

# "What we see and what we know: Partners in human vision"

John McCann

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# Edwin Land

- “Science is the technique of keeping yourself from kidding yourself.”
- “Every great invention is a sudden cessation of stupidity! [Necessary, but not sufficient]”
- “Always test the opposite of what you believe.”

Nothing is better than an experimental surprise.  
That experiment is trying to tell us something!

I saw a shadow on that tree.







I looked around. Nothing was shadowing the sun!



**Blue  
Paint !**





**There is no shadow cast on the tree!  
There is blue paint on the tree made me see a shadow.**



# What did I mean?

I said “I saw an shadow on that tree.”

- I saw a part was darker, and bluer - a sensation.
- I had a perception that a part was a shadow - a cognition.
- I recognized that a part was an absence of sunlight.
- I learned that the paint was darker and bluer.
- I still saw a shadow on the tree.

# Why was the shadow still there after I knew it was blue paint?

- Sensation
- Perception
- Recognition
- Knowing
- Conscious
- Unconscious
- Top-down
- Botton-Up
- Inference

What do these word mean?

# See and Know

- When I learned that I had been fooled, should that knowledge change something ?
- Is it a paradox?
- I learned that I was wrong, but that had no effect
- Why ?

**When we change our  
minds...**

**We don't change  
appearance!**

# *Tromp-l'oeil*



Frescos of Ignatius of Loyola HDR.jpg

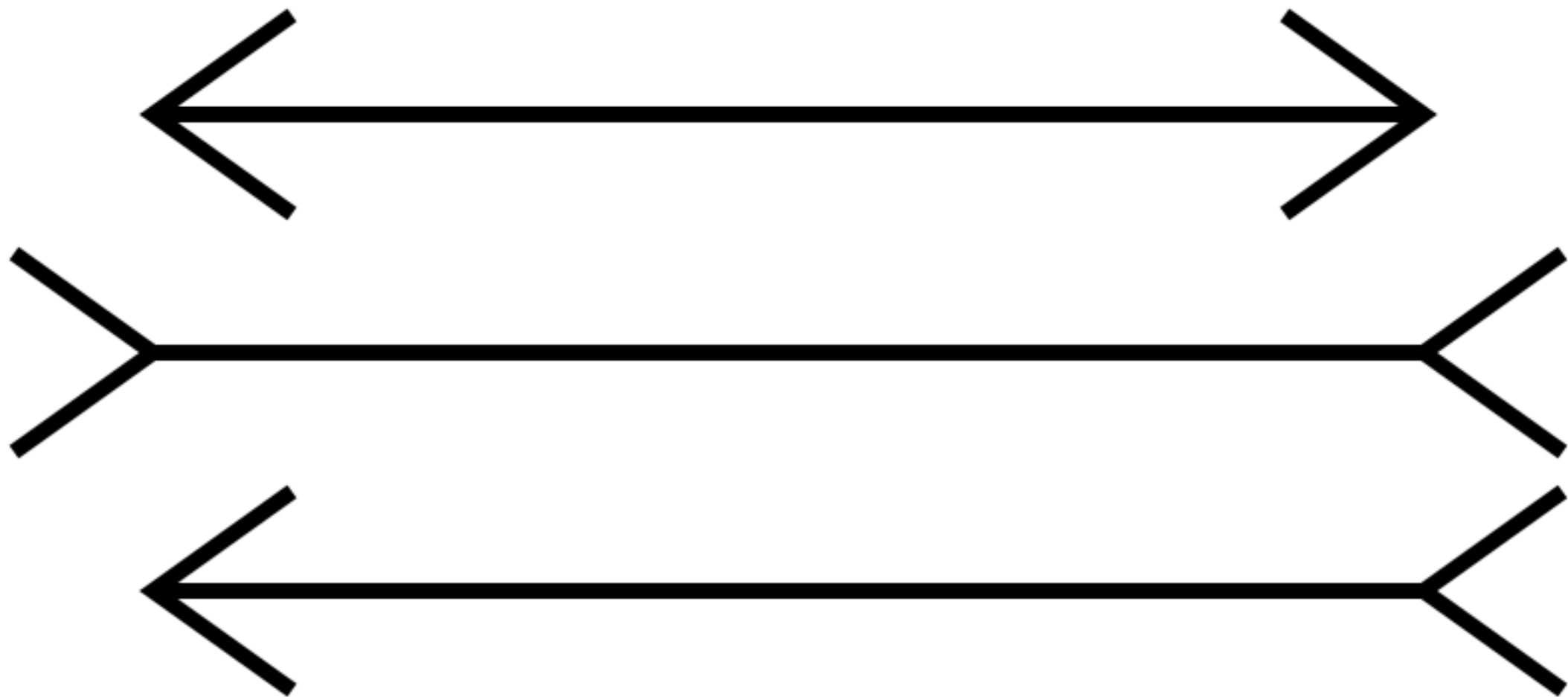


Jesuit Church, Vienna, by Andrea Pozzo, 1703



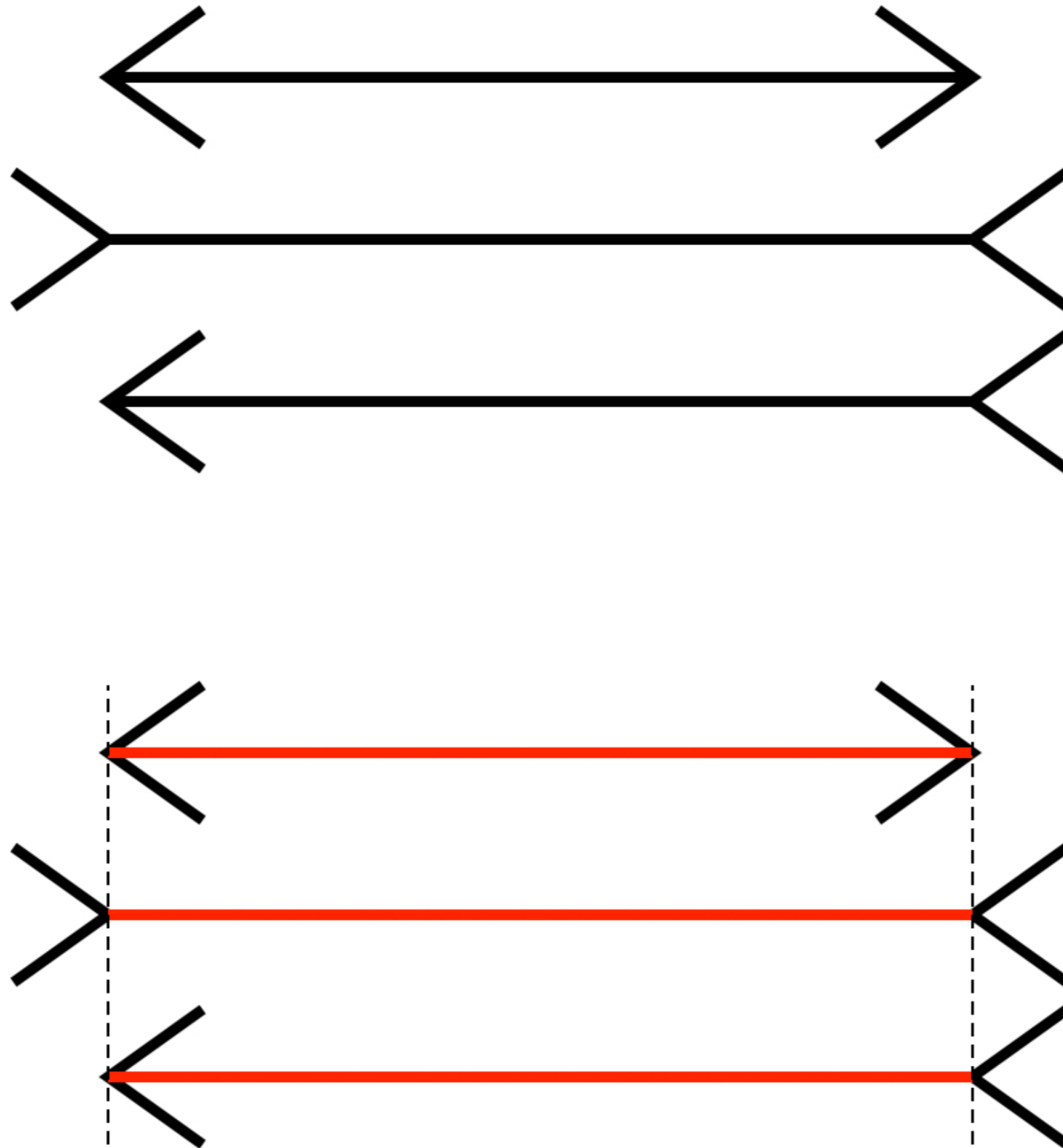
Tromp-l'oeil Still-Life by [Samuel Dirksz van Hoogstraten](#) (1627–1678); 1664

# Müller-Lyer Illusion





# See and Know



# Dalmatian Dots

Learning affects recognition time

Raise your hand when you see a dog.



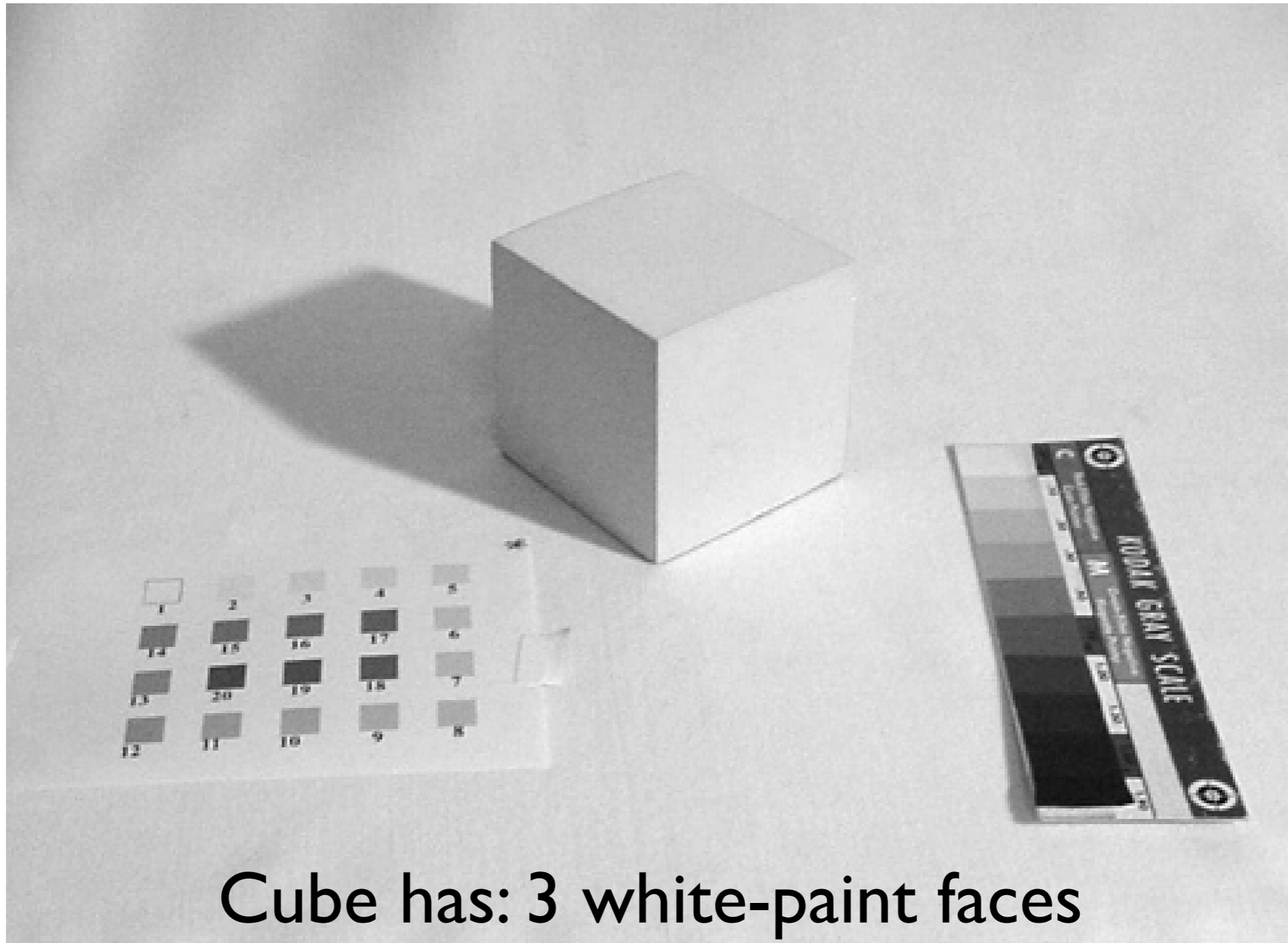
# Old woman Young woman: Coexist



Are shadows and surfaces the same ?



# Are shadows and surfaces the same ?

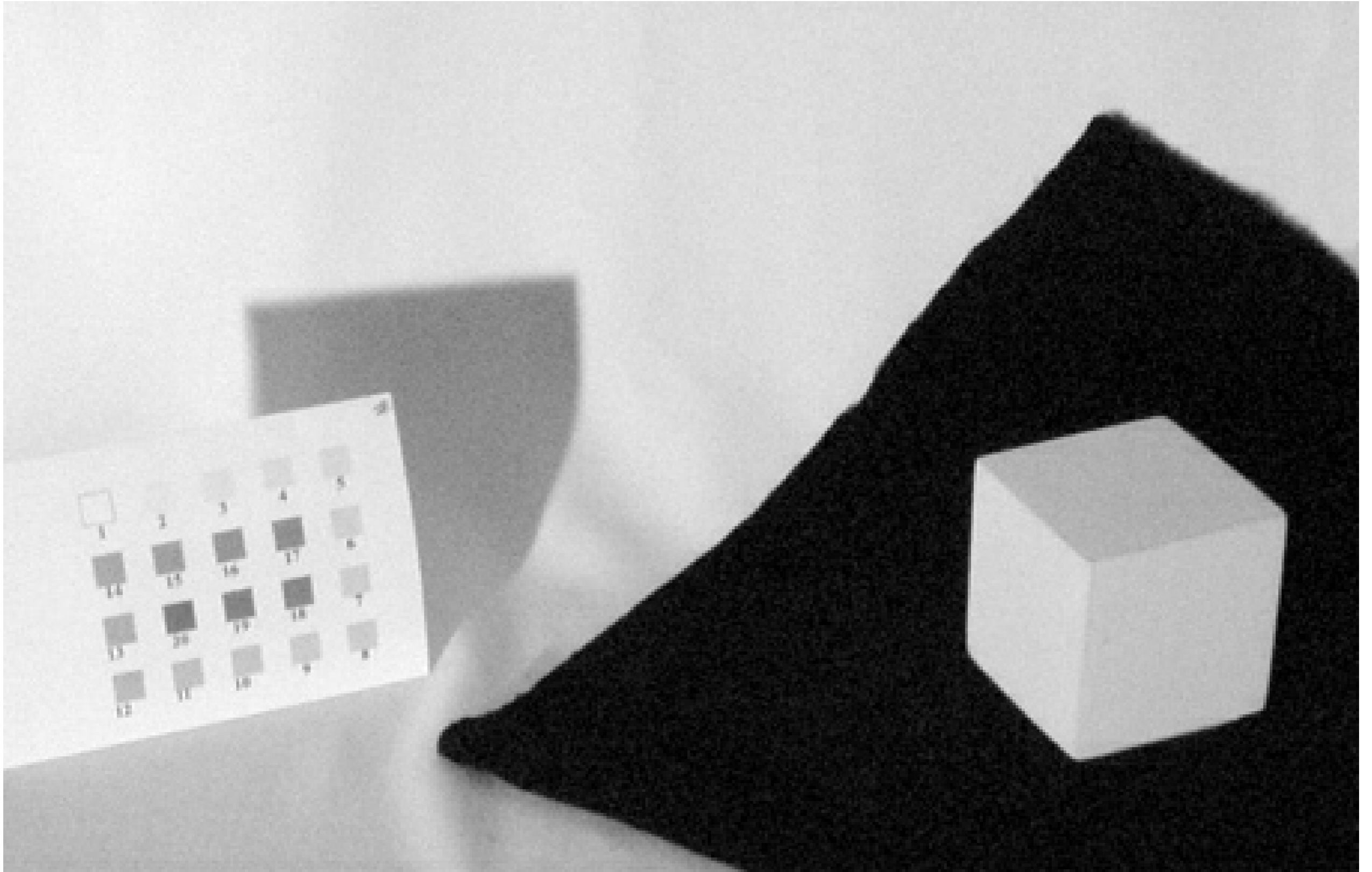


**Cube has: 3 white-paint faces**

**3 different gray-paint faces**

J. McCann, "The Appearance of Brightness and Lightness,"  
in Eighth Color Imaging Conference, Scottsdale, Arizona pp. 18 - 23, (2000).  
<[http://mccannimaging.com/Retinex/Publications\\_files/00CIC.pdf](http://mccannimaging.com/Retinex/Publications_files/00CIC.pdf)>

Do we care?



Are shadows and surfaces the same ?

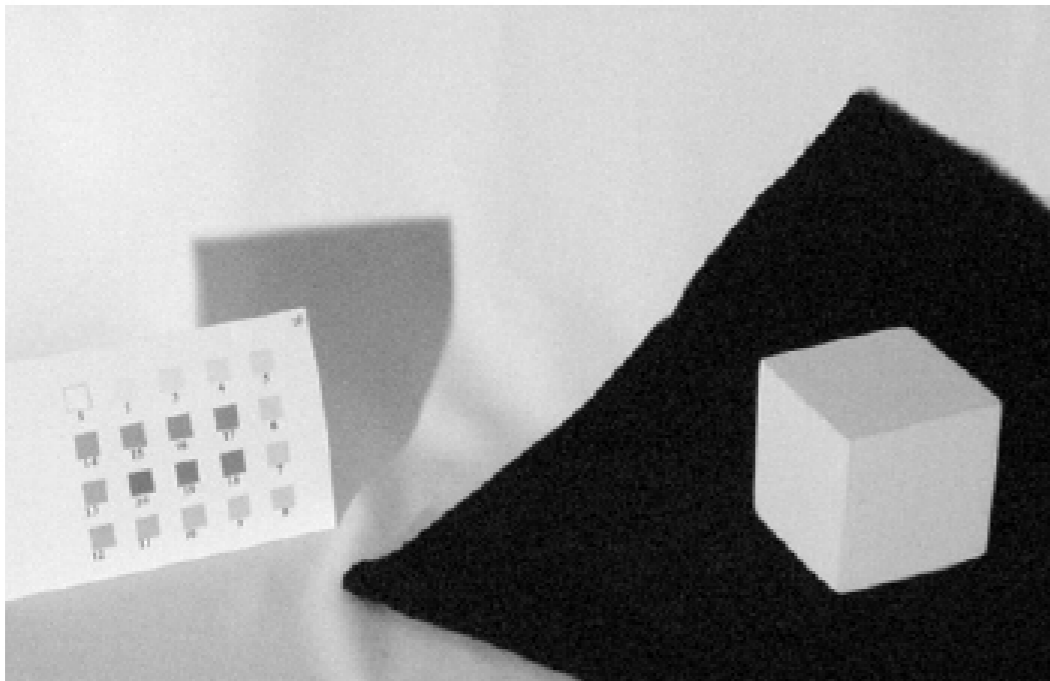
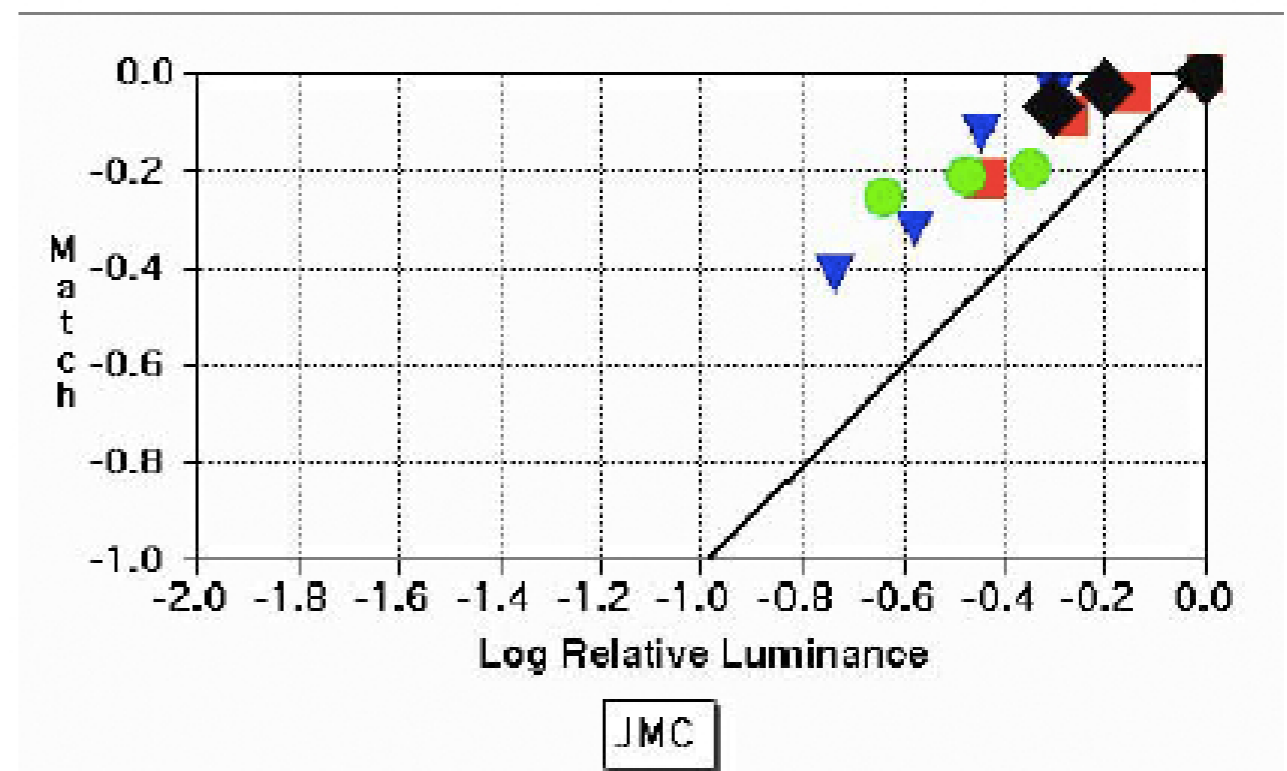
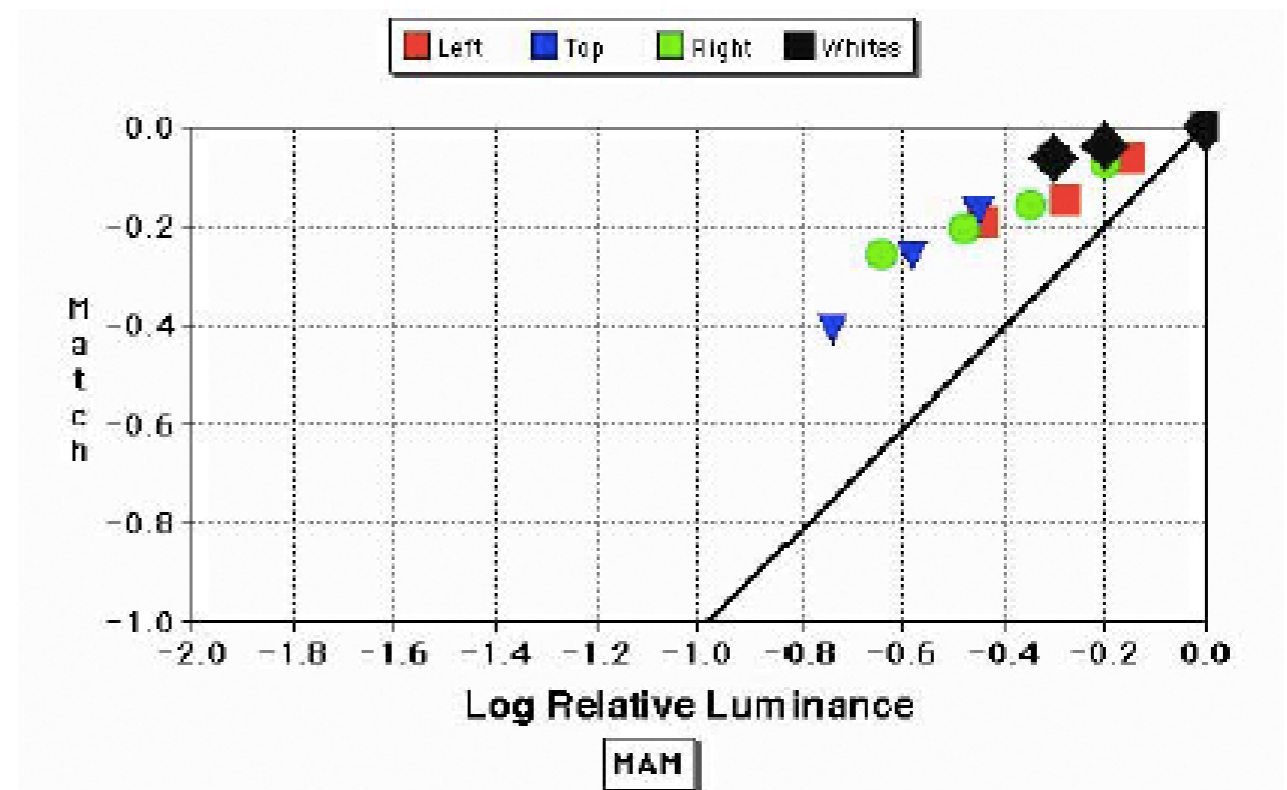


Figure 5 shows a photograph (above) of the left illumination experiment. The matching data for two observers is shown on the right. The horizontal axis plots log relative luminance measured from the eyepoint of the observer. The vertical axis plots log relative luminance of the matching square on the left. The squares, triangles and circles plot data from different reflectances in the left, top, and right positions. The larger diamonds plot the data from illumination only matches for all white reflectances.



**When matching sensations, we do not care.  
We build the match out of edges.**





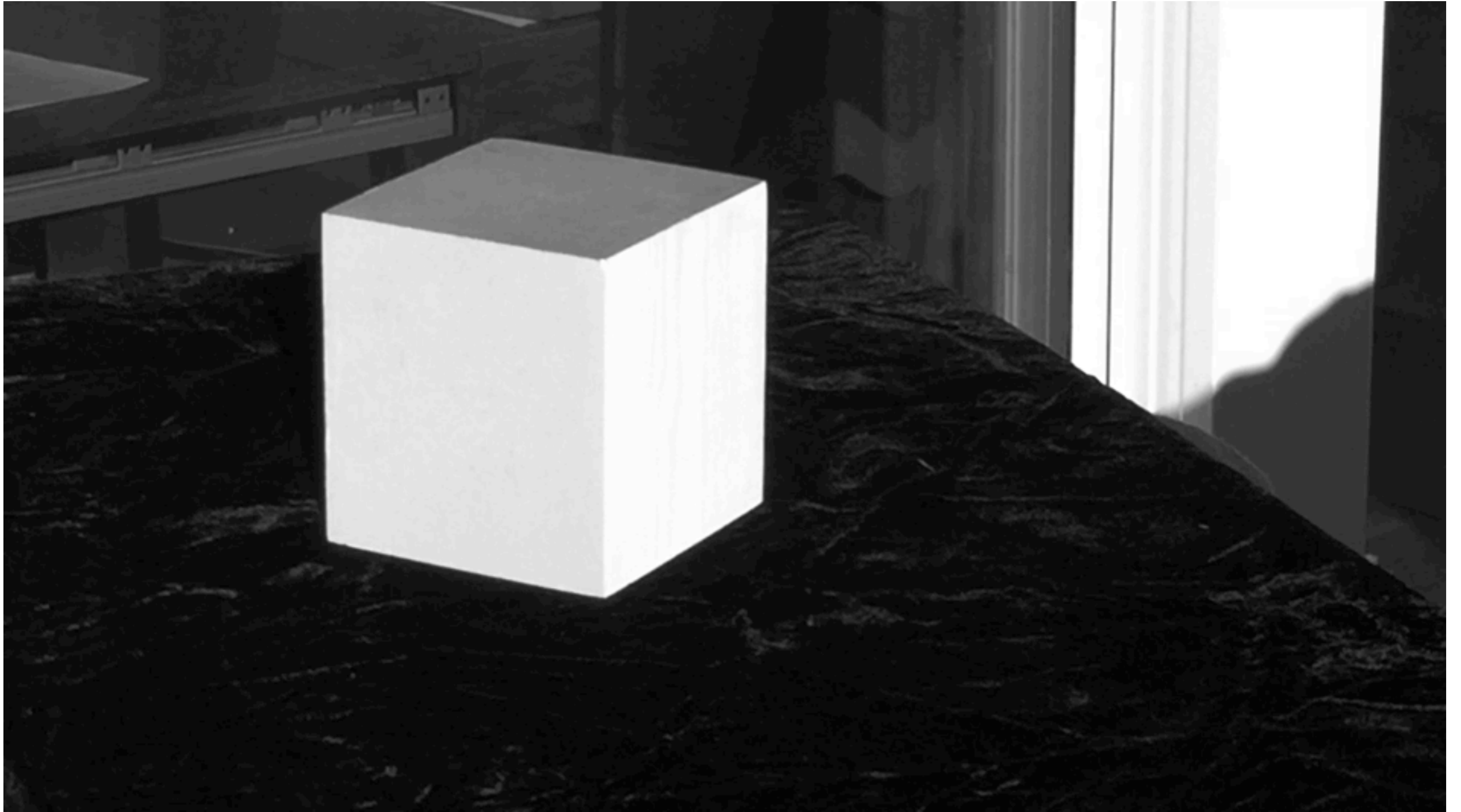
**Cornell Box**  
SIGGRAPH'84

# Don Greenberg

Jacob Gould Schurman Professor of Computer Graphics

**“You have moved the sun !!!**





# We know we are moving reflectances !

- We do not see that the paint has moved
- We see the light has moved

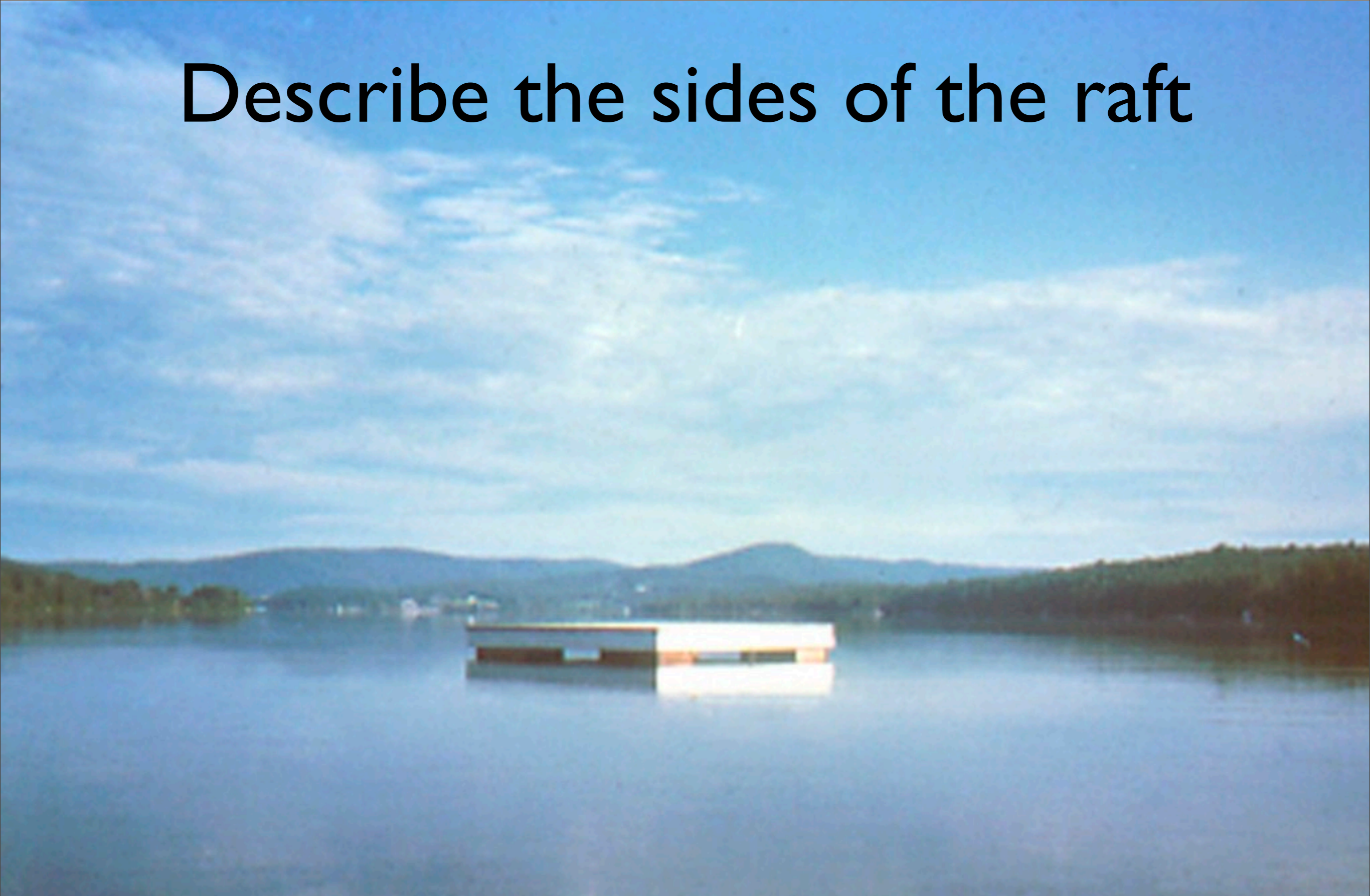
# Why was the shadow still there after I knew it was blue paint?

What do these word mean?

- Sensation
- Perception
- Recognition
- Knowing
- Conscious
- Unconscious
- Inference



# Describe the sides of the raft



J. J. McCann and K. L. Houston, "Color Sensation, Color Perception and Mathematical Models of Color Vision,," in: Colour Vision , Academic Press, London, 535-544, 1983.  
[http://mccanimaging.com/Retinex/Publications\\_files/83AICsm.pdf](http://mccanimaging.com/Retinex/Publications_files/83AICsm.pdf)

# Radiance

**20,000 deg K**  
**Relative Radiance = 1**

**4000 deg K**  
**Relative Radiance = 10**

*Very different*

# Observers



**WARNING:** The question you ask observers will affect their answers!



# Psychophysical Quantities

## OSA: Science of Color

### Sensation =

mode of mental functioning.

that is directly associated with the stimulation of the organism

### Perception =

mode of mental functioning that includes the combination of different sensations and the utilization of past experience in recognizing the objects and facts from which the present stimulating arises

OSA Science of Color(1953)

# Sensation

If you are a fine arts painter,  
what paint mixture would you choose to paint the

*Appearance*

of each face of the raft?



Darker Bluish  
Gray



Bright Yellowish  
White

**Monet painter question**



# Perception

If you are a house painter,  
what paint mixture would you  
*recognize*

as the color of the paint actually on each face of the raft?



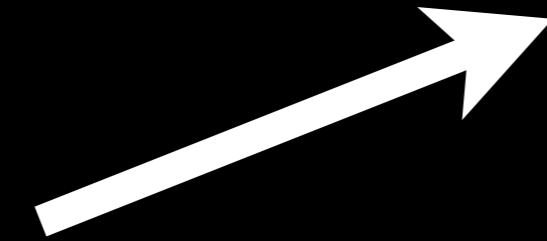
White House Paint

**House painter question**



# Which Question ?

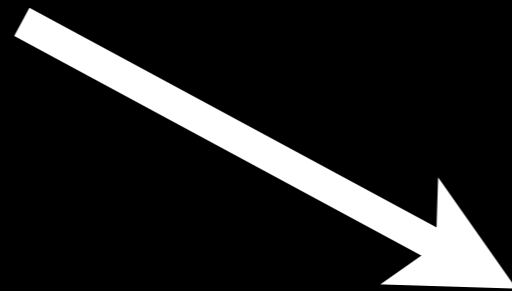
What problem are we solving?



Accurate:  
“Reproduce exactly”



Sensation;  
“Slightly different”



Perception:  
“Same”



What problem are we solving?

Radiance  
[physics]

$\text{Wm}^{-2}\text{sr}^{-1}$

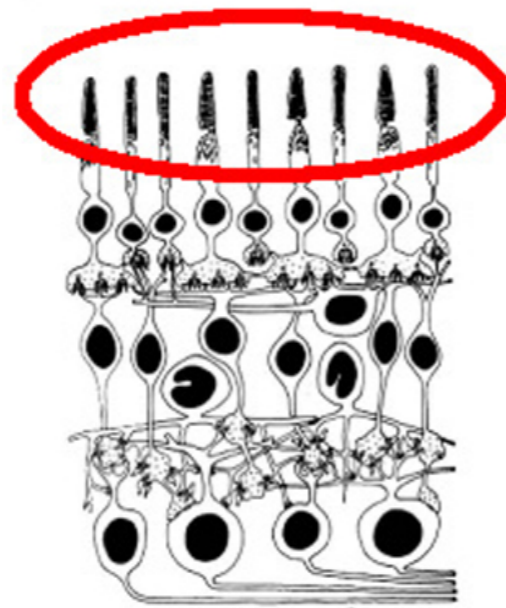
Appearance  
[sensation]

Edges &  
Gradients

Recognition  
[perception]

Reflectances  
& Illuminants

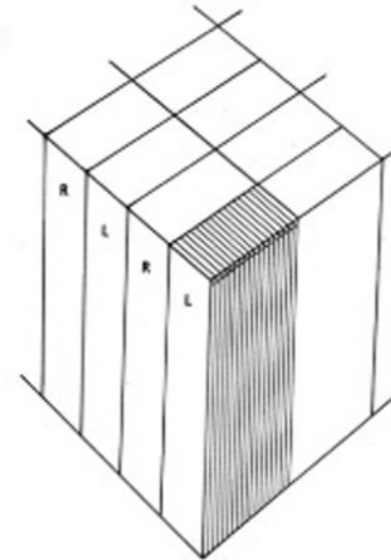
# Appearance $\neq$ Receptor Quanta Catch



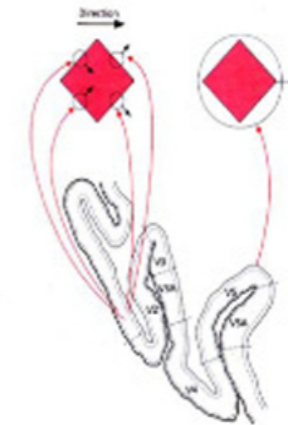
**Retina**



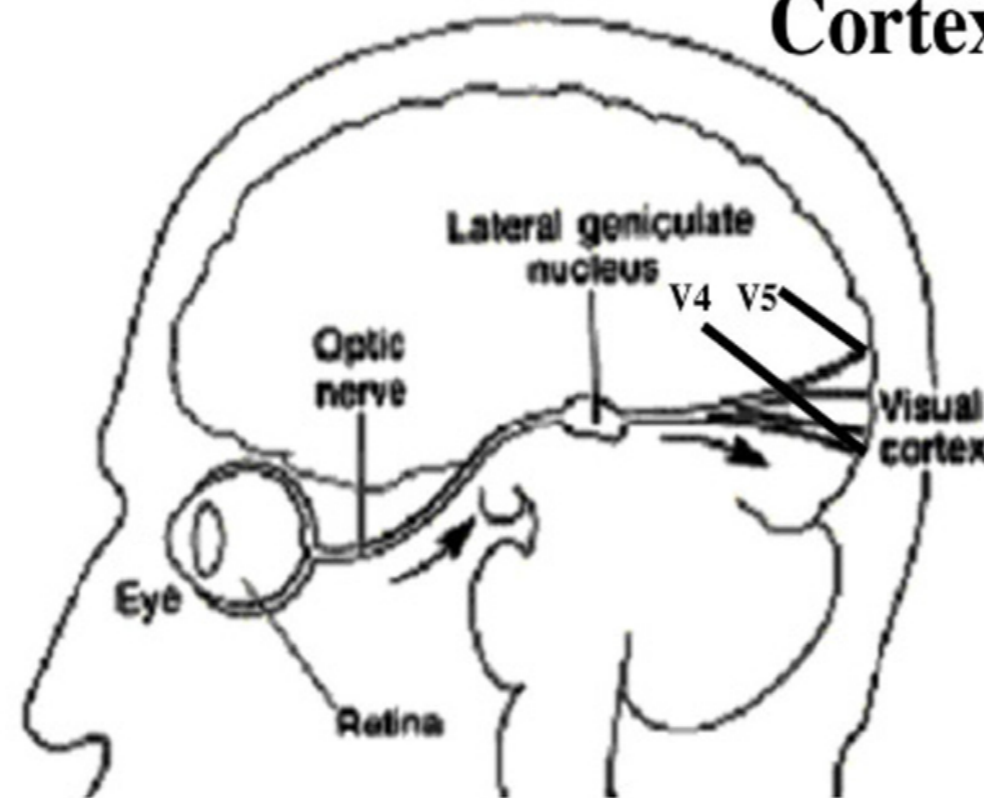
**Optic Nerve**



**Primary Visual Cortex**



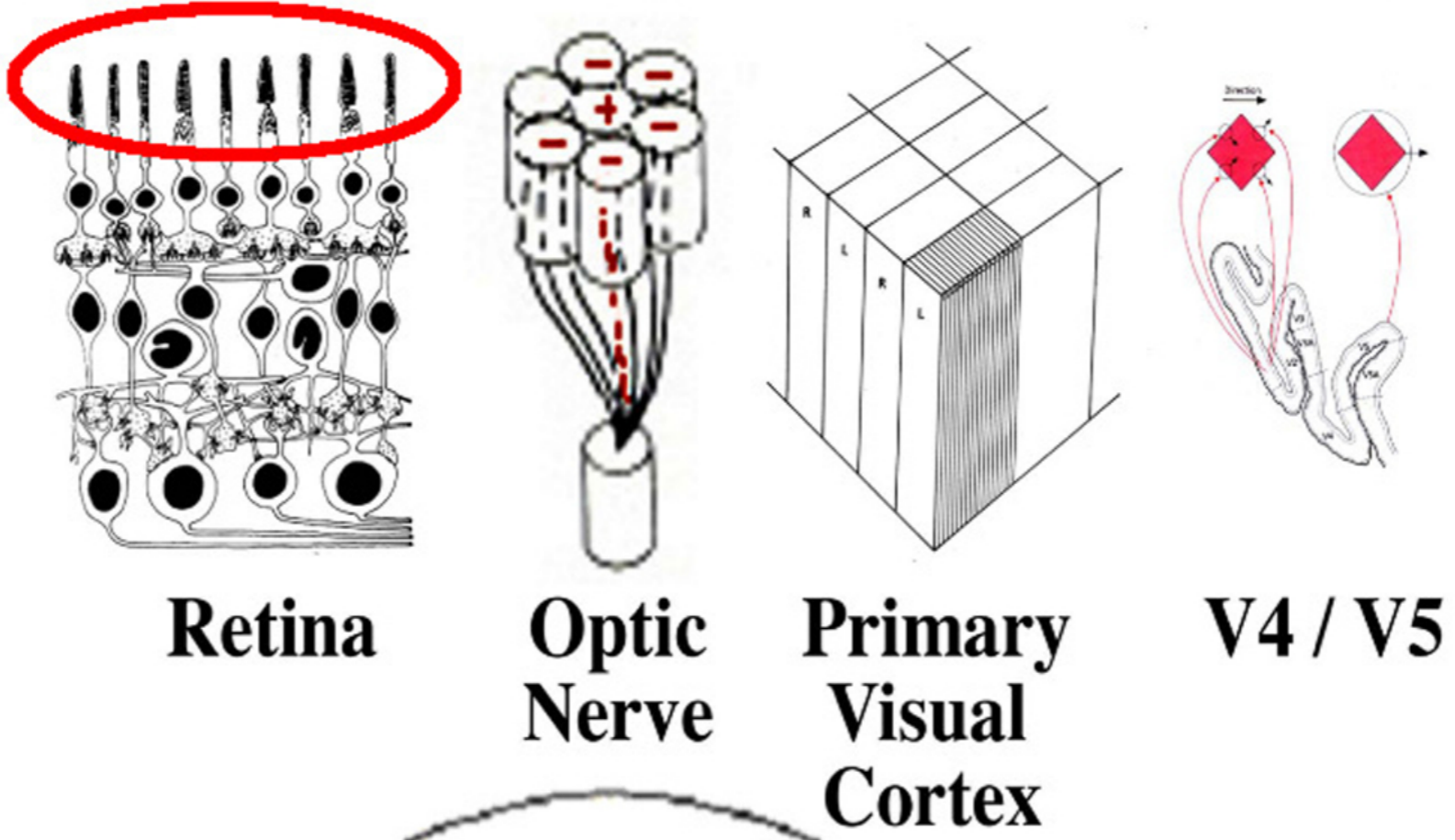
**V4 / V5**



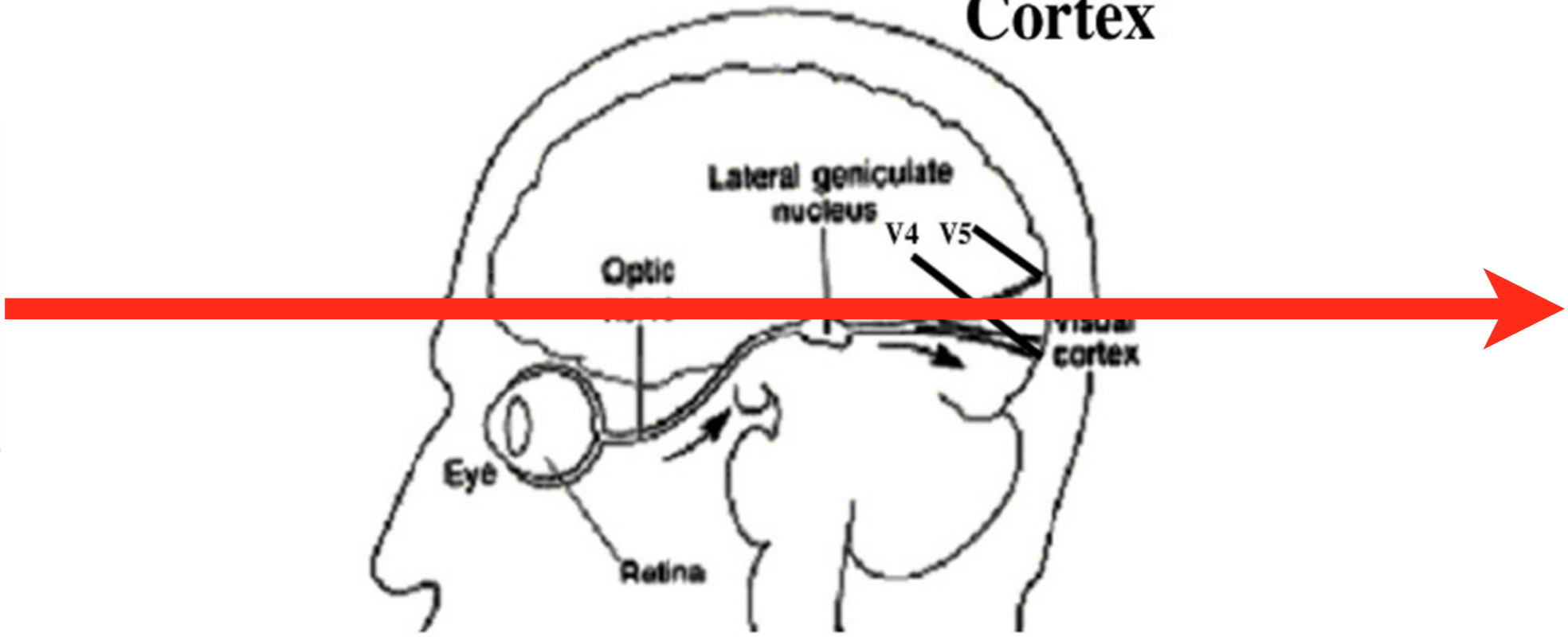
$$\text{Appearance} = f(\text{Spatial Comparisons})$$



# Appearance $\neq$ Receptor Quanta Catch



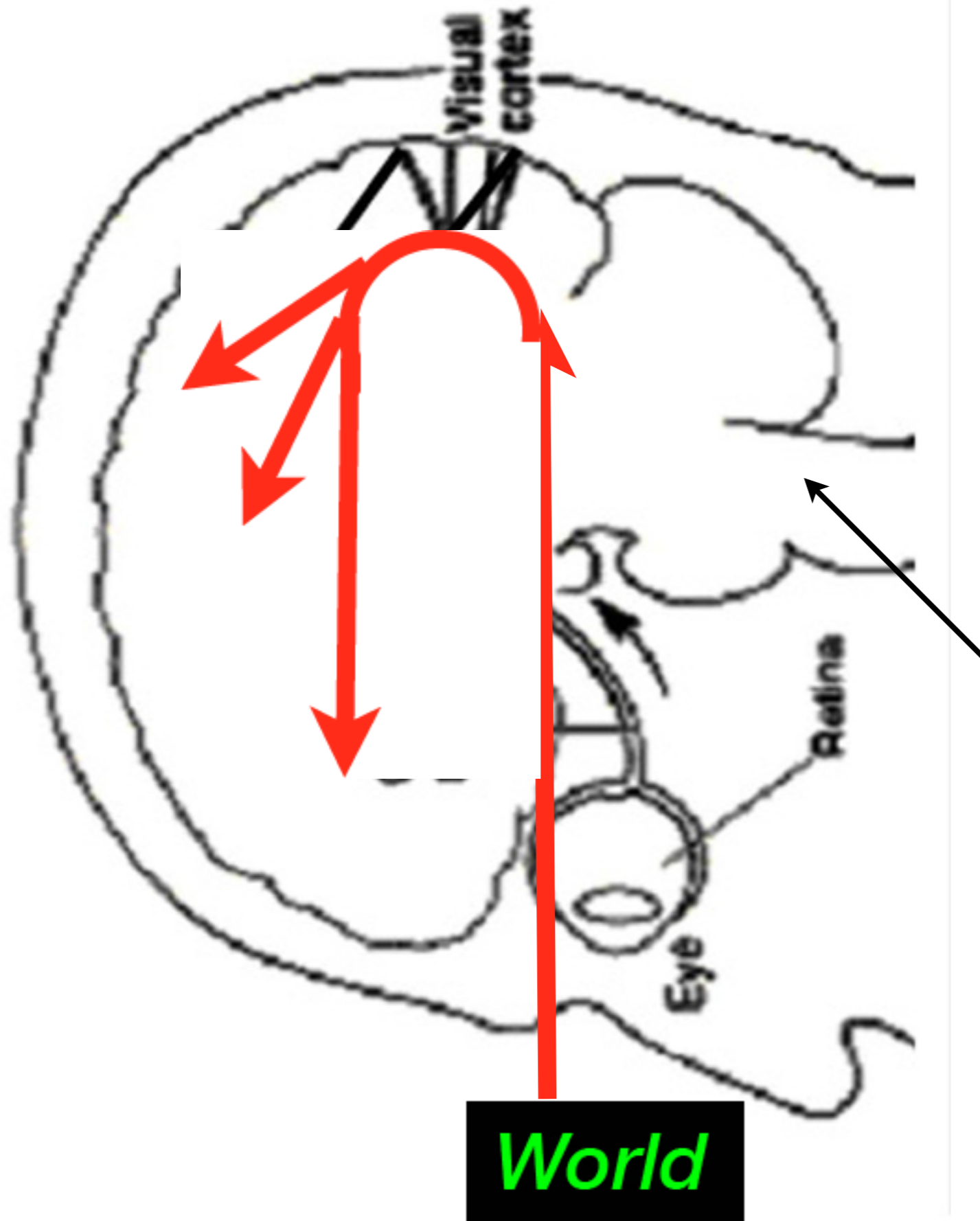
**World**



**Vision**

**Neurophysiology**

## *Vision*



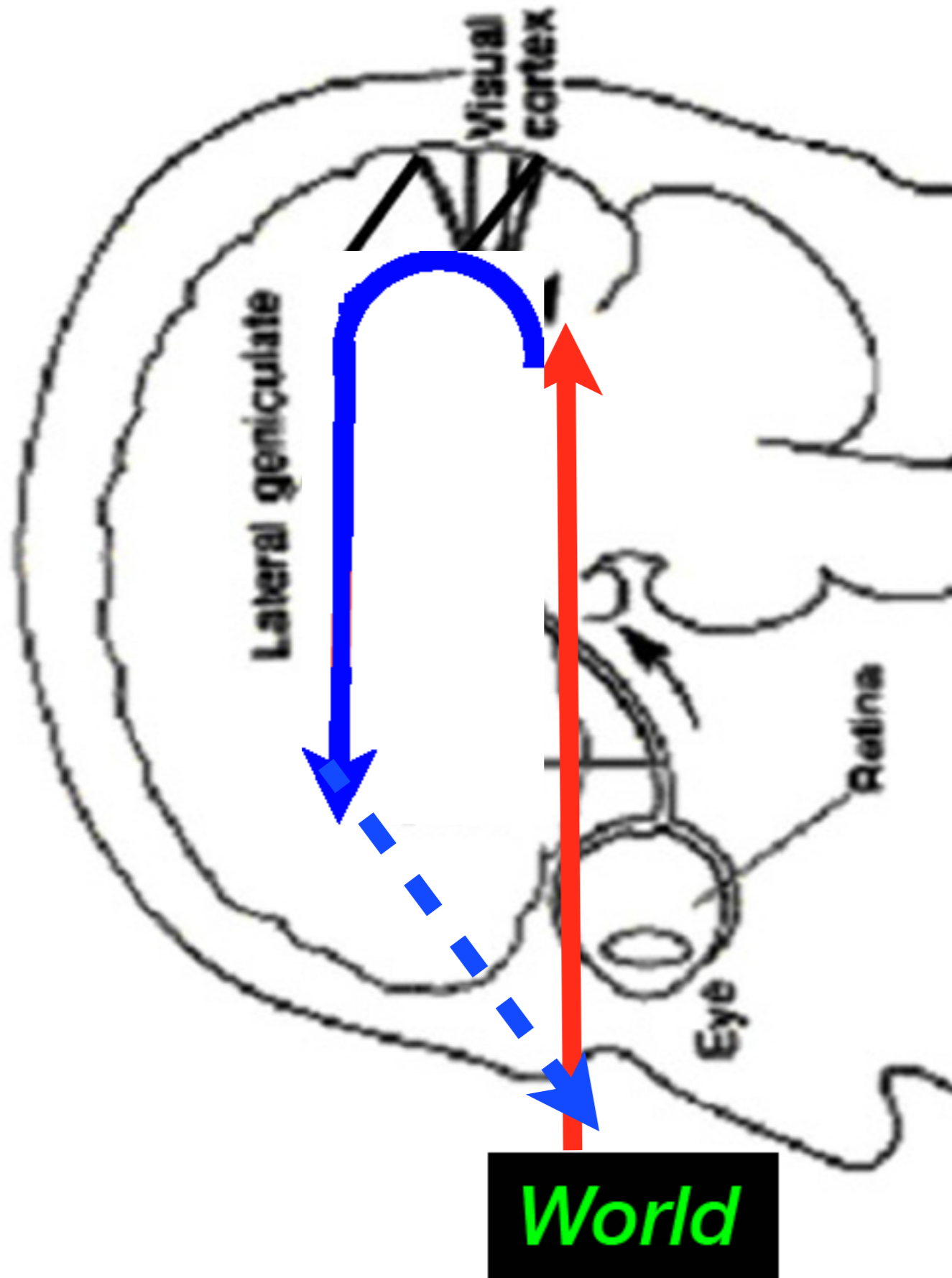
## *Neurophysiology*

A cascade of spatial comparisons

Layers of an onion

Each layer compares and passes the comparison on to the next

## *Vision*



## *Perception*

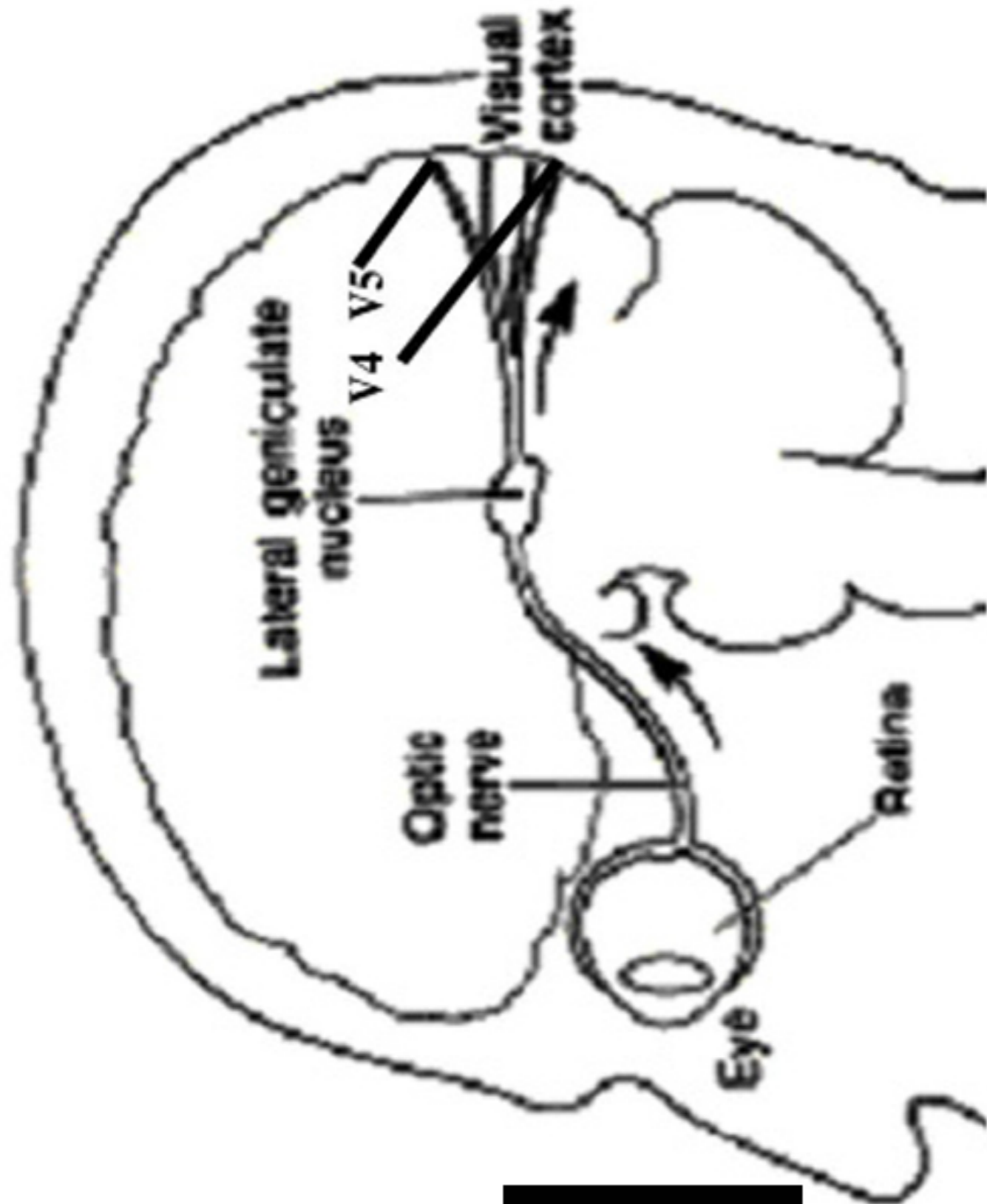
We perceive  
the surface  
reflectance of  
objects in the  
world

recognition?  
cognition?  
learning?  
top-down?

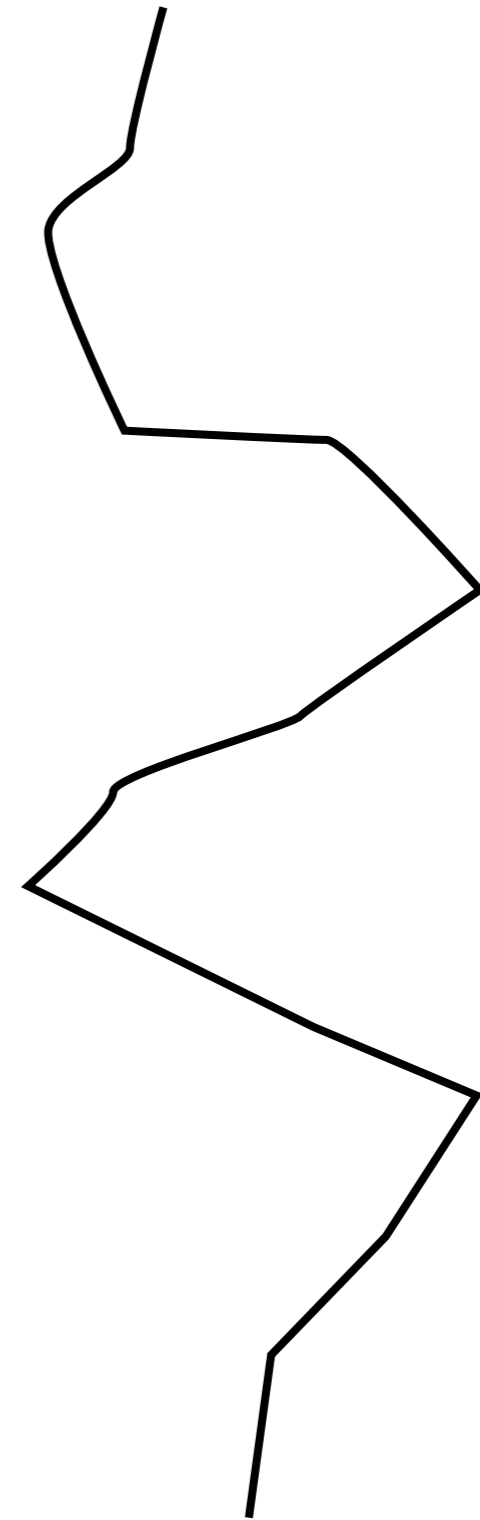
requires a partnership of  
SEE and KNOW

# Vision

# Any Number of Models



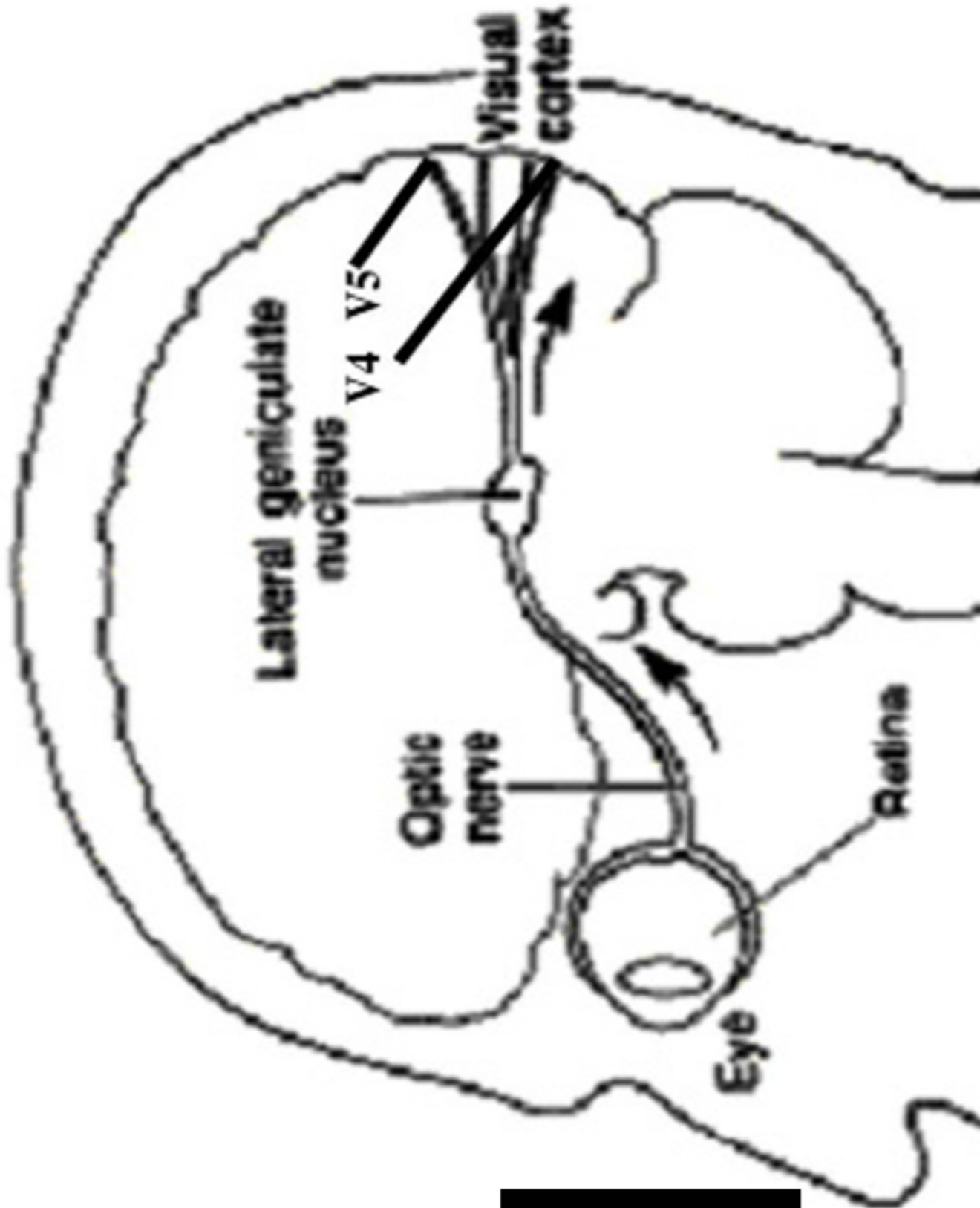
**World**



What is your favorite?

# Vision

# Any Number of Models



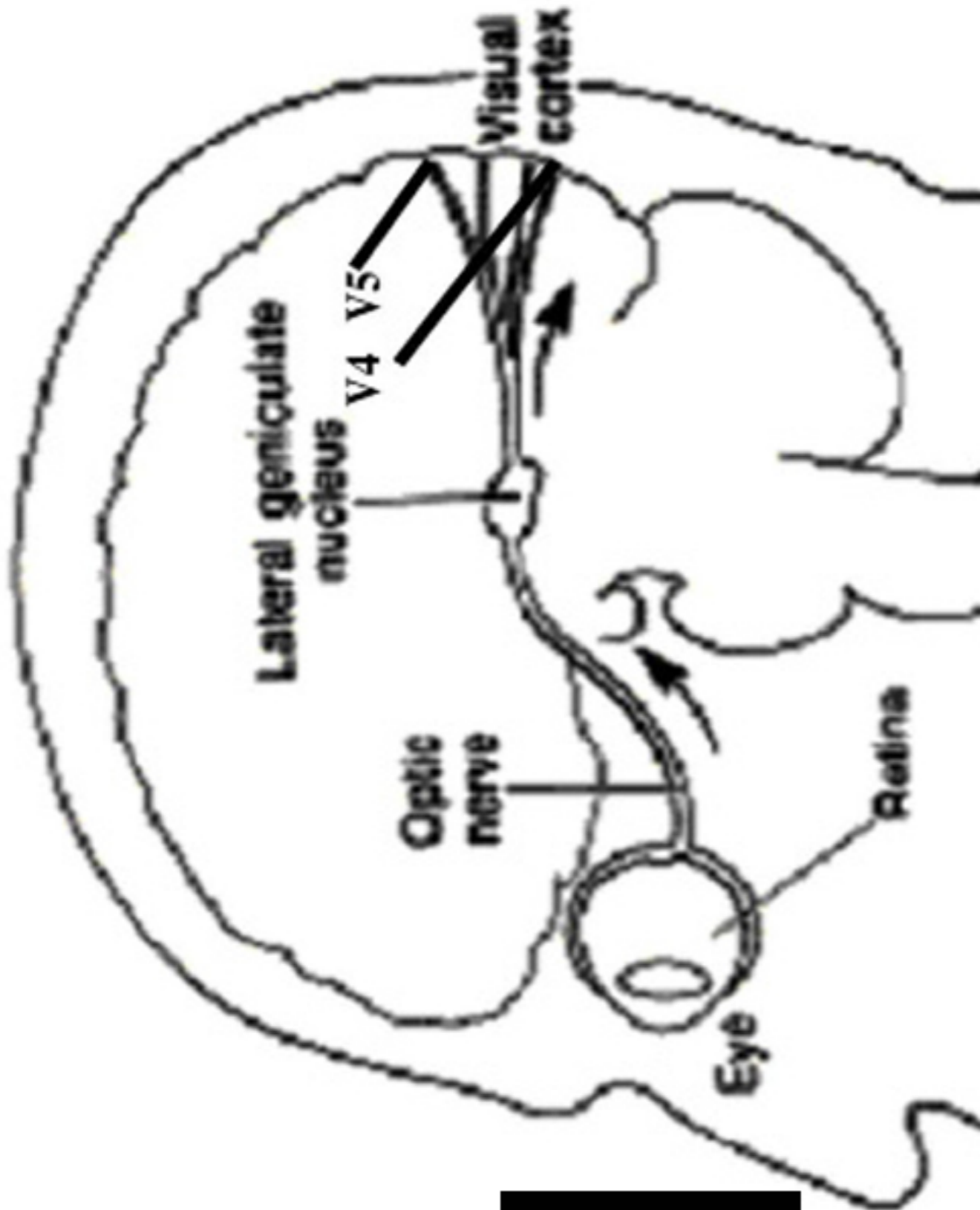
**World**



What is your favorite?

# Vision

# Any Number of Models



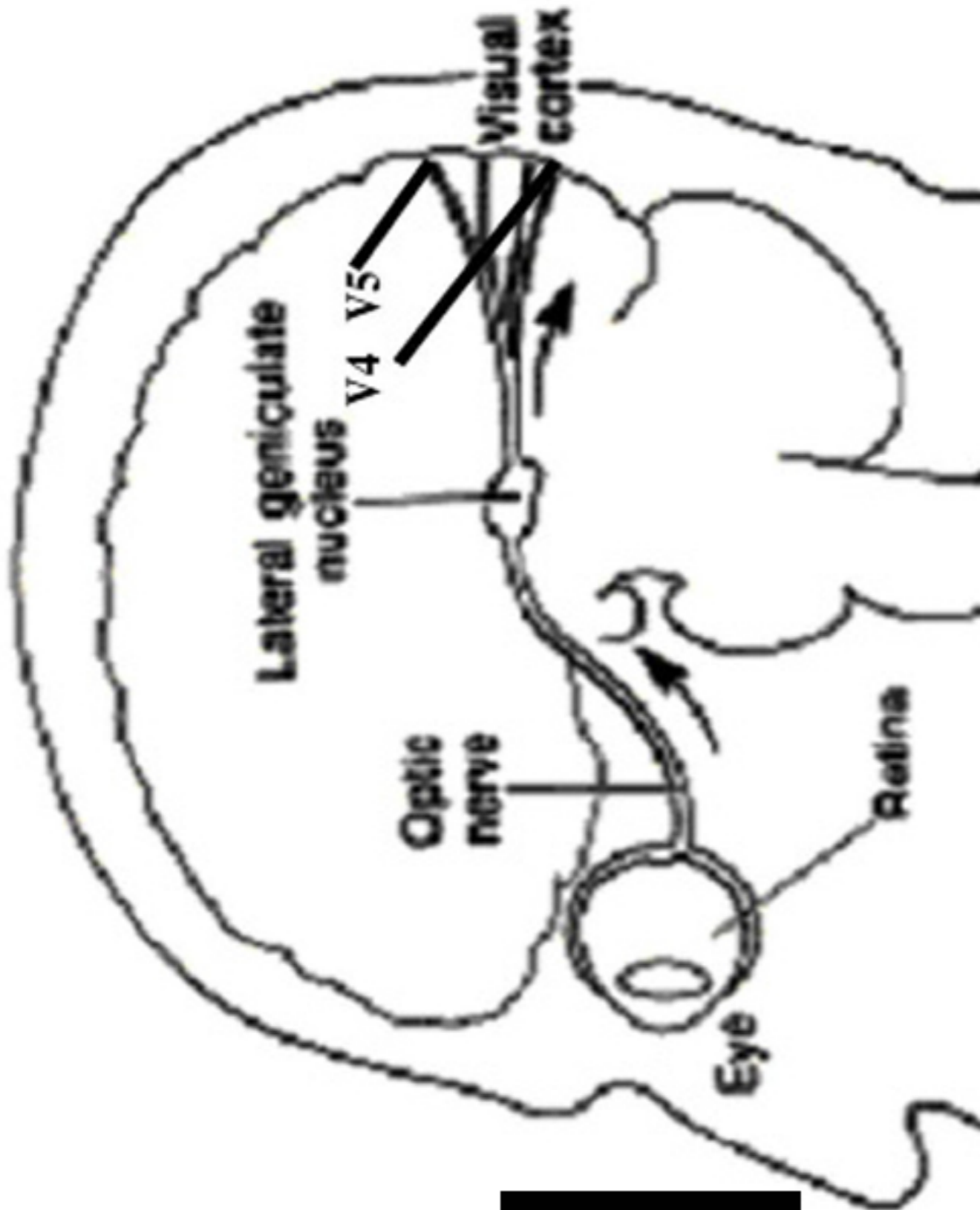
**World**



What is your favorite?

# Vision

# Any Number of Models



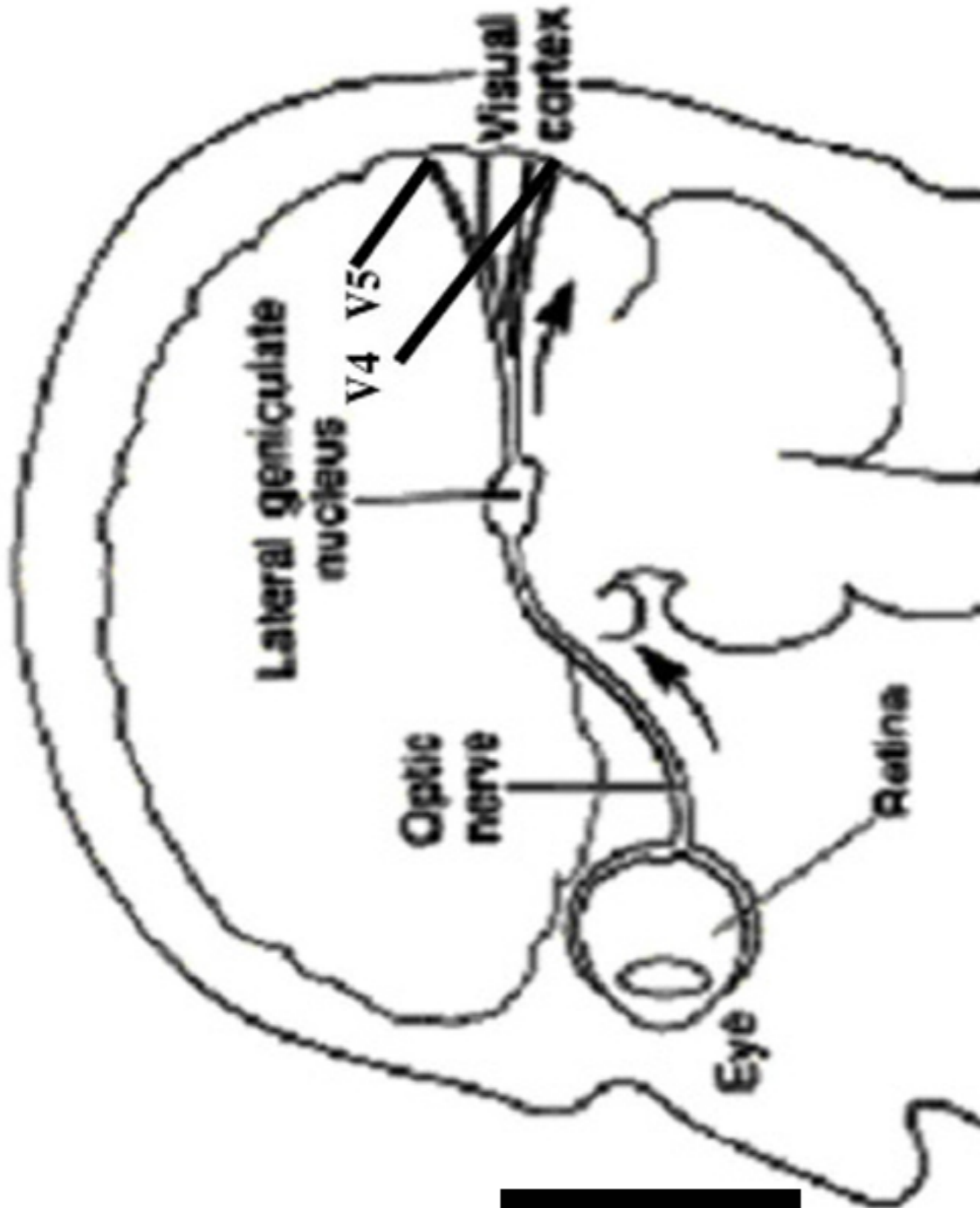
**World**



What is your favorite?

# Vision

# Any Number of Models



**World**

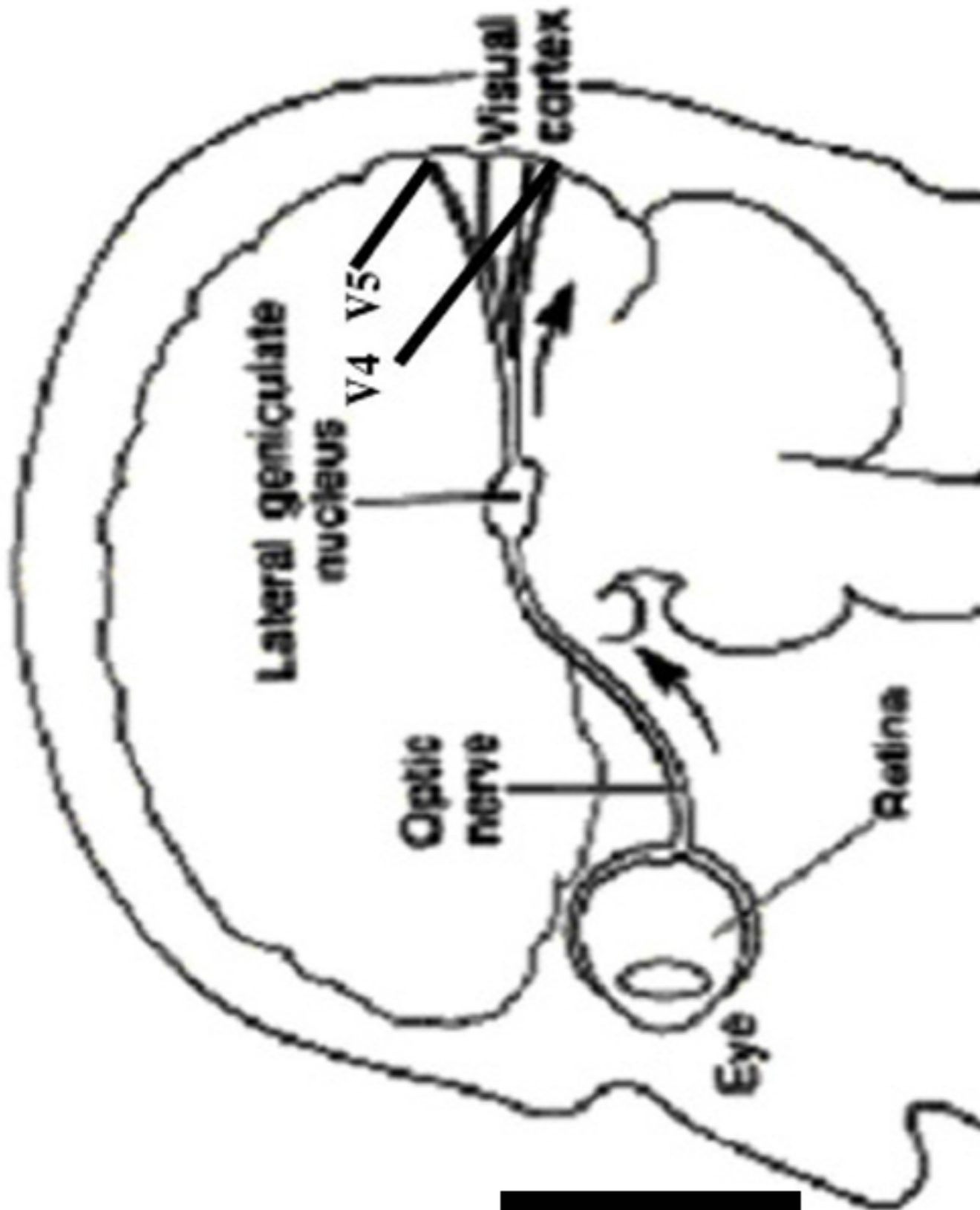


What is your favorite?



# Vision

# Any Number of Models

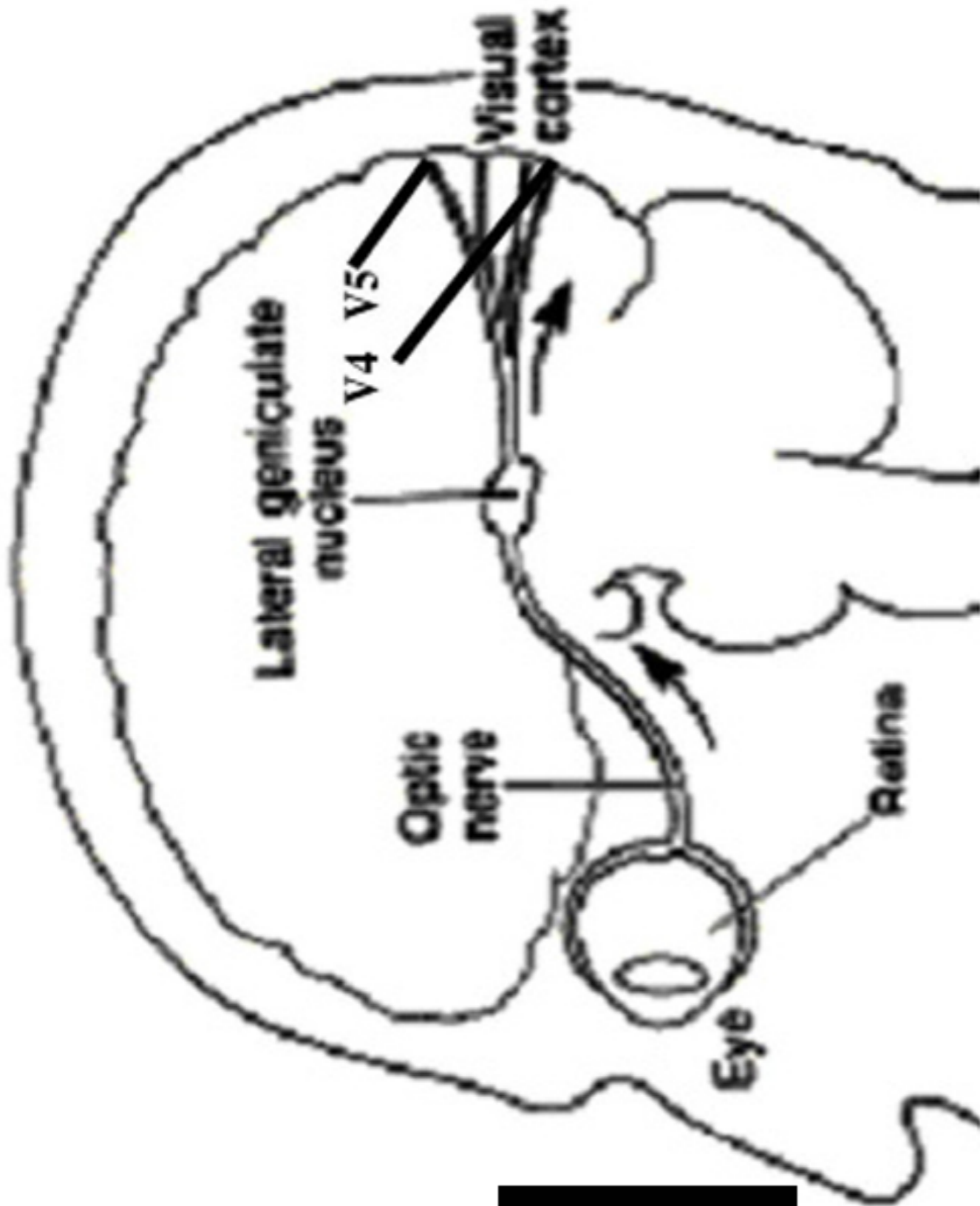


**World**



What is your favorite?

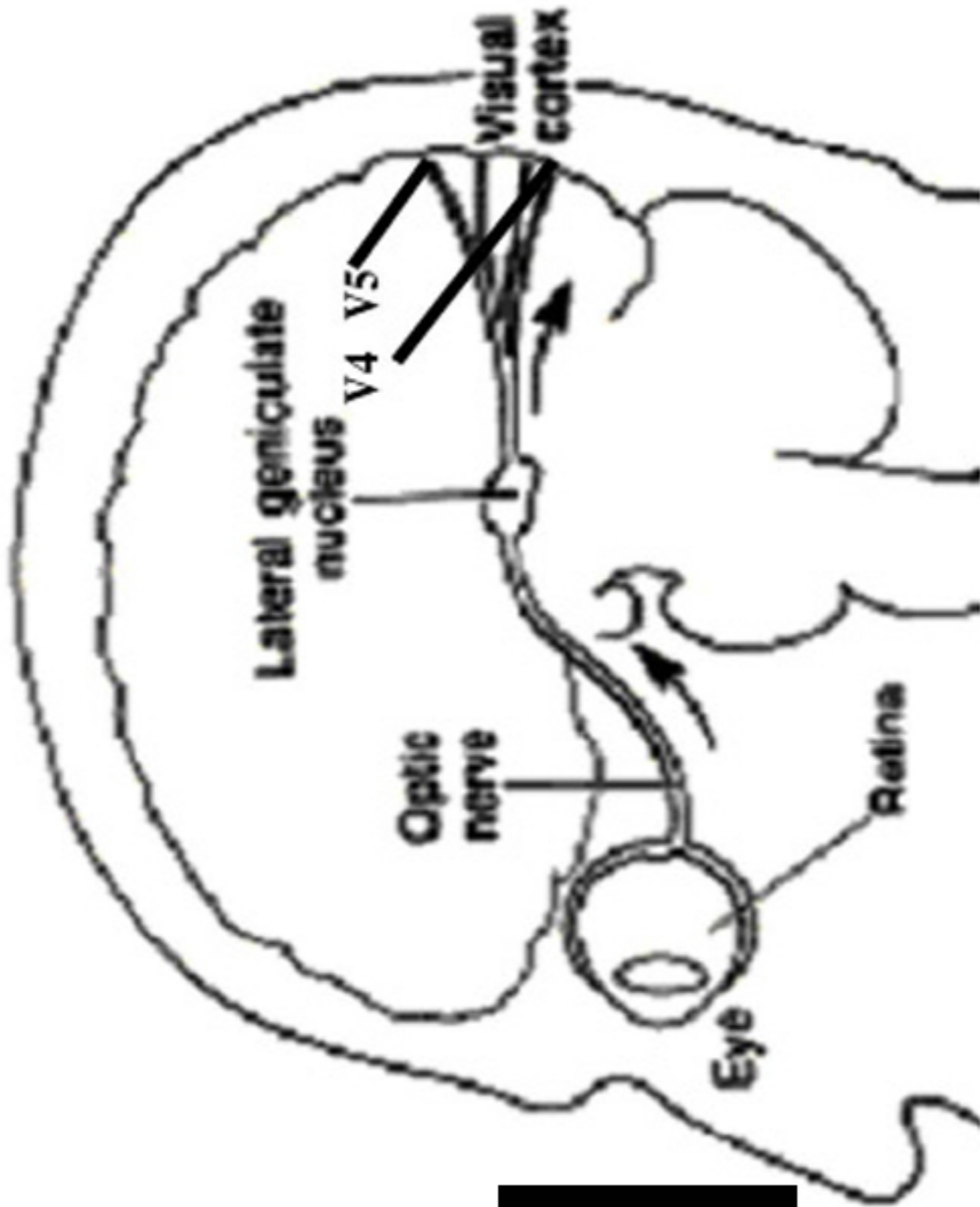
# Vision



**World**



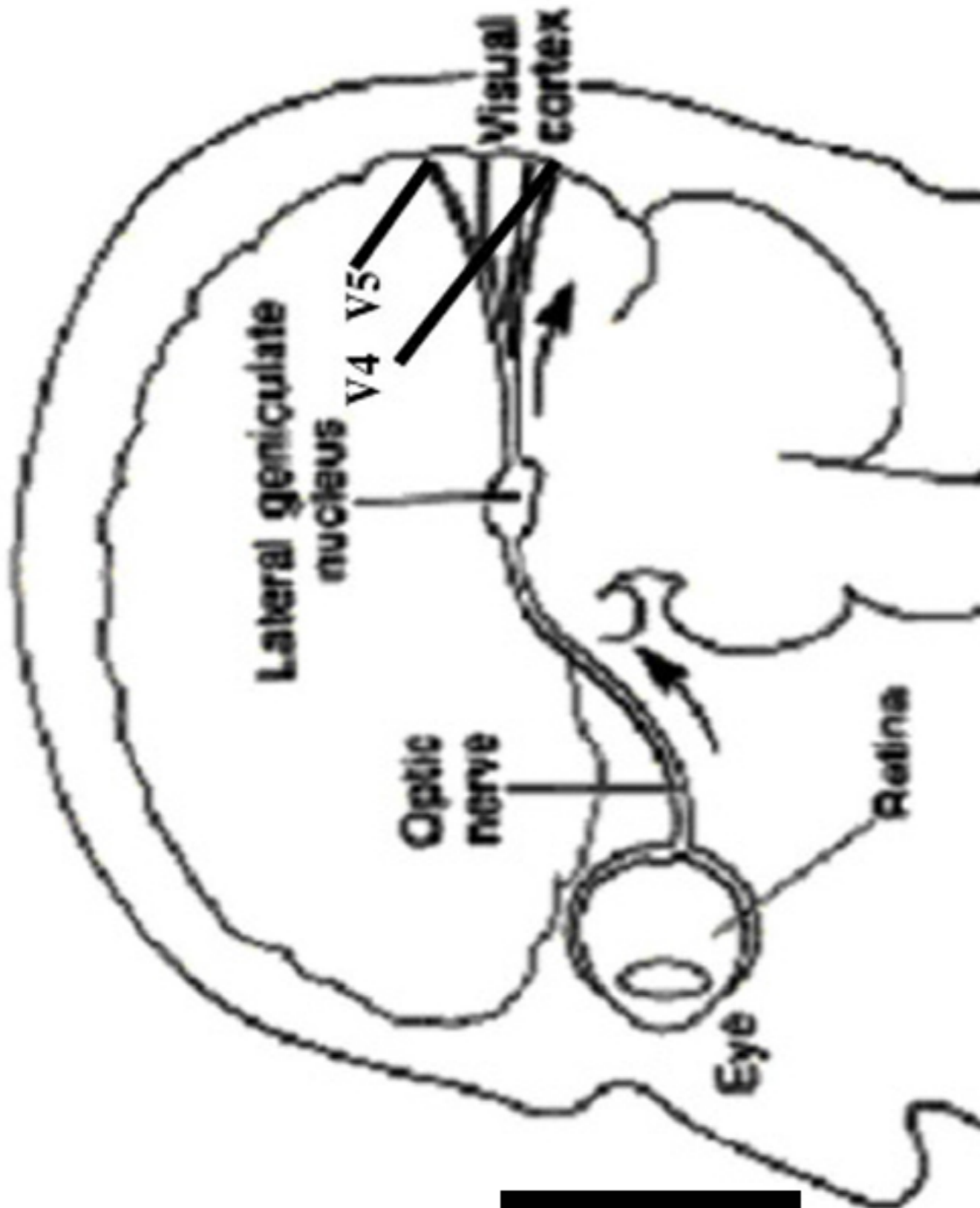
# Vision



**World**



# Vision



**World**



My favorite model...  
this week.

# Paradoxes abound

- We sense
- We perceive
- We recognize
- We know

They all exist in parallel ?

We should not confuse them

We just need to remember  
to care about the words we use.

The language we use helps us collaborate.

Collaboration is important !



Thank  
you

[mccanns@tiac.net](mailto:mccanns@tiac.net)

# Thanks Don



# Thank You

# "What we see and what we know: Partners in human vision"

- How many times a week do we do “double takes”?
- We see something, and then it registers that what we saw does not fit right. Then, we look again. We either confirm, or reconsider what we saw.
- Vision is a complex process that integrates the massive amount of data coming up the optic nerve with our understanding of where we are, and what we are doing.
- That integration takes place somewhere, or perhaps everywhere in the brain.
- When we perform a psychophysical experiment we measure something. In colorimetry, we think we are measuring the quanta catch of visual pigments in rods and cones - an early step. Matching things usually measures things that happen early in the visual process.
- However, perception is often defined as recognizing something about the world around us. Recognition implies cognition, or higher cortical mechanisms - knowing.
- Psychophysics covers the full range of seeing and knowing. It covers receptors through cortex.