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Seeing the True Colors of Mars

A lesson for astronomers from a chemist

Like the Moon, Mars displays a distinctive pattern of light and dark areas that early astronomers designated as *terrae* (lands) and *maria* (seas). The notion that the dark areas were actual bodies of water was abandoned late in the 19th century in favor of the belief that they were tracts of vegetation. Unlike their lunar counterparts, the Martian maria exhibit seasonal changes in intensity and seasonal changes in outline suggestive of the growth and decay of vegetation like we experience here on Earth. But the major underpinning of the vegetation theory stemmed from the fact that many observers perceive the color of the dark areas on Mars as distinctly bluish-green.

The palette of reported colors includes grass green, moss green, olive, teal, and even robin's-egg blue. These eyepiece impressions are so common that a popular 1953 book about the possibility of life on Mars, written by physiologist and space-medicine pioneer Hubertus Strughold, bore the title *The Green and Red Planet*. Yet all these vivid hues are literally in the eye of the beholder — the products of an optical illusion discovered early in the previous century by a French chemist.

Michel-Eugène Chevreul (1786-1889) was a towering figure of chemistry in the 19th century. In 1823 he embarked on an exhaustive study of natural dyes and was soon appointed Director of Dyeing at the Manufacture des Gobelins, France's national tapestry workshop, where he was tasked with improving color fastness and intensity in woolen goods.

As part of his rigorous approach to the technology of dyeing, Chevreul also investigated color perception. He discovered that the perceived color of an object depends on the color and brightness of its surroundings, which he called "the law of simultaneous contrast of colors." He wrote: "In the case when the eye sees at the same time two contiguous colors, they will appear as dissimilar as possible, both in their optical composition and in the height of their tone."

Simultaneous contrast causes colored highlights to impart their complementary hue to any adjacent low-luminosity features. For Mars observers, the implications should have been obvious — a dark neutral marking viewed against a bright reddish background will take on a bluish-green cast. In his 1833 work *A Treatise on Astronomy*, the British astronomer (and accomplished chemist) Sir John Herschel dismissed the greenish color of the Martian maria as a contrast illusion arising from "a general law in optics." Indeed, many impressionist painters made great use of simultaneous contrast, yet only a handful of astronomers seemed to be aware of it. By the dawn of the 20th century, leading Mars observers like Eugène Antoniadi and Percival Lowell seemed oblivious to the illusion.

Gerard Kuiper made a very painstaking attempt to determine the true colors of Mars during the planet's 1954 apparition. Widely regarded as the father of modern planetary science, Kuiper used

▲ This color composite of Mars captured by the European Space Agency's Rosetta spacecraft attempts to accurately depict the planet's true hues.

ESA & MPS FOR OSIRIS TEAM MPS / UPD / LAM / IAA / RSSD / INTA / UPM / DASP / IDA the 82-inch Cassegrain reflector at the University of Texas's McDonald Observatory, employing a binocular viewer (a rare accessory at the time) and a pair of eyepieces that yielded a magnification of 900×. At this generous image scale, the Martian disc appeared a whopping 6° in diameter — 12 times the diameter of the Moon seen with the unaided eye.

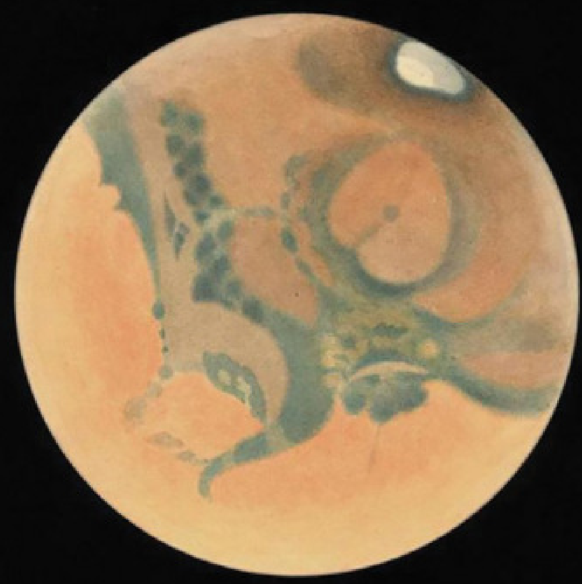
Kuiper placed a chart issued by the Glidden Paint Company containing 180 rectangular swatches of various color shades at arm's length just below the eyepiece and illuminated it with a lamp that was a close spectral match for sunlight. The intensity of the lamp was carefully adjusted to match the apparent surface brightness of the chart's color patches with the telescopic image of Mars.

To Kuiper's surprise, the apparent color of the planet's dark markings seemed to depend greatly on the quality of the seeing. He noted that Mare Acidalium had a greenish hue in poor or average seeing, but when the seeing improved, it lost nearly all green color, and whenever the seeing was truly excellent, it had the same ochre color as its surroundings. These visual impressions were repeated on several nights.

Kuiper resumed his color observations in 1956. Once again, he found that with rare exceptions "the dark areas are, to a first approximation, *neutral*, having the same color as the rest of the planet, only darker."

The dark regions look somewhat greenish at first, but this color disappears when one looks straight at the area in question. The initial color impression seems to be due to contrast with the ocher desert regions. If one looks straight at the dark areas, there is no apparent correlation between seeing and color, as was reported in my 1954 observations. Apparently, this correlation was due to the circumstance that, with poor seeing, the eye tends to wander over the planet while, with good seeing, it fixes on the area being studied.

Kuiper's account points to a phenomenon that perceptual psychologists call negative afterimages. We perceive color using our retina's cone cells. There are three types of cone cells, each containing a different photopigment that responds to light of long wavelengths (orange-red), medium wavelengths (yellow-green), or short wavelengths (blue-violet). When these photoreceptors are overstimulated, their photopigments are depleted and they lose sensitivity. Normally, images on the retina are moved to fresh photoreceptors by tiny, random, involuntary eye movements. But if you stare at a brightly illuminated red object for 20 to 30 seconds, then shift your gaze to a white or grey surface, you will briefly see a ghostly afterimage with a cyan (blue-green) complementary color.



Eugène Antoniadi depicted the colors of Martian markings in shades of green in this beautiful 1909 watercolor. Even the most gifted observers can be deceived by the effects of simultaneous contrast. South is up.

COURTESY RICHARD MCKIM

William K. Hartmann, who received his doctorate in astronomy as a student of Kuiper at the University of Arizona, is a talented artist whose paintings of planetary landscapes are among the most realistic. In 1988, Hartmann observed Mars with a 24-inch Cassegrain reflector from the summit of Mauna Kea. Although the dark markings looked "bluish-grey" at the eyepiece, he found that in "a textbook display of simultaneous contrast" they could be very realistically depicted in an acrylic painting using only pigments on the warm (reddish brown) side of neutral.

According to the renowned space artist Don Davis, the appearance of the dusty soil covering Mars is a drab, ruddy brown that's a dead ringer for cumin spice powder. The dark, feldspar-rich basalt rocks that comprise the planet's dusky features are generally neutral grey, with thin, ephemeral coatings of dust deposited and swept away according to the whims of Martian winds.

When you observe Mars during this apparition, bear in mind the phenomenon of simultaneous contrast and how it influences your eyepiece impressions. Perhaps you'll see the planet in a whole new light.

■ A chemist by profession, Contributing Editor **TOM DOBBINS** has often observed simultaneous contrast while studying Mars at the eyepiece.