Chapter 2

Defining Our Viewing Parameters and Methods

Since this is first and foremost a book for the observer, let us clarify the use of any term referring to 'dark' things in space, and discard all those that we cannot physically see for ourselves. First we need to deal with the ultimate of dark subjects: dark matter and dark energy, likely the bulk of the mass and energy in the universe. However, while accounting for as much as 95% of the total, and being completely invisible, the combined effect of the two is accountable to researchers attempting to analyze the expansion and total mass of the universe. To date, there are some plausible theories concerning these mysterious components of the universe, and these are the only explanations we have for the apparent giant deficiency of mass and energy in the cosmos. Separately or together, they are successfully implied, even proven, and indirectly observable in measured galactic rotation, orbital velocities and temperatures of galaxy clusters, as well as in the readily seen imaged gravitational lensing of galaxies and other objects located far beyond (see Chap. 1, Fig. 1.3) – even within the Milky Way itself.

Dark matter itself is reckoned to be the dominant component of galaxies, appearing to constitute *most* of all galaxies' mass or control over their development; apparently dark matter entirely fills each galactic halo (the vast, roughly spherical matter all around, 'above' and 'below,' all galactic discs, including those regions with a very tenuous stellar population). Regardless, in the sense of all we are considering here, is not dark matter itself, or its effect upon the order of the universe, observable within any deep space object; the prospect of seeing it is still not within the parameters of the average observer or any other. Therefore, it is important that the reader not confuse the subject at hand in this particular writing with this most baffling, and perhaps most significant part of the universe, yet to be understood or properly defined.

By the same measure of what is meant by the term 'dark,' let us also exclude from this discussion all of those other extremely subtle cosmic discoveries that

A. Cooke, *Dark Nebulae, Dark Lanes, and Dust Belts*,
Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-1186-4_2,

often utilize the same or similar terminology but are applied to a different class of celestial phenomena entirely. These are also not normally observable, at least in the generally accepted sense of the term. In recent years, advanced space age technologies have uncovered dark lanes even around individual stars (likely comprising matter for forming solar systems), or even leftover dark and dusty matter around planets (such as in the case of Neptune, where a dark mantle many times the planet's diameter orbits around it). The term 'dark lane' has even been used to describe certain near-undetectable features in the white icy Martian polar caps.

The list can go on, but suffice it to say that these types of phenomenon cannot be included for the purposes intended here, especially since it is unlikely any of them would be even remotely possible to observe with the means normally available to most observers. And it is hardly necessary to comment that we will not be expecting to see that most feared of dark phenomena – black holes – yet to be observed or imaged by any means. However, as in other cases of esoteric questioning, it has been possible for major research institutions to observe and measure the effects of them. (The effect of a massive black hole at the heart of the Milky Way has been studied from observations – made in not normally visible wavelengths – of stars circling around its extreme inner core.)

What we will look at, however, includes many examples – some notable – from among those that typify the traditionally accepted definitions of the terminology (dark lanes, dust lanes, dust belts, dark nebulae), and which include the dusty mantles encircling and permeating many galaxies, the mysterious dark tentacles and lanes crisscrossing many globular star clusters, occasional dark bands and mottled regions within some planetary nebulae, dark voids within our own star system that snuff out clouds of background stars or luminosity (i. e., Barnard's Dark Nebulae), those unlit and partially lit portions within otherwise bright diffuse nebulae (especially star-forming regions of infant open star clusters). Supernova remnants commonly contain dark details that contribute much to their visual splendor, even if their makeup is not truly dark. More than a few mature open star clusters (those that have mostly emerged from their cradle cocoons of creation) also command a little attention, not because of themselves but because of remnants of dark lanes or unlit regions that seem to be revealed in their midst. Overall, it seems there is considerable potential. However, the very nature of these phenomena requires a more subtle approach than with most others.

As astronomical observers, often it seems there are few extremes to which we will not go in order to gather every possible photon of light from the remote reaches of space. The obsession to extract the maximum from whatever may be there is only normal, after all, since the universe, as we know it, is only defined to our senses by what we can see. It's our natural common compulsion. However, it seems that whatever we are able to see is never enough, brilliant enough, or sufficiently telling in detail to lay the monster to rest. Indeed, the reality is that we are always grasping at shreds of detail, and those shreds of detail that we are able to see always lie tantalizingly close to the visual limit – which explains the popularity today of imaging over actual live observing in the amateur community.

Regardless of our approach, though, as observers of one type or another, the countless faint glowing specks and diffuse patches that populate the vault above continue to beckon us all – almost hypnotically. Thus, the never-ending, age-old ‘disease’ (sometimes termed and well-known in astronomical circles as ‘aperture fever’), which affects (infects?) the majority of observers, is always a constant reminder that the cosmos will only begrudgingly yield its secrets to mere mortals. However, those very difficulties we encounter as observers should also be a constant reminder of the need to remain open to any and all means available that may enhance the performance of whatever equipment we already have, whether our viewing is live or via imaging. Strangely, different approaches, and especially new technologies, have become competitive issues to many in the amateur astronomical community – even sore spots – as what is considered an acceptable method to one is an anathema to others. (As primarily a live observer, this author, too, has been guilty on occasion of not being too eager to praise the more indirect methods of observing, such as CCD imaging. Guilt indeed.) Even the word ‘cheating’ has been used when describing certain means other than those ordained by others! However, shouldn’t the objective only be to *see* more? We should all keep this in kind before dismissing anything out of hand.

In the ongoing quest for more light and better vision of one kind or another, it is all too easy to overlook the fact that dark objects in space are only visible as a consequence of being observed as a kind of cosmic silhouette against glowing backgrounds; they may even appear to shape many illuminated subjects. As any avid observer knows, dark structures in the cosmos consist of more types than just the familiar dark nebulae of the Milky Way, although many have much in common. Whether viewing ‘local’ spectacles, such as star clusters, illuminated and planetary nebulae, or examining details in far-flung distant galaxies, one would be hard pressed not to notice the many dark and dusty lanes, belts, streaks, spots, and voids that characterize or punctuate so many of them. Perhaps many of us have spent only a little more than superficial time exploring these phenomena, let alone really contemplating or even fully comprehending their significance.

What Types of Dark Feature Can We Expect to See?

Some straightforward, easily observed examples (Fig. 2.1a–h) typify the various categories of dark features that form much of the basis of this book, and that we can expect to be able to observe. While being among the most prominent, and readily observed examples, they clarify the essence of what is being discussed, even though the majority are not likely to be quite so accessible at the eyepiece. Most of those shown in Fig. 2.1 may be seen even with fairly small apertures (though with larger ones, naturally they will appear more striking and detailed).

(a) Within the ‘Lagoon Nebula,’ M8, the bright open cluster of newly forming stars irradiate and effectively illuminate the surrounding molecular hydrogen (HII) gas, which serves as a backdrop for the many dark lanes transecting it.
(b) The famous ‘Propeller Lanes’ – the first such dark features to be noted in a globular cluster – show readily at the 2 o’clock position towards the right upper side of the Great Hercules Cluster, M13.

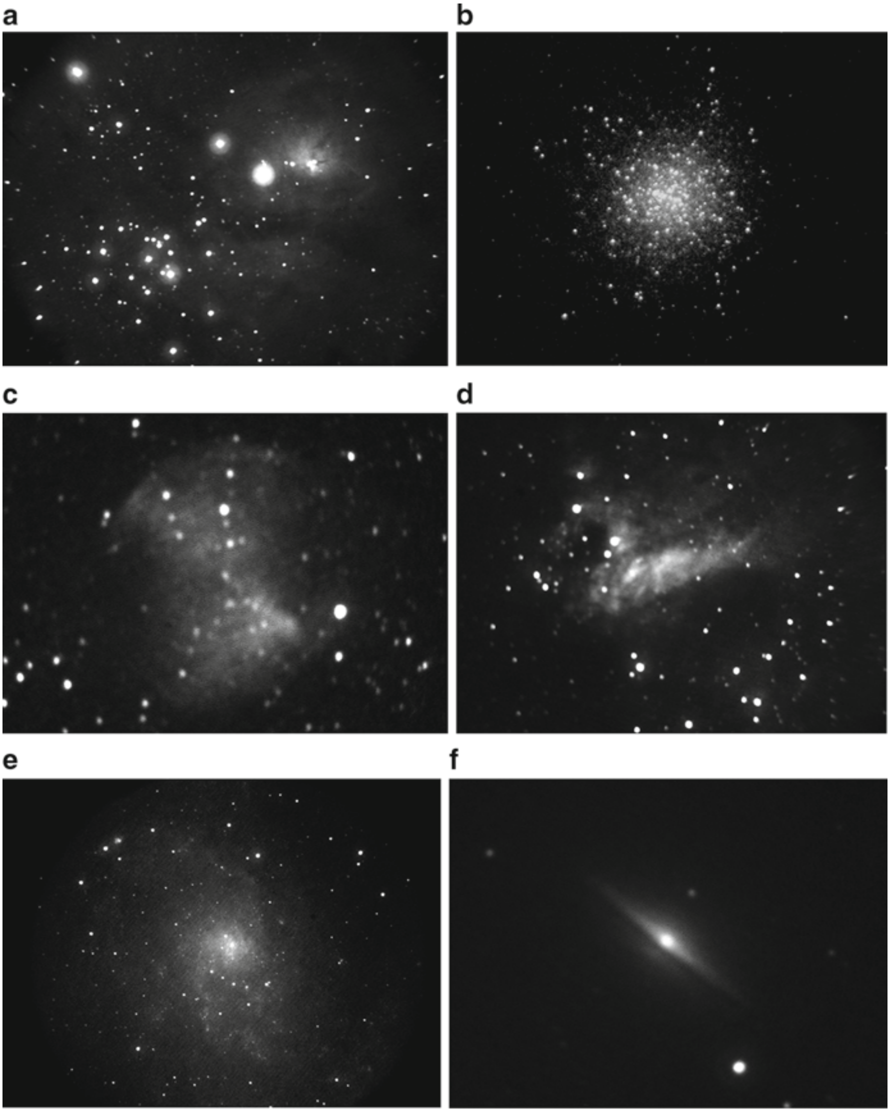

Fig. 2.1 (**a**–**f**) Deep space objects showing dark features (**a**) M8, the Lagoon Nebula; (**b**) M13, the Great Hercules Cluster; (**c**) M27, the Dumbbell Nebula; (**d**) M17, the Omega Nebula; (**e**) M33, the Pinwheel Galaxy; (**f**) M104, the Sombrero Galaxy; (**g**) M82, the Starburst Galaxy; (**h**) M1, the Crab Nebula (Images by Antony Cooke: standard digital camera, 18-in. Newtonian Reflector, Generation 4 image intensifier; exposures from 1 to 10 s)

g h

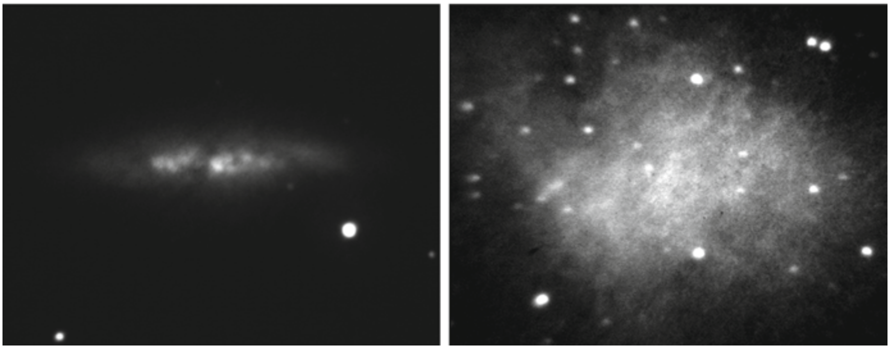

Fig. 2.1 (continued)

(c) Within the planetary 'Dumbbell Nebula,' M27, can be seen many dark details including intriguing concentric striations, presumably produced by variations in stellar wind vibration and difficult to detect by most means of observing (see "Viewing Skills, Accessories and Other Considerations" later in this chapter).
(d) The 'Omega Nebula,' M17, illuminated by young stars and defined by dark nuances. Even the surrounding space is made noticeably darker on one side than the other by the presence of dust.
(e) The 'Pinwheel Galaxy,' M33, is notable for its many mottled HII regions in its spiral arms (the largest being similar to our own 'Great Nebula in Orion,' M42), as well as dark details (interstellar matter) throughout the whole structure.
(f) The prominent dust belt surrounding the 'Sombrero Galaxy,' M104, is the defining feature that characterizes its appearance, in addition to the slightly oblique but otherwise edge-on, presentation relative to us.
(g) The striking bipolar character of this Starburst Galaxy are on full display to see, appearing as dark features intersecting the core at near right angles to it; the galaxy is bright and substantial in the field of view, and the detail is plentiful and complex.
(h) Remarkable irregularities are visible in the overall structure of this star wreckage (the remains of the supernova of 1066); while dark features in such objects are not common observing fare for observers, occasionally a few such details may be present and justify the effort at the eyepiece, as can be seen in this rare example.

While the dark regions and details shown in these examples are immediately obvious, hopefully they will serve to suggest a little of the enormous viewing potential awaiting the observer. More interesting, ultimately, are the many subtle and specific nuances and shapes comprising each dark feature, as we delve a little further and deeper into each one. Indeed, it seems there are no two such structures or features quite alike.

Preparing the Eye for Observing

Dark lanes or features may be elusive in nature, since they are not illuminated, after all, but contrasted against what are usually pretty faint illuminated larger regions. As an approach to preparing for a viewing session, perhaps the best first step might be to seek out fine images from a large observatory, the Hubble Telescope, or possibly exceptional amateur examples, *if* appropriate ones can be found. By the word appropriate, the inference is that the images are not awash in light, eliminating any subtle dark detail in order to show what is illuminated. It is all too true that whereas imagery of the Hubble Telescope and other advanced instruments are serving us much better these days, you will likely often be disappointed to find how wildly overexposed the central regions of many subjects are in order to show the full extent and glory of the spectacle. The upshot is a magnificent sight, obtained, though, *usually at the expense of those very dark features that we might have hoped to see with our telescopes!*

Those very bright regions are what make dark features visible, of course, but usable exposures on these images cannot be taken for granted. However, the listings of objects at the end of each chapter of this book reference the features under discussion, a little pertinent information for each object, as well as listing suitable images that are available online wherever useful. There is nothing better than examining in advance a good representation of what one is looking for, or hoping to see. Sometimes previously missed faint dark features ‘jump out,’ or at least take on new significance in the live view when we are better prepared. Naturally, some of these referenced images are more helpful than others; many may be simply too low in resolution to help in defining subtleties of the type we might hope to see at the eyepiece.

Thus, because of the intended purposes of much observatory imagery, keep in mind that live viewing often produces surprisingly different visual impressions of everything we see. This is particularly noticeable with images of globular clusters, which may be unrecognizable in their real time counterparts. Although the details shown in such grand imagery are not likely to be visible at the eyepiece, those that we *might* have seen are all too often erased by the brilliant stellar illumination all around as it intrudes into everything in the frame. Many such examples of globular clusters show finely resolved stellar populations right to the cores, while appearing completely devoid of any evidence of the dark lanes that have become the source of much discussion and controversy. Frequently, this is due to the length of exposure that allows some of the light of stars *behind* the dark obscuring material to penetrate and register, or perhaps it is the finesse of the image (as in many Hubble Space Telescope examples) that actually detracts from the eye’s sensitivity to noticing subtle irregularities. Rest assured, the lanes, at least as we know them visually, have not disappeared! It is a sad fact that a healthy supply of appropriate images of globular clusters, and often many other deep space objects – that we might have hoped to use as a guide – simply don't exist in most readily accessible reference sources. Whenever you are fortunate enough to find them, you might try to affect a kind of reversed mental polarity (in approach if not actuality), where you consciously allow any dark features to define what you see, and not the other way around. This can be applied in live viewing, too, of course.

The challenge of finding appropriate resources doesn't stop with images but also, surprisingly, extends to written reference materials. For the most part, you will soon become aware that within commonly available sources, to find anything beyond the most general or superficial remarks, even the most basic descriptions about dark regions and features is also something you cannot take for granted, because usually all of the attention is focused instead on what is illuminated, or on other more esoteric aspects. It remains an unexpected challenge to find insightful, detailed information or descriptions about any of these dark phenomena. And certainly, it is rare to find in detailed discussions about specific deep space objects more than the mere acknowledgment of to any features' existence – if anything at all. Perhaps odder still in many respectable sources is the frequent omission, or even the slightest reference, to *celebrated* dark features, now generally well-known and regularly sighted, such as, for example, the famous ‘Propeller Lanes’ in the great globular cluster, M13, in Hercules (Fig. 2.1b).

The observer should always remember to bear in mind, though, that just because part of any subject may appear dark, it does not necessarily follow that dusty matter is present; it may be that there is simply nothing there! In other instances, dark details may be merely less luminous portions of a whole. Regardless, once our interest in looking for such features has been prompted, it is likely that we will always look at everything just a little differently, just to make sure we don't miss anything. And viewing is still likely to be interesting when we are not seeing true dark features, because what is merely *less* illuminated still may appear to be sculpting what we see.

Actually, while many amateur observers have pretty much ignored what is unlit in the universe, they are in good company. Apparently, most of the great observers of the past have given the subject surprisingly short shrift, too, as specific and detailed descriptions of cosmic dark features seems always to have been in short supply. Among those ’big league’ astronomers, certainly one notable exception was the legendary E. E. Barnard, who was so fascinated by one type of dark phenomenon – the dark nebulae of the Milky Way – that he cataloged and carefully plotted them, 370 in all. There are, indeed, in Barnard's catalog detailed descriptions of these phenomena, although perhaps not all of them are necessarily helpful to the amateur observer. However, at least it would be good to find the same level of readily available descriptions for everything else that is dark in space, too. Thus, this book is a small attempt to begin to redress the overall imbalance for the observer, especially one who has access to a moderate-to-sizeable telescope and some decent viewing situations – that is, dark, transparent air.

For obvious reasons, within this writing we cannot look into more than a fraction of all that there is to see. But with the degree of attention accorded those selected for analysis in this book, there should be enough to ponder that it might cause the observer to re-examine alternative viewing approaches and some interesting new potential targets.

Viewing Skills

- First of all, for seeing any dark features or detail, there is nothing to beat dark sites and dark adaptation. The cosmos is never awash in visible light for the amateur observer, and contrast remains the key. Thus we need to maximize whatever ability we have to register the very light against the dark features that show. Always allow a little while for dark adaptation before any serious observing begins – just 20 min away from light sources should accomplish much of the benefit we need. However, with enhanced electronic viewing devices (see later) of all types, their viewing screens are so brilliant relative to anything we are used to in astronomy that much adaptation won't even be possible, let alone necessary! We will, however, still need dark skies.
- Remember that only the central portion of the retina provides detail in vision (the macula), and the outer portions are the most light-sensitive. That old skill known to all seasoned astronomers as averted, or indirect, vision, will reveal dark regions and details better than anything else, plus it costs nothing! While there are differences among many in the astronomical community on how much boost it can actually provide, there can be little doubt that successfully utilized, it can result in near dramatic gains in whatever the eye is able to detect.
- The word 'detect' is the key here, and while our peripheral view of the world shows nothing like the amount of detail we see in the central field, our first consideration is becoming aware of otherwise elusive sights. Once spotted, 'seeing' them more readily with ones' central part of vision becomes almost a routine. Typically, most people who have never spent any time with a telescope in the dark are unaware of this benefit. Others may suffer from the terrible medical deterioration of the central vision known as 'macula degeneration,' and will be all too aware of this critical aspect of eyesight.
- You might experiment with what part of the eye's field of vision is most effective; many observers feel that the inner part of the field is more sensitive than the outer, although this writer does not recommend one over the other. However, all of our natural reflexes try to bring our attention towards the central macula as we observe. Thus, the skill of this part of astronomical 'seeing' involves learning to steer one's visual reflexes away from the brain's natural visual 'programming' to center the image for detail. Instead we have to apply them to a technique that defies all of our instincts: scanning the image around the periphery – something that requires practice and patience to fully master. It is made all the more difficult by the eye's tendency to 'flicker' around the field in protest. However, once mastered, new details suddenly appear more readily.

- Additionally, from time to time you might throw the image in and out of focus; the newly focused image seems to refresh the eye, and details seem more readily revealed. The eye also seems to benefit from starting to focus again from scratch, and perhaps we will find that the point of sharpest focus seems to vary by tiny amounts. We can only assume that the eye may impose certain focal adjustments of its own that may put additional strain on it; relieving this strain could therefore only benefit.
- You might try periodically tapping the telescope tube – thus taking advantage of the sensitivities of one's vision to motion in order to snare subtleties in the field of view that may initially escape attention. It may even help in initially locating an object, after which the object seems to take on increasing prominence. While we know that cats' vision is dominant toward motion, humans also share a degree of the same sensitivities.
- There is also the matter of determining ideal illumination in the eyepiece view via the magnifications we select. If there is too much brilliance, often by utilizing too low a power, any subtle dark features could become washed out, something certainly true of many time exposures. Although the eye does not store light in the same manner as do time exposures, it is not able to prevent the encroachment of light on surrounding areas. The way we see brighter stars as somehow larger than dimmer ones illustrates this well. Thus such underutilization of magnification only contributes further to any existing lack of awareness we might have of the dark features themselves.
- In a seeming contradiction, it is also true that many deep space subjects only reveal their true dark details to the maximum extent when subjected to magnifications that one would normally consider ridiculous for faint subjects, but such powers may be effective through the unique attributes of the particular object under scrutiny. After all, decreased illumination in the eyepiece would also seem to mean less contrast – at least theoretically that would seem to be the case, but in practice that is not how it plays out. The eye has certain inexplicable attributes with regard to its specific sensitivities, although highly subtle indeed. Only trial and error will determine which power selections to use. Therefore, always take the time to try several magnifications *for each object in view;* there will always be one with which dark features stand out better than the others. Any skilled observer has experienced these seemingly inexplicable quirks of optics and vision, and probably is at a loss to explain them.

Utilizing these simple techniques adds to our 'seeing' skills – the ability of the eye and the brain to extract and transmit any and all scraps of visual information, ultimately assembling what we 'see' by assembling them into a composite, an amazing testimony to the special human abilities to put such a jigsaw puzzle together. While the process sometimes may be slow, the effect of it is that whatever is eventually perceived to be present in the image becomes obvious, but only after the fact! The upshot of all of this is so striking that one can hardly imagine how these subtleties and details were not easily seen at first glance.

As with all things in practical astronomy, in addition to these viewing skills and others acquired over extended time at the eyepiece, good viewing conditions, a minimally light-diffracting telescope, and some additional specialized types of equipment can all help further with the rather delicate subjects we are looking at. And dark features are always delicate subjects to be sure. Plus, while no special additional equipment, beyond the normal hardware amateur observers use, is actually a *necessity,* in order to participate most effectively there can be no doubt that certain filters and electronic devices (most are highly infrared sensitive) do show dark regions better – and also reveal some that would otherwise be invisible. Also by ramping up the illumination of what we see, they provide increased contrast and even ease of viewing. Indeed, if the opportunity allows, it is interesting to observe these objects through a succession of natural, filtered, and intensified viewing, (and still through as wide a range of magnifications as the subject will allow). In each of these methods of viewing, quite a noticeable variety may be seen, when just as strikingly different aspects become more or less prominent.

Equipment, Accessories, Viewing Skills, and Other Considerations

Telescopes

Astronomy has always been tied closely to the development of optics and telescope design. It has only been possible to ascertain proper scientific conclusions with the advent of more sophisticated means of probing the cosmos, and thus, we cannot blame earlier observers for incorrect conclusions they may have drawn; they were only able to deduce what they did from the quality of information reaching their eyes and minds. Indeed, we can only marvel at just how much they were able to accurately determine. We benefit today not only from better optics than many earlier observers had at their disposal, but also from a better understanding of the many subtle nuances of the subjects we are seeing. Although all of them may look dark, certainly they all do not fit the same blanket description!

Because one cannot overemphasize the critical need for contrast in observing anything dark, that is, the degree of illumination versus a similar degree of darkness, success is thus tied to aperture at the most superficial level. It is also tied to optical quality and design. In this regard, modern instruments hold a tremendous advantage over those available to earlier astronomers. Thus, while all telescopes today probably will deliver greater contrast than anything available not so long ago, obtaining the maximum potential contrast is only as good as the telescope design will allow. Considering what is available, many optical and mounting designs are, quite frankly, less than ideally suited to delivering this important attribute. It is dependent on various factors, including introducing too much scattering and diffraction of light, instability of the assembly itself, even awkwardness imposed on live observing, all of which degrade either the image or what may be gained from the efforts taken, to a greater or lesser degree.

There is no shortage of comments regarding the relative merits of different types of telescope, but a few additional words emphasizing an all important ingredient – contrast – for revealing best all that is contained within this book would not be out of order. Telescopes with large secondary mirrors, for example, such as the very popular lens/mirror catadioptric designs, are among the least suited to this form of astronomy (to say nothing of other forms of it), because of their huge, light scattering secondary mirrors, as well as the light absorption caused by the additional corrector plate optical component. Although they may be capable of giving us fine images through later computer processing, for live viewing, regretfully, they are much less than ideal. And poorly mounted instruments that vibrate, wobble, do not allow fine adjustments, are awkward to manipulate, or that otherwise react unfavorably to every tap and gentle wind gust will likely prove just as damaging to the eye's ability to resolve fine detail, especially the ever-subtle and elusive character of dark objects and features.

Perhaps surprisingly, more than a few dark objects and features will provide dramatic views at the eyepiece. However, aside from a crucial need for the darkest skies and most transparent air possible, having a few extra tricks up our sleeves will be found to be helpful. A good, larger pair of binoculars will prove invaluable, or an extremely low power, wide aperture scope. Once commonly termed a 'richest field' telescope (RFT), this might prove even better for all but the smaller nebulae. Many of these nebulae are extended objects that will not only benefit from wide fields of view but also the increased contrast that low powers bring about.

Refractors, with no secondary mirrors to cause diffraction, may appear to be an ideal choice for our purposes, but still need to be approached carefully, as they present other detrimental issues all of their own. For sufficiently large apertures, most achromatic telescopes of this variety will prove too costly to buy and come with a host of other drawbacks, not the least of which is chromatic aberration, especially among the larger sizes, along with drastically increasing weight and unwieldy lengths with every inch of aperture gained. Chromatic aberration, appearing as bright color fringes around focused objects, and not completely solved by the development of achromatic lenses, would tend to eliminate these telescopes as an ideal choice for seeing subtle dark details near the periphery of any object, along with rapidly increasing problems of this type seen in the larger examples. And this is even if apertures approaching the much more typical amateur Newtonian (8 in. and larger) were practical from a cost standpoint. As a final comment, it is fair to say that the color-fringed images seen in any of these larger achromatic refractors would shock habitual users of almost any other type of modern telescope.

Apochromatic refractors were designed to overcome all such chromatic aberration problems, and certainly they do; they offer almost faultless performance in this regard, along with reasonably compact focal lengths. However, while likely to be the best of all, optically, of all the refractor family (indeed, of any other?), sadly their extremely high price relative to aperture makes them a questionable choice for most amateur budgets, at least if live viewing is your main priority. For imaging, they can hardly be faulted, despite the fact that resolution is still commensurate with aperture. Regardless, some remarkable amateur imagery has been produced by surprisingly small apochromatic refractors – although not more so than with fine Newtonian reflectors of little more aperture – but the apochromatic refractor's very compactness compared to other refractors (typically featuring focal ratios far lower than normal achromatic varieties), and simplicity of use may make such a telescope the choice of the astro-imager on the go, if not the live observer of subtle deep space objects. Perhaps the more significant downside, though, is obtaining them in larger sizes – unless money is no object, and portability not a requirement – because they rapidly become disproportionately heavy and costly with increasing size. Prepare to be stunned by the prices of these larger sizes. Those that the average observer is likely to have will not usually exceed 7 in. (17.5 cm), and in fact, in the commercial marketplace significantly larger sizes than 7–8 in. are actually unknown to this writer. Even then, this still does not deal with the type of telescope that offers the most ease of use from a visual standpoint. And sadly, it is not the apochromatic type. For live viewing, as opposed to imaging, considering that virtually all varieties except the Newtonian require that the observer to peer in from underneath (or use a diagonal, which further reduces image brightness), this seemingly innocuous characteristic is more significant than it may seem at first blush. And we should fully realize that larger apertures of good quality always produce more detailed images than comparable smaller ones; thus, for my money, this brings us back to the Newtonian. Other types of reflector still do not have equal advantages and come with other drawbacks of their own.

The Newtonian reflector design (actually known formally as dioptric) ought to be taken more seriously by those all too quick to ignore its lineage, performance, and sheer value. It is still the best overall telescope for the money and comes with some significant advantages over any other design. Isaac Newton, the scientific colossus, not only produced the exquisite design itself (a more pure form there never has been), but he solved the problems of optical mirror making to the degree that reflecting telescopes finally became practical.

Because we are looking for contrast above all, Newtonians with longer rather than shorter focal lengths feature smaller secondary mirrors, and, in addition to their optical simplicity and purity of design, scatter the least light and will thus prove the best contrast performers among the reflector breed. For maximum results, however, many may suffer from too large a secondary mirror in configurations of short focal ratios; try to select one with a diameter less than 20% of the primary. Even less, say 15%, is better yet. However, since all Newtonians are virtually certain to utilize secondary mirrors with appreciably less than the huge catadioptric secondary average of 35%, a good one will provide infinitely superior viewing (especially of subtle subjects in deep space) than any of these telescopes would offer at the best of times.

It is worth pointing out that the telescope used for all of the author's imaging in this volume is of the Newtonian design, but its F4 configuration and 22% secondary mirror makes it less suited than would be those of longer focal lengths and smaller secondaries. However, in practice, the quality of the telescope and its substantial 18-in. aperture (to say nothing of its outstanding mechanical design) certainly compensates to a large degree, and most observers would be hard pressed to tell too much difference between this instrument's performance and one with a secondary mirror significantly smaller. The payoff is, of course, that such telescopes, with their short focal lengths, have made what would have been truly sizable and unwieldy instruments of yesteryear quite practical today, something we must always consider when transporting our equipment to places where the sky is truly dark and transparent. Long focal ratios and small secondaries in this configuration are capable of delivering results not significantly inferior to the best refractor designs, contrary to popular misconception. It is fairly safe to say that the very best refractor would still not perform much better than a fine Newtonian of perhaps no more than a third larger. However, such telescopes are likely to be more difficult to transport to favorable sites, if not impossible.

Remember, above all, for seeing dark detail, we need light grasp, along with good optical quality and design if we are to have the best resolution and contrast possible. This means optics that are clean and scratch free. In addition, the telescope preferably should have ease of use, portability (in order to get to dark sites), and, presumably for most people, the affordability that still allows all the other requirements! These qualities are the name of the game. None of the things featured in so many commercial products today (all those fancy electronic 'features'), which cost so much and deliver so little in terms of viewing itself, are likely to provide a real return for the money. With the exception of good digital setting circles (which become quite critical when tracking down dark shadows of the night), there are few such features that offer value in line with the high cost at which many of them come.

Regarding suitable apertures, for live viewing of all dark subjects and features, sadly it is not realistic to expect *exceptional* views of anything other than the most prominent dark objects (and thus, relegating the potential to those relatively nearby), with apertures much less than 8 in. (for a reflector). While lesser sizes are far from useless for the purpose, only more substantial apertures than these will have any realistic prospect of resolving the more subtle features and details, especially the least obviously dark ones at that. By way of differing eyesight capabilities as well as viewing skills, some observers might disagree and lower or raise that number somewhat. However, hardly anyone would disagree that the true realm of witnessing deep space at the eyepiece, and accordingly being able to see potential dark features, lies with apertures significantly *larger* than the minimums any of us might recommend.

Thus, it is fair to say that the best potential *for viewing at the eyepiece* is most likely to be delivered for most observers using telescopes of 12–20 in., and in good conditions. Otherwise, a more indirect approach with smaller apertures, utilizing time exposure or compound imaging of one type or another, may be the only avenue for the serious observer in order to best pursue what is described here. While indirect forms of observing may suit many, it will not suit all, although it does enable telescopes of apertures much smaller than those discussed here to offer surprisingly impressive results. And while image intensifiers (more below) enable moderate apertures to perform with the light grasp of much larger ones, resolution is still dependent on aperture itself; however, contrast will be enhanced. These devices really come into their own when coupled to the more imposing apertures available to amateurs, such as the the range just mentioned. As with everything else in astronomy, ever-increasing apertures of high quality (and hence ever-increasing light grasp) will deliver ever-increasing results.

Specialized Filters

Despite the fact that many of today's advanced polarizing filters were originally designed to soak up the sky glow of cities, they often do noble service in dark conditions, too, by blocking competing wavelengths within or even around the objects we are trying to study. Once this potential was realized, many different types of specialized wave-blocking filters would soon emerge, produced in numerous varieties.

Common in the marketplace today, no manufacturer offers a more sophisticated or prolific range than those offered by Lumicon (now owned by Parks Optical). With the use of these specialized filters best suited to different objects, some objects appear distinctly more luminous than with unaided viewing – perhaps surprisingly even under the best and darkest of conditions. Subjects seem to stand out from the backdrop much more noticeably, and many dark regions often take on new prominence. Although there are so many different filters, it is fair to say that only narrowband varieties are truly useful. However, keeping an open mind and trying whatever may be on hand still remains the best approach. By this, you can take it that some of the broadband varieties intended for general purpose are of limited value to our special needs, but you should probably try them anyway. One never knows what experimentation may bring with any particular object.

Some of the more sophisticated catalogs of such products are worth perusing. Lumicon's specialized filters for general deep space use include Ultra High Contrast (UHC) filters for enhancing illuminated nebulae, Oxygen III (doubly ionized oxygen) filters for certain illuminated and planetary nebulae as well as supernova remnants, their special and much celebrated 'Horsehead' filter, also potentially useful for a host of other faint nebulae, but made famous for showing that single item exclusively.

It is always worth checking the catalogs of the major telescope manufacturers as well, such as Meade and Celestron; they offer extremely comprehensive ranges of filters at reasonable prices, even if not necessarily quite as sophisticated a product line as that produced by Lumicon. Another company, Orion, while essentially supplying products to a broader segment of the astronomical public, also produces perhaps the best narrowband filter overall, under the name 'Ultrablock.' In the opinion of this writer, this filter works perhaps more effectively on a wider range of subjects than does any other, while also being surprisingly affordable ($100). Certainly no aspiring observer of dark and delicate detail should rule out any of these accessories casually, as they will pay for themselves many times over with impressive results that they are likely to produce at first glance through the eyepiece. Always bear in mind, however, that despite the increased contrast, the view will be dimmer, and they are not usually effective when used in conjunction with electronic enhancing devices (see below).

Electronically Enhanced Viewing

This is not the first book in which this writer has extolled the virtues of some very advanced electronic technology available today. Criticisms of this preference are hard to understand in light of the advantages that they bring and in spite of their relatively high cost; but there is nothing to beat a closed mind. There are several options, although those referred to here are either CCD video devices or image intensifiers. Aside from dramatically boosting the brilliance of what we see, part of their effectiveness is that they are so responsive to infrared and other wavelengths normally invisible (or only slightly so), making parts of hitherto dark regions show as illuminated to some degree, thus rendering them visible where they were not before. On a more immediately obvious note, they also boost the bright backdrop of emission nebulae, and many truly dark details may become more readily visible through the greater contrast resulting from their use. For the observer, this is one of their greatest strengths (especially concerning image intensifiers); it certainly more than compensates for their less than strong responses to light wavelengths in the blue part of the spectrum. However, dark skies are essential for most of the benefits of contrast; otherwise the effects of sky glow are also increased, which will void much of these subtle gains. As with every other type of viewing, the key to the best results still remains the quality of the air and the degree of darkness itself.

Regardless, the value of enhancing devices is frequently misunderstood; some people simply will never try anything beyond what they consider to be a valid observational approach. Many were jaded by the use of such devices long ago, while the technology was still in its infancy. It is likely that these same people have not tried a modern image intensifier eyepiece. But should astronomy be relegated to a sport where there are prizes for purists and ideologues, even when others may be actually seeing more? In the great scheme of things, it seems to this writer that anything that can help extract more insights ought to be fair game. But more specifically, let us examine individually how each of the two primary electronic aids may help us:

Image Intensifiers

The most advanced image intensifiers today, in particular Generation III, but even more so those of Generation IV, often dramatically reveal dark lanes in many deep space objects. (We can safely discount earlier generations in this quest, as they introduce too much image noise and too little enhancement of what we are trying to see.) While the wavelengths of light emitted from HII regions suits the response of these devices well, there is another benefit. The extreme heat (±10,000°K) of those same regions causes infrared radiation to be emitted, too, and because image intensifiers are also responsive to these wavelengths, otherwise unseen radiation becomes visible. Thus, these regions are further enhanced, and colder, dark and dusty regions are even better contrasted against them. However, image intensifiers are less favorably suited towards blue wavelengths, making reflection nebulae harder to see!

Furthermore, since image intensifiers have a less useful range of magnifications than we may be accustomed to, only larger apertures coupled with these devices allow higher powers to be used effectively. This is an important consideration, quite outside further increases in the brilliance of the image. An advantage with late generation (IV) devices is superior resolution than any other type of electronic viewing device. However, because some dark subjects only reveal the most interesting fine detail when examined more closely, we may not always be able to take advantage of the resolution in every case, another downside with smaller apertures.

Despite the brilliance of their output, the selected characteristic green phosphor screens of image intensifier tubes are nevertheless geared towards *some* degree of dark adaptation, although the images they produce are brilliant by astronomy-in-the-field standards. While this may seem less so in the dark of night, you may safely use a dim flashlight (or a bright one when used indirectly) to look at charts without compromising whatever degree of dark adaptation is needed and remains. Incidentally, while the intensifier the green color may be initially distracting, in the darkest conditions the eye, and eventually the brain, registers the image more simply as black and white.

CCD Video Cameras

Less direct than image intensifiers, but still possible to use as live viewing devices of sorts, frame-integrating CCD video cameras also provide good potential for enhancing and detecting dark detail. Relatively inexpensive, they have a strong response in the red and infrared part of the spectrum, even if not quite as much as the best image intensifiers. However they remain highly viable options for the observer looking to extract more from his or her telescope time and especially budget. By and large, because many of the previous comments about image intensifiers apply to CCD video cameras as well, we need not elaborate too much; suffice it to say, the primary differences with CCD video lie with the observing experience itself. While the chips they utilize are amazingly sensitive to low light levels, and offer some of the same advantages as image intensifier eyepieces, they lack true real time capabilities (but only by a few seconds!) and do not have quite the crispness, resolution, and refinement of view. The result of compounding many individual frames to build the image simulates the live experience fairly effectively, although viewing is confined to a monitor, and the personal connection unique to live viewing is somewhat diminished, if not lost altogether. But don't be put off by the frequent elitism decrying any types of electronic device – or the use of *anything* outside the most accepted norms of observing (the norms established according to others' ideas). These new-fangled tools do the job.

Observing with Electronic Enhancing Devices

The following comments apply to both image intensifiers and to a large degree to CCD video cameras as well; the responses of both are similar, if not quite identical, through much of the spectrum:

- *Globular Clusters*. The light from globular star clusters is skewed toward the red and orange frequencies, due to their makeup of old Population II stars. Thus, this very type and its characteristic coloration means that with electronic enhancement, we can expect significantly more dazzling views of these objects than the views of many others. While image intensifiers, especially, make some objects take on a subtly different appearance – due to the differences in the spectral response of these devices versus the human eye – globular clusters are a perfect fit. Significantly differences to the overall visual impression of the structure and form of such clusters, as might be the case in objects where a wide range of light wavelengths are present, do not apply. This is despite the minor downside that the subtle dimensional effects we experience in the conventional view – where such clusters appear to loom out towards us in a ball of lighted points – are lost, which is an illusion anyway, of course. Electronically, these objects tend to look altogether more two-dimensional, although in no way does it negatively impact the prominence of dark lanes within these clusters. These are actually greatly enhanced.
- *Dark Nebulae*. With these subjects, there is always unseen potential for surprises. Being parts of the interstellar matter we know as the great dark belt of the Milky Way, it has often been reported that image intensifiers reveal nebulous patches, as well as other unexplained sights, where none are cataloged on any standard chart! However, what we are likely seeing are regions within the interstellar matter made newly visible by the intensifiers' response to infrared wavelengths: maybe star birth activity is taking place deep within a dusty cloud, or a faded deep space object is still emitting some heat. Although any number of other possible explanations could also apply, these tools' special value to the astronomer is only further emphasized. Naturally, where star fields are particularly bright, any dark nebulae present will be greatly enhanced; the densest among them (i.e., molecular clouds such as B86) standing out like a long time exposure. Larger regions of dark nebulae may be very effectively viewed with low magnifications (in conjunction with an RFT – see earlier), or no magnification at all (see Chap. 3).
- *Galaxies*. With image intensifiers, these objects provide some of our greatest viewing pleasures and surprises, as well as some of our greatest disappointments. It seems there is no way to precisely predict the way any galaxy will

appear; some that one might expect to show little detail (such as face-on spirals with predominantly young blue stars in the galactic arms) can provide remarkable views. Surprisingly, in such instances, spiral form is often significantly enhanced where gas and dust is being irradiated to a significant degree and well placed, although the overall glow that fills out the galactic halo in conventional views is usually absent. Instead, cleanly separated spiral arms may be seen, sometimes strewn with mottled patchiness (i.e., M51), and dark regions between them often show well. However, just the opposite may result when irradiated interstellar matter is buried deep within the galactic structure.

Where galaxies are seen edge-on (i.e., NGC 891, NGC 4565), dark interstellar matter present in the arms is seen in concentration instead – through the galactic plane towards the core as dust belts. Here, these devices will seldom disappoint, throwing typically dark regions into stark relief against a typically brilliant hub, and usually with pronounced detail all along the belt. While greatly enhanced in brilliance, featureless galaxies such as ellipticals, being composed chiefly of old red stars, still do not appear more visually interesting than in the conventional view. Their forms will only appear more prominent because of their dominant Population II star makeup; however, dusty matter is still absent! We may have some pleasant surprises, however, with certain lenticular galaxies, as with some irregular, peculiar, and starburst galaxies (i.e., M82, NGC 253, NGC 5128), which usually have hugely varied and striking dark regions and features, and may produce some of the most exceptional views of all.

- *Diffuse Nebulae*. Because these regions are often where star formation is taking place, we are likely to find electronic image enhancement particularly helpful in exposing unsuspected detail, while throwing many hot and irradiated regions into more striking prominence. Because these nebulae frequently contain reflection components as well, we can expect to see these aspects much reduced, sometimes rendered even invisible. However, dark details are likely to take on new prominence (i.e., the 'dark lagoon' in M8), while the dark 'folds' and other shapes take on new significance (i.e., M42, M16). Some nebulae will resemble long images of exposure photography.
- *Planetary Nebulae*. These subjects, made visible by irradiated molecular hydrogen and hot ash, will seldom disappoint. Often, some examples suddenly reveal remarkable amounts of detail, such as the 'Cat's Eye Nebula,' NGC 6543, where the twisted helical-appearing form for which it has become famous jumps out in the view at first glance. We would be unlikely to see such revelations in conventional viewing without giant apertures. Other planetaries will show the ionized rings, regions where irradiation is taking place most strongly as the winds from the central stars push the glowing HII and ash ever further outwards and, characteristically of many planetaries, with startling clarity. Any dark detail and features present that are usually lost in the conventional view may be significantly enhanced. The variations of such detail are potentially limitless, and we may regard these objects as some of our best opportunities for image intensification.

Astronomy Software

Many observers have increasingly utilized advanced computer applications, the best of which provide extensive catalogs and information. This type of software is the new horizon for many, and brings a level of professional observatory sophistication to amateur observing that would have been unheard of not so very long ago. Among the very best is the *SkyX Professional Edition* for Windows or Mac, available from Software Bisque, which will provide detailed 'specs' for every conceivable object, as well as create and print custom sky charts, including dark nebulae from several catalogs. This software can even direct and drive your telescope with unrivaled accuracy and offers almost limitless additional capabilities. Certainly such means represent a new world of true accessories today, especially for those looking for a more refined approach to their observing or imaging sessions.

Imaging Method for Illustrating This Book

With the author not being an astro-imager in the accepted sense of the term, in some circles his alternative to commonly ordained imaging methods might be met with similar rejection to the hi-tech accessories just discussed! However, the goal was to provide a decent guide to what might be expected *in the live view at the eyepiece under dark skies* – with moderate to large apertures, utilizing a wide selection and composite of live viewing approaches (eyepiece alone, with special filters, CCD video viewing, image intensifier eyepiece, etc.) – a good overall average, one could say, if such a thing is possible. Without overlooking the fact that things always look better in the live view than on the printed page, a little comparison to results in the field will soon give the reader a good basis for expectation.

Because, from the author's perspective, it was also necessary to accomplish this in a fast, simple, straightforward manner, the images contained in these pages were obtained in the same ready and straightforward manner as those deep space images that were featured (and described as his best method to date) in *Make Time for the Stars* (Springer 2009), only with the slight refinements experience brings. It should also be emphasized that, while indeed the results do noble service in these pages as a good visual reference, they still lack that certain indefinable 'something' of the live view, as ultimately does all imagery. Thus, in addition to the allowances one must make according to equipment utilized, etc., one must adjust one's expectations accordingly and reasonably. It is always better in person. In certain cases, because the specific range of responses of the image intensifier utilized is so different to that of the eye, the images may not be *exactly* as one would see with conventional viewing. In other instances, certain attributes stand out better, and sometimes not as well. However, this is only a general caveat; the images are not radically different from what might be seen live, and as such, remain well in line with such views.

Simply stated, all images (unless otherwise credited) were obtained by the author in the following manner:

- Short exposures were made at the eyepiece, via image intensifier (Generation 4) and either a standard digital camera with manual settings, or CCD video camera, with the focus carefully adjusted and as wide a setting as possible for the aperture.
- The camera was secured with a universal adapter that clamps directly onto the image intensifier eyepiece; considerable care was taken to ensure accurate alignment of these components.
- A Barlow lens was frequently included at times for extracting maximum resolution of detail, sometimes necessitating significantly longer exposures than utilized in the past, usually a couple of seconds or so, though never more than 15 s for the very faintest of subjects. Consequently, such lengthy exposures, of course, also necessitated more accurate polar alignment of the telescope, something that may be less stringently adhered to with 2–4 s exposures. Regardless, in concept at least, these images are as close to snapshots as possible.
- Every effort was made to maximize the use of pixels in the frame, including using the zoom lens of the camera to fill it to the maximum. In many instances it will be necessary to do this in order to eliminate coma at the edges of the field, the downside of the Newtonian reflector configuration.
- From the CCD video stream, single frames were extracted in what amounted essentially to 1/30 of a second snapshots! This reveals the great light sensitivities of these devices and the advanced chips they use. The camera was attached to the telescope tube, but for extremely wide angles was not coupled to the telescope optics; instead, a non-magnifying 1.5-in. primary lens with adapter was used.
- Generally, ISO settings never exceeded 400, in order to reduce image graininess.

The images are all are monochromatic – not in color – by default. Thus the illustrations used in this volume are comfortably presented in monochrome. (Image intensifiers are not designed to do otherwise, since they are set for maximum response at specific frequencies.) Because the intensifier output is green, the camera was set for maximum vividness in that part of the spectrum, which helps to compensate a little for differences on the printed page. Regardless, in deep space, this is also how the eye tends to perceive most color; when starved of its usual light levels, color is sacrificed for sensitivity, and the vivid hues we usually see in today's grand deep space imagery is not how we would ever see these objects were they close on hand, even situated nearby! While those spectacular colors do, in fact, exist, the low levels of light we would experience from almost any vantage point in space would still render them virtually colorless to our eyes. Of course, individual stars do show color, albeit in a somewhat more restrained fashion than we might believe we are seeing. In the appearance of the vault above, color is at a premium. Regardless, it is the absence of blatant color in extended objects that is the point here; we are primarily concerned with dark, colorless features anyway.

In spite of the care that one must take to secure optimal results, there can surely be nothing easier, or so frequently unexpectedly revealing, as this particular method of imaging. And seeing results immediately in the field on the screen of the camera does have its rewards after all; just ask any user of CCD video cameras. Only a little further experimentation is necessary for best results with each piece of equipment (telescope, camera, object, etc.), but suffice it to say, just as with film, keep the camera ISO setting low to moderate; otherwise, it will most likely lead to unsatisfactory, grainy images, which no amount of post processing can seem to eradicate. You might also keep the camera image size set only to medium (or even less) to avoid really large, unwieldy frames. One is hardly likely to need an image as wide as a room, or one that reveals no more detail than a smaller one; maximum resolution possible will likely already have been obtained much before this. We will not be able to attain the fine resolution of a long time exposure anyway. For those observers primarily bent towards live viewing, but interested in recording some of what they see by this method, post observation image adjustment at the computer is mercifully minimal.

Summing Up

Despite the author's bias towards visual astronomy, this is not to say that *nothing* here will apply to other less direct means of observing, such as long exposure imaging of any kind; indeed, virtually all of what is contained here is relevant to any form of practical astronomy. Perhaps this is even more significant than it seems, should it cause practitioners of any type to expand or refine their approach and stress dark features in their images. However, unless dark features or any particular object are accessible to the *visual* astronomer, they were not likely to feature in the author's imagery. Some of the more esoteric examples of dark or dust regions, such as Bok globules (possibly visual evidence of the condensing stages of stellar birth), remain primarily imaging subjects, and even then the unfortunate fact remains that quite sophisticated means are still required to capture them. However, if inspired to take up the chase of such difficult dark subjects, the most avid astro-imagers today are not likely to be deterred!

Because we cannot undertake a review of everything that there is to see, or even a fraction of it, the purpose of selecting certain subjects to review in detail is to merely introduce apparently often-neglected possibilities, if not also to encourage an added meaning to deep space observing. We will sample a good cross section of subjects and explore the potential in detail. If the result is a greater awareness of at least the type and range of features present and worth looking for, then the desired objective will have been achieved. (In the examples chosen for in-depth discussion, where observatory images add otherwise hard to describe insight, they will be included). After initially indicating the most immediately obvious dark region(s), the primary goal will be to spotlight as many dark features as possible within the entirety of the subject, either by simple description or graphic illustration. Some details will be subjective; others will only be explained away because illuminated matter is not actually present and a void truly exists. In describing them, it will not be enough to state merely that there is ‘a dark lane’ or a ‘dark region’!

Finally, we should always bear in mind that observing dark subjects and features, while fully tracing their extent and implications, requires a degree of patience along with all the refinements of well-practiced astronomical ‘vision.’ Perhaps properly anticipating the full visual potential is the most important preparation of all, as long as we do not end up with a mindset that ‘imposes’ details that aren’t there. We would not willingly wish to become modern-day ‘Martian canal’ observers, after all.

http://www.springer.com/978-1-4614-1185-7

Dark Nebulae, Dark Lanes, and Dust Belts
Cooke, A.
2012, XI, 243 p. 75 illus., Softcover
ISBN: 978-1-4614-1185-7