Neural Correlates of Consciousness

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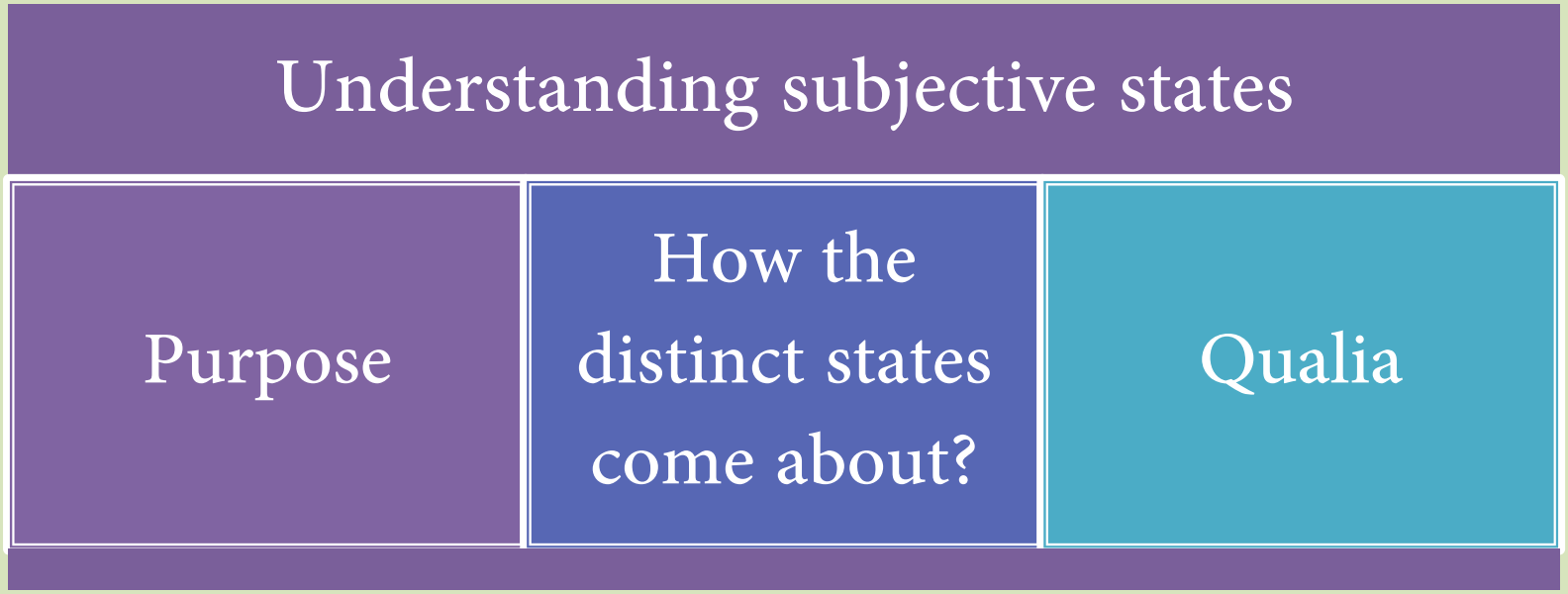
A new field is born…



"In most brain states are not directly associated with conscious sensations:
We have almost no access to the structures that give rise to speech, to depth perception or color vision, to the rapid sequence of sensory-motor transformations necessary to play soccer, climb a rock wall, or return a tennis ball, let alone those influencing perspiration, heart rate, or the action of our immune systems; unlike qualia, these proceed in blankness. Where is the difference between the two?"

The Inchoate Science of Consciousness, Koch (2005)

Brain to consciousness

Greatest unsolved question in science

Self consciousness

- The **ability to examine** one's **own** desires and thoughts

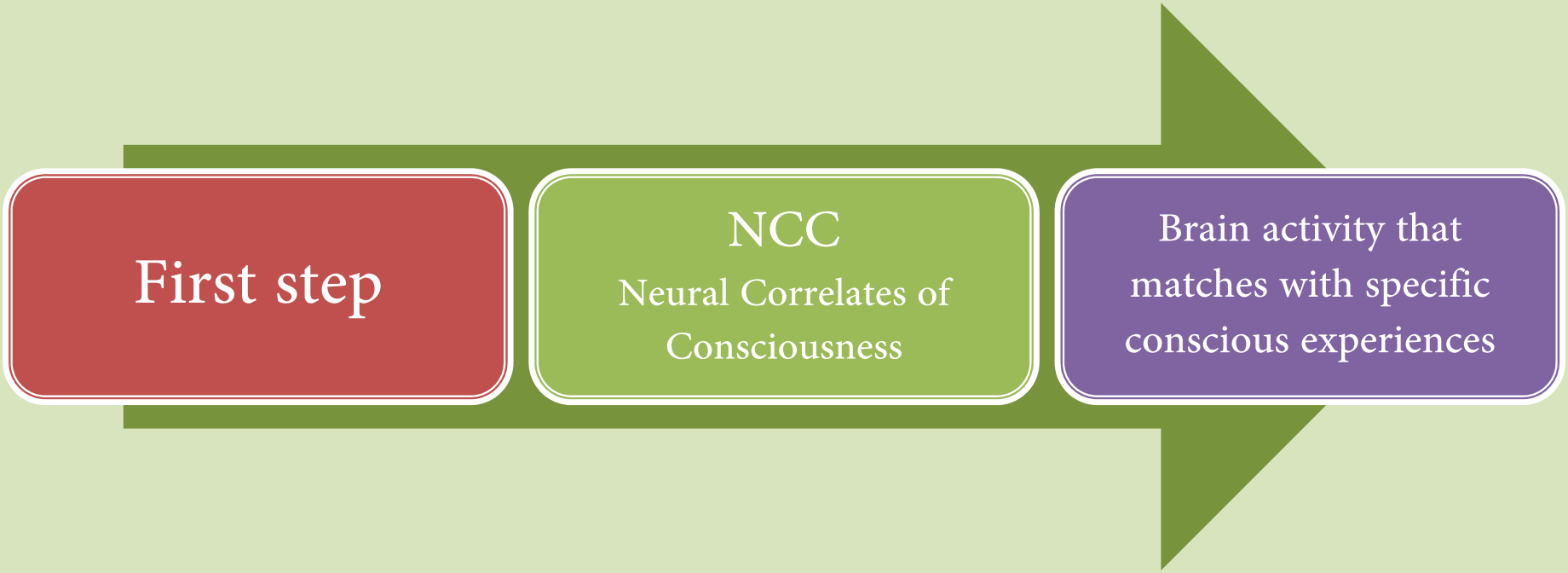
Content of consciousness

- What are you **actually** conscious of **at** this moment?

Brain relationship?

- Which **processes** relate to consciousness and non-consciousness?

We still don’t understand enough -- but



NCC are the minimal set of neuronal mechanisms or events jointly sufficient for a specific conscious percept or experience.

The concept

simple

- Special set of neurons
- Activity → Consciousness

physical

- Consciousness would have a physical location

but

- where to start?
- Hint: start small!

questions

Which neurons are needed to have any form of consciousness at all?

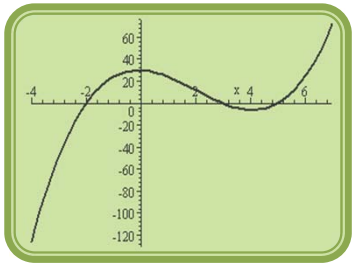
What are the smallest set of neurons responsible for a particular percept?

Enabling factors?

Minimal conditions needed for any consciousness

Specific factors?

Minimal conditions needed for a **particular** conscious percept

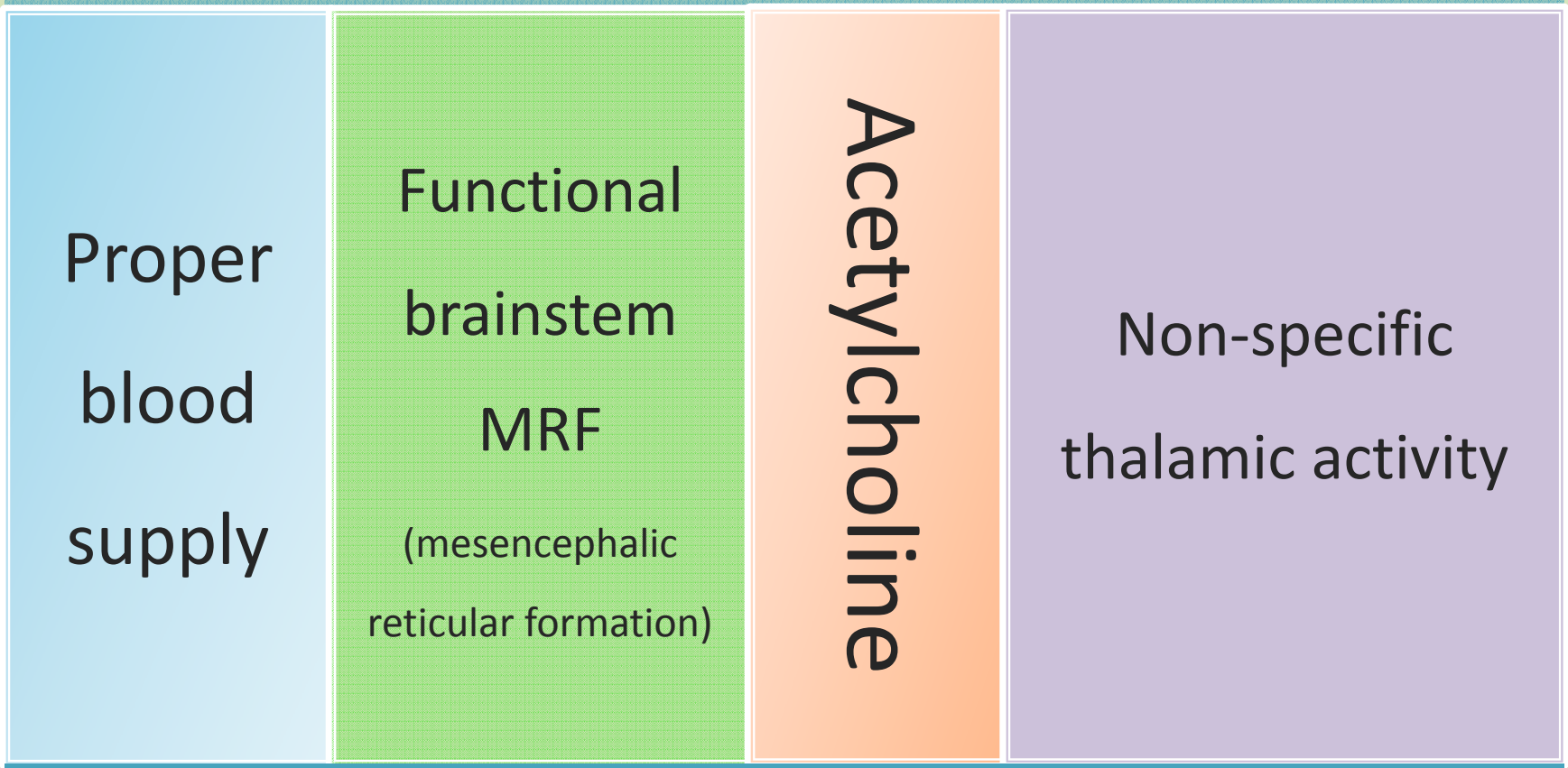


Continuous or discontinuous?

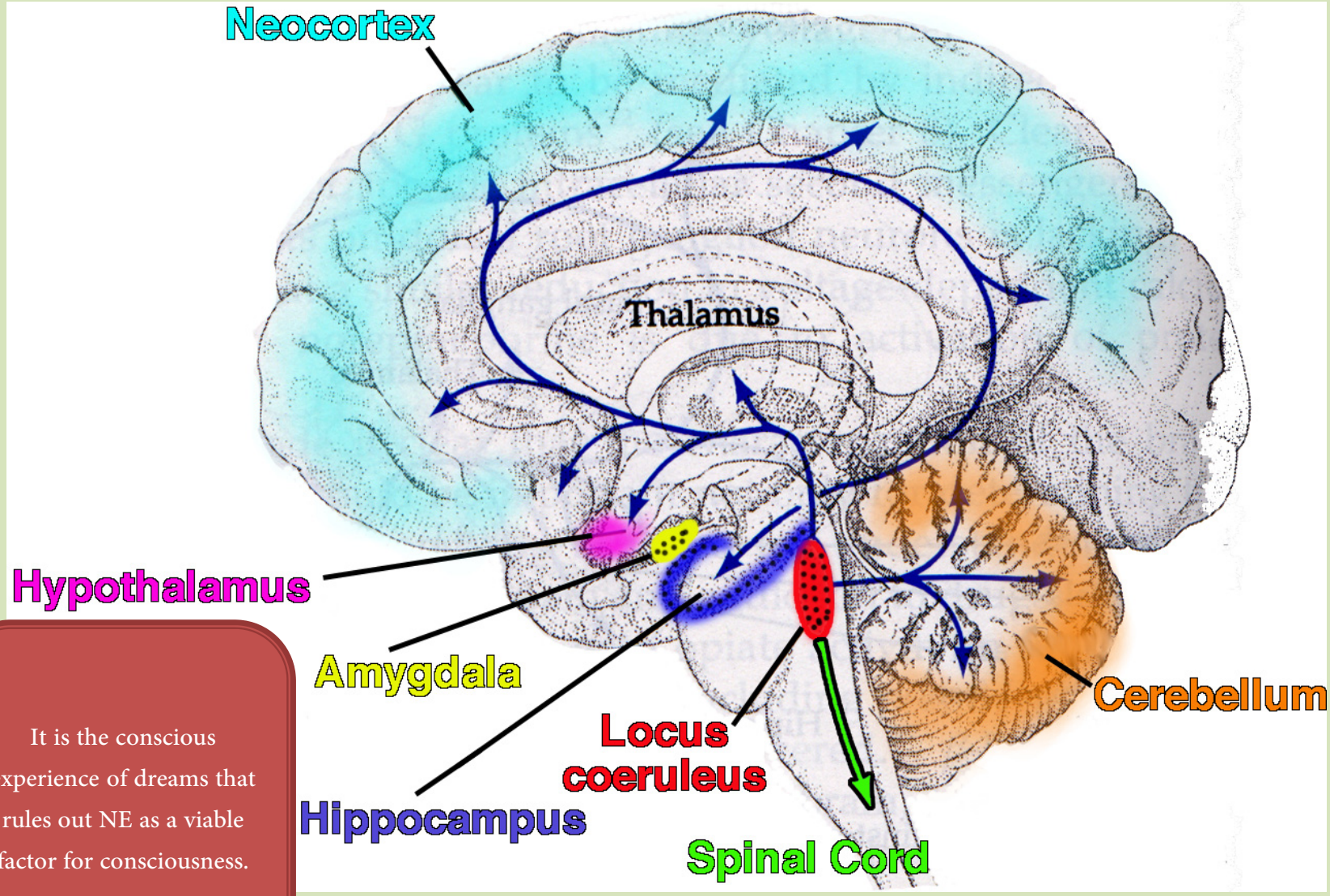
- Modulating the degree of consciousness?
- Is it as simple as on or off?

Enabling factors:

(what must be in place for consciousness to occur)

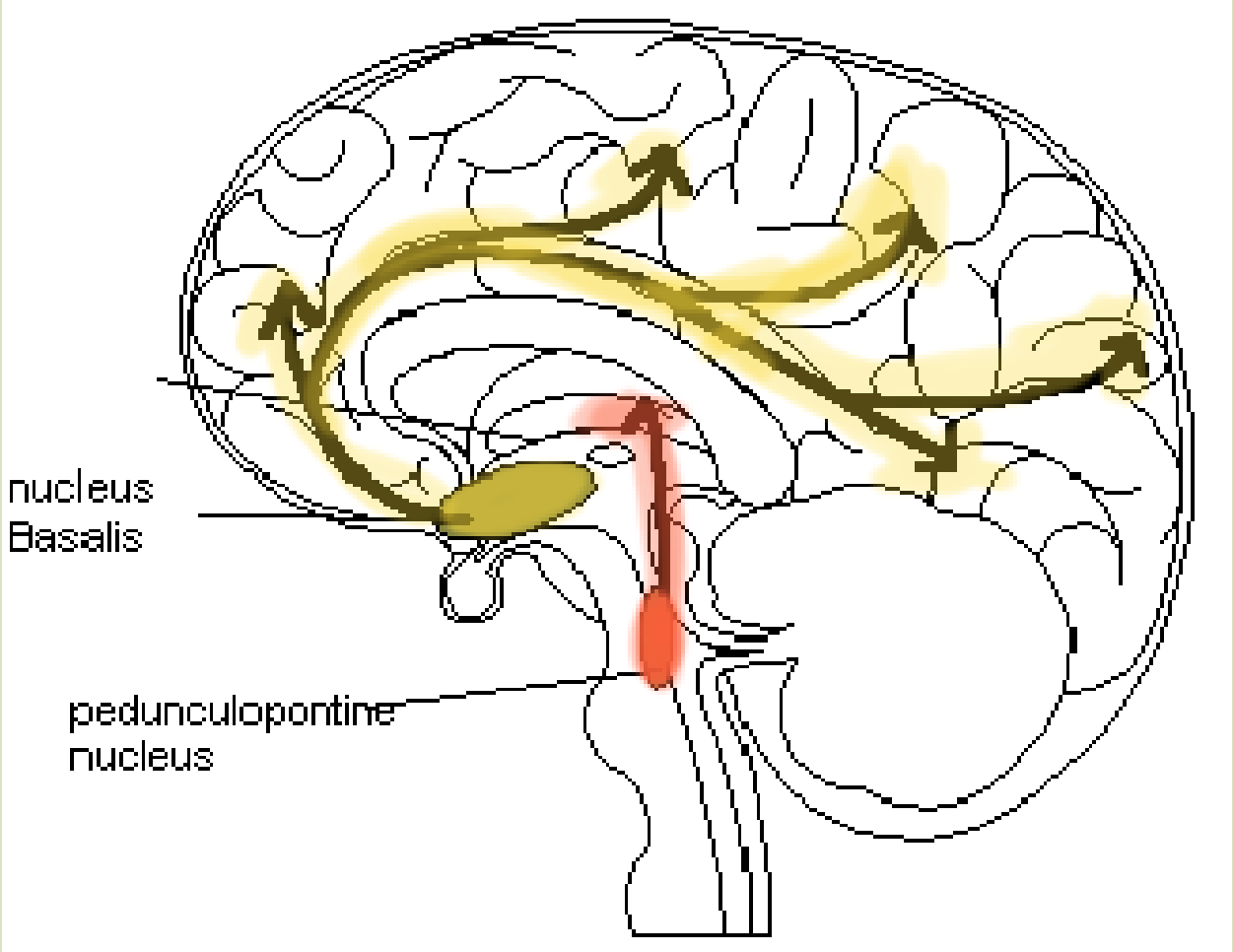


Projections of Norepinephrine-containing neurons



It is the conscious experience of dreams that rules out NE as a viable factor for consciousness.

Major cholinergic projections



Nucleus basalis projects to neocortex.

Pedunculopontine nucleus (PPN) projects to the thalamus

Why might the cholinergic neurons be part of the NCC?

Thalamus

- Brainstem to thalamus
- Influence sensory information from the thalamus.
- Propitious location

Cortex

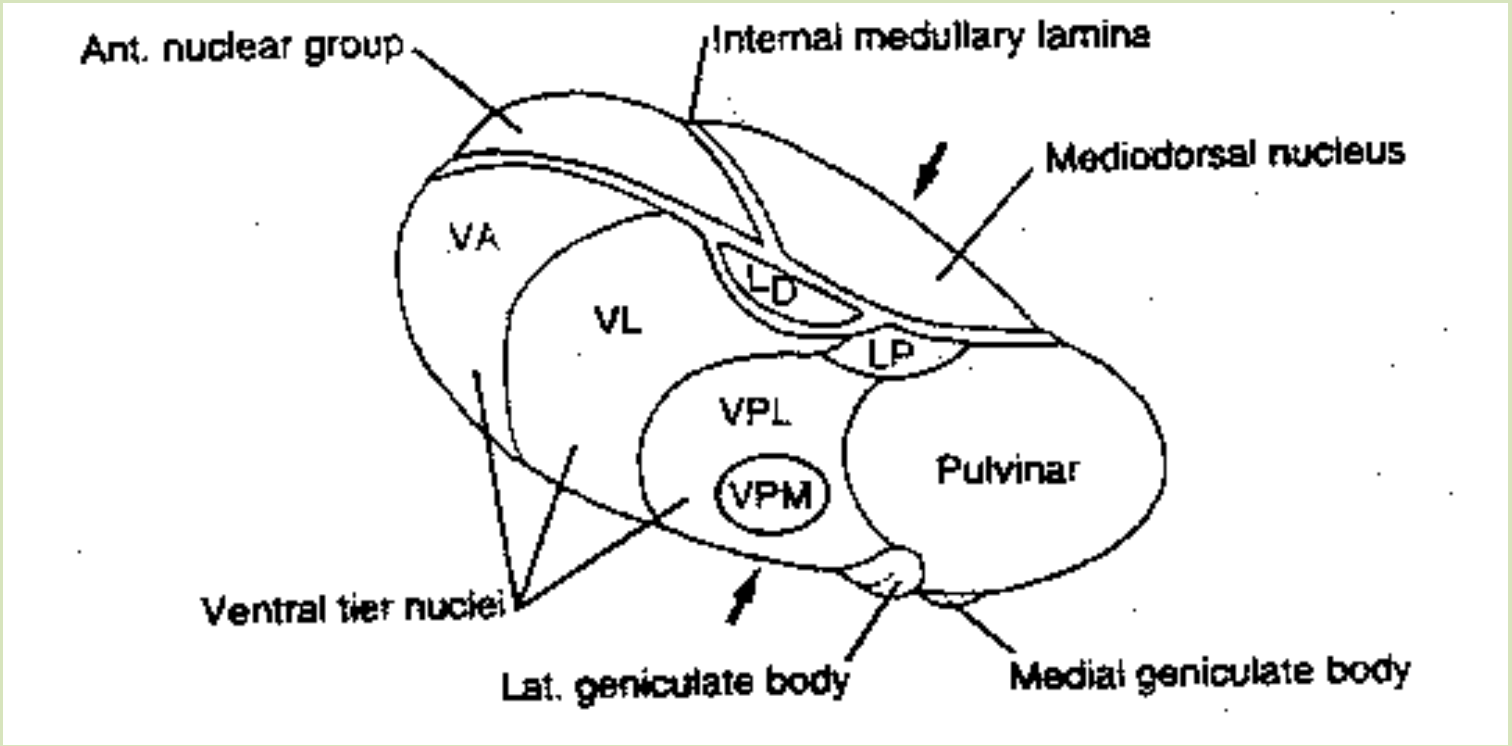
- All cortical regions
- Limbic system

Sleep-Wake

- Increased cholinergic activity is associated with wakefulness.

Dementias

- Alzheimer's, Parkinson's disease
- Loss of cholinergic pathway



Anatomically, the body of the thalamus is divided by a Y-shaped band of white matter (known as the **internal medullary lamina**) into three large cell groups: **mediodorsal**, **anterior** and **lateral**. **Intralaminar nuclei** are found within the lamina itself and a **reticular nucleus** surrounds the thalamus on the dorsal side.

CONSCIOUSNESS AND COGNITION 4, 163–166 (1995)

Visual Awareness and the Thalamic Intralaminar Nuclei

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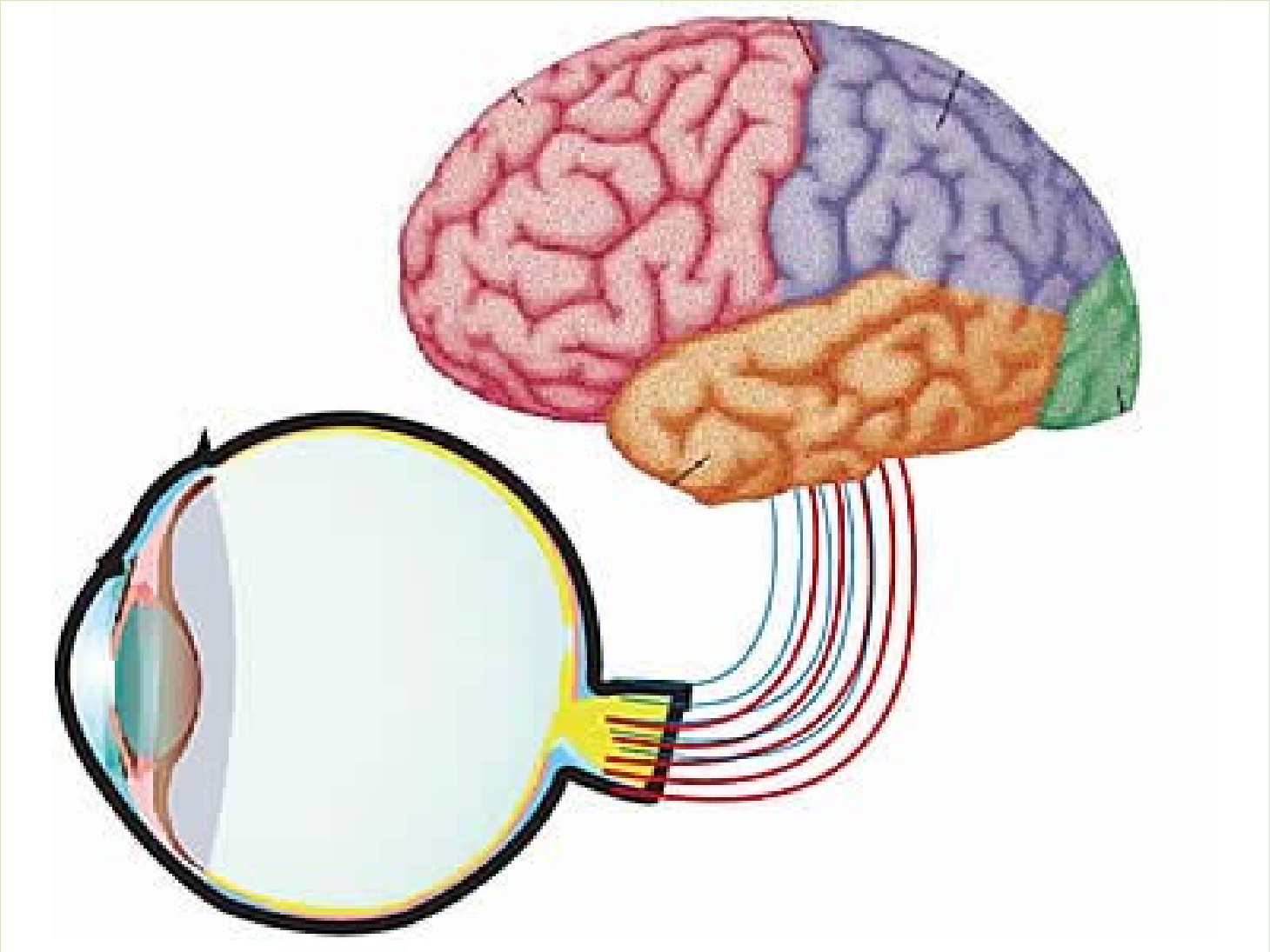
We argue that the current known anatomy of connections between the intralaminar nuclei (ILN) of the thalamus and visual cortical areas makes it unlikely that neuronal activity in the ILN mediates *visual* awareness.

In the lead article, Bogen (1995) argues that the collection of thalamic nuclei, collectively known as the intralaminar nuclei (ILN), subserves the neuronal mechanism(s) underlying the subjective experience of consciousness (what is sometimes called the Neural Correlate of Consciousness). In his view, neuronal activity in the ILN does not mediate the *content* of conscious experience—this is the domain of cortex—but the subjective aspects. As Bogen points out, this is not a new proposal, having been advocated already in a related form by Jaspers and Penfield.

What you see is not always what you perceive



Why is vision special?

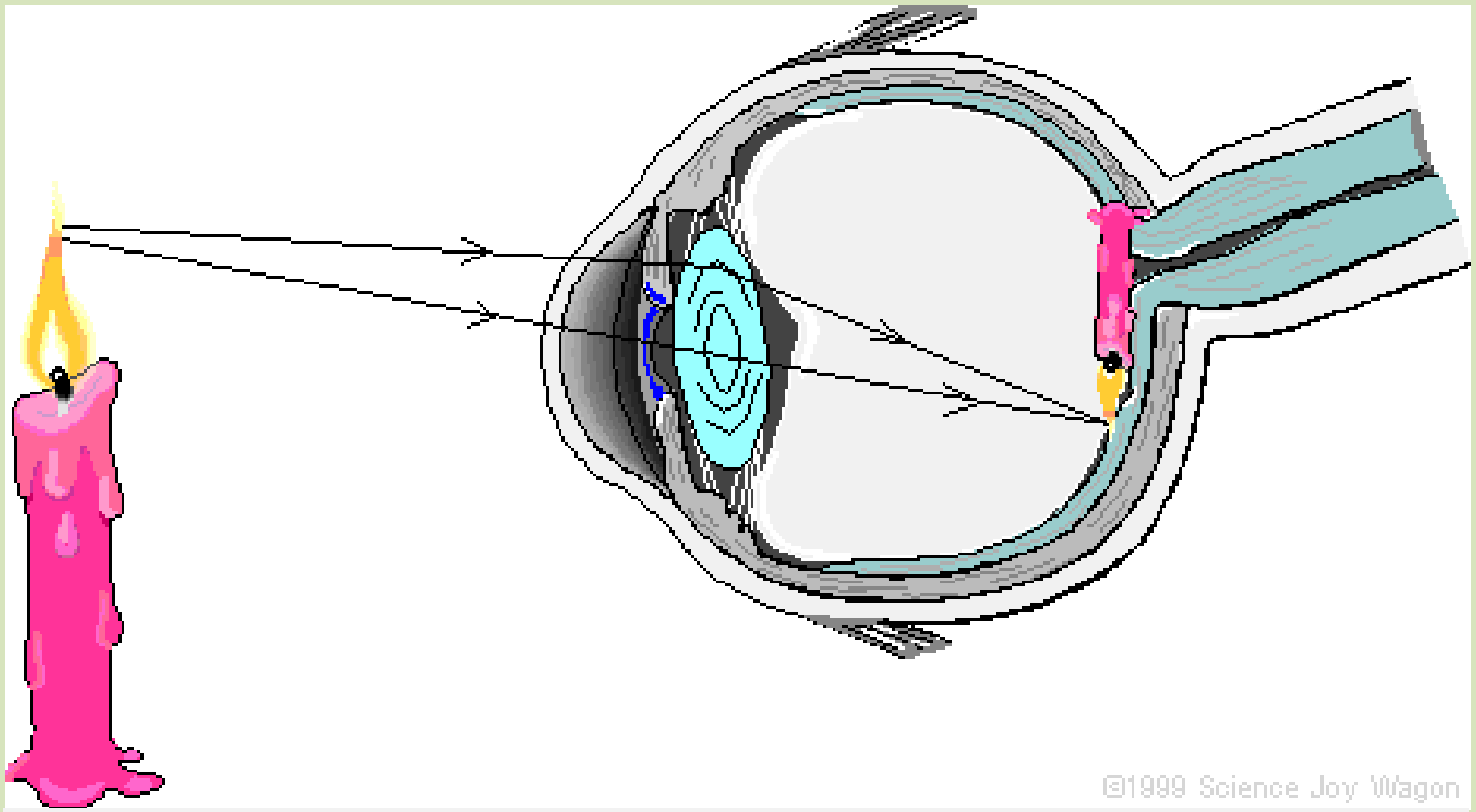
- For humans, who are diurnal, vision is vital sense
- Can perceive information at a distance
- Localize objects accurately
- Vision tends to dominate over other senses
- Approx 1/3 of cerebral cortex dedicated to visual analysis and perception
- Most widely researched sensory system

Visual system: complex processor

- The visual system has to:
  - translate discrete points of light falling onto our photoreceptors in the retina into meaningful objects that we recognize
  - discriminate objects from other aspects of the visual scene i.e. background environment
  - recognize these objects in different orientations, even if it has only ever seen a lion from the front

- Today: how the brain begins to represent sensory information & processes it to form integrated percepts

Visual information is contained in the light reflected from objects

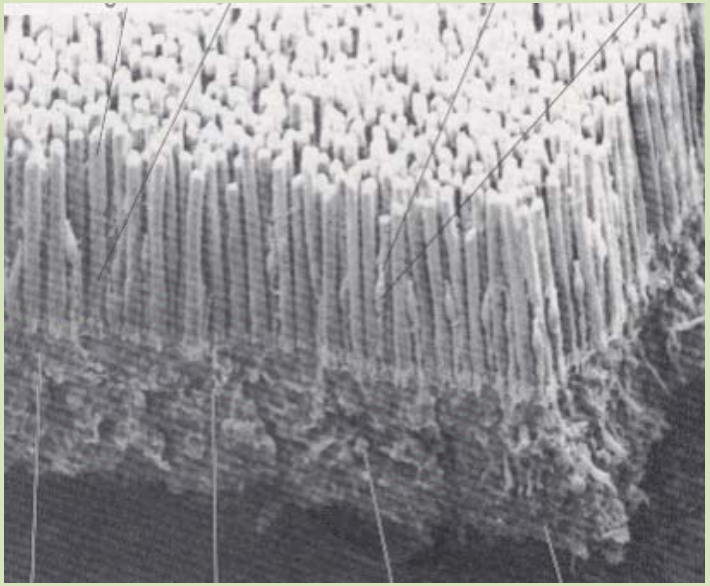


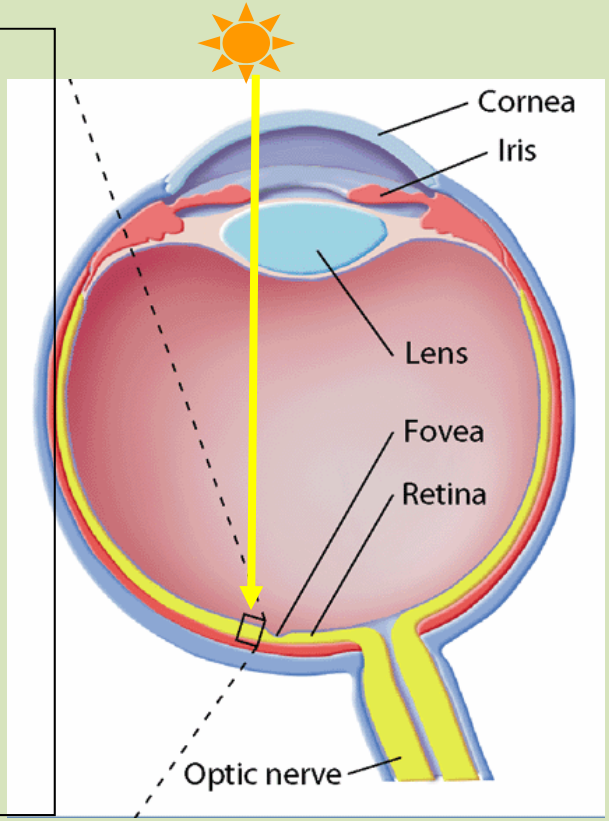
As light passes through the lens, the image is inverted and an optical image is focused onto the back surface of the eye, the “retina”.

Visual processing begins in the retina

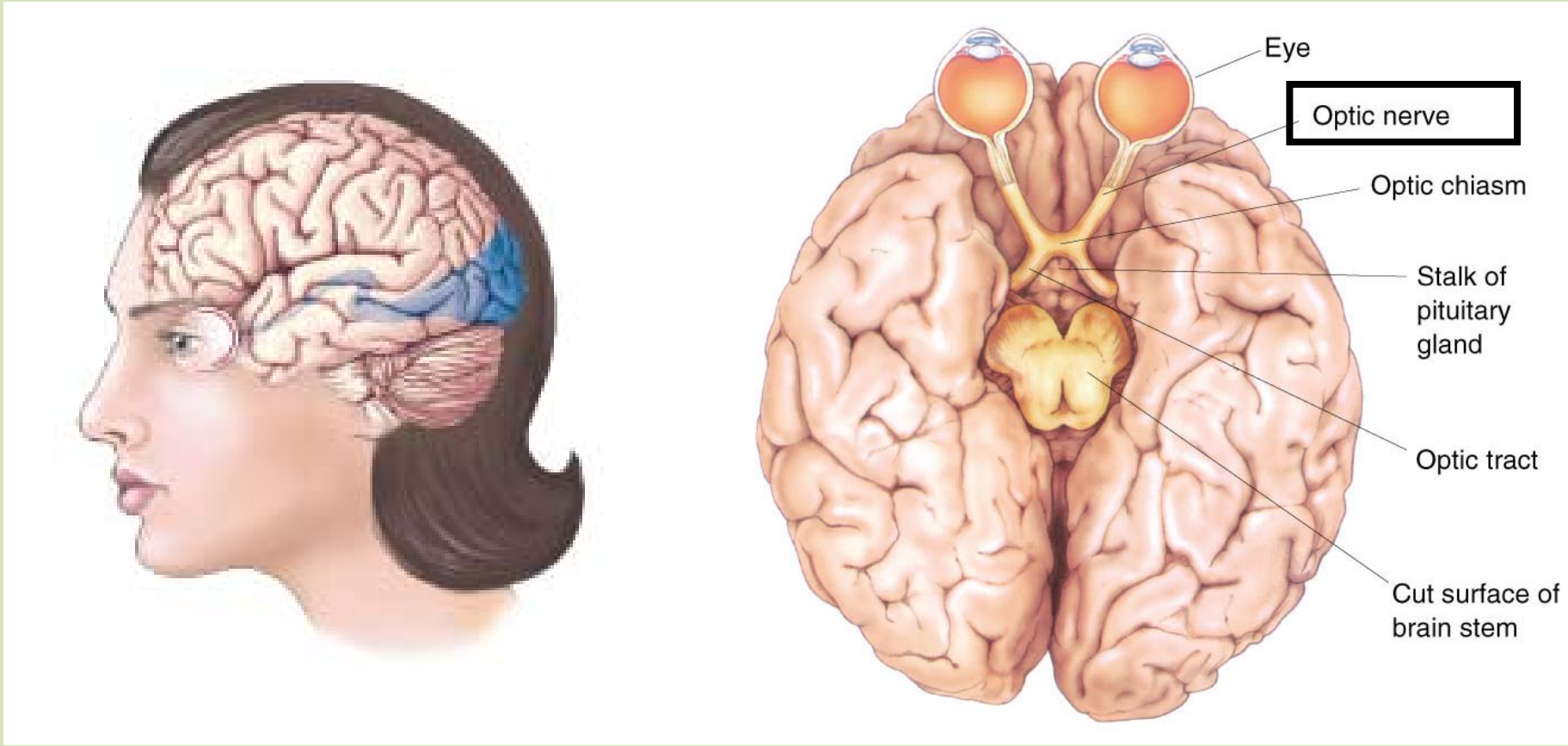
Receptor cells are highly specialized, and sense selective changes in the environment, e.g., light (photons) and sound waves. Stimulation leads to changes in receptor molecules, which open/close ion channels.

Vision: photoreceptors on the retinal surface contain pigments that are sensitive to light





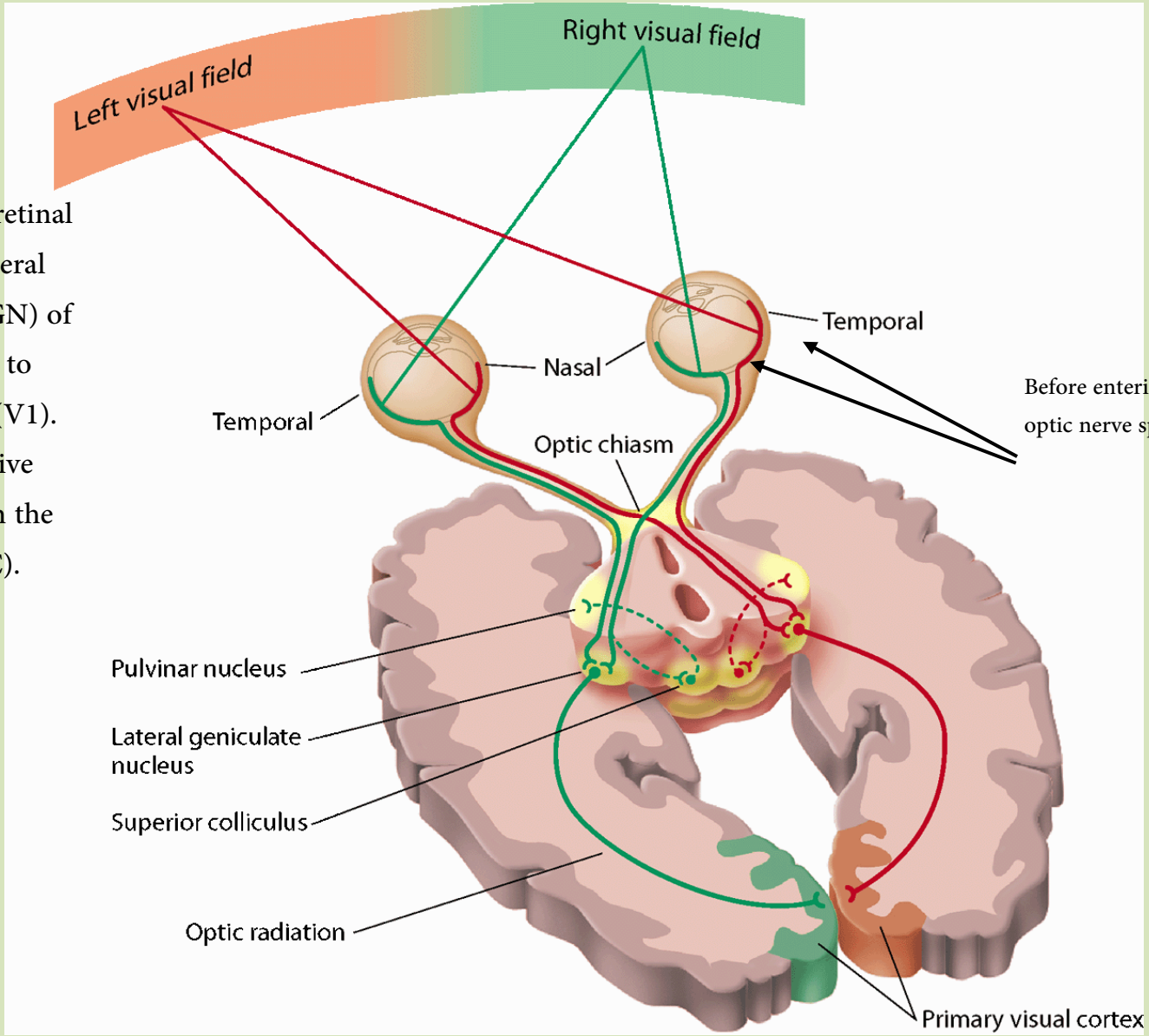
Optic nerve



The axons of the ganglion cells form the optic nerve which carried visual signals from the retina into the brain. Some axons cross at the optic chiasm. The result is that each visual field is represented contralaterally (opposite side) in the brain.

Anatomy of the visual system

In the main pathway, retinal signals travel to the lateral geniculate nucleus (LGN) of the thalamus and then to primary visual cortex (V1). There are also alternative pathways, e.g., through the superior colliculus (SC).



Before entering the brain, each optic nerve splits into 2 parts

Conscious percept

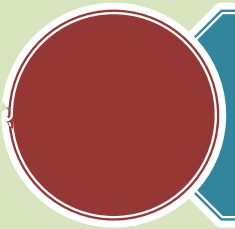
How the brain

represents stimuli from the senses

There is a special coalition of neurons acting in a specific way.

What is the neuronal counterpart of each subjective experience?

There is a unique neuronal correlate of consciousness for:

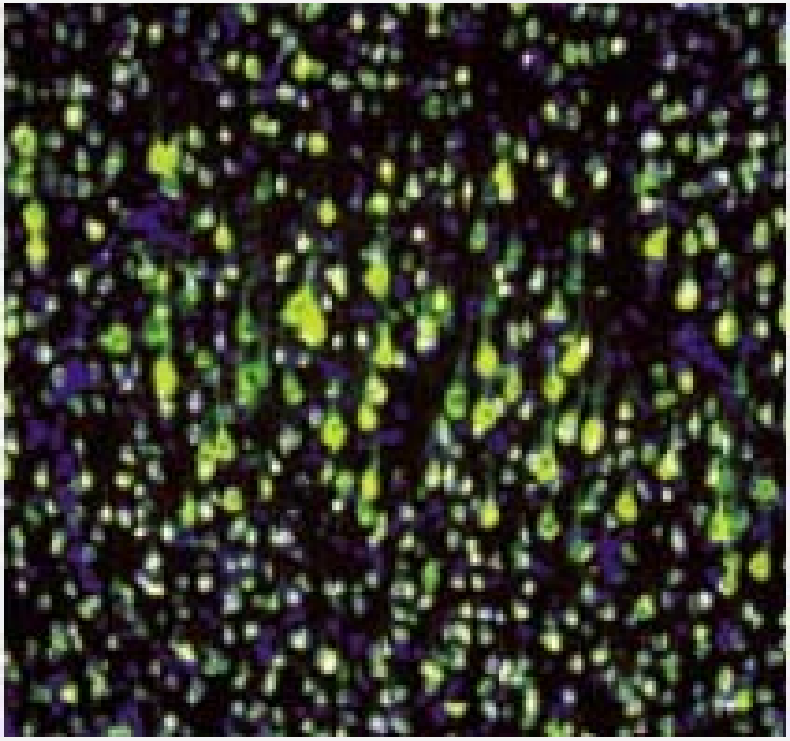


seeing a red patch

seeing one's grandmother

feeling angry

Perturbing or halting any neuronal correlate of consciousness will alter its associated percept or cause that percept to disappear.



A coalition of pyramidal neurons linking the back and front of the cortex fires in a unique way. Different coalitions activate to represent different stimuli from the senses (*left*). *In a mouse cortex* (*right*) *these pyramidal cells* (*green*) *lie in brain layer 5, surrounded by nonneuronal cells* (*blue*).

Koch, 2005

Direct cause and effect mechanisms

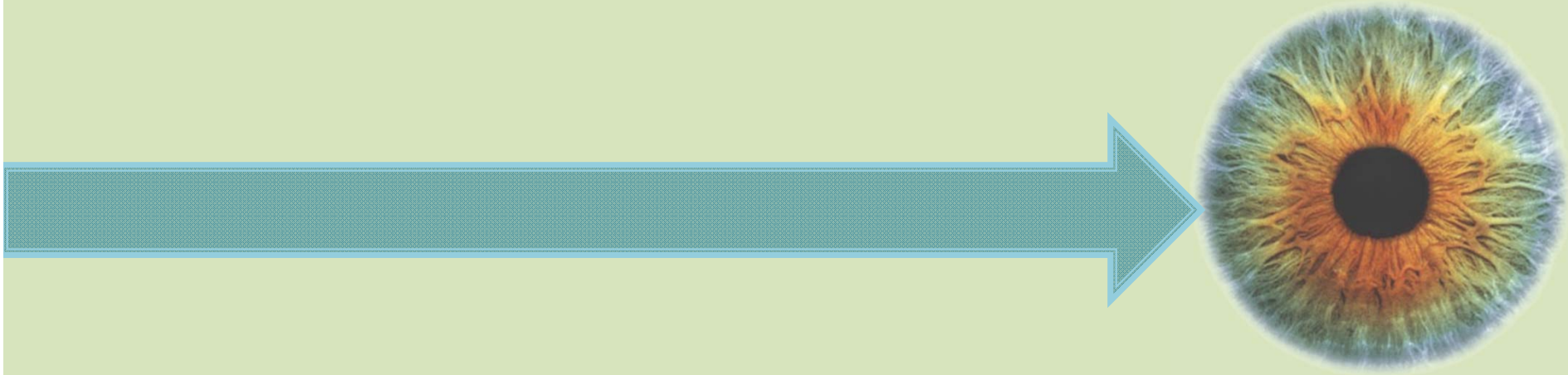
- According to Christof Koch:
  - Every conscious percept is associated with a specific coalition of neurons acting in a specific way.

Perturbing or halting any NCC will alter its associated percept or cause that percept to disappear.

How does one figure out which set of neurons, and what activity among them constitutes a conscious percept??

Describe visual consciousness

- Main function of the visual system is to perceive objects and events
- Information available to our eyes is not enough to provide a unique interpretation coming into our eyes
- Top down processing is needed



Top down processing:

your brain infers that the person has a face

What we are aware of at any moment, in one sense or another, is not a simple matter.

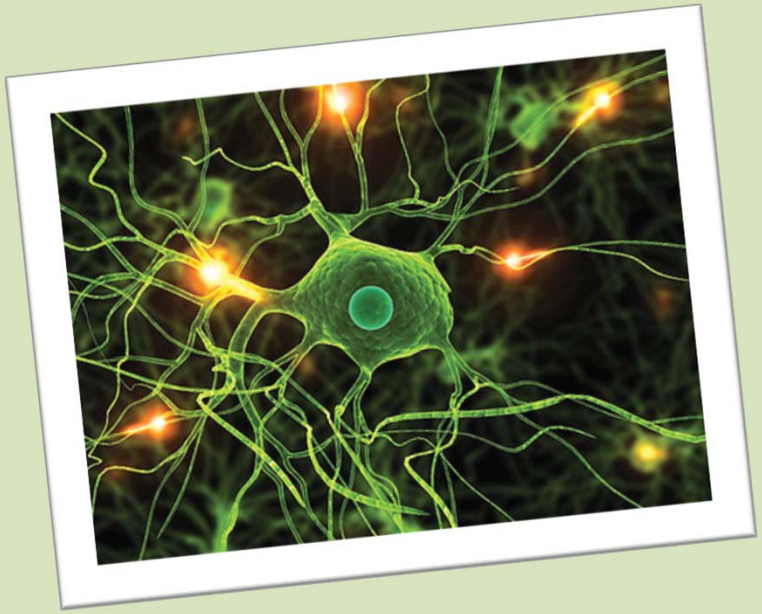
Explicit representation

- Something that is symbolized without further processing

Implicit representation

- More processing is required

Active representation

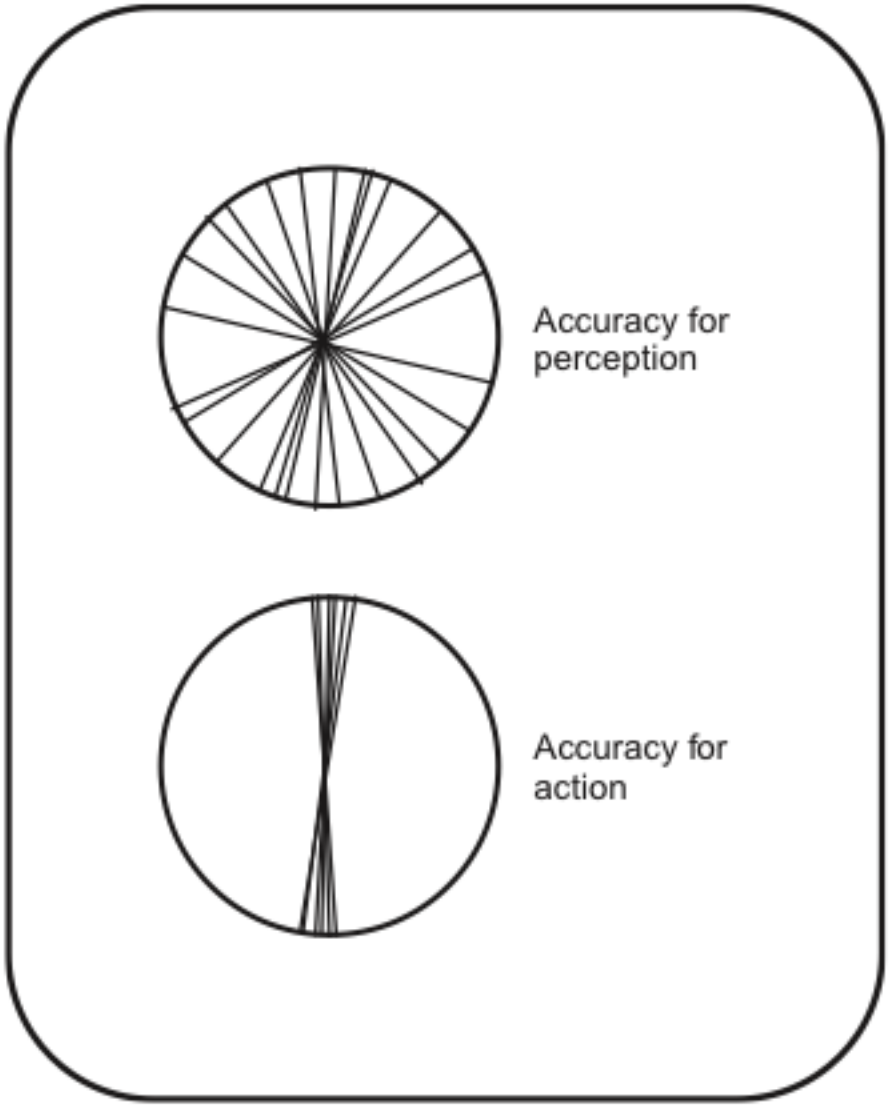


Latent representation

“statue of liberty”

Case study - Diane

Carbon monoxide poisoning unconscious comatose	Functionally blind Could not see the big E	Mail slot experiment Apperceptive agnosia Unconscious visual processing



She can do it, but can't report it. Results from subject DF. Each line represents one of DF's attempts at either matching the orientation of a mail slot or actually posting a letter into it.

Image: Frank Tong

OLD pathway

retina

Superior Colliculus

Blind sight

PARIETAL

lobes