Inhalt

Kevan A. C. Martin

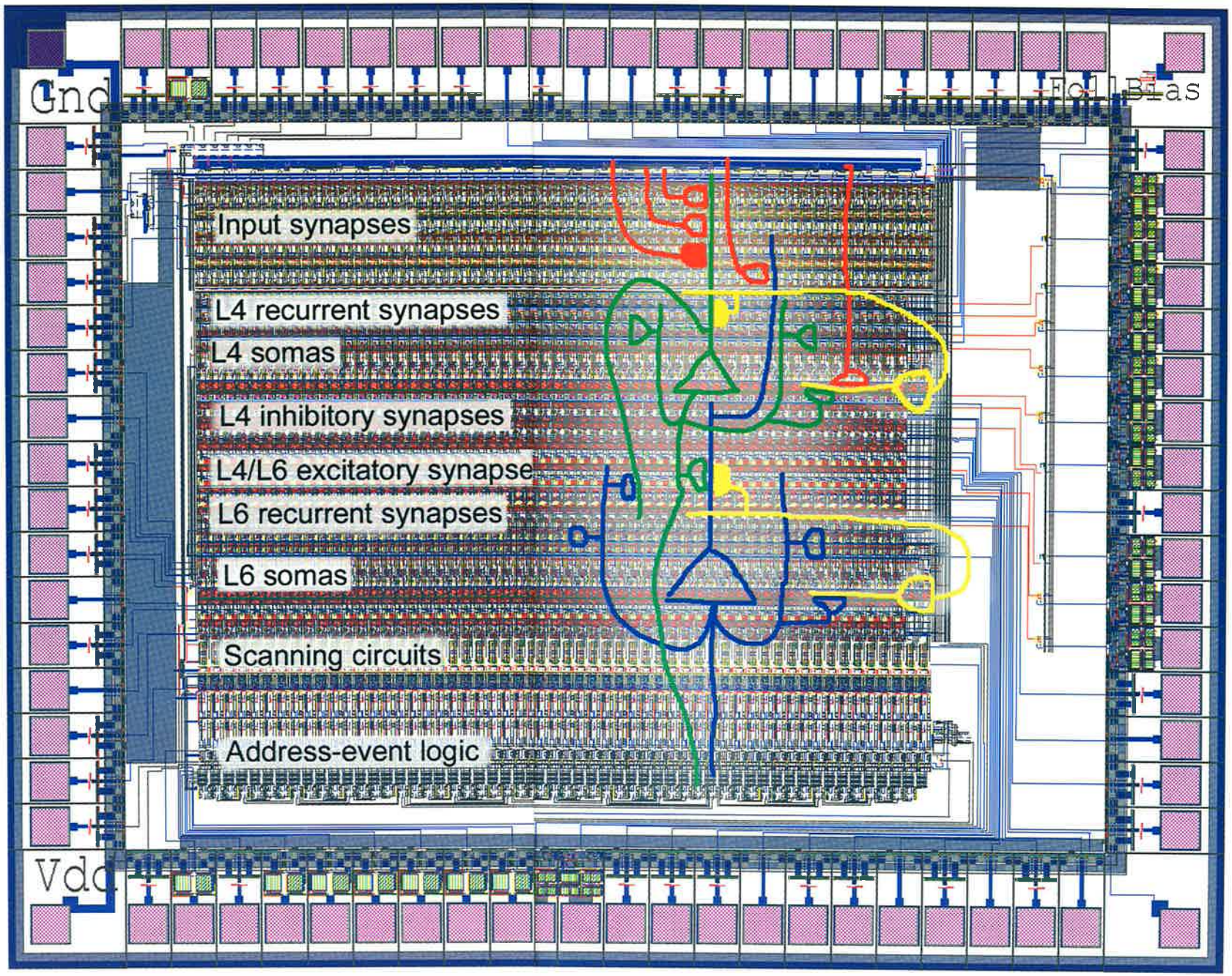
Vision, in my view

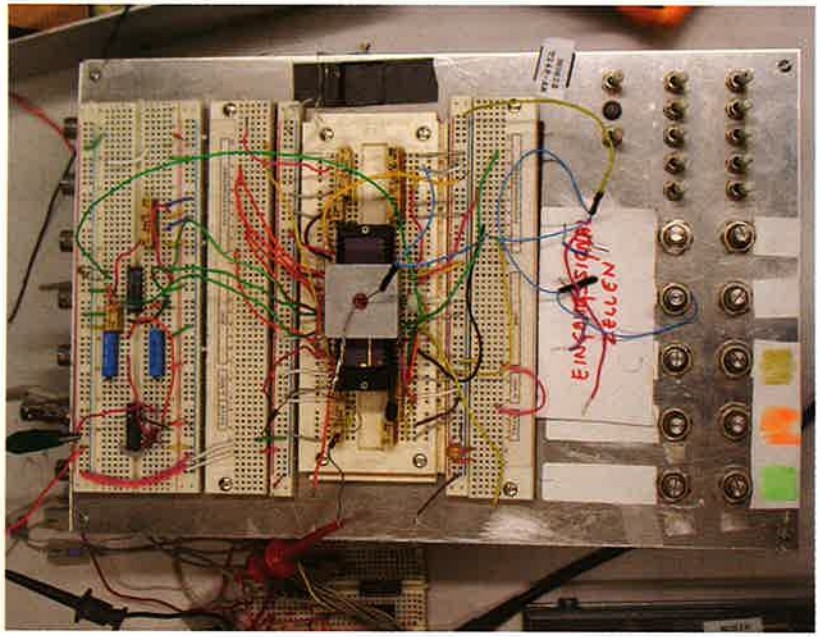
eye.jpg — "Wär nicht das Auge sonnenhaft, / Die Sonne könnt es nie erblicken" [If the eye were not sun-like / It could not see the sun] – Goethe.

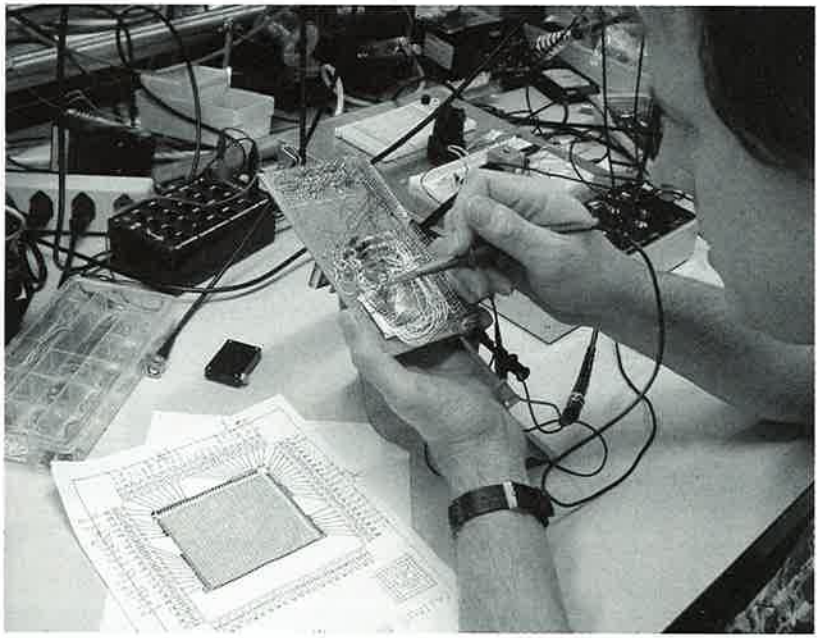
purkinje.jpg (courtesy Peter König) — Johannes Kepler first correctly described the dioptrics of the eye in 1604, but it was only in 1837 that Treviranus first described the structure of the retina. In 1838 Purkinje first discovered that by shining a bright light into the side of the eye, the optics of the eye allow the retina and its blood vessels to be projected onto the wall in front of the observer.

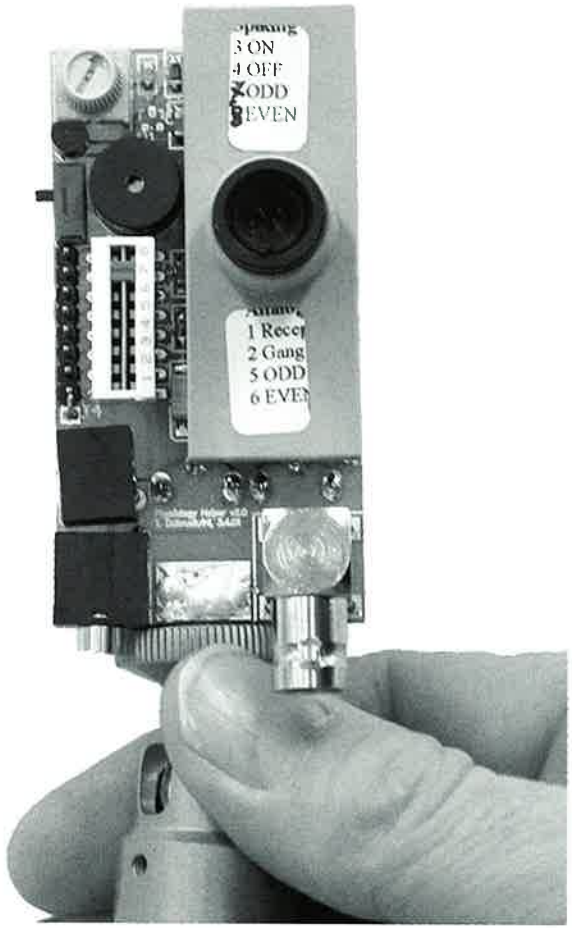
shihclos.jpg — The retina is not a video camera, it is an extension of the brain. The retina preprocesses the image to extract essential information about the world – particularly the edges of objects. The retina's view of the world is seen here by means of an artificial retina built by Jörg Kramer.

shihchip.jpg (courtesy Shih-Chi Liu) — To think about vision, we use models. These can be computer simulations or physical models like electronic circuits. Building part of the visual system in an electronic analogue provides the most immediate insights into the mechanisms of vision. Computer aided design methods are used to create the layout for a new 'chip' that emulate part of the retina or visual brain.





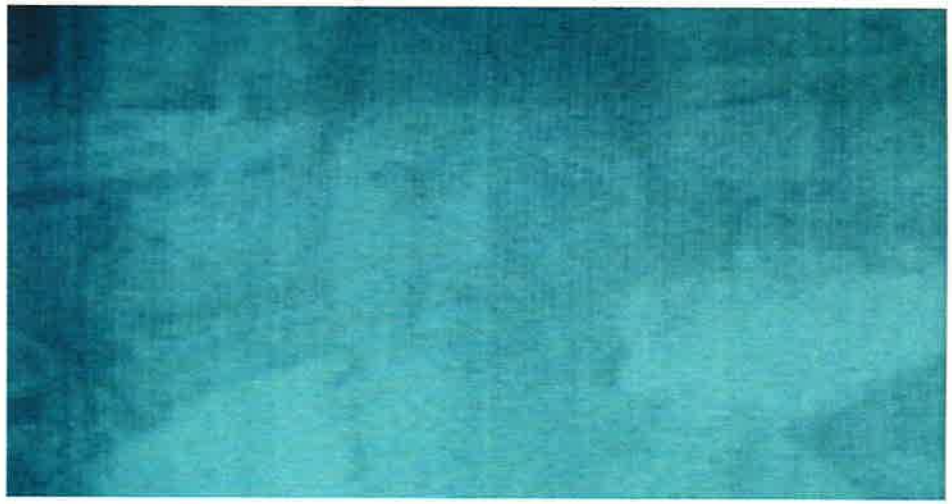




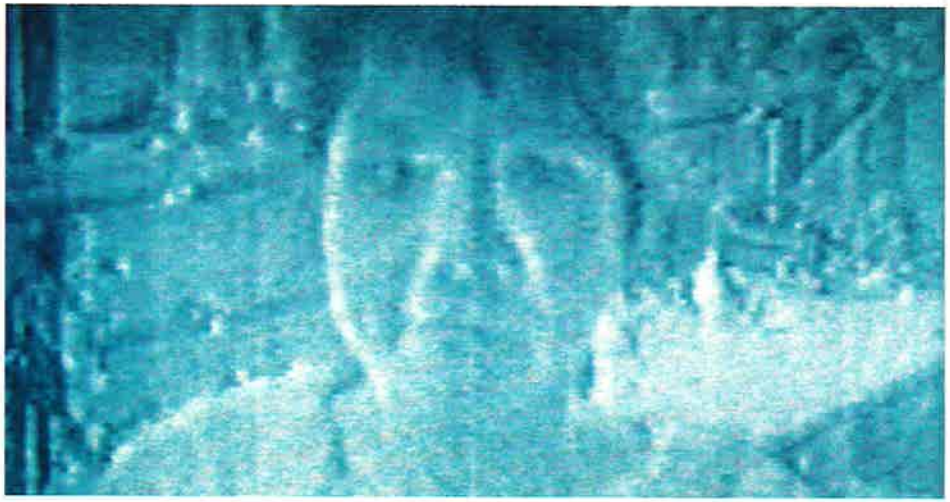
friend_i.jpg (courtesy Tobi Delbrück) — 'The physiologists friend' – one successful portable artificial retina powered by a 9V battery.

breadboa.jpg (courtesy Shih-Chi Liu) — The silicon circuits are assembled and tested and tuned on a 'breadboard' after fabrication as a very large scale integrated (VLSI) circuit.

tobi_wit.jpg (courtesy Tobi Delbrück) — After successful experiments with 'breadboard' circuits, a more permanent 'wireup' board can be built to operate the analogue VLSI chip.



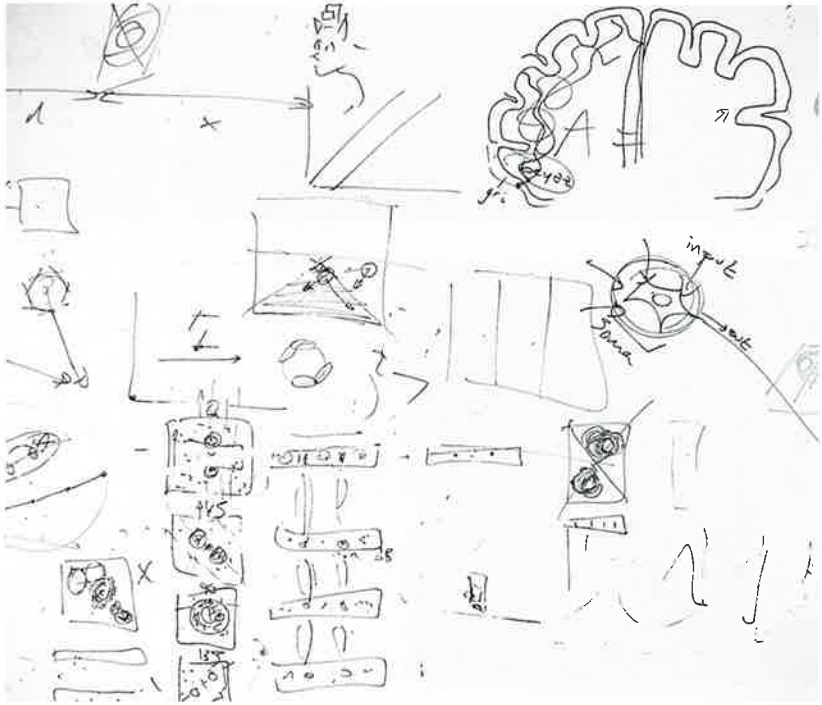
shihstab.jpg (courtesy Jörg Kramer, Tobi Delbrück and Shih-Chi Liu) — If an image is held stable on the retina, it disappears in a few seconds, like the Cheshire Cat in *Alice in Wonderland.*



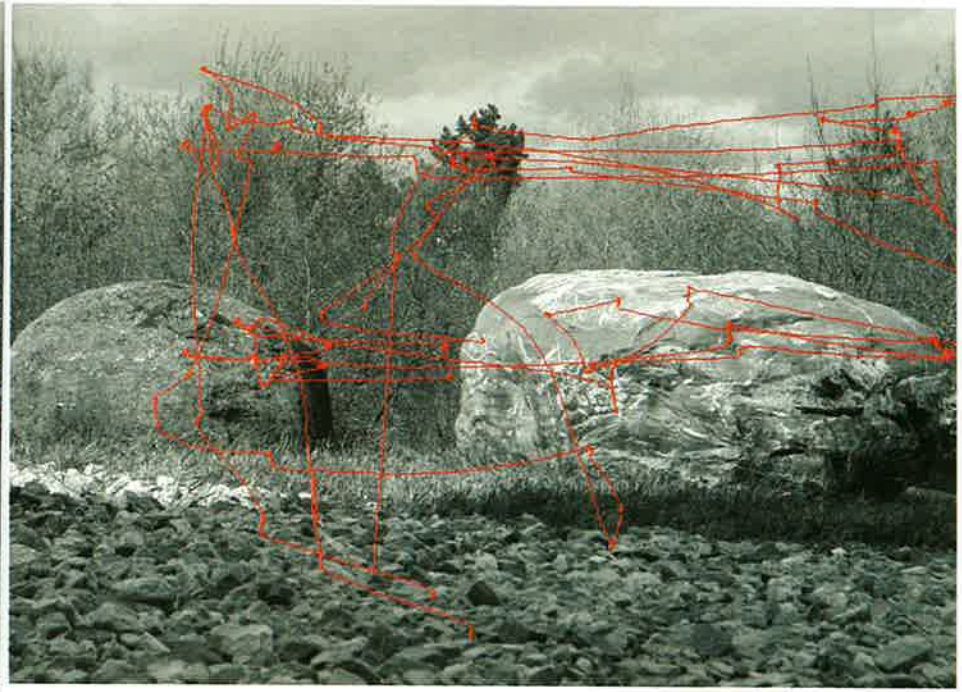
retinamo.jpg (courtesy Jörg Kramer, Tobi Delbrück and Shih-Chi Liu) — Our world does not disappear, because our eyeballs continually make tiny movements, about three times per second, to keep the retina constantly stimulated. Here the artificial retina was continuously moved to view the stationary world.

blink1.jpg (courtesy Jörg Kramer, Tobi Delbrück and Shih-Chi Liu) — If an image is stabilized on the retina, then anything that moves – eyeblinks – are easily detected.

rodrigo.jpg — Each eye has 6 million photoreceptors used for day vision, and 100 million photoreceptors used for night vision. Their activity is funneled to 1.5 million optic nerve fibres which send the eye's messages the brain where we use 10^{10} nerve cells to interpret and act on our eyes' messages.



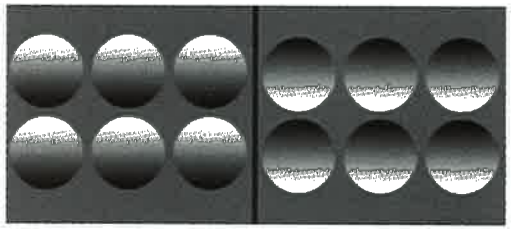
skydive.jpg / whiteb.jpg — The mystery is how our perception of the world remains stable, despite the continual movement of our head and eyes. Somehow our brain compensates for these movements and informs us as to what is really moving relative to ourselves.



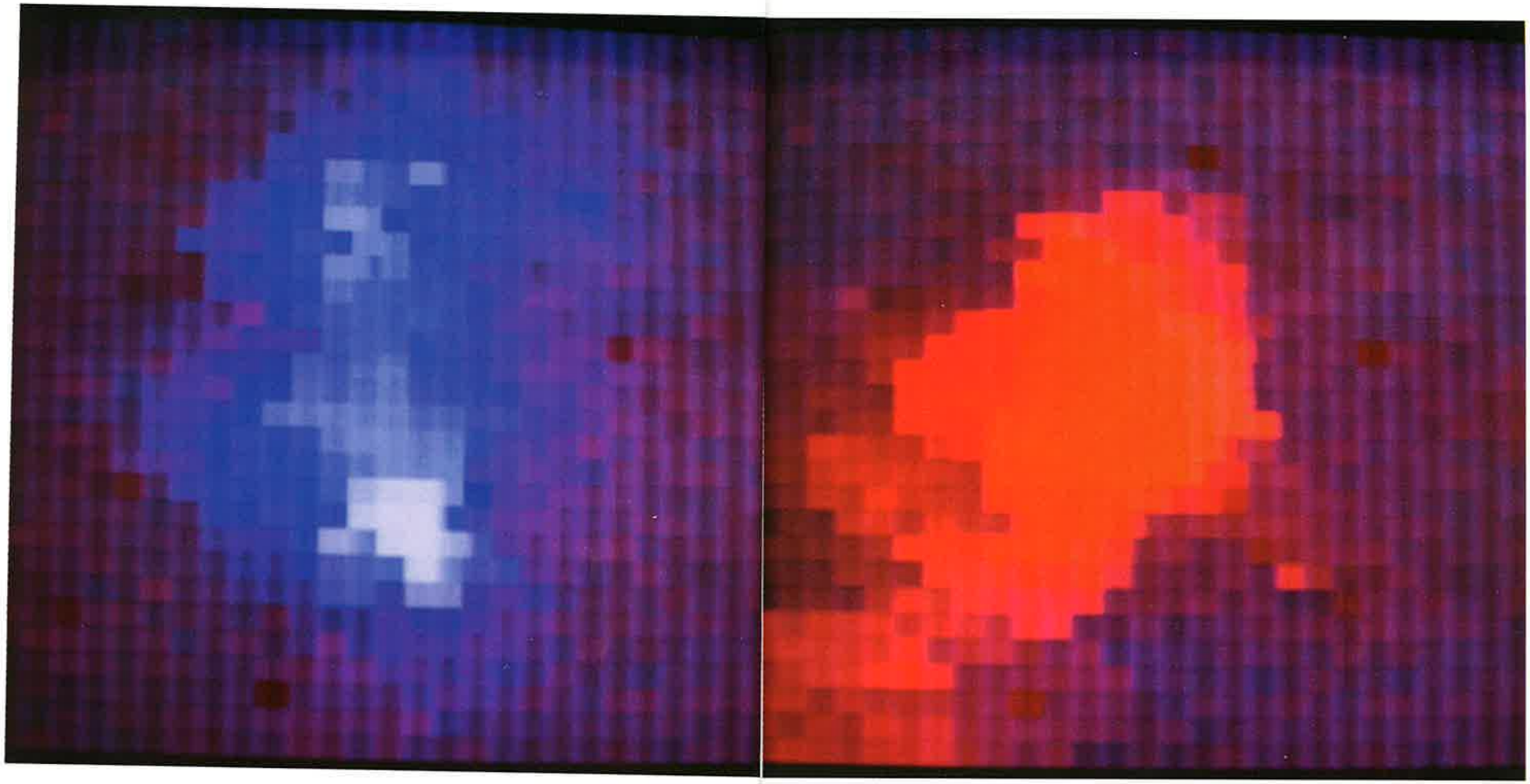
wolf1.jpg / wolf2.jpg / connie.jpg (courtesy Peter König and Wolfgang Einhäuser) — We always try to place the most interesting part of a scene on the most sensitive part of our retina – the fovea – for long enough to make sense of it. To do this requires the combined work of 12 muscles, which turn the two eyes on different axes. The position of an eye can be recorded in real time by recording the changes in the positions of the "Purkinje images" – the reflections of a fixed point of light from the lens and cornea.

retinate.jpg — To decipher the meaning of a retinal image we use many regions of our brain, which automatically focus the image of an object on the retinae, move each eye to combine the two retinal images into a single 3-D representation of the object, and in a split second produce, seemingly effortlessly, a conscious perception of the object that is consistent with our past experience of the world. Even these unfamiliar scenes – of a vision laboratory – are immediately interpretable to us.

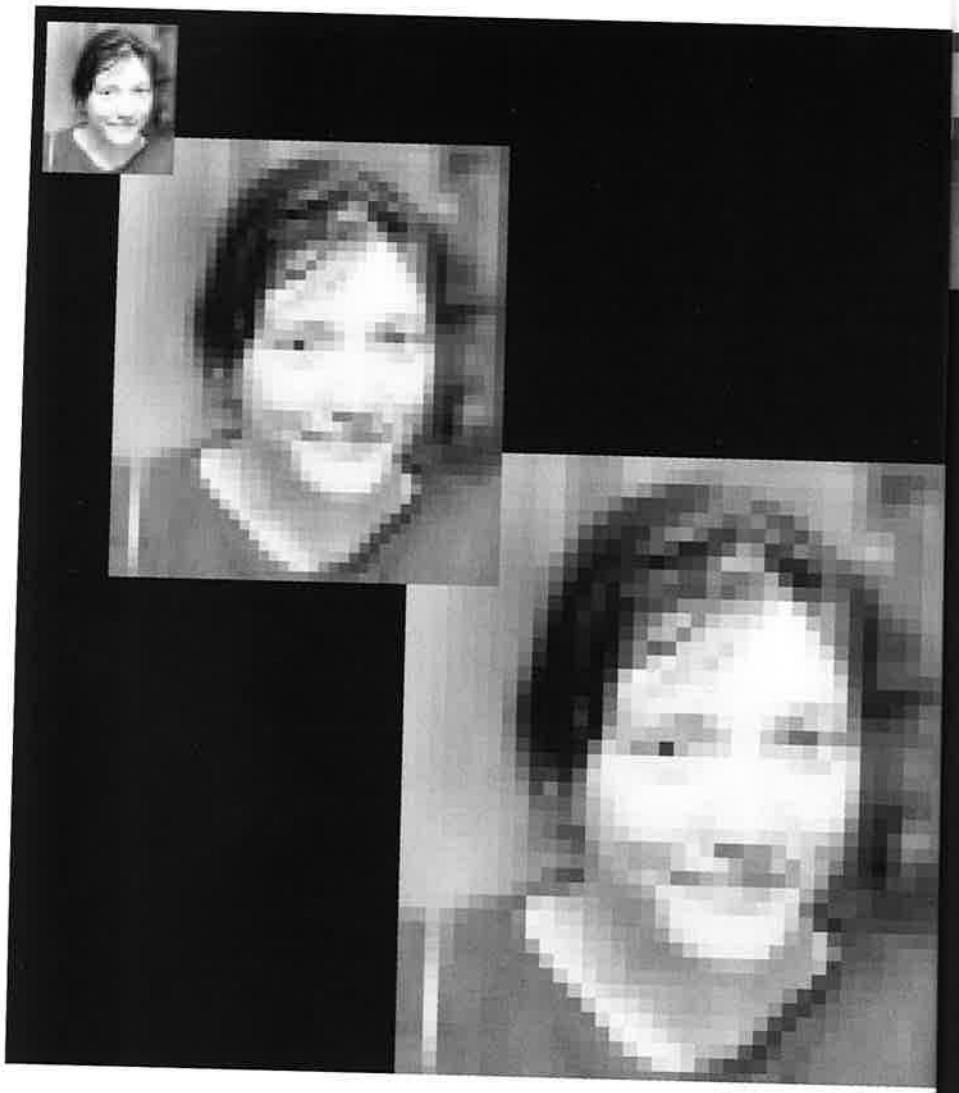
shadowb1.jpg (courtesy Catriona Bass) — In Plato's allegory, the prisoners saw only shadows of 'reality' cast on the walls of their cave. Our own interpretation of reality is also strongly influenced by shadows. We can tell the age and sex of a person simply from their shadow.



eggbox.jpg — Our experience tells us that the source of light is usually above us, so the shadows cast by an object determine whether we interpret the identical form as concave or convex.



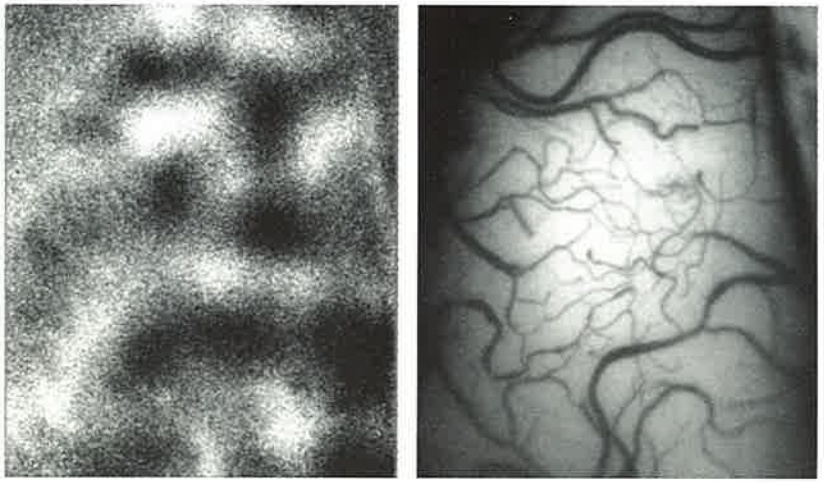
bluemove.jpg / redmove.jpg (courtesy Alan Stocker) — The form of a moving object is usually less important to us than its speed or whether it is going to hit us. In this model retina, the direction of motion of an object is coded as a colour and its speed as an increase in the intensity of the pixels of the retina. Here the blue blob indicates the motion of a hand moving up and to the right and red indicates the hand moving down and to the left.

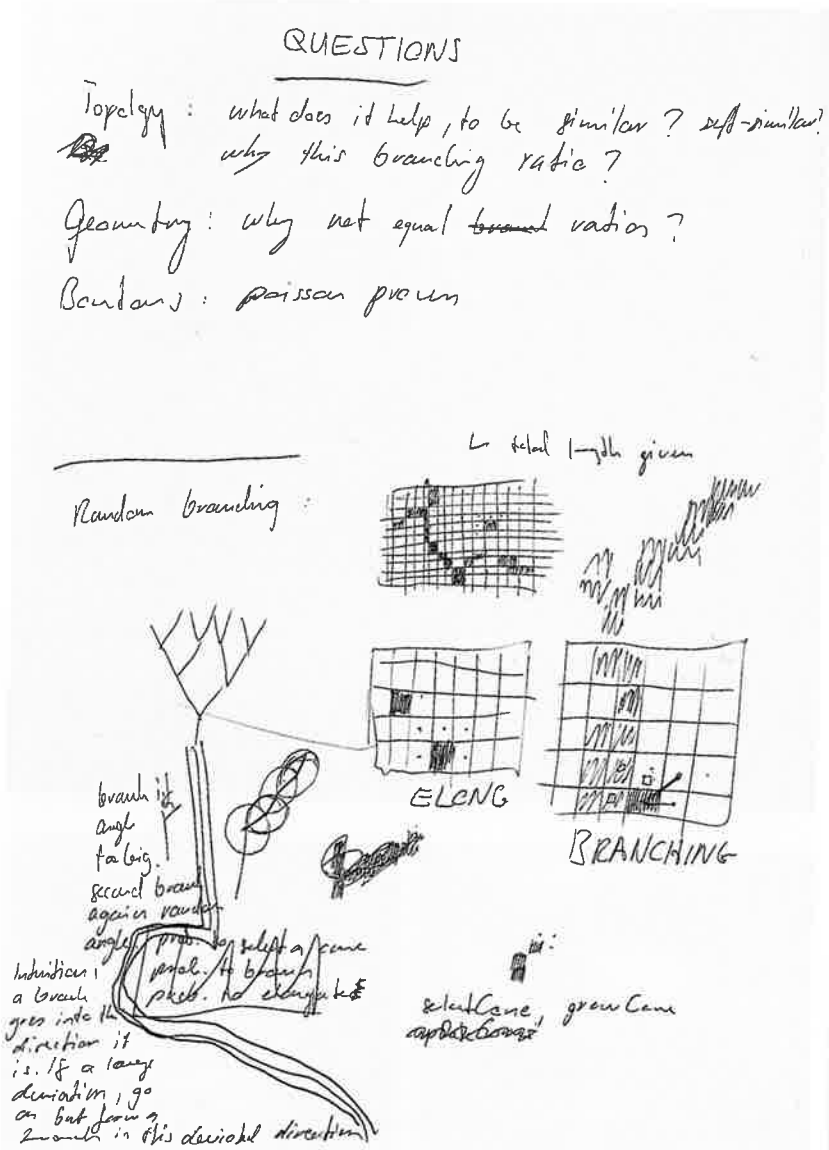


mishahea.jpg (courtesy Tobi Delbrück) — If we can't see the forest for the trees, it means we are too close. Paradoxically, if we move some distance, details of the image may become easier to recognize.

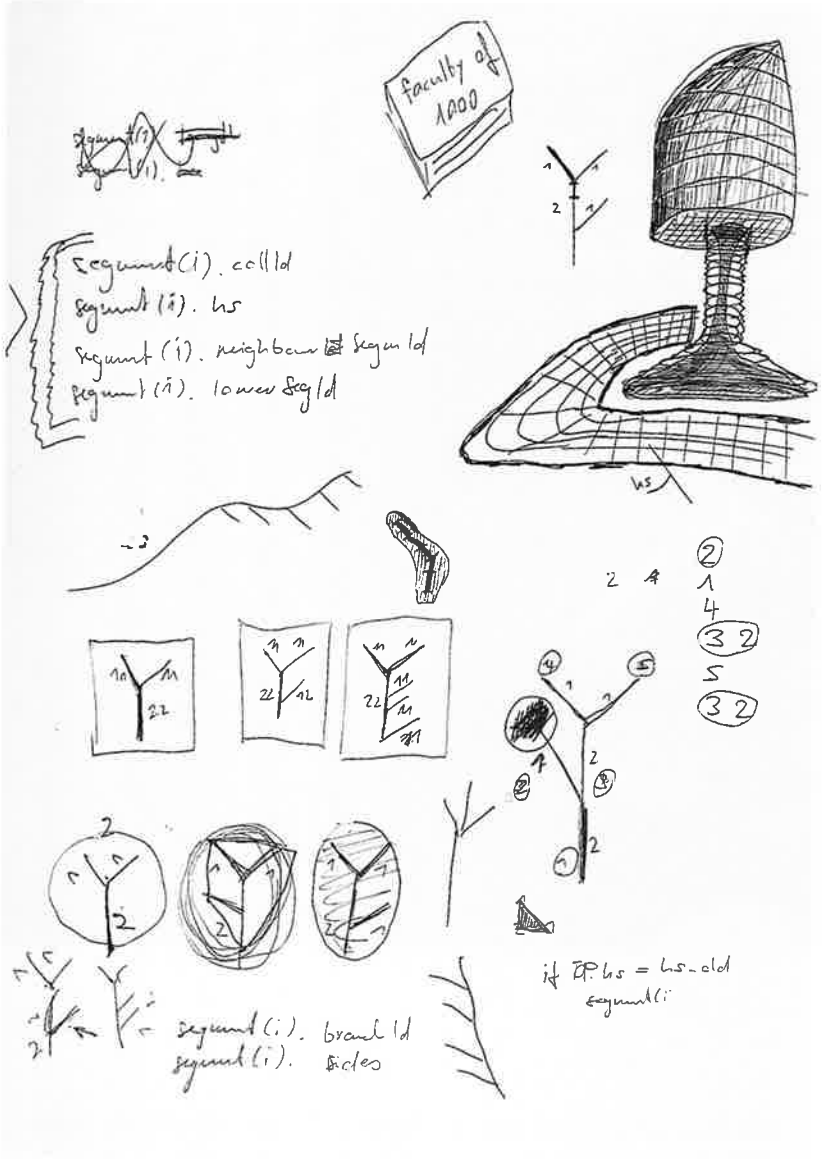
layer3py.jpg (courtesy John Anderson and Tom Binzegger) — Nerve cells from the visual brain. "Swiftly the head-mass becomes an enchanted loom where millions of flashing shuttles weave a dissolving pattern" – Charles Sherrington.

optimage.jpg (courtesy Nuno da Costa) — In 1890, Roy and Sherrington showed that neural activity caused changes in local blood flow in the brain. These changes in blood flow can be recorded with functional magnetic resonance image (fMRI), or shown here, by taking a video image of the brain and recording the changing absorbance to light of the brain itself. Here the dark zones indicate the patches of brain activity evoked by a vertical visual stimulus. The light zones are activated by horizontal visual stimuli and are inactive.

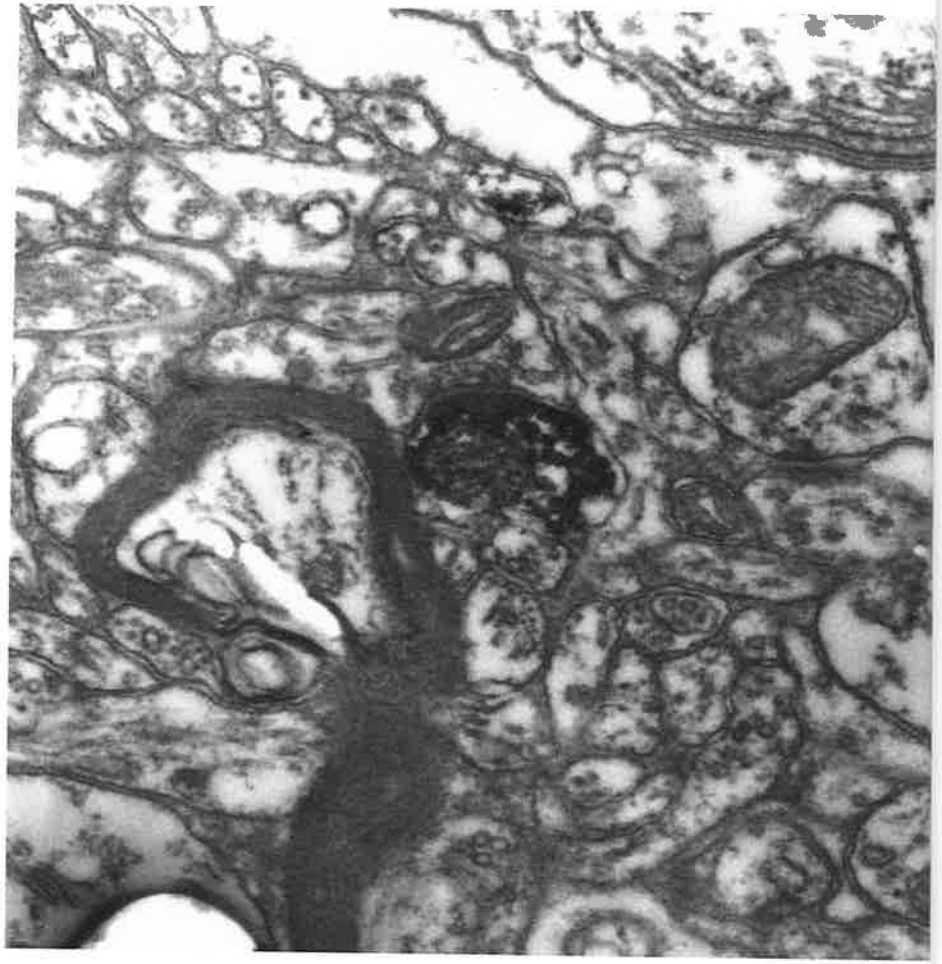




dood1.jpg / dood2.jpg (courtesy Tom Binzegger) — Motor activity is necessary for thought. Doodling is a common way of activating the unconscious brain processes that produce the solutions – seemingly from thin air.



"Vision, in my view, is the cause of the greatest benefit to us, inasmuch as none of the accounts now given concerning the universe would ever have been given if men had not seen the stars or the heaven" – Plato.



emsynaps.jpg (courtesy John Anderson) — The dark object in the centre of the electron micrograph is a labled nerve cell, which forms a synapse – a 'protoplasmic kiss' – with another nerve fibre in the visual brain. "What mysterious forces precede the appearance of these processes? Promote their growth and ramification? and finally establish those protoplasmic kisses which seem to constitute the final ecstasy of an epic love story" – Santiago Ramon y Cajal.