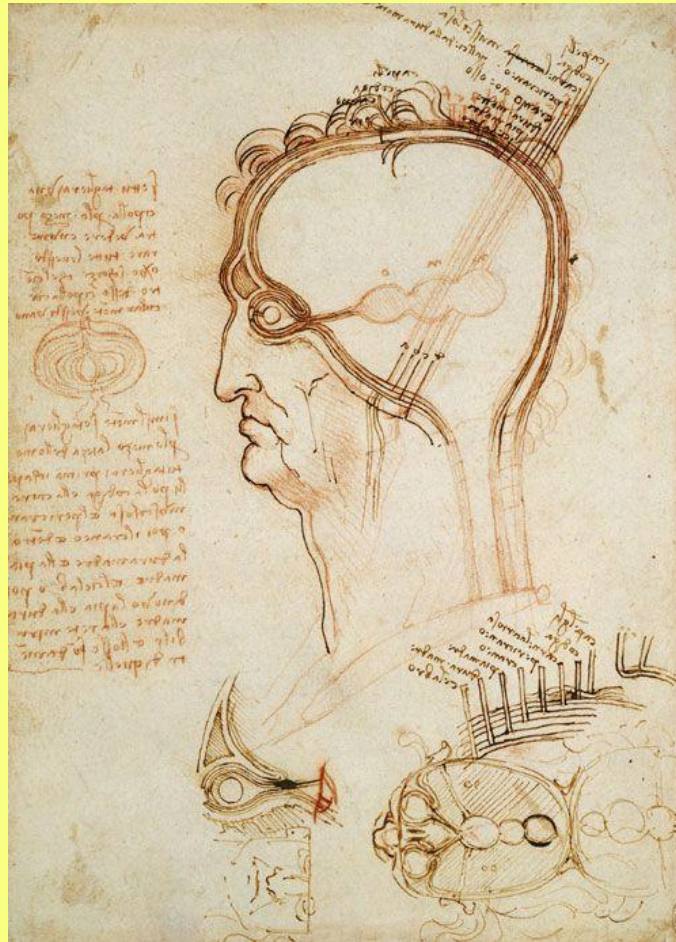


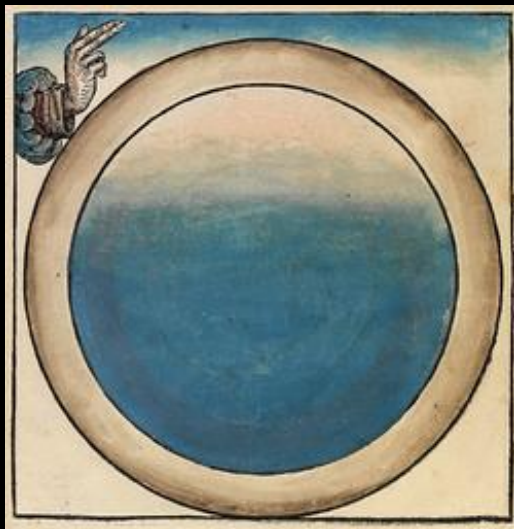
The Window on the soul



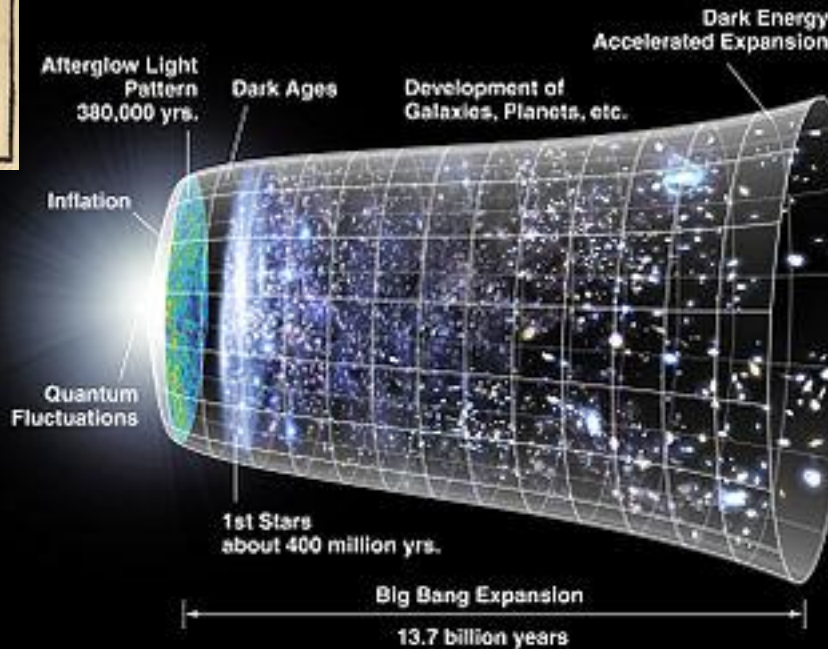
GRESHAM COLLEGE

William Ayliffe

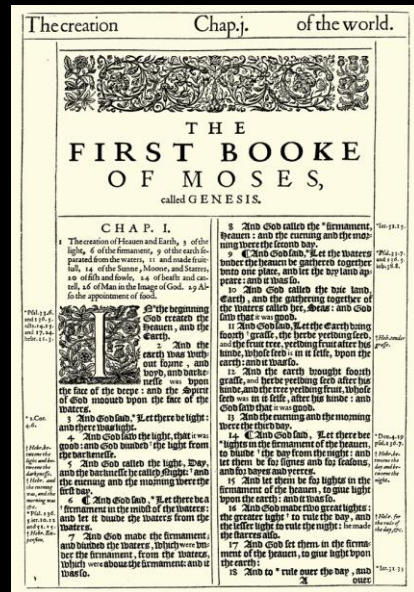
May 29th 2013.



First Day of Creation (1493
Nuremberg Chronicle)



In the beginning God created the heaven and the earth. And the earth was without form, and void; and darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters. And God said, Let there be light: and there was light. And God saw that it was good. And the evening and the morning were the first day.



"esse est percipi"

("to be is to be perceived")

George Berkeley 1709:

"It is indeed an opinion strangely prevailing amongst men, that houses, mountains, rivers, and in a word all sensible objects have an existence natural or real, distinct from their being perceived by the understanding

familiar objects like tables and chairs are only ideas in the minds of perceivers, and as a result cannot exist without being perceived

*There was a young man who said
"God Must find it exceedingly odd*

*To think that the tree
Should continue to be*

When there's no one about in the quad."

Ronald Knox



Windows and light

The countenance is the portrait of the soul, and the eyes mark its intentions.

Cicero (B.C. 106-43)

'Ut imago est animi voltus sic indices oculi'

The face is a picture of the mind as the eyes are its interpreter

Thomas Phaer: 1510-1560: Paediatrician

The eyes...are the wyndowes of the mynde, for both ioye & ange...are seene... through them. 1545 Regiment of Life

Translation of *Regimen sanitatis Salernitanum*

These lovely lamps, these windowes of the soule

Joshua Sylvester, Divine Weekes and Workes (1591)

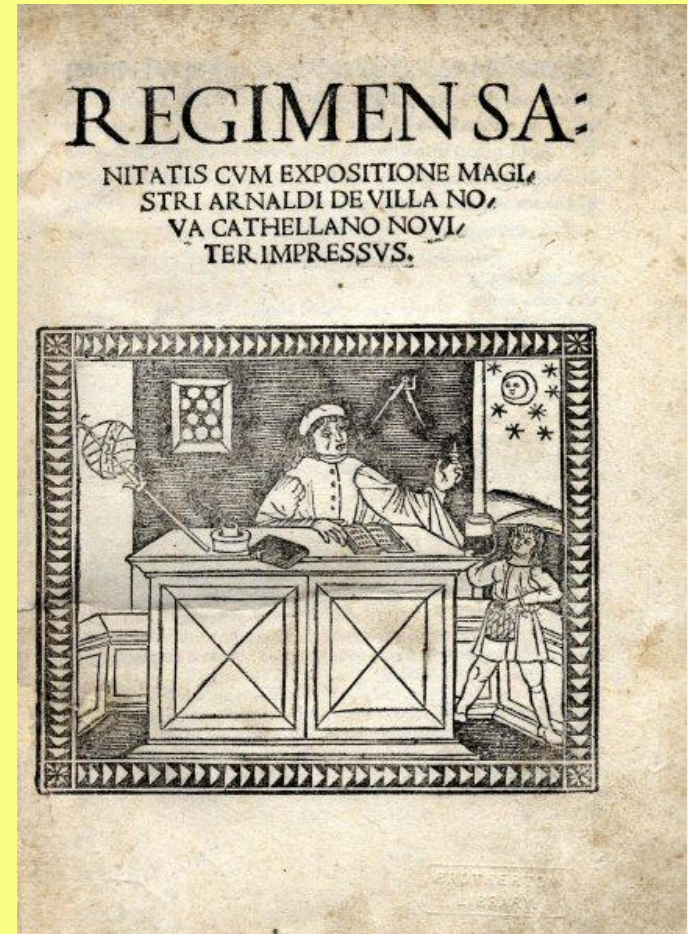
The eies...are called the windowes of the heart, by which love enters into the same

Stefano Guazzo, Civile Conversation (1584)

French, 'Les yeux sont le miroir de l'dme (mirror of soul)

You cannot hide the soul. Through all his unearthly tattooings, I thought I saw the traces of a simple honest heart; and in his large, deep eyes, fiery black and bold, there seemed tokens of a spirit that would dare a thousand devils.

Herman Melville, Moby Dick



“Who are you going to believe, me or your own eyes?”

Groucho Marx

God's light

Pseudodionysian light metaphysics

Abbot Suger, friend of Louis VI and Regent to his son, reconstructed the choir of St. Denis, Benedictine Priory. 1140-44. Glazed the upper Choir "Nova Lux"

Used stained glass with much expensive blue.

The primary light Lux is substance distinguished from light of heavenly bodies Lumen which flows from it
Lux = Divinity:

Pseudo-Dionysius (Denys) C5th anonymous theologian.

Ascribed to Athenian Convert of St. Paul Acts 17:34 D. the Areopagite

Comes to West as gift of Byzantine **Michael the Stammerer** to **Louis the Pious** at Compiègne 827

Charles the Bald commissions John Scotus to translate

"Quid Distant inter Sottum et Scottum"



Suger at foot of Virgin in infant of Christ window



monks gaze heavenwards to the path created by St Benedict.

Closing the window

Judicial blinding

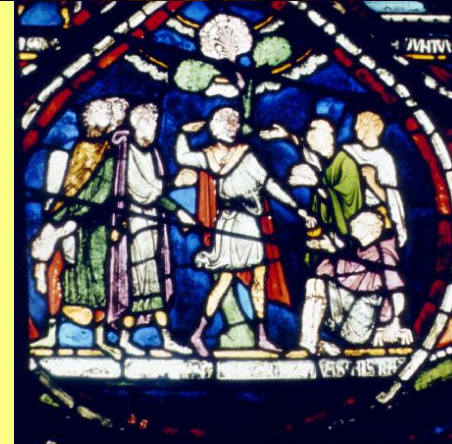
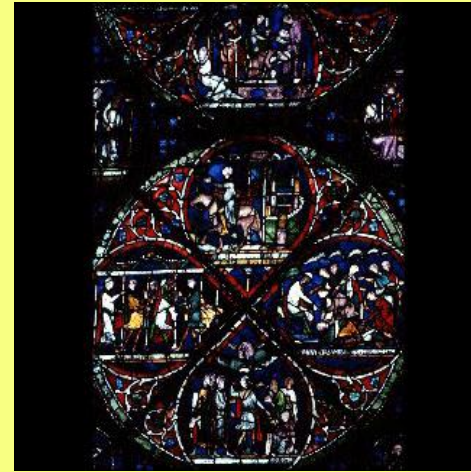
Canterbury Cathedral: North Aisle, Trinity Chapel:

Eilward of Westoning

St. Thomas, appears to him in bed and paints the sign of the cross with his crook. The membra swell so Eilward's sight is restored.

Miracles took place in 1171-3, recorded by William and Prior Benedict and used by the glaziers 1213-20.

Unusual miracle since it depended on the appearance of St. Thos rather than blood cult



Windows for the body and soul

Getting information about the internal system

Examine skin

Pulse

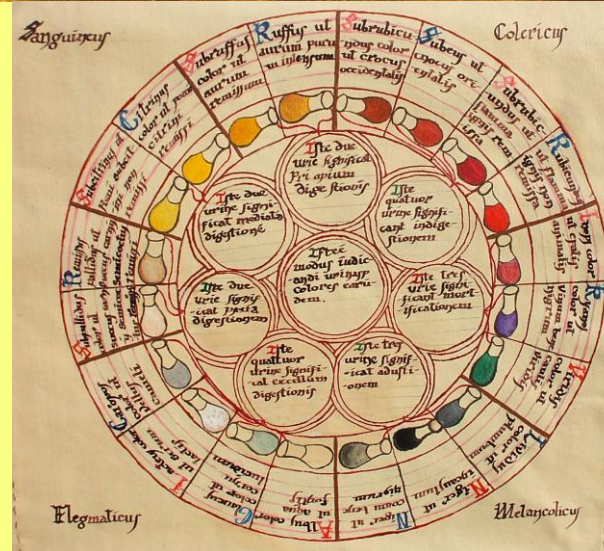
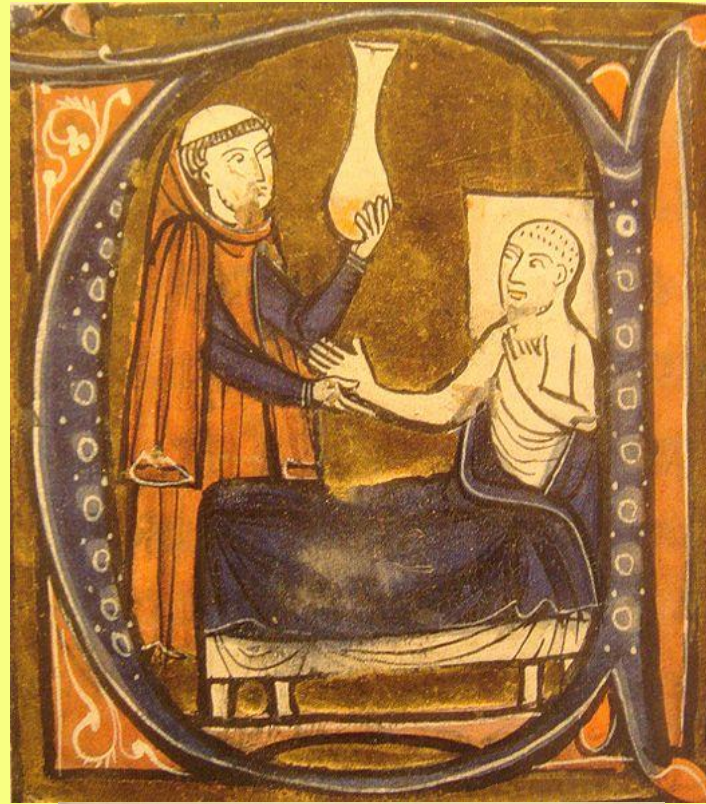
Eye discolouration

Tongue

Faeces

Urine

Depiction of the Persian physician Al-Razi, in Gerard of Cremona's "Recueil des traités de medecine" 1250–1260.



The Dropsical Woman

Louvre

1663 Gerrit Dou, pupil of Rembrandt,
medical practice in C17th—
visual inspection of urine as a diagnostic
tool

Doctor, robe and hat, examining a specimen
of urine.

Hooke's microscope, Blood pressure,
Laennec's stethoscope in the future.

Unethical physicians and charlatans,
claimed to predict a patient's prognosis
condemned by many physicians,

Thomas Brian, 1637 pamphlet, *The Pisse-
Prophet or Certain Pisse-Pot Lectures*.



Iridology

Window on the soul?

Iris is beautiful and most obvious

Characteristics of the iris thought to reflect patient's systemic health.

Iris charts, describe iris in zones corresponding to different parts of the body.

Iridologists see the eyes as "windows" into the body's state of health.

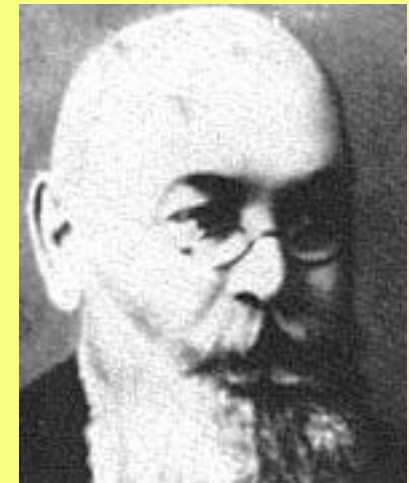
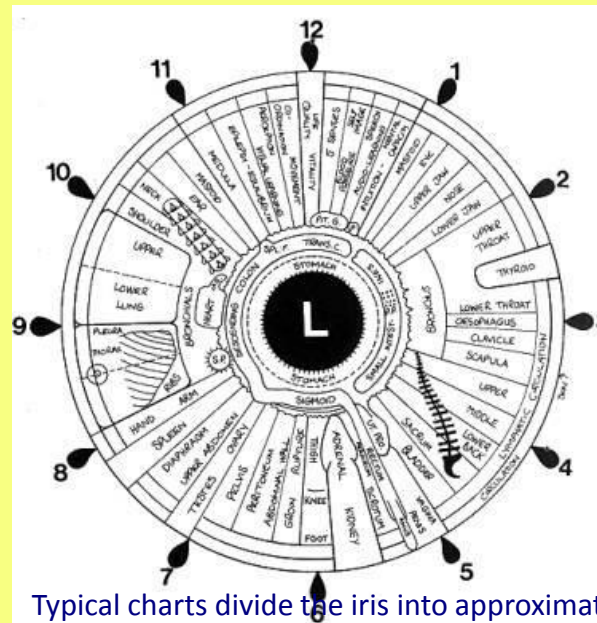
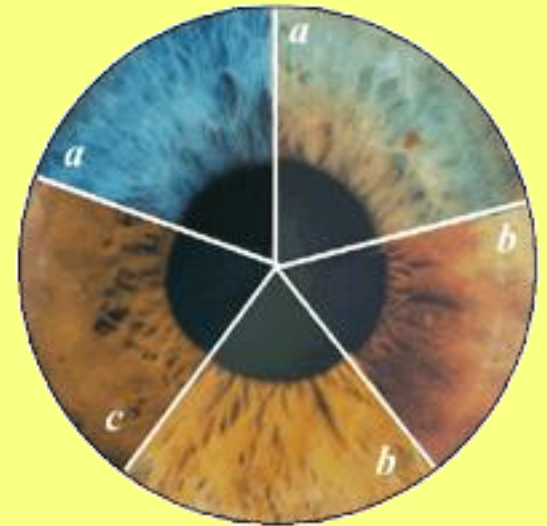
Chiromatica Medica, 1665 Philippus Meyeus (Philip Meyen von Coburg).

Ignaz von Peczely: 1826-1911

Hungarian physician.

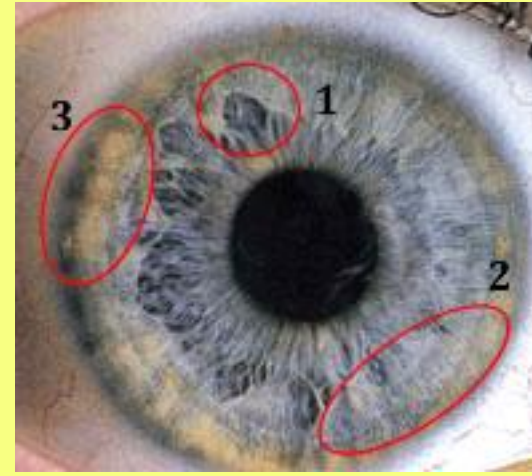
Similar streaks in the eyes of a man he was treating for a broken leg and the eyes of an owl whose leg von Peczely had accidentally broken many years before.

Augendiagnostik (eye diagnosis)



Typical charts divide the iris into approximately 80-90 zones. zone for kidney located on inferior iris

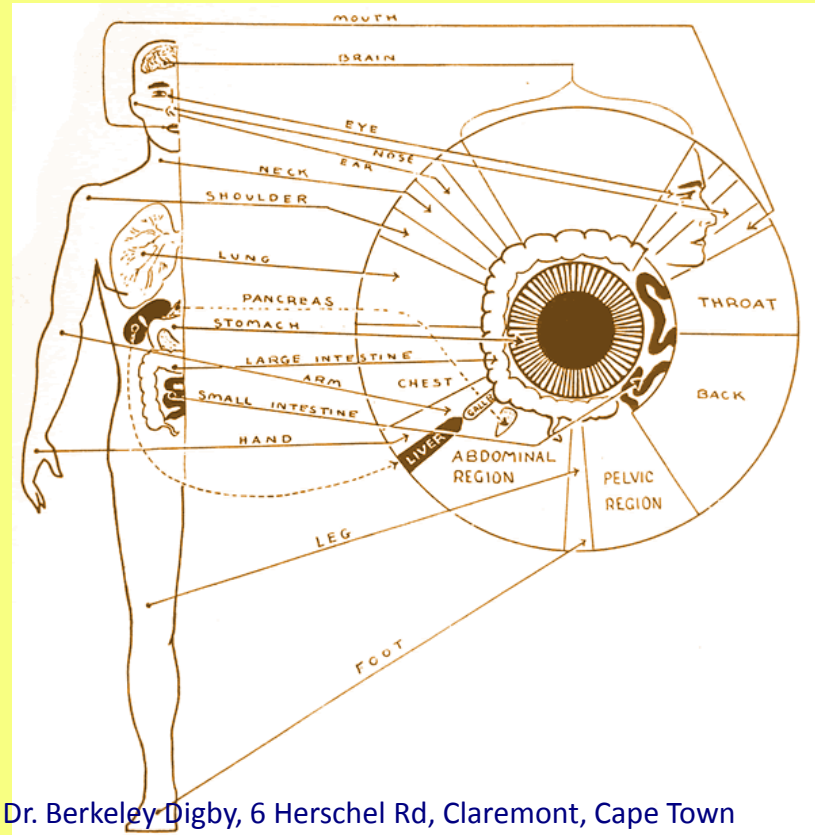
The whitish colour of the iris fibres indicates a general state of over-acidity in the tissues and inflammation which is likely to affect muscles and joints.



1) There are many weaknesses or openings in the iris fibres in the bowel wreath indicating an atonic bowel from chronic constipation

2) There are concentric 'rings around the iris which are called 'stress rings' usually found in tense nervous subjects and indicating a need for more minerals to nourish the nervous system.

3) Muddy deposits in the lymphatic zone around the edge of the iris indicate toxic buildup in the lymph and unhealthy cholesterol.



window to the soul

Everyone has a different structure iris.

Matt Larsson: Orebro University Sweden
428 subjects personality traits compared
to structures in the iris

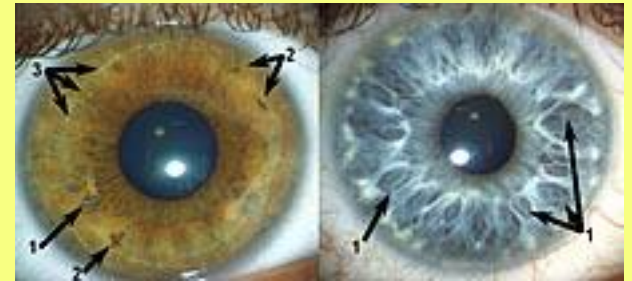
patterns in crypts

contraction furrows - outer edge curves
formed when the pupils dilate.

Those with densely packed crypts more
warmhearted, tender, trusting, and likely
to sympathise with others.

More contraction furrows more neurotic,
impulsive and likely to give way to
cravings.

Eye structure and personality could be
linked



Left: Distinct contraction furrows
(marked '3') - a sign of the person
being neurotic. Right: Numerous
'crypts' lines going away from the iris
(marked '1') - this signifies a warm-
hearted and trustworthy person



Transcription factors

Proteins that bind to specific sites on DNA.

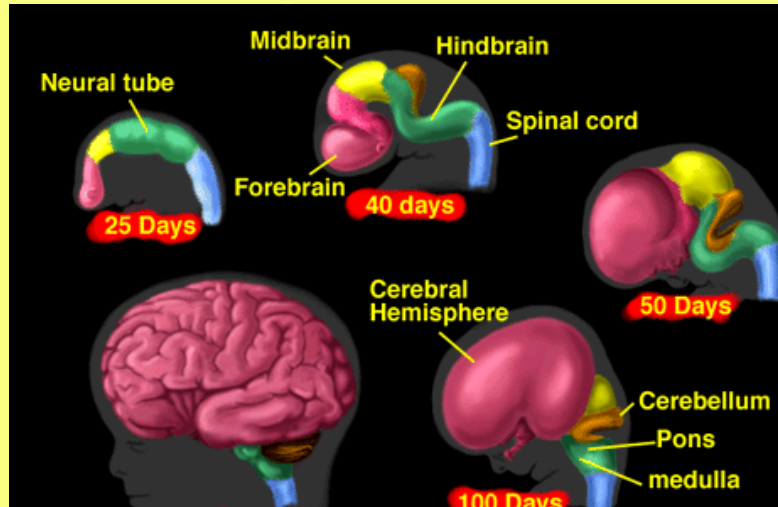
TFs and cofactors stabilize the transcription-initiation machinery to enable gene expression.

PAX-6 gene responsible for the development of the iris also involved in frontal lobe brain formation, which influences personality.

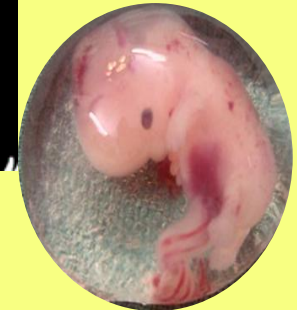
Differences in the iris could be used as a biomarker for different personalities

mutation of PAX-6 linked to impulsiveness and poor social skills.

Perhaps autism



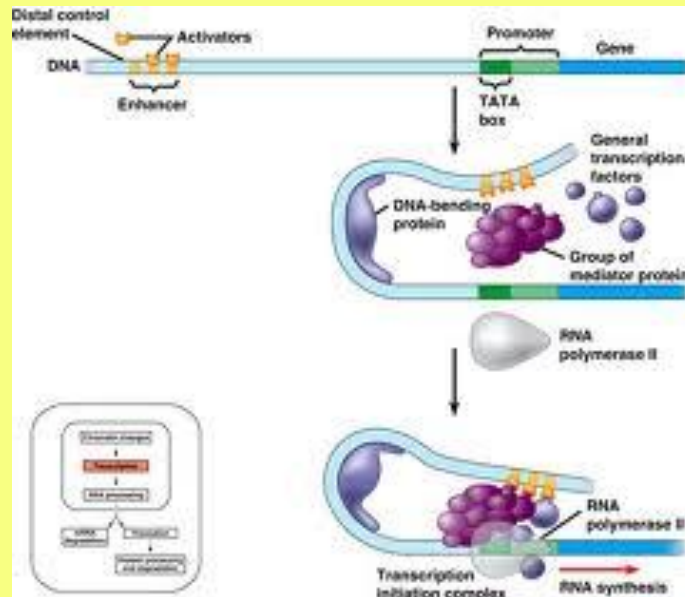
five weeks



six-week embryonic age



seven weeks



PAX-6

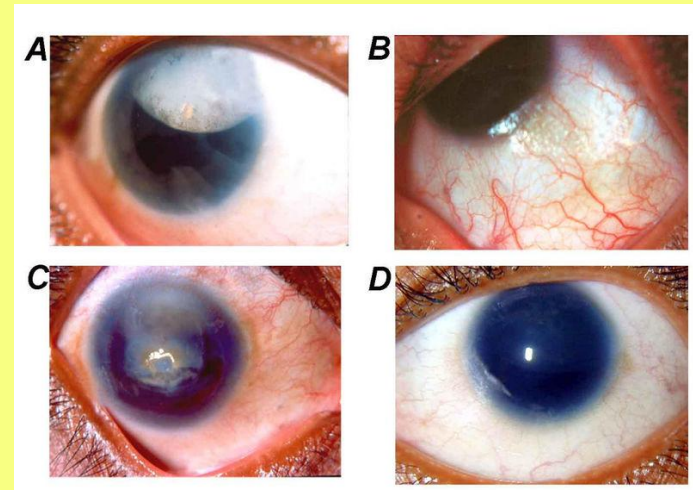
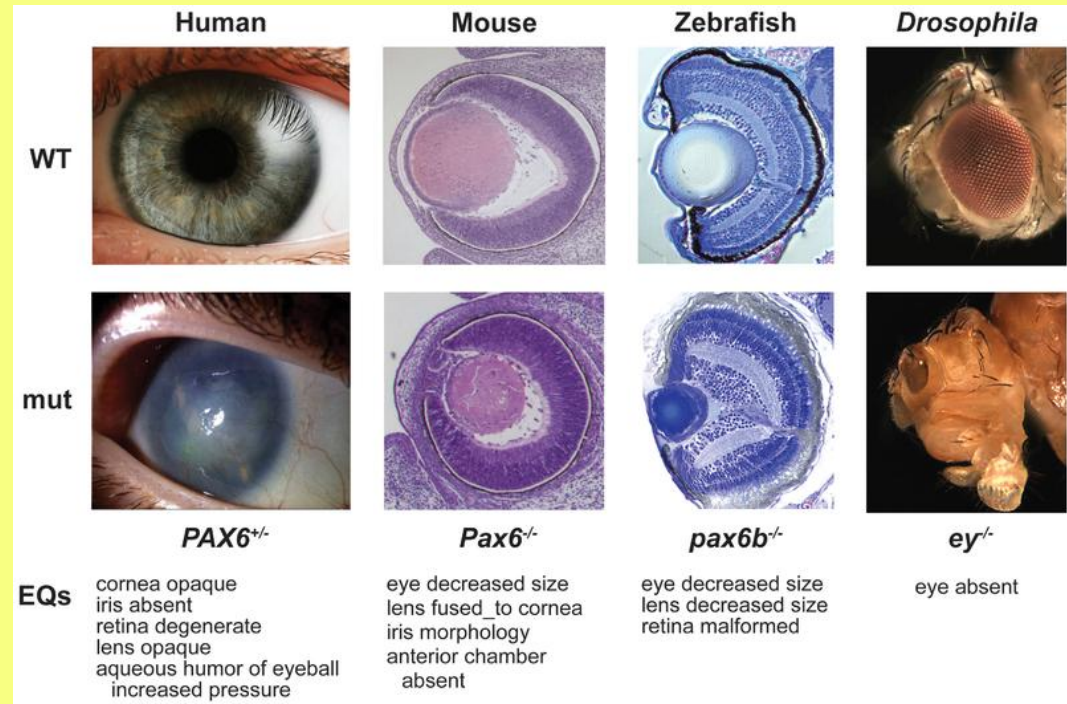
"master control" gene for the development of eyes, sensory organs, neural tissue.

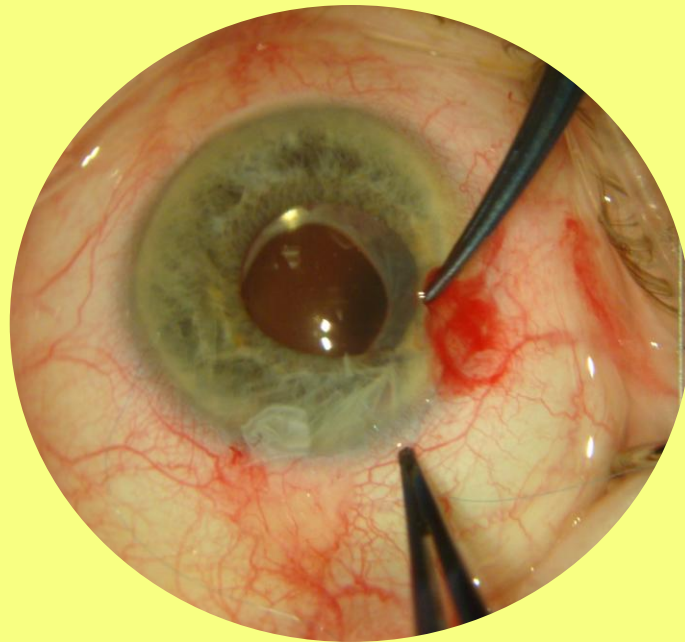
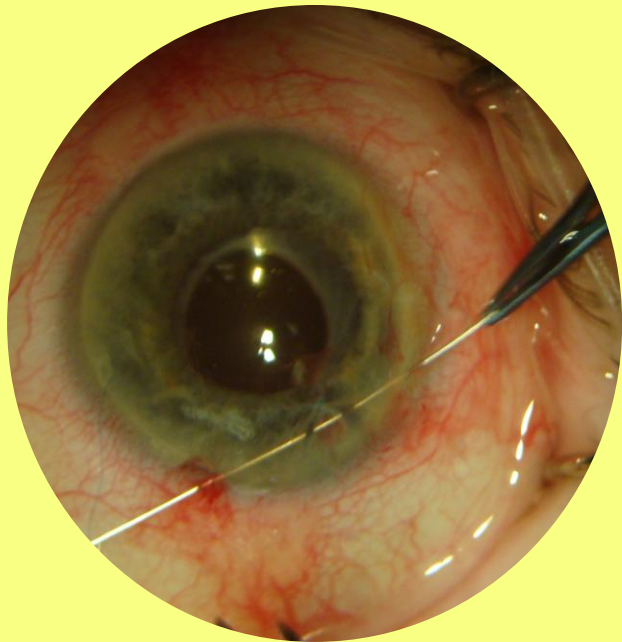
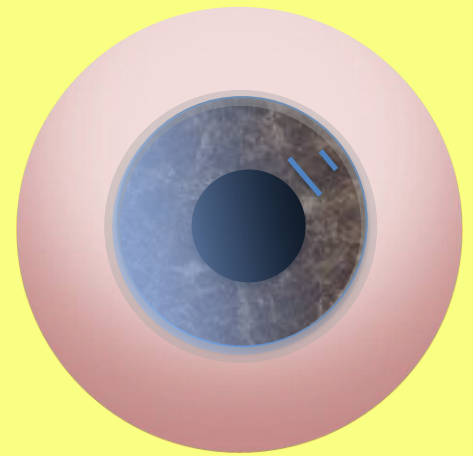
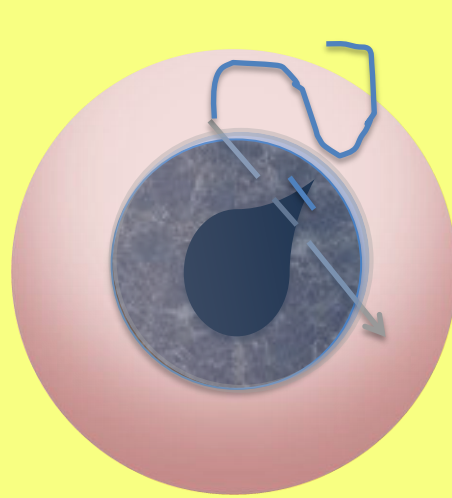
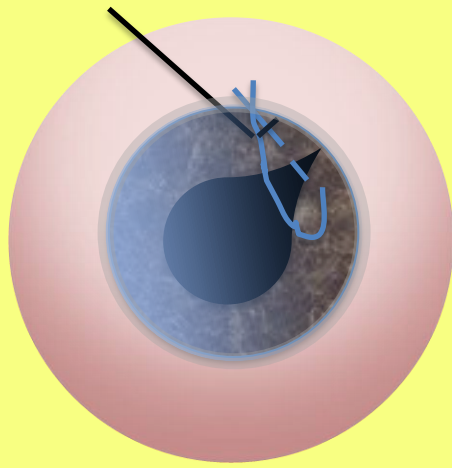
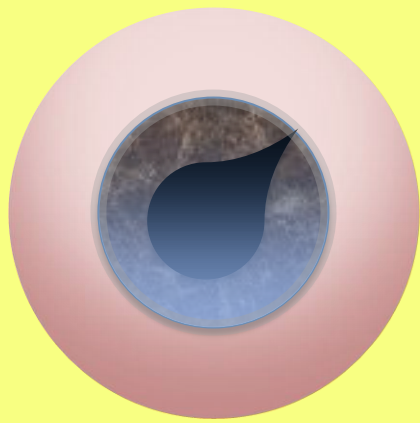
95% similar to the pax gene found in zebrafish, diverged from human evolutionary development around 400 MYA.

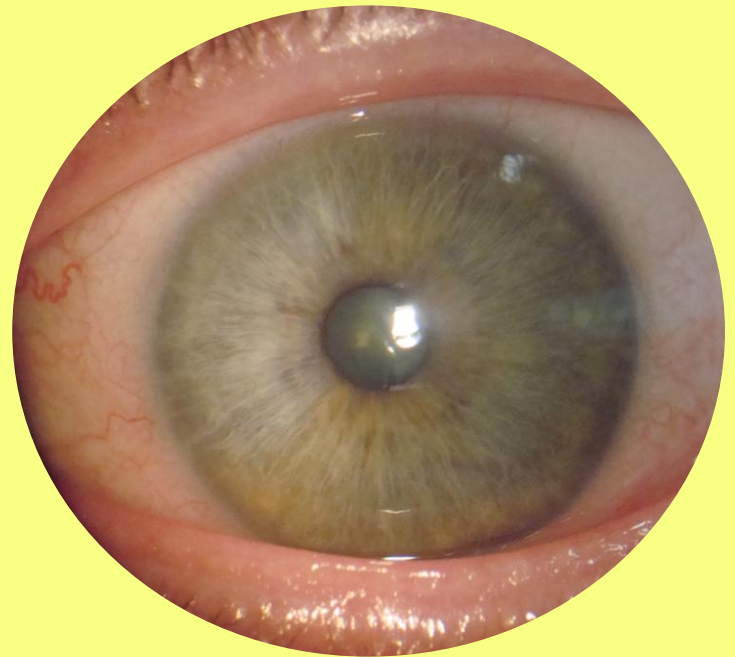
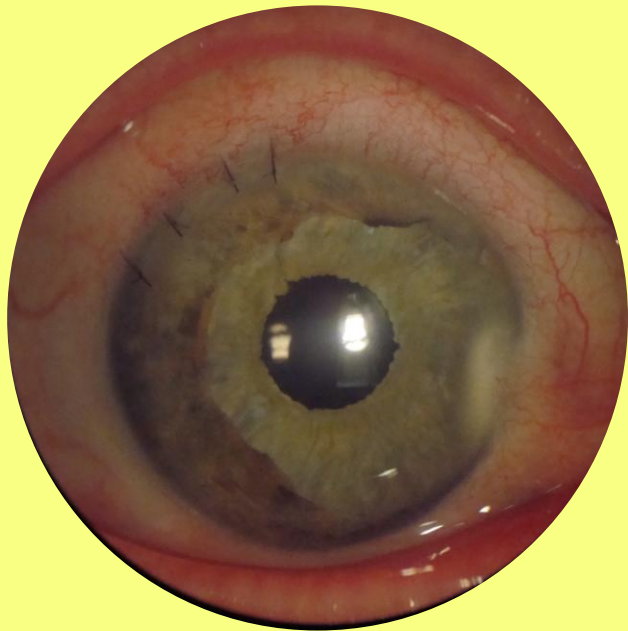
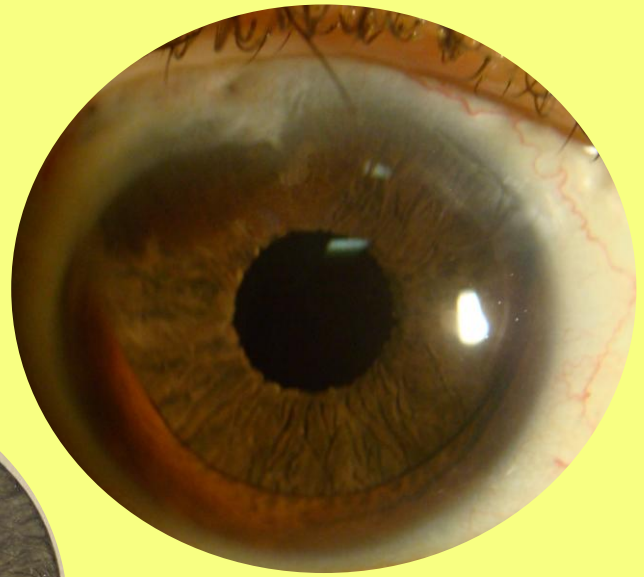
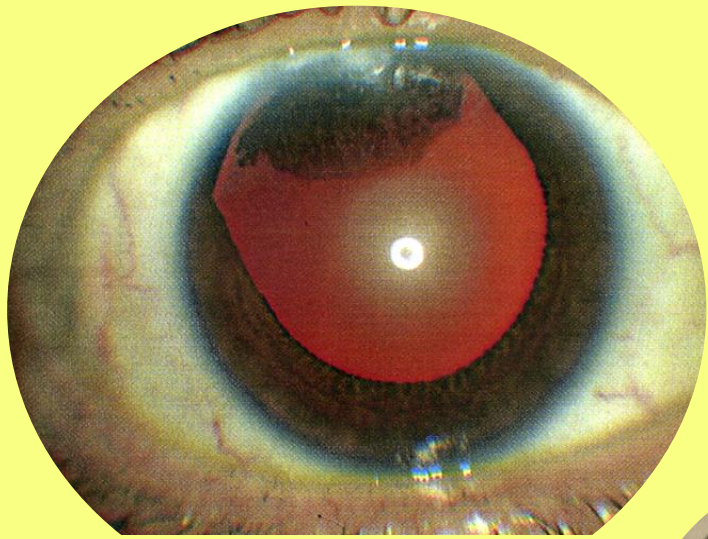
Highly conserved gene across evolutionary lineages.

Regulator for coordination and pattern formation required for differentiation and proliferation to successfully take place

Responsible for instructing cells in embryonic development to differentiate into cells of the brain and eye.







Beyond the iris

Window to the body: the retina

3 problems to be solved:

- The retina of the patient must be adequately illuminated
- The observer's pupil and the light source must be aligned.
- The observer and patient have to be emmetropic so that parallel rays emitted are focused by the observer.

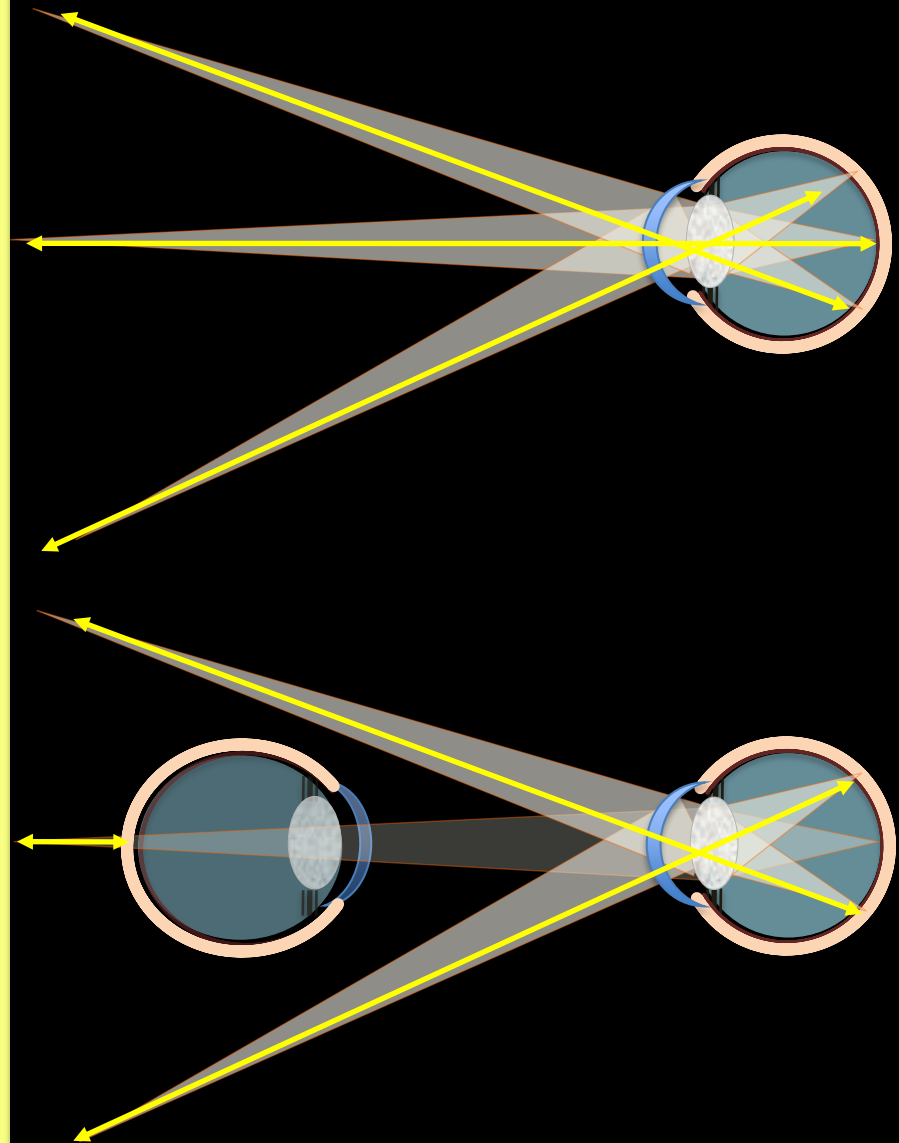
1810 **Bénédict Prevost** (1755-1819): Prof of Philosophy Montaubon, animal luminosity disappears in complete darkness 'It is not the light which proceeds from the eye to an object that enables the eye to perceive that object, but the light which arrives in the eye from it.'

luminosity could only be observed when light entered the eye from without.

1821 **Karl Asmund Rudolphi**. the luminosity of an animal eye depends on the direction of the ingoing rays. Same effect in eye of a decapitated cat.

1735: **Duddell**: human albino,

Fermin had noted luminosity of the eye of an Ethiopian albino (and concluded that this patient could thus see at night, because his eyes were like those of night animals)



Invention of Ophthalmoscope

1847 **Charles Babbage** (1792-1871), gave a device to ophthalmologist Thomas Wharton Jones,

Mr. Babbage showed me the model of an instrument which he had contrived for the purpose of looking into the interior of the eye. It consisted of a bit of plain mirror, with the silvering scraped off at two or three small spots in the middle, fixed within a tube at such an angle that the rays of light falling on it through an opening in the side of the tube, were reflected into the eye to be observed, .

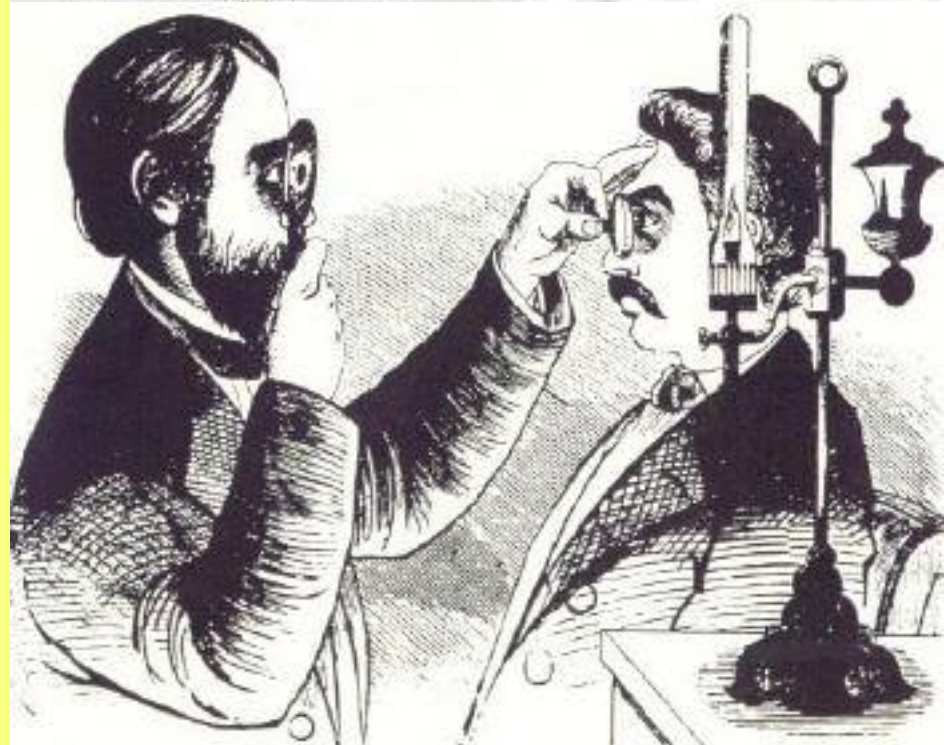
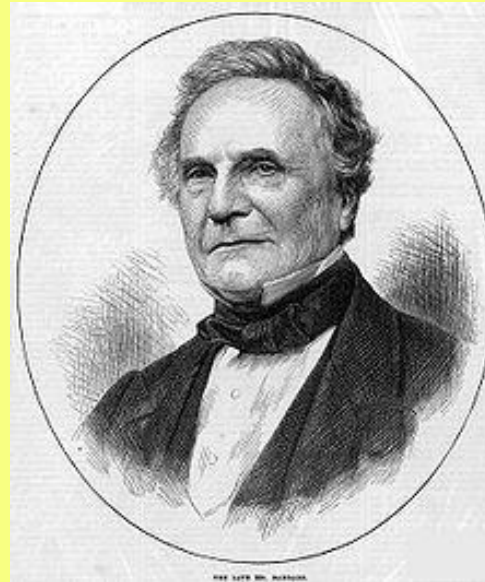
1850: **Hermann von Helmholtz** (1821-1894)

Augenspiegel "eye-mirror" looking through the lens into the back of the eye only produced a red reflection. With a condenser lens a clearer inverted image, then magnified X5. combination of a mirror and condenser lens an indirect ophthalmoscope. In use until 1990.

3 components:

A light source;
mirror to direct light toward the eye
device to focus the image on the retina.

Actually not a mirror but four plates of glass to increase the number of rays reflected into the eye. The illumination was poor.



Mystery of Amaurosis solved

Blindness in a normal looking eye was called **Amaurosis**

Neither the pt nor the ophthalmologist saw anything!

The cause of this condition was a mystery until the back of the eye visualised.

Multiple causes of this previously enigmatic condition were rapidly discovered

It was thought that glaucoma was a disease with a normal appearance of the back of the eye.

1855 von Graefe, who initially believed the nerve was swollen, demonstrated cupping.

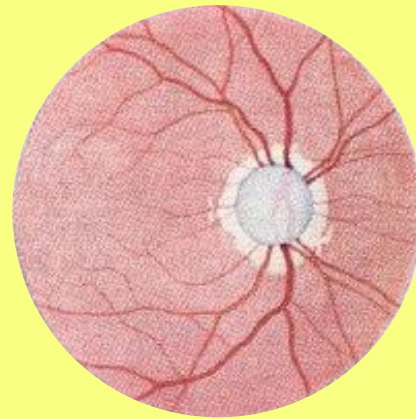
Iridectomy treatment of the previously mysterious and untreatable disease.

von Graefe in 1855 and Heymann in 1856 described renal retinitis

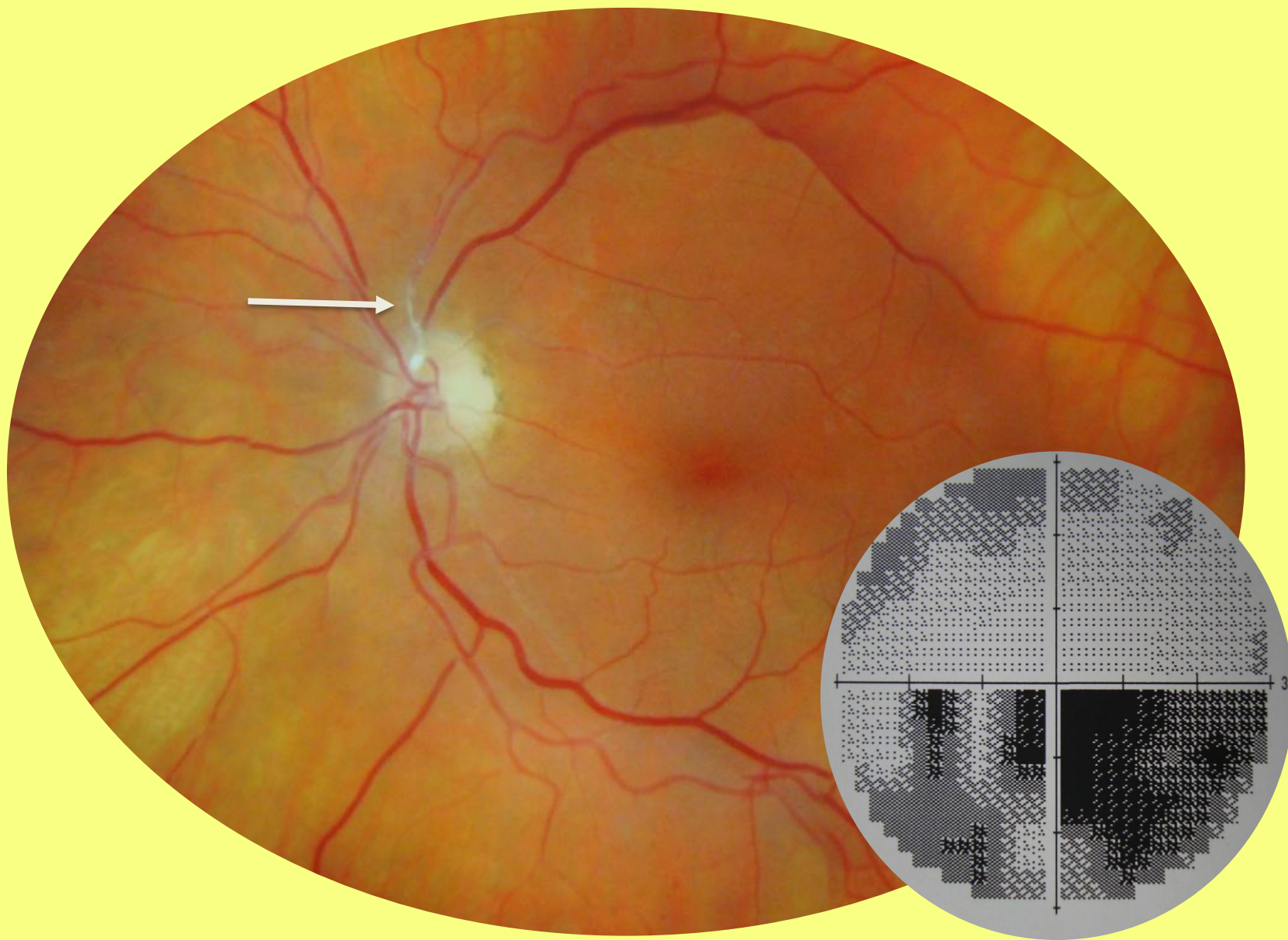
Coccius in 1853 described detachment of the retina and retinitis pigmentosa.

1855: von Jager describes diabetic retinopathy.

Controversial as believed this was due to hypertension, or inflammatory due to elevated albumin “diabetic retinitis”

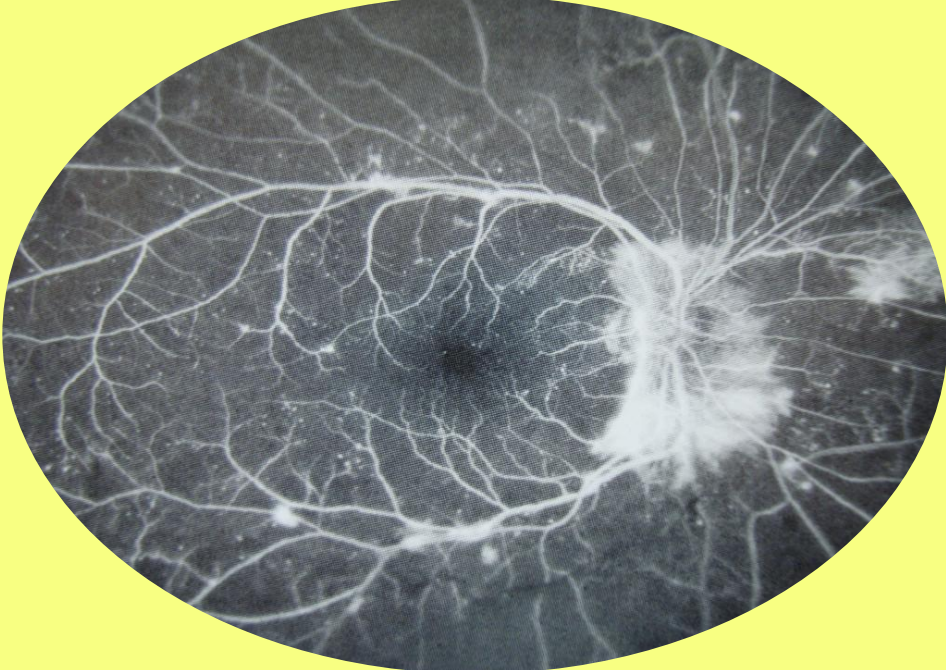
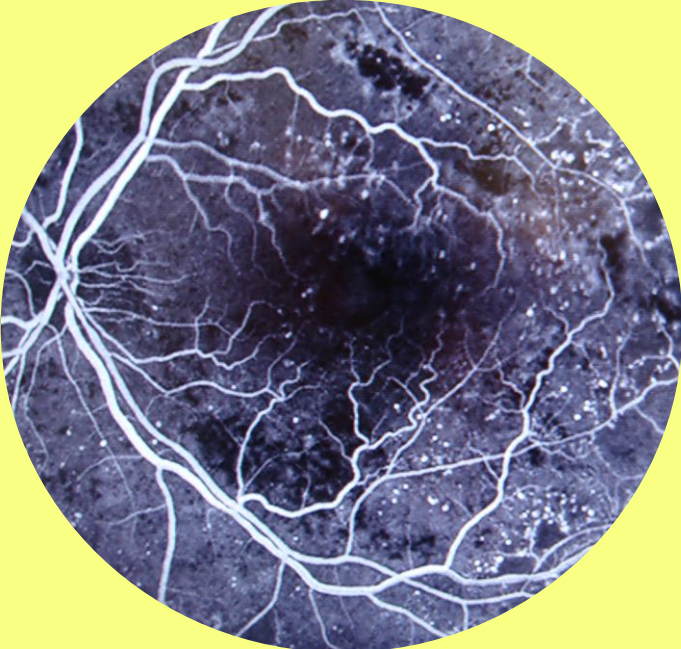
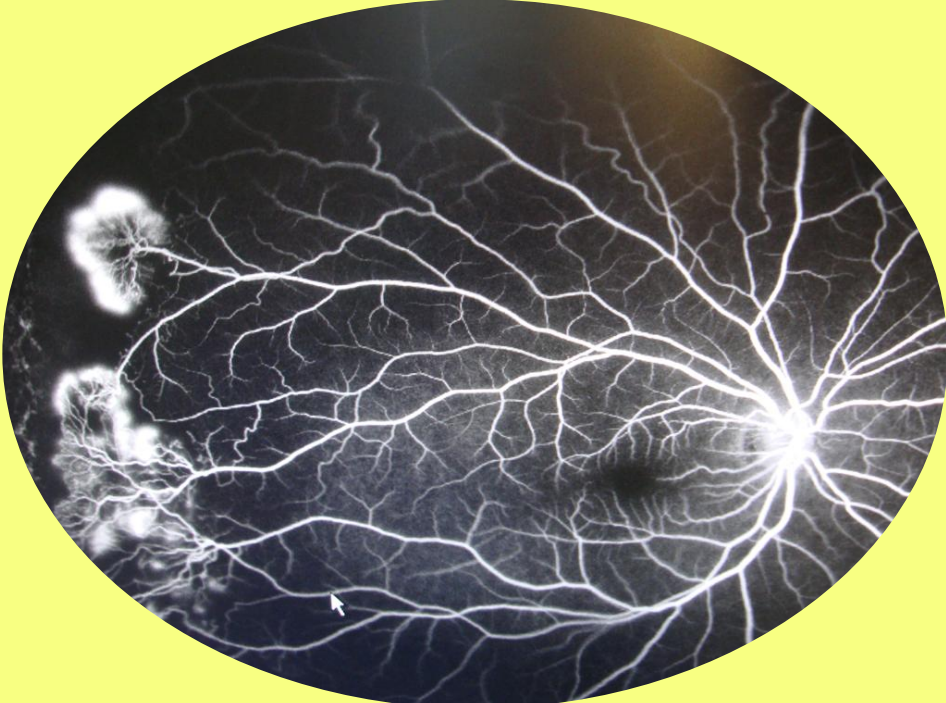


Retinal arteriolar occlusions Stroke



Growth of new vessels

- Sickle
- Diabetes
- Macular degeneration



How do the windows of the soul work?

How did they come about

Eyesight to visual perception

Light gathering molecules

Conversion to electricity

Organs of reception

Neural wiring

Neural processing

Colour/shape/form

Construction of the visual scene

Disease and damage

Reconstruction of damaged eyes

The future

“The Eye has Dominion over all Things. The World was made for the Eye and the Eye for the World”
(John Taylor address to Oxford Students)

Biochemical mechanisms evolve before the eye

Receptor-cell structures start to evolve

Multi-cellular eye assembled.

Hyalocyte

Receptor

Pigment cell

First order interneuron

Four sequential evolutionary processes

(i) evolution of molecular components,

(ii) evolution of cell structures,

(iii) evolution of cell types

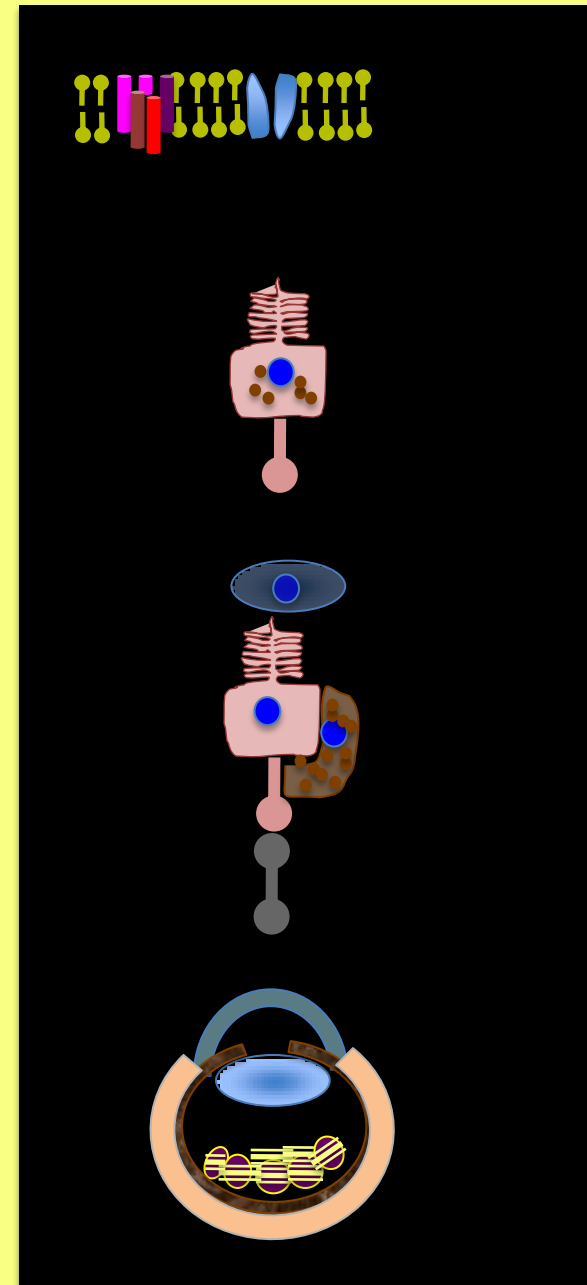
(iv) evolution of organ shape

Only a limited number of ways to form image.

Genetic toolkit

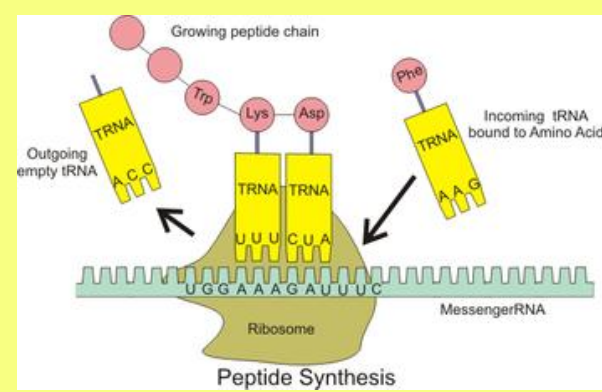
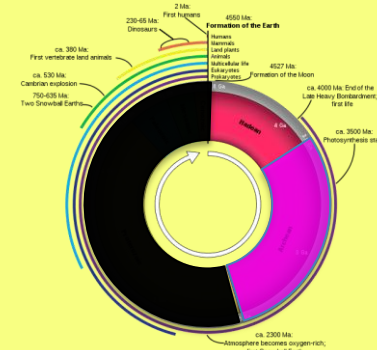
Convergent evolution common

10 different types of eyes.



ARCHEON EON

Αρχή: *beginning*
3,800-2,500 MYA



Hot CO₂, N, Methane atmosphere. No O₂

Intense UV from young dim sun

Bombardment and volcanoes

Acidic ocean, carbonate rocks rare

Lipids on clay, combined with a/a proto-cells.

Bags of self replicating molecules.

Self-replicating ribonucleic Acids: precursors to current life (DNA), RNA and proteins.



RIBOSOMES: ancient molecular machines produce protein in all living cells

Productive nano-machines that combine small molecular building blocks under digital control to build complex structures.

STROMATOLITES: layered accretions formed in shallow water by biofilms of microorganisms

3.5BYA: fossils of these mats



ARCHEON EON
3,500MYA PROKARYOTES

Early organisms harvest light (photoreceptive)

3 main capture molecules

Chlorophyll: light to make carbohydrate

Photosynthesis

Photolyases (cryptochromes): Use blue light to repair RNA/DNA

Magnetic field detector in retina

Rhodopsins: light proton pump generates electrochemical gradient storing energy (motility) No role in vision

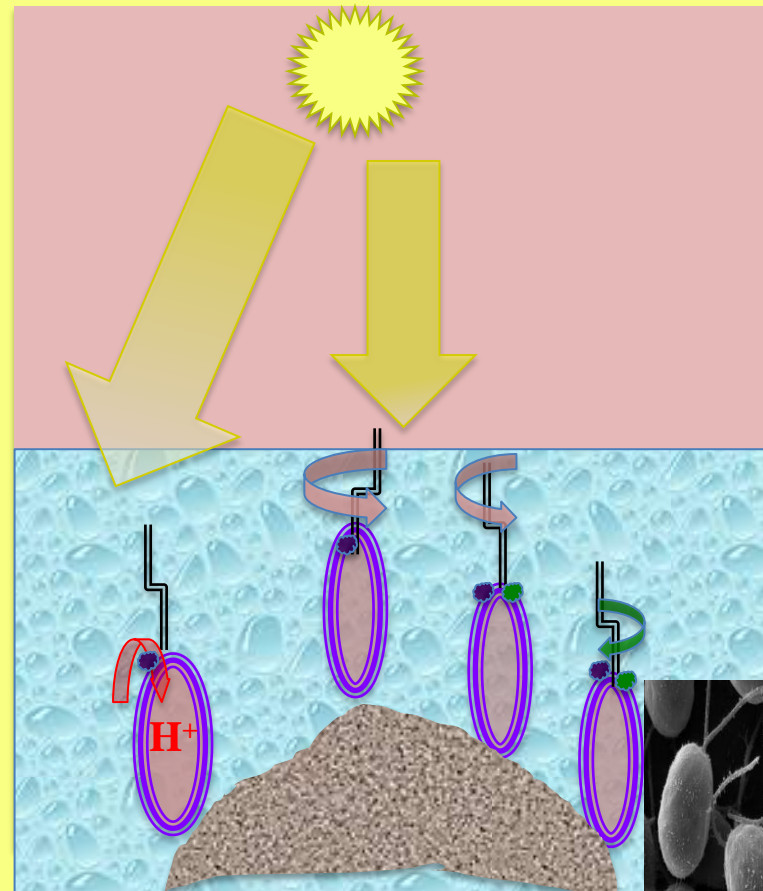
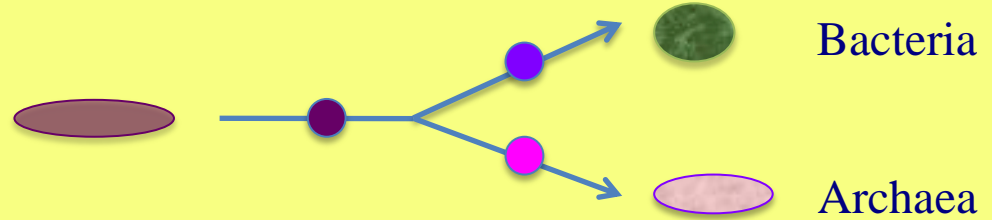
Cyanobacteria: 2,000MYA: occupy every niche on earth. Cause toxic blooms and scum. Also live in other organisms. Bluish pigment phycocyanin accessory to chlorophyll

Release O₂

Toxic extinctions

Archea: Originally found as extremophiles, but also in guts methanogens

Halophilic archaeobacteria, use sensory **rhodopsins** for phototaxis.



PROTEROZOIC EON
(Early Life)
2,500-650 MYA

EUKARYOTES

Acquisition of a nucleus

Konstantin Mereschowsky (1855-1921)

Lyn Margulis (1938-2011)

Endosymbiosis

Organelles: domestication of ingested prokaryotes

Chloroplasts from incorporation of cyanobacterium

Mitochondria from proteobacteria: **Use O₂**

Can shield eyespot, so can work out direction of light for free swimming

OCELLOID: resembles an eye.

Hyalosome; lens: change shape, accommodation. lens consists of concentric clear layers High RI 1.52. Ray tracing shows focus on the retinoid

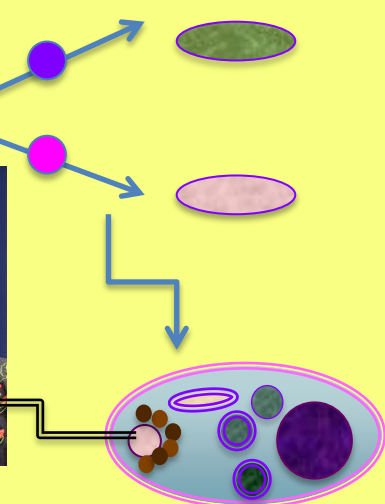
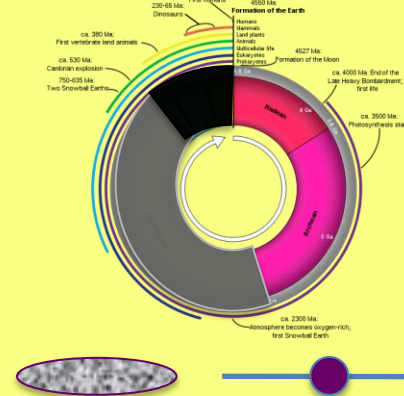
Clear space filled with carotenoid globules

Melanosome; pigment cup

plastid (chloroplast) origin

filled with carotenoid globules

lined with unknown visual pigment.

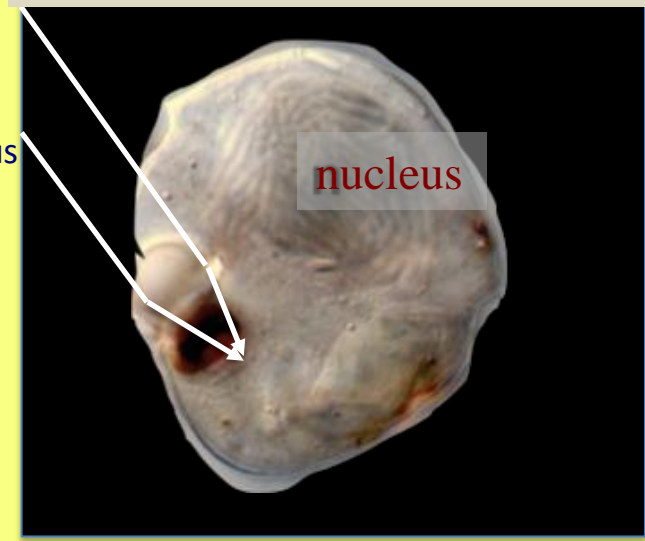


Bacteria

Archaea

Eukaryotes

Dinoflagellate
 After Mona Hoppenrath 2009 BMC Evol Biol



Four classes of sensory tasks

Nilsson 2009

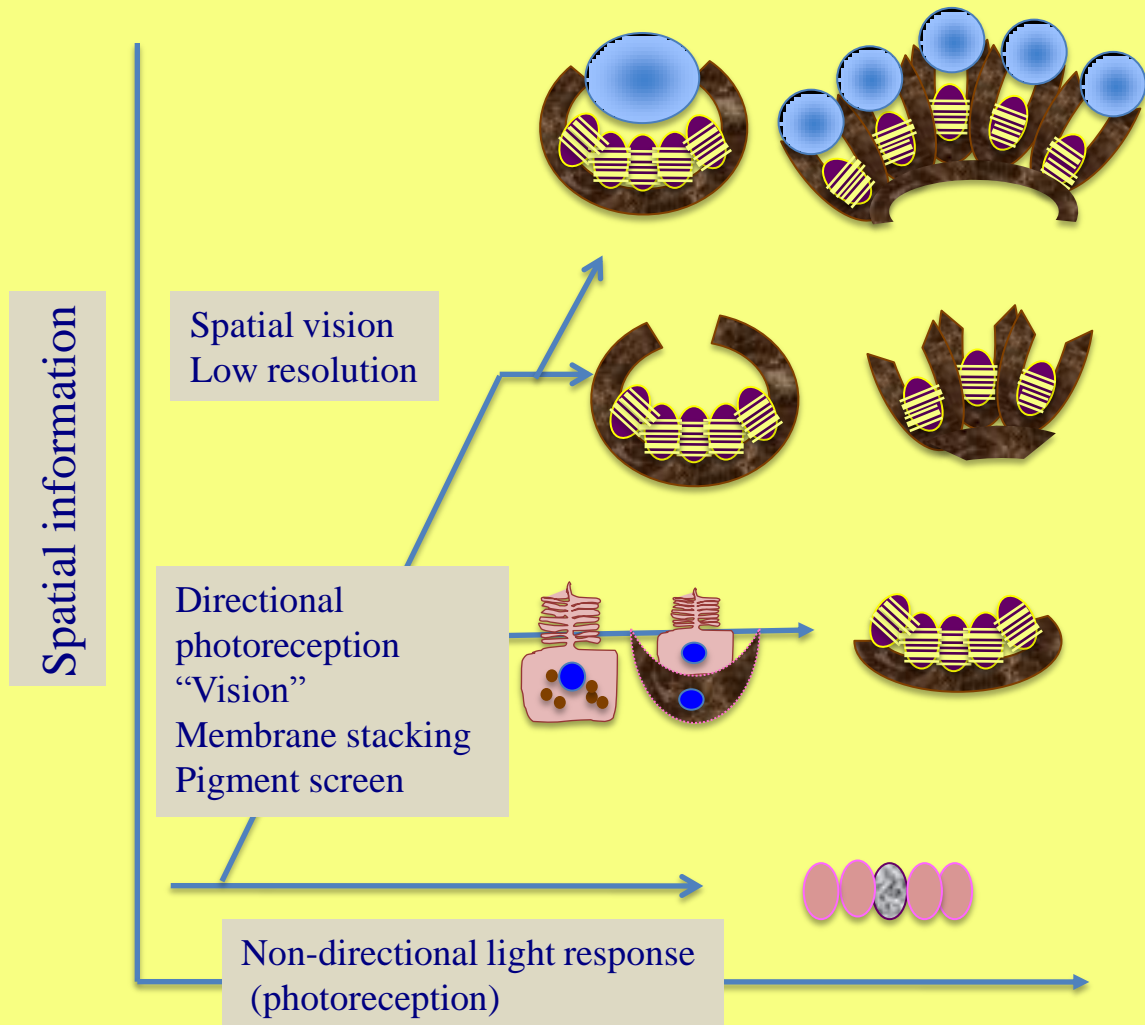
Class 1 tasks: Behaviours controlled by monitoring of ambient light. No direction
Circadian rhythm, light avoidance, shadow detection (predator), surface detection for burrowers

No organ

Class 2: Behaviours based on direction of light: phototaxis, control of posture, approach of predators

Class 3: Tasks requiring low spatial resolution. Detection of self motion, object avoidance, habitat selection, orientation to landmarks or celestial objects (moon, sun)

Class 4: Tasks requiring high resolution: detection and pursuit, predator evasion, mate detection, fine landmarks, visual communication, recognition of individuals



Many bauplans for eyes

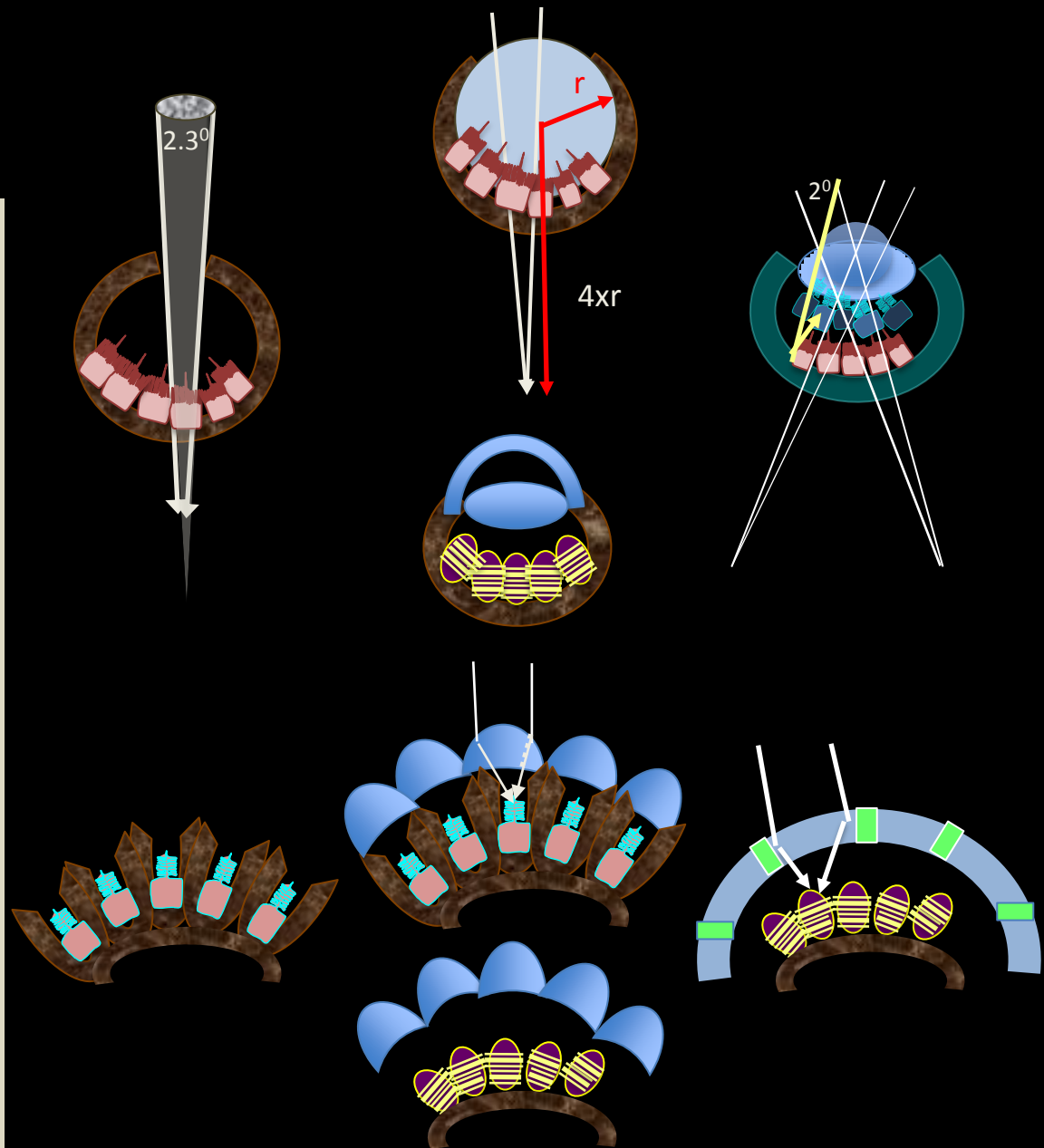
Image-forming eyes are common
No one design for eyes dominates.
Less than dozen distinct blueprints

Insect eye, hundreds of miniature
eyes assumed to have evolved
independently of the vertebrate eye

Eyes of squid and octopuses resemble
those of vertebrates.

They appeared independently and
evolved to form similar structures.

Is the wide variety of eyes evidence
that the organ could not have
developed just once?



Many types of eyes

Eyes present in 95 % of all animal species
vision provides an advantage in various
environments

Compound eyes

Marine worms

Arc clams

Trilobites

Insects

Single chamber eyes: Camera eyes:

Squid eye

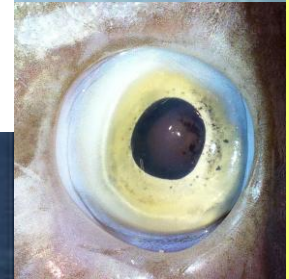
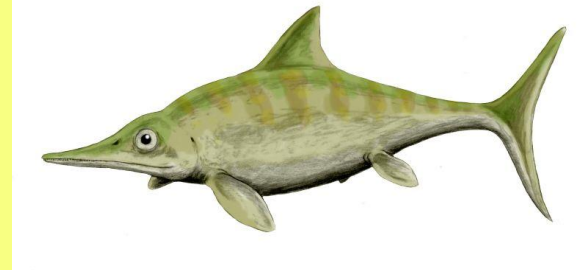
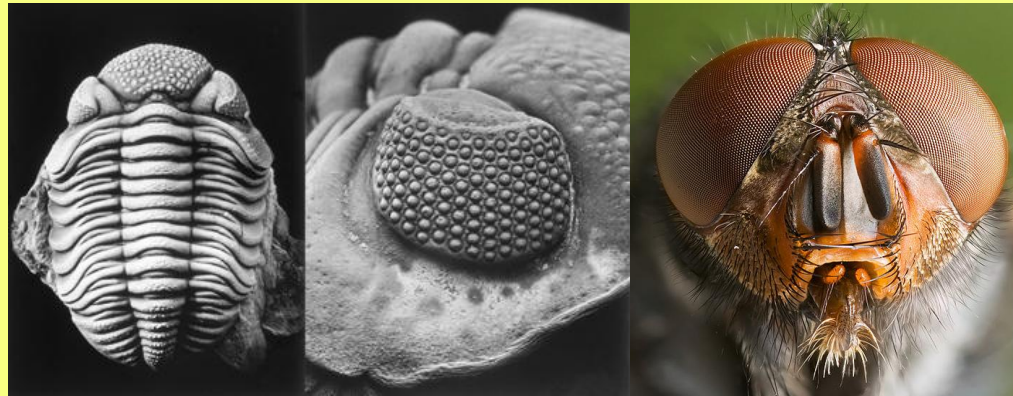
Jellyfish eye

Fish eye/Human eye

Octopus and humans superficially similar eye
design

convergence - the independent origin of similar
traits - represents an element of predictability in
evolution.

Shape of marine animals. Optimal shape is elongated
and smooth. Fish, whales, dolphins and ichthyosaurs.
very different evolutionary histories



Ancient theories of vision

Ancient optics was not concerned with the physics of light but with the process of sight.

The ray was a line of sight not a path for light energy.

Based on connection between the object and the visual organ. Like touch.

Three ways in which contact could be established.

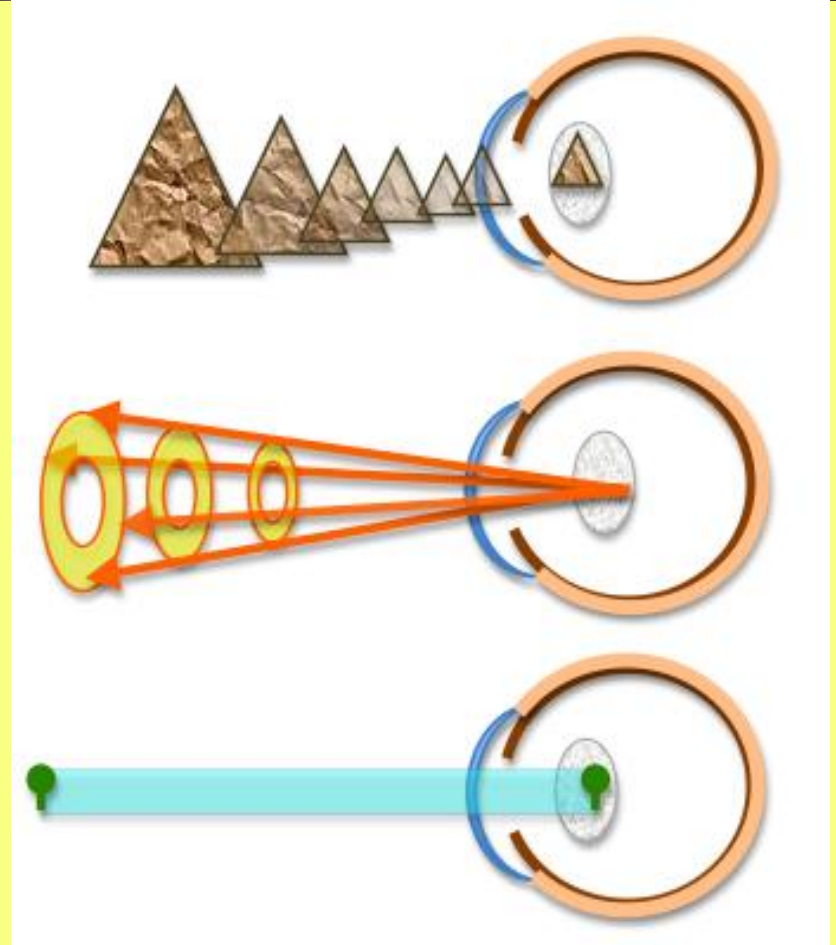
1. The object could send its image through the intervening space. **Atomists** (Leucippus, Democritus, Epicurus).

Thin films (eidola Gk, simulacra Latin). Lucretius: Shedding locusts, calves, or skin of a snake. Coagulated convoys of atoms, which transport the visible qualities. As detected by mirror image of scene on cornea

2. The eye could send out a ray to the object. Proposed by Plato, Euclid, developed by Ptolemy

3. Contact could be made through the medium (usually air) that intervened. Aristotle "colour sets in motion what is transparent-and lies between air-and every colour has in it the power to set in motion what lies in-between".

The colour of the object shapes and moves the medium into the eye where the humours assume the qualities of the object as it is being seen. Air needs to be lit



Light to electricity

photoreceptors

Visual pigment: Protein called opsin wrapping aldehyde vitamin A derivative (**11-cis retinal**). Packaged in the membranes of discs

Animal opsins (type-II opsins) are unique to animals: unrelated to bacterial and algal opsins (type-I opsins)

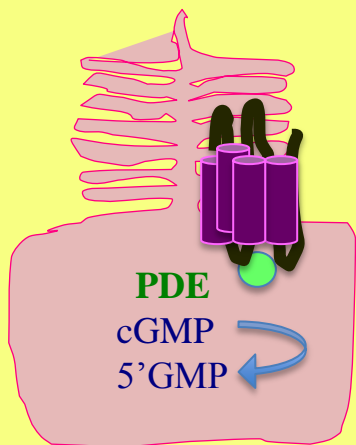
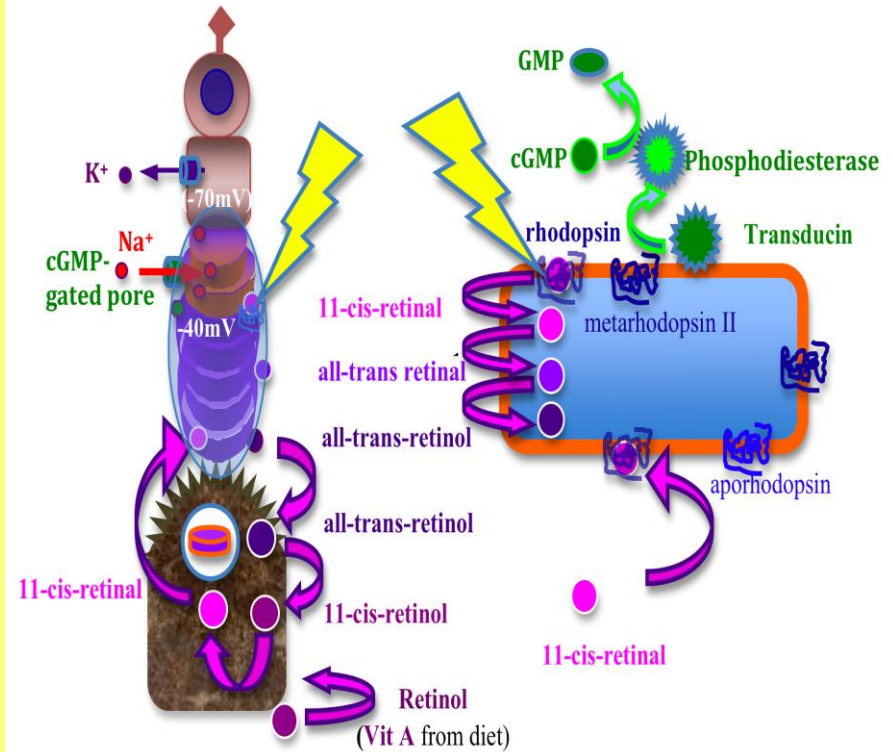
G protein coupled receptors only in eukaryotes; yeast, choanoflagellates and animals.

Activated by light-sensitive compounds, odors, pheromones, hormones, and neurotransmitters:

Initiate signal transduction cascades to activate the cell

Light changes **11-cis** to an **all-trans** conformation.

TRANSDUCIN the molecule that transduces light stimuli into more familiar chemical signals for the cell



Photopigment configurational change **hyperpolarises** the membrane from a depolarised state
OFF-responses
 Shadows activate

Photoreceptors, have leaky pores. K^+ leaks out.
 A pump for inward Na^+ is active in dark, needs energy (**cGMP**), keeps the cell partially depolarized ($-40mV$ cf $-70mV$ of other nerve cells).
 Constant glutamate release into synapse.
 conversion of photon to electrical signal, stabilizes cell membrane, reducing release.
 i.e Light turns the cell OFF

Animal electricity

Luigi Galvani (1737-1798): Bologna:

Surgeon scientist:

Galvinism: Birth of electrophysiology:

The electric current delivered by a Leyden jar or a rotating static electricity generator

applied electrical currents to animal muscles and nerves. Induced muscle contraction.

Nerves not water channels, as Descartes thought, but electrical conductors

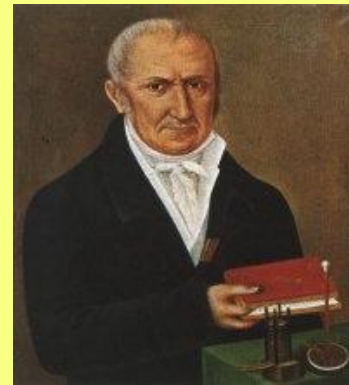
1791: "animal electricity" *electrical activity is produced by activity of the cerebrum where it is extracted from the blood.*

1797: dismissed from chair by the Napoleonic regime. refused to take the oath of allegiance required by the occupation.

Alessandro Volta (1745-1827): Pavia:

Animal tissue was not necessary for conduction of electricity.

1800: pile of zinc and silver discs and between alternate discs, a piece of cardboard that had been soaked in saltwater. A wire connecting the bottom zinc disc to the top silver disc could produce repeated sparks. No frogs were injured



Animal electricity road show

Giovanni Aldini (1762-1834): Nephew of Galvani
George Forster was hanged 8am, 18th Jan 1803 at Newgate Prison, (drowning wife and child in the Paddington Canal). After hanging for an hour in sub-zero temperatures, Aldini procured the body and began his galvanic experiments.

On the first application of the process to the face, the jaws of the deceased criminal began to quiver, muscles contorted, **one eye opened**. the right hand was raised and clenched, and the legs and thighs started to move.

Mr Pass, beadle of the Surgeons' Company, so alarmed that he died of fright soon on return home.

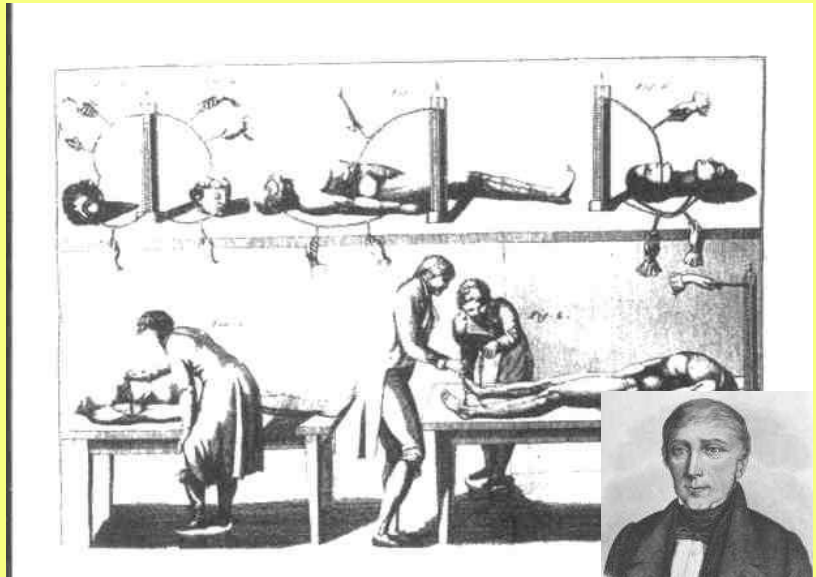
Mathew Clydesdale: Anatomised the day after his hanging. First public execution for 10 years the theatre was crowded

By varying the voltage, *'Rage, horror, despair, anguish, and ghastly smiles united their hideous expression in the murderer's face-surpassing far the wildest representations of Fuseli or a Kean'*. Pointed finger at crowd.

Mary Wollstonecraft Shelley (1797-1851)

1818: "Frankenstein, or Modern Prometheus",

"Perhaps, a corpse would be reanimated; galvanism had given token of such things."

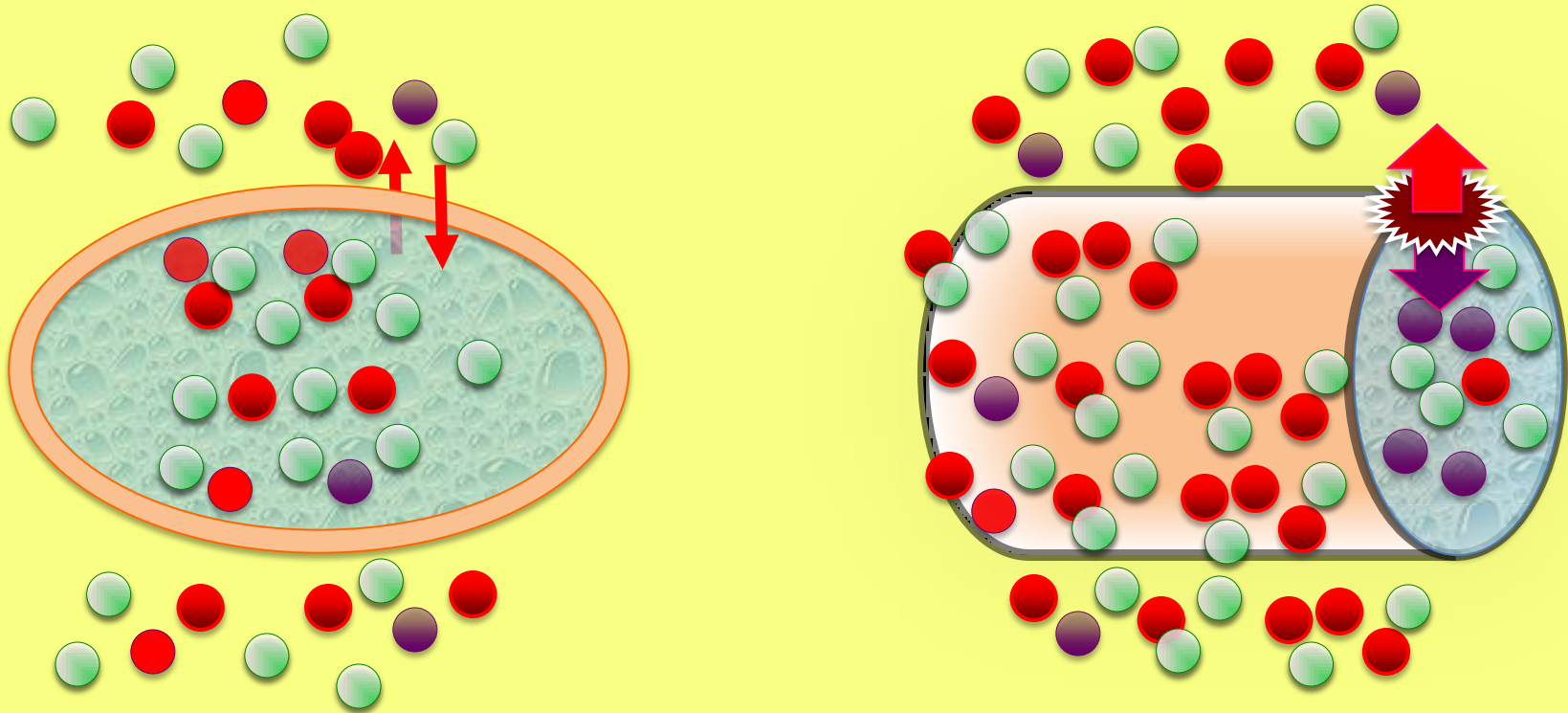


Corpse of Matthew Clydesdale (murderer) Glasgow University anatomy theatre: Dr. Ure and Prof. Jeffray on the 4 November 1818. Corpse animates and grimaces

Generation of resting potential

origin of Galvanism, animal electricity.

Hodgkin & Huxley Plymouth Marine Biology/Trinity



Nerve cell contains and is bathed in **salt solution**.

Na⁺/K⁺/Ca²⁺ and **Cl⁻**.

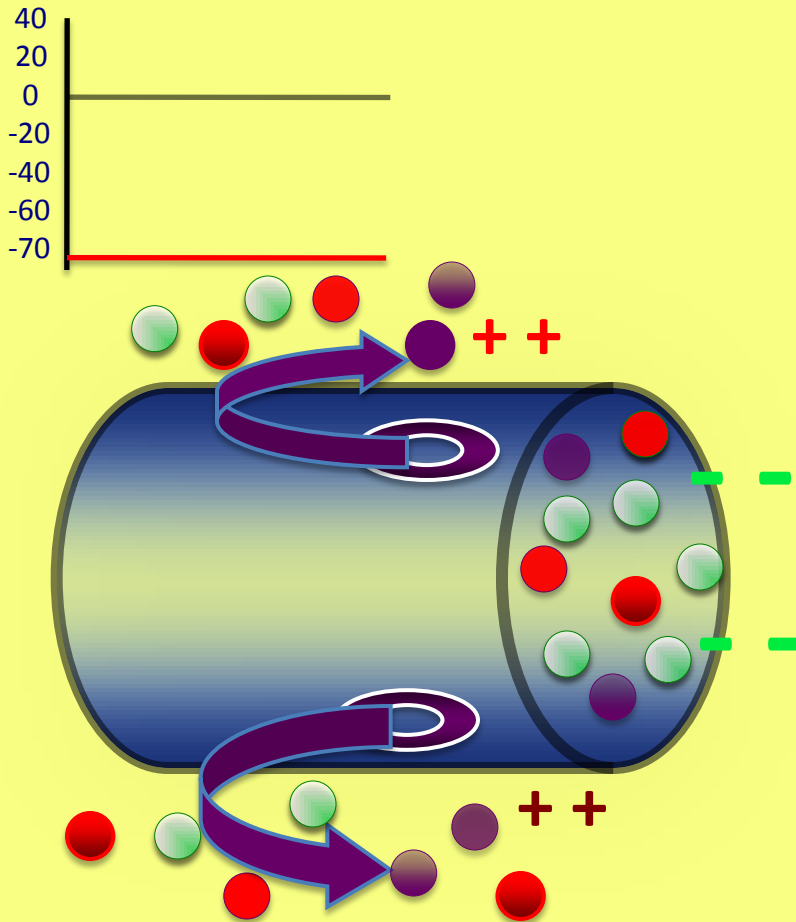
Active ATP-fuelled pump exchanges **Na⁺** for **K⁺**

Develops an ionic gradient

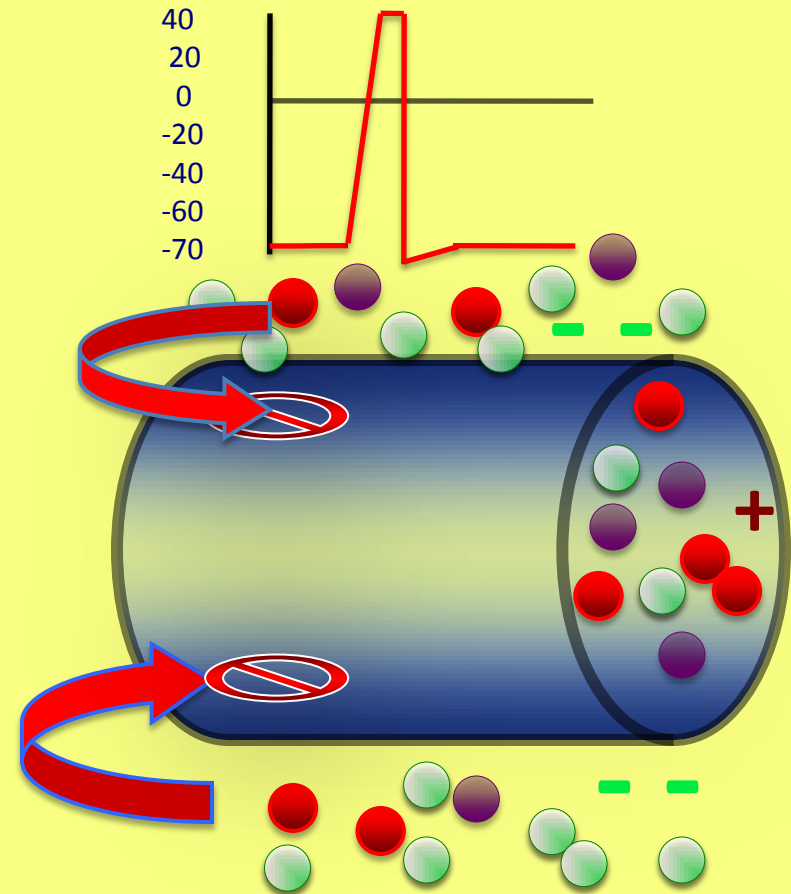


Ion	K ⁺	Na ⁺	Ca ²⁺	Cl ⁻
Outside	5	150	2	150
Inside	100	15	0.0002	13
Ratio	1:20	10:1	10,000:1	12:1

Generation of action potential



K⁺ leaks out along ionic gradient
negative charge inside (resting potential)
Inside and outside of cell differ
by about 1/10th volt (70mV) –ve inside



Sudden opening of **Na⁺** channels allows
Na⁺ to flood in: Reversing the membrane
Potential. 1/1000th second. Then close
Then more **K⁺** pores open restoring balance

Retinal structure

BIPOLAR CELLS:

Pass information from receptors to Ganglion cells

Cone BPC: 2 types.

One excited when cone absorbs more light **on centre**,

One excited when cone absorbs less light **off centre**.

Rod BPC: Finer bushier dendrites. Connect to 20-50 rods.

Always depolarise.

Via **amacrine cells** hitch hike onto the cone pathway.

HORIZONTAL CELLS

Large cells, (no axons).

Turned off (hyperpolarised) by light.

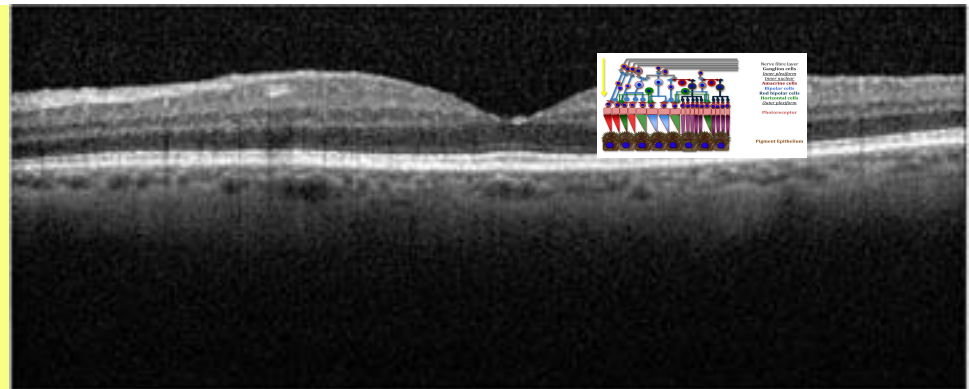
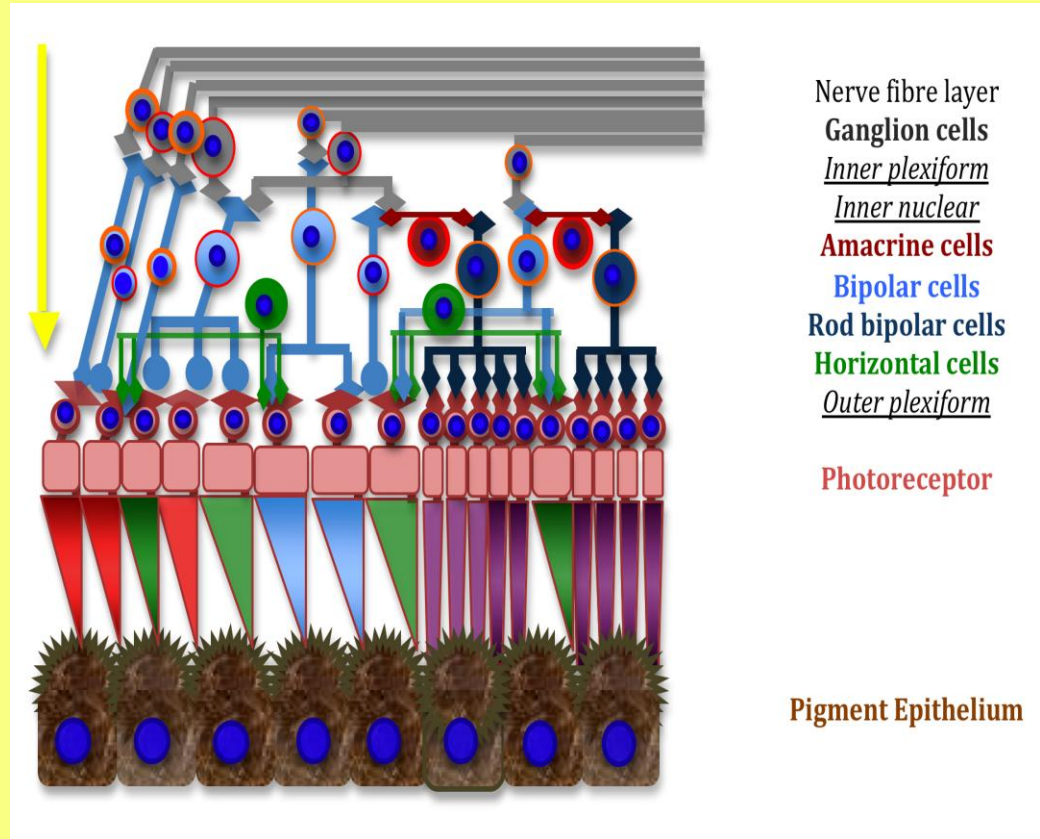
Responsible for **Centre Surround** receptive field

Feed back sharpens edge detection.

AMACRINE CELLS

Outnumber **HC** by 10:1. come in a variety of shapes, use several neurotransmitters.

Twenty or more different types.



Receptive fields

Hartline: limulus crab axon: Stimulating receptors inhibited neighbouring axons.

1950: Stephen Kuffler (Wilmer) cat retina.

In dark steady irregular firing 2-20/sec!

In diffuse light?...

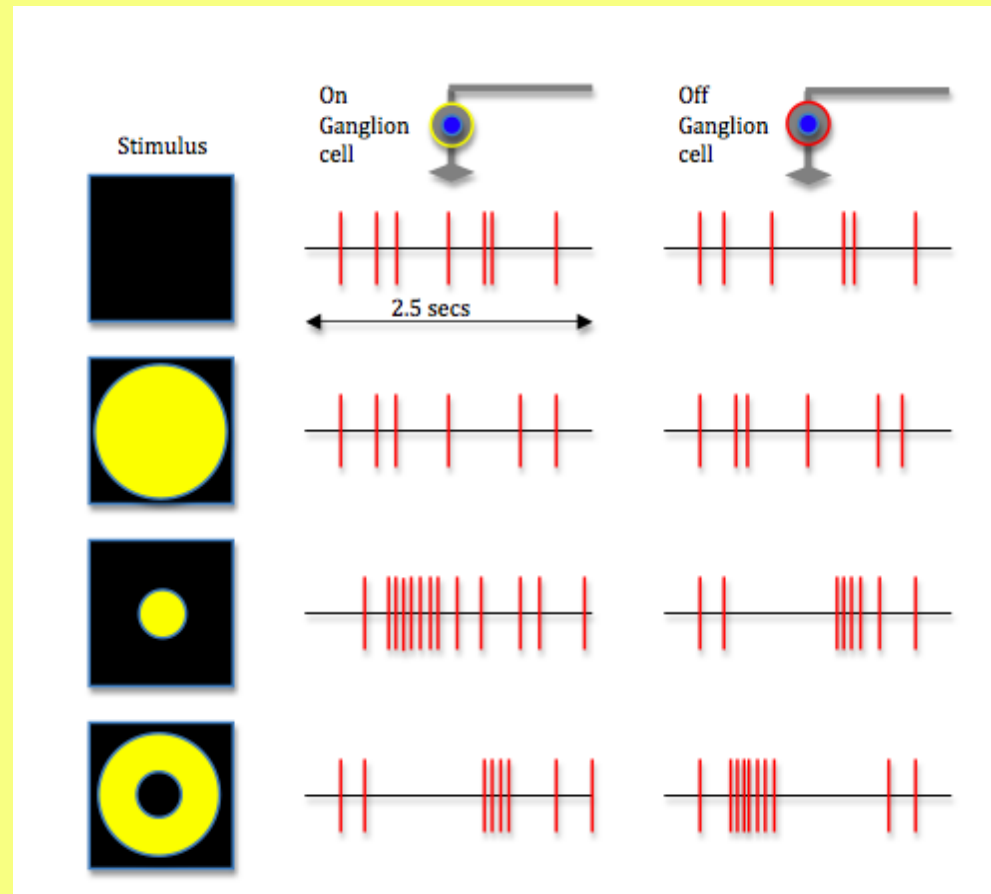
Shining small spots: areas were found that increased rate, others that decreased rate.

About equally distributed.

Moving away from on centre the spontaneous rate was inhibited. Turning light off a quick burst.

Centre surround.

In nature, dark objects are as common as light ones, (like this text). The eye developed both on-center cells and off-center cells to pass on this information.



Chiasm

Galen: Optic nerves come together (but remain on their own side)

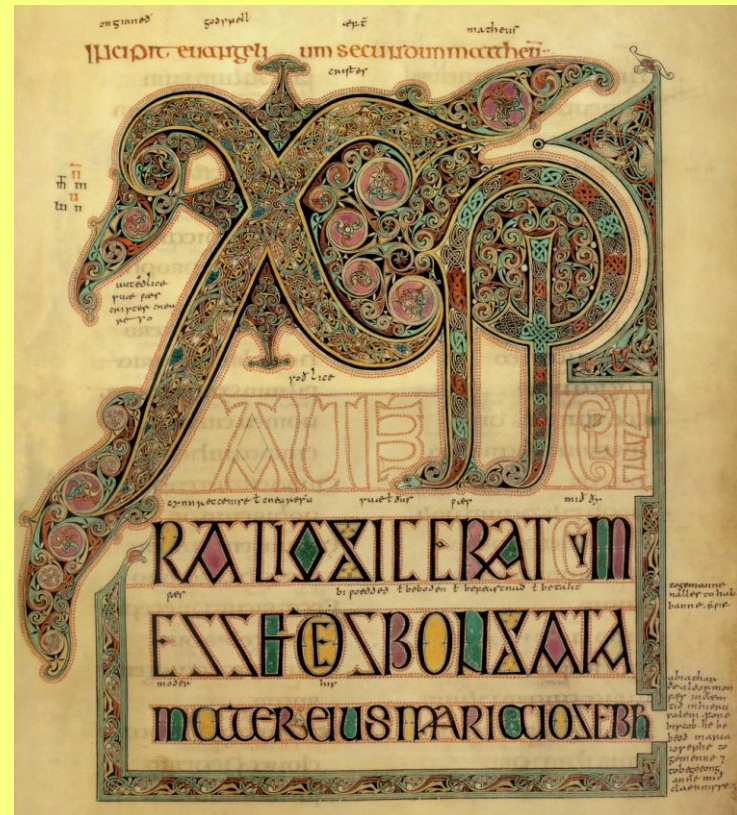
Vesalius: Concurred.

Descartes: argued that because our lenses reverse the image falling on the retinas, there must be a partial fibre crossing in the brain so that the two reversed images, one from each eye, can be brought into register in the pineal.

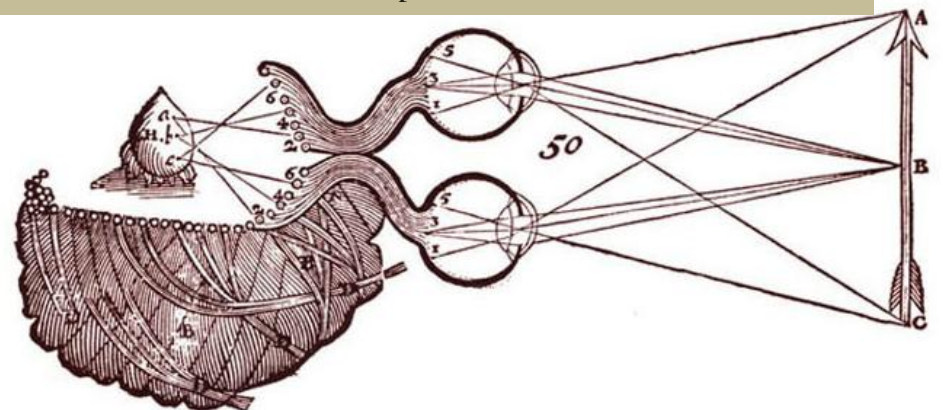
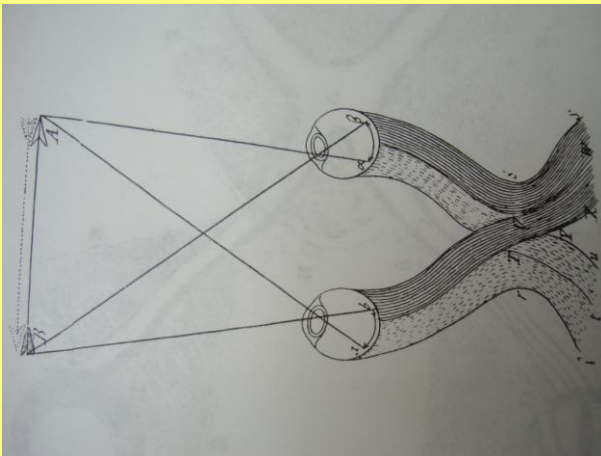
Newton: Hemidecussation

John “Chevalier” Taylor: Partial decussation

Some surrogate 'person' in the brain must have a map of what is seen: seeing was to be possible: Brainy in the numskulls?



Gospel according to Matthew, Eadfrith of Lindesfarne.
"Christi autem generation sic erat"
"The birth of Christ took place thus."



Medieval theories of the Soul/Brain

Aristotle (384-322 B.C.) Cardio-centric theory of body functions (the heart as the acropolis of the body)

Plato (429-347 B.C.) and **Galen (129-199 A.C.)**

Soul itself resides in the brain, where process of thought occurs, and the memory of images is stored. Origin of visual pathway located in anterior ventricle, where animal spirits could interact with the visual spirits carried by the optic nerve.

Theory incorporated into medieval philosophy

Albertus Magnus. Introduces the idea of localisation of different functions in different parts of the brain. Simplified by disciples for teaching less learned monks



Albertus Magnus (fresco, 1352, Treviso) Tommaso da Modena



“Philosophy for the simple”. (Philosophia pauperum)

Albert of Orulamünde.” (late C13th c.) manuscripts of “Brother Albert, O.P.” Dominican teacher; Thüringen, compiled digests, of natural philosophy and psychology used in schools throughout the Middle Ages.

Chapter on the soul (**De anima**) discusses **THREE VENTRICLES OF THE BRAIN.**

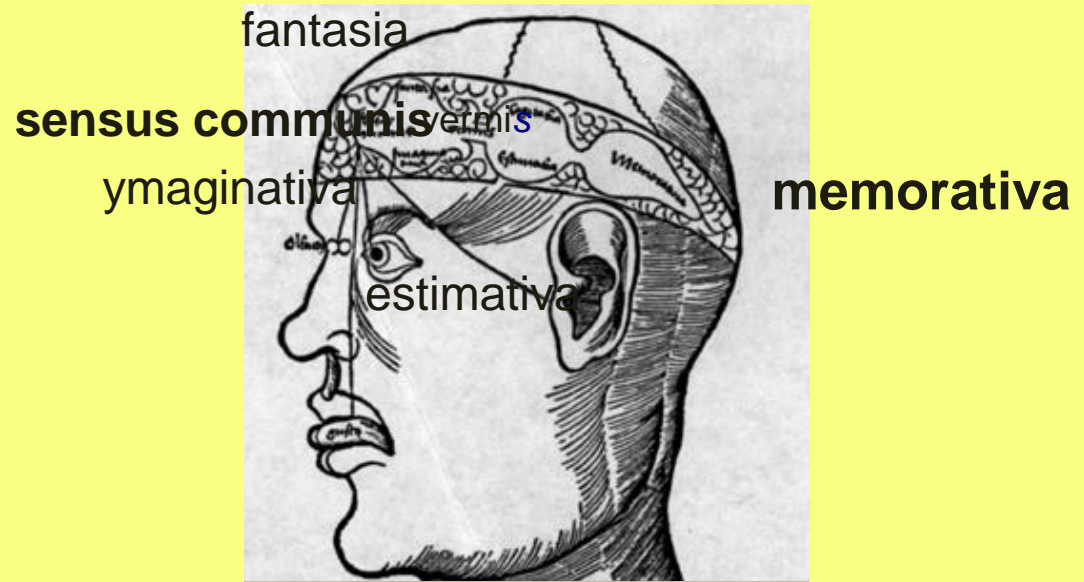
The first cell (the lateral ventricles; considered as one cavity) received information from the special senses and the body; amalgamated into **sensus communis** “common sense”.

Second cell (3rd ventricle). Images created from sensation interact with the seat of reasoning . Thought (cogitativa) and judgement (estimativa).

The third cell (4th ventricle) was where memory resided.

Galen believed that the folds, gyri had no function.

It was not until phrenology in the C19th that this view was challenged.



Gregor Reisch, *Margarita Philosophica* (1504)



Saint Dominic (1170-1221), Perugia Altarpiece Fra Angelico.

Leonardo da Vinci (1452–1519)

Eyes as window on the soul

ILLUSTRATING HOW SIGHT WORKS C1489-92

Wax injection, confirms Galen's paired anterior ventricle (lateral ventricles),

Brain has three inter-connected ventricles, each facilitates a particular stage in perception.

Also described the **imprensiva**, a brain structure that mediates between sense organs (such as the eye) and the senso comune.

Not been recognised by any anatomist before or after

The first ventricle, sensus communis, receives information gained from the senses. **Second chamber** thought and judgement. Leonardo believed that this was the site of the human soul,

Third chamber called the memoria, where information could be stored.

Eye transmits images through the sense organs to the understanding where they are judged.

Forms created in the imagination are inferior; ultimately they fade and die in the memoria.

The eye, which is the window of the soul, is the chief organ whereby the understanding can have the most complete and magnificent view of the infinite works of nature;

Ear comes second, which acquires dignity by hearing things the eye has seen.



Andreas Vesalius 1514-1564

Padua: Public dissection performed (unusually) with his own hands by Vesalius. In 1584 dissections were moved indoors.

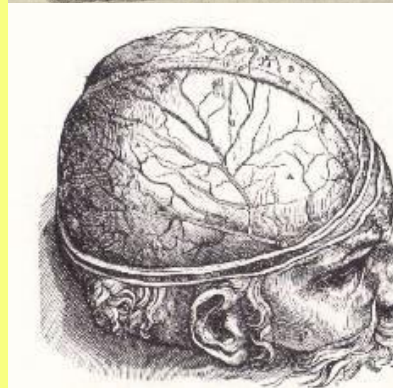
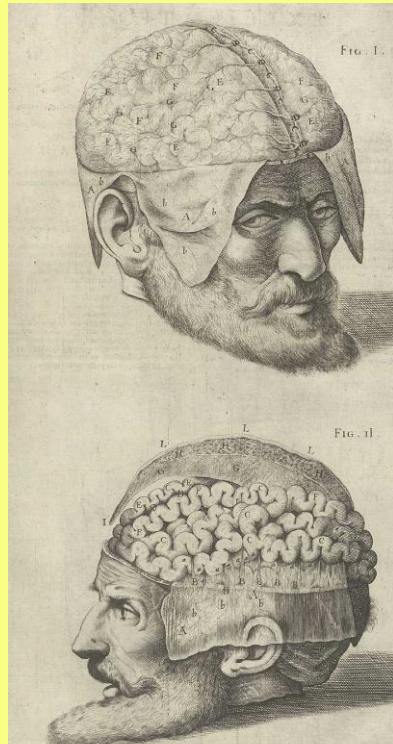
Opposed ventricular theory; “Such are the inventions of those who never look into our makers ingenuity”.

Animals had ventricles but not souls?

Shakespeare alludes to the ventricular theory in *Love’s Labours lost*.

A foolish extravagant spirit full of forms, figures, shapes, objects, ideas apprehensions, motions, revolutions. They are begat in the ventricle of memory, nourished in the womb of pia mater.

However gyri shown in similar fashion to medieval images. Low status organ.



The anatomy lesson of Dr. Joan Deyman: Rembrandt 1606-69

Joris Fonteijn of Diest, Black Jan, notorious thief was condemned to death on 27 Jan 1656. Rembrandt was broke and had applied for cessio bonorum (bankruptcy).

The anatomy theatre was in the attic of the meat market, where the dissection took place on the 29th, following prayers to bless good coming from evil. Cold weather ideal.

The stomach and intestines were removed first, then the dissection of the brain.

The assistant holding the skull cap is Gysbrecht Matthijsz Calcoen, a master of the Amsterdam Guild of surgeons f.1552 as the surgeons separated from Wooden Shoe and Ice Skate Manufacturers Guild.

Deyman was paid with 6 silver spoons worth 31 guilders 19 stuivers, for three demonstrations.

The painting was mostly destroyed by fire in 1723.



Thomas Willis 1621-1675

Gresham connection

IMPORTANCE OF THE CORTEX.

1664: Cerebri Anatomie the first systematic approach to the functional anatomy of the brain. Opposed the concept of ventricular localization of brain function and proposed 3 areas in the brain: the corpus striatum received sensory input, converted to perception and imagination in the hard overlying tissue, corpus callosum, before passing on to **cerebral cortex** where they were stored as memories.

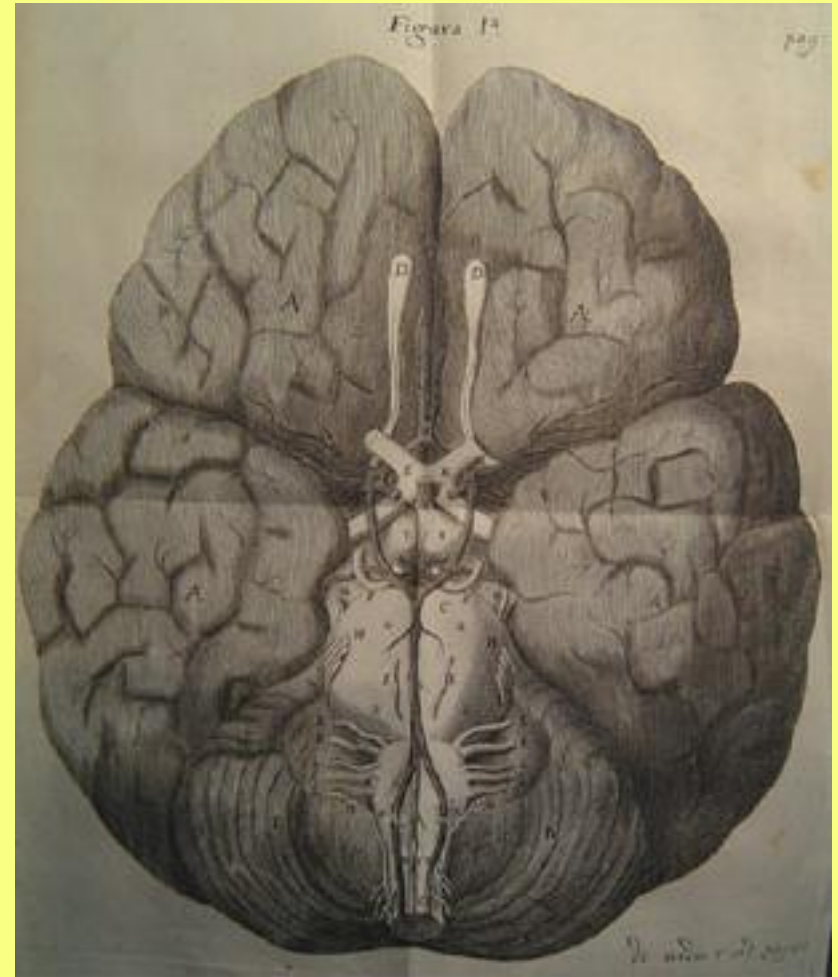
Theory on brain function achieved widespread influence

Charles Sherrington (1852–1952), "Thomas Willis practically refounded the anatomy and physiology of the brain and nerves... Willis put the brain and the nervous system on their modern footing so far as that could be then done".

Christopher Wren (1632–1723). familiar with anatomy, models of muscles and eyes. Performed ink injections into carotid arteries, used by Willis & Lower to determine circulation of the brain and the physiological significance of the circle of Willis.

Alcohol well-preserved specimens of brains.

Gave up interest in physiology and anatomical drawing for architecture.



Visual perception

ability to interpret information from visible light reaching the eye. This perception is called eyesight or vision

Nicolaus Steno: Danish anatomist and polymath; In 1665 gave a lecture *Discours sur l'Anatomie du Cerveau [Discourse on Brain Anatomy]* in Paris: *Gentlemen, instead of promising to satisfy your curiosity about the anatomy of the brain, I intend here to make the sincere, public confession that this is a subject on which I know nothing at all*

Our perception does not identify the outside world as it really is, but the way we are allowed to recognize it, is a consequence of transformations performed by our senses.

photons converted to images,
vibrations into sounds

chemical reactions into smell and taste.

Actually, the universe is silent, colourless, inodorous, and dark.

The outermost part of the brain, the grey-matter rind (**cortex**, which envelops the white matter core) that is the organ of perception.

This has only become known in the last 100 years.



Beezer, drawn by Malcolm Judge. The Man (ie "the reader") is dependent on the decisions of the **numskulls**. He has the freedom only to reflect on what has occurred, all his thoughts and actions are instigated by Brainy and sent from Brainy's 'suggestion box' seeming therefore to "Man" to be his own. He doesn't know of the existence of the numskulls. What he thinks is actually a consequence of the Numskulls action, not his own free will.

Where do thoughts come from and why do people behave as they do?



Localisation of vision to the occipital lobe

Bartolomeo Panizza (1785 – 1867) b. Vicenza. q Padua, studies at Bologna and Pavia.

Follower of Gall, the first to attribute visual function to the posterior cortex.

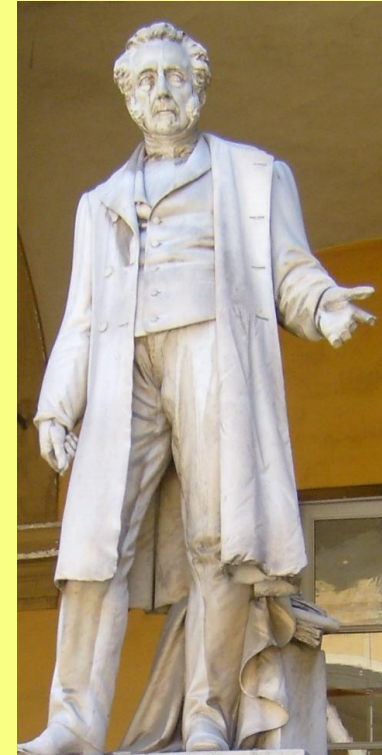
Examined brains of pts blind after strokes and experimental lesions in animal brains, concluding the occipital brain was crucial for vision.

1855 **Osservazioni sul nervo ottico** (Observations on the Optic Nerve).

Discovery was ignored prevailing theory of the thalamus as the highest sensory centre and the cortex associated with intellectual function.

None of Gall's areas for example, had sensory or motor function.

It took a horrible war to prove him correct.



Battle of Antietam September 17, 1862

Gen. McClellan confronted Lee's army of Northern Virginia at Sharpsburg Maryland.

At dawn Hooker's division assaulted Lee's left flank, 23,000 casualties. Musket 300m/s 1 ounce. Minie ball rifle.

4th New York at the left front receive fire of the North Carolina regiments of Anderson's Brigade. Private Patrick Hughes, Irish immigrant, shot in head with a musket. dazed and in shock, bleeding heavily, he dragged himself to the rear and received first aid

25 Sep moved, to Mount Pleasant Hospital in Washington

8 yrs later **Dr. Keen and Thomson:**

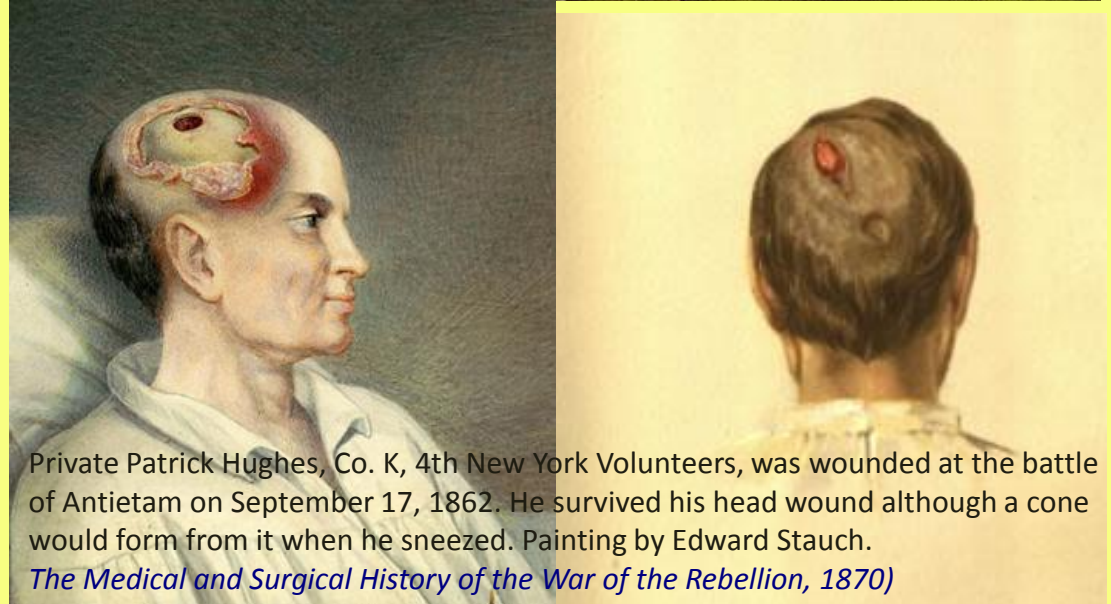
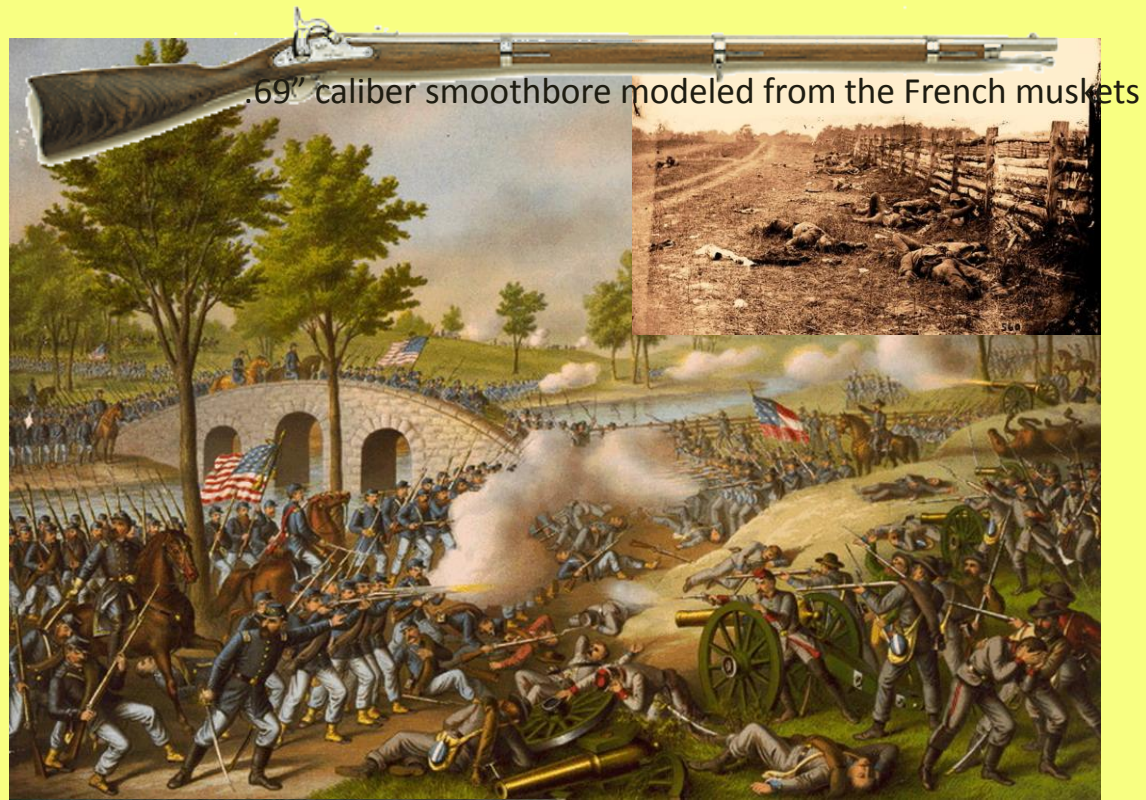
complained sight in his right eye was poor, however whiskey affected him as usual and his sexual power was undiminished!

No bone has closed this opening, but the scalp and hair dip down into the hollow. The arterial pulsations are barely perceptible.

Visual field split down the middle of fixation.

The visual map in the brain is therefore centred on the fovea, half coming from the world located on the left side of fixation and one half coming from the right side.

Newton's hemi-decussation in the chiasm thus correct.



Private Patrick Hughes, Co. K, 4th New York Volunteers, was wounded at the battle of Antietam on September 17, 1862. He survived his head wound although a cone would form from it when he sneezed. Painting by Edward Stauch.

The Medical and Surgical History of the War of the Rebellion, 1870)

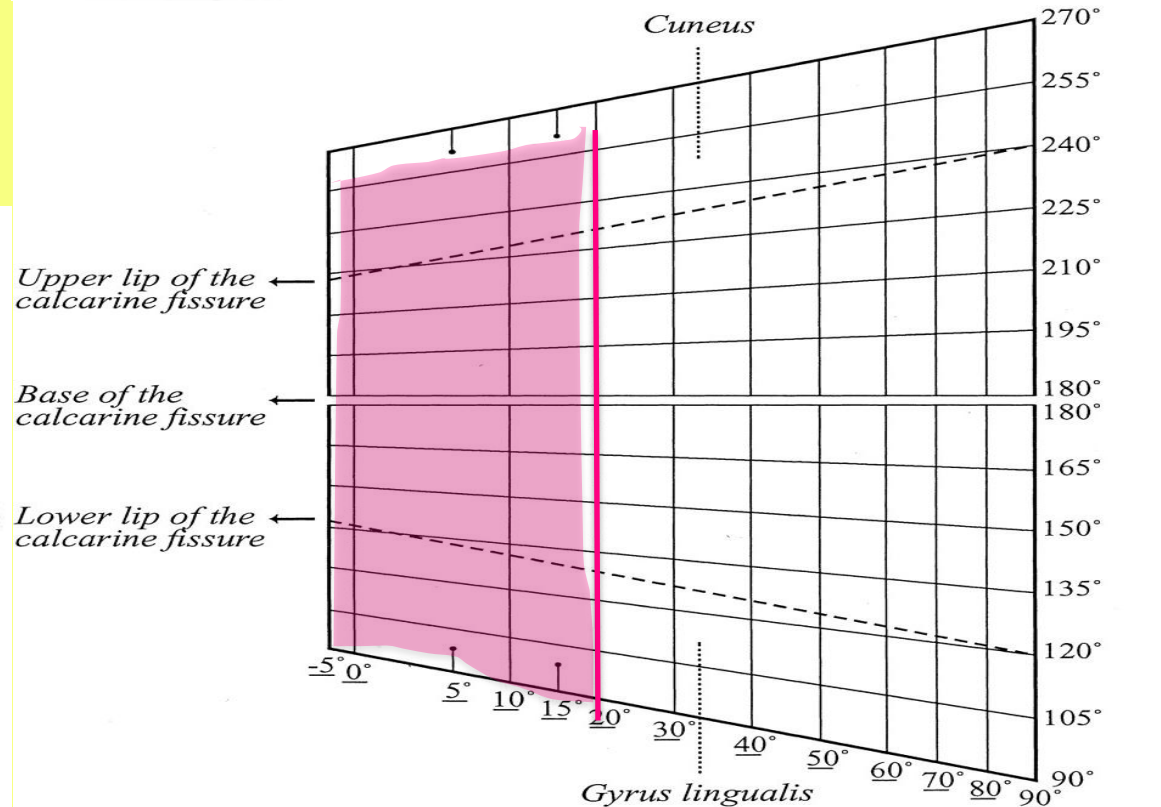
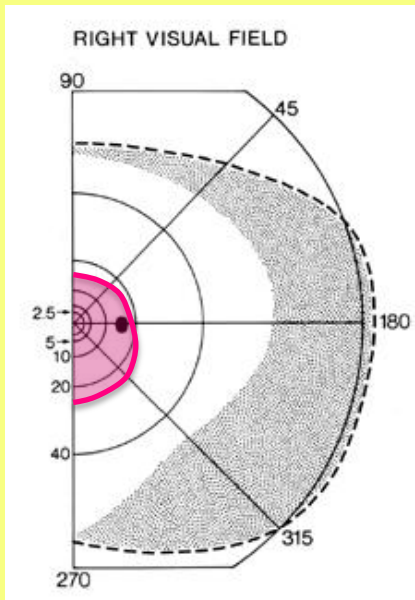
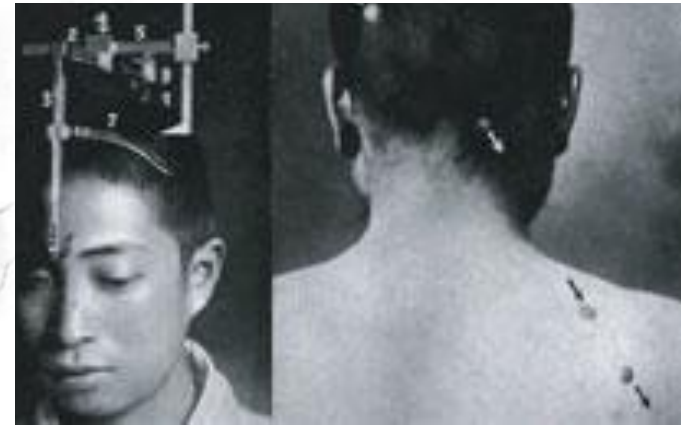
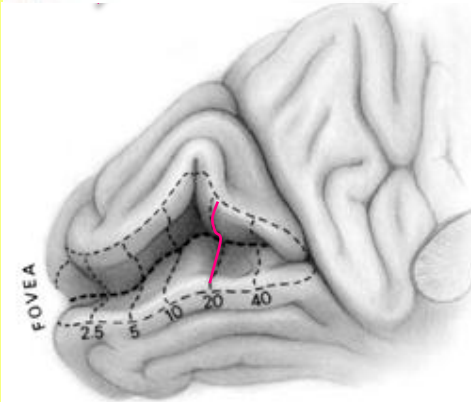
Tatsuji Inouye

Russians equipped with new **Mosin-Nagant Model 91**. Small diameter 7.6mm, High velocity 620 m/s. Colonel Sergei Ivanovich Mosin designed the bolt and receiver, the Belgian Emile Nagant, designed the magazine system.

As a young Japanese ophthalmologist, Dr. Inouye examined soldiers with visual defects for their pension board.

Inouye invented a device called the cranio-coordinometer.

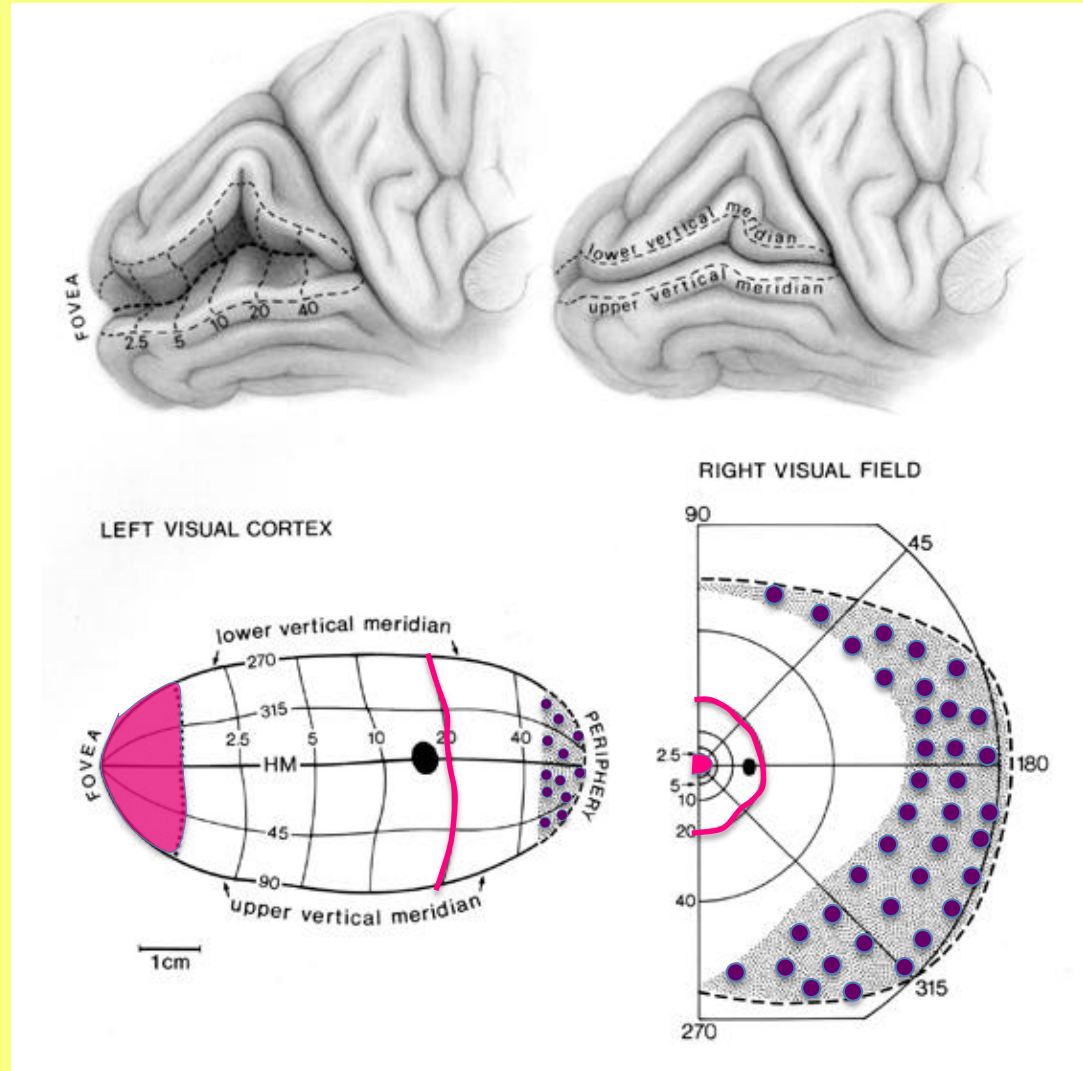
He discovered that vision was mapped in an orderly fashion along the base and walls of the calcarine fissure. Also noted the distortion: The central field is very magnified. Explains Ferrier's result.



Modern mapping

Magnification of central vision:

Massive % of visual cortex field map devoted to central vision. (55% of the surface of visual cortex represents central 10° of vision.)



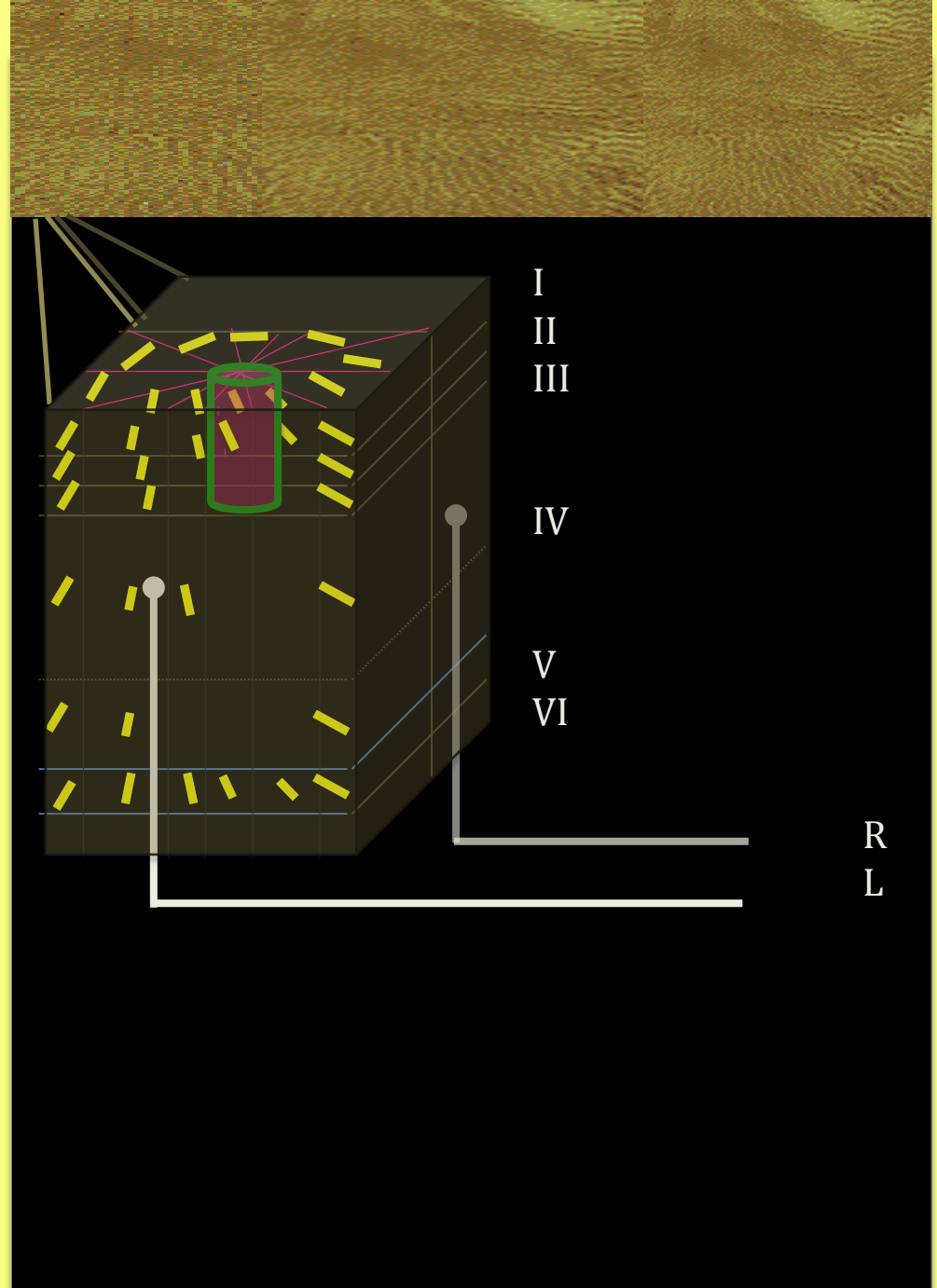
Information extracted in the visual cortex

Stereopsis (depth perception)

Disparity between the two sets of information allows the brain to construct stereopsis, a realistic impression of depth.

Orientation of lines:

Radiating from the centre are vertical arrays of simple and complex cells with the same orientation sensitivity.



Simple cells of visual cortex

Respond best to particular orientation of the bar of light.

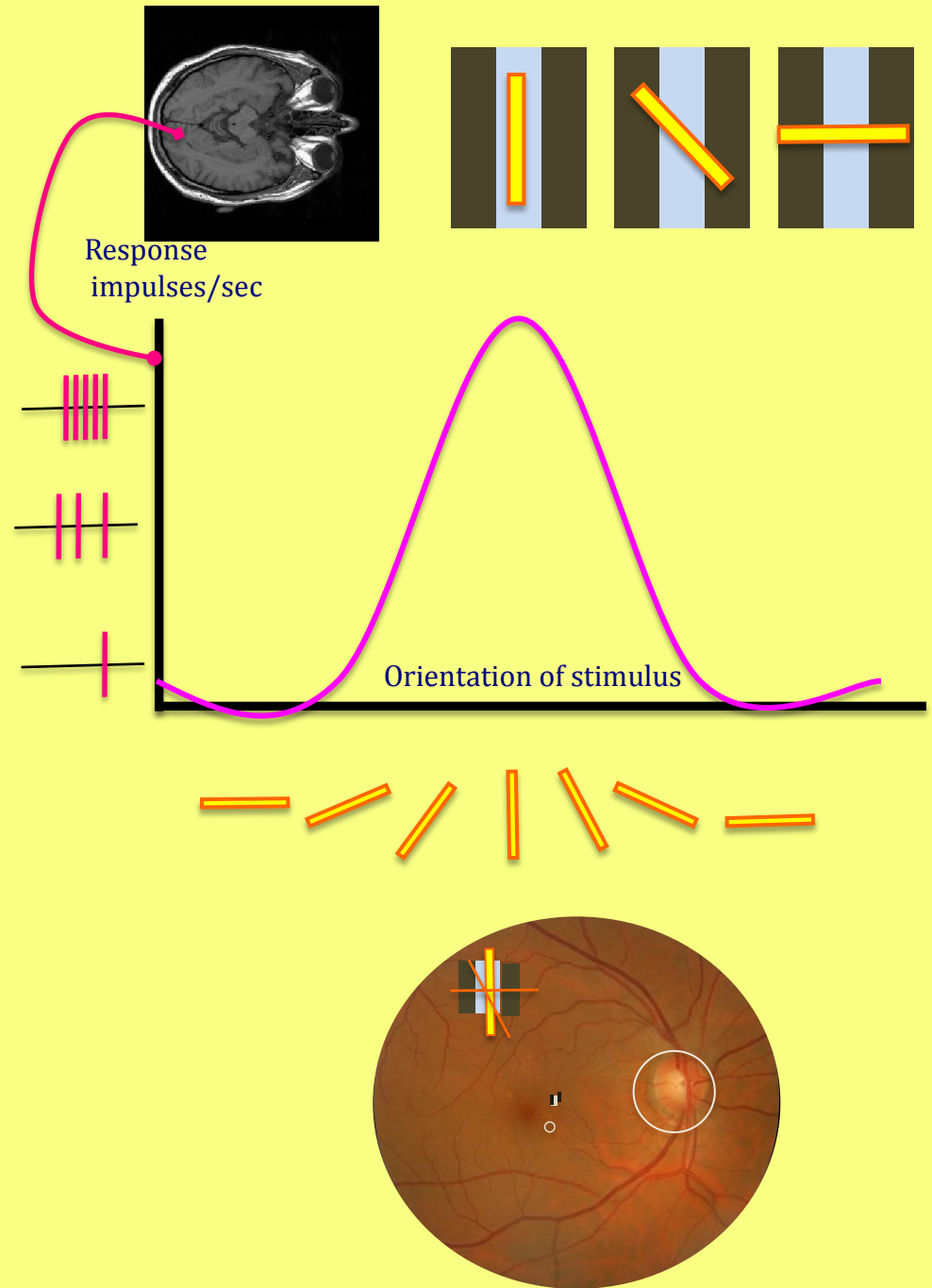
Response, decays as orientation tilts 10^0 to either side, (difference between one o'clock and two o'clock is 30 degrees).

No response when the line is oriented 90 degrees to the optimal.

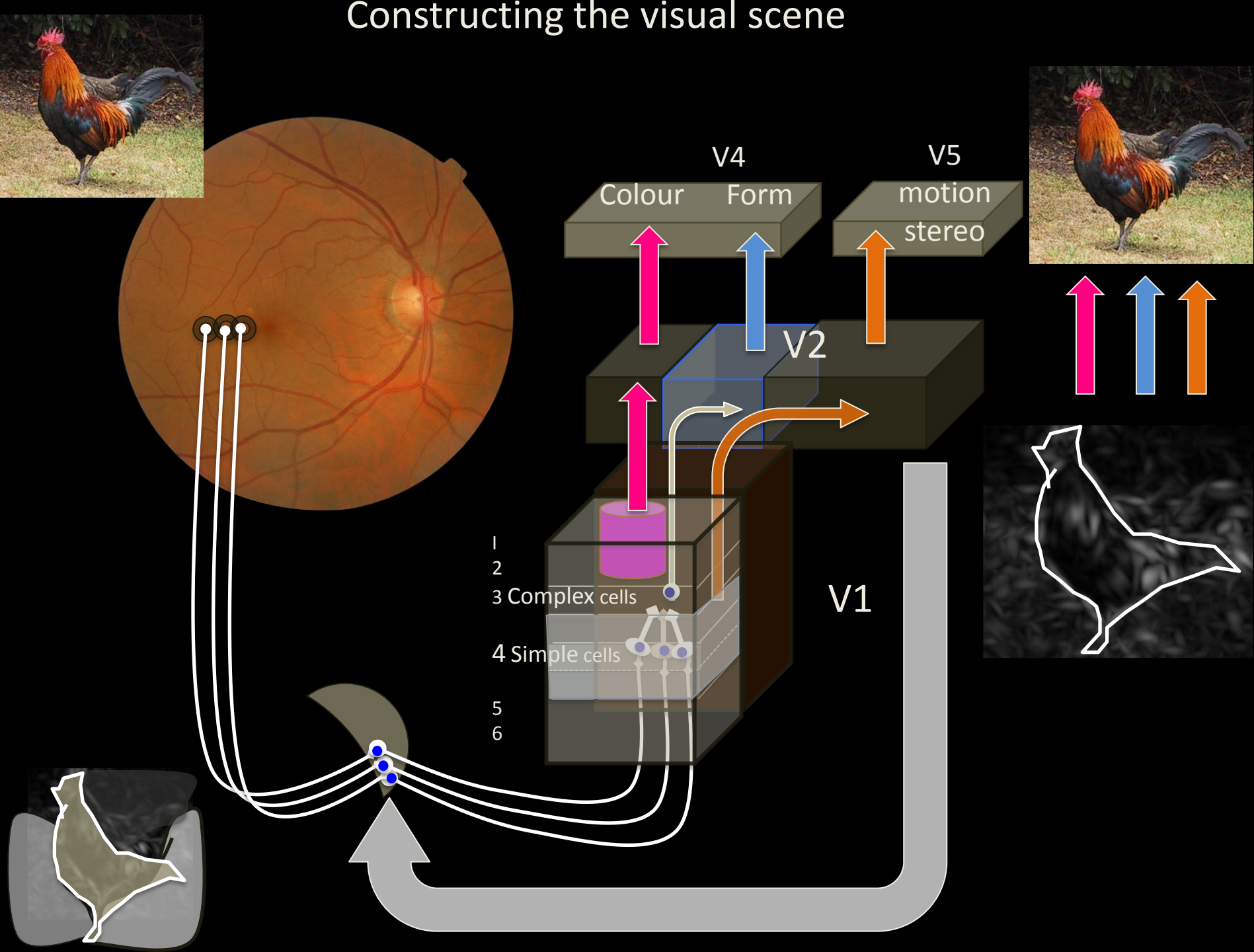
Unlike cells at earlier stages in the visual path, these **orientation-specific cells** respond far better to a moving than to a stationary line.

Size: near fovea 0.25^0 . (moon 0.52^0
 $150\mu\text{m}$)

In periphery 1^0 ($288\mu\text{m}$)



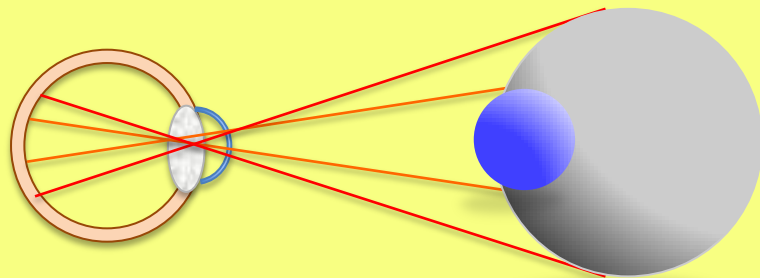
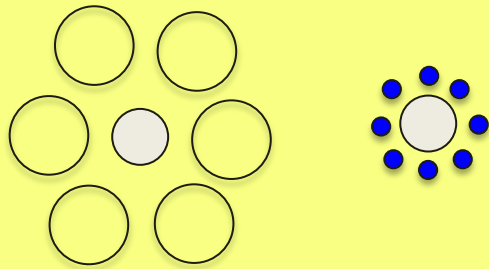
Constructing the visual scene



What you think you see is not what you see

One dimensional retinal image used to generate 3D model of the world

Useful for navigating and survival



Geometrical illusions

Inverted T-illusion: A. Fick 1851:

A: It appears that the lines are same length.

Actually vertical line **A** is 12.5% shorter than the horizontal one.

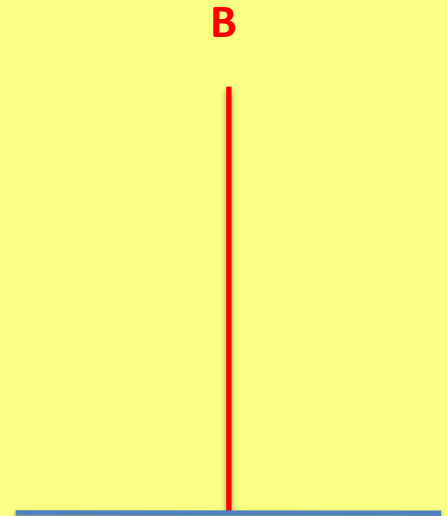
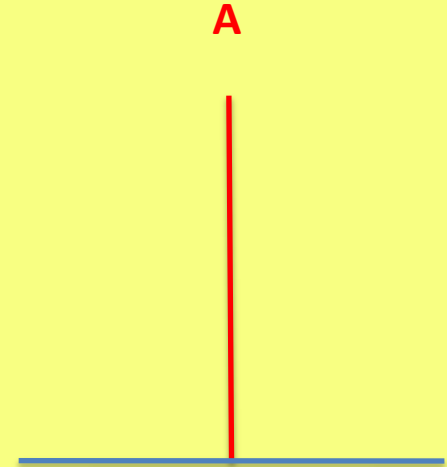
B: Lines of the same length; perception that vertical line is longer than the horizontal one.

Many explanations;

However even when bisection is eliminated, **L**, vertical still 3-5% longer.

Fick, A. (1851) Da errone quodam optic asymmetria bulbi effecto. Marburg, Koch

Avery & Day: J Exp Psych 1969



Shape and size illusions

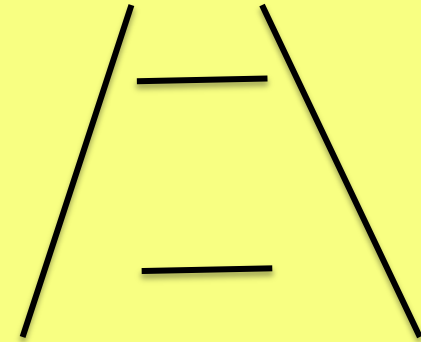
Ponzo Illusion

Mario Ponzo (1882-1960) Italian Psychologist. suggested that the human mind judges an object's size based on its background.

Ponzo illusion 1928

Two identical lines within a pair of converging lines. the top bar is perceived as being longer than the lower.

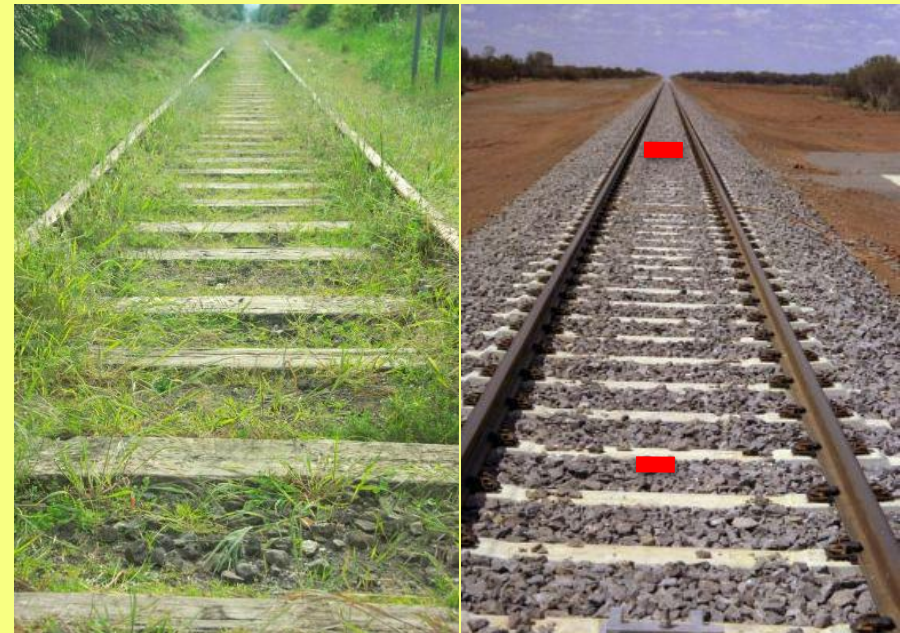
We interpret the converging sides as parallel lines receding into the distance. In 3D world, an object located farther away would have to be larger than a nearby object for both to produce retinal images of the same size.



Converging lines are depth cues

Context is an important influence of perception. The more visual cues present surrounding the two horizontal lines, the more powerful the illusion.

Ponzo illusion also present in other species, pigeons, rhesus monkeys, and chimpanzees.



Johann Poggendorff

Family, ruined by the French siege, aged 16 apprenticed to apothecary in Hamburg.

1820 entered the university Berlin.

1824: Editor of Gilbert's *Annalen der Physik*, dies. Publisher, appoints Poggendorff editor of its successor, ***Annalen der Physik und Chemie***, becomes foremost scientific journal in Europe.

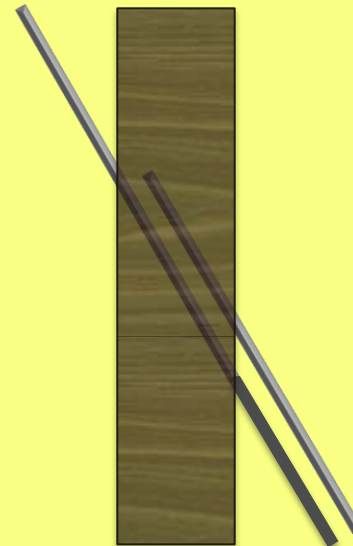
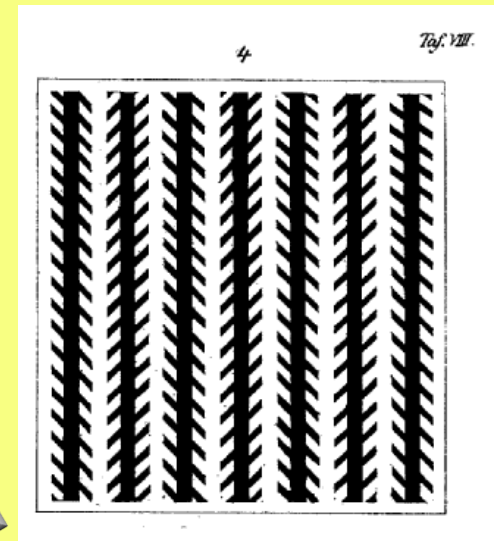
1838 Hon. Ph.D. prof. University of Berlin

Zollner's original letter the lines on the diagram were thickly drawn. Poggendorff observed another distinct illusion.

The right continuation of the line appears shifted down

Many theories about why this simple geometrical illusion occurs or diminishes. It the human visual system is extremely poor at interpreting the path of diagonal lines, although it is not understood why.

Deconstruction of the Poggendorff figure into its component parts, however, suggests that the illusion might be a combination of several effects



Studies on Poggendorff illusion

As the acute angle is reduced, the illusion progressively weakens

Even with virtual subjective lines, the Poggendorff illusion persists.

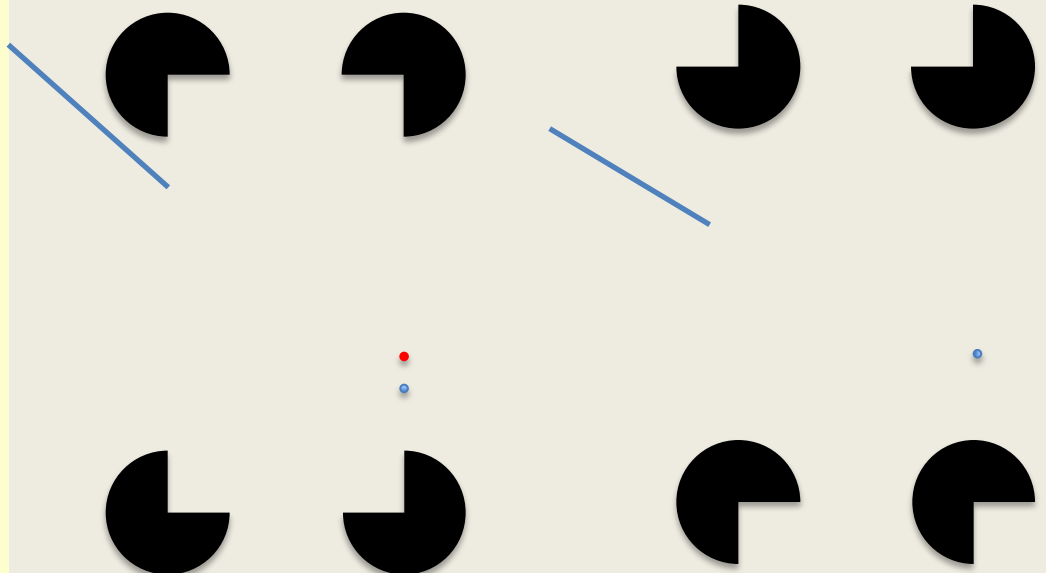
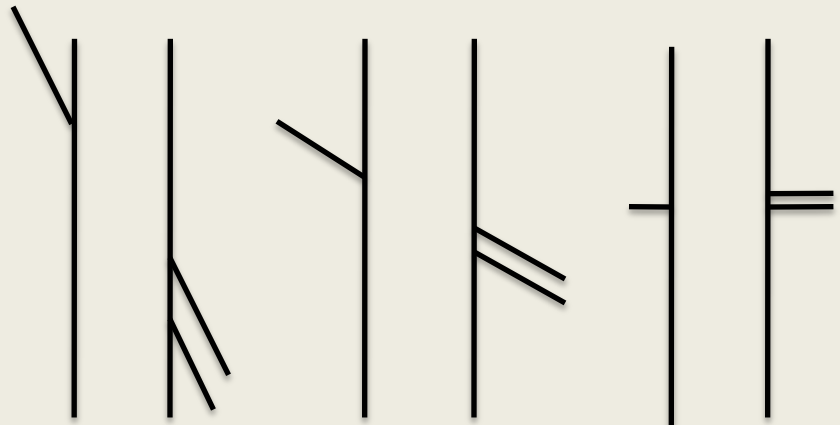
length, orientation, or position are encoded early in the processing of the retinal image.

Studies suggest that subjective contours are also processed early in the visual pathways, most probably in V2 or even V1

Morgan MJ. Vision Res. 1999 Jul;39(14):2361-80. The Poggendorff illusion: a bias in the estimation of the orientation of virtual lines by second-stage filters.

Tibber, Melmouth & Morgan. Biases and Sensitivities in the Poggendorff Effect when Driven by Subjective Contours Invest Ophthalmol Vis Sci. 2008; 49: 474-478

City University



Poggendorf illusion in natural environment

Thorsten Hansen. University Ulm.

The ability to recognise that 2 pieces of an object are the same (Colinearity) is basic; Poggendorf effect is unexpected.

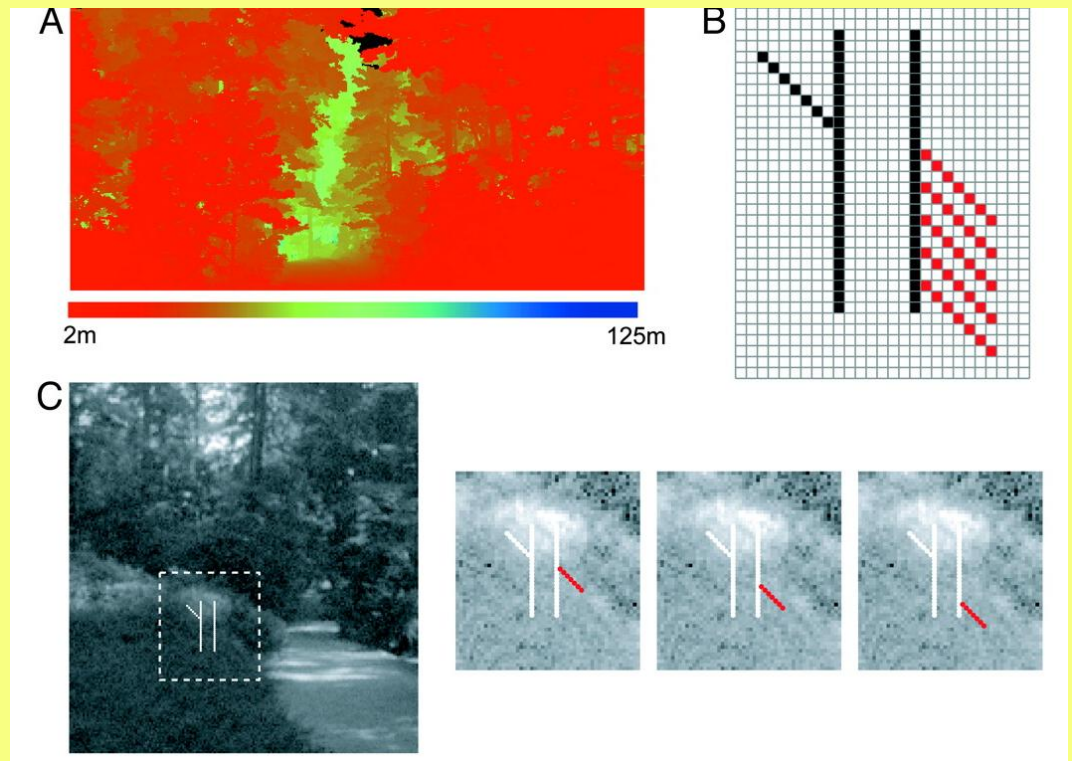
In real world Viewed with BE the two parts have disparity causing a displacement of the junction, the left is moved upwards in LE, the right junction is moved downwards RE.

When the two half-images are fused, compensation of the disparity enables correct perception of a single oblique line behind a distant object.

If the same 3D compensation mechanism is triggered by a 2D drawing; the Poggendorff illusion occurs.

Catherine Howe, Zhiyong Yang, and Dale Purves

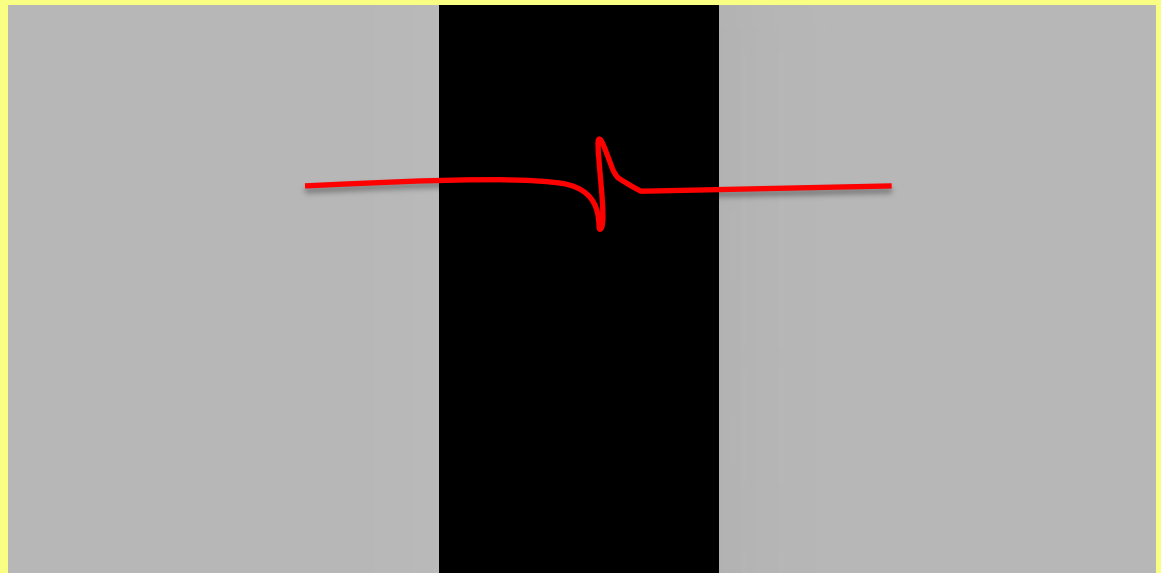
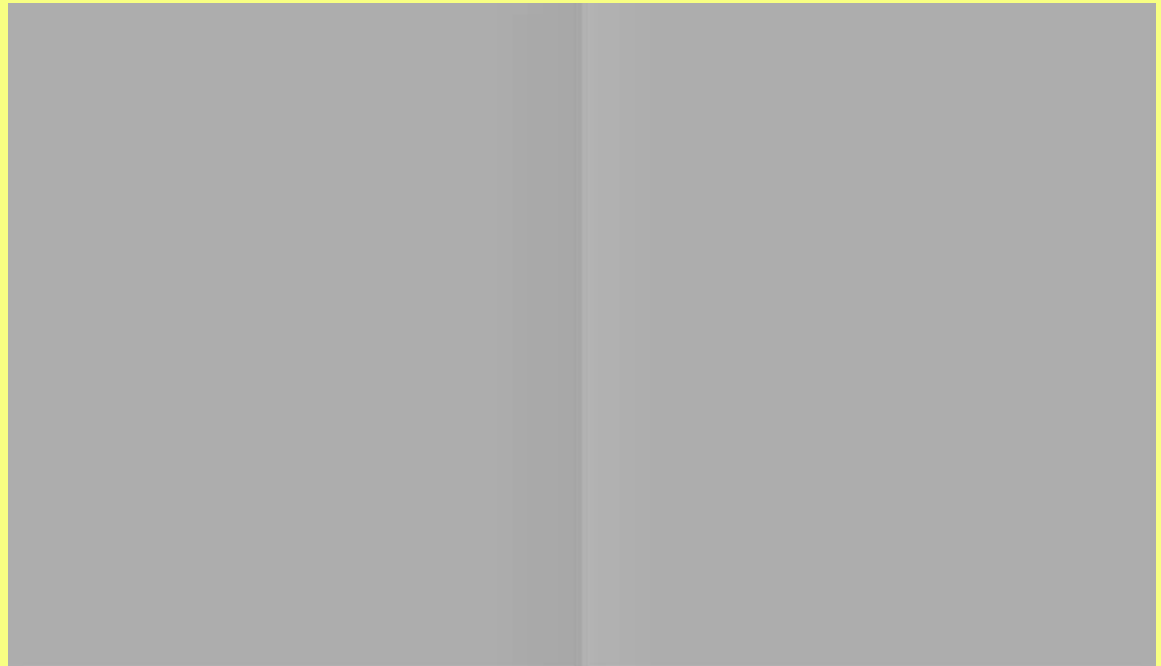
In natural environment most sources creating an oblique segment will have actually projected above the point that is a continuation of the line. So a co-linear line interrupted will appear to be displaced down.



Cornsweet illusion

Left part of the picture seems to be darker than the right one. In fact they have the same brightness.

We see this effect because of the small gradient effect in the middle of the image.

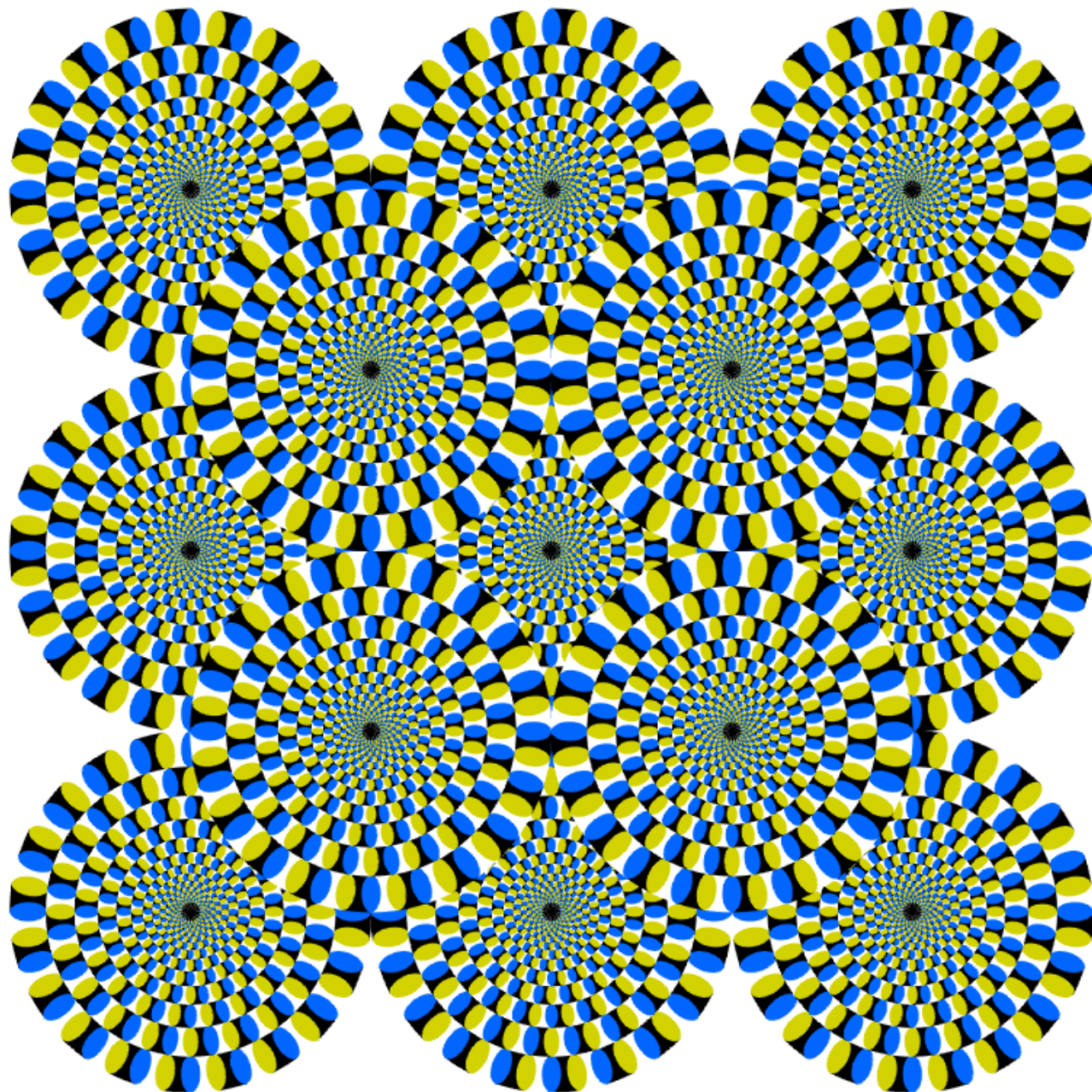


Kitaoka & Ashida (2003)
rotation of the “wheels” occurs in
relation to eye movements. On
steady fixation the effect
vanishes. asymmetric luminance
steps are required which triggers
motion detectors.

fMRI: significant activation in a
motion-sensitive area in the
human extrastriate visual cortex
during the observation of the
figure. Enhanced by eye
movements.

Kuriki: J.Vision 2008.

Akiyoshi Kitaoka, Professor,
Department of Psychology,
Ritsumeikan University, Kyoto,
Japan







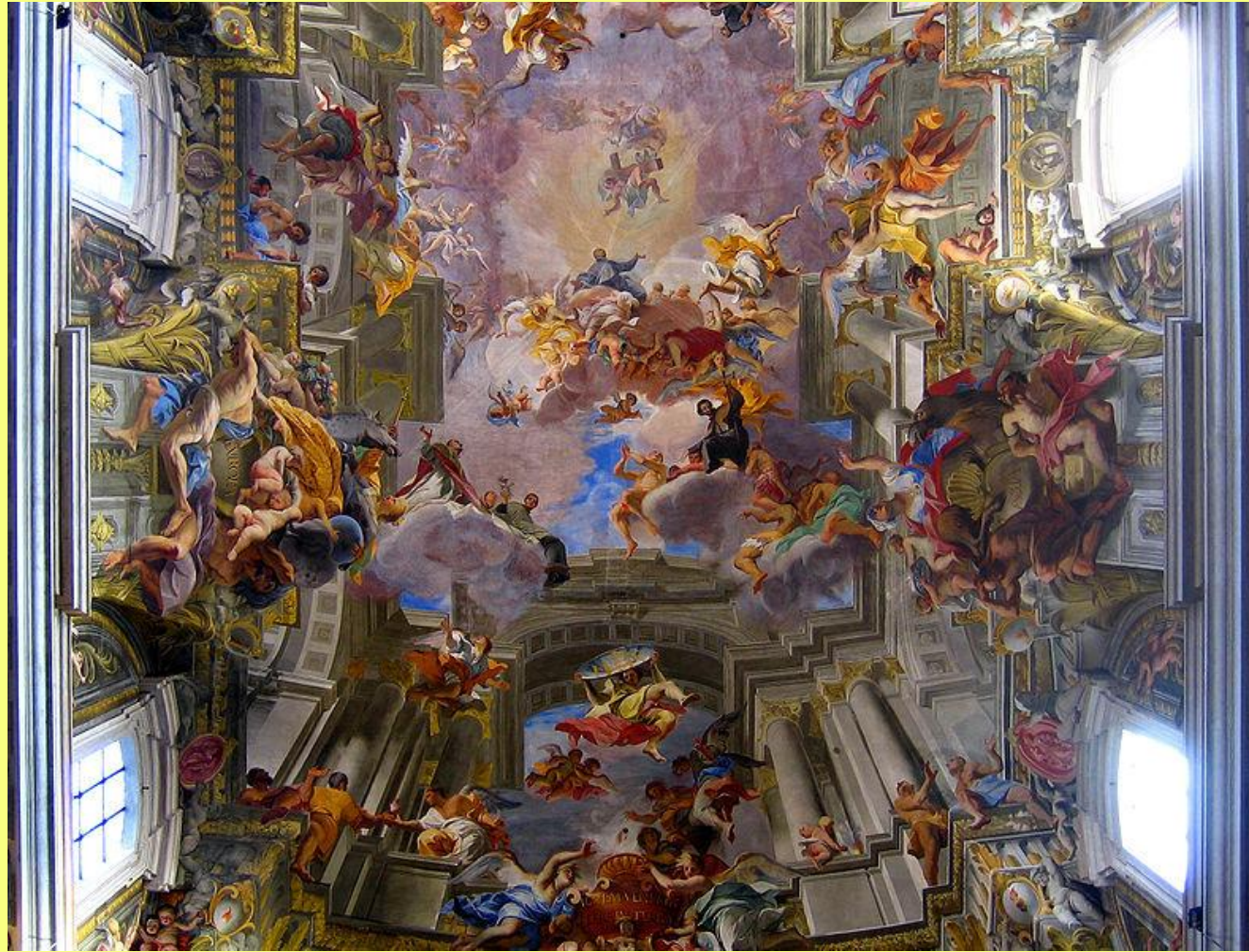
Illusions in art

C17th, Baroque trompe l'oeil murals combine actual architectural elements with an illusion.

in a particular place, the architecture blends with the decorative painting.

The dome and vault of the Church of St. Ignazio in Rome, painted by **Andrea Pozzo**.

Due to complaints of blocked light by neighbouring monks, Pozzo was commissioned to paint the ceiling to look like the inside of a dome, instead of actually constructing one.



Optical illusions in architecture

Parthenon designed by Iktinos, built BCE 447-438.

Society of Dilettanti 1846 sent Penrose to investigate theory of John Pennethorne that what appeared straight was actually curved or inclined.

Penrose 1847 “**Anomalies in construction of the Parthenon**”: “optical refinements” .

Stylobate platform was indeed curved.

Normally, columns appear narrower in their middle than at their ends. Parthenon columns have a small bulge in the middle, giving them straight appearance.

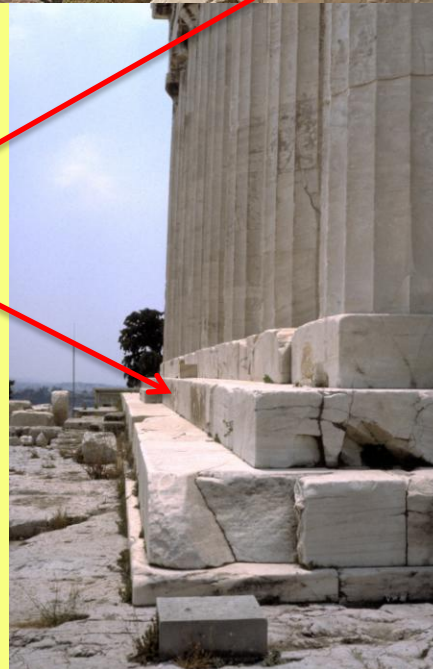
Against bright sky, corner columns appear thinner and further apart than those on a dark background.

Columns at the corners 1/40th (6cm) larger in diameter than all the other columns.

The spacing smaller than between the other columns by about 25cm.

Horizontal lines appear to “dip” in the middle, so the Stylobate upward curvature of its centre of 2.36” on the ends, 4.33” on the sides. Also in Peisistratid temple in Corinth

Hatched-line illusion: The triangular outline of the roof makes the top part of each column appear to slant outwards. So, the columns were slanted inwards so that they would meet if they were extended one mile into the sky.



How the Parthenon would appear without optical refinements. “straight lines” are not geometrically straight. makes architecture appear “correct” : **counter-perspective.**

Eyes Window on the soul in more than one sense

*There was a young man who said
"God Must find it exceedingly odd
To think that the tree
Should continue to be
When there's no one about in the quad."*

*"Dear Sir: Your astonishment's odd;
I am always about in the quad.
And that's why the tree
Will continue to be
Since observed by,
Yours faithfully, God."*



Ronald Arbuthnott Knox (1888 –1957)
Classicist and Anglican priest
Eton, Baliol, translator of Bible

Thank YOU!

Thanks to patients and staff at the hospitals

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Colleagues at Gresham

Nikolai Serakof Welcome Institute

David Hubel : Eye Brain and Vision. 1995.

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George Mather, University of Sussex (georgem@biols.susx.ac.uk)

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Tutis Vilis: University of Western Ontario, London, Canada.

<http://www.physpharm.fmd.uwo.ca/undergrad/sensesweb/L1Eye/L1eyeProb.swf>

