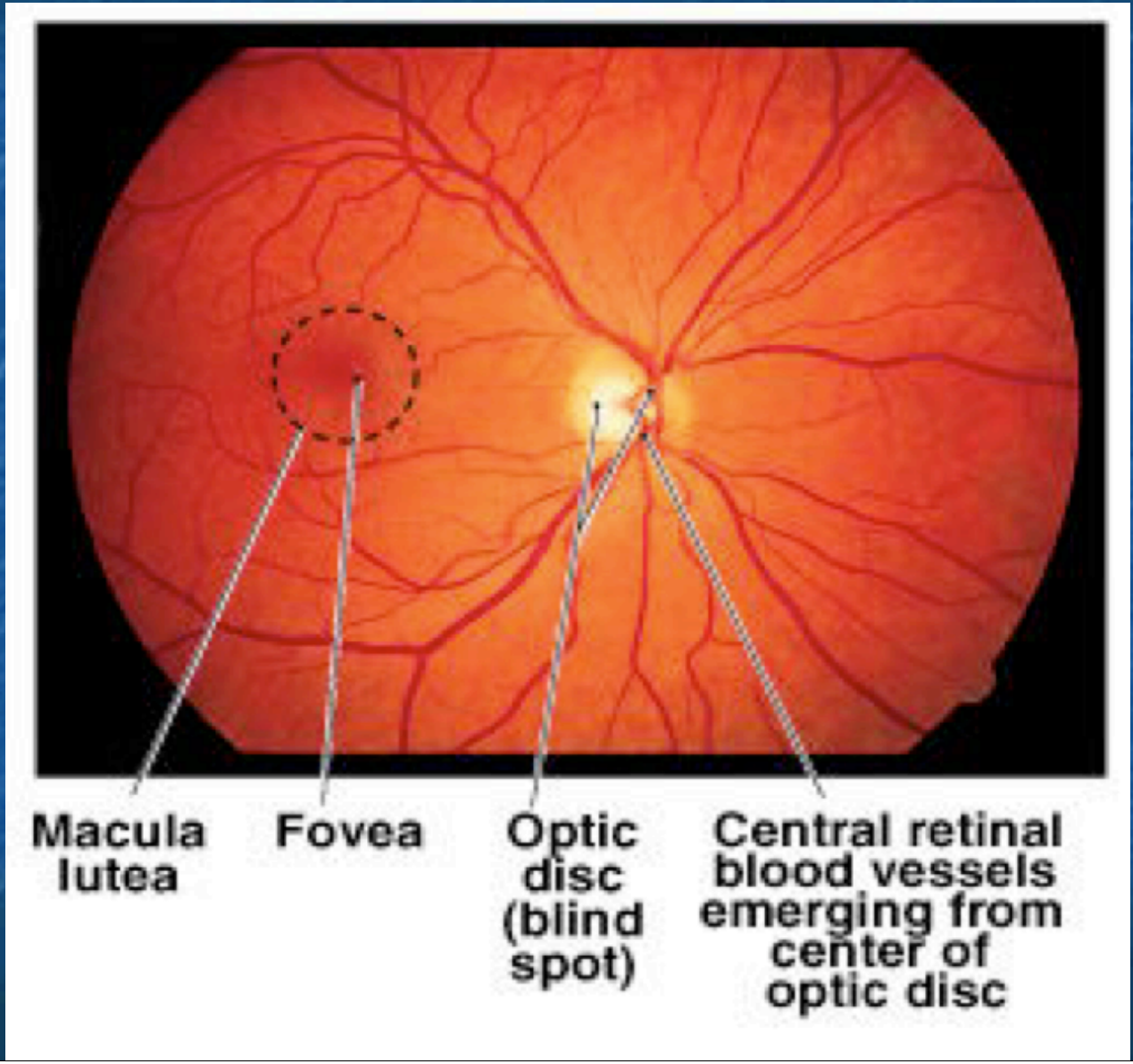

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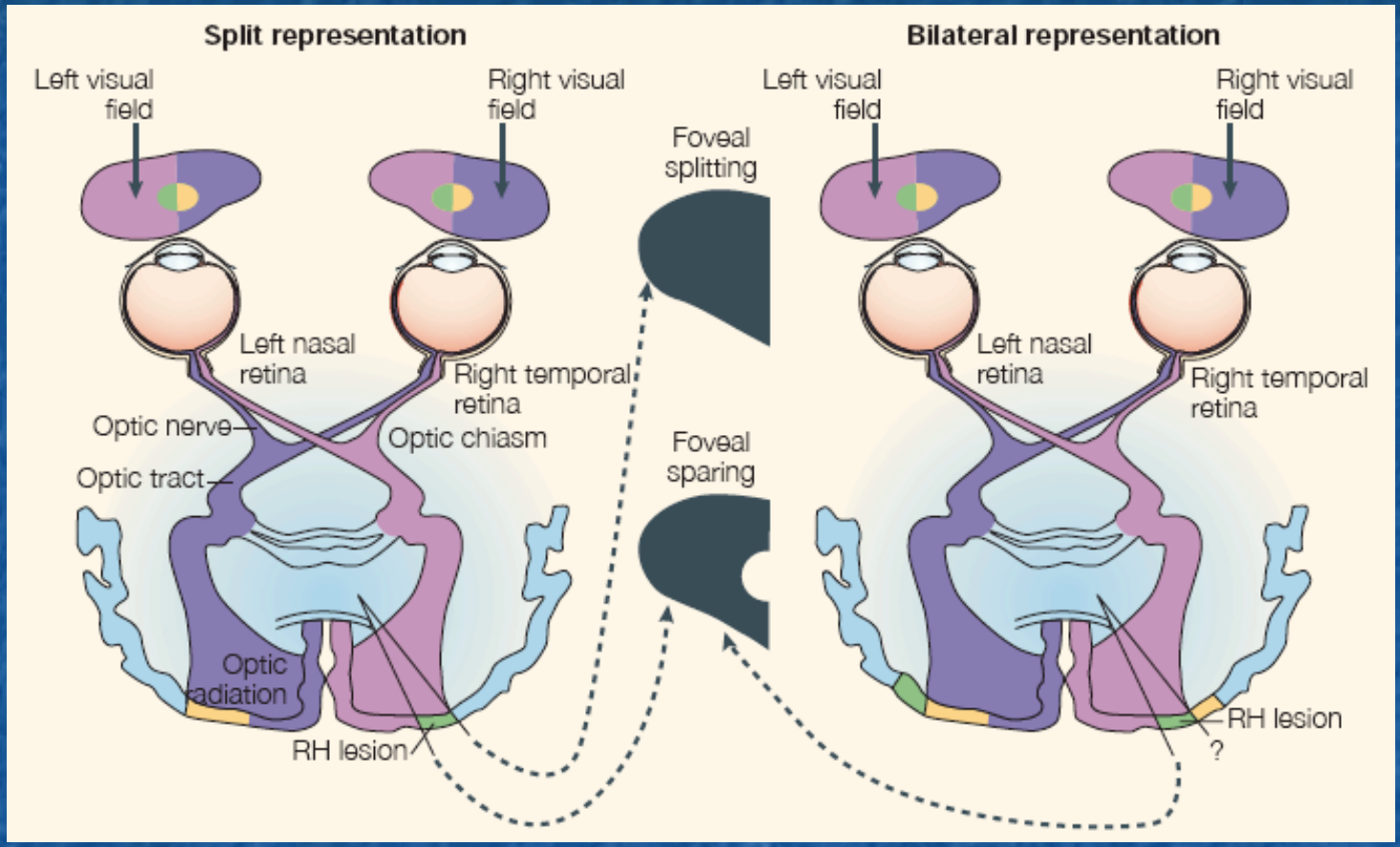
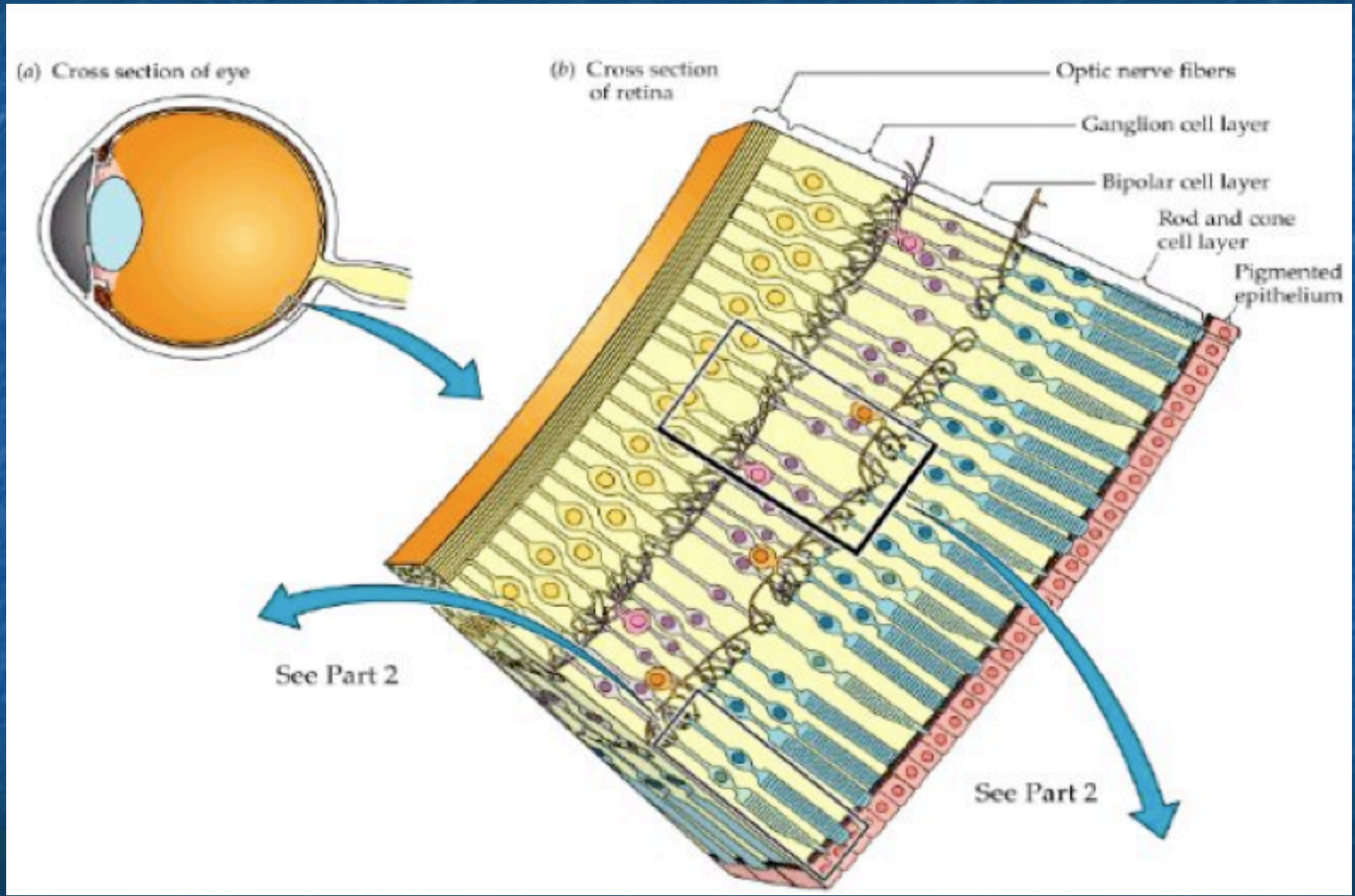


The human fovea seems to be precisely vertically split (see Lavidor & Walsh, 2004, for a review)

Within the eyes



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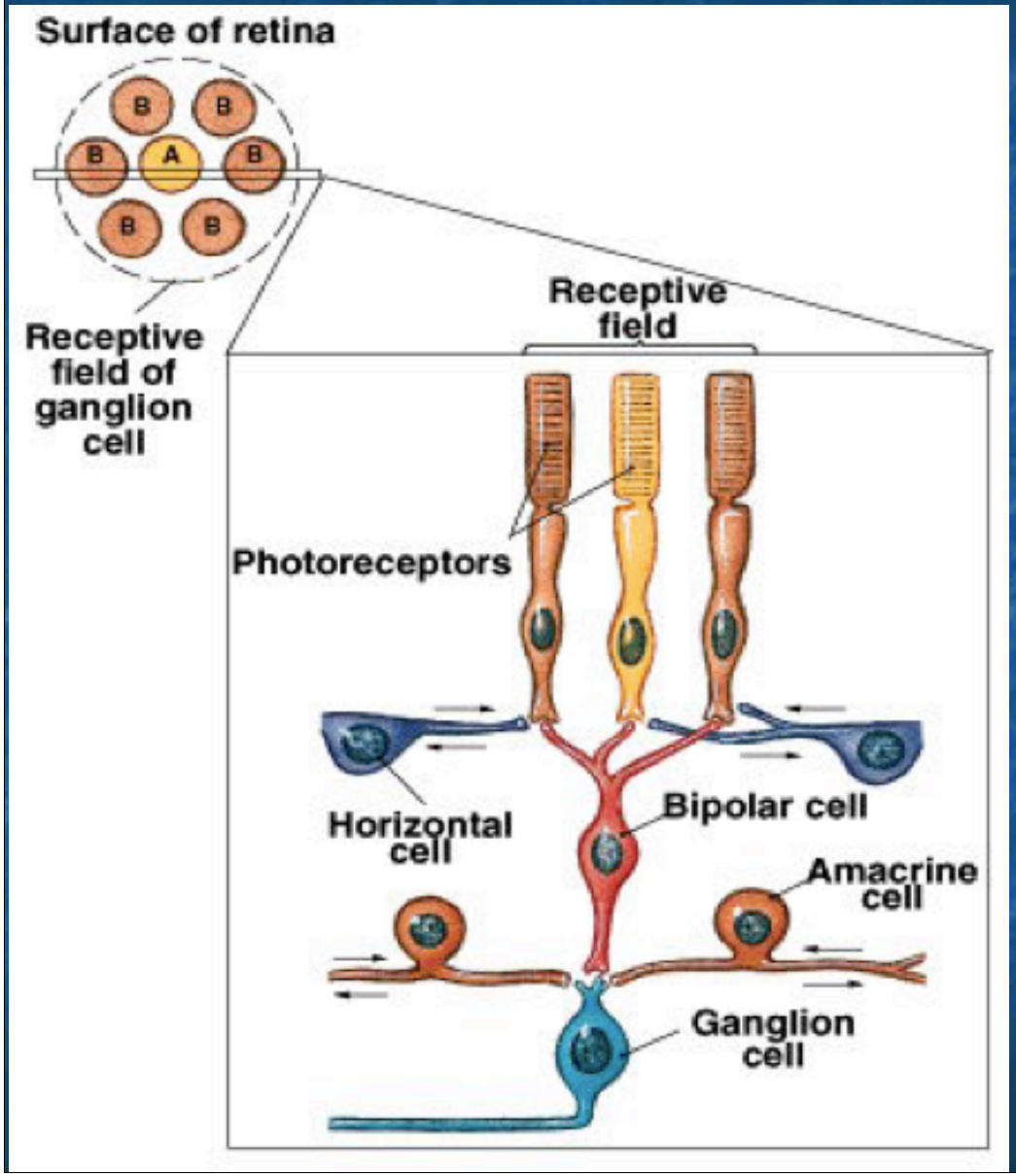
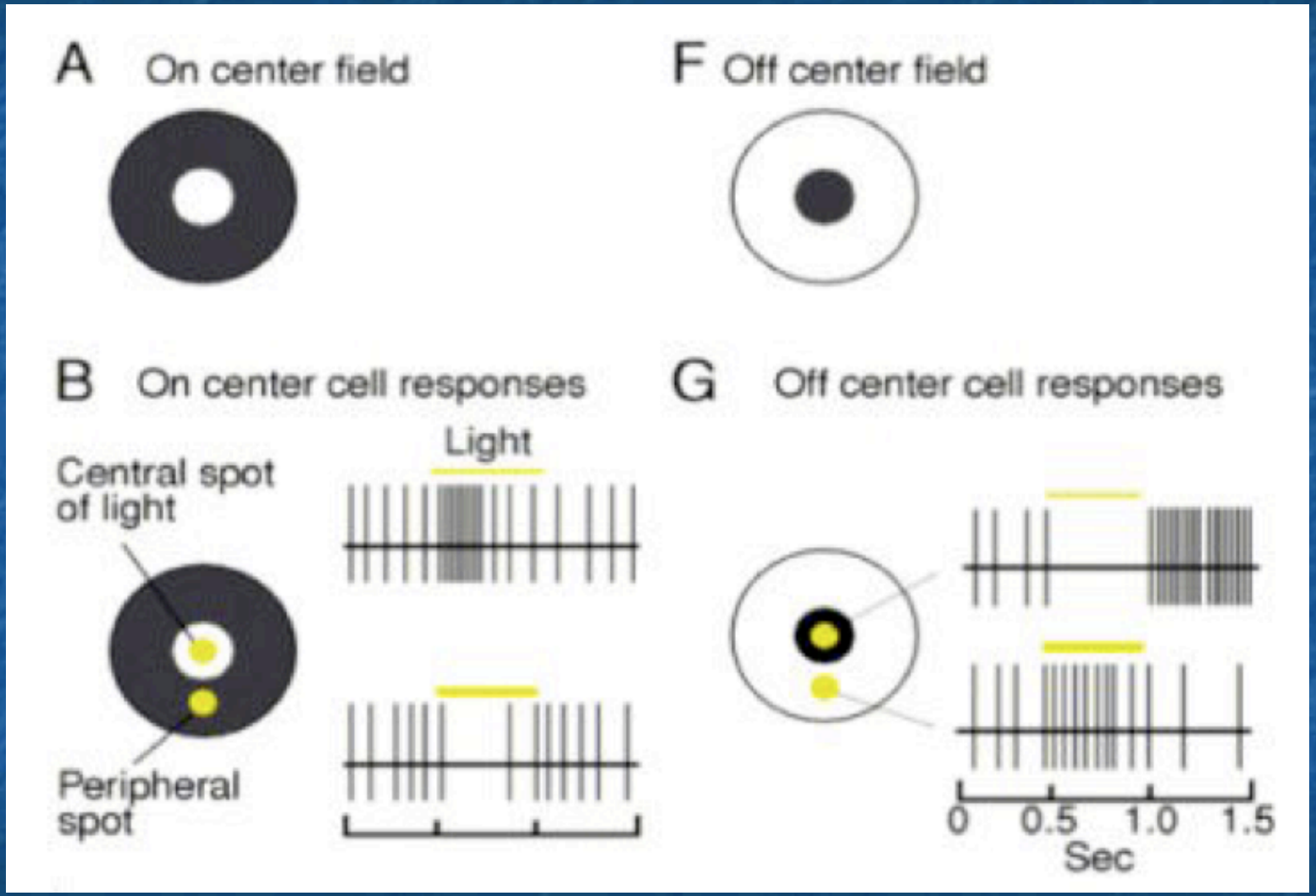


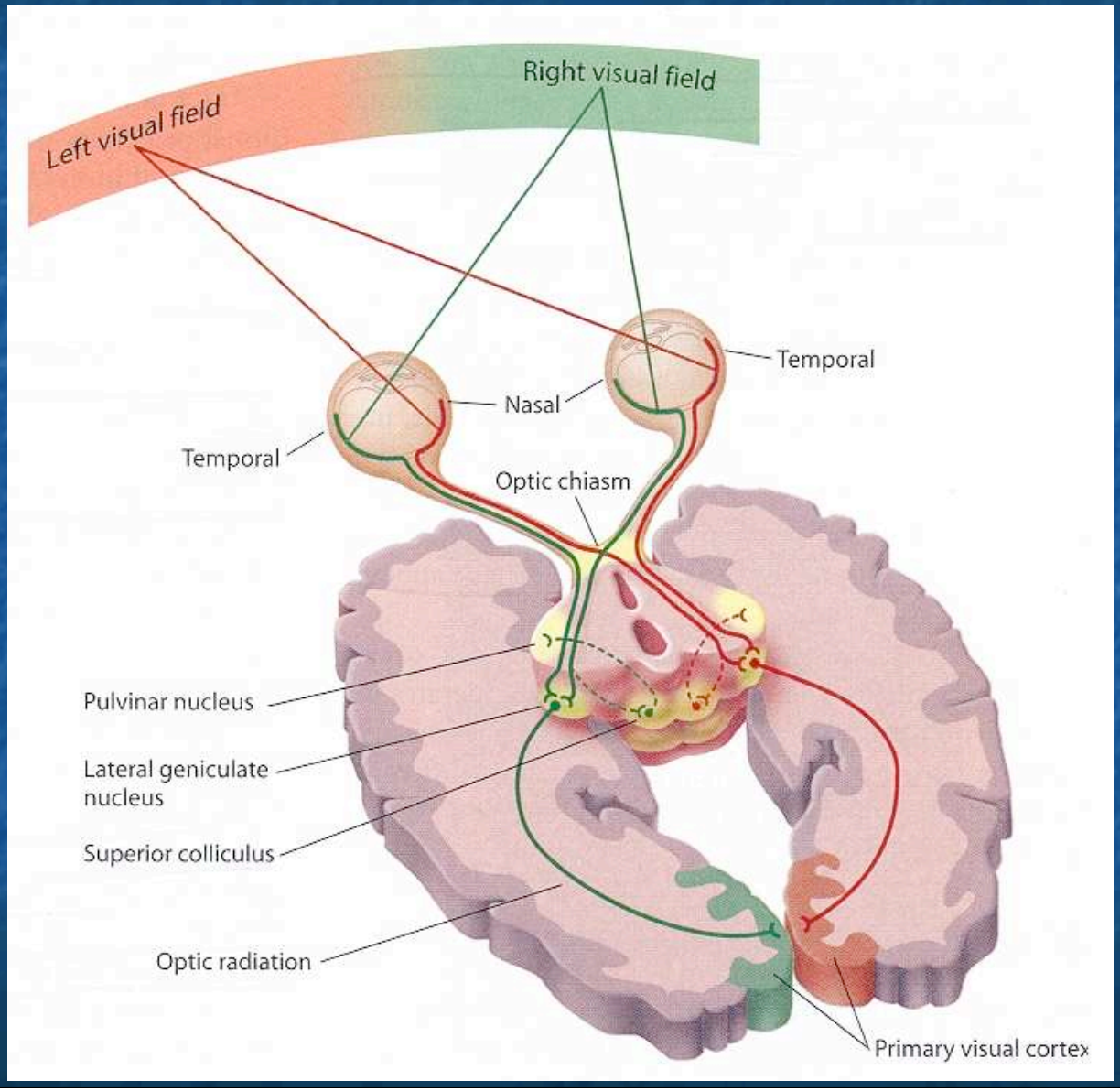
There are two synapses between the receptors and the brain, allowing for encoding into receptive fields.

Within the eyes

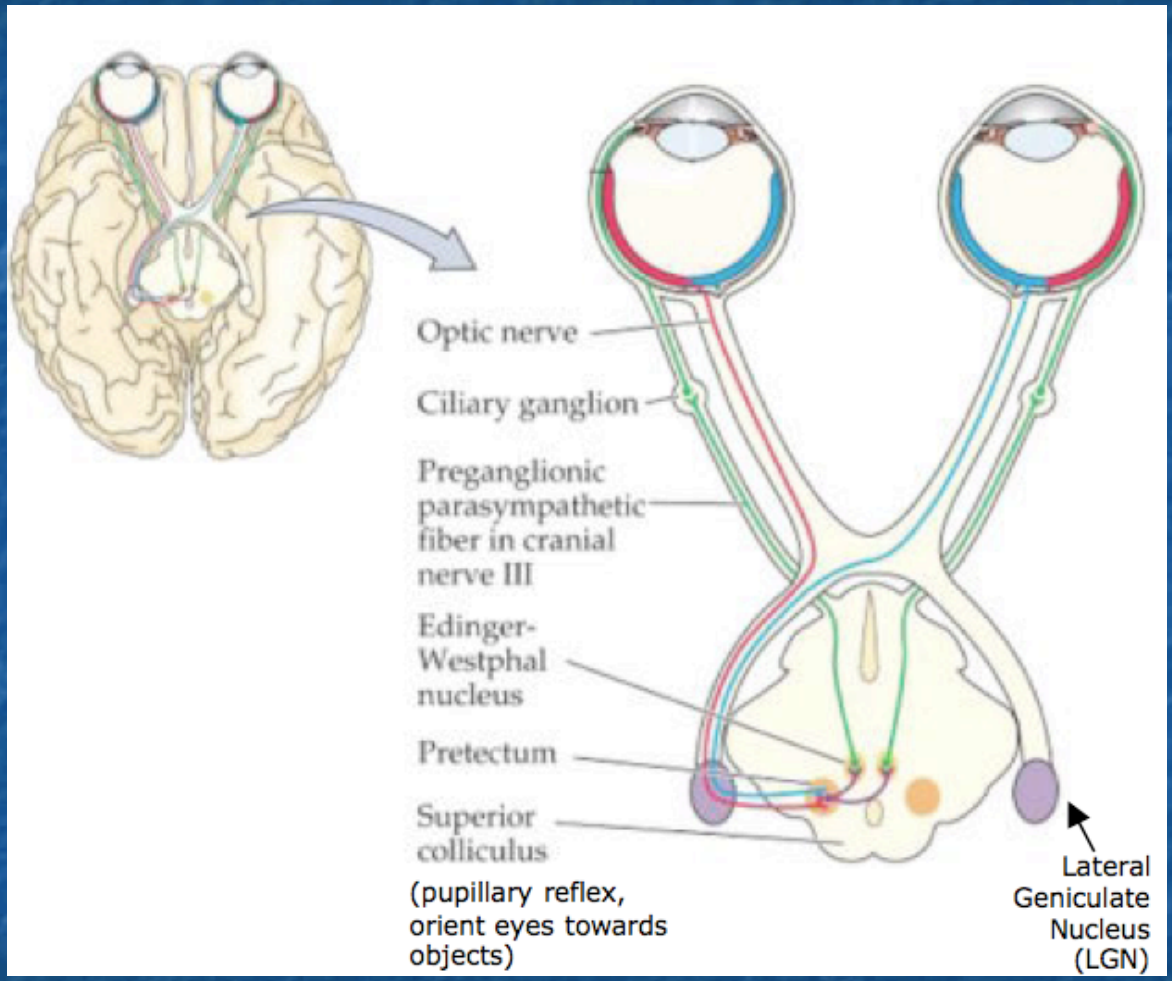


Receptive fields at the retina

The whole pathway

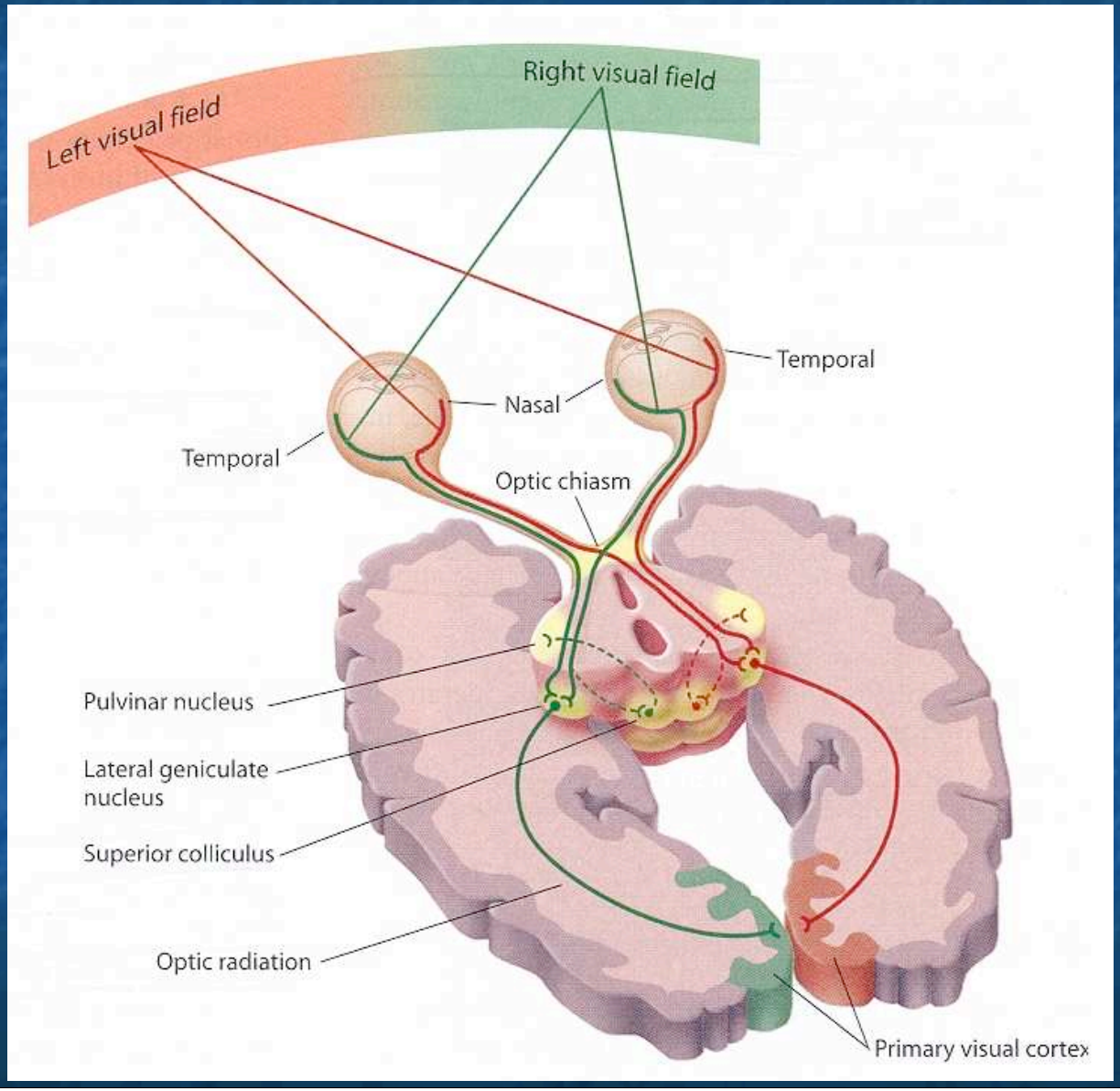


Within the optic chiasma

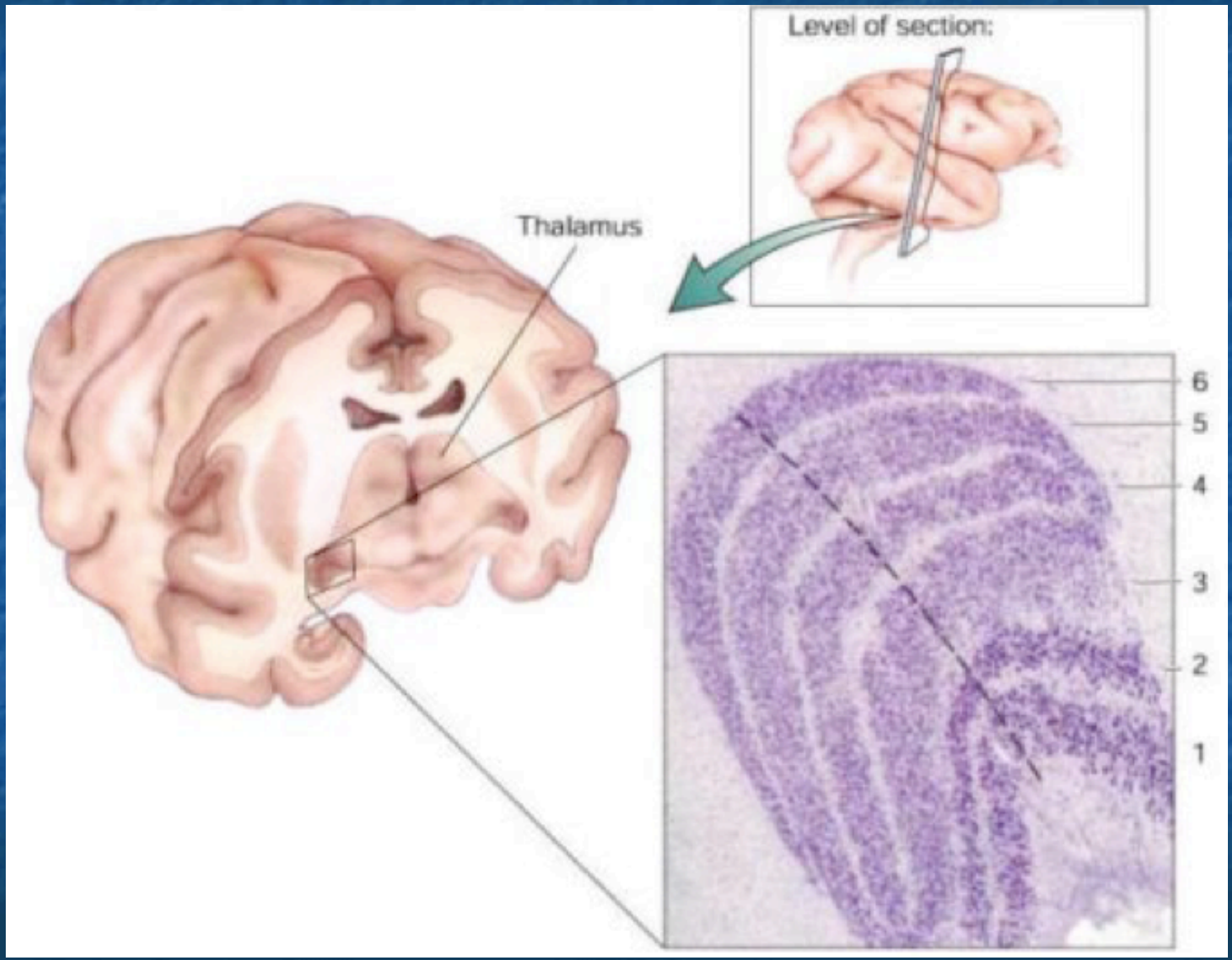


The two pairs of retinal hemifields are divided at the optic chiasma

The whole pathway



Within the lateral geniculate nucleus



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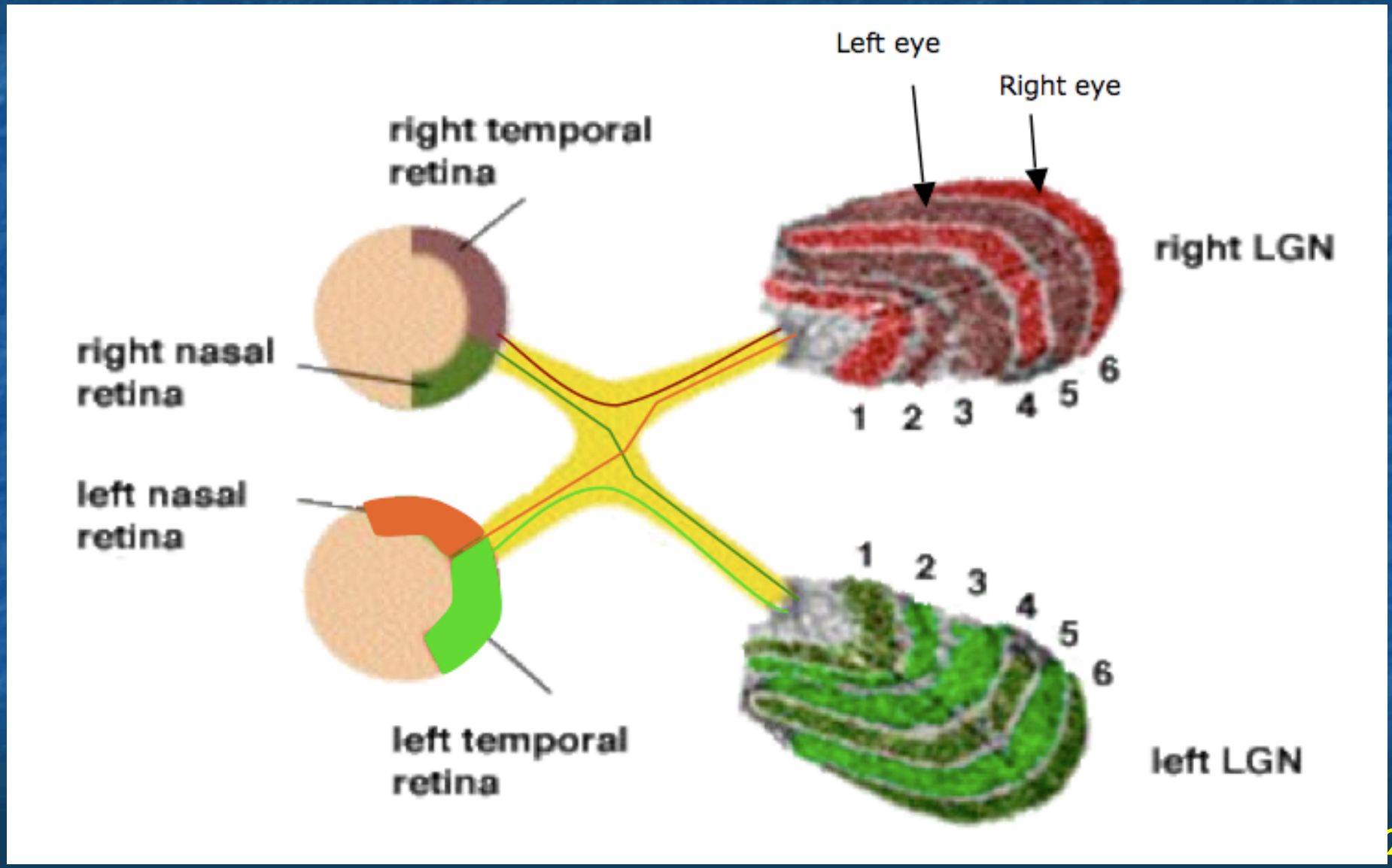
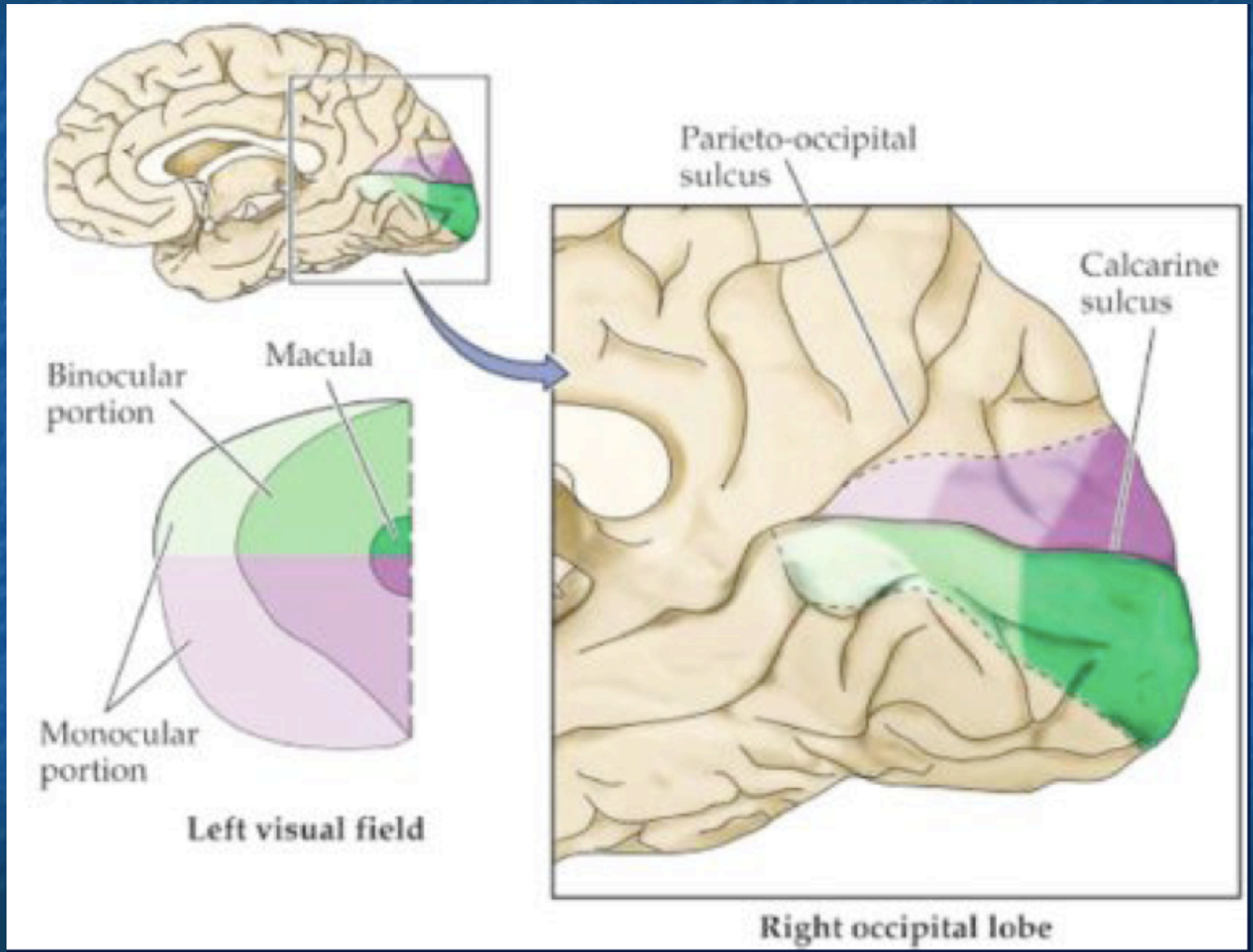


Within the lateral geniculate nucleus

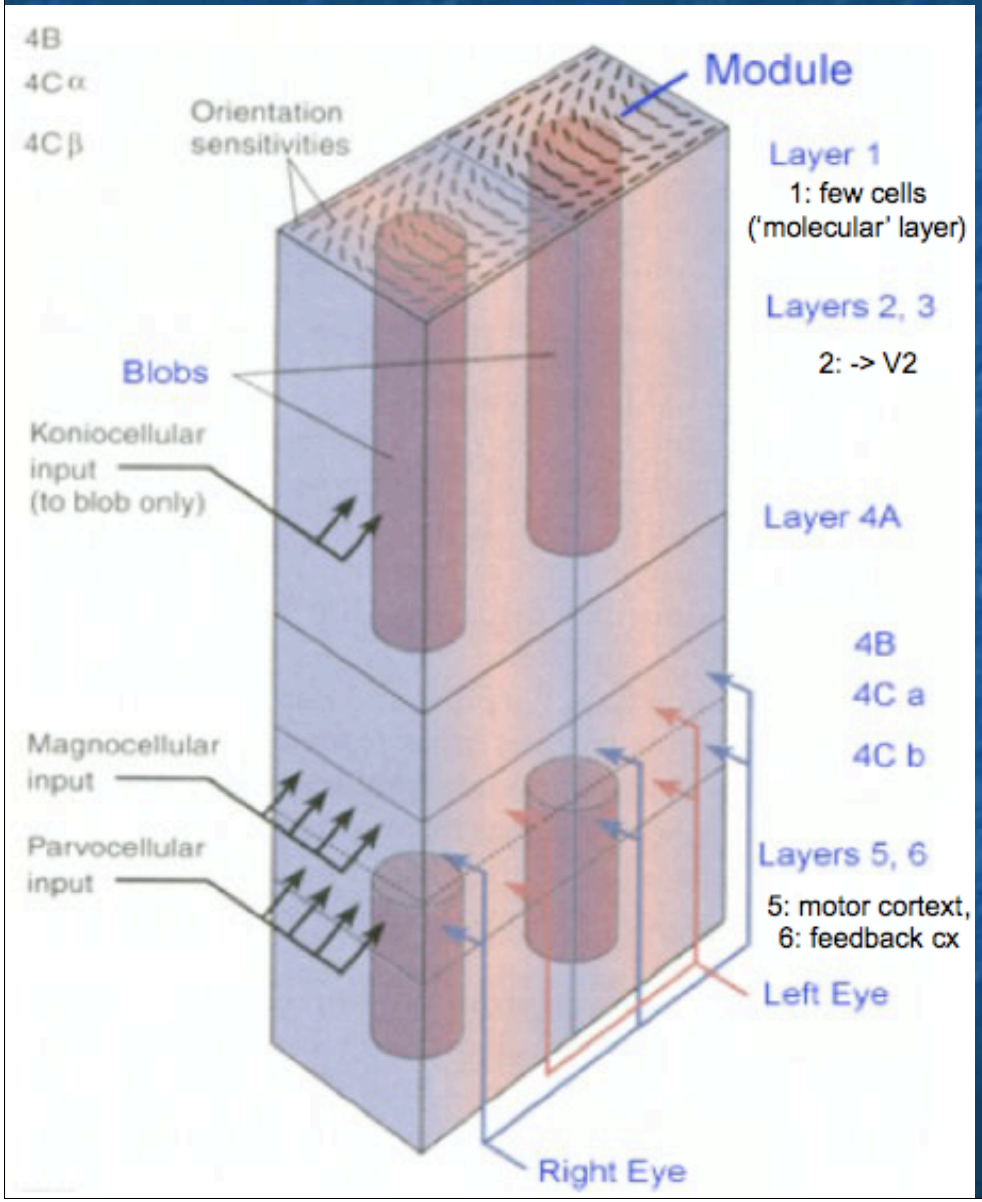
The relatively slow *parvocellular* neurons predominate, and are more concerned with sustained representations of colour, and high spatial frequencies (fine detail)

The minority of *magnocellular* neurons transmit information fast, and are concerned with transient representations of low spatial frequencies (blurrier shapes) and movement

Within the visual cortex



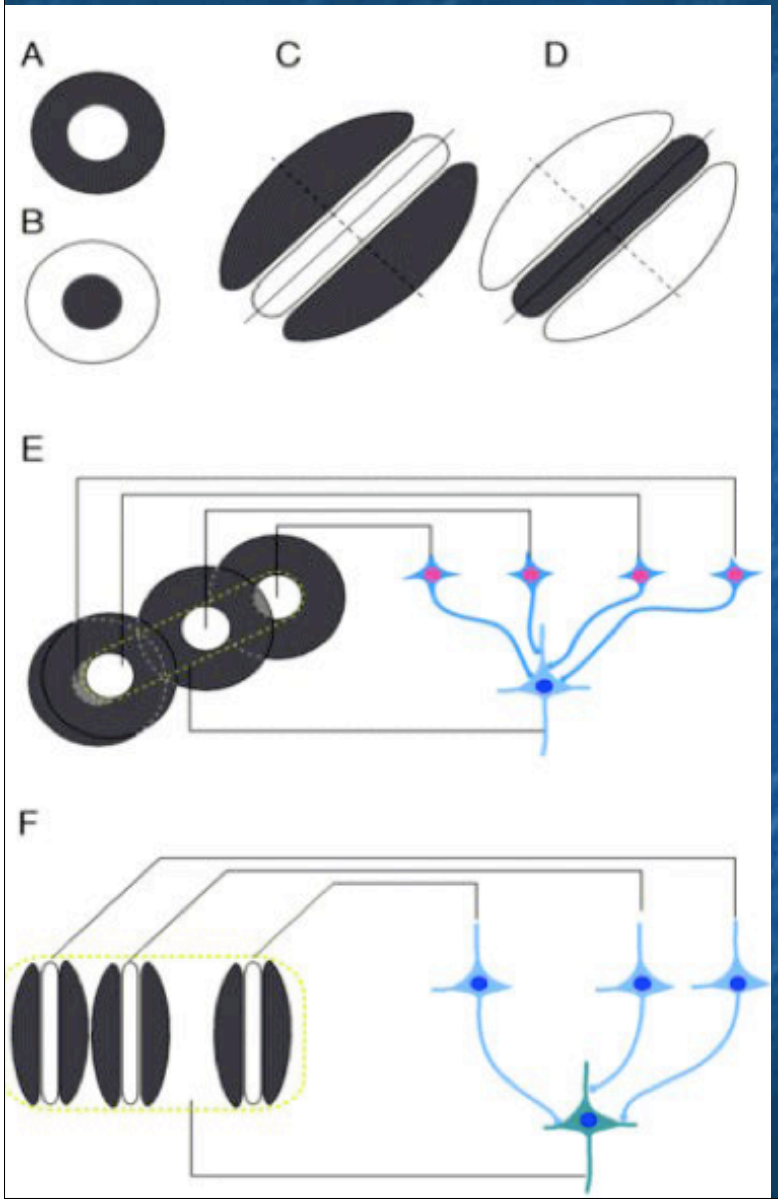
Within the visual cortex



The cortical surface is divided up into functionally distinct microcolumns, each about 30 μm in diameter

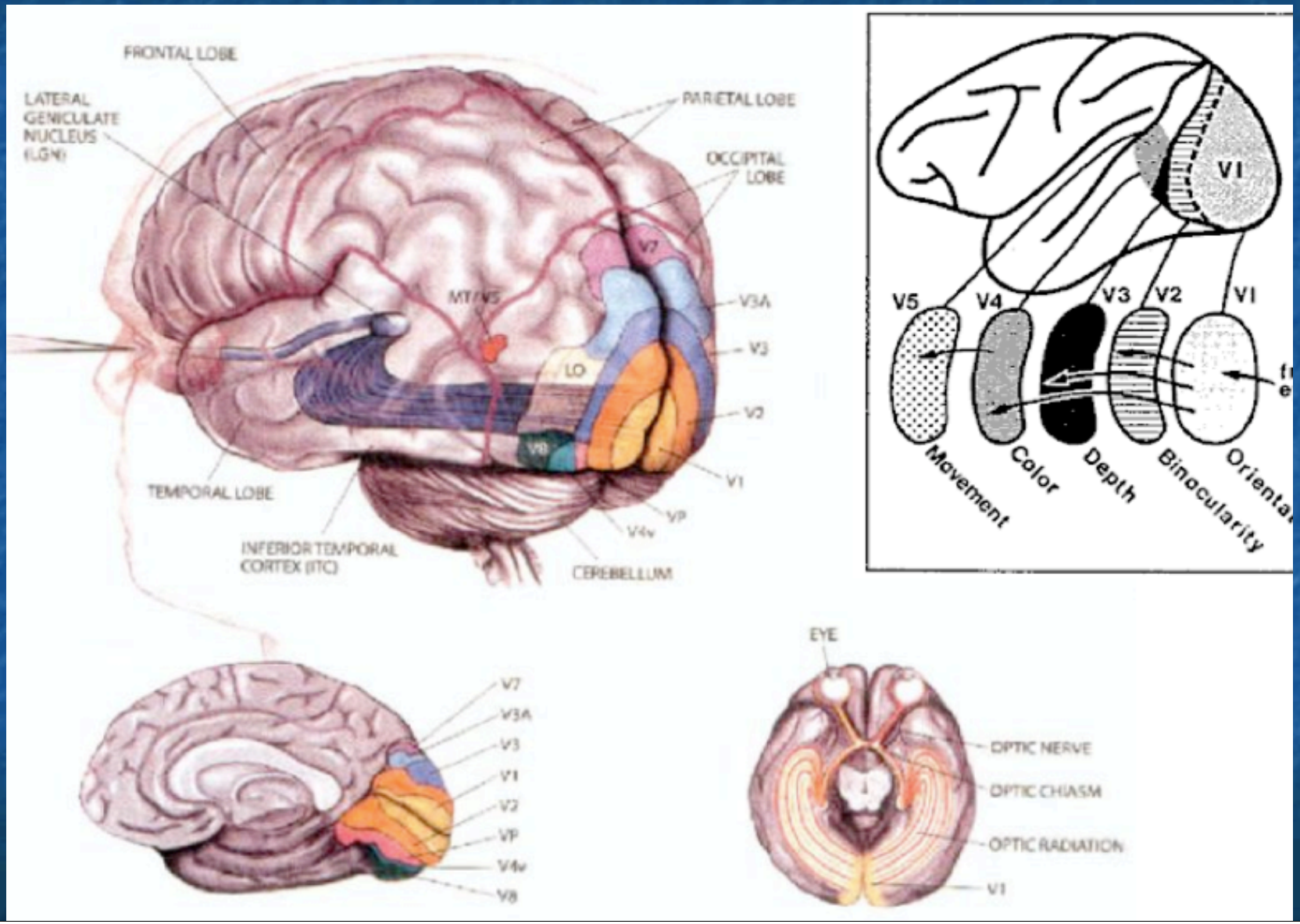
They tend to increase and decrease their firing rates together

Within the visual cortex



Hubel and Wiesel defined simple and complex cells in the visual cortex, the latter responding to movement

Within the visual cortex



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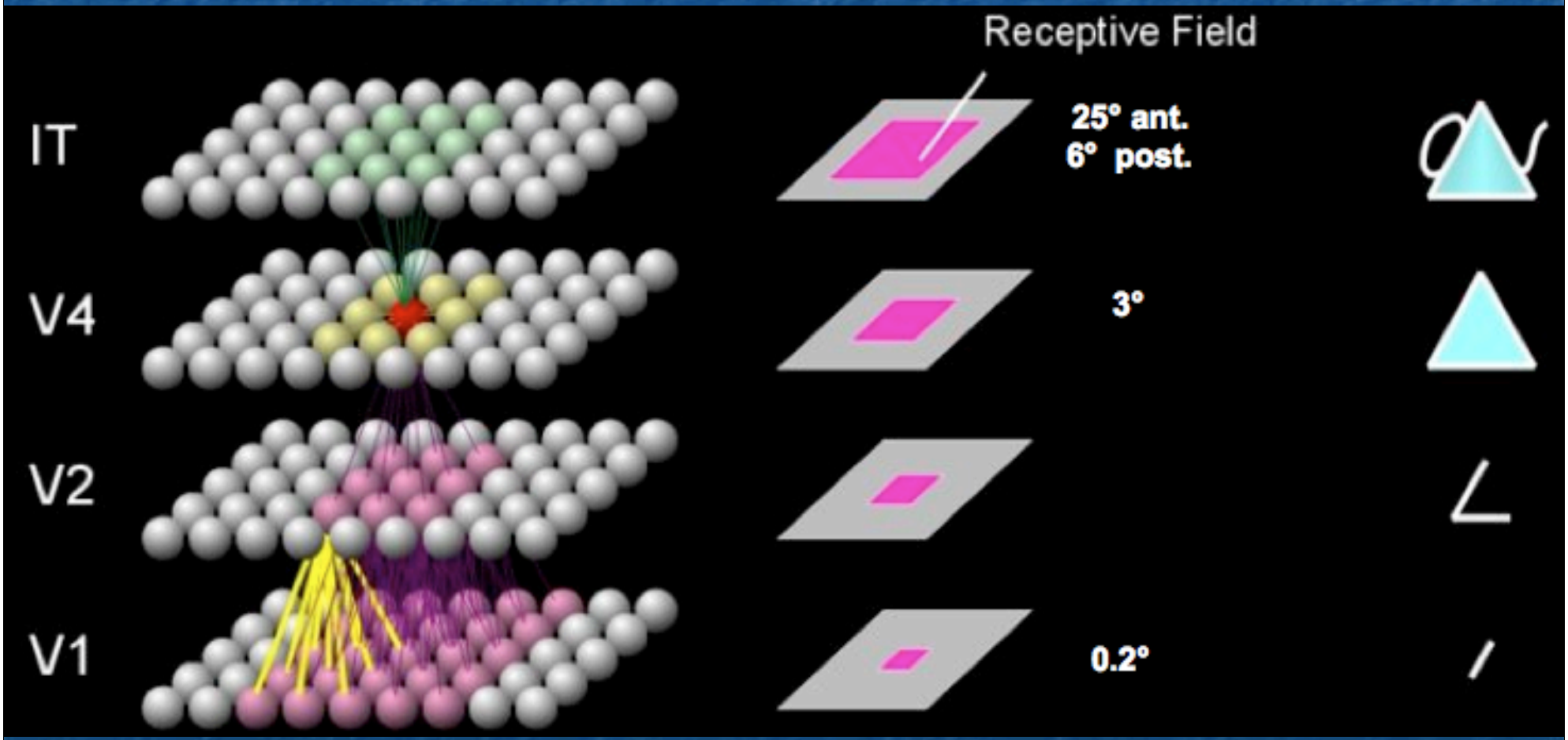

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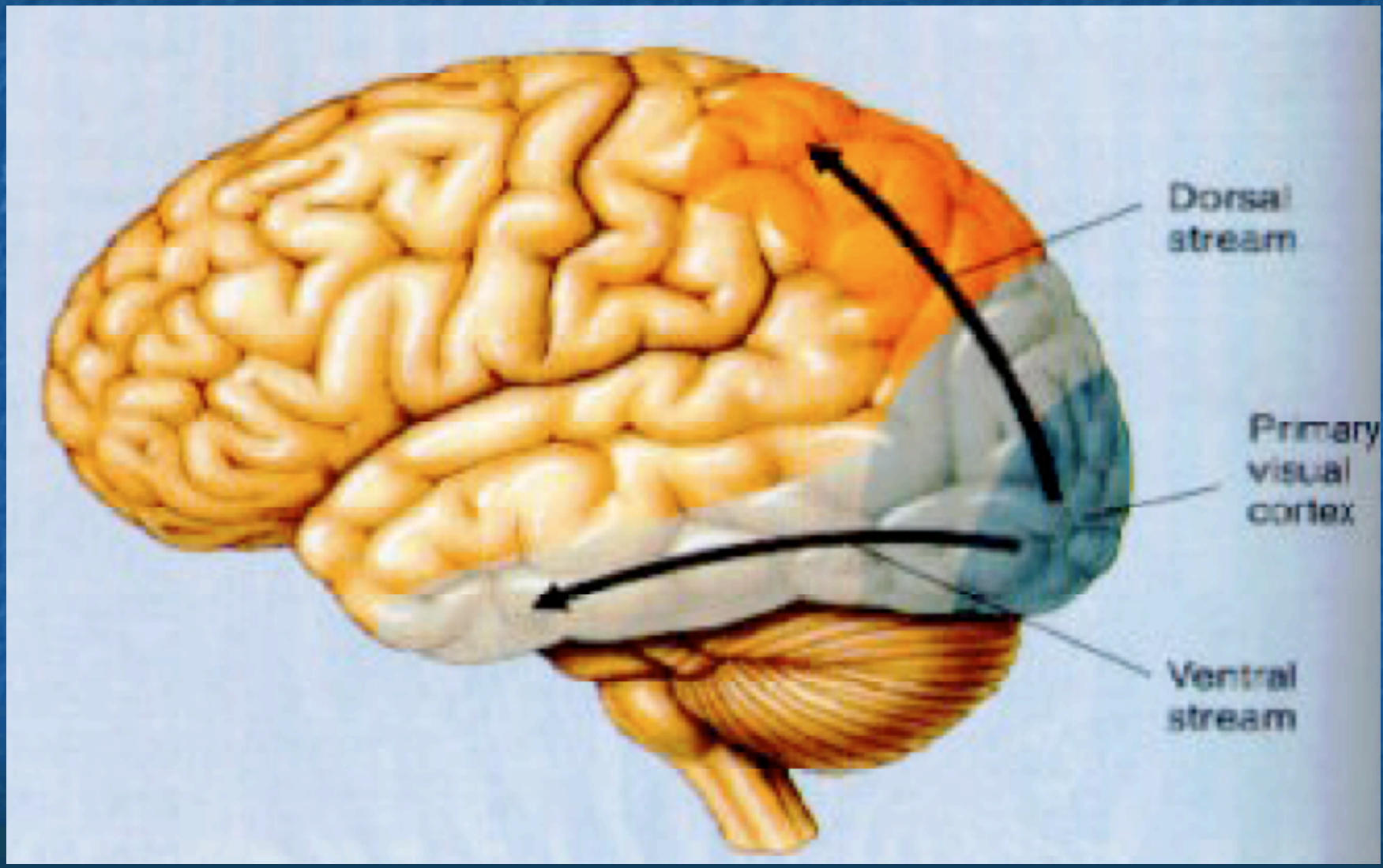
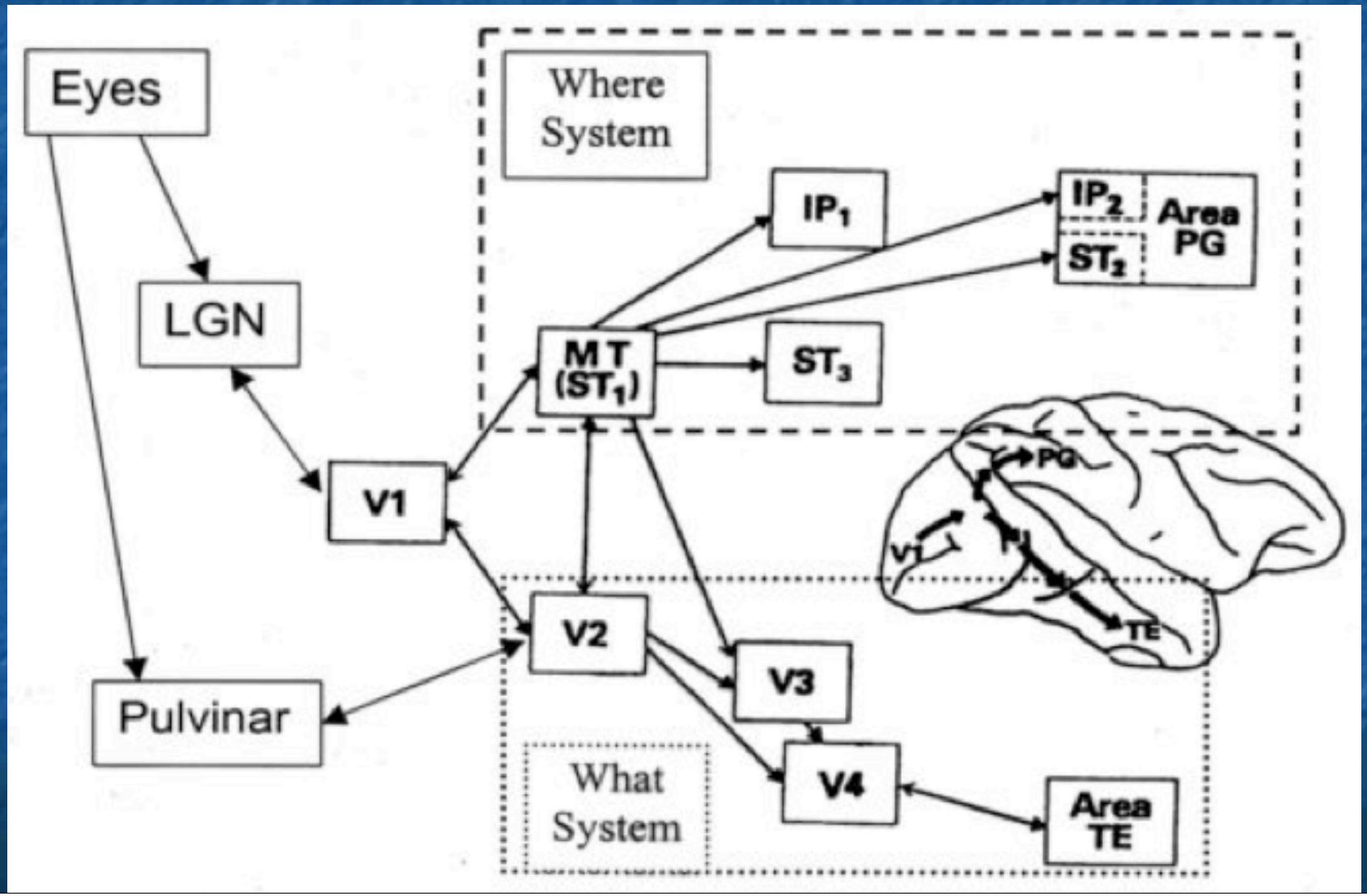


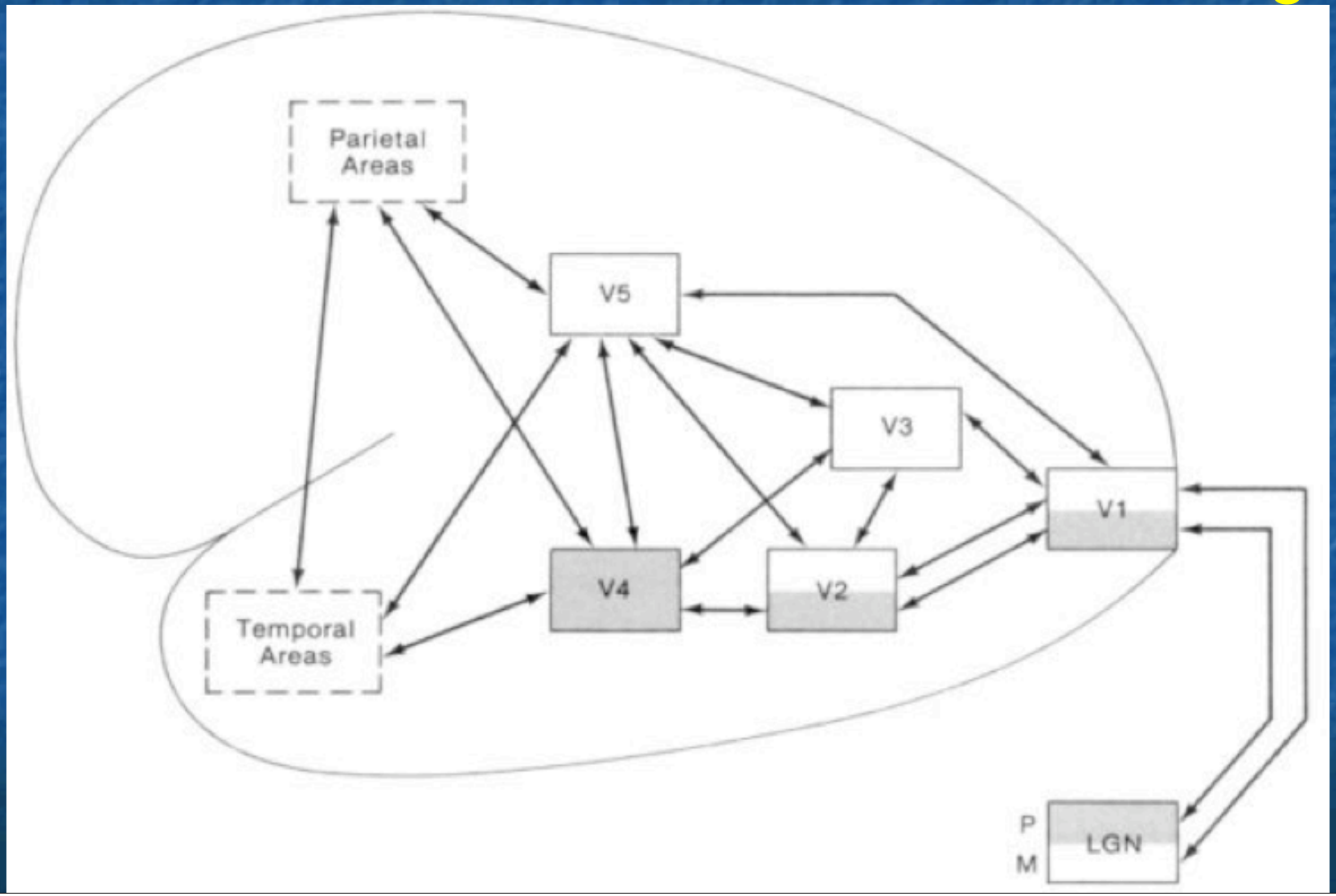
Within the visual cortex

Milner & Goodale (1993, 1998)

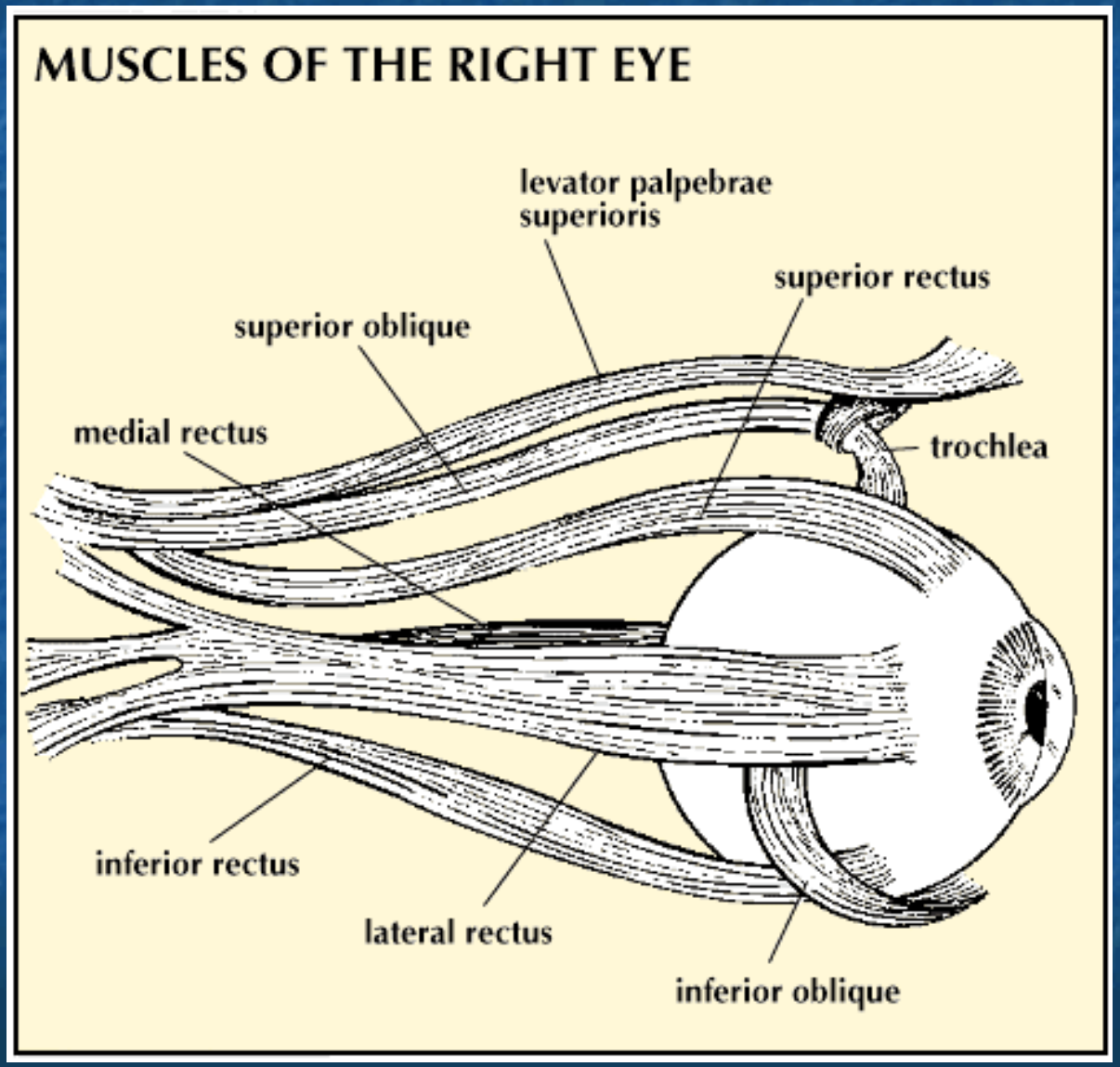


Within the visual cortex

Re-entrant signaling



Obtaining visual information

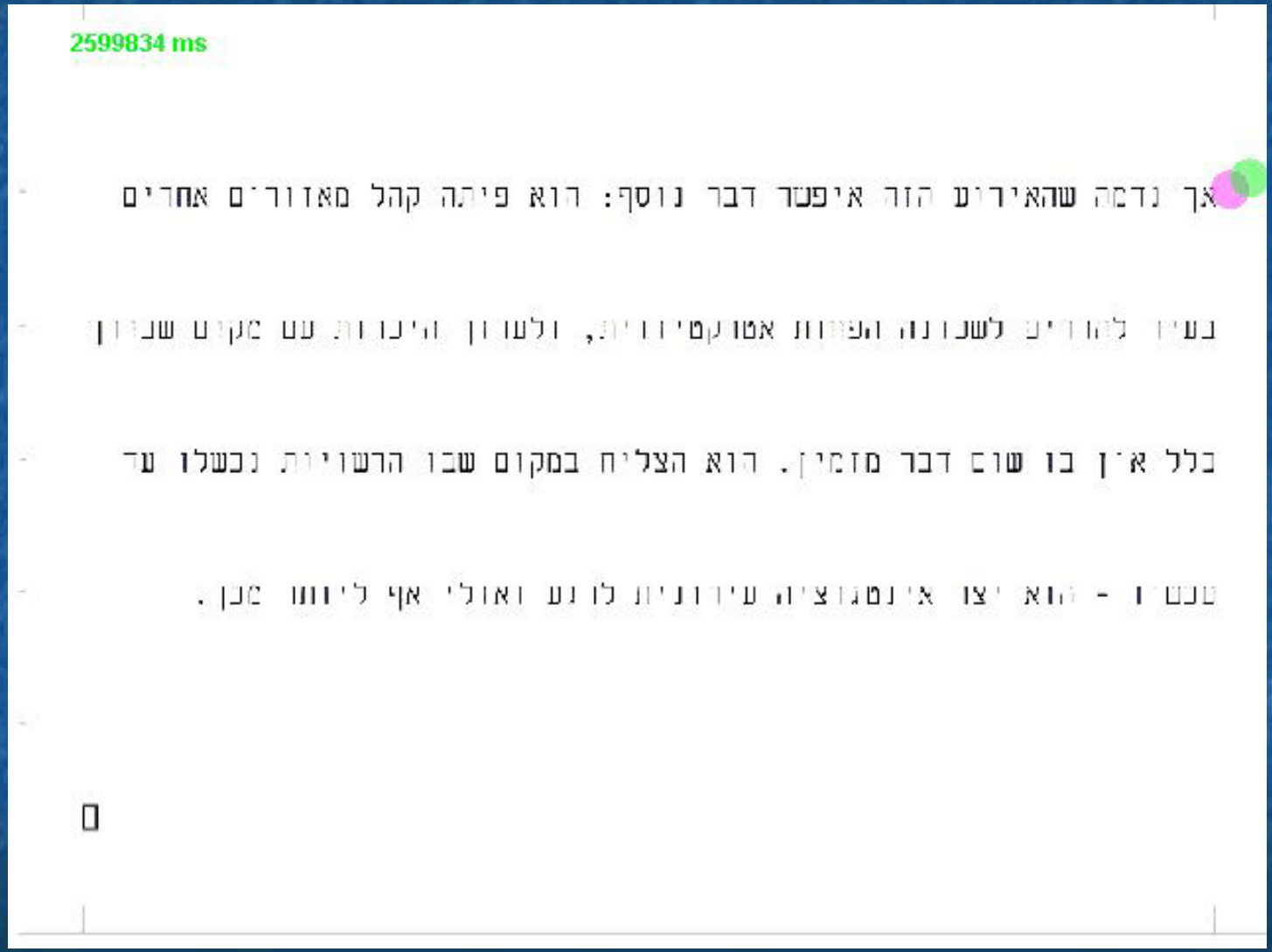


Reading and eye fixations

(Animation by Piers Cornelissen)

There are advantages and disadvantages of both electronic and hardcopy journals. Hardcopy journals are more easily browsed, more portable and, of course people are very much used to their format. Electronic journals save on paper and their format has improved considerably over the past few years, but there are still problems over managing copyright restrictions and persuading people to use electronic instead of hardcopy journals. There is also the problem of portability. More and more journals are now being published in electronic format, although some publishers will only let you subscribe to an electronic journal provided you also subscribe to the hardcopy (more money for the same thing). Some electronic journals cost over 100% more than their equivalent hardcopy. With all these factors in mind I have been discussing individual and shared-subscriptions with the Biochemistry Department, the RSL and Blackwell's. Whilst I feel that a move from hardcopy to electronic journals will be a very slow process in the ULP Library, electronic publishing is being carefully monitored and I would hope to introduce a few electronic texts into the Library alongside the journals which are already available for free over the Internet.

Binocular disparity in reading

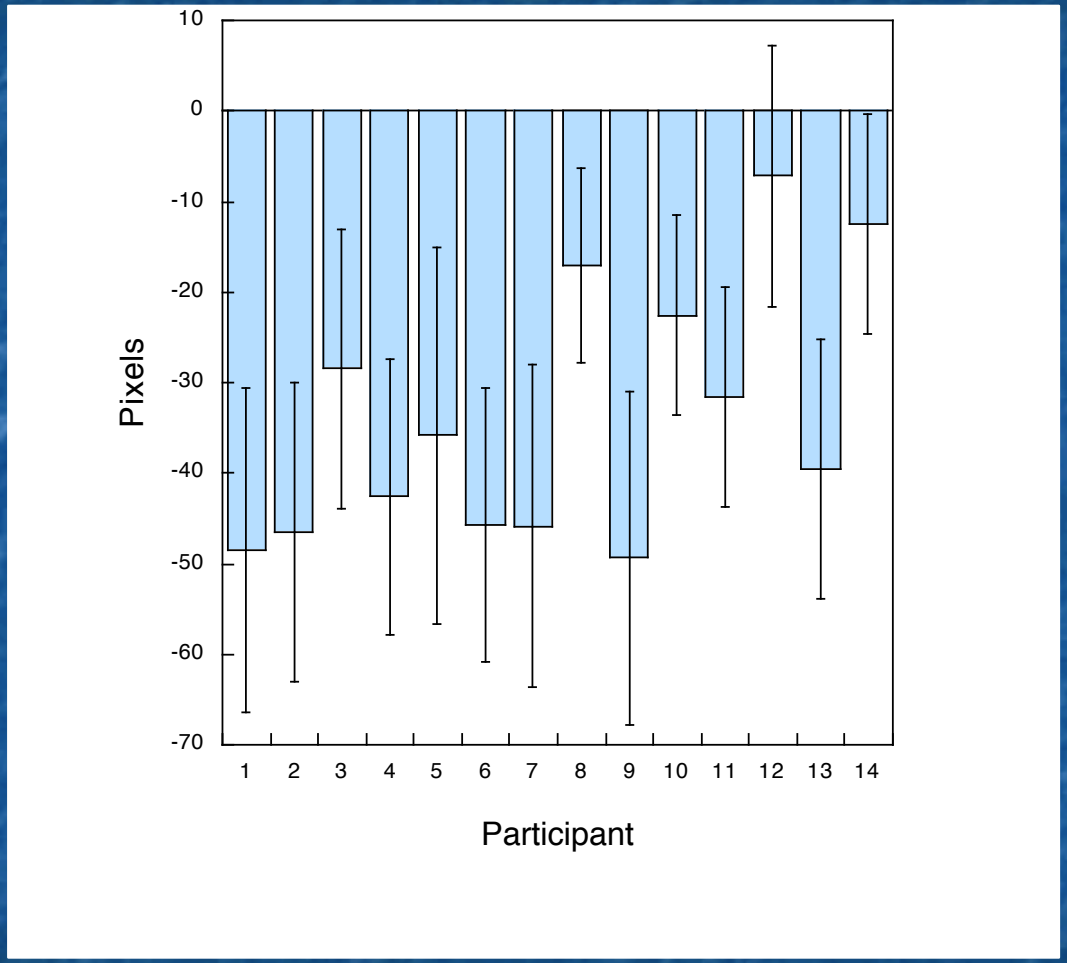


Theories of eye-movements

"Cognitive" theories involve substantial higher-level direction of eye-movements

"Visuo-motor" theories involve sampling the world and rely on evolutionarily older adaptations

Fixation disparity is normal



Precise conjoint fixation often does not happen in reading

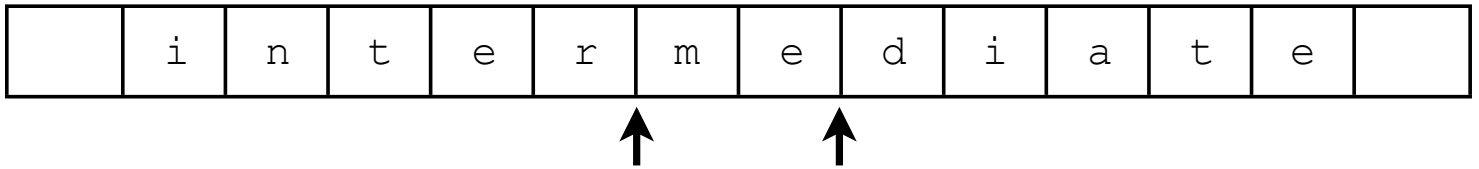
Binocularity
Non-conjoint fixations

Contralaterally projecting visual fields seem to be prioritized (Toosy *et al.*, 2001)

Uncrossed fixations in reading are also prioritized (corresponding to closer objects in depth perception)

We can make precise predictions about the effects of differential overlaps in non-conjoint fixations

Hemifoveal coordination



(a) Crossed fixations:

LH from RE							**m**	**e**	**d**	**i**	**a**	**t**	**..**
LH from LE									d	i	a	t	e

RH from RE	..	i	n	t	e	r							
RH from LE		**..**	**n**	**t**	**e**	**r**	**m**	**e**					

Three fixation "strategies"

crossed:

.intermediate.

1 1 3 3 3 3 5 5 3 3 3 3 1 1

conjoint:

intermediate

0 3 3 3 3 3 3 3 3 3 3 3 3 0

uncrossed:

.intermediate.

2 2 3 3 3 3 4 4 3 3 3 3 2 2

Summary

We can undestand what is functionally required of the brain in order to process written language and the visual aspects of speech

We can project these functional requirements onto the anatomy, and we can test the anatomical pathways themselves so as to understand their representational capabilities

We can make testable predictions regarding the visual representation and processing of language