Introduction

> The art of seeing nature is a thing almost as much to be acquired as the art of reading the Egyptian hieroglyphs.
>
> John Constable, quoted in C.R. Leslie, *Memoirs of the Life of John Constable*, Phaidon, 1951, p. 327

> The first great mistake that people make in the matter, is the supposition that they must see a thing if it be before their eyes.
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> John Ruskin, *Modern Painters*, vol. 1, George Allen & Sons, 1908, p. 54

> However extraordinary it may seem, it remains a fact that the things one notices are the things with which one is familiar; it is very difficult to see new things even when they are before our very eyes.
>
> Marcel Minnaert, *The Nature of Light and Colour in the Open Air*, Dover, 1954, p. vi

Since this book is intended to encourage you to use your eyes, unaided by a telescope, I should begin by saying a few words about the eye. Many people assume that the eye is like a camera, and that therefore we must see whatever is before our eyes. But, to see, you must look. Seeing is a conscious act and, unless you look actively, and have some idea of what you are looking for, you probably won't see many of the things mentioned in the subsequent pages. The eye is not a camera; it is an extension of the brain, the organ of thought. Observation thus favours the prepared mind. One of the most important lessons for anyone interested in what the sky has to offer is not to take seeing for granted. It is something that you have to work at, and which involves knowledge and patience in almost equal measure.

You should also not underestimate the power of the eye. It is widely believed that looking at the sky without a telescope, particularly at night, is a waste of time. Compared with the telescope the unaided eye seems a feeble thing, hardly up to the challenge of seeing the faint, the small, or the unusual.

But the eye is a Jack-of-all-trades, a superbly flexible organ which can scan the entire sky in a matter of seconds, and take in with a single glance the spectacle of a clear dark sky, the majesty of the Milky Way, or the thrill of a meteor shower. These are not things that can be done with a telescope. And the more you use your eyes, the better you become at spotting things.

The other great advantage of relying on your eyes rather than on a telescope is that your eyes are always with you. Most astronomical telescopes are not very portable, and you won't always have one to hand when there's something worth seeing. If you rely on only your eyes, you'll never be caught short when there is something to see. This is not to say that a telescope isn't worth having. Far from it: the Moon's surface, or the disc of a planet, seen through a powerful telescope, are extraordinary sights. But a telescope does not, in itself, overcome the major disadvantage most people face when looking at the sky: not knowing what to look at, or how to look at it.

While on the subject of optical instruments, there is the important question: to photograph, or not to photograph? I have found that photography can get in the way of looking carefully, and enjoying a sight. In any case, you soon discover that many of the sights that you want to photograph are quite common. If, like me, you are not a particularly skilled photographer, and lack the patience necessary to improve your skills, leave photography to others. I now seldom carry a camera. I believe that the only point of lugging a camera around is for those once-in-a-blue-Moon events, and of which there are few, if any, good images. There are occasions when I could have kicked myself for not having a camera to hand, like the time I saw Manhattan looming above the horizon some 40 km across water from the shores of Connecticut. But I did have binoculars, and I spent the time exploring the sight, rather than fiddling around with the controls of a camera. In fact, I would say that, given a choice, binoculars are more useful to a skywatcher than a camera. The decision, of course, is yours. There are some grand sights to be photographed, as you can tell from the photographs in this book.

What of U.F.O.s, or unidentified flying objects? Leaving aside the issue of whether aliens have visited the Earth from another world, a subject too vast and contentious to be dealt with here, there will be occasions when you will see something in the sky that perplexes you. Don't jump to conclusions; there will almost certainly be a rational explanation. In defence of my scepticism, I offer my own U.F.O. experience. One night some years ago, in the city where I live, I saw four or five glowing ovals flying swiftly overhead. I had hardly glimpsed them out of the corner of my eye than they vanished behind some nearby buildings. They moved silently, one behind the other, weaving slightly from side to side. I realised that they were not aircraft or I would have heard their engines. What were they? For years after, I remained perplexed by what I had seen. Then one night, by chance, I saw a similar formation. This time I had binoculars to hand. I quickly raised them to my eyes, focused, and saw geese. As soon as I did so I could see why they looked like fast-moving glowing ovals. In the first place they were flying directly over me just above roof height so they took only a few seconds to cross my entire field of view, which made their apparent speed very great indeed. Secondly, they made no noise, something that had added to my confusion the first time I saw them. Finally, the glowing ovals were their wings, which reflected the orange glow of the streetlights below. This has been my only U.F.O. sighting to date. I have no doubt I shall see other things that puzzle me, and which I may be unable to explain, though I don't expect ever to see a flying saucer.

Finally, a few words about the rewards of skywatching. Sadly, light pollution due to street lamps prevents us from seeing all but the brightest stars. Astronomers complain that today's skies, especially city skies, are barren wastelands, devoid of all but a handful of stars, and hardly worth a second glance. But although light pollution makes it all but impossible to see faint stars and galaxies, including our own Milky Way, it doesn't prevent us from seeing the Moon, planets and the brightest stars. In fact, where the Moon and planets are concerned, you can see almost as many of the Moon's many aspects from most cities as you can from the darkest countryside. And, at their brightest, planets can be seen without difficulty even from the centre of a large city.

Above all there is the pleasure of simply allowing your eyes to roam until they fasten on something interesting, and of recognising it for what it is. The chances of seeing something hitherto unknown, or extremely rare, are slim. If you are new to skywatching, you will make many discoveries, but they will be of things that are new to you. If you are unfamiliar with the sky, you soon find that nature is brimming with optical phenomena that you have never heard of, let alone seen. If you keep your eyes peeled, there is a chance that you will see something that is new to you almost daily, or see something familiar in a new light. When you first see such phenomena you experience a thrill of discovery – always a magical moment. But it won't take you long to realise that most of these sights are everyday events, and that it was merely ignorance that stopped you noticing them sooner.

Gradually your experience of nature acquires another dimension as you realise that what we see is the result of the passage of light through the atmosphere, of reflection and refraction in the world around us. Rainbows and halos are particularly striking examples of this, but they are not in a special category. They are explicable by the same optical principles as ordinary shadows. When you understand this, experience stops being a disconnected series of seemingly one-off events. You begin to think of the sky as a single entity, and you find that you can anticipate phenomena.

The greatest thrill comes when you are sufficiently familiar with the sky to know when something out of the ordinary is happening. But the greatest reward is not in seeing something unusual, but in realising that it is unusual. This serendipitous state cannot be achieved overnight. You have to acquaint yourself with the everyday before you are in a position to notice the unusual. This takes time, patience, and a certain amount of commitment, though it's never a chore. In fact, that is part of the fun.

Cambridge University Press
0521809258 - Out of the Blue: A 24-Hour Skywatcher's Guide
John Naylor
Excerpt
More information

Chapter 1 | DAYLIGHT

> It is a strange thing how little in general people know about the sky. It is the part of creation in which nature has done more for the sake of pleasing man, more for the sole and evident purpose of talking to him and teaching him, than any other of her works, and it is just that part in which we least attend to her
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> John Ruskin: *Modern Painters*, vol. 1, section III, ch.1 'Of the Open Sky'

1.1 The colour of the daytime sky

Our atmosphere is a thin, transparent layer of air, not much more than 100 km deep, that separates us from the dark and starry void beyond. On cloudless nights we look out at this fathomless darkness, and only the twinkling of stars betrays the presence of the atmosphere through which we gaze. But when the Sun is up, the whole sky glows brightly, and the dark abyss is concealed from us by an almost tangible blue dome that seems forever out of reach, beyond even the highest clouds and the furthest horizon.

There is no blue dome, of course. Instead during daylight hours we are immersed in what is known as airlight, which is the glow of the atmosphere when it is illuminated by the Sun. We look *through* airlight rather than at it, though it is so faint that we notice it only when looking through several kilometres of atmosphere. A blue sky seems distant because of the cumulative effect of airlight from points near and far. Most airlight, however, reaches us from the atmosphere within a few kilometres of where we happen to be. Although there are traces of air 100 km and more above the Earth's surface, the density of the atmosphere diminishes rapidly with altitude, so much so that 75% of its mass lies within 10 km of sea level. To give you some idea of what this means, on a 25cm globe, this depth of atmosphere is equivalent to the thickness of a sheet of paper. The remaining 25% of air that lies more than 10 km above ground becomes ever more tenuous until it finally peters out some 150 km above our heads.

Sadly, Ruskin's remarks about people's knowledge of the sky are as true today as they were in his day. Ask almost anyone what the colour of the sky is, and they will almost certainly reply that it is blue. But, on closer inspection, everyone can see that, although the dominant colour of a clear sky is blue, it is never uniformly blue. It varies from one part of the sky to another,

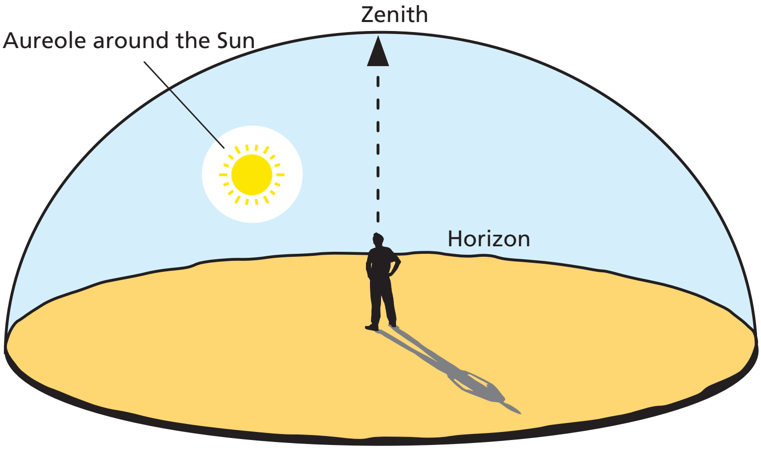

Figure 1.1 During daylight a cloudless sky appears to be a flattened dome. The zenith is the point in the sky directly above your head; it seems closer than the horizon, which is the circle where the sky appears to meet the Earth. When the Sun is close to the horizon, the darkest, bluest part of the sky lies at the zenith. The sky is less blue towards the horizon. Around the Sun there is often a whitish aureole.

and from day to day. Nor is it as blue as it could be: the vivid, saturated blue visible in the spectrum that is formed when a narrow beam of sunlight passes through a prism. Don't take my word for any of this. Step outside on any clear day, and look around the sky for a few minutes. Looking at the sky for yourself is far more enlightening, and much more fun, than simply reading about it. The things to concentrate on are its colour and brightness.

Begin by looking for the bluest part of the sky. Where is it in relation to the Sun? Compare its colour and brightness with that of the horizon. With a small mirror you can examine both at the same time: while looking at the horizon hold the mirror level with your eye, and adjust it so that you can see a reflection of another part of the sky. In this way you can directly compare any two parts of the sky.

Now shield your eyes with an outstretched hand, and look towards the Sun, making sure that your hand covers the Sun at all times. Your eyes can easily be permanently damaged by gazing at the Sun for more than a few moments. What colour is the sky directly around the Sun? How bright is it compared with the rest of the sky?

If you have a panoramic view you may be able to notice the distance at which the colour of the sky becomes apparent. Compare the appearance of things that are near you with those that are far away, and look for the blue airlight scattered by the intervening air between you and the more distant objects. At what point does this become noticeable? A few hundred metres? Several kilometres?

If you have time, see how the Sun's height above the horizon affects the distribution of colour and brightness over the whole sky. Compare the sky at midday, mid-afternoon and sunset.

Finally, what of the sky's colour on different days? The difference between a really clear sky and one that is even slightly hazy is quite startling.

If you want to notice subtle variations in sky colour you'll find a cyanometer useful. This simple device was invented some 200 years ago by a Swiss physicist, Horace de Saussure. It consists of several numbered strips of card each painted a different shade of blue. Saussure's original cyanometer consisted of 16 strips. Shades of blue, ranging from dark blue to light blue, are created by mixing Prussian Blue with white.

In use, you simply hold up the strips and sort through them until you find one with a hue that matches that of the portion of sky that you are looking at, and make a note of the number. You will find that doing this helps you notice variations in sky colour in a way that cannot be done merely by passive observation.

1.2 Why is the sky blue?

'Why is the sky blue?' is one of those deceptively simple questions that children ask. As with so many naïve questions, there is no simple answer. In the first place, the question presupposes that the sky has a uniform colour, and that colour is its only important feature. If you have looked at the sky attentively you will know that on a clear day its colour and brightness vary from zenith to horizon. When the Sun is low, the sky is bluest and least bright at the zenith. As the Sun climbs higher, the zenith gradually ceases to be the bluest part. Near the horizon and around the Sun, the sky is brighter and less blue. In fact, at the horizon the sky varies from light grey to white, and is never blue. The colourless glow around the Sun, known as an aureole, is not present in exceptionally clean air such as that found in polar regions.

It's difficult to say when people first began to wonder about the colour of the sky. In part they would have been hampered by their lack of knowledge of the relationship between colour and light. Until the end of the seventeenth century, when Newton established that sunlight is composed of several colours, and that an object takes its colour from the light that illuminates it, the view was that colour is an inherent property of an object and that sunlight merely serves to illuminate what is already there. Nevertheless, some 200 years before Newton, Leonardo da Vinci drew attention to the fact that a piece of blue glass looks bluer if it is thicker. He suggested that if the inherent colour of the atmosphere was blue then the sky should look bluer near the horizon. Because this is not the case, he concluded that sky colours were due to some other cause. He favoured particles of moisture in the atmosphere. Newton himself believed that the sky's colour had the same cause as the colours that can be seen in a thin film of oil. These colours are due to the destructive and constructive interference of light.

The first person to study the colour of the sky systematically was Horace de Saussure. He invented the cyanometer to help him keep a record of changes in sky colour from day to day and in different localities. Saussure believed that the atmosphere had no colour of its own, and that sky colours were due to vapours.

The correct explanation for sky colours finally emerged towards the end of the nineteenth century as a consequence of experiments made by an Irish physicist, John Tyndall. Tyndall carried out an extensive investigation of the circumstances in which bluish colours occur when a beam of white light passes through a medium composed of tiny particles.

We associate colour with pigments. A pigment is any substance that alters the appearance of a beam of light by absorbing some colours and reflecting others. Paints are pigments. But air is not pigmented. In this sense it really is almost colourless. All the colours we see in the sky during daylight, from the blue of midday to the rosy hues of sunset, are due to selective scattering by molecules of the gases that make up the atmosphere.

In a vacuum, a beam of light is invisible unless it enters the eye directly. But if this beam encounters a tiny particle, a fraction of its light spreads, or is scattered, in all directions. If the beam is bright enough, and the medium through which it passes contains a high concentration of small particles, we see a little of its light without having to look directly at the source. If the particles are very small, as molecules are, the degree of scattering depends on the wavelength of the light: the shorter the wavelength, the greater the degree of scattering. This form of scattering is known as selective scattering. This is what Tyndall was investigating, though in his day it was called Tyndall scattering of light.

The correct explanation for selective scattering was given by an English physicist, John Strutt, at the end of the nineteenth century. (Strutt inherited the title of Lord Rayleigh from his father so selective scattering is also known as Rayleigh scattering.) He showed that selective scattering occurs only when light encounters particles that are much smaller than the wavelength of light. A typical molecule of gas is over a thousand times smaller than the wavelength of light, which is why selective scattering occurs within the atmosphere.

Strutt also showed that the degree to which the shortest wavelengths of light are scattered by very small particles is some 10 times greater than it is for the longest ones. This is why the colour of scattered sunlight is heavily weighted in favour of the bluer end of the spectrum. We perceive the shortest wavelengths as violet and blue and the longest ones as red. In fact about 40% of the light from the bluest part of a clear sky is composed of shorter wavelengths. The presence of longer wavelengths in scattered sunlight makes the sky appear less blue than it would if only the shorter wavelengths were scattered. Incidentally, although violet has a shorter wavelength than blue, the sky doesn't look violet because there is more blue than violet in sunlight. Furthermore, our eyes are more sensitive to blue than they are to violet, so violet light appears less bright than blue light of the same intensity.

Molecules are very weak scatterers of light, which means that the amount of light scattered by each molecule is tiny. So, despite the vast number of molecules that make up the atmosphere, the total amount of scattered sunlight within the atmosphere is small compared with the total amount of light that reaches the Earth from the Sun. Scattered light appears far brighter and more vivid than it really is because we see it against the dark void beyond the atmosphere. The whole sky right down to the horizon appears bright because almost every molecule scatters some light towards the ground.

The diminishing blueness towards the horizon is due to multiple scattering, scattered light that is itself scattered when it encounters further molecules. Light from the zenith encounters fewer molecules on its way through the atmosphere to the ground than light from the horizon does because the amount of atmosphere in this direction is several times less than it is in the direction of the horizon. Zenith light therefore looks bluer because it retains a larger proportion of shorter wavelengths compared with longer wavelengths than light from the horizon does. On the other hand, light scattered from the furthest horizon encounters many more molecules, and so blue light from the horizon is scattered away from the observer's line of sight to a greater degree than scattered red light.

You might expect that this would make distant objects appear redder than they in fact are. The reason the horizon looks white under normal circumstances is that scattered blue light reaches us from the air that lies between us and the horizon. The combination of long wavelengths from the distant horizon and short ones from the near horizon causes the horizon to

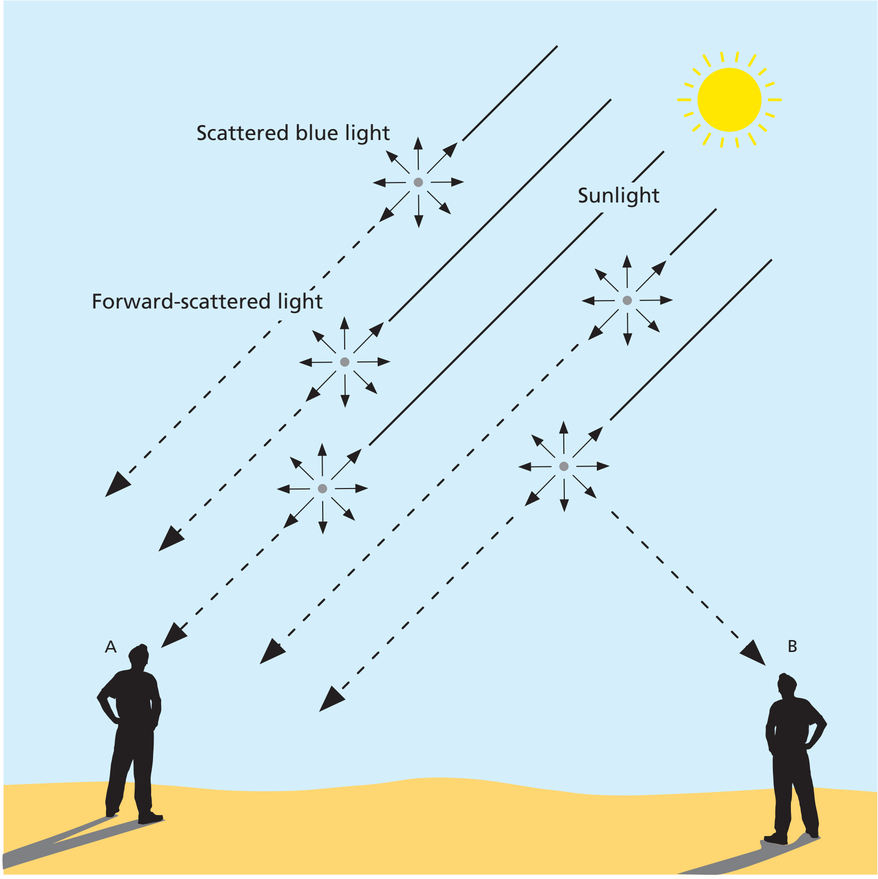

Figure 1.2 Airlight. The sky looks blue because sunlight is scattered by molecules in the atmosphere. A molecule scatters about ten times as much blue light as it does red light. Consequently, scattered sunlight, called airlight, contains far more blue light than unscattered sunlight. At the same time, forward-scattered light is deficient in blue light. In other words the proportion of red light to blue light is greater than in unscattered sunlight. From a direction perpendicular to the Sun's rays (B in diagram) airlight looks blue, whereas looking towards the Sun (A in the diagram) the sky looks less blue.

look white. The preponderance of long wavelengths over short ones in light from the distant horizon is very obvious during a total eclipse of the Sun, when the horizon turns orange. During the totality, when you are within the Moon's shadow, the atmosphere immediately around you is not directly illuminated by the Sun, and so you don't receive enough scattered blue light to make the distant rosy horizon look white.

The greater amount of atmosphere in the direction of the horizon also