Chapter 10

Observing Techniques

Training the Eye

It's often been said that the person behind the eyepiece of a telescope or pair of binoculars is much more important than the size or type or quality of the instrument itself. An inexperienced observer may look at the planet Jupiter and perhaps detect its two major dark equatorial bands, while an experienced one will typically see more than a dozen belts and bands using the very same telescope at the same magnification. Again, a novice may glimpse a nebula as a barely visible ghostly glow in the eyepiece, while a seasoned observer will see intricate details and even in some cases various hues. It's all a matter of the training of the eye—and along with it the brain that processes the images formed by the telescope.

Sir William Herschel—the greatest visual observer who ever lived—long ago advised: "You must not expect to *see at sight*. Seeing is in some respects an art which must be learned." He also pointed out that "When an object is once discovered by a superior power, an inferior one will suffice to see it afterwards." (In other words, the eye-brain combination has been alerted to its presence.) And another great observer of the past, William Henry Smyth, stated that "Many things, deemed invisible to secondary instruments, are plain enough to one who 'knows how to see them'."

There are four distinct areas in which an observer's eye can be trained to see more at the eyepiece (whether it be that of a telescope or a pair of binoculars). Let's start with that of *visual acuity*—the ability to see or resolve fine detail in an image. There's no question that the more time you spend at the eyepiece, the more such detail you will eventually see! Even without any purposeful training plan in mind,

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the eye-brain combination will learn to search for and see ever-finer detail in what it is viewing. But this process can be considerably speeded up by a simple exercise repeated daily for a period of at least several weeks. On a piece of white paper, draw a circle about 3 in. in diameter. Then using a soft pencil randomly draw various markings within the circle, ranging from broad patchy shadings to fine lines and points. Now place the paper at the opposite side of a room at a distance of at least 20 ft or so, and begin drawing what you see using the unaided eye. Initially, only the larger markings will be visible to you. As you repeat this process over a period of time, you will be able to see more and more of them!

Taking this a step further, cut out that white disk and attach it onto a black background. Next, darken the room and illuminate the image with a low-intensity flashlight mounted in front of it. Doing this more closely simulates the view of a planetary disk seen against the night sky through a telescope. Tests have shown improvements in overall visual acuity by a factor of as much as ten using these procedures! Not only will you see more detail on the Sun, Moon and planets as a result, but you will also be able to resolve much closer double stars than you were previously able to.

A second area of training the eye-brain combination involves the technique of using *averted* (*or side*) *vision* in viewing faint celestial objects. This makes use of the well-known fact that the outer portion of the retina of the eye contains receptors called *rods*, which are much more sensitive to low levels of illumination that is the center of the eye which contains receptors known as *cones*. (See the discussion below involving color perception by the cones.) This explains the common experience of driving at night and seeing objects out of the corner of the eye appearing brighter than they actually are if you turn and look directly at them.

Applied to astronomical observing, averted vision is used in detecting faint companions to double stars and dim stars in open and globular clusters. But it's especially useful (and most obvious) in viewing low-surface-brightness targets like nebulae and galaxies, where increases in apparent brightness of two, to two and a half times (or an entire magnitude), have been reported! Once having centered such an object in the field of view, look to one side of it (above or below also works), and you'll see it magically increase in visibility. (Be aware that there is a small dark void or "dead spot" in the fovea between the eye and ear that you may encounter in going that direction.)

One of the most dramatic examples of the affect of averted vision involves the so-called "Blinking Planetary"—a name coined by the author many years ago in a *Sky & Telescope* magazine article about it. Also known as NGC 6826, it's located in the constellation Cygnus and is easily visible in a 3- or 4-in. glass. Here we find an obvious bluish-green tenth-magnitude nebulosity some 27 seconds of arc in size surrounding a ninth-magnitude star. Staring directly at the star, there's no sign of the nebulosity itself. On switching to averted vision, the nebulosity instantly appears and is so bright that it drowns out the central star. Alternating back and forth between direct and averted vision results in an amazing apparent blinking effect!

A third important area involving the eye-brain combination is that of *color perception*. At first glance, the stars all appear to be white. But upon closer inspection, differences in tint among the brighter ones reveal themselves. The lovely contrasting hues of ruddy Betelgeuse and blue-white Rigel in the constellation Orion is one striking example in the winter sky. Another can be found in the spring and summer sky by comparing blue-white Vega in Lyra and orange Arcturus in Bootes. Indeed, the sky is alive with color once the eye has been trained to see it! Star color, by the way, is primarily an indication of surface temperature: ruddy ones are relatively cool while bluish ones are quite hot. Yellow and orange suns fall between these extremes.

While the rods in the edge of the eye are light sensitive, they are essentially colorblind. Thus, for viewing the tints of stars (whether single, double or multiple) and other celestial wonders, direct vision is employed—making use of the color-sensitive cones at the center of the eye. Stare directly at an object to perceive its color and off to the side to see it become brighter (unless it's already a bright target like a planet or naked-eye star). It should be mentioned here that there's a peculiar phenomenon known as the "Purkinje Effect" that results from staring at red stars—they appear to increase in brightness the longer you watch them!

One final area involving preparation of the eye to see is that of *dark adaptation*. It's an obvious fact that the eyes needs time to adjust to the dark after coming out of a brightly lit room. Two factors are at play here. One is the dilation of the pupils themselves, which begins immediately upon entering the dark and continues for several minutes. The other involves the actual chemistry of the eye, as the hormone rhodopsin (often called "visual purple") stimulates the sensitivity of the rods to low levels of illumination. The combined result is that night vision continues to improve noticeably for perhaps half an hour or so (and then continues to do so very slowly for many hours following this initial period). This is why the sky looks black on first going outside, but later looks gray as you fully adjust to the dark. In the first instance, it's a contrast effect and in the second the eye has become sensitive to stray light, light pollution and the natural airglow of the sky itself that were not seen initially (Fig. 10.1).

Stargazers typically begin their observing sessions by viewing bright objects like the Moon and planets first and moving to fainter ones afterward, giving the eye time to gradually dark-adapt naturally. This is mainly of value in observing the dimmer deep-sky objects like nebulae and galaxies. Double stars themselves are generally so bright that they can be seen to advantage virtually immediately upon going to the telescope. Exceptions are faint pairs and dim companions to brighter stars (where the radiance of the primary often destroys the effect of dark-adaptation). White light causes the eye to lose its dark-adaptation but red light preserves it, making it standard practice to use red illumination to read star charts and write notes at the eyepiece. Another helpful procedure is to wear sunglasses when venturing outside on a sunny day if you plan to look for "faint fuzzies" than evening. It's been shown that bright sunlight—especially that encountered on an ocean beach or near other reflecting bodies of water—can retard the eye's dark adaptation for as long as several days!

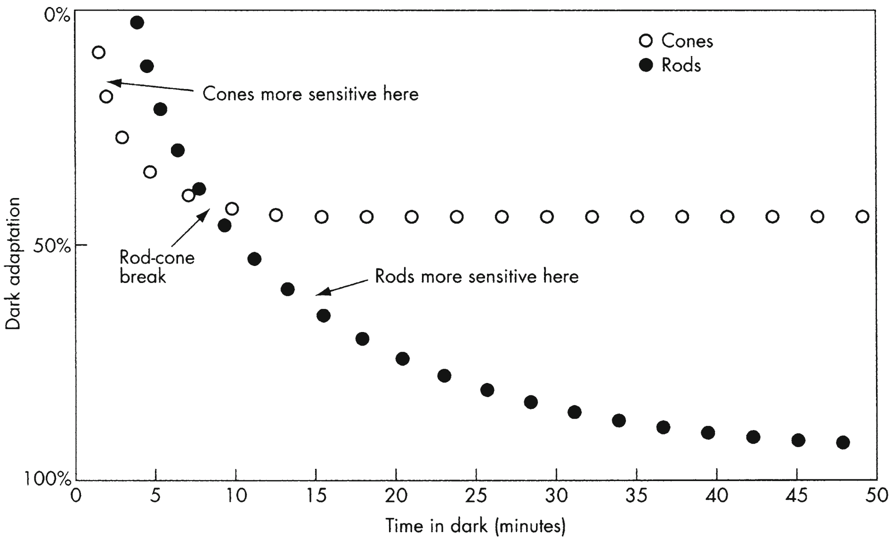


Fig. 10.1 Dark adaptation times for both the color-sensitive cones (*open circles*) at the center of the eye and the light-sensitive rods (*black dots*) around the outer part of the eye. At the "rod-cone break" some 10 min after being in the dark, the sensitivity of the cones levels off and remains unchanged. The rods, however, continue to increase their sensitivity to low light levels, with complete dark adaptation taking at least 4 h! For all practical purposes, the eye is essentially dark-adapted in about 30–40 min

Sky Conditions

A number of atmospheric and related factors affect the visibility of celestial objects at the telescope. In the case of double and multiple stars, the most important of these is atmospheric turbulence or *seeing*, which is an indication of the steadiness of the image. On some nights, the air is so unsteady (or "boiling" as it's sometimes referred to) that star images appear as big puffy, shimmering balls, and detail on the Moon and planets is all but non-existent. This typically happens on nights of high atmospheric *transparency*—those having crystal-clear skies, with the air overhead in a state of rapid motion and agitation. On other nights, star images are nearly pinpoints with virtually no motion, and fine detail stands out on the Moon and planets like an artist's etching. Such nights are often hazy and/or muggy, indicating that stagnant tranquil air lies over the observer's head.

One of the most dramatic and revealing accounts of the changing effects of seeing conditions upon celestial objects comes from the great double star observer, S.W. Burnham, in the following account of the famed binary system Sirius (α Canis Majoris): "An objects glass of 6-in. one night will show the companion to Sirius perfectly: on the next night, just as good in every respect, so far as one can tell with

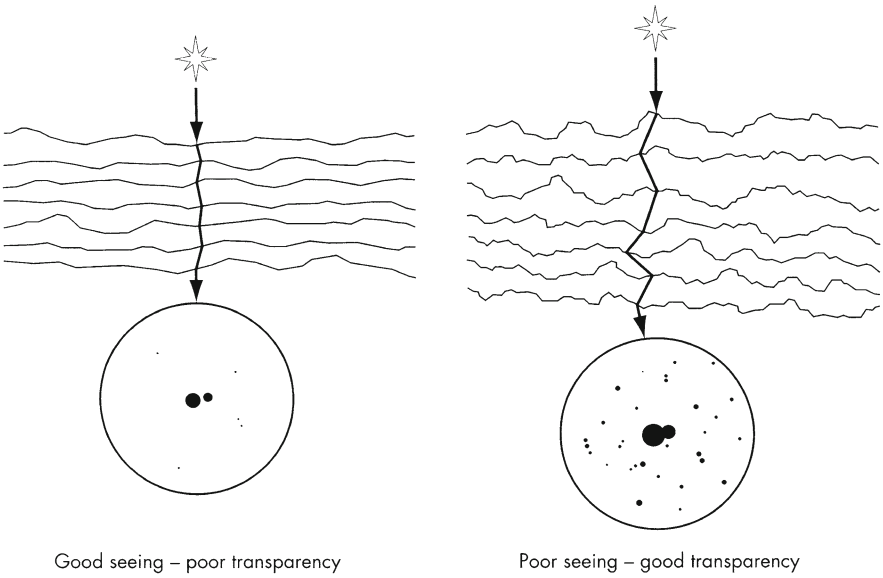


Fig. 10.2 On nights of good "seeing" or atmospheric steadiness, the air above the observer is tranquil and lies in relatively smooth layers, often resulting in somewhat hazy skies. This allows starlight to pass through undisturbed and produces sharp images at the eyepiece. In poor seeing the atmosphere is very turbulent, typically bringing with it crystal-clear skies and an ideal time to view faint objects. But the resulting star images are often blurry shimmering balls of light, making such nights largely useless for seeing fine detail on the Moon and planets or for splitting close double stars

the unaided eye, the largest telescope in the world will show no more trace of the small star than if it had been blotted out of existence."! (Fig. 10.2)

Various "seeing scales" are employed by observers to quantify the state of atmospheric steadiness. One of the most common of these uses a 1–5 numerical scale, with 1 indicating hopelessly turbulent blurred images and 5 stationary razor-sharp ones. The number 3 denotes average conditions. Others prefer a 1–10 system, with 1 again representing very poor and 10 virtually perfect seeing, respectively. (In some schemes, the numerical sequence is reversed, with lower numbers indicating better and higher numbers poorer seeing.) While casual stargazing can often be done even in less than average quality seeing, many types of observing such as sketching or imaging fine lunar and planetary detail, or splitting close double stars, requires good to excellent conditions.

Another factor affecting telescopic image quality is that known as "local seeing"—or the thermal conditions in and around the telescope itself. Heat radiating from driveways, walks and streets, houses and other structures (especially on nights following hot days), plays a significant role in destroying image quality that's totally unrelated to the state of the atmosphere itself. For this reason observing from fields or grassy areas away from buildings and highways gives the best results.

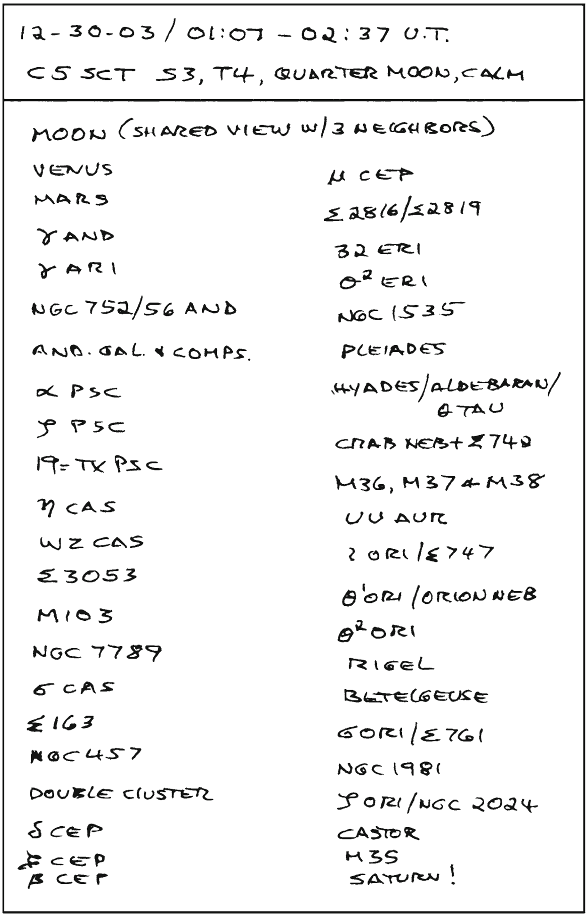
The cooling of the telescope optics and tube assembly is especially critical to achieving sharp images. Depending on the season of the year, it may take up to an hour or more for the optics (especially the primary mirror in larger reflectors) to reach equilibrium with the cooling night air. During this cool-down process, air currents within the telescope tube itself can play absolute havoc with image quality, no matter how good the atmospheric seeing is—especially in closed systems like the popular Schmidt-Cassegrain telescope. Reflecting telescopes should have tubes at least several inches larger than the primary mirror itself to allow room for thermal currents to rise along the inside of the tube rather than across the light path itself. Surprisingly, even the heat radiating from the observer's body can be a concern here, particularly with Dobsonian reflectors having open-tubed truss designs.

No discussion of sky conditions and their impact on observing would be complete without mentioning the hindering effects of bright lights—both natural and man-made. Especially around the time of full-Moon, bright moonlight not only destroys the observer's dark adaptation (discussed above) but also wipes out many of the sky's faint wonders like nebulae and galaxies. And a modern accompaniment is the menace of light pollution—illumination from ever-more homes, office buildings, shopping malls and cars lots, directed skyward instead of downward where it's actually needed. This has much the same result as bright moonlight as it illuminates the atmosphere through which the observer must look. But additionally in the case of artificial lighting, haze and passing clouds intensify its impact by bouncing it back down into telescopes, binoculars and observers' eyes. Fortunately, the planets and brighter stars (including variables and doubles), as well as the Moon itself, are largely immune to all this and so bright nights are not necessarily a total loss for observing.

Record Keeping

The annuals of both amateur and professional astronomy attest to the personal as well as scientific value of keeping records of our nightly vigils beneath the stars. From the former perspective, an account of what has been seen each night can bring pleasing memories as we look back over the years at our first views of this or that celestial wonder—or when we shared their very first look at the Moon or Jupiter or Saturn with loved ones, friends and even total strangers. Our eyepiece impressions written and/or sketched on paper, or perhaps recorded on audio tape and/or electronically imaged, can provide many hours of nostalgic pleasure in years to come.

From a scientific perspective, you may become involved in searching for comets or patrolling the sky for novae, or monitoring the brighter spiral galaxies for possible supernova outbursts. Even negative observations may be of value to professional astronomers. Often has the call gone out to the astronomical community in the various magazines, journals and electronic media asking if anyone happened to be looking at a certain object or part of the sky on a given date and at a particular time. If you happened to be at "the right place at the right time" requested but noted nothing unusual in your observing log, that is still a fact of real importance to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C5 SCT S3, T4, QUARTER MOON, CALM
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CASTOR
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SATURN!

Fig. 10.3 A busy night's entry from the author's personal observing logbook. The date and times are given in Universal Time (U.T.)—that of the Greenwich, England, time zone. A 5-in. Celestron Schmidt-Cassegrain catadioptric telescope (C5 SCT) was used under conditions of average seeing (S) and good transparency (T), and the sky was brightened by the light of a first-quarter Moon. All of the targets viewed on this particular night are celestial showpieces! Normally, more time should be given to viewing fewer objects than shown here in order to fully enjoy and appreciate the cosmic pageantry

researchers. (This frequently happens in attempting to determine when a nova in our galaxy or a supernova in a neighboring galaxy first erupted.) And, of course, there's always the possibility that you will be the first to see and report something new in the sky yourself! (Fig. 10.3)

The information in your logbook should include the following: the date, and beginning and end times of your observing session (preferably given in Universal Time and date); telescope size, type and make used; magnification/s employed; sky conditions (seeing and transparency on a 1–5 or 1–10 scale, along with notes on passing clouds, haze, moonlight and other sources of light-pollution); and finally a notation of each object seen (accompanied if you're so inclined by sketches, photographs and/or electronic images). And here, an important point should be borne in mind regarding record-keeping at the telescope. Limit the amount of time you spend logging your observations to an absolute minimum (using a red light to preserve your dark adaptation when you do!). Some observers spend far more time writing about what they see at the eyepiece than they actually do viewing it!

Observing Sites and Observatories

Where you use your telescope (and less so your binoculars) is a very important consideration. Some observers have no choice in this matter, being confined for various reasons to viewing from a balcony or a driveway or a rooftop, or even through an opened upstairs bedroom window—all of which are considered "no-nos"! We've already mentioned the deleterious affect on images of heat rising from paved surfaces and radiating from buildings. Probably worst of all is observing from a rooftop, as some observers living in apartments in large cities do to get above the lights and surrounding buildings. A tarred roof surface will radiate heat after a warm day long into the night, engulfing both observer and telescope in a sea of unstable air. And while looking through open windows—especially during the winter months when it's cold outside and warm inside—has always been considered useless due to the temperature gradient, some observers (typically those using long-focus refractors) have been able to get reasonably sharp images by sticking the telescope tube as far outside of the window as possible. Needless to say, sky visibility in any case is quite limited! And as for balconies, any movement on or anywhere around it (even someone walking inside the house or apartment) will typically result in annoying gyrations of the images seen in the telescope.

With light pollution ever on the increase, more and more stargazers are traveling with their telescopes to find dark skies. In some cases, these are designated astronomy club sites while in others they are city, county, state or national parks. While this has its advantages—particularly for observers whose main interest is viewing faint deep-sky wonders—the inconvenience of packing up the telescope, accessories, and necessities like water and proper clothing, and driving there and back, limit the number of observing sessions compared to simply stepping out into a backyard. And for those who believe that only the Moon and planets can be observed from urban areas, the author has on many occasions viewed—and also shown to others—even some of the brighter galaxies like that in Andromeda from the heart of a number of major cities. Two helpful references here are *Visual Astronomy in the Suburbs* by Anthony Cooke (Springer, 2003) and *Urban Astronomy* by Denis Berthier and Klaus Brasch (Cambridge University Press, 2003).

Fortunate indeed is the observer who has a proper shelter for his or her telescope—one where the instrument can be left safely outdoors, protected from the

Fig. 10.4 A charming example of the classical domed observatory. The most aesthetic-looking of the various types of telescope shelters, it offers the greatest protection from wind and stray light. However, it also has the most limited view of the sky (due to its narrow slit) and is the most costly of all the types of housings. Photo by Sharon Mullaney

elements, and be ready to use almost immediately upon demand. The *domed observatory* is the best-known and most aesthetic-looking of such structures, and offers the maximum protection from wind and stray lights. But of the various types, it's also the most costly, requires the longest cool-down time (for the temperature inside the dome to reach equilibrium with that outside), and provides only a limited vista of the sky through its narrow slit (Fig. 10.4).

An alternative to the dome is the *roll-off roof observatory*, in which the entire top of the structure rolls back on tracks to reveal the whole visible heavens. Depending on the height of its walls, it may offer only limited protection from wind and lights. A delightful compromise between these two types is the *flip-top roof observatory*. Here, a structure with low walls and hinged peak roof splits into two sections—one half typically swinging to the east, the other half to the west. Chains or ropes control how high or low the halves extend, the observer adjusting them to reveal whatever part of the sky is being viewed, while at the same time using them as a shield against wind and lights (Fig. 10.5).

Mention should also be made of a very unique telescope shelter first built by famed stargazer Leslie Peltier to house his short-focus 6-in. refractor. Referred to

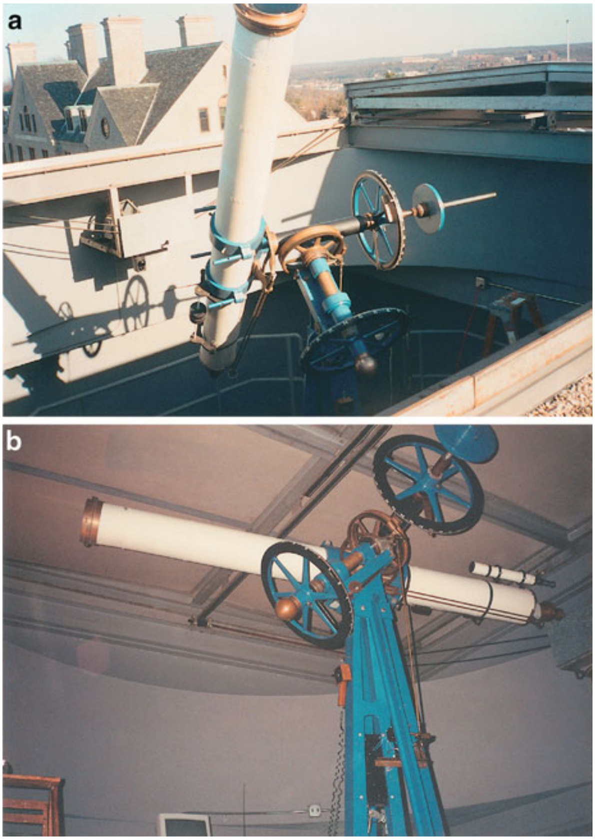

Fig. 10.5 (**a**, **b**) A typical roll-off roof observatory—this one housing a classic Alvan Clark 8-in. refractor, shown with the roof in both its opened (*left*) and closed (*right*) position. This structure provides the maximum coverage of the sky, but both the observer and telescope are exposed to the wind and elements (the actual degree to which depending on how high the walls are) and there's little protection against stray light. Photos by Sharon Mullaney

as the "merry-go-round observatory," the observer rides sitting in cushioned comfort in a chair with both the instrument and structure housing it as they circle in azimuth on a track to reveal a particular part of the sky. The telescope itself points skyward through a kind of trap door on the flat roof of the box-shaped observatory, and is mounted within in such a way that very little head motion is required to look into the eyepiece no matter where it's pointed. A number of other observers have constructed their own versions of Peltier's design and all who have consider this the ultimate in a personal telescope shelter. For more about the merry-go-round observatory, see Peltier's delightful autobiography *Starlight Nights* (Sky Publishing, 2000).

It should be pointed here out that many of the classic observers of the past—including the greatest observational astronomer of them all, Sir William Herschel—worked in the open night air unprotected by any kind of structure. So, too, do a majority of stargazers today, including the author, who has extensively used all three types of observatories (and on one occasion Peltier's merry-go-round itself!) over the years as both an amateur and professional astronomer.

Personal Matters

There are a number of little-recognized factors that impact the overall success of an observing session at the telescope. One concerns proper dress. This is of particular importance in the cold winter months of the year, when observers often experience sub-zero temperatures at night. It's impossible to be effective at the eyepiece—or even to just enjoy the views—when you're numb and half frozen to death! Proper protection of the head, hands and feet are especially critical during such times, and several layers of clothing are recommended as opposed to one heavy one for thermal insulation of the body in general. During the summer months, the opposite problem arises, as observers attempt to stay cool. In addition to very short nights at this time of the year, there's the added annoyance of flying insects together with optics-fogging humidity and dew. (See the discussion on dew caps and heated eyepieces in Chap. 7.)

Another concern is proper posture at the telescope. It's been repeatedly shown that the eye sees more in a comfortably seated position than when standing, twisting or bending at the eyepiece! If you must stand, be sure that the eyepiece/focuser is at a position where you don't have to turn and strain your neck, head and back to look into it. This is especially a problem with large reflecting telescopes. And while not as critical, the same goes for positioning finder scopes where they can be reached without undue contortions.

Proper rest and diet both play a role in experiencing a pleasurable observing session. Attempting to stargaze when you're physically and/or mentally exhausted is guaranteed to leave you not only frustrated—but looking for a buyer for your prized telescope! Even a brief "cat nap" before going out to observe after a hectic day is a big help here. Heavy dinners can leave you feeling sluggish and unable to function alertly at the telescope. It's much better to eat after you're done stargazing—especially so since most observers find themselves famished then (particularly on cold nights!). Various liquid refreshments such as tea, coffee and hot chocolate can provide a needed energy boost (and warmth when desired). And while alcoholic drinks like wine do dilate the pupils, technically letting in more light, they also adversely affect the chemistry of the eye. This reduces its ability to see fine detail on the Moon and planets or resolve close double stars, and especially being able to glimpse "faint fuzzies" like dim nebulae and galaxies!

Finally, there's the very important matter of *preparation*. This is not just being aware of what objects are visible on given night at a particular time of year, or which of them can be seen from your site and with your instrument, or deciding on those you plan to observe this time out. It goes beyond this to understanding something about the physical nature of the wonder you're looking at—facts such as its type, distance, physical size, luminosity, mass, temperature, velocity towards or away from you, speed of rotation, composition, age, and place in the grand cosmic scheme of things. In other words, as stargazers we must "see" with our minds as well as our sight. (To better grasp the importance and purpose of preparation before going to the eyepiece, see the beautiful mandate found in the opening lines of Chap. 12, as set forth by the classic observer Charles Edward Barns.)