Meeting on Schiaparelli and His Legacy
Accademia di Brera
Milano, 19 October 2010

Some historical crossroads between astronomy and visual neurophysiology

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Dipartimento di Scienze Neurologiche
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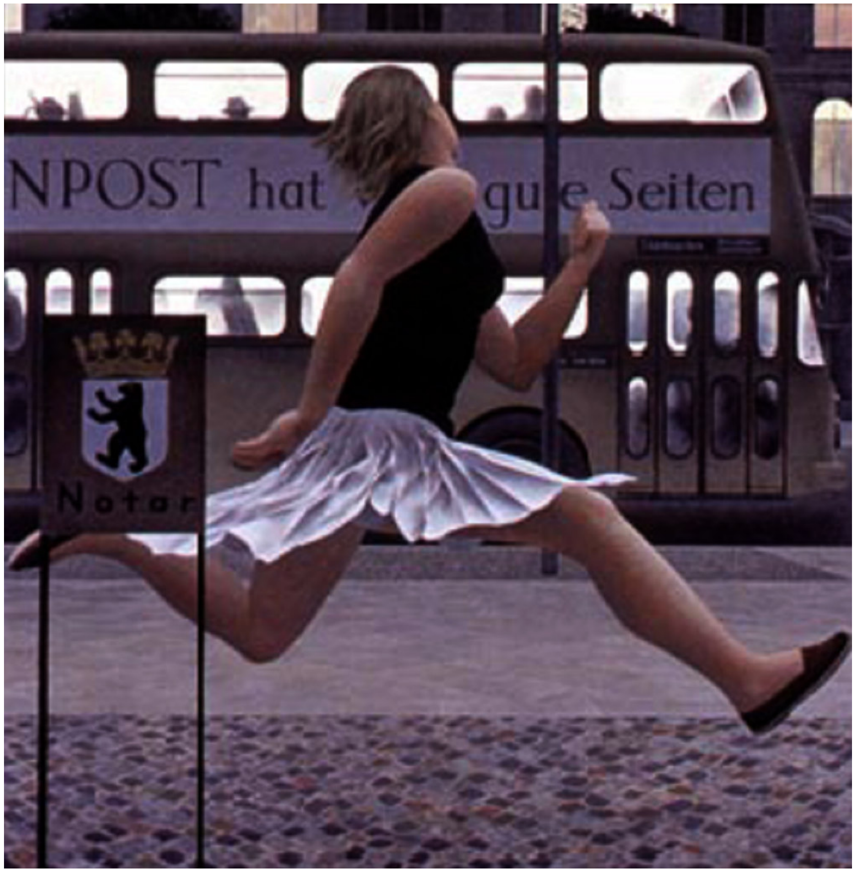
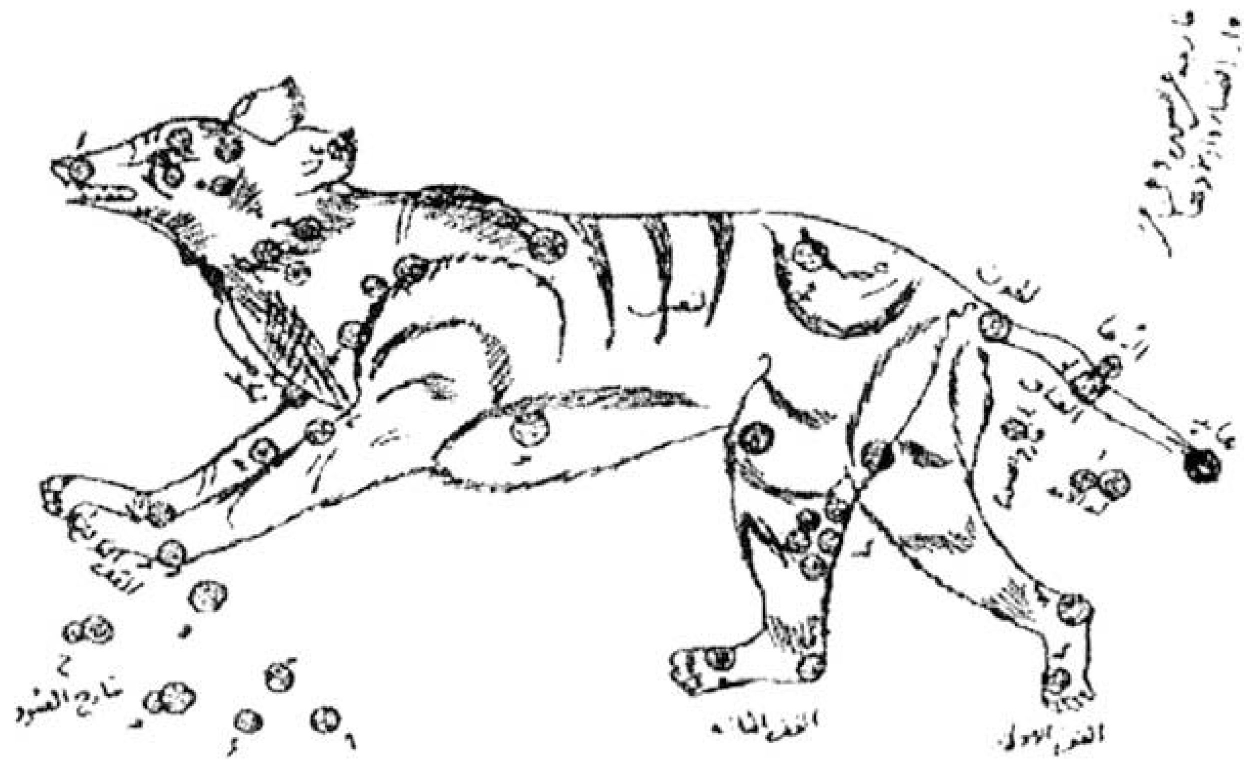
Seeing, either by naked eye or through telescopes, is a staple ingredient of both amateur and professional astronomy, which uses seeing as a measure of the stillness and clarity of Earth’s atmosphere. More generally, seeing is an optical and neurophysiological process as well as an art.

Modern neuroscience distinguishes seeing for action, that is for guiding behaviour, and seeing for conscious awareness, that is for acquiring knowledge. These two modes of seeing depend on partly different brain areas and mechanisms.


NPOST hat
Seiten
Notar

….contemplation of the skies is not what we evolved for…. For example, the sun and the moon look much the same size to us; yet the sun is 400 times as far away and 400 times as large as the moon, and by the rules of size constancy should appear as such. The reason why it does not is that we have no way to judge the relative distances of celestial bodies: it was earthly, not astronomical lengths that shaped our visual system (Paola Bressan, Clinical and Experimental Ophthalmology,**33**: 574, 2005).


Alcor
Mizar

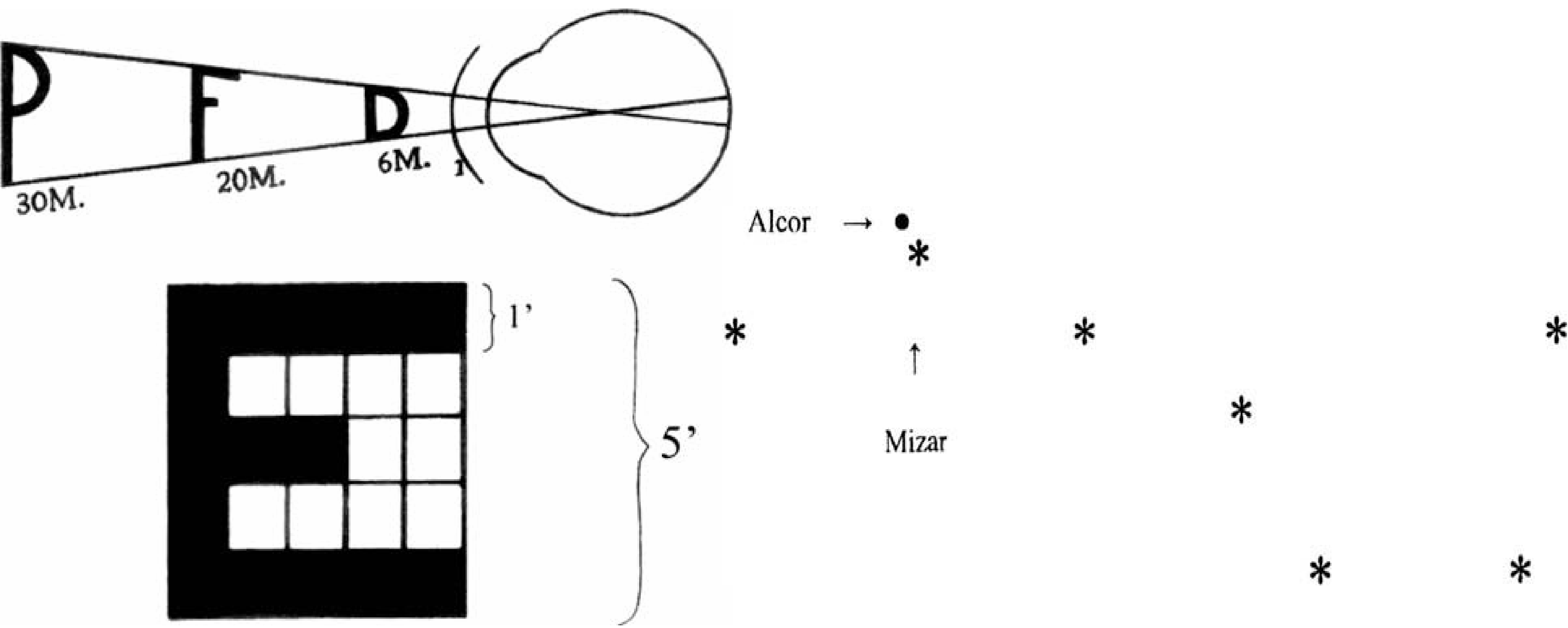


HISTORY OF OPHTHALMOLOGY

An Ancient Eye Test—Using the Stars

George M. Bohigian, MD

SURVEY OF OPHTHALMOLOGY VOLUME 53 NUMBER 5 SEPTEMBER–OCTOBER 2008



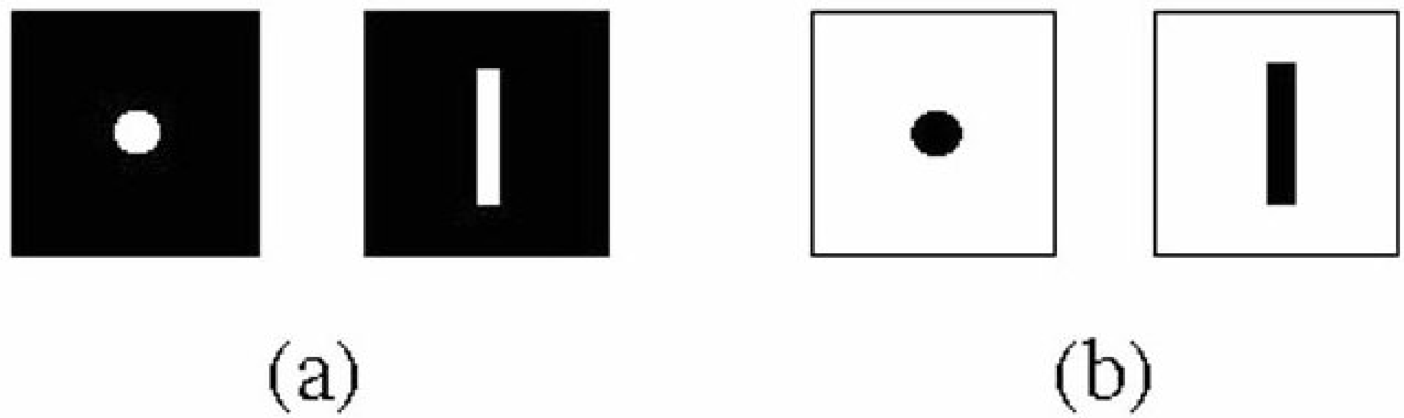


Figure 1. The task of detection involves stating whether the spot or line is present. (a) Bright test object on a dark background. (b) Dark test object on a bright background.

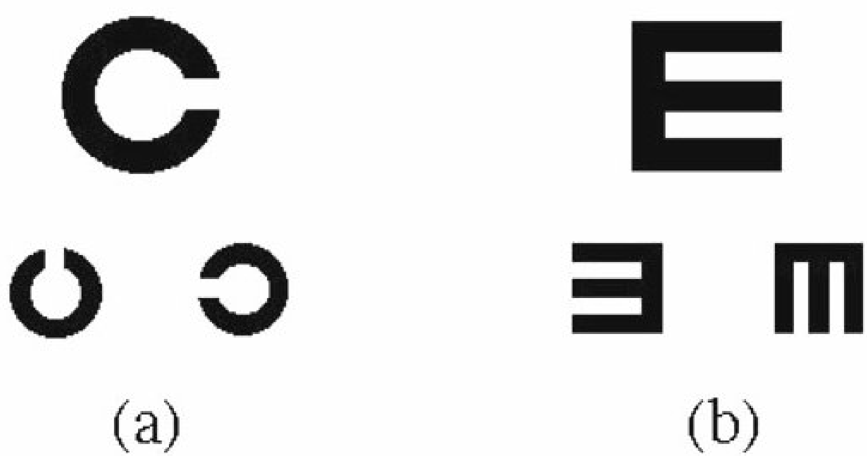


Figure 2. (a) Landolt C. (b) Illiterate E.

Figure 3. The task of recognition. Naming the test objects, in this case, letters of the alphabet (Snellen).

François Arago

ASTRONOMIE POPULAIRE

PAR

FRANÇOIS ARAGO

NOUVELLE ÉDITION

MISE AU COURANT DES PROGRÈS DE LA SCIENCE

TOME DEUXIÈME

ŒUVRE POSTHUME

ÉDITÉ PAR L. GUÉRIN

LIBRAIRIE THÉODORE MORGAND

5, RUE BONAPARTE, PARIS

1867

CHAPITRE III

DE LA SENSIBILITÉ DE L'ŒIL POUR LA VISION DES ÉTOILES

La sensibilité de l'œil est très-variable suivant les points de la rétine où l'image vient se former. Ainsi, lorsqu'on regarde directement une très-faible étoile avec un télescope, on peut ne pas la voir, tandis qu'on aperçoit distinctement des étoiles qui ne sont pas plus brillantes situées à droite ou à gauche de la première. Les astronomes ont eu mille fois l'occasion de remarquer que pour observer les très-faibles satellites de Saturne, il faut diriger sa vue à quelque distance du point où le satellite se trouve; en ce sens, on peut dire sans paradoxe, que pour apercevoir un objet très-peu lumineux, il faut ne pas le regarder.

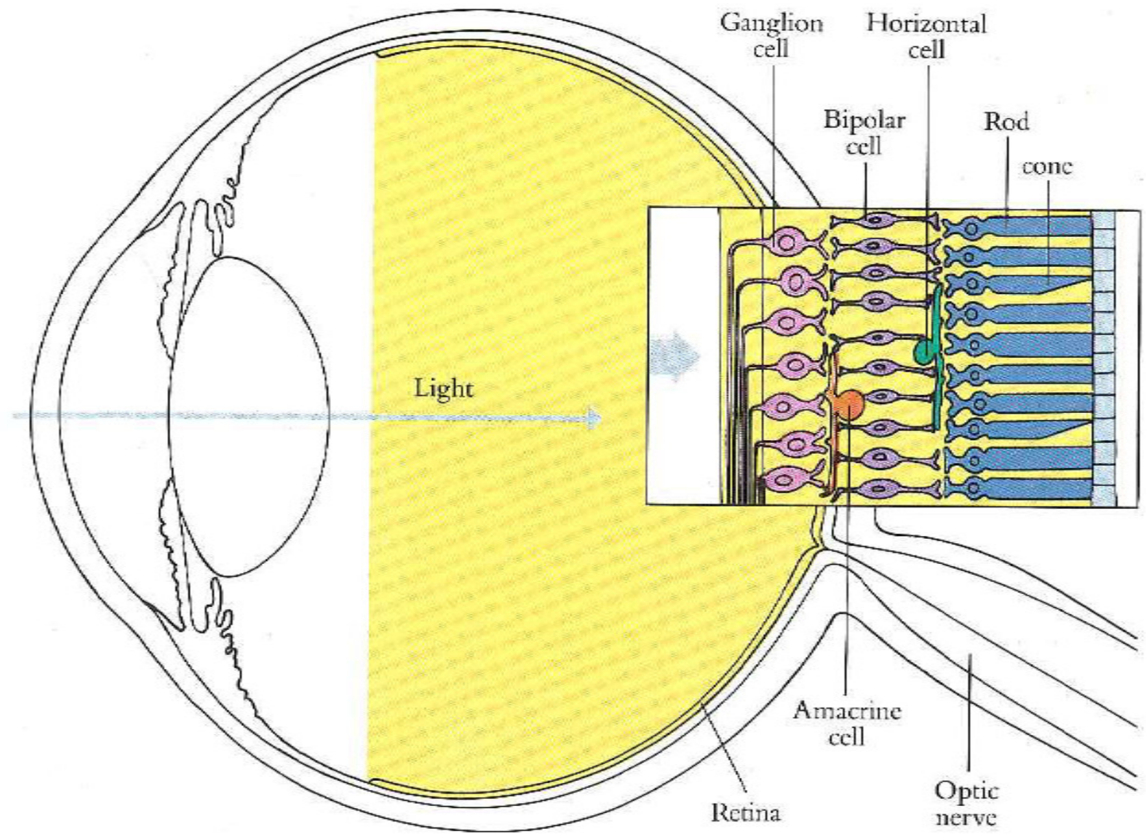
Cette remarque est citée dans un ouvrage d'Herschel comme résultant de ses propres observations, mais elle était déjà consignée dans un Mémoire de Cassini IV.

Peut-être expliquera-t-on le fait d'une manière très-simple, en faisant observer que le centre de la rétine étant le point qui, dans l'acte de la vision est le plus fréquemment employé, doit conséquemment le premier perdre de sa sensibilité.

Il y a de très-grandes différences quant à la sensibilité entre des vues d'ailleurs très-saines.

Tout le monde se rappelle ce vers d'Ovide sur les pléiades :

Quæ septem dici, sex autem esse solent.


Ganglion cell
Horizontal cell
Bipolar cell
Rod
cone
Light
Amacrine cell
Retina
Optic nerve

Human fovea

cones only

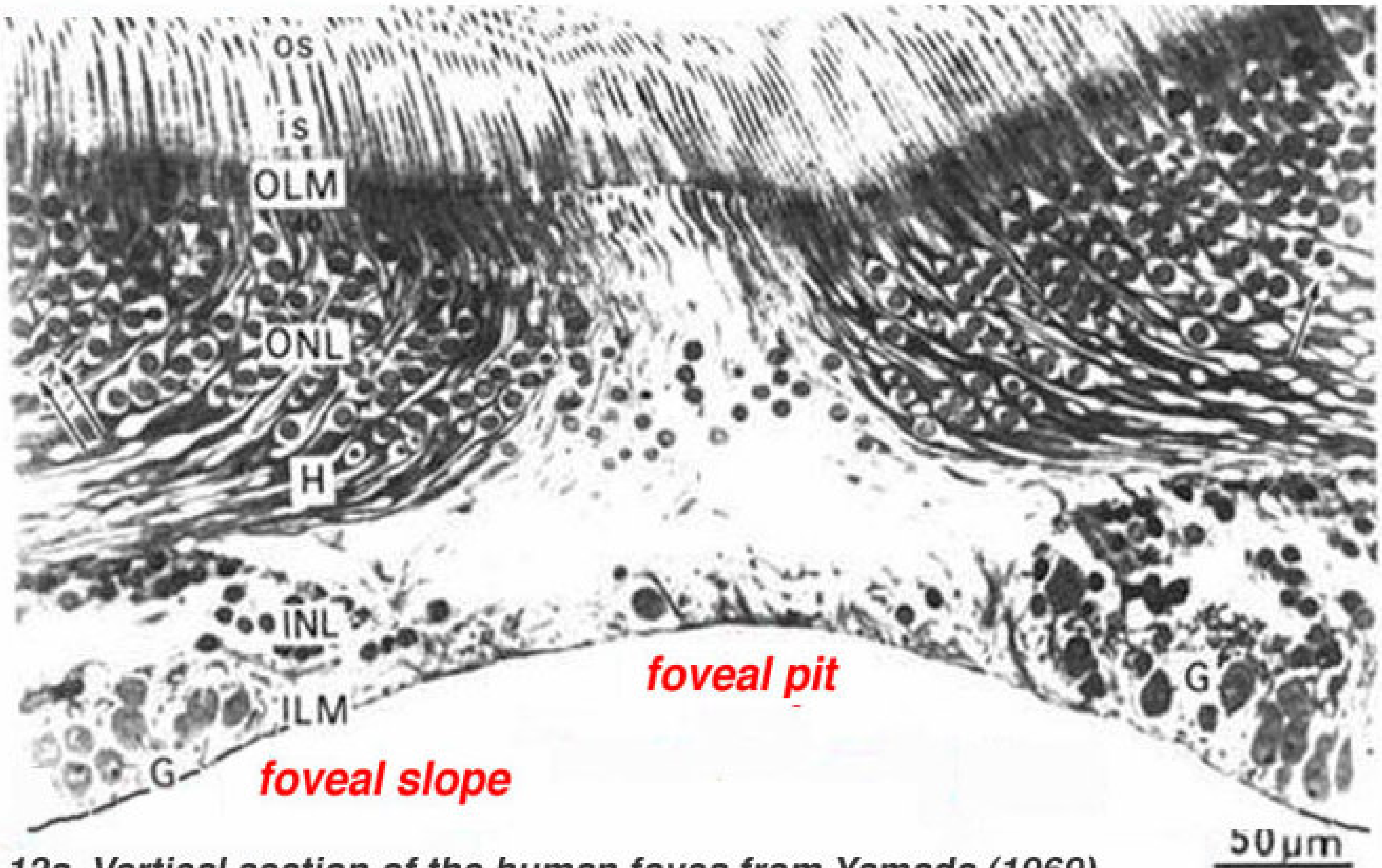


Fig. 12a. Vertical section of the human fovea from Yamada (1969).
os, outer segments; is, inner segments; OLM, outer limiting membrane; ONL, outer nuclear layer; H, Henle fibers; INL, inner nuclear layer; ILM, inner limiting membrane; G, ganglion cells

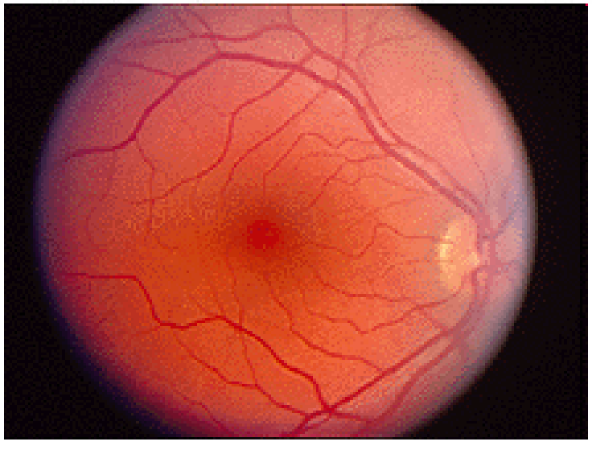
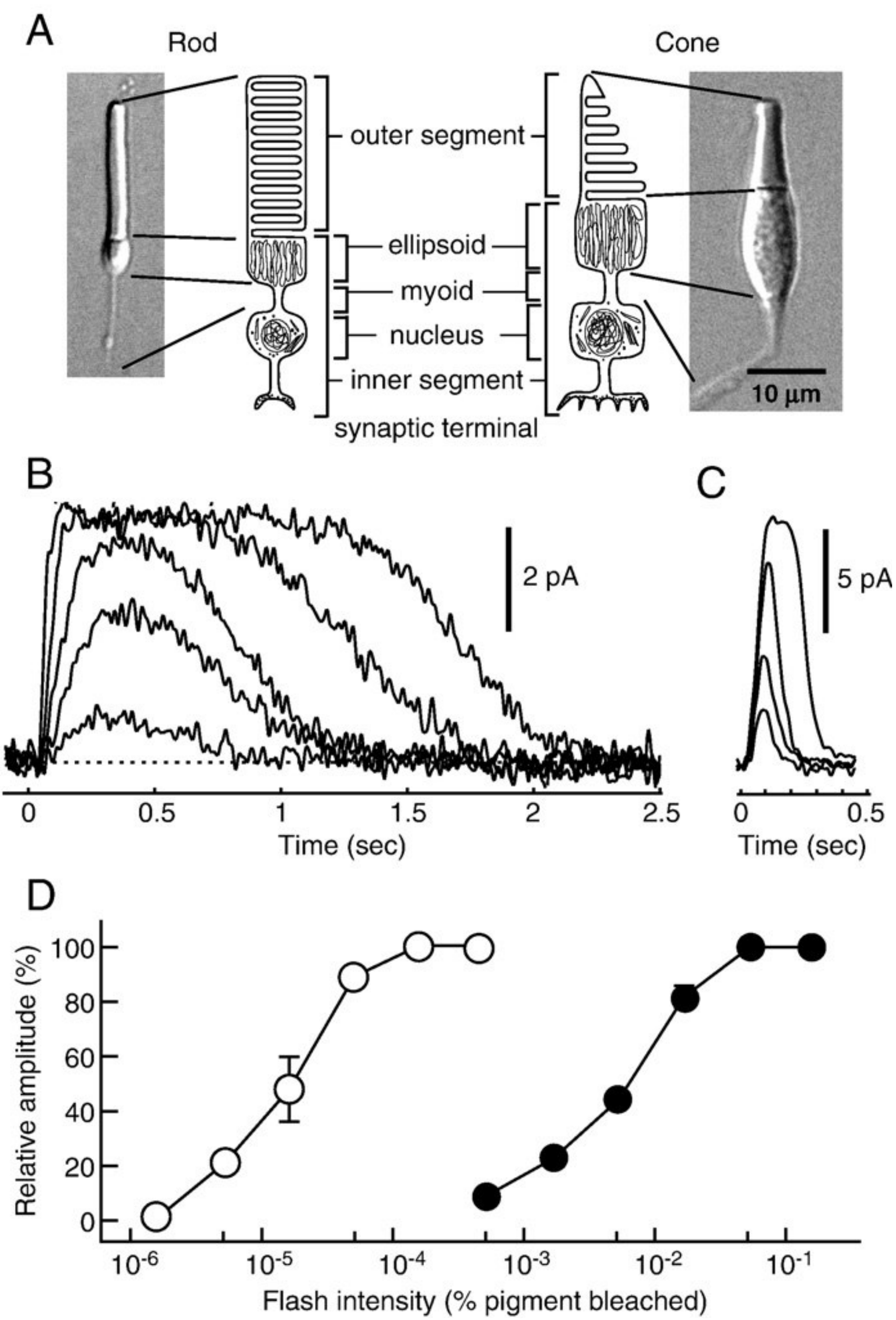


TABLE 9.1 LUMINANCE VALUES FOR TYPICAL VISUAL STIMULI

	Scale of luminance (mL)	
Sun's surface at noon	10^{10}	Damaging
	10^{9}	
	10^{8}	
Tungsten filament	10^{7}	Photopic
	10^{6}	
	10^{5}	
White paper in sunlight	10^{4}	
	10^{3}	
	10^{2}	
Comfortable reading	10	
	1	Mixed
	10^{-1}	Scotopic
White paper in moonlight	10^{-2}	
	10^{-3}	
White paper in starlight	10^{-4}	
	10^{-5}	
Absolute RL	10^{-6}	

Source: Riggs, 1965b



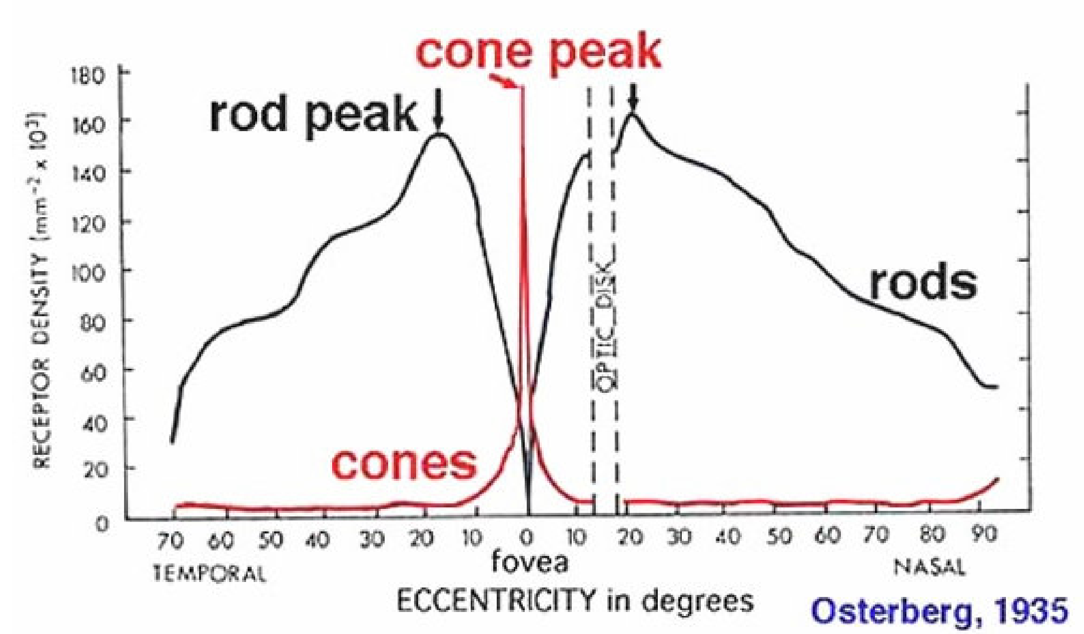
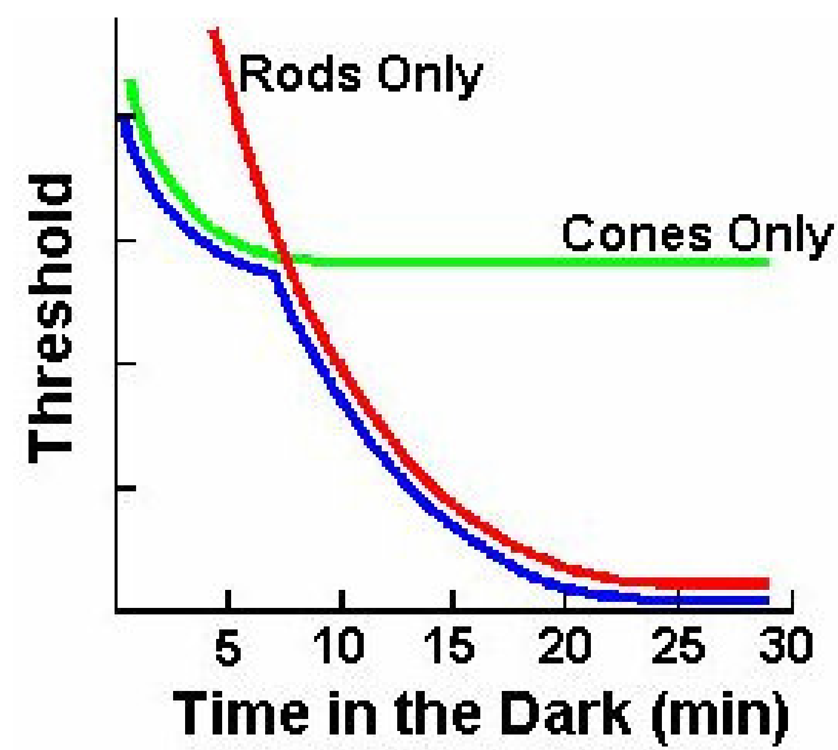
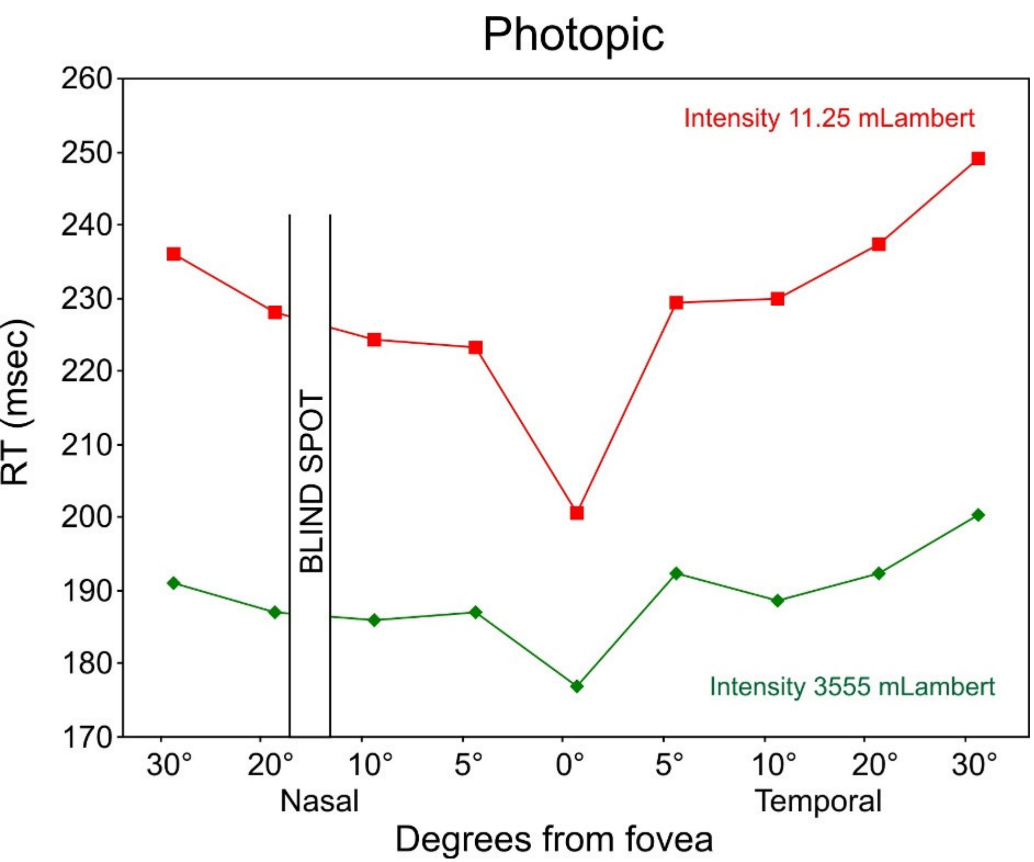
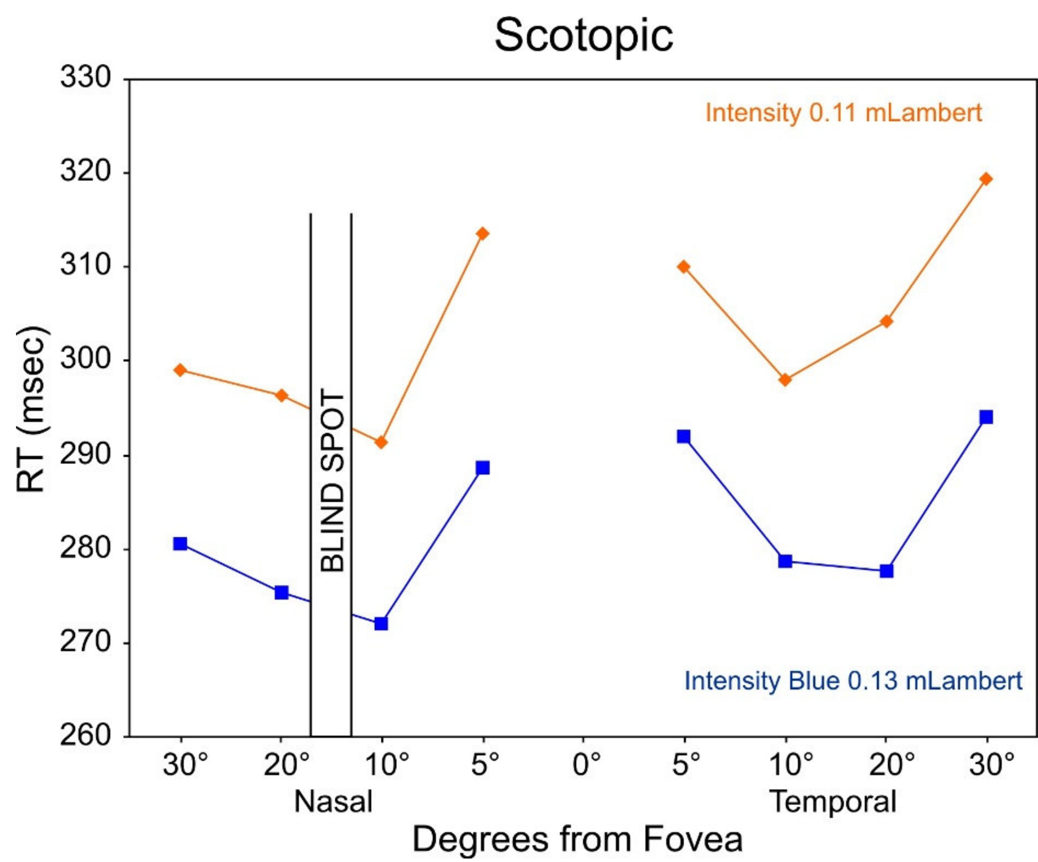
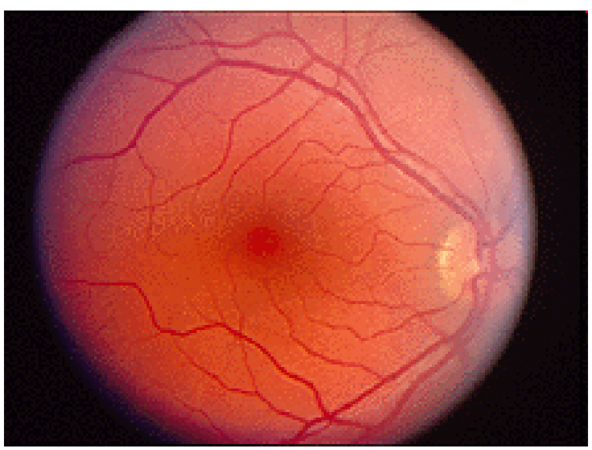


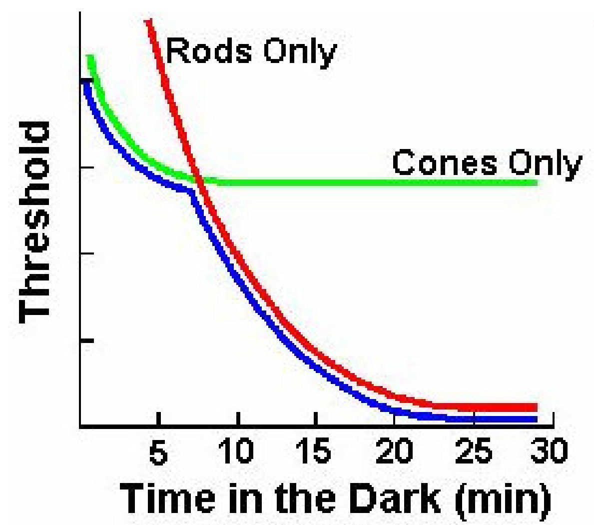
Fig. 20. Graph to show rod and cone densities along the horizontal meridian.




Photopic
260
250
240
230
220
210
200
190
180
170
RT (msec)
Intensity 11.25 mLambert
BLIND SPOT
Intensity 3555 mLambert
30°
20°
10°
5°
0°
5°
10°
20°
30°
Nasal
Temporal
Degrees from fovea


Scotopic
330
320
310
300
290
280
270
260
RT (msec)
Intensity 0.11 mLambert
BLIND SPOT
Intensity Blue 0.13 mLambert
30°
20°
10°
5°
0°
5°
10°
20°
30°
Nasal
Temporal
Degrees from Fovea




Rods Only
Cones Only
Threshold
5
10
15
20
25
30
Time in the Dark (min)

COMMENTARY

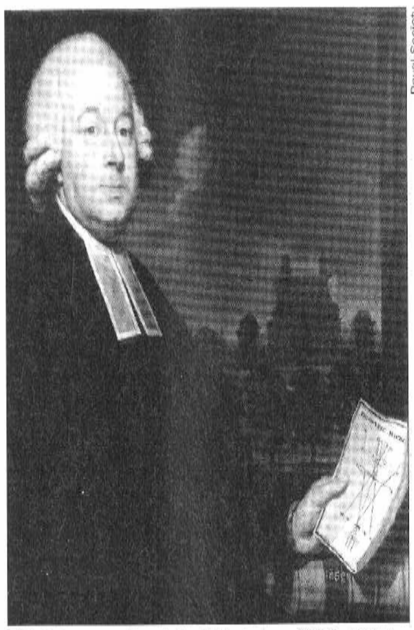
Errors of judgement at Greenwich in 1796

J. D. Mollon and A. J. Perkins

The origins of experimental psychology can be traced back to 1796, when the then Astronomer Royal dismissed his assistant for making some seemingly inaccurate measurements. But there is more to the story than meets the eye.

THIS year marks a bicentenary significant for both astronomy and cognitive science. In the winter of 1796, the 63-year-old Astronomer Royal, Nevil Maskelyne, dismissed his 24-year-old assistant, David Kinnebrook, on the grounds that Kinnebrook differed from him by 800 milliseconds in judging stellar transits — that is, in estimating the moment a given star passed the meridian wire in the Greenwich telescope. The incident, recorded in the printed version of the Greenwich observations[1] and noted by von Lindeneau in 1816 (ref. 2), prompted Bessel at Königsberg to study differences between himself and other well-practised observers[3]. Bessel introduced to astronomy the concept of the 'personal equation', an attempt to correct for the constant errors of particular observers, and his measurements led to the general realization that perceptual and cognitive processes took a quantifiable time. This astronomical interest in the personal equation in turn gave rise to the studies of reaction times and order judgements that dominated the first laboratory of experimental psychology, founded by Wundt in Leipzig in 1879 (refs 4–6); and chronographic instruments, developed by astronomers to minimize personal differences, provided the necessary apparatus[7,8]. Historians have taken Kinnebrook's

then mentally translated the ratio of the two spatial intervals into a temporal ratio, so estimating the moment of transit. He then prepared for the next wire, adjusting laterally the ocular of the telescope so that it was optically centred on the wire currently being used. The right ascension of the star was estimated by reducing the five separate readings to give an average time for the passage of the central meridian wire. The interval between the readings



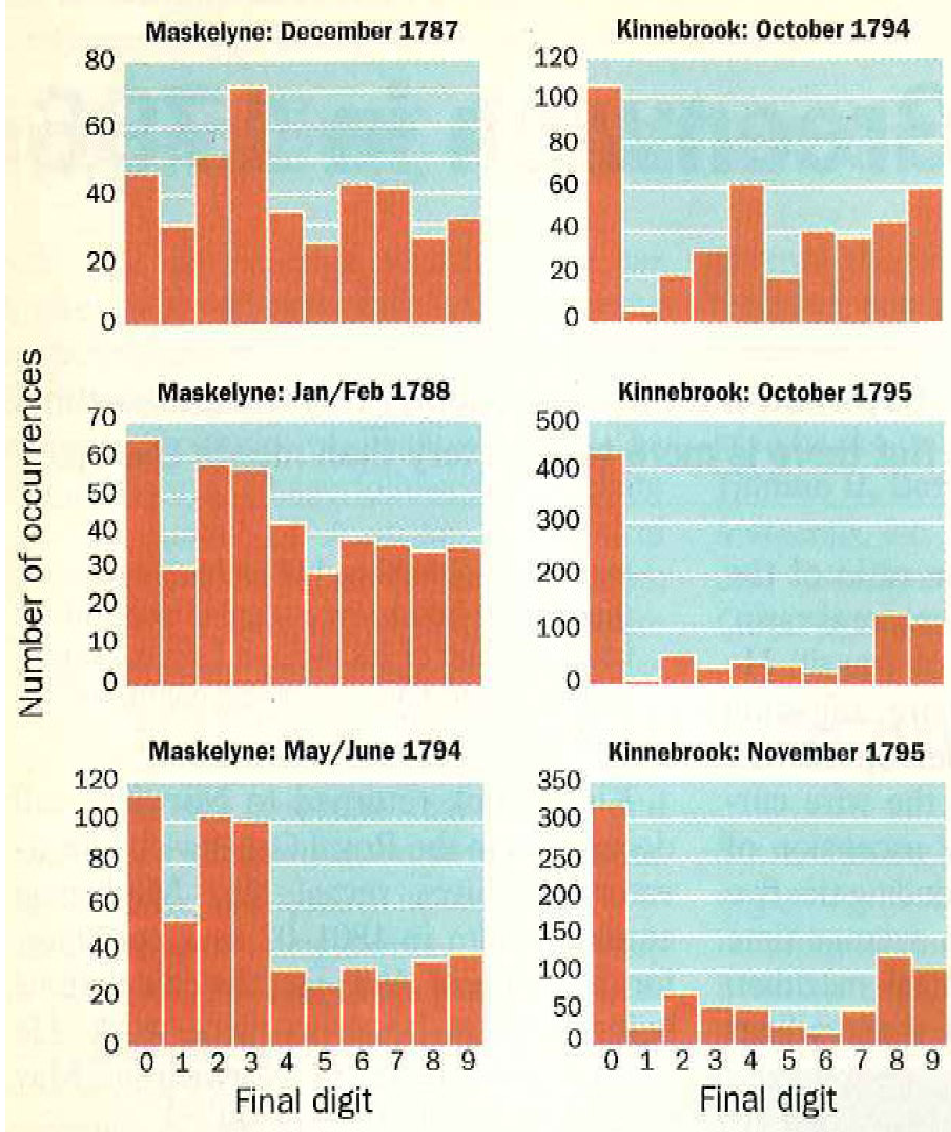
Royal Society

Fifth Astronomer Royal: Nevil Maskelyne (1732–1811).

method of observing, but rather suppose that he fell into some irregular and confused method of his own, as I do not see how he could have otherwise committed such gross errors.

Kinnebrook returned to Norwich, and documents in the Royal Greenwich Observatory Archives reveal that Maskelyne employed him in 1801–02 as a computer for the *Nautical Almanac*, the calculations being done at home as piece work. He died a bachelor in Norwich in May 1802, still only 30 years old[12,13].

In the literature of experimental psychology, the discrepancy between the estimates of Maskelyne and Kinnebrook is often attributed to 'prior entry', a phenomenon of selective attention: an event arriving on a channel to which we are attending is perceived as earlier than a concurrent event arriving on a channel to which we are not attending[14]. Modern experiments confirm the existence of prior entry for discrete events, but the subjective displacements are of the order of 50–100 msec (ref. 15). An alternative view, traceable to Bessel himself[3], is that time is lost in the switching of attention from one channel to the other: the observer who attends primarily to the clock will switch his attention at the critical beat and will find the



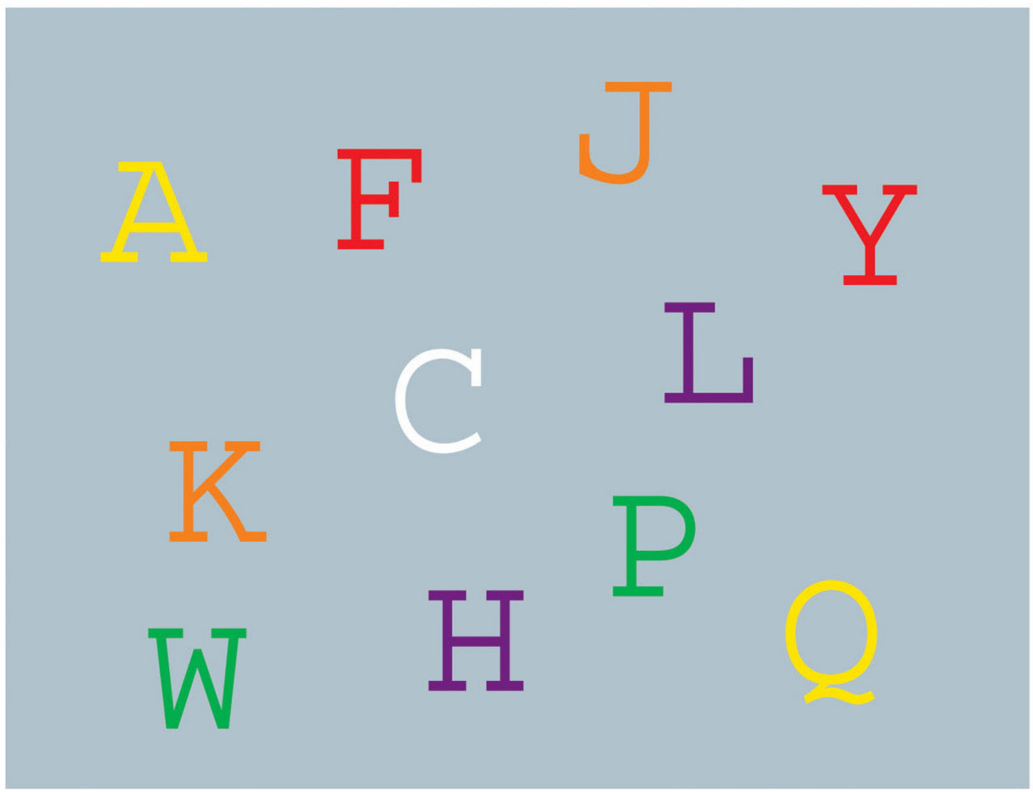
Histograms showing for Maskelyne (left) and Kinnebrook (right) the number of readings in which a particular final digit was used. Both men have marked biases, but in the autumn of 1795 Kinnebrook is rounding many of his observations.

Mollon JD, Perkins AJ.
Nature. 1996 Mar 14;380(6570):101-2.

In the 19th century astronomers were the first scientists to convince themselves that the reliability of scientific observations depended on the reliability of the observer. They became convinced that studying man and human psychophysiology was essential for achieving accuracy and objectivity in astronomy and other sciences alike. It was the astronomer Friedrich Bessel who coined the term “personal equation” to denote an inherent individual bias in making observations, judgements and measurements. It was the astronomer Adolph Hirsch who tried to get truly objective assessments of stellar transit time through mechanization or by measuring the personal equation and correcting for it. It was astronomy that created the field of mental chronometry and handed it down to psychology and physiology. It seems ironic that such a strenuous attempt at getting rid of the human factor for scientific accuracy in the assessment of the transit time of stars was largely forsaken a few year later in the saga of the astronomical exploration of the planet Mars.

Even under excellent conditions of seeing, details from Mars'surface could only be glimpsed in flashes, similar to tachistoscopic stimulus exposures in the experimental psychology laboratory. After each of such glimpses, the art of sketching Mars consisted of recording the seen image, hopefully before the memory could fade.

But: sources of error were not limited to seeing because memory can fade very rapidly, and errors of conjunction usually occur. Further, drawing can be imprecise and unfaithful.

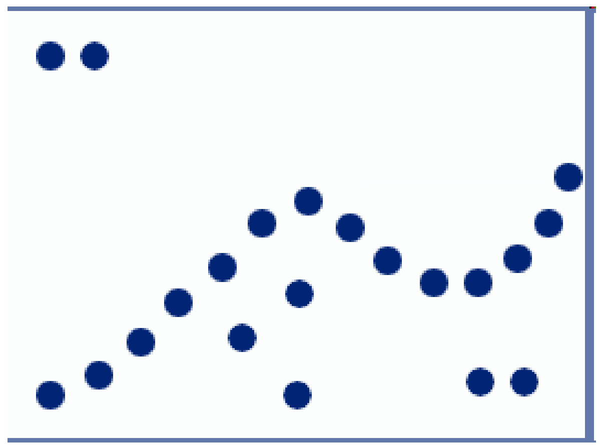


SENSATION AND PERCEPTION, Figure 8.9 © 2006 Sinauer Associates, Inc.

Bottom up influences
Optical illusions
Visual illusions
Completions
Subjective contours

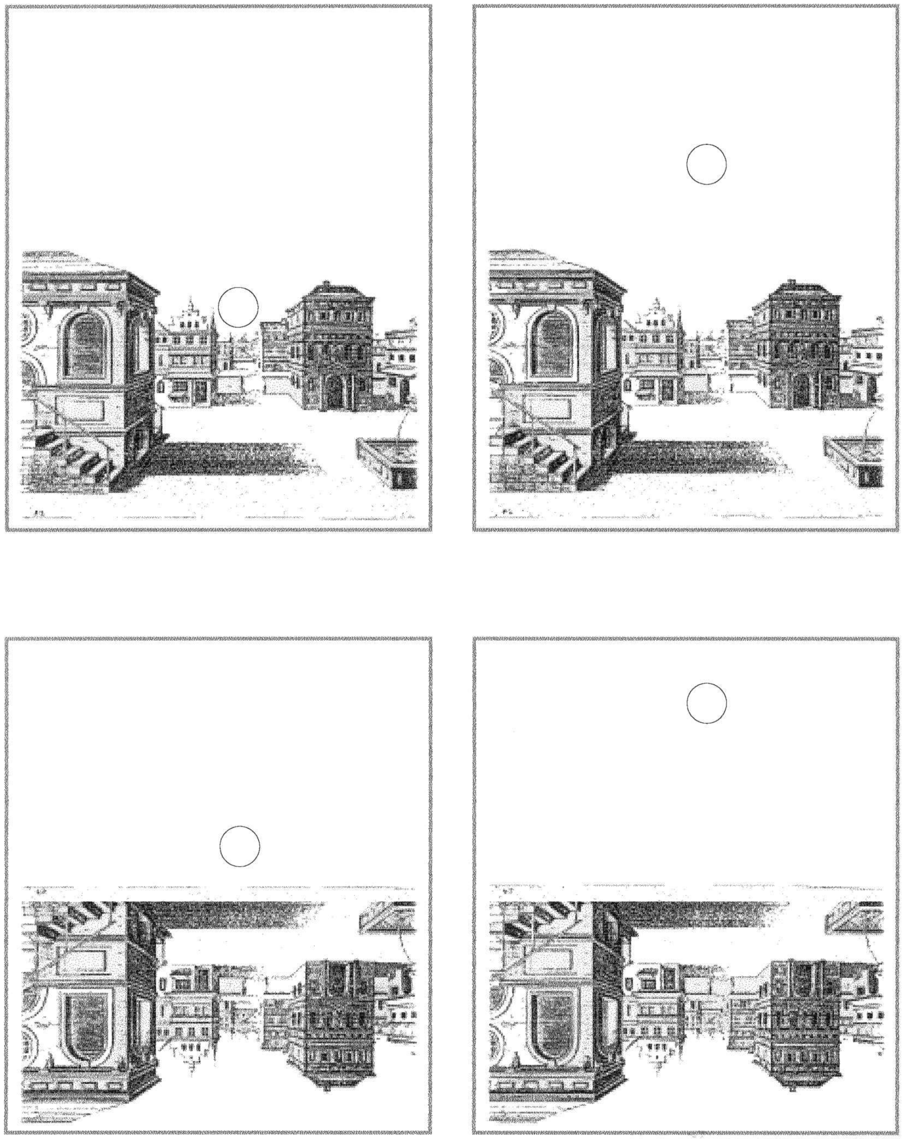
Top down influences
« Innocent » expectancies
« Ideological » expectancies

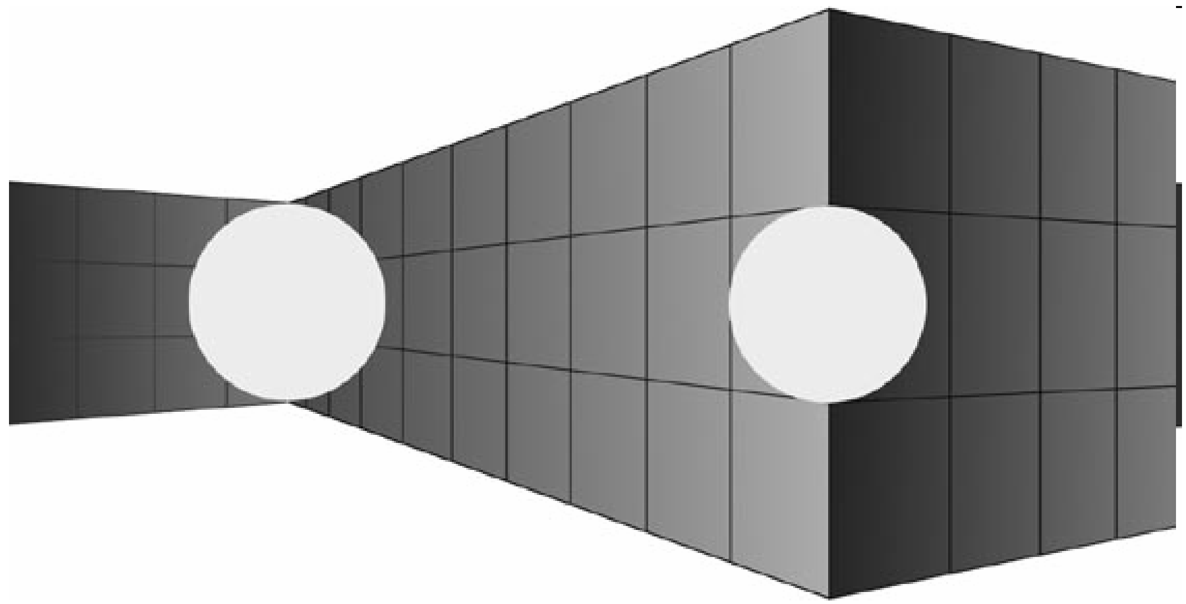
The fusion into lines or streaks of minute and possibly blurred spots or blobs or splotches too small to be distinctly and separately defined. It appears that the webcam electronic imaging technology can show "canals" on Mars through such fusion. Another possibility is linear fusion of distinct elements by the Gestalt principle of grouping according to good continuation.



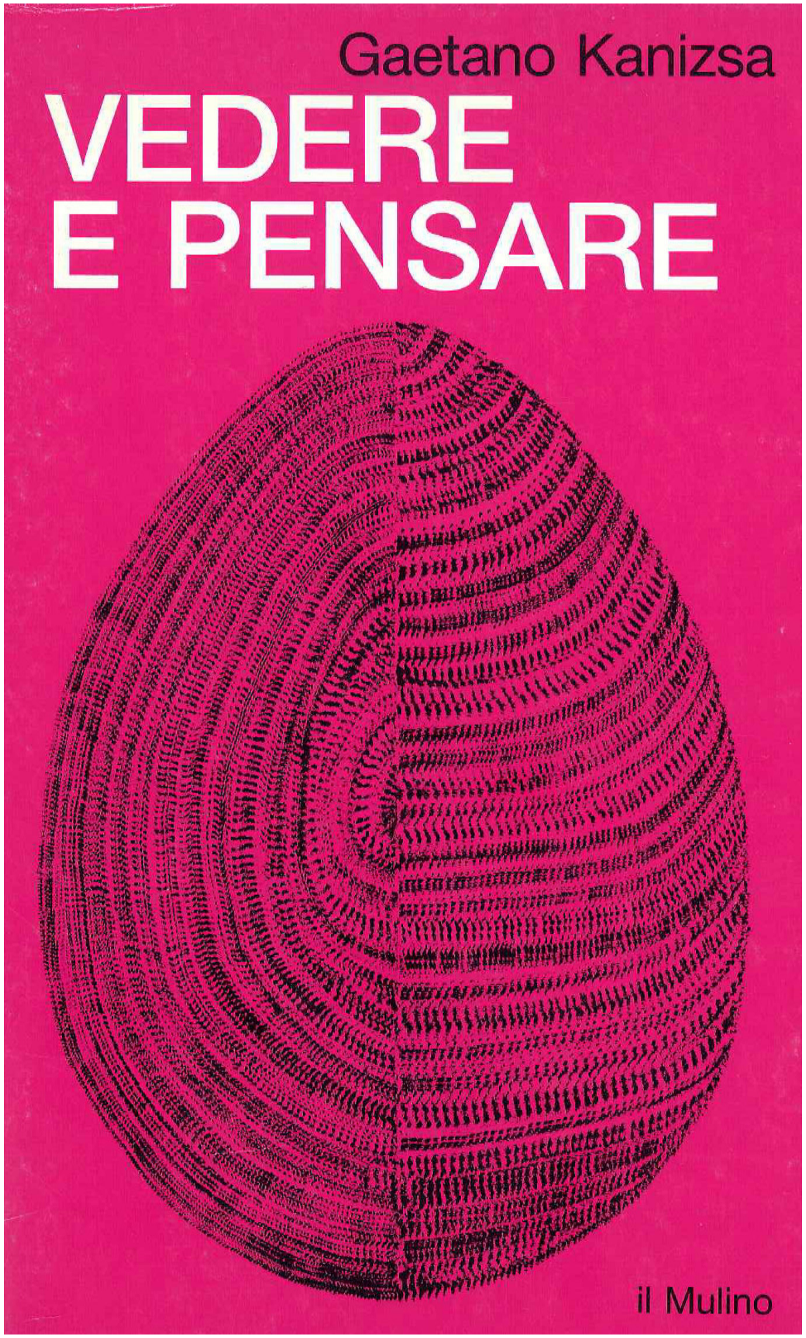
Coauthor Thomas Dobbins captured the webcam image of Mars at left in excellent seeing using a 14-inch Schmidt-Cassegrain operating at f/28 on September 26, 2003. A composite of the sharpest 380 frames from a 900-frame video recording, it captures many of the canals depicted in Lowell's 1895 chart of the Solis Lacus region (center), but as diffuse streaks rather than the hard, fine lines recorded by Lowell. Using the 1954 ALPO Mars map (right) as a reference, see if you can discern the canals Agathodaemon, Nectar, Helorus, Ambrosia, Bathys, Acampsis, Daemon, and Coprates, as well as the oases Gallinaria Silva, Phoenicis Lacus, Thithonius Lacus, and Melias Lacus. South is up.

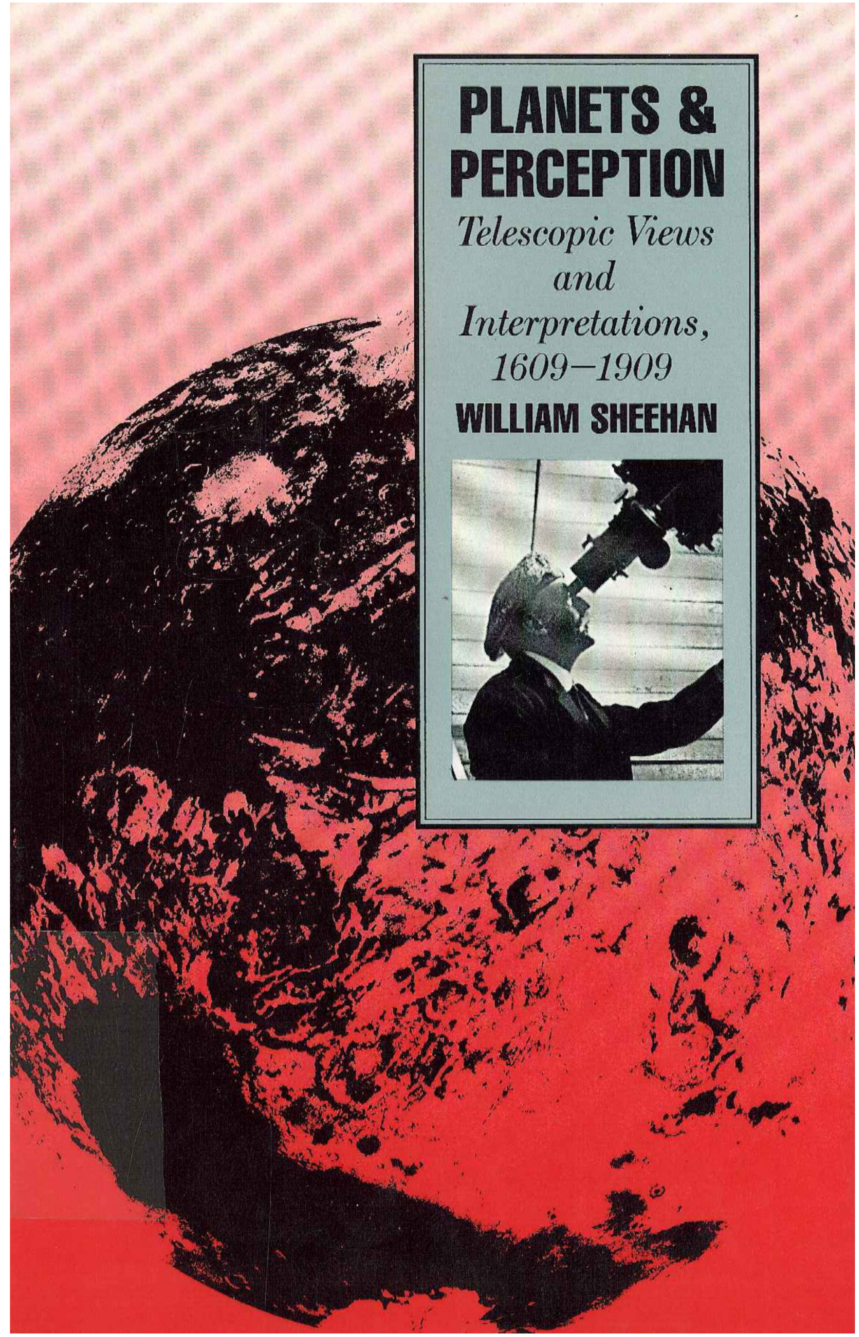
Sky & Telescope | March 2004

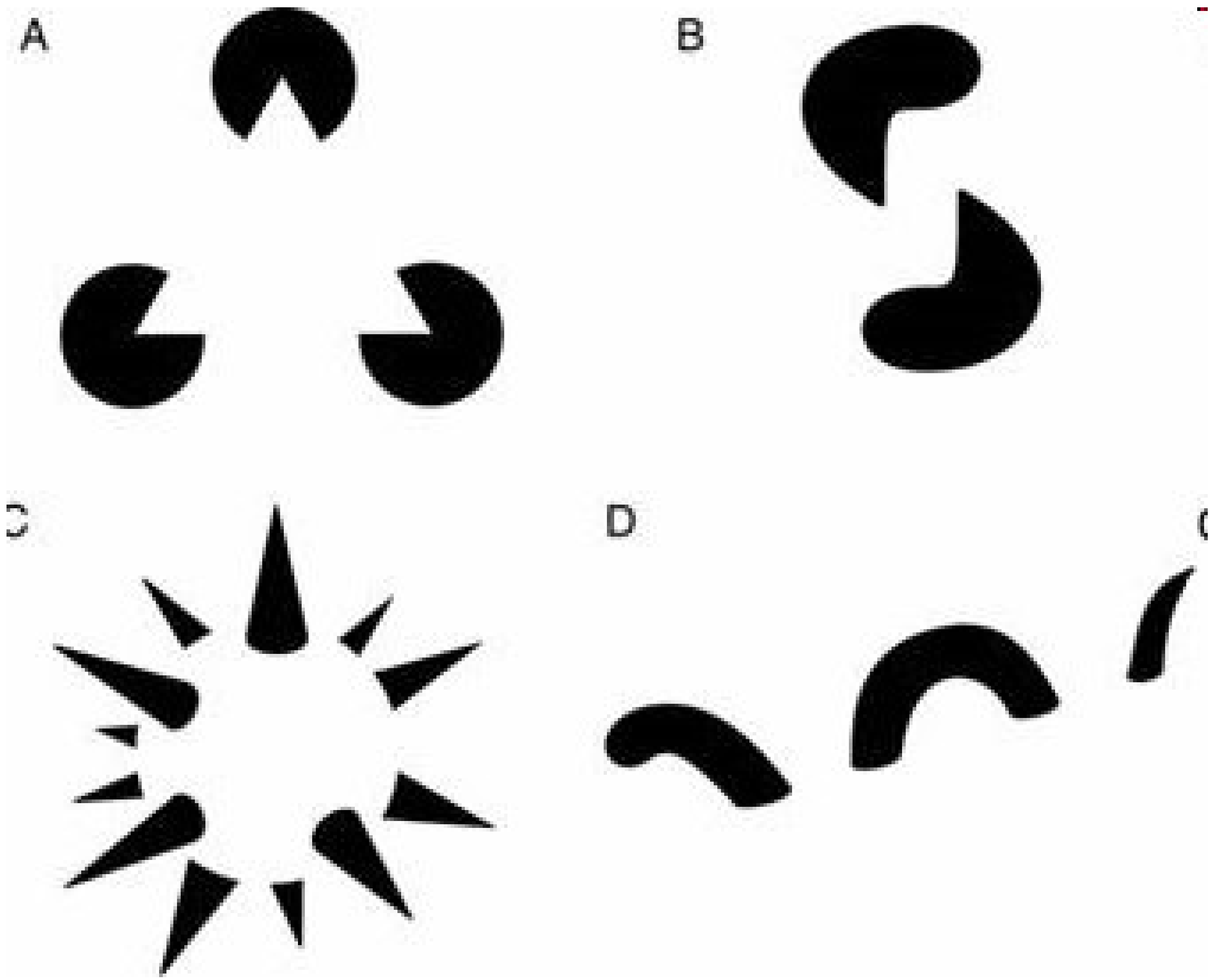


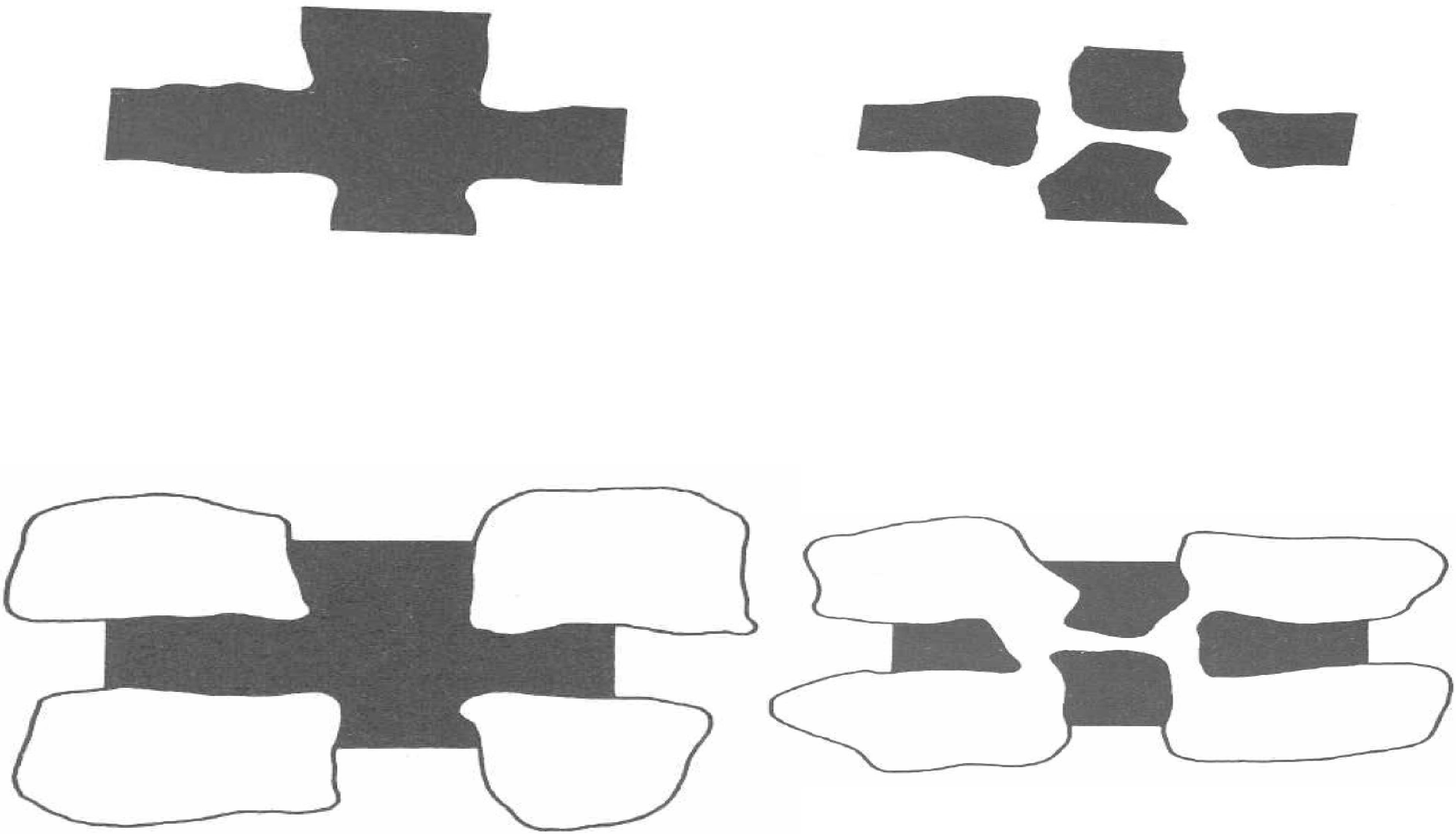


The Moon Illusion


Gaetano Kanizsa
VEDERE
E PENSARE
il Mulino

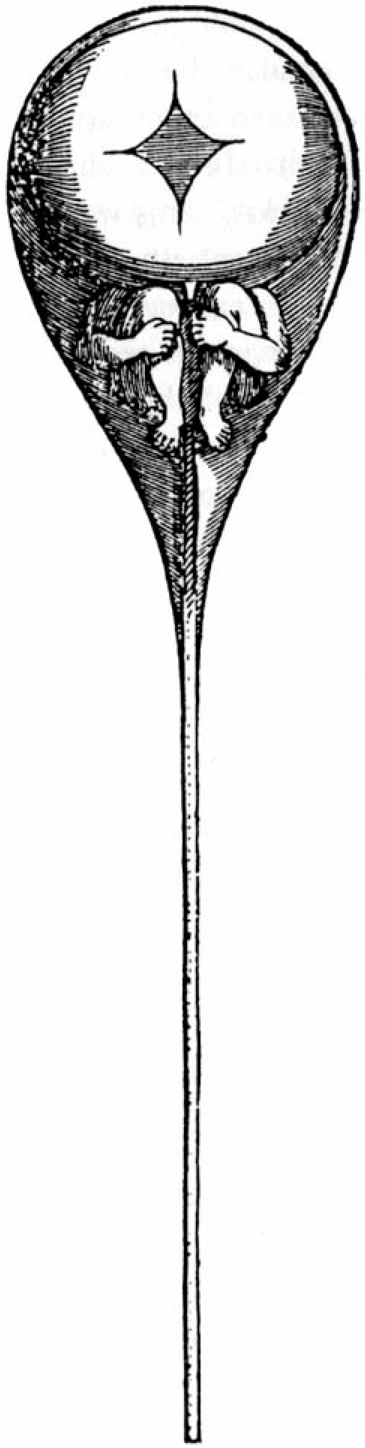

PLANETS &
PERCEPTION
Telescopic Views
and
Interpretations,
1609–1909
WILLIAM SHEEHAN


A
B
C
D

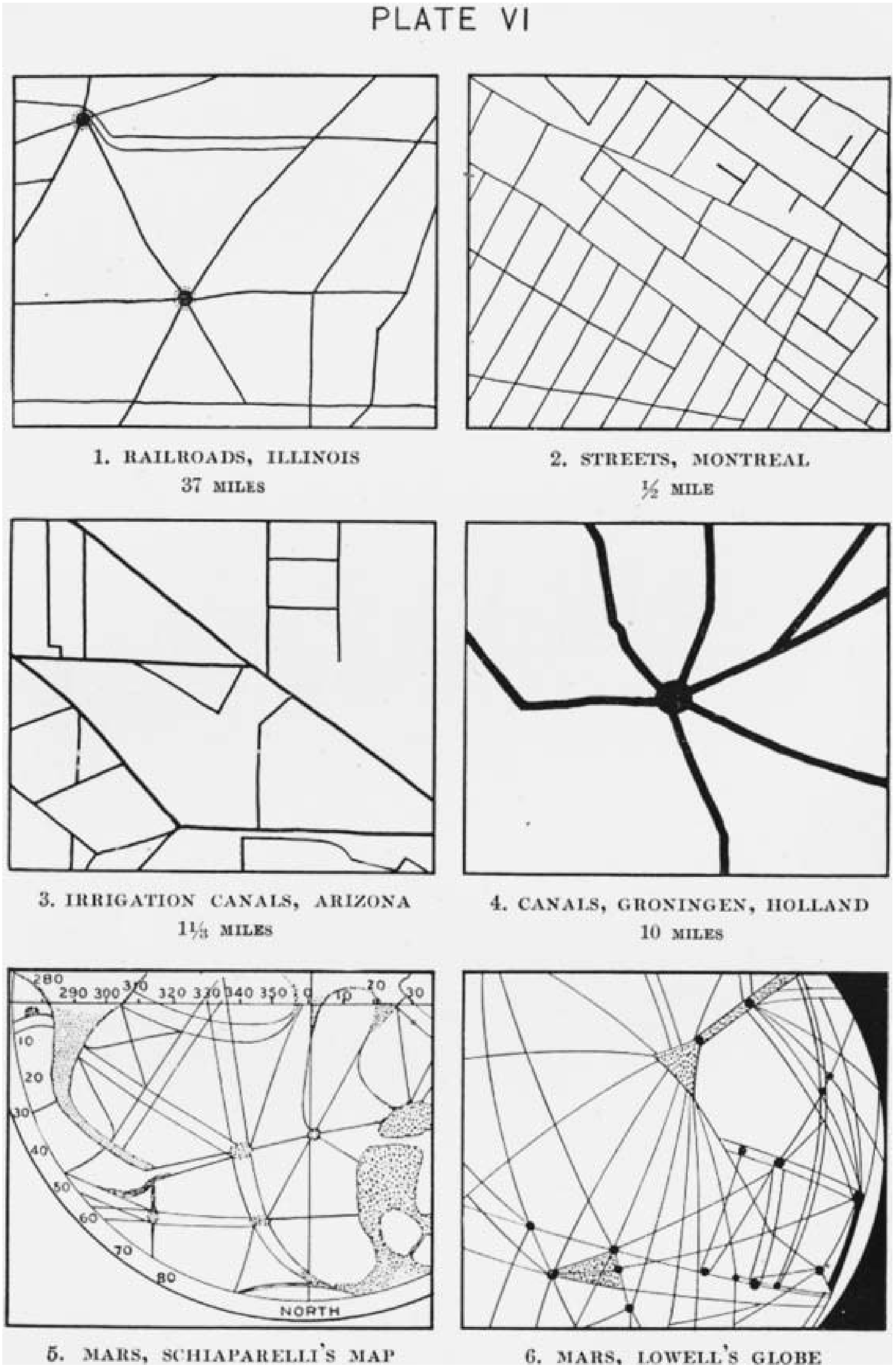


A B C

12 13 14



Preformationism: Fully formed homunculi and amimalculi contained in sperms and eggs.
Wishful thinking generates wishful seeing under the microscope.



Mapping the Mars Canal Mania: Cartographic Projection and the Creation of a Popular Icon

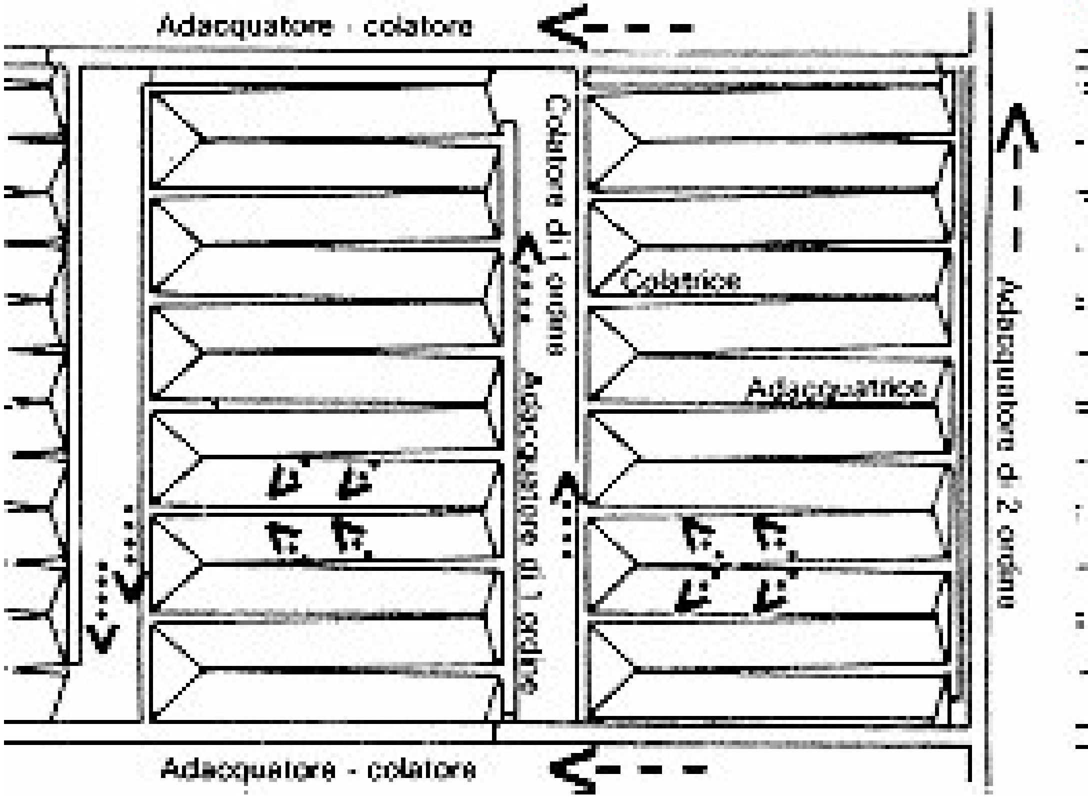
K. Maria D. Lane, *Imago Mundi* 58:2 2006

Geographers of Mars

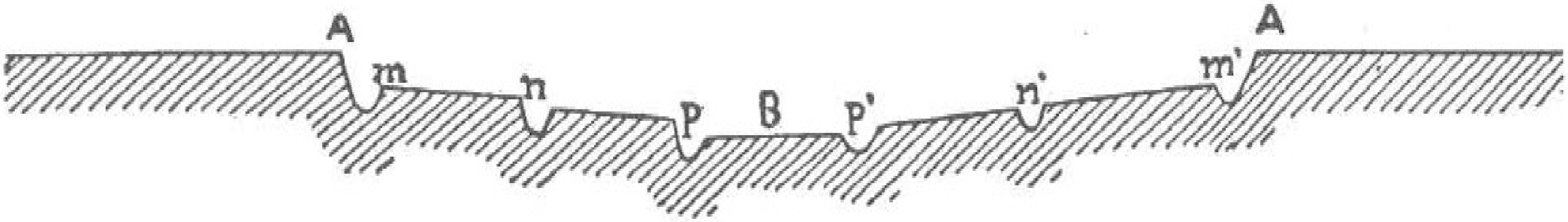
K. Maria D. Lane, *ISIS* 96: 477, 2005

Mars must be a paradise for the plumbers! ….It will be interesting to investigate which social order is most convenient to the predicament we have described…to find out whether the interests strongly shared by the inhabitants of a valley are likely to favour, more than it is possible on this earth, the institution of a collective socialism, such that each valley can become a fourierist phalanstery, and Mars a paradise for the socialists! ….(in) a planet where the well-being of each person is so strongly linked to that of everybody else, wars and international disagreements are certainly unknown, and all efforts and resources are aimed at fighting the strictures imposed by a hostile Nature, rather than at fighting each other as the crazy inhabitants of another planet are always willing to do.

Schiaparelli, La vita sul pianeta Marte, in Natura ed Arte, 1895

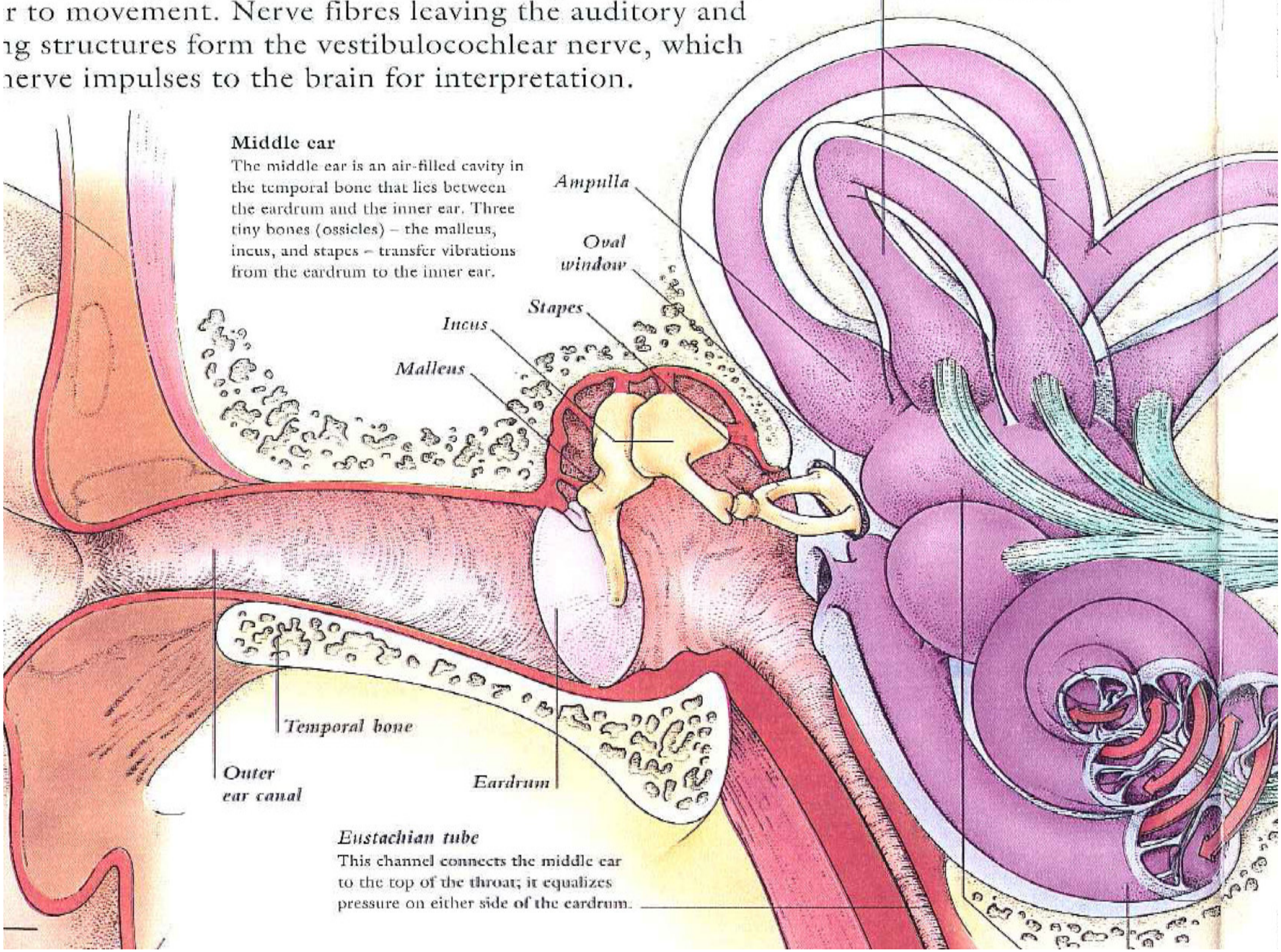


Water meadows (*marcite*) in southern Lombardy



From Schiaparelli, 1895

RS ARE ORGANS OF BOTH HEARING AND BALANCE. The :es for these sensory functions are located in separate 'the inner ear. However, both depend on stimulation alized receptors called hair cells that respond to sound r to movement. Nerve fibres leaving the auditory and ıg structures form the vestibulocochlear nerve, which ıerve impulses to the brain for interpretation.



…….by debating the nature of personal differences in observations and how to eliminate them, astronomers sketched different conceptions of `man'. While some, like Hirsch, believed personal differences were due mainly to different brains, others, like Wolf, believed they were mainly due to different levels of skill and education.

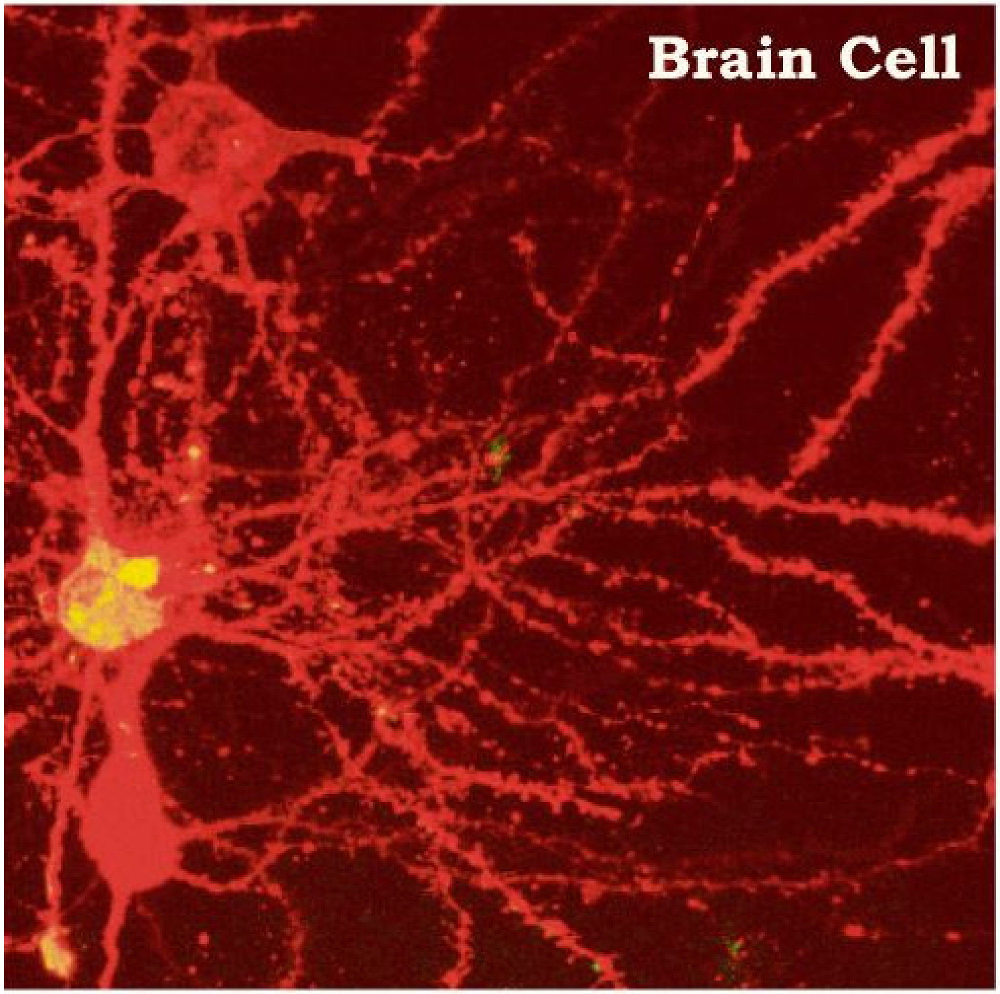
Exit the frog, enter the human: physiology and experimental psychology in nineteenth-century astronomy
JIMENA CANALES, British Journal for the History of Science 34(2): 173-197.

An obviously false dichotomy: Education acts on the brain and different levels of skill are sustained by the brain. The difference is always made by the brain.

To know how the human brain furnishes the medium through which all members of our species cognize, emote, and act would be tantamount to solve the perennial mind–brain problem: an achievement which, in William James'words, would make all previous achievements pale (Roger Sperry, 1952).

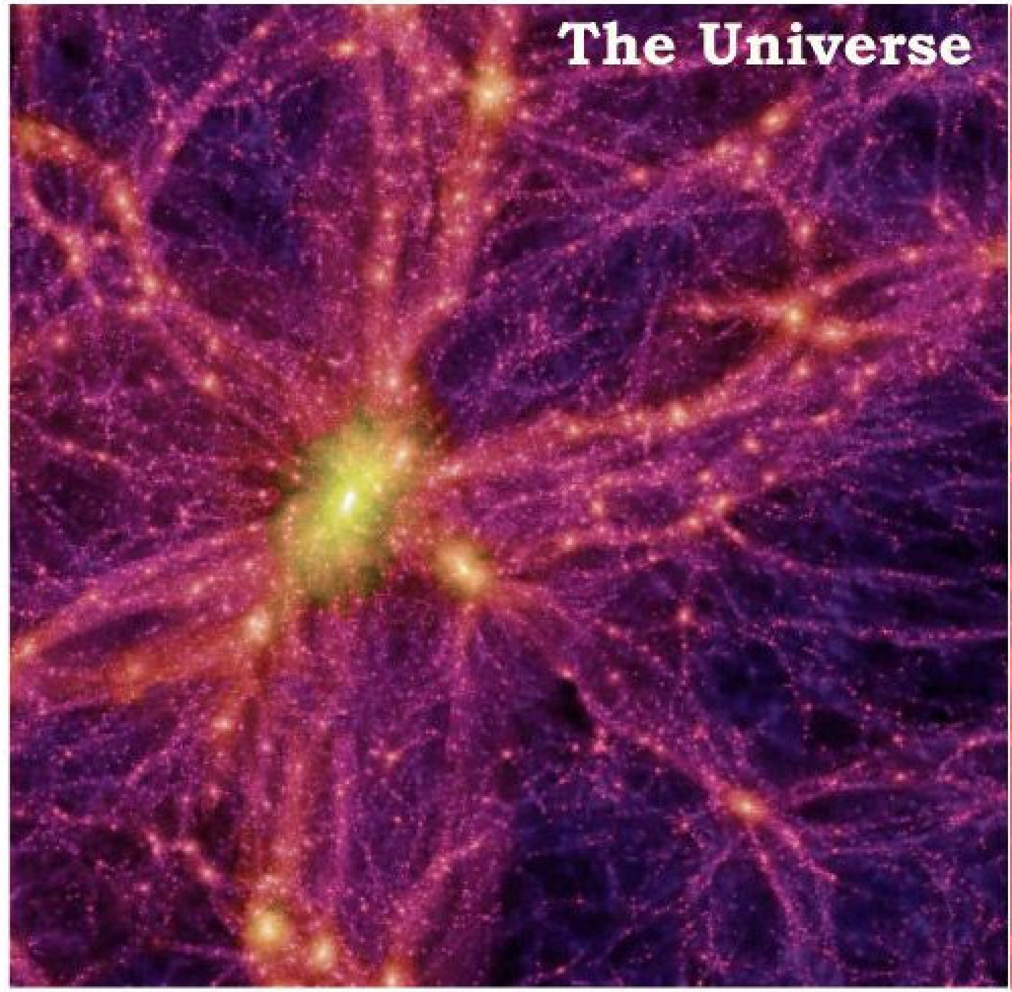
Should not there be an immense number and diversity of inhabited worlds in the Milky Way? Scientists differ about the strength of the argument, but even at its best it is very different from actually detecting life elsewhere. That monumental discovery remains to be made (Carl Sagan, 1994)

One is only micrometers wide. The other is billions of light-years across. One shows neurons in a mouse brain. The other is a simulated image of the universe. Together they suggest the surprisingly similar patterns found in vastly different natural phenomena. *DAVID CONSTANTINE*



Mark Miller

Mark Miller, a doctoral student at Brandeis University, is researching how particular types of neurons in the brain are connected to one another. By staining thin slices of a mouse's brain, he can identify the connections visually. The image above shows three neuron cells on the left (two red and one yellow) and their connections.

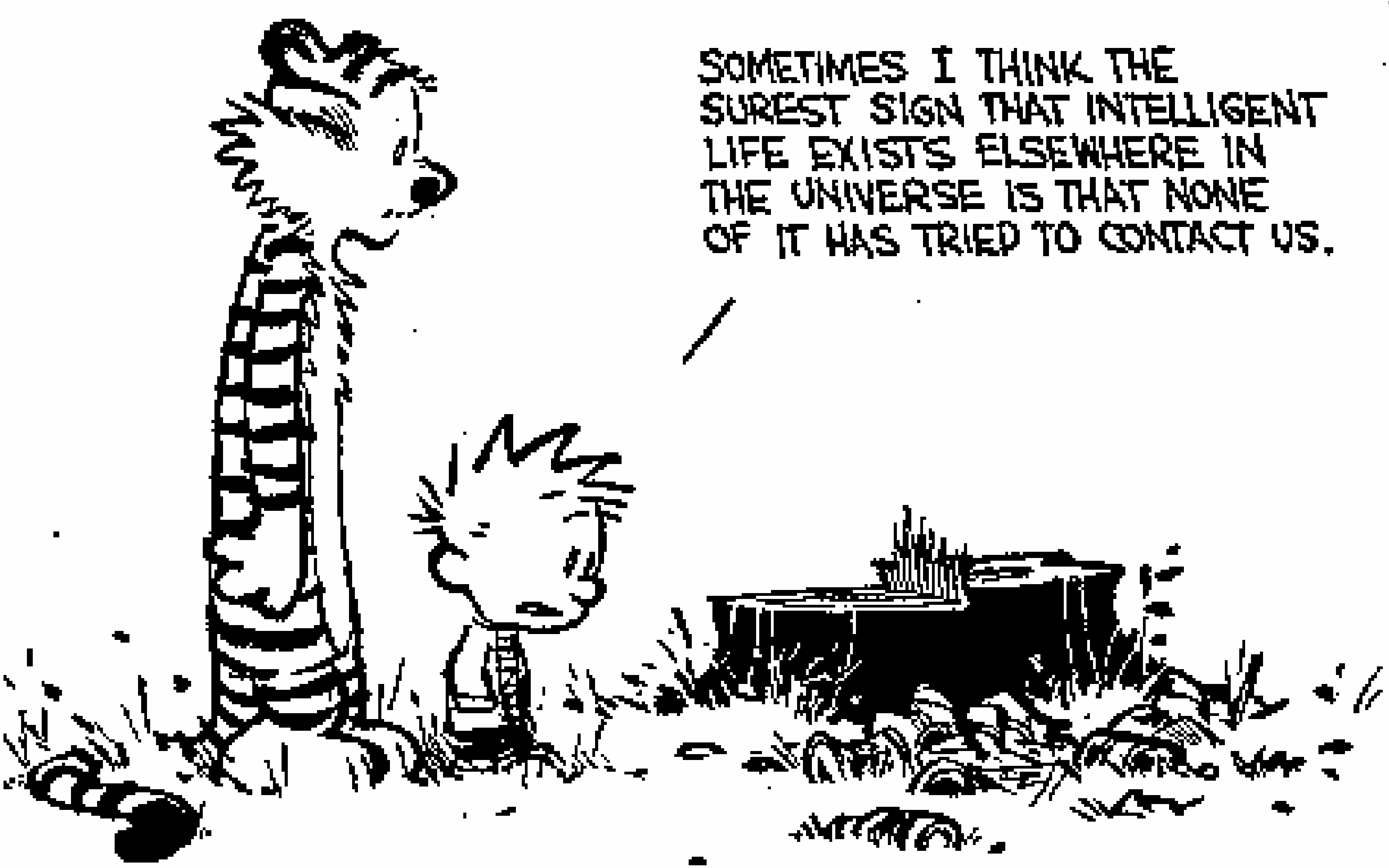


Virgo Consortium

An international group of astrophysicists used a computer simulation last year to recreate how the universe grew and evolved. The simulation image above is a snapshot of the present universe that features a large cluster of galaxies (bright yellow) surrounded by thousands of stars, galaxies and dark matter (web).

Source: Mark Miller, Brandeis University; Virgo Consortium for Cosmological Supercomputer Simulations; www.visualcomplexity.com

The New York Times


SOMETIMES I THINK THE SUREST SIGN THAT INTELLIGENT LIFE EXISTS ELSEWHERE IN THE UNIVERSE IS THAT NONE OF IT HAS TRIED TO CONTACT US.