# Why Is the Sky Blue?

Henrike Holdrege

*"The discussion of color has always brought some considerable risk, a fact that inspired a predecessor to say that waving a red flag before a bull will rouse him to anger, but any mention of color at all will send the philosopher into a rage."* (Goethe[1])

In a 2021 issue of *Science*, the journalist Daniel Ackerman writes in his review of the book by Kai Kupferschmidt, *Blue: In Search of Nature's Rarest Color*:

> The book's most fascinating chapters, *Seeing* and *Speaking*, dwell on how we perceive and communicate color. "Blue light is not actually blue," writes Kupferschmidt. Light is merely electromagnetic radiation — photons with particular wavelengths. It becomes "blue" only through a dance with the eye, the brain, and our shared understanding of the world.[2]

Kupferschmidt's statement that "blue light is not actually blue," expresses a conviction that is widely shared by writers, physicists, educators, and many other voices. It amounts to a definition of what color is. Blue light, and all other colored light, is said to be *merely* particular wavelengths. The word *merely* is expressive. It means that colors have no reality, that we *only see* things as colored, and that a colorful world is not the real world.

This understanding of color denies that human experience is the basis for all knowing. Doubt about human experience is a most deeply ingrained prejudice of modern western societies, and it is their bane, estranging us from the world we live in and from ourselves. In a time when virtual reality has become a dominant part of our experience, and when questions about "fake news" and "fact checking" have become pressing, the question whether we can rely on our experiences as encounters with a real world is of heightened urgency.

Centuries-long philosophical and natural scientific debate and reasoning seem to deny that the world we perceive and experience is real. However, there is a glaring inconsistency in the reasoning. People who speak like Kupferschmidt take the brain to be real. They take the instruments used for researching brain activity for real, as well as the researcher's actions, interventions, and measurements. They take to be real everything that led to the science of electromagnetic radiation and photons with particular wavelengths. When they then come to the conclusion that brain activity is real but the perception of color is not, the reasoning becomes unreasonable. They declare one set of observations to be real, another set of observations to be unreal. When you question sense perceptions, you must also question the sense perceptions, observations, and measurements involved in brain research. The claim that denies reality to sense perceptions undermines and destroys the foundation of all natural science. If color as perceived is not real, then the brain as perceived and the measuring instruments as perceived are also not real.

The late philosopher Ronald Brady argues that the statement that one class of observations (those of brain functions as observed by neuroscience) should be set apart from all other observations — like color, taste, sound, warmth, touch, balance, and so on — is not a result of experience-based science but the result of a preference for a worldview. It is believed, but not substantiated by observation.[3]

Once we realize that in science we cannot shun sense experience, that the basis of all knowing is human experience, we do not ask what "is behind" and "causes" color. We do not set the class of phenomena relating to electromagnetic radiation and brain research, or any other class of phenomena, above and against the class of visual phenomena. Phenomena relate to each other, certainly, but they do not cancel each other out, the one being real, others not being real. How phenomena relate to phenomena is the question of research rooted in experience. It is here that we meet hindrances and our own limitations. We need to ask ourselves: What underlying preferences help to shape our judgments? What are our hidden assumptions? What are our rigid thought forms? What are our conceptual limitations?

How can color research based on phenomena unfold? Phenomena inform and modify our knowledge. By attending to appearances of color in the world, the question "Why is the sky blue?" becomes the question "Where and how does the color blue appear?"

## Attending to Colors

Smoke from fire is usually not colorful. But under certain conditions, it appears blue. I create these conditions at The Nature Institute by hanging a black cloth from a windowsill under a large window. In front of the cloth, an incense stick burns. The smoke curls up and takes on a blue hue when seen in front of the black cloth (see photo). Where the smoke is more concentrated, it is light blue; where the smoke is less dense, it is darker blue. When you shift your position and see the smoke in front of the bright wall, the blueness disappears. When you move the incense stick closer to the wall into the space shaded by the windowsill, the color blue disappears. For the smoke to appear blue in front of a black background it must be illumined.

During the winter months in northeastern North America, we have ample opportunity to observe the same phenomenon on a larger scale. The smoke from wood stoves rising from chimneys is beautifully blue seen in front of dark hillsides, especially on sunny days. Against a bright overcast sky, the same smoke is yellowish.

Opalites too provide the opportunity to study these color phenomena. Opalites are man-made and of milky glass. Lying in a white bowl, they are milky white. Lying on a black cloth on a window sill and seen from above, they show a beautiful blue. The more translucent parts appear darker blue, the less translucent parts lighter blue. If you place an opalite in front of the window and look through it at the cloudy but bright winter sky, the stone shows a warm honey yellow. The opalites lying on white paper take on a slightly yellow hue. (See photos.)

These color phenomena arise through colorless media. Here, the medium is smoke or milky glass. It is turbid — translucent but not transparent.

When in recent summers wildfires raged in the western United States and smoke obscured the sky, on some days the color of the sun high in the sky was orange or red. And we in the northeast knew that smoke from these wildfires was drifting on high winds eastward when our sun on cloudless days turned to yellow/orange long before setting. At the same time, the sky was not clear blue but rather leaden grey blue.

Distant mountains often appear blue, the more distant ones a lighter blue than the nearer ones (see photo). Even the wooded hill near my house that I see every morning from my study is dark violet or even blue on some days while the sun is rising behind the hill and shining into the atmosphere in front of the hill but not yet on the trees.

The sky is darker blue above us and lighter blue toward the horizon. On days with high air humidity it is of a paler blue than on other days. On high mountains, the sky appears dark blue-violet.

Air borne particles from dust, smoke, or pollution, and air humidity with its tiny water droplets make the atmosphere a turbid medium. Looking to the horizon, we look at the darkness of space through a medium more turbid than when we look up at the sky. This is why the sky near the horizon is paler blue or even white. Looking at far distant mountains, we look through a greater depth of turbid atmosphere than when we look at nearer mountains. This is why the nearer ones are darker blue than those in the distance.

The sun high in the sky is bright and blinding. When setting it shines with a warm yellow light. Everything it illuminates takes on a warm hue. On certain days the setting or rising sun is orange or red. Also the moon can be yellow, orange, or even red.

I remember the early morning of June 8, 2004. That day, Venus was in transit, which is a rare

cosmic event. I went out after sunrise to observe the tiny, dark disk of Venus in the bright disk of the sun. I had the glasses with me which we use to observe solar eclipses. Looking through them at the sun, I could not see anything. Then I noticed how red the sun was. It was a very hazy day. With naked eyes I saw the silhouette of Venus.

With each phenomenon we study, we look and observe carefully. That is not as simple as it might sound. Once in a workshop, I showed smoke rising in front of a dark background but did not mention color. Afterwards, none of the participants remembered having seen blue smoke. Instead, they all had enjoyed watching the movements of the smoke. When we direct our attention, we often see only what we attend to. When, in courses, we work with phenomena in the way I have described, participants notice how they become more attentive and awake in their perceptions.

While observing the various phenomena, questions arise. Do the different situations in which colors appear relate to each other? Can we find a principle that manifests itself in various phenomena? For the color appearances described here, we find colorless turbid media to be one condition. In the case of the cool colors, the turbid medium — in front of darkness — is illumined and brightens the darkness with a violet, blue, or light blue veil. In the case of the warm colors, the turbid medium — in front of a light source (or luminous background) — darkens the brightness to yellow, orange, or red hues. In the interplay of matter and light, of darkness and brightness, the colors arise. The interplay creates the splendor of sunrises and sunsets and the immense blueness of our skies. Such splendor of atmospheric colors we do not find on the moon. Since the moon has no atmosphere, its sky is black and its sun is blindingly bright, always.

In the phenomenological way of approaching color and the visual world, phenomena arise out of the interplay of other phenomena. They "explain" each other, or we might say, they illumine each other. They call to us for attention. When we attend, we engage and perceive; and we are rewarded with experiences. The world gets richer and richer.

In high school and college, I learned to think about color in the framework of optics as taught by modern physics. I remember a winter morning when I was on my way to school as a young public school teacher. I noticed how grey my surroundings were. The world was not colorful, and I did not yet have the appreciation for the subtle colors of winter. When some years later I met a different way of studying the visual world, I began to awaken to the reality of a colorful world. Since then, my interest continues to deepen and broaden. My appreciation for the world I see is ever growing.


References

1. Goethe, J. W. von (1995). *Scientific Studies* (Princeton: Princeton University Press, p. 165).

2. Ackerman, Daniel (2021). "Blue," *Science* vol. 372, pp. 1034-5.

3. Brady, Ronald (2008). "Direct Experience" in G. Maier et al. *Being on Earth,* Chapter 1. https://www.natureinstitute.org/book/being-on-earth